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Domestic determinants of international cooperation: an analysis of the intricate relationship between energy politics and climate change mitigation

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ABSTRACT

In this dissertation, we study the interaction between international relations and domestic politics regarding climate change mitigation demonstrating that the struggle between the interests of major political groups in domestic politics is key to explain the positions a country undertakes in international climate negotiations. Cost-benefit analysis – based on the country's own vulnerability its risks to climate change, and costs it will incur to reduce GHG emissions – does not, on itself, explain a country's decision of whether to act and to what extent to act on climate change. This is so because states are not unitary but polyarchic actors, formed by groups with heterogeneous preferences that will try to influence the policy process to maximize its own gains, and because climate concerns are not alone in informing groups preferences. Given the global public good nature of climate change mitigation, climate action is more likely to receive political support when it can promote additional benefits, or co-benefits, valued by major political groups.

We test this framework in action that aims at steering energy systems away from fossil fuels and towards low carbon energy sources, or promoting energy decarbonization. First, by checking the trajectory of carbon intensity of energy supply in the G20 countries between 1971 and 2015 and comparing it with the trajectory of energy supply, demonstrating that energy security – a key objective of energy policy and a co-benefit of energy decarbonization – did increase by raising the share of low carbon primary energy sources in G20 countries' energy matrices. Then by demonstrating that in a G20 country, Brazil, the role of the co-benefit of energy security in catalyzing climate action in the energy sector is missed due to the disconnect between the trajectories of energy and climate politics and the interests of key domestic energy actors. This analysis help explain why Brazilian positions in the climate regime are structurally conservative and reformist standings have been only circumstantial and points to which changes are necessary to change it.

Key words: International politics; climate change; energy politics and policies; G20; Brazil.

Resumo

Nesta tese, estuda-se a interação entre relações internacionais e política interna em relação à mitigação da mudança do clima demonstrando que entender o conflito entre interesses de grupos políticos centrais na política interna é chave para explicar as posições de um país nas negociações internacionais do clima. A análise de custo-benefício – baseada na vulnerabilidade de um país, seus riscos em relação à mudança do clima, e nos custos que incorrerá para reduzir suas emissões de gases de efeito estufa – não explica, sozinha, a decisão de um país em agir e em que medida agir para mitigar a mudança climática. Primeiro porque Estados não são atores unitários e, sim, poliárquicos, formados por grupos com preferências heterogêneas que tentarão influenciar o processo político para maximizar seus ganhos; e porque a preocupação com a mudança do clima é analisada em meio a outras preferências dos grupos. Dada a natureza de problema global comum da mitigação da mudança do clima, é mais provável que a ação de mitigação receba apoio político quando promova benefícios adicionais, valorizados por importantes grupos políticos.

Testa-se essa moldura em ações que almejam diminuir a participação de combustíveis fósseis e aumentar a de fontes de energia de baixo carbono nos sistemas energéticos na direção, o que se denomina descarbonização energética. Primeiro, descrevendo a trajetória da intensidade de carbono da energia nos países do G20 entre 1971 e 2015 e comparando-a com a trajetória das matrizes energéticas, demonstrando que a segurança energética – objetivo chave de política energética e benefício adicional de aumentar o papel de fontes de baixo carbono na matriz energética – aumentou ao elevar a participação de fontes de baixo carbono nas matrizes energéticas. Depois, ao demonstrar que em um país do G20, Brasil, o papel do benefício adicional da segurança energética em catalisar ação climática no setor energético foi anulado em razão da desconexão entre as trajetórias das políticas energética e climática e dos interesses de grupos políticos centrais. Esta análise ajuda a explicar porque as posições brasileiras no regime internacional do clima são estruturalmente conservadoras e os avanços reformistas foram circunstanciais e aponta para mudanças necessárias para reverter esse quadro.

Palavras-chave: Política internacional; mudança do clima; política energética; G20; Brasil.

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LIST OF ACRONYMS

AMFORP: American and Foreign Power Company

ANEEL: Agência Nacional de Energia Elétrica

ANP: Agência Nacional do Petróleo, Gás e Biocombustíveis

BASIC: Brazil, South Africa, India and China, coalition

BNDES: Banco Nacional de Desenvolvimento Econômico e Social

BP: British Petroleum

BRASPETRO: Petróleo Brasileiro S.A. (PETROBRAS on foreign ventures)

BRICS: Brazil, Russia, India, China and South Africa

CARICOM: Community of Caribbean Countries

CCEE: Câmara de Comercialização de Energia Elétrica

CDM: Clean Development Mechanism

CENAL: Comissão Executiva Nacional do Álcool

CFC: Chlorofluorocarbon

CH_4: Methane

CIDE: Contribuição de Intervenção no Domínio Econômico

CIMGC: Comissão Interministerial de Mudança Global do Clima

CNAEE: Conselho Nacional de Águas e Energia Elétrica

CNAL: Conselho Nacional do Álcool

CO_2: Carbon Dioxide

CO2/TPES: Carbon Intensity of Energy Supply

CONTRAN: Conselho Nacional de Trânsito

COP: Conference of Parties

COPERSUCAR: Cooperativa de Produtores de Cana de Açúcar do estado de São Paulo

CPFL: Companhia Paulista de Força e Luz

CRAB: Comissão Regional de Atingidos por Barragens

CRC: Conta Resultados a Compensar

CUT: Central Única dos Trabalhadores

DNAEE: Departamento Nacional de Águas e Energia Elétrica

ELETROBRAS: Centrais Elétricas Brasileiras S.A,

ELETROBRAS: Centrais Elétricas Brasileiras S.A.

ELETRONORTE: Centrais Elétricas do Norte do Brasil S.A.

ELETROSUL: Centrais Elétricas do Sul do Brasil S.A.

EMBRAPA: Empresa Brasileira de Pesquisa Agropecuária

EPE: Empresa de Pesquisa Energética

FBMC: Fórum Brasileiro sobre Mudança do Clima

FURNAS: Furnas Centrais Elétricas

GASBOL: Gasoduto Brasil – Bolívia

GDP PPP: Gross Domestic Product, Purchasing Power Parity

GHG: Greenhouse Gases

IAA: Instituto Nacional do Álcool

IAEA: International Atomic Energy Agency

IBGE: Instituto Brasileiro de Geografia e Estatística

IBSA: India-Brazil-South Africa Dialogue Forum

ICMS: Imposto sobre Circulação de Mercadorias e Serviços

IEA: International Energy Agency

IMF: International Monetary Fund

INES: International Nuclear Events Scale

INPE: Instituto Nacional de Pesquisas Espaciais

IPCC: Intergovernmental Panel on Climate Change

IRENA: International Renewable Energy Agency

LED: Light-Emitting Diode

LNG: Liquefied Natural Gas

LULUCF: Land Use, Land Use Change and Forestry

MAB: Movimento dos Afetados por Barragens

MERCOSUR: Mercado Común del Sur

MME: Ministério de Minas e Energia

MRV: Monitoring, Report and Verification

MST: Movimento dos trabalhadores Sem Terra

N_2O: Nitrous Oxide

NGO: Non-Governmental Organization

NIMBY: Not In My Back Yard

OC: Observatório do Clima

OECD: Organization for Economic Cooperation and Development

ONS: Operador Nacional do Sistema

OPEC: Organization of the Petroleum Exporting Countries

PDE: Plano Decenal de Expansão de Energia

PES: Payment for Environmental Services

PETROBRAS: Petróleo Brasileiro S.A.

PM10, PM2.5: Particulate Matter (number refer to size of particule)

PNPB: Programa Nacional de Produção e Uso do Biodiesel

PROCONVE: Programa de Controle de poluição do ar por Veículos automotores

PRODEEM: Programa de Desenvolvimento Energético dos Estados e Municípios,

Programa ABC: Programa Agricultura de Baixo Carbono

PROINFA: Programa de Incentivo às Fontes Alternativas de Energia Elétrica

PSA: Production Sharing Agreements

PT: Partido dos Trabalhadores

R&D: Research and Development

SBF: Sociedade Brasileira de Física

SBPC: Sociedade Brasileira para o Progresso da Ciência

SIN: Sistema Interligado Nacional

TPES: Total Primary Energy Supply

UEMOA: West African Economic and Monetary Union

UHE: Usina Hidrelétrica de grande porte

UNFCCC: United Nations Framework Convention on Climate Change

WB: World Bank

Introduction

Climate change is one of the most pressing issues of current international affairs. Rising concentration of Greenhouse Gases (GHG) in the atmosphere has short-term – more extreme weather events, such as severe droughts, more common and intense fires, change in rain patterns, floods, hurricanes and tsunamis – and long-term – increasing average global temperature, or global warming – effects. Science has proven that climate change is directly related with human activities, especially the use of fossil fuels as energy sources, which escalated in the 20th Century and still answer for around 80% of global primary energy supply. The current impact of human action on the environment is unprecedented; a new geological epoch, the Anthropocene, was inaugurated. Without serious engagement to alter human action, the continuation of life – human and, especially, other species – is threatened.

International negotiations on climate change have started in the 1990s, focusing on building consensus around the issue and obtaining commitments to mitigate climate change effects. At first, members of the United Nations Framework Convention on Climate Change (UNFCCC) opted for a top-down approach without creating a mechanism to ensure reciprocity. But climate change mitigation is a global public good, non-excludable and non-rivalrous, so incentives to free ride exceed incentives to comply with commitments – even more when there are no sanctions for non-compliance. GHG emissions continued to rise.

In 2015, UNFCCC members inaugurated a different approach. Emission reduction targets would be designed nationally and reviewed periodically; reviews of climate commitments would be boosted by a system of monitoring, reporting and verification to be created in the regime. Under this new approach, real progress in tackling climate change depends on whether UNFCCC members truly implement their pledges and increase ambition of their commitments in the review process. While institutional improvements in the UNFCCC regime are welcomed, progress depends on how climate change is assimilated by domestic politics and incorporated in domestic policy.

This dissertation focuses the interaction between international relations and domestic politics regarding climate change mitigation. It aims at contributing to theory by demonstrating how international commitments on climate change mitigation cannot be understood by focusing systemic variables alone. Given the nature of the climate problem – requiring change in long-term and deeply-rooted practices and structures of current political and economic processes – domestic variables play a key role in shaping commitment to climate change mitigation. Only by analyzing systemic and domestic variables simultaneously we can understand why some countries have been more active than others in pursuing climate change mitigation.

Cost-benefit analysis is a traditional tool employed to explain climate action. According to it, a country's decision of whether to act and to what extent to act on climate change considers the country's own vulnerability – its risks – to climate change and the costs it will incur to reduce GHG emissions. Yet, we find this formula incomplete, for two main reasons. First, states are not unitary but polyarchic actors (MILNER, 1997): they are formed by different groups that have heterogeneous preferences, and each group will try to influence the policy process to maximize its own gains (BANG, UNDERDAL and ANDRESEN, 2015). Because risks and costs of climate change are unevenly distributed among these groups, political struggle will determine the outcome. Second, climate concerns are not alone in informing groups preferences (PURDON, 2015). Different objectives are pursued simultaneously. When climate action can promote, in addition to climate change mitigation, additional benefits – co-benefits – valued by different groups, it is more likely that the action will receive their political support.

We propose a framework in which the struggle between interests of major political groups helps explaining climate action in democracies and their positions in international negotiations. First, major actors in domestic climate politics are identified as well as the relationships between them. When focusing the actors, we identify who the major actors are, which are their interests and how these interests are pursued through in the political process. When focusing the relationship between the actors, both the nature of their relationship and its structure are at focus: what kind of relationship it is, and how it develops. We hypothesize that the climate policy outcome will be explained by the struggle between interests of major actors and the institutions that mediate their interactions.

Second, we expect that co-benefits of climate change mitigation will be key in explaining policy outcomes. Because direct benefits of climate change mitigation are not appropriable by the groups that engage in climate action, we hypothesize that co-benefits will be an important variable in their cost-benefit analysis of whether to act and how much. When groups identify co-benefits from acting on climate change mitigation, these might push them to truly act, or at least make them pressure the government for action. But when co-benefits are not identified, groups will not act, so policy change is delayed. Different actors might value co-benefits differently; the impact co-benefits will have in the policy outcome will depend on the political power of the actors that value it.

In this dissertation, we test the framework in energy-related climate action. Due to the impact of fossil fuel combustion on GHG concentration, seriously mitigating climate change means pursuing deep decarbonization, a profound and structural transformation of how we produce and use energy. Its main pillars are increasing energy conservation and efficiency and steering energy systems and energy end-use away from fossil fuels and towards low carbon energy sources. This latter phenomenon we call energy decarbonization. Energy decarbonization of utmost relevance for global climate change mitigation, but might or might not produce co-benefits that are valued by major political groups in different countries. The more major domestic actors identify co-benefits from energy decarbonization and value it, the more likely they will offer their political support to action that pursue it; if co-benefits from energy decarbonization are not identified or valued by major political actors, the less likely that an agenda focusing energy decarbonization will be successful. In other words, co-benefits would become catalyzers of climate action if they are highly valued by major domestic actors among their various interests.

The dissertation has two different parts. In the first, we aim at demonstrating that co-benefits play a key role in advancing energy decarbonization. We start by offering a longer and more precise description of the climate problem and of our theoretical framework, chapter 01. In chapter 02, we first list the most-commonly identified co-benefits of energy decarbonization, among them enhancing energy security, a key objective of energy policy. Then we compare the trajectory of energy supply in the 19 countries members of the G20 between 1971 and 2015 with the trajectory of carbon intensity of energy supply in the same period, aiming to discover if there is a relationship between advancing energy decarbonization and increasing energy security. In other words, if in countries where energy decarbonization has advanced are countries in which it also contributed to increase energy security.

In the second part, we want (a) to demonstrate how the trajectory of energy policy in a G20 country is explained by elements of international political economy and the struggle between interests of major domestic political groups and (b) to understand if and how co-benefits from energy decarbonization work as catalyzers of climate action in the energy sector. We hypothesize that a more conservative or reformist (VIOLA, FRANCHINI and RIBEIRO, 2013) position in the international climate regime will, in great extent, be influenced by if and how co-benefits of climate action in general, and of energy decarbonization in particular, are perceived by major political actors. The institutional background of how positions are formulated and the evolution of the paradigms of foreign policy are also important variables to explain the nuances.

To do so, we embark on a case study. We chose to study Brazil because of its position both among the greatest world's energy producers and consumers and among world's greatest GHG emitters. We accept that Brazil is atypical among the G20 members given the higher share of low carbon primary energy sources in its energy matrix and the smaller role of energy-related emissions in total GHG emissions. Yet, there is neither reason to believe that the drivers that explain the trajectory of Brazilian energy policy would be different from the ones that explain it in other G20 countries, nor that co-benefits from energy decarbonization, if perceived by major political groups in Brazil, would not play an important role in driving climate action here. We accept that understanding Brazilian commitments in the climate regime requires adding variables from other emitting-sectors, especially land use, land use change and forestry (LULUCF), and we do that. Still, given the rising role of energy-related emissions in Brazilian GHG emissions profile, which is likely to increase even further if LULUCF and agriculture emissions are reduced, justifies the relevance of our analysis.

The dissertation proceeds in other two chapters. In chapter 03, we first detail the trajectory of the political economy of energy in Brazil, identifying the international influences and major actors and their interests, and how these influences and interests shaped the energy policy trajectory. Then we demonstrate that major energy actors in Brazil understand that potential co-benefits of energy decarbonization counteract key goals of energy policy; hence, co-benefits fail to work as catalyzers of climate action. In chapter 04, we focus the trajectory of climate politics and policies in Brazil to demonstrate that they are largely disconnected. We then explain the trajectory of Brazilian commitment in the international climate regime by looking at the interaction of the political economy in largest emitting sectors and paradigms of foreign policy. We argue and justify why, in our view, Brazil will remain, in the near-future, a conservative power in the climate regime and a laggard in deep decarbonization.

Our data collection included primary and secondary data. Among the first, we analyzed different datasets from different sources such as The World Bank, the International Energy Agency, the World Resources Institute, British Petroleum, the Climate Observatory and the Brazilian government, on different energy-related climate topics, e.g., trajectory of GHG emissions and energy supply. The datasets were used as sources of data on their own and as input for our own calculations, performed when we did not find the data we needed. We also analyzed reports from international agencies, national governments and academia on several issues related to our research.

For the second part of the dissertation, to help us in reconstructing the trajectory of energy and climate politics between 1971 and 2015 and understanding the different views on the political struggles, we also conducted 64 interviews with key actors involved with Brazilian energy policy and politics, among them members of government, members of energy-related regulatory agencies, entrepreneurs, representatives, CEOs, academics, members of civil society. Most of the interviews took place between April and July 2016; a handful later in 2016 and in 2017. A complete list of interviewees is presented. However, we do not identify them when we cite their comments. We are aware that this makes it harder for verifying our findings or replicating them. Yet, after 05 pilot interviews we understood that some agents were not comfortable to answer all our questions unless anonymity was offered, given that many times they refer to topics that are considered politically sensitive. Therefore, and in order to guarantee the same treatment to all interviewees, we offered them anonymity first hand, in our first contact with each person. In choosing the interviewees, we started from a smaller list and expanded it by accepting suggestions that were made by the interviewees themselves (snowball sampling). In all interviews, a few questions remained the same, but another set of questions was elaborated according to the expertise of the interviewee (semistructured questionnaire). All interviewees were very open to answer our questions, and most provided a great deal of details when doing so. The information they provided was recorded and transcribed but, due to our commitment with anonymity, cannot be made public. And because our main objectives with the interviews was to rebuild the trajectory of energy and climate politics in Brazil during the period studied as well as gather the perception of different actors involved with them, the interviewee was cited only either when they provided an information that was not also found in other sources or when they very clearly referred to information that we considered crucial to understand the process. Otherwise the information they provided was merged with the information from other sources (cross-analysis of data).

Among our secondary data, we reviewed literature on climate change, climate change mitigation, the interaction between energy and climate change, the politics of decarbonization, energy, energy politics, the political economy of energy and climate change in Brazil, Brazilian environmentalism, the fragmentation of the Brazilian political system and Brazilian foreign policy.

We understand that our research offers several pieces of contribution to literature. First, it demonstrates that the idea that co-benefits can play an important role in advancing climate change mitigation is consistent with an empirical analysis of the 1971-2015 trajectory of energy supply in world's major emitting countries. Second, it provides a through reconstruction of the political economy of energy in Brazil between 1971 and 2015, in both electricity and fuel sectors. Third, by demonstrating that the perception of major political actors on co-benefits of climate action impacts national commitment with climate change mitigation, it advances an analytical framework to help explaining the rationale behind different positions of members of the international climate regime.

There is no reason to think that this analytical framework is unable to explain results in other cases (STEINBERG, 2015). Our research offers a preliminary illustration of a theory (ODELL, 2001) that could be employed to study other cases, which we were unable to do due to constraints of time and resources. It could also be advanced further, e.g. using game theory, developing new insights. While the field of climate politics has expanded greatly in the last decade, especially by employing comparative analysis, a focus on the politics of energy decarbonization is still underdeveloped, and would benefit highly from further research.

Introdução

A mudança climática é uma das mais prementes questões na política internacional contemporânea. O aumento da concentração de gases de efeito estufa na atmosfera tem efeitos de curto – mais eventos climáticos extremos, como secas severas, incêndios de grande gravidade e proporção, mudança em padrões de precipitação, enchentes, furacões e tsunamis – e de longo – aumento da temperatura média do planeta, ou aquecimento global – prazos. A ciência provou que a mudança do clima tem relação direta com atividades humanas, especialmente o uso de combustíveis fósseis como fonte de energia, que aumento exponencialmente no século XX e ainda responde por cerca de 80% do fornecimento global de energia. Esse impacto da ação humana no meio ambiente é sem precedentes; uma nova época geológica, o Antropoceno, foi inaugurada. Sem engajamento sério para modificar a ação humana, a continuação da vida – humana e, especialmente, de outras espécies – no planeta está ameaçada.

Negociações internacionais sobre mudança do clima começaram nos anos de 1990, com foco em construir consenso sobre o tema e obter compromissos para mitigar os efeitos da mudança climática. No início, os membros da Convenção Quadro das Nações Unidas sobre Mudança do Clima optaram por uma estratégia *top-down*, sem criar mecanismos para assegurar a reciprocidade. Mas a mitigação mudança do clima é um bem global comum, não-exclusivo e não-rival, portanto incentivos para "pegar carona" (*free ride*) nas ações alheias ultrapassam os incentivos para cumprir os próprios compromissos – e ainda mais quando não há sanções para o não-cumprimento. As emissões de gases de efeito estufa continuaram a subir.

Em 2015, os membros do regime climático mudaram de estratégia. As metas de redução de emissões seriam designadas nacionalmente e revisadas periodicamente; as revisões seriam estimuladas por um sistema de monitoramento, relato e verificação a ser criado. De acordo com essa nova estratégia, progresso real em enfrentar a mudança do clima depende de real implementação dos compromissos pelos países membros e aumento de sua ambição no processo de revisão. Avanços institucionais no regime internacional são bem-vindos, porém progresso depende de como a mudança do clima é assimilada na política interna dos países e incorporada a políticas, gerais e setoriais.

Essa tese foca a interação entre relações internacionais e política interna em relação à mitigação da mudança do clima. Ambiciona-se contribuir com a teoria ao demonstrar como compromissos internacionais em mitigar a mudança do clima não podem ser compreendidos se apenas variáveis sistêmicas são focadas. Dada a natureza do problema do clima – que requer mudança em práticas e estruturas enraizadas no processo político-econômico – variáveis internas têm papel fundamental em delinear o compromisso com a mitigação da mudança do clima. Compreender porque alguns países têm sido mais ativos do que outros em adotar políticas de mitigação da mudança do clima requer combinar variáveis sistêmicas e internas.

A análise de custo-benefício é uma ferramenta tradicional empregada para explicar a ação em mudança do clima. De acordo com ela, a decisão de um país em agir e em que medida agir para mitigar a mudança do clima depende de sua vulnerabilidade – seus riscos – em relação à mudança do clima e dos custos que terá para reduzir suas emissões de gases de efeito estufa. Considera-se esta fórmula incompleta, por duas razões principais. Em primeiro lugar, Estados não são atores unitários e, sim, poliárquicos (MILNER, 1997): são formados por diferentes grupos que possuem preferências heterogêneas, e cada grupo buscará influenciar o processo político para maximizar seus ganhos (BANG, UNDERDAL e ANDRESEN, 2015). Como riscos e custos da mudança do clima são desigualmente distribuídos entre os grupos, o conflito político determinará o resultado. Em segundo lugar, a preocupação com a mudança do clima não é isolada de outras preocupações (PURDON, 2015): diferentes objetivos são buscados simultaneamente. Quando diferentes grupos notam que a medidas que promovem mitigação da mudança do clima podem lhes proporcionar benefícios adicionais é mais provável que ofereçam seu apoio político para as medidas.

Propõe-se uma moldura em que os conflitos entre interesses de atores políticos centrais ajudam a explicar ações de mitigação da mudança do clima em democracias e as posições desses países nas negociações internacionais. Primeiro, atores centrais para a política climática interna são identificados, bem como as relações entre eles. Ao focar nos atores, quer-se identificar quem são, quais seus interesses e como esses interesses são buscados por meio do processo político. Ao focar a relação entre os atores, tanto sua natureza como sua estrutura estão em foco: que tipo de relação e como se desenvolve. A hipótese é que o resultado político (ação climática) será explicado por meio do conflito entre os interesses de atores centrais para o tema bem como das instituições de medeiam as interações entre eles.

Segundo, espera-se que benefícios adicionais de ação que ambiciona a mitigação da mudança do clima serão importantes para explicar o resultado. Como benefícios diretos da mitigação da mudança do clima não são apropriáveis pelos grupos que promovem ação climática, presume-se que benefícios adicionais serão parte de seu cálculo de custo-benefício – se devem agir ou não, e em que medida. Quando grupos identificam benefícios adicionais, esses podem servir como incentivos para que os primeiros ajam, ou pressionem seus governos, para agir. Porém se benefícios adicionais não são identificados os grupos não terão incentivos para agir, e o resultado político (ação climática) será adiado. O apelo de um co-benefício pode ser diferente para diferentes atores; o impacto de um co-benefício dependerá do poder político de atores que o valorizam.

Nesta tese, essa moldura é testada em ações climáticas relacionadas à energia. Dado o impacto da combustão de fontes de energia fóssil na concentração de gases de efeito estufa, a mitigação da mudança climática requer a descarbonização profunda, uma transformação estrutural do modo de produzir e consumir energia. Seus pilares são a busca da conservação da energia e da eficiência energética e a substituição de fontes fósseis por fontes de baixo carbono nos sistemas energéticos e usos finais de energia – este último fenômeno é denominado descarbonização energética. Descarbonização energética tem relevância ímpar para a mitigação da mudança do clima, e pode produzir benefícios adicionais que serão ou não valorizados por grupos políticos importantes. Quando grupos identificam benefícios adicionais da descarbonização energética, mais provável que ofereçam apoio para ação que a promova; mas se benefícios adicionais não são identificados ou valorizados por atores políticos centrais, menos provável que essa agenda tenha sucesso. Em outras palavras, benefícios adicionais seriam catalizadores de ação climática no setor de energia se valorizados por grupos políticos importantes dentre seus tantos interesses.

A tese tem duas partes. Na primeira, demonstrar-se-á que benefícios adicionais têm papel relevante em fazer avançar a descarbonização energética. No capítulo 01 é trazida uma descrição mais longa e precisa do problema da mudança do clima e da moldura teórica adotada na pesquisa. No capítulo 02, elencar-se-ão os benefícios adicionais da descarbonização energética mais comumente identificados na literatura, entre eles aumentar a segurança energética, um objetivo chave de política energética. Em seguida, comparar-se-ão a trajetória de suprimento energético nos 19 países membros do G20 entre 1971 e 2015 com a intensidade de carbono da energia no mesmo período, de modo a descobrir se há relação entre avanço da descarbonização energética e aumento da segurança energética. Em outras palavras, se, nos países em que a descarbonização energética avançou no período de estudo, ela teria também contribuído para aumentar a segurança energética.

Na segunda parte da tese, (a) demonstrar-se-á como a trajetória de políticas energéticas em um país do G20 é explicada por elementos de economia política internacional e pelo conflito entre interesses de grupos políticos importantes e (b) investigar-se-á se e como benefícios adicionais da descarbonização energética funcionam como catalizadores de ação climática no setor de energia. A hipótese é que posições mais conservadoras ou reformistas (VIOLA, FRANCHINI e RIBEIRO, 2013) no regime internacional de mudança climática serão, em grande parte, determinadas por atores políticos que percebem que obterão ou não benefícios adicionais da ação climática, em geral, e da descarbonização energética, em particular. O contexto institucional que determina como posições são formuladas e os paradigmas de política externa também são variáveis importantes na explicação.

Para fazê-lo, optou-se por um estudo de caso. Escolheu-se o Brasil para o estudo de caso por sua posição entre os maiores países produtores e consumidores mundiais de energia e maiores emissores de gases de efeito estufa. É fato que o Brasil é atípico entre os membros do G20 porque sua matriz energética tem maior participação de energias primárias de baixo carbono e suas emissões de gases de efeito estufa têm menor participação do setor energético. Todavia não há motivo para acreditar que os vetores que explicam a trajetória da política energética brasileira são diversos dos que explicam a mesma trajetória em outros países do G20, e nem que benefícios adicionais da descarbonização energética, se valorizados por atores políticos importantes, não poderiam ter papel em acelerar a descarbonização energética no Brasil. Sabe-se que para compreender os compromissos brasileiros no regime internacional climático requer incluir variáveis de outros setores, em especial uso da terra, mudança de uso da terra e florestas (LULUCF, sigla em inglês), e isto é feito. No entanto, a participação crescente de emissões do setor energético no total das emissões brasileiras de gases de efeito estufa – que deve ser ainda mais relevante caso as emissões de LULUCF e da agricultura sejam reduzidas – justifica a relevância desta análise.

A tese prossegue em dois outros capítulos. No capítulo 03, primeiramente detalhar-se-á a trajetória da economia política da energia do Brasil, identificando as influências internacionais, os atores principais e seus interesses, e como essas influências e esses interesses moldaram a trajetória das políticas energéticas. Em seguida, demonstrar-se-á como atores centrais na política energética brasileira entendem que benefícios adicionais da descarbonização energética vão de encontro a objetivos centrais de política energética; no Brasil, os benefícios adicionais não funcionam como catalizadores de ação climática. No capítulo 04, focar-se-á a trajetória da política climática no Brasil para demonstrar que se desenvolveu separadamente da trajetória da política energética, e que, em larga medida, as duas permanecem desconectadas. A trajetória do compromisso brasileiro no regime internacional de mudança climática é explicada pela interação entre a economia política nos setores com maior participação no total de emissões e os paradigmas de política externa. Argumenta-se, e justifica-se, que o Brasil é e permanecerá um ator conservador no regime internacional do clima e um país atrasado na descarbonização profunda de sua economia.

A pesquisa envolveu dados primários e secundários. Entre os primeiros, foram analisadas bases de dados do Banco Mundial, da Agência Internacional de Energia, do *World Resources Institute*, da *British Petroleum*, do Observatório do Clima e do governo brasileiro, em diferentes temas relacionados a clima e energia, e.g. trajetória de emissões de gases de efeito estufa e de fornecimento de energia. As bases de dados foram utilizadas como fontes em si e como aporte para cálculos próprios, realizados sempre que não foram encontrados os dados necessários. Também foram analisados relatórios de agências internacionais, governos nacionais e academia, em diferentes temas relacionados à pesquisa.

Para a segunda parte da tese, e para auxiliar na reconstrução das trajetórias das políticas energética e climática entre 1971 e 2015 e no entendimento das diferentes visões sobre os conflitos políticos, foram feitas 64 entrevistas com pessoas envolvidas na política energética brasileira, entre elas membros do governo federal, membros de agências reguladoras, empresários, representantes de associações do setor, membros da academia e membros da sociedade civil. Uma lista completa de entrevistados é apresentada. Porém os entrevistados não são identificados quando seus comentários são citados. Está-se ciente de que este fato torna mais difícil a verificação de nossos resultados por outros pesquisadores. No entanto, após 05 entrevistas-piloto, compreende-se que algumas pessoas não estavam confortáveis em responder parte de nossas perguntas a menos que o anonimato fosse assegurado, dado que alguns temas tocados eram considerados politicamente sensíveis. Por este motivo, e para assegurar um tratamento idêntico a todos os entrevistados, o anonimato foi oferecido a cada pessoa no primeiro momento em que a contatamos. Ao escolher os entrevistados, iniciou-se com uma lista menor que foi expandida por meio de indicações feitas pelos entrevistados (*snowball sampling*). Em todas as entrevistas, parte das perguntas permaneceu igual, mas parte foi elaborada de acordo com o *expertise* da pessoa entrevistada (questionários semiestruturados). Todos os entrevistados foram muito receptivos às perguntas e as responderam abertamente, e a maioria forneceu uma grande quantidade de detalhes ao fazê-lo. As informações que eles deram foram gravadas e transcritas, porém não podem ser tornadas públicas dado nosso compromisso com o anonimato. E porque nossos principais objetivos com as entrevistas eram ter mais elementos para reconstruir a trajetória das políticas energética e climática no Brasil durante o período estudado e obter a percepção de diferentes atores envolvidos, os entrevistados foram citados diretamente apenas quando as informações que forneceram não constavam também de outras fontes ou quando eles muito claramente fizeram referência a uma informação que foi considerada crucial para entender o processo. Caso contrário as informações que forneceram encontram-se combinadas com as informações de obtidas por outras fontes (análise cruzada de dados).

Entre os dados secundários, foi revisada literatura sobre mudança do clima, mitigação da mudança do clima, a interação entre energia e mudança do clima, política da descarbonização, energia, política energética, economia política da energia e mudança do clima no Brasil, ambientalismo brasileiro, fragmentação do sistema político brasileiro e política externa brasileira.

A tese oferece diversas contribuições para a literatura. Em primeiro lugar, demonstra que a hipótese de que benefícios adicionais podem ter papel importante para fazer avançar a mitigação da mudança do clima é consistente com a análise empírica da trajetória do fornecimento de energia entre 1971 e 2015 nos maiores países emissores de gases de efeito estufa. Em segundo lugar, reconstrói a economia política da energia no Brasil entre 1971 e 2015, tanto no setor elétrico como no setor de combustíveis. Em terceiro lugar, ao demonstrar que a percepção de atores políticos importantes sobre benefícios adicionais da ação climática, em geral, e da descarbonização da energia, em particular, tem impacto no compromisso nacional com a mitigação da mudança do clima, a tese avança uma moldura analítica que ajuda a explicar a lógica por trás de diferentes posicionamentos dos países no regime internacional climático.

Não há motivo para acreditar que esta moldura analítica não é capaz de explicar resultados para outros países (STEINBERG, 2015). A pesquisa oferece uma ilustração preliminar de teoria (ODELL, 2001) que pode ser empregada em outros estudos de caso, que não foram realizados por escassez de tempo e recursos. Ela pode também ser mais desenvolvida no futuro, e.g. com o uso da teoria dos jogos. O campo de estudo da política climática foi expandido de maneira acelerada durante a última década, especialmente por meio de análise comparativa; o foco em política da descarbonização energética, porém, é ainda pouco desenvolvido e se beneficiaria de mais pesquisas.

Chapter 01: The climate problem and driving forces on mitigation

1.1. CLIMATE CHANGE AND THE TRAJECTORY OF INTERNATIONAL CLIMATE POLITICS

1.1.1. Discovering anthropogenic climate change: the science

The climate has always intrigued humanity. Since ancient times, understanding climate patterns was key to allow better chances of surviving. In fact, the development of agricultural societies is directly related to climate stability (FEYNMAN and RUSMAIKIN, 2007), and it was agriculture that has enabled humanity to settle down and develop into greater groups. Climate stability started approximately 11,000 years ago, after the last Glacial Period was over, and lasted through a period called the Holocene. The impact of the climate on humanity was never questioned. But the human impact on the climate was discovered more recently.

In the 19th Century, science started to study the physics of the global greenhouse effect – the relationship between increasing concentrations of some gases in the atmosphere and rising average temperatures on the planet. In 1861, John Tyndall discovered that complex molecules such as water and carbon dioxide (CO_2) can absorb thermal radiation and theorized that changes in their concentration in the atmosphere could be responsible for "*mutations of climate*" (IPCC, 2007a, p. 105). In 1896, Svante Arrhenius calculated that doubling or halving the atmospheric concentration of CO_2 would lead to relevant changes of average temperature of around 4-5^{o}C (HULME, 2009, p. 46); this climate sensitivity could be the cause of glacial advances or retreats (IPCC, 2007a, p. 105). Guy Callendar, in 1938, perfected Arrhenius calculations and found that doubling the CO_2 concentration in the atmosphere would lead to a 2^{o}C rise of the mean global temperature, and that fossil fuel combustion was directly related to the rising CO_2 (IPCC, 2007a, p. 105). Callendar was the first to theorize over the relationship between human activities and global warming. Yet he thought the change was beneficial, as it would prevent another ice age (HULME, 2009, p. 53).

Nuclear weapons showed that humanity had mastered forces capable of planetary effects (WEART, 2011, p. 68). In the post-war period, evidences of the human impact on the planet improved. In 1957, Roger Revelle and Hans Suess proved that it takes oceans centuries to fully absorb CO_2 from the atmosphere, so rising emissions would build up in the atmosphere (WEART, 2011, p. 68; IPCC, 2007a, p. 105). Charles Keeling proved it by his series of measurements of the concentration of CO_2 in the atmosphere at the South Pole and at Mauna Loa, Hawaii, which showed that CO_2 concentration was rising between 0.5 and 1.3 parts per million (ppm) per year (HULME, 2009, p. 55). But the studies of the time were shy to pinpoint possible consequences of global warming; sea level rise was among the few they reported (WEART, 2011, p. 68).

In the 1970s, better technology allowed climate research to become more precise. The warming potential of other gases such as methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs) was discovered; findings pointed that their concentration in the atmosphere was also increasing (IPCC, 2007a, p. 105). The use of satellites improved measurements of the solar irradiance, proving that the sun could not be blamed for the rising temperatures in the second half of the 20th Century (IPCC, 2007a, p. 108). Syukuro Manabe and Richard Wetheral's computational model simulated the three-dimensional consequences of doubled atmospheric CO_2 concentration: average global temperature 2.9^{o}C higher, but greater warming at the poles, more moderate in the tropics and cooling in the stratosphere (HULME, 2009, p. 57).

In the 1980s, research on deep ice cores in Greenland showed that rapid and large climate fluctuations had occurred during the last ice age and were directly related with the concentration of CO_2 in the atmosphere, phenomenon latter denominated Dansgaard-Oeschger events (IPCC, 2007a, p. 106). In the 1990s, this research was expanded to Antarctic ice cores and new sedimentary cores from different regions; it would measure the concentration of atmospheric CH_4 found on ice cores, and those showed the same correlation previously found for CO_2 (IPCC, 2007a, p. 107). Wallace Broecker alerted that the world was wrong to expect incremental changes in the climate: recent changes in atmospheric composition could provoke abrupt changes again (HULME, 2009, p. 60-61). In the following decade, better climate models as well as findings from research on radiative forcing, cryosphere, and ocean and ocean-atmosphere dynamics supported the claim that human activities were promoting rapid change not only in the concentration of gases in the atmosphere but in a variety of Earth systems, and that those changes are all connected.

In 2000, Paul Crutzen and Eugene Stoermer argued that the Anthropocene, a new geological epoch featuring humankind as the greatest driver of planetary change, had been inaugurated (CRUTZEN and STOEMER, 2000). Human activities were impacting the oceans, biochemical cycles, sensitive ecosystems; exhausting freshwater systems; reducing the ozone layer; and driving the sixth great extinction of species, the first caused by a biological species (CRUTZEN and STOEMER, 2000; STEFFEN et al, 2011a, p. 850). In 2009, scientists warned that a systemic disruption of Earth systems was on its way and it could end the safe operating space for humanity (ROCKSTROM et al, 2009). They identified nine planetary boundaries that need to be respected to avoid the systemic disruption, and calculated the safe limits for the first seven: (i) climate change, (ii) ocean acidification; (iii) stratospheric ozone depletion; (iv) nitrogen and phosphorus cycles; (v) global freshwater use; (vi) change in land use; (vii) biodiversity loss; (viii) atmospheric aerosol loading; and (ix) chemical pollution (ROCKSTROM et al, 2009, p. 472-473). According to their calculations, the safe limits on three of them – biodiversity loss, nitrogen cycle and climate change – had already been trespassed (ROCKSTROM et al, 2009, p. 472-473).

Figure 1.1: Planetary Boundaries

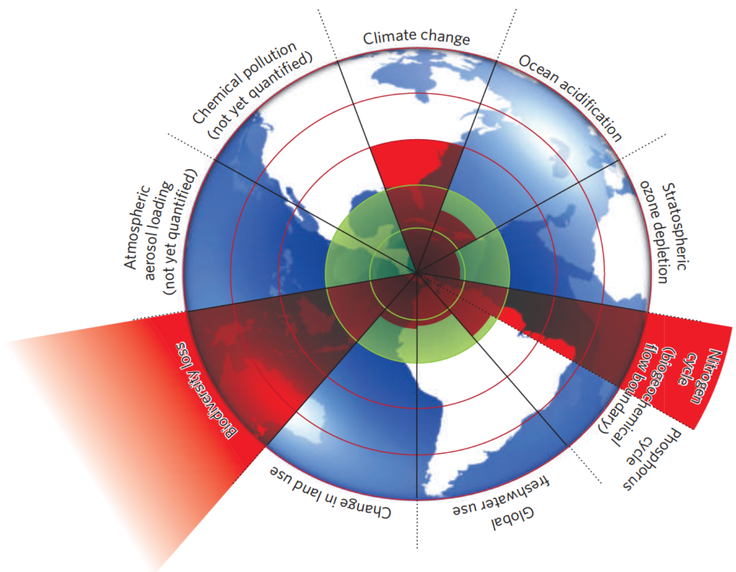
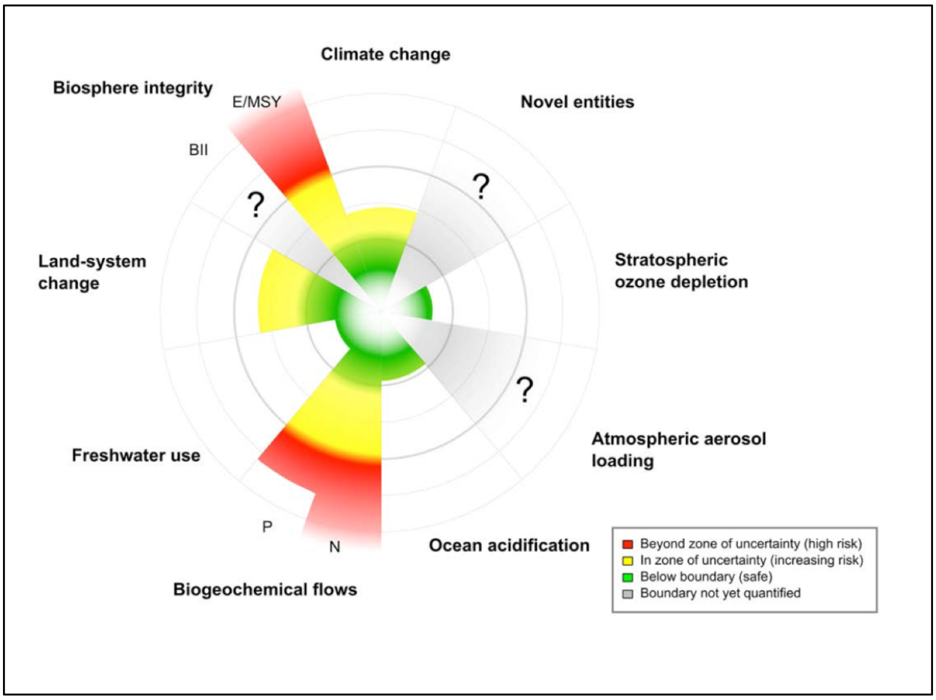


Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

Source: ROCKSTROM et al, 2009, p. 472.

In 2015, researchers revised their work on the planetary boundaries. They updated the planetary boundaries to: (i) climate change; (ii) biosphere integrity (in two roles: information bank of the genetic diversity and biosphere functioning); (iii) land-system change; (iv) freshwater use; (v) biochemical flows (nitrogen and phosphorus cycles); (vi) ocean acidification; (vii) atmospheric aerosol loading; (viii) stratospheric ozone depletion; and (ix) novel entities that could cause unwanted geophysical and/or biological effects (STEFFEN et al, 2015). They also updated control variables and their current values for eight of the boundaries (STEFFEN et al, 2015). And they argued that climate change and changes in biosphere integrity are core planetary boundaries: they are "*regulated by the other boundaries and provide the planetary-level overarching systems within which the other boundary processes operate*" (STEFFEN et al, 2015). Their key relevance is related to the fact that "*transitions between time periods in Earth history have often been delineated by significant shifts in climate, the biosphere, or both*" (STEFFEN et al, 2015).

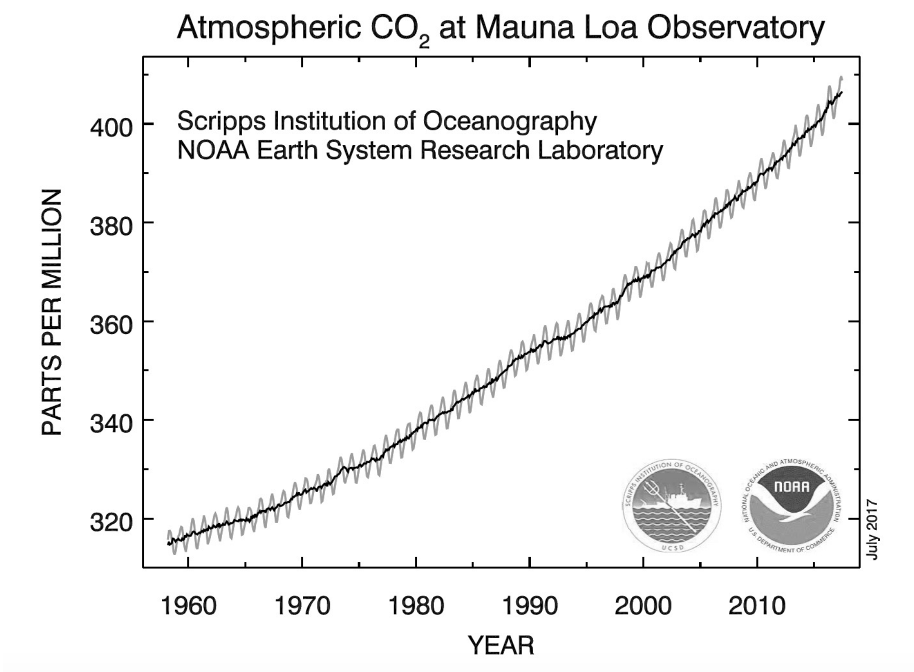
Figure 1.2: Planetary Boundaries 2.0



Source: STEFFEN et al, 2015.

Although science has also identified worrying predictions for the long-run – e.g. higher average temperatures, sea-level rise, changes in air and water currents –, consequences of global warming are already being experienced thought more common extreme weather events. Precipitation patterns are being modified, and severe droughts – with intense and long-lasting water shortages – and/or flooding follow it. Heat waves are more constant and extended. The wildfires season starts earlier and/or lasts longer than usual. News on hurricanes and tsunamis are becoming ever more common, even in places where they did not usually happen. Artic ice is melting faster than usual during Summer, and retreating ice layer is causing earthquakes in Greenland. The urgency of mitigating climate change is obvious if humankind is to avoid experiencing greater instability of the Earth system. Yet, the concentration of Greenhouse Gases (GHG) continues to rise, and at an increasingly faster pace: "*total anthropogenic GHG emissions have risen more rapidly from 2000 to 2010 than in the previous three decades*" (IPCC, 2014a, p. 42).

Figure 1.3: Keeling Curve, Mauna Loa Observatory, 1958-2017 full data



Source: Earth System Research Laboratory, Global Monitoring Division, available at <https://www.esrl.noaa.gov/gmd/ccgg/trends/> retrieved 11 Aug 2017.

1.1.2. Climate change becomes a global political issue

As scientific evidence of the impact of human activities on the environment became stronger and started to be communicated outside academic circles, the topic entered the political agenda. International Conferences to debate climate change started to take place around the 1980s and experts called on governments to act on it. In 1992, the international regime on climate change was inaugurated, but after 25 years of negotiations very little has been achieved.

Concerns over conservation of natural landscapes have existed for a long time; in the 19th Century, conservational groups emerged in different parts of the world. But it was in the 1960s that the impact of human activities on the environment entered the political agenda. The environmental revolution (MCCORMICK, 1989) that took place in Western industrial societies at that time was a complex phenomenon, gathering under the same umbrella people with different demands. On its basis are both science and counter-culture movements questioning the status quo.

On the one hand, scientific evidence of the impact of human activity on the environment was strengthened due to more investment in research and better technology. These results were also more openly communicated to the public at the time compared to previous decades, thanks to more independent media and more freedom of speech in these societies: e.g. the impact of Rachel Carson's 1962 book *Silent Spring*, denouncing the links between the widespread use of pesticides and reduced bird populations, was very significant. Several environmental disasters contributed to bring the topic to public opinion's attention as well: e.g. the collapse of a pit-heap in Aberfan, Wales, in 1966; oil spills around the Isles of Scilly, in 1967, and off the coast of California, in 1969 (MCCORMICK, 1989); the eutrophication of Lake Erie and the fire on Cuyahoga River in the United States, in 1969.

On the other hand, different counter-culture groups emerged by questioning dominant cultural traits of the time. They argued that higher material standards achieved in the 1940s and 1950s had created a conformist society, indifferent to environmental degradation, poverty, war and nuclear danger (MCCORMICK, 1989). The hippie movement, by reigniting the back-to-the-land crusade and defending causes like vegetarianism, recycling and organic farming, was an important exponent. In 1972, the

United Nations held its Conference on the Human Environment in Stockholm, Sweden; participants determined that development at any level should consider its impact on the environment. In 1987, the Brundtland Commission concluded that development would be sustainable if allowed present generations to meet their needs without compromising the ability of future generations to meet their own needs (UN, 1987).

Climate change slowly started to be singled out from other environmental issues as scientific evidence of global warming and of its consequences improved. In the 1970s, links between the intense droughts in the American Midwest, Russia and Africa and research on global warming brought the topic to public knowledge (WEART, 2011, p. 70). In 1979, the first international conference on the topic, gathering 300 experts from more than 50 countries, was held in Geneva: World Climate Conference, (WEART, 2011, p. 70). In 1983, the United States National Academy of Sciences published its first report arguing that effects of global warming could affect agriculture, worsen deaths and illnesses, and change the habitats of disease vectors, so maybe the seriousness of the issue had been overlooked (WEART, 2011, p. 70-71). In 1985, experts from 29 countries, for the first time, called on governments to act on climate change (WEART, 2011, p. 71).

The 1988 World Conference on the Changing Atmosphere was a game changer. It was another meeting of experts, but for the first time they presented specific policy advice: they named changes in the atmosphere a major threat to international security and urged governments to reduce GHG emissions by 20% below 1988 levels by 2005 (WEART, 2011, p. 71). With major groups opposing the idea of acting on the issue,[1] governments reacted by creating the Intergovernmental Panel on Climate Change (IPCC).

The IPCC would report on advances in climate science to inform policy-making, but members would act both as climate experts and as representatives of their governments and wording would need to be approved by consensus. As a result, IPCC Reports' Executive Summaries are compromises between the most advanced climate science and political positions. Conclusions of IPCC's first report, from 1990, are vague – a significant part of the climatologists was still very cautious or skeptic with evidence on

[1] E.g. in 1989, the fossil fuel industry and its allies founded the Global Climate Coalition, funding reports focusing the uncertainty of climate science and lobbying aggressively against climate action (WEART, 2011, p. 72).

climate change. Only in the 2nd Report, from 1995, the group finally stated the key role of human interference in causing climate change (WEART, 2011, p. 72-73). In the 3rd Report, from 2001, details on the interference were made clear: human activities had increased the atmospheric concentrations of key GHG gases – CO_2, CH_4, N_2O – since the pre-industrial era, due to the combustion of fossil fuels, agriculture and land-use changes (IPCC, 2001, p. 04).

In 1992, United Nations members gathered in the Earth Summit signed the United Nations Framework Convention on Climate Change (UNFCCC) inaugurating an intergovernmental forum to negotiate solutions to the problem. But few governments reacted with more than inexpensive plans to improve energy efficiency (WEART, 2011, p. 73). In 1997, the Kyoto Protocol was signed, establishing compulsory GHG emission reduction to UNFCCC Annex I countries. But extensive discord followed its implementation, and little progress towards reducing GHG emissions was achieved. Public opinion was becoming more aware of climate change, thanks to studies that linked global warming and extreme weather events[2] and research that portrayed climate change as a security threat[3] (WEART, 2011, p. 75). In 2006, the Stern Review strengthened the case for action by showing that the costs of inaction on climate change are significantly higher than the costs of action (STERN, 2006, p. viii).

In 2007, the IPCC released its 4th Report. At that time, agreement on the seriousness of the threat presented by climate change and the insufficiency of policies on place to revert it was reported with high confidence (IPCC, 2007b, p. 03-04). It is now a consensus. Its 5th Report, published in 2014, the IPCC states that "*human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history*" (IPCC, 2014b, p. 02).[4] Despite the consensus, action still lags

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[2] In the beginning of the 2000s, extreme weather events became more frequent: e.g. the 2003 heat wave in Europe; forest fires from Alaska to Arizona; massive icebergs breaking away from the Antarctic ice shelf.

[3] In 2003, the United States Pentagon published a study warning that climate change would disrupt food, water and energy supply, so the potential threat to global security was real (WEART, 2011, p. 75).

[4] The text in a following paragraph is even more explicit: "The evidence for human influence on the climate system has grown since the IPCC Fourth Assessment Report (AR4). It is **extremely likely** that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in GHG concentrations and other anthropogenic forcings together. The best estimate of the human-induced contribution to warming is similar to the observed warming over this period. Anthropogenic forcings have likely made a substantial contribution to surface temperature increases since the mid-20th century over every continental region except Antarctica[4]. Anthropogenic influences have likely affected the global water cycle since 1960 and contributed to the retreat of glaciers since the 1960s and to the increased surface melting of the Greenland ice sheet since 1993. Anthropogenic influences have very likely contributed to Arctic sea-ice loss since 1979 and have very

much behind scientific requirements to mitigate climate change. If disagreements over the certainty of global warming were overcome, they are now fueled by how the burden of action should be shared. And this is intrinsically related to the nature of the issue.

1.1.3. The nature of the climate problem

Science has identified the rising concentration of atmospheric GHG as the cause of climate change: "*the global emissions of GHGs lead to changes in atmospheric concentrations, then to changes in radiative forcing, and finally to changes in climate*" (IPCC, 2014a, p. 242). The diagnosis indicates straightforward action: to cut GHG emissions so to stabilize at first and then reduce GHG concentration in the atmosphere. Yet it is not easily put into practice. Emissions result from a wide range of human activities that are at the core of current modes of production and consumption. They are a normal output of activities directly related to current living standards and welfare levels, achieved over two centuries of technological innovation but increasing impact on the environment. At heart, mitigating climate change means questioning this status quo and re-building the human relationship with the Earth System on a different basis.

Climate change is driven mostly by world's dependence on fossil fuels: "*CO_2 emissions from fossil fuel combustion and industrial processes contributed about 78% to the total GHG emissions increase from 1970 to 2010, with similar percentage contribution for the period 2000–2010*" (IPCC, 2014a, p. 45). Coal was already an important energy source since the 11th Century in China and the 13th Century in England (STEFFEN, CRUTZEN and MCNEILL, 2007, p. 615), but its use was greatly expanded since the 18th Century. Petroleum and natural gas followed and became key fuels in late 19th Century.

The exponential use of fossil fuels coincides with the Industrial Age. Their use solved an energetic bottleneck and allowed consistent innovation in different areas. Without fossil fuels, there would be no internal combustion engines, which revolutionized industrial machinery and transportation; no synthetized ammonia, a fertilizer produced through an energy-intensive process that sharply increased crop yields in the 20th

likely made a substantial contribution to increases in global upper ocean heat content (0–700 m) and to global mean sea level rise observed since the 1970s" (IPCC, 2014b, p. 05; our emphasis in bold). Note that "extremely likely" refers to 95-100% agreement between the scientists, according to note 1 on IPCC, 2014b, p. 02.

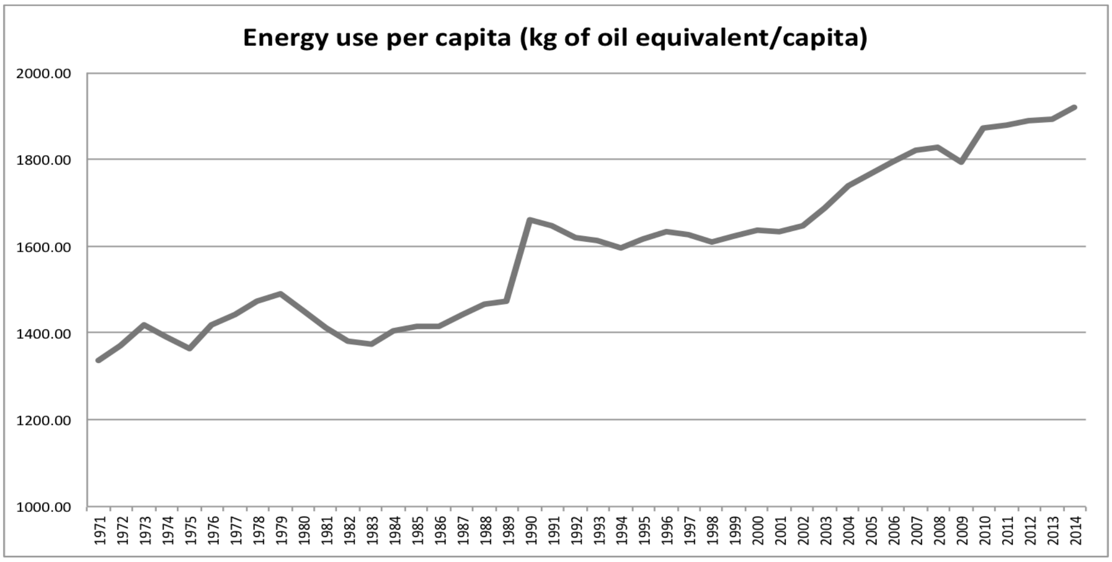
Century (STEFFEN, CRUTZEN and MCNEILL, 2007, p. 616). They also allowed gains of scale in the steel industry; the development of polymers; and many other developments. Industrial societies used four to five times more energy than agrarian ones, and seven to nine times more than hunter-gatherers (STEFFEN, CRUTZEN and MCNEILL, 2007, p. 616).

During the second half of the 20th Century, period called The Great Acceleration, a new economic model was established. The Bretton Woods system backed economic recovery and pushed economic growth (STEFFEN et al, 2011b, p. 850). Economic integration, international financial flows, and new trade agreements gave rise to greater economies of scale and mass consumption. Science and technology were integrated into the civil economy through partnerships between government, academia and industry, furthering innovation (STEFFEN et al, 2011b, p. 850). Growth was the new motto, and availability of cheap fossil fuels was key to allow it. In fact, between 1950 and 2000, global economic activity increased by more than fifteen-fold; world population doubled; the number of motor vehicles increased 1,750 times; and the use of petroleum almost quadrupled (STEFFEN, CRUTZEN and MCNEILL, 2007, p. 617).

The digital revolution impacted socio-economic dynamics and raised human pressure on the Earth System even more. World population continues to grow; urbanization accelerated worldwide, and at faster pace in emerging economies. More frequent international travelling, more automated industrial production and expanding use of electronic gadgets raised the use of energy. Between 1971 and 2014, per capita use of energy increased 43.60% (WB, 2017).[5] And it had a serious impact on emissions: "*nearly three-quarters of the anthropogenically driven rise in CO2 concentration has occurred since 1950, and about half of the total rise has occurred in just the last 30 years*" (STEFFEN, CRUTZEN and MCNEILL, 2007, p. 618).

5 Own calculations based on data referred.

Figure 1.4: World energy use per capita, 1971-2014 (kg of oil equivalent/capita)



Source: Own elaboration based on data from WB, 2017 (indicator <EG.USE.PCAP.KG.OE> from 22 Dec 2017).

Climate change is considered "*the greatest and widest-ranging market failure ever seen*" (STERN, 2006, p. viii). This is so because the costs and benefits from burning fossil fuels are decoupled. The benefits – cheap energy, from fuels that are easily stored and provide high energetic output per unit, allowing a wide range of activities to be performed – are enjoyed by the ones that burn the fuel, while the costs – GHG emissions, raising the concentration of GHG in the atmosphere and producing climate change – are shared by all humankind and other species. This externality is not easily fixed.

Hardin (1968) has explained that common goods – non-excludable but rivalrous –[6] will perish if decisions about their use are left to individuals alone. Individuals involved in the provision of common goods face a prisoner's dilemma: while it is in the common interest to cooperate in providing the good, sharing costs and benefits, the best outcome for the individual is reached when they can appropriate all benefits without incurring in any cost. So, it is rational to defect. Successful provision of common-pool resources

[6] Non-excludability means that people that did not contribute to the good's provision cannot be excluded from its use. Rivalry means that the use of the good by one individual diminishes their availability to another one. Hardin gives a common grazing area as example: because it is common, nobody can be stopped from taking cattle to graze there, but the grass eaten by one animal cannot be eaten by another one. So, the more animals one farmer puts in the area, the less food will be available to another farmer's animals (see Hardin, 1968).

requires agreement between the parties on limits of exploitation and measures to protect the asset. It is most likely to take place when a small and stable group, in which members trust each other and accept reciprocity, is involved, lowering the transaction costs (OSTROM, 1990).

Climate change mitigation is a public good. Public goods are non-excludable and non-rivalrous: either climate change mitigation is provided for the whole humankind or it is not provided at all. Marginal costs and benefits are at the heart of each person's decision to act to provide a public good when the group is large, so incentives to free ride are maximum. Unless there is some form of coercion or separate and selective interests at play, public goods are most likely not to be provided by the group itself (OLSON, 1971).

On top of it, climate change mitigation is no ordinary public good: it was defined as a wicked or diabolical problem (PRINS et al, 2010; STEFFEN, 2011). First, it is intrinsically global, once it is centered around atmospheric changes. Second, it operates on a time scale that is beyond the human usual experience – it took GHG concentration decades to rise to their current numbers, and it will take the same or longer for them to stabilize. In other words, costs of mitigating climate change – reducing GHG emissions – will be incurred in present, but the benefits will be felt in the future, perhaps centuries from today (STEFFEN, 2011, p. 22-23; IPCC, 2014a, p. 225). Third, it involves intra and intergenerational equity issues (STEFFEN, 2011, p. 23; 24; IPCC, 2014a, p. 225). Fourth, the climate is a complex system, so it does not follow a linear fashion: a small change in GHG concentration can trigger massive impacts on climate (STEFFEN, 2011, p. 24-25); changes could be irreversible and lead to catastrophe (IPCC, 2014a, p. 225).

Public goods are usually provided by governments on behalf of all constituency. But climate change mitigation is a global public good, and there is no global government. The international regime on climate change was created to deal with this challenge: to build grounds for cooperation among United Nations members to reduce climate change. Yet, so far, it has been unable to meet its challenge.

1.1.4. Evolution of the international regime on climate change

In 1992, the United Nations members signed the UNFCCC. It is a diplomatic piece that declares the relevance of climate change and the need to act on it and establishes a framework for joint action – it does not prescribe any specific target or objective. The Kyoto Protocol, signed in 1997, established the first steps towards a concerted effort to fight climate change. Negotiations were difficult and almost failed to produce an agreement (WEART, 2011, p. 74). Parties would not agree on how to share the burden of tackling climate change and on the design of the mechanisms to push it.

First, there were disagreements over the level of necessary carbon emission reductions: while European Union defended stringent targets, views from Australia and the United States, who argued for weaker ones, prevailed (BODANSKI and RAJAMANI, 2012, p. 10). Second, the United States defended flexibility mechanisms to help Annex I countries meet their emissions reduction targets (so targets could be met with action mostly undertaken abroad), while the European Union, together with many developing countries, aimed at limiting it, so reductions at home would have to be more substantial (BODANSKI and RAJAMANI, 2012, p. 10).[7] Finally, emerging economies refused to commit to reducing their curve of emissions (BODANSKI and RAJAMANI, 2012, p. 10). At the last minute, the text[8] requiring 37 industrialized countries – listed in the Annex I of the UNFCCC and answering for around 65% of total global carbon emissions at the time – to reduce their emissions by at least 5% below 1990 levels in the period between 2008 and 2012 was approved. Yet, compliance faced severe opposition from status quo actors in many countries, including the United States. When the country withdrew from the Protocol, in 2001, alleging unfair competition with emerging economies in international markets, the share of global emissions covered by the agreement was reduced to around 45%; and it was further reduced to around 30% in 2005, when the Protocol entered into force, due to the rising share of China and India in global emissions (BASSO and VIOLA, 2017, p. 178).

[7] Flexibility won: it allows (i) an international emissions trading system, (ii) joint mitigation commitments and (iii) the possibility of credits for sink activities; it also created the Clean Development Mechanism, by which Annex I countries can obtain credit for emission reduction projects implemented in non-Annex I ones (BODANSKI and RAJAMANI, 2012, 10)

[8] The Kyoto Protocol was signed in 1997 and entered into force in 2005. It has two commitment periods: the 1st between 2008 and 2012, and the 2nd between 2013 and 2019. However, the Doha Amendment (agreement on the 2nd commitment period) requires 144 ratifications to enter into force; only 108 were obtained so far (until 21 Dec 2017).

In 2007, UNFCCC members agreed on the Bali Road Map, a new negotiation process that should result, by 2009, in a New Global Climate Deal to replace the Kyoto Protocol after 2012. In 2009, however, major divergences on the nature of the agreement and of the commitments that would be undertaken prevented an official accord to be adopted. A last-minute deal crafted between the United States and the BASIC countries (Brazil, South Africa, India and China), the Copenhagen Accords, maintained the goal of limiting global average temperature rise to 2^{o}C from pre-industrial levels, but no measure to implement or enforce it was agreed. In 2010, in Cancun, emerging economies presented voluntary pledges to reduce the growth of their emissions, but in more than one case they inflated their projected emissions and based their cuts on these projections. The Cancun Agreements established action on mitigation, transparency, technology, financing, adaptation and forests, but no agreement on the replacement of the Kyoto Protocol was approved in the occasion.

In December 2011, Canada withdrew from the Kyoto Protocol. By 2012, when the Protocol's 1st commitment period was over, only New Zealand, the European Union and Russia[9] had reduced their emissions compared to 1990 levels. In the same year, the Doha Amendment was signed, creating a 2nd commitment period (2013-2019) for the Protocol. Yet, Japan and Russia opted out of the agreement. Therefore, countries – the European Union, Switzerland, Norway, Australia and New Zealand – required to reduce carbon emissions until 2019 account for only 13% of 2013's global emissions and for 9% of 2019's projected amount (BASSO and VIOLA, 2017, p. 179).

Several reasons for the inability of this first approach of the climate regime to tackle climate change have been highlighted in the literature.

First, it is argued that the idea of a universal agreement is not compatible with the nature of the problem. Climate change involves distinct cooperation problems: coordinating emissions regulations; compensating for losses due to emission controls; coordinating climate adaptation; coordinating scientific assessment and investment in technology (KEOHANE and VICTOR, 2011, p. 13). Coordinating regulations to reduce emissions is already very difficult given that every country wants to avoid the costs in which it will necessarily incur (KEOHANE and VICTOR, 2011, p. 13). When the other cooperation problems are put against each other in the bargain, the result is a paralysis.

[9] Russia reduced its emissions due to lower economic activity after the dismantling of the Soviet Union.

Second, the regime granted universal membership and equal voting rights to participants. Members of this large group are very heterogeneous in their capacity and incentives to promote climate change mitigation. In addition, lack of leadership from the larger emitters,[10] especially the United States and China, has reduced ambition of other members (ESTY and MOFFA, 2012, p. 784). The result has been a series of conferences in which members divide in groups prioritizing different agendas and commitments are leveled at the lowest common denominator. Many have been arguing that negotiations in climate clubs gathering key countries could reach better outcomes for climate change mitigation (VICTOR, 2011; HOVI et al, 2016).

Finally, there is no mechanism to ensure reciprocity, to reduce free riding incentives (ESTY and MOFFA, 2012, p. 785). Sanctions for non-compliance could play this role, as they do in other regimes. Or other measures, such as access to financial transfer, to technologies or to markets could be employed instead. A paradox is in place: from the one side, it is hard to think that, given the complexity of the issue of climate change, the discipline of burden sharing can be maintained without some mechanism to ensure reciprocity (ESTY and MOFFA, 2012, p. 785); from the other side, key countries – in terms of share of GHG emissions – reject a regime with sanctions or other reciprocity mechanism.

In 2013, negotiations to reach a New Global Climate Deal restarted, but opted for a bottom-up approach. At COP19, in Warsaw, it was decided that each UNFCCC member should present, by 1st October 2015, Intended Nationally Determined Commitments (INDCs) that would inform a future treaty to replace the Kyoto Protocol after 2020. INDCs are quantifiable information pieces on how each country would contribute to tackle global climate change, including the reference point and base year, time frames and periods for implementation, scope and coverage, planning processes, assumptions and methodological approaches for estimating and accounting GHG emissions and removals. The 2015 Paris Agreement is founded over these commitments. Although they are not part of the accord as compulsory targets, they are acknowledged as starting points and should be revised periodically to have their stringency increased. A system of Monitoring, Reporting and Verification (MRV) would boost transparency and encourage it. This is key to address the global warming challenge, since the Paris Agreement

[10] Except the European Union.

settles 1.5^{o}C as limit of long-term average global temperature increase but even if all INDCs were implemented as pledged, global average temperature by 2100 would still be at least 2.6 to 3.1^{o}C higher (ROGELJ et al, 2016, p. 634).[11]

Because most countries have limited commitment to decarbonization, this new approach seems to be the only way forward to fight climate change: it allows countries to frame their own commitments on climate action and leaves space to strengthen them. Yet, it distances the world from what is needed to truly mitigate the problem: each country will implement action according to their perceived short-term advantages.

First, many of the pledges presented in the Paris Conference were vague and unambitious in terms of emissions reduction; they were presented as such to settle a comfortable benchmark against which progress in the reviewing process will be measured.[12] Second, it is unclear if the MRV system to be implemented will be an effective tool for enforcement of commitments and for guaranteeing that reviews will truly increase commitments' ambition. So far, not many details of its functioning were settled.

In summary, following this new approach, real progress in tackling climate change depends on whether UNFCCC members really implement their pledges and increase ambition of their commitments in the review process. Although the international regime remains relevant as a forum to coordinate action between the UNFCCC members so to achieve global climate stability, enacting and implementing commitments that are in tandem with scientific requirements to fight climate change requires understanding how climate change is assimilated by domestic politics and incorporated into domestic policy.

[11] And one of the major emitters, the United States, has already withdrawn from the accord, reducing its coverage.

[12] A brief analysis of key INDCs show this: The United States and Canada's chose 2005 as baseline; when translated into the 1990 baseline, their pledges do not represent a substantial reduction of emissions. Japan indicated 2013 as baseline, an important setback from its Kyoto and Copenhagen commitment. China committed to peak its emissions by 2030, but Chinese emissions are expected to reach 35-40% of total global emissions by then. India did not commit to peak emissions. Mexico promises reductions regarding a business as usual scenario. Russian commitments are poor considering that the baseline is 1990 and after that Russian emissions were reduced by more than 50 per cent due to economic collapse. Brazil pledged to cut 37% of its GHG emissions until 2025, compared to 2005 levels, and 43% until 2030 (BASSO and VIOLA, 2017, p. 180).

1.2. The interaction between international climate negotiations and domestic politics

International cooperation can be studied through the lenses of international variables. Applying this focus, the study of international environmental cooperation usually concentrates on either international institutions and analyze if and how they affect country's behavior in cooperation stances, or on the size of the coalition required for cooperation, usually employing game theory (DOLSAK, 2001, p. 416). The above analysis of the reasons for the failure of the international climate regime in promoting climate change mitigation classifies in the first type.

However, domestic variables always play a role in international cooperation. The relevance of domestic variables in understanding international cooperation depends on the issue area in question: maybe systemic variables offer reasonable explanations of cooperation in international security or international trade, but climate change mitigation requires ubiquitous change in practices and structures; therefore, it is expected that domestic variables that inform these practices and structures will interfere with it more than they do with security or trade (PURDON, 2015, p. 04). Unit-level explanations that focus elements at the national level of countries key to global GHG emissions can add to theory on international cooperation.

Studying the interaction between international and domestic politics on climate change is justified by at least two arguments. First, due to the heterogeneity of UNFCCC members and their varied vulnerabilities and interests on climate change, climate agreements and international institutions do not "*produce uniform and standardized effects at the domestic level*" (PURDON, 2015, p. 04). Understanding which are these interests and how they permeate domestic politics could help clarifying why some countries engage more than others in climate change mitigation.

Second, understanding climate policy implementation requires delving into domestic politics. The world is not short of climate regulation: it has been mushrooming since UNFCCC was created. In 1992, 22 laws and policies related to climate change were enacted in 17 different countries; in 2015, they were 1220 in 160 different countries – 55 times more.

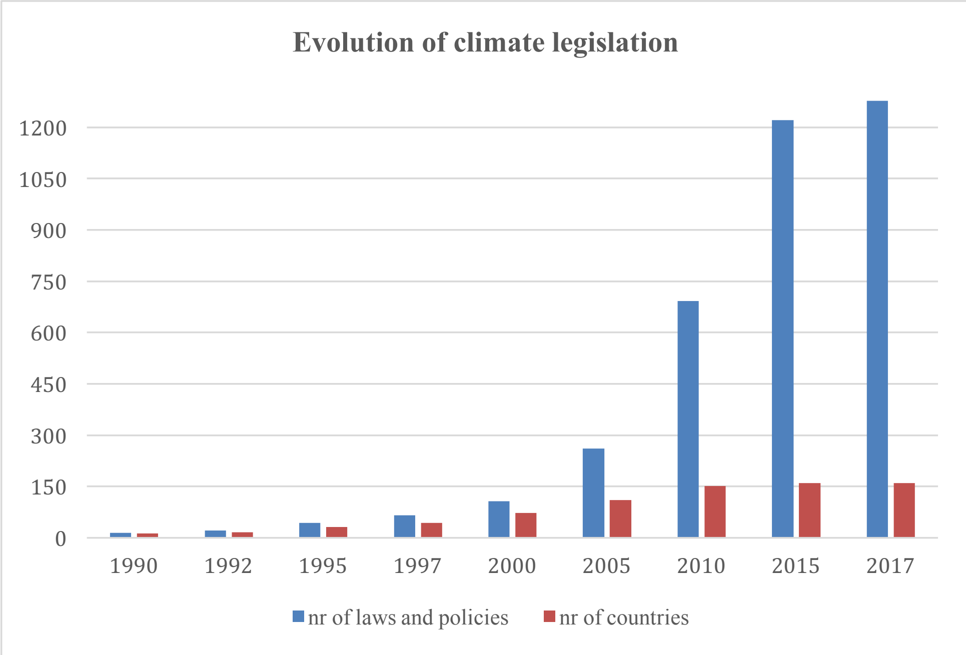


Figure 1.5: Evolution of climate legislation 1990-2017

Source: Own elaboration, based on data from Grantham Research Institute, available at <http://www.lse.ac.uk/GranthamInstitute/climate-change-laws-of-the-world/>, retrieved 13 Aug 2017.

However, most laws are not making an impact in GHG emissions. Most regulatory pieces are just programmatic orders, or are not directed to countries' main sources of emissions, or lack implementation. So, it is hard to see how they would represent real change in countries socioeconomic structure towards a low carbon future. More than understanding why countries participate in the international regime or how much climate policy they enact, it is of utmost importance to analyze climate policy implementation, or the effects of policy on GHG emission reduction trends (PURDON, 2015, p. 06). And this requires analyzing domestic variables.

1.2.1. Domestic politics in International Relations

The interaction between domestic politics and international relations has been a topic of IR especially since the development of the second image by Waltz. In *Man, the*

State, and War (1959), Waltz argues that international conflict has roots in three different levels: human nature (first image), the internal structure of states (second image) and international anarchy (third image). When talking about the second image, Waltz attacks the Kantian idea that domestic structure, especially ideology, is decisive in determining the states behavior in the international sphere – that imperialist values would be at the core illiberal states, while the opposite would take place in liberal ones. In his view, if this were true, changing the domestic structure of a state would change its behavior in the international system. But, according to Waltz, states focus primarily in surviving in the anarchic international system, no matter their ideological affiliation; and it is the uneven distribution of power among them that structurally constrains their actions (WALTZ, 1979). Thus, understanding states' behavior in the international sphere requires analyzing the international structure itself and the place each state occupies in it (WALTZ, 1979).

Following Waltz's argument, other authors accepted that the international level should be the first focus of an international analyst but argued that domestic politics play an intervening role that introduces residual variance in the predictions of the systemic theory (MORAVICSIK, 1993, p. 09, referring to KEOHANE). It is due to domestic politics that states are not perfectly rational decision-makers, or unable to constantly mobilize resources for international issues, or unable to present stable preferences (MORAVICSIK, 1993, p. 09-11, referring to KEOHANE). Critics of the residual variance approach argue that separating domestic interests and international bargaining in different moments or adding domestic elements only as needed generates *ad hoc* explanations of the interrelation between international and domestic politics, with no theoretical value (MORAVCSIK, 1993, p. 14).

The second image concept was recovered and reversed by Gourevitch. He argues that domestic politics affects international affairs, and international relations, especially economic relations and military pressures, constrain domestic behavior (GOUREVITCH, 1978, p. 911). But hoping, as different scholars have, that a specific aspect of domestic politics – e.g. ideology, economic features, pressure from masses – can alone explain how a state behaves in the international sphere is fruitless because politics matter (GOUREVITCH, 1978, p. 901). Coalitions will benefit or not from policies that follow positions taken and so they will try to influence them; understanding the how process of getting a policy adopted affects its content is key (GOUREVITCH, 1978, p. 905). In his view, international relations and domestic politics are intrinsic interrelated and should be analyzed simultaneously (GOUREVITCH, 1978, p. 911).

The second image-reversed approach established a framework to understand how domestic factors and international ones interact with each other in molding interests, strategy and bargaining. But it did not explain how this interaction develops. Putnam filled this gap by writing about the two-level games (PUTNAM, 1988).

In Putnam's view, statespeople are playing games simultaneously at the domestic and international arenas: they play two games making one move. At the international game, they seek to maximize their ability to satisfy domestic pressures while minimizing the adverse consequences of foreign developments (PUTNAM, 1988, p. 434). At the national game, domestic groups pressure them to adopt policies that favor their group and statespeople seek power by forging coalitions among those groups (PUTNAM, 1988, p. 434). According to the author, the signature and ratification of an agreement is affected by negotiators' strategies, domestic institutions, and interests of major coalitions, as gains from international bargaining are unevenly distributed among domestic actors (PUTNAM, 1988, p. 441-452). The two-level games analysis acknowledges that national interest does not follow automatically from the existence of a state: domestic groups fight each other in trying to define it (PUTNAM, 1988, p. 460). Statespeople are challenged to reconcile domestic and international imperatives (PUTNAM, 1988, p. 460).

Milner builds on the second image reversed and the two-level games ideas and develops a theory on when and under what terms are countries able to cooperate (MILNER, 1997, p. 05-06). She argues that "*cooperation among nations is affected less by fears of other countries' relative gains or cheating than it is by the domestic distributional consequences of cooperative endeavors*" (MILNER, 1997, p. 09). Milner's theory is based on two basic assumptions. First, she rejects the idea of the state as a unitary actor: states are polyarchic, *"composed of actors of varying preferences who share power over decision making"* (MILNER, 1997, p. 11). Second, understanding a state's behavior in the international sphere requires analyzing interests of its domestic actors – mainly the Executive, the Legislative, and societal interest groups –; domestic institutions, which regulate power sharing between the actors; and the distribution of information among them (MILNER, 1997, p. 11).

According to Milner, domestic actors are rational and have stable basic interests: the Executive and the Legislative branches of government want to be elected and reelected; societal interest groups want to maximize their income (MILNER, 1997, p. 33-37). Their policy preferences follow from these interests. Because international cooperation results in change in policies, which have distributional consequences for domestic groups, each group will try to influence it (MILNER, 1997, p. 16).

Political institutions matter because they mediate how preferences from different domestic groups are aggregated (MILNER, 1997, p. 18). Institutions determine which actors can set the agenda, amend proposed policy, ratify or veto policy and propose public referendums (MILNER, 1997, p. 18). In addition, domestic actors also share information on policy issues. The more information a domestic actor has on a policy domain, the more they can influence the policy outcome according to their preferences (MILNER, 1997, p. 21).

Milner concludes that cooperation is even more difficult than Realists assume when domestic and international politics are considered simultaneously (MILNER, 1997, p. 234). If states are no longer unitary but polyarchic, *"rather than the struggle for state survival always taking priority, the struggle for internal power and compromise now dominates"* (MILNER, 1997, p. 257). In her view, internal divisions play a negative role in cooperation: the more domestic actors' preferences differ, the less likely cooperation will be (MILNER, 1997, p. 251). Depending on the institutional structure, political leaders' preferences could matter for cooperation, especially when they play a key role in initiating negotiation (MILNER, 1997, p. 251). Cooperation also might vary by issue area if structures of domestic preferences and power sharing arrangements also vary (MILNER, 1997, p. 252). At the end, *"international cooperation often seems to be a continuation of domestic politics by other means"* (MILNER, 1997, p. 252).

1.2.2. Domestic explanations of climate change mitigation

Domestic constraints to international policy decisions, such as policies to mitigate climate change, are usually national political and economic factors or characteristics of actors within countries (DOLSAK, 2001, p. 416). Among the factors, three groups are considered key in explaining policy outcomes: institutions, interests and ideas.

Institutions are “*formal or informal procedures, routines, norms and conventions embedded in the organizational structure of the polity or political economy*” (HALL and TAYLOR, 1996, p. 938). Or “*the rules of the game*” (NORTH, 1990, p. 03). Institution-oriented explanations of policy outcomes focus the structure of the political economy: how the combination of sanctions and incentives it generates shape patters of political influence and organization, and favors actors that behave in determined ways (PURDON, 2015, p. 10-11). Interests are “*real, material interests of principal actors, whether conceived as individuals or groups*” (PURDON, 2015, p. 12, referring to HALL). Interest-based explanations focus the divergence or convergence of actors’ interests and how they inform the policy outcome. The outcome can also be influenced by ideas – “*concepts and knowledge including science, development and legitimacy, as well as inherited practices deployed almost without thinking, such as culture*” (PURDON, 2015, p. 14, referring to HAAS). New ideas can alter interests and transform institutions (PURDON, 2015, p. 15).

Institutional analysis is vastly explored in climate change politics literature (PURDON, 2015, p. 03). Research correlating climate policy outputs – and, sometimes, also outcomes – with e.g. type of political regimes, relationships between the main political actors, economic growth, income or education is widespread regarding high and middle-quality democracies and major authoritarian regimes – very limited regarding low-quality democracies, such as most Latin American democracies, though. The role of interests and ideas is less explored, as they are more difficult to observe than institutions; but integrating the three factors is key to improve the explanatory power of climate change politics (PURDON, 2015, p. 03).

1.2.2.1. Interests in climate change mitigation

In climate politics, material interests are related to “*variation in costs and benefits of various policy actions across actors, tensions between political and economic objectives, trade-offs between short- and long-term effects, and geographical variation in who wins and who loses*” (PURDON, 2015, p. 12). According to economic theory, cost-benefit analysis would be a valid rationale of the decision to act on climate change. The analysis measures the risks of global warming against the costs to prevent or slow it (NORDHAUS, 1991, p. 923). Because social welfare is maximum when the marginal costs of reducing GHG emissions equals the marginal damage of those emissions, this is the efficient level of action for a state to pursue (NORDHAUS, 1991, p. 924). In other words, a country's decision of whether to act and to what extent to act on climate change considers the country's own vulnerability – its risks – to climate change and the costs it will incur to reduce GHG emissions (SPRINZ and VAAHTORANTA, 1994, p. 78).[13] Higher vulnerability and lower costs would enhance chances of significant engagement.

However, this cost-benefit calculus is not straightforward due to the complexity of the climate change issue. Several issues can alter its predictions. E.g., intergenerational factors can play an important role: older people will have a different assessment of the cost-benefit equation than young people, but people older than 40 years old have more economic and political power but are conservative than younger people in high to middle-income democracies – and this is a major obstacle for consistent decarbonization.

Predicting variation in cost-benefit analysis require focusing at least two variables. First, states are not unitary but polyarchic actors. If risks and costs of climate change are unevenly distributed among domestic groups, each group will try to influence the policy process so that the adopted policy minimizes its own losses. The extent to which a group can do it depends on other features of the domestic political structure: the group's relative power and influence on the policy process and the level of concentration of power of the political system in question, as it affects the political feasibility of policy change (BANG, UNDERDAL and ANDRESEN, 2015, p. 07-08).

Second, even if concerns with climate change play a role in domestic policy-making, they are among many other concerns that inform the interests of domestic actors (PURDON, 2015, p. 14). Climate policy making is embedded in wider policy concerns; understanding why a climate policy path is pursued in one country requires analyzing other features of the socio-economic and political context in question. This is the reason why "*the interests at play in climate change politics can be more complex*

[13] The authors do not refer to climate change specifically in their article.

than much of the international climate policy literature suggests" (PURDON, 2015, p. 14).

Adding indirect costs and benefits of climate policy to the cost-benefit analysis would already improve its predictions.

1.2.2.2. Co-benefits as drivers of climate policy

Policy change is hardly motivated by direct costs and benefits only. A policy intended to tackle an issue will also affect other issues, either as means to achieve its ends or indirect outcomes. Complex problems, such as climate change, are even more likely to cause intended or unintended indirect outcomes, due to the pervasive kind of intervention they require. The public good nature of climate change might even turn indirect outcomes into the main reason for some actors' support to climate policies.

In fact, the literature has identified that countries act on climate change, "*apart from a sense of altruism towards future generations*" (KEOHANE and OPPENHEIMER, 2016, p. 147): (i) to achieve domestic purposes, "*such as to reduce air pollution (including soot/black carbon) emissions or to achieve energy system changes that are not directly related to climate change*" (KEOHANE and OPPENHEIMER, 2016, p. 147); (ii) to respond to pressures from domestic constituencies; (iii) to gain specific benefits from other states; (iv) to gain diffuse benefits from other states or civil society elsewhere; (v) to impress constituencies, or avoid blame, by cultivating international reputation or to leverage international negotiations for domestic purposes (KEOHANE and OPPENHEIMER, 2016, p. 147). Their international commitments also reflect this. In their analysis of the INDCs, Keohane and Victor (2016) found that interests reflected on the pledges range from (i) creating the public good of climate change mitigation; (ii) providing local public goods that happen to address climate change mitigation as well; (iii) generating competitive economic benefits; (iv) bargaining for side-payments; and (v) creating reputational benefits (KEOHANE and VICTOR, 2016, 04).

These indirect effects of climate policies are named additional benefits, or co-benefits. While the direct benefits of climate policy are related to climate objectives – e.g. reducing GHG emissions to limit impact on global average temperature, sea level rise or biodiversity –, co-benefits are non-climate consequences of climate policy, e.g.: changes in energy security, labor supply and employment, the distribution of income, the degree of urban sprawl, the sustainability of socio-economic growth (IPCC, 2014a, p. 232). Co-benefits are pervasive and inseparable from direct benefits (IPCC, 2014a, p. 394); they may complement the direct benefits of climate change mitigation (IPCC, 2014a, p. 211). But the extent to which they "*will materialize in practice as well as their net effect on social welfare differ greatly across regions, and is strongly dependent on local circumstances, implementation practices, as well as the scale and pace of the deployment of different mitigation measures*" (IPCC, 2014a, p. 392).

The cost-benefit analysis remains a valid tool to help explain why, despite the public good nature of climate change, some countries act to mitigate it. However, its original formulation – measuring the country's vulnerability to climate change against the costs it will incur to reduce GHG emissions – needs to be updated. First, all potential gains and losses – direct and indirect – need to be accounted. When benefits from climate change mitigation cannot be appropriated by the ones that act to provide it, it is necessary to inquire if co-benefits from climate policies could be key drivers of climate action. Second, it is necessary to accept the polyarchic nature of states – the degree of polyarchy varies significantly in hybrid, authoritarian or democratic regimes – and to identify the interests of the domestic politics principal actors and to what extent they are able to influence policy making. In democratic regimes, the quality of democracy is very relevant to determine the balance between long-term public interests and short-term specific interests: in high-quality democracies, the balance is better than in low-quality democracies; in low-quality democracies, poor institutions promote irrational cleavages and alignments.

Chapter 02: Decarbonizing energy systems

2.1. THE CHALLENGE OF DEEP DECARBONIZATION

Limiting increase of average global temperature to 2°C, let alone 1.5°C agreed in the Paris Conference, requires structural changes in current modes of production, consumption patterns and lifestyles – or deep decarbonization. Reducing emissions from any sector – LULUCF, agriculture, waste – is important. But due to the impact of fossil fuels combustion on total GHG emissions, the challenge will never be achieved without transforming energy systems.

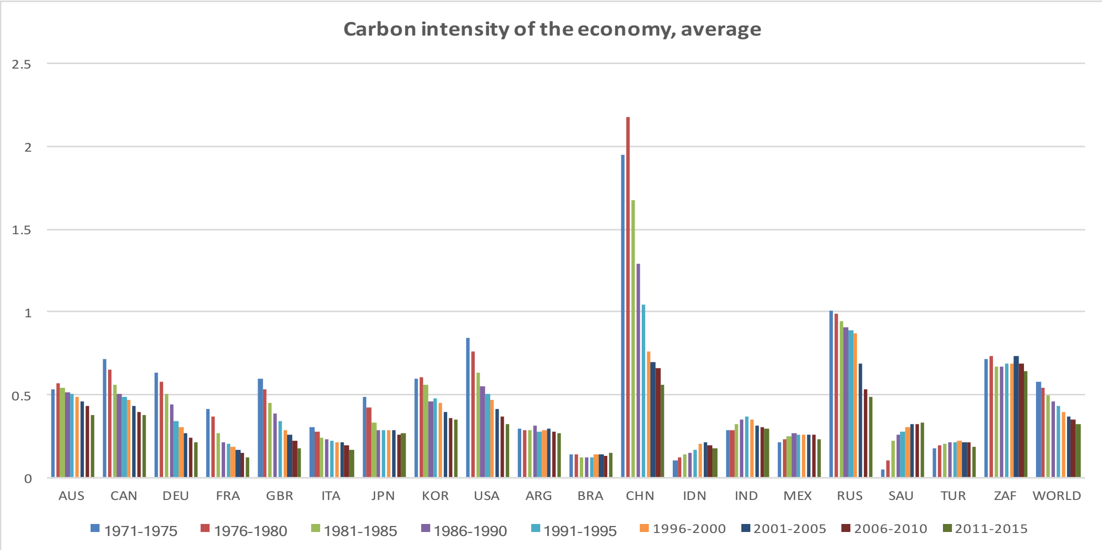
According to the IPCC, fossil fuel combustion and industrial processes answered for 78% of the total GHG emissions increase from 1970 to 2010, with a similar percentage for the period between 2000 and 2010 (IPCC, 2014a, p. 06). Global energy supply alone has answered for 47% of the increase in global GHG emissions between 2000 and 2010 (IPCC, 2014a, p. 45) and 35% of total GHG emissions of 2010 (IPCC, 2014a, p. 516). Emissions from the energy supply sector are growing more rapidly as well: while they increased 1.7% per year between 1990 and 2000, they accelerated to 3.1% per year between 2000 and 2010 (IPCC, 2014a, p. 516). IPCC's scenarios show that CO2 emissions from the sector are expected to "*almost double or even triple*" by 2050 compared to 2010 numbers (IPCC, 2014a, p. 20).

Deep decarbonization means reducing the carbon intensity of economic activity. It rests on 03 pillars: energy efficiency and conservation; decarbonization of electricity and fuels; and switching to low carbon energy sources in energy end-uses (SDSN-IDDRI, 2015). [14] The pillars interact; deep decarbonization is achieved when pillars are implemented at sufficient scale (SDSN-IDDRI, 2015, p. 08). Countries are at different

[14] Energy efficiency and conservation are achieved by improving products and processes, e.g.: improving vehicle technologies, smart urban design and optimizing logistical chains; improving end-use equipment, architectural design, building practices and construction materials; improving equipment, production processes, material efficiency and the re-use of waste heat. Decarbonizing electricity means replacing uncontrolled fossil fuel-based generation with renewables, nuclear power or fossil fuels with carbon capture and storage, CCS; decarbonizing liquid and gas fuels means using biomass or synthetic fuels – e.g. hydrogen – produced through low carbon processes instead of fossil fuels. Switching to low carbon energy sources in end uses means the electrifying space and water heating and cooling, as long as that the electricity source is low carbon; adopting electric, biofuel or hydrogen vehicles; directly using biofuels, hydrogen or synthetic natural gas in industrial activities. SDSN-IDDRI, 2015, p. 09.

stages of the deep decarbonization process – e.g. the trajectory of carbon intensity of the economy in the 19 countries of the G20 between 1971 and 2015:

Figure 2.1: Carbon intensity of the economy, average (TPES/GDP PPP, 2005 USD)



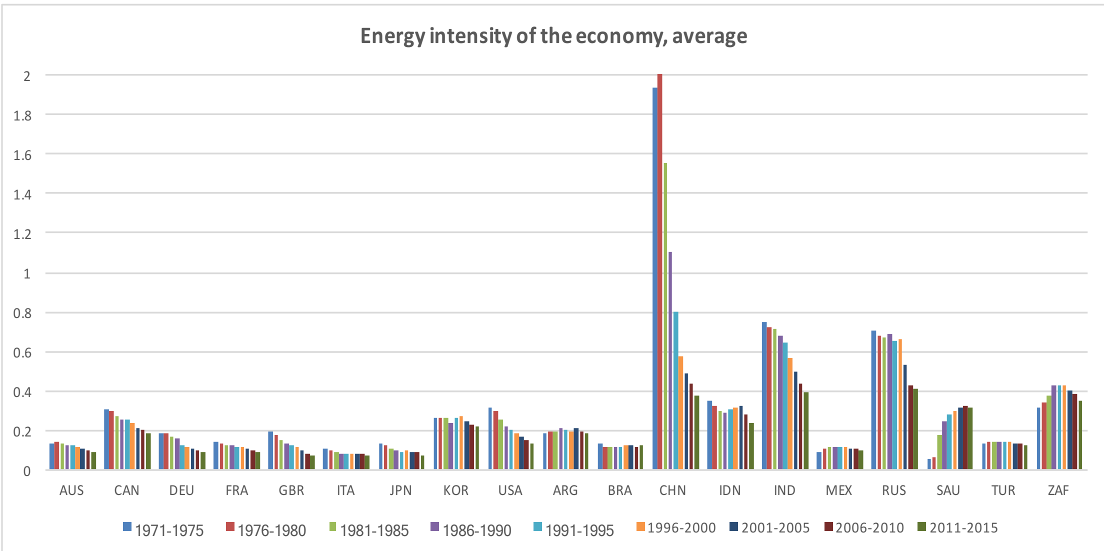
Source: Own elaboration, based on data from IEA, 2017c.

The 1st pillar of deep decarbonization, energy efficiency and conservation – usually measured by reducing the energy intensity of GDP – is boosted by technically improving products and processes. E.g.: improving vehicle and appliances technologies; changing urban design to reduce commuting and the use of private transportation; better architectural design, building practices and materials in buildings, to reduce the need of artificial lighting and cooling/heating systems; optimizing logistical chains; improving equipment and production processes in manufacturing; reusing and recycling materials (SDSN-IDDRI, 2015, p. 08). While the strategies are different, they are both directed to reduce energy demand. They might be successful in reducing GHG emissions, especially when energy demand is stable or has been in a downward trend. Yet progress is likely to be slow-paced and incremental. In addition, they are unlikely to be sufficient to deter rising emissions when energy demand is increasing.

These changes usually follow when economic activity becomes less concentrated in highly energy intensive activities, e.g. heavy industry, and more concentrated in less intensive ones, e.g. services. It is expected that energy efficiency would have advanced the most in industrialized economies, given the transformation in economic structure that has been taking place. We can observe that if we analyze the G20 countries between 1971 and 2015.

In the period, global energy efficiency has advanced by 34.31%; but while in the industrialized economies of the G20 energy efficiency has, on average, increased by 43.90%, in the emerging economies of the same group it has, on average, decreased by 14.54% (IEA, 2017b). The United Kingdom is the industrialized economy in which energy efficiency has improved the most in the period: 66.74%; the country has achieved, among the members of the G20, the lowest levels of energy use between 2011 and 2015. China has also made consistent progress, enhancing energy efficiency by 82.93% between 1971 and 2015, but it still ranks 3rd in the group in energy use, after Russia and India. Among the setbacks, Saudi Arabia has increased its energy use by 362.82% between 1971 and 2015, and now has the 5th most energy-intensive economy amongst the G20 members, after South Africa, whose energy efficiency has worsened by 7.68% in the period (IEA, 2017b).[15]

Figure 2.2: Energy intensity of the economy, average (TPES/ GDP PPP, 2005 USD)



Source: Own elaboration and calculations, based on data from IEA, 2017c.

[15] All calculations on this paragraph are of our own, based on data referred.

The 2nd and 3rd pillar of deep decarbonization, decarbonization of electricity and fuels and reducing carbon intensity of energy in end-uses, are achieved by switching to low carbon primary energy sources in electricity and fuel supply and in end-uses – hence reducing the carbon intensity of energy supply. This is what we refer to in this dissertation as energy decarbonization.[16]

2.2. DEFINING ENERGY DECARBONIZATION

Fossil fuels are the main global source of energy. Coal, oil and gas answered, together, for 86.72% of global Total Primary Energy Supply (TPES) in 1973 (IEA, 2017a, p. 46) and 81.43% of global TPES in 2015 (IEA, 2017a, p. 37). In this period, total global TPES has increased roughly 2.24 times (IEA, 2017a, p. 46-47). This means that although the relative importance of fossil fuels in global energy supply might have slightly diminished in 42 years, GHG emissions from fossil fuel combustion have never been greater.[17]

Decarbonizing energy supply, or switching from fossil fuels to low carbon primary energy sources in producing electricity and fuels, tackles emissions from the energy supply side: it reduces the carbon intensity of energy supply.

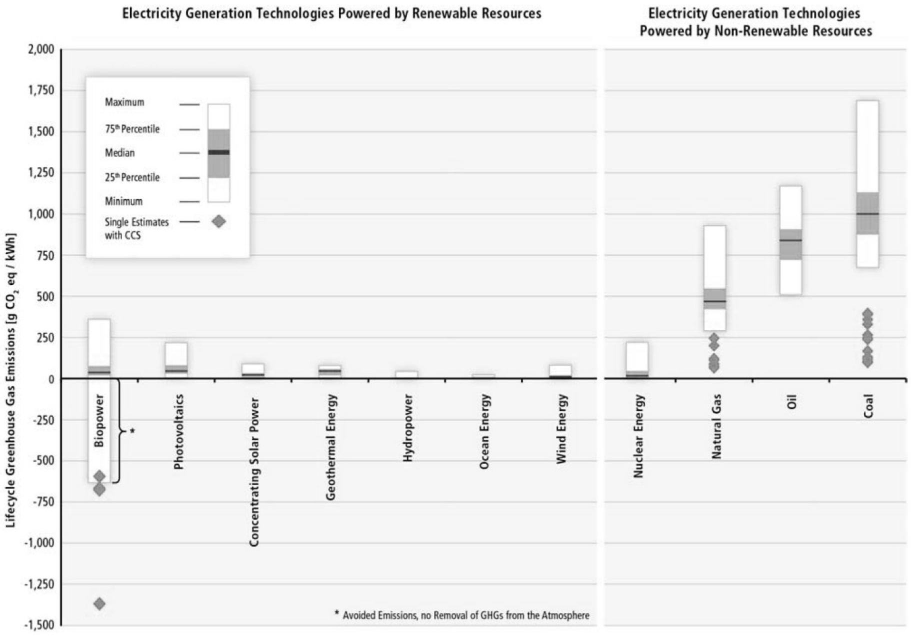
It is important to distinguish between primary and secondary energy. Primary energy is harvested directly from natural resources: e.g. coal, oil, natural gas, uranium, sunlight, wind, water movement. They can either employed directly to generated work – e.g. wind energy moves a windmill that pumps water or grinds grain – or transformed into secondary energy. Electricity and transport fuel are secondary energy forms largely employed in contemporary economy. Both can be produced from a variety of primary energy sources that have different carbon footprint.

In this dissertation, low carbon energy sources are primary energy sources that can be transformed into electricity or transport fuel while emitting substantially less GHG than fossil fuels. Renewables – hydraulic, solar, wind, geothermal, ocean, biomass energies – and nuclear energy qualify as low carbon energy sources. When generating 1kWh of electricity, solar concentrated, geothermal, hydropower, ocean and wind energy

[16] The focus of the dissertation will be in switching from fossil fuels to low carbon primary energy sources in producing electricity and fuel, due to the relevance of emissions from this activity in total global GHG emissions.
[17] All calculations on this paragraph are of our own, based on data referred.

technologies emit maximum 100g of CO2 equivalent, and median values range from 04 to 46g CO2eq/kWh (IPCC, 2012, p. 733). Emissions from other low carbon sources are higher compared to these because they depend on the quality of raw material (nuclear power) or present suboptimal production processes (solar photovoltaic, and bioenergy); yet nuclear and solar photovoltaic emissions are still considerably lower than emissions fossil fuels, and maximum emissions from bioenergy compare to minimum emissions from the lowest emitting fossil fuel, natural gas (IPCC, 2012, p. 733).[18]

Figure 2.3: Lifecycle emissions from electricity technologies



Source: IPCC 2012, p. 732.

The same is true when comparing lifecycle emissions from petroleum products and biofuels in transportation:

[18] Lifecycle emissions are considered, not including land use change emissions.

Figure 2.4: Lifecycle emissions from transportation fuels

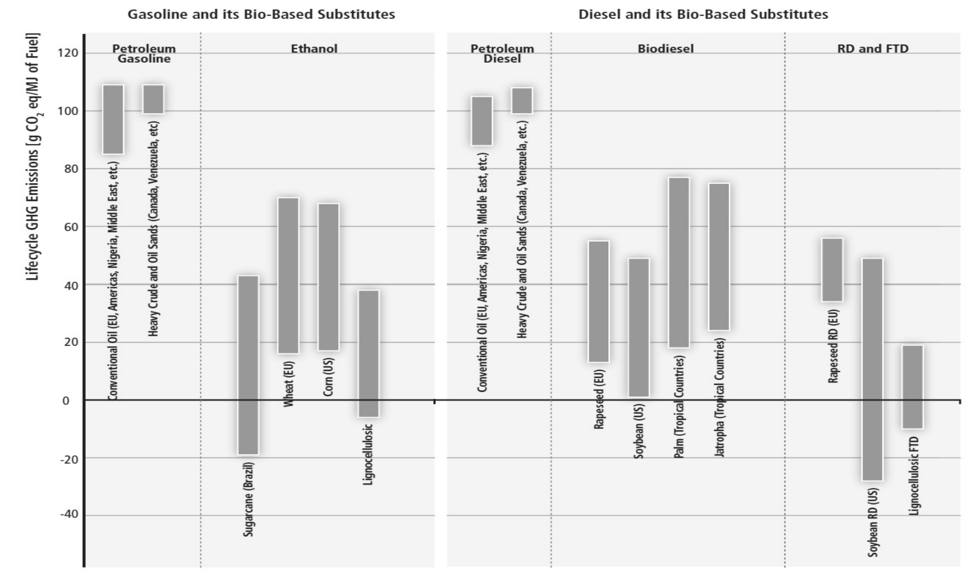


Figure 9.9 | Illustrative ranges in lifecycle GHG emissions of petroleum fuels, first-generation biofuels and selected next-generation lignocellulosic biofuels without considering land use change. (Sources for estimates plotted: Wu et al., 2005; Fleming et al., 2006; Hill et al., 2006, 2009; Beer et al., 2007; Wang et al., 2007; CONCAWE, 2008; Macedo and Seabra, 2008; NETL, 2008, 2009; CARB, 2009; Hoefnagels et al., 2010; Hsu et al., 2010; Kaliyan et al., 2010; Larson et al., 2010; Neely et al 2010). Note: FTD = Fischer-Tropsch diesel; RD = Renewable diesel (RD is different from biodiesel in processing and product properties). For common feedstock and fuel categories shown in both Figure 2.10 and above (e.g., sugarcane ethanol, FTD), the references cited and the ranges of GHG emission estimates are identical.

Source: IPCC, 2012, p. 734.

The choice of primary source to produce either electricity or transport fuel is complex. Costs and availability of raw materials, costs and availability of technology, land use, reliability, the conversion efficiency rates of different sources and technologies, and public acceptance are some of the factors considered in energy planning. Therefore, a decision to switch from fossil fuels to other primary energy sources is never a climate policy decision alone. It considers a variety of factors, including synergies and tradeoffs across mitigation and other policy objectives and the effects of mitigation on these other objectives (IPCC, 2014a, p. 544).

According to our theoretical framework, we argue that the decision to switch from fossil fuels to low carbon energy primary energy sources is facilitated when it can provide additional benefits, other than climate change mitigation, valued by political actors. In the next section, we list and explore potential co-benefits from switching from fossil fuels to low carbon energy commonly identified by the literature.

2.3. CO-BENEFITS OF ENERGY DECARBONIZATION

So far, the literature has not established criteria to identify a co-benefit: which metrics should be applied; what is the connection between the political actor and the co-benefit (how the actor perceives it; how many people need to value it in order for it to have its catalyzing consequences). We understand that different criteria would have important consequences for the research and intend to work on this in future occasions. For this work, however, we opt for a simple strategy: by reviewing the literature, we enumerate the most-commonly cited positive consequences from switching from fossil fuels to low carbon energy as primary energy sources and consider them potential co-benefits of energy decarbonization.

2.3.1. Reducing air, water and soil pollution and their impacts

Fossil fuels were formed after centuries of decomposition of organic material and thus have high carbon content. Their combustion liberates part of this carbon content in the atmosphere, where it combines with oxygen to form carbon dioxide, the main GHG, or carbon monoxide. In addition, other compounds such as sulphur dioxide, nitrous oxides, ammonia and non-methane volatile organic compounds are also released during the combustion process. These substances pollute air, water and soil; the impact to ecosystems and human health is very relevant. In 2015, diseases caused by pollution were responsible for 9 million premature deaths, or 16% of all deaths worldwide – 03 times more than AIDS, tuberculosis and malaria combined, and 15 times more than all wars and other forms of violence (LANDRINGAN et al, 2017, p. 01).

Particulate matter – in two sizes, PM10 and PM2.5 – and black carbon are byproducts of coal and oil combustion. These nanoparticles penetrate human body and, together with sulphur dioxide, nitrous oxides and volatile organic compounds, cause several cardio-pulmonary and respiratory conditions, e.g. cerebrovascular conditions, heart failure, chronic bronchitis, upper and lower respiratory symptoms, aggravation of asthma and lung cancer (IPCC, 2012, p. 739; IPCC, 2014a, p. 547-548). Around 3.2 million people die prematurely every year from these conditions (IPCC, 2014a, p. 547). Recently, research showed that kidney function can also be affected by the concentration of PM2.5 (BOWE et al, 2017). The World Health Organization estimates that 80% of the world's population is exposed to outdoor air pollution that exceeds its recommendations (IPCC, 2014a, p. 548). Nitrogen oxides and other volatile organic compounds also cause smog (IPCC, 2014a, p. 548).

Carbon monoxide concentrations in the atmosphere are also highly affected by fossil fuel combustion. The compound combines with hemoglobin in the bloodstream and stumbles the supply of oxygen to cells in human body, increasing cardiovascular morbidity and mortality numbers.

Acid rain is also directly related to burning fossil fuels, especially coal. High quantities of sulphur dioxide are released in the atmosphere and react with oxygen, creating sulphuric acid. Reducing acid rain was one of the main objectives of the first international agreements on transboundary pollution. In addition, the accumulation of sulphur dioxide and nitrogen oxides in water and soil cause their acidification (IPCC, 2014a, p. 548), affecting ecosystems. High concentration of nitrogen oxides also contributes to the eutrophication of rivers and lakes (IPCC, 2014a, p. 548).

Coal and oil combustion also releases lead, mercury and other metals into the environment. They are highly toxic. They can contaminate water, soil and livestock and cause neuro pathologies – e.g. the Minamata disease, from mercury poisoning in fisheries in Japan, discovered in the 1950s. Polyaromatic hydrocarbons, also a byproduct of coal and oil combustion, are related to development of cancer in different human organs (IPCC, 2012, p. 739).

Due to its chemical composition, the impact of burning coal is proved the most deleterious to ecosystems and human health, followed by oil. But even natural gas, burning much cleaner than coal or oil, pollutes more than low carbon sources.

Electricity supply from non-combustion renewable energy sources or nuclear power result in considerably lower pollutant emissions compared to fossil fuels (IPCC, 2012, p. 740). Particulate matter, ammonia and nitrogen oxides residues are substantially lower in power production employing solar photovoltaic, solar concentrated, hydro, wind or nuclear technologies compared to coal or natural gas (IPCC, 2014a, p. 548; figure 3 below). Sulphur dioxide residues from specific solar technology can be higher. In transportation, carbon monoxide and hydrocarbons residues are reduced when ethanol or biodiesel is blended into gasoline and diesel, respectively (IPCC, 2012, p. 740). The use of pure bioethanol increases the concentration of aldehydes, but they are much less toxic than the formaldehydes that follow gasoline or diesel combustion (IPCC, 2012, p. 740). The concentration of ultrafine pollutant particles at the atmosphere of the city of São Paulo decreases when consumers of flex-fuel cars opt for ethanol compared when they opt for gasoline (SALVO et al, 2017).

Figure 2.5: Air pollutants from 1Kwh of electricity from different sources

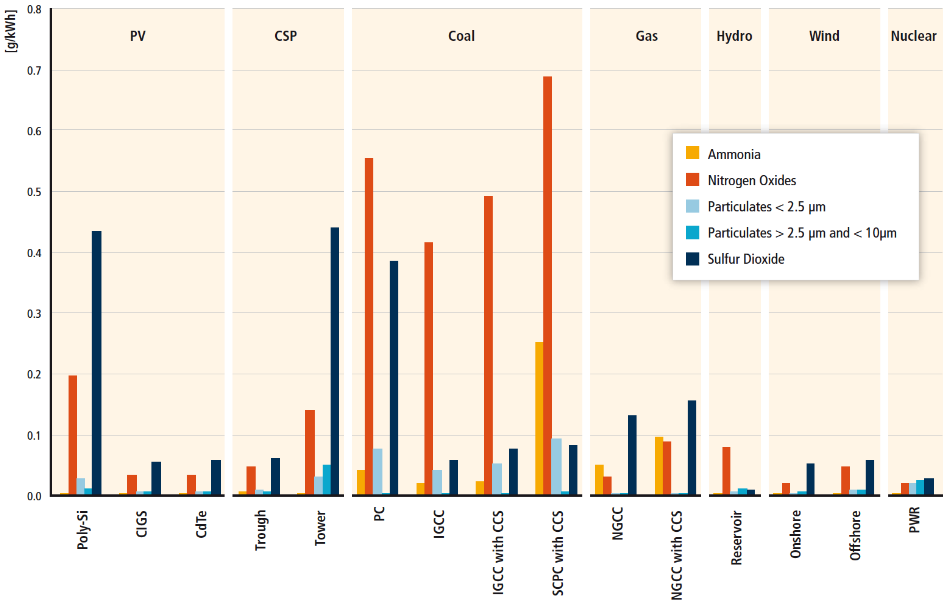


Figure 7.8 | Life-cycle inventory results of the production of 1 kWh of electricity for important air pollutants contributing to particulate matter (PM) exposure, the leading cause

Source IPCC, 2014a, p. 548.

Renewable energy and nuclear power are not carbon or pollution free. Every technology presents different challenges and can cause important local impacts that need to be considered. Nuclear waste is a relevant issue; current technology for solar photovoltaic panels use scarce materials which mining have important environmental impacts; wind energy can impact wildlife and bird migratory routes; reservoirs of hydropower plants can impact local ecosystems; lifecycle water use of some low carbon technologies can be as high as the use of fossil fuels.

Yet, denying the impact of the use of fossil fuels is mischieving. Scientific evidence is consistent and shows that burning fossil fuels raises air, water and soil pollution levels.

Ignoring the long-term and serious consequences of pollution to ecosystems and human health can bias decision-making and endorse policy choices that might not be the best available options considering broad societal interests.

2.3.2. Reducing risks from energy production

Technical risks from producing electricity or transport fuel depend on chosen primary energy technology. Risks could be classified in two types: risks of accidents and fatalities and risks of contamination.

In general, fossil fuels have higher accident and fatality rates than non-fossil fuels. In case of electricity production, when the number of deaths in accidents normalized by the amount of electricity generated over the years is compared for different energy technologies, accidents around coal, oil or gas energy are ahead of low carbon energy sources (IPCC, 2012, p. 746). Hydropower and nuclear power have the lowest fatality rates among centralized technologies; however, when accidents take place, the consequences are usually very large (IPCC, 2012, p. 746).[19] Other renewable technology – solar, wind, biomass, geothermal – present very low fatality rates; their decentralized nature strongly limits their catastrophic potential (IPCC, 2012, p. 746-747).

Risks of contamination of land and water are also substantially higher for fossil fuels compared to renewable energy. E.g, oil spills are, unfortunately, very common (IPCC, 2012, p. 747). Offshore exploration can result in disastrous spills that deeply affect maritime ecosystems – such as the 2010 Deepwater Horizon oil spill in the Gulf of Mexico; the 2011 oil spill caused by Chevron along the Brazilian coast; the 2016 oil spill from Shell's Brutus offshore platform in the Gulf of Mexico. Onshore production is not safer: the devastating 2006 oil spill from Citgo refinery in the Calcasieu River and the 2013 spills in Magnolia and Mayflower refineries, all in the United States, prove it. It is incredibly common for oil pipelines to leak: the 2011 Little Buffalo oil spill, in Canada, and the 2014 Trans-Israeli pipeline oil spill are only two examples of many. And oil tankers are not much safer: the 2002 sinking of MV Prestige released an enormous amount of oil along the coast of Portugal and Spain. The environmental impact of oil

[19] The Banqiao Reservoir Dam in China (1975), causing more than 170 thousand deaths, and the Chernobyl nuclear accident (1986) illustrate it.

spills is extraordinary; they disturb maritime ecosystems; affect birds, penguins, vegetation and other species; destroy freshwater resources. The exploitation of shale gas is also risky: if the chemicals used in the fracking process spill, they can contaminate local water (IPCC, 2012, p. 747). Coal mining damages and pollutes ecosystems and severely impacts the health of miners.

Risks of contamination by renewable sources are not zero: solar photovoltaic panels use hazardous substances, which mining and disposal must be careful; the process of obtaining geothermal energy could contaminate groundwater (IPCC, 2012, p. 747). Other operational risks also exist: the construction of hydropower reservoirs can flood large areas, destroying vegetation, disturbing wildlife and dislocating populations; wind energy can interfere with birds' migratory routs and might affect navigation routes when offshore. And operational risks from other renewable energies are yet not well understood (IPCC, 2012, p. 747). Nevertheless, scientific assessment of risks so far point to substantial reduction of accidents, fatalities and contamination of land and water when switching from fossil fuels to renewables.

And the same is true for nuclear energy, surrounded by inaccurate information that vilifies it compared to other primary energy sources. Nuclear accidents are classified according to the International Nuclear Events Scale (INES) from the International Atomic Energy Agency (IAEA). Two have been considered major accidents at maximum level, INES 7: Chernobyl, 1986 (ex-USSR, now Ukraine) and Fukushima-Daiichi, 2011 (Japan) (IAEA, 2017a); Kyshtym, 1957 (Russia) was considered a serious accident (INES 6); Windscale Pile, 1957 (United Kingdom) and Three Mile Island, 1979 (United States) were considered accidents with wider consequences, INES 5 (IAEA, 2017b). Yet, real damages from these accidents varied according to safety protocols in place and how fast required action was undertaken – e.g., prompt action in isolating the reactors, quick and efficient food safety campaigns and evacuation significantly reduced the long-term consequences in Fukushima (STEINHAUSER et al, 2014).

Risk of nuclear radiation leakage is real and serious, and even the most stringent security scheme cannot reduce the possibility of accidents to zero. Yet, statistically, accidents involving fossil fuels are much more common and generate more losses than nuclear energy. Nuclear waste is also a cause of concern, but technological improvements have substantially reduced it – e.g. fourth-generation reactors recycle used fuel. In sum, misinformation leads to biased conclusions regarding nuclear energy: while risks of nuclear energy are fully assessed, several risks of using fossil fuels are externalized, so the first is considered more lethal than the second. Adding all variables to the equation is key: e.g., the use of nuclear energy between 1971 and 2009 caused 4,900 deaths but prevented other 1.84 million just by not contributing to air pollution (KHARECHA and HANSEN, 2013).

2.3.3. Increasing energy access

Hundred million people still lack access to basic energy services around the world. IEA estimates that 2.5 billion people, or 38% of the global population, relied on traditional biomass – fuelwood, charcoal, agricultural waste and animal dung – for cooking in 2016 (IEA, 2017b). Among these, 31.32% were in sub-Saharan Africa and 65.92% were in Asia – 31.20% of them in India and 12.28% in China (IEA, 2017b). In 2016, almost 1.1 billion people lacked access to electricity, most of them in rural areas (IEA, 2017b, p. 11). From this total, 55.47% were in sub-Saharan Africa and 41.41% were in Asia – 22.54% in India alone (IEA, 2017b). The global electrification rate reached 86% in 2016, but in the same year only 43% of the total sub-Saharan population and 23% of the rural sub-Saharan population had access to electricity (IEA, 2017b).

Access to electricity plays an important role in enhancing livelihood conditions at the household level (IPCC, 2014a, p. 546): important health and educational benefits usually follow electricity provision. While the same benefits could be reaped from electricity provided by fossil fuels, renewable energy play an important role in providing electricity to rural population. In remote areas, decentralized grids and mini-grid systems based on renewables are usually more competitive than their alternatives (IPCC, 2012, p. 721; IPCC, 2014a, p. 546). Electricity generation from renewables can also mean technology trade and knowledge transfer to the community and diminished exposure of the regional economy to the volatility of fossil fuels prices (IPCC, 2014a, p. 546).

Renewable technology can also be employed directly in other rural chores: solar energy can be used in heating and crop drying; biofuels can be used for transportation; wind can power water pumping and grain grinding; biogas and modern biomass can be used for heating, cooling, lighting or cooking (IPCC, 2012, p. 723). Abandoning traditional biomass in cooking is directly related to health gains due to decreased indoor air pollution, and to social and environmental gains, because less time is spent in gathering cooking fuel and deforestation rates can diminish in areas where charcoal is widely employed in the task (IPCC, 2012, p. 721). In remote areas, due to their distance from natural gas supply chains, [20] replacing traditional biomass with renewable electricity, biogas or modern biomass also enhances security of supply.

2.3.4. Creating employment opportunities

In times of financial crisis and transformations of the job market, job creation is an important asset to an economy. In 2016, the global renewable energy sector employed 9.8 million people,[21] 1.1% more than in 2015 (IRENA, 2017a, p. 03). Solar photovoltaic is the largest employer having offered 3.1 million jobs in 2016, 12% more than in 2015 (IRENA, 2017a, p. 03). Liquid biofuels follow, with 1.7 million jobs, most of them in feedstock supply (IRENA, 2017a, p. 03). Large hydropower employed 1.5 million people; wind, 1.2 million; solid biomass, 0.7 million; and biogas, 0.3 million (IRENA, 2017a, p. 03). Solar heating and cooling was the only renewable sector that reduced employment opportunities in 2016 compared to 2015, by 12%; still, 0.8 million people were employed in the sector in 2016 (IRENA, 2017a, p. 03). From 2012 to 2016, jobs in solar photovoltaic and wind energy doubled (IRENA, 2017a, p. 03).

Falling costs of technologies and supportive policies are behind job creation in the renewable sector (IRENA, 2017a, p. 05). In fact, research shows that a stable and favorable policy framework is key to guarantee investments and job creation in renewables (IRENA, 2017a, p. 05). The advance of favorable frameworks has guaranteed an increase of 414% in installed capacity of renewable energy worldwide in 12 years, from 47GW in 2004 to 241.6GW in 2016 (FS-UNEP-BNEF, 2017, p. 12). Levelized costs of generating electricity from solar photovoltaic and wind energy been decreasing consistently since 2009 (FS-UNEP-BNEF, 2017, p. 16). On the flip side, rising automation – mechanization of feedstock harvesting; automation in the production of solar panels and wind turbines, and of operation and maintenance – will very likely

[20] Modern cooking devices usually employ natural gas or electricity as fuel.
[21] 8.3 million if large hydropower is not considered in the equation, 2.8% more than in 2015. IRENA, 2017a, p. 03.

mean fewer jobs in the future (IRENA, 2017a, p. 05). Yet, automation is not exclusive to the renewable energy sector: it is also taking place in energy production from fossil fuels as well as in almost every economic sector.

On average, however, renewable energy creates more jobs than fossil fuels (IRENA, 2017a, p. 06). Taking the example of the United States, while the fossil fuels chain is still the major employer in the energy sector – employed 1.1 million workers, or 55% of the total, in 2016 – renewables are expanding their numbers: employment in the solar industry increased by 25% in 2016 compared to 2015, and in the wind energy by 32% (US DEPARTMENT OF ENERGY, 2017, p. 08). If the electric segment of the energy industry is considered alone, employment in solar photovoltaic and concentrated industries has surpassed employment in coal, oil and natural gas jointly: the first answered for 43% of the electric power generation workforce in 2016 and the second for 22% (US DEPARTMENT OF ENERGY, 2017, p. 28). Interestingly, solar energy accounted for 1% of total United States' electricity generation capacity in 2016 while coal accounted for 26%; the solar industry, however, offered 02 times more jobs than the coal industry (IRENA, 2017a, p. 06). However, this could be a very short-term trend, since automatization is advancing fast in the solar industry, as it is also advancing in other industries.

It is a fact that new technologies will usually expand much faster than mature ones in the same segment if they find a favorable financial and political background and the added job positions are related to this phenomenon. Yet, if these new disrupting technologies manage to endure, the industry can be changed for good.

2.3.5. Enhancing energy security

2.3.5.1. Evolution of the concept of energy security

A key objective of energy policy is increasing energy security, or enhancing security of energy supply. Energy security is defined broadly as reaching "low vulnerability of vital energy systems" (IPCC, 2014a, p. 475; 546). According to the IPCC, this low vulnerability depends on (i) the sufficiency of resources to meet national energy demand at competitive and stable prices and (ii) the resilience of the energy supply

(IPCC, 2014a, p. 546). Yet the concept of energy security is highly context dependent (KRUYT et al, 2009, p. 2166) and has changed throughout the last half a century.

After the end of World War II, European countries and Japan started rebuilding their economies and the United States experienced strong economic growth. Major energy inputs were required to meet rising demand. Coal played an important role – it was even one of the key assets behind the beginning of the European market, in the 1950s –, but energy requirements were increasingly met by oil, a cheap commodity while supplied mostly by the Seven Sisters.[22] However, the nationalization of oil production and the creation of the Organization of the Petroleum Exporting Countries (OPEC) changed this dynamic, especially after OPEC's first oil embargo against several Organization for Economic Cooperation and Development (OECD) members in 1973. At the time, OECD members were very dependent on OPEC countries oil production and the embargo hit their economies hard. Securing oil supply became a key concern, and different measures were undertaken to enhance it.

The first was establishing international regimes in oil producing regions where disruptions of oil flows would be less likely to occur (CHERP and JEWELL, 2011, p. 203). Following the Carter Doctrine, the United States' military presence in the Persian Gulf was increased to defend the free movement of oil (CHERP and JEWELL, 2011, p. 203). Establishing a global market for oil products, where the presence of different actors would keep the power from being concentrated in the hands of a few, was aimed as well (CHERP and JEWELL, 2011, p. 203). Creating the International Energy Agency (IEA) was also in tandem with this idea. The IEA was established in 1974 as an agency of the OECD, focused in enhancing its members' energy security. It would serve its mandate by promoting dialogue with oil producing countries, developing members' emergency self-sufficiency in oil supplies by regulating oil stocks that could be traded among them, and establishing a comprehensive information system of oil markets, as well as permanent consultation with oil companies (IEA, 1974).

Second, oil production in regions friendlier to OECD members, such as the North Sea, the Alaska and Canada, was bolstered (CHERP and JEWELL, 2011, p. 203), even

[22] The Seven Sisters were multinational oil companies that controlled oil supply from the 1940s until the 1970s: Anglo-Iranian Oil Company (now BP); Gulf Oil (later part of Chevron); Royal Dutch Shell; Standard Oil Company of California (SoCal, now Chevron); Standard Oil Company of New Jersey (Esso, later Exxon); Standard Oil Company of New York (Socony, later Mobil, now part of ExxonMobil); Texaco (later merged into Chevron).

if oil production in those regions was more expensive than in the Middle East. Norwegian oil production between 1976 and 1980 was 6.22 times higher than oil production by the same country between 1971 and 1975; British oil production was 90.66 times higher in the same period (BP, 2017).[23] Comparing the decades 1971-1980 to 1981-1990, Norwegian oil production increased 4.45 times, while British oil production rose 4.17 times (BP, 2017).[24] A third measure was to encourage energy conservation and the diversification of energy sources (CHERP and JEWELL, 2011, p. 203). The IEA included both objectives under its tasks, undertaking long-term cooperative efforts on energy conservation and on the on development of alternative sources of energy, including nuclear, to reduce members' dependence on imported oil (IEA, 1974).

By the 1990s, the energy matrices of industrialized economies were different. Oil remained a key primary energy source, but natural gas' relevance was rising (CHERP and JEWELL, 2011, p. 203). This was due to liberalization of electricity supply in several countries (CHESTER, 2010, p. 888) and lower gas prices – due to an extensive pipeline network built between ex-USSR republics and Western Europe after the end of the Cold War, which intensified gas exports from the first to the latter. Liquefaction technology would expand gas' participation even further in the 2000s (CHESTER, 2010, p. 888). Together with nuclear energy, which had become an important source of electricity in several countries, gas would reduce the role of coal (CHESTER, 2010, p. 888).

By the turn of the century, the international energy regime was much more complex than the post-war one. Energy supply was more diversified, both in terms of primary energy sources as well as suppliers; economic interdependence between regions had increased; energy demand in emerging economies, especially Asian countries, was soaring; global security issues had become much more intricate (CHESTER, 2010, p. 888). The importance of energy, especially electricity, in daily living had risen (CHERP and JEWELL, 2011, p. 206) due to technological revolutions. The impact of energy production on the environment was disclosed. In this scenario, threats to energy security came from lack of access to primary energy sources but also, e.g., aging energy infrastructures, technological failures, extreme natural events, economic

[23] Own calculations based on data referred.
[24] Own calculations based on data referred.

and political crises, regulatory uncertainty, climate change (CHERP and JEWELL, 2011, p. 207). Achieving energy security became a multi-dimensional challenge.

2.3.5.2. Energy availability remains a major policy concern

The multi-dimensional challenge of achieving energy security has different definitions. It can be expressed as securing access to primary energy sources, then transforming and distributing it through robust – safe and technological up-to-date, capable of resisting hazards – and resilient – flexible, adaptable, capable of overcoming disruptions – energy systems (CHERP and JEWELL, 2011, p. 207-208). It can also mean combining geological, geopolitical, economic, environmental and societal elements: ensuring uninterrupted access to available primary energy sources at affordable costs and acceptable environmental and societal impacts (KRUYT et al, 2009, p. 2167). A third option is identifying which types of risks can affect energy security as well as the scope and severity of their impact (WINZER, 2012, p. 37-39). Finally, a broader definition would clarify who the subject of energy security is, which values it is serving and from what threats (CHERP and JEWELL, 2014, p. 416, citing BALDWIN).

Despite the polysemic nature of energy security (CHESTER, 2010), some issues are more present than others in the varying definitions. An analysis of 104 studies of energy security published between 2001 and 2014 identified 83 definitions of energy security and 07 major themes related to it: energy availability, infrastructure, energy prices, societal effects, environment, governance and energy efficiency (ANG, CHOONG and NG, 2015). Energy availability – continued access to primary energy sources – is included in 82 of the definitions, or 99% of them, and its pivotal relevance has not changed overtime (ANG, CHOONG and NG, 2015, p. 1082). It is followed by infrastructure, key to ensure stable and uninterrupted energy supply and present in 72% of the definitions, and energy prices or affordability, found in 71% of them (ANG, CHOONG and NG, 2015, p. 1082). Concerns over societal effects of energy security, environmental impacts, governance issues and energy efficiency occupied, respectively, 37%, 34%, 25% and 22% of the studies analyzed. Their relevance also changed over time: environmental issues appear in only 01 of 11 studies published between 2001 and 2005, but 01 in every 02 definitions over 2010 and 2013; societal effects were more present in studies published either between 2001 and 2005 or 2010 and 2013 than between 2006 to 2009; governance and energy efficiency appear sparsely in definitions between 2001 and 2005, but in about a third of the ones published between 2010 and 2013 (ANG, CHOONG and NG, 2015, p. 1082).

Indicators that are commonly used to measure energy security capture the relevance of energy availability. Energy resources estimates, reserves to production ratio, energy matrix diversity indices and mean variance of portfolio theory are commonly found in the literature among simple indicators (KRUYT et al, 2009, p. 2168-2170). Dependence on energy imports seems a key one. It can be expressed, e.g., by the share of oil imports relative to total oil consumption in an economy; by net imports, the difference between energy imports and energy exports; or by an economy's dependence on energy imports weighted with its fuel diversity.[25] Energy imports could be justified as a measure of energy security because they "*provide a straightforward and insightful indicator that does not require specific expertise to comprehend*" (KRUYT et al, 2009, p. 2169).

In the literature, dependence on foreign energy supply has a negative connotation to energy security. Importing energy is considered detrimental to security of supply because it "*exposes an economy to risks that are outside of its jurisdiction*" (MANSSON, JOHANSSON and NILSSON, 2014, p. 04). Hence, "*independence of imports in general and less reliance on individual exporters in particular are usually regarded as something to strive for*" (MANSSON, JOHANSSON and NILSSON, 2014, p. 04).

2.4. ENERGY SECURITY, A KEY DRIVING FORCE OF ENERGY DECARBONIZATION: THE G20 COUNTRIES

Reducing the carbon intensity of energy supply is key to mitigate climate change. Yet, it is not clear that concerns over climate change would be the main/only drivers of it. Following our framework in which we argue that co-benefits could catalyze action that contributes to climate change mitigation, we want to investigate the role of energy security concerns as a driver of energy decarbonization.

[25] This is an adaptation of the Shannon Index (KRUYT et al, 2009, p. 2169), commonly used to characterize species diversity in a community.

We hypothesize that the objective of enhancing energy security plays a key role in reducing or increasing the carbon intensity of energy supply. Countries, especially after the 1970s oil crises, would be inclined to develop their own energy supply and/or diversify their energy matrix to reduce their dependence from foreign supply or from a specific energy supplier. Energy security concerns will not be the only reason for countries to pursue energy decarbonization: other co-benefits, which are not tested due to lack of a complete time series dataset but will be highlighted in some specific cases, will also be at play. Neither is the relationship between energy security concerns and energy decarbonization straightforward: different variables such as availability of technology, price of technology, cost-competitiveness of the energy source compared to others, side-effects of the use of the energy source will also influence the relationship. Nevertheless, we want to show that there is a relationship between enhancing security of energy supply, or reinforcing energy availability, and energy decarbonization.

To test it, we analyze the evolution of carbon intensity of energy supply of the 19 countries members of the G20[26] and compare it with the evolution of their energy matrix for a period of 44 years, 1971 to 2015.[27] The 19 countries are chosen due to their impact in global governance, in global GHG emissions and in energy production and use. Together, they answered for 80.98% of global CO2 emissions from fossil fuel combustion[28] in 1971 and for 76.71% in 2015, and for 79.81% of global TPES in 1971 and for 73.25% in 2015 (IEA, 2017c).[29]

2.4.1. Evolution of the carbon intensity of energy supply

Between 1971 and 2015, global carbon intensity of energy supply decreased 6.26%. Among the 19 countries studied, the carbon intensity of energy supply decreased by more than global average in 10 (Canada, Germany, France, United

[26] The European Union, the 20th member of the G20, is not part of the analysis (i) to avoid endogeneity (since four – Germany, France, United Kingdom and Italy – of its current members are in the analysis); (ii) because although competence over energy policy is shared between the European Union and its members (<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:ai0020>), their energy matrix trajectories differ substantially; and (iii) to establish a coherent analysis of individual countries so to allow comparison between them.
[27] The period was chosen due to the availability of data for the dependent variable – the carbon intensity of energy supply – as a complete time series from the IEA.
[28] CO2 emissions from fossil fuel combustion exclude emissions from land use, land use change and forestry (LULUCF) and any other emissions that are not directly related with burning fossil fuels.
[29] Own calculations based on data referred.

Kingdom, Italy, South Korea, United States, Argentina, Russia and South Africa); in Japan, it decreased by less than the global average; and in 08 countries (Australia, Brazil, China, Indonesia, India, Mexico, Saudi Arabia and Turkey) the carbon intensity of their energy supply increased (table 2.1, below).[30]

Table 2.1: Evolution of carbon intensity of energy supply, 1971-2015 (Mt of CO2/Mtoe)

	1971	2015	1971-2015 (%)
AUS	2.78	3.04	9.45
CAN	2.41	2.03	-15.53
DEU	3.21	2.37	-26.06
FRA	2.67	1.18	-55.85
GBR	2.98	2.16	-27.54
ITA	2.74	2.17	-21.04
JPN	2.81	2.66	-5.34
KOR	3.12	2.15	-31.11
USA	2.70	2.28	-15.45
ARG	2.45	2.23	-9.18
BRA	1.25	1.51	20.71
CHN	2.00	3.04	52.41
IDN	0.72	1.96	172.67
IND	1.19	2.43	103.59
MEX	2.18	2.36	8.24
RUS	2.53	2.07	-18.10
SAU	1.72	2.40	39.17
TUR	2.14	2.46	15.34
ZAF	3.46	3.01	-12.94
WORLD	2.52	2.37	-6.26

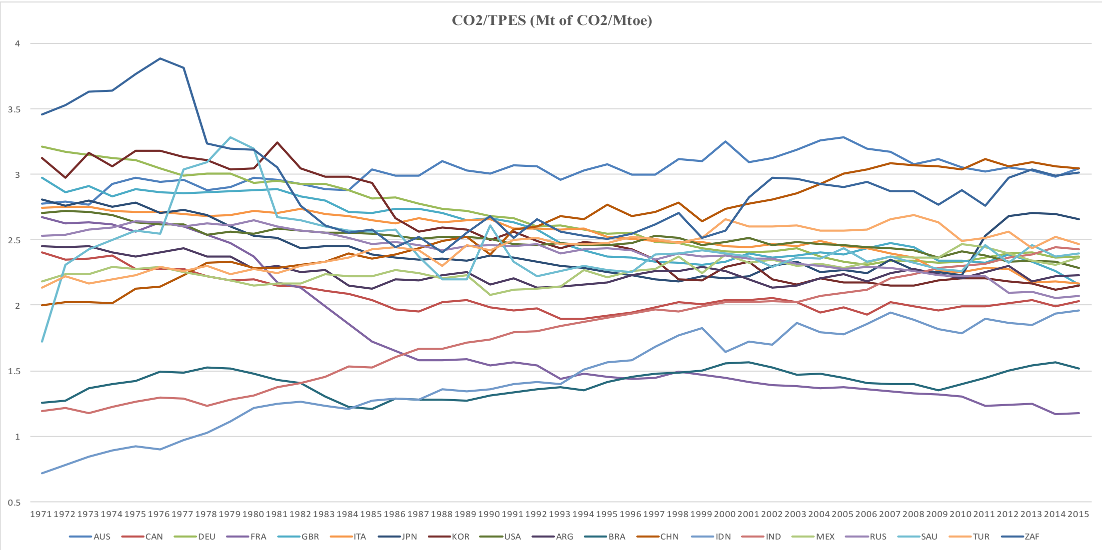
Source: Own calculations, based on data from IEA, 2017c. Consider: Russia, from 1971 to 1989, is USSR. From 1990 to 2015, Russian CO2/TPES decreased 15.88%.

Yet, understanding the trajectory of carbon intensity of energy supply in each of the countries enriches our analysis. Some countries have started from medium carbon intensity of energy supply and managed to consistently and substantially reduce it; France is the greatest example. Others have managed to roughly maintain it, having started from medium-high (Australia), medium (Mexico and Argentina), or lower (Brazil) levels of carbon intensity of energy supply. In other cases (China, India, Indonesia) the ascending trend is clear, even if the starting point is different. Finally, in some cases

[30] On tables and figures, countries are represented by 03-digit alphabetic country codes (Alpha-3 code) from the International Standards Organization, version 3166; available at <https://www.iso.org/obp/ui/#search>.

(Saudi Arabia, South Africa) the variation of carbon intensity of energy supply in the period was quite significant.

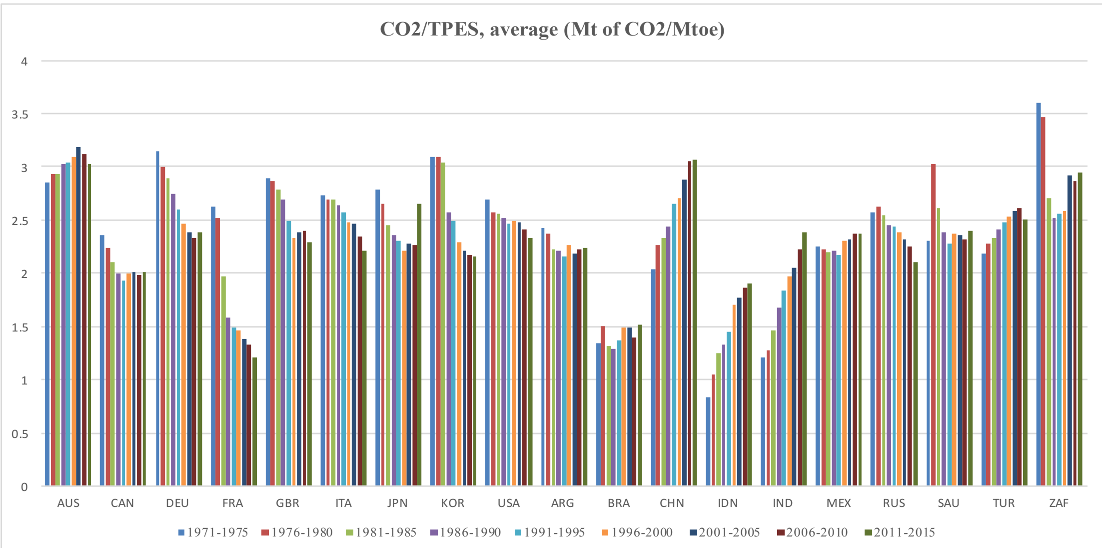
Figure2.6: Trajectory of CO2/TPES for G20 countries, 1971-2015



Source: Own elaboration, based on data from IEA, 2017c. Consider: Russia, from 1971 to 1989, is USSR.

Comparing five-year average carbon intensity of energy supply during the period:

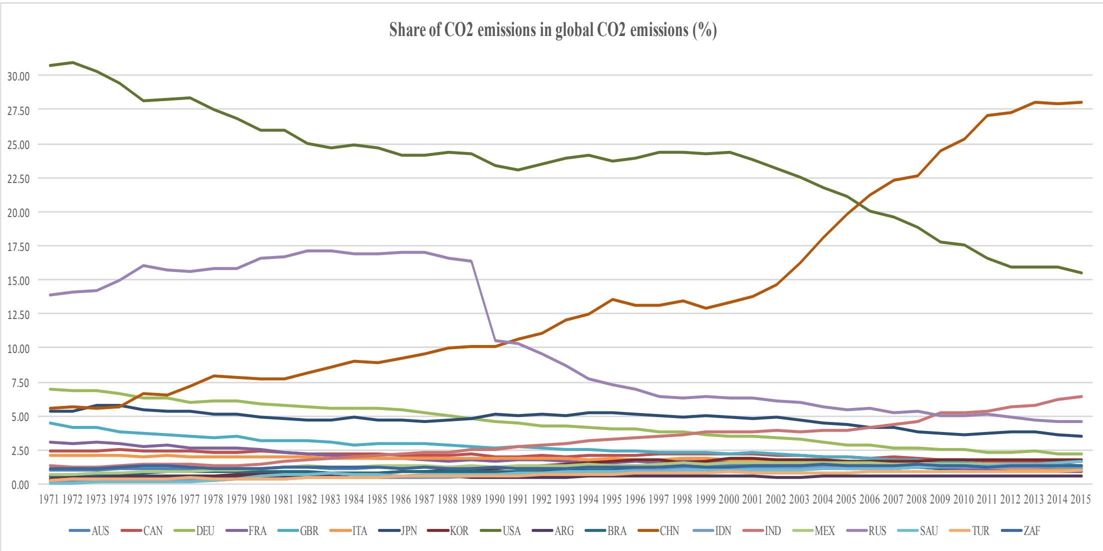
Figure 2.7: 05-year average CO2/TPES for G20 countries, 1971-2015



Source: Own calculations based on data from IEA, 2017c. Consider: Russia, from 1971 to 1989, is USSR.

Our sample is very heterogeneous. Although they are all among the greatest world economies, their size, composition and rate of growth vary a lot. Consequently, the share of each country CO2 emissions in global emissions also varies, both in a single year and in the time series. Some countries have less than 1% of the emissions in the beginning of the analyzed period and a little more than that in the end of the period – Turkey has 0.30% of the global emissions in 1971 and 0.95% in 2014; Mexico has 0.67% in 1971 and 1.33% in 2014; Saudi Arabia has 0.09% in 1971 and 1.56% in 2014. Other countries start from a higher level and manage to decrease their share in the period: e.g. the European countries and Japan. The United States and China are outliers, answering alone for substantial share of global CO2 emissions going in opposing directions in the period.

Figure 2.8: Share of CO2 emissions in global CO2 emissions (%)



Source: Own calculations based on data from IEA, 2017c. Consider: Russia, from 1971 to 1989, is USSR.

2.4.2. Transformations of the energy matrices: general trends in the G20

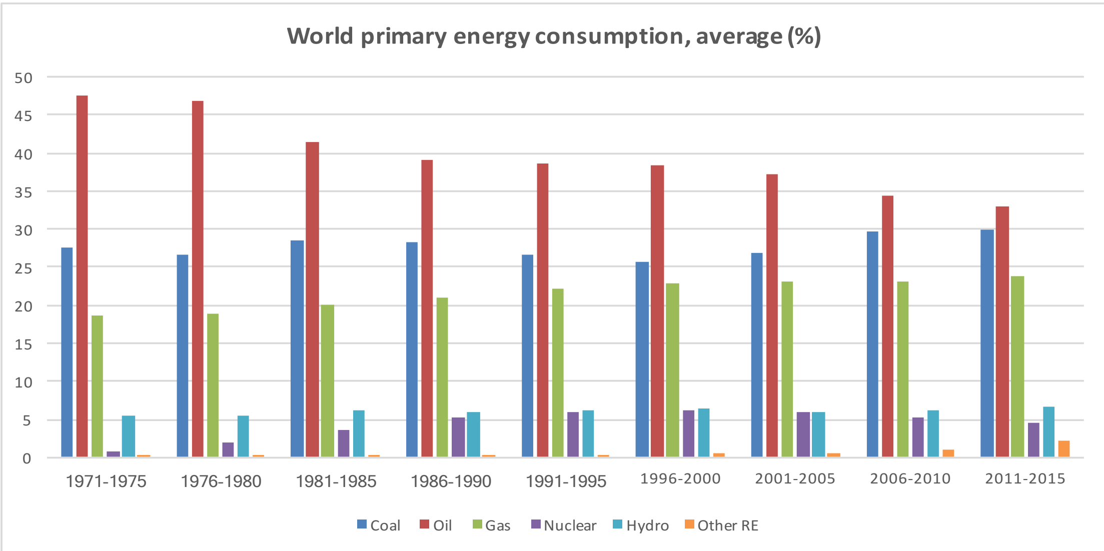
Between 1971 and 2015, the carbon intensity of global energy supply diminished 6.26%. Enduring global dependence on fossil fuels as primary energy sources is the reason for such a small change. Yet, while fossil fuels remain the most relevant primary energy sources, the share of each of them has changed throughout the period, as seen in Table 2.2 and Figure 2.9, below:

Table 2.2: World primary energy consumption, average (%)

World primary energy supply, average (%)	1971-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
Coal	27.53	26.69	28.46	28.35	26.68	25.59	26.97	29.79	29.96
Oil	47.54	46.74	41.42	39.08	38.58	38.50	37.13	34.39	32.97
Gas	18.54	18.88	20.14	21.00	22.15	22.82	23.18	23.17	23.75
Nuclear	0.88	2.06	3.64	5.31	5.93	6.16	6.03	5.33	4.50
Hydro	5.44	5.54	6.20	6.02	6.28	6.46	6.05	6.23	6.63
Other RE	0.06	0.08	0.15	0.24	0.38	0.47	0.65	1.09	2.19
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Own calculations based on data from BP, 2017. Other RE include wind, geothermal, solar, biomass and waste. Biofuels are not included due to lack of data for the complete time series.

Figure 2.9: World primary energy consumption, average (%)



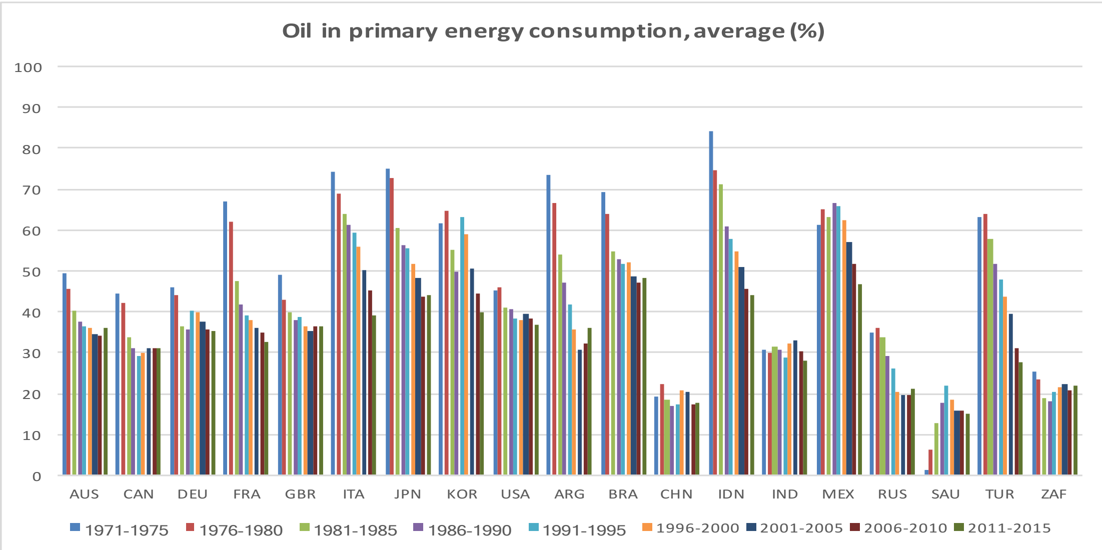
Source: Own calculations based on data from BP, 2017. Other RE include wind, geothermal, solar, biomass and waste. Biofuels are not included due to lack of data for the complete time series.

Oil participation as primary energy source has decreased between 1971 and 2015. While it provided, on average, 47.54% of global primary energy between 1971 and 1975, its share has consistently decreased during the decades, reaching average 32.97% between 2011 and 2015 (BP, 2017).[31] Coal participation has had both moments of increase and of decrease in the period; overall, its share has increased slightly, changing from 27.53% of average global energy supply between 1971 and 1975 to 29.96% between 2011 and 2015. The share of natural gas, on the other hand, has consistently increased in the period, although at a slower pace compared to the

[31] All calculations are our own, based on data from the source referred.

decreasing share of oil: from average 18.54% between 1971 and 1975 to average 23.73% between 2011 and 2015. When all three trends are merged together, a clear picture of a world highly dependent on oil changing into one in which coal, oil and natural gas share global energy supply more equally presents itself (Figure 2.9, above).

Figure 2.10: Share of oil in primary energy consumption, average (%)



Source: Own calculations based on data from BP, 2017. Note: Russia, from 1971 to 1984, is USSR.

The share of low carbon energy sources in the global energy matrix has doubled in the period, but remains small: from average 6.37% between 1971 and 1975 to average 13.32% between 2011 and 2015. Hydropower's participation remained roughly flat, having changed from average 5.44% between 1971 and 1975 to average 6.63% between 2011 and 2015. Hence, the rising participation of low carbon sources in the global matrix is not due to hydropower. The driver is nuclear energy, having changed from an average 0.88% participation between 1971 and 1975 to peak average 6.16% between 1996 and 2000, then decreasing to average 4.50% between 2011 and 2015. The impact of nuclear power is clear, since the share of low carbon primary energy sources in the global energy matrix increases consistently, on average, to peak between 1996 and 2000, and then decreases slightly, nuclear energy following the same trend. Only between 2011 and 2015 the trends decouple and the share of low carbon energy sources in global energy provision rises again, now pulled by the participation of new renewables – wind, solar, geothermal, biomass and waste.

These trends are consistent with our hypothesis that energy decarbonization is related to the objective of strengthening energy security.

After the 1970s oil crises, reducing dependence on imported oil from OPEC members became a priority for major energy consumers who are net oil importers. Diversifying oil suppliers was a strategy: exploiting more expensive oil reserves became cost-competitive due to rising oil prices. Some countries that were previously net oil importers became net exporters – e.g. the United Kingdom, between 1981 and 2005 (BP, 2017).[32] A second strategy was using more coal. Coal reserves are more evenly distributed around the globe compared to major oil fields and its exploitation is also cheaper than oil's. Therefore, coal participation as a primary energy source has increased in the period. Since middle 2000s, China and India – the 1st and the 2nd greatest coal producers, respectively (IEA, 2017a, p. 17) – rising energy demand increased global use of coal even further.

The use of natural gas, a third strategy to diversify the energy matrix, was pushed up by the construction of pipelines, facilitating gas exports and reducing its price, and the development of technology to produce Liquefied Natural Gas (LNG), allowing it to be exported by ships. Fourth, the development of nuclear energy is also in tandem with the trend: it became an importance source of energy for countries that could afford to invest in this more expensive technology. For countries with small reserves of fossil fuels, it became a major energy source.

Finally, renewable sources enhanced energy security in specific cases (section 2.4.3., below). Changes in hydropower production were small at the global aggregate level but relevant in specific cases. Other renewables developed, at commercial scale, much more recently. Their share in global energy production is still small, but their use is growing rapidly, faster than the use of any other primary energy source. The expected technological breakthrough in energy storage could be a game changer for the role of new renewables.

[32] Own calculations based on data referred.

2.4.3. Similarities and differences among the 19 countries

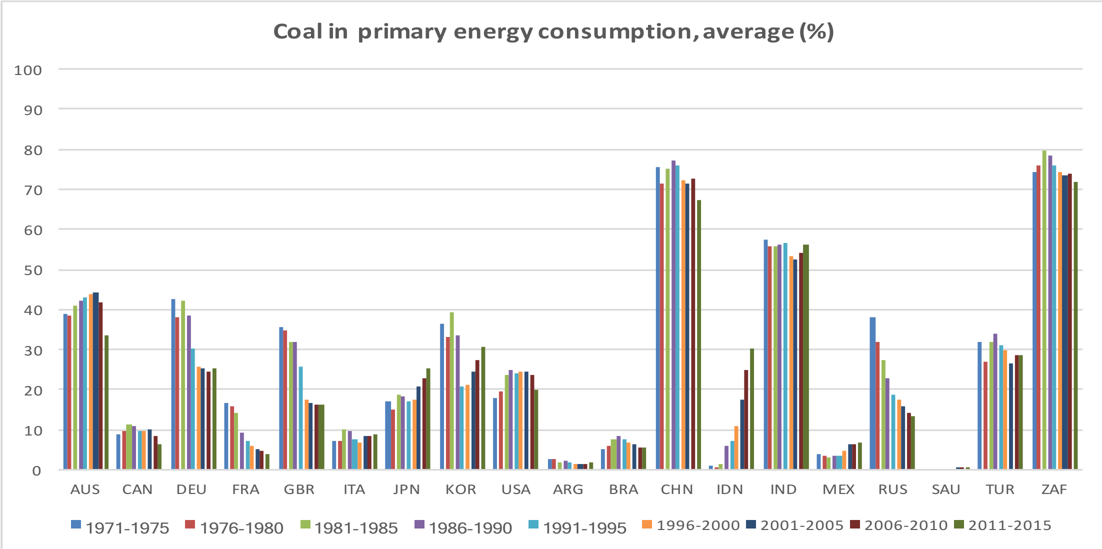
Our sample is heterogeneous. The countries were chosen due to their role in energy production and consumption, and the weight of their carbon emissions in global carbon emissions. Yet, when we analyze the trajectory of the carbon intensity of their energy supply and compare with changes in the composition of their energy matrix, we find similarities and differences that further support our hypothesis.

2.4.3.1. Coal-dependent economies

Australia, China, Indonesia, India and South Africa have two features in common: they are coal-dependent economies and the carbon intensity of their energy supply between 1971 and 2015 has been either roughly stable at medium-high to high levels or growing (Figures 2.6 and 2.7, above).

The 05 countries are among the greatest producers and consumers of coal: in 2016, China ranked 1st, producing 44.60% of world's coal; India, 2nd; Australia, 4th; Indonesia, 5th; and South Africa, 7th (IEA, 2017a, p. 17). Australia, Indonesia and South Africa are net exporters of coal – world's 1st, 2nd and 5th, respectively –, while China and India are net importers – world's 1st and 2nd, respectively (IEA, 2017a, p. 17). The relationship between coal consumption and carbon intensity of their energy is so close that even a slight change in the second can be traced to a change in the first: e.g. Australia's carbon intensity of energy has changed from average 3.23 Mt of CO2/Mtoe between 2001 and 2005 to 3.12 between 2006 and 2010 and 3.02 between 2011 and 2014; the share of coal in its total primary energy consumption was average 44.09% between 2001 and 2005, 41.81% between 2006 and 2010 and 33.58% between 2011 and 2015.

Figure 2.11: Share of coal in primary energy consumption, average (%)



Source: Own calculations based on data from BP, 2017. Note: Russia, from 1971 to 1984, is USSR.

Yet, the countries also have differences. While coal has provided roughly 40% of its energy supply from 1971 to 2015 – with peaks of 44% between 1996 and 2005 –, Australia has reduced its dependence on oil since the 1970s – from 49.32% average between 1971 and 1975 to 35.90% average between 2011 and 2015 – and raised the share of natural gas in its energy matrix, from 6.60% average between 1971 and 1975 to 24.92% average between 2011 and 2015 (BP, 2017).[33] In Indonesia, coal's share in total energy consumption has increased sharply between 1971 and 2015, while oil's share has decreased substantially – from average 84.34% between 1971 and 1975 to average 44.20% between 2011 and 2015 (BP, 2017) –, indicating that the second might have been replaced by the first – the rising levels of carbon intensity of energy is another evidence of it. In South Africa, coal answered for more than 70% of total energy consumption throughout the period, explaining why the carbon intensity of its energy remains high.

China and India present a different picture. Both are highly dependent on coal, but China is more dependent than India proportionally: until 2011, coal answered for more than 70% of total energy consumption in China, having decreased after that; in India, coal has kept a 50-55% share in total energy consumption between 1971 and 2015 (BP,

[33] Own calculations based on data referred.

2017). Both are also dependent on oil, but India is more dependent than China: the share of oil in its total energy consumption is about 10% higher than China's (BP, 2017). In both countries, the use of gas has been increasing, but due to the great amounts of energy both economies have been requiring lately, it still amounts less than 10% on both energy matrices (BP, 2017).

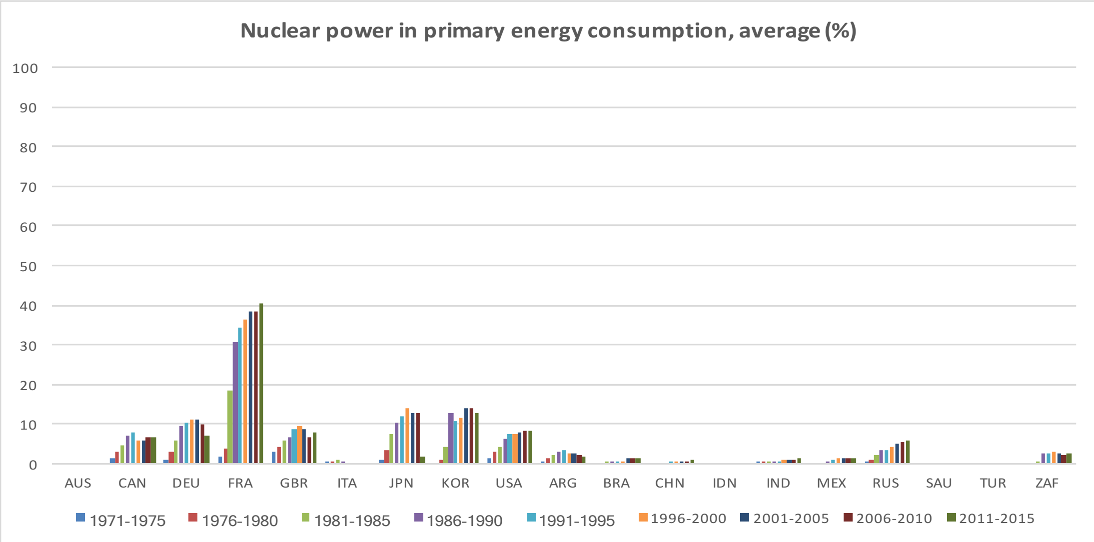
Decreasing carbon intensity of energy in coal-dependent countries – especially if they are larger producers, such as these 05 countries of our sample – is difficult. Coal is a relatively cheap[34] and firm – not intermittent – primary energy source. So, when energy security is a priority, a country that has large coal reserves has strong motivation to exploit them, maintaining the carbon intensity of its energy matrix high. Yet, the side-effects of burning coal to human health and the environment are very relevant and can catalyze social and political pressure for change – exactly what is happening partially in China. Despite its claim about following a path of decarbonization, the Chinese dependence burning coal is astonishing for the second decade of the 21st century. Air pollution levels are so high in Chinese major cities that the Chinese authoritarian regime has been forced to search for alternative primary energy sources. Although coal remains Chinese major primary energy source, hydropower, wind power and nuclear power plants are being built simultaneously, in great number and at accelerated pace. If China and Russia finally reach an agreement regarding the construction of a pipeline, Siberian natural gas could also become a major energy source.

2.4.3.2. The nuclear solution

Among the 19 countries of our sample, none has reduced the carbon intensity of its energy supply more than France: by 55.89% between 1971 and 2015, or from 2.67 Mt of CO2/Mtoe in 1971 to 1.18 in 2015 (IEA, 2017c).[35] And in no other country nuclear energy has grown to provide average 40% of its energy supply (Figure 2.12, below) and 70% of its electricity (Figure 2.13, below). For this reason, France is the best example of decarbonization among the G20 countries.

[34] Discounting the externalities.
[35] Own calculations based on data referred.

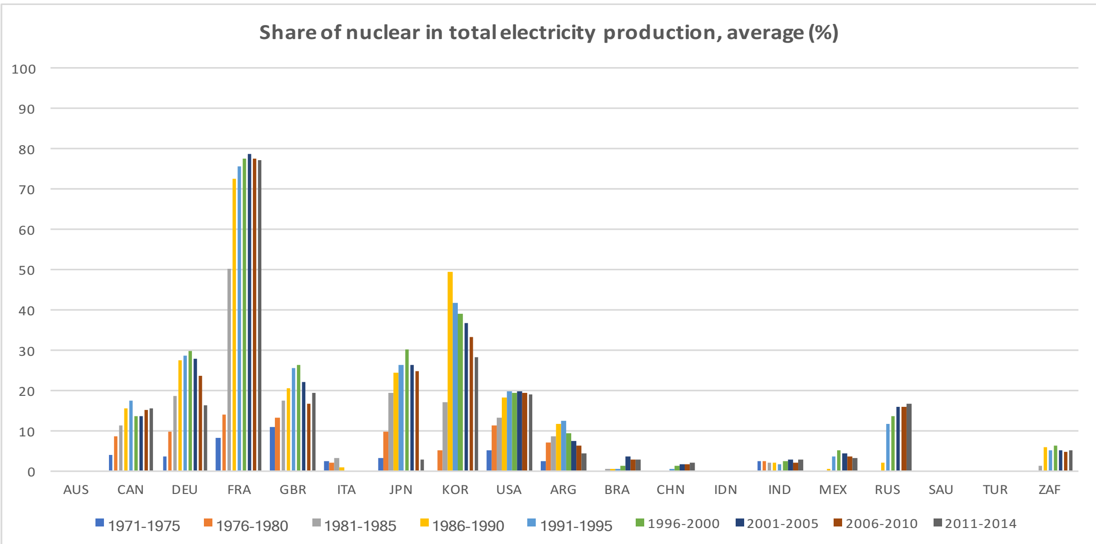
Figure 2.12: Share of nuclear in primary energy consumption, average (%)



Source: Own calculations based on data from BP, 2017. Note: Russia, from 1971 to 1984, is USSR.

France was not alone in investing in nuclear energy: the technology was spread to 14 of the 19 countries of our sample.[36] Nuclear answers for a relevant share of electricity supply in Japan and South Korea, and for a smaller share in Canada, Germany, the United Kingdom, the United States and Russia.

Figure 2.13: Share of nuclear in total electricity production, average (%)



[36] Nuclear energy was developed in Italy until the 1980s and discontinued following a popular vote after the Chernobyl accident (1986). But Italy imports electricity from France and Switzerland, countries that employ nuclear as a primary energy source. We found no record of nuclear energy in Australia, Indonesia, Saui Arabia and Turkey.

Source: Own calculations based on data from WB, 2017 (indicator <EG.ELC.NUCL.ZS> from 18 Set 2017). Russia: no data from the ex-USSR was available in the WB dataset, and first piece of data available from Russia was from 1990; graph in the figure reflects this. In BP, 2017, data for nuclear energy in electricity production is available for all 19 countries from 1985 to 2015. Considering this dataset, the average share of nuclear power in electricity production in Russia between 1986 and 1990 is 11.73%.

Nuclear is a firm primary energy source that generates almost zero carbon emissions in the process of producing electricity. Therefore, it contributes to reduce carbon intensity of energy supply without the downside of intermittency featured by renewables. If we observe the evolution of carbon intensity of energy in France, Japan and South Korea (Figure 2.9, above) and compare with nuclear electricity output (Figure 2.13, above) we will see that there is a parallel: when nuclear electricity output decreases – what happened in Japan, to a great extent, and South Korea, to a lesser extent, following the Fukushima-Daiichi nuclear accident (2011) – carbon intensity of energy supply increases.

France is unique among the three countries by having reduced its consumption of coal consistently and decisively between 1971 and 2015 (Figure 2.11, above). Japan and South Korea, however, remain dependent on coal, and this dependence increases when nuclear electricity output decreases – the same is true to Germany, to a lesser extent. The three countries managed to consistently reduce their dependence on oil: in France, share of oil in total energy consumption was reduced from 67% average between 1971 and 1975 to 32.65% average between 2011 and 2015; in Japan, from 74.89% average between 1971 and 1975 to 44.10% average between 2011 and 2015; in South Korea, from 61.60% average between 1971 and 1975 to 39.81% average between 2011 and 2015 (BP, 2017).[37] And the share of natural gas in total energy consumption increased in all three countries, more sharply in Japan and South Korea: from 7.50% average between 1971 and 1975 to 14.96% average between 2011 and 2015 in France; from 1.50% average between 1971 and 1975 to 22.35% average between 2011 and 2015 in Japan; and from 2.48% average between 1986 and 1990 to 15.83% average between 2011 and 2015 (BP, 2017).[38]

Nuclear energy also played a role in reducing carbon intensity of energy in the United States, Russia, Canada, Germany and the United Kingdom. In fact, all of them

[37] Own calculations based on data referred.
[38] Own calculations based on data referred. The first record of gas consumption in the time series for South Korea is from 1986.

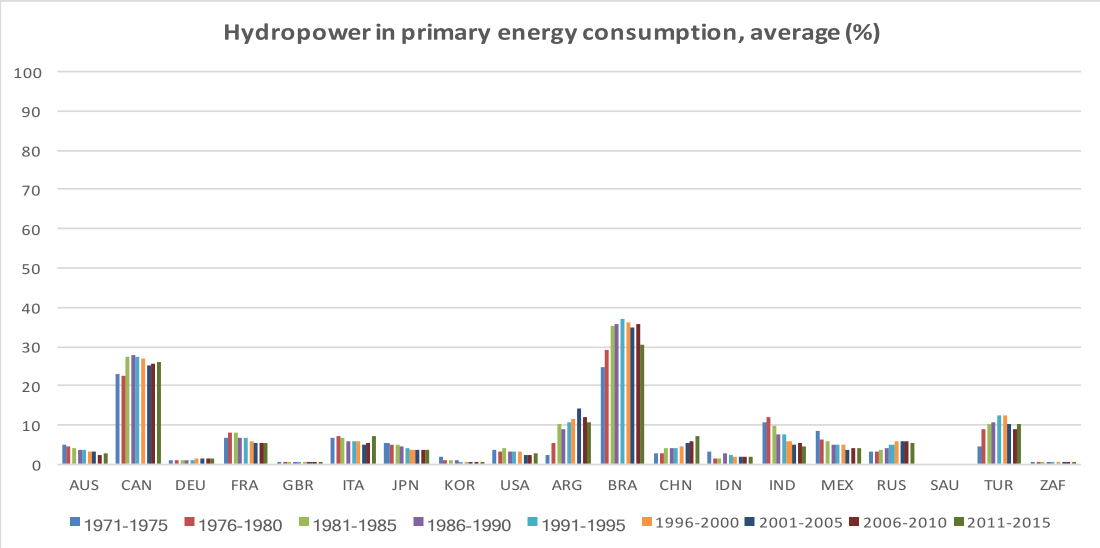
are among the world's largest nuclear energy producers: the United States is the 1st, having produced 32.30% of the global nuclear energy output in 2015 (IEA, 2017a, p. 19); Russia is the 3rd; Canada, the 6th; Germany, the 7th; and the United Kingdom, the 9th (IEA, 2017a, p. 19). Nuclear will soon become more relevant in China: although nuclear answered for average 2% of total electricity output between 2011 and 2015 (Figure 2.13, above), China is world's greatest 5th nuclear power producer and is currently building, simultaneously, 20 nuclear power plants (WORLD NUCLEAR ASSOCIATION, 2017). The main driver is another co-benefit of energy decarbonization – reducing air pollution (WORLD NUCLEAR ASSOCIATION, 2017). But if nuclear reduces Chinese dependence on coal, the carbon intensity of its energy matrix will also decrease significantly.

Despite its straightforward contribution to both enhancing energy security and decreasing carbon intensity of energy supply, nuclear remains a contentious primary energy source. After the Fukushima-Daiichi nuclear accident (2011), public opinion in some parts of the world raised opposition to nuclear energy, and the political decision to phase-out their use was adopted in Germany, Switzerland and California. Governments claim that new renewables will replace nuclear, but this is yet to be seen: both in Japan and Germany the use of coal increased following reduced share of nuclear in energy supply. While storage technology for new renewables is still under development, a debate more grounded in science, comparing all costs and side-effects of using both nuclear and fossil fuels is necessary.

2.4.3.3. Hydropower: an old low carbon energy primary source

Looking at Figure 2.13, above, we observe a positive slope for most countries that adopted nuclear energy, meaning that its use was small before the 1970s and increased with time. When we look at Figure 2.14, below, we observe a different picture: while this positive slope can be seen in the case of China and, to some extent, Argentina and Turkey, a negative slope is seen for Australia, France, Japan, the United States, Indonesia, India and Mexico, and a bell-shaped curve for Brazil and Canada:

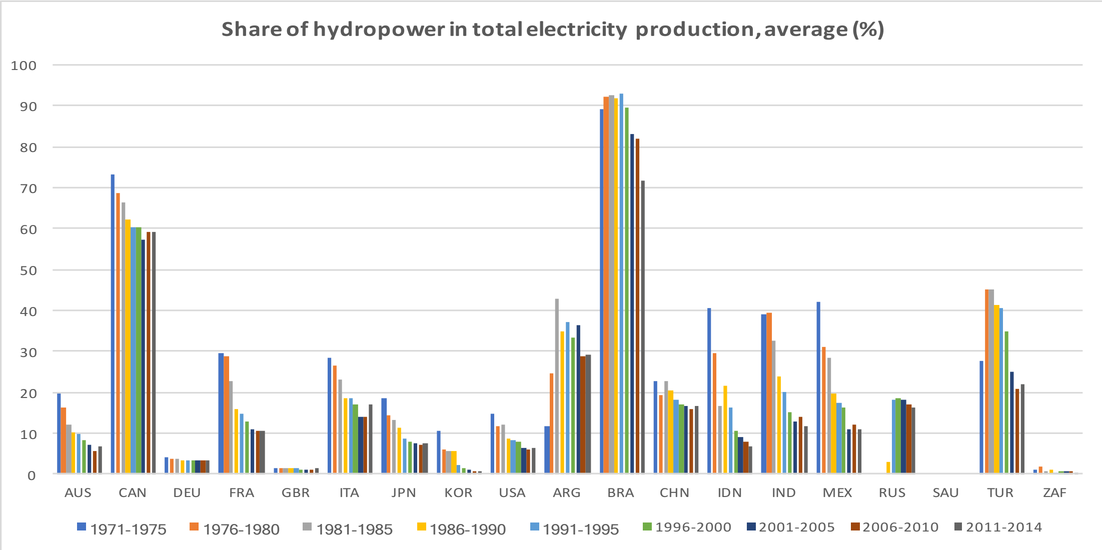
Figure 2.14: Share of hydropower in primary energy consumption, average (%)



Source: Own calculations based on data from BP, 2017. Note: Russia, from 1971 to 1984, is USSR.

What this means is that countries started exploiting their hydropower before the 1970s oil crises. In many countries, the bulk of the hydropower potential was already being exploited by then. After the crises, hydropower was further developed where potential still existed – in countries where it was already exploited and in countries where it was not yet exploited. Thus, even if some countries might have started exploiting their hydropower potential after the 1970s oil crises, and even if hydropower did enhance energy security for all countries that exploited it having started earlier or in the context of the 1970s oil crises, this was not a global new trend. In fact, we observe that in places where most of the hydropower potential was already being exploited, rising electricity demand started to be met by different primary energy sources, so the share of hydropower in total electricity production started to decrease:

Figure 2.15: Share of hydropower in total electricity production, average (%)



Source: Own calculations based on data from WB, 2017 (indicator <EG.ELC.HYRO.ZS> from 18 Set 2017). Russia: no data for the ex-USSR was available in the World Bank data, and first year of data available to Russia was 1990; graph in the figure reflects this. In BP, 2017, data for hydropower in electricity production is available for all 19 countries from 1985 to 2015. Considering this data, the average share of hydropower in electricity production in Russia between 1986 and 1990 is 15.46%.

Among the 19 countries, Canada and Brazil stand out having significant share of their primary energy supply and of their electricity supply provided by hydropower. They are the 2nd and 3rd world's largest hydropower producers, following China – country that produced 28.40% of total global hydropower output in 2015 (IEA, 2017a, p. 21). In both countries oil share in total energy consumption decreased between 1971 and 2015: from 44.52% average between 1971 and 1975 to 31.01% average between 2011 and 2015 – nadir of 29.27% average between 1991 and 1995 – in Canada; from 69.40% average between 1971 and 1975 to 48.14% average between 2011 and 2015 – nadir of 47.14% average between 2006 and 2010 – in Brazil (BP, 2017).[39] Coal's share also has a similar shape and trajectory in both countries: answers for less than 10% of total energy supply, and increased until 1990 and decreased afterwards (Figure 2.9, above). Share of gas in total energy supply has also increased in both countries, although from a higher starting point and slightly in Canada and from almost insignificant shared and sharply in Brazil (Figure 2.15, below).[40]

[39] Own calculations based on referred data. Biofuels are not included.
[40] Own calculations based on referred data.

Hydropower is also relevant in Argentina and Turkey and has played a secondary role to natural gas in enhancing their energy security after the 1970s oil crises. The share of oil in the Argentinian energy consumption decreased from 73.31% average between 1971 and 1975 to 35.89% average between 2011 and 2015 – nadir of 30.68% average between 2001 and 2005 –; in the Turkish, it decreased from 63.24% average between 1971 and 1975 to 27.81% average between 2011 and 2015 (BP, 2017).[41] Hydropower's share in total energy consumption increased from 2.24% average between 1971 and 1975 to peak 14.28% average between 2001 and 2005 then 10.71% average between 2011 and 2015 in Argentina, and from 4.67% average between 1971 and 1975 to peak 12.57% average between 1991 and 1995 then 10.31% average between 2011 and 2015 in Turkey (Figure 2.15, above). Coal's role remained roughly stable in both countries in the period: from a little more to a little less than 2% in Argentina and roughly 30% of the energy matrix in Turkey. Therefore, the primary role in both countries was played by natural gas: from 21.27% average between 1971 and 1975 to 49.34% average between 2011 and 2015 in Argentina, and from 0.10% average between 1981 and 1985 to 31.48% average between 2011 and 2015 in Turkey (BP, 2017).[42] The fact that coal maintained a relevant share of Turkish energy matrix and natural gas' share in the Argentinian energy matrix is larger than in Turkey explains why carbon intensity of energy has increased in the Turkey and decreased in Argentina in the period.

Hydropower provided very significant share of electricity production in Indonesia, India and Mexico, and a smaller share in Australia, France, Italy, Japan, South Korea, the United States. Yet, in all cases hydropower's relevance has been decreasing (Figure 2.15, above) following increasing participation of other primary energy sources in producing electricity. China is an interesting case: world's largest hydropower producer, it has been able to maintain hydropower's participation in electricity provision at around 16-17% since mid-1990s, a 20-year time interval in which electricity demand escalated in the country. The Chinese have been able to do it by investing heavily in new large-scale hydropower plants: e.g. the Three Gorges Dam became world's largest

[41] Own calculations based on referred data.
[42] Own calculations based on referred data. The first record of gas consumption in the time series for Turkey is from 1982.

hydropower plant in 2012, when all its water turbines started operating; it has 22,500MW generating capacity.

Hydropower is a widely spread primary energy source and no carbon emissions or pollutants are generated from its operation – other GHG emissions, such as methane, are relevant from reservoirs when in tropical climates. Yet, it faces important opposition due to the impacts to the local environment and populations when reservoirs are built. In many countries, alternatives have been adopted, such as small power plants with small reservoirs or run-of-the-river technology. Although these alternatives mitigate the local environmental and social impacts of hydropower plants, they reduce their ability to be a firm source of energy, negatively impacting energy security. If backup of no-reservoir or run-of-the-river hydropower plants is ensured by fossil fuel thermal power plants, the overall impacts – considering carbon emissions and pollution – might be greater. Just like the debate around nuclear power, alternatives to hydropower plants with reservoirs need to be assessed considering lifecycle economic, social and environmental costs.[43]

2.4.3.4. The emergence of other renewables

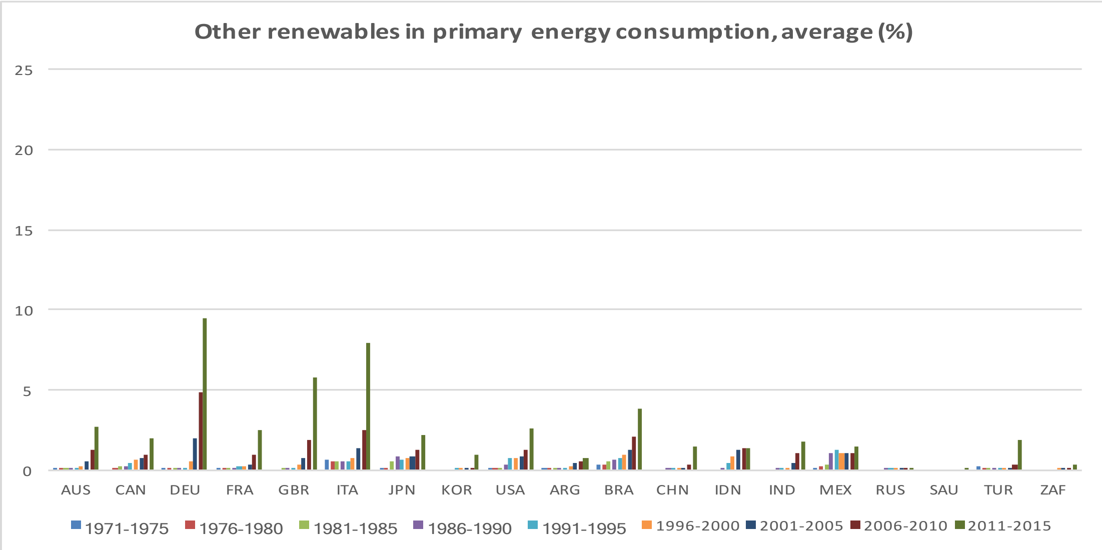
The use of renewables other than hydropower as a source of energy is not new. Windmills to pump water or grind grains were common in several parts of Europe already in medieval times, and became common in the Americas in the 19th Century. Also in the 19th Century, an ethanol blend became popular as lamp fuel, displacing whale oil in the United States; steam was produced for the first time by solar power system in France; electricity was produced directly from sunlight using a selenium solar cell; the first geothermal district heating system is built in the United States; an engine that run on vegetable oil is demonstrated for the first time in the 1900 World's Fair, in Paris. Yet, contrary to hydropower, it was in the context of the oil crises of the 1970s that other renewables received systematic policy support and investments that would allow their development into primary energy sources to produce secondary energy at large scale.

[43] Another variable to be considered is how climate change is affecting rain patterns, therefore volume and regime of rivers in the long-run. In countries relying on hydropower, this is a major issue to future security of energy supply.

One of the first countries develop new renewables in the oil crises context was Germany. A combination of security of supply, innovation, environmental and socio-economic concerns fueled it. The 1970s oil crises raised concern over energy security, and larger exploitation of German coal reserves as well as the development of nuclear energy were considered alternatives to the use of oil (JACOBSSON and LAUBNER, 2006, p. 261). At same the time, the environmental movement was rising in Germany by offering an alternative view of society based on questioning status quo and pushing ecological concerns (HAKE et al, 2015, p. 04). Anti-pollution protests found fertile ground in Germany because increased use of coal was proved to worsen acid rain, and German forests – valued strongly in the German culture – started to be damaged by it. The same was true for anti-nuclear protests, especially after the Chernobyl accident. A small niche was formed around renewables, especially wind, after R&D support had been granted, and organizations around it – including labor unions defending jobs in the new sector – worked as advocacy coalitions for the technologies (JACOBSSON and LAUBNER, 2006, p. 263). In the 1980s and 1990s, policy support increased and financing measures for renewables were incorporated into German law. In the 2000s, their participation in the German electric matrix started to become relevant. The participation of the Green Party in the coalition government between 1997 and 2005 was key for long-term promotion of renewables.

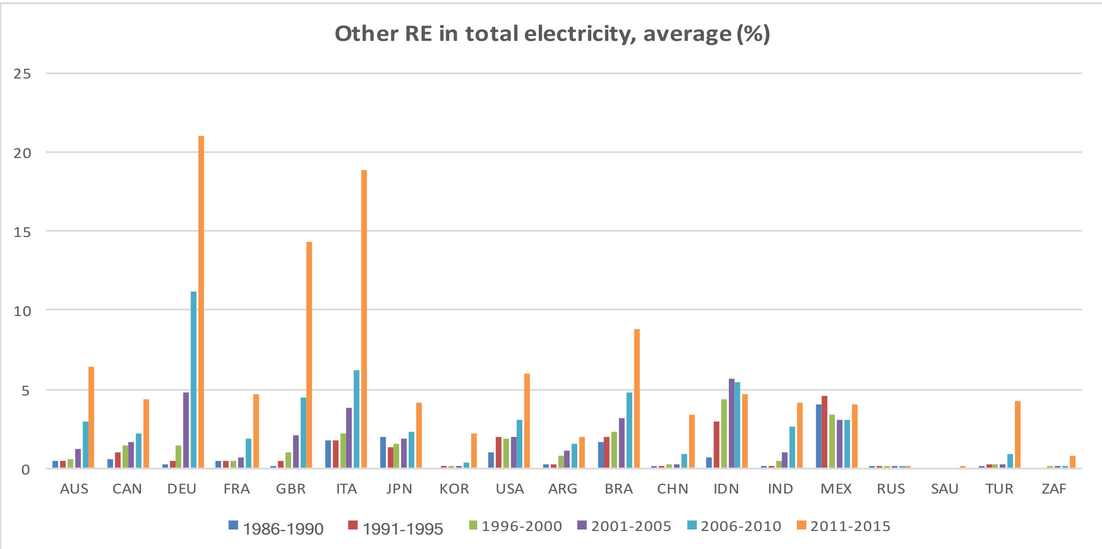
Globally, improvements in technology in the context of high prices of oil between middle 2000s and middle 2010s have expanded the use of renewables. Their shares in total energy production is still small (Figure 2.16, below), but they are expanding faster than any other energy source. They are already relevant in the electric matrix of some countries (Figure 2.17, below).

Figure 2.16: Share of other renewables in primary energy consumption, average (%)



Source: Own calculations based on data from BP, 2017. Notes: (1) other renewables refer to wind, solar, geothermal, biomass (for electricity generation) and waste; biofuels are not included. (2) Russia, from 1971 to 1984, is USSR.

Figure 2.17: Share of other renewables in total electricity production, average (%)



Source: Own calculations based on data from WB, 2017 (indicators <EG.USE.ELEC.KH.PC>, <SP.POP.TOTL> and <EG.ELC.RNWX.KH> in tables dated from 18 Set 2017). Notes: (1) Russia: no data for the ex-USSR was available in the World Bank data, and first year of data available to Russia was 1990; the figure reflects this. In BP, 2017, data for hydropower in electricity production is available for all 19 countries from 1985 to 2015. Considering this dataset, the average share of hydropower in electricity production in Russia between 1986 and 1990 is zero. (2) Other renewables refer to all renewable sources excluding hydropower for the WB and to wind, solar, geothermal, biomass (for electricity generation) and waste for BP.

Among the 19 countries, Germany has the largest share of renewables in its energy matrix: average 9.49% of primary energy consumption between 2011 and 2015 (BP, 2017)[44] and average 21.57% of total electricity production between 2011 and 2015 (WB, 2017). Germany is followed by Italy and the United Kingdom: average 7.95% and 5.79% of primary energy consumption between 2011 and 2015 (BP, 2017), respectively, and average 16.63% and 12.78% of total electricity production between 2011 and 2015, respectively (WB, 2017). Although having only average 1.44% of its primary energy consumption between 2011 and 2015 (BP, 2017) and average 3.29% of its total electricity production between 2011 and 2015 (WB, 2017) provided by renewables, China is the largest renewable developer. In 2007, it had 6.45% of global wind energy installed capacity and 2.14% of global solar energy installed capacity – Germany had 23.71% and 45.03%, respectively (IRENA, 2017b); in 2015, Chinese numbers had increased to 31.16% and 19.38%, respectively, while German's were 10.74% and 17.71%, respectively (IRENA, 2017b). In 2015, 21.88% of the global electricity produced by wind energy was produced in China, and 15.67% of the global electricity produced by solar energy was also produced there (IRENA, 2017b).

The secondary role of renewables in global energy supply is related to its intermittency. The amount of electricity that can be produced by wind and solar varies at any moment in time due to the intrinsic features of the primary energy source. Therefore, energy planning usually limits the amount of energy to be obtained from renewables to avoid outages and installs back up energy from firm primary energy sources, usually fossil fuels, to maintain a stable output. This is counterproductive from the point of view of carbon emissions, as having more renewables on the grid means having more fossil fuel thermal power plants as well.[45] Yet, investment in R&D to develop energy storage technology has increased substantially and cumulatively in the past decade, and a race to discover cost-efficient large-scale storage options.[46] When – and not if – the first

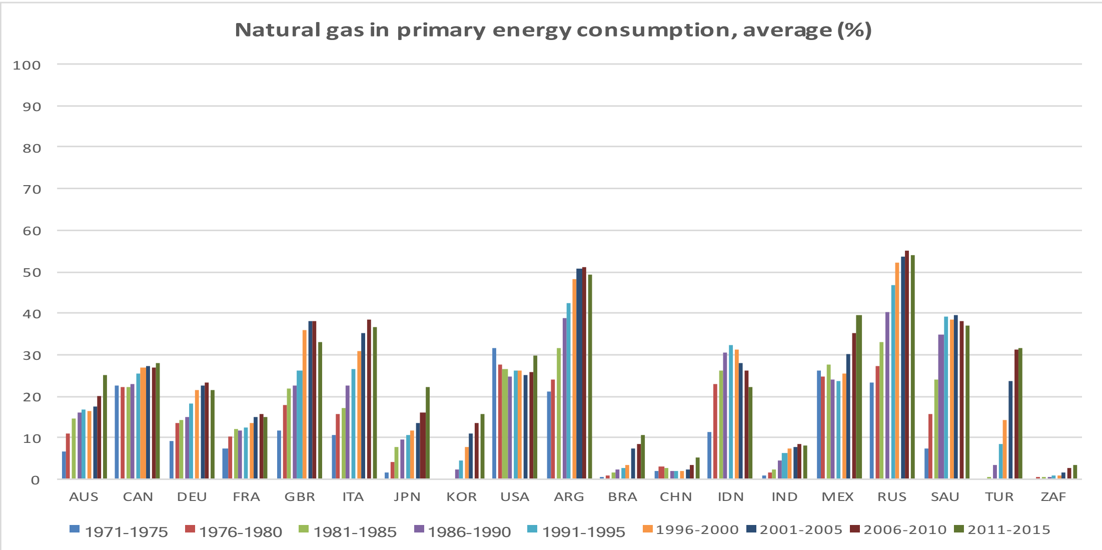
[44] Own calculations based on data referred.
[45] To date, hydropower plants with reservoirs are the only renewable technology capable of overcoming intermittency. If hydropower can be combined with other renewables, the use of fossil fuels thermal power plants might be reduced. Technology to store electricity produced from wind, solar, geothermal and other renewable primary sources is under development, not commercially available; modern sources of biomass are still classified as seasonal.
[46] To be employed, e.g., in electricity utilities. Substantial efficiency gains have been obtained for small-scale technologies, such as automotive batteries; and prices are dropping since 2013.

winners start crossing the finish line, the position of renewables in the global energy matrix might start to change.

2.4.3.5. Natural gas: the greatest driver of energy decarbonization between 1971 and 2015

Rising share of natural gas in total energy consumption was the greatest driver of energy decarbonization between 1971 and 2015. Participation of natural gas in total energy consumption increased in 18 of the 19 countries of our sample between 1971 and 2015 – it decreased only in the United States, by little, 2.91% (BP, 2017):[47]

Figure 2.18: Share of natural gas in primary energy consumption, average (%)



Source: Own calculations based on data from BP, 2017. Note: Russia, from 1971 to 1984, is USSR.

In some countries, the share of natural gas in total energy consumption rose from almost insignificant to substantial: Turkey, where it increased from zero in the 1970s to average 31.48% between 2011 and 2015; Brazil, where it increased from average 0.41% between 1971 and 1975 to average 10.79% between 2011 and 2015, or 26 times more; Japan, where it increased from average 1.51% between 1971 and 1975 to average 22.35% between 2011 and 2015, or 14 times more; and Korea, where it increased from zero in the 1970s to average 15.85% between 2011 and 2015 (BP,

[47] Own calculation based on data referred.

2017).[48] In other countries, natural gas' share was less or around 10%, on average, in the 1970s and increased 03 times – Australia and Italy – or more – Saudi Arabia – on average until the middle the 2010s. In Germany, France, the United Kingdom, Argentina and Russia, it doubled. In Canada and the United States, natural gas' share did not change much, on average, but remained relevant throughout the period; in China and India the share changed substantially, but is still small compared to other primary energy sources (BP, 2017).[49]

The United States and Russia are world's greatest producers of natural gas; they answered for 20.70% and 17.80%, respectively, of global natural gas production in 2016 (IEA, 2017a, p. 15). Russia is currently world's largest natural gas exporter (IEA, 2017a, p. 15) and traditionally supplied the product to net gas importers European countries. Yet, geopolitical tensions following the invasion of Crimea by Russia in 2014 and increasing production of non-conventional gas in the United States put both countries in competition to supply those markets. And although other suppliers – e.g. Qatar, Indonesia and Australia – sell the product to gas-hungry East Asia, the strife between the United States and Russia could be repeated there. A recent technological revolution in the transportation of liquefied natural gas in extremely large ships has taken place.

When natural gas replaces coal or oil, carbon intensity of energy supply decreases because gas has much less carbon in its composition than coal or oil. Natural gas combustion generates roughly half of the emissions of coal combustion (EIA, 2017).[50] When the efficiency of coal-fired and gas-fired thermal power plants is similar[51] and methane leakage is controlled in gas-fired thermal power plants,[52] replacing coal-fired power plants with gas-fired ones reduces the impact of electricity generation on global warming (ZHANG, MYHRVOLD and CALDEIRA, 2014). Globally, the expanded use of

[48] Own calculation based on data referred.
[49] Own calculation based on data referred.
[50] Information from the United States Energy Information Administration, available at <https://www.eia.gov/tools/faqs/faq.php?id=73&t=11>. The exact reduction depends on type of coal (anthracite, lignite, subbituminous, bituminous) and the concentration of the compounds of natural gas. Natural gas is composed mostly of methane, propane and ethane, the latter two in smaller concentrations; it might contain traces to small shares of pentanes, hexanes, nitrogen, carbon dioxide and oxygen.
[51] In this context, efficiency measures the amount of energy that is obtained from burning a unit of fuel. Between 2012 and 2014, coal-fired power plants efficiency rates ranged between 34% and 43%, depending on the type of technology employed, quality of coal used and operational conditions. Gas-fired power stations efficiency rates ranged between 36% and 53%. In 2014, the weighted average efficiency for all countries was 38% for coal-fired, 48% for gas-fired and 40% for oil-fired power plants. NIEROP, VREE and KIELICHOWSKA, 2016.
[52] Methane has higher warming potential than carbon dioxide. If leakages of methane in gas-fired power stations are not controlled, the effect of using them to replace coal-fired ones might worsen climate change.

natural gas as primary energy source was the main driver of energy decarbonization between 1971 and 2015.

Yet, if this trend persists, it could block the deeper transformation of energy systems required to put the world on track with deep decarbonization. Investments in energy systems have long-term returns. If natural gas is accepted as a major step towards energy decarbonization, market forces will allocate resources to further the use of natural gas, both in R&D that would update current technologies and in new facilities. Carbon lock-in – the process of locking economies "*into fossil fuel-based technological systems through a path-dependent process driven by technological and institutional returns to scale*" (UNRUH, 2000, p. 817) – is a major threat to action on climate change mitigation.

2.4.4. The complex interaction between energy security and energy decarbonization

In the previous sections, we have investigated the evolution of the carbon intensity of energy supply for the 19 countries members of the G20 and compared to the evolution of their energy matrices to identify if there is a correlation between concerns over enhancing energy security and switching from fossil fuels to low carbon energy primary sources. We found that there is a relation between the two concepts, yet it is complex and needs to be qualified to make sense of the trends in energy decarbonization in the last 44 years.

First, the carbon intensity of energy supply at the global level decreased 6.26% (IEA, 2017c) between 1971 and 2015 while the global energy supply increased 2.56 times, or 156% (BP, 2017) in the period.[53] Fossil fuels remained, by far, the largest primary energy sources. This means that the greatest driver of energy decarbonization in the period was the use of natural gas, which emits less carbon dioxide when burned compared to other fossil fuels. Consumption of natural gas increased in 18 of the 19 countries analyzed, many times from insignificant shares in 1971 to a third or half of total energy supply in 2015. In the only country in which the share of natural gas in the energy matrix has not increased, on average, in the period, the United States, it has

[53] All calculations are of our own, based on data referred.

provided around 30% of total energy supply in the 1970s, then decreased to around 25% from the 1980s to the 2000s and finally increased again to around 30% since 2011.

Second, countries invested in exploiting their low carbon energy resources potential. For net energy importers, the idea of reducing their dependence from imported fossil fuels made sense after the 1970s oil crises and fueled the transformation. But the idea of diversifying the energy matrix, obtaining energy from different energy sources, played a role as or more relevant in the context of energy security concerns and it was adopted by net energy importers and net energy exporters as well.

Third, nuclear energy was present in the energy matrix of countries that answered for the most significant reductions of carbon intensity of energy supply between 1971 and 2015. France reduced the carbon intensity of its energy supply by 55.85% in the period, while the share of nuclear energy in its primary energy consumption changed from average 1.88% between 1971 and 1975 to average 40.38% between 2011 and 2015 (BP, 2017) – or from average 8.06% of total electricity production between 1971 and 2014 to average 77.11% of total electricity production between 2011 and 2014 (WB, 2017).[54] Yet, it is not possible to say that nuclear energy did played the role of decreasing the carbon intensity of energy supply alone: countries are heterogeneous and the trajectory of the composition of the energy matrix needs to be seen as a whole to interpret the trends in each case.

Fourth, hydropower potential was already being exploited by most of the countries in our sample before the 1970s oil crises and its share in global energy consumption remained roughly flat in the period, so its role in energy decarbonization was secondary. Yet, hydropower has had a significant role in maintaining lower carbon intensity of energy supply in countries that have it among their largest primary energy sources – Canada and Brazil. Other renewables, on the other hand, emerged as alternative primary energy sources in the context of replacing oil, partially in the context of the 1970s oil crises, when technology started to be developed and policies provided financing options in some countries, and partially in the context of rising high oil prices around the 2000s, when technology – especially wind energy – was mature and gains of scale became possible. Their share in total energy consumption is still small at global

[54] All calculations of our own, based on data referred.

scale, but relevant in some countries; and the technology breakthrough for storage expected for the next five years could be a game changer for renewables.

Finally, many countries (including China, USA, India and Indonesia) remain heavily dependent on coal, the most carbon intense energy source. The share of coal in global energy supply has risen since the 1970s. Coal maintains its prominence due to its relative abundance compared to oil and gas and the lower costs of its exploitation – when the significant socio-economic and environmental externalities from its use are not accounted, and they usually are not. The use of coal has increased in power-hungry emerging economies such as middle-lower income India and middle-income China, the 2nd and the 1st world's coal producers. But it has also increased at industrialized high income Germany due to the decision of phasing out nuclear energy. Carbon lock in – enduring dependence on fossil fuels due to the cycle of continuing social and institutional acceptability of fossil fuels as primary energy sources and more investments on technological development that perpetuates their use – is a major, if not the greatest, threat to action on climate change mitigation on the levels required by climate science.

Overall, we found an important relation between concerns over enhancing energy security and energy decarbonization between 1971 and 2015. Yet, our analysis does not allow to rule out other drivers that could also play a role in energy decarbonization since switching from fossil fuels to low carbon primary energy sources provides additional co-benefits. Countries are heterogeneous in their energy resources, institutions, interests, values. Understanding the rationale of trajectory of energy policy requires delving in these details, and identifying which actors are involved, what are their interests and how they pursue them given the institutional framework. In the next chapter, the Brazilian case becomes our focus.

Chapter 03: Brazilian energy politics, 1971-2015

3.1. CONTEXTUALIZING BRAZIL

Brazil is the largest country in South America, occupying a vast area of 8,511,965 km^2. The longest distance from North to South amounts to 4,328 km, and from East to West to 4,320 km; Brazil has 7,491 km of coast line. According to official Brazilian Censuses, since the 1970s, Brazilian population more than doubled: from 94,508,583 inhabitants in 1970 to 190,755,799 inhabitants in 2010; in the first count, 55.98% of the population was urban, while the amount increased to 84.36%[55] in the second count (IBGE, 2017). According to World Bank data, Brazil had 207,652,865 inhabitants in 2016, an increase of 112.48%[56] compared to 1971 numbers (WB, 2017). Although inequality has decreased in Brazil between 1981 and 2015[57] – from Gini Index 58 to 51.3 (WB, 2017) – it is still among the highest in the world.

Brazil is a federative republic in which powers are divided between federal, state and municipal levels – although the federal government concentrates much of the fiscal and legislative competences. At the municipal level, power is divided between the Executive and the Legislative (01 house); at the state level, between the Executive, the Legislative (01 house) and the Judiciary. At federal level, power is divided between the Executive, the Legislative (02 houses, the Chamber of Representatives and the Senate), and the Judiciary. Between 1971 and 2016, Brazil had 10 Presidents, 02 political regimes – authoritarianism, in the period of the military dictatorship that lasted from 1964 to 1984, and democracy, since 1985 –, and 02 federal Constitutions.

Between 1971 and 2015, Brazilian GDP increased 4.67 times, or 367.05%[58] (IEA, 2017c). Brazil was the 7th largest world economy in 2016 (WB, 2017).[59] GDP per capita (PPP) increased 2.45 times or 145.33%:[60] from 4,813.05 international dollars (2005 base year) in 1971 to 11,807.72 international dollars (2005 base year) in 2015 (JAMES et al, 2012). Between 1971 and 2016, domestic energy supply (TPES) increased 4.10

[55] Own calculations based on data referred.
[56] Own calculations based on data referred.
[57] 1981 is the first year in the time series for Brazil.
[58] Own calculations based on data referred. Numbers consider Purchase Power Parity (billion 2005 USD). Other data sources (World Bank, IMF) did not offer GDP PPP numbers for the entire time series.
[59] Brazil reached 3,141,333 millions of international dollars in 2016, according to World Bank data.
[60] Own calculations based on data referred.

times, or 326%, and oil remained the main primary energy source (figure 3.1, below) (EPE, 2017). Brazil is world's 7th largest GHG emitter[61] (WRI, 2017) and 7th largest energy consumer[62] (IEA, 2017c). Although Brazilian energy use increased in the period, the energy intensity of the economy remained flat at 0.10 Mtoe/billion 2005 USD (IEA, 2017c).[63] This phenomenon is tributary to the uniqueness of the Brazilian energy matrix compared to world average or to the other members of the G20.

3.2. Brazilian energy and emissions profile

Total energy matrix

Compared to the other members of the G20, Brazil has higher participation of low carbon energy sources – especially hydropower and sugarcane products – in its energy matrix. While fossil fuels share in total energy matrix in G20 countries was, on average, 83.04% between 2011 and 2015, and world average was 86.68% in the same period, in Brazil it was 64.54% (BP, 2017). Between 1971 and 2015, hydropower's supply increased more than 09 times in Brazil, from average 4,982.08 10^3toe between 1971 and 1975 to average 37,022.62 10^3toe between 2011 and 2015 (figure 3.1, below) (EPE, 2017). In the same period, sugarcane products' supply increased more than 13 times, from average 4,302.48 10^3toe between 1971 and 1975 to average 46,550.46 10^3toe between 2011 and 2015 (figure 3.1, below) (EPE, 2017). Hydropower's share in the Brazilian energy matrix doubled in the period, from average 6.07% between 1971 and 1975 to average 12.76% between 2011 and 2015, and sugarcane products' share tripled, from average 5.32% between 1971 and 1975 to average 15.97% between 2011 and 2015 (figure 3.2, below) (EPE, 2017).[64]

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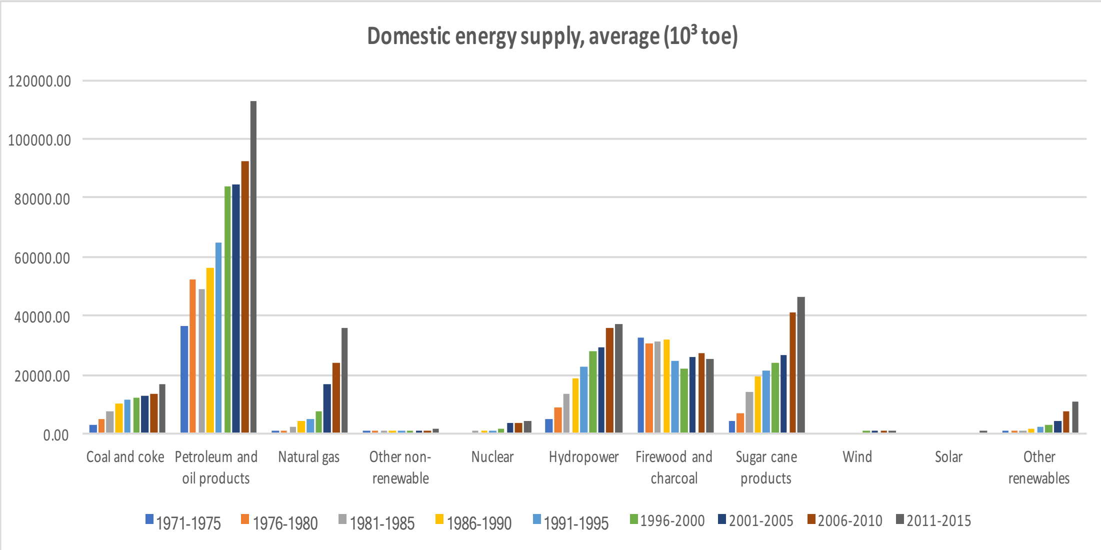
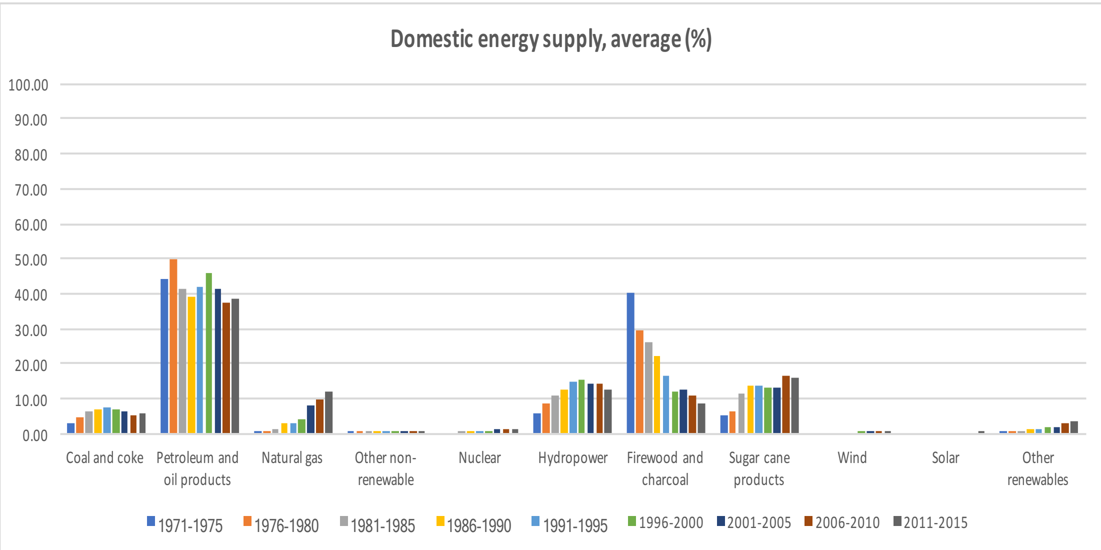
[61] Including LULUCF emissions; 2014 data.
[62] Considering European Union countries individually; if European Union is added, Brazil becomes the 8th, 2015 data.
[63] Own calculations based on data referred.
[64] All calculations on paragraph are of our own, based on data referred.

Figure 3.1: Brazilian domestic energy supply, average (10^3 toe)



Source: Own elaboration, based on data from MME, 2017. Note: Hydropower includes electricity imports originated from hydraulic sources.

Figure 3.2: Brazilian domestic energy supply, average (%)

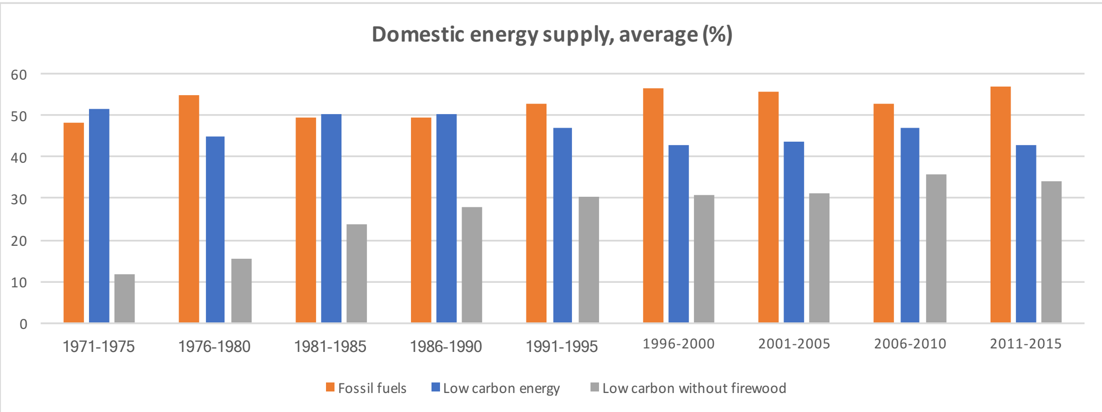


Source: Own elaboration, based on data from MME, 2017. Note: Hydropower includes electricity imports originated from hydraulic sources.

Yet, Brazil is still dependent on fossil fuels, and this dependence is rising. Between 1971 and 1975, fossil fuels' share in the Brazilian energy matrix was average 48.27% and low carbon energy sources' share was average 51.73% (EPE, 2017). Fossil fuels share in average G20 countries energy matrix was 88.44% in the period, and in world average energy matrix they occupied 93.62% of the in the period (BP, 2017). Between 2011 and 2015, fossil fuels' share in the Brazilian energy matrix was average 56.77% and low carbon energy sources' share was average 42.69% (EPE, 2017). In the same period, fossil fuels share in average G20 countries energy matrix was 83.04%, and in world average energy matrix they occupied 86.68% (BP, 2017).[65]

Increasing dependence on fossil fuels was first seen in the middle 1970s but reversed in the 1980s: between 1976 and 1980, fossil fuels participation in the Brazilian energy matrix was average 54.97% and low carbon energy sources was average 44.96% – higher share of oil in the energy matrix was the cause; between 1981 and 1985, their shares were, respectively, average 49.47% and average 50.33%, and between 1986 and 1990, respectively 49.54% and 50.24% (EPE, 2017). Yet, fossil fuels' share in the Brazilian energy matrix overcame low carbon energy sources' share again in the beginning of the 1990s and, to date, this trend was not reversed (figure 3.3, below). And if we remove firewood and charcoal from the equation – there is growing controversy around whether burning biomass from slow-growing forests has lower or higher climate impact than burning fossil fuels[66] – low carbon energy's share in the Brazilian matrix is increasing from average 11.70% between 1971 and 1975, but has never been higher than fossil fuels' (figure 3.3, below) (EPE, 2017).[67]

Figure 3.3: Fossil fuels and low carbon energy sources in the Brazilian energy supply, average (%)



Source: Own elaboration, based on data from MME, 2017. Note: Hydropower includes electricity imports originated from hydraulic sources.

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[65] Own calculations based on data referred. BEN consolidated data 1970-2016.
[66] E.g., see HOLTSMARK, 2015.
[67] All calculations on paragraph of our own, based on data referred.

Between 1971 and 2016, domestic energy supply increased 4.10 times, or 326%, and oil remained the main primary energy source (figure 3.1, above) (EPE, 2017). But its participation in the Brazilian energy matrix decreased slightly, from average 44.41% between 1971 and 1975 to average 38.79% between 2011 and 2015 (EPE, 2017). Firewood and charcoal were the main energy source between 1971 and 1975, but their share has decreased consistently since – from average 40.03% between 1971 and 1975 to average 8.68% between 2011 and 2015 (EPE, 2017). Coal's share has increased and peaked between 1991 and 1995, and then decreased to around 5% of total domestic energy supply; and other renewables, including wind and solar energy, still have a very small participation in the matrix (figure 3.2, above). Therefore, the 5.62% decrease in dependence from oil has been replaced mostly by higher shares of hydropower and sugarcane products, as seen above, and by natural gas – which participation changed from average 0.48% between 1971 and 1975 to average 12.33% between 2011 and 2015 (EPE, 2017).[68]

Electricity matrix

If we focus electricity generation only, participation of low carbon energy sources is even more relevant.

Between 1971 and 2016, Brazilian electricity generation increased 11.22 times (EPE, 2017). Hydropower – the greatest primary source of electricity in Brazil since the 1970s – production increased 6.79 times, from average 57,947.20 GWh between 1971 and 1975 to average 393,569.80 GWh between 2011 and 2015 (figure 3.4, below) (EPE, 2017). Yet, hydropower's participation in the electricity matrix has been diminishing: from average 89% between 1971 and 1975, with peaks of average 92% between 1976 and 1995, to average 80% in the 2000s and 69.85% between 2011 and 2015 (figure 3.5, below).[69]

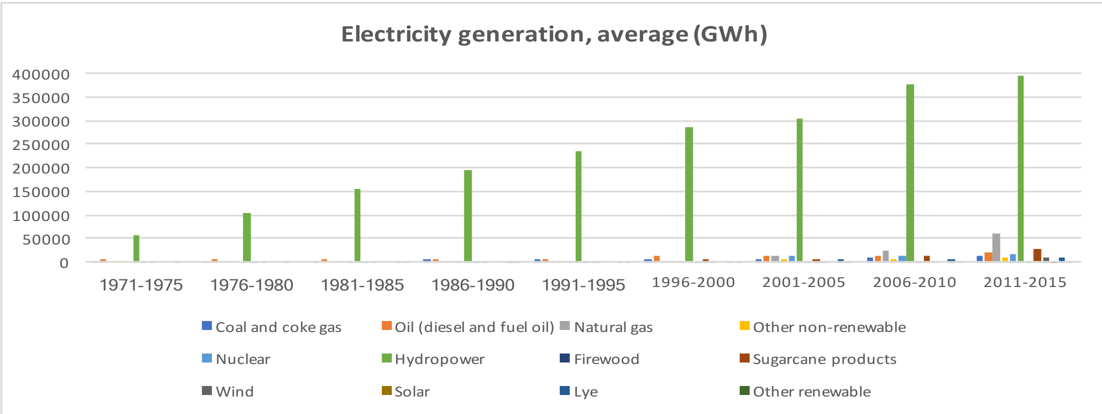
Other low carbon energy sources – nuclear energy, sugarcane products and wind energy – participation in electricity generation has increased, but together they had less than 10%, on average, of total electricity production between 2011 and 2015 (figure 3.5, below). Among the fossil fuels, coal's share remained flat, and oil's share roughly halved

[68] All calculations on paragraph of our own, based on data referred.
[69] All calculations on paragraph of our own, based on data referred.

(figure 3.5, below). Natural gas' participation, however, increased from null to average 10.54% between 2011 and 2015 (figure 3.5, below).[70]

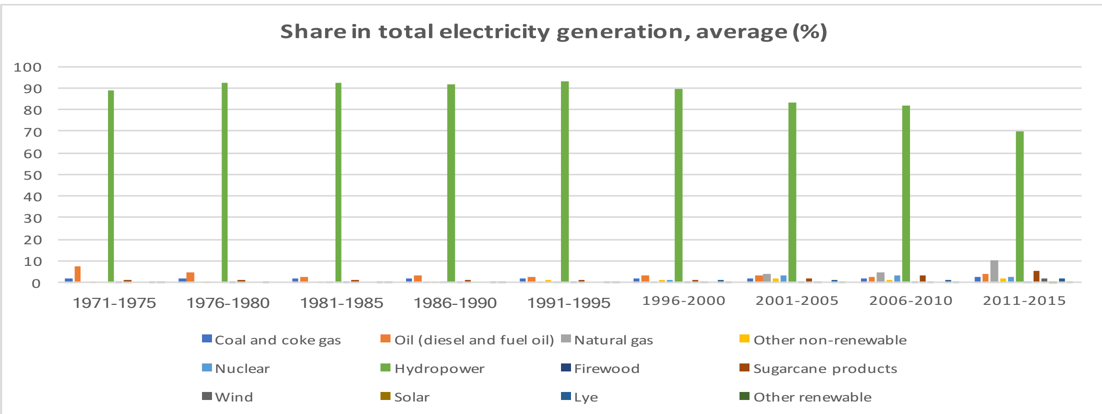
The numbers show that decreasing hydropower production is being replaced by a mix of sugarcane and wind energy, to a lesser extent, and natural gas thermal power plants, to a greater extent.

Figure 3.4: Brazilian electricity generation, average (GWh)



Source: Own elaboration, based on data from MME, 2017.

Figure 3.5: Share of primary sources in electricity generation, average (%)



Source: Own elaboration, based on data from MME, 2017.

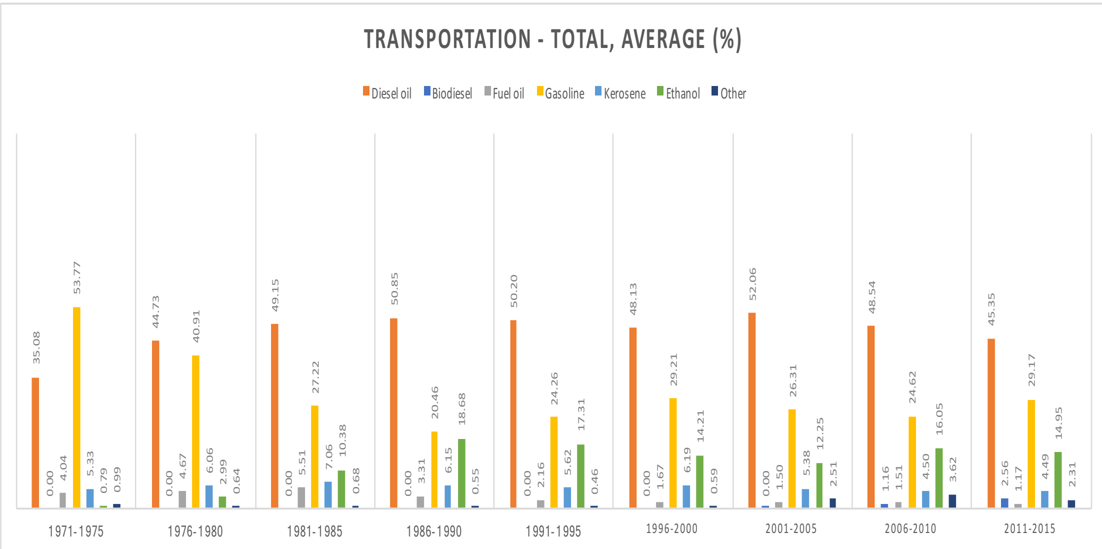
[70] All calculations on paragraph of our own, based on data referred.

Transport matrix

Differently from the electricity matrix, Brazilian transport matrix has always been highly dependent on fossil fuels. The share of renewables in transport has increased, but it is still much smaller than the share of fossil fuels.

Between 1971 and 2016, total energy use in the transport sector increased 5.73 times,[71] from 14,420 10³ tep(toe) to 82,651 10³ tep(toe) (EPE, 2017). The share of fossil fuels – diesel oi, fuel oil, gasoline, kerosene – in total transport matrix (air, road, water, rail), was, on average, 98.22% between 1971 and 1975 and 80.18% between 2011 and 2015. The share of renewables – ethanol and biodiesel – was, on average, 0.79% between 1971 and 1975 and 17.51% between 2011 and 2015. Although the share of fossil fuels has decreased and the share of renewables has increased when the total time interval is considered, it has oscillated through the years: fossil fuels' decreasing and renewables' increasing between 1971 and 1990; then fossil fuels' increasing and renewables' decreasing between 1991 and 2005; another decrease for fossil fuels between 2006 and 2010, then increase again.

Figure 3.6: Share of different fuel in total transportation matrix, average (%)

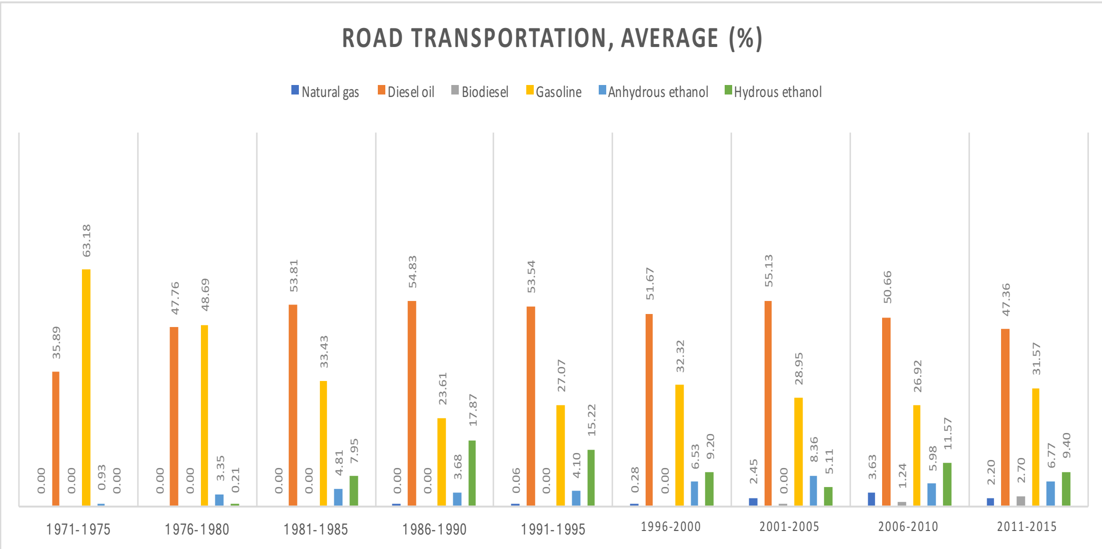


Source: Own elaboration, based on data from MME, 2017.

71 Own calculations based on data referred.

Considering road transport matrix separately – the share of road transport in Brazil is massively larger than any other modal –, dependence on fossil fuels is still high. Between 1971 and 2016, fuel consumption in road transport increased 6.23 times, from 12,426 10^3 tep(toe) to 77,436 10^3 tep(toe). The share of fossil fuels – diesel oil, gasoline and natural gas – decreased from 99.07%, on average, between 1971 and 1975 to 81.13%, on average, between 2011 and 2015. The share of renewables – biodiesel and ethanol, both anhydrous and hydrous – increased from 0.93%, on average, to 18.87%, on average, in the same time intervals. The oscillation seen in total transport matrix is true also in the road matrix.

Figure 3.7: Share of different fuels in road transport matrix, average (%)



Source: Own elaboration, based on data from MME, 2017.

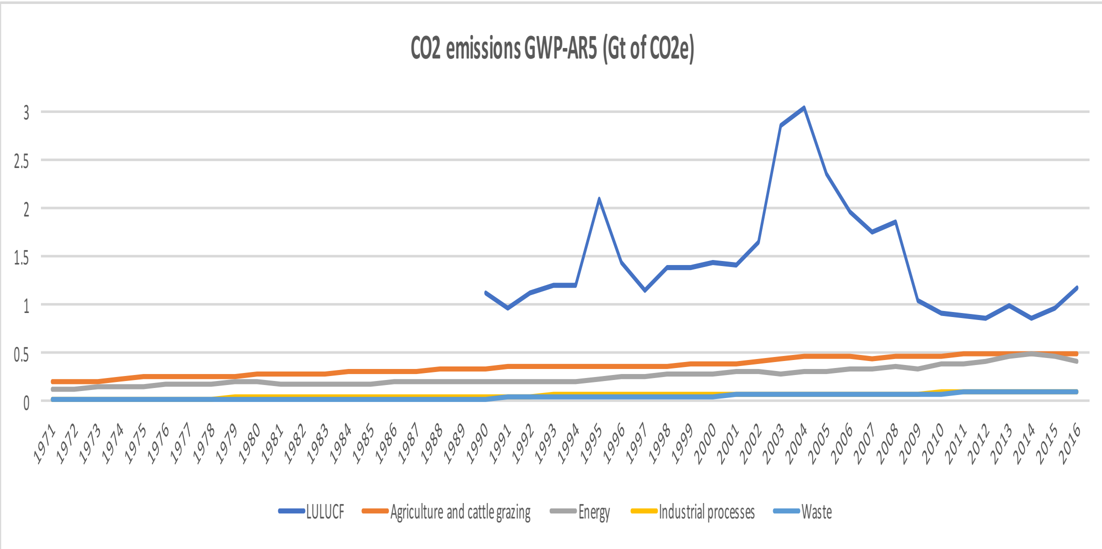
Brazilian emissions

Since 1990, when land use, land use change and forestry (LULUCF) emissions have started to be measured in Brazil,[72] this sector has been, by far, the greatest driver

[72] 1990 is the first year in which we find estimates for Brazilian LULUCF emissions in the following databases: OBSERVATORIO DO CLIMA, *System Gas Emissions Estimation (SEEG);* WORLD RESOURCES INSTITUTE, *Climate Data Explorer (CAIT);* Brazilian MINISTERIO DA CIENCIA, TECNOLOGIA E INOVACAO (MCTI) (Ministry of Science, Technology and Innovation), *Sistema de Registro Nacional de Emissões (SIRENE)* (National System of Registry of Emissions). The CARBON DIOXIDE INFORMATION ANALYSIS CENTER (CDIAC) built estimates, using historical land-use data in a model, for land use change emissions since 1700, but there is no data for Brazil. The Brazilian INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (INPE) (National Institute of

of Brazilian emissions. Deforestation, the main driver of Brazilian LULUCF emissions, has always been a major issue in the country; large areas cleared of forest in the Amazon region have made headlines and became an international concern.[73] It was not until middle 2000s that Amazon deforestation was reduced, and its impact in estimates of Brazilian GHG emissions was substantial: from average 3.12 Gt of CO2e emitted between 2001 and 2005 to average 2.46 Gt of CO2e emitted between 2011 and 2015 (OC, 2017).[74] Yet deforestation has been rising again recently: in 2016, LULUCF emissions (in absolute numbers, Gt of CO2e) have reached the same level they had in the beginning of the 1990s (OC, 2017).[75]

Figure 3.8: Brazilian CO2 emissions, GWP-AR5, per sector (Gt of CO2e)



Source: Own elaboration, based on data from OC, 2017.

Comparing the relative weight of different sectors' emissions in total Brazilian emissions, we observe that since the middle 2000s agriculture and cattle grazing emissions and energy emissions are occupying larger shares of total emissions. While LULUCF emissions remain dominant – the sector had average 70.76% of total Brazilian emissions between 2001 and 2005, average 59.43% between 2006 and 2010, and

Spatial Research) built a database for GHG emissions from land use change for the Amazon region, the *INPE Emission Model,* and the first year in the time series is 2002.

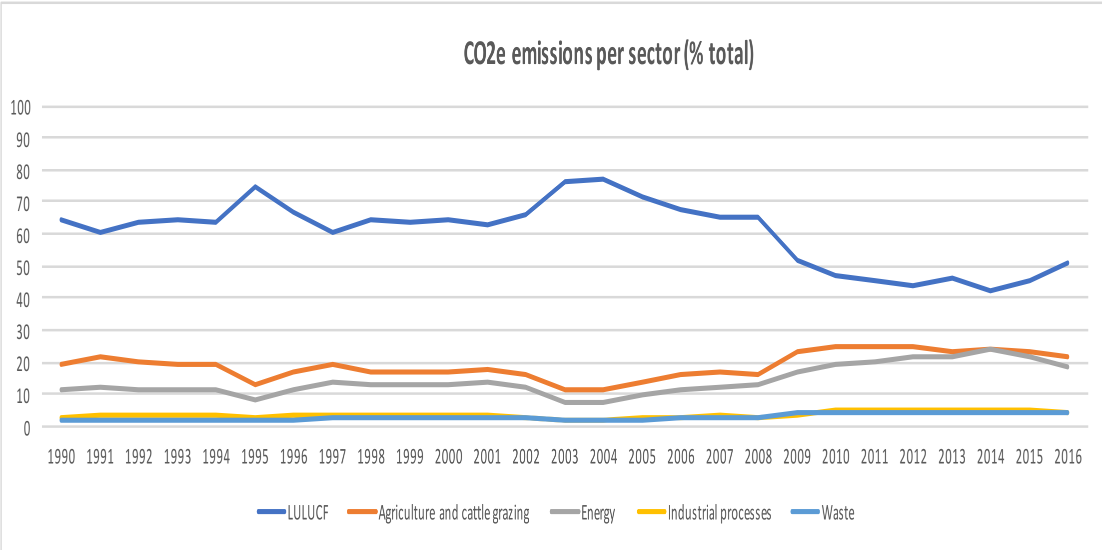
[73] Yet, deforestation has not taken place only in the Amazon region, but in many different parts of Brazil. Recently, deforestation in the Brazilian savannah has been as intense or more than deforestation in the Amazon region.

[74] Own calculations based on data referred.

[75] Own calculations based on data referred.

average 44.71% between 2011 and 2015 –, agriculture and cattle grazing's share increased from average 14.35% between 2001 and 2005, to average 19.24% between 2006 and 2010 and average 24.04% between 2011 and 2015; in the same intervals, energy sector's share increased from average 10.15% to 14.55% and 21.79% (figure 3.9, below). Interestingly, while agriculture and cattle grazing's emissions increased 4.8% both between 2001-2005 and 2006-2010 and between 2006-2010 and 2011-2015, energy emissions increased at a faster pace in the second comparison: 4.4% between 2001-2005 and 2006-2010 and 7.23% between 2006-2010 and 2011-2015 (OC, 2017).[76]

Figure 3.9: Share of CO2e emissions per sector, GWP-AR5 (% total)



Source: Own elaboration, based on data from OC, 2017.

This is consistent with the trends we observed in chapter 02. The participation of fossil fuels, especially natural gas, in the Brazilian energy matrix has accelerated recently. Yet, carbon intensity of energy supply in Brazil is going in the opposite direction of global's – or the 19 members of the G20 average. While carbon intensity of world energy supply decreased from average 2.52 Mt of CO_2/Mtoe between 1971 and 1975 to average 2.38 Mt of CO_2/Mtoe between 2011 and 2015 – the average for the 19 members of the G20 decreased from 2.42 Mt of CO_2/Mtoe to 2.30 Mt of CO_2/Mtoe, respectively – carbon intensity of Brazilian energy supply increased from average 1.34

[76] Own calculations based on data referred.

Mt of CO_2/Mtoe between 1971 and 1975 to average 1.51 Mt of CO_2/Mtoe between 2011 and 2015 (IEA, 2017c).[77]

3.3. TRAJECTORY OF BRAZILIAN ENERGY POLITICS

Energy politics is both embedded in the political economy and influences it, due the pivotal role of energy for economic activity and human life. Understanding how energy politics unfolds requires identifying key actors, their interests, and how they interact through the institutions that shape energy policy.

We divide the analysis of the Brazilian energy politics during these 44 years in three periods – 1971 to 1994, 1995 to 2003, and 2004 to 2015[78] – and three main themes – political economy landscape, electricity politics, and fuel politics. The start and end dates of each period coincide with important milestones in the Brazilian political economy landscape that influenced energy politics. And because electricity and fuel politics have developed in parallel but created separate paths since their origin in Brazil, we understand that a decoupled analysis suits better our objectives.

3.3.1. 1971-1994

3.3.1.1. Political economy landscape

Authoritarianism and Import Substitution Industrialization

In 1971, the Bretton Woods system that guaranteed the convertibility to US dollars to gold came to an end. The United States and ex-USSR relations were in a moment of détente and the European Communities were experiencing its first wave of enlargement. Brazilians were living through the period of strongest political restrictions but greatest economic growth of Brazil's recent history. The military were in power since a political coup in 1964. In 1968, they enacted the Institutional Act nr. 05, restricting political and social rights to an extreme and inaugurating the period, lasting until 1974, that would become known in Brazilian history as "Years of Lead". Simultaneously, between 1968

[77] Own calculations based on data referred. Brazil had the second lowest carbon intensity of energy supply, on average, in both periods; after India (1.21 Mt of CO_2/Mtoe) in the first and France (also 1.21 Mt of CO_2/Mtoe) in the second.

[78] We sometimes refer to 2016 and 2017 as well, but 2015 is the end date of our study period.

and 1973 Brazilians experienced the “Economic Miracle”, period in which real GDP growth rate was 11.2% on average – manufacturing grew yearly 13.3% on average; construction, 15% (LAGO, 1990, p. 239). Investments in infrastructure were considered key by the military. Electricity generation grew yearly 12.1% on average in the period, developed mostly by state-owned enterprises (LAGO, 1990, p. 239).

In 1974, the military started, in the words of President Geisel, a “slow, gradual and safe” process of political liberalization. The 1973 oil shock hit Brazil hard: the country imported 80% of its oil in the beginning of the 1970s (OLIVEIRA, 2007, p. 43), so expenses with oil imports hit the balance of payments. The military aimed at maintaining high rates of economic growth – they depended on it to legitimize the regime, which was increasingly being contested by the opposition. So, instead of adjusting the internal demand to absorb the impact of higher prices of oil and avoid permanent inflation, they opted for continuing the Import Substitution Industrialization strategy by using foreign loans – abundant at the time – to invest in capital goods manufacturing.[79] Brazilian foreign debt escalated in the period. Yet, in the end of the 1970s, when the second oil shock hit and the United States raised interest rates, Brazil was no longer able to maintain the strategy. Interest rates in foreign debts escalated; inflation hit historic records; recession followed, and inaugurated the “Lost Decade”.

In the beginning of the 1980s, the federal government focused in adjusting the economy to obtain commercial surpluses to reduce deficit in the balance of payments and increase foreign currency needed to pay interest on foreign loans. Domestic interest rates were raised, as well as taxes. Brazil signed an agreement with the International Monetary Fund (IMF) to keep up with the payments. But the cost of debts increased faster than the Brazilian capacity to offset them.

Re-democratization, inflation and cronyism

By 1984, Brazilians were on the streets campaigning for direct elections, hoping that democracy would not only reinstate civil and political rights but also economic stability. In 1985, a civil president was indirectly elected to government, inaugurating a

[79] The Import Substitution Industrialization had started in Brazil in the 1930s. The idea was reducing Brazilian dependence on imports of manufactures by producing them domestically. In Brazil, it would be implemented in 03 phases, first focusing in non-durable goods, then durable goods and later capital goods.

new period in the Brazilian political history. In 1986, 512 Federal Representatives and 33 (out of a total of 82) Senators were elected to write a new Federal Constitution, enacted in 1988.[80] In 1989, the first direct elections for President after the military coup took place, and 22 candidates representing different political parties run (TRE-PE, 2017), and 21 received votes (IPEA, 2017).[81] The new federal government was elected under a platform of opening the Brazilian economy to globalization and increase economic competition. Unfortunately, the first years of the New Republic were filled with corruption scandals and economic measures that failed, just like the previous ones, to control inflation. In 1992, President Collor renounced just before being impeached by the Parliament. The Vice-President, Itamar Franco, took over the mandate.

Between 1993 and 1994, a new economic policy to tackle inflation, *Plano Real*, was gradually implemented. Contrary to their predecessors, it succeeded. Economic growth was resumed, pushed by agribusiness, and Brazil started to attract foreign direct investments again. The Ministry of the Economy that endorsed the implementation of the policy in the Franco administration, Fernando Henrique Cardoso, was elected in the 1994 Presidential elections. The process of economic opening and privatizations that had started in 1990 was boosted since 1995-1997. Yet, Brazilian democracy remained low quality. Based on coalitions between too many political parties that have no clear stances and offer support on exchange of positions in government, Brazilian cronyism – deeply rooted in the country's long history of patrimonialism – deepened. Messy relationships between private capital, state-owned corporations and politicians completed the picture.

3.3.1.2. Electricity politics

Brazil, a hydropower country

Hydropower has been a relevant source of Brazilian electricity since the 19th Century. Hydropower and thermal power plants were both present among the first electricity ventures in Brazil; hydropower, however, proved more cost-effective, as coal

[80] In fact, among the senators 49 were elected in 1986 and 33 just kept their mandates had been elected in 1982 (CAMARA DOS DEPUTADOS, 2017). The Congresspeople were not elected exclusively to write the new constitution: once their task was over, they completed their mandates as federal representatives and senators until 1990.
[81] In the 1994 Presidential election, 08 candidates received votes; in 1998, 12 candidates; in 2002, 06 candidates; in 2006, 07 candidates; in 2010, 09 candidates (IPEA, 2017).

was imported at the time (GOMES et al, 2012). Later, coal reserves were found in the South of the country, but in small amounts and low carbon content, not enough to sustain large-scale electricity production (GOLDEMBERG and LUCON, 2007, p. 08).[82] Throughout the 20th Century, hydropower was consolidated as the main source of electricity in Brazil: in 1900, hydro answered for 53% of the 10.85MW – 5.75MW – of the total electricity installed capacity (GOMES et al, 2012); in 2001, it answered for 61GW and generated 95% of total domestic electricity supply (ANEEL, 2002, p. 26).

The first Brazilian hydropower plants were specifically built either by industrialists that needed to generate electricity for their business (LEITE, 2009, p. 04) or foreign investors that won local concessions to supply electricity for large Brazilian cities (OLIVEIRA, 2007, p. 35; LEITE, 2009, p. 05). Among the foreign groups acting at the time, emphasis to the Brazilian Traction, Light & Power Company Ltd. (Canadian and American capital), especially through their subsidiaries in São Paulo and Rio de Janeiro, and the American & Foreign Power Company (AMFORP), acting in both places as well as in other Brazilian cities (ELETROBRAS, 2017). These early concessions were negotiated with city governments and established a "Gold Clause", according to which payments for electric services would be half in local currency and half in gold standard, making them very attractive for investors (OLIVEIRA, 2007, p. 35).

In the 1930s, as nationalism was raising also in Brazil, the role of foreign companies in the electric sector became controversial (OLIVEIRA, 2007, p. 35). The 1934 Water Code[83] established that the hydropower potential of Brazilian rivers was thereafter property of the federal government and any activity related to electricity supply – transformation, transmission, distribution – was subject to concession or authorization by it.[84] The *Conselho Nacional de Águas e Energia Elétrica*, CNAEE (National Council for Water and Power), later *Departamento Nacional* de *Águas e Energia Elétrica,* DNAEE National Department for Water and Power) was created to manage it. The code also established that tariffs would be calculated according to nominal costs (cost-of-service pricing, abolishing the Gold Clause) and capital would be remunerated

[82] The first Brazilian thermal power plants were wood-fired. In 1887, Porto Alegre street lights were fueled by a 160kW capacity wood-fired thermal power plant built by Fiat Lux Company (its capacity was expanded to 18,630kW). In 1896, a 68kW unit was inaugurated in Manaus, and another unit with around 2300 kW (3200 HP) in Belém. ELETROBRAS, 2017.
[83] Federal Decree 24643, from 10 Jul 1934.
[84] Federal Decree nr. 24643, from 10 July 1934.

according to the historic cost of installations/investment (GOMES et al, 2002). As private investors were discouraged to participate in the electric sector, state-owned enterprises entered the business.

Different Brazilian states would commission studies on the electric potential of their primary energy sources and enact electrification plans, establishing state electric utilities to implement them.[85] In 1964, AMFORP subsidiaries were nationalized (ELETROBRAS, 2017). The federal government created state-owned regional electricity suppliers: CHESF in 1945, in the Northeast of the country; FURNAS in 1947, in the Southeast; ELETROSUL in 1968, in the South; and ELETRONORTE in 1972, in the North (OLIVEIRA, 2007, p. 36). Gradually, a new bureaucratic structure for the electric sector would be established: state-owned enterprises would dominate it; generation and transmission would be at the federal government's hands, and states would be responsible for distribution (FERREIRA, 2000). Yet, some state utilities (for generation and transmission) were well developed and would coexist with the federal ones in the new model.

First oil shock: nuclear is not an option

In the context of the first oil shocks, the military aimed at expanding the role of nuclear energy. The Brazilian nuclear program had started after World War II for Scientific, medical, industrial and military reasons (PATTI, 2014, p. 12). In 1967, the military stated that as supplier of uranium – Brazil has the 12th world's largest deposit (IAEA, 2017c) and the 6th world's largest operating deposit of uranium (IAEA, 2017d) – Brazil should develop know-how on the complete cycle of nuclear power, first acquiring foreign nuclear reactors and nuclear fuel and later producing both domestically (PATTI, 2014, p. 15-16). In 1971, Brazil purchased from the United States its 1st nuclear-fired thermal power plant, Angra 1 (PATTI, 2014, p. 15-16), operating since 1985.

[85] E.g.: Companhia Estadual de Energia Elétrica, CEEE (1943) in Rio Grande do Sul; Companhia Energética de Minas Gerais, CEMIG (1952), in Minas Gerais; Companhia Paranaense de Energia, COPEL (1954), in Paraná; Centrais Elétricas de Santa Catarina, CELESC (1956), in Santa Catarina; Companhia Elétrica de Goiás, CELG (1956), in Goiás; Espírito Santo Centrais Elétricas, ESCELSA (1956), in Espírito Santo; Companhia de Eletricidade do Amapá, CEA (1957), in Amapá; Centrais Elétricas Matrogrossenses, CEMAT (1958), in Mato Grosso; Centrais Elétricas do Maranhão, CEMAR (1959), in Maranhão; Companhia de Eletricidade do Estado da Bahia, COELBA (1960), in Bahia. ELETROBRAS, 2017.

In 1974, *Plano 90* was enacted: 12 nuclear-fired thermal power plants would be built until 1990 to complement hydroelectricity generation (PATTI, 2014, p. 16). The United States would not agree on transfer technology to Brazil, so the deal was closed with Germany, in 1975: an agreement on the construction of at least 08 nuclear reactors plus knowledge on the nuclear fuel cycle (PATTI, 2014, p. 18). Domestic opposition to *Plano 90* was significant, and grew after projects of two nuclear power plants to be built in a preserved area of the Atlantic Forest in São Paulo state were released: physics students, later organized in the *Sociedade Brasileira de Física*, SBF (Brazilian Society of Physics); the *Sociedade Brasileira para o Progresso da Ciência*, SBPC (Brazilian Society for the Advancement of Science); professional associations of journalists, architects and engineers; feminists; environmental groups; and even the Catholic church (HOCHSTETLER and KECK, 2007, p. 80-81). They alleged economic costs of nuclear power, risks of nuclear energy and ecological values (HOCHSTETLER and KECK, 2007, p. 82). International opposition, especially from the United States under President Carter, also grew, as Brazil was reluctant to sign the Treaty on the Non-proliferation of Nuclear Weapons – it would join only in 1998 (PATTI, 2014, p. 18). The nuclear program was hit in the early 1980s mostly by fiscal collapse of the State, reducing the original program to further 02 reactors only and slowing down the pace of their construction. Currently, only 02 nuclear-fired thermal power plants operate in Brazil; the 3rd one has not been finished yet, and is involved in corruption scandals.[86]

Strengthening the rule of hydropower

The 1973 oil shock hit Brazilian economy hard, but it did not affect the ongoing trajectory of the electric sector: the role of hydropower was reinforced in Brazil (OLIVEIRA, 2007, p. 37). Electricity generation, now under the mandate of *Centrais Elétricas Brasileiras S.A,* ELETROBRAS – created in 1962 as the holding company of the 04 federal electricity suppliers, also responsible for long-term planning and investment decisions (OLIVEIRA, 2007, p. 37) – was substantially expanded. Funding

[86] The construction of Angra 2 started in 1981; it was suspended between 1986 and 1993 and resumed in 1994. The power plant began operating in 2000. Angra 3 is still under construction. According to *Plano Decenal de Expansão de Energia 2024,* no further nuclear-fired thermal power plants are planned to be built in Brazil.

came from a combination of taxes and parafiscal levies,[87] retained earnings from the state-owned utilities and international loans obtained from multilateral development banks and other lenders (OLIVEIRA, 2007, p. 38). New projects had no financial risk. Non-depreciated assets could be annually reevaluated in line with inflation; and if tariffs were unable to provide the 10-12% legal rate of return on non-depreciated assets, power companies would keep an account in their balance sheets[88] to recover the deficits in future tariff increases (OLIVEIRA, 2007, p. 40). Electricity became a state-owned business: between 1974 and 1983, ELETROBRAS's share in total investments in the electric sector rose from 32.6% to 60.7% (OLIVEIRA, 2007, p. 40).

In 1973, Brazil and Paraguay agreed to jointly explore the hydroelectric potential of the Paraná river.[89] The construction of a joint hydropower plant had been an issue in the 1960s: at first, Brazil wanted to use part of the water unilaterally, but disagreements between the two countries on sovereignty over the area lead to the 1966 *Ata de Iguaçu*, the agreement on a joint project. In 1974, *Itaipu Binacional*, the binational enterprise that would build the hydropower plant and administer it, was constituted. Argentina had its own hydropower project for the Paraná river and opposed the building of the Itaipu dam, but in 1979 an agreement between the two countries and Argentina was reached.[90] Itaipu has 14,000 MW of installed power and started operating in 1984, reaching full capacity of electricity generation in 2007, when all turbines were in use.[91]

On top of expanding the number and the capacity of hydropower projects, the military decided to explore economies of scale and scope that would be offered by interconnecting regional grids and created a national system, *Sistema Interligado Nacional,* SIN. The SIN would increase security of supply by allowing electricity generated all over Brazil to follow centralized dispatched decisions by the federal government (FERREIRA, 2000; GOMES et al, 2002) – in 2016, 90.4% of total Brazilian

[87] Such as the federal tax on power consumption (*Imposto Único sobre Energia Elétrica – IUEE,* channeled to the National Electrification Fund) and compulsory loans from industrial consumers of electricity. OLVEIRA, 2007, p. 38.

[88] Conta de Resultados a Compensar, CRC.

[89] Tratado entre a República Federativa do Brasil e a República do Paraguai para o aproveitamento hidroelétrico dos recursos hídricos do rio Paraná, pertencentes em condomínio aos dois países, desde e inclusive o Salto Grande de Sete Quedas ou Salto do Guairá até a foz do rio Iguaçu, from 26 Apr 1973.

[90] Acordo Tripartite entre Brasil, Paraguai e Argentina para aproveitamento dos recursos hidráulicos do trecho do rio Paraná desde as Sete Quedas até a foz do Rio da Prata, from 19 Oct 1979.

[91] Itaipu was granted priority in dispatch, so Southern and Southeastern state power companies were forced to reduce their generation and postpone expansion projects. This created a conflict between the federal administration and the states (OLIVEIRA, 2007, p. 42).

electricity supply was transmitted through the SIN (MME, 2017, p. 08). In this centralized model, rising demand was met by expanding hydropower's installed capacity and connecting new projects to an also expanding SIN. Large hydropower plants were preferred to smaller ones. Between 1974 and 1984, 36,515MW of hydropower installed capacity were added to the Brazilian SIN.[92]

1980s: the collapse of model

In the early 1980s, the strategy of meeting increasing electricity demand by building new hydropower plants collapsed. The main reason was lack of financing. Costs of producing electricity had escalated after the federal government implemented a single tariff system, but tariffs were controlled by the government and adjusted below inflation levels, hoping to reduce inflation rates.[93] Unable to obtain domestic funding, ELETROBRAS increasingly sought foreign loans to continue its operation and the expansion of the electric system. But international funding had become more and more expensive after the second oil shock and the new interest rates applied by the United States in the beginning since 1979. Electric sector's indebtedness climbed: while *"only 20% of the industry's financial resources went to service debt, a fraction that rose steadily and peaked at 98.4% in 1989*" (OLIVEIRA, 2007, p. 43). The impact over the Brazilian balance of payment was very substantial (GOMES et al, 2002; FERREIRA, 2000).

Conflicts between the federal and states governments also increased. Power consumption decreased in the 1980s, consequence of the economic crisis that was installed. Reduced demand and lack of financing delayed new power projects. Some states decided to withhold payments from their utilities to ELETROBRAS arguing they needed cash and the tariffs were not enough to cover their needs (OLIVEIRA, 2007, p.

[92] UHE Ilha Solteira (1973), installed capacity of 3444MW; UHE Jupiá (1974), 1551MW; UHE São Simão (1978), 1710MW; UHE Paulo Afonso IV (1979), 2462MW; UHE Sobradinho (1979), 1050MW; UHE Foz do Areia (1980), 1676MW; UHE Itumbiara (1981), 2082MW; UHE Tucuruí (1984), 8340MW; UHE Itaipu (1984), 14000MW.

[93] Real costs of producing electricity were much lower in the South and Southeast of Brazil compared to the North and Northeast. When the single tariff system was adopted, profitable companies no longer invested in efficiency, as they would no longer be able to appropriate gains from efficiency so costs increased rapidly. Yet tariffs – which were calculated according to costs – did not increase because the federal government controlled them hoping to reduce inflation. As a result, the amounts placed in CRC accounts also increased fast (OLIVEIRA, 2007 p. 42). The credits in the CRC accounts became an important issue by the 1990s, when the federal government decided to privatize the electric sector.

44). By the time of the transition from the military regime to democracy, reforms started to be discussed.

Marginal reforms

In 1985, the federal government enacted a policy to reorganize the electric sector, *Plano de Recuperação do Setor de Energia Elétrica* (Plan for the Recuperation of the Electric Sector). The plan intended to tackle three issues: clarify projected electricity demand for the next years; prioritize investments in the sector; and implement measures to resume economic viability of the sector (ALQUERES, 1987, p. 198). It identified that demand for electric power would expand in Brazil in the following years, as economic activity would be resumed and new industrial ventures in the North of the country would require substantial amounts of electricity to operate (ALQUERES, 1987, p. 198). Therefore, investments would prioritize generation (ALQUERES, 1987, p. 199). Economic viability would be guaranteed by rising tariffs and new foreign loans that would be undertaken by the federal government and supervised by the World Bank (ALQUERES, 1987, p. 200-201). Amidst the process of renegotiation of foreign debts and conflicts among electric utilities for resources for their own projects, the plan was not fully implemented and failed (MERCEDES, RICO and POZZO, 2015, p. 22).

In 1987, while the new Federal Constitution was discussed and debates among societal groups about political decisions started to become more common, rumors spread that electricity rationing could be implemented in Brazil.[94] The Ministry of Mines and Energy (MME) organized a working group – *Revisão Institucional do Sistema Elétrico, REVISE* (Institutional Revision of the Electric System) – with the participation of government actors and power utilities, to assess causes and identify remedies to the crisis (OLIVEIRA, 2007, p. 45). The stakeholders identified three critical problems with the ongoing model. First, state-owned enterprises' management performed poorly and was not accountable to consumers (OLIVEIRA, 2007, p. 45). Second, persisting conflicts between the ELETROBRAS and its subsidiaries and between the group and states' utilities had undermined ELETROBRAS coordinating authority in the electric sector (OLIVEIRA, 2007, p. 45). Third, the cap on tariffs that had been established overlooked

[94] The federal government enacted Decree nr. 93901 in 09 Jan 1987 explaining how rationing would be implemented if needed.

financial viability in the electric sector (OLIVEIRA, 2007, p. 45). Overall, it is said that the REVISE group represented interests of those in the sector, who sought small adjustments, especially higher tariffs (OLIVEIRA, 2007, p. 45), instead of substantial reforms that could reduce their role. Again, nothing was implemented (OLIVEIRA, 2007, p. 45).

Between 1988 and 1993, new legislation that affect the electric sector was enacted. The 1988 Federal Constitution establishes that the hydropower potential of Brazilian rivers is still property of the federal government, yet states and municipalities will participate or receive financial compensation by the federal government in case of exploration.[95] The Constitution also establishes that public service concessions will follow public tender procedures, guaranteeing transparency and equal opportunity to all bidders that qualify to participate.[96] This command was complemented in 1993, when the Brazilian Law on Public Tender Procedures[97] was enacted. Also in 1993, under Itamar Franco administration, open access to the electric grid was approved;[98] the cost-plus tariff regime was replaced by prices regularly revised; the single tariff system was abolished, so tariffs rose; and the federal government paid states the amounts accumulated in their CRC accounts (OLIVEIRA, 2007, p. 46-47).

While these measures were discussed and approved, installed capacity of electricity production was stalled and rising electricity demand was met by depleting hydropower reservoirs (GOMES et al, 2002). The system was planned to guarantee electricity production by coordinating the use of water in different reservoirs, to a limit, and new electric projects would complement it. In the beginning of the 1990s, when new electric projects were suspended, power outages were avoided because favorable rain cycles mitigated the exhaustion of reservoirs (GOMES et al, 2002). Reforms implemented between 1988 and 1994 were only marginal: they aimed at making the power industry more transparent and more responsive to market forces and adjusted the sector slightly, but did not offer a viable strategy to resume investment and sustain it in the long run (OLIVEIRA, 2007, p. 48).

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[95] 1988 Federal Constitution, article 20, *caput* and 1st paragraph. The same rule applies to oil, natural gas and other mineral resources.
[96] 1988 Federal Constitution, article 37, item XXI.
[97] Federal Law nr. 8666, from 21 Jun 1993.
[98] Federal Decree nr. 1009, from 22 Dec 1993. ANEEL, the Electric Sector Regulatory Agency, would become responsible for regulating access to the grid (Federal Decree nr. 2655, from 02 Jul 1998).

3.3.1.3. Fuel politics

"The oil is ours": state monopoly over oil resources and activities

Oil exploration has started in Brazil during the Monarchic period and intensified in the 1950s, after former President Vargas created PETROBRAS.[99] At first, oil was prospected mainly onshore – in Bahia, Alagoas, Sergipe and the Amazon region – but soon it was realized that these reserves were not promising (LUCCHESI, 1998, p. 22).[100] Brazil was highly dependent on imported oil and the impact of this dependence on the Balance of Payments was major (LUCCHESI, 1998, p. 23). When the military government came to power, self-sufficiency on energy resources became a key pledge. Offshore exploration, without abandoning onshore activities, became PETROBRAS main focus (LUCCHESI, 1998, p. 23)

Between 1969 and 1974, massive investments in acquiring and developing technology to prospect oil in the sea, and in training Brazilian experts were made (LUCCHESI, 1998, p. 27). In 1974, oil was discovered in the offshore Campos Basin, along the Southeastern coast of Brazil. Timing was excellent, since oil prices had escalated after the first oil shock. This discovery reignited the dream of self-sufficiency in oil production. More investments in R&D and technology development led to more discoveries, in deeper areas. After the second oil shock, exploration of those reserves became commercially viable (LUCCHESI, 1998, p. 28). But PETROBRAS did not have enough capital to undertake exploration of all discovered fields, so the federal government decided to allow foreign oil companies to participate in the exploration by signing risk contracts.[101] This business model was very controversial at the time: different sectors, aligned with nationalism, opposed risk contracts, arguing that Brazilian resources would be appropriated by foreigners; another argument was that PETROBRAS was investing much more than foreign companies, and this is true. Yet, risk contracts were employed by the federal government between 1976 and 1988 to

[99] Federal Law nr 2004, from 03 Oct 1953. Between 1954 and 1997, it was the sole company authorized to prospect and explore oil reserves; to refine oil; to transport, import and export oil products in Brazil. Federal Decree nr. 53337, from 23 Dec 1963. Private companies could still commercialize oil products: *Petrobras Distribuidora* was created in 1971 and would compete with other companies in this activity.
[100] *Relatório Link* (Link Report), named after its coordinator, Walter K. Link.
[101] Foreign companies would invest upfront in exploring the oil fields; after the field starts to produce, the company would keep part of the gains, covering its initial costs plus making profit; but if the field would not produce, the company would receive nothing.

explore offshore oil fields. By 1984, Brazil was producing 500 thousand barrels of oil per day (LUCCHESI, 1998, p. 29).

Although the centralizing model through which the Brazilian oil sector was developed suffered from many problems and critics, Brazil was not the only country to apply it. Through the decades, PETROBRAS became a world-class oil company. It accumulated important know how in oil exploration, both in Brazil and abroad, in partnerships with foreign companies through BRASPETRO, and became worldly known by its expertise in deep offshore oil production. Between 1975 and 1994, domestic oil reserves increased more than 07 times, from 120,730 10^3 m^3 to 854,468 10^3 m^3 (EPE, 2017); gas reserves also increased, from 25,936 10^6 m^3 in 1975 to 198,761 10^6 m^3 in 1994 (EPE, 2017).

In 1988, the Federal Constitution reinstated PETROBRAS' monopoly over research, development and exploration of oil fields.[102] Risk contracts were no longer allowed. But this changed again in the 1990s. By the time, the process of opening the Brazilian economic and creating more competition was being implemented, and the oil sector was not to be left out of it. In 1995, the Federal Constitution was amended to allow either state-owned or private companies to develop oil activities in Brazil.[103] It was the end of *de jure* PETROBRAS monopoly, but it would start to take place in 1997, when the law that regulated the constitutional text was enacted.

The rise and fall of the ethanol alternative

The sugarcane industry has been politically influential throughout the history of Brazil. Since the 1930s, sugarcane producers have lobbied for government protection from oscillations of the international sugar market, and ethanol became an alternative (LEITE, 2009, p. 123). Ethanol outputs increased: in 1941, Brazil already produced 650 million liters of it (MOREIRA and GOLDEMBERG, 1999, p. 231). But sugar remained sugarcane's industry main product.[104]

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[102] 1988 Federal Constitution, article 177.
[103] Amendment nr 09, from 09 Nov 1995.
[104] In 1960s, following the United States' embargo against Cuba, IAA acted to promote the Brazilian product; sugar exports increased by 250% between 1965 and 1974 (HIRA and OLIVEIRA, 2009, p. 2451).

By the beginning of the 1970s, international sugar prices collapsed again (MOREIRA and GOLDEMBERG, 1999, p. 230). The sugarcane industry was more organized – e.g. sugarcane producers and owners of mills and refineries from the state of São Paulo had jointly created an association to represent their interests, COPERSUCAR – and actively lobbied for more government protection. The Pro-Alcohol Program[105] was originally conceived to bail out the sugar industry, but it became a measure to reduce Brazilian dependence on imported oil by the time the first oil shock hit. Brazil imported 80% of its petroleum at the time; on top of creating deficits in the Balance of Payments, Brazilian energy dependence was a national security concern (HIRA and OLIVEIRA, 2009, p. 2451-2452).[106] Ethanol was aimed to replace 20% of the projected demand for gasoline in 1980. To achieve it, Bank of Brazil would lend money with negative interest rates to new distilleries; ethanol prices would be kept at 65% of gasoline prices, the difference being subsidized by the federal government (minimum price policy); PETROBRAS would purchase and maintain large ethanol regulating stocks; and a production quota and export controls were established to sugar (HIRA and OLIVEIRA, 2009, p. 2452).

Pro-Alcohol had both supporters and critics. The sugar industry, President Geisel, the Ministry of Industry and Commerce were in favor of it; the automotive industry also "*was quietly supportive (…) hoping for subsidies*" (HIRA and OLIVEIRA, 2009, p. 2452). PETROBRAS, the MME and financial agencies (Ministry of Finance, the Central Bank and Bank of Brazil) were against it (HIRA and OLIVEIRA, 2009, p. 2452). The second group considered Pro-Alcohol inflationary and tried to modify it; they envisaged a PETROBRAS subsidiary that would control the ethanol market and cassava as an alternative source of ethanol (HIRA and OLIVEIRA, 2009, p. 2452). By 1978, the debate was still heated; ethanol outputs had increased based on earlier idle capacity of the sugarcane industry (HIRA and OLIVEIRA, 2009, p. 2453; LEITE, 2009, p. 124).

But when the second oil shock hit, the deadlock was broken in favor of the first group. *Conselho Nacional do Álcool*, CNAL (National Council of Ethanol) and *Comissão Executiva Nacional do Alcool*, CENAL (National Executive Commission of Ethanol) were

[105] Launched by Federal Decree nr 76593, from 14 Nov 1975. An Inter-Ministerial Commission (CINAL) was also created, to coordinate the activities from different Ministries on ethanol.
[106] Other goals were: to increase agricultural incomes in the Northeast of Brazil, were part of the sugarcane industry was located; to increase economic growth by employing idle economic resources, especially land and labor; and to push the domestic capital goods sector. HIRA and OLIVEIRA, 2009, p. 2452.

created[107] to set new production targets and oversee their implementation. Substantial financial resources were created to the program, jointly by the government and private groups (HIRA and OLIVEIRA, 2009, p. 2453). Ethanol started to be considered as a fuel in itself – hydrous ethanol – to replace gasoline, in addition to remain in the gasoline mix (LEITE, 2009, p. 124). As the federal government enacted further incentives, the automotive industry started manufacturing ethanol-only vehicles (HIRA and OLIVEIRA, 2009, p. 2453).[108] Reduced taxes and easier financing conditions to purchase ethanol-fueled cars were put in place (HIRA and OLIVEIRA, 2009, p. 2453; LEITE, 2009, p. 125). By 1985, 85-90% of all new light vehicles sold in Brazil and 20% of the entire fleet were ethanol-fueled (HIRA and OLIVEIRA, 2009, p. 2454).

By the middle 1980s, the picture reversed. Oil prices started to decrease; ethanol prices reached 80% of the gasoline price (MOREIRA and GOLDEMBERG, 1999, p. 240). Credit became more expensive, and maintaining subsidies of Pro-Alcohol Program became too costly. In 1988, incentives were removed (LEITE, 2009, p. 125). Around the same time, international sugar prices were increasing; the federal government removed sugar export quotas (HIRA and OLIVEIRA, 2009, p. 2454) and the industry switched products – many ethanol-only mills that had been built went bankrupt. Severe ethanol shortages followed: Brazil became a net importer at the time (MOREIRA and GOLDEMBERG, 1999, p. 240; HIRA and OLIVEIRA, 2009, p. 2454); long lines to find ethanol in gas stations were in the headlines; consumer trust in ethanol vehicles collapsed (HIRA and OLIVEIRA, 2009, p. 2454). In 1989, taxes on gasoline-fueled vehicles were lowered; in 1990, the Collor administration dissolved *Instituto Nacional do Álcool*, IAA (National Ethanol Institute).[109] The Pro-Alcohol Program was over.

Throughout the 1970s and the 1980s, the use of ethanol as a fuel had a secondary driver, relevant in larger cities with a substantial fleet, especially São Paulo: air pollution. Although air pollution concerns were not relevant to launch the Pro-Alcohol program, they were used to justify it afterwards. Before 1980, 54g of carbon monoxide emissions resulted from gasoline combustion per kilometer; in 1990, when ethanol was added to the mix, only 13.3g (MOREIRA and GOLDEMBERG, 1999, p. 236). In 1990s,

[107] Federal Decree nr 83700, from 05 Jul 1979.
[108] The first 100% ethanol-fueled car was Fiat 147, produced in small scale in 1979.
[109] Federal Law nr 8029, from 12 Apr 1990.

technological advances[110] drastically reduced emissions of several air pollutants both for gasoline and ethanol engines (LEITE and LEAL, 2007, p. 16). In the following years, ethanol production would continue to supply the mandatory mix in gasoline; gas stations still offered ethanol as a fuel, but few consumers would keep their ethanol-fueled cars.

3.3.2. 1995-2003

3.3.2.1. Political economy landscape

Coalitional presidentialism and privatizations

During the Cardoso administration, the implementation of a new economic model, in which the state would become a regulator of economic activity instead of an economic actor itself, deepened. Economic stability was achieved by a tripod of economic policy established after *Plano Real*. First, fiscal discipline: the federal government would respect spending targets, keeping them below tax revenue. Second, inflation targets would be established and respected by the federal government, using Central Bank's settled interest rates as a tool to control them. Third, exchange rate would fluctuate – after a period of control, 1994-1999 – so the Brazilian economy would follow global trends more closely.

Implementation of the National Privatization Plan[111] continued. Different sectors were restructured to increase private participation and enhance competition, aiming at providing better services to the population. Privatizations started in sectors that were attractive to private capital and could more easily be organized: steel, telecommunications and banks. But the energy sector – electric sector and oil and gas sector – and other infrastructure components were also at stake, due to their intrinsic value to enhance competition of the Brazilian economy. In the period, Brazil took important steps towards adjusting its economy along with changes in the global economy. But they were not enough to change the domestic productive structure or increase productivity, long-term economic bottlenecks in Brazil.

Reforms were not without opposition. Debates were deep-heated in the period; day-to-day demonstrations against the privatizations were seen all around Brazil.

[110] Electronic fuel injection and catalytic converters.
[111] Federal Law nr. 8031, from 12 Apr 1990.

Reforms were more successful in some sectors compared to others. But the agenda was partially successful largely because the federal government had the support from a large coalition of center-wing and right-wing parties in the Parliament. Through the 1990s, left-wing parties – usually against reforms – increased their representation in the Parliament: from 20.1% of all representatives elected to office in 1990 to 22.4% in 1994 and the same in 1998 (RODRIGUES, 2009, p. 21). But they were still minority compared to center-right coalition: it had 79.9% of the federal representatives elected to office in 1990 and 77.6% in 1994 and 1998 – representation of right-wing parties decreased from 44.6% in 1994 to 42.1% in 1998; center-wing's increased from 33% to 35.5% (RODRIGUES, 2009, p. 21).

Between 1995 and 2003, Brazilian presence in international forums was enhanced. Economic adjustments were seen largely as positive by the international community. Brazil was respecting international agreements and changing long-term imbalances. Presidential diplomacy was largely employed to push Brazilian agenda.

3.3.2.2. Electricity politics

Privatization: a partial reorientation of the electric sector

When the Cardoso administration took office, the electric sector was included in the privatization agenda. Reforms were inspired by ones implemented the United Kingdom in the 1980s and aimed at creating a competitive market in the electric sector. Conditions for their implementation were reversing vertical integration in the power sector, separating generation, transmission and distribution; privatizing utilities; implementing competition in generation and commercialization of electricity; and ensuring free access to transmission lines (GOMES et al, 2002; GOLDEMBERG and PRADO, 2003). Notwithstanding, clashing views regarding both the macroeconomic goals being pursued by the reforms and the new electric model endured throughout their implementation. As a result, reforms were implemented in a limited way.

In 1995, the rule that restricted the ownership of hydropower projects to Brazilian or companies registered in Brazil was abrogated.[112] A new law established that all hydropower concessions granted after 1988 without following public tender procedures

[112] Amendment nr 06 to Federal Constitution of 1988.

and concessions granted before 1988 but which construction were not yet under way were voided[113] (OLIVEIRA, 2007, p. 49).[114] These concessions would be offered to private investors in public auctions following international standard practices (OLIVEIRA, 2007, p. 49). The legal framework also established that consumers whose load was 3000 kW or higher were free to choose their electricity supplier, and that independent power providers were authorized in operate in the electric market (GOMES et al, 2002). In 1996, the regulatory authority of the electric sector, *Agência Nacional de Energia Elétrica,* ANEEL (National Regulatory Authority on Eletricity), was created.[115]

Privatization faced opposition. BNDES, appointed by the federal to manage the privatization process, was focused in obtaining maximum returns for the Treasury from selling state-owned utilities and enforcing maximum competition in the sector as fast as possible. When state governors initially opposed the privatization of distribution utilities that were under ELETROBRAS control but served state governors political patronage, BNDES offered soft loans to renegotiate their debt with the federal government (OLIVEIRA, 2007, p. 49; 52).[116] But power sector incumbents also opposed privatization and acted through MME and ELETROBRAS to insert themselves in the process (OLIVEIRA, 2007, p. 52).

Their arguments were technical. In a report signed by the consultancy Coopers and Lybrant on their behalf, in the context of the RE-SEB Project, they argued that a decentralized and fully competitive electric market was not in tandem with Brazilian hydro-dominated electric system, and the lack of a coherent strategy could harm national interest (OLIVEIRA, 2007, p. 52). They defended that investment decisions, to be optimal, should be still be coordinated within a privatized market; and opposed decentralized control over dispatch and the transmission network, as efficient use of hydropower reservoirs needed coordination (OLIVEIRA, 2007, p. 52). Uncoordinated dispatch, prioritizing the best price for each generator, would reduce overall generating capacity of the hydropower system by 30%, due to spilled water and other operational specificities (OLIVEIRA, 2007, p. 54).

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[113] Federal Law nr 8987/1995. The legal framework regulating the concession of electricity services was complemented by law nr 9074/1995.

[114] According to Oliveira, the federal government recovered 33 hydropower concessions ready-for-sale to private investors immediately after enacting the law (OLIVEIRA, 2007, p. 49).

[115] Federal Law nr 9427/1996.

[116] ESCELSA, Rio Light and COELBA were the first electric utilities to be privatized, the first in 1995 and the other two in 1996.

A hybrid model resulted from accommodating these demands.[117] BNDES offered to replace ELETROBRAS in funding large-scale power projects (OLIVEIRA, 2007, p. 52; 53). Centralized dispatch would be maintained and an independent operator[118] would be responsible for it – as well as for operating the transmission system; it would prioritize least-cost (considering short-term marginal costs) operating power plants, and in dispatch them in sequence (OLIVEIRA, 2007, p. 54-55). Hydropower plants would sell their energy to the SIN according to a certificate issued by ANEEL that indicated their levels of "assured energy", based on historical rainfall data; additional power that would be produced in wet years would be sold in the spot market (OLIVEIRA, 2007, p. 54-55). And a financial mechanism[119] was created to mitigate the hydrological risk – risk of unfavorable water flows in specific locations, due to weather conditions – among hydropower plants, thus socializing risks and revenue flows across the entire system (OLIVEIRA, 2007, p. 55). This accommodation would maintain ELETROBRAS utilities competitive in the new system and would maintain hydropower more competitive than other primary sources, what suited MME – which staff was dominated by long-term hydropower engineers (OLIVEIRA, 2007, p. 56).

A wholesale electricity market, in which generating utilities and distribution utilities, as well as large-scale consumers,[120] were free to sign bilateral contracts of power supply, was created.[121] Special rules would regulate the transition from the old (cost plus) to the new (opportunity costs) system. During 09 years, prices would be kept at 1996's levels, indexed to inflation, to avoid sharp increase of tariffs (OLIVEIRA, 2007, p. 56-57). Distributing utilities were required by ANEEL to buy at least 85% of the projected demand of their captive consumers in firm bilateral contracts; they were thus forbidden to take the risk of leaving a larger share of electricity to be bought in the spot market –

[117] The consequences of the California electricity crisis, in 2000-2001, also played a role in strengthening the case for a hybrid market with centralized dispatch. See section 3.4.1, below.
[118] *Operador Nacional do Sistema Elétrico*, ONS (Operator of the National Electric System), a not-for-profit civil association composed of representatives of power utilities and of large electric power consumers, created in 1998 (Federal Law nr 9648 from 27 May 1998 and Federal Decree nr 2655 from 02 Jul 1998). In 2004, ONS was put under inspection of ANEEL (Federal Decree nr 5081, from 14 May 2004). In 2017, it became responsible for coordinating dispatch in isolated systems as well (Federal Decree nr 9022, from 31 Mar 2017).
[119] Mecanismo de realocação de energia (power allocation mechanism).
[120] Consumers that demand 3,000kW or more are considered large-scale (Federal Law nr 9074, from 07 Jul 1995). Consumers that demand between 500kW and 3,000kW are named special consumers and can obtain authorization to purchase electricity directly from suppliers, including small scale supply projects. The Brazilian Parliament is currently discussing projects of law that would allow any consumer to purchase electricity directly from a supplier.
[121] Federal Law nr 9648 from 27 May 1998 and Federal Decree nr 2655 from 02 Jul 1998.

which fluctuated more, so it could or not offer better prices – and undersupply their consumers (OLIVEIRA, 2007, p. 57). Later, the amount was increased to 95% and 100% of the demand. As a result, prices in the wholesale market were in fact administered, not truly competitive (OLIVEIRA, 2007, p. 57). By 1998, 16 distribution utilities and 04 generation companies had been privatized (OLIVEIRA, 2007, p. 58).

Natural gas enters the grid

Natural gas has entered the Brazilian electricity matrix later than world average. In 1989, it appears for first time as an electricity source in energy balances, answering for 0.10% of total electricity generation in Brazil (EPE, 2017). Throughout the next decade, its participation remained small, reaching 0.41% in 1998 (EPE, 2017). Between 1999 and 2003, its share in electricity production increases, but at slower pace than expected by the federal government (see next section, "The 2001 supply crisis"): it produced 0.79% of total electricity in 1999, and 3.60% in 2003 (EPE, 2017).[122] Expanding the use of gas-fired thermal plants in electricity production was a strategy since the beginning of the privatization process, strengthened after the 2001 supply crisis, but it never really took off until the 2010s.

Increasing the share of natural gas in the Brazilian energy matrix was a multi-causal decision, based on geopolitical, economic and technical arguments involving different actors.

In different occasions of the second half of the 20th Century, the federal government had considered using more natural gas in Brazil. Increasing energy security and enhancing Brazil's role before neighboring countries were among the reasons.[123] In the 1950s, before gas reserves were discovered in Brazil, Bolivia offered Brazilian private investors to develop natural gas from Bolivian fields, but the ventures did not materialize (MARES, 2006, p. 172). After the first oil shock, in 1974, Brazil and Bolivia agreed that 2.5bcm of Bolivian natural gas would be delivered to the Brazilian market per year – increased to 4.1bcm per year in 1978 – for 20 years (MARES, 2006, p. 172-

[122] All numbers presented in the paragraph are own calculations based on referred data.
[123] Brazil has natural gas reserves. It has been exploring them since the 1970s in the Northeast of the country and the 1980s in the Southeast. Yet, given Brazil's small gas reserves, a larger role for natural gas was directly related to connecting Brazil with producing fields from neighboring countries. When large reserves of deep offshore oil were discovered, around 2007, Brazilian domestic gas production was expected to increase (OLIVEIRA, 2007, p. 61).

173). At the time, rivalry between Brazil and Argentina in the Southern Cone was high and the bid for Bolivian gas was part of this context (MARES, 2006, p. 176);[124] concerns over security of energy supply also played a role. But Brazil decided to invest in hydropower – the agreement with Paraguay to build Itaipu is from the same period – and in prospecting petroleum offshore instead, so the agreement with Bolivia was never implemented (MARES, 2006, p. 196). By the time the agreement between Bolivia and Argentina expired,[125] Brazil and Bolivia engaged again in negotiations.

The context was different this time. In the beginning of the 1990s, Brazilian economy was opening and increasing participation of private capital in economic activity was a priority. Natural gas was expected to play a key role in increasing competitiveness in the electric sector.[126] Gas-fired thermal power plants are smaller and cheaper than large hydropower plants, so more of them can be built in a shorter period. They can also attract more potential investors given they require lower investment levels. Besides, gas could increase security of electricity supply by complementing hydroelectricity, avoiding reservoirs to be depleted. In 1990, the report *Reexame da Matriz Energética Nacional* (Reexamination of the National Energy Matrix) recommended the federal government to raise natural gas' share in the primary energy matrix[127] from 2% in 1990 to at least 4.5% in 2000 and 6% in 2010 (PASSOS, 1998; MARES, 2006, p. 186).

The Brazilian private sector endorsed the strategy. In fact, during the 1980s – before the Bolivia-Brazil pipeline became a real project – representatives of different industrial segments in the Southern states of Brazil had commissioned studies on the viability of connecting, though pipelines, their businesses to natural gas fields in Argentina or Bolivia (PASSOS, 1998).[128] By supplying their businesses with a cheaper energy source they would reduce their fixed costs and increase the competitiveness of their products. When negotiations between Bolivia and Brazil on building the GASBOL

[124] Argentina and Bolivia had signed, in 1968, a 20-year contract, according to which Bolivia would provide, through a pipeline that would be built, 1.5bcm of natural gas per year for 07 years and 1.7bcm of natural gas per year for 13 years (MARES, 2006, p. 173-174). In 1972, the YABOG began operating (MARES, 2006, p. 174).

[125] Although controversy over the price of the has had arisen between the Bolivia and Argentina in the end of the 1970s and beginning of the 1980s – when Argentina had expanded its domestic production of natural gas due to substantial private investments – their agreement was extended several times (MARES, 2006, p. 175-176).

[126] The privatization of the Brazilian electric sector was inspired by the British, in which natural gas played a key role in increasing competitiveness by replacing coal-fired thermal power plants in the 1980s.

[127] The energy matrix encompasses all secondary uses of energy, e.g. electricity, heating and fuel.

[128] In from Paraná and Santa Catarina, they organized in the association INFRAGAS, and started studies on gas imports from Bolivia or Argentina directly to their markets. In Rio Grande do Sul, the private sector articulated with the state government to import gas from neighboring Argentina. PASSOS, 1998.

started, the private sector organized to participate in ventures to build the pipeline and other infrastructure projects that would follow it (PASSOS, 1998).[129]

In 1992, Brazil and Bolivia signed the first agreement on the GASBOL.[130] Around the time, talks were also held with Argentina, but the partnership was settled with Bolivia considering lower gas prices offered by the latter and geopolitical interests. On the one hand, the GASBOL project was partially funded by the World Bank and the Inter-American Development Bank. Among their reasons to support the GASBOL project were (i) the development of an alternative export market for Bolivian gas, once Argentina had become self-sufficient; (ii) their interest in developing strong regulatory agencies in Brazil and Bolivia so that private capital would play a greater role in both economies – Argentina had advanced earlier in this direction; (iii) the opportunity to play a larger role in Bolivia and Brazil's development, given GASBOL's social and environmental implications; and (iv) GASBOL was considered key for enhancing gas transportation in the Southern Cone (MARES, 2006, p. 191). On the other hand, Brazil also preferred GASBOL to bolster its role as a regional power (MARES, 2006, p. 192).[131]

The GASBOL was built between 1997 and 1999 and is 3,150 km long, connecting Santa Cruz de la Sierra, in Bolivia, to Canoas, in Brazil. A complex legal structure involving public and private funds was created to fund and manage the project, but PETROBRAS involvement was key. The project was considered very risky by private investors: Brazil was a potential large market for gas, but GASBOL's gas prices were settled in US dollars and linked to international oil prices; thus, if international oil prices would rise or the Brazilian would devaluate, gas would become too expensive for end users, but suppliers would have long-term contracts to honor (MARES, 2006, p. 193-194). The GASBOL took off only after PETROBRAS entered take-or-pay contracts with gas suppliers and assumed the major financial risks of the project (MARES, 2006, p. 194).

[129] In 1992, in São Paulo, *Sociedade Privada do Gás*, SPG (Private Society of Gas) was created. It gathered some of the largest companies of the Brazilian private sector (contractors, capital goods, banks) and several international electric companies, and engaged in discussions with the federal government on how to make the Bolivia-Brazil pipeline project attractive to the private sector (PASSOS, 1998).

[130] *Acordo de Alcance Parcial sobre Promoção de Comércio entre Brasil e Bolívia para fornecimento de gás natural*, internalized in Brazil by Federal Decree nr 681 from 11 Nov 1992. Bolivia would supply natural gas to Brazil for 35 years, through a pipeline that would be built between the two countries.

[131] Bilateral relations with Argentina had improved at the time, they were partners in Mercosur. Brazil also expected that the partnership with Bolivia could entice it to enter Mercosur (MARES, 2006, p. 192).

Yet, the measure was not enough to expand the role of natural gas in electricity generation. ONS' option to prioritize in dispatch least-expensive electricity meant thermal plants would remain idle whenever hydropower plants could answer the demand, given the disparity of costs (OLIVEIRA, 2007, p. 55). Reducing gas-fired power plants risks meant they should contract 100% of their production. But ANEEL had both capped the prices for wholesale contracts that distributors could pass to consumers and regulated electricity tariffs to end-users (OLIVEIRA, 2007, p. 61). Thus, gas-fired thermal generators revenues "*were squeezed between the cap on electricity price fixed by ANEEL and the natural gas price fixed by PETROBRAS in its take-or-pay contract*" (OLIVEIRA, 2007, p. 61). In the end of the 1990s, when the Brazilian currency was also strongly devaluated,[132] this is not a good business plan to attract private investors.[133]

The 2001 supply crisis

The 2001 power supply crisis is a hallmark in the Brazilian electricity history. Between 2000 and 2002, it was one of the most commented issues in Brazil. It influenced the results of the 2002 Presidential election, and lead to the reformulation, once again, of the electric sector. It was also a catalyst of the diversification of the electricity matrix and energy efficiency policies.

Throughout the 1990s, but especially after inflation was controlled by *Plano Real* and economic growth reached higher numbers, electricity demand was rising fast. Yet, investments, in new power projects, undertaken primarily by the public sector so far, had stalled as foreign loans became too expensive; reforms were taking longer than expected to reorient the sector and attract private investment (see section "Privatization: a partial reorientation of the electric sector", above). By 2000, hydropower reservoirs

[132] Since the beginning of Plano Real, the federal government had guaranteed an artificial parity (first strict, then fluctuation in bands) between the Brazilian currency and the US dollar to contain. In 1999, after strong financial crises in Asia and the negotiation of an agreement between the federal government and IMF to avoid one in Brazil, the parity was abandoned, and the Brazilian currency devaluated fast.

[133] Natural gas can also be used in vehicles. In Brazil, pollution from vehicles started to be regulated in 1986, after *Programa de Controle da Poluição do Ar por Veículos Automotores*, PROCONVE was established (Resolution CONAMA nr 18, from 06 May 1986). After the GASBOL was finished and offer of natural gas increased, the adaptation of automobile engines to use natural gas was encouraged in Brazil: it was both a way of find use for the gas and reducing air pollution. Many light vehicle owners embraced it: the gas-fueled national fleet increased from around 39,000 cars in 1999 to around 600,000 in 2003 (DONDERO and GOLDEMBERG, 2005, p. 1703). The fleet is concentrated mostly in larger Brazilian cities, such as São Paulo and Rio de Janeiro, where fuel stations are better connected to natural gas supply chains.

were a lot below optimal level, and ONS warned that electricity provision could be hindered.

The threat of shortage in electricity provision was caused by both lack of investment in new generation projects and weather drier than expected in 2001. A hydro-dominated power system such as the Brazilian can guarantee stable provision of electricity when hydropower reservoirs are kept at optimum level. There is some flexibility because the more intense depletion of reservoirs in drier years can be compensated by their repletion in wetter years, maintaining a multi-year balance. The weather had prevented potential shortages in previous occasions. In 2000-2001, however, the winter was particularly dry, so reservoirs were depleted too fast; the system almost collapsed.

It is debated whether the crisis could have been anticipated or not. Some experts blame the mismatch between the establishment of a new regulatory framework and the pace of privatization for the crisis. Privatization started before regulatory authorities were established, so legal insecurity regarding how disputes would be settled, including potential conflicts with other uses of watercourses, delayed investments (ARAUJO, 2001, p.10-11). Others say that the government opted to ignore the irreconcilable nature of a fully competitive electric market, in which amounts supplied and prices would fluctuate according to market rules, and a hydro-dominated electric system, in which centralized dispatch was necessary to guarantee security of supply and the optimal management of reservoirs capacity. Had the new electric model been adjusted earlier, investments would have been resumed earlier (FERREIRA, 2000; TOLMASQUIM, 2000; SAUER, 2002; GOLDEMBERG and PRADO, 2003).

It is also said that lessons from previous successful transformation of state-dominated into competitive electric sectors were ignored (ARAUJO, 2001, p. 07-08). According to those lessons, three simultaneous conditions need be in place by the time of the transformation. First, power generation should have idle capacity to guarantee supply during the transitional period. Second, demand should be rising slowly, so it can be met by the existing plus idle generation capacity. Third, offer of cheap fuel to generate electricity by new projects needs to be abundant. None of them was present in the Brazilian case: demand was rising fast; idle capacity became fully employed in a short period of time; and the regulatory framework around natural gas (see section

“Natural gas enters the grid”, above) was a major barrier to create a gas-fired thermal power plants alternative (ARAUJO, 2001, p. 11).

In trying to mitigate the crisis, the federal government induced diversification of electric sources. Gas-fired thermal power plants were targeted first: in 2000, an emergency plan to build gas-fired thermal power plants, *Programa Prioritário de Termeletricidade*, was enacted. Subsidies were offered to potential projects: supply of natural gas for at least 20 years; minimum prices for at least 90% of the electricity produced; and access to financial resources from BNDES were guaranteed.[134] 49 gas-fired thermal power plants were projected[135] and private capital was expected to invest. Yet, private capital was not dissuaded to enlist (see section “Natural gas enters the grid”, above). Therefore, fewer thermal power plants were built, and only after the federal government decided to directly invest on them through PETROBRAS (TOLMASQUIM, 2000, MARES, 2006, p. 194; OLIVEIRA, 2007, p. 67). In July 2001, power transmission projects were declared priority by the federal government, so they would be carried out immediately.[136]

Wind energy was also targeted: a priority program enacted in July 2001 aimed at adding 1050MW of installed capacity of wind energy to the SIN by December 2003.[137] This resolution was never regulated by ANEEL, as required, so the program never entered into force. In December 2001, a provisional measure[138] created the *Programa de Incentivo às Fontes Alternativas de Energia Elétrica* PROINFA (Incentives to Alternative Electric Sources). It aimed at adding 3,300MW of installed capacity to the SIN by wind, biomass and small hydropower plants. But implementation started only in 2004. The share of wind energy, renewable biomass and small-scale hydropower plants in electricity generation did increase following this initiative, but later (see section “Diversifying the electricity matrix: wind, renewable biomass and small hydropower plants”, below). Their role in the 2001 supply crisis was minor.

The most successful strategy to mitigate the impact of the 2001 supply crisis was energy conservation. A national program to promote energy efficiency and compulsorily

[134] Federal Decree nr 3371, from 24 Feb 2000.
[135] Portaria MME nr 43, from 25 Feb 2000.
[136] Casa Civil, Resolution GCE nr 32, from 30 Jul 2001.
[137] *Programa Emergencial de Energia Eolica*, PRO-EOLICA (Emergency Program for Wind Energy), Resolution GCE nr. 24, from 05 Jul 2001.
[138] Provisional Measure nr 14, from 21 Dec 2001.

reduce energy consumption was enacted in 2001.[139] A 20% cut in consumption was targeted to avoid collapse of the power system and consumers received a quota: for any amount consumed above the quota, the consumer would receive a penalty; if they exceeded their quota twice, power supply would be cut (OLIVEIRA, 2007, p. 67-69). Free consumers qualified to a cap-and-trade system: if their consumption felt below their quota, they could sell the remaining to other consumers, who then could consume beyond their quota; prices were negotiated bilaterally (OLIVEIRA, 2007, p. 69). The strategy was remarkably successful: consumption dropped from 15 TWh in April 2001 to 11 TWH in July 2001, and 12.5 TWh from April 2002 to December 2004 (LEITE, 2009, p. 62); average consumption dropped more than 20% and outages were avoided. In 2002, the weather changed and reservoirs were replenished by a rainy season. Several gas-fired thermal power plants were in full production by then as well. Quotas were removed (OLIVEIRA, 2007, p. 70).

Although Brazil advanced in energy efficiency due to the crisis – ONS estimated that the crisis led to a 7% permanent reduction in power consumption (OLIVEIRA, 2007, p. 70) –, it had negative economic consequences. Industrial output was reduced during the crisis and led to a 2% reduction in expected 2001's GDP. Because earlier contracts were disregarded during the crisis – the emergency status allowed it –, conflicts between generating utilities and distributing utilities arose (OLIVEIRA, 2007, p. 70). Consumers were forced to compensate generators and distributors losses: after the crisis, tariffs for small consumers increased 2.9%, and 7% for large consumers (OLIVEIRA, 2007, p. 70).

The political impact of the crisis was also major. The industrial sector was furious with its losses; consumers could not understand why they were being punished with higher electricity tariffs if they had complied with their quotas. The crisis was largely explored by the opposition during the 2002 Presidential election campaigns, who blamed lack of central planning for the shortages – long-term technicians from the electric sector agreed. The Cardoso administration approval rates collapsed after the crisis, and the opposition won the 2002 Presidential elections. Among the key points of the regulatory changes implemented by the Lula da Silva administration when it came to power was resuming centralized planning of the electric sector.

[139] Federal Law nr 10295 from 17 Oct 2001 and Federal Decree nr 4059 from 19 Dec 2001.

"Alternative energy" in electricity generation: first steps

During the 1995-2003 period, the first policy pieces to add "alternative energy" – primary electricity sources other than hydropower and thermal power are sometimes labelled "alternative energy" in Brazil – to electricity supply are enacted. At first, "alternative energy" sources were confined to specific projects in places isolated from the SIN. Later, they were included among the potential primary sources to supply the SIN. But regulatory changes postponed the increase of their shares in the electricity matrix until later 2000s.

In December 1994, the federal government created the *Programa de Desenvolvimento Energético dos Estados e Municípios*, PRODEEM (Program for Energy Development in States and Municipalities).[140] The program aimed at expanding access to electricity in communities isolated from the SIN via micro-grids, employing decentralized renewable sources. The implementation of the program was coordinated by the MME. From 1995 to 2002, micro-grids run by solar photovoltaic technology were installed in multiple locations around the country. But the program was suspended after the federal auditor found discrepancies between the objectives of the program and its execution.[141] In 2003, the new federal administration launched *Programa Nacional de Universalização do Acesso e Uso da Energia Elétrica* to provide electricity services to communities lacking access to the SIN.[142] The program prioritizes extension of the existing grid when possible, but the use of complementary mini-grids employing different primary energy sources – among them wind, solar and biofuels – was also authorized.[143]

In 2001, the Provisional Measure nr 14 created PROINFA. It aimed at adding 3,300MW of installed capacity to the SIN. Diversifying the Brazilian electricity production, by expanding the use of other renewable energy sources, and generating economic

[140] Federal Decree from 27 Dec 1994.

[141] Among the irregularities, they found that the option for solar photovoltaic technology in all projects was not at the best interests of the communities in which the micro-grids were installed but because MME wanted to standardize all projects. The federal government had chosen to use imported solar photovoltaic technology without providing technical assistance and replacement parts to the communities, so many of the projects were not running after their first years. If decisions would be taken case by case instead, other energy sources could have proven more cost-effective. The auditor also found excess centralization of decision-making in Brasília, without participation of the communities involved and lack of coordination between the different entities participating in the program. TCU, 2003.

[142] Federal Decree nr. 4873, from 11 Nov 2003.

[143] MME, Portaria nr 60, from 12 Feb 2009. Among the primary energy sources listed are: hydraulic, biofuels, natural gas, solar and wind, or hybrid systems combining hydraulic, solar, wind, biomass and diesel (item 3.1.1, (a) from the referred regulatory piece).

growth, by boosting new manufacturing chains that would create jobs were among the objectives of PROINFA.[144] In 2002, it was established that independent power providers operating wind, renewable biomass or small-scale hydropower plants would generate these 3,300MW.[145] But the Decree specifying measures to implement the Law was enacted only in December 2002.[146] The federal administration changed in 2003 and adjusted the program, enacting a new Law[147] and another Decree[148]. Implementation would start in 2004.

3.3.2.3. Fuel politics: deregulation, auctions and the flex-fuel vehicle

The end PETROBRAS monopoly? Deregulation and auctions

In 1995, PETROBRAS monopoly over the oil sector, reestablished by the 1988 Federal Constitution, was formally abolished. The Constitution had restated federal government's property over mineral resources, including oil resources, but a constitutional amendment allowed the federal government to appoint either state-owned or private companies to explore these resources in Brazil.[149] In 1997, implementation was detailed.[150] In a transitional period, between 1997 and 2000, PETROBRAS could finish ongoing exploratory projects and start exploring areas already discovered (LUCCHESI, 1998, p. 30). PETROBRAS became a mixed-economy company, linked to MME, that, ideally, would function according to market rules and compete with other companies in the oil sector (LEITE, 2009, p. 83). In practice, because the federal government remained the largest shareholder of PETROBRAS and private capital was not attracted to transport and refining, the fuel market remained largely concentrated at the hands of the federal government.

A regulatory authority for the sector was created, *Agência Nacional do Petróleo*, ANP (National Regulatory Authority for Oil, Gas and Biofuels).[151] Competitive public

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[144] After 2010, following the Brazilian pledge at COP 15, reducing energy-related GHG emissions was included.
[145] Federal Law nr 10438, from 26 Apr 2002.
[146] Federal Decree nr 4541, from 23 Dec 2002.
[147] Federal Law nr 10762, from 11 Nov 2003.
[148] Federal Decree nr 5025, from 30 Mar 2004.
[149] Amendment nr 09, from 09 Nov 1995, adding paragraph 1st to article 177 of the 1988 Federal Constitution.
[150] Law nr 9478, from 06 Aug 1997.
[151] Created by Law nr 9478, from 06 Aug 1997. In 2005, it became the regulatory authority for natural gas and biofuels as well (Law nr 11097, from 13 Jan 2005). The law also created *Conselho Nacional de Política Energética*,

tender procedures would determine which companies allowed to explore oil and gas resources; partnerships with PETROBRAS were possible (LUCCHESI, 1998, p. 30). Auctions would take place in rounds, in which the exploration of onshore or offshore several areas – named blocks in the auctions – would be offered to bidders; concession agreements would be signed. It was expected that the new regulatory model would attract private investment, Brazilian and foreign, and accelerate discoveries and exploration of oil and natural gas in Brazil – and it did.

Between 1999 and 2002, 157 blocks, covering 425,378 km^2, were auctioned; 88 blocks, covering 166,032 km^2 were sold, generating total bonus of BRL 1.47 billion (ANP, 2017). 10 to 18 international private investors participated in each of the 04 rounds (ANP, 2017), and won rights to explore, develop or produce in more than half of them (LEITE, 2009, p. 84). In 2003, once the Lula da Silva presidency started, the private investors were cautious to bid; it was not clear that the new administration would maintain the new model (LEITE, 2009, p. 85). Only 04 foreign companies made offers and won in the 5th round of auctions, in 2003; PETROBRAS won a large share of the 101 blocks sold, amounting to 21,951 km^2 (ANP, 2017). As the new administration maintained the new rules, hesitation was soon overcome. In 2004, in the 6th round of auctions, presence of domestic and foreign private companies in the bid was again significant (LEITE, 2009, p. 85).

The end of PETROBRAS monopoly was not without controversy in Brazil. Groups aligned with the left, in favor of a strong state presence in the economy, such as political parties – including *Partido dos Trabalhadores*, PT (Worker's Party), who would later have its president, Lula da Silva, elected to the Presidential office – labor unions (*Central Única dos Trabalhadores*, CUT; *Força Sindical*), union representing oil sector employers (*Federação Única dos Petroleiros*) and the association representing landless rural workers defending land reform (*Movimento dos trabalhadores Sem Terra,* MST) consistently opposed the measure. Strikes and manifestations against the Constitutional amendment were organized, including violent demonstrations at the Parliament building (see Annex 01). Although these groups and other groups generally opposed any privatization, the end of PETROBRAS monopoly and its transformation into a mixed

CNPE (National Council of Energy Policy), a consultative body to advise the President and MME on energy policy. Members of the CNPE were determined by Federal Decree nr 3520, from 21 Jun 2000.

economy company had more opposition than privatization in other economic sectors. The fact that PETROBRAS had been created with popular support during the 1950s' "the oil is ours" campaign and that it was perceived by large part of the Brazilian population as a very successful state-owned company played an important role.

Ethanol is back: the flex-fuel technology

By the 1990s, the Pro-Alcohol Program came to an end and sales of ethanol-fueled vehicles plummeted. Following the new economic model, the federal government started deregulating fuel prices, and by 2001, all sugarcane products prices were deregulated.[152] Ethanol's market share remained small. In 2002, international oil prices were rising again, so interest for ethanol increased in Brazil (LEITE and LEAL, 2007, p. 17). But a 100%-ethanol vehicle would not be successful: consumers were skeptical after the ethanol shortages in the 1990s. The picture would change with the development of the flexible-fuel technology.

The automobile industry had extensively researched flex-fuel engines throughout the 1990s, when sales of ethanol-only vehicles had declined sharply.[153] Both the ethanol industry and the automotive industry were in favor of it, the latter because it would not need to develop different engines to accommodate ethanol and gasoline separately. In the beginning of 2002, some prototypes of flex-fuel engines were presented. These engines had been originally designed to run on gasoline but adapted to run on any mix of gasoline plus hydrous ethanol or anhydrous ethanol (RAMOS, 2016, p. 66). Later in the same year, the federal government extended tax benefits from ethanol-only vehicles to flex-fuel vehicles.[154] In 2003, the first flexible-fuel car, running on both gasoline and ethanol, was launched in Brazil.

Flex-fuel vehicles are very successful in Brazil. In 2004, 22% of the light vehicles sold in Brazil were flex-fuel (MME and EPE, 2013, p. 05); in 2005, their share in total sales was 57% (HIRA and OLIVEIRA, 2009, p. 2454); in 2011, more than 80% (MME and EPE, 2013, p. 05). The share of flex-fuel vehicles in the national light-vehicle fleet

[152] By 1997, several sugarcane products prices were deregulated, following Portaria from Ministerio da Economia, Fazenda e Planejamento nr 64, from Mar 1996 and Portaria from MME nr 114, from 1996. Hydrous ethanol prices were deregulated in 1999. All products of the sector were deregulated in 2001.
[153] First studies in Brazil were undertaken by Bosch, starting around 1994.
[154] Federal Decree nr 4317 from 31 Jul 2002.

was 48% in 2011, 53% in 2012 (MME and EPE, 2013, p. 06) and 57.82% in 2013 (MME and EPE, 2014, p. 43).[155] The federal government projects that 79% of the Brazilian light-vehicle fleet will have flex-fuel engines in 2024 (MME and EPE, 2015, p. 56).[156] In a research published in 2013, 60% of the flex-fuel vehicle owners justified their choice on the freedom to choose which fuel to use (MME and EPE, 2013, p. 13-14). And the choice of fuel depends mostly on the prices offered at the fuel station (MME and EPE, 2013, p. 16).

Many consumers calculate the difference between the relative price of ethanol (price of a liter of ethanol divided by how many kilometers the car can run using it) and relative price of gasoline before making their choice (SOUZA and POMPEMAYER, 2015, p. 66). Ethanol sales thrived until the federal government started controlling domestic gasoline prices; this intervention undermined ethanol's competitiveness and the use of ethanol was severely reduced (see section "Oil prices become a heterodox economic tool", below).

3.3.3. 2004-2015

3.3.3.1. Political economy landscape

A low-quality democracy at lower levels of global value chains

Between 2004 and 2010, international prices of commodities were high. The Chinese economy was growing 11.16% a year on average (WB, 2017),[157] and its appetite for raw materials benefited large exporters. Brazil is very competitive in agriculture and mineral commodities and accumulated large surpluses in the Commercial Balance. Revenues increased government budget and government spending followed it. Salaries and pensions were raised; the number of public jobs escalated. Cash transfer programs that had started in the previous administration were reformulated and expanded. Brazilian economy was growing around 4% per year, but always below the emerging markets average, pushed by consumption levels.

In 2003, a left-wing administration had started. Lula da Silva was elected to office following a campaign in which he had abandoned several of its long-term pledges

[155] All percentages in the phrase: own calculations based on data referred.
[156] Own calculations based on data referred.
[157] Own calculations based on data referred.

against international financial organizations and the private capital. His administration kept most of the economic design started during Cardoso's years, but changed a few key points. First, privatizations were no longer pursued and remaining state-owned companies were strengthened. Second, further macroeconomic reforms – pension, tax, labor, education – much-needed to increase Brazilian competitiveness and productivity in the industrial and service sectors, were postponed. Third, public capital – BNDES – was used to finance the operations of Brazilian multinationals in the country and abroad, a strategy justified to enhance the country's position in the international system – which also would produce corruption money to the Workers' Party and other parties of the government coalition.

In fact, Brazil became an active actor in several different international forums in the period. It formed coalitions with other large emerging countries to rebalance and reform the international system, with mixed results. It was successful in paying its debt with the IMF, for the first time in three decades; in becoming a limited international donor to South American and African countries; in leading a United Nations' Peace and Rebuilding mission in Haiti. It failed: in having a permanent seat at the United Nations Security Council; in changing the rules of international trade to the Doha round of WTO; in increasing the integration of South America under its leadership; in negotiating with Iran the end of the latter's nuclear weapons program. Former president Lula da Silva was very popular, in Brazil and abroad – until the collapse of the Iran deal, in May 2010. In 2009, the newspaper *The Economist* launched a historic edition about how Brazil had overcome its "country of the future syndrome" and took off. But the flight would be short.

In 2011, former president Dilma Rousseff took office. Member of the same political party as former president Lula da Silva and considered his successor, former president Rousseff had a very different personality and governing style. Her administration would be much more centralizing and would deepen the state intervention in the economy initiated in 2007, producing major macroeconomic imbalances since 2010.

Brazilian currency was appreciated after many years of commercial surpluses, but industrial output had plummeted. Chinese economic growth slowed down since 2013 and Brazil was no longer benefiting from strong commodities' exports, so the budget was shrinking. Inflation was rising. The Brazilian population lifted from poverty demanded further improvements in public services that would preserve its gains: better public health, better transport services, better education. In 2013, demonstrations against public spending in the 2014 World Cup and 2016 Olympic Games took Brazilian streets and global headlines. In 2014, Operation Car Wash, an ongoing major investigation of corruption schemes in Brazil, became nationally and internationally known.

Rousseff was reelected to office in the most competitive election in the Brazilian recent period. Several populist and controversial measures were enacted since 2013 to increase support, e.g.: nominal inflation rates were kept lower than real inflation rates by increasing the control domestic oil products prices, penalizing PETROBRAS and the ethanol production chain; large consumers paid reduced electricity prices when real prices were rising due to lower rainfall rates that depleted reservoirs and required the government to dispatch more expensive thermal power plants. After the election, measures were lifted and the real impact of economic losses was felt. As inflation rose and deficits increased, Operation Car Wash started to disclose the involvement of politicians of the Worker’s Party in corruption schemes. In 2015, former president Rousseff lost support from her broad political coalition, especially center and right-wing parties; in 2016, she was impeached from office.

After 30 years of re-democratization, 25 years of direct presidential elections and decades into the globalization process, Brazil has advanced. Yet it remains a laggard in economic performance when compared to other emerging countries. Politics became more infected by cronyism than ever; very expensive electoral campaigns were funded by money coming from huge corruption schemes. Brazilian productivity and competitiveness is declining during the 21st century, excepting in agriculture and mineral goods.

3.3.3.2. Electricity politics

Re-centralization: long-term planning, auctions and fixed tariffs

After being elected to office, Lula da Silva implemented changes that steered the electric sector towards centralization. The idea was to tackle some issues that were left unresolved when reforms through privatization had started. Two were considered key. First, lack of long-term planning and policy guidance for the system (OLIVEIRA, 2007, p.

58). Second, systemic risk. Before privatization, the federal government, through ELETROBRAS, controlled both prices and the behavior of electric utilities. But in the new model there was no ensured rate of return for investors and tariffs would fluctuate, shifting risks to investors (OLIVEIRA, 2007, p. 62). But investors are not able to manage large macroeconomic risks like the federal government is, and currency fluctuations can impact, in a short period of time, the profitability of investments (OLIVEIRA, 2007, p. 63). In addition, there is no clear responsibility for inherent hydrological risks and investors lack the tool to manage it individually (OLIVEIRA, 2007, p. 63). And finally, projection of demand was uncertain under volatile economic growth, so power was likely to be under-provided (OLIVEIRA, 2007, p. 64-65).

In 2004, re-centralization started to be implemented. [158] Liberalization and privatization processes ceased: private capital was invited to participate in the electric market in partnership with state-owned utilities (OLIVEIRA, 2007, p. 71).[159] *Câmara de Comercialização de Energia Elétrica,* CCEE, a regulated environment in which electricity contracts would be negotiated, replaced the wholesale electricity market. Contracts were divided in three categories: generation, distribution and commercialization; the market was divided in two categories: regulated market, in which contracts to supply normal consumers were settled, and free market, in which contracts to supply free consumers were settled (OLIVEIRA, 2007, p. 71). In the regulated market, contracts would no longer be negotiated bilaterally: they would be settled through public tender process. Long-term fixed price – a variant of cost-plus tariff regime, replacing the market pricing mechanism – contracts between generators and distributors with fixed prices would be negotiated in the auctions (OLIVEIRA, 2007, p. 71). ANEEL was to remove caps on tariffs, and they would be allowed to approach real long-term marginal costs; average costs would be used to fix the power tariffs for consumers (OLIVEIRA, 2007, p. 71).

Centralized long-term planning was resumed. Performed by ELETROBRAS until the beginning of the 1990s, long-term planning had been assigned to the Secretariat of Energy at MME in 1999, but became indicative only (LEITE, 2009, p 59). By then, it was expected that market forces would be enough to balance supply and demand after the new model was fully implemented (OLIVEIRA, 2007, p. 58). Lula da Silva had blamed

[158] Federal Law nr. 10848, from 15 Mar 2004.
[159] Many distribution utilities had been privatized at that point, and remained so. But they would co-exist with state-owned companies, still playing the larger role in power generation.

lack of long-term planned for the 2001 power supply crisis during his campaign, so resuming it was, in his view, a priority. So, in 2003, *Empresa de Pesquisa Energética,* EPE, a government entity responsible for research in the energy field, associated to MME, was created by provisional measure[160], converted into law in 2004.[161] The first *Plano Decenal de Expansão Elétrica,* PDE – a piece of planning in which EPE prospects power demand for the following ten years, and then establishes which projects would be authorized to fulfill it – was published in 2006,[162] and an annual revision has followed since.[163]

Three principles guide long-term planning in the electric sector: security of supply, affordability of tariffs and universal access to power services (MME and EPE, 2015, p. 389). Since 2010, it should also assure that energy-related GHG emissions are kept under the targets settled by Brazilian pledges in COP15, in Copenhagen (MME and EPE, 2015, p. 389).[164] Central planning prioritizes projects to expand power services following these principles and auctions are organized accordingly. Large-scale projects are preferred (SCHAEFFER et al, 2015, p. 30). And because the call for tenders determines which technologies can bid – different technologies are not to compete among themselves anymore, as they were in the earlier model – since 2003 large hydropower plants and/or large thermal power plants have been called to sell the largest shares of electricity to the SIN. Wind, renewable biomass or small-scale hydropower plants were given a complementary role, and solar was excluded from bids until 2014 – higher prices of solar electricity compared to other sources were alleged.

In sum, Lula da Silva's administration overruled most of the changes that had been implemented by the Cardoso's administration. The earlier model was based on merit of the market economy; unwarranted public administration of utilities; conviction that long-term strategic planning coordinated by the federal government was no longer necessary (LEITE, 2009, p. 63). Lula da Silva's government believed that greater control over the electric system was possible and desired. Central long-term strategic planning was resumed; tariffs would be controlled to remain low, despite inexorable increase in costs

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[160] Provisional Measure nr 145, from 11 Dec 2003.
[161] Federal Law nr. 10847, from 15 Mar 2004 and Federal Decree nr. 5184, from 16 Aug 2004.
[162] PDE 2015.
[163] Except for 2009: there is no PDE 2018.
[164] By the time of this writing, the most updated version of PDE was PDE 2024, published in 2015, so no reference to the Paris Agreements are made.

of new hydropower projects (see next section) and fluctuation of fossil fuel price; state-owned utilities were trusted to act on public's best-interest, in opposition to profit-seeking private utilities (LEITE, 2009, p. 64). Re-centralization was in tandem with interests of powerful groups, especially large state-owned utilities, influential in Brazilian energy policy (SCHAEFFER et al, 2015, p. 30) since the 1960s. As they regained their position of privilege in Brazil, new demands were voiced by the Brazilian society and new technologies were disrupting the international electric market.

Large hydropower plants at a crossroads: run-of-the-river technology and future power output

Brazil has many large hydropower plants and most of them were built during the military administrations, when environmental standards were lower. When civil democracy was reestablished, environmental values were slowly – and imperfectly – integrated into the legal framework. Hydropower projects were largely criticized by environmentalists due to the impacts of large dams in dislocating population and reducing biodiversity. In 1986, prior environmental impact assessment of hydropower projects became a requirement to have them approved.[165] Large hydropower plants became even more controversial after research found that hydropower dams in tropical regions could emit more carbon[166] than coal-fired thermal power plants with similar installed capacity – case of UHE[167] Samuel and UHE Três Marias (ROSA et al, 2002; FEARNSIDE, 2005) as well as UHE Balbina (KEMENES, FORSBERG and MELACK, 2011).[168] The debate on how security of supply should be guaranteed and if it should preempt other constitutional rights is among the most controversial issues of the period and has generated more heat than light.

On the one hand, the federal government, long-term technicians of the electric system – who occupy important positions in state-owned utilities and in the federal

[165] CONAMA (entity composed of representatives from the government (federal, state and municipalities), the private sector and civil society, charged with discussing environmental policy) Resolution 01, from 23 Jan 1986; complemented by Resolution nr 06, from 16 Sep 1987 and Resolution nr 23, from 19 Dec 1997.
[166] Adding the amount of carbon from methane (CH_4) emissions from decomposition of vegetation that were left in the area before flooding and from dioxide of carbon, CO_2 (ROSA et al, 2002).
[167] UHE is the acronym employed by MME for large hydropower plants, with more than 30MW of installed capacity (ANEEL, 2008).
[168] Calculations showed that UHE Balbina annual emissions are equivalent of 50% of total annual CO2 emissions derived from burning fossil fuels in the city of São Paulo (KEMENES, FORSBERG and MELACK, 2011).

government administration –, large constructors and the private sector support the construction of new large hydropower plants. They justify it by arguing that security of supply and cost-effectiveness are enhanced by scale: scale reduces prices; efficiency, transmission losses or environmental impacts play second fiddle.[169] Accordingly, large hydropower plants would be the first choice to expand power services in Brazil, and they should be built were large hydropower potential remains. Two river basins – Amazon river and Tocantins river – concentrate 75.62% of the remaining Brazilian hydropower potential (ELETROBRAS, 2016).[170] Long-term planning projects that 22 UHEs will start operating until 2024; 12 are in the Amazon river basin, answering for 92.93% of the projected expansion in terms of installed capacity (MME and EPE, 2015, p. 85).[171]

On the other hand, many environmental NGOs acting in the Amazon region, the *Movimento dos Afetados por Barragens*, MAB (Movement of People Affected by Dams) and civil organizations defending the rights of indigenous people oppose large hydropower plants. They argue that preserving local biodiversity and traditional ways of living of indigenous peoples is guaranteed by the federal constitution and international treaties, and large hydropower dams would destroy it. They have been voicing their pledges in Brazil – large manifestations have taken place in the project sites, in large Brazilian cities and in the capital, Brasília, engaging leftist political parties, since the projects were announced – and abroad. They also entered several legal battles against the federal government on specific projects, UHE Belo Monte being the most widely known.[172] Many projects have been postponed or adapted to accommodate those interests – not successfully appeasing their opposition, though.

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[169] This is the same that was reasoning employed by the military administrations.

[170] Own calculations based on data referred. The Amazon river basin, alone, has 71.55% of the estimated remaining Brazilian hydropower potential (ELETROBRAS, 2016).

[171] Own calculations based on data referred. Projects answering for the remaining 7% of projected hydropower expansion are in the Southern states of Brazil, and one project is in Rio de Janeiro (MME and EPE, 2015, p. 85).

[172] UHE Belo Monte had been planned since the 1980s, but the project was postponed due to lack of financial resources. Since 2009, indigenous populations, with the support of federal administration departments and environmental organizations, have been protesting the construction, arguing that the area to be flooded would kill biodiversity and affect their right to maintain traditional ways of living, so they needed to be heard before any decision on the project was made. The case became widely known in Brazil and abroad, and public opinion sided mostly with the indigenous populations. Authorization to build was issued, though, and the construction continued. Building was resumed in 2011. In the same year, representatives of the indigenous populations started a case at the Inter-American Court of Human Rights against the Brazilian federal government. In the end of 2015, the case was accepted by the Court. In December 2015, Brazilian federal courts suspended the authorization to operate. Later, the measure was reversed. In 2016, UHE Belo Monte started operating, although not all turbines have been activated yet. The case at the Inter-American Court and other legal battles are still under litigation, and, considering the positions of organizations involved, new ones could be initiated. The idea of building hydropower plants in Peru to purchase

Adopting run-of-the-river technology was among the solutions. Instead of building a large dam that would storage large amounts of water to guarantee that a steady flow goes through the hydropower turbines and electricity outputs are constant, run-of-the-river technology uses smaller dams, so electricity production is affected by hydrological variation. When normal flows of water vary substantially over the seasons – the case of Amazonian rivers –, security of supply is affected, so back-up systems will be activated. And because dispatchability – the possibility of quickly turning it on or off, adjusting electricity output according to demand – is believed by electricity system technicians to be a key feature of a back-up system, thermal power plants fired by fuels that can be stored have played this role. Unfortunately, these fuels are usually fossil fuels.[173] Therefore, the choice of run-of-the-river technology does not mitigate the aggregate impact of electricity production over the environment.

In fact, the share of fossil fuels in electricity production has increased from average 8.97% from 2001 to 2005 to 16.84% between 2001 and 2015 (figure 3.8, below). Although a bad hydrological cycle depleting reservoirs in Southern parts of the country also played a role in increasing the share of fossil fuels in electricity production, it is not clear that this trend will be reversed by favorable weather patterns: in 2016, when rainfall amounts came closer to historical average, fossil fuels still occupied 14.96% of total electricity output (EPE, 2017).[174]

[insert_Figure_3.8: share of fossil fuels in electricity production, average (%)]

Not everybody agrees with this solution. Environmental NGOs, important sectors of the Brazilian academia and supporters of new renewable technologies challenge the idea that present and future security of supply requires either new hydropower plants with large reservoirs or fossil fuel-fired thermal power plants. Their argument is three-

part of the electricity also faces substantial opposition in Brazil and in Peru. Planning was advanced, but has been slowed down after important Brazilian constructors have been arrested in Operation Car Wash. In 2017, ODEBRECHT announced it was selling several projects to Chinese investors. The future of Brazil-Peru partnership is still unclear.

[173] Renewable biomass like sugarcane can, in theory, be stored as well. But in practice it is not, as producers choose to adjust the production of other sugarcane (sugar, ethanol) products instead of keeping stocks. The sector has also suffered major losses due to the control of oil product prices practiced in Brazil from 2006 to 2014, affecting both ethanol and renewable biomass electricity output.

[174] Own calculations, based on data referred.

fold. First, they claim that long-term strategic planning is too optimistic over rates of economic growth that are at the basis of future demand projections; when real rates are considered, expected demand is lower so installed capacity needs to be expanded at smaller rates. Second, they argue that energy conservation and energy efficiency have a substantial role to play in Brazil: except for the 2001 power supply crisis, they have been largely ignored so far. Enacting and implementing policy that tackle both seriously could also reduce projected demand. Distributed generation could play an important role as well. Third, they defend that security of supply can be enhanced by investing in technologies that offer seasonal complementarity to hydropower and are cost-competitive in Brazil, such as wind (PEREIRA and LIMA, 2008, p. 53-54) and sugarcane products.[175] In their view, fossil fuel back-up systems are only an option, reinforced by an outdated understanding of security of supply that is not aligned with key role of climate change mitigation in the agenda of the 21st Century.

This is an ongoing debate in Brazil. In fact, discussing the future of the Brazilian electricity matrix is much more complex than comparing a few technical options and cost-effective solutions (see chapter 04). The political turmoil triggered by Operation Car Wash could affect the outcomes of the debate, but the results of the 2018 elections are key to understand if they will (see chapter 04).

When all stars align: wind energy in electricity generation

In Brazil, potential to generate electricity from renewable sources is significant. The first wind energy assessments were undertaken in the 1970s and highlighted potential for wind turbines in the Northeastern coast of Brazil (AMARANTE et al, 2001, p. 09). Later wind patterns in several areas in the Northeast and in the South of the country were found to be extremely convenient for 50m and 70m-high wind turbines (AMARANTE et al, 2001, p. 09). In 2013, potential to use wind turbines with varying height from 80m to 200m was tested and results were even more encouraging (CEPEL, 2017). In Brazil, the first large-scale wind turbine was installed in 1992, in Fernando de

[175] During the fall and winter season in the South and Southeast of Brazil (where most hydropower plants are located), rainfall decreases; hydropower outputs are lower, as the level of water in reservoirs decrease. Yet, best wind patterns generate electricity take place during the winter and the largest amounts of sugarcane are harvest during this period, so these primary sources could play a greater role in electricity generation, complementing hydropower production.

Noronha islands. Several others followed, in an experimental basis. PROINFA accelerated the development of the wind energy sector in Brazil, and the role of wind energy in electricity generation has increased since 2009.

PROINFA was divided in two phases: the first targeted a short-term – until 2008 – addition of 3,300MW of installed capacity to the SIN, provided equally by wind, renewable biomass and small-scale hydropower plants; the second aimed that the three technologies combined would provide, in 20 years, at least 10% of total electricity consumed annually in Brazil.[176] In the first phase, different incentives were offered to investors: BNDES would finance the projects, but at least 60%[177] of the technology employed should be produced in Brazil; ELETROBRAS would purchase the electricity directly from these producers in public calls offering 20-year contracts that would pay a higher price for electricity output compared to large hydropower and thermal power plants (DUTRA and SZKLO, 2006). PROINFA was financed by a feed-in tariff.[178] Two public calls were made; 1422 MW from wind energy, 1191 MW from small hydropower plants and 685MW from renewable biomass were sold, 3299MW in total (DUTRA and SZKLO, 2006). In the second phase, new projects would participate place in public auctions organized by ANEEL to purchase electricity from "alternative sources"[179] or extra power to keep a surplus in the grid.[180]

Wind power flourished in Brazil after the incentives offered by PROINFA and the system of public bidding that followed it. The wind industry had expanded abroad: Germany and other countries had implemented their own incentives for wind power production and a whole new sector had developed. But it started suffering setbacks by the time the financial crisis hit Europe and incentives for wind energy were reformulated. Brazilian economy was stable and growing at the time – Chinese demand for international commodities kept prices high –; thus, after PROINFA and the regulatory changes in the electric sector, Brazil became a very attractive market for wind power companies. *"It was one of those few occasions in which all stars align"* (Interviewee 45, 14 Jul 2016). In 2008, the wind sector has lobbied to participate in auctions in which

[176] Law nr 10438, from 26 Apr 2002 and Law nr 10762, from 11 Nov 2003.
[177] In the second phase, 90%.
[178] Revenues from *Conta de Desenvolvimento Energético*, created by Law nr 10438, from 26 Apr 2002. An amount is charged from every electricity consumer connected to the SIN, except low-income residential consumers, and put in this account for different uses.
[179] Leilões de energia alternativa.
[180] Leilões de energia de reserva.

wind energy could compete with thermal sources and has offered competitive prices. In some auctions, the prices offered by wind power were even more competitive than what large hydropower plants could offer, no other source could offer the same prices (Interviewee 05, 18 Apr 2016). Since 2009, wind share in electricity production has increased: in 2016, it produced 5.78% of total electricity supply (EPE, 2017).[181]

The federal government understands that wind energy will play a key role in future production of electricity in Brazil (MME and EPE, 2015, p. 91). This position has support from different actors: the wind sector, environmentalists, part of the Academia, some labor organizations and state governments in which wind energy potential is high, who defend that the complementarity of hydrological and wind cycles should be further explored in Brazil. There is no clear opposition to this pledge if the role of natural gas as a back-up energy remains; but when it is argued that wind power could replace natural gas, then long-term electric technicians and actors aligned with the fossil fuels sector oppose it. Their main argument is that security of supply becomes too complex when intermittent primary sources are added to the grid and only cost-competitive storage technologies could change this picture. The debate has a lot of nuances to it; it is not clear how it will develop (see chapter 04).

Further diversifying the electricity matrix: renewable biomass and small hydropower plants

PROINFA has also played a key role in expanding the participation of small hydropower plants in electricity production. They are not a novelty in the grid: the first hydropower projects in Brazil were small-scale and today would classify as such; the oldest small hydropower plant still generating electricity to the SIN is from 1911 (ANEEL, 2017).[182] Yet, the 2001 power supply crisis and PROINFA were important to enhance their status in Brazil: from all hydropower plants operating in the SIN, 66.74% were added after 2002 – after the 2001 supply crisis – and 61.40% after 2004 – when PROINFA's implementation started (ANEEL, 2017).[183] Their installed capacity answers

[181] Own calculations based on data referred.
[182] Small hydropower plants are hydropower plants between 30 and 30000 KW of installed capacity and reservoir smaller than 13km^2 (ANEEL Resolution nr 675, from 04 Aug 2015). Earlier, the limit for the reservoir was 3km^2 (ANEEL Resolution nr 652, from 09 Dez 2013).
[183] Own calculations based on data referred.

for 72.57% and 67.02%, respectively, of total small power plants installed capacity in the grid (ANEEL, 2017).[184]

Brazil has also great potential to generate electricity from renewable biomass. Different raw materials can be used to produce electricity: sugarcane products; rice and peanut husk; coconut shell; biogas; urban waste; forest waste (COELHO, MONTEIRO and KARNIOL, 2012). In Brazil, sugarcane products are largely employed in electricity generation. It is very common to use sugarcane bagasse – what is left after the plant is pressed to take the liquid content out to produce sugar or ethanol –, and straw to produce electricity in the sugarcane industry, a process known as cogeneration.[185] After PROINFA, this electricity started to be sold to the SIN as well. Between 2004 and 2016, the share of sugarcane products in total electricity supply increased from 1.80% to 6.09% (EPE, 2017).[186]

The sugarcane industry is especially strong in the Southeast of the country. Their lobby to increase the share of sugarcane products in the SIN follows a three-fold argument: sugarcane electricity offers zero carbon emissions; it is not intermittent: during 08-09 months of the year, the sector can provide a constant production of electricity; and it complements hydropower, because sugarcane harvest takes place during the Southeastern winter, when reservoirs are depleted (Interviewee 15, 09 May 2016). In some bids in which sugarcane products have competed with fossil fuels and other biomass sources, they were able to offer the most competitive prices – e.g. *16º Leilão de Energia Nova*, from 29 Aug 2016.[187] Ongoing technological progress to produce 2nd generation ethanol has beneficial spillover effects on electricity generation from sugarcane products (Interviewee 05, 18 Apr 2018).

Solar, energy efficiency and distributed generation: status and barriers in Brazil

Brazil has potential to substantially reduce future energy demand if energy efficiency is addressed. During the 2001 power supply crisis, the National Policy for

[184] Own calculations based on data referred.
[185] According to Moreira and Goldemberg, approximately 450-500kg of steam can be produced from 1ton of sugarcane bagasse; steam will be used in the mill to generate electricity and mechanical power (MOREIRA and GOLDEMBERG, 1999, p. 237-238).
[186] Own calculations based on data referred.
[187] Information on the auctions can be obtained in <www.ccee.org.br>.

Conservation and Rational Use of Energy[188] was enacted and several initiatives to reduce energy use either entered into force – the electricity consumption targets, but they were temporary – or were revisited – labelling initiatives. Since 2000, distribution utilities are required to invest a share of their liquid revenues in research and development and energy efficiency measures.[189] But although they must report the amount spent, they are not required to specify in which measures it was spent (Interviewee 01, 04 Apr 2016). Labelling initiatives remain in force,[190] but have accomplished little.

According to federal government's calculations, 2024's projected energy demand could be reduced by 4.7% and projected electricity demand could be reduced by 5.3% if energy conservation measures were implemented (MME and EPE, 2015, p. 373-374). And these numbers project only marginal gains from replacing technologies and appliances for more energy efficient ones (MME and EPE, 2015, p. 375-381): they do not include practices that could have much greater impact on future energy demand – e.g. better electricity transmission; changes in building codes; better transportation infrastructure. These measures require multi-sectoral coordination between different regulatory authorities in the federal government, in states and in municipalities, and coordination not a strong feature of Brazilian public administration.

Compared to other sources, solar energy has been largely neglected in Brazil. Average irradiation in Brazil is much higher than in European countries that have been investing in solar technology; in the Northeast and Central regions of the country, levels are among world's best to generate electricity outputs (PEREIRA et al, 2017). Solar technologies were not included in PROINFA because they were considered too expensive. Solar photovoltaic technology was authorized to bid in electricity auctions for the first time in 2014, when it sold 891MW that entered in the Brazilian grid in 2017 (MME and EPE, 2015, p. 408). Solar projects participated in other 03 auctions to

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[188] Federal Law nr 10295, from 17 Oct 2001 and Federal Decree 4059, from 19 Dec 2001.
[189] Federal Law nr 9991, from 24 Jul 2000.
[190] Electric appliances are classified according to their electricity use following the *Programa Nacional de Conservação de Energia Elétrica,* PROCEL (National Electricity Conservation Program), in force since 1986. Automobiles are also classified since 2009, following *Programa Brasileiro de Etiquetagem Veicular*, PBE (National Automobile Labelling Program); yet critics consider conservation standards of PBE too low compared to the ones in force in Europe, Japan or South Korea – the automotive industry lobbies against raising them.

date,[191] and long-term planning expects that solar will add more 6GW of solar installed capacity to the SIN until 2024 (MME and EPE, 2015, p. 408).

Yet, solar is most competitive in distributed generation.[192] Producing electricity closer to consumer sites reduces transmission losses, improving energy efficiency; fewer future large-scale power plants might be needed as well. The use of solar thermal technology to heat water – in Brazil, electric showers are most common, due to abundant electricity provision in the military government – has increased; in 2017, the federal government has included the technology in low-cost housing projects.[193] It is expected that expanding the use of solar thermal technology will spare 6.7TWh annual electricity consumption by 2024 (MME and EPE, 2015, p. 379).

Yet, there are several barriers for the expansion of distributed generation in Brazil.

First, distributed generation requires smart grids and they are the exception in Brazil. Small scale projects exist, but the topic was largely ignored by the federal government until 2010, when a study group was formed and produced a report (MME, 2010). In 2012 ANEEL enacted the first regulatory piece addressing micro and mini-generation;[194] several larger-scale pilot projects commissioned by distribution utilities followed.[195] Micro and mini-generation were mentioned for the first time in long-term planning in PDE 2022, published in 2013; in the 2015 revision, it was estimated that they can contribute to reduce 100TWh of electricity demand in the SIN by 2024, or 12.64% of total demand predicted for the same year (MME and EPE, 2015, p. 382).

Second, fiscal and financial barriers need to be tackled. Electricity distribution is taxed by states;[196] distributed generation is a type of electricity distribution, so prosumers could be required to pay taxes for generating electricity if they add it to the grid. To revert this situation, in 2015, an agreement was mediated by the federal government to exempt distributed generation from state taxes; 21 states have joined so

[191] Yet, in 28 Aug 2017 there was an auction to terminate several agreements signed in previous bids; 250MW of solar installed capacity planned to enter the grid were cancelled.
[192] Solar could also replace fossil fuels in several isolated grids in areas not connected to the SIN, mostly in the North of Brazil. ANEEL has enacted Resolução Normativa nr. 493, in 05 Jun 2012, to encourage it. However, "*there is strong opposition from actors involved in supplying fossil fuels to the region*" (Interviewee 51, 28 Jul 2016).
[193] Project Minha casa, minha vida.
[194] Resolução Normativa nr 482, from 17 Apr 2012, modified in 2015 by Resolução Normativa nr 678.
[195] A list of the projects can be seen in <http://redesinteligentesbrasil.org.br/projetos-piloto-brasil.html>, retrieved 15 Nov 2017.
[196] Imposto sobre Circulação de Mercadorias e Serviços, ICMS.

far.[197] Lack of financing options for small scale projects is another barrier. Interest rates are very high in Brazil, and despite the low-risk nature of the investment in distributed generation, banks offer no special lines of credit with lower interest rates, so many potential prosumers cannot invest in the technology (Interviewee 60, 12 Aug 2016). If these barriers are tackled and distributed generation expands, the business model of distribution utilities will need to be revised: their revenues are based in electricity sales and these could substantially decrease (Interviewee 51, 28 Jul 2016).

Finally, maintenance is a third barrier. In Brazil, few companies offer specialized maintenance of solar panels, so the service is still quite expensive and the average consumer cannot afford it (Interviewee 60, 12 Aug 2016). The grids themselves will require better maintenance as well to reduce transmission losses, otherwise they could offset gains from distributed generation (Interviewee 60, 12 Aug 2016).

Intervention in the electricity sector

By the beginning of Rousseff's administration, industrial growth had decelerated. Among the incentives discussed to push it was reducing the costs of electricity: power tariffs are very high in Brazil compared to world average, and considered to damage competitiveness. At the same time, part of the utilities concessions contracts would come to an end in a few years; concern over how to honor long-term electricity provision contracts were in the agenda.

In 2012, the federal administration enacted a Provisional Measure[198] that would hit the electric sector hard. The federal government would grant a 20% reduction in the final price of electricity to industrial consumers by (i) exempting the sector from paying some levies;[199] (ii) anticipating the renewal of generation and transmission concessions which contracts would end starting in 2015; (iii) resources from the federal Treasury to restore financial capacity in the sector. The plan would work as long as the vast majority of generating concessions was renewed according to the new rules and rainfall patterns would maintain reservoirs' capacity high.

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[197] Convênio ICMS 16, from 22 Apr 2015, from *Conselho Nacional de Política Fazendária* (CONFAZ).
[198] Provisional Measure nr 579, from 11 Sep 2012, later converted into Federal Law nr 12783, from 11 Jan 2013.
[199] Reserva Global de Revisão, RGR; Conta Consumo de Combustíveis, CCC; reduction of the contribution from distribution utilities to Conta de Desenvolvimento Energético, CDE.

Yet, the opposite took place. Around 40% of the generation utilities whose contracts should be renewed did not accept the conditions offered by the federal government. As a result, they were allowed to sell their power outputs in the spot market – aiming at receiving higher prices – and long-term contracts with distribution utilities were broken. In addition, rainfall levels were low in 2013 and 2014, so short-term power prices escalated. Distribution utilities were forced to purchase electricity in the spot market, paying very high prices – thermoelectric plants had to be activated due to low rainfall levels.[200] And because the government had to honor the 20% discount to consumers in a year of Presidential elections, utilities were not allowed to pass the higher prices to them, facing severe financial losses that were only partially compensated by new financial inputs from the Treasury.

The measure was considered a disaster. Power prices were not reduced due to structural changes in power provision – more efficiency, reduced losses – or in the taxation system. They were artificially and temporarily pushed down, causing great losses to distribution utilities, ELETROBRAS and the Treasury. The electric market was rebalanced after the government enacted a new regime to electricity tariffs, reducing power prices when more hydropower is available – green flag prices – and increasing prices when more thermal power plants need to be turned on – yellow and red flag prices. Distribution utilities recovered from their losses using the new flag system and receiving resources from the Treasury. ELETROBRAS suffered severe losses that added to previous deficits and could lead to corporation default, only avoided so far because ELETROBRAS is supported by the national Treasury. Industrial consumers enhanced their competitiveness temporarily, obtaining larger profits from sales. The citizen, both as taxpayer – due to losses to the Treasury – and consumer – yellow and red flags prices became extensively employed recently –, is, literally, paying the bill.

3.3.3.3. Fuel politics

Legal battles in rounds of auctions

Although the Worker's Party had criticized the new regulatory model for the oil and gas sector in the 1990s, it did not change it when in the presidential office, during Lula

[200] Two auctions were carried to replace the long-term contracts and reduce the need of purchasing power in the spot market, but their results were suboptimal.

da Silva’s and Rousseff’s administrations. Between 2004 and 2015, total area of 416,188 km^2 was object of concessions in 07 rounds (6^{th} to 13^{th}; 8^{th} was cancelled) of auctions; between 07 and 20 Brazilian companies and 04 and 18 foreign companies won concessions in each round; the federal treasury received at least BRL 6.6 billion more than expected in the 07 rounds jointly considered (ANP, 2017). In 2017, in the 14^{th} round, concessions of 37 blocks, amounting to 25011km^2 and BRL 3.8 billion, were awarded to 10 Brazilian companies and 07 foreign companies. Contracts are expected to be signed in 2018.

During this period, different societal groups initiated legal cases against the auctions, for different reasons. First in 2006, during the 8^{th} round. ANP’s call for tenders had restricted the number of areas a candidate could bid for. This clause was largely criticized by groups that interpreted it as restricting PETROBRAS participation – the largest winners of bids so far –; the auction was interrupted by a legal injunction voiding the clause. The injunction was not well received by those who interpreted as interference in the auction process, which otherwise had respected the rules and been transparent since its beginning. (LEITE, 2009, p. 86). The 8^{th} round of auctions was cancelled.[201]

Results of the 12^{th} round were partially voided by legal decisions. In 2014, members of *Ministério Público Federal* – the legal representative of public interests in the federal sphere, created by the 1988 Federal Constitution – started different cases against the exploration of shale gas in sedimentary basins in the states of Paraná and Bahia; in 2016, in Alagoas and Sergipe. The cases required results of the auctions regarding shale gas exploration in the referred areas to be suspended until a regulatory decision from 2012,[202] requesting assessment of environmental impacts in sedimentary basins prior to auctions, is implemented. Injunctions were granted: the results of the auction were suspended regarding shale gas exploration in the areas and ANP was disallowed to call new tenders for shale gas exploration in the areas until environmental assessment is concluded. The first final decision, on the Paraná case, confirmed the injunction.

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[201] Final decision, cancelling all results of the 8^{th} round of auctions, was published in 2013.
[202] Portaria Interministerial MME and *Ministério do Meio Ambiente*, MMA (Inter-ministerial Decision from MME and Ministry of the Environment) nr 198, from 05 Apr 2012.

In 2017, another legal injunction was granted against the 2nd and 3rd rounds of auction of deep offshore oil areas. A *Ação Popular* – legal measure that allows citizens to start a legal case to protect collective rights – was started in Amazonas on the basis that ANP had fixed too low prices for the blocks, so the Treasury was not receiving a just price for the concessions; the end of compulsory participation of PETROBRAS was also questioned (see section "Deep offshore oil: Brazil, an oil power?", below). Several other cases were initiated by the Worker's Party, *Central Única dos Trabalhadores* and several labor unions, in other Brazilian states. Injunction was granted in the Amazonas case, but the federal government could reverse it with a decision from the *Tribunal Regional Federal-1*, the superior court in that jurisdiction, obtained in the following day. The auction was delayed by a few hours only. In the auction, PETROBRAS plus 07 foreign companies in the 2nd round and PETROBRAS plus 06 foreign companies in the 3rd rounds won contracts. To date, there is no new legal decision changing the results of these rounds; but societal groups such as the *Sindicato dos Petroleiros do Amazonas* (Amazonas Oil Workers Labor Union) have stated their intention to appeal.

Oil prices become a heterodox economic tool

Auctions did increase oil and gas production in Brazil. In 2006, Brazil became self-sufficient in oil production, but soon the deficit was resumed. Self-sufficiency, however, is relative. Even when Brazil produces around the same amounts of oil that it consumes, it exports a lot of its oil to be refined abroad and imports foreign oil to be used in refining in Brazil. Brazilian oil is mostly heavy, more expensive to be transformed into oil products like gasoline and requiring specific technology not yet developed domestically. Exporting part of Brazilian oil and importing lighter oil, more expensive, to be mixed with the national product in the refining process allows best gains of national refining technology. But it might generate important deficits in the Balance of Payments.

Albeit no longer a *de jure* monopolist, and competing with several companies in oil and gas exploration and production, PETROBRAS remains a *de facto* monopolist in transportation and refining: too little is imported or refined by other companies. Since the federal government is still the largest shareholder of PETROBRAS, it can successfully intervene in the domestic oil market by controlling prices of refined oil products, even though the strategy might cause substantial losses to the company and face opposition from other shareholders. And this is exactly what happened between 2011 and 2014.[203]

During Lula da Silva's first mandate, Brazilian Balance of Payments accumulated surpluses. International demand for agriculture commodities and raw materials such as iron ore was high, pushed by China; Brazil is very competitive in these sectors and exports broke records year after year. In 2003, the surplus in the Brazilian Commercial Balance was USD 23,7 billion; in 2006, USD 45,1 billion (BCB, 2017). In 2007, deep offshore oil reserves were discovered and the federal government expected Brazil to become a major oil exporter in a short period of time. Public spending, especially with payroll and pensions, rose throughout Lula da Silva's administration, and faster than economic growth. Income and credit were expanded, and consumption followed. But taxes remained high; infrastructure, poor; investment, low; and productivity levels, stalled.

In 2011, by the time Rousseff took office, Brazilian economy was navigating rough waters. Economic activity was slowing down and inflation was rising. On top of facing the effects of the decisions taken during Lula da Silva's administration, the international oil price was rising, so higher inflation rates were expected. In trying to push economic growth and control inflation, the federal government decided to maintain prices of domestic oil products artificially lower than their real ones. PETROBRAS was forced to sell oil products in the domestic market for a lower price than what the company paid to import them. In addition, rate of *CIDE combustíveis* – tax that needs to be paid when fuel is imported or commercialized – was reduced[204] until full exemption in 2012, until 2014. Between 2011 and 2014, oil prices were subsidized by the federal government in Brazil (COSTA and BURNQUIST, 2016).

The consequences of the subsidies were dire. PETROBRAS had to absorb huge losses. The price of its shares collapsed; minority shareholders started lawsuits in the United States, where PETROBRAS shares are also listed – corruption scandals that followed would increase the amount of class actions. By the time the deep offshore oil auctions started, in 2013, PETROBRAS had no financial capacity to invest and keep up with partnerships, as required by law (see next section).

[203] In fact, intervention in domestic oil prices started in 2006, but became more acute after 2011.
[204] CIDE paid over gasoline had started to be reduced in 2008. RAMOS, 2016, p. 70.

The ethanol industry was also penalized. The sector had been investing heavily in renewing and expanding sugarcane plantations, modernizing the mills and harvest mechanization (Interviewee 15, 09 May 2016). Since the international financial crisis hit, in 2008, credit had become more scarce and expensive; rainfall levels had been lower in the period, reducing harvest yields (COSTA and BURNQUIST, 2016). Brazilian light-vehicle fleet increased in the period – the federal government also offered tax exemptions for purchase of industrialized products such as house appliances and automobiles – and most of the new additions were flex-fuel. But because gasoline relative prices were lower than ethanol prices (see section "Ethanol is back: the flex-fuel technology", above), consumers would opt for the first to fill their cars. High debt levels and low earnings accumulated; many sugarcane producers went bankrupt in the period (Interviewee 15, 09 May 2016).

In 2015, after Rousseff was reelected to office, the policy was reversed: international oil prices decreased, but in Brazil they increased and were kept above international levels; *CIDE combustíveis* was also reinstated. This decision was taken to diminish PETROBRAS losses (COSTA and BURNQUIST, 2016). But it affected Brazilian competitiveness deeply. All productive chains were penalized: freight transport is mostly carried by diesel-fueled trucks in Brazil; rising oil prices will affect all economic sectors, raising inflation levels as well. On top of that, electricity became more expensive in the period, due to higher dependence on fossil fuel-fired thermal power plants.

Ethanol diplomacy: big promises, small results

The period between 2003 and 2006 was one of the most favorable to the ethanol industry in recent history. The sector had invested heavily in R&D and technology in previous years, so productivity had risen – from 3900 liters/hectare/year in 1980 to 5600 liters/hectare/year in 2001 (HIRA and OLIVEIRA, 2009, p. 2454).[205] Verticalization was also reducing costs and enhancing scale. Flex-fuel vehicles and higher prices of oil products were sustaining high consumption of ethanol in Brazil.[206] Brazilian ethanol was

[205] Compared to the beginning of the Pro-Alcohol Program, outputs increased from 594,985m^3 of ethanol in 1974-1975 to 27,604,120m^3 in 2010-2011 (STATTMAN, HOSPES and MOL, 2013, p. 22).
[206] It is also argued that the sector received indirect subsidies between 2006 and 2010, when domestic oil products prices were maintained higher than international oil products prices (COSTA and BURNQUIST, 2016) and gasoline retail taxes were 58% higher than ethanol's (HIRA and OLIVEIRA, 2009, p. 2454), but there is no consensus.

also exported more and more, valued by its ability of diversifying the fuel matrix and reducing GHG emissions from fuel use.[207] Former President Lula da Silva and former Ministry of Foreign Affairs Celso Amorim understood that ethanol could be a key diplomatic tool to promote Brazilian leadership in the international system and launched what was later called the ethanol diplomacy.

The ethanol diplomacy was a diplomatic strategy to position Brazil as a leader in international energy debates and enhance Brazilian soft power (MACHADO, 2014). By developing partnerships to share its know-how in sugarcane farming and ethanol production in the context of a growing international market for biofuels, Brazil would increase its leadership in energy and sustainability topics, thus its influence the international system (MACHADO, 2014).

Between 2006 and 2008, Brazil launched different multilateral and bilateral initiatives regarding biofuels. Memorandums of Understanding on biofuels signed in the India-Brazil-South Africa (IBSA) Dialogue Forum and between Brazil and the West African Economic and Monetary Union (UEMOA); a working group on the topic was create in MERCOSUR; bilateral cooperation agreements were signed with Benin, Burkina-Faso, Ghana, Mozambique, Kenya, Rwanda, Ethiopia, Senegal, Nigeria, Guinea-Bissau, Algeria and South Africa; partnerships were established with the United States, the European Union, Sweden, China and Japan (MACHADO, 2014). EMBRAPA – the Brazilian state-owned company leader in agriculture R&D – opened two offices in Africa, in Acra and Maputo. In 2008, the International Conference on Biofuels was held in São Paulo. Between its inauguration in 2006 and 2010, it is estimated that diplomats working in the Division of Renewable Resources of the Department of Energy of the Ministry of Foreign Affairs would spend 80% of their time working on biofuels politics (Interviewee 04, 18 Apr 2016).

The strategy did project Brazilian expertise in the field, but it was largely unsuccessful to create an international market for biofuels. In the United States, Brazilian sugarcane ethanol competes with corn ethanol locally produced; even if the Brazilian product has higher energy content and generates lower lifecycle GHG emissions, lobby to protect national producers is very strong. The same is true in

[207] In California, Brazilian sugarcane ethanol is classified as advanced compared to corn ethanol because its lifecycle emissions are 50% lower than gasoline's, while corn's is 30% lower.

Europe, where Brazilian ethanol has lower penetration and arguments that it could reduce food output are employed to justify its restriction.[208] Sugarcane plantations were introduced in some Caribbean countries, but they largely failed in Africa for reasons that include lack of finance resources after the 2008 financial crisis hit.

After the deep offshore oil reserves were discovered, the strategy was not abandoned, but it lost diplomatic priority. Cooperation initiatives on biofuels were still among the different issues negotiated by diplomats, but they no longer had the participation of the President or the Minister of Foreign Affairs (Interviewee 04, 18 Apr 2016). The strategy did promote the Brazilian ethanol and opened some doors to the ethanol industry abroad, especially in the United States and, potentially, in Asia; but results were small (Interviewee 15, 09 May 2016).

In 2016, during COP 22, Brazil and other 19 countries launched the BioFuture Platform to facilitate dialogue on strategies to "*accelerate development and scale up deployment of modern sustainable low carbon alternatives to fossil based solutions in transport, chemicals, plastics and other sectors*",[209] among them biofuels. So far, the initiative has not borne fruit to Brazilian biofuels. Another major obstacle is the ongoing electrification process in transportation: if storage technology continues to improve and expected outbreaks in solar and wind power take place, combustion engines might become museum pieces quite rapidly.

Deep offshore oil: Brazil, an oil power?

In 2007, PETROBRAS announced that oil had been found under salt layers of the Brazilian continental platform, around 04 to 06 km from the seabed. At the time, international oil prices were rising – average USD 80 per barrel in 2007, and would hit

[208] In Europe, the oil industry, food industry, part of the automobile industry, local producers of ethanol – from beet juice, wheat, agriculture residues – and some NGOs lobby against the Brazilian ethanol (KOHLHEPP, 2010, p. 225). They usually argue that ethanol production increases deforestation in the Amazon region, reduces output of crops used for food and is not sustainable. These arguments are all false. First, sugarcane plantations are concentrated in the Southeast and Northeast regions of Brazil, very far from the Amazon. Second, Brazil has a very large territory and a relatively small area is used to grow sugarcane; much larger areas are employed to grow food, making Brazil one of world's largest food producers and exporters. Third, sustainability criteria have become very stringent lately, especially in the largest producing region, São Paulo, where regulation has improved and investment in new techniques and technologies have been made to respect it. For more details, see KOHLHEPP, 2010.

[209] <http://biofutureplatform.org/about/>

more than USD 100 per barrel in 2008 (BP, 2017).[210] The deep offshore oil was named "black gold" by the federal government, despite the intrinsic risks and high costs of its exploration.

Deep offshore oil discovery reignited or reinforced nationalism in several actors of the Brazilian society. Sectors that have opposed the end of PETROBRAS monopoly started campaigns to grant the company exclusiveness in the exploration of the reserves; the federal government advertised that the exploration would generate revenues that could provide better public education and health services. On the other hand, environmentalists warned that exploring oil so deep could increase risks of leakage and other impacts on marine ecosystems.

Soon after the discovery, debates on how the exploration would be regulated started. Revenues were expected to be high, and states and municipalities wanted to receive part of it. Controversies between governors and representatives of states on the coast near where the oil had been found and other states mounted; it was common to see them in debates in the different commissions of the Parliament and in meetings with the federal government. After long negotiations, in 2010 the regulatory model for deep offshore oil exploration was established.[211]

Production Sharing Agreements (PSA), not concession agreements, would be signed, meaning that the government would be a partner in the revenues of the exploration. On top of the bonus, paid to the federal government in any oil or gas exploration, royalties were also established, 15% of production. Royalties would be divided between the federal government, states and municipalities: part of it would go directly to producing states and municipalities and part would be put in a Social Fund and distributed by the federal government to all Brazilian states and municipalities.[212] In 2013, it was decided that royalties had to be employed in education and public health.[213] PETROBRAS was required to have participation of at least 30% in every project.

In October 2013, the 1st area of deep offshore oil was auctioned. A joint venture between PETROBRAS and foreign companies from 03 countries won the bid to explore

[210] Own calculations based on data referred.
[211] Federal Law nr 12351, from 22 Dec 2010.
[212] The division is: 22% to the federal government; 22% to producing states; 5% to producing municipalities; 2% to municipalities somehow affected by the production (e.g. pipelines or other transportation structures); 24.5% to the social fund to be shared among states; and 24.5% to the social fund to be share among municipalities.
[213] Federal Law nr 12858, from 09 Sep 2013.

a piece of the Santos sedimentary basin. But critics argued that the compulsory participation of PETROBRAS was a stumbling block to receive better offers in the bid, since the company had lost its financial capacity during the period in which the federal government controlled domestic oil products prices and it had to absorb great losses. After long negotiation and political battles between opposing groups, in 2017 the rule was modified: in the next rounds of auctions, PETROBRAS would have right of preference but was not required to participate in the deep offshore oil exploration projects.[214] In October 2017, ANP organized the 2nd and 3rd rounds of auction. PETROBRAS participated in 03 of the 06 winning join ventures and will lead exploration in 03 of the 06 auctioned blocks; foreign companies from 07 different countries will explore the other 03 blocks.

Demonstrations against deep offshore oil auctions were common, but involved a minority of the population. In 2017, groups started legal cases against the auctions and an injunction was granted to stop them; but the injunction was overruled hours later, after the federal government appealed and obtained a different decision. During the bidding procedures, it is common to have minor demonstrations against them in different Brazilian cities.

Exploration of deep offshore oil reserves did increase Brazilian oil output: in June 2017, pre-salt oil production overcame post-salt production; Brazil is now among the largest oil producers. Yet, oil production costs are very different around the world. It is not clear that production will remain profitable if another raise of production outputs from OPEC members – or Saudi Arabia alone, who has the lower extracting costs and produces a very light oil, preferred by the market – is announced.

The rise of biodiesel

The development of biodiesel in Brazil has many similarities with ethanol's. Both emerged to reduce dependence on oil imports and find alternative markets to agriculture commodities that have economic and political relevance in Brazil. Both rely on large-scale agriculture crops as their main source of raw materials. Both have faced or face important opposition from groups that condemn the agribusiness industry and argue that

[214] Federal Decree nr 9041, from 02 May 2017 and Resolution CNPE nr 13, from 08 Jun 2017.

the products promote deforestation, reduce land availability for food production, and are not sustainable. But although the military government tried to add both ethanol and biodiesel in the Brazilian energy matrix, the latter would be incorporated only in the 2000s.

In 1980, after the second oil shock and rising prices of oil, the National Energy Commission created the *Programa Pro-óleo* (Pro-oil Program).[215] The policy expected to mix vegetable oils and diesel into a new fuel for heavy vehicles, 30% being the concentration of the first; in the long run, vegetable oils were expected to completely replace diesel (POUSA, SANTOS and SUAREZ, 2007, p. 5394). The program was not successful; it was abandoned after the international oil prices dropped in later 1980s (POUSA, SANTOS and SUAREZ, 2007, p. 5394).

In 2002, the Cardoso administration launched *Pro-biodiesel:* a research network to add biodiesel to the Brazilian energy matrix was created.[216] At the time, international oil prices were in upward trend. The soy industry had expanded its plantations and productivity was rising: around 1400 tons/month of soy oil were produced in the state of Mato Grosso by November 2000 (POUSA, SANTOS and SUAREZ, 2007, p. 5394). Soybean products international prices were fluctuating, so the industry was looking for market diversification (STATTMAN, HOSPES and MOL, 2013, p. 27). Soybean is not the best oleaginous crop to produce biodiesel but it was widely available – availability and price of raw materials had been key features of earlier biofuels initiatives, in Brazil and abroad (LEITE and LEAL, 2007, p. 20). When the federal administration changed, in 2003, an Inter-Ministerial group was created to study the topic. According to the group, biodiesel could alleviate Brazil's dependence on imported oil and promote social inclusion.

In 2004, *Programa Nacional de Produção e Uso do Biodiesel*, PNPB (National Program for Production and Use of Biodiesel) was enacted.[217] PNPB was designed to be a multi-crop program to introduce biodiesel in the Brazilian matrix and promote the social inclusion of small-scale producers of oleaginous crops (STATTMAN, HOSPES and MOL, 2013, p. 28). The program would offer incentives to encourage biodiesel

[215] National Energy Commission, Resolution nr 07, from 22 Oct 1980.
[216] Portaria from Ministry of Science and Technology nr 702, from 30 Oct 2002.
[217] Federal Decree nr 5297, from 06 Dec 2004.

production, expecting it to reach 2% in the diesel mix between 2005 and 2007. The percentage would become compulsory in 2008.[218] Some benefits would be offered only to small-scale producers of poorer regions producing traditional types of oleaginous crops.[219] Large-scale producers would need to purchase the production of small-scale farmers to receive a social fuel seal and qualify to sell their biodiesel in ANP auctions.

This specific aspect of the program was not successful. Implementing the compulsory mandate required large-scale production of biodiesel. Traditional oleaginous crops – jatropha, palm varieties, castor oil – are produced in small scale and have higher economic value in the cosmetics industry; they could not be cornerstones of biodiesel production (STATTMAN, HOSPES and MOL, 2013, p. 28; Interviewee 09, 20 Apr 2016; Interviewee 10, 25 Apr 2016). By 2009, soybeans were the main source of biodiesel (78.8%); bovine fat (14.6%) and cotton seed oil (4.1%) followed; and other products, including oleaginous crops with higher oil content, accounted for only 2.6% (STATTMAN, HOSPES and MOL, 2013, p. 28). The social fuel seal is still required from biodiesel producers, but it is very unlikely that soybeans will be displaced as the main source of biodiesel in Brazil.

Since the beginning of the program, the industry has lobbied for higher mandates of biodiesel in the diesel mix. In 2016, targets of 8% by 2017, 9% by 2018 and 10% by 2019 were established.[220] The political power of soybeans producers in Brazilian politics is directly related to those targets. They allow the soy industry to employ its idle capacity according to projected demand for soybean bran – its main product, base of animal feed; soybean oil is a secondary product – (Interviewee 09, 20 Apr 2016; Interviewee 10, 25 Apr 2016). Current diesel-fired internal combustion engines can run with much higher concentration of biodiesel in the diesel mix (Interviewee 09, 20 Apr 2016; Interviewee 10, 25 Apr 2016). More ambitious targets would reduce air pollution much faster, with important benefits to public health; but would require imported biodiesel to be met – measure the Brazilian biodiesel sector would oppose.

Biodiesel is more widely used than ethanol: many countries allow light vehicles to run on diesel and have been investing in biofuels to reduce those emissions. Thus,

[218] Federal Law nr 11097, from 13 Jan 2005.
[219] Federal Law nr 11116, from 18 May 2005.
[220] Federal Law nr 13263, from 23 Mar 2016.

Brazilian biodiesel exports would potentially have a larger market than Brazilian ethanol's. Yet, Brazilian soybean-based biodiesel faced important opposition from groups that identified the expansion of soybean production as a key driver of Amazon deforestation. These groups are partially right: soybean plantations are very large in the states that occupy the Southern border of the Amazon region – e.g. Rondônia, Mato Grosso, Tocantins. The international pressure from retailers and NGOs to boycott Brazilian soybean products was very strong, so major soybean traders signed, in 2006, the Brazil's Soy Moratorium: a voluntary agreement that they would not purchase soybeans produced in deforested areas of the Amazon (GIBBS et al, 2015).[221] The agreement is a step forward in the preservation of the Amazon forest and removed obstacles for Brazilian soybean products abroad. But it also shows limited knowledge of the international and the environmental community about the impact of agriculture on Brazilian biomes: soybean production is vastly concentrated in the Brazilian savannah – the Brazilian biome that has faced the largest rates of deforestation in recent decades.

3.4. What and who drives energy politics and policies in Brazil?

3.4.1. The political economy of energy

In the 1970s, energy supply was largely concentrated at the hands of state-owned enterprises. Three were the main reasons for it. First, a tradition of nationalism and centralization that had started during former President Vargas' administrations and was deepened by the military. The state should play a key role in economic development so that national – and not specific groups' – interest would be prioritized. Second, energy supply was considered a topic of national security by the military, not to fluctuate according to the will of markets. Third, a trend of a strong role for the state in economic activity in general, and in the energy sector in particular, was active in international system in the 1970s – present in many, but not every country – and Brazil was embedded in it.

Designating the state to manage energy systems was a common move in the 20th Century. Although private ventures were usual in the origins of the electric sector, few countries, such as the United States and Hong Kong, had maintained the mode of

[221] The agreement was valid until 2016; in 2016, it was established that it remains valid unlimitedly.

regulated enterprise (VICTOR and HELLER, 2007, p. 02). Establishing state-owned enterprises in different economic sectors, including energy, resonated with enhancing the role of the state in the economy, a development model largely adopted in the second half of the 20th Century (VICTOR and HELLER, 2007, p. 255). In emerging economies such as Brazil, China, Mexico, India and South Africa, the first electric enterprises were private for-profit ventures that served major cities; when electricity became an essential service, it was considered too important to be left "*in the hands of profiteers outside the state control*" (VICTOR and HELLER, 2007, p. 255). Maintaining electricity provision under the state control would also allow the government to reap political benefits – of expanding electricity services, highly visible to constituencies, or jobs (VICTOR and HELLER, 2007, p. 255).

In the fuel sector, the creation of OPEC had dramatically increased the role of states as well. The transnational companies once dominating the oil market, the Seven Sisters, lost around 50% of their production share after the nationalizations; their oil output in the Middle East decreased from 25.5 million barrels per day in 1973 to 6.7 million barrels per day in 1982 (AYOUB, 1994, p. 52). In a period of newly independent nations, national sovereignty over natural resources was considered key; countries wanted to obtain either full rent of their oil or have full information to allow what they considered a more equal rent sharing (AYOUB, 1994, p. 50). In Brazil, the nationalist wave that had put water resources under governmental control also affected mineral and oil resources. After PETROBRAS was created, it became monopolistic in Brazil.

While choices made by military governments were embedded in the international political economy, they bolstered interests of key domestic groups, whose support was decisive for the success of the strategy.

First, the military deepened the role of hydropower in Brazil. The largest Brazilian hydropower plants were built or projected during these years, and the first hydropower projects in the Amazon region were seen. Large projects were preferred to take advantage of economies of scale and scope; the SIN was created to connect them to consumer regions. It is easy to see why the military were successful in their strategy being the hydropower industry a well-established sector in Brazil by the time they took office. Brazilian contractors had long built reservoirs; they would support new hydropower projects that would employ their expertise and provide them revenue. In addition, the electricity bureaucracy was recruited mostly in the hydropower sector.

Second, the sugarcane industry had always been a powerful sector of the Brazilian economy. Although its economic relevance could have started to be reduced when industrialization advanced, it retained political influence. Ethanol became a real alternative fuel for light-duty vehicles due to earlier mandatory mix in gasoline, creating market for the ethanol. The Pro-Alcohol was launched to both reduce Brazilian dependence on oil imports and counterbalance low prices of sugar in the international market. It faced important opposition from the oil sector, MME and financial authorities (see section “the rise and fall of the ethanol alternative”, above), but at the end the coalition that favored it was stronger than its opposition.

Third, PETROBRAS was a strong actor in the 1970s. After the oil shocks, increasing Brazilian oil output was a key strategy for a regime that understood dependence on foreign energy supply as a threat to national security. And it was in tandem with PETROBRAS interests. Brazilian oil production flourished under heavy state investment that allowed PETROBRAS to explore offshore oil. It reduced dependence on oil imports and reduced deficit in the Balance of Payments, and it also increased the influence of PETROBRAS in Brazilian politics.

Finally, nuclear energy was also seen as a strategic development by the military government, but it found more opposition than support among Brazilian elites. Although the military and diplomats understood that developing nuclear energy was key to increase security of energy supply as well as to enhance Brazil’s status in the international system, opposition from numerous groups of the Brazilian society – physicists, environmentalists, journalists, engineers, the Catholic church –, arguing the costs and risks of the technology, ecological values and non-proliferation, was fierce. Lack of financing options was key to delay, later deter, further nuclear projects in Brazil, as it was key to delay new hydropower projects. But the coalition against nuclear power played a role as well, given that hydropower projects were later resumed – facing other political issues, of course – but nuclear remains a marginal technology in Brazilian energy matrix.

In the 1980s, the picture was different. At the time, the earlier paradigm of stronger presence of the state in the economy was replaced by liberal reforms that had started to be implemented in the Western hemisphere. In the United States and the United Kingdom, they advanced to transform the economic structure (VIOLA and LEIS, 2007, p. 42). The collapse of the USSR represented the end of socialism and weakened the idea of state intervention in the economy. Market economy and democracy spread around the world. A period of hegemony of democratic market economies in the international system was inaugurated (VIOLA and LEIS, 2007), although the scale in which both democracy and market economy developed in different countries would vary. The core of the international system was transitioning from an industrial society to a knowledge society (VIOLA and LEIS, 2007, p. 42).

Brazilian economy was faltering in the 1980s. Heavily dependent on foreign loans to support its Import Substitution Industrialization, the federal government could no longer contract them when international interest rates were raised. Re-democratization advanced and power returned to civil control. Brazil would join globalization, but its complex and heterogeneous society and economic structure would make the transition to the new paradigm piecemeal (VIOLA and LEIS, 2007).

In the 1990s, following the election of former President Collor and former President Cardoso, a new economic model was implemented. Ideally, the role of government would change from economic agent to economic regulator; the private sector was to become the main economic agent, and market competition was to be the new rule; efficiency and cost-effectiveness would be rewarded. The energy sector was in line to face these adjustments. However, changes were selective. The struggle between what was considered ideal in the view of the federal government and economic agents and intrinsic features of the Brazilian power system in the view of electricity actors limited change in the electric regime. In the fuel sector, reform was less ambitious: fewer actors participated and their interests were accommodated from the start.

Reforms of the Brazilian energy sector were embedded in a global trend. Since the 1980s, industrialized countries – e.g. the United Kingdom – in which the state had played a key role in energy supply, were undertaking reforms to increase the role of private actors and increase economic efficiency, aiming to reduce tariffs (VICTOR and HELLER, 2007, p. 262). Emerging economies followed in the 1990s, although their motivation was different: it was imperative to overcome financial insolvency in the power sector and resume investments in new generating capacity to avoid energy bottlenecks (VICTOR and HELLER, 2007, p. 257; 262).

In Brazil, the electricity sector was in critical shape since investments had stalled, postponing new projects, and costs of generating electricity had been decoupled from electricity tariffs, a (unsuccessful) measure to fight inflation in the 1980s. The federal government aimed at creating a competitive electric market by increasing the number of agents – through privatizing utilities and engaging private capital in new electricity projects – and diversifying the electricity matrix, giving private capital choices to invest other than expensive large hydropower plants.

However, electricity incumbents and the electric bureaucracy opposed it. They argued that a hydro-dominated electricity system was less efficient under full competition, as centralized dispatch is necessary to best use hydropower resources. Although the argument is technical, it is not neutral: if the new model was to be adjusted to hydro resources, it would handicap other sources. And this is exactly what happened: the negotiations to accommodate demands of hydropower agents and hydrophilic bureaucracy delivered a hybrid new model, adapted to the interests of hydropower. Other technologies could never be as competitive as hydro under the new rules, so they were relegated to a secondary role. To date, actors on each side disagree over the causes of the 2001 power supply crisis. Economic actors argue that delays of privatizations and changes to adapt the system to hydropower's interests postponed much needed investments in expanding electricity generation. The hydropower sector and actors opposing the new role of the government in the economy blame federal government's lack of long-term planning for it.

A hybrid model, or dual market, in which private entrepreneurs and state-owned companies coexist, has been the normal outcome of reforms in the electric sector of emerging economies (VICTOR and HELLER, 2007, p. 30). According to the literature, the cause lies in structural forces rooted in the political and institutional context. In other emerging countries that engaged in reforming their electric sector, such as China, India and Mexico, incumbents – the main primary energy source employed in electricity generation in these countries are coal and oil – also resisted (VICTOR and HELLER, 2007).[222] In the contentious process of reform, new organizational and political interests that steer the process from the ideal model are created, and an alternative equilibrium – the dual market – is the result (VICTOR and HELLER, 2007).

In Brazil, the impact of the outcomes of the California electricity crisis also played a role in pushing the sector towards a hybrid model. The Californian crisis, caused by shortage of power and escalating prices due to droughts, delays in new generating plants and market manipulation, took place in 2000-2001, around the same time as the Brazilian power supply crisis. California had partially deregulated its electricity market in the 1990s. In 2000, private wholesalers – Enron Corporation among them – manipulated supply and prices by taking plants offline during peak demand and forcing distribution utilities to purchase power at very high prices; as consumer retail rates were capped, distribution utilities faced severe financial constraints, and power shortages followed. The state of California stepped out to solve the crisis. The crisis fueled the debate of the new model for the electric sector in Brazil, strengthening the arguments of the opposition to full deregulation and decentralized dispatch and increasing acceptance of a hybrid market with centralized dispatch.

In the fuel sector, more competition instead of full competition was planned, for two reasons. First, the financial health of PETROBRAS was not perfect, but the picture was far from the critical situation found in the electric sector. Second, PETROBRAS was both an oil company and a symbol of national sovereignty to large shares of the Brazilian population and political parties. Thus, adjustments that could open the oil sector to international competition as well as adapt PETROBRAS to compete, in Brazil and abroad, were planned. PETROBRAS' monopoly was extinct. Private investors were attracted to oil exploration, now granted by concession agreements negotiated in auctions. PETROBRAS became a mixed-capital company, the federal government remaining the largest shareholder, and kept a *de facto* monopoly in transportation and refining. But the changes were not without controversy: political actors aligned against the new role of the government were largely against it, and protests were common, sometimes violent. The powerful unions from PETROBRAS were major players in limiting the new role of the corporation.

[222] Having larger shares of hydropower in the power matrix makes reforms harder because while initial costs of hydropower plants are massive, their operational costs are very low; unless the system is calibrated it becomes very difficult for alternative fuels to compete (VICTOR and HELLER, 2007, p. 13).

The Pro-Alcohol program ended in 1988. Incentives had been kept by foreign loans, which had become too high in the 1980s. At the time, international oil prices were decreasing and international sugar prices were rising, so interests of the oil sector and sugarcane producers were not hurt – although consumers were, by shortages of ethanol in the domestic market, as well as ethanol-only distilleries, who went bankrupt. Later, the sugarcane industry modernized and increased its outputs, so it was again interested in a larger market for ethanol that could buffer fluctuations of the international sugar market. When the flex-fuel technology became commercially viable, the sugarcane sector, allied with automotive industry, lobbied extensively to have it adopted, so ethanol could be back as a fuel in itself, not only mixed in gasoline. The flex-fuel alternative was attractive to the Brazilian automotive industry because it allowed production to continue after small adaptations of existing engines, which already operate in a gasoline-ethanol blend. The sector – with the exception of companies from Korean and Japanese origins – has resisted stringent energy efficiency labeling for cars offered in the Brazilian market (VIOLA and BASSO, 2016, p. 824-825); offering a full-ethanol engine in Brazil would increase their costs, so the flex-fuel alternative was preferred. Full-ethanol vehicles would also require infrastructure changes, pipelines and reservoirs, never developed in Brazil – ethanol travels from production sites to distribution points in diesel-fueled trucks, a true contradiction (VIOLA and BASSO, 2016, p. 822). Consumers would probably resist them at first, given the memory of the ethanol shortages in the 1990s. The fact that the flex-fuel technology would allow for more competition in the fuel market – although imperfectly, given that prices are administered – was a plus to the Cardoso administration and other actors aligned with the new economic model.

When former President Lula da Silva was elected to office, the Brazilian economy was reorganized and had resumed growth; the fiscal situation was also much more stable, given the adjustments made. International circumstances had also changed: international prices of commodities were rising due to Chinese demand, and Brazil – very competitive in commodities exports – was to be one of the few countries to maintain commercial surpluses with China. Although Lula da Silva's administration did not reverse key changes implemented by Cardoso's administration, it did not pursue them further, steering the economy towards stronger role for the state.

New changes were made in the electric sector. Privatizations stalled. The regulatory model became closer to the fuel sector: contracts for power generation and transmission would be sold in auctions. Long-term planning was resumed; it was decided that it should prioritize security of supply and affordability of tariffs. Hydropower's advantages in the Cardoso's model persisted in Lula da Silva's, the only change being an understanding that, after the 2001 power supply crisis, thermal power plants should be built and kept as back-up systems to provide electricity if low rainfall would affect reservoirs capacity again. This understanding was enforced by auctions that would determine previously which technologies could participate. Hydro and thermal technologies were clearly given an advantage: at first, they were the only technologies allowed to bid in existing power and new power auctions.[223]

Expanding electricity installed capacity was no longer an urgent issue: demand had decreased since the campaigns to reduce consumption in 2001-2002, so there was idle capacity. But long-term planning reassumed projects of large hydropower plants in the Amazon region, facing strong opposition from environmentalists. By the end of the decade, when electricity demand had increased and was rising but controversy over large hydropower plants remained, thermal power plants were more and more employed, pushing electricity prices upwards.

While wind and solar power production increased in the United States and Europe in the 2000s, Brazil remained a laggard, despite substantial potential. Incentives to develop and deploy new renewable technologies had been in place in many industrialized economies since the 1990s; by the 2005, OECD countries share in global electricity production from wind and solar technologies was 90.20% and 91%, respectively (IEA, 2017a, p. 22; 24). China soon joined: changes in the leadership of the Communist Party and long-term planning inserted the Chinese in the race to produce wind and solar technology in large scale. The Chinese government offered substantial incentives to production and deployment of wind technology; regarding solar, at first considered expensive to be employed in China, they aimed at developing an export-oriented solar photovoltaic industry (HOCHSTETLER and KOTSKA, 2015). Later, air

[223] There are five types of auctions in the electric sector: (i) existing power: existing electric projects can sell their output through long-term contracts; (ii) new power: new electric projects can sell their output through long-term contracts; (iii) adjustment: short-term contracts to adjust electricity supply when long-term contracts fail to provide the amount of electricity expected; (iv) reserve power: extra electricity to supply the grid, usually provided by "alternative sources"; (v) PROINFA: only technologies listed in PROINFA can bid.

pollution from coal-fired thermal power plants pushed them to include solar among a varied range of low carbon technologies massively deployed in the country (BASSO and VIOLA, 2014). By 2015, China had world's largest installed capacity in both wind and solar photovoltaic electricity – 129.3 GW and 43.2 GW, respectively; it became the 2nd largest wind power producer, after the United States, and the largest solar photovoltaic power producer (IEA, 2017a, p. 23; 25).

In Brazil, incentives to new renewable technologies were shier. PROINFA, launched in 2002 and regulated only in 2004, embraced wind energy, not solar. It combined a small wind energy target with a national production requirement of 60%, later 90%, aiming at developing a domestic wind industry. The strategy was successful for wind energy: the combination of reserve auctions, subsidized finance from BNDES and market production encouraged the development of a local wind industry, which, unlike solar, involves heavy, low-technology components (HOCHSTETLER and KOTSKA, 2015, p. 82-83). The same framework would not work for the high-tech requirements of solar technology. When the financial crisis hit Europe and wind producers started looking for new markets to invest, Brazil became a preferred destination and wind energy gained scale.

By 2008-2009, wind power was cost-competitive with hydro and thermal power. Long restricted to reserve power auctions and PROINFA auctions, the wind sector lobbied to bid in new power auctions, arguing that complementary hydrological and wind cycles could bring about a hydro-wind electric system, instead of the hydro-thermal that was in place. Wind's participation in bids increased. But long-term electric bureaucrats opposed hydro-wind electric system arguing intermittency would enhance complexity in dispatch.

The picture would change in 2013. Former President Rousseff administration's strategy to force a reduction of electricity prices to consumers backfired after it was not accepted by some generating utilities. At the time, the federal government interpreted that the economic situation in market economies had deeply deteriorated since 2008 because of excess influence of markets and small presence of the state; so international circumstances required stronger presence of the state in the economy (VIOLA and FRANCHINI, 2018). Intervention in the energy sector became common. The government pledged a 20% reduction in electricity prices to push slowing industrial production, but the strategy to guarantee it backfired (see section “Intervention in the electricity market”, above). Distribution utilities were compelled to purchase more expensive electricity in the spot market, where prices had escalated – low rainfall rates in 2013 and 2014 had reduced hydropower output and forced thermal power to be purchased. In trying to mitigate rising power prices, wind, sugarcane products and even solar energy were authorized to bid in new power auctions. At this point, availability overcame electric bureaucracy’s opposition to larger participation of these sources in the grid due to their intermittency – wind and solar – or seasonality – sugarcane products (Interviewee 05, 18 Apr 2016; Interviewee 15, 09 May 2016; Interviewee 45, 14 Jul 2016). But it was short-lived, lasting until rainfall levels increased and hydropower reservoirs levels rose. As for the losses from the disastrous strategy, Brazilian consumers are paying still the bill.

While the structure of the fuel regime did not change from Cardoso administration to Lula da Silva’s or Rousseff’s. Civil society groups have occasionally voiced their opposition to oil exploration and in legal decisions postponed or deterred the exploration of some fields. The discovery of deep offshore oil, however, was a turning point. First, it downgraded the ethanol diplomacy, a keystone of the presidential agenda during Lula da Silva’s 1st term in office; emphasis would be transferred to other issues. It also reignited long-term discourses of national sovereignty over oil and gas resources and increased the use of PETROBRAS as an economic tool. During the 2nd Lula da Silva’s and Rousseff’s administrations, intervention in the oil market escalated. PETROBRAS’ *de facto* monopoly of oil transportation and refining was used to force the company to maintain domestic prices of oil products much lower than international prices so that inflation could be artificially controlled. The lobby of the sugarcane industry against it and the consequences to its producers was not sufficient to revert the measure. The rise of biodiesel is related to lobby of the powerful Brazilian soybeans industry.

3.4.2. Views on co-benefits of energy decarbonization

In chapter 02, we have explored how co-benefits could push energy decarbonization – switching from fossil fuels to low carbon primary energy sources in electricity generation and fuel provision. Since climate change mitigation is a global common good, non-appropriable by groups that promote it, it is a weak catalyst of change in energy systems; energy decarbonization would be more likely when groups might obtain other benefits – co-benefits – from it. We then explored the most commonly perceived co-benefits from energy decarbonization: reducing air, water and soil pollution; reducing risks from energy production; increasing energy access; creating employment opportunities; and enhancing energy security. We concluded that while several of these co-benefits might be at play in different countries as driving forces of climate policies, energy security remains a key objective of energy policy. Thus, energy decarbonization more likely to be pursued when it can help enhancing energy security.

In the beginning of this chapter, we analyzed the structure of Brazilian energy matrix and Brazilian GHG emissions. Brazilian is a peculiar case among the G20 economies because low carbon energy sources occupy a larger share among primary energy sources in the Brazilian energy matrix compared to average. In addition, the energy sector is not the greatest driver of Brazilian GHG emissions. Yet, contrary to the global trend, the share of low carbon energy sources has been decreasing in the Brazilian energy matrix. Given that climate change concerns have been decoupled from energy policy in Brazil (see chapter 04), we now explore if and how co-benefits, especially energy security, could work backwards compared to G20 average: as catalyzers of higher participation of fossil fuels in the Brazilian energy matrix.

Energy security's polysemic nature means energy security will have different definitions depending on how it is framed. The literature has identified that 07 major themes are usually related to it: energy availability, infrastructure, energy prices, societal effects, environment, governance and energy efficiency (ANG, CHOONG and NG, 2015). Understanding, in a specific case, which ones are employed and why requires analyzing the context in which energy security is defined: who defines it is as important as what they mean by it.

Concerns over energy availability have been present throughout the trajectory of Brazilian energy politics between 1971 and 2015. During the military years, securing continued access to primary energy sources was considered a matter of national security. After the first oil shock, this understanding was deepened, and reducing dependence on energy imports became a priority. According to this view, exploring Brazil's own energy resources was the best strategy to guarantee security of supply.

Investing expanding hydropower installed capacity, exploring oil and gas, onshore or offshore, and developing ethanol as an alternative fuel, despite the costs involved – substantial shares of the budget were devoted to it; extensive foreign loans were also contracted – were decisions taken under this framework. But they were also in tandem with interests of influential groups in Brazilian politics, such as the hydropower sector and sugarcane producers.

When former President Cardoso administrations implemented reforms in the energy sector, security of supply was supposed to be guaranteed by a competitive market in which offer and demand determine the optimal output. In the electric sector, increasing diversity of primary energy sources would offer investors more options to enter the market as well as raise competition between sources. Reducing prices was key, and competition between agents as well as managerial efficiency would guarantee it. But the hydropower sector managed to adapt the rules to its benefit arguing that a fully competitive market would harm energy security. In the fuel market, it was expected that the end of PETROBRAS monopoly would attract investors and enhance oil outputs.

During former President Lula da Silva administrations, the understanding about security of supply changed: it became again subject to strategic decision-making. In the electric sector, the federal government would decide in long-term planning which primary sources would contribute to future energy supply, and enforce it in auctions in which the technologies allowed to bid were chosen previously. Tariffs would be kept affordable not by competition but by prioritizing sources that would offer the lowest prices in dispatch. Yet, because thermal power plants were considered the only accepted back-up option – intermittency or seasonality of other renewables was considered to disallow them to play a larger role in the electric grid; nuclear is opposed by large groups in Brazil – the strategy would work only in wet years. When rainfall levels were lower than average and hydropower reservoirs were depleted, more expensive thermal power plants would become the only option, and higher electricity tariffs would follow. During former President Rousseff's administration, tariffs were temporarily forced down by government intervention in the market, harming ELETROBRAS and later all consumers, who now must pay higher prices. And the same happened in the fuel sector.

The trajectory of energy politics between 1971 and 2015 revels three pieces of information regarding energy security. First, it has always been a priority for the federal government. Second, its meaning would change according to preferences of the administration in power, and so would the strategies to pursue it. Third, some actors have sought and obtained regulatory advantages that were reflected in the definition and/or the strategies to pursue security of energy supply.

More specifically, the recent trend of increased participation of fossil fuels in the energy matrix is directly related with the understanding, dominant in the government, electric sector and electric bureaucracy, that only firm energy sources can serve as backbone technologies in electricity generation. According to this view, since the bulk of remaining hydropower potential is located in the Amazon region, where exploitation is contentious, the only option to guarantee continuous power provision is to increase the share of fossil fuels, especially natural gas, in the electricity matrix. Wind energy can play a role as secondary source. But as long as cost-competitive large-scale storage technologies are still unavailable, they cannot have a larger role. Sugarcane bagasse is also considered secondary.

But this is not the only option. Arguments over a new configuration for the power matrix, expanding the use of new renewables to complement hydroelectricity provision and employing the hydropower's reservoirs as batteries of the system, are resisted. Despite proved complementarity between hydrological and wind cycles or sugarcane harvests, or the potential reduction in demand by large-scale deployment of distributed generation, the system is inertial towards the hydrothermal option. The influence of hydropower and fossil fuels' groups in Brazilian politics is related to it. Powerful unions of PETROBRAS and ELETROBRAS, strongly related to the Worker's Party, were also very important drivers for maintaining this understanding.

Other aspects of energy security – infrastructure, societal effects, environmental impacts, governance and energy efficiency – did enter the debates on specific points, but they are largely marginal compared to the importance given to the theme of availability of energy resources. The institutional resistance to accept new actors in energy debates can be partially blamed for it, but lower mobilization of those actors around energy issues, compared to other issues (see section 4.1, below), is also part of the equation.

Other potential co-benefits from pursuing energy decarbonization are also referred very sparsely. The debate over reducing pollution from fossil fuels combustion exists and is important; yet, it has not been strong enough to drive changes in the paradigm of energy policy, making it a valued co-benefit from decarbonization. Two main reasons can be pointed for this outcome. First, given the large share of hydropower in the power matrix, air pollution from electricity generation is not a national issue.[224] Second, as the debate over air pollution has focused changes in the fuel sector, it has faced strong opposition from important groups. Over the decades, regulation to reduce emissions from air pollutants has advanced in Brazil, pushed mostly by air pollution levels in major metropolitan areas. Yet, it still lags behind more stringent regulations from industrialized countries. Law enforcement is a major issue (see chapter 04), but opposition from the automotive industry and fossil fuels sector also help explain why deeper changes have not been adopted.

Compared to Sub-Saharan Africa and regions of Asia, energy access is a minor issue in Brazil. In 2000, in average 95% of the Brazilian population had access to electricity services, compared to average 73% of world population, 23% of the Sub-Saharan Africans, 43% of the Indians and 53% of the Indonesians (IEA, 2017b). In 2016, Brazil achieved universal access to electricity services – only 3% of the rural population still lacks it. Meanwhile, 14% of average world population, 57% of the Sub-Saharan Africans, 18% of the Indians and 9% of the Indonesians remains lacks access to power services (IEA, 2017b). Increasing energy access has been a concern of recent administrations. Policies to create new grids to provide electricity services to communities isolated from the SIN have been enacted. Yet, although they were designed to employ low carbon energy sources – especially solar energy –, many irregularities were found in the execution of projects, as well as opposition from fossil fuel agents (see sections "'Alternative energy' in electricity generation: first steps" and "Solar, energy efficiency and distributed generation: status and barriers in Brazil").

Debates over reducing risks from energy production are also minor in Brazil. They were important arguments of the opposition to nuclear power and sometimes are introduced in the debates against large hydropower plants. Yet, they are hardly present

[224] It is discussed at regional and local levels, especially in regions of coal mining, where coal-fired thermal power plants are employed.

in debates over the impacts of fossil fuels. Lastly, discussion of employment opportunities in the energy sector is largely decoupled from the debate on the adoption of new energy technologies. In fact, hydropower and fossil fuel sectors are large employers in Brazil, and most of the employees are civil servants who fiercely fight for maintaining the stability of their jobs – and this privileged status is subsidized by the rest of the Brazilian population. Entrants in the energy system – wind and solar, particularly – would never offer the same conditions, reason why the job opportunities they could offer are sometimes referred as inferior.

Overall, we learn from this analysis that potential co-benefits from energy decarbonization are largely missed in Brazil, so they do not act as catalyzers of the process. In fact, the major understanding that energy security is lessened by further employment of low carbon energy sources in electricity generation is an important driving factor of the increasing shares of fossil fuels in the energy matrix.

Chapter 04: Brazilian energy politics and climate change mitigation

4.1.1. Climate change mitigation and energy politics are largely disconnected

4.1.1.1. Climate change is not a driving force of energy politics and policies

Concerns over climate change have been marginal in energy politics and policies. Although the issue is referred to in long-term planning since late 2000s, it has not steered it. Scientific data shows that climate change will impact Brazilian energy production, but it has not influenced long-term planning yet. Energy conservation, a key strategy to reduce energy consumption therefore GHG emissions from energy use, is only sporadically implemented in Brazil. Carbon lock-in is taking place in Brazil as much as in most of the rest of the world.

In the 1970s and early 1980s, climate change was not yet a scientific issue, let alone a political one. Environmental aspects of energy production were not considered by the military governments before choosing which energy projects to pursue. Hydropower and sugarcane ethanol fit the military's view of expanding energy production by relying on abundant domestic primary energy sources, thus reducing dependence on energy imports. Had substantial coal or oil reserves been discovered in Brazil at that point, they would probably have been more largely employed as well.

By the 1990s, the energy sector was being opened to private investment and competition. Impacts of energy production would sporadically enter the debate: e.g. large hydropower plants in the Amazon region were opposed by several societal groups. But these manifestations were inserted in a larger picture: social demands had been suppressed over the authoritarian period and social groups now claimed to have their voice heard. Environmental concerns were secondary: although impacts of large hydropower plants were frequently debated, environmental consequences of expanding fossil fuel thermal power production were not (HOCHSTETLER and TRANJAN, 2016). Even the hydropower sector, who lobbied against the new regulatory model, would not include environmental consequences of fossil fuel-fired thermal power plants in their arguments. PROINFA was launched in the context of a power supply crisis as a measure to increase diversification in the electricity matrix.

From late 2000s through the 2010s, climate change became a contentious issue in Brazil, yet largely detached from energy debates. At least three pieces of evidence support this argument.

First, energy conservation is not taken seriously in Brazil. The 2001 power supply crisis was overcome by reducing electricity demand, both by suppressing useful consumption – strategy that should never be repeated – and reducing wasteful use by adopting energy efficiency initiatives, many of which abandoned when higher levels of electricity output were resumed. Energy efficiency initiatives are very shy and uncoordinated in Brazil, despite their potential to reduce present and future energy demand – the 2001/2002 initiatives led to a 7% to 14% permanent reduction in power consumption (OLIVEIRA, 2007, p. 70; COSTA, 2013) –, and so energy-related GHG emissions. On the one hand, lobby against energy efficiency initiatives is silent but real from actors whose business models would be affected by reduced energy demand; no serious debates on how to update them are being held. On the other hand, many more actors would benefit by these measures, but they are dispersed. Differently from other energy-related issues, *“energy efficiency has no political godfather in Brazil”* (Interviewee 51, 28 Jul 2016), so it hardly advances.

Second, by now science has proven that climate change will affect Brazilian energy systems, especially hydroelectricity outputs, but those impacts are not incorporated into long-term energy planning (LUCENA et al, 2009; LUCENA, SCHAEFFER and SZKLO, 2010). Predicted larger periods of dry weather will reduce water flows and affect reservoirs capacity in areas that answer for 70% of total current SIN installed capacity and 63% of total hydropower installed capacity (LUCENA et al, 2009, p. 882). Expanding hydropower production in the Northern region – current strategy of long-term planning – will not help, as lower water flows are expected in the Northern rainy season as well (LUCENA et al, 2009, p. 882). Biodiesel production will be affected if temperatures rise as expected the Center-West region of the country; soybean production might head south, where land is more expensive and already occupied by other crops, including sugarcane plantations used for ethanol production and food crops (LUCENA et al, 2009, p. 887). The federal government defy these predictions by arguing that climate models need to be refined before long-term planning is altered, and claims to be partnering with research institutes to do so (Interviewee 20, 16 May 2016).

Third, carbon lock-in is taking place in Brazil as much as in other countries. As seen in chapter 03, fossil fuels' share in the Brazilian energy matrix was average 48.27% between 1971 and 1975 and average 56.77% between 2011 and 2015 (EPE, 2017). Natural gas use – from average 0.48% between 1971 and 1975 to average 12.33% between 2011 and 2015 in the energy matrix, and from null between 1971 and 1975 to average 10.54% between 2011 and 2015 in electricity generation (EPE, 2017) – is driving this change. The federal government predicts that natural gas demand will increase by 57.26% until 2024, and gas-fired electricity generation by 75.96% (EPE, 2015, p. 49).

The use of natural gas in Brazil has important consequences for current and future Brazilian GHG emissions. First, although Brazil is going in the same direction with the rest of the world by allowing a larger share of natural gas in its energy matrix, its energy emissions are increasing instead of decreasing from this change – because in Brazil natural gas is replacing low carbon energy sources and not more carbon-intensive fossil fuels. Second, the federal government prediction on the future role of natural gas is steering investors' interest towards natural gas exploration and infrastructure and away from developing low carbon energy sources. By reducing the participation of low carbon energy sources in its energy matrix, Brazil might be losing a potential comparative advantage in a future carbon-priced economy.

4.1.1.2. Brazilian environmentalism: the late discovery of energy GHG emissions

First energy-related environmental issues

The environmental movement has evolved in Brazil in parallel with their world counterparts (VIOLA, 1988). At first – beginning in the 1950s through the 1970s – conservation movements emerged. Combining science and developmentalism and focusing on protecting natural areas and wildlife, they argued that development plans could coexist with conservation practices if they were rational, or followed scientific advice (HOCHSTETLER and KECK, 2007, p. 68-70).[225] In later 1970s through the

[225] E.g. the Brazilian Foundation for the Conservation of Nature (FNBC), formed shortly after the military coup; AGAPAN (*Associação Gaúcha de Proteção ao Ambiente Natural*, Gaucho – nickname of the residents of Rio Grande do Sul – Association for the Protection of the Natural Environment), created in 1971 and headed by the agronomist Jose Lutzenberger, who would later become Minister of the Environment in the Collor administration.

1980s, politicization grew. Environmental groups joined one of two types: *loci* of critique of authoritarianism, denouncing the impact of military developmentalism on the environment; or groups that focused local environmental demands (VIOLA, 1988; HOCHSTETLER and KECK, 2007, p. 71-72). The latter mushroomed, especially in the South and Southeast of the country – e.g. campaigning against a new airport site in São Paulo and against nuclear energy (HOCHSTETLER and KECK, 2007). In the 1982 state elections, candidates affiliated with the environmental movement would have, for the first time, a minor participation, running under different parties – none of them focused on the environment – tickets (VIOLA, 1988).

After the re-democratization and the return of the left to the political stage, in later 1990s and through the 2000s, Brazilian environmental movement professionalized, created national and transnational links, and embraced issues from civil society's agenda (VIOLA, 1988; HOCHSTETLER and KECK, 2007, p. 109-110). Many exiles returned, including the ones that had experienced the Green's political ascension in Europe and founded the Brazilian Green Party, in 1987. The 1988 Federal Constitution devotes a chapter to the environment. In 1992, Brazil hosted the Earth Summit. While Brazilian government stances in the Conference failed to show serious environmental commitment, Brazilian environmentalists hosted a civil society forum that gathered hundreds of organizations and, despite some intrinsic disagreements, cemented the environmental movement in the country (HOCHSTETLER and KECK, 2007, p. 115-121; 127-130).

While climate change was not yet a political matter, environmentalists would debate 03 energy-related issues in Brazil: nuclear energy, air pollution and hydropower dams.

The nuclear program was pursued by the military governments in the context of the first oil shocks (see section "first oil shock: nuclear is not an option", in chapter 03, above). In 1980, the federal government and the governor of the state of São Paulo announced plans to build 02 nuclear power plants in Jureia-Itatins, a preserved area of the Atlantic Forest in São Paulo state. Since 1973, an environmental group, Pro-Jureia, had been active in opposing real estate projects in the area (HOCHSTETLER and KECK,

AGAPAN tried to engage more politically, but its actions were severely hampered by the Medici administration (VIOLA, 1988).

2007, p. 81). They were joined by a much larger coalition in opposing the nuclear power plants: the Brazilian Society of Physicists; the Brazilian Society for the Scientific Progress; professional associations of journalists, architects and engineers; feminists; other environmental groups; and even the Catholic church (HOCHSTETLER and KECK, 2007, p. 80-81).

This heterogeneous constituency employed different arguments against nuclear power. Left-wing organizations and the Catholic church alleged mostly economic costs of nuclear power: Brazil was a developing country and most Brazilian still lacked the minimum to live, so resources could be put to a better use in other initiatives (HOCHSTETLER and KECK, 2007, p. 82). Scientists argued risks of nuclear power, in which they were joined by environmental groups, who also added ecological values to the equation. Environmentalists proposed a moral high ground, combining preservation of the environment and development without incurring in unnecessary risks such as nuclear energy. These groups were also active in Rio de Janeiro and Rio Grande do Sul, where they successfully lobbied for an amendment of the state constitution forbidding the construction of nuclear power stations in the state. (VIOLA, 1988; HOCHSTETLER and KECK, 2007, p. 82).

The coalition was successful: the 02 power plants in São Paulo were not built. Both opposition and lack of finance forced the military to abandon projects of 09 nuclear-fired power plants.[226] In 1985, Angra 1, on the coast of the state of Rio de Janeiro, started operating. Works on Angra 2 started in 1981, were suspended in 1986 and resumed in 1994; the power plant began operating in 2000. Angra 3 is still under construction. Opposition to nuclear power is still strong in Brazil. According to PDE 2024, no further nuclear-fired thermal power plants are planned to be built in Brazil (MME and EPE, 2015).

In the beginning of the 1970s, the São Paulo metropolitan area was one of the most polluted in the world (HOCHSTETLER and KECK, 2007, p. 187). Industrial activity in the metropolitan area had expanded fast in earlier decades, and air and water quality suffered. Cubatão, in the surroundings of São Paulo, became internationally known as the "Valley of Death" due to the heavy pollution from petrochemical and steel industries

[226] In 1974, *Plano 90* was enacted. 12 nuclear-fired thermal power plants would be built to complement hydropower in electricity generation. Only 03 projects, Angra 1, Angra 2 e Angra 3, remained.

– thousand tons of pollutants were emitted every day; at least 250 tons of suspended particulate matter, highly detrimental to human health (HOCHSTETLER and KECK, 2007, p. 191-192). The issue was complex; grassroots movements were concerned that strong control of pollution could result in job losses; polluting industries would resist controls (HOCHSTETLER and KECK, 2007, p. 197-198). By middle 1980s, an oil pipeline explosion and several chemical leaks boosted a coalition between grassroots organizations, scientists, political leaders and environmental bureaucracy; regulation on pollution was made more stringent and implementation was monitored (HOCHSTETLER and KECK, 2007, p. 198-200).

When industrial pollution levels decreased but smog remained, controlling pollutants from diesel-fueled heavy-duty vehicles and from the fast-growing light-duty vehicle fleet became more and more relevant. In 1986, *Programa de Controle de poluição do ar por Veículos automotores* PROCONVE (Program to Control Air Pollution from Road Vehicles) was launched.[227] It established phased reductions of pollutants to be obtained by technical adjustments in new vehicles. The program was successful. It targeted a reduction of 91.66% in carbon monoxide emissions, 85.71% in hydrocarbons' and 70% in oxides of nitrogen's (NOx) for light-duty vehicles in 10-year time; emissions from model 1998-1999 vehicles running on the gasoline-ethanol blend had decreased by 95.44%, 89.37% and 84.11%, respectively, compared to model 1988-1989; ethanol-only vehicles emissions were reduced by 95.19%, 88.75% and 82.30%, respectively (ANDERSON, 2009, p. 1018).[228] Since July 1994, heavy-duty diesel-fueled vehicles are required to use metropolitan diesel, containing lower concentration of sulphur.[229]

In-use vehicle emissions would be controlled by periodic inspections. Different Brazilian states established it and found many unlawful changes in engines (HOCHSTETLER and KECK, 2007, p. 210). Yet, in São Paulo state and municipality fought for almost a decade over the jurisdiction to perform inspections – the latter was

[227] CONAMA Resolution 18, from 06 May 1986.
[228] Own calculations based on data of tables 1 and 2, source referred. Raising ethanol in the blend also helped: in 1993, the ethanol blend in gasoline was established in 22% (Law nr 8723, from 28 October 1993). Later, flexibility in setting the blend: between 20% to 24% in 2001 (Law nr 10203, from 22 Feb 2001); between 20% and 25% in 2002 (Law nr 10464, from 24 May 2002); between 18% and 25% in 2011 (Law nr 12490, from 16 Set 2011); and between 18% and 27.5% in 2014 (Law nr 13033, from 24 Set 2014).
[229] CONAMA Resolution 08, from 31 Aug 1993. Sulphur concentration in metropolitan diesel was limited to 2000 mg/kg in 2001; to 500 mg/kg for metropolitan between 2005 and 2006; 50 mg/kg in 2009; and to 10 mg/kg in 2013. ANP Resolutions 310/2001, 12/2005, 15/2006, 31/2009, 42/2009, 65/2011 and 50/2013. Since 2008, biodiesel-diesel blend is compulsory in Brazil – see section "the rise of biodiesel" in chapter 03.

focused on revenues that were expected from it (HOCHSTETLER and KECK, 2007, p. 210). In 2008, a legal injunction allowed the municipality to perform inspections until 31 Dec 2014; after that, inspections were suspended. In 2017, the *Conselho Nacional de Trânsito*, CONTRAN (National Traffic Council) established that, starting in 2019, inspections will be compulsory in all Brazilian states and the federal district, and will be performed by state traffic authorities.[230]

The anti-dam movement started in Brazil as land struggle. It first emerged in the South of the country, gathering intellectuals, usually Catholic church priests living in local communities but linked to international discourses, and owners of small rural properties (ROTHMAN and OLIVER, 1999, p. 49). They argued that dams were disabling traditional ways-of-life by flooding areas considered vital to maintain local communities' livelihoods (ROTHMAN and OLIVER, 1999, p. 50). *Comissão Regional de Atingidos por Barragens* CRAB (Regional Committee of those Displaced by Dams) was established and fought mostly for compensation for *atingidos'* – people affected by the construction of dams, owners of land in the flooded area or not – losses. In 1987, it obtained a substantial victory: CRAB and ELETROSUL, the regional state-owned generation company, agreed that prior to the construction of Itá and Machadinho dams, in river Uruguay, *atingidos* would be compensated in cash or land in other areas. In 1991, the MAB was created, gathering similar dam opposition groups from all Brazilian regions.

During the re-democratization, Brazilian civil society underwent important changes and many alliances formed during the repressive period broke apart. Anti-dam coalitions were affected. In the Catholic church, conservative groups were empowered; rural demands were weakened after 1988 Federal Constitution failed to contemplate the agrarian reform (ROTHMAN and OLIVER, 1999, p. 51); and lack of finance deferred new hydropower projects, thus mobilization against them decreased. At the same time, the environmental movement had become more politically engaged and started winning struggles against industrial pollution in urban areas. Land struggles started to be reframed as a political ecology struggle. The anti-dam movement started a new phase by entering the socio-environmentalism framework.

Around the same time, the Amazon forest had become a focus of international attention. A large transnational coalition (see next section) protested deforestation and

[230] CONTRAN Resolution nr 716, from 30 Nov 2017.

environmental degradation at the region. Large hydropower projects like Balbina and Tucuruí were among their targets (VIOLA, 1998, p. 09). UHE Balbina is one of the greatest environmental disasters in Brazil. Built in a flat area and small size drainage basin, its dam flooded 2360km^2 of tropical forest and generates only 112.2MW of electricity, on average (FEARNSIDE, 1989). The reservoir was built without removing the vegetation. While the flooded forest rots, the water has become acidic, corroding the hydropower plant's turbines (FEARNSIDE, 1989); and its GHG emissions are equivalent of 50% of total annual CO2 emissions derived from burning fossil fuels in the city of São Paulo (KEMENES, FORSBERG and MELACK, 2011). The opted solution for new large hydropower plants in the Amazon region has failed to mitigate both socio-environmental impacts and GHG emissions (see section "large hydropower plants at crossroads: run-of-the-river technology and future power output", in chapter 03) and needs to be part of a broader debate on the future of Brazilian low carbon transition.

Does tacking climate change mean fighting deforestation?

When climate change became a political concern, deforestation was already on the headlines, especially because of the international attention on Brazilian Amazon forest.

By the 1980s, a transnational network that involved local communities, scientists and international NGOs had evolved around the issue of Amazon deforestation (VIOLA, 1998; ROTHMAN and OLIVER, 1999, p. 52; HOCHSTETLER and KECK, 2007).[231] The conflicts in the region had started in the 1970s, after the military governments encouraged the use of the area to produce commodities – to reduce deficits in the balance of payments (VIOLA and BASSO, 2014).[232] Incentives to deforest came mostly from rules on land allocation: starting a procedure to be recognized as owner of a piece of land required its use for over a year, and clearing the native vegetation and putting cattle on it qualified as use (BINSWANGER, 1991). In the 1980s, the rate of deforestation escalated and large empty areas could be seen in satellite images. Rubber tappers would protest cattle ranchers and land speculators, whose activities threatened

[231] Deforestation in the Amazon gained international attention after several foreign scholars dedicated to study local communities' struggles and shared their knowledge abroad (HOCHSTETLER and KECK, 2007, p. 164). Brazilian Amazon had "a powerful hold on the imagination of the green movement": the loss of forest was visible and villains and victims could be easily pinpointed (HURRELL, 1991, p. 197).

[232] Migration of small rural producers had also been bolstered by the military, but small land owners integrated better with the local communities. Large land owners, on the other hand, arrived with different objectives.

their traditional ways-of-living. After the murder of one of their leaders, Chico Mendes, in 1988, the first prosecutions of land owners in the Amazon were started; the socio-environmentalist discourse was incorporated by new and old organizations in Brazil and abroad (HOCHSTETLER and KECK, 2007, p. 165).

Yet deforestation rates remained high. Between 1990 and 2005, 18,353km^2, on average, of forest were cleared every year – 29,059km^2 in 1995 and 25,000km^2, on average, between 2002 and 2004 (INPE, 2017).[233] In 1996, a Provisional Measure required Amazonian landowners to maintain the forest in 80% of their land – *reserva legal*.[234] In 2001, although keeping 80% was still the rule, exceptions to reduce it to 50% were approved.[235] But enforcement was weak. This changed in 2003: deforestation was given political priority after Marina Silva, ex-rubber tapper, became Minister of the Environment (2003-2008); stronger institutional capacity and more effective law enforcement were put in place (HOCHSTETLER and VIOLA, 2012, p. 760-761). Cooperation between states and the federal government was boosted (VIOLA and FRANCHINI, 2012); new national parks and conservation units were created, and law enforcement became more effective, especially after the Brazilian Forest Service was put in charge of overseeing activities in forested areas[236] (HOCHSTETLER and VIOLA, 2012, p. 761; VIOLA, 2013). Carlos Minc, Minister between 2008 and 2010, continued Silva's work.

In addition, new collaborative networks emerged (HOCHSTETLER and KECK, 2007; VIOLA, 2013). Illegal logging was traced by NGOs and their sales in industrialized countries decreased. In 2006, large soybeans consumers established the soybean moratorium, an agreement that they would not purchase crops produced in deforested areas; in 2009, a cattle moratorium was also put in place – cattle ranching (GODAR, TIZADO and POKORNY, 2012; MARGULIS, 2003) and soybean production are the

[233] Own calculations based on data referred. Data refers to deforestation in all Brazilian states in the Amazon region ("Legal Amazon").
[234] Provisional Measure nr 1511, from 25 Jul 1996, altering the Forest Code, Law nr 4771, from 15 Set 1965. *Reserva legal* is an area inside the rural property that needs to be preserved to allow the sustainable use of natural resources. It is different from *area de proteção permanente* (permanent protection area), area around rivers or other hydric courses that must be protected to preserve hydric resources. The Provisional Measure would be reedited several times until 2001.
[235] Provisional Measure nr 2166-67, from 24 Aug 2001. It allowed *reserva legal* in the Amazon area to be reduced to 50% if the landowner could present proof of potential use of the area for economic purposes in a sustainable way (agreement from environmental and agriculture authorities was necessary). In 2012, the new Forest Code (Law nr 12651, from 25 May 2012) was enacted, and maintains this latter understanding
[236] Federal law nr 11284, from 02 Mar 2006.

main economic activities of owners of large land properties in the legal Amazon. The murder of the activist Dorothy Stang, in 2005, increased media attention to the issue. New finance – in 2008, the federal government established the Amazon Fund to collect donations, including foreign, to the protection of the Amazon forest, allowing BNDES to allocate them to initiatives against deforestation and sustainable use of the biome[237] – also helped. After 2005, deforestation rates started to decrease. The 2006-2014 average deforestation rate was 8,356km^2/year, 54.47% lower than 1990-2005's; the 2009-2014, 6,059km^2/year, 67% lower (INPE, 2017).[238]

When climate change entered Brazilian politics, deforestation became its focus. The fact that climate change mitigation was backed by large coalitions in Brazil is related to this link with Amazon deforestation. Given that LULUCF emissions have long had the largest share in Brazilian GHG emissions, reducing Brazilian emissions meant reducing deforestation, especially the largely-advertised and protested Amazon deforestation. Very few actors of the Brazilian society would be against it given that the Amazon had emerged to public opinion as a national treasure that should be preserved.

It is true that action to reduce emissions from other sectors is in the agenda. *Plano Nacional sobre Mudança do Clima* (Brazilian Climate Change Plan) – developed by an Inter-Ministerial Committee on Climate Change[239] as a framework for Brazilian climate action – describes measures to be undertaken in different sectors, including energy. Yet, some still lack implementation. Some were implemented half-way – e.g. incentives to ethanol production, abandoned after the deep offshore oil was discovered and the ethanol diplomacy failed to make an international commodity out of it (see section "ethanol diplomacy: big promises, small results", in chapter 03). Finally, other measures have been implemented but the climate objective was ignored – e.g. the program to guarantee universal access to electricity by creating isolated electricity generation in areas too far from the SIN, which ended up using fossil fuels as a primary energy source in much larger scale than renewables (see section "'alternative energy' in electricity generation: first steps", in chapter 03).

[237] Federal Decree nr 6527, from 01 Aug 2008. Norway is one of the greatest donors to the fund.
[238] Own calculations based on data referred.
[239] Federal Decree nr 6263, from 21 Nov 2007.

Reducing emissions from energy production and use is much harder than reducing LULUCF emissions. Energy systems are embedded in complex economic and political relations that constitute society itself. Change will involve political struggle between groups with different, sometimes opposing, interests, pursuing a wide range of objectives, sometimes non-energy related, through energy politics. In addition, societal concern over energy matters *per se* was usually low in Brazil: unless an atypical event – such as the ethanol shortage in the 1990s or the power supply crisis in 2001/2002 – took place, few groups would occupy themselves with energy politics.

This is changing, though, and activities in the Parliament show it. The *Comissão Mista sobre Mudança do Clima,* a committee involving Federal Representatives and Senators to discuss and monitor climate change action in Brazil, was created in the Parliament in 2007,[240] and energy-related debates are frequently in its agenda. When we compare the 08 *Legislaturas* – legislative periods of 04 years, duration of a Federal Representative mandate – since the re-democratization, the number of energy-related Projects of Law presented by Federal Representatives has escalated.[241] While only 05 *Frentes Parlamentares* – political groups, with participation of Congresspeople and societal groups, created around an issue to increase its debate in the Parliament – were dedicated to energy-related issues in the 52nd *Legislatura* (2003-2006), 19 were in the 55th.[242]

4.1.2. A low-quality democracy and its impact on energy politics

Between 1971 and 2015, Brazil changed. The economy grew, but at a lower pace than average emerging economies: in 1975 Brazil was the 8th world economy and remained in the same position in 2016. The agriculture sector modernized and industries were created. The population more than doubled and became increasingly urban. And democracy was reinstated. These changes have deeply impacted both the composition of the Brazilian society and interests of its groups. Yet change was not complete. Many features of the old regime – older than the military years – persisted after re-

[240] *Ato Conjunto* (between the House of Representatives and the Senate) nr 01, from 28 Feb 2007.
[241] See annex 02. We compared the number of projects of law including ten energy-related words proposed in the House of Representatives between the beginning of the 48th and the middle of 55th Legislature (1987-2016). Change is visible after the 51st (1999-2003).
[242] Numbers for the 55th *Legislatura* (2015-2018) are considered only until 31 Oct 2017. See annex 03.

democratization, and impacted ongoing transformation in several fields, including energy.

First, a disclaimer. This issue – long-term features of Brazilian societal organization and their impact on the political sphere, if not on several other spheres – is very complex. Researchers from different training have dedicated themselves to it extensively. We cannot ignore it, as it influences energy policy and politics. Yet, a proper analysis would require a much deeper delving into these matters, which is not the point of this dissertation. Thus, we opt for briefly discussing some cultural/sociological traits and their impact on the political system, then the implications for energy politics.

In Brazil, patrimonialism, cronyism and short-term thinking have always settled the tone of socio-political relations. They can be observed since Colonial times, when perhaps they were also typical in other places of the Western hemisphere, and more clearly since the end of the 19th Century, when transition to a Republican form of government required their substitution by values that would put society and politics more in tune with collective goals and demands. They were certainly eased: increasingly, actors understand the importance of adopting universal values and long-term thinking to build a true community. Transition to democracy enhanced hopes that old values would be mitigated even further. Yet, they were not extinct, and deeply affect the political system.

In the first Brazilian democratic experience, from 1889 to 1930, politics was an activity of the elites, as in most countries in the world at that time. Following patterns that had been established during Colonial times and through the Monarchic period, civil society was weak and excluded from political participation. Patrimonial elites and political leaders would rule through clientelism and patronage. Power would be concentrated at the hands of individuals: political parties were a façade for personal power, serving individual's interests. And although national territorial unity had been maintained throughout the Brazilian history, politics remained decentralized, a local business – which further enhanced power of local coalitions. Fraud and coercion dominated elections. (MAINWARING, 1999, p. 65-69).

Between 1946 and 1964, the second democratic experience, the first modern political parties – embracing the masses – emerged. Political participation had expanded and civil society was more organized, especially in more urbanized areas, where information could travel faster. Labor unions had been formed, not spontaneously, though: corporatism dominated them. Peasant unions could also be seen. Where transformation was deeper, landlords lost political power – but they were still very strong in rural states. From now on, elites would need to conquer some popular allegiance to rule. Yet clientelism and patronage, not true mass entitlement, were used to build political support (MAINWARING, 1999, p. 73-75).

During the military period, two structural transformations deepened and further modified Brazilian society, affecting our third democratic experience: industrialization and urbanization. Both phenomena had started earlier but intensified and became irreversible during the military rule. Industrialization raised the relevance of industrial and financial elites in Brazil (WEYLAND, 2005, p. 102). More connected to global transformations, those elites would favor macroeconomic reforms that were adopted in the 1990s, in which they were not joined by traditional elites, who benefit from a closed economy. Urbanization increased complexity of social structure: urban groups are more heterogeneous than rural groups, so interests became more fragmented (WEYLAND, 2005, p. 102). In the 1980s, groups united to fight for democracy, but soon after democracy was resumed their differences became evident.

Re-democratization gave room for civil society activities and political representation. Yet, because profound traits of Brazilian politics – patrimonialism, cronyism and focus on narrow interests – were not erased, a stable, but low quality democracy, was the result.

Two factors contribute for the stability of Brazilian democracy. First, fragmentation. Contemporary social groups are heterogeneous, and so are their short-term interests. As they focus in pursuing these, they do not build alliances with other groups to advance common demands. Each group sees democracy as an opportunity to pursue their own interests. But the more each group presses their narrow interests, the more they become susceptible to divide-and-rule tactics and cooptation (HOCHSTETLER, 1997; WEYLAND, 2005, p. 102). Therefore, a complex social structure increases small-scale conflicts – between groups, more and more common in the Brazilian society –, but dissipates large-scale ones – uniting groups for a common cause – that could endanger the system.

Second, the left was included in the political debate. Its representation in the Parliament has been increasing – 20.1% of the elected federal representatives were affiliated to left-wing parties in 1990, 22.4% in 1994 and 1998, and 32.5% in 2002 (RODRIGUES, 2009, p. 21). With the left, different causes, once excluded from the political debate, are now part of it, so there are fewer incentives to overturn the regime (WEYLAND, 2005, p. 102). Yet, it does not mean that the debate on public interest gained political momentum. Although the left has, in the world, historically defended the public interest, in Brazil the left has been dominated by populism and many left-wing groups have roots in corporatism. While they act to defend privileges for their group, they contribute to fragmentation and become pray of the divide-and-rule and cooptation tactics as much as any other group.

Brazilian democracy is low quality because public interest has never guided it. The impulse of incorporating it to the new democracy, in the 1980s, was largely outshined by lobby of different interest groups – by then more numerous than before – that felt entitled to pursue their narrow interests in the new regime (WEYLAND, 2005, p. 102; VIOLA and LEIS, 2007, p. 80). Privileges were expanded, not reduced (VIOLA and LEIS, 2007, p. 80). In addition, budgetary clientelism – targeted benefits offered by the Executive for legislative support (HOCHSTETLER, 2017) – and patronage remained largely employed in political activity.

Brazilian party system is weakly institutionalized (MAINWARING, 1999). The number of political parties exploded in the 1990s and the 2010s – Brazil has the most fragmented party system in the world. A new electoral law abolished requirements to vote a straight party ticket, allowed representatives to change parties at will as well as alliances between them in elections at the municipal, state and federal levels, and removed threshold for representation in Congress (MAINWARING, 1999, p. 100). Between 1982 and 1994, 68 political parties had at least one candidate running in an election (RODRIGUES, 2009, p. 20). In 1995, 23 political parties were officially registered in Brazil (RODRIGUES, 2009, p. 20). In 2015, 28 parties had Representatives in the lower house of Congress; the largest one had only 13% of the Representatives.

Most parties are still disconnected from broad societal interests they are supposed to represent: they fail to enact a true programmatic agenda and debate it with both society and their peers. Party allegiance is at best unstable: politicians act on personal strategies pursuing narrow interests of their own or of their immediate support group; they might change parties to enhance their chances of doing so. Political parties' weak roots in society discredit them as legitimate societal representatives: parties and politicians are the least-trusted institutions in Brazil (MAINWARING, 1999, p. 127).

Yet, while politicians are certainly to blame for their behavior, they do so in the context of long-term questionable relations between them and patrimonial elites – and other groups joined them after the re-democratization. From this angle, they do represent society as it is. The representation deficit is real when we consider that the Brazilian society is highly heterogeneous. More and more Brazilians value public interest, accountability, transparency; several sectors have been investing in increasing productivity and efficiency, breaking the rent-seeking vicious circle. These groups coexist with traditionally-thinking ones, even if the division between them is blurry – the duality is clearer in economic activity. But no political party represents the forward-thinking (VIOLA and LEIS, 2007, p. 80-81). In fact, "*the deficit between the economy that keeps the country running and the politicians that govern it is one of the greatest problems of contemporary Brazil*" (VIOLA and LEIS, 2007, p. 81).[243]

Therefore, political parties remain peripheral to the government process and the administration becomes the dominant focal point of pressure group politics (HAGOPIAN and MAINWARING, 1987; MAINWARING, 1999, p. 125). Citizens decide their vote based on individual figures rather than party affiliation (MAINWARING, 1999, p. 125). Some hope that an individual candidate will be able to remain uninvolved with the political system and still deliver partially on their pledges. Others reinforce the damaging logic by offering support to candidates that, if elected, will act on behalf of their narrow interests. The non-modern part of the business sector would go to the extreme of offering support to different individual candidates, enhancing their connections in a future government (MAINWARING, 1999, p. 125).

This has major consequences for energy politics. Energy production has traditionally involved large infrastructure projects that require substantial initial funding and massive investment. And infrastructure projects are a favorite tool for rewarding legislative support in Brazil (HOCHSTETLER, 2017, p. 264). Several Brazilian contractor companies that are investigated under corruption charges in Operation Car Wash have

[243] Free translation from Portuguese.

been involved in building, e.g., large hydropower reservoirs. It is common that hydropower projects' initial budget is overrun by 50% to 100%. Contractors blame licensing procedures for it. Yet while the Ministry of the Environment and licensing authorities might be defending a different set of priorities from other Ministries and contractors regarding large hydropower plants, the corruption scandals point that licensing procedures are not the main cause for substantial delays and cost increases.

In our interviews, corruption was referred as an important obstacle for a deeper transformation of Brazilian energy production and use (Interviewee 02, 07 Apr 2016; Interviewee 30, 31 May 2016; Interviewee 34, 07 Jun 2016; Interviewee 37, 15 Jun 2016; Interviewee 51, 28 Jul 2016; Interviewee 56, 02 Aug 2016). Small hydropower plants and wind energy projects are not corruption-proof, but they involve actors different from traditional powerful sectors and, usually, lower budgets. Larger use of renewable fuels could challenge the dominance of the powerful oil actors. While we cannot state that this is a major obstacle for their larger participation in the energy matrix – we cannot even guarantee that, given the chance, these actors would not engage in spurious practices themselves; we have evidence that they act to defend their own narrow interests as well, e.g. the lobby from soybeans sector to keep the biodiesel mandate under levels that can be produced by domestic companies, avoiding competition with biodiesel imports –, we cannot state the opposite either. Solar distributed generation, smart grids and energy efficiency invert the dominant – centralizing, large projects – logic in the energy sector, so they would be even less prone to corruption practices. And yet they are largely opposed – not in speech, but in lack of action on e.g. regulatory change, infrastructure adjustments, finance opportunities for *prosumers* – by a large share of politicians and bureaucrats.

As we wrote in our disclaimer, it is not the focus of this dissertation to delve into these matters further, as they are very complex and require careful investigation to produce scientific evidence. But it is crucial to have them in mind, especially when discussing an overarching and contentious issue such as energy production and use.

4.1.3. Some lessons from our analysis of energy politics and policies

We draw four main observations from our analysis of energy politics and policies.

First, energy decision-making is concentrated in the hands of the federal administration. This means that changes in the federal government can lead to important changes in energy policy. Having in mind that in Brazil patrimonial elites have actively participated in politics and that the administration is the dominant focal point of special interests, the profile of the administration and its support base will substantially influence the policy output. We can observe that during the 1990s, more competition was aimed, so market agents were invited to the sector; in the electric sector, some diversification of primary sources occurred as well. When the administration changed, competition was reduced. Lula da Silva’s administrations tried to use the energy sector to project Brazilian influence in the international system, with impacts in the domestic market. During Rousseff’s mandates, intervention in the energy sector increased.

Yet, some energy actors are powerful and will influence decision-making. Hydropower agents managed to adjust the new model for the electric sector to benefit their primary source. The sugarcane industry lobbied for flexible-fuel light-duty vehicles to increase ethanol’s consumption, creating a buffer for fluctuations of international sugar prices. Soybeans producers influenced legislation that establishes the biodiesel mandate and its subsequent increases. Energy decisions, thus, are taken according to a combination of federal administration profile and the influence of energy actors interests.

Nevertheless, actors that emerged more recently – wind sector, sugarcane biomass for electricity production – are not as able to shape the debate. They depend on circumstantial opportunities – e.g. escalating electricity prices after the unsuccessful intervention of the federal government in the electric market and lower rainfall rates in 2012/2014 – to gain more space in the sector. Other actors – solar photovoltaic and distributed generation, energy efficiency – have even lower capacity to influence the debate.

Long-term planning is also concentrated in the hands of the energy bureaucracy and seem unsusceptible to other actors’ influence, especially outside the energy sector. PDEs – the annual pieces in which the administration details 10-year plans for the energy sector – are published in two versions. The first is a preliminary version, open to contributions from any societal actor. The second is the final version. We compared the preliminary and final texts of 04 PDE editions – PDE 2021, PDE 2022, PDE 2023 and PDE 2024 – and found that, apart from some layout changes or longer elaboration on economic premises, the preliminary and final texts are identical. A caveat: we did not have access to the information of how many contributions had been made to these PDE editions or their content, as it is not available. The preliminary version of PDE 2026 was published, and 62 contributions were sent,[244] but the final text is not yet available.

Second, the participation of non-energy actors in the energy debate is low and they usually fail to form a consistent coalition to pursue their demands. It is true that they do not have enough space in official energy stances: only 01 representative from the civil society and 01 representative of the academia are members of the CNPE (*Conselho Nacional de Política Energética,* National Council of Energy Policy), responsible for assisting the President in establishing the guidelines of energy policy.[245] But they also engage little when opportunity is given: among the 62 contributions to PDE 2026, only 07 belong to civil society actors, including environmental NGOs, and 05 to the academia.

We identify two connected reasons for this. One, non-energy actors do not seem interested in energy topics *per se*; their engagement happens when energy topics become a means to an end. Societal actors protest hydropower plants because they displace populations and impact biodiversity; they oppose industries when they pollute their air and water; they favor solar thermal or solar photovoltaic electricity to reduce their power bills. This observation carries no judgement in it: energy actors also act pursuing specific ends. But it leads to our following observation: focus is usually on narrow interests, which are heterogeneous from group to group, thus preventing larger coalitions, which could carve more space for participation in the political debate, to be formed.

Groups fight a large hydropower project because it will displace them or people they know, or affect their ways-of-living; but they would hardly oppose the project if it was built somewhere else. The same is true for wind projects. NIMBY research can explain it. This focus on narrow, near-term interests leads to irrational situations such as: in Brazil, we have consistent opposition to large hydropower plants but hardly none to fossil fuel thermal power plants (HOCHSTETLER and TRANJAN, 2016, p. 509-510), despite their extremely harmful effects to human health, the environment and climate change. Run-of-the-river technology was adopted in hydropower plants in the Amazon

[244] See annex 04.
[245] Federal Decree nr 3520, from 21 Jun 2000.

region, requiring larger use of thermal power plants, thus increasing GHG emissions and environmental effects elsewhere. Environmentalists fit the same pattern: they "*frame environmental issues in adversarial ways, sharply dividing the actors who cause the problems from those who would solve them*" (HOCHSTETLER and KECK, 2007, p. 19).[246]

Third, the long-term is largely missed. The federal administration fails to truly incorporate it in energy planning: future energy demand is projected from past demand plus expected economic growth that usually fails to materialize; future electricity expansion does not include climate effects on rainfall patterns or water flows, which will affect hydroelectricity output. In the Parliament, the debate is piecemeal. Other societal actors also ignore the long-term: apart from future scenarios built by some academic actors and environmental NGOs, society is not discussing which energy system Brazil should develop to tackle its varying problems. This is tributary of our low-quality democracy: seriously considering the long-term means focusing on what is best for the collectivity, and not specific groups.

Fourth, climate change is a marginal concern in the energy discussion. This is no surprise considering the first three observations: tackling climate change is a public good; it would hardly be a priority when decision-making is concentrated in the hands of a few actors are focused on short-term and narrow interests and issues are framed in an adversarial fashion. Without a serious perception of public interest and public good, climate action depends on large coalitions understanding that valued co-benefits would result from it.

In the energy sector, these coalitions do not exist. In the energy debate, when climate benefits are argued, they are usually coupled with short-term interests. The wind sector explores it to enhance its role in the electricity matrix, although climate is not their main argument, but cost-effectiveness; the same is true for the solar and sugarcane sector. To the civil society, the connection between energy and climate change is still largely missed; when it participates in the energy debate, its demands target specific

[246] We are not, by any means, stating that environmental impact of large hydropower plants should be ignored. In fact, we compiled a list of the current large hydropower plants that obtained operation license – the last license of the environmental licensing process – to find that a very small number did offer environmental compensation for their impact (see Annex 05). But a broader debate with society, one that includes local environmental impacts but also national and global, and considers climate change, is missing.

projects focusing their own narrow interests. Some environmentalists and most of the academia are more capable of seeing the big picture, but their ability to influence the debate is very low, because special interests are much more powerful (VIOLA and FRANCHINI, 2018).

4.2. BRAZIL IN THE INTERNATIONAL CLIMATE REGIME

Understanding the trajectory of the Brazilian positions in the climate change regime requires combining international and domestic elements: political economy, including bureaucratic politics and politics in the largest GHG emitting sectors, and paradigms of foreign policy. In the previous section, we have tackled the first part of the equation, so now we focus on the second: the intersections between climate politics and Brazilian foreign policy in the period.

4.2.1. Brazilian foreign policy and trajectory of Brazilian positions in the climate regime

4.2.1.1. 1990-2006: Brazil is a conservative climate power

Although Brazilian foreign policy features more continuity than rupture, some change can be observed. In the late 1980s and early 1990s, the early days of the climate regime, important transformations in the international sphere were taking place. Liberal reforms were spreading around the world, increasing the role of private agents in the economy. Revolutions in communications, information and transportation and the collapse of socialism propelled globalization (RICUPERO, 2017, p. 547). A global market for trade, investments and financial flows was rising; companies were becoming increasingly transnational, creating global value chains; innovation was replacing hard resources as key economic asset (VIOLA and LEIS, 2007; RICUPERO, 2017, p. 573).

Re-democratization was underway in Brazil, and a new government was directly elected after its campaign to modernize Brazilian economy and join globalization. Brazil would abandon the Import Substitution Industrialization in favor of economic opening and reforms aimed at changing the role of the government from the main economic agent to regulator. Private agents would drive the economy, and competition would raise quality of products and services. But transformation would not be complete. Being Brazilian society very heterogeneous, some sections would align with the change, transforming their activity and productivity; other sections would still perform traditional activities with low productivity. (VIOLA and LEIS, 2007, p. 42; RICUPERO, 2017, p. 586).

Nevertheless, this transformation influenced change in Brazilian foreign positions compared to previous decades. Brazil would accept limitation to its national sovereignty; embrace human rights, protection of women and reproductive health; improve the protection of intellectual property rights; strengthen relations with its neighbors, especially Argentina; condemn nuclear proliferation and accept a partnership with Argentina to mutually monitor the use of nuclear power in the countries; condemn terrorism; accept freer trade and promote MERCOSUR as a strategy to better integrate the Brazilian economy in a globalized world (VIOLA, 2004, p. 33; RICUPERO, 2017). By doing so, Brazil was abandoning its authoritarian past and becoming a modern country (RICUPERO, 2017).

This change included new stances regarding environmental treaties. Brazil became member and internalized all environmental treaties signed at the time: the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal;[247] the Montreal Protocol on substances that deplete the ozone layer[248] and its London amendment; [249] the Convention on Biological Diversity; [250] the Global Environmental Facility[251] (VIOLA, 2004, p. 35-36). Brazil applied to host the 1992 United Nations Conference on Environment and Development, the Earth Summit, to mitigate its international picture of an environmental villain granted after "the disaster of 1987" (STODDARD, 1992, p. 527), when records of deforestation in the Amazon were largely advertised (HOCHSTETLER and KECK, 2007, p. 113). During the Conference, Brazil actively defended an agreement on carbon emissions, arguing that climate change was relevant and should be given priority by the international community, although countries had different historical responsibilities to the issue and those should be reflected in action to mitigate it (VIOLA, 2004, p. 38). But it opposed a binding agreement on forests,

[247] Signed in 1989; Brazil accedes in 01 Oct 1992 and the treaty enters into force in Brazil in 30 Dec 1992.
[248] Signed in 1987; Brazil accedes in 19 Mar 1990.
[249] Signed in 1990; Brazil accedes in 01 Oct 1992.
[250] Signed in 1992, and Brazil is a founding member.
[251] Created in 1990, Brazil participates since 13 Jun 1994.

discussed in the same occasion, siding against other major forest countries (VIOLA, 2004, p. 38) – the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests was adopted instead. This opposition would be later voiced in the climate regime during the discussions of the Kyoto Protocol.

Understanding this discrepancy requires considering the domestic realm. When former President Cardoso took office, he inaugurated a period in foreign policy in which Brazil would be very realistic in considering its power assets. It would place itself as a global middle power, whose strength was founded on soft power assets: culture, long-term stability and lack of conflict with neighbors, strong diplomatic tradition of cooperation in international affairs (RICUPERO, 2017, p. 587-588). Re-democratization and the recently acquired economic stability also boosted Brazilian international profile. Brazilian performance was globally relevant in some areas, such as international trade, but a larger global presence was limited by domestic structural issues; the country remained a key regional power in South America (RICUPERO, 2017, p. 587-588).

Brazilian positions in the climate regime were affected by domestic structural issues. While further opening the Brazilian economy to globalization and private capital, the Cardoso administration encouraged investment in several economic sectors, including mining, energy, timber exploration and soybean plantation – activities developed in different Brazilian areas, including the Amazon region, with great impact in deforestation. The administration had low capacity to fight illegal deforestation and weak surveillance technology – a radar system became operational only in 2002 (VIOLA, 2004, p. 39). Having deforestation as the main source of emissions, Brazil adopted a defensive standing in the climate regime. It would support the Kyoto Protocol as long as: (a) it would not impose binding commitment for developing countries, arguing that historical/cumulative per capita emissions should serve as basis to calculate responsibility for mitigating emissions, maintaining the right to develop as a fundamental component of the world order (VIOLA, 2004, p. 40; HELD, NAG and ROGER, 2012, p. 59); and (b) commitments would not involve forests – what, in the Brazilian interpretation, meant they remained under national sovereignty (VIOLA, 2004, p. 40).

Brazil also proposed that money from fines imposed to Annex 1 countries that did not comply with their emission reduction targets should be destined to a Clean

Development Fund, to be employed in mitigation activities in non-Annex 1 countries. The proposal was rejected. Brazil and the United States articulated to transform it in a market mechanism instead, the Clean Development Mechanism, CDM. When CDM was approved, Brazil would accept that reforestation and forestation would count as carbon sink activities, but not avoided deforestation (VIOLA, 2004. p. 41). Brazilian negotiators worried that including it would make Brazil internationally liable for high rates of deforestation in the Amazon (HOCHSTETLER and VIOLA, 2012, p. 761).

By acknowledging the relevance of climate change and supporting the regime while charging industrialized countries with action to mitigate it and denying the inclusion of deforestation in the treaty, Brazilian position was a mix between globalist stances that underlined foreign policy at the time and nationalistic positions from earlier periods. In 1972, during the United Nations Conference on the Human Environment in Stockholm, Brazil had led developing countries against industrialized ones by considering that concerns with the environment were an imperialist agenda from Northern countries, denying the right to development (VIOLA, 1988). Since then, the opposition to environmental treaties had changed. But the understanding that Brazil could not engage further either because forests should remain under national sovereignty or further commitments from emerging economies would jeopardize their right to develop had not.

In the context of the ratification of the Kyoto Protocol, some changes started to be seen in domestic climate institutions. In 1999, the 2nd Cardoso administration created the *Comissão Interministerial de Mudança Global do Clima*, CIMGC (Interministerial Commission on Global Climate Change) to coordinate action on climate change across ministries, institutionalizing the issue in the government. In 2000, the *Fórum Brasileiro sobre Mudança do Clima*, FBMC (Brazilian Climate Change Forum), an informal channel gathering representatives from municipal, state and federal levels, NGOs, academics and business to discuss ideas on climate change was inaugurated (VIOLA, 2002). Although these institutional changes did not affect Brazilian positions in the international regime or enhance domestic commitment with the issue, they formed the basis of a governance apparatus that would develop further in subsequent years.

When former President Lula da Silva was elected to office, international and domestic circumstances had changed. Prices of international commodities were in upward trend, to the benefit of large commodity exporters like Brazil. After adjustments during *Plano Real,* fiscal stability had improved – further adjustments were needed in 2003, following increased deficit in 2002 – and Brazil had resumed economic growth. Between 2003 and 2006, Lula administration maintained economic measures that the former administration had implemented, guaranteeing economic stability, but no longer pursued measures that would push it forward: privatizations ceased; educational, labor, pension and tax reforms were postponed. The federal government became again a more central actor in economic activity by strengthened role of state-owned enterprises, use of national resources for political ends and economic intervention, measures that would be intensified after 2006.

In foreign policy, although the new administration maintained some of the initiatives established by the former, such as active participation in World Trade Organization's Doha round to reduce barriers to Brazilian agriculture production and the focus on South America as a strategic area to better integrate Brazil and its neighbors into the international system (RICUPERO, 2017, p. 608), Lula da Silva implemented important changes. The realistic view on Brazilian power was replaced with an understanding that Brazil was and should behave – and be treated – as a global power, joining the United Nations Security Council as a permanent member, participating in military and peace missions and increasing its international presence in other continents, especially Africa (RICUPERO, 2017). In addition, taking advantage of their higher profile in international affairs in the period, Brazil would focus on partnering with emerging economies, believing that those partnerships would boost Brazilian position in the international system (RICUPERO, 2017; VIOLA and FRANCHINI, 2018). Partnerships with other developing countries were also established. The IBSA (India, Brazil and South Africa) dialogue, the Forum BRICS (Brazil, Russia, India, China and South Africa), the Africa–South America Summit, the Summit of South American-Arab countries, the CARICOM (Community of Caribbean Countries)-Brazil summit are among the South-South initiatives (RICUPERO, 2017, p. 608).

Climate change was a marginal issue in the early years of government. Yet, former President Lula da Silva chose Marina Silva, a long-term and internationally respected environmentalist, as Minister of the Environment (2003-2008). In addition to implementing important bureaucratic changes – creating a specialized environmental career path for public servants and defending her technical staff against other ministries, whose priorities not always matched – she created cooperation strategies between Amazonian state authorities and the federal government and monitored regulatory changes – and their enforcement – that effectively led to reduction of deforestation rates (HOCHSTETLER, 2017, p. 266-267; HOCHSTETLER and VIOLA, 2012, p. 761, VIOLA and FRANCHINI, 2018).

4.2.1.2. 2006-2011: transition to moderate conservatism

The reduction of deforestation rates is at the heart of the change in the Brazilian position in the climate regime from conservative to moderate conservative.

Amazon deforestation rates started to decrease in 2005: from 27,800km^2 in 2004 to 19,000km^2 in 2005; in 2009, 7,500km^2 of Amazon forest were lost (INPE, 2017). Change was tributary to important regulatory and institutional advances in forest governance. First, a 1996 modification of the Forest Code – implemented since 2006 – increased the minimum area to be protected by landowners in the Amazon region to 80%. In 2006, a new law allowed the Union to transfer areas of its property to private agents that could manage it sustainably and established the Brazilian Forest Service to oversee activities in forested areas. [252] In 2007, a pilot program of Payment for Environmental Services, PES for forest protection – Forest Protection Payment – was instituted in the state of Amazonas. New national parks and conservation units were created,[253] and law enforcement became more effective: the number of law enforcement operations to deter illegal logging and fines levied for violation of forestry regulations were record. (HOCHSTETLER and VIOLA, 2012; VIOLA and FRANCHINI, 2012; VIOLA, 2013).

Positions of most governors and several mayors in Amazonian states changed. If earlier they opposed any commitment with reducing deforestation, decreasing rates of deforestation and the opportunity to receive CDM funds to undertake forest conservation reverted their stances. Amazonian landowners and agriculturalists responded to pressure from transnational environmental networks: NGOs started to trace illegal logging and their sales in industrialized countries decreased; large consumers

[252] Federal law nr 11284, from 02 Mar 2006.
[253] Federal law nr 11284, from 02 Mar 2006.

established the soybean and cattle moratoriums, according to which they would not purchase crops or beef produced in deforested areas (HOCHSTETLER and KECK, 2007; HOCHSTETLER and VIOLA, 2012; VIOLA, 2013). They, self-interestedly, created a coalition with environmentalists and the Ministry of the Environment, overcoming the long-term position of diplomats and participating in the development of REDD+ in COP15 (HOCHSTETLER and VIOLA, 2012, p. 762; VIOLA and FRANCHINI, 2018).

Reduced deforestation broke a new balance between the governmental authorities that influenced Brazilian positions in the international regime. Ministers of the Environment had traditionally been recruited due to their environmental profiles, as opposed to many other Ministries, usually offered by the President to political parties in exchange of legislative support; hence, they maintained, at least partially, responsiveness to environmentalists (HOCHSTETLER, 2017), actors that had been committed with strong climate action since the 1990s (HOCHSTETLER and VIOLA, 2012). When deforestation rates were reduced and more actors came to support a stronger Brazilian commitment in the climate regime, they strengthened the positions of the Ministry of the Environment. The Ministry of Foreign Affairs and Ministry of Science, Technology and Innovation, who had usually shaped Brazilian commitments, acquired a new, and more reformist, partner (HOCHSTETLER and VIOLA, 2012; VIOLA and FRANCHINI, 2012; KASA, 2013).

Business coalitions were also formed to pressure the federal government to change its position in the climate regime. In June 2009, the United States House of Representatives approved the Waxman-Markey Act, imposing border taxes for imports from countries without climate commitments. The US Senate later rejected it, but corporations worried about their competitiveness in the international market (HOCHSTETLER and VIOLA, 2012, p. 762-763). Three corporate coalitions emerged around middle 2009, to pressure the federal government for new stances in the climate regime.

First, *Aliança de Empresas Brasileiras pelo Clima* (Brazilian Business Climate Alliance), formed by 14 companies from agribusiness, planted forests and bioenergy sectors.[254] It pressured the government to reduce deforestation in the Amazon region and to accept market mechanisms for avoided deforestation (VIOLA, 2010, p. 102; KASA, 2013, p. 1058). Second, *Carta Aberta ao Brasil sobre Mudanças Climáticas* (Open letter to Brazil about Climate Change), gathered 22 large Brazilian companies led by *Vale*, *Instituto Ethos*, *Pão de Açúcar* and CPFL. They requested the government to make a formal commitment to reduce emissions and adopt policy to consistently reduce the curve of emissions growth by focusing on energy efficiency, controlling deforestation, reforestation of degraded areas and market mechanism for avoided deforestation; in exchange, they committed to publish annually their GHG emissions and use it to inform their managerial decisions and, later, reduce them (VIOLA, 2010, p. 102; KASA, 2013, p. 1058). Third, *Coalizão de Empresas pelo Clima* (Corporate Coalition for Climate), led by AES Brasil, Shell, AMBEV and *Fundação Brasileira para o Desenvolvimento Sustentável* was more ambitious: it requested the federal government to undertake mandatory emissions reductions by 2020 compared with the 2007 baseline (VIOLA, 2010, p. 103).

In addition, public opinion's knowledge on and support for climate action increased. Extreme weather events raised public opinion's awareness: in 2004, a hurricane formed in the South Atlantic caused substantial damage in the state of Santa Catarina, something never experienced before in Brazil; in 2005, drought in the Amazon region affected harvest outputs and caused forest fires (HELD, NAG and ROGER, 2012, p. 68). Intense coverage of the media over climate topics was substantial: a study monitoring global warming reportage across 50 national and regional newspapers between 2005 and 2008 found that their number rose by around 200% in the 1st half of 2007 due to coverage of the Stern Review, Al Gore's documentary "An Inconvenient Truth" and IPCC's 4th Report (HELD, NAG and ROGER, 2012, p. 68-69). Compared to global average, Brazilians are rhetorically very supportive of environmental policy in general and climate action in particular – but willingness to support is never matched by willingness to pay (BAKARI and BERNAUER, 2017).

After Marina Silva left Lula da Silva's administration in 2008 – over disagreements on priority of traditional developmentalism, defended by other Ministries especially since

[254] The bioethanol industry, a member of the Alliance, had been defending change in the Brazilian position since 2006 and lobbied in favor of a domestic emission trading market in Brazil and international market for carbon offsets (KASA, 2013, p. 1058).

2006, and environmental protection – and became a candidate in the 2010 Presidential elections, the climate topic was included in the campaign. Other candidates were forced to acknowledge it, and did to different degrees. The federal government and the candidate supported by Lula da Silva, Ms. Rousseff, were forced to raise the status of climate change in the national debate, and it accelerated the change in the Brazilian position in the climate regime. (HOCHSTETLER and VIOLA, 2012, p. 763-764; HELD, NAG and ROGER, 2012, p. 69; VIOLA, FRANCHINI and RIBEIRO, 2013, p. 295-296; VIOLA and FRANCHINI, 2018).

In 2007, the federal administration created the *Comitê Interministerial sobre Mudança do Clima* (Interministerial Committee on Climate Change),[255] headed by the Ministry of the Environment to coordinate national action on climate change.[256] Since May 2008, Carlos Minc had replaced Marina Silva in the Ministry. In 2009, the committee discussed the voluntary pledge that would be presented at COP15. Brazil committed to reduce 36.1% to 38.9% of its curve of emissions growth in 2020 emissions.[257] The 2009 pledge was an advance from earlier positions, considering Brazil had been reluctant to accept emission reduction targets; but it was still very poor because the baseline was an inflated business-as-usual emissions scenario (BASSO and VIOLA, 2017, p. 182). Tributary to the dependence of international climate positions on domestic action, Brazil was simply saying to an international audience that it was going to do what it had already started to do (HOCHSTETLER and VIOLA, 2012, p. 768; VIOLA and FRANCHINI, 2018). The commitment was incorporated into the National Climate Change Policy.[258]

Despite its transition to moderate conservatism, Brazil remained allied with the very heterogeneous G-77/China group and carved a new coalition with carbon-intensive economies – China, India and South Africa, members of the BASIC alliance with Brazil – in the climate regime. These alliances cannot be understood by looking at assets that play an important role in climate change mitigation: Brazil has higher participation of low carbon primary energy sources in the energy matrix compared to world average, and

[255] Federal Decree nr 6263, from 21 Nov 2007.
[256] The committee enacted *Plano Nacional sobre Mudança do Clima* (National Plan on Climate Change), in 2008, the coordinating piece of national action on climate change. Several action courses already existed and were recast as climate action (HELD, NAG and ROGER, 2012, p. 62).
[257] Later included in the *Política Nacional sobre Mudança do Clima* (National Climate Change Policy) by the Federal Decree nr 7390, from 09 Dec 2010.
[258] Law nr 12187, from 29 Dec 2009.

potential to further increase it; low per capita carbon emissions if LULUCF emissions are zeroed; potential to substantially reduce emissions if energy efficiency and conservation are undertaken. By focusing these assets, partnership with reformist powers – the European Union, Japan, countries that might not share Brazilian assets but have made real commitments to advance decarbonization – would make more sense. Instead, the alliances were formed within the new paradigm established by former President Lula da Silva in foreign policy and, most importantly, the “Workers’ Party parallel diplomacy” (RICUPERO, 2017, p. 612).

During Lula da Silva’s mandates, the multipartite consensus that has historically marked Brazilian foreign policy was largely dismissed (RICUPERO, 2017, p. 609). The upgraded role of the Office of the Presidential Advisor on Foreign Affairs, headed by Marco Aurélio Garcia – a long-term advisor of the Workers’ Party – in designing foreign policy in parallel with the Ministry of Foreign Affairs throughout the three Worker’s Party mandates was key (RICUPERO, 2017, p. 612). More strongly in some areas than others, foreign policy was no longer beyond party politics, representing the interests of the Brazilian state, but became subordinated to the Workers’ Party objectives and ideology (RICUPERO, 2017, p. 611). Eager to promote Brazil as a great global power, Lula da Silva would use South-South partnerships as a preferred strategy to pursue it (RICUPERO, 2017).

Examples abound in South American countries and Africa. In countries as different as Angola, Peru, Mozambique and Equatorial Guinea, large Brazilian contractors such as Odebrecht and OAS – now investigated by Operation Car Wash– won contracts to explore large infrastructure projects, many times financed by subsidized BNDES loans; Brazilian vessels were sold to Namibia while the Brazilian Navy took charge of training the new Namibian naval force (ZANINI, 2017). BNDES also financed infrastructure projects in Argentina, Cuba, Ecuador, Nicaragua and Venezuela while these countries were governed by leftist parties aligned with Workers’ Party values. Most strikingly, Lula da Silva’s administration quietly accepted the nationalization of PETROBRAS assets and operations in Bolivia, adding to the huge losses of the company (RICUPERO, 2017, p. 620-622). By inaugurating Brazilian diplomatic representation in countries with which Brazil has little or none economic or political affairs and trying to compete with China as a new international donor, Lula da Silva’s administration made clear how much it misjudged Brazilian real power assets – and mismanaged resources of the Treasury. The illusion of the Brazilian great power status was quickly made clear after the commodities boom was over and the effects of measures from the "new economic matrix" dismantled economic stability.

In any case, according to this framework, remaining a member of the G-77/China in the climate regime makes sense because Brazil is a developing country, sharing with other members the same development demand. The BASIC alliance – inserted within the G-77/China group and working to enhance the positions of developing countries in the climate regime – is another coalition of emerging economies to help rebalance the international system. The BASIC members, with some variation, have already been partnering in other groupings. The IBSA dialogue promotes international cooperation in varied topics, e.g. education, energy, science and technology, agriculture. The forum BRICS has pressed for reforms of the IMF and World Bank structures to increase the role of emerging economies, although its capacity to influence the world order is much more restricted than the Workers' Party foreign policy discourse acknowledges (VIOLA and FRANCHINI, 2018). The paradigm of foreign policy implemented during the Workers' Party mandates played an important role in reverting Brazilian moderate positions and maintaining Brazil as a conservative climate power in the international regime (VIOLA, 2013, p. 323).

4.2.1.3. 2011-2015: return to conservatism

Between 2011 – particularly since 2014 – and 2015, Brazil resumed a more conservative profile. At first, while deforestation rates remained lower, energy and agriculture emissions were becoming more relevant in total Brazilian emissions. By involving these groups, coalitions needed to support stronger climate stances became more complex and more difficult to be formed (BASSO and VIOLA, 2017, p. 182). Since 2014, when deforestation rates started rise again – a 60% increase took place between 2014 and 2017 –, the situation has become more dramatic. Brazil is resuming its earlier profile of a laggard in controlling deforestation (VIOLA and FRANCHINI, 2018), and reformist stances became even less likely to be pursued in the near-term future. During the 2011-2015 period, Brazilian foreign policy remained aligned with the paradigms established by Lula da Silva's administration, although former President Rousseff established a much lower profile due to her aversion of foreign affairs (RICUPERO, 2017, p. 643-645).[259]

In 2011, due to changes in domestic policy and politics regarding especially the energy sector, but also LULUCF and agriculture, Brazil went back to the traditional conservative standing in the climate regime. It joined other UNFCCC members in requesting industrialized economies to commit to a second period of compulsory emissions reduction targets before emerging economies accepted binding targets. In 2012, Brazil hosted the United Nations Conference on Sustainable Development (Rio+20). Although it was not an exclusive climate conference – it was centered on Agenda 21, the outcome of the 1992 Earth Summit[260] – it was an opportunity to further climate commitments. But Brazil framed the conference broadly and promoted a diffuse definition of green economy – in which developmental issues are at the core of sustainability –, against a more consistent one defended by the European Union (BASSO and VIOLA, 2017, p. 182). While the links between sustainability and social and economic issues should never be disregarded, this changed the focus of the discussions on climate change from the very resisted but unavoidable topic of deepening emission reduction targets. At COP18, in the same year, Brazil reaffirmed its 2011's position. At the occasion, the Kyoto Protocol was renewed for a 2nd commitment period without targets for emerging economies.

In 2013, at COP19, Brazilian position was a negative surprise. The delegation it reinforced the common but differentiated responsibilities and reinstated the doctrine of historical emissions as the pivotal stone to calculate carbon rights. According to it, countries responsibilities to climate change mitigation and consequent should be measured against cumulative emissions, and not present-day emissions. The doctrine had never been accepted by industrialized countries and has been strongly criticized by

[259] Former President Rousseff did take positions to differentiate its foreign policy from former President Lula da Silva: by choosing a new Minister of Foreign Affairs; by reducing Brazilian standings regarding the Palestine-Israel conflict and the Arab Spring; by voting to condemn violations of human rights in Iran (RICUPERO, 2017, p. 644). Yet, similarities between foreign policy positions of the two mandataries are much more common than differences: the incident involving the suspension of Paraguay from MERCOSUR, against long-term Brazilian diplomatic standings, to allow Venezuela to be confirmed as a member of the bloc is an example of it.

[260] Two were the main themes: how to further sustainable development by promoting sustained and inclusive economic growth, social development and environmental protection, and how to improve international coordination for sustainable development.

most scientists and analysts. On top of representing a recipe for major failure of international cooperation, since blaming the present generation for the behavior of previous generations leads to perpetual conflict, it is also unfair to other countries: while it recognizes that emerging economies are different from developed ones it forgets that the former differ from poorer countries – and these are a lot more vulnerable to climate change. Brazil had abandoned the doctrine in 2009; reinstating it was an important setback in Brazilian positions, contributing to further put the country on the grounds of conservatism.

In 2014, at COP20, Brazil went further to propose the concentric differentiation of countries, which only difference regarding the unsuccessful Kyoto Protocol is that it divides the world in 03, not 02 groups. The group in the central circle, required to undertake binding emission reductions by the Kyoto Protocol, is still constrained by compulsory emission targets; countries placed in the 2nd and 3rd circles, around the central, are not, but can adopt emission reduction targets if desire; all targets must be determined nationally, and no enforcement measure to increase compliance is established. The doctrine is a variation on the theme of common but differentiated responsibilities, presenting the same distortions as the doctrine of historical emissions.

By 2015, countries were required to present their Intended Nationally Determined Contribution, INDC to prior to the COP21, in Paris. Brazil pledged to reduce, by 2025, GHG emissions by 37% below 2005 levels and indicated its intention to reduce emissions by 2030 43% below 2005 levels. The Brazilian INDC has both positives and negatives. On the one hand, it indicates a baseline, which is an advance compared to the business-as-usual scenario of the 2009 pledge. On the other hand, deforestation peaked in 2005, so it is a poor baseline. Besides, pledges for specific sectors – merely indicative, as stressed by the text – either are too broad or lack ambition.

Regarding LULUCF emissions, Brazil pledged to strengthen and enforce the implementation of the Forest Code. Yet, the Forest Code was changed in 2012 to allow the area of *reserva legal* to be reduced. Although consistent implementation of the law is always welcomed, in this case the law itself represents a setback in fighting deforestation. Brazil also pledged to zero illegal deforestation by 2030, which means that for a decade and a half deforestation rates could remain high as they are now. The pledges to restore and reforest 12 million hectares of forests by 2030 and to enhance sustainable native forest management systems are welcomed. Yet, given the recent setbacks in controlling deforestation affecting the status of implementation of earlier pledges, it is still very difficult to see how these new targets will be enforced.

In the agriculture sector, Brazil pledged to strengthen the *Programa Agricultura de Baixo Carbono, Programa ABC* (Low Carbon Emissions Agriculture Program), to restore 15 million hectares of degraded pasturelands and to enhance integrated crop-livestock-forestry systems in 05 million hectares, all by 2030. The objectives are positive, but almost irrelevant. First, finance opportunities and subsidies for conventional agriculture – which, in Brazil, employs very high rates of fertilizers, affecting the global cycle of nitrogen, and record rates of pesticides – were expressively higher than the ones destined to *Programa ABC* in the period 2012-2016. Second, according to information from EMBRAPA, Brazil has around 172.3 million hectares of pasturelands (DIAS-FILHO, 2014, p. 12); 50% of it are severely degraded and 25% moderately degraded, so around 129.2 million hectares are degraded (DIAS-FILHO, 2014, p. 24). The INDC target of restoring 15 million hectares is very shy.

Finally, in the energy sector, Brazil pledged to: (a) increase the share of sustainable biofuels in the energy mix to approximately 18%; and (b) achieve 45% of renewables in the energy mix, through (b.1) expanding the use of renewables other than hydropower in total energy mix to between 28% to 33%, (b.2) increasing the share of renewables other than hydropower in electricity supply to at least 23%, and (b.3) achieving 10% efficiency gains in the electricity sector, all by 2030. Except for the efficiency target – which is sadly ambitious considering the poor efficiency levels found in Brazil – the other numbers are not ambitious. First, Brazil has for years sustained amounts higher than 18% of biofuels in the energy matrix – in 2016, they were 19.9% (MME, 2017, p. 26). Second, renewables share in the energy matrix amounted to 43.5% in 2016 (MME, 2017, p. 21), and renewables other than hydropower share in the energy matrix was 30.9% in 2016 (MME, 2017, p. 21). The share of renewables other than hydropower in the electricity matrix was 13.7% in 2016 (MME, 2017, p. 22), making this target a little more challenging – but hardly so considering the evolution of wind and sugarcane biomass electricity generation in the Brazilian grid.

These numbers show that although Brazil has presented a binding commitment to reduce its emissions by 2025 and 2030, they do not represent a real departure from a conservative position. In fact, as much as before, Brazil is pledging to do what it has already started to do. If we focus the energy numbers, we can see they create a buffer zone for Brazil to increase the share of fossil fuels in the energy matrix – which is exactly what has been happening recently. This conservative position is tributary to the influence of powerful actors in Brazilian politics, to whom climate change is either a long-term concern, thus far from their self-interestedly actions, or a problem to be solved by other, high carbon-intensive, countries.

4.2.2. What can we expect from Brazil?

According to our theoretical framework, we argue that international cooperation is affected by domestic distributional consequences of agreements. Climate change is a global public good; therefore, domestic constituencies will more likely act on climate change mitigation when co-benefits from action – which can be appropriated – are perceived. Thus, the more a constituency perceives co-benefits from needed action on climate change, the more active a country's role in the international climate regime.

At first, understanding Brazilian positions in the international climate regime required analyzing the politics of deforestation. Although few groups profited from deforestation and a large share of the Brazilian population was against it, Brazil remained a conservative force (VIOLA, FRANCHINI and RIBEIRO, 2013) in the international regime. Two were the main reasons. First, the few groups benefiting from deforestation are influential in Brazilian domestic politics, soybeans and cattle producers mainly. They would not lobby in favor of deforestation, but they would counter argue the benefits of activities that happened to replace forest to Brazilian economy – exports, thus dividends to the country; jobs – as well as financing politicians' campaigns. Second, the federal government dismissed illegal deforestation as a problem too complex to be solved (VIOLA, FRANCHINI and RIBEIRO, 2013).

When deforestation rates were reduced, the balance of forces that influenced in Brazilian climate position changed. First, forces that oppose deforestation became stronger compared to forces that would benefit from it; many soybeans and cattle producers aligned with them due to the moratoria from purchasing markets – their incentives to comply with mitigating deforestation had changed. Second, climate legislation in industrialized countries modified incentives to Brazilian sectors that export to those markets: they would favor and lobby for stronger Brazilian climate positions to avoid being penalized in the competition with exporters from more climate-friendly economies. But with a caveat: Brazilian commitment should be strong enough to allow competition with other emerging economies – who were also committing to climate targets – in the industrialized markets, but not too strong – this would harm Brazilian competitiveness. Third, public opinion became more attentive to the climate problem, and responded in the 2010 Presidential elections by voting expressively with Marina Silva, a candidate with a long history of environmental activities.

While emission reduction targets could be met by the decreasing LULUCF emissions, the new balance of forces – with more actors joining reformists – overcame the most conservative ones and Brazil became a moderate conservative power (VIOLA, FRANCHINI and RIBEIRO, 2013) in the climate regime.

The return to conservatism can be attributed to three main drivers. First, when deforestation rates were controlled, emissions from other sectors, mainly agriculture and energy, became more relevant in the total amount, and a more complex coalition of forces was needed to maintain Brazil as a moderate conservative force. Although some actors were self-interestedly aligned with the climate cause – the ethanol and new renewables industries –, energy politics is still largely decoupled from climate politics in Brazil. In the agriculture sector, the transition to low carbon is still in its very early stages, and there is no concrete evidence that it will accelerate soon.

Second, amidst economic crisis, unemployment, rising inequality and massive corruption scandals, Brazilian public opinion became less attentive to environmental topics in general and climate change in particular (VIOLA and FRANCHINI, 2018). This weakened reformist coalitions, and strengthened the role of conservative actors in influencing climate positions. Their role in forming climate positions was helped by, third, both Brazilian long-term diplomatic stances in the climate regime, which had been conservative, and larger objectives of foreign policy, which, since former Lula da Silva administration, have been aligned with South-South partnerships, countries that traditionally played a more conservative role in the climate regime.

Understanding what we can expect from Brazil in the near future requires projecting the expected trajectory of emissions in three main sectors – LULUCF, agriculture and energy – and how forces from a large constellation of actors will interact, delivering a more conservative or more reformist stance.

First, LULUCF emissions are rising again. Despite important advances in controlling deforestation between 2006 and 2013, deforestation rates resumed higher levels since 2014. This means that forces that benefit from deforestation are still powerful compared to actors that oppose it, and further institutional and financial support is necessary to consolidate earlier reduction trends. Given that it took Brazil many decades to successfully tackle deforestation at first, and that higher rates of deforestation re-emerged quickly following regulatory – new Forest Code – and institutional – reduced monitoring capacity from environmental authorities; lack of personnel; lack of financial resources – changes, this setback cannot be taken for granted: it is a major concern for future Brazilian climate commitments.

In the agriculture sector, emissions are also rising. Reducing them means that traditional agriculture – using great amounts of fertilizers and pesticides – and cattle producers need to adopt low carbon practices. Despite current resistance from traditional agriculturalists, who argue that climate policy could reduce Brazilian productivity in the short-run and increase prices of crops, we believe that this sector has a good chance to develop towards low carbon practices in the medium term. Agriculture sector has a strong presence of producers that export to international markets and invest in research and development. Different technologies that would reduce emissions are under development: genetic modification of crops to make them more resistant to predators without the use of pesticides; mixing crops in plantations so that two or more species with different nutritional needs can grow in tandem, reducing the use of fertilizers; new livestock feed that could reduce enteric fermentation of ruminants, thus methane emissions from cattle grazing. They depend on more resources to be developed faster, and more support to be employed at large scale, so the availability of finance will be an important variable regarding how fast they are adopted. New requirements of low carbon advances in international markets could speed it up.

Third, emissions from energy are also rising. Although starting from lower emissions compared to world average thanks to larger role of hydropower in electricity generation and ethanol in the fuel sector, Brazil is moving backwards. Given (i) trajectory of energy emissions and the inertia that is typical in energy investment, and (ii) the balance of forces in energy politics, largely disconnected or dismissing the climate issue, (iii) the intrinsic relevance of energy GHG emissions for deep decarbonization, the energy sector is, in our view, the most important bottleneck for future Brazilian climate positions.

Brazilian GHG emissions from the energy sector have been increasing since the beginning of the international negotiations; they became more relevant in total Brazilian emissions due to reduced role of LULUCF. Our analysis of the Brazilian energy matrix and energy politics and policies show that Brazil is incurring in carbon lock-in as much as other major economies, mainly by allowing larger shares of natural gas in the energy matrix but also by the enhanced role of oil products in the fuel sector. Yet, in the Brazilian electricity matrix, the effects of carbon lock-in are more deleterious than abroad: natural gas is replacing renewable energy sources, not other fossil fuels, so it causes an increase, not a decrease, in energy-related GHG emissions.

The electric system has not incorporated the value of climate change mitigation. Objectives are set having short-term interests in focus. Reliability is still understood to depend on firm resources – hydropower with reservoirs and fossil fuels – that can quickly be employed, even if technological advances could offer similar secure provision through a more complex operational system in which different renewable sources would complement each other. Prices do not embed externalities – to the environment, to human health – from primary energy sources use. Climate adaptation is also absent: long-term planning neglects scientific previsions on impacts to primary energy sources, especially future hydropower potential.

Concern with climate change is not a driving force in the fuel sector either. Oil outputs and oil products consumption have been increasing in Brazil. The sugarcane industry has been harmed by recent control of domestic oil prices, which damaged ethanol's competitiveness in the domestic market. Biodiesel producers have been lobbing to increase biodiesel share in the diesel mix, but in a pace that allows the domestic soybean industry to provide it, avoiding competition with imported biodiesel. Furthermore, energy conservation and efficiency play second fiddle in Brazil: despite the great potential to contribute to climate change mitigation – and, on a larger perspective, to economic and social development –, it has been consistently neglected by key political and economic actors.

According to the federal government and the Brazilian diplomacy, Brazil already has a low carbon energy matrix; they sometimes argue that other countries should undertake efforts to match Brazil before pressing for further Brazilian commitments. The Brazilian 2025 and 2030 pledges leave margin for increasing the share of fossil fuels in the energy matrix, compared to current levels. While many other countries have been investing – to different levels – in updating their economic and energetic structure towards low carbon, Brazil is counting on having higher participation of low carbon energy sources in its energy matrix compared to global average to secure its future. We do not believe this will be enough.

As seen in the beginning of this chapter, from the perspective of moving forward towards deep decarbonization, a transformation of energy systems is key. Even with an energy matrix that has a higher share of low carbon primary energy sources than world average, Brazil still needs to undertake important measures to align it with a decarbonized future: investing in energy efficiency and conservation; further decarbonization of electric and fuel sectors; and transforming structure of end-use sectors. Without it, even if Brazil does decrease its LULUCF and agriculture emissions – which should not be taken for granted –, the country will be moving away, not towards, deep decarbonization.

Furthermore, by allowing its energy system to have a higher participation of fossil fuels, Brazil might be losing an important comparative advantage in a future global low carbon economy. Although it is unlikely that the topic will be negotiated any time soon in the World Trade Organization, given the deadlock in the Doha Round, consumers have started to add the environmental impact – including GHG emissions – to the criteria with which they differentiate energy products – Woo et al (2014) show this for electricity. Although this is still a minor trend localized in specific parts of the world, it could spread relatively quickly after better storage options for wind and solar energy is developed and larger use of smart grids is expanded in a world deeply connected through global value and production chains.

In sum, the current picture and the perspective for the near-term future indicate that Brazil is not advancing towards decarbonization. Brazil has acted to curb emissions from deforestation, but this trend has been partially reverted in the last years. And even if it had not, reducing deforestation from extreme predatory/irrational levels for a middle-income country does not tackle the core of its economic structure, which transformation is key for becoming a low carbon economy. While a more serious commitment to reduce deforestation to near zero and from the energy sector – which is at the heart of the economic structure – with climate change is not perceived, Brazil will remain conservative or moderate conservative (VIOLA, FRANCHINI and RIBEIRO, 2013) player in the climate regime.

Concluding remarks

This research is embedded in the literature that aims at understanding how commitment with climate change mitigation is shaped by the interaction between international relations and domestic politics variables. We argue that cost-benefit analysis remains an important tool in explaining why countries engage with climate change mitigation. Yet, its original formula – a country's decision of whether to act and to what extent to act on climate change considers the country's own vulnerability and costs it will incur to reduce GHG emissions – needs to be complemented. First, because states are not unitary but polyarchic actors, formed by groups that have heterogeneous preferences, and each group will try to influence the policy process to maximize its own gains. Second, because climate concerns are not alone in informing groups preferences.

We advanced a framework in which the struggle between interests of major political groups helps explaining climate action in democracies and their positions in international negotiations. First, major political actors, their interests and the relationships between them are identified. It is expected that the struggle between major political actors' interests and the institutions that mediate their interactions will condition the policy outcome. Second, it is expected that additional benefits from climate action – benefits other than the direct benefit of decreasing GHG emissions, named co-benefits through the dissertation – will be important to explain climate engagement. When major political actors perceive co-benefits from climate action, it is more likely that they will offer their support to the agenda. But when co-benefits are not perceived or valued by them, the outcome becomes less likely. Due to the impact of fossil fuel combustion – the main cause of rising concentration of GHG in the atmosphere, according to the IPCC – we decided to test this framework in energy-related climate action. We hypothesized that energy decarbonization, or steering energy systems and energy end-use away from fossil fuels and towards low carbon energy sources, becomes more likely when major political actors identify and value co-benefits from it.

The hypothesis was tested using two different approaches, starting in chapter 02 – after a longer and more precise description of the climate problem and of our theoretical framework in chapter 01. We first listed the co-benefits of energy decarbonization most-commonly identified by the literature, and noticed that enhancing energy security is central among them. It is also a key objective of energy policy, especially when it is interpreted as continued access to primary energy sources. Then we explored the trajectory of energy supply in the 19 countries members of the G20 – world's greatest energy producers and users, as well as largest GHG emitters – between 1971 and 2015, period of 44 years, and compared with the trajectory of carbon intensity of energy supply in the same period, demonstrating that energy decarbonization has advanced more in countries where it also contributed to increase energy security.

For the second part of the analysis, we focused in detailing (a) how the trajectory of energy policy in a G20 country is explained by elements of international political economy and the struggle between interests of major political groups and (b) if and how co-benefits from energy decarbonization catalyze climate policy in the energy sector. We opted for studying Brazil, and justified that while we accept that Brazil is atypical among the G20 members given the higher share of low carbon primary energy sources in its energy matrix and the smaller role of energy-related emissions in total GHG emissions, there is neither reason to believe that Brazil would be different from other countries in pursuing multiple objectives through energy policy, among them energy security, nor that co-benefits of energy decarbonization would play in Brazil a smaller role that they play in other countries in pushing climate action.

In chapter 03, we detailed the trajectory of the political economy of energy in Brazil between 1971 and 2015, both regarding electricity and fuels, identifying the major actors and their interests, and how they pursued these interests through politics and policies. We found that the federal government is a key actor in Brazilian energy politics, both directly, given the impact of regulation in a sector that is at the heart of political and economic activity, and by its participation in energy supply as the owner, then a shareholder, of state-owned energy enterprises. In fact, a strong role for the state in the energy sector was not uncommon throughout the world in the 20th Century; it has diminished after the 1980s/1990s in most countries, but remains relevant in other countries, including Brazil. This has at least two important consequences for Brazilian energy politics. First, hydropower and oil & gas sectors – in which the state-owned enterprises play an important role – have been and remain very powerful. The fact that important part of the energy bureaucracy has been recruited from these niches also add to their dominance over other niches in energy politics. To be sure, the sugarcane industry, producer of ethanol, and the soybeans industry, major producers of biodiesel, are also powerful, but their strength does not match the other two. Second, changes in the federal government, altering profile and goals of the federal administration, directly affected energy policies between 1971 and 2015.

The second objective of the case study was to understand if and how co-benefits from energy decarbonization work as catalyzers of climate policy in the energy sector. Through our research, we understood that, due to the evolution of the Brazilian energy matrix, the trajectory of Brazilian environmentalism – explored in detail in chapter 04 – and the profile of Brazilian GHG emissions, climate change concerns have been decoupled from energy politics in Brazil. In fact, the two fields have developed separately in Brazil remained so until recently – many actors still believe that the topics should not merge, given the Brazilian energy profile compared to world average. Thus, potential co-benefits from energy decarbonization do not contribute to propel higher participation of low carbon energy sources in Brazilian energy supply.

In fact, in the Brazilian case they work backwards. Energy security, which was found to correlate with energy decarbonization for the other G20 countries, decreases, not increases, if more low carbon energy sources are added to the Brazilian energy matrix, according to major actors in energy politics – most of the energy bureaucracy, hydropower and oil & gas sectors. In their view, only hydropower plants with large reservoirs and fossil fuel thermal power plants are firm energy sources, so they must occupy the largest share of power supply. Allowing increasing role for other low carbon sources, such as wind and solar, would, therefore, diminish energy security. Being energy security a pivotal goal of energy policy, it must be upheld, even if, according to this view, it means that fossil fuels will have greater participation in energy supply, since the construction of large hydropower plants currently faces several constraints. We also considered the role of other potential co-benefits to propel energy decarbonization in Brazil, and found that their effects are either null or reinforce the view found for energy security.

In chapter 04, we explored why climate and energy are decoupled in Brazil. We demonstrated that the trajectories of climate and energy politics in Brazil are largely disconnected. Given the impact of land use, land use change and forestry (LULUCF) emissions in total Brazilian GHG emissions, the long trajectory of environmentalism fighting deforestation and the high visibility of the issue to domestic and international audiences, climate change has traditionally related to deforestation, and climate policy has focused action in this sector. The trajectory of Brazilian positions in the international climate regime have largely reflected it – the institutional background of how positions are formulated (and who participates) and the evolution of the paradigms of foreign policy are also important variables.

While the coalition of political actors, domestic and transnational, against deforestation remained weaker than the coalition that benefited from it, deforestation was considered beyond tackling, and Brazil resisted undertaking minimum commitment with reducing GHG emissions, justifying it on an extreme interpretation of the principle of common but differentiated responsibility. Brazil changed its position in late 2000s, accepting reduction of its GHG emission curve and adopting more collaborative stances in the international regime. By that time, the coalition against deforestation had been strengthened and the problem started to be seriously tackled, reducing rates of deforestation; they are also joined by other actors that were in tune with changing views on climate change in the international political economy, adding political pressure on the federal government for a stronger Brazilian commitment in the international regime. Later, emissions from energy and agriculture sectors became more relevant in total Brazilian GHG emissions. Hence, maintaining a more responsible stance in the regime required a larger coalition of forces, including agriculture and energy, to whom the climate issue remained alien. Adding to it, the coalition fighting deforestation was weakened and deforestation rates increased again and climate change lost prominence to political actors that have pushed for a more active commitment in previous years. Brazil resumed a more conservative position in the international regime.

In sum, our analysis confirms that co-benefits of energy decarbonization play a role in pushing climate policy in the energy sector. Yet, in Brazil, the potential role of these co-benefits is absent because climate change is decoupled from energy politics. Powerful political groups, whose political relevance would be partially reduced by a higher participation of low carbon energy in the matrix, understand that advancing energy decarbonization counteracts energy security, a key goal of energy policy. This understanding has increased the participation of fossil fuels in Brazilian energy supply, putting Brazil in the opposite direction than the global trend. There is no evidence to suggest that this picture will change while the strength of political forces engaged in energy politics is maintained.

During our research, we discovered an important intervening variable: the fragmentation of the Brazilian political system and low quality of Brazilian democracy. In the beginning of the studied period, a military dictatorship was in power in Brazil. Re-democratization took place in late 1980s, but it was unable to overcome profound features of Brazilian politics – patrimonialism, cronyism and focus on narrow interests. Brazil has too many political parties, most of them created to pursue narrow interests of specific groups. They are disconnected from broad societal interests they are supposed to represent, and party allegiance is at best unstable. Political parties' weak roots in society discredit them as legitimate societal representatives. Brazilian democracy is low quality because public interest has never guided it. The impulse of incorporating it to the new democracy, in the 1980s, was largely outshined by lobby of different interest groups that felt entitled to pursue their narrow interests in the new regime. Privileges were expanded, not reduced; budgetary clientelism and patronage remained largely employed in political activity.

This has major consequences for our findings, both directly and indirectly.

First, energy production has traditionally involved large infrastructure projects that require substantial initial funding and massive investment. This is especially true in Brazil, where large hydropower plants provide a substantial share of total electricity supply and oil & gas exploration is very expensive, mostly undertaken offshore, in deep waters. Operation Car Wash has been uncovering a major corruption scheme that involves major companies, and many of them have participated in energy ventures in Brazil. Hence, in addition to having to cope with the impact interventionism in energy policy and bearing the losses caused by the political use of PETROBRAS and ELETROBRAS, it is very likely that Brazilians were further fooled by corruption practices that plagued energy policy making.

Second, climate change mitigation is a public good. By definition, it will not be valued by specific interest groups focused in pursuing their narrow interests. When the public interest plays a minor role in politics, climate action depends on large coalitions that value co-benefits that result from it. But when major political actors understand that potential co-benefits play against their interests, they will win the political struggle against other actors that could push the climate agenda. In this scenario, climate policy is likely to remain erratic, advancing while climate change receives attention from public opinion in activities whose exploration are of interest of relatively weak groups – case of deforestation in the 2000s – but ceasing to advance when circumstances change. International commitments reflect it.

Deep decarbonization requires structural transformation of socio-economic systems, and energy production and use are at the heart of it. Brazil is lagging behind its G20 peers regarding action that form the 03 pillars that sustain it. Energy intensity of GPD, measuring energy conservation and energy efficiency – the 1st pillar –, has improved in Brazil between 1971 and 2015, but by mere 8.51%, from average 0.14Mtoe/billion USD, 2005 prices between 1971 and 1975 to 0.13Mtoe/billion USD, 2005 prices between 2011 and 2015 (IEA, 2017b). But carbon intensity of energy supply – measuring the 2nd and 3rd pillars, switching from fossil fuels to low carbon energy sources in energy systems and energy end-uses – has increased, not decreased, in Brazil in the period, by 20.71%: from average 1.34Mt of CO2/Mtoe between 1971 and 1975 to 1.51Mt of CO2/Mtoe between 2011 and 2015 (IEA, 2017b). The economic transformation undergone by the Brazilian economy in the period – advancing the role of industrial activities, partially reverted in recent decades, and service sectors in the economy – has been offset by increased dependence on fossil fuels: carbon intensity of Brazilian GDP – measuring the 03 pillars aggregated – has increased by 10.36% between 1971 and 2015 (IEA, 2017b; Figure 2.1, above).[261] Brazil is distancing itself from deep decarbonization. The disconnection between climate change and energy politics is an important variable in explaining this outcome.

The argument that Brazil is ahead of many countries in the process of mitigating climate change and advancing deep decarbonization is false. Brazil has a small share of world's GHG emissions and it has substantially decreased since deforestation rates were reduced: while in 1990 Brazil had 4.28% of total global emissions including LULUCF, in 2014 it answered for 2.78% of global emissions including LULUCF (WRI, 2017). Yet, when LULUCF emissions are excluded, Brazilian GHG emissions almost doubled in the period – increased 1.89 times – and so has its share in global emissions:

[261] All calculations on this paragraph are of our own, based on data referred.

Brazil had 1.86% of total global emissions excluding LULUCF in 1990 and 2.30% in 2014 (WRI, 2017). When we consider CO2 emissions from fossil fuel combustion only, they increased 144.60% in Brazil between 1990 and 2015 at the aggregate level and 76.42% at per capita level – from 1.23 tons of CO2/capita to 2.17 tons of CO2/capita, still lower than world average that was 3.88 tons of CO2/capita in 1990 and 4.40 in 2015 (IEA, 2017). Brazil is among the G20 countries in which the share of fossil fuels in total primary energy supply has increased if we compare the average between 1991-1995 and 2011-2015 – the same happens in Japan, to a larger extent, and Canada, Argentina, India, Mexico and Turkey, to a lesser extent (BP, 2017).[262]

Reducing emissions from activities that are at the heart of the economic model is much harder than reducing emissions from deforestation. An energy matrix that has a higher share of low carbon primary energy sources than world average does not qualify Brazil to claim to be in the path toward deep decarbonization. First, because this picture could be substantially reverted given (a) the impact of climate change on hydrological cycles, which has been informed by science but not incorporated into long-term planning and (b) current understanding on energy security, uphold by major energy actors and directing investment in the sector – which, by nature, have long inertia. Second, because energy efficiency and conservation play second fiddle in Brazil. The status of Brazilian energy matrix should be understood as a comparative advantage in decarbonization, encouraging policy makers to undertake further measures to deeply decarbonize the Brazilian economy instead of a (false) guarantee of membership in a future global low carbon economy.

Promoting a true transition to become a low carbon economy requires checking the quality of emission reductions as well as their quantity. Only when changes are made at the core of the economic structure they might truly transform it and generate further reductions in the future. Measures that have most potential to promote deep decarbonization reduce emissions in cascade – e.g. creating an efficient and low carbon public transportation system. Congestions are reduced, and with them substantial GHG and air pollutant emissions; when personal vehicles are used less frequently, fuel consumption decreases, further impacting emissions. In the long run, less and less people will acquire personal vehicles, and so emissions are kept under check, stable.

[262] All calculations in the paragraph are of our own, based on data referred.

And technological changes that could reduce emissions even further – different fuel, electrification of the system – are more easily and rapidly implemented if the focus is on large but fewer transportation vehicles than if they need to be undertaken by millions of small vehicle owners.

If measures to reduce GHG emissions focus the short-term only, they might fail to work when circumstances change. In Brazil, and this is not different from many countries, too much focus is put in short-term measures and very little in long-term ones (VOGT-SCHILB, HALLEGATTE and GOUVELLO, 2015). Tackling deforestation was a substantial improvement for Brazilian emissions, rule of the law and respect for the environment. But reducing deforestation[263] is too little. Brazil needs to transform its energy and agriculture systems is necessary if Brazil is to implement deep decarbonization.

Can we expect Brazil to move toward deep decarbonization in the future? It is possible, but it depends on several variables, including improving Brazilian democracy. Deep decarbonization requires valuing climate change mitigation, a public good, and understanding that the public interest goes beyond group struggle. We need to understand the big picture and realize, as a society, that action in one field by one actor leads to results in other fields and to several other people. We also need to overcome the simplistic divides between good guys and bad guys and seriously discuss alternatives that work for the community. Less individualism and new civic values, and to believe that entrenched societal traits are can – and should – be modified when we realize they do not serve the common good (VIOLA and LEIS, 2007, p. 81).

[263] Deforestation rates have been growing again recently – e.g., in the Amazon region, 5,000 km^2 of forest was cut in 2014; 6,200 km^2 in 2015; 7,900 km^2 in 2016; and estimated 6,600 km^2 in 2017 (INPE, 2017). The federal government seems incapable of controlling it; zeroing illegal deforestation by 2030, as pledged in the Brazilian INDC, is very unambitious.

Conclusão

Essa pesquisa está inserida na literatura que busca compreender como o compromisso com a mitigação da mudança do clima é moldado pela interação entre variáveis de relações internacionais e de política interna. Argumentou-se que a análise de custo-benefício segue relevante para explicar porque países se engajam ou não com a mitigação da mudança climática, mas que sua fórmula original – a decisão de um país em agir e quanto agir em relação à mudança do clima considera sua vulnerabilidade e os custos em que incorrerá para reduzir emissões de gases de efeito estufa – precisa ser complementada. Em primeiro lugar, porque Estados não são atores unitários, e, sim, poliárquicos, formados por grupos que têm preferências heterogêneas, e cada grupo tentará influenciar o processo político para maximizar seus ganhos. Em segundo lugar, porque a preocupação com a mudança do clima não está sozinha, existe entre outras preocupações do grupo.

Avançou-se uma moldura analítica em que o conflito entre interesses de atores políticos centrais ajuda a explicar ação climática em democracias e seus posicionamentos nas negociações internacionais. Primeiro, atores políticos centrais, seus interesses e as relações entre eles são identificadas. É esperado que o conflito entre interesses de atores políticos relevantes e instituições que medeiam as interações entre eles condicionarão o resultado político. Segundo, é esperado que benefícios adicionais da ação climática – benefícios outros que a redução de emissões de gases de efeito estufa – sejam importantes para explicar engajamento climático. Quando atores políticos relevantes percebem que obterão benefícios adicionais da ação climática, torna-se mais provável que ofereçam apoio político para medidas que a promovam. Quando, porém, benefícios adicionais não são percebidos ou valorizados pelos grupos, o mesmo resultado se torna menos provável. Dado o impacto da combustão de combustíveis fósseis – causa principal do aumento da concentração de gases de efeito estufa na atmosfera, de acordo com o IPCC – decidiu-se testar essa moldura em ação climática no setor energético. Formulou-se a hipótese de que a descarbonização energética, ou aumento da participação de fontes primárias de baixo carbono em sistemas energéticos e usos finais de energia, é mais provável quando atores políticos centrais identificam e valorizam benefícios adicionais que dela resultam.

A hipótese foi testada em duas partes, começando no capítulo 02 – após uma mais longa e precisa descrição do problema climático e de nossa matriz teórica no capítulo 01. Os benefícios adicionais da descarbonização energética mais frequentemente identificados pela literatura foram listados, e notou-se que o aumento da segurança energética é central entre eles, além de ser também um objetivo estratégico de política energética, especialmente quando interpretado como acesso continuado a fontes primárias de energia. Em seguida foram exploradas as trajetórias de suprimento de energia nos 19 países membros do G20 – os maiores produtores e consumidores mundiais de energia, e os maiores emissores de gases de efeito estufa – entre 1971 e 2015, período de 44 anos, e comparou-se com a trajetória da intensidade de carbono da energia no mesmo período, demonstrando-se que a descarbonização da energia avançou mais em países nos quais ela também contribuiu para o aumento da segurança energética.

Na segunda parte da pesquisa, o foco esteve em detalhar (a) como a trajetória da política energética em um país do G20 é explicada por elementos de economia política internacional e o conflito entre interesses de grupos políticos relevantes e (b) se e como os benefícios adicionais da descarbonização da energia catalisam políticas climáticas no setor de energia. Optou-se por estudar o Brasil, justificando que enquanto o país é atípico em entre os membros do G20 porque tem maior participação de fontes primárias de baixo carbono em sua matriz energética e menor participação de emissões do setor energético no total de emissões de gases de efeito estufa, não há razão para acreditar que o Brasil seria diferente de outros países ao buscar objetivos múltiplos na política energética, entre eles aumentar a segurança energética, nem que benefícios adicionais teriam, no Brasil, um papel menor em incentivar ação climática do que têm em outros países.

No capítulo 03, detalhou-se a trajetória da economia política da energia do Brasil entre 1971 e 2015, tanto em relação à eletricidade como em relação a combustíveis, identificando os atores principais e seus interesses, e como eles buscaram esses interesses através de políticas. Identificou-se que o governo federal é ator central em política energética no Brasil, tanto diretamente, dado o impacto da regulação em um setor que está no coração da atividade econômica e política, como por sua participação no fornecimento de energia como proprietário, depois acionista, de estatais do setor energético. Um papel central para o Estado no setor energético não era incomum em muitos países durante o século XX, mas diminuiu na maioria deles após os anos 1980-1990, permanecendo relevante em alguns outros, como o Brasil. Esta evidência tem ao menos duas consequências importantes para a política energética brasileira. Primeiro, os setores hidrelétricos e de petróleo e gás – nos quais estatais têm papel relevante – foram e permanecem poderosos. O fato de que uma parte importante da burocracia energética é recrutada nesses nichos também tem peso em sua dominância em política energética. Isso não quer dizer que outros setores, como o canavieiro, produtor de etanol, e a indústria da soja, maior produtora de biodiesel, não sejam poderosos; são, mas sua força não se compara à força dos dois primeiros. Segundo, mudanças no governo federal, alterando seu perfil e objetivos da administração, afetaram diretamente as políticas energéticas entre 1971 e 2015.

O segundo objetivo do estudo de caso era compreender se e como benefícios adicionais da descarbonização da energia funcionam como catalisadores de políticas que objetivam uma maior participação de fontes primárias de baixo carbono no fornecimento de energia. A pesquisa nos mostrou, por meio da evolução da matriz energética brasileira, da trajetória do ambientalismo brasileiro – desenvolvida em detalhes no capítulo 04 – e do perfil das emissões brasileiras de gases de efeito estufa, que a preocupação com a mudança do clima esteve desconectada da política energética no Brasil. De fato, os dois campos políticos desenvolveram-se separadamente no Brasil e permaneceram separados até recentemente – e alguns atores ainda argumentam que os tópicos não deveriam ser combinados em razão do perfil da matriz energética brasileira comparado com a média mundial. Por conta disso, potenciais benefícios adicionais da descarbonização da energia não contribuem para impulsionar maior participação de fontes primárias de baixo carbono no fornecimento de energia no Brasil.

Na verdade, no caso brasileiro eles são um obstáculo. De acordo com atores importantes na política energética – grande parte da burocracia do setor energético, e os setores hidrelétrico e de petróleo e gás – a segurança energética, que tem correlação com descarbonização da energia nos países do G20, diminui, e não aumenta se mais fontes primárias de baixo carbono são adicionadas à matriz energética brasileira. Para esses atores, apenas grandes hidrelétricas com reservatórios e usinas térmicas a combustíveis fósseis são fontes de energia firme, e, portanto, devem ter papel central no fornecimento de energia. Autorizar uma participação maior de outras fontes primárias de baixo carbono, como eólica e solar, diminuiria a segurança energética. Como segurança energética é um objetivo primordial de política energética, ela deve ser priorizada, ainda que, de acordo com essa visão, a participação de combustíveis fósseis na matriz energética aumente, uma vez que a construção de novas grandes usinas hidrelétricas com reservatório atualmente enfrenta sérios desafios. Também foi considerado o papel de outros potenciais benefícios adicionais para impulsionar descarbonização energética no Brasil, mas os resultados encontrados são nulos ou reforçam a visão encontrada para segurança energética.

No capítulo 04, explorou-se porque clima e energia são temas desconectados no Brasil. Demonstrou-se que as trajetórias das políticas climática e energética se desenvolveram separadamente. Dado o impacto de emissões de LULUCF no total de emissões brasileiras, a trajetória do ambientalismo combatendo o desmatamento e a altíssima visibilidade do tema para audiências nacionais e internacionais, mudança do clima tem, no Brasil, relação direta com desmatamento, e políticas climáticas focaram ações nesse setor. A trajetória de posições brasileiras no regime internacional do clima reflete essa evidência – o aparato institucional que determina como as posições são formuladas (e quem participa) e a evolução dos paradigmas de política externa também são variáveis relevantes.

Enquanto a coalizão de atores, internos e transnacionais, contra o desmatamento manteve-se mais fraca em relação à coalizão que se beneficiava dele, o desmatamento era considerado impossível de ser combativo, e o Brasil resistia em comprometer-se em reduzir minimamente suas emissões de gases de efeito estufa, justificando com uma interpretação extrema do princípio da responsabilidade comum porém diferenciada. O Brasil mudou sua posição no final dos anos 2000, aceitando redução da curva de emissões e adotando uma postura mais colaborativa no regime. Nessa época, a coalizão contra o desmatamento havia ganhado força e o problema começou a ser atacado, diminuindo as taxas de desmatamento; novos atores também mudaram sua postura em relação ao tema do clima, em razão de mudanças na economia política internacional, aumentando a pressão sobre o governo federal para que o Brasil tivesse uma postura mais firme no regime do clima. Mais tarde, emissões dos setores de energia e agricultura tornaram-se mais relevantes no total de emissões brasileiras; manter uma posição mais responsável no regime passou a requerer uma coalizão maior de forças, incluindo atores dos setores de energia e agricultura, para quem o tema do clima permanecia desconhecido. Além disso, a coalizão que combatia o desmatamento perdeu força e taxas de desmatamento aumentaram e o tema do clima perdeu prioridade para atores políticos que haviam pressionado por compromissos mais responsáveis nos anos anteriores. Como consequência, o Brasil reassumiu seu perfil conservador no regime internacional do clima.

Em resumo, a pesquisa confirma que benefícios adicionais da descarbonização da energia têm papel em impulsionar a ação climática no setor de energia. No entanto no Brasil esses potenciais benefícios adicionais não têm esse papel porque o tema da mudança do clima é dissociado da política energética. Grupos políticos poderosos, cuja relevância política seria parcialmente diminuída por uma maior participação de fontes primárias de baixo carbono na matriz energética, entendem que o avanço da descarbonização energética é incompatível com a segurança energética, um objetivo central da política energética. Por conta dessa interpretação, a participação de fontes fósseis na matriz energética brasileira tem aumentado, colocando o Brasil na direção contrária da tendência global. Não há evidência que sugira que este quadro será revertido enquanto o balanço de poder entre as forças engajadas na politica energética for mantido.

Durante a pesquisa, descobriu-se uma importante variável interveniente: a fragmentação do sistema político brasileiro e a baixa qualidade da democracia brasileira. No começo do período de estudo, a ditadura militar estava no poder no Brasil. A redemocratização ocorreu nos anos 1980, mas foi incapaz de mudar características profundas da política brasileira – patrimonialismo, clientelismo e foco em interesses específicos. O Brasil tem partidos políticos em demasia, e a maioria deles serve para buscar os interesses de grupos específicos. Eles são desconectados de interesses sociais amplos que deveriam defender, e fidelidade partidária é extremamente instável. Esses partidos não são representantes legítimos da sociedade. A democracia brasileira tem baixa qualidade porque o interesse público nunca a guiou. O impulso de incorporá-lo à nova democracia, nos anos 1980, deu lugar ao lobby de diferentes grupos de interesse, que à época se sentiram capazes de buscar seus interesses específicos no novo regime. Os privilégios foram expandidos, não reduzidos; o clientelismo e patrimonialismo permaneceram.

Essa evidência tem consequências, diretas e indiretas, importantes para os resultados dessa pesquisa.

Em primeiro lugar, a produção de energia tradicionalmente envolve grandes projetos de infraestrutura que requerem investimento inicial substancial. Isso é especialmente verdadeiro no Brasil, onde grandes hidrelétricas produzem uma parte substancial da eletricidade e a exploração de petróleo e gás ocorre majoritariamente *offshore*, em águas profundas. A Operação Lava-Jato tem descoberto esquemas de corrupção hercúleos, que envolvem grandes empresas as quais muitas vezes participaram em projetos energéticos no Brasil. Por isso, além de ter que lidar com o intervencionismo em política energética e arcar com os prejuízos do uso político da PETROBRAS e da ELETROBRAS, é muito provável que os brasileiros tenham sido também enganados por práticas corruptas ao longo de décadas da trajetória de política energética.

Em segundo lugar, a mudança do clima é um bem global comum. Por definição, não é valorizada por grupos de interesses focados em buscar seus interesses específicos. Quando o interesse público tem papel menor na política, a ação climática depende de grandes coalizões que valorizem benefícios adicionais que dela resultem. Mas se atores políticos relevantes entendem que potenciais benefícios adicionais vão contra seus interesses, eles vencem o conflito político contra outros atores que poderiam impulsionar a agenda do clima. Neste cenário, a política climática muito provavelmente se manterá errática, avançando enquanto o tema do clima recebe atenção da opinião pública em atividades cuja exploração é de interesse de grupos relativamente fracos – caso do desmatamento nos anos 2000 – mas retrocedendo quando as circunstâncias mudam. Os compromissos internacionais refletem isso.

A descarbonização profunda requer uma mudança estrutural dos sistemas socioeconômicos, e a produção e o uso da energia estão no coração dessa mudança. O Brasil está ficando para trás de seus pares no G20 em relação a implementar os 03 pilares que sustentam essa mudança. A intensidade da energia do PIB, que mede progressos de conservação da energia e de eficiência energética – o 1º pilar –

melhorou no Brasil entre 1971 e 2015 mas muito pouco, meros 8.51%, da média de 0.14Mtoe/bilhão de USD, preços de 2005 entre 1971 e 1975 para 0.13Mtoe/bilhão de USD, preços de 2005 entre 2011 e 2015 (IEA, 2017b). Mas a intensidade de carbono da energia – que mede o 2º e o 3º pilares, aumentar a participação de fontes de baixo carbono nos sistemas energéticos e usos finais da energia – aumentou, e não diminuiu, no Brasil no período, em 20.71%: da média de 1.34Mt de CO2/Mtoe entre 1971 e 1975 para a média de 1.51MT de CO2/Mtoe entre 2011 e 2015 (IEA, 2017b). A transformação econômica da economia brasileira no período – aumentando a participação de atividades industriais, parcialmente revertida em décadas mais recentes, e de serviços na economia – foi neutralizada pela crescente dependência de combustíveis fósseis: a intensidade de carbono da economia brasileira – que mede o agregado dos 03 pilares – aumentou em 10.36% entre 1971 e 2015 (IEA, 2017b; Figure 2.1, above).[264] O Brasil está se distanciando da descarbonização profunda, e a desconexão entre a mudança do clima e a política energética é uma variável importante para explicar esse resultado.

O argumento de que o Brasil está na frente de muitos países no processo de mitigar a mudança do clima e avançar a descarbonização profunda é falso. O Brasil tem uma porcentagem pequena das emissões globais de gases de efeito estufa e essa tem diminuído desde que o desmatamento foi reduzido: enquanto em 1990 o Brasil tinha 4.28% do total das emissões globais incluindo LULUCF, em 2014 o montante era 2.78% das emissões globais incluindo LULUCF (WRI, 2017). No entanto, se as emissões de LULUCF são excluídas, as emissões brasileiras quase dobraram no período – cresceram 1.89 vezes – e também a participação das emissões brasileiras no montante global: o Brasil tinha 1.86% das emissões globais excluindo LULUCF em 1990 e 2.34% em 2014 (WRI, 2017). Se apenas as emissões de CO2 provenientes da queima de combustíveis fósseis for considerada, elas aumentaram 144.60% no Brasil entre 1990 e 2015 em valores agregados e 76.42% em valores per capita – de 1.23 toneladas de CO2 per capita em 1990 para 4.40 toneladas de CO2 per capita em 2015 (IEA, 2017). O Brasil está entre os países do G20 nos quais a participação de combustíveis fósseis na matriz energética aumentou se compararmos as médias entre 1991-1995 e 2011-2015 – o mesmo aconteceu no Japão, em grande medida, e no

[264] Todos os cálculos desse parágrafo são nossos, baseados nos dados referidos.

Canadá, na Argentina, na Índia, no México e na Turquia, em menor medida (BP, 2017).[265]

Reduzir emissões provenientes de atividades que estão no coração do modelo econômico é mais difícil do que reduzir emissões de desmatamento, e ter uma matriz energética com maior participação de fontes de baixo carbono comparada com a média mundial não qualifica o Brasil a afirmar que está no caminho da descarbonização profunda. Primeiro porque esse quadro pode ser substancialmente revertido dado (a) o impacto da mudança do clima nos ciclos hidrológicos brasileiros, o que tem sido informado pela ciência climática, mas ainda não está incorporado no planejamento energético de longo prazo e (b) o atual entendimento sobre segurança energética, repetido por atores importantes do setor energético e que direciona os investimentos no setor – os quais, por natureza, têm inércia longa. Segundo porque conservação da energia e eficiência energética são considerados secundários no Brasil. O status da matriz energética brasileira deveria ser compreendido como uma vantagem comparativa na descarbonização, encorajando atores políticos a adotar novas medidas para descarbonizar profundamente a economia brasileira, e não como uma (falsa) garantia de participação em uma futura economia global de baixo carbono.

Promover uma transição real para a economia de baixo carbono requer checar a qualidade das reduções das emissões além da quantidade. Apenas quando as alterações forem feitas em atividades centrais para o modelo econômico é que a transformação ocorre e pode gerar mais reduções de emissões no futuro. Medidas com maior potencial para promover a descarbonização profunda reduzem emissões em cascada – e.g. criar um sistema de transporte público eficiente e de baixo carbono. Os congestionamentos são reduzidos, e, com eles, emissões significativas de gases de efeito estufa e outros poluentes; quando veículos particulares são usados com menos frequência, o consumo de combustíveis cai, diminuindo as emissões ainda mais. No longo prazo, menos pessoas irão adquirir veículos particulares, e as emissões podem ser mantidas estáveis. E mudanças tecnológicas, que podem reduzir emissões ainda mais – diferentes combustíveis, eletrificação do sistema –, são mais facilmente implementadas se o foco está em menos veículos de transporte, ainda que maiores, do que se precisarem ser adotadas por milhões de proprietários de pequenos veículos.

[265] Todos os cálculos desse parágrafo são nossos, baseados nos dados referidos.

Se as medidas para reduzir emissões de gases de efeito estufa estiverem focadas apenas no curto prazo, elas podem falhar em produzir as reduções quando as circunstâncias mudarem. No Brasil, e isso não é diferente de muitos outros países, o foco tem sido demasiado em medidas de curto prazo e muito pequeno em medidas de longo prazo (VOGT-SCHILB, HALLEGATTE e GOUVELLO, 2015). Diminuir o desmatamento foi um avanço substancial para reduzir as emissões brasileiras, e também para assegurar o respeito às leis e ao meio ambiente. Mas reduzir o desmatamento [266] é muito pouco. O Brasil precisa transformer seus sistemas de agricultura e energia se quiser implementar a descarbonização profunda.

Pode-se esperar que o Brasil vai avançar na direção da descarbonização profunda no future? É possível, mas isso depende de diferentes variáveis, incluindo a melhora da qualidade da democracia brasileira. A descarbonização profunda requer a valorização da mitigação da mudança do clima, um bem comum, e o entendimento de que o interesse comum vai além dos conflitos de interesses de grupos. É preciso entender o quadro mais amplo e compreender, como sociedade, que a ação de um ator em um setor leva a resultados em outros setores e para outros atores. É preciso susperar a divisão simplista entre vilões e mocinhos e discutir seriamente alternativas que funcionem para a comunidade. Menos individualismo e novos valores cívicos, e acreditar que traços sociais bastante enraizados podem – e devem – ser modificados quando se percebe que eles não servem para o bem comum (VIOLA e LEIS, 2007, p. 81).

[266] O desmatamento voltou a crescer recentemente – e.g., na região amazônica, 5,000km2 de floresta foi cortado em 2014; 6,200km2 em 2015; 7,900km2 em 2016; e estimados 6,600km2 em 2017 (INPE, 2017). O governo federal parece incapaz de controlar o desmatamento; zerar o desmatamento illegal até 2030, conforme prometido na INDC brasileira, é muito pouco ambicioso.

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List of Interviewees

(Positions current of time of interview. All interviews done by the PhD Candidate)

Abbud, Omar Alves; Legislative Consultancy of the Brazilian Federal Senate (focus: Infrastructure).

Abramovay, Ricardo; Professor at Faculty of Economics, Business and Accountancy, University of São Paulo.

Almeida Prado Jr, Fernando Amaral; Sinerconsult (consultancy in the energy area).

Almeida, Edmar Luiz Fagundes de; Professor at Faculty of Economics, Federal University of Rio de Janeiro (member of group Energy Economics).

Angelo, Claudio; Climate Observatory.

Azevedo, Tasso; Climate Observatory.

Badanham, Luis Fernando; Coordinator of Sustainability, Ministry of Mines and Energy of Brazil.

Baitelo, Ricardo; Greenpeace Brazil.

Borges da Cunha, Kamyla; Institute of Energy and the Environment (IEMA), think tank.

Bursztyn, Marcel; Professor at Center for Sustainable Development, University of Brasilia.

Camargo, Ivan; Professor at Faculty of Technology, University of Brasilia.

Campos de Souza, Ciro; Socio-environmental Institute (Instituto Socioambiental).

Campos Filho, Mário Ferreira; President of Association of Sugar and Energy Industries of Minas Gerais (SIAMIG).

Cardoso, Mario; Analyst (Environmental focus) at the National Confederation of Industry Brazil.

Dutra Faria, Ivan; Legislative Consultancy of the Brazilian Federal Senate (focus: Infrastructure).

Faria, Ricardo Moura de Araújo; Head of the Special Counsel for Analysis of Sectorial Policy, Ministry of Mines and Energy of Brazil.

Feldmann, Paulo; Professor at Faculty of Economics, Business and Accountancy, University of São Paulo.

Ferreira, Felipe Rodrigues Gomes; Diplomat, Head of the Division of Climate, Ozone and Chemical Security of the Brazilian Ministry of Foreign Relations.

Ferreira, Luiz Roberto; Brazilian Independent Electricity Producers Association (APINE).

Fraxe Neto, Habib Jorge; Legislative Consultancy of the Brazilian Federal Senate (focus on environment).

Gannoun, Elbia Silva; Executive-President of the Brazilian Wind Energy Association (ABEEOLICA).

Garcia, Rodrigo Sarmento; Analyst (Industrial Policy focus) at the National Confederation of Industry Brazil.

Goldemberg, José; Professor at Institute of Energy and Environment, University of São Paulo.

Gorini Oliveira, Ricardo; Director of Economic, Energy and Environmental Studies, Energy Research Company, Ministry of Mines and Energy of Brazil.

Guerra, Fábio Bandeira; Economic Advisor of the Brazilian Association of Vegetable Oil Industries (ABIOVE).

Hochstetler, Kathryn; Professor at London School of Economics, expert in climate politics and Brazilian politics.

Hollauer, Gilberto; Director, Ministry of Mines and Energy of Brazil.

Jannuzzi, Gilberto De Martino; Professor at Mechanical Engineering Faculty, Division of Energy, University of Campinas.

Kassmayer, Karin; Legislative Consultancy of the Brazilian Federal Senate (focus: Environment).

Kloss, Emerson Coraiola; Diplomat, Head of the Division of Renewable Energy Resources of the Brazilian Ministry of Foreign Relations between 2011 and 2015.

La Rovere, Emilio Lebre; Professor at Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering, Federal University of Rio de Janeiro.

Leão Sousa, Eduardo; Executive-Director of Brazilian Sugarcane Industry Association (UNICA).

Lucero, Everton Frask; Diplomat, Head of the Division of Climate, Ozone and Chemical Security of the Brazilian Ministry of Foreign Relations between 2013 and 2015.

Lucon, Oswaldo dos Santos; Professor at Institute of Energy and Environment, University of São Paulo.

Lutes, Mark; World Wide Fund for Nature Brazil (WWF Brazil).

Maciel, Alexandra Albuquerque, Analyst at the Brazilian Ministry of the Environment.

Meira Filho, Luiz Gylvan; Institute for Advanced Studies, University of São Paulo.

Mendes Thame, Antonio Carlos de; Federal Representative (PV-SP).

Miranda, Mário Dias; President of the Brazilian Association of Energy Transmission Companies (ABRATE).

Montalvão, Edmundo; Legislative Consultancy of the Brazilian Federal Senate (focus: Infrastructure)

Moraes, Marcelo; Director, Brazilian Association of Investors in Electric Auto-production (ABIAPE) and Environmental Forum of the Electric Sector (FMASE).

Munhoz, Fernando Colli; Analyst, Brazilian Electricity Regulatory Agency (ANEEL).

Nassif Avellar, Corina Lovinson; Analyst at Patri Políticas Públicas.

Oddone, Decio; Director-General at Brazilian Oil, Gas and Biofuels Regulatory Agency (ANP).

Pedrosa, Paulo; President of Brazilian Association of Large Energy Consumers (ABRACE).

Pires, Adriano; Brazilian Center for Infrastructure (CBIE), consultancy in the infrastructure area.

Rittl, Carlos; Climate Observatory.

Rubim, Barbara; Greenpeace Brazil.

Salgado, Reinaldo José de Almeida; Diplomat, Head of the Department of Energy of the Brazilian Ministry of Foreign Relations.

Sauer, Ildo Luis; Professor at Institute of Energy and Environment, University of São Paulo.

Schaeffer, Roberto; Professor at Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering, Federal University of Rio de Janeiro.

Senna Ganem, Roseli; Legislative Consultancy of the Brazilian Chamber of Representatives (focus: Environment).

Severi, Márcio; President, Brazilian Association of Clean Energy Producers (ABRAGEL).

Silva Lima, Hélio José da; Senator (PMDB-DF).

Sirkis, Alfredo Helio; Federal Representative (PV-RJ) between 2011 and 2015 and Secretary Executive of the Brazilian Climate Change Forum.

Souza, Zilmar Jose de; Advisor for Bioelectricity, Brazilian Sugarcane Industry Association (UNICA).

Tavares, Wagner Marques; Legislative Consultancy of the Brazilian Chamber of Representatives (focus: Infrastructure).

Teixeira Jr, Manoel; Director, Embrapa Agroenergy.

Tokarski, Donizete José; President of the Brazilian Union for Biodiesel and Biokerosene (UBRABIO).

Tolmasquim, Maurício Tiomno; President of the Energy Research Company, Ministry of Mines and Energy of Brazil, between 2004 and 2016.

Tomé Silva, Carlos Henrique Rubens; Legislative Consultancy of the Brazilian Federal Senate (focus: Environment).

Valverde Machado Filho, José; advisor of Federal Representative Arnaldo Jardim (PPS-SP).

Vilela, Daniel Elias Carvalho; Federal Representative (PMDB-GO) and President of the Commission for Climate Change of the Brazilian Congress in 2016.

Zilles, Roberto; Professor at Institute of Energy and Environment, University of São Paulo.

Greve dos petroleiros começa a perder fôlego

Refinarias retomam, aos poucos, a produção

por Fátima Belchior
do Rio

Trinta e um dias depois de iniciada, a greve dos petroleiros dá sinais claros de ter perdido o fôlego. Os números divulgados pela Petrobrás indicam que, gradualmente, há uma volta ao trabalho. Nas refinarias, cuja capacidade nominal é de 1,5 milhão de barris por dia, foram processados ontem 631 mil barris, ante 605 mil barris na véspera.

Embora o problema hoje esteja no abastecimento de derivados de petróleo (a Petrobrás está reprogramando embarques de óleo bruto importado, pois não tem onde estocá-lo), os campos marítimos e terrestres entraram num rápido processo de retomada de produção. Na noite de ontem, a expectativa da Petrobrás era de fechar o dia com 600 mil barris de óleo bruto. de gás natural, foram produzidos 9,2 milhões de metros cúbicos, diante dos nove milhões registrados na véspera.

''Há um desgaste físico e psicológico, mas não político'', admitiu, ontem, o diretor do Sindipetro-Rio, Gilberto Puig, baseado em Macaé. Os números do Sindicato confirmam que há uma volta ao trabalho: de 29 plataformas produtoras na Bacia de Campos, 16 estavam paradas, segundo Abílio Tozini, diretor do Sindipetro-Rio. Já houve momento, informou ainda, que todas estiveram paradas. Os números da Petrobrás indicavam, à noite, que das 29 apenas duas continuavam em greve. Nas demais 27, com produção parcial, realizavam-se assembléias, para decidir um rumo para o movimento no litoral fluminense, maior região produtora de petróleo do País.

A falta de dinheiro — pois os contracheques da semana passada foram zerados —, a ameaça de demissão em cartas individuais e a pressão de familiares — tudo pesou para reduzir a adesão à grave, segundo Tozini. Os petroleiros da Refinaria Duque de Caxias (Reduc), onde não houve nenhum aumento de produção, passaram o dia na porta da Refinaria em assembléia e atos públicos, num clima de grande tensão. ''O fim da greve está por um fio e, agora, depende do governo, pois a Federação Única dos Petroleiros (Fup) já cedeu'', comentou Tozini, referindo-se ao fato de a entidade ter diminuído o número de propostas encaminhadas.

Abastecimento

O aumento da produção de gás natural na Bacia de Campos (chegou ontem a 4,1 milhões de metros cúbicos, ante a média normal de 4,6 milhões de metros cúbicos por dia) já permite que as indústrias do Estado do Rio respirem aliviadas. A Companhia Siderúrgica Nacional (CSN), maior cliente da Petrobrás, está recebendo 800 mil metros cúbicos, por dia, que normalmente compra 1,440 milhões de metros cúbicos por dia. No início da greve, sua cota foi reduzida a 200 mil metros cúbicos por dia, informou seu presidente, Silvio Coutinho, que ainda não contabilizou os prejuízos com a falta do gás natural em sua empresa.

A Companhia Estadual de Gás (CEG), segundo seu presidente Hequel Osório, começou, na noite de quarta-feira, a normalizar totalmente a entrega de gás a seus clientes, estabelecendo suprimento à Antarctica. No Rio, 50 empresas chegaram a ser prejudicadas pela greve.

Rio de Janeiro e São Paulo

O suprimento de combustíveis (gasolina, óleo diesel e óleo combustível) esteve mais folgado, ontem, no Rio, com o bombeio de distribuidores aos postos, informou Silvio Thomé, do Sindicato Nacional do Comércio Atacadista de Combustíveis e Derivados de Petróleo (Sindicom).

Em São Paulo, as distribuidoras tinham, ontem, gasolina, óleo diesel e álcool para entregar aos seus clientes, mas não em quantidade suficiente para normalizar o mercado. O Estado do Paraná, sobretudo na região oeste, era, ontem, o ponto mais crítico do País em matéria de abastecimento de combustíveis.

Em nota divulgada na noite de ontem, a Petrobrás informou que as refinarias de São Paulo estão produzindo, em média, 135,4 mil barris por dia de óleo diesel. Com importações de 90 mil barris por dia para aquela região, há um total de 225,4 mil barris por dia, volume superior aos 176 mil barris de demanda do Estado de São Paulo e estados do Centro-oeste.

VIRADA HISTÓRICA - 4

Contras fazem quebra-quebra no Congressc

Petroleiros e sem-terra forçam entrada no Congresso e vidros são quebrados; Força Sindical faz panfletagem

PAULO SILVA PINTO
DENISE MADUEÑO
Da Sucursal de Brasília

MUDANÇAS NA CONSTITUIÇÃO

Grupos de sindicalistas contrários à quebra do monopólio do petróleo pressionaram de forma literal o Congresso ontem. Quebraram três vidraças da fachada do prédio e invadiram o Salão Negro.

Depois de abraçar a Câmara, os manifestantes —ligados à CUT e à JR-8 (juventude do MR-8)— desceram a rampa com deputados. Em seguida, eles queriam entrar no prédio para ter acesso às galerias do plenário da Câmara.

A segurança deixou uma abertura de 20 centímetros na porta de vidro e só permitiu a passagem de parlamentares e da imprensa.

Os manifestantes —a maioria deles um grupo de 200 trabalhadores sem terra— começaram a bater as bandeiras e chutar os vidros. Os próprios deputados fizeram uma barreira para que o grupo não avançasse para o Salão Verde.

Ali, dez membros da Força Sindical distribuíam, sem serem incomodados pela segurança, panfletos pró-flexibilização do monopólio a deputados que iam para o plenário.

"Chegamos de terno e gravata às 14h, e ninguém perguntou na portaria aonde íamos", disse Luiz Antônio de Medeiros, presidente da Força Sindical. "Se eles não conseguiram entrar, é porque não têm competência", disse.

O deputado Jair Meneguelli (PT-SP) disse que "a gente poderia pôr nosso pessoal aqui (nos corredores do Congresso), mas eles preferem as galerias".

FHC

O presidente Fernando Henrique Cardoso soube dos tumultos no Congresso por meio de seu computador pessoal. Às 16h45, quando recebia o ministro da Justiça, Nelson Jobim, FHC resolveu acessar as notícias do Congresso.

"Ih, deu tumulto no Congresso!", disse o presidente. Ele leu trecho da informação, atribuída ao deputado Jair Meneguelli (PT-SP) de que os seguranças da Câmara não souberam negociar com os manifestantes. FHC ironizou a declaração. "Tá bom, não souberam...", disse o presidente.

Spis

O coordenador da Federação Única dos Petroleiros, Antônio Carlos Spis, responsabilizou ontem os seguranças pela quebra de dois vidros, às 15h, na entrada do Congresso Nacional. "O clima está quente por aqui", afirmou Spis.

Segundo afirmou à **Folha**, por telefone, a delegação de cerca de 500 petroleiros e trabalhadores rurais tentou negociar com os seguranças para entrar no Congresso.

Um ato público contra a quebra do monopólio do petróleo foi realizado ontem, às 12h30, em frente à sede da Petrobrás, no centro do **Rio**. Às 13h, a **Folha** contou 83 pessoas na manifestação.

Colaboraram a **Sucursal do Rio e a Reportagem Local**

Lula Marques/Folha Imagem

Manifestantes invadem o Salão Negro do Congresso

Sérgio Lima/Folha Imagem

Lula cumprimenta Brizola durante ato pró-monopólio

NO AR

Derrubando Getúlio

NELSON DE SÁ
Da Reportagem Local

O momento histórico na tela da Globo, sempre com ele, o porta-voz Alexandre Garcia:

"Neste momento está sendo encerrada a votação... (vaias) Eis o resultado! São 374 votos derrubando... (ops) abrindo o monopólio. 141 votos contra, três abstenções, uma presença que é recorde, 508 deputados. Neste momento, em primeira votação, acaba de ser aberto o monopólio do petróleo. Foi aprovada a emenda que abre o monopólio em primeira, e em geral decisiva, votação."

Em poucas frases, foi-se mais um pouco de Getúlio.

Três vidraças

Os telejornais de ontem bem que se esforçaram, buscando tornar mais dramática a reação contra a derrubada histórica do monopólio da Petrobrás.

"Manifestantes revoltados invadem o Congresso", abriu a Globo, falando em tumulto.

"Quebra-quebra", veio na sequência a Bandeirantes.

"Os sindicalistas rompem a segurança do Congresso para tentar impedir a votação da emenda do petróleo", na CNT.

No SBT, "muita confusão no Congresso Nacional".

Na Record, "manifestante chegam a quebrar vidraças".

Três vidraças, para ser mai exato. Os manifestantes, qu nem conseguiram encher rampa do Congresso, nas cena de televisão, somaram uma 300 pessoas. Qualquer encontr de estudantes reúne mais.

Os líderes da CUT, com Vicentinho, como o president da federação dos petroleiros surgiram perdidos lá no mei com bandeirinhas. Não com líderes, mas esforçando-se, ele também, em fazer número.

Não podia ocorrer de form mais melancólica a derrubad de um monopólio erguido con comoção e luta —entre outros do próprio pai do president Fernando Henrique Cardoso.

Três vidraças, e acabou.

Companheiros

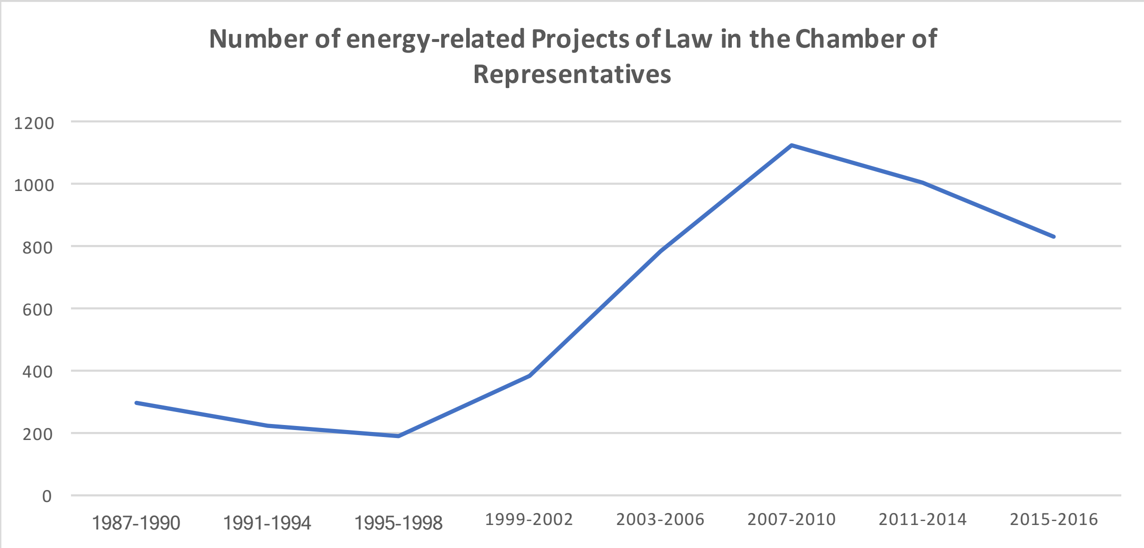
Sérgio Motta, em meio a discurso oficial, em entrevist ao TJ Brasil, saiu-se com um frase saudosa dos seus velhos bons tempos de esquerda:

"A luta dos companheiros, que eu respeito... eu acho qu eles deixaram de estar voltado para o interesse do conjunto d população e estão voltados par os interesses dos empregado das empresas estatais."

Que companheiros que nada.

ANNEX 02

Evolution of number of energy-related Projects of Law in the Chamber of Representatives



Source: Own elaboration, based on search (below) undertaken at the website <http://www.camara.leg.br/buscaProposicoesWeb/pesquisaSimplificada> in July 2017.

Search items
fuel (combustiv*)
electricity (eletric*)
oil (petrol*)
etanol
biodiesel
eolica
solar
biomassa
hidrel*
termoel*

Results	Projects of Law
48a Legislatura (1987-1990)	292
49a Legislatura (1991-1994)	219
50a Legislatura (1995-1998)	188
51a Legislatura (1999-2002)	382
52a Legislatura (2003-2006)	785
53a Legislatura (2007-2010)	1121
54a Legislatura (2011-2014)	1002
55a Legislatura (2015 and 2016)	831

ANNEX 03

Energy-related Frentes Parlamentares

55a Legislatura (2015- 31 Oct 2017)	President (Party/State)
FP ambientalista	Sarney Filho (PV/MA)
FP em defesa da Companhia Hidroelétrica do São Francisco (CHESF)	Danilo Cabral (PSB/PE)
FP em defesa da redução do preço da energia elétrica	Fabio Garcia (PSB/MT)
FP em defesa da renovação das concessões no setor público de energia elétrica	Pompeo de Mattos (PDT/RS)
FP em defesa do setor elétrico brasileiro	Erika Kokay (PT/DF)
FP em defesa dos consumidores de energia elétrica, combustíveis e telefonia	Cesar Hallum (PRB/TO)
FP mista de incentivo à geração de eletricidade por meio de energias renováveis	Sergio Vidigal (PDT/ES)
FP mista do biodiesel	Evandro Gussi (PV/SP)
FP mista em apoio ao carvão mineral	Alceu Moreira (PMDB/RS)
FP mista em defesa da energia alternativa	Beto Rosado (PP/RN)
FP mista em defesa da Petrobras	Davidson Magalhaes (PCdoB/BA)
FP mista em defesa das energias renováveis, eficiência energética e portabilidade da conta de luz	Mendes Thame (PV/SP)
FP mista em defesa das PCHs e microgeração	Pedro Uczai (PT/SC)
FP mista em defesa de FURNAS	Leonardo Quintão (PMDB/MG)
FP mista em defesa de municípios sede de usinas hidroelétricas e alagados	Valdir Colatto (PMDB/SC)
FP mista pela criação da indústria de petróleo e gás no Brasil	Beto Rosado (PP/RN)
FP mista pela segurança hídrica e elétrica do Brasil	Fausto Pinato (PP/SP); Mario Negromonte Jr (PP/BA)
FP mista pró-gás natural	Mendes Thame (PV/SP)
FP pela valorização do setor sucroenergético	Alexandre Baldy (PODE/GO)

54a Legislatura (2011-2014)	President (Party/State)
FP ambientalista	Sarney Filho (PV/MA)
FP em defesa do fundo social do pré-sal	Benedita da Silva (PT/RJ)
FP em defesa dos consumidores de energia elétrica, combustíveis e telefonia	Cesar Hallum (PRB/TO)
FP em defesa dos consumidores, distribuidores e revendedores de derivados de petróleo, gás natural e biocombustíveis	Wellington Fagundes (PR/MT)
FP mista do biodiesel	Jeronimo Goergen (PP/RS)
FP mista em defesa do carvão mineral	Afonso Hamm (PP/RS); senator Delcídio do Amaral (PT/MS)
FP mista em defesa da energia alternativa	Antonio Balhmann (PROS/CE)
FP mista em defesa das PCHs e microgeração	Pedro Uczai (PT/SC)
FP mista pró-gás natural	Mendes Thame (PSDB/SP)
FP pela valorização do setor sucroenergético	Arnaldo Jardim (PPS/SP)
53a Legislatura (2007-2010)	President (Party/State)
FP ambientalista	Sarney Filho (PV/MA)
FP em defesa dos estados e municípios produtores de petróleo	Solange Amaral (DEM/RJ)
FP mista em defesa do carvão mineral	Senator Delcídio do Amaral (PT/MS)
FP pró-biocombustíveis	Mendes Thame (PSDB/SP)
52a Legislatura (2003-2006)	President (Party/State)
FP ambientalista	Fernando Gabeira (PV/RJ)
FP em defesa da energia de fontes renováveis	Mauro Passos (PT/SC); Ivan Valente (PSOL/SP)
FP em defesa do carvão mineral	Francisco Turra (PP/RS); Yeda Crusius (PSDB/RS)
FP em defesa do desenvolvimento sustentável dos recursos minerais, hídricos e saneamento ambiental	Hamilton Casara (PSBD/RO)
FP pró-biocombustíveis	Mendes Thame (PSDB/SP)

Source: Own elaboration, based on data from <http://www.camara.leg.br/internet/deputado/frentes.asp>, retrieved 31 Oct 2017.

ANNEX 04

Contributions presented to the Ministry of Mines and Energy during the period of *Consulta Pública* (Public Consultation) nr 34, from 07 July 2017, regarding Plano Decenal de Expansão de Energia – PDE 2026:

Representatives of agents of the energy sector

1. ABBIOGAS – Associação Brasileira de Biogás e Biometano
2. ABCM – Associação Brasileira do Carvão Mineral
3. ABDAN – Associação Brasileira para o Desenvolvimento de Atividades Nucleares
4. ABEEOLICA - Associação Brasileira de Energia Eólica
5. ABGD - Associação Brasileira De Geração Distribuída
6. ABIAPE - Associação Brasileira dos Investidores em Autoprodução de Energia
7. ABIOVE - Associação Brasileiras das Indústrias de Óleos Vegetais
8. ABRACE - Associação Brasileira de Grandes Consumidores Industriais de Energia e de Consumidores Livres
9. ABRAGEL - Associação Brasileira de Geração de Energia Limpa
10. ABRAGET - Associação Brasileira de Geradoras Termelétricas
11. ABRAPCH - Associação Brasileira de Pequenas Centrais Hidrelétricas e Central Geradora Hidrelétrica.
12. ABSOLAR – Associação Brasileira de Energia Solar Fotovoltaica
13. APINE - Associação Brasileira dos Produtores Independentes de Energia Elétrica
14. Associação Sul-mato-grossense de Produtores e Consumidores de Florestas Plantadas
15. Camara Setorial da Cadeia Produtiva das Florestas Plantadas
16. COGEN – Associação da Indústria de Cogeração de Energia
17. FMASE – Forum de Meio Ambiente do Setor Eletrico
18. UBRABIO - União Brasileira do Biodiesel e Bioquerosene
19. UNICA - UNIÃO DA INDÚSTRIA DE CANA DE AÇÚCAR

Agents of the energy sector

1. Brookfield Renewable Partners
2. CEMIG – Companhia Energetica de Minas Gerais
3. CESP – companhia Energetica de São Paulo

4. CPFL – Companhia Paulista de Força e Luz
5. EDP – Energias de Portugal
6. Elektro Distribuidora de Energia
7. ELETROBRAS
8. ELETRONORTE
9. ELETRONUCLEAR
10. Eneva
11. Equatorial Energia
12. FURNAS
13. General Eletric
14. Koblitz Energia Ltda
15. Logum Logística
16. Orion Assessoria Empresarial
17. PETROBRAS
18. Santo Antonio Energia
19. Stanhope Brasil Energias
20. TRADENER Comercializadora de Energia
21. Transportadora Brasileira do Gasoduto Bolívia-Brasil
22. VOITH Hydro Ltda
23. WEG S.A.

Government

1. CEPEL – Centro de Pesquisa em Energia Eletrica (ELETROBRAS)
2. EMBRAPII – Empresa Brasileira de Pesquisa e Inovação Industrial
3. MME
4. Secretaria de Energia e Mineração do Estado de São Paulo

Other entities of the energy sector

1. Instituto Acende Brasil
2. IBP – Instituto Brasileiro do Petroleo, Gas e Biocombustiveis

Academia

1. COPPE-UFRJ
2. FGV – Direito SP
3. GESEL – UFRJ
4. IEE – USP
5. UFRGS

Civil Society

1. Adriano Lisboa
2. Associação dos Empregados da ELETROBRAS
3. E Castro Automação
4. Gabriel Brito
5. Greenpeace
6. Grupo de Trabalho de Infraestrutura (GT-Infra), Frente por uma Nova Política Energética para o Brasil (FNPE), Fórum Mudanças Climáticas e Justiça Social (FMCJS), Aliança dos Rios da Panamazônia e Observatório do Clima (OC)
7. Joilson Costa

Source: Own elaboration, based on data from <http://www.mme.gov.br/web/guest/consultas-publicas;jsessionid=0B0B4D61DB954FA96F3210B1B3D4B97C.srv155?p_p_id=consultapublicaexterna_WAR_consultapublicaportlet&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=1&_consultapublicaexterna_WAR_consultapublicaportlet_consultaId=34&_consultapublicaexterna_WAR_consultapublicaportlet_mvcPath=%2Fhtml%2Fpublico%2FdadosConsultaPublica.jsp> retrieved 31 Oct 2017.

ANNEX 05: UHES GRANTED OPERATING LICENSE, INFO ON ENVIRONMENTAL IMPACT AND ENVIRONMENTAL COMPENSATION

UHE	State	Info on EIS*	Current status	Value of the project (in BRL)	Impact	Environmental compensation (in BRL)
1. Água Vermelha	MG/SP	No	Operating License under analysis (UHE inaugurated before 1986)	372.581.985,00	0,62	2.310.008,00
1. Aimorés	ES/MG	Yes	Operating License renewed	No info	No info	No info
2. Barra Grande	RS/SC	Yes	Operating License rectified	No info	No info	No info
3. Batalha	MG/GO	Yes	Operating License granted	303.544.060,00	No info	1.517.720,30
4. Belo Monte	PA	Yes	Granted authorization to supress vegetation	25.885.000.000,00	No info	No info
5. Boa Esperança	MA/PI	No	Operating License renewed (UHE operating since 1970; state licenses expired in 1999)	No info	No info	No info
6. Cachoeira Dourada	GO/MT	No	Checking requirements for Operating License	289.000.000,00	No info	No info
7. Caconde	SP/MG	No	Operating License granted (UHE operating since 1966)	41.672.699,00	0,56	233.367,00 (1)
8. Canoas I	PR/SP	Yes	Under inspection for Operating License	No info	No info	No info
9. Canoas II	PR/SP	Yes	Licensing procedure has started (info on Operating License from 25 Nov 2014)	No info	No info	No info
10. Capivara	PR/SP	Yes	Operating License expired (UHE operating since 1977)	543.000.437,46	No info	No info
11. Chavantes	PR/SP	Yes	Operating License renewed (UHE operating since 1971)	No info	No info	No info
12. Corumbá IV	GO	Yes	Operating License renewed	450.751.000,00	No info	No info
13. Emborcação	GO/MG	Yes	Operating License issued (UHE operating since 1981)	No info	No info	No info
14. Estreito (Rio Tocantins)	MA/PI	Yes	Operating License issued	3.949.800.000,00	3,82	72.234.311,00
15. Foz do Chapecó	RS/SC	Yes	Renewed authorization to capture and transport biological material	2.207.120.000,00	No info	No info
16. Funil	SP/RJ	Yes	Operating License renewed (UHE operating since 1969)	No info	No info	No info
17. Igarapava	MG/SP	Yes	Operating License renewed (earlier licenses issued by Minas Gerais and São Paulo)	281.556.873,35	No info	No info
18. Ilha Solteira	MS/SP	Yes	Operating License issued (UHE operating since 1986, under regularization)	No info	No info	No info
19. Itá	RS/SC	Yes	Operating License renewed (Notice of Infraction, 02 Aug 2002: downstream flow does not respect minimum requirements)	1.063.279.721,00	No info	No info

20. Itabepi	BA/MG	Yes	Operating License being renewed	No info	No info	No info
21. Itumbiara	GO/MG	No	Operating License renewed (UHE operating since 1981)	No info	No info	No info
22. Jaguara	MG/SP	Yes	Under regularization; environmental studies under analysis (UHE operating since 1971)	No info	No info	No info
23. Jirau	RO	Yes	Operating License issued	10.000.000.000,00	No info	No info
24. Jupiá	MS/SP	Yes	Under regularization (info on Operating License from 2011)	No info	No info	No info
25. Luiz Carlos Barreto de Carvalho (Estreito)	MG/SP	Yes	Operating License issued (UHE operating since 1969)	No info	No info	No info
26. Luiz Gonzaga (Itaparica)	BA/PE	Yes	Operating License renewed	4.284.709.416,77	No info	7.520.554,00
27. Machadinho	RS/SC	Yes	Operating License renewed (under rectification)	1.150.000.000,00	No info	No info
28. Marimbondo	MG/SP	Yes	Operating License valid (UHE operating since 1975)	No info	No info	No info
29. Ourinhos	PR/SP	Yes	Operating License issued	58.000.000,00	1,50	870.000,00 (2)
30. Peixe Angical	TO	Yes	Operating License valid	1.874.085.196,00	No info	No info
31. Ponte de Pedra	MS/MT	Yes	Operating License renewed	19.802.000,00	No info	No info
32. Porto Colombia	MG/SP	Yes	Operating License issued (UHE operating since 1973)	No info	No info	No info
33. Porto Primavera	MS/SP	Yes	Operating License expired	No info	No info	No info
34. Queimado	GO/MG	Yes	Operating License valid	420.000.000,00	1,00	1.400.000,00
35. Rosal	ES/RJ	Yes	Operating License renewed	No info	No info	No info
36. Rosana	PR/SP	Yes	Requirements for Operating License under apreciation	No info	No info	No info
37. Salto Grande	PR/SP	Yes	Operating License rectified (UHE operating since 1958)	No info	No info	No info
38. Santa Clara	MG/BA	Yes	Operating License renewed	No info	No info	No info
39. Santo Antônio (Rio Jari)	AP/PA	Yes	Operating License issued (rectification under analysis since 06 May 2009)	1.099.711.000,00	No info	No info
40. Santo Antônio (rio Madeira)	RO	Yes	Operating License renewed (process started with Installation License)	12.198.630.798,00	No info	No info
41. São Manoel	MT/PA	Yes	Operating License rectified (EIA de 26/02/2010 não contem os estudos socioambientais do componente indígena. A verificação do estudo visando sua aceitação só será iniciada após apresentação do EIA completo)	2.292.951.980,00	No info	No info
42. São Salvador	GO/TO	Yes	Operating License rectified (first EIA-	562.960.000,00	44,66	2.869.650,00

			RIMA, issued in 2001, was rejected because requirements from Resolução CONAMA n. 001/86 were not met)			
43. São Simão	GO/MG	No	Operating License issued (UHE under regularization, operating since 1978)	No info	No info	No info
44. Serra da Mesa	GO	Yes	Authorization to supress vegetation renewed (Environmental authority from Goiás issued Operating License in 2003)	No info	No info	No info
45. Serra do Facão	GO/MG	Yes	Operating License rectified	1.062.934.000,00	0,05	11.000.000,00
46. Simplício	MG/RJ	Yes	Operating License issued	1.348.666.497,00	No info	No info
47. Sobradinho	BA	Yes	Operating License renewed (UHE operating since 1979)	360.290.295,32	No info	No info
48. Taguaruçu	PR/SP	No	Operating License issued (issued by São Paulo, IBAMA to renew it)	2.119.970.757,94	No info	No info
49. Teles Pires	MT/PA	Yes	Complementary studies under analysis to issue Installation License	2.474.951.554,00	No info	No info
50. Volta Grande	MG/SP	Yes	Operating License issued (environmental licensing under regularization, UHE operating since 1974)	No info	No info	No info
51. Xingó	AL/SE	Yes	Operating License renewed	7.578.688.700,46	No info	No info
52. Paulo Afonso (I a IV), Piloto e Apolônio Sales	AL/BA/PE	Yes	Operating License renewed (UHEs operating since: Paulo Afonso I = 1955; Paulo Afonso II = 1961; Paulo Afonso III = 1971; Paulo Afonso IV = 1979; Usina Piloto = 1949; Apolônio Sales = 1977).	197.000.000,00	No info	No info

Source: Own elaboration, based on information from: <https://servicos.ibama.gov.br/licenciamento/consulta_empreendimentos.php>, retrieved em 26 Oct 2017.
Note: 78 UHE are listed at IBAMA website.

(*) EIS: Environmental Impact Statements, in Brazil *Estudos de Impacto Ambiental* (EIA) and *Relatório de Impacto Ambiental* (RIMA).

(1) Allocated at: PARNA Serra da Bocaina (SP/RJ), Estação Ecológica de Mico Preto (SP), Estação Ecológica de Tupiniquins (SP).

(2) Allocated at: PARNA Ilha Grande/PR e APA Ilhas e Várzeas do Rio Paraná/PR e MS - elaboração do plano de manejo. Criação de Unidade de Proteção Integral Federal/PR - elaboração de estudo para criação de uma unidade de proteção integral em área de araucária no Paraná / aquisição de terras na unidade.Criação de Unidades de Proteção Integral Estaduais na área de influência do empreendimento no Estado de São Paulo e no Paraná - aquisição de áreas, criação , implantação, elaboração do plano de manejo e repasse para administração e custeio das unidades.