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Public policies for smart grids in Brazil

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ABSTRACT

The evolution of existing electricity grids to smart grids is aimed at accommodating increasing shares of renewable generation thus contributing for the de-carbonization of economy, offering more diversified services to consumers, enhancing different types of markets (energy, capacity, ancillary services) and improving the system's overall efficiency. As the economic characteristics of the electricity sector tend to discourage investments in smart grids, many countries have adopted incentive policies to foster the deployment of new technologies, which vary according to the particular characteristics of each country. Therefore, the design of specific public policies for Brazil must consider not only the motivations involved, but also the existing challenges for the implementation of smart grids and the socio-economic context. Moreover, the relevance of the proposed policies can be seen from different perspectives. This justifies the need to elicit information from multiple stakeholders for decision support purposes. This paper presents and assesses a set of policies identified by different stakeholders as having a potential to foster the development of smart grids in Brazil. The methodology to shape this set of policies consisted of a thorough literature review of international experiences, combined with meetings with experts in several domains. Then, these policies were assessed by applying a Delphi questionnaire aiming at measuring their effectiveness in fulfilling the objectives associated with investments in smart grids. A first conclusion is that all policies were assessed as having a positive impact taking into account each of the objectives, differing only in the priority to be assigned to each one. The policies that were considered more relevant were: "Incentive Policies for Promoting Demand-Side Management, Distributed Generation and Storage", "Regulatory Changes to Foster Innovation in the Energy Sector" and "Regulation of New Business Models". Among the policies with the worst scores, "Mandatory Rollout of Smart Meters" and "Establishing Quality Standards for the Telecommunications Industry" were ranked as the two lower-ranked policies, i.e., they were assigned lower priority under all objectives.

1. Introduction

The evolution of existing electricity grids to smart grids strongly relying on information and communication technologies (ICT) is expected to contribute to improving the system's overall efficiency. This includes enhancing quality of service, decreasing technical and non-technical losses, saving operational costs, facilitating the penetration of dispersed generation based on renewable sources and deferring investments on generation and network capacity, while empowering consumers and allowing new business models to emerge (e.g., aggregators). Smart grids will allow innovative demand-side management benefitting from dynamic electricity pricing, diffusion of electric mobility, and the introduction of electricity storage systems [1]. However, the economic characteristics of the electricity sector, particularly with respect to the regulatory framework and traditional business models, tend to discourage investments in smart grids [2–5]. In this context, many countries have adopted incentive policies to foster the deployment of smart grids [6,7].

It is noticeable that these policies vary, depending on the specific characteristics of each country [8,9]. Therefore, the design of specific

Abbreviations: ANEEL, Brazilian regulator of the electrical energy sector; CAPEX, Capital expenditures; EU, European Union; ICT, Information and communication technologies; MCDA, Multi-criteria decision analysis/aid; OFGEM, Office of Gas and Electricity Markets; OPEX, Operational expenditures; RIIO, Revenue = Incentives + Innovation + Outputs; V2G, Vehicle-to-grid

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public policies for Brazil must consider not only the motivations involved, but also the existing challenges for the implementation of smart grids and the socio-economic context of the country. The pursuit of efficiency gains and the improvement of the quality of service offered by the electrical system are the main drivers for the development of smart grids in Brazil. The relevance of the proposed policies related to the development of smart grids can be seen from different perspectives, which justifies the importance of eliciting information from multiple stakeholders for decision support purposes.

The aim of this paper is to present and assess a set of policies identified by different stakeholders as having a potential major contribution for the development of smart grids in Brazil. The methodology to shape this set of policies consisted of a thorough literature review of international experiences, combined with meetings with experts in several domains (companies and entities in the electricity sector, government bodies including regulators, and academia), in order to characterize the current situation and the development prospects of smart grids in Brazil. An assessment of these policies was made by applying a Delphi questionnaire [10–12], with the purpose of measuring how effective these policies are in fulfilling the objectives associated with investments in smart grids.

This introduction provided the context and motivation of the study. Section 2 examines the need of public policies for the development of smart grids due to the economic characteristics of the electricity sector. Section 3 presents the set of public policies. Section 4 describes the application of the Delphi method to elicit information from stakeholders. The main results obtained are presented in Section 5 and discussed in Section 6. Finally, some conclusions and implications are drawn in Section 7.

2. Public policies for smart grids

It has been recognized that conventional grids are inadequate to meet the demands of the electrical system in the near future, due to concurrent needs: increasing the penetration of renewable sources, deploying micro-generation and storage systems, implementing active demand-side management mechanisms, and accounting for the expected growth of electric mobility including electric vehicles operation in vehicle-to-grid mode [13–15]. The dissemination of distributed generation based on renewable and intermittent sources may result in bidirectional energy flows in the grid and the growing share of electric vehicles imposes new technical challenges. Active demand control, storage systems and electric vehicles may increase problems in the grid. As a result, a *smarter* grid requires further control and automation mechanisms, including the deployment of smart metering systems at the customers' premises. This emerging technological paradigm, in which consumers will play a more prominent role through demand response mechanisms, needs to be supported by appropriate public policies, including regulatory ones, promoting investments on technological innovations in the grid [16–19].

Several technical and economic characteristics of the electricity sector must be taken into account when discussing the implementation of smart grids. Besides being an industry that requires instantaneous balance between demand and supply, the electricity sector is a capital-intensive industry with a homogeneous product, almost inelastic demand and regulated (access to grid) tariffs due to the existence of natural monopolies in the network businesses [20,21]. These characteristics do not favor the occurrence of innovation processes endogenously to the dynamics of the sector. Innovation generally occurs because the firm obtains a new process or product that allows it to increase profits for a certain period of time [22]. Given that electricity is a homogeneous good, product differentiation is limited. Moreover, new technologies tend to have initially a higher cost than the conventional alternatives. As a result, the market conditions do not favor the diffusion of technologies, for instance those with lower environmental impact [23,24].

Whenever the innovation process is hindered by the industry's characteristics and/or the regulatory framework, it is appropriate to adopt public policies that mitigate barriers to innovation and therefore encourage economic agents to innovate. But in order to succeed, it is necessary to know the characteristics of those barriers and the typologies of policy instruments [25]. Policy makers should intervene only when the implementation of innovation policies is justifiable. In addition, the interaction of different interest groups and agents with government institutions is essential to the creation of a coalition of stakeholders supporting the emerging technologies [26].

The diffusion of new technologies in the electricity sector follows a process that begins with research and development activities aimed at solving technical problems and reducing costs. Considering the nature of these activities, stakes are high and results are highly uncertain. Then, in general, a demonstration stage follows, in which the new technology must prove its feasibility. Finally, there is the market development and commercial distribution stage. It is important to highlight the value of public policies throughout this process to fund research and development activities as well as demonstration activities, and also to support the penetration of new technologies in the market [27]. In this context, Kiss and Neji [28] recognize the important role of government intervention in the innovation process, whose success depends on the public policy strategies adopted. More specifically, Sung and Song [26] emphasize the central role of government in technology development in the field of renewable energy.

In the case of smart grids, the scope of research and development projects, as well as demonstration projects, is quite broad. We note the relevance of carrying out projects related to grid automation, large-scale integration of renewable energy, electric vehicles, demand-side management as well as exploratory pilot projects related to technological solutions like smart metering or regulatory changes like dynamic tariffs [29,30]. Since a technological transition is a process that goes beyond the technological sphere, these projects must also include other variables, especially the issue of social acceptance [31]. For instance, it is quite important to develop studies that address the price elasticity of demand in order to gauge the real impacts that demand response measures have on the system. For this purpose, Toft et al. [32] suggest that research is needed to achieve a better understanding of what makes consumers accept or reject smart grid technologies in order to properly develop and effectively spread these new technologies and achieve the political goals envisaged.

Given that the electricity distribution is a natural monopoly and heavily regulated [3,33], the peculiarities of the market diffusion of smart grids should be emphasized. The incentives to smart grids tend to be more associated with changes in the regulatory setting than the formulation of public policies in a broader sense. In contrast to conventional grids, smart grids are characterized by a higher proportion of operating costs relative to the amount of capital invested. Therefore traditional regulatory models, which are predominantly cost service or incentive regulation, do not encourage investments in smart grids, because they are focused on the asset base [3,34]. Namely, the economic and financial attractiveness of investments in the grid automation and the rollout of smart meters become questionable under most present regulatory frameworks. It is thus necessary to discuss the asset base