

INCENTIVE MECHANISMS FOR CLEAN ENERGY INNOVATION IN BRAZIL

PATHS FOR AN ENERGY BIG PUSH



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Incentive mechanisms for clean energy innovation in Brazil

Paths for an energy big push



This document was prepared by Camila Gramkow of the Economic Commission for Latin America and the Caribbean (ECLAC) and by Mayra Juruá Gomes de Oliveira, Marcelo Poppe and Bárbara Bressan Rocha of the Center for Strategic Studies and Management (CGEE), based on project reports produced by Edilaine Camillo of the Scientific and Technology Policy Department of the Institute of Geosciences of the State University of Campinas, with the support of Victo José da Silva Neto and Tatiana Bermudez of the same Department, and the contributions of experts from the Energy Research Office (EPE) and members of the Energy Big Push Brazil project – Axis 3 Working Group.

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Executive summary

This report presents the work carried out under Axis 3 of the Energy Big Push (EBP) Brazil project, which was aimed at identifying strategic guidelines and key policy instruments to accelerate investments in clean energy innovation in Brazil. The report describes the survey and analysis of the national regulatory and policy framework for energy innovation in Brazil, reviews the experiences of leading countries in clean energy investments with a focus on innovation and the outlines strategic actions lines and key incentive mechanisms for Brazil.

The present report contributes to a better understanding of the policy mechanisms that can help put in motion a set of complementary and coordinated investments, with a focus on innovation, for the construction of a more sustainable, resilient and low-carbon energy matrix and, at the same time, for the promotion of a more inclusive, efficient and competitive economy. The main premise of EBP Axis 3 is that the development of energy technology occurs within the innovation system, which is an intricate, complex and dynamic environment in which multiple incentive mechanisms and diverse stakeholders play a role. In this context, the present work emphasizes the importance of policy coordination to accelerate clean energy innovation.

The survey and analysis of the available incentive mechanisms for energy innovation in Brazil was the first phase of the work carried out under Axis 3 of EBP, which consisted of a mapping exercise of incentive mechanisms that can directly promote energy research and development activities (R&D) in the country. Existing instruments that can foster innovation in general (i.e., which can be applied to the specific case of R&D projects in the energy field, but also to projects in other areas) in Brazil were covered, which included science scholarships, programs and research infrastructure (grants and calls for projects, etc.), funds and programs for cooperation projects, resources to support scientific events, grants for companies (economic subvention), credit lines (preferential loans), variable income investments, tax incentives for innovation and others types of incentives. Specific mechanisms to promote innovation in the energy sector were also identified, including the Electric Energy Sector Fund, the Electric Energy Sector Research and Technological Development Program, the Land and Water Transport Sector Fund and Rota 2030 – Mobility and Logistics. The main finding from this analysis is that, despite diverse existing mechanisms, in addition to sectorial policies and plans in the areas of energy, transport and climate that address clean energy to some extent, Brazil does not present a coordinated and long-term national strategy for the development of low-carbon energy innovation. In addition, most of the mechanisms available to

encourage R&D in the country are not explicitly focused on the energy sector and are concentrated in the provision function and in the form of reimbursable resources.

The survey and analysis of incentive mechanisms in Brazil allowed the identification gaps and obstacles to energy innovation in the country. This analysis became an input for the review of selected international experiences, which sought to map lessons learned and best practices that could be useful to the Brazilian context. Based on criteria such as leadership in innovation in general and in renewable energy in particular, energy system transformation, relevant governance and coordination mechanisms, among others, the cases of the United Kingdom, Denmark, Japan, Norway, Chile and Finland were reviewed. The analysis of these countries revealed the importance of a continuous and robust flow of public resources for R&D activities in the long term, consistent with national priorities in the areas of energy, climate, science, technology and innovation (ST&I) and development.

Building on these findings and on the contributions of EBP Axis 3 Working Group, a set of 16 lines of action to increase clean energy innovation investments in Brazil were drawn. These lines are structured in three levels. At the strategic level, key government bodies and relevant stakeholders should coordinate and define the key technological characteristics of the energy system Brazil aspires to in the long run. At the second level (tactical-operational), technological roadmaps of the strategic technological systems identified at the strategic level would be developed, presenting the specific objectives and milestones to be achieved over in the short, medium and long-terms for each priority technology system. The design of roadmaps should be based on an informed and evidence-based decision-making process that involves government, industry and academic stakeholders. At a third level (policy), the mix incentive mechanisms would be defined. The incentive mechanisms are the tools to achieve the established objectives of the roadmaps for each strategic technology system. Key incentive mechanisms to accelerate clean energy innovation in Brazil are also presented in this report.

Preamble

Context and motivation

The climate and sustainability commitments of the Paris Agreement and the 2030 Agenda and its 17 Sustainable Development Goals have inspired several global, regional and national initiatives. In this sense, the Energy Big Push (EBP) Brazil project originated from the convergence of motivations and synergic efforts in the activities of its partners that permeate the themes of sustainable development, energy transition and international cooperation.

In 2015, a global initiative led by 24 countries and the European Union was launched, aimed at accelerating clean energy innovation, named Mission Innovation (MI). The representatives of the Brazilian government in the MI—the Ministry of Foreign Affairs (MRE in its Portuguese acronym) and the Ministry of Mines and Energy (MME in its Portuguese acronym)— mobilized the Energy Research Office (EPE in its Portuguese acronym) in order to conduct a survey of investments in research, development and demonstration (RD&D) in energy technologies to support the monitoring of innovation efforts in the energy sector in the country.

The EPE took the first steps in this direction and organized a first database of public and publicly oriented investments in RD&D, between 2018 and 2019, using the classification of the International Energy Agency (IEA). Based on this initiative, the need to incorporate other data sources and expand the time series was identified to improve the understanding of the main efforts in energy innovation in the country based on a single, structured and harmonized data set. In this context, the Centre for Strategic Studies and Management (CGEE in its Portuguese acronym) was invited as a strategic partner to design and implement a project that, in a collaborative way, would be able to build technical and institutional capacity to meet the need to expand access to strategic data for decision making in the energy sector.

The Brazilian government's need to have inputs and strategic information to accelerate the sustainable and low-carbon energy transition, fully coincides with the Big Push for Sustainability approach in the energy sector. The United Nations Economic Commission for Latin America and the Caribbean (ECLAC) has been developing this approach since 2016 to support countries in the region in building more sustainable development styles. The Big Push for Sustainability represents a coordination of policies (public

and private, national and subnational, sectorial, fiscal, regulatory, financial, planning, etc.) that leverage national and foreign investments to produce a virtuous cycle of economic growth, generation of jobs and income, reduction of inequalities and structural gaps and promotion of environmental sustainability (ECLAC/FES, 2019).

Investments in the expansion, integration and diversification of clean and renewable energies represent one of the major opportunities for a Big Push for Sustainability in Latin America and the Caribbean, due to its multiple positive impacts in several areas, which are discussed in more detail the final project report. In the context of ECLAC's technical cooperation program with the German technical cooperation agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) to support selected countries in the region in a position to develop their strategies for implementing the 2030 Agenda, in line with the Big Push for Sustainability approach, ECLAC joined the efforts of CGEE and partners of the Brazilian government to promote a big push for investments with a focus on clean energy innovation in Brazil.

The IEA also joined efforts for an Energy Big Push in Brazil, within the scope of its Clean Energy Transition Program (CETP). This program's mission is to accelerate global clean energy transitions, mainly in major emerging economies, through activities that include collaborative analytical work, technical cooperation, training and capacity building and strategic dialogues. The program provides cutting-edge support to governments whose energy policies will significantly influence the prospects for —and the speed of— the global transition towards more sustainable energy production and use, with Brazil being one of the priority countries. The IEA's broad energy experience, mainly in analysis and survey of clean energy research and development (R&D) expenditures, clearly converges with EBP.

In 2019, based on the synergistic motivations of the partners, the EBP project kicked-off within a framework of multi-institutional collaboration at the international, regional and national level, forming a unique environment to exchange of experiences and share knowledge for an Energy Big Push in Brazil.

The Energy Big Push project

The objective Energy Big Push (EBP) project is to support the promotion of more and better public and private investments in sustainable energies, with an emphasis on innovation, contributing to an Energy Big Push in Brazil.

The project is structured in four axes. Each axis corresponds to a specific objective, as indicated below:

- Axis 1 - Development of a process for collecting, structuring and managing data on public and private investments in research, development and demonstration (RD&D) in energy;
- Axis 2 - Survey of technical, economic, social and environmental performance indicators associated with low carbon energy solutions;
- Axis 3 - Identification of strategic guidelines and key policy instruments to accelerate investments in energy innovation;
- Axis 4 - Innovative and effective communication strategy of project results, targeted at decision makers.

For each of these axes, working groups were formed, which met regularly and offered technical and data contributions to the EBP project. In addition to CGEE, EPE, ECLAC and IEA, the working groups were formed by experts of MRE, MME, Ministry of Science, Technology and Innovations (MCTI), Brazilian Electricity Regulatory Agency (ANEEL), National Agency of Petroleum, Natural Gas and Biofuels (ANP), Funding Authority for Studies and Projects (Finep), National Council for Scientific and Technological Development (CNPq), Brazilian Industrial Innovation Agency (EMBRAPII) and Institute for Applied Economic Research (IPEA) — see participants list in the Annexes. Therefore, more than a dozen institutions, national, regional and global, have been mobilized and actively contributing to EBP, bringing the universe of energy and the universe of innovation stakeholders closer. The collaboration of each partner takes place on a voluntary basis, in an effort to value the different experiences of each participant, strengthen the collective intelligence of the group and add value to the results obtained in the project.

From the inputs and interactions of the working groups, preliminary technical reports on axes 1, 2 and 3 were generated, presenting preliminary estimates and considerations for each of these axes. The preliminary reports were presented and discussed at the Energy Big Push Workshop, held at the CGEE in October 2019. The workshop aimed to provide exchange of experiences, learning among peers and an opportunity to review and improve the preliminary results of the project. The event was attended by 47 people, including experts and representatives of the project's partner institutions (see list of participants in annex 1). The rich discussions of this workshop generated key inputs for the final reports on axes 1, 2 and 3 and for the communication and engagement activities on axis 4, as well as the final project report that summarises and integrates the results of each axis in the light of the approach of the Big Push to Sustainability.

The reports produced within the framework of the EBP are, therefore, the result of a collective effort and the contributions from several partner institutions and experts that are working on the theme. These are:

- The Axis 1 final report: Overview of energy innovation investments in Brazil: Data for an energy big push;
- The Axis 2 final report: Performance indicators associated with low carbon energy technologies in Brazil: Evidence for an energy big push;
- The Axis 3 final report, which is the present document: Incentive mechanisms for clean energy innovation in Brazil: Paths for an energy big push;
- Final EBP project report: A big push for sustainability in Brazil's energy sector: Subsidies and evidence for policy coordination.

EBP is expected to be a process of co-creating several studies and analysis to support decision-making; capacity building and learning acquired by the teams of the various agencies involved on the project on issues related to sustainable energy, innovation and investments; and, finally, the development of recommendations on the topics covered, which may serve as inputs for public policies to accelerate investments in clean energy in Brazil, with a focus on innovation.

Introduction

This report presents the work carried out within the framework of Axis 3 of the Energy Big Push (EBP) Brazil project. The main objective of Axis 3 is to identify strategic guidelines and key policy instruments to accelerate investments in clean energy innovation in Brazil. This work included a survey and analysis of the national regulatory and policy framework for energy innovation in Brazil, a review of international experiences of leading countries in clean energy investments with a focus on innovation and a set of recommendations for incentive mechanisms that include a set of 16 strategic guidelines. Understanding the policy mechanisms that can help put in motion a set of complementary and coordinated investments, with a focus on innovation, for the construction of a more sustainable, resilient and low-carbon energy matrix and, at the same time, for the promotion of a more inclusive, efficient and competitive economy is one of the key axes of EBP, alongside Axis 1 and Axis 2 described earlier.

In the present report, the importance of coordination for a big push for clean energy innovation in Brazil is analysed. This approach considers that energy technology development happens within a broad system of innovation, in which multiple incentive mechanisms and stakeholders play a role. A shift towards a more sustainable energy system requires significant investments not only in the expansion of productive capacity of clean energies and more efficient use of energy. Complementary investments in building scientific, technological and innovative capabilities and competences to equip the economy and the labour force with the necessary capacities that make this transition an opportunity for socioeconomic development are also required. According to the Big Push for Sustainability approach (ECLAC/FES, 2019), unlocking domestic and foreign investments for such a shift requires broad policy coordination. If a wide range of policies (public and corporate, regulatory and market, national and subnational, macroeconomic, energy, climate and science, technology and innovation etc.) is aligned and cohesive with the development path the country is seeking, a favourable enabling environment to mobilize the required investments is created, building on reduced uncertainties, corrected price signals and an adequate policy mix. The increase in sustainable investments can lead to a “big push” for a new cycle of economic growth, job creation, social inclusiveness, development of productive chains and technological capabilities, while improving environmental sustainability.

The analysis presented in this report can help inform the appropriate policy mix for clean energy innovation, for the context of Brazil, to help build the energy system the country seeks for the long-term. The inputs provided by Axis 3 are based on evidence regarding the opportunities and gaps within the

existing incentive mechanisms framework for energy innovation in Brazil, which allows to understand the specificities of the country. In addition, this report also brings evidence on the lessons learned from the review of international experiences of selected countries that have been at the forefront of clean energy investments globally. This set of evidence can support the development of a coordinated policy mix, informed by evidence from the national and the international experiences.

This report is organized as follows. The first chapter is dedicated to the survey and analysis of the available energy innovation incentive mechanisms in Brazil. Chapter II focuses on the review of relevant international experiences, provides an overview of the main characteristics of the selected countries and discusses main lessons learned and insights for Brazil. Chapter III outlines strategic guidelines and action lines to consider when designing the policy mix to promote clean energy innovation in the country. Finally, Chapter IV offers final remarks and recommendations of key incentive mechanisms for an energy big push in Brazil.

I. Survey and analysis of incentive mechanisms for energy innovation in Brazil

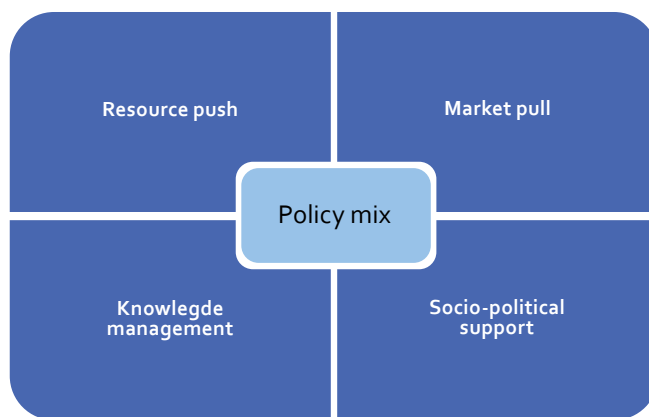
The survey and analysis of the existing incentive mechanisms for energy innovation in Brazil was the first phase of the work carried out under Axis 3 of EBP, which consisted of carrying out a mapping exercise of incentive mechanisms that can directly and indirectly promote research and development activities (R&D) in energy. Existing instruments that can foster innovation in general (i.e., which can be applied to the specific case of R&D projects in the energy field, but also to projects in other areas) in Brazil were covered, which included science scholarships, programs and research infrastructure (grants and calls for projects, etc.), funds and programs for collaborative research projects, resources to support scientific events, grants for companies (economic subvention), credit lines (preferential loans), variable income investments, tax incentives for innovation and others types of incentives. Specific mechanisms to promote innovation in the energy sector were also identified, including the Electric Energy Sector Fund, the Electric Energy Sector Research and Technological Development Program, the Land and Water Transport Sector Fund and Rota 2030 – Mobility and Logistics. This approach considers that energy technology development happens within a broad system of innovation, in which multiple incentive mechanisms and stakeholders play a role. In addition to the R&D incentive mechanisms, the mapping exercise also covered incentive mechanisms to innovations at market or commercial stage.

The existing incentive mechanisms in Brazil for low-carbon energy technology development were classified as per their functions as defined by the International Energy Agency (IEA, 2019a and 2020, diagram 1):

- (i) Resource push: To be successful, technology innovation requires sustained flows of funding for R&D activities, skilled workforce, as well as clearly defined priorities based on identified innovation gaps to guide innovation activities. These are “resources” to the innovation system, which contribute to push technology innovation forward;
- (ii) Knowledge management: New products and processes can be developed due to the generation of novel and improved knowledge within the innovation system. Incentive mechanisms for energy innovation should seek good knowledge management, so that it is protected (including, when appropriate, through intellectual property rights), disseminated through dynamic knowledge networks and transmitted along the value chain;

- (iii) Market pull: To ensure that new ideas and products reach markets, market-based incentive mechanisms such as performance-based market instruments (e.g. quotas, standards, carbon pricing), tax incentives, public procurement and pre-commercial procurement can contribute to pulling innovation activities and fostering market creation with niche and early-deployment incentives. This kind of incentives reduce risk and uncertainty of investing in innovation, by ensuring that newly developed technologies find their place in markets;
- (iv) Socio-political support: Successful innovation usually requires, at a minimum, no effective opposition from the socio-political environment. This applies mainly to controversial technologies, but also to new technological paradigms that can face resistance to emerge. Energy innovation strategies and related incentive mechanisms should seek buy-in from, and engage with, all relevant innovation stakeholders, including consumers and industry.

Diagram 1
Policy mix of incentive mechanisms as per their functions



Source: Created by the authors based on information from the International Energy Agency (IEA).

Table 1 shows an overview of the incentive mechanisms available to energy innovation in Brazil and although this is a simplification, each has been allocated according to the four categories of mechanisms functions. Annexes 7 and 8 provide the full list and key characteristics of the incentive mechanisms covered in this study.

Table 1
The mechanisms to encourage innovation in energy in Brazil by function

Provide resources	Generate knowledge	Support markets	Mobilize society
Science scholarships	Science scholarships	Wind, solar, biomass: Market creation (electricity bidding, discount on grid charges, net metering, tax incentives). Wind and solar: Deployment (preferential loans, REIDI (Regime Especial de Incentivos Para o Desenvolvimento da Infraestrutura), local content requirement, tax incentives)	Energy efficiency: Energy Efficiency Law, Procel-Eletrobrás, Conpet-Petrobras, Programa Brasileiro de Etiquetagem (Instituto Nacional de Metrologia, Qualidade e Tecnologia, Inmetro in its Portuguese acronym)
Cooperative projects (Programa Conecta, Funtec, EMBRAPII)	Support to research (research projects and infrastructure)	Electric mobility: Market creation (tax incentives– Rota 2030, IPVA and imports) Deployment (preferential loan)	Biofuels: Programa Brasileiro de Etiquetagem, RenovaBio Wind and solar: net metering

Table 1 (concluded)

Provide resources	Generate knowledge	Support markets	Mobilize society
Subvention (Economic Subvention to National Innovation, CENTELHA Program, TECNOVA)	Cooperative projects (Green & Yellow fund, Programa de Apoio à Pesquisa em Empresas – PAPPE, FAP's cooperative projects; Programa Conecta, Funtec, EMBRAPPII)	Energy efficiency: Deployment (PEE ANEEL, preferential loan, Rota 20-30)	
Variable income investment (Finep and BNDES' programs and funds)	International cooperation (Finep subvention)	Biofuels: Market creation (mandatory addition, biodiesel bidding, RenovaBio) Deployment (Programa Brasileiro de Etiquetagem, preferential loans)	
Preferential loans (Finep's and BNDES' programs)	Sectoral funds (agrobusiness, biotechnology, terrestrial and water transportation, energy)		
Tax incentives (Lei do Bem, Rota 2030, Programa de Apoio ao Desenvolvimento Tecnológico da Indústria de Semicondutores e Displays – PADIS)			
R&D ANEEL (electric energy)			
	Sectoral funds (agrobusiness, biotechnology, terrestrial and water transportation, energy)		

Source: Created by the authors based on information from EBP Axis 3 Working Group.

The analysis carried out provided evidence that, despite multiple existing mechanisms, in addition to sectorial policies and plans that address clean energy in the areas of energy, transport and climate, Brazil does not present a coordinated and long-term national strategy for the development of low-carbon energy innovation. In addition, the following main obstacles to advance the development of these technologies in Brazil were identified:

- Guarantee the continuity of flows of public spending for energy R&D over time, consistent with national priorities, to ensure the durability, credibility and effectiveness of resource-push mechanisms;
- Develop consistent plans and links between climate, energy and development priorities such as energy security and sovereignty, renewable energy development, energy efficiency improvement, carbon capture and storage, productivity, competitiveness etc;
- Improve priority setting in order to better coordinate priorities defined in energy, climate, science, technology and innovation (ST&I) and development policies and incentive mechanisms;
- Improve coordination among different government bodies and innovation stakeholders (e.g. academia, technology experts, advocacy groups, industry players, citizens) related to the priority setting;
- Balance incentive mechanisms as per their functions in the policy mix (diagram 1), especially between resource-push and market-pull instruments, given that most mechanisms explicitly targeted at energy innovation are focused on the first function;
- Strengthen support for the innovative process in all its stages, including from the earliest basic research stages to the stages of experimental development and early commercialization in niche markets. Innovation is a learning process that is intrinsically subject to risk —which is

associated with predictable events— and uncertainty —related to unknown and uncertain events whose probability is incalculable— at various degrees. Basic research, for instance, involves extremely high uncertainty and risk levels, whereas secondary technical improvements to a known product are less subject to them. It is important to note that innovations involving higher the degrees of uncertainty and risk require more robust incentive mechanisms (Gordon and Cassiolato, 2019). For example, disruptive innovation projects, such as those that involve radical product and process innovation, require powerful incentives that effectively reduce uncertainty and risk such that investments in them become attractive, which can include non-reimbursable finance, risk capital and pre-commercial procurement (see table 2).

Table 2
Relation between innovation, uncertainty, risk and incentive mechanisms

Type of innovation	Uncertainty	Risk	Incentive mechanism
Basic research and invention	Strong/True	Incalculable	<ul style="list-style-type: none"> • Non-reimbursable finance • Pre-commercial procurement • Risk capital
Radical product and process innovation not developed by the firm	Extremely high	Very high	<ul style="list-style-type: none"> • Public shareholding • Economic subvention (grant) • Non-reimbursable finance • Public procurement • Risk capital
Product and process innovations developed within the firm	Very high	High	<ul style="list-style-type: none"> • Non-reimbursable finance for joint firm and STI centres projects • Public shareholding • Economic subvention (grant) • Non-reimbursable finance • Public procurement • Risk capital
New generation of known products	Moderate	Moderate	<ul style="list-style-type: none"> • Subsidized loans (e.g. interest equalization schemes) • Non-reimbursable finance for joint firm and STI centres projects
Innovation under licensing, product adaptation and differentiation, improvements and adaptations to products and processes	Low	Low	<ul style="list-style-type: none"> • Reimbursable finance (which can be subsidized in some cases) • Fiscal incentive
Product differentiation, innovation of a known product, late uptake of process innovation within own firm, secondary technical improvements	Very low	Very low	<ul style="list-style-type: none"> • Reimbursable finance (e.g. loans) • Fiscal incentive

Source: Created by the authors based on José Luis Gordon and José Eduardo Cassiolato, "O Papel do Estado na Política de Inovação a partir dos seus instrumentos: uma análise do Plano Inova Empresa", *Revista de Economia Contemporânea*, vol. 23, No 3, Rio de Janeiro, November, 2019.







II. Review of the international experience

The survey and analysis of incentive mechanisms in Brazil helped identify gaps and obstacles for energy innovation in the country and became an input for the second phase of the work carried out under Axis 3 of the Energy Big Push (EBP) Brazil project, which consisted of reviewing international experiences. This analysis was aimed at identifying lessons learned and practices carried out in other countries to accelerate clean energy innovation that could be relevant for the case of Brazil. The review of international experiences was based on selected countries according the following criteria:

- Present a prominent position in global rankings of innovation in general and of innovation in renewable energy;
- Have started or gone through a relevant low-carbon energy transition process;
- Present a significant degree of coherence in their set of objectives, policies and incentives for the development of clean energy innovations;
- Implemented governance mechanisms to coordinate different stakeholders;
- Sought to coordinate policies in various areas (energy, climate, science, technology and innovation (ST&I), development etc.);
- Present research and development (R&D) incentive mechanisms that are aligned with the country's priorities for low-carbon energy innovation;
- Bear some resemblance with the Brazilian energy system and challenges.

Based on these criteria and on consultations with experts of EBP Axis 3 Working Group (see annex 5 for a list of participants), the six countries included in the analysis of international experiences are: the United Kingdom, Denmark, Japan, Norway, Chile and Finland (see diagram 2).

Diagram 2
Countries included in the international experiences review

United Kingdom	Denmark	Japan	Norway	Chile	Finland
					
GII: 5 th	GII: 7 th	GII: 15 th	GII: 19 th	GII: 51 th	GII: 6 th
GEII: 9 th	GEII: 10 th	GEII: 3 th	GEII: 1 th	GEII: 20 th	GEII: 2 th
*	*	*	*	*	*
Global leader in offshore wind power	Leadership in wind power and biopower share in the electricity matrix	Second solar power installed capacity in the World	40% of primary energy supply based on hydropower	Leadership in solar power production in Latin America	Leadership in biopower share in the electricity matrix

Source: Created by the authors based on Cunliff, Colin and David Hart, "Global Energy Innovation Index: national contributions to the global clean energy innovation system", *Information Technology and Innovations Foundation*, August, 2019; Cornell University, Institut Européen d'Administration des Affaires (INSEAD) and World Intellectual Property Organization (WIPO), *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation*, Ithaca, Fontainebleau and Geneva, 2019; and International Energy Agency (IEA), *World Energy Outlook 2019*, IEA, Paris, 2019.

Note: GII refers to the country's position in the Global Innovation Index and GEII refers to the country's position in the Global Energy Innovation Index.

Denmark ranked 7th in the Global Innovation Index 2019 (Cornell University, INSEAD and WIPO, 2019) and 10th in Global Energy Innovation Index (Cunliff and Hart, 2019). In terms of low-carbon transition of the Danish energy system, renewables have escalated from 16,3% to 32,6% from 2006 to 2017 (IEA, 2017a). The country intends to further expand the presence of variable renewable energy in its production and consumption patterns. Denmark's energy policy is closely connected with an ambitious climate policy. Brazil and Denmark share common challenges, hence the measures applied in Denmark might be useful to Brazil. In both Brazil and Denmark, the transport sector is one of the main fossil fuel users and thereby, of pollution and greenhouse gas (GHG) emissions. Both countries are also struggling to improve the energy efficiency in other sectors, as well. In terms of strategic plans, Denmark presents two important initiatives worth mentioning: Denmark's Digital Strategy and the Danish National Energy Efficiency Action Plan.

Finland ranked 6th in the Global Innovation Index 2019 and 2nd in the Global Energy Innovation Index (ibid.). Nuclear power generation represents a high share of the Finnish energy sector. In terms of transformation of the energy system, Finland is on the track towards sustainability. Since the 1970's, the share of bioenergy and waste in the total primary energy supply has been growing steadily. In the last decade, biomass and waste-based power supply grew by 2,7% yearly. In the opposite direction, oil supply decreased by 8,6% since 2007 (IEA, 2018b). Primary energy supply declined by 6,8% compared to 2007, which indicates significant energy efficiency gains. The country is investing public money in R&D to develop better solutions for biofuels (2nd generation) and is also investing heavily in wind power generation and smart grid solutions. In terms of relevance to the Brazilian case, Finland can provide an example of how to coordinate energy and climate policies, whereby the Climate Change Act has been a fundamental landmark. Also, the country is a leader in biofuels power production and much of that success is due to technological innovation, similarly to the case of Brazil.

Japan ranked 15th in the Global Innovation Index 2019 and 3rd in the Global Energy Innovation Index (ibid.). In terms of transformation of the energy system, Japan is going through a major reorganization of its production and consumption. Following the Fukushima Daiichi nuclear incident in 2011, the Japanese government has deactivated all its nuclear power plants. Energy supply became more dependent on oil,

gas and coal from abroad to meet domestic consumption. The Japanese government is fostering the adoption and development of renewables, whereby their share in the primary energy supply increased from 4,0% in 2010 to 5,7% in 2015 (IEA, 2016). Also, renewables production grew 56% between 2005 and 2015, with solar photovoltaic (PV) and wind power forging ahead. These circumstances may represent opportunities for development of new solutions for energy efficiency, energy security, environment protection and renewables production, even in a scenario of nuclear power generation reestablishment. In this context, Japan can be a hub for new solutions, both in technological and market terms, which is acknowledged in the 2014 Strategic Energy Plan and in the 2015 Long-term Energy Supply and Demand Outlook. In terms of relevance to the Brazilian case, Japan excels in planning the R&D activities, monitoring their results and in implementing innovative mechanisms to turn basic research in innovation.

Norway ranked 19th in the Global Innovation Index 2019 and first in Global Energy Innovation Index (ibid.). Norway is one of the world's largest oil and gas exporter. Wind power is starting to gain momentum in Norway in the recent years, as production from this source has doubled between 2011 and 2015 and is becoming a relevant source of electricity generation (1,7% in 2017; IEA, 2017b). Similar to Brazil, hydropower is the largest source of total energy supply (40%) in Norway. Norway has implemented a set of policies that has succeeded in accelerating the penetration of electric vehicles in the country's transport system. Efforts to develop the needed infrastructure have been supported through a constant stream of consistent programs. Norway also presents cutting-edge research on carbon capture storage and energy efficiency technologies.

The United Kingdom (UK) ranked 5th in the Global Innovation Index 2019 and 9th in Global Energy Innovation Index (ibid.). In terms of low carbon energy transition, the UK reduced its energy-related carbon dioxide emissions to their lowest absolute levels since 1988 (IEA, 2019a). The UK's five-year carbon budget approach was used as reference for the Paris Agreement. Record investments in offshore wind and solar PV alongside a shift from coal to gas, which were supported by various incentive mechanisms, have led to a significant transformation of the country's power sector over the last five years. The UK is a market leader in offshore wind with an installed capacity of around 7,9 gigawatts (GW) in 2017 and has a competitive renewable energy industry. In terms of relevance to the Brazil, the UK experience shows an example of how-to coordinate climate energy policies that are also aligned with energy R&D policies and programs. UK's policies on energy efficiency and the transport sector low carbon transition through the development of electromobility could also be relevant experiences. The country's experience with offshore wind could also be of interest to Brazil, in which this technology presents high potential.

Chile ranked 51th in the Global Innovation Index 2019 and 20th in the Global Energy Innovation Index (ibid.). In terms of low-carbon energy transition, Chile is providing ambiguous policy signals (IEA, 2018a). However, while the country has been successful in increasing deployment of solar and wind energy, it has increased oil imports, both to counter imported natural gas shortages and to cope with the economic growth and the increase in energy demand that followed. In spite of that, Chile has announced an update of its Nationally Determined Contribution to the Paris Agreement, whereby the country commits to reach peak emissions by 2025 and become carbon neutral by 2050 (Government of Chile, 2020). Chilean government representatives are proposing investments in clean energy as a way for a green recovery from the COVID-19 crisis (Schmidt, Jobet and Couve, 2020). Chile is improving its institutional setup in order to engage society in a broad public consultation and participatory decision-making process to define medium- and long-term energy goals. Also, the Chilean government is investing in R&D activities to generate clean energy innovations, including an important project to develop solar photovoltaic (PV) technologies and capabilities. Chile and Brazil share common challenges. Both countries are middle-income Latin American countries that present similar levels of energy innovation, as per their ranking positions in the Global Energy Innovation Index (Brazil – 17th, Chile – 20th).

From the review of the experience of these selected countries, main lessons learned and insights were drawn for Brazil, which are discussed below.

Long-term strategies, goals and plans to guide incentive mechanisms

Incentive mechanisms are means to achieve goals. The policy goals are part of broader plans, which are related to the country's long-term strategy and its vision of future, including the future of energy systems and the long-run sustainability of development. To be translated into public policies, long-term strategies, goals and plans require coordination and the engagement of government at all levels in the federation and of decision making. In Denmark, for instance, energy and climate plans were designed by multiple stakeholders, and the Digital Strategy involved three governmental levels: national authority, regional authorities and municipal authorities. Broad consultations and social participation are vital to identify common national aspirations, build consensus, trust and legitimacy, increase transparency, manage risks and generate the necessary engagement for transformative changes. In Chile, the construction of the National Energy Policy 2050 embodied the democratic spirit by defining three complementary instances of democratic participation: at the political-strategical, technical and public levels. Participatory processes of decision making can help build coordinated energy and climate policies, consider new perspectives and insights and design more resilient long-term goals and policies that may change less across different administrations.

Structured governance to coordinate climate, energy and ST&I areas

Policy coordination is a major challenge for any country. The countries covered in this study showed various ways of structuring governance arrangements to coordinate energy and climate policies. In the United Kingdom, for instance, both policies are under the responsibility of a single department (equivalent to a Ministry in Brazil), the Department of Business, Energy and Industrial Strategy (BEIS). In Japan, a long-term strategy that intertwines energy and climate goals under the same framework was established. In Finland, the same articulation can be observed under the National Energy and Climate Strategy for 2030. There are various governance arrangements within the countries reviewed, which clearly establish share responsibilities and roles in a way that allows coordination across these policy areas.

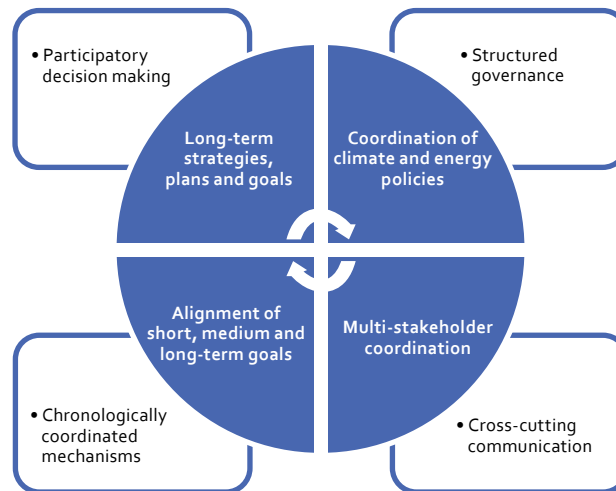
Cross-cutting communication and multi-stakeholder coordination

The review of international experiences shows that cross-cutting communication and multi-stakeholder coordination across the main government bodies and decision makers and stakeholders involved with climate, energy and science, technology and innovation has been a common feature in leading countries. Relevant stakeholders are mobilized in the design, implementation and evaluation stages of policy making in these areas. There are diverse arrangements for managing transversal coordination. Finland, for instance, has put coordination in the letter of law. The Climate Change Act (609/2015) defines each actor's responsibility and attributes to the Energy Department of the Ministry of Economics the role of coordination. Coordination is a challenge not only for different governmental ministries and entities, but also refers to creating more interactions between public bodies, private companies and academia. In the United Kingdom, for instance, government-supported centres of R&D coordinate efforts with industry and academia in conducting innovation projects. Norway's R&D programs and institutions (OG21, ENERGY21) are supervised by council members from these three social groups.

Chronological alignment of R&D incentives mechanisms and energy and climate priorities

Energy, climate and ST&I are long-term policy areas, which underline the significance of aligning goals across time. Japan provides an example of the importance of chronological matching. First, the country has set the medium and the long-term policy goals to later define short and medium-term incentives that meet the long-term goals. This chronological matching leads to coherence in time between R&D mechanisms and nations' priority setting (see diagram 3).

Diagram 3
Long-term goal setting and coordination within government, across stakeholders and in time



Source: Created by the authors based on information from EBP Axis 3 Working Group.

Balance between different incentive mechanisms

The review of the international experience underlines the importance of having a balanced mix of incentive mechanisms for innovation as per their four functions (see diagram 1). Almost all the countries reviewed show a balanced mix of innovation incentives between these functions. Furthermore, the international experience also highlights the importance of deploying a broad range of instruments, including compulsory ones, such as feed-in tariffs and renewable energy quota obligations, especially for emerging technologies, such as less mature renewable energy technologies.

Robust support to all the stages of the innovation process

All stages of the innovation process should be equally supported: from basic and applied research to experimental development, demonstration and commercialization if a country wants to successfully develop energy innovations to support low-carbon energy transitions, as the international experience review shows. In Denmark, for instance, different entities are in charge of different stages of the innovation process, whereby R&D funding agencies support basic research and part of the development stages, the local energy agency supports the experimental development and demonstration of new technologies and the innovation funds support the commercialization of the technology through various channels that are available for large companies, small and medium enterprises (SMEs), start-ups and academic entrepreneurship. The analysis of the international experiences also suggests that technology development and commercialization stages of energy innovations depend on robust, strong initiatives that foster projects in cooperation with companies of all sizes, such as public R&D centres—as ORE Catapult (United Kingdom) or the National Institute of Advanced Industrial Science and Technology (Japan). Network service and incubators also play an important role.

Focus on the transformation of energy systems as a whole

The R&D programs of the countries reviewed in the present study have a focus on broadly understood low-carbon energy system transitions, which involves the transforming of energy system entirely, and not only fostering a few specific energy sources. Beyond renewable energy, complementary areas are also seen as priorities to transform the energy system, such as distributed energy resources (distributed energy generation, energy storage, electromobility and charging infrastructure, energy efficiency and demand management). The Smart Energy of Finland and Energy System Catapult of the United Kingdom, are

examples of innovation programs that seek to induce the incorporation of range of different technologies in the energy sector besides the renewable energy source —such as digitalization, internet of things (IoT), artificial intelligence, energy storage systems, smart networks— which can enhance connectivity and integration of the energy system and optimize energy production and consumption from a systemic viewpoint. This broad focus also requires incentive mechanisms for building new business models and orienting consumer demand.

Strengthening the transformation of knowledge into technology and innovation

In Brazil, knowledge is generated mainly through scientific publication: Brazil is ranked 13th in volume of scientific papers produced in 2016 in the world. Patent applications by academic and research organizations in Brazil has been increasing since the early 2000's. However, there are limited links between the research conducted in academia and its application or deployment by industry, government or society. The review of the international experiences shows that leading countries have programs focused on turning the research developed by academia into practical application or solutions by businesses, government (e.g. public health systems) etc. For example, Japan's ACCEL program (Accelerated Innovation Research Initiative: Turning Top Science and Ideas into High-Impact Values) funds the Proof of Concept (POC) to bridge the gap between the practical application of the most relevant research results achieved by the projects funded by the basic research programs. The country also sponsors the A-STEP program that seeks to bring innovations from academia to the market. The A-STEP program funds the entire innovation chain. A key lesson that can be learned from the review of the international experiences, including A-STEP, is that the specific incentive instrument (grants or interest-free loans) employed should consider the stage of technological development and innovation (theoretical or more advanced research results), whereby the most initial stages (basic research, for instance) require more robust incentives (such as grants, non-reimbursable finance etc.) as the earlier stages of innovation are also the stages that involve most risks and uncertainties (see table 2). Other instruments, such as credit (with market interest loans) are more appropriate to the later stages of innovation (such as commercialization), in which the technological maturity translates into less risks and higher profit possibilities.

Public procurement can be a strong incentive mechanism for energy innovation

In Finland, the KEINO Competence Centre is a network-based organization comprised by a range of stakeholders related to public procurement and innovation support. Funded by the Ministry of Economic Affairs and Employment, consists of developing competences for sustainable and innovative public procurement and scale-up good practices across all governmental levels. Several strategies and roadmaps, both in national, regional and organizational level, have identified public procurement as a tool to achieve sustainability goals. KEINO Centre's main objective for 2018-2021 is to increase the number of innovative and sustainable procurements by 5%. The case of Finland illustrates how public procurement can be adjusted to foster sustainable solutions.

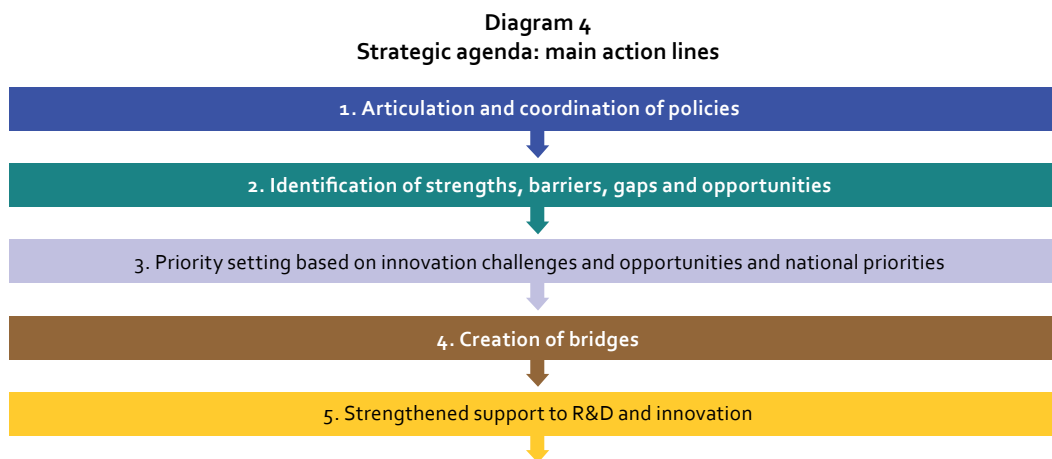
The role of international collaborations

International collaboration on energy innovation is increasingly relevant in a context of exponential reduction in costs of and fast-paced growth in deployment of clean energy. Chile is an emblematic example of international cooperation. The Solar Program from Chile strongly relied on the cooperation with Germany. This program aims at developing a national solar industry with cutting-edge technological capabilities to deal with local challenges and make Chile a competitive player in the global solar power market. The German government, through its development bank, is co-financing with the Interamerican Development Bank (IDB) projects to install Concentrated Solar Power Plants (CSP) in Chile. Also, a German innovation centre has been established in Chile (the Fraunhofer Chile Research) and won a bid to develop an excellence centre in solar energy technologies back in 2012/2013. The specificities of Chilean desert create different challenges for solar generation compared to Germany and other countries.

III. Strategic guidelines and key policy instruments for an energy big bush in Brazil

The survey and analysis of energy innovation incentive mechanisms in Brazil (phase 1) as well as the review of international experiences (phases 2 and 3) provided the foundations for the elaboration of recommendations of strategic guidelines and key policy instruments to accelerate clean energy innovation in Brazil.

The preliminary recommendations comprised a strategic agenda, structured along five main action lines (diagram 4). The fourth action line was disaggregated in two sublines: 4.1. implementation of programs and incentive mechanisms that address all stages of the innovation process; 4.2. implementation of incentive mechanisms to foster the development of low-carbon energy innovation ecosystems. And, the fifth action line comprises five sublines: 5.1. adaptation of existing innovation incentive mechanisms to target clean energy and reactivation of previous incentive mechanisms; 5.2. implementation of long-term R&D programs for the most strategic and promising areas; 5.3. implementation of demonstration programs, 5.4. implementation of test facilities and test platforms and 5.5. implementation of incentive mechanisms to stimulate the commercialization of renewable energy and energy efficiency technologies and entrepreneurship.



Source: Created by the authors based on information from EBP Axis 3 Working Group.

These preliminary recommendations were presented and discussed at the Energy Big Push Workshop, held at the Centre for Strategic Studies and Management (CGEE in its Portuguese acronym) on 30 and 31 October 2019 (see annex 1 for the list of the participants). In order to receive the feedbacks and inputs to improve the preliminary version, a facilitation methodology named as “market of information” was applied, with the support of EBP Axis 4 Working Group. Different groups of experts discussed a range of specific questions and produced a collection of sentences, which represent the main ideas brought from multiple rounds of discussion. The main sentences obtained from these contributions are summarized in table 3 and were applied to improve the preliminary proposal.

Table 3
Contributions from the Energy Big Push Workshop

Coordination is essential for a sustainable energy transition: there is some information coordination going on at the operational level of energy and innovation agencies in Brazil
There are many obstacles to coordination (lack of communication, conflict of agendas etc.)
Coordination should be thought at the level of the innovation systems, since the level of coordination depends on the sector maturity and their respective groups of interest
Defining what kind of energy transition the country will pursue and the associated national strategy is key and should consider sustainability, efficiency, market signals, etc.
The energy transition should be presented as an opportunity to facilitate the coordination of relevant stakeholders
Social aspects should be fully taken into account in the context of energy transition
Energy priorities should be linked to industrial policy
The innovation programs should be coordinated with incentive mechanisms for the development of the new business models and market design
The core technologies for Brazil should be identified
Clear definition of the roles and responsibilities of each agency
Engage more stakeholders and build support from wider society
Lack of strategy and the weak support to clean energy innovation and development partly owes to the abundance of natural resources in Brazil
The R&D public budget should be oriented to core technologies
The incentive mechanisms should be revised, adapted and updated as the energy system transforms
Engage the fossil fuel industry in the transition

Source: Created by the authors based on inputs from experts who attended the Energy Big Push Workshop.

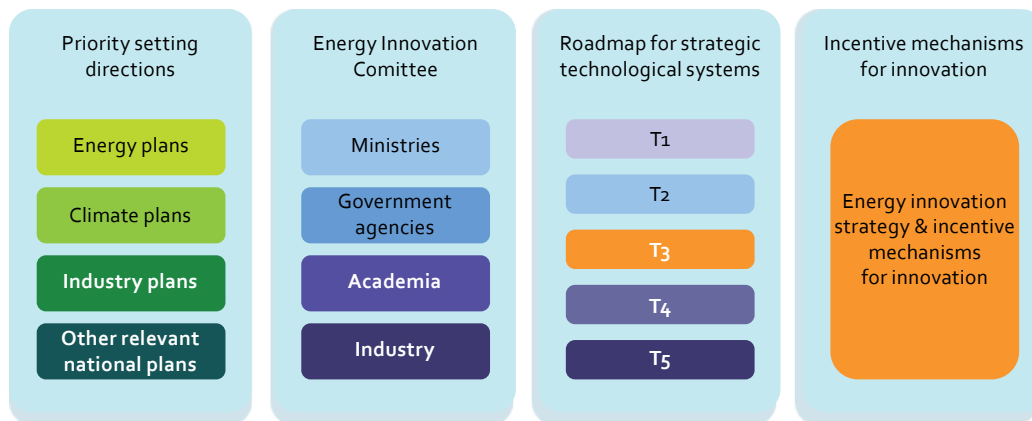
The final recommendations result, thus, from a collaborative effort under EBP activities (Axis 3 Working Group meetings), which included the survey and analysis of the available incentive mechanisms for energy innovation in Brazil, the review of the international experience and the valuable contributions received from experts at the workshop. The final recommendations to accelerate clean energy innovation in Brazil are structured along three different action levels:

- (i) **Strategic level:** concerns high-level decisions regarding strategic innovation areas across energy, climate change and science, technology and innovation (ST&I) policies;
- (ii) **Tactical-operation level (technology system):** refers to roadmaps for the development of the technology systems prioritised at the strategic level;
- (iii) **Policy level (incentive mechanisms for innovation):** concerns the incentive mechanisms for innovation that should be implemented or adapted to foster the implementation of the technology roadmaps.

Diagram 5 summarizes the recommendations at these three levels and shows how they relate. At the strategic level, key government bodies and relevant stakeholders should form an Energy Innovation Committee (EIC), or similar forum, to coordinate key players, who should be involved in the priority setting process. The EIC should define the strategic technology systems (from energy production, to distribution and use, which might include specific renewable energy sources —wind, solar, biofuels etc., smart distribution

networks, energy storage systems, energy efficiency and/or electromobility) for an energy big push in Brazil, based on data and technical information obtained from processes of energy planning, national development priorities, climate goals and relevant innovation and technology indicators (such as the data development in Axis 1 and indicators developed in Axis 2 and including inputs and outputs of the innovation system, etc.), expert literature, international best practices etc. Technological systems (T₁, T₂, T₃...) that are deemed strategic should be consistent with national plans and strategies.

Diagram 5
The three-level recommendations for an energy big push in Brazil



Source: Created by the authors.

At the second level (tactical-operational), specific groups of stakeholders, related to each strategic technological system as defined by the EIC would work on developing technological roadmaps that consider gaps, obstacles, strengths and opportunities for innovation, prioritize investments in the development of solutions with most co-benefits, line with the Big Push for Sustainability approach (ECLAC/FES, 2019), and present clear and well-defined short-, medium- and long-term goals to guide decision-making.

At a third level (policy), incentive mechanisms should be designed, implemented or, if it is an existing mechanism, adapted to promote the development of each roadmap. The incentive mechanisms are the tools to achieve the established goals of the roadmaps for each strategic technology system. This entire process should be built upon the guidelines of the strategic level (line of action 1.1).

Strategic level

Action Line 1.1: Understand what energy system Brazil aspires to in the long run

Firstly, it is necessary to set the main features of the energy system the country seeks in the long term. There are several possible paths to pursue energy transition, as highlighted by the Big Push for Sustainability approach (ECLAC/FES, 2019). While different countries may opt for different strategies to drive the energy transition and achieve national policy goals, these strategies need to include innovation components. For instance, countries such as the United Kingdom or Denmark, which aim for a partial or full transformation of energy systems towards low-carbon sources, have established links between their national priorities and their innovation policies. The objective is to ensure that innovation activities are aligned with the country's goals. Compared with the Organisation for Economic Cooperation and Development (OECD) member countries, Brazil is in an advantageous position of having a large participation of low-carbon energy sources in its energy system currently. The path to be chosen by Brazil should take into account

local capacities as well as economic and social issues and technological barriers and opportunities. There is a need for a whole-of-government innovation strategy aligned with energy and climate goals, including energy access, affordability and sustainability, as well as broader national priorities. In these circumstances, the country could improve its energy system by investing in energy efficiency, increasing flexibility, introducing new business models, apart from transforming the installed capacity. All these aspects should be taken into consideration to decide what kind of transition the country is looking for.

Action Line 1.2: Enhance coordination

The articulation and coordination of the policy makers, energy planners and regulatory and innovation agencies could be enhanced, for example, through the establishment of the EIC. Achieving the sustainable energy system that is envisaged depends on coordinating actions in terms of energy planning, climate goals, ST&I policies and sustainable development. Moreover, contemporary challenges—such as sustainable economic development, climate change mitigation and adaptation, and energy systems transition—require overcoming the unilateral decisions of governmental departments, since their multidimensionality require coordination. There is informal coordination at the operational level, but a systematic interaction and coordination among the main Brazilian governmental bodies and stakeholders at the strategic level is needed to set coordinated priorities in terms of energy, innovation, climate and development. Based on the international experiences mentioned in this study, it is recommended to create a formal transversal committee—an Energy Innovation Committee—in Brazil comprised by representatives from (Portuguese acronyms in parenthesis):

- Ministries: Ministry of Mines and Energy (MME), Ministry of the Environment (MMA), Ministry of Infrastructure (MI), Ministry of Agriculture, Livestock and Supply (MAPA), Ministry of the Economy (ME), Ministry of Science, Technology and Innovations (MCTI) and Ministry of Education (MEC);
- Planning and regulation bodies: Energy Research Office (EPE), Brazilian Electricity Regulatory Agency (ANEEL), National Petroleum Agency (ANP) and National Operator of the Electric System (ONS);
- Other agencies: Funding Authority for Studies and Projects (Finep), National Economic and Social Development Bank (BNDES), National Council for Scientific and Technological Development (CNPq), Brazilian Industrial Innovation Agency (EMBRAPPII), National Institute of Metrology Standardization and Industrial Quality (Inmetro) and Brazilian National Council of State Funding Agencies (CONFAP).

Business and academic representatives should also be involved in the EIC. To build consensus and reconcile diverse interests regarding the innovation needs for the energy transition, the decision-making process of the EIC should be participatory and include public consultation. Once the needs are identified, the representatives of the most relevant sectors—those that may boost energy innovation or even block innovation development—should also take part on the EIC to help on the elaboration of the energy innovation strategy.

The EIC should work in a systematic way and its focus should be the alignment of development, climate and energy areas with ST&I strategies and R&D promotion efforts. The idea of participatory governance arrangements observed in the international experience could be applied to provide the actors with adequate responsibilities and/or political space to play an active role in the three relevant areas—energy, climate, development and ST&I—and to enhance existing synergies and develop new ones.

Action Line 1.3: Provide data and evidence to inform decision-making on energy priorities

There is a need for better data related to energy innovation, such as public expenditures on R&D activities that is developed under Axis 1 of EBP and indicators developed under Axis 2 of EBP. A platform should be created to provide the transition committee with relevant and robust data and evidence-based information

for strategic decision-making. The selection of the most strategic areas to tackle the energy transition and accelerate innovation should rely on well-structured databases on energy, sustainability and innovation indicators. To make this task possible, it is necessary to invest in reliable databases, especially in the areas where data are not complete; specific indicators, such as publications and patents, are also essential to track the evolution of public policies regarding the low-carbon energy evolution and innovation. It is also necessary to present data from the national industrial matrix, as well as consider the technological maturity of the various sectors that could integrate the national energy innovation strategy.

Action Line 1.4: Establish strategic guidelines and define priority technological systems

Despite the absence of specific plans to coordinate diverse policy areas, there are elements in national strategies, energy plans, climate plans and ST&I policies that can help identify synergies and foster articulation. Brazil's Nationally Determined Contribution (NDC) could be a starting point for relating the goals of these diverse areas. The 10-year Energy Plan (PDE in its Portuguese acronym) should also be considered, as it provides relevant directions for the future role of technology systems and subsystems related to renewable energy supply, distributed generation, energy storage, electric vehicles, charging infrastructure, energy efficiency and energy demand management. However, as per the review of the international experiences, the country should seek explicit coordination in terms of innovation for the energy transition, with information on: long-term plans, efficiency and flexibility criteria, need for public investment (by area or solution); milestones to be achieved in the short-, medium- and long-runs, etc. Evidence-based data and indicators described in Line of Action 1.3 should inform and guide the EIC in relation to the country's environmental, economic and social demands and in terms of technological strengths, gaps, barriers and opportunities. Stakeholders that take part in the EIC should be able to reconcile various national needs and priorities to identify strategic technology systems.

Action Line 1.5: Set specific missions for research, development and innovation agencies

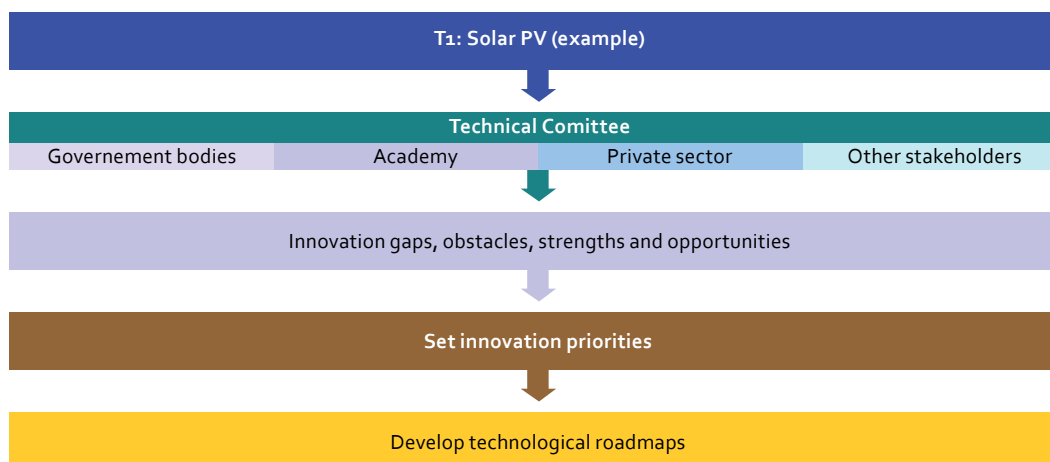
Brazilian federal agencies on research, development and innovation present skilled human resources that are essential to the consecution of public policies such as the ones described in this report. However, each government agency should be responsible for specific, clear and complementary missions, so that there are no overlaps and inefficiencies. That is also a matter of good governance i.e. who does what when it comes to ST&I policies. By doing so, coordination costs decrease and, more importantly, agencies gain legitimacy before the government and society. In turn, specific role-setting contribute to more resilient federal agencies and public organizations in the face of crisis and circumstances of political and institutional instability. ST&I incentive mechanisms and development public policies in general should be revised as needed to adapt to the ever-changing landscape and to the transformations induced by the results of past policies.

Tactical – operational level (technology system)

Following the establishment of strategic guidelines and priority technological systems (T₁, T₂, T₃ etc.) to accelerate the transformation of the energy system in line with national priorities, it is important to establish roadmaps for the development of technological systems that provide opportunities for the country's development.

Diagram 6 illustrates the process of designing technology system roadmaps, including the stakeholders to be involved (Action Line 2.1), principles to elaborate roadmaps (Action Line 2.2) and how the priorities and demands of each technology system should guide the incentive mechanisms framework (Action Line 2.3).

Diagram 6
Example of roadmap design process



Source: Created by the authors.

Action Line 2.1: Coordinating stakeholders at the tactical – operational level

Coordination is a challenge to be addressed at multiple levels. In order to set and implement energy innovation roadmaps for the most relevant technological systems set at the strategic level—which may encompass one or more technological innovation system (TIS)—, it is necessary to facilitate coordination between the relevant agents. The formation of technical committees is a common practice internationally: these are usually formed by representatives from key sectors (academia, industry and government) so they can align interests and manage expectations regarding inputs, outputs and outcomes for each roadmap. The solar PV roadmap design process, for instance, should be guided by its own technical committee, the energy efficiency roadmap would also have a committee of its own and so on.

The participation of international stakeholders in the technical committee, such as the IEA and ECLAC, for instance, could contribute to these committees by bringing global and regional perspectives of energy system transformation, fostering opportunities of international collaboration and creating spaces for peer learning and strategic dialogues. It is noteworthy that, depending of the technological maturity of each TIS (say, solar PV is much less developed in Brazil than biofuels) coordination mechanisms become more necessary.

Technical committees should also engage state companies in the arrangements, especially in the context of less mature TIS. Accelerating clean energy innovation is impossible without the engagement the private sector. It is of paramount importance, therefore, that the private sector is also involved in the technical committees.

Action Line 2.2: Map innovation gaps, obstacles, strengths and opportunities for each technology system

The energy system is comprised of several technology systems and subsystems that require various sets of technologies and competences. The integration of the systems and subsystems also requires specific technologies and competences. In these circumstances, the technological roadmaps should be built upon an analysis of the innovation gaps, obstacles, strengths and opportunities for the technological system in question, considering the technological readiness level, existing technological competences and capabilities, R&D infrastructure, productive capacity, technical issues, internal and external market concerns, potential to contribute to the energy supply, environmental and social impacts etc. Such analysis would also reveal supply chain readiness and bottlenecks, as well as business opportunities.

The Technology Needs Assessment under MCTI, to be finalized in the end of 2020, could be a starting point to identify innovation gaps. In addition, other governmental initiatives in place could contribute to this effort, such as the Working Group on Smart Grid created in 2010 and led by the MME, and the National Platform for Electric Mobility launched in 2020 and hosted by the German Technical Cooperation (GIZ) with the support of various governmental bodies. The IEA Innovation Gaps Framework, which identifies key long-term technology challenges for research, development and demonstration that need to be filled in order to meet long-term clean energy transition goals, could be another input in this process.

Action Line 2.3: Develop roadmaps

Roadmaps should be developed for each of the technological system or subsystem indicated as strategic (action line 1.4) by their respective technical committees. Technological roadmaps (or strategic development plans) should be comprised by clear and specific objectives and milestones to be achieved over in the short, medium- and long-terms. These roadmaps should identify the most critical areas for development.

The results of action line 2.1 (map innovation gaps, obstacles, strengths and opportunities) could be a key input for the technical committee to develop roadmaps. The elaboration of roadmaps should take into account the local productive infrastructure to avoid increasing dependence on foreign technology. The roadmap of each technology should be updated from time to time, given the fast pace of technological change, the effectiveness of incentive mechanisms used and the changing socioeconomic and political landscape. The updates also have the role of informing policy makers of the need to lift or revise incentive mechanisms to address the need for technological development.

Policy level (institutional level)

Following the elaboration of technological roadmaps for each technology system, it is necessary to implement new incentive mechanisms or adapt the existing ones to foster the development path outlined in each roadmap. The following action lines are drawn in generic terms, as a more specific recommendations would require developing the previous action lines, as suggested earlier.

Action Line 3.1: Implementation of incentive mechanisms to connect different stages of the innovation process

There are several research groups in Brazilian academic institutions with relevant research results and recognized competences in the energy field; and there are relevant mechanisms to fund the academic research (see Chapter I). However, there are significant challenges in translating theoretical work and patent registration into applied results. Bridging the gap between academic research related to low-carbon energy solutions in Brazil (publications and patents) and development of technologies that are applied in practice should be the starting point of a mix of incentive mechanisms. In this sense, a program oriented to foster the development of the strategic technology systems should be implemented. The solar PV is an example of technology that could be benefited from this kind of program, once there have been similar efforts to encourage its development (CNPq has funded research projects on organic solar cells).

Incentive mechanisms to fund Proof of Concept (POC) with the obligation of achieving practical results could be a way of creating bridges between basic and applied research and experimental development. The transfer of practical results to industry and, where applicable, to government should also be incentivized by mechanisms based on the approach "fast track from concept to the market". In this case, applicants should indicate a pathway that could take the product to the market and funding may be granted on a phase-by-phase basis, according to each achieved milestone. The improvement of energy efficiency within the major pollutant industries is a fertile ground for this kind of program.

Another critical aspect to contemplate is that the set of incentive mechanisms should consider that different innovation projects require different instruments (see table 2), whereby the most risky and uncertain innovation projects (e.g. basic research, invention) require more robust incentive instruments such as technology-specific public procurement (“*encomenda tecnológica*”) and non-reimbursable finance (Gordon and Cassiolato, 2019; Gordon, 2019). These types of incentives are essential to develop new solutions, especially in areas that present large potential for greenhouse gas emissions reductions, but are high-risk, high-uncertainty projects. Innovation projects that present lower levels of risk and uncertainty (such as improvements and adaptations to known products and processes) should be supported by other types of incentive mechanisms, such as loans and fiscal incentives (*ibid.*).

Action Line 3.2: Strengthen knowledge networks, promote collaboration and foster the development of innovation clusters

Even though the available innovation incentive mechanisms in Brazil are not targeted at low-carbon energy solutions, the available mechanisms in Brazil can foster clean energy innovation, such as the Finep Conecta Program, BNDES Funtec and EMBRAPII. Indeed, there is evidence that green innovation in Brazil has been induced by the existing innovation incentive mechanisms (Gramkow and Anger-Kraavi, 2018). However, the review of international experience of leading countries shows that bold, robust and explicit incentive mechanisms are necessary to develop clean energy innovation ecosystems, that is, to articulate government agents, researchers, productive sector stakeholders and even members of the community towards clean energy R&D and innovation.

The implementation of an innovation platform targeted at large companies, small and medium enterprises (SMEs), universities and research institutes that work complementarily and collaboratively to develop new technological capabilities and create business opportunities in low-carbon energy markets can be an effective way to mobilize and coordinate relevant players in seizing the opportunities of energy innovation. The platform should be built on the guidelines identified at the strategic level. Based on international experiences, the platform should contemplate facilities to strengthen public and private partnerships for clean energy innovation and to identify funding opportunities. Multinational corporation subsidiaries have a strong participation in the Brazilian productive structure, including the sectors that provide equipment and solutions for the energy system. The platform, as well as other incentive mechanisms, should also seek to connect these companies with local agents so as to build local capabilities for low-carbon development and to strengthen Brazil’s participation in global value chains.

Action Line 3.3: Adaptation of existing incentive mechanisms

The existing incentive mechanisms in place in Brazil can support the development of clean energy innovation. However, these should be adapted according to the strategic guidelines and roadmaps established at the strategic and tactical-operational levels. The technical committee of each technological system should inform policy makers, innovation agencies, etc. on the adaptation needs to target the priority energy innovation investments according to the roadmaps for strategic technologies and advances in their development to promote an effective alignment of the mechanisms to encourage innovation. In other words, the technical committee should be in constant communication with policy makers to establish and update incentive mechanisms and research topics.

The reorientation or adaptation of incentive mechanisms should consider academic research mechanisms (such as CNPq and FAPs programs) and programs that target the industrial sector both on its own (e.g. economic subvention by Finep) and in collaboration with research centres (such as EMBRAPII). Finep, for example, has a program to support Internet of Things (IoT) innovations in companies. EMBRAPII, on the other hand, promotes, among others, collaborative programs in Information and Communication Technologies. Both institutions could have the clean energy development as a strategic research theme (in line with strategic guidelines and roadmaps). Sectorial funds could also play a significant role in strengthening support the development of low-carbon energy solutions in Brazil. It should be noted that

the cross-cutting nature of energy solutions allows them to be supported through various existing sector funds (CT-Energy, CT-Transport, CT-Agriculture, CT-Petroleum, CT-Information).

Action Line 3.4: Implementation of long-term R&D and innovation programs for strategic technology systems

International experiences show that the most strategic and promising areas are supported by long-term innovation programs (at least a 5-year period); and it is not just the case for developed countries, since Chile has two relevant long-term innovation programs (solar and ocean energy). In Brazil, there are no such specific programs for low-carbon energy solutions at the federal level. The exception is the FAPESP Bioenergy Program (BIOEN), created in 2008 to stimulate and articulate R&D activities using industrial and academic laboratories to promote knowledge and its application in areas related to bioenergy production in the state of São Paulo. Even if the technological system of bioenergy is already at an advanced stage of development, there is fertile ground for further developments and a growing demand for more modern and more efficient technologies, as well as to strengthen Brazil's position in global markets, that can be supported by long-term innovation programs aimed at the modernization of the productive infrastructure and the development of local capacities to strengthen participation in the global value chain. Vital for building technological and innovation capabilities in the country, long-term R&D incentive mechanisms should be focused on strategic technological systems and priority areas for investment identified in the technology roadmaps - that balance gaps, obstacles, strengths and opportunities in terms of new business models, domestic and global market position, energy security and sustainable development.

Action Line 3.5: Implementation of demonstration programs

One way to improve support for the clean energy innovation, which depends on field experiments to be tested and approved over time, is to implement long-term demonstration programs. The demonstration programs support the experimental testing of a technology, system or method under realistic conditions prior to the commercial development of the technology and its introduction in markets. This type of program also connects equipment producers in the energy sector (hardware, software and engineering companies) and users (services) and triggers learning processes, ultimately creating business opportunities related to new energy systems or supply chain demands. The development of renewable energy technologies, such as coastal, marine, solar and wind energy, depends heavily on demonstration programs. The scope and reach of these programs in leading countries —such as Japan and Denmark— may be very distant from the context of Brazil, demonstration programs are still essential to create and adapt solutions to the Brazil's diverse landscape and power system specificities. ANEEL's R&D program has already financed small demonstration projects, but these were isolated initiatives and the program is not focused on this type of project. A starting point could be a small program targeted a couple of technological demands that could be addressed mostly by local competencies. It is noteworthy that a programme targeted at demonstration-stage innovation projects require systematic follow-up activities to monitor the stages of the projects and provide feedbacks to improve the product or process.

Action Line 3.6: Implementation of test facilities and test platforms

One way to improve support for the development stage is to implement test platforms as part of the public R&D infrastructure to conduct experimental development, as well as a complement to the local companies' R&D and innovation infrastructure. This type of structure also allows the connection of the agents of the technological innovation ecosystem and the creation of new demands for technology and new business opportunities, as tests and experiments reveal new challenges related to the supply chain of new energy technologies.

In the context of increasingly diverse and integrated energy sources, test platforms play an important role in combining, on a small scale, different renewable energy sources and system technologies (such as storage technologies and new digital services); and aggregate different layers and interfaces of smart

energy systems (energy providers, energy consumers, energy market operators, etc.) to verify on-site the possibilities of integrating energy systems. In addition to working as a living laboratory, test platforms can also foster the development of an innovation ecosystem by allowing various agents of different technology systems to work together in the search for new energy solutions, new business models, etc.

A test platform could also help deal with the most urgent challenges to improve the operation of the Brazilian electrical system and build resilience.

Action Line 3.7: Implementation of incentive mechanisms to stimulate the commercialization new energy technologies

Building a low-carbon, efficient and resilient energy system can involve investing in numerous new solutions from diverse energy sources to efficient uses of energy and grid integration and management technologies, which translate into business opportunities. All leading countries in energy innovation present strong programs to encourage entrepreneurship and to create new businesses or start-ups focused on low-carbon energy solutions. There are some programs aimed at investing in start-ups in Brazil, such as Fundo Primatec, Fundo Criatec and Fip Anjo. However, these initiatives are focused on capitalizing new companies and have a limited reach compared to international experiences.

The CENTELHA Program, managed by Finep, has a broader proposal since it provides subsidies to start-ups located in favoured innovation structures in the country (business incubators and accelerators, technology parks, co-working spaces, etc.). A strong entrepreneurship program requires complementary support, such as networking services, entrepreneurial guidance and advice, third-party technology verification, support to access to risk capital, etc. These mechanisms could be extended to academic entrepreneurs who wish to bring research results to market.

A strong program of complementary incentive mechanisms to foster the commercial development of clean energy innovation should be implemented, including incentive mechanisms to encourage start-ups, incubators (such as technological development centres at universities) and effective support for entrepreneurial capacity building (including networking, guidelines on how to set up and run a business, support to access funding etc.) which could be provided, for instance by entities such as the Brazilian Micro and Small Business Support Service (SEBRAE).

Action Line 3.8: Leverage international partnerships

International partnerships can generate opportunities for productive exchanges — in terms of knowledge, experiences, resources and technology transfer. In the area of energy, Brazil is already involved in a series of bilateral partnerships and international forums, including Mission Innovation, the Biofuture Platform and the Technological Collaboration Programs of the IEA. At the regional level, the country has been involved in activities of peer-learning and strategic dialogues with Latin American and Caribbean countries, with which it shares similar challenges, and which can offer relevant experiences and lessons learned to each other, in addition to discussing perspectives for integration of energy infrastructure. In addition, Brazil actively participates in regional energy cooperation forums, such as the Regional Energy Planners Forum, the Regional Observatory for Sustainable Energy (ROSE, which aims to develop, implement and monitor strategies, plans and policies of sustainable energy based on objective evidence) and the Regional Political Dialogues on Energy Efficiency, led by ECLAC in collaboration with other entities working at the regional level, including the Latin American Energy Organization (OLADE), the Inter-American Development Bank (IDB) and the International Renewable Energy Agency (IRENA). There are many opportunities for international cooperation, however, the level of engagement depends on each nation and its strategies.

IV. Final remarks and paths to accelerate clean energy innovation in Brazil

Incentive mechanisms are tools to achieve goals. Clean energy innovation incentive mechanisms thus depend on the energy system transformation a country is seeking to achieve. There are several types of possible energy transitions, which often involve coordinating investments in complementary areas such as renewable energy sources, distributed generation, smart grid, energy storage, electric vehicles, charging infrastructure, energy efficiency, energy demand management and carbon capture and storage. In the present study, it was argued that different countries opted for different strategies to drive the energy transition they aspire to, which underlines the flexibility of the approach. The recommendations presented in the previous Chapter reflect the general guidelines and the main elements that should be considered in designing the policy mix for clean energy innovation in Brazil. Even though further specification may depend on detailing goals and a strategy for energy transition in the country, the following recommendations and key messages for an energy big push in Brazil can be drawn.

Firstly, a big push for clean energy innovation in Brazil will only be possible if significant, stable and predictable public resources are mobilized in the short, medium and long terms. To this end, it is necessary to establish a continuous and sustained budget flow for R&D programs for priority clean energy technologies. A balanced combination of R&D incentive mechanisms, according to the degree of uncertainty and the level of technical and market risks, is essential to accelerate innovation in low-carbon energy. R&D incentive mechanisms should include differentiated incentive modalities, so that innovation projects presenting higher risk and uncertainty can be supported by mechanisms that reduce these challenges, such as economic subvention, non-reimbursable finance for joint firm and STI centres projects, technology-specific public procurement and public shareholding. Projects that show lower risk and uncertainty can be supported by subsidized loans and fiscal incentive mechanisms. In this way, public resources would focus on incentive mechanisms that reduce uncertainty and risk to unlock innovation investments and make these attractive for the productive sector to invest more, thus leveraging private investment in R&D.

All stages of the innovative process should be targeted by incentive mechanisms, from research development, to demonstration, testing and experimentation, to commercial development and introduction to the market. To contribute to the commercial success of a new technology, which depends on demand-

side aspects, including scale-deployment, is vital to design incentive mechanisms that promote the profitability of investments in such technology. When fostering diffusion or uptake of the newly developed technologies, it is necessary to consider complementary and coordinated policies that operate throughout the value chain, such as some sort of incentive or advantage for consumers who invest in sustainable energy sources, renewable-energy-sources dedicated auctions combined with financing for electricity generation (conditional on local content requirements), subsidized loans for capital goods that are more efficient in the use of energy, tax incentives (tax relief or exemptions, accelerated depreciation), among others. In the case of variable renewable energies, such as solar and wind, there is a high upfront capital cost and a lower operation and maintenance cost, compared to conventional fossil sources of energy. Therefore, these energy sources require specific financing arrangements to foster uptake at a scale compatible with the energy transition the country seeks to achieve.

Energy efficiency is a fertile field of development, with socioeconomic and environmental co-benefits. Incentive mechanisms in the area of energy efficiency (tax exemptions, accelerated depreciation, subsidized credit) should be dedicated to companies that are large consumers of fossil energy, in which there are considerable opportunities for reducing greenhouse gas and pollutant emissions, as well as costs related to energy consumption. In addition, incentive mechanisms should consider consumers.

A more ambitious energy big push strategy for clean energy innovation could include not only energy production and generation technologies, but also energy systems as a whole, for example including energy distribution, storage technologies, end-use sectors, as well as the integration of emerging energy technologies on existing systems. Digital technologies could be one of the focus areas of a more comprehensive strategy, since their transversal character allows for the development of several relevant technologies, such as smart grids, intelligent energy storage systems, technologies related to energy efficiency such as internet of things, automation, artificial intelligence, industry 4.0 etc.

Finally, yet not less important, a big push for sustainability in the energy sector requires broad coordination and articulation of energy, climate, ST&I and development plans and policies, which not only generates efficiencies and synergies between the R&D efforts and investments made, but also contributes to mobilize the relevant stakeholders and the necessary investments.

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Annexes

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Annex 7 Summary of incentive mechanisms for energy innovation in Brazil

Table A1
Summary of incentive mechanisms for energy innovation in Brazil, 2019

Incentive mechanism	Legislation	Resources origin	Executor	Manager	Type/Requirements
Direct energy R&D and innovation incentive mechanisms					
Sectorial Fund of Energy (CT-Energ – Finep/CNPq)	Law 9.991/2000, Law 10.848/2004, Law 12.212/2010, Law 12.111/2009, Decree 3.867/2001.	Between 0,75% and 1% of the net income of the utilities of transmission, generation and distribution of electricity	Finep and CNPq	Finep and CNPq	Grant (non-refundable) but companies must invest a financial counterpart
Program of Research and Technological Development of the Electric Power System (R&D ANEEL)	Law 9.991/2000, Law 10.438/2002, Law 10.848/2004, Law 11.465/2007, Law 12.212/2010, Law 13.203/2015, 13.280/2016	Utilities must invest by contract and Law at least 0,75% of their net income in R&D activities and 0,25% in energy efficiency programs (final use)	ANEEL	ANEEL	Mandatory investment
Sectorial Fund of Terrestrial and Waterway Transportation (CT- Transport – Finep/CNPq)	Law 9.994/2000, Decree 3.915/2001	10% of the income received by the National Department of Highways (DNER in its Portuguese acronym) due to contracts established with telecom operators and similar, which use the services infrastructure of the federal terrestrial transport	Finep and CNPq	Finep and CNPq	Grant (non-refundable) but companies must invest a financial counterpart
Program Rota 2030 – Mobility and Logistic (2018-2023) (ME)	Law 13.755/2018; Decree 0.557/2018; Provisional Measure 843/2018	N/A	ME and MCTI	ME and MCTI	Tax incentive: up to 12,5% of the R&D expenditure by firms in the country can be deducted from income tax and profit tax
Program of Support to Technological Development of the Semiconductor and Display Industry (PADIS in its Portuguese acronym)	Law 11.484/2007; Ordinance MCTI/MDIC 1.945/2014	N/A	ME and MCTI	ME and MCTI	Tax incentive subject to mandatory R&D investment
Indirect incentive mechanisms may be used for energy innovation					
Incentives mechanisms/regulatory tools for centralized generation					
Electricity bidding (“leilões”)	Law 10.848/2004, Decree 5.463/2004	N/A	ANEEL, EPE and CCEE	ANEEL, EPE and CCEE	N/A

Table A1 (continued)

Incentive mechanism	Legislation	Resources origin	Executor	Manager	Type/Requirements
Discount over the grid's use charges	ANEEL-Normative Resolution 481/2012, Law 13.097/2015	N/A	ANEEL	ANEEL	Discount of 80% over charges of the use of transmission and distribution grid (TUST and TUSD) for solar PV, wind, biomass or qualified cogeneration and small hydro plants
Preferential Loans (BNDES)	Federal Constitution 1988 (article 40) Law 5.662/1971, Law 10.556/2002, Law 11.786/2008, Law 6.000/1973, Decree-Law 1.940/1982, Decree 7.162/2010 Decree 7.439/2011 Decree 7.653/2011 (BNDES) Resolution 1.467/2007, Resolution 1.800/2009, Resolution 2.314/2012, Resolution 2.534/2013 Resolution 2.619/2014 Resolution 2.851/2015, Resolution 3.149/2017, Resolution 3.259/2018, Resolution 3.383/2018 (BNDES General Regulation of Operations) Law 11.488/2007	FAT/PIS/PASEP, National Treasury, Fund of the Merchant Navy (FNM), Social Security Fund (FGTS); overseas funding raising; public emissions of debentures; private emission of Credit Letters of Agrobusiness (LCA) and Financial Letters	BNDES	BNDES	Loan (refundable)
Especial Regime of Incentives to the Development of Infrastructure (REID)	Law 11.488/2007	N/A	ANEEL	ANEEL	Tax incentive
Incentives mechanisms/Regulatory Tools to distributed or isolated generation					
Net-metering	ANEEL-Normative Resolution No. 482/2012; ANEEL-Normative Resolution 786/2017	N/A	ANEEL	ANEEL	Credit in the consumer electricity bill
Tax incentives (PIS/PASEP, ICMS and IPI)	Law 13.169/2015 (PIS/PASEP) Agreement – ICMS/2015 (CONFAZ) Law 8.322/14 (IPI)	N/A	N/A	N/A	Tax incentive
Preferential loans	See Annex VIII	See Annex VIII	See Annex VIII	See Annex VIII	See Annex VIII

Table A1 (continued)

Incentive mechanism	Legislation	Resources origin	Executor	Manager	Type/Requirements
Incentives mechanisms to the expansion of local productive capacity of wind turbines and solar PV system					
Preferential loan conditioned to local content requirement (BNDES)	Federal Constitution 1988 (article 40) Law 5.662/1971, Law 10.556/2002, Law 11.786/2008, Law 6.000/1973, Decree-Law 1.940/1982, Decree 7.162/2010 Decree 7.439/2011 Decree 7.653/2011 (BNDES) Resolution 1.467/2007, Resolution 1.800/2009, Resolution 2.314/2012, Resolution 2.534/2013 Resolution 2.619/2014 Resolution 2.851/2015, Resolution 3.149/2017, Resolution 3.259/2018, Resolution 3.383/2018 (BNDES General Regulation of Operations)	FAT/PIS/PASEP, National Treasury, Fund of the Merchant Navy (FNM), Social Security Fund (FGTS); overseas funding raising; public emissions of debentures; private emission of Credit Letters of Agrobusiness (LCA) and financial Letters	BNDES	BNDES	Loan (refundable) conditioned to local content requirement
Program of Support to Technological Development of the Semiconductor and Display Industry (PADIS)	Law 11.484/2007; Ordinance MCTI/ MIDC 1.045/2014	N/A	ME and MCTI	ME and MCTI	Tax incentive conditioned to mandatory R&D investment
Tax incentive (PIS/PASEP, IPI and ICMS)	Law 13.097/2015 (PIS/PASEP) Decree 8.950/16 (IPI) ICMS 101/96 (CONFRAZ)	N/A	N/A	N/A	Tax incentive
Incentive mechanisms/regulatory tools to foster electric mobility					
Regulatory tool (ANEEL)	ANEEL - Normative Resolution 819/2018	N/A	ANEEL	ANEEL	N/A
Program Rota 2030 – Mobility and Logistic (2018-2023) (MIDIC)	Decree No. 9.557/2018 Decree No. 9.442/ 2018	N/A	ME	ME	Tax incentive
Tax incentive (IPVA and imports)	IPVA (each State has its own specific legislation) CAMEX Resolution 82/ 2018 (Imports)	N/A	N/A	CAMEX (Imports)	Tax incentive

Table A1 (continued)

Incentive mechanism	Legislation	Resources origin	Executor	Manager	Type/Requirements
Preferential Loans (BNDES)	Federal Constitution 1988 (article 40) Law 5.662/1971, Law 10.556/2002, Law 11.786/2008, Law 6.000/1973, Decree-Law 1.940/1982, Decree 7.162/2010 Decree 7.439/2011 Decree 7.653/2011 (BNDES) Resolution 1.467/2007, Resolution 1.800/2009, Resolution 2.314/2012, Resolution 2.534/2013 Resolution 2.619/2014 Resolution 2.851/2015, Resolution 3.149/2017, Resolution 3.259/2018, Resolution 3.383/2018 (BNDES General Regulation of Operations)	FAT/PIS/PASEP, National Treasury, Fund of the Merchant Navy (FNM), Social Security Fund (FGTS); overseas funding raising; public emissions of debentures; private emission of Credit Letters of Agrobusiness (LCA) and financial Letters	BNDES	BNDES	Loan (refundable)
Incentive mechanisms/regulatory tools to foster energy efficiency					
National Policy of Conservation and Rational Use of Energy (MME)	Law 10.295/2001 The Decree 9.864/2019	N/A	MME	MME	N/A
Program of Energy Efficiency (PEE) (ANEEL)	Law 9.991/2000, Law 11.465/2007, Law 12.212/2010, Law 13.203/2015, 13.280/2016	Utilities are obliged by Law to invest at least 0,75% in R&D activities and 0,25% in energy efficiency programs (final use)	ANEEL	ANEEL	Mandatory investment
National Program of Electric Energy Conservation (PROCEL in its Portuguese acronym)	Ordinance 1.877/85 Law 10.295/2001 Law 13.280/2016	Electrobras and Program of Energy Efficiency (PEE-ANEEL)	Electrobras	MME	Labelling, education diagnosis, monitoring, and information
National Program for Rational Use of Oil Derivatives and Natural Gas (CONPET-Petrobras)	Decree 99.250/1990 Presidential Decree 18/07/1991	Petrobras	Petrobras	MME	Labelling, diagnosis, monitoring, education and information
Brazilian Program of Labelling (PBE- INMETRO)	Law 10.295/2001	INMETRO	INMETRO	INMETRO	Labelling
Program Rota 2030 – Mobility and Logistic (2018-2023) (ME)	Decree No. 9.557/2018 Decree No. 9.442/2018	N/A	ME	ME	Tax incentive

Table A1 (continued)

Incentive mechanism	Legislation	Resources origin	Executor	Manager	Type/Requirements
Preferential loans (BNDES)	Federal Constitution 1988 (article 40) Law 5.662/1971, Law 10.556/2002, Law 11.786/2008, Law 6.000/1973, Decree-Law 1.940/1982, Decree 7.162/2010 Decree 7.439/2011 Decree 7.653/2011 (BNDES) Resolution 1.467/2007, Resolution 1.800/2009, Resolution 2.314/2012, Resolution 2.534/2013 Resolution 2.619/2014 Resolution 2.851/2015, Resolution 3.149/2017, Resolution 3.259/2018, Resolution 3.383/2018 (BNDES General Regulation of Operations)	FAT/PIS/PASEP, National Treasury, Fund of the Merchant Navy (FNM), Social Security Fund (FGTS); overseas funding raising; public emissions of debentures; private emission of Credit Letters of Agrobusiness (LCA) and financial Letters	BNDES	BNDES	Loan (refundable)
Incentive mechanisms/regulatory tools to foster the production and consumption of Biofuels					
Regulatory framework	Law 12.490/2011	N/A	N/A	N/A	N/A
National Program of Production and Use of Biodiesel (PNBD in its Portuguese acronym)	Law 11.097/2005, Law 11.116/2005; Normative instruction MAPA 01 and 02/2005 Resolution ANP 31/2004 Resolution BNDES 1.135/2004 Ordinance No. 512/2017	N/A	MAPA	MAPA	Tax incentive Commercial incentive Preferential loan
Mandatory addition of anhydrous ethanol to the gasoline	Law 12.490/2011 Ordinance No. 75/2015	N/A	MAPA	MAPA	N/A
Mandatory addition of biodiesel to the diesel	Law 13.576/2017 Law No. 13.576/2017	N/A	National Council of Energy Policy (CNPE)/MME	National Council of Energy Policy (CNPE)/MME	N/A
Biodiesel Bidding (National Agency of Petroleum, Natural Gas and Biofuels, ANP in its Portuguese acronym)	Ordinance MME 476/2012; Ordinance MME 576/2015 Law 13.263/2016	N/A	ANP	ANP	N/A

Table A1 (concluded)

Incentive mechanism	Legislation	Resources origin	Executor	Manager	Type/Requirements
RENOVABIO	Law 13.576/2017 Resolution CNPE 5/2018	N/A	MME	MME	Tax incentive and carbon credit conditioned to mandatory targets (biofuels production and commercialization)
Preferential loans to biofuels production or distribution/transport (BNDES)	Federal Constitution 1988 (article 4o) Law 5.662/1971, Law 10.556/2002, Law 11.786/2008, Law 6.000/1973, Decree-Law 1.940/1982, Decree 7.162/2010 Decree 7.439/2011 Decree 7.653/2011 (BNDES) Resolution 1.467/2007, Resolution 1.800/2009, Resolution 2.314/2012, Resolution 2.534/2013 Resolution 2.619/2014 Resolution 2.851/2015, Resolution 3.149/2017, Resolution 3.259/2018, Resolution 3.383/2018 (BNDES General Regulation of Operations)	FAT/PIS/PASEP, National Treasury, Fund of the Merchant Navy (FNM), Social Security Fund (FGTS); overseas funding raising; public emissions of debentures; private emission of Credit Letters of Agrobusiness (LCA) and Financial Letters	BNDES	BNDES	Loan (refundable)

Source: Created by the authors based on information from EBP Axis 3 Working Group.

Note: N/A stands for not available.

Annex 8 Preferential loans for innovation in Brazil

Table A2
Preferential loans for innovation in Brazil led by Finep and BNDES

Instrument	Description	Target audience	Financing range
Finep Reimbursable Financing - Incentive program to innovation in Brazilian companies	<p>Supports strategic investment plans led by Brazilian companies. The Program has specific guidelines as the increase in national and international competitiveness, the expansion of the R&D activities carried out in Brazil, the strengthening of local supply chains and the cooperation between companies and ST&I centres. The Program works along five lines of action: (i) pioneering innovation (plans with high level of innovations with breakthrough potential); (ii) innovation for competitiveness (development and improvement of products, process and service that may enhance the company's competitiveness); (iii) innovation for performance (technology upgrading through technology absorption or acquisition to improve productivity, costs or product performance); (iv) critical innovation (long-term projects oriented by government strategic proposals to improve the technology, economic and social autonomy of the country); and (v) pre-investment (studies of technical and economic feasibility, geological studies and initial projects)</p>	<p>Large and medium-sized innovative companies (gross operational income above R\$ 16 million) headquartered in Brazil</p>	
Finep Inovacred Program	<p>Supports the development of new products, process and services or the improvement of the existing ones in order to enhance the company's competitiveness. The program also comprises organizational and marketing innovation. The Inovacred Program cover a broad range of activities related to innovation as knowledge creation (e.g. prototypes, basic engineering, absorption of technology and demonstration), activities that use or improve knowledge (e.g. acquisition and adaptation of technology, improvement of technology, R&D infrastructure, industrial design, scale-up) and activities that support the knowledge use (e.g. quality control systems, technical regulation and validation, studies of feasibility, technology forecasting, innovative business model). The financial support is provided by financial institutions from the region in which the companies are located (development banks, commercial banks with specific lines for development)</p>	<p>Small and medium sized companies with gross operational income up to R\$ 90 million</p>	<p>From R\$ 150.000 to R\$ 3 million for companies with gross operational income up to R\$ 16 million and from R\$ 150 thousand to R\$ 10 million</p>

Table A2 (continued)

Instrument	Description	Target audience	Financing range
Finep lot - Innovation for Internet of Things	Supports the execution of Strategic Plan of Innovation (PEIs) and projects on products, services and services based on digital technologies –related to the concept of Internet of Things and other enabling technologies of Advanced Manufacturing with applications in health care, industry, agrobusiness and urban development (cities).	Companies with gross operational income equal or above R\$ 16 million	Projects' minimum value is R\$ 5 million
Finep Inovacred 4.0	This program is part of Finep IoT program to support the elaboration and implementation of Strategic Business Plans of Digitalization which encompass the use, in production lines, of enabling technologies, including internet of things; cloud computing; big data; digital security; additive manufacturing; digital manufacturing; systems integration; digitization; computing and cloud; simulation system; advanced robotics; and artificial intelligence.	Companies with gross operational income up to R\$ 300 million with economic activities in sectors of manufacturing industry and agriculture.	
Finep Inovacred Express	Support R&D activities carried out by micro and small companies through a facilitated process. To access the loan, the companies must meet at least one of the specific requirements assigned by Finep (have received public incentives to R&D in the last 5 or 10 years; have patents or have applied for patents in the last 5 years and be located in technology incubators or parks). The loan may be applied in all kind of activities (scientific, technological, organizational and commercial) that take to the implementation of new or improved products and process. The activities may be outsourced.	Micro and small companies (gross operational income up to R\$ 16 million)	Up to R\$ 200.000
Finep Startup	The program aims at covering the financing gap between the financial contribution made by acceleration programs, angel-investor and crowdfunding and the financial contributions made by seed money funds and venture capital. The program focuses on knowledge intensive companies and prioritizes the following areas: agriculture technology, smart cities, construction technology, blockchain, defence, artificial intelligence, creative economy, education, internet of things (IoT), advanced manufacturing, microelectronic, nanotechnology, augmented reality, virtual reality and mixed reality. The supported start-ups are selected through an evaluation process that starts with a public call.		Up to R\$ 1 million

Table A2 (concluded)

Instrument	Description	Target audience	Financing range
BNDES Finem – Innovation	Supports disruptive or incremental innovations (product, process and marketing); R&D activities; environments and structures to support innovation (technological parks, incubators etc.); innovation infrastructures (labs, R&D centres, pilot plan and demonstrative plants); new business model, content production and distribution in new digital platforms (applied to culture, education and health); IT and software innovation; installation of industrial plants with unprecedented features focused on goods that are not still manufactured in Brazil; installation/adaptation of industrial plants or manufacturing of equipment and systems qualified as Advanced Manufacture.	Companies headquartered in Brazil; foundations associations and cooperatives; public organizations from direct and indirect administration	From R\$ 10 million
BNDES – Innovative Micro, Small and Medium Companies	Supports innovative investment projects of micro, small and medium companies. The project must aim at the development of new process and or the development of a new product and the introduction in the market; the installation/modernization of installations of companies located in technological parks; the strengthening the financial capacity of companies that are caring out innovative efforts.	Companies headquartered in Brazil or individual entrepreneurs, both with annual income or revenue up to R\$ 300 million	Up to R\$ 20 million
BNDEs Finem – Technology of Information	Supports the development of technology solutions that may enlarge the companies' competitiveness and enhance the clients' productivity. Includes Data Centre, Contact Centres and ITES – BPO (Information Technology Enabled Services - Business Processes Outsourcing).	Companies headquartered in Brazil that have activities related to the software supply chain in Brazil	From R\$ 10 million (business plan and investments)
BNDES Direct 10 – Innovation	Supports Investment Plans of Innovative Companies, in which may be included: payment of own R&D, engineering, marketing and communication teams; specialized technical services (studies and projects, R&D and innovation); training; acquisition of national equipment (accredited by BNDES); acquisition of import equipment that do not have national similar; intangible assets (acquisition of intellectual property or national software); building and furniture and operational expenses. The benefited companies must have to attend some criteria: have already been supported by BNDES or other public innovation initiative in the last five years; have registered intellectual property in the last five years; is located at a technological park.	Innovative companies (micro, small and medium) companies	From R\$ 1 up to R\$ 10 million
BNDES Finem – Support to National Engineering	Supports projects of local engineering activities in strategic sectors that enhance the companies' capabilities; infrastructure for research, development, engineering, products, tests and trials; engineering services of conceptual projects and basic engineering performed by engineering consulting companies.	Companies headquartered in Brazil; foundations associations and cooperatives; public organizations from direct and indirect administration	From R\$ 10 million

Source: Created by the authors based on information from EBP Axis 3 Working Group.



Today, Brazil and many countries around the world are seeking to stimulate economic recovery and improve people's quality of life. In this context, the Economic Commission for Latin America and the Caribbean (ECLAC) of the United Nations has been developing the Big Push for Sustainability, a renewed approach to support the efforts of the countries of the region to design more sustainable development models, by coordinating policies to promote investments that will transform existing models.



The ECLAC office in Brasilia and the Center for Strategic Studies and Management (CGEE), in conjunction with various partners, developed the Energy Big Push Brazil project, which provides evidence to promote innovation investments for a sustainable energy transition in Brazil. This publication aims to enhance readers' understanding of the policy framework for energy innovation in Brazil, outlines the experiences of countries at the forefront of clean energy innovation and proposes a set of action lines that could accelerate investments in this area, contributing to an energy big push in Brazil.