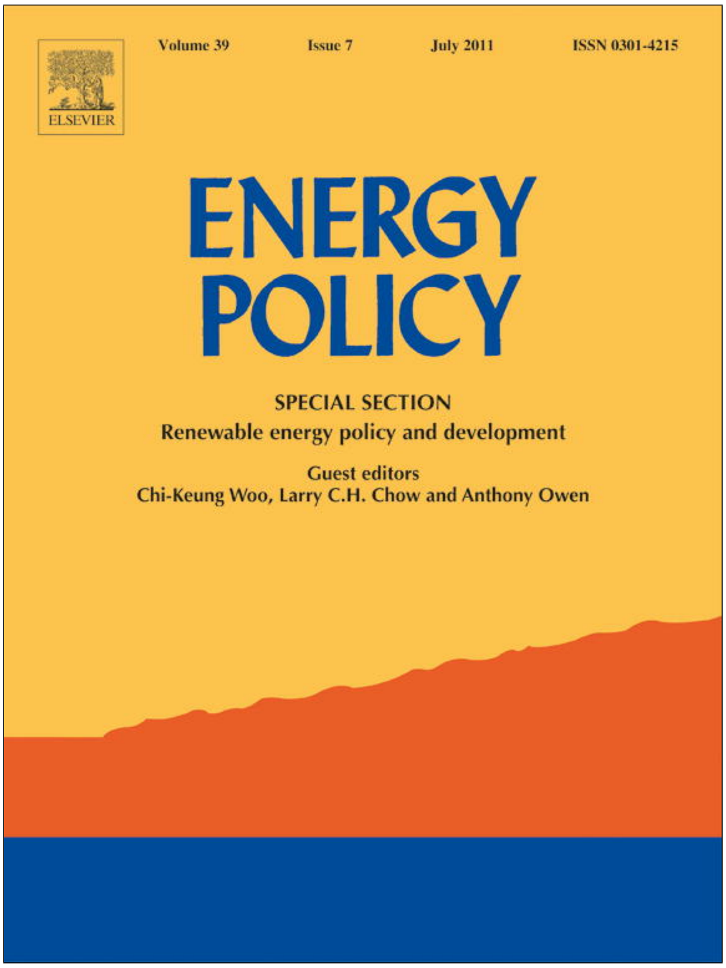
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Enhancing information for solar and wind energy technology deployment in Brazil

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ABSTRACT

Brazil's primary energy matrix is based on more than 47% of renewables, and more than 85% of its electricity is generated by hydro power sources. Despite this large fraction of renewable energy resources, less than 0.3% of the national energy supply comes from solar or wind sources. This paper presents a diagnostic review on the penetration of the solar and wind energy technologies in Brazil. It also includes a survey of the latest government policies and incentives for renewable energies deployment by entrepreneurs, industry and commercial and residential consumers. In addition, the paper analyses how to best meet the requirements for policy support and information technology to boost the deployment of solar technology and wind energy in Brazil. This study was mostly based on results of a widely distributed survey covering key issues, and also by personal interviews carried out with key stakeholders in order to better understand the issues highlighted in the survey responses. The study pointed out some of the main obstacles to effectively promote and improve government policies and actions for investment in solar and wind energy market in Brazil.

1. Introduction

It is well known that the intimate relationship between energy, environment and socioeconomic development. Several publications discuss how the human society should make use of its energy resources with the lesser environmental impact while enhancing the energy security and allowing a solid sustainable development necessary to provide all kinds of services to the ever growing world population— health, food, entertainment, transport, etc. (Dincer, 2000; Sims, 2004; Omer, 2008). This approach calls for a worldwide action from all countries to increase the insertion of renewable energy sources into their energy matrices. In spite of the expiring Kyoto Protocol in 2012 and the disappointing results of 2010 Copenhagen Climate Change Conference, many countries are developing their own domestic policies to promote renewable energy for electricity generation and transport as a strategic objective of enhancing energy security rather than to meet the IPCC

Abbreviations: ANEEL, Agência Nacional de energia Elétrica (Brazilian Agency for Electric Energy); CCST, Centro de Ciência do Sistema Terrestre (Research Centre for Earth System); CEPEL, Centro de Pesquisas de Energia Elétrica (Research Centre in Electricity); COPEL, Companhia Paranaense de Energia (Energy Company of Paraná); CPTEC, Centro de Previsão do Tempo e Estudos Climáticos (Centre for Weather Forecast and Climate Studies); CRESESB, Centro de Referência para Energia Solar e Eólica Sérgio de Salvo Brito (Reference Centre for Solar and Wind Energy Sérgio de Salvo Brito); CSP, Concentrated solar power plants; ELETROBRAS, Centrais Elétricas Brasileiras S. A.; EMAE, Empresa Metropolitana de Água e Energia (Metropolitan Company for Water and Energy); EPE, Empresa de Pesquisa Energética (Companhy for Energy Research); EU, European Union; GEF, Global Environment Facility; IDS, Interconnected Distribution System; INMET, Instituto Nacional de Meteorologia (Brazilian Institute for Meteorology); INPE, Instituto Nacional de Pesquisas Espaciais (Brazilian Institute for Space Research); IPCC, Intergovernmental Panel on Climate Change; IPP, Independent power producers; LABSOLAR, Laboratório de Energia Solar/UFSC (Laboratory for Solar Energy); LACTEC, Instituto de Tecnologia para o Desenvolvimento (Technology Institute for Development); MME, Ministério de Minas e Energia (Ministry of Mines and Energy); OECD, Organisation for Economic Co-operation and Development; ONS, Operador Nacional do Sistema Elétrico (Brazilian Operator for Eletricity System); PB, Paraíba State; PE, Pernambuco State; PI, Piauí State; PR, Paraná State; PROCEL, Programa Nacional de Conservação de Energia Elétrica (Brazilian Programme for Electricity Saving); PROINFA, Programa de Incentivo às Fontes Alternativas de Energia Elétrica (Incentive Program for Alternative Energy Sources); PV, Photovoltaic power plants; R&D, Research and Development; RJ, Rio de Janeiro State; RN, Rio Grande do Norte State; RS, Rio Grande do Sul State; SEINFRACE, Secretaria de Infraestrutura do Ceará (Goverment Department for Infrastructure of State of Ceará); SEINPE, Secretaria de Energia, Indústria Naval e Petróleo do Rio de Janeiro (Goverment Department for Energy, Naval Industry and Petroleum of State of Rio de Janeiro); SWERA, Solar and Wind Energy Resources Assessment Program; UFAL, Universidade Federal de Alagoas (University of Alagoas); UFPE, Universidade Federal de Pernambuco (University of Pernambuco); UFMA, Universidade Federal do Maranhão (University of Maranhão); UFSC, Universidade Federal de Santa Catarina (University of Santa Catarina); UNEP, United Nations Environment Programme; WI, Worthiness Index.

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appeal for reduction of greenhouse emissions (Li Li et al., 2010; Bang, 2010, Bollen et al., 2010).

The 4.2% increase in the total consumption of electricity was an important benchmark with regard to the performance of the Brazilian energy sector in 2008. The total domestic electric energy supply reached 463.1 TWh. Hydroelectric plants stand for 70% of this total. If other renewable energy sources, such as wind and biomass are included, the renewable energy share achieves around 90% in Brazil. This figure is amongst the highest in the world compared to the global average of 15.6%. (EPE (Empresa de Pesquisa Eneregética), 2009)

Fig. 1 compares the electricity supply structure for Brazil and the rest of the world. Brazil ranks in third place among the top 10 renewable electricity producers, behind China and the E.U., thanks to its large water resources. As for its primary energy matrix resources (renewable resources only) Brazil ranks the 17th position along with Denmark and Belgium, owing to Brazil's robust domestic bioenergy development. On the whole, 47% of the Brazilian primary energy matrix comes from renewable sources, which significantly contrasts with the global average of 12%, and with the 7% average for OECD countries (EPE (Empresa de Pesquisa Eneregética), 2009).

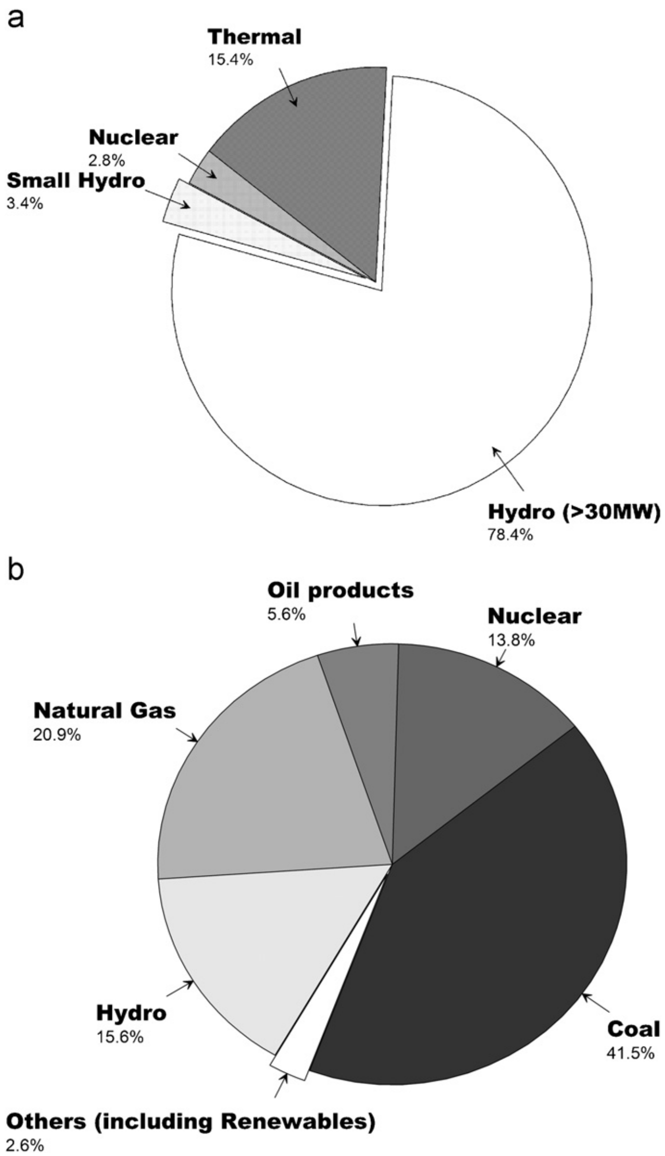

Fig. 1. Share of several energy sources in Brazilian (a) and World (b) energy matrixes.

In 2008, hydroelectricity stood for about 15% of the Brazilian primary energy matrix. Here, the maximum capacity of hydroelectric generation is close to being achieved in the most industrialized regions. On the other hand, there are still unexploited resources on major river basins in remote areas (like Amazon and Cerrado areas) at a high environmental cost and relatively low energy density when compared to hydroelectric plants in operation.

In 2008, about 31% of the Brazilian primary energy was derived from biomass sources (ethanol and other byproducts from sugarcane, biodiesel, wood and natural charcoal). There was a significant increase in biodiesel production— 188.7% following the good results of 2007. Such expressive growth was due to a mandatory biodiesel addition to mineral fuel, mainly used for public transport and freight (EPE (Empresa de Pesquisa Eneregética), 2009).

The outstanding growth in renewable energy share throughout 2008 was due to adoption of ethanol derived from sugarcane (27.1×10^6 m^3)— a 23% growth with respect to the previous year. Besides that, the production of anhydrous ethanol, added to mineral gasoline, achieved 9.6×10^6 m^3— a 16% growth in the same period. Moreover, in the last 3 years, several thermal power plants using cane bagasse came into operation to increase electricity system security. Thermal plants allowed a better management of water flow rates in major river basins in order to meet the electricity demand in dry seasons.

As seen above, the country has held leadership positions with regard to the use of renewable energy resources. However, this approach is still unsatisfactory with regard to wind energy and particularly solar energy resources. This work is based on a research under the support of the United Nations Development Program (*Enhancing information for renewable energy technology deployment in Brazil, China and South Africa*) aimed at determining how to best gather missing resource, policy, risk management and technology information requirements to boost the deployment of solar and wind energy in Brazil. The methodology was based primarily on consultations with stakeholders. The paper presents and analyzes the answers for a widely distributed feedback survey covering key issues concerning the solar and wind energy technology deployment in Brazil. Personal interviews, meetings, phone calls and e-mail exchanges completed the survey.

Briefly, this work describes the status of solar and wind energy resource deployment in Brazil and, also, the major efforts of the Brazilian scientific community to provide reliable information on solar and wind energy assessment. Furthermore, it describes the main national supportive policies to the promotion of renewable sources of energy and to provide regulatory frameworks to entrepreneurs, industry and commercial and residential consumers.

2. Solar and wind energy resource assessment

Brazil's wind energy production has escalated up from 22 MW in 2003 to 609 MW in early 2010, thanks to the PROINFA, which is a government program to promote the deployment of wind power, biomass fuels and small hydroelectric power. Furthermore an additional 256.4 MW of wind power is being deployed. Seventy-one additional projects have been approved in 2009, as a result of the country's first wind-only auction. The contracts, adding up about 1800 MW, will set out in July 2012 for a 20 years grant period. Another auction for renewable energy held in 2010 will add 1519 MW of wind power spread over 50 new projects contracted.

Table 1
Wind energy assessment in Brazilian territory.

Identification	Scope	Institutions involved	Methodology employed	Spatial resolution	Year
Brazilian atlas for wind energy[a]	Brazilian territory	ELETROBRAS and MME	MASS/MesoMap system and WINDMAP	Up to 1 km	2001
Wind energy overview for Brazil[b]	Brazilian territory	ANEEL	Mesoscale model (MM5) and WAsP	Up to 1 km	2003
SWERA—Brazil report[c]	Northeastern and southern regions	UNEP, GEF, INPE	Mesoscale model (Eta/CPTEC)	10 km	2008
Wind energy atlas for the northeastern region[d]	Northeastern region	ANEEL	Statistical methods using wind data	–	1998
Wind energy atlas for Ceará[e]	Regional state area	SEINFRACE	MASS/MesoMap system and WINDMAP	1 km	2001
Wind energy atlas for Alagoas[f]	Regional state area	LACTEC, ELETROBRAS and UFAL	MASS/MesoMap system and WINDMAP	200 m	2008
Wind energy atlas for Rio de Janeiro[g]	Regional state area	SEINPE	MASS/MesoMap system and WINDMAP	200 m	2003
Wind energy for Paraná[h]	Regional state area	COPEL	MASS/MesoMap system and WINDMAP	1 km	1999
Wind energy atlas for Rio Grande do Sul[i]	Regional state area	Federal government	MASS/MesoMap system and WINDMAP	1 km	2002
Wind energy for Bahia[j]	Regional state area	COELBA	MASS/MesoMap system and WINDMAP	1 km	2002
Wind energy for Espírito Santo[k]	Regional state area	State unit government	MASS/MesoMap system and WINDMAP	1 km	2010
Wind energy for Minas Gerais[l]	Regional state area	CEMIG	MASS/MesoMap system and WINDMAP	1 km	2010
Wind energy atlas for São Paulo[m]	Regional state area	EMAE	KAMM model and WAsP	200 m	2010
Wind energy atlas for Maranhão[n]	Regional State area	UFMa	Unknown	Not available	–

[a] Amarante et al. (2001a).
[b] Amarante et al. (2001).
[c] Pereira et al. (2008).
[d] ANEEL (1998).
[e] Amarante et al. (2001b).
[f] ELETROBRAS (2008).
[g] Amarante et al. (2003).
[h] Amarante and Schultz (1999).
[i] Amarante et al. (2002a).
[j] Amarante et al. (2002b).
[k] Amarante et al. (2010a).
[l] Amarante et al. (2010b).
[m] Campos et al. (2010).
[n] In progress. Not available yet.

Table 2
Available information on solar energy assessment for the Brazilian territory.

Identification	Institutions involved	Methodology employed	Spatial resolution	Year
Brazilian atlas for solar energy[a]	UNEP, INPE and LABSOLAR/UFSC	BRASIL-SR model based on satellite data	10 km	2006
Brazilian solarimetric atlas: ground database[b]	MME, ELTROBRAS and CRESESB	Statistical methods using ground data	Not available	2000
Solar radiation atlas of Brazil[c]	INPE, INMET and LABSOLAR/UFSC	BRASIL-SR model based on satellite data	50 km	1998

[a] Pereira et al. (2006).
[b] Tiba (2000).
[c] Colle and Pereira (1998).

Assuming that the projects contracted in the auctions are built according to schedule, the prospect for wind energy in Brazil is very positive. Developing wind power will contribute to Brazil meet its strategic objectives of enhancing energy security, creating more jobs and, at the same time, reducing the country's energy-related greenhouse gas emissions. The potential inland wind power resources could reach more than 145,000 MW according to the Brazilian Wind Atlas (2001). In spite of this, the long-term growth of the Brazilian wind capacity depends not only on a competitive price for this energy (today at US$74 per MWh) but also on the sustainable domestic development of the wind technology.

Several wind energy assessment reports for the Brazilian territory are available today and many others are under development. The national and regional Wind Atlases listed in Table 1 are examples of these research efforts, most of them supported by Brazilian Federal and State governments, to generate reliable databases necessary for planning and boosting the wind energy exploitation. These publications indicate that the most promising areas are located in the Brazilian Northeastern region and in some states of the Southern and Southeastern regions (Amarante et al., 2001c; Pereira et al. 2008). Nonetheless, these assessments must be reviewed to cope with the technological advances of the new wind turbines, not to mention the vast and yet unknown wind potential offshore.

In contrast with other renewable energy sources (wind, biomass and small hydroelectric plants) that have specific support by government incentives and policies, the penetration of the solar technology in Brazil is lagging far behind. There have been some important efforts, listed in Table 2, to increase the available information on the Brazilian solar energy resources. Fig. 2 presents a relative comparison between solar energy resources[1] in Brazil and in countries where the solar energy market is far more advanced, such as Germany and countries in the Iberian Peninsula. It also shows the mean annual solar resources for each of the five Brazilian geo-political regions. Besides the large annual solar irradiation, its seasonal and inter-annual variability are low due to the fact that much of the Brazilian territory is located in a tropical region. Earlier studies have pointed out that the solar technology could be cost-effective all over the Brazilian territory regarding particular conditions for each region. Applications like

[1] *Based on annual mean daily solar global irradiation.*

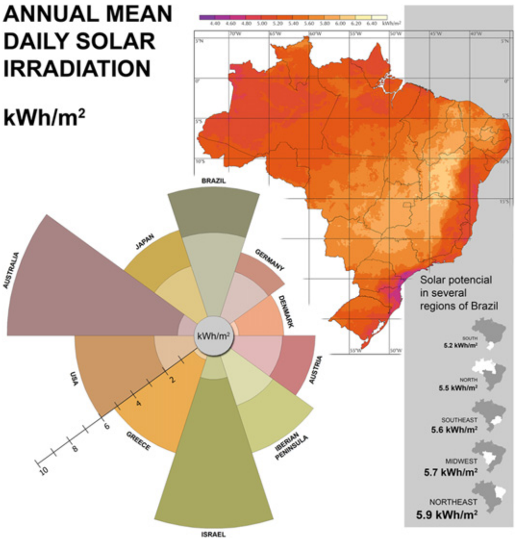

Fig. 2. Mean annual range of the solar resources in Brazil compared to other countries.
Source: Pereira et al. (2006).

PV plants in the Amazon region to provide electricity for remote areas and small villages, concentrated solar power plants (CSP) in the arid area of Northeastern region and water heating in South and Southeast of Brazil are examples for feasible exploitation of solar resources (Martins et al., 2008).

3. Current status of solar energy in Brazil

Solar energy for water heating is by far the most widespread application of solar energy in Brazil. Local solar heating industry is well developed and able to supply a growing market. However there is still a need for more aggressive public awareness on the advantages of this technology to further boost this development.

Currently, more than 5 million m^2 of solar heating collectors are installed and government incentive programs were shaped to promote large-scale use of this technology (DASOL, 2011). The chief program is the PROCEL, created to promote a more efficient electricity generation and consumption so as to reduce costs and support investments in this sector (ELETROBRAS, 2010; Pereira et al., 2009). Fig. 3 shows the payback time for water heating systems in Brazil taking into account the solar irradiation data produced by SWERA project (http://swera.unep.net/). The map was prepared considering a compact low cost system designed to replace the electric shower in households of low-income families (area of 1.6 m^2, volume of 120 liters, life cycle of 20 years and an estimated total cost of US$ 500). It assumes a 0.12 US$ per kWh of electricity and the interest rate of 10% per year. The payback time is smaller mainly for regions with greater energy demand and located in the subtropical climate of the Southern and Southeastern regions.

Despite the great solar resource and high value that can be attributed to grid-connected PV systems in commercial areas of urban centers in Brazil, the installed PV capacity is meager and restricted to universities and research institutes. PV applications have a promising future in commercial urban tropical and subtropical regions where high midday air-conditioning loads have normally a demand curve in a good match with the solar irradiation curve. Another important factor in this analysis is the comparison between the peak load values in summer and winter. The greater the demand in summertime compared to the demand in wintertime, the more closely the load is likely to match the actual solar resource. This is the typical picture for most metropolitan areas and large cities in Brazil (Martins et al., 2008).

Fig. 3. Payback time for water heating by a compact low cost solar system designed to replace the electric shower in household of low-income families.
Source: Pereira et al. (2008).

Fig. 4. Illustrative map of the interconnected electricity distribution system in Brazil.
Source: Pereira et al. (2008).

Other important future application for PV generation is in remote areas not connected to the Brazilian Interconnected Distribution System, like Brazilian Amazon region (Fig. 4). There are currently only a few hundreds of mini-grids operated by independent power producers (IPPs) or local state utilities in the Brazilian Amazon, that cover the main share of local demand. All the electricity is generated in fossil fuel power plants but most of the sites are not easily accessible, increasing cost and decreasing reliability of supply. The potential for using PV systems, however, is huge, and can be estimated in tens to hundreds of MWp, even if only a fraction of the existing Diesel oil plants would adopt some PV to an optimum Diesel/PV mix. Nevertheless, solar energy is not even mentioned in the major national program for renewable energy sources, the PROINFA.

3.1. Current status of wind energy in Brazil

According to the National operator of Electrical System (ONS), electricity generated by wind power reached 556.9 GWh in 2008. The installed capacity in wind power increased about 68% in the period 2007–2008. Since 2008, the wind power has increased around 65% achieving 921 MW in early 2011. The total wind energy capacity installed in Brazil is the largest in Latin America, even then it matches up to less than 1% of the total electricity capacity estimated for Brazil (ANEEL, 2011). The installed wind power generation capacity in Brazil is far behind the one observed in other developing countries such as China (42 GW) and India (13 GW), as for 2010, according to the Global Wind Energy Council (http://www.gwec.net/).

There are 51 wind plants installed and in operation, ranging from 0.3 MW to 100 MW, and most of them are located in the Brazilian Northeastern and Southern regions, where the wind energy resource assessment indicates more economic feasibility. A list of all wind farms in operation in both Brazilian regions is presented in Table 3 with its location and generation capacity. There is only one not listed in Table 3 located in Southeastern region (São Francisco de Itabapoana/RJ) generating 28 MW.

The total wind power installed capacity will reach 2.8 GW in 2012, a merely 2% of the current world installed capacity yet it represents an internal growth of more than 200%. Table 4 shows the increase in wind power capacity due to the new granted

Table 4
Expected growth in the installed wind power capacity after the wind energy auctions in 2009 for each federal unit of Brazil.
Source: ANEEL (2011).

Brazilian region	Federal unit	Power (MW)	%
Northeastern	Piauí	23.4	63
	Ceará	588.9	
	Rio Grande do Norte	521.3	
	Pernambuco	4.2	
	Paraíba	9.7	
	Bahia	192.1	
Southeastern	Rio de Janeiro	249.2	12
Southern	Santa Catarina	301.5	25
	Rio Grande do Sul	234.5	
Total		**2120.5**	**100**

Table 3
List of major Brazilian wind farms in operation.
Source: ANEEL (2011).

Identification	Location	Power (MW)	Owner
Brazilian northeastern region: *726 MW*			
Praia Formosa	Camocin/CE	104.4	Eólica Formosa Geração e Comercialização de Energia S. A.
Canoa Quebrada	Aracati—CE	57	Bons Ventos Geradora de Energia S. A.
Eólica Icaraizinho	Amontada/CE	54.6	Eólica Icaraizinho Geração e Comercialização de Energia S. A.
Bons Ventos	Aracati—CE	50	Bons Ventos Geradora de Energia S. A.
Volta do Rio	Acaraú—CE	42	Central Eôlica Volta do Rio S. A.
Parque Eólico Enacel	Aracati—CE	31.5	Bons Ventos Geradora de Energia S. A.
Eólica Praias de Parajuru	Beberibe—CE	28.8	Central Eólica Praia de Parajuru
Praia do Morgado	Acaraú—CE	28.8	Central Eólica Praia do Morgado
Parque Eólico do Beberibe	Beberibe/CE	25.6	Eólica Beberibe S. A.
Foz do Rio Choró	Beberibe/CE	25.2	SIIF Cinco Geração e Comercialização de Energia S. A.
Eólica Paracuru	Paracuru/CE	23.4	Eólica Paracuru Geração e Comercialização de Energia S. A.
Taíba Albatroz	São Gonçalo do Amarante/CE	16.5	Bons Ventos Geradora de Energia S. A.
Eólica Canoa Quebrada	Aracati—CE	10.5	Rosa dos Ventos Geração e Comercialização de Energia S. A.
Eólica de Prainha	Aquiraz/CE	10	Wobben Wind Power Indústria e Comércio Ltda.
Taíba	São Gonçalo do Amarante/CE	5	Wobben Wind Power Indústria e Comércio Ltda.
Lagoa do Mato	Aracati—CE	3.23	Rosa dos Ventos Geração e Comercialização de Energia S. A.
Mucuripe	Fortaleza—CE	2.4	Wobben Wind Power Indústria e Comércio Ltda.
Parques Presidente, Coelhos, Atlantica, Caravela, Mataraca, Albatroz e Camurim	Mataraca/PB	45	Vale dos Ventos Geradora Eólica S. A.
Millennium	Mataraca/PB	10.2	SPE Millennium Central Geradora Eólica S. A.
Vitória	Mataraca/PB	4,5	Cardus Energia Ltda.
Alhandra	Alhandra/PB	2.1	Cedin do Brasil Ltda.
Pedra do Sal	Parnaíba/PI	18	Eólica Pedra do Sal S. A.
Alegria I	Guamaré/RN	51	New Energy Options Geração de Energia S. A.
RN 15 Rio do Fogo	Rio do Fogo/RN	49.3	Energia s Renováveis do Brasil S. A.
Macau	Macau/RN	1.8	PETROBRAS S. A.
Parques Mandacaru, Santa Maria e Gravatá Fruitrade	Gravatá/PE	14.85	Eólica Gravatá Geradora de Energia S. A.
Xavante	Pombos/PE	4.95	Eólica Gravatá Geradora de Energia S. A.
Pirauá	Macaparana/PE	4.95	Eólica Pirauá Geradora de Energia S. A.
Eólica Olinda	Olinda/PE	0.225	Centro Brasileiro de Energia Eólica - UFPE
Fernando de Noronha	Fernando de Noronha/PE	0.225	Centro Brasileiro de Energia Eólica - UFPE
Brazilian southern region: *166.9 MW*			
Parques de Osório, Sangradouro e Índios	Osório/RS	150	Ventos do Sul Energia S. A.
Parque Eólico de Palmares	Palmares do Sul/RS	8	Parques Eólicos Palmares S. A.
Elétrica de Palmas	Palmas/PR	2.5	Ventos do Sul Energia S. A.
IMT	Curitiba/PR	2.2	Electra Power Geração de Energia Ltda.
Eólica Água Doce e Horizonte	Água Doce/SC	13.8	Central Nacional de Energia Eólica Ltda.
Eólica Bom Jardim	Bom Jardim da Serra/SC	0.6	Parque Eólico de Santa Catarina Ltda.
Total Capacity:	921 MW (including wind power plant in RJ)		

Table 5
List of new wind power plants under construction in Brazil.
Source: ANEEL (2011).

Identification	Location	Owner	Power (MW)
Macaúbas	Brotas de Macaúbas/BA	Macaúbas Energética S. A.	30
Novo Horizonte	Brotas de Macaúbas—BA	Novo Horizonte Energética S. A.	30
Seabra	Brotas de Macaúbas—BA	Seabra Energética S. A.	30
Morro dos Ventos IV	João Câmara—RN	Desa Morro dos Ventos IV	28.8
Púlpito	Bom Jardim da Serra—SC	Púlpito Energia Eólica S. A.	30
Aquibatã	Água Doce—SC	Aquibatã Energia Eólica S. A.	30
Cruz Alta	Água Doce—SC	Cruz Alta Energia Eólica S. A.	30
Rio do Ouro	Bom Jardim da Serra—SC	Rio de Ouro Energia Eólica S. A.	30
Salto	Água Doce—SC	Salto Energia Eólica S. A.	30
Bom Jardim	Bom Jardim da Serra—SC	Bom Jardim Energia Eólica S. A.	30
Amparo	Água Doce—SC	Amparo Energia Eólica S. A.	22.5
Campo Belo	Água Doce—SC	Campo Belo Energia Eólica S. A.	10.5
Santo Antônio	Bom Jardim da Serra—SC	Santo Antônio Energia Eólica S. A.	3
Cascata	Água Doce—SC	CascataEnergia Eólica S. A.	6
Eólico elebrás Cidreira 1	Tramandaí/RS	Elebrás Projetos S. A.	70
Coxilha Negra V	Santana do Livramento/RS	Eõlica Cerro Chato I S. A.	30
Coxilha Negra VI	Santana do Livramento/RS	Eõlica Cerro Chato II S. A.	30
Coxilha Negra VII	Santana do Livramento/RS	Eõlica Cerro Chato III S. A.	30
Total capacity			**500.8**

projects of the December 2009 auction for each Brazilian state: 63% of the total new wind power capacity will be located in the Northeastern region. Table 5 presents a list of wind farms under construction.

In addition to that, Brazil has developed a high-quality industrial competence to produce wind turbines from 250 W stand-alone unities to up to 3 MW systems to deliver for the national market and to export. The CRESESB homepage presents a guide for institutions and companies working on wind generators (http://www.cresesb.cepel.br/guia_cresesb.php). There, it is possible to find contacts for manufacturers operating in Brazil like IMPSA WIND, Wobben WindPower, General Electric do Brasil, ENERSUD, ELETROVENTO, TECSIS and for commercial representatives from multinational companies.

Recent studies (Amarante et al., 2001c) have shown that hydroelectric power plants located in Northeastern and Southern regions have almost similar hydrological seasonal regimes: higher water flow during austral Summer–Autumn (Dec–Apr) and critical reservoir levels are sometimes reached during austral Winter–Spring (Jul–Oct). This fact has posed an important historical challenge to the operation and planning of the Brazilian Interconnected Electric System, and it is also reflected in tariffs for large industrial consumers in the whole country. Moreover, wind measurements show that seasonal wind regimes are complementary to the seasonal hydro regimes. The higher the wind power penetration in the Brazilian electricity grid, the higher will be the water savings achieved in the hydro power plant reservoirs during the critical dry season. The benefit from complementary performance is even more marked in the Northeastern region, especially for managing hydro power plant reservoirs in the basin of the São Francisco River. Although no studies have been reported to evaluate how much the solar and hydro energy resources availability are complementary, it is most likely that the surface solar irradiation declines during rainy seasons as a result of the higher cloudiness.

4. Brazilian government policies and incentives

Over the last 25 years energy policy in Brazil has sought to reduce the country's dependence on foreign energy supply and stimulate the development of domestic energy sources. However, it was left behind in a huge unexploited potential of renewable energy sources such as solar (photovoltaic and thermal), and to a lesser extent wind power to generate electricity. A recent economic analysis by Austin and Faeth (2000) indicates that these indigenous energy sources could be profitable and environmentally sound for a sustainable and clean development.

The effective growth of the Brazilian renewable energy market depends strongly on the policy-makers. The growth will be as fast as the research institutes, government organizations and policy makers propose, discuss and implement energy policy frameworks conducive to support the renewables. The key issue is that energy policy initiatives should be shaped to break a variety of barriers that preclude investments from occurring.

Recently, a major barrier is related to the adverse rank for the renewable energies regarding the economic, regulatory, or institutional issues when compared to other conventional sources of energy supply. The barriers include subsidies for fossil fuels consumption mainly in remote areas like Amazon; technological difficulties to connect intermittent energy supply from solar and wind generation systems to the distribution grid; lack of reliable information on the energy resources variability; fuel-price risk assessment; high initial capital costs; capital markets volatility and financing risks and poor credibility and stability of regulatory and institutional aspects. Some of these barriers are the results of market distortions that unfairly discriminate against renewable energy increasing the renewable energy cost when compared to the conventional energy sources.

According to the present study, the low effectiveness of government policies to promote the incorporation of new renewable energy sources to the electricity generation matrix has been the main criticism of the Brazilian performance in this area. Table 6 lists the major government policies and actions to promote, directly or indirectly the solar and wind technology development and deployment for power generation.

Currently, there are no country programs specifically formulated to increase the penetration of the solar heating technology in dwellings, public buildings or for industrial applications. Only PROCEL can be mentioned as a government action that indirectly supports the solar heating systems to improve the energy efficiency in buildings. Since end of 2009, the government program "My Home My Life" was implemented to reduce the deficit in housing for families with low income. This program requires the use of solar heaters in the financed dwellings. Despite of triggering an increasing demand for heaters, these initiatives are the

Table 6
Federal government policies to directly or indirectly promote the wind and solar energy technologies.

Identification	Year	Responsible agency	Goal	Energy sources	Current status
National Program "Minha Casa, Minha Vida" (My home, my life)	2009	Ministry of cities	Provides financial resources to reduce deficit on housing in metropolitan areas and large cities for low-income families	Requires solar water heating systems in financed dwellings	Ongoing
ELETROBRÁS/GTZ Technical Cooperation Project	2005	ELETROBRAS an MME	Provides for helping power distribution utilities located in the northern and northeastern regions to achieve the goals of the *Light for All* Program through the use of Renewable Energy	Solar, wind and biomass	Pilot projects implemented
Program of Incentive for Alternative Energy (PROINFA)	2002	Ministry of Mines and Energy	Promote the use of renewable technologies for electricity generation through incentives and subsidies in a short-term prospect	Wind, biomass and small hydro plants	Ongoing. This program substitute PROEÓLICA
Emergency Program of Wind Energy (PROEÓLICA)	2001	Power Crisis Management Chamber	Emergency measure to add around 1 MW of wind capacity to the national grid till December/2003	Wind	Accomplished
Program for Universalization of Electric Power Light *for All*	2003	Ministry of Mines and Energy	Intends to deliver electricity in remote and rural areas not reached by the IDS.	Does not address Wind and Solar but considers both viable	Ongoing
National Electricity Conservation Program (PROCEL)	1985	ELETROBRAS	Regulates standards, requirements and actions aiming at to improve indexes for the energy efficiency of equipments and buildings.	Considers solar water heating systems in order to substitute electric shower	Ongoing

Table 7
Regional policies implemented or in discussion by regional governments to promote solar systems deployment for electricity generation or water heating.

Goal	Cities and states	Status
Incentive and regulation policies for solar systems for water heating	*Cities*: São Paulo, Peruíbe *States*: Rio de Janeiro (in public buildings)	Implemented
Incentive and regulation policies for solar systems for water heating	*Cities*: Campinas, Asis, Piracicaba, Americana, Araraquara, Araçatuba, Franca, São José dos Campos, Rio de Janeiro, Juiz de Fora, Ponte Nova, Uberaba (in Brazilian Southeastern region), Curitiba and Porto Alegre (in Brazilian Southern region) *States*: São Paulo	In discussion and waiting approval in the State or Municipal Legislative Hall
Incentive and regulation policies for solar energy for several applications	*Cities*: Piracicaba, São José dos Campos and Peruíbe (all in Brazilian Southeastern region)	In discussion and waiting approval in the State or Municipal Legislative Hall
Municipal policy for global warming and climate change, alternative energy	*Cities*: Curitiba (in Brazilian Southern region)	In discussion and waiting approval in the State or Municipal Legislative Hall
Program for solar energy adoption in urban buildings	*Cities*: Campo Grande (in Brazilian Mid-West region)	In discussion and waiting approval in the State or Municipal Legislative Hall
Project Solar Light	*State*: Minas Gerais (in Brazilian Southeastern region)	Implemented since 2005, it aims to supply countryside areas far from the electric distribution network with electric power generated by PV systems
State policy for solar energy	*State*: Ceará (in Brazilian northeastern region)	In discussion and waiting approval in the State Legislative Hall

direct incentive programs for market expansion and promotion of solar heaters.

On the other hand, there are many regional initiatives from medium to large size cities to promote the solar heating by giving discounts in municipal taxes and making its usage mandatory in new public and private buildings. Table 7 describes the most important regional policies in effect or pending approval by Legislative Houses. In addition to the cities policies, some state governments are discussing and implementing programs to promote solar energy generation. Since 2005, the state of Minas Gerais (in Southeastern region) is using solar PV systems to supply electricity for countryside areas far from the electric distribution grid (Solar Light Program). The Legislative Hall from the state of Ceará (in the Northeastern region) is discussing a regional policy to promote penetration of solar energy technologies.

Table 8 presents the new proposals in discussion in the Brazilian Congress of government programs and policies to promote and regulate the exploitation of non-conventional renewable energy resources (excluding large hydroelectric plants). The draft law 630/2003 promises to promote a policy of encouraging non-conventional renewable energy projects in Brazil. The main points of this draft law are regarding promotion of recurrent auctions for alternative energy plants, developing national industry, reducing the use of fossil fuels in power plants, regulating tax exemptions for electric and hybrid vehicles and tax reductions on goods imported for the development of renewable energy projects and creating a national fund to support research and development on alternative energy sources technology. The discussions and negotiations on the subjects regulated by this law project are lasting for 7 years and several experts

Table 8
Proposed federal government policies to encourage the use of the renewable energy resources—all under discussion or waiting for approval in the Brazilian Congress.

Identification	Goal	Energy sources
Public Policy Programs and Incentives for Solar Heaters	Provides the mandatory adoption of solar water heaters in projects for popular housing, and authorizes the Executive Power to create Public Policy Programs and Incentives for deployment and use such equipment in buildings	Solar
National Policy for Alternative Energy	Provides the National Policy for Alternative Energy among other provisions.	Solar, wind, biomass and hydro
Solar Heaters in National Habitation Programs	Provides the mandatory adoption of solar water heating in buildings financed with workers security funds managed by government institutions	Solar
Solar Heaters in Buildings supported by PNH and PAC	Provides the requirement of solar heaters in popular housing financed by Brazilian Habitation Program (PNH) and Brazilian Sharp Growth Program (PAC), and non-residential buildings including government and military buildings	Solar
Alternative Energy for Isolated Systems Program (FAIS), Solar Energy for Water Heating Program (PAES) and Distributed Generations Program (PGD)	Promote the distributed generation and modifies the PROINFA regulation in order to increase the renewable energy share in the Brazilian Energy Matrix.	Mostly solar
Brazilian Program for Solar Heaters—PROSOL	Create and regulate the Brazilian Program for Solar Heaters—PROSOL.	Solar
PL630/03—Renewable Sources of Energy	Provides incentives for energy production from renewable sources and alternative fuels; encourages the development of research related to these energy sources; and establishes the National Fund for Research and Development of Alternative Sources and Renewable Energy.	All kinds of renewable energy sources
PL6311/09—Incentive Program for Development and Exploitation of Alternative Sources of Energy (REINFA)	Provides the incentive program to promote development and exploitation of alternative sources of energy and sets out measures to stimulate the production and consumption of clean energy.	All kinds of renewable energy sources

in energy sector believe in little chance of being voted or approved in a short term.

5. Consultation with stakeholders

A better insight into concerns and barriers to the penetration of solar and wind technologies in the domestic market was assessed through a national consultation with different stakeholders. The consultation sought to reach consensus around some key points concerning how to best gather the necessary information on resource, technology and policy and risk management requirements for expansion of the renewable energy deployment in Brazil. This approach was achieved in two steps: (i) an opinion poll containing 20 assertions addressing major aspects of market regulations, government policies, education, training and technology transfer; and (ii) personal interviews seeking to clarify points raised in the first step.

The opinion poll was sent to several companies, universities and research centers, governmental or non-governmental organizations and associations, all linked directly or indirectly to solar and wind energy. Table 9 lists the content of the feedback form. The respondent was prompted to assign a value between 0 (zero) to 5 (five) for each assertion according to its relevance from the point of view of his company or organization. The value zero (0) means the statement is irrelevant or has no importance whatsoever, and value five (5) is for the most worthy or essential assertions. Contribution to the survey was voluntary and a total of 50 out of 120 questionnaires were completed and returned in due time for analysis.

5.1. Analysis of questionnaire answers

The analysis has followed two approaches based on the scores attributed to each assertion:

1. the evaluation of typical scores for each assertion and their distribution around central values;
2. the evaluation of a worthiness index *(WI)*, calculated for each assertion in the feedback form as the ratio "$WI=(S5-SL2)/(S5+SL2)$", taking in account the frequencies of scores equal to "5" ($S5$) and scores lower or equal to "2" ($SL2$). The $S5$ denotes the frequency of responses indicating the assertion as essential to improve the deployment of solar and wind energy. The $SL2$ stands for the number of consultants that assign the assertion with low or without importance. The WI index ranges from -1 to 1 and not only ranks the importance of the issue raised by each assertion but also provides information on consistency of the answers. The larger the WI index, the higher is the importance of that particular assertion. For instance, the $WI=1$ denotes that no answer with score less than 2 was received for the assertion. The $WI=-1$ means that particular assertion did not receive any score "5" from all of the consultants. The $WI=0.5$ indicates that the frequency of score equal to "5" was threefold larger than the scores lower or equal to "2". In the other way, the $WI=-0.5$ stands for frequency of scores lower or equal to "2" three times larger than the frequency of score equal to "5".

Fig. 5 shows the central scores and the variability of answers attributed for each assertion. The Box and Whiskers plots show the median, maximum and minimum values, and the 25% and 75% percentiles for each assertion. Four plots are presented taking in account all the answers and the three classes that were organized according to the professional area of the interviewee: entrepreneurs, national associations and universities/research institutions.

Based on the median scores and respective variability distribution, one can notice that assertions *(E)* and *(K)* have achieved highest scores with lower variability. The assertions *(A)*, *(D)*, *(L)*, *(N)*, *(O)*, *(Q)* and *(R)* have also achieved the median score that equals ***5***, but with higher variability. The following items received intermediate but still significant scores by the consultation: *(C)*, *(F)*, *(G)*, *(H)*, *(I)*, *(J)*, *(M)* and *(P)*. The assertions *(B)* and *(S)* were attributed the lowest scores. Furthermore, the responses have shown some distinct behaviors between classes of interviewers:

I. *Entrepreneurs:* overall, the scores present uneven distribution, as shown in Fig. 5. This can be explained by the diversity of

Table 9
Key questions addressed by the questionnaire.

(A) **Provide and support new sources of consistent and scientifically based information on the solar and wind energy resources.**
(B) **Evaluate the impacts of the climate changes on the solar and wind energy resources in the medium and long term.**
(C) **Promote new knowledge in the areas of solar and wind energy, based on scientific research and state of the art technology through research consortia with leadership organizations and international networks.**
(D) **Encourage national collaborations between research centers and the industry for the development of solar and wind technologies.**
(E) **Enhance the government policy to promote a broad capacity for training human resources in the areas of solar and wind energy.**
(F) **Create mechanisms, incentives and the necessary support to foster collaborations between research centers and the local industry for the development of national market for solar and wind technologies.**
(G) **Create efficient mechanisms for effective technology transfer in the entire chain of development of solar and wind power through technical and scientific exchange with accredited international research institutes, universities and industries.**
(H) **Perform actions and awareness campaigns to promote the energy efficiency in dwellings and in commercial and industrial buildings.**
(I) **Establish greater incentives and regulations for the promotion and use of solar thermal energy.**
(J) **Perform awareness campaigns in order to demonstrate opportunities and economic advantages of solar thermal energy by residential users, industry and commerce, thus removing the existing natural barrier to new technologies.**
(K) **Improve the government regulations for the electricity generation with intermittent sources (solar and wind).**
(L) **Perform incentives and actions to enhance the domestic market of solar and wind technologies in industrial scale.**
(M) **Promote regularly energy auctions to provide a long-term vision by the market of solar and wind energies and to create confidence amongst investors**
(N) **Establishment of reference values for the price of solar and wind power in order to ensure the economic viability of power plants, and thus, stimulating the market.**
(O) **Facilitate credit lines for the small investor and for the end-users to purchase, install and system maintenance; and guarantee contracts for small private plants for solar energy and wind power generation.**
(P) **Reduce the financial risks associated with investments in renewable energy in order to encourage greater participation of the Brazilian companies of generation and distribution of electricity.**
(Q) **The adoption of renewable solar and wind power could be leveraged through the government fiscal policies and public awareness of their environment benefits.**
(R) **Adoption of tax reduction on equipment and profits of companies operating on renewable technologies for the consolidation of this type of generation.**
(S) **The PROINFA was a successful initiative to develop the national market for wind energy and it is allowing for the advance of national industry geared toward meeting the growing demand.**
(T) **The PROINFA needs to be improved to expand the national wind energy industry and should incorporate other renewable energy resources such as solar.**

professional areas of the interviewees (bankers, industries, developers, etc). Scores for assertions *(B)*, *(J)*, *(L)*, *(M)*, *(O)*, *(S)* and *(T)* present the largest spread, indicating a great diversity of opinions amongst the interviewees. By far, the assertions, which received the lowest scores, are *(B)*, *(J)* and *(S)*. The most important issues pointed out by this category are *(M)*, *(N)*, *(R)* and *(T)*, which have reached a median score of 5 by more than half of the interviews.

II. *National organizations and associations:* answers from this category present the largest overall spread between scores as a result of the small number of responses received (8 answered forms) in this category. The assertions *(H)*, *(I)* and *(M)* present the largest spread also indicating a great diversity of opinions amongst the interviewees. The items with lowest scores are *(B)* and *(S)*. In contrast to the entrepreneur's opinion, assertion *(J)* received a high score.

III. *University and research institutions:* results present a more smooth distribution of scores. Nonetheless, assertions *(M)*, *(N)*, *(P)* and *(S)* exhibit a large spread indicating important diversity of opinions amongst the interviewees. The assertion that achieved the lowest scores was *(S)*.

Fig. 6 depicts the results obtained for analysis of worthiness index obtained for each assertion. According to this survey index the assertions with lowest relevance for the development of solar and wind energies in Brazil are assertions *(B)* and *(S)*. Both assertions have negative worthiness index (Fig. 6a). Analogously, the aspects of chief importance to promote the development of solar and wind energies in Brazil are *(K)*, *(L)* and *(Q)*. Table 10 summarizes the most and the less relevant issues pointed out by analysis of the questionnaire responses.

The plots (b), (c) and (d) in Fig. 6 show the *WI* index for the three categories described earlier. Very distinct profiles are observed in each category. Responses received from associations and national organizations present several assertion with worthiness index equal to one— no responses were equal to or lower than 2 for *(D)*, *(F)*, *(J)*, *(K)*, *(L)*, *(N)*, *(O)*, *(P)*, *(Q)*, *(R)* and *(T)*. More than 90% of responses received from universities or R&D institutes have selected *(H)* and *(L)* as the most relevant assertions. The assertion *(S)* was the only one to obtain a negative worthiness index in R&D category. For entrepreneurs, the assertion *(Q)* is far most important and *(B)* is the most worthless one.

In addition to the responses for the feedback form, a more personal assessment was made through interviews conducted by telephone, e-mails and professional meetings with stakeholders in government offices, universities, private companies and NGO's. Some of these interviews have basically addressed the same key points and aspects already unveiled by the earlier analysis. Among these aspects, it is worth to mention the requirement for increasing national investments in scientific and technological development. Tables 11–14 present the most frequent viewpoints mentioned in these personal interviews adding important information to the results presented before. The key issues were arranged in groups to improve understanding: *Scientific and Technologic Development; Fiscal Incentives, Regulation of Energy Sector* and *Social Actions*.

6. Conclusions

Although solar and wind energy technologies have an enormous potential in Brazil, significant barriers and market failures slow down the transition to a more solar and wind economy. These barriers are chiefly in lack of reliable information, have larger costs as compared to more conventional energy sources such as hydro, meager infrastructure, lack of national expertise and human resources and unclear regulations concerning administration, technical and legal issues.

This work presented the most recent products, government policies and incentives relevant to the solar and wind energy deployment by entrepreneurs, industry and commercial and residential consumers. In addition a national survey was conducted in an attempt to address the reasons behind the hitherto slow transition toward a larger deployment of solar and wind energy resources, and how to best gather the requirements on support policies and information technologies.

The evaluation of the survey responses was made by defining scores for each assertion, and a worthiness index *(WI)* calculated for each assertion in the feedback questionnaire ranked the importance and consistency of each assertion. The *WI* also

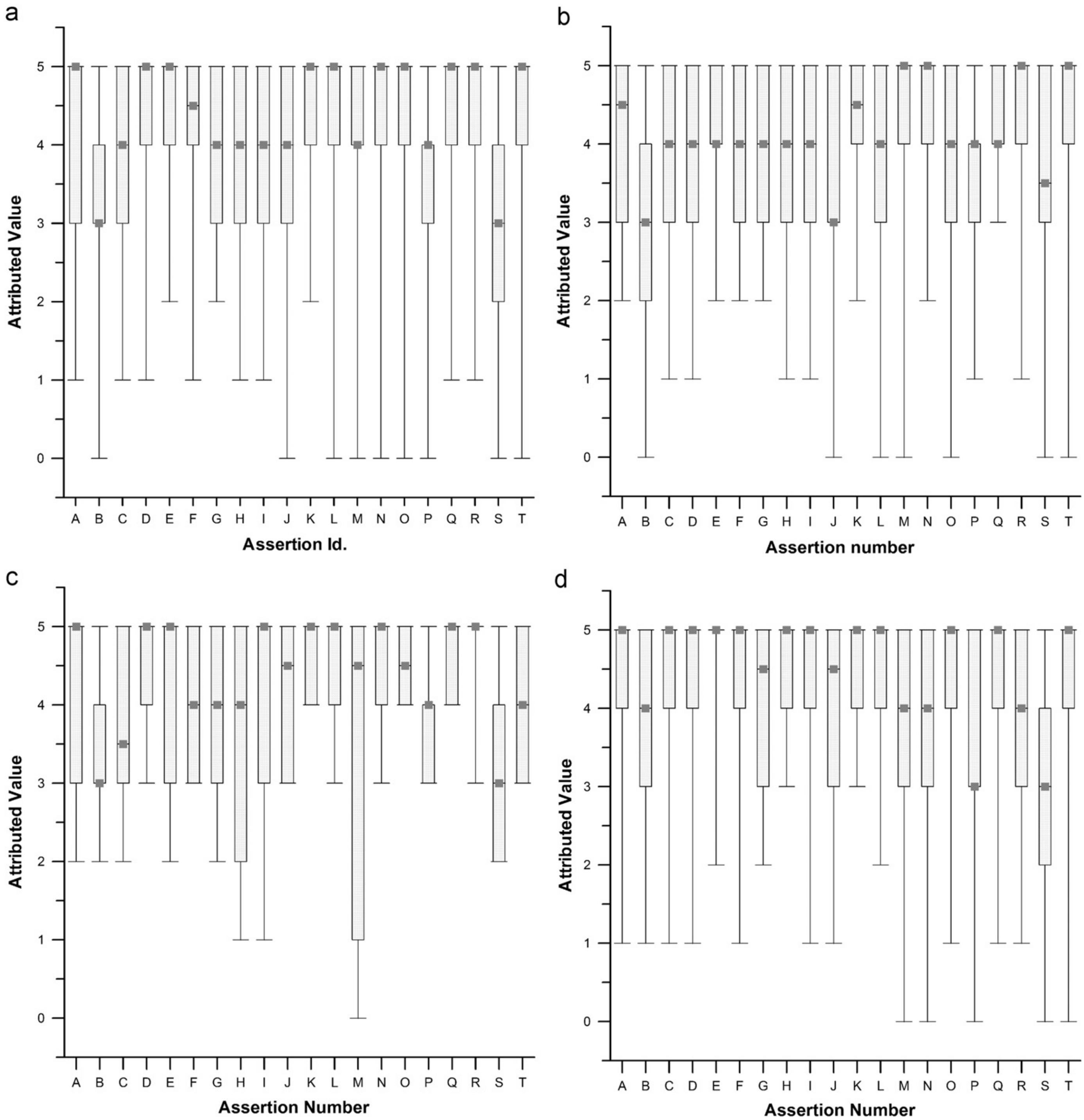

Fig. 5. Box and whiskers plots describing the distribution of values attributed for each assertion taking into account all forms received back (a); only the answers from entrepreneurs (b); the answers from national organizations and associations (c) and responses from universities and research institutes (d).

allowed the identification of the main gaps and outlined the possible actions to boost investments in solar and wind technologies in Brazil.

The survey has shown that the key issues to meet this goal lie mainly on domestic efforts to upgrade the existing government regulations for renewable sources, in addition to promoting better incentives and supportive programs, allied to public awareness. Developing national solar and wind technology require large initial investments both to build infrastructure as well as to develop the essential technological knowledge and human resources. It is necessary to create the scale economy through incentives for the national industry. These investments increase the cost of providing solar and wind electricity, chiefly during early years.

Several specific points were addressed by the stakeholders, some of them biased by the source of information. From the technical–scientific point of view it is quite important to increase capacity building of human resources throughout the chain of

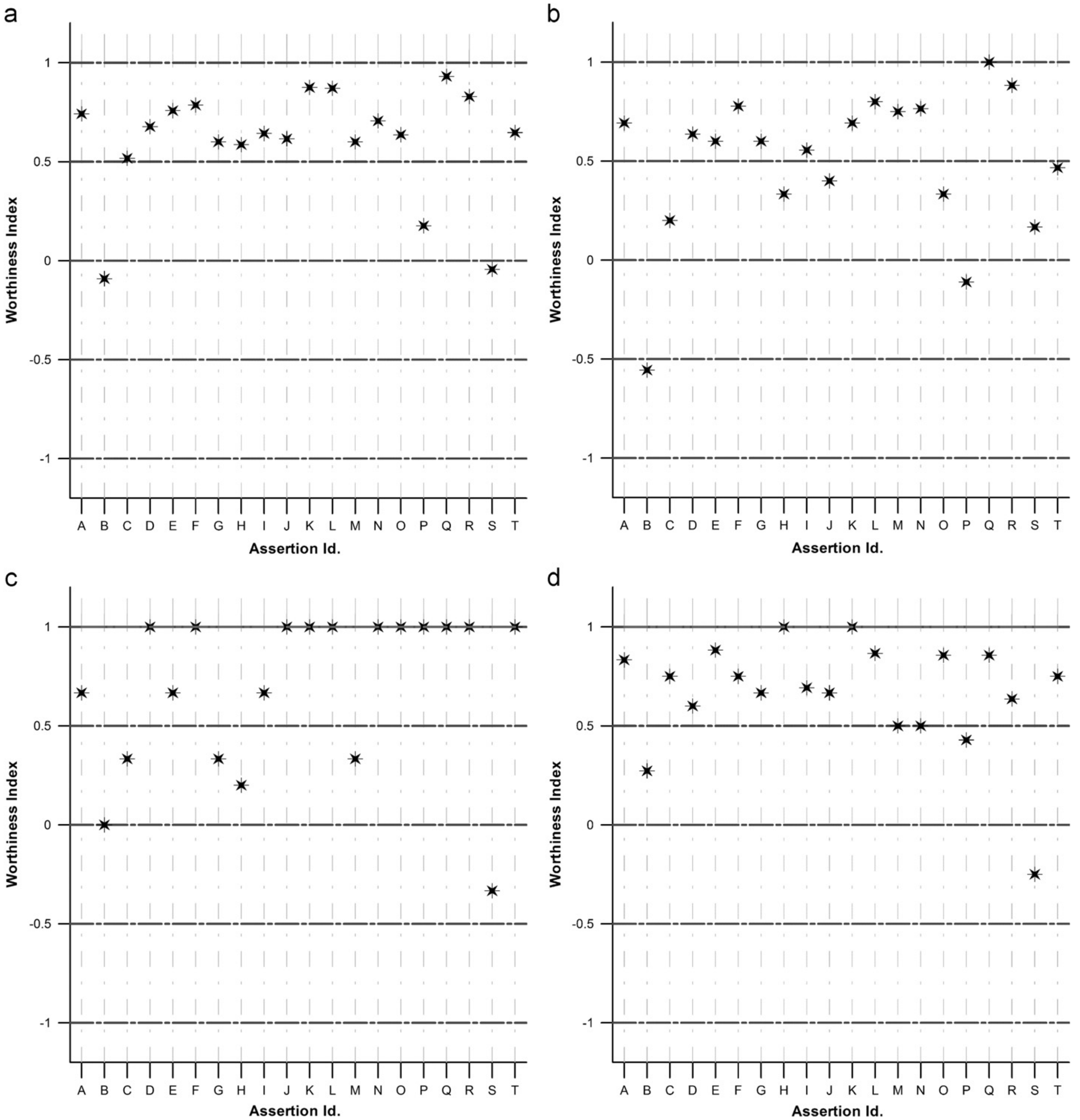

Fig. 6. (a) Worthiness index (WI) for each assertion taking into account all responses received; (b) *WI* taking into account responses received from entrepreneurs; (c) *WI* for responses received from national associations and organizations; and (d) *WI* obtained for universities or R&D institutes.

knowledge: from the scientific research on solar and wind energy resource assessment, data acquisition and analysis to the technology for electricity generation in distributed systems. The scientific community also pointed out the need for a better understanding of surface topography and microclimate impacts on the variability of solar and wind resource, mainly in some specific areas where the power density is larger. Without reliable resource information, potential investors tend to avoid the risk related to the wind or solar project development. Mainstream investors, venture capital firms and independent power producers are not aware of viable renewable options.

From the entrepreneur point of view, several incentive programs must be devised on the municipal, state and federal levels to facilitate the new projects development. Two issues were indicated as the highest priority: defining a reference value for the price of solar and wind energies allied with tax reductions and exemptions on equipment and profits of companies operating on these renewable technologies.

Table 10
The aspects pointed out as essential and not important for development of solar and wind energy in Brazil.

Id.	Assertion	Worthiness index
Assertions pointed out as of lowest relevance		
B	Evaluation of the impacts of the climate changes on the solar and wind energy resources in the medium and long term.	−0.09
S	The PROINFA was a successful initiative to develop the national market for wind energy and it is allowing for the advance of national industry geared toward meeting the growing demand.	−0.04
Assertions pointed out as of highest relevance		
Q	The adoption of renewable solar and wind power could be leveraged through the government fiscal policies and public awareness of their environment benefits.	0.93
K	Improvement of government regulations for the electricity generation with intermittent sources (solar and wind).	0.88
L	Incentives and actions to enhance the domestic market of solar and wind technologies in industrial scale.	0.87

Table 11
The scientific and technologic issues.

Issue 1	Organize an advisory panel at the Ministry of Science and Technology devoted to human resources building for the solar and wind energy area. This panel should be composed exclusively of highly qualified and recognized experts.
Issue 2	Increase the national capacity building of human resources at various levels of demand involving the whole chain of knowledge: from scientific development to the technology application of solar and wind energy.
Issue 3	Foster and organize a Brazilian inter-institutional cooperative network of R&T&I for solar and wind power with the immediate goal of bringing together the available expertise and the laboratories.
Issue 4	Support and endorse Brazilian research institutes to achieve scientific and technological self-competence, for example, through the development of numerical models to estimate the wind and solar power resources.
Issue 5	Promote public announcements of opportunities by national agencies, such as CNPq, for supporting research, new projects and programs to leverage the development of R&T&I and for training researchers within and outside the cooperative network proposed in the previous issue.
Issue 6	Reduce the excessive bureaucratic and legal barriers that hamper synergy and decrease scientific dissemination between research institutes, universities and private enterprise.
Issue 7	Organize a technical–scientific committee aiming at devising industrial policies for wind and solar power. This committee should include members of the industry and skilled professionals of the electricity sector.
Issue 8	Promote international partnerships for technological transfer in order to reduce the current dependence on imported black-box models for solar and wind energy resource assessment.
Issue 9	Revise and adapt for specific environmental conditions prevailing in tropical regions like Brazil, the high performance numerical models for the wind and solar energy assessment developed for high-latitude regions like Europe and North America.
Issue 10	Increase investments in spreading out the national infrastructure for high-quality data acquisition of solar and wind resources to contribute in model development as well as to provide more consistent energy resource assessments.
Issue 11	Promote development of national technologies to replace fossil fuels and other conventional energy resources for electricity generation and public transportation and cargo.

Table 12
Fiscal Incentives issues.

Issue 1	Provide tax exemption on the commercialization of solar heaters for small businesses in order to ensure the same benefit offered to the large companies.
Issue 2	Provide tax exemption or reduction for leveraging the energy supply chain as proposed in the government law projects PL630/2003 and PLS311/2009.

Table 13
Energy market regulation issues.

Issue 1	Promote wind energy auctions at a regular annual basis, with biddings for installed capacity of at least 1 GW/year for a minimum grant period of 10 years, which is an appropriate time period for the development and upholding the Brazilian energy market in healthy competition environment.
Issue 2	Establish an index for technology nationalization around 60% of values of products and services in power plants, with increments every 2 years in order to stimulate the development of the Brazilian industry and to maintain the investment rate in new technologies and to stimulate new jobs.
Issue 3	Establish suitable regulations for connecting PV systems to the electricity grid and for trading this energy.
Issue 4	Create guidelines to regulate the technology transfer from developed countries in order to avoid technologies no longer used in the countries of origin due to its inefficiency.
Issue 5	Create regulatory framework for generation, transmission and distribution of solar and wind power in order to guarantee: (1) the minimal security and transparency so as to encourage new investments, and (2) the adequate technical evaluation of projects submitted to energy auctions.
Issue 6	Establish tangible goals when devising and implementing incentives programs and policies for promotion of renewable energy taking into account that: (1) financial incentives should be long enough to create confidence by the investor, and (2) the coverage should be large enough to produce an economy of scale, but small as much as necessary to minimize the tariff impact.
Issue 7	Regulate the "smart grid" concept in order to decentralize the distribution system.
Issue 8	Create an incentive tax for setting up industries and factories in Brazil and for financing equipments purchase not available in the Brazilian market.
Issue 9	Establish a fee award in order to facilitate the development of Brazilian industry for electronic devices in PV systems.
Issue 10	Provide government guarantees for the purchase of energy produced by the private entrepreneurs with a financial value that allows the implementation new plants.
Issue 11	Regulate the distributive power generation in order to meet the demands of the vast Brazilian territory, mainly in remote areas, where government investments are not feasible.

Table 14
Social actions issues.

Issue 1	Break the psychological barrier for new technologies by promoting awareness campaigns focusing the final consumers (residential, industrial and commercial). The campaigns should promote the benefits and feasibility for renewable energy applications and prospects for cost reduction.
Issue 2	Employ policy actions to meet social, educational and environmental issues and provide solar harvesting devices for low-income populations.
Issue 3	Set up more effective marketing campaigns to change habits of consumption and waste disposal.
Issue 4	Organize popular workshops and short courses on low cost power devices manufactured with recycled materials.

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