NEW MISSION-ORIENTED POLICIES TO RENEWABLE ENERGY IN BRAZIL: A COMPARATIVE ANALYSIS BASED ON A SYSTEMATIC LITERATURE REVIEW

Hudson L. Mendonça, IAG/PUC-Rio, Phone +55 21 98158-0077, E-mail: hudson@phd.iag.puc-rio.br
Marcus Vinicius de A. Fonseca, COPPE/UFRJ, Phone +55 21 99984-3226, E-mail: vfonseca@labrinto.coppe.ufrj.br

Overview:
Mission-oriented programs have constantly been used as innovation policies at times when governments (or society) are faced with complex challenges that demand radical innovations and multiplayer coordination. The Apollo and Manhattan projects are the most cited historical examples. Nowadays, the worldwide climate-change question, including the energy source issue, appears as an example of a mission-oriented challenge. Recently, the Brazilian government launched three programs (PAISS, PAISS 2 and Inova Energia) to foster innovations in renewable energy sources such as biofuels, solar and wind power. These programs dealt with radical innovations, big challenges and multiplayer coordination, but did not use some important mission-oriented best practices. Thus, this article's aim is to compare these programs' characteristics using mission-oriented policy constructs and suggest possible improvements based on the literature review.

Keywords - mission-oriented; public policy; innovation; renewable energy; Brazil; Finep; BNDES

1. Introduction:

The "Inova Empresa" Plan, launched in March 2013 by the Brazilian Federal Government, was the largest financing innovation policy in Brazil's recent history. From the beginning the plan had an unprecedented budget (by Brazilian standards) of US$ 16.5 billion, just to support technological innovation in a wide range of initiatives. The core of the policy, called "Inova Programs" or "Inova Family", was composed of 11 sectoral and thematic initiatives, and corresponded to 65% (US$ 10.6 billion) of the whole Plan budget (Brazil, 2013).

These "Inova Family" initiatives had a unique set of characteristics, which were unprecedented in Brazil and, in a certain way, also worldwide. The most important aspect of these programs was each initiative's attempt to integrate all Federal efforts around a specific theme, aiming to improve the efficiency of investments in innovation. To reach this goal, these undertakings were structured as mission-oriented programs (Mazzucato & Penna, 2015). The implications of this decision constitute one of the key-points of this paper.

Three of the Inova programs (and 17% of the entire Plan budget) were concerned with renewable energy: PAISS (2011), Inova Energia (2013), and PAISS 2 (2014). The PAISS and PAISS2 aimed to bring Brazil "back into the game" of ethanol production and other advanced sugarcane bio-products. The second one, Inova Energia, targeted a wider scope, with three different lines designed to rethink the Brazilian electrical sector, calling for new technologies in smart grids, solar and wind generation, in addition to electric cars and their components (motors, batteries etc.).

This issue is especially important because the energy sector is changing worldwide and Brazil could be a key player in this transformation process. Global investments in renewable energy have been growing in recent years, reaching US$ 285.9 billion in 2015, which is equivalent to an addition of 147 gigawatts (GW) to the energy matrix. It was the first time since the industrial revolution that investments in renewable sources of energy exceeded investments in fossil sources (REN21, 2016).

In addition to historical trends and current numbers, important specialized energy sector institutions predict a continuous growth of renewable sources in the world energy matrix. The International Energy Agency (IEA) and even some oil companies like British Petroleum (BP) forecast that renewable sources will continue to grow in the next decades, and will be responsible, in relative terms, for the greater part of additional energy generation in the world from now on. (BP, 2016; IEA, 2015).

Following this trend, and reaffirming it, 177 countries, including the most important economies of the world such as the United States, China, Japan, Russia, India, Germany, France, UK, Brazil etc. signed a cooperation agreement in Paris during the 21st Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC). In this agreement these countries committed their best efforts to keeping global warming below 1.5ºC (UNFCCC, 2016). Researchers from the UNFCCC, other institutions and

specialists agrees that this goal will only be reached with the improvement and diffusion of renewable energy sources and new low-carbon technologies (BP, 2016; IEA, 2015; REN21, 2016; UNFCCC, 2016).
Brazil has a high potential in this scenario, but many things to do if it really wants to be a key player in this transformation process. Brazil already produces 43.5% of its primary energy from renewable sources (EPE, 2015), and still has a huge expansion potential in biomass (Ferreira-Leitao et al., 2010), solar (UFPE, CEPEL, & CHESF, 2000), wind (CRESESB, CEPEL, Camargo Schubert, & TrueWind, 2001), hydroelectric (EPE, 2015) and other sources However, the country ranks only in 69th place in the Global Innovation Index (Cornell University, INSEAD, & WIPO, 2015).
Therefore, this paper's aim is to investigate how mission-oriented constructs could improve the impact and effectiveness of public innovation policies in renewable energy in Brazil, using the Inova programs focused on this kind of energy (PAISS, PAISS2 and Inova Energia) as references.

2. Understanding Renewable Energy Inova Programs

The "Inova Empresa" Plan had three specific renewable energy programs: PAISS, PAISS 2 and Inova Energia. These programs had some common characteristics and it is important to understand their range and novelty. The first characteristic in common was the nature of the programs themselves. Though the specific goals of each program were completely different, all of them were directed towards dealing with a real big problem that could be solved through innovations and/or diffusion of new technologies. All these programs aimed to provide total support for each step in achieving these objectives, from scientific efforts, followed by development and prototypes, until the initial phase of commercialization of these innovations (Finep & BNDES, 2011, 2014; Finep, BNDES, & ANEEL, 2013).
As regards coordination, all of them was led, formulated and operated by Finep, the Brazilian Innovation Agency, and BNDES, the Brazilian Economic and Social Development Bank. The "Inova Energia" Program also included the Brazilian Electricity Regulatory Agency, ANEEL. The integration and cooperation of these key Brazilian institutions around the same goals was the first step and a big novelty of the Inova Programs (Brazil, 2013). These institutions were the sponsors of each program. The related Ministries (Science, Technology and Innovation; Development, Industry and Foreign Trade; Agriculture and Mining and Energy) acted as a higher council and were more active in the macro-formulation and general evaluation of the progress achieved.
The three programs tried to combine all these sponsors' innovation support instruments. In Finep`s case, we are referring to grants and loans for universities, technological institutes, startups, SMEs and large companies. Finep could also invest in the equity of program-selected companies. BNDES used similar instruments, with the exception of grants for companies, because, according to Brazilian legislation, only Finep could operate this kind of resource. The conditions and amount of funding offered by BNDES was also different. In ANEEL's case, the mechanism for supporting innovation inside the program was different. One of the regulatory obligations of power companies in Brazil is to invest at least 1% of their turnover in research and development (R&D). The general acceptance of these expenditures is made by ANEEL. Companies that were approved in the Inova Energia Program could automatically include this R&D expenditure in ANEEL's regulatory 1% provision.
The process and governance of the programs were very similar. They started with a public call in which participants needed to sign a letter of interest containing basic information about the institution (firm, university or research institute), the key team and its alignment with the call's objectives. At this stage the sponsors simply made a single filter of the participants, then promoted match-making events and distributed material with basic information about the approved institutions. The aim of this first stage was to introduce institutions with similar interests and technological solutions to each other in an organized and secure way.
The second step involved encouraging leading companies to build consortia with SMEs, universities, technological institutes, etc. to provide an entire solution to one or more of the problems mapped in the public call. Wider scopes of collaboration guaranteed more access to grants and better loan and investment conditions. The main objective of this arrangement was to foster complete innovative solutions (basic/applied research, technological development, testing and initial commercialization) of the participants and financial support as counterparts of the leading companies.
In the third phase the sponsors sliced the innovation and business plans sent by consortia into specific projects. Each project was directed to a specific combination of instrument (grant, credit etc.) and sponsor (Finep, BNDES or ANEEL) already approved on merit. The guarantees, certifications, legal issues and other bureaucratic requirements were operated only by the specific sponsor of the project. Each sponsor had its own internal rules to be observed by participants.

During the whole process the selection of instruments, projects and supported companies, universities and technological institutes was undertaken jointly by a technical committee composed of managers of the sponsors: BNDES and Finep sat on all of them, and BNDES, Finep and ANEEL on committees related to the Inova Energia Program. Once approved by this committee, the final arrangement was approved by each sponsor's board of directors.
The common general concept, process and governance help the external public to understand the innovative points of these programs better, but each one has its own characteristics.

2.1 PAISS (2011)

The first of the Inova Programs, launched even before the general Inova Empresa Plan, the PAISS –Joint BNDES-FINEP Plan to Support Technological Industrial Innovation in the sugar-energy and sugar-chemical sectors –acted as a pilot project of BNDES-Finep institutional cooperation in the Inova Empresa Plan.
The aim of this program was to support the development, production and pioneering commercialization of new industrial technologies to process sugarcane biomass. The program had specific subthemes that could be aggregated in three main areas, with all of them exclusively using sugarcane biomass as a raw material (Finep & BNDES, 2011).

- 2nd generation (2G) bioethanol from sugarcane;
- New biochemical products from sugarcane and;
- Gasification of sugarcane biomass.

The motivations behind this option were the huge amount of residues (bagasse, straw and leaves) produced by the 1st generation bioethanol industry: 64% of sugarcane biomass or 415 millions of tons each year (Ferreira-Leitao et al., 2010). The 2G bioethanol could increase Brazilian bioethanol production by 50% with no additional land use (Milanez et al., 2015). Biogas and other biochemicals could increase the added value of sugarcane and industrial sectors related to it.
As usual, the PAISS Program suffered from "first-mover effects" and feedback from the players involved was used to improve the others. The program's budget totaled R$ 1 billion, with R$ 500 million from Finep and R$ 500 million from BNDES (Finep & BNDES, 2011).

2.2 Inova Energia (2013)

Following changes that were happening in the world electrical sector, Inova Energia included ANEEL, the Brazilian Electricity Regulatory Agency, in Finep and BNDES's previous cooperation efforts to support innovation. This inclusion was critical because most of Brazil's electricity sector operates according to a centralized system model and this market is highly regulated. ANEEL is also important in Brazilian electricity R&D efforts because power distribution companies have a legal obligation to invest in innovations for the sector.
The Inova Energia had three macro objectives:

- To support the development and diffusion of technological solutions for implementing smart grids in Brazil;
- To support the development and technological mastery of Brazilian companies in the solar and wind energy industrial value chain;
- To support industry development and integration in the hybrid/electrical vehicle segment and foster greater energy efficiency in Brazil's auto industry.

These three goals were encapsulated into three specific lines, with a total of 10 subthemes. We did not discuss each subtheme, but overall features..
The budget of the program totaled R$ 3 billion, with R$ 1.2 billion from Finep, R$ 1.2 billion from BNDES and R$600 million from ANEEL (Finep et al., 2013).

2.3 PAISS 2 - Agro (2014)

The PAISS 2, also known as PAISS Agro, had objectives that complemented those of the first PAISS. While PAISS focused on industrial solutions aimed at adding value to, and increasing the productivity of, sugarcane bio-products, PAISS 2 focused on improving performance "outside and inside the gate". PAISS 2 had five lines (Finep & BNDES, 2014):

- New varieties of sugarcane with more biomass or ATRs (total recoverable sugars);
- Equipment to improve sugarcane planting or harvesting;
- Systems for planning, managing and controlling sugar production;
- Biotechnology applied to sugarcane;

- Development of agro-industrial solutions and complementary varieties of sugarcane.

Both PAISS and PAISS 2 brought Brazil "back into the game" in the advanced biofuels world stage (Nyko et al., 2013). The PAISS 2 budget (Agro) totaled R$ 1.48 billion, with R$740 million from Finep and another R$ 740 million from BNDES.

3. Methodology:

The central research question can be defined as: how could mission-oriented constructs improve the impact and effectiveness of new renewable energy innovation policies in Brazil? We will try to answer this question analyzing the recently launched Inova programs focused on this kind of energy (PAISS, PAISS 2 and Inova Energia) and also the literature about mission-oriented policies.

As secondary objectives we can list:

- Identify the typical parameters of a mission-oriented program;
- Classify and compare PAISS, PAISS 2 and Inova Energia, following these parameters;
- Suggest improvements for future editions of these programs.

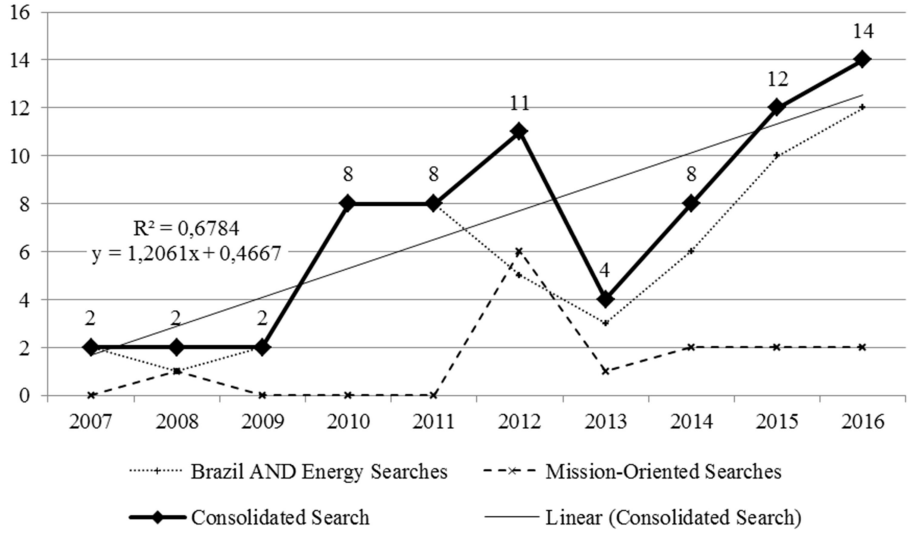
The first step in comparing these recent Brazilian renewable energy innovation policies is to create comparable parameters. In this paper we do this through a systematic literature review of mission-oriented innovation policies, focused on initiatives in energy as a sector and Brazil as a region. We ran four searches in the Scopus database, restricted to the last 10 years and to articles and reviews. After the literature review we used public data, reports containing results and evaluations of the process, presentations, studies made by Finep/BNDES, news and semi-structured interviews with Finep professionals to classify the programs in the constructs observed in the literature review. Having performed the literature review and collected data/information, we compared renewable energy Inova Empresa programs with mission-oriented constructs.

In the first search we looked for mission-oriented public policies to build the recent benchmarks. Then, we used "mission-oriented" AND "public policy" keywords to run it. We also searched for the concept of mission-orientation associated with innovation efforts. We used "mission-oriented" AND "innovation" as keywords in this case. We refer to these two searches as "mission-oriented searches".

To improve the reach in energy as a sector and Brazil as a region, we ran other two searches. One with "Brazil" AND "energy" AND "innovation" to increase our knowledge regarding the latest efforts in energy sector innovations in Brazil. We also ran the search "Brazil" AND "energy" AND "public policy" to better understand public energy policies in Brazil in the last years. We refer to these other two searches as "Brazil and energy searches".

The combination of these searches returned 188 articles/reviews. We applied a thematic filter to exclude pure technical papers and restrict subject areas to those linked to the scope of this article: Business, Management and Accounting; Social Sciences; Economics, Econometrics and Finance; and Decision Sciences. The final literature review obtained from these searches returned 74 articles.

Figure 1: Publications by Years - Business, Management and Accounting, Social Sciences, Economics, Econometrics and Finance, and Decision Sciences



Authors in these papers totaled 189, but only six have published more than one article about these themes: Yokoo, Y., Gobbo, J. A., Ismail, K. A. R., Johnson, F. X., Lino, F. A. M. e Silveira, S., and even these authors have written only two articles each of those returned by our searches. The diversity of authors writing about these themes, but with no one standing out in these areas provides us with some interesting insights that we will explore in our results.

The timeline of the number of articles/reviews in Figure 1 show us a growth trend in publications in these areas ($\beta > 0$ and $R^2 = 0.678$). We can also observe that there are more publications about Brazil and energy than the mission-orientation concept. The peak of publication about mission-orientation in 2012 occurred because a special issue of Research Policy was launched that year: "The need for a new generation of policy instruments to respond to the Grand Challenges" (volume 41, issue 10).

Regarding the journals, the most important publications in the area have the highest H Index too. The average H Index of journals with two or more publications in our searches was 50.1. The special issue of Research Policy propelled it to the top of the ranking. The sectorial focus of the Journal of Cleaner Production put it in second place. They also have the biggest H Index of the listed journals.

Table 1: Top Journal Ranking in Publishing

Rank	Outlets of Articles/Reviews	N*	H Index
1	Research Policy	5	160
2	Journal of Cleaner Production	4	96
3	Technological Forecasting And Social Change	3	68
4	Energy Economics	2	85
5	Technovation	2	82
6	Resources Conservation and Recycling	2	75
7	Industry and Innovation	2	41
8	Innovation	2	22
9	Foresight	2	20
10	Energy Research and Social Science	2	14
11	Environmental Development	2	13
12	Journal of Technology Management and Innovation	2	13
13	Gestão e Produção	2	9
14	Espacios	2	3

*N = number of articles/reviews

As regards the keywords, the most cited ones in mission-oriented searches was: "Innovation" (8), "Innovation Policy" (3) and "Public Procurement" (3) – the others were cited only twice or less. "Innovation" or "Innovation policy" do not constitute a surprise because they have been used as keywords in searches, but "Public Procurement" appears as an important keyword, and none of the Inova Programs deals with it.

In the case of Brazil and Energy searches, the most cited keyword was: "Brazil" (30), "Innovation" (23), "Biofuel" (9), "Biofuels" (8) and "Ethanol" (8). "Brazil" and "Innovation" were keywords from the parameters of the searches, but the others did not, and all three are linked to the biofuels concept. This is important because, despite the discovery of the pre-salt oil and gas reserves, or the continentally integrated Brazilian electricity system, most research about energy in Brazil in the last 10 years has been directed towards biofuels.

After this screening process, we performed a content analysis based on titles and abstracts to identify the articles that helped us answer our research question and achieve our secondary objectives. In these articles we looked for constructs that define a typical mission-oriented program, mainly the cases focused on renewable sources. Based on these articles and their constructs, we built a comparison chart and analyzed the similarities and differences between Inova programs and the benchmarks.

To collect data to run the comparisons we used many sources of primary and secondary data, such as Finep, BNDES and ANEEL websites; program evaluation reports; public and internal presentations; official databases; public calls and their official results, sectoral BNDES/Finep studies, news items and semi-structured interviews with Finep professionals.

4. Literature Review:

We started the literature review by defining the central concept of this paper: mission-oriented policies. These policies are more focused on radical innovations needed to achieve clearly set goals of national importance (Cantner & Pyka, 2001; Ergas, 1987). In contrast to those developed according to the mission-orientation concept, diffusion-oriented policies focus on providing general innovation-related public goods to diffuse technological capabilities throughout industrial infrastructure and produce a large volume of incremental innovations (Ergas, 1987).

The original mission-orientation concept was use to classify countries' policies. Researchers in the innovation policy area tried to classify countries' policies as mission or diffusion-oriented (Cantner & Pyka, 2001; Chiang, 1991; Ergas, 1987) but even they themselves, and many other authors, admitted that this could be complicated because countries could adopt different strategies in different sectors, timing, regions or innovation contexts (Anadón, 2012; Ergas, 1987; Hahn & Yu, 1999). We could cite as examples of changing policy directions/strategies, the defense innovation policies between 1948 and 1989 during the period known as the "cold-war" (Mowery, 2012); the increase in the amount and direction of energy innovation policies after the 1970s oil and gas crisis (Anadón, 2012); or the current discussion regarding the generation of radical innovation versus diffusion of incremental clean technologies (Eleftheriadis & Anagnostopoulou, 2015; Mazzucato & Penna, 2015).

A radical innovation (LEIFER et al., 2000) "is a product, process, or service with either unprecedented performance features or familiar features that offer potential for significant improvements in performance or cost. Radical innovations create such a dramatic change in products, process or services that they transform existing markets or industries, or create new ones."

In this paper we adopted the institutional approach, using public agents and specific programs as the unit of analysis (Dosi, 2016; Foray, Mowery, & Nelson, 2012; Rumpf, 2012; Santos, Ianda, & Padula, 2014). This orientation permits a more accurate analysis of the characteristics and results of policies in specifics sectoral, regional and time contexts. Having defined the central concept and the unit of analysis, we can proceed to a description of the characteristics of a mission-oriented program.

The first is the alignment of the program with the country's general policies (economic, industrial, environmental etc.) (Ergas, 1987; Mazzucato & Penna, 2016). An example is the Chinese Renewable Energy Scale-up Program (CRESP), created to build a legal, regulatory, and institutional environment conducive to large-scale, renewable-based electricity generation. It was created in full alignment with the 10th Chinese Five-Year Plan, the national plan which establishes China's priorities (Abdmouleh, Alammari, & Gastli, 2015; World Bank, 2016).

The second is the need for a clear objective involving a major challenge to be solved. Generally it involves the development of a set of new technologies to achieve this major objective. Defining measurable intermediate goals are important for managing and evaluating the progress of mission-oriented programs. The Apollo Program, whose aim was to send the first human being to the moon, is an oft-cited example of a clear objective mission-oriented program (Mazzucato & Penna, 2016; Veugelers, 2012).

The third central characteristic is a focus on high impact radical innovations. It is important to be able to justify politically, economically and/or socially the choice of one program over another (Amanatidou, Cunningham, Gök, & Garefi, 2014; Dasgupta & Stoneman, 2005). By definition, in diffusion-oriented policies there is no focus on requiring the achievement of a few specific targets, so policy makers can therefore spread funds more widely and foster more incremental innovations. An example of a mission-oriented program situated in the radical innovation dimension is the Manhattan Program, the program that developed nuclear bomb technology during the second World War (Foray et al., 2012; Mazzucato & Penna, 2016; Mowery, 2012).

Another important characteristic, which could be interpreted as a consequence of the radical innovation bias, is the focus on generation of new technologies instead of the diffusion of existing ones (Ergas, 1987). Some authors refer to the importance of balancing the generation of new technologies with diffusion of innovations (Glennie & Bound, 2016; Hahn & Yu, 1999), but it is widely agreed that that mission-oriented programs are generally more focused on the generation of new technologies.

The fifth question regarding mission-oriented programs concerns the time-frame for results. The long-term view is generally necessary, but less required than in the case of diffusion-oriented policies (Chiang, 1991). It also depends on the kind of mission being specified. The Manhattan project delivered expected results in less than six years, but challenges like climate-change prevention demand much more time to be solved

(Amanatidou et al., 2014; Veugelers, 2012). The concern about long-term missions versus political cycles was detected as a considerable risk factor in mission-oriented programs (Amanatidou et al., 2014).

A sixth characteristic that differentiates mission-oriented programs is the role of government. The government's priority-setting role is always critical in the mission-oriented paradigm (Ergas, 1987; Makhoba & Pouris, 2016; Mazzucato & Penna, 2015; Rumpf, 2012). But the government's role could sometimes be extended to a more active participation, including the execution of part of the program in public facilities such as technological institutes, universities or companies (Mazzucato, 2016; Mowery, 2012).

Our seventh issue is program governance. Mission-oriented programs generally have a more centralized decision process than other technology policies, with just one (or few) government agencies taking the critical decisions (Ergas, 1987; Mazzucato, 2013; Mazzucato & Penna, 2015). However, the programs could differentiate the decision process according to whether they are setting priorities, monitoring overall progress or evaluating performance (Foray et al., 2012). Ergas emphasizes the need to centralize all decisions in one agency that could combine technical expertise, financial resources and decision-making autonomy (Ergas, 1987).

Another important question is "what could be seen as success or failure in the case of a mission-oriented program?" The evaluation process in diffusion-oriented programs has broader indicators of success like the number of PhDs in the private sector, percentage of GDP invested in R&D, number of innovative companies etc. (Dutta, 2011). Mission-oriented programs usually have a "mission accomplished" target (Ergas, 1987). However, mission-oriented programs can frequently generate spillovers. Defense-backed technologies like GPS, internet, microprocessor, touch screens etc. are spinoffs of mission-oriented initiatives (Mazzucato, 2013; Mowery, 2012).

The ninth characteristic concerns program participants. While other technology programs could aim at just one part of the innovation chain (universities, SMEs, big corporations, technological institutes, government facilities, regulators etc.), mission-oriented programs need to act in the whole universe of involved players and coordinate them in the same direction: the intended goal (Amanatidou et al., 2014; Choung, Hwang, & Song, 2014). This big challenge is one of the reasons that a centralized governance model is required in mission-oriented programs (Cantner & Pyka, 2001). Regarding this issue,, an important recommendation is appropriate: the project leader should be a big corporation in order to guarantee the financial support and technical quality and diversity needed to deal with the challenges and oscillations during the process (Ergas, 1987).

The tenth and final mapped critical characteristic of a mission-oriented program is its public policy instruments. To solve a big and complex question, all efforts need to be analyzed jointly and go in the same direction. Table 2 provides a good overview for understanding the diversity of technology policy instruments that could be used in mission-oriented programs.

Table 2: Technology policy instruments

Policy tool	Examples
Public enterprise	Innovation by publicly-owned industries, setting up of new industries, pioneering use of new techniques by public corporations, participation in private enterprise
Scientific and technical	Research laboratories, support for research associations, learned societies, professional associations, research grants
Education	General education, universities, technical education, apprenticeship schemes, continuing and further education, retraining
Information	Information networks and centers libraries, advisory and consulting services, databases, liaison services
Financial	Grants, loans, subsidies, financial sharing arrangements, provision of equipment, buildings, or services, loan guarantees, export credits, etc.
Taxation	Company, personal, indirect, and payroll taxation, tax allowances
Legal and regulatory	Patents, environmental and health regulations, monopoly regulations
Political	Planning, regional policies, honors or awards for innovation, encouragement of mergers or joint consortia, public consultation
Procurement	Central or local government purchases and contracts, public corporations R and D contracts, prototype purchases
Public services	Purchases, maintenance, supervision, and innovation in health services, public building, construction, transport, telecommunications
Commercial	Trade agreements, tariffs, currency regulations.
Overseas agents	Defense sales organization

Source: Rothwell (1983, apud Hahn & Yu, 1999)

Public procurement (Edquist & Zabala-Iturriagagoitia, 2012; Lember, Kattel, & Kalvet, 2015; Mowery, 2012; Veugelers, 2012; Zelenbabic, 2015), legal/regulatory frameworks and grants (Abdmouleh et al., 2015; Hahn & Yu, 1999; Mazzucato & Penna, 2015; Mowery, 2012; Polzin, Migendt, Täube, & von Flotow, 2015; Veugelers, 2012) deserves some special attention as critical instruments for mission-oriented programs.

These characteristics and framework could be used to analyze every mission-oriented program, but some considerations are needed when we talk about renewable energies. First of all we need to consider that climate-change as a mission is a global challenge and a solution necessarily involves many countries and many technologies (Abdmouleh et al., 2015). It is very different from missions like sending a man to the Moon or Mars (NASA, 2016), or building nuclear bombs, which could be conducted by only one country and use one or a few central technologies.

Another question concerns specific instruments for renewable energy. The most cited is the "Feed-in Tariff" (FiT), which is a long-term contract used to guarantee the attractiveness of deals involving renewable energy generation (Eleftheriadis & Anagnostopoulou, 2015; Polzin et al., 2015). Another important indirect mechanism is specific taxes or compensation payments for non-renewable sources like coal, oil and gas (Polzin et al., 2015).

5. Results and Discussion

After mapping the constructs that define mission-oriented program characteristics, we organized them in a comparable way. Table 3 shows the listed characteristics and their values. Based on the literature review the characteristics of mission-oriented programs were slashing filled.

Analyzing each of these items, we found considerable alignment with macro policies. During the Inova programs period Brazil had two major guidelines for economic/innovation policies: The PBM, Greater Brazil Plan 2011-2014, which acted as an industrial policy (ABDI, 2014), and the ENCTI, National Science, Technology and Innovation Strategy 2012-2015 (Brazil, 2012). Both elected renewable energy as a national priority.

As regards objectives, PAISS and PAISS2 had more specific goals and involved fewer technologies than Inova Energia, but both objectives were clear and their aim was to solve big questions (like changing the energy matrix to a more sustainable pattern). The large number of technologies and challenges established in Inova Energia was noteworthy when compared with the literature's recommendations.

The three programs were mainly focused on radical innovations, but Inova Energia had some incremental innovation challenges too, such as new equipment to measure bidirectional electricity flows. In addition, the three were more focused on generating new products, processes and technologies instead of just improving or diffusing existing solutions.

The innovations demanded by PAISS 2 and Inova Energia theoretically required more time-to-market than those in PAISS. Biotechnological challenges, as PAISS 2, usually demand more time to be overcome. Systemic changes in the energy mix, as expected in Inova Energia outputs, also demand a longer-term view. PAISS also a demanded long-term view, but it was focused on a set of challenges in just one specific and consolidated industry: sugar-energy/chemical.

The role of government is critical throughout the process – setting priorities, monitoring progress, and evaluating performance – of the three programs. All the discussions and operations of subsidies are made by National Agencies (Finep, BNDES or ANEEL) or Ministries. But in this point we detected an important difference when we compared the Inova programs with the literature review findings. The literature strongly recommends that this process be conducted in a centralized manner. The top governance of Inova programs was conducted by an inter-ministerial committee composed of representatives of five ministries and two agencies: Finep and BNDES. Operational issues, such as monitoring the process were dealt with by Finep and BNDES in PAISS and PAISS 2, and included ANEEL in the case of Inova Energia. Each agency had its own internal approval process, budget and other rules that resulted in an increase in the program's management complexity.

Table 3: Mission-Oriented Program Characteristics

#	Characteristic	Classification			
1	**Alignment with General Economic/Innovation Policy**	**High**	Medium	Low	
2a	**Clear Objective**	**Yes**	No		
2b	**Big Question to be Solved**	**Yes**	No		
2c	**Number of New Technologies Involved**	**One**	**Few**	Many	
3a	**Degree of Innovation**	Incremental	**Radical**		
3b	**Potential Impact**	**High**	Medium	Low	
4	**Program Focus**	**Innovation Generation**	Competence Diffusion		
5	**Time to Practical Results**	Short Term (less than 2 years)	**Medium Term (3 to 5 years)**	**Long Term (6 to 10 years)**	**Very Long Term (more than 10 years)**
6a	**Role of Government - Setting Priorities**	**High**	Medium	Low	
6b	**Role of Government - Monitoring Overall Progress**	**High**	Medium	Low	
6c	**Role of Government - Evaluate Performance**	**High**	**Medium**	Low	
7a	**Decision Process - Setting Priorities**	**Centralized (1 Institution)**	**Semi-Centralized (2 or 3 Institutions)**	Decentralized	
7b	**Decision Process - Monitoring Overall Progress**	**Centralized (1 Institution)**	Semi-Centralized (2 or 3 Institutions)	Decentralized	
7c	**Decision Process - Evaluate Performance**	**Centralized (1 Institution)**	**Semi-Centralized (2 or 3 Institutions)**	Decentralized	
8	**Evaluation Metrics**	**Specific goals**	Macro Indicators		
9a	**Project Leadership**	Government	**Large Corporation**	Universities / Research Institutes	SMEs
9b	**Participant Types (Companies, Universities etc.)**	One	Few	**Many**	**All**
10a	**Instruments (Subsides, Grants, Taxes, Procurement etc.)**	One	Few	**Many**	**All**
10b	**Grant**	**Yes**	No		
10c	**Procurement**	**Yes**	No		
10d	**Legal/Regulatory**	**Yes**	No		
10e	**Feed-in Tariff***	**Yes**	No		

All their evaluation metrics are in line with the literature, targeting specific goals such as as 2G ethanol enzymes or high performance pre-treatments in PAISS, biotechnological seedling manipulation or new sugarcane varieties with more biomass in PAISS 2 and new supercapacitor/battery technologies or thin film solar panels in the case of Inova Energia.

The three programs considered that all kinds of institutions were eligible to send proposals: universities, technology institutes, SMEs etc., but each project needed to be led by a large corporation, called the leading company. This format is completely aligned with the literature, and helped to increase the breadth and robustness of proposed solutions.

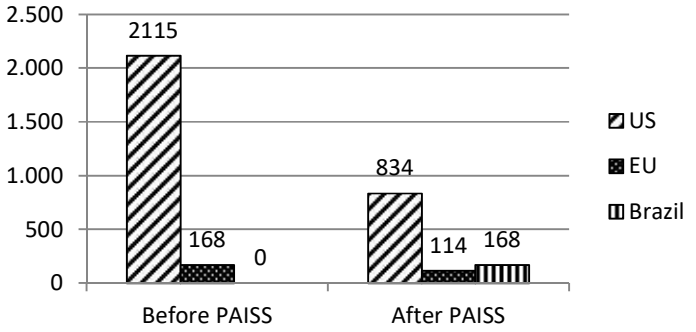
Lastly, these Inova programs had a good set of financial instruments such as grants, subsidized loans and equity options, but they were restricted to merely financial instruments. Inova Energia had the R&D obligation expenditure provided by ANEEL in its instruments portfolio, but in practical terms it was very similar to a financial instrument. According to the literature the most important instruments for mission-oriented programs are grants, procurement and legal/regulatory incentives**.** Inova programs were not able to incorporate procurement or substantial legal/regulatory incentives and provided less grants than the other financial instruments – 73.4% of the available funds were subsidized loans (Brazil, 2013).

Table 4: Characterizing Renewable Energy Inova Programs as Mission-Oriented Policies

Characteristic	PAISS		PAISS 2		Inova Energia	
Alignment with general Economic/Innovation Policy	**High**	PBM, ENCTI	**High**	PBM, ENCTI	**High**	PBM, ENCTI
Clear Objectives	**Yes**	Specific Subthemes	**Yes**	Specific Subthemes	**Yes**	Specific Subthemes
Big Question to be Solved	**Yes**	Biofuels Productivity	**Yes**	Biofuels Productivity	**Yes**	New Energy Sources and Eletrical System
Number of New Technologies Involved	**Few**	Ethanol 2G, Gaisification	**Few**	Agri Biotech, New plantation systems	**Many**	Solar, Termo Solar, Wind, Smart Grid, Batteries, Powertrains etc
Degree of Innovation	**Radical**	New worldwide	**Radical**	New worldwide	**Radical/Incremental**	New worldwide, but some subthemes are just incremental innovations
Potential Impact	**High**	Biofuels could change Brazil (and world) energy matrix	**High**	Biofuels could change Brazil (and world) energy matrix	**High**	Electrical vehicles, renewables energy sources and smart grid technologies could change Brazil (and world) energy mix
Program Focus	**Innovation Generation**	Focuses on new solutions	**Innovation Generation**	Focuses on new solutions	**Innovation Generation**	Focuses on new solutions
Time to Pratical Results	**Medium Term (3 to 5 years)**	Industrial improvments in biofuel chain	**Long Term (6 to 10 years)**	Biotech improvments in biofuel chain	**Long Term (6 to 10 years)**	Energy industrial and software improvments
Role of Government - Setting Priorities	**High**	Priorities defined by Ministries and Governmental Agencies	**High**	Priorities defined by Ministries and Governmental Agencies	**High**	Priorities defined by Ministries and Governmental Agencies
Role of Government - Monitoring Overall Progress	**High**	Project selection and monitoring performed by Finep and BNDES	**High**	Project selection and monitoring performed by Finep and BNDES	**High**	Project selection and monitoring performed by Finep, BNDES and ANEEL
Role of Government - Evaluating Performance	**High**	Evaluation made by an Interministerial Committe	**High**	Evaluation made by a Interministerial Committe	**High**	Evaluation made by a Interministerial Committe
Decision Process - Setting Priorities	**Decentralized**	Intermisterial Committee and class/sectoral representative entities	**Decentralized**	Intermisterial Committee and class/sectoral representative entities	**Decentralized**	Intermisterial Committee and class/sectorial representative entities
Decision Process - Monitoring Overall Progress	**Semi-Centralized (2 or 3 Institutions)**	Finep/BNDES	**Semi-Centralized (2 or 3 Institutions)**	Finep/BNDES	**Semi-Centralized (2 or 3 Institutions)**	Finep/BNDES/ANEEL
Decision Process - Evaluating Performance	**Decentralized**	intermisterial Committee	**Decentralized**	Intermisterial Committee	**Decentralized**	Intermisterial Committee
Evaluation Metrics	**Specific goals**	e.g.: 2G bioethanol enzymes	**Specific goals**	e.g.: new sugarcane varieties with mor biomass or ATRs	**Specific goals**	e.g.: improved thin film solar panel
Projects Leadership	**Large Corporation**	Each project must have at least one leading company	**Large Corporation**	Each project must have at least one leading company	**Large Corporation**	Each project must have at least one leading company
Participant Type (Companies, Universities etc)	**All**	Any kind of institution could send an interest letter and/or join a project	**All**	Any kind of institution could send an interest letter and/or join a project	**All**	Any kind of institution could send an interest letter and/or join a project
Instruments (Subsides, Grants, Taxes, Procurement etc)	**Few/Many**	Many financial instruments, but no procurement, tax or regulatory.	**Few/Many**	Many financial instruments, few grants and no procurement, tax or regulatory.	**Few/Many**	Many financial instruments, few grants and regulatory, but no procurement or taxes.
Grant	**Yes**	Grants to companies, universities and technological institutes	**Yes**	Grants to companies, universities and technological institutes	**Yes**	Grants to companies, universities and technological institutes
Procurement	**No**	No procurement	**No**	No procurement	**No**	No procurement
Legal/Regulatory	**No**	No regulatory integration	**No**	No regulatory integration	**Yes**	ANEEL participation
Feed-in Tariff*	**No**	No FiT	**No**	No FiT	**No**	No FiT

The general features of Inova renewable energy programs can be seen in Table 4. We can observe that most mission-oriented constructs were used by these initiatives to reach their goals, including the main ones: clear targets, alignment with major policies and radical innovation generation. However, the decentralized governance of the programs and their lack of integration with legal/regulatory and procurement instruments deserves some attention. Together, they constitute two important operational points that could make the programs deviate from their planned route.
The Inova renewable energy programs are still ongoing. The selection and contracting process takes up to two years to complete. The projects themselves take up to five years depending on the size of the challenge and the solution's level of radicalness. The first results of PAISS are now are materializing and can be divided into expectations and reality. As regards expectations, the program put Brazil back on the map of advanced biofuels producers as shown in Figure 2.

Figure 2: 2G Ethanol production estimated to 2015 (in millions of liters)



Source: Nyko et al., (2013)

The previous reality was different. When the PAISS was launched, in 2011, the price of crude oil stood at over US$ 110,00/barrel. In the middle of 2014 the price of barrel fell dramatically and since then has fluctuated between US$ 30,00 and 60,00 (Parente, 2016). During this same period the sugar price has almost doubled (NASDAQ, 2016). This large change in relative prices led to the postponement of all investments in sugarcane ethanol precisely at the end of the development cycle of 2G ethanol technologies. Other issues also influenced this trajectory, but this is not the focus of our discussion in the present article.
The Inova Energia and PAISS 2 are much too recent to analyze their results, but this could be an interesting subject for future research.

6. Conclusions

Brazil definitely has the potential to be a big player in terms of world renewable energy. Its continental dimensions, high incidence of solar radiation , the unexplored wind and hydro power potential, and the urban and agricultural biomass surplus, all place the country in a privileged situation in the renewable energy market.
The aim of PAISS, PAISS 2 and Inova Energia was not only to bring to Brazil the application of renewable energy generation, but also these industries' innovations and production chains. They constituted a great advance in terms of innovation policies in Brazil and the integration of financing instruments and Federal institutions in the same direction was unprecedented and desirable. But, despite this great alignment of objectives, some issues limited the program's reach, notably the design of its governance and lack of critical instruments.
As regards the instruments, most funds were composed of subsidized loans (73.4%), a policy instrument that is not fully appropriate for radical and high-risk innovations. The low level of grants available put a cap on the program's ambitions. Only in 2011, the US Department of Defense (DoE) provided 68 times more grants than the sum of PAISS, PAISS 2 and Inova Energia grants during the whole process (Anadón, 2012; Brazil, 2013).
The lack of formal integration with regulatory, procurement and fiscal efforts could be noticed as a point to be observed in future efforts. During the period some of the government's actions were even at odds with incentives for biofuel and renewable electricity sources: coal/gas

thermoelectricity auctions (to provide emergency energy security) or gasoline prices artificially kept at low levels (to control inflation) constitute two examples.

The governance of the programs could be improved according to the literature benchmarks. The number of institutions setting priorities, monitoring the process and evaluating performance delayed the process and made priority investments and project integration less effective than they could have been. In the Inova Energia case, the scope became wider than it should have been to foster a real transformation of the sector. The lack of integration of Finep, BNDES and ANEEL's operational systems and processes also hampered integration efforts.

On of the program's strong points was the collaborative design of phases. In each selection step the participant could build new relationships. Official events, workshops and technology supply books helped the participants to establish cooperation agreements and improved their projects during the process. This concept was an alignment between mission-orientation and open innovation (Chesbrough, 2003) concepts and could be an interesting point to explore in future research.

As mentioned in the literature review, we need to talk specifically about biofuels. Brazil had a successful trajectory since the 1970s when the mission-oriented Proálcool program created a complete infrastructure foe sugarcane ethanol consumption (from sugarcane plantation to ethanol pumps at gas stations). The flex fuel powertrains developed at the beginning of the 2000s also deserves attention in this trajectory (Mazzucato & Penna, 2016). In this context, PAISS and PAISS 2 helped to provide the sector with a new direction, aimed at increasing productivity and international competitiveness.

In the electricity sector, Inova Energia helped to provide some important technology inputs, but in the national integrated Brazil electricity grid, the critical issue is regulation. The role of energy auctions and smart grid rules were much more critical to accomplishing the program's mission than the technologies themselves. In the case of the electric/hybrid vehicle powertrains and batteries line, the main question was the difficulty of setting national priorities. The pre-salt discovery, incentives for biofuels (including PAISS and PAISS 2) and the strategy of multinational automobile companies in Brazil (they preferred to keep their electric vehicle R&D efforts at headquarters) sent contradictory signals to investors in this sector.

Some issues limited the findings of our study. The parameters of some mission-oriented constructs could be better delimited/qualified. A structured survey using the Likert scale could improve this point in future studies. Another question is the evaluation of results. The process is not formalized or described in the literature, official documents or reports. Obviously, the task of establishing a cut-off point for mission accomplishment and/or evaluate the externalities of these programs has become harder. Two significant exogenous factors also create some noise in program evaluation: the dramatic drop in oil prices since 2014 and the current economic and institutional crisis in Brazil which began at the end of 2015.

The analysis of advances in knowledge (even if the mission's goals are not reached) and the adequate time to reach each goal are important questions to be discussed and limitations to deeper analysis in our context.

One point should be emphasized in the case of future studies: of the 189 authors found, only six had more than one article published about the theme. This point could possibly indicate a lack of specialists, consensus or interest in the area. This constitutes a good issue for other investigations and suggests that using longitudinal studies to analyze the concrete results of Inova programs could be an interesting approach.

Evaluating not only the program, but also agencies' internal processes, including management, competencies and technical expertise, could provide us with a new perspective on the coordination, monitoring and instrument operation design. This would enable us to better understand the strengths and weaknesses of these programs.

A survey to transform the qualitative analysis of mission-oriented constructs into quantitative ones could give us a better understanding of the factors involved and produce more finely-tuned suggestions.

Last, but not least, the crossing combination of mission-orientation and open innovation concepts which are a feature of the Inova program's innovative design could suggest new constructs for mission-oriented programs in Brazil, and even worldwide.

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