Regulatory Framework for Interconnection of Costumer-Generators and its Barriers: A case study on PV

Author:
Mateo Sotomayor

To:
Agência de Cooperação
Técnica Alemã – GIZ
Deutsche Gesellschaft für
Technische Zusammenarbeit (GIZ) GmbH

May 2011

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Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Brazilian-German
Energy Program

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Author: Mateo Sotomayor

Developed for: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

Program: Brazilian-German Energy Program

Program No.: PN 2009.9053.1-001.00

Coordination: Dr. Johannes Kissel

May 2011

Executive Summary

The installation and operation of costumer generators in Brazil is possible without any restriction as long no (unauthorized) electricity is injected the distribution grid. In the case of electricity injection of costumer generators the achievement of authorization by following the official proceedings is too complex.

The missing regulatory incorporation of distributed generation respective costumer generation is the fundamental barrier for its diffusion. Especially small PV generators are regarded neither by regulation nor by distribution utilities. The definition of DG applies for industrial generators with a high own consumption rather than for costumer-generators. These industrial generators may act as IPs or OCs, but for costumer generation this would be a far to complex task. The complicated regulation and according to Filho (2005) the different norms between the different distribution utilities makes diffusion of costumer generators difficult (cf. Starrs (2002)).

To make the electricity injection practicable and legal, the restrictions in the regulatory framework can be adjusted towards costumer-generation. One option would be a net-metering or net billing for an adjusted form of OCs or the introduction of a new legal entity – the small DG. This opens the possibility of different compensation methods for consumer-generators as Net-Metering, Net-Billing. A feed-in tariff as it exists in Germany and as experts in Brazil demand it would be achievable under the adjustment of the regulations of IPs and might be harder to achieve.

Further a simplification of the connection procedure for costumer-generation is recommended. An elaboration of a separate standard for the interconnection procedure for costumer generators in the Prodist is conceivable. This should happen by ANEEL in collaboration with all participating stakeholders.

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1. Introduction

„Grid connected photovoltaic in Brazil, not in a hundred years“, might be the critical statement of experts regarding the historical development of the photovoltaic market in Brazil. This statement might be surprising in the light of Brazils sunny perspectives mentioned in the literature (cf. Dhere et al.) as well suited for grid connected PV due to the availability of solar resources and its possible contribution to reduce the load in the metropolises (cf. Martins et al., 2008). But reality of PV development looks more far cloudy in Brazil than in other transition economies as China or India. Although the electricity generation costs of photovoltaic systems are close to Brazils regulated costumer tariffs and due to the prognosis that grid parity would be reached with-in a few years (cf. Salamoni, 2009), the governmental energy planning agency EPE does not consider PV as a option for future energy generation in its ten years ahead planning report (PDE, 2010).

Context of discovery and explanatory statement of the research

Besides the commonly stated arguments in the literature explaining the absence of grid connected PV in the Brazilian energy matrix with deficient economical competitiveness, as well other barriers for market diffusion of PV must be identified and documented for a successful implementation of PV in the Brazilian energy matrix. The difficulties of the market penetration of PV experienced in the United States (cf. Margolis, Zuboy, 2006; Alderfer et al., 2000; Dymond, 2002; Sepa, 2004; Goldman et al., 2005) lead to the question weather similar difficulties could happen in Brazil and might hinder its penetration there. For initiate developments of a Brazilian PV market the already existing restrictions as technical barriers or as barriers through business practices have to disappear. To ensure a smoothly diffusion of PV these restrictions must a) be identified b) systematically reduced.

Respective the request of various stakeholders for a regulatory framework for distributed generation (DG) legitimates the research on barriers of interconnection of costumer-generator, especially PV and the explanations of the actual proceeding pathway to connect to the grid. The explanation of the current interconnection procedure makes it transparent and applicable to everybody who wants to connect costumer-generators to the grid. Its identification may result in the development of a new barrier-free regulatory framework.

The report explains the status quo of the proceedings in costumer-generation projects identifying the existing interconnection barriers resulting from regulatory obstacles in Brazil with the objective of the deduction of recommendations to reduce the existing barriers. Results of the report are:

- The historical and actual development of PV in Brazil
- An overview of the actual regulatory framework, existing rules and proceedings for interconnection of DG – respective costumer-generation with the example PV
- An analysis of the existing barriers for interconnection of costumer-generators, especially PV and recommendations for its overcoming
- Recommendations how to interconnect despite the interconnection barriers and advice on incentive schemes within the legal framework

The following report can be used in addition to Filho (2010) “Survey of the electricity market focusing on distributed generation” for GIZ.

Methodology

Following report inquired different kind of data with different approaches. On the one hand the explicit data on the barriers of interconnection for a costumer-generators with the grid has been identified though analysis of the legal framework of DG; on the other hand the technical interconnection data and interconnection experiences of the individual PV systems had been collected.

For the identification of interconnection barriers of costumer generators the framework by Painuly (2001) is applied. According to Painuly (2001) the first step is the detection of a technology, which might have the potential for penetration in a certain country – in this case PV. After that, it is to name the barriers and measures to overcome the detected barriers for the chosen technology. This is carried out by literature review, research on the current legal framework, site visits and expert interviews with involved stakeholders. In this report, case studies on already existing applications makes real existing barriers visible, semi-structured expert interviews are used to obtain as well possible interconnection barriers for PV.

Generally, the identification of interconnection barriers was done by the following approaches:

1. Literature review: Literature on barriers in general and especially in the US, on grid connected distribution projects in Brazil and on the actual legislation was appraised. The current legal framework for electricity generation was analyzed for the case of costumer-generation.

2. Case studies: Site visits in different regions in Brazil gave the opportunity to study the subjects closely.

3. Interviews with stakeholders: Semi structured expert interviews were hold personally. Experts contacted have been technical consultants, NGOs, representatives of research and professional associations. This approach may be the most crucial for the "identification of the barriers as the perception of stakeholders on barriers may reveal the lacunae in existing policies and help in identification of measures to overcome the barriers." (Painuly, 2001, p.78)

In this qualitative research design case studies and interviews in the above-described mixed approach are an essential part of the data collection. The used methods are presented completely for an inter-subjective understanding. Therefore the following clause explicates among others the case study as qualitative research technique, the interview as inquiry method, the choice of experts, the analysis and their verification.

Choice of the research design

The choice of a qualitative or quantitative research design is essential for data generation. Different indicators adumbrate different types of barriers in Brazil. This report proves barriers for the interconnection by empirical investigation. By the observation of individual cases its existence is proved inductively. The open and flexible approach of qualitative research helps to identify and analyze authentically the research object and make the way for information which “might be get lost in a quantitative approach because it standardization” (Mayer, 2008, p.25). The small quantity of cases (connected systems) is not enough to provide a significant critical mass for a quantitative design. The nature of the research case - with the characteristics of individual cases and its information spread to little amount of people - makes the case study an adequate research strategy.

Qualitative Technique: Case study

The multiple-case study is identified as an adequate qualitative research technique referring the research questions. Its linear-analytic structure fulfils the exploratory, descriptive and explanatory purpose (YIN, 2003, p. 152) of this research case.

Inquiry Method: Expert Interviews

The method chosen to inquire the data is the problem-centered interview according to Mayring (1999). The interview is conducted in an open and semi-standardized form. “Open” means the interviewee is free to formulate his own answer to a question (Mayring, 1999, p.50). “Semi-standardized” means that no mandatory survey form exists and that it is possible to adjust the questions depending on the situation in the interview (Mayring, 1999, p.50). A semi-standardized interview allows comparison with other interviews while ensuring the focus on the research question and leaving the freedom to animate experts to open their unconscious knowledge (cf. Franz and Kopp, 2004).

As described in Mayring (1999, p.53) five stages were followed to conduct the problem centered expert interview:

1. Problem analysis
2. Construction of the survey form
3. Test stage
4. Conducting Interview
5. Recording the interview

Problem analysis, construction of the survey form and test stage

Before creating the interview guideline and conducting the interviews the comprehensive topic was researched profoundly. Based on the background of the literature survey an interview guideline was developed with special attention to Hopf (1978) theory on guideline development. The interview guideline is attached in ANNEX A. To raise the quality of the interview by sharpening the technique and modifying the questions, test interviews were conducted before conducting the interviews with the experts.

Identification of the case studies and interviewees

First step was the identification of existing grid connected PV applications, which would be representative as subjects for the case studies. In this step as well the representatives, who have been responsible for the installation and grid connection of the PV application could be identified. As there is just a small amount of even smaller PVS in Brazil the contacted person was often project owner and project developer or even equipment manufacturer the same time. All observed projects have been already in operation except two, which was shut down and was still in the process of negotiation phase with the utility.

For the 42 operating PVS in Brazil – accumulating 230 kW installed capacity - 19 experts and representatives could be identified, while 11 could be contacted and interviewed – responsible for 23 installations accumulating 150 kW. The identified PV systems range from a capacity of 0,6 to 30 kW. The cases chosen consists already operating PV systems. For 4 systems the identification of the responsible expert was not possible. For further objectivity five interviews with representatives from the regulatory agency, distribution utility, NGOs were conducted on the status of interconnection. All in all the interviewees represented by researchers, private companies, regulatory agency, distribution utility and NGOs.

The first contact with the potential interviewees was by email. To dispel eventual misunderstandings due to language barriers, the interviewees were informed of the procedures and content of the interview by email.

Conducting the expert interviews

Where it was possible the interview was taken place within a personal meeting. Otherwise the interview was conducted by phone. This allows in case of misunderstandings in the ex post need of a more specific details to contact the interviewee again easily because of the personal contact with the interviewee. As described in Helmke (2009) the expert interviews were conducted in the mother tongue of the interviewee, not at least as a gesture of politeness but because of the consideration that the interviewee may concentrate better on the content of his answer.

At the beginning of the interviews the context of the interview was described and its focus was underlined. In the run-up of the interview the interview settings with the partners were defined. An exploratory question was used to stimulate the interview by asking simple questions on the procedure in of the specific project in general. In this orientation phase both the interviewer as well the interviewee has the possibility to orientate and get into the topic. The interview guideline was used in a flexible way where it was necessary to conduct/orientate the interview, for example to stimulate the interviewee if the information flow was interrupted and to detail information or to complete it. With the developing results of the interview additional Ad-hoc questions could be raised and entered. These questions were added in the following interviews, when it was necessary. For the transcription a digital recorder was used recording the interview. In the centre of interest was just the content of the interview. Narrative elements of style were not taken into account in the interpretation or analysis

Processing the survey data

According to Mayring (1999, p. 73) the processing and solidification of the interview data is done by transcription through summarized minutes. The basis of the summarization is to raise the content into a higher abstraction level for reducing the material for focus on the content of the interview.

Analysis method

The reports main purpose is not to portray each single case. Rather, the report synthesizes lessons from the different cases and is organized around the barriers of interconnection to cross case analyze them.

Construction of descriptive systems

For the analysis of the interview the method qualitative content analysis according to Mayring (Mayring, 1999, S.9; Flick, 2009, p. 468) is applied. The validity and reliability of the information of this interpretative approach are underlined by selected citation in the minutes, known as selective plausibility (Flick, 1999, p. 239). However, the transcripts of the minutes can be found in the ANNEX B.

Verification

For verification of the right transcription of the interview the minute was send to the interviewee to cross check it. For verification of each interview on “operator” side the interconnection utility should have been contacted and interviewed as well to the proceedings. But the research detected that most of the installed PV systems had been connected without knowledge of the utility.

2. Historical development of PV in Brazil

In the end of the seventies the first Photovoltaic systems appeared in Brazil. Its usage was primary for telecommunication purpose (Fabiana, 2009). From the beginning of the eighties PVS extended in the area of water pumping and solar water heating (MME, 2009).

With the company Heliodinâmica a first mover on the PV market pushed for the start of a solar energy industry in Brazil. The company began the production of silicon ingots with the Czochralski method (Fabiana, 2009) providing the main pre-product for integrated circuits and PV wafers. Protected by the "Lei da informatica" – a law for building up Brazils IT industry – the company was able to develop PV applications despite the international competitive markets (Tolmasquim, 2003). In the mid of the 80s the company held about 100 employees and a production capacity of 1 MWp per year (Fabiana, 2009). At this time the company produced wafers, solar cells, solar modules and other components for rural electrification as DC motors and pumping systems for export to industrial and as well to developing countries.

But with abolishing the protectionism and market opening in 1992 foreign companies were starting to compete successfully and squeezed Brazilian PV equipment suppliers out of the market (MME, 2009).

In 1994 PRODEEM, (Programa de Desenvolvimento Energético de Estados e Municípios) a program to provide electricity to isolated communities was introduced. Within this program 5,2 MW_p were installed in about 7000 off-grid communities (Ruiz et al., 2007). Unfortunately its implementation was deficient to meet its goals. With its execution by international public bid it failed to develop an own PV industry because of the import of all equipment (Ruiz et al., 2007). It also failed in proving basic electricity needs, job creation, and distribution of renewable energies to the communities because of inadequate training on O&M and poor quality of installation. All in all it just full field 18 % of all systems planned originally.

In 2003 the MME overhauled PRODEEM with and training and revitalization plan (Ruiz et al., 2007) and in 2005 it was incorporated in the “Light for all” Program (Luz para Tudos). Its objective is to supply every household in Brazil with electricity at its minimum costs. With the goal to electrify 10 million till 2008 the program was extended till the end of 2011 and exceeds currently the original goal by 3,7 Mio people. An evaluation of this program is still under process. But according to Filho (2005, p 77) The utility companies shall provide electricity access to every household in Brazil till 2015.

To meet the technical requirements for electrification with PVS within “Light for all” the INMETRO (Brazilian Institute for Metrology, Standardization and Industrial Quality) set a voluntary labeling scheme for PV equipment and systems in 2003 into force (IEA, 2010). At the moment international equipment suppliers are dominating the Brazilian PV market. There are just manufactures of inverters on national market, which are not competitive.

R&D of solar energy in Brazil has a quite long history, especially solar thermal applications. Driven by the oil crisis (MME, 2009) and ambitious goals of space and military programs Brazil started its research within international research cooperation in the 70s. At the moment the Instituto Militar de Engenharia, the Centro de Pesquisas e Desenvolvimento da PETROBRAS and the Brazilian Centre for Development are researching in the development of new solar cell structures. The Brazilian Centre for Development of Solar PV Energy (CB-Solar) was created at the Univeristity Pontifícia Universidade do Rio Grande do Sul (PUC-RS) with support from public institutions in 2004. It is the biggest and most modern PV laboratory in Latin America develops energy novel conversion structures of PV, its large-scale fabrication and training of human resources. Having in mind that the State of Minas is currently responsible for 24% of all the worldwide production of MG-Si (Dhere, et al.) and Brazils reserves in $SI\text{-}O_2$ are the biggest in the world (Moehrike, 200X) the CB-Solar is working at a proceeding for the a production line for solar for 2013 (Solarserver, 2011). The interconnection of PVS with the grid is still in the experimental stage (Fabiana,

2009) and mostly Universities and utility companies are researching in its compatibility to the Brazilian environment.

3. Regulatory framework for interconnection of decentralized generation (DG)

This chapter drafts the common legal framework for access of power generation systems to the distribution grid. Costumer-generation does not play an individual role in the Brazilian legislation. Therefore the aim of this chapter is to outline the current legislation regarding costumer-generation. This is done according to Benedito (2009). The following analysis shows the effects of the current legislation for costumer-generation and distributed generation in general. Finally methods within the law are conducted to bring a costumer-generation system legally on-grid. Of course the same framework could be applied for other forms of distributed generation respective costumer generation other than PV.

PV in the legal context

In the Brazilian law the theological reduction is common and the current legislation often differentiates between the diverse forms of electricity production. But it does not pay special attention on electricity production by costumer-generation or other distributed generation systems. Within the theological context the use of analogies makes it possible to classify costumer-generation in the general legal framework, which is regulating the production, transmission, distribution and commercialization of electricity in Brazils electrical system. In the following table the applicable laws on the different forms of distributed electricity generation are presented.

Table 1 Legal Framework touching electricity generation with distributed generation

Name	Object
Lei Federal N° 9.074	Among other, it establishes rules for the granting of concessions and permits for public services. Defines the independent electricity producer and its costumers.
Dectreto Federal	Defines the independent electricity producer and the autonomous producer. Among other things, it regulates the production of electricity by independent

N° 2.003	producers and auto-producers.
Resolução ANEEL N° 281	Establishes the general conditions to access the electricity transmission and distribution systems including its use and connection.
Lei Federal N° 10.848	Among other, it directs the commercialization of electricity and amends other Acts.
Resolução ANEEL N° 390	Among other, it establishes the requirements for granting permission to explore and repower thermal power plants and other alternative sources of energy and for the process of registration of power plants with small capacity.
Decreto Federal Nº 5.163	Among other, it regulates the commercialization of electricity, the process of granting concessions and authorizations to generate electricity
Resolução Normativa Nº 77 & Lei Federal N° 10.762,	Constitutes the procedures related to the reduction of the transmission and distribution fees for the use of electrical systems for hydro plants and for those using solar power, wind, biomass cogeneration or comparable, with installed capacity less than or equal to 30,000 kW.

In the following the content of the different laws touching distributed generation are presented and the relevance of the legal framework respective costumer-generation is discussed.

Power Producers in the legal Framework

For grid connected electricity production the Brazilian legal framework differs between two types of power producers:

- Produtor Independente de Energia (Independent Power Producer - IP)
  The independent Power Producer is described as bodies cooperate or a consortium of companies holding a concession or authorization to produce electricity for its sale on own risk.

- Auto-Produtor (Own consumer - OC)

  The Decreto Federal N° 2.003/96 defines the Autonomous Power Producer as bodies cooperate or natural person or a consortium of companies holding a concession or authorization to produce electricity exclusively for its own consumption.

Both definitions are as well given in the Lei Federal N° 9.074/95 and Decreto Federal N° 2.003/96. Especially Decreto Federal N° 2.003/96 clarifies the conditions for authorization and licensing as well as the unrestricted access to the transmission and distribution grid for OCs and IPs.

The Registration as a Power Producer at ANEEL

Besides Decreto Federal N° 2.003/96 that refers to hydro and thermal power generators the proceeding for the concession, permission, authorization or registration of power generators for renewable energies is directed by the Resolução ANEEL n° 390/09. It excludes hydro and wind but as well as thermal power plants. This Resolução replaced the Resolução ANEEL N° 112/1999 and applies as well to IPs and OCs.

According to the Resolução 390/09 an authorization is just need for plants bigger than 5 MW while the installation of a plant inferior 5 MW just has to be registered at ANEEL. If excess electricity should be commercialized or injected to the grid – an authorization for commercialization as an OC applies due to article 26 of the law 9427/96.

To register the system at ANEEL the forms for registration (*formulario de registro*) and an environmental licensing has to be presented according to Art. 19 §1. The registration form pays special attention on the technical characteristics of the customer-generation system. A sample of the form can be found in the ANNEX C. According to Art. 21 all technical requirements have to be proved and signed by the responsible engineer registered at the council of architecture and agronomy (*Conselho Regional de Arquitetura e Agronomia – CREA*). For registered plants inferior than 5 MW Article 20 assures the commercialization and the free access to the transmission and distribution grid. Article 24 refers to the grid interconnection procedure (*Procedimentos de distribu*ção *- Prodist*).

Procedure for access

The laws 9.074/1995 and Decreto 2003/1996 guarantee the access and use of the transmission and distribution grid (T&D grid) to IPs and OCs. For systems only registered at ANEEL Resolução 390/09 takes effect. For the access to the distribution grid all the present resolutions by ANEEL, the technical norms by the Brazilian Association for technical norms (Associação Brasiliera de Normas Tecnicas – *ABNT*) and the *Prodist* as well as the standards of the accessed distribution utility have to be applied (Prodist 2010, p. 7).

Resolução 281/1999 gives the stipulation of interconnection and the use of the T&D grid. It defines the mutual responsibilities of T&D utilities and the power generating costumers and ends with the conclusion of the contract for the use of the distribution grid (*Contrato de Uso do Sistema de Distribuição* – cf. ANEEL RESOLUÇÃO Nº 281/99 Art. 10 § 2). The responsibilities of the T&D utilities are:

I – Delivery of all necessary information to the costumer to connect the utility on its installations

II – Provision of measurements to enable the access to its grid

III – Execution of the connection contracts and the contracts for the use of the system with the costumers

IV – Execution of the measurement on the connection points of the systems and charge the costs for interconnection and use of its system.

The responsibilities of the costumer-generator are explained in article 6 of the same Resolução. To request the connection to the grid from a utility the costumer-generator has to provide the utility with all the information needed for the technical assessment. This includes the conduction of necessary studies, measurements and installations for the connection at the access point and its use as well as the contractual agreements between the parties.

For the execution of the grid access both parties has to apply the Proceedings for Distribution of Electricity (Procedimentos de Distribuição de Energia Electrca no Sistema Eletrico Nacional – PRODIST). The PRODIST is a body of rules for the proceedings to interconnect the distribution grid. It defines proceedings, rules and standards for all parties that want to connect to the distribution grid. It establishes the technical requirements and conditions for connecting and operating on the distribution grid as well the explanation how to connect to the distribution grid.

The proceeding to access the distribution grid with any kind of generation system consists of four steps. For generators that only need to register at ANEEL, just the second two steps are mandatory (Prodist 2010, p.8):

1. *Consultation for access* (consulta) to the grid should be done to gain technical information that might support relevant studies on the access points.
2. *Information for access (informa*ção*)* and a formal response by the distribution utility on the consultation for access is obligatory and has to be presented with in sixty days.
3. *Request for access (solicita*ção *de acesso)* to the distribution grid.
4. *Technical report for access (parecer de acesso)* through the distribution utility within a deadline that consists all the conditions and the technical requirements for the connection and use of the distribution grid.

In the *request for access*, the costumer should elaborate a detailed description of the project, with all foreseen equipment at the connection point (Benedito 2010, p.90). Depending on the kind of installation it contains the concessionary contract (*contrato de concessão),* the authorization form or the register form. Further the modality of the installation for the connection including its datasheets, localization, physical arrangement, diagrams and metering element are forming part.

The utility may verify the documents of the costumer and demand formally additional information and studies from him within 30 days after receiving the request for access In this case the utility has to deliver the necessary information for the request within its responsibility. The costumer has to present the results within 60 days after the receiving the formal request. Else wise the request for access loses effect. (Prodist 2010b, p. 12).

The next process step is the *technical report for access* to the grid. It is handled in charge free by the distributer. In general it shall incorporate the necessary actions the costumer has to take, define the point of access and its estimated costs and the justification for the action, the characteristics of the grid and the access point, the definition of the necessary execution of construction work with its responsibility assignment, the financial participation, the contract models, the user fee, the responsibilities of the costumer, the information on actions that may harm the generation system and the impacts on the grid.

The technical report is to handle within 30 days after the receipt of the request for access (see Figure 1), if no additional retrofitting on the distribution grid is necessary. If the utility demands for an additional study/information or/and retrofitting the deadline for the technical report is within 120 days. The necessary contracts between the utility and the costumes shall be closed within 90 days after the emission of the technical report else wise its conditions are annulled (compare Figure 1). (Prodist 2010b, p.14)

More detailed data on the duties within the access proceeding is given in the Prodist especially in Molulo 3.

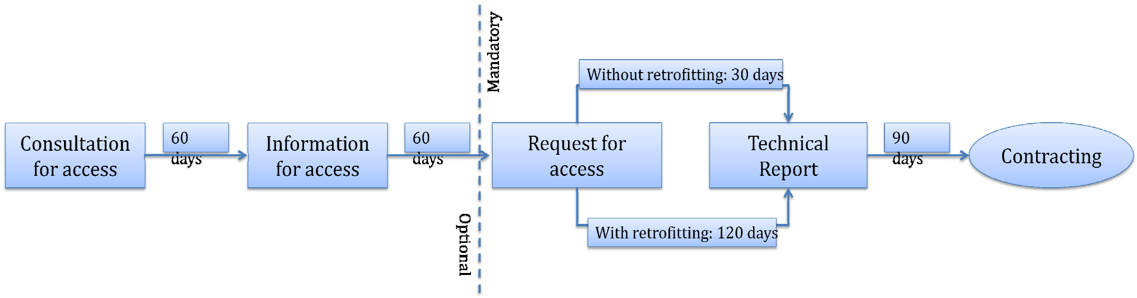

Figure 1: Obligatory proceeding steps to access the distribution grid

Technical regulations

For the classification of the generation system regarding the requirements for the access the module 3 of Prodist gives the framework (see Table 2).

Table 2: Voltage level of the grid against electric capacity as in Prodist

Installed capacity	Voltage level	Nominal voltage	Phase
x < 10 kW	Low	254 / 127 V or 440 / 220 V	Single-phase
10 kW < x < 500 kW	Low	220 / 127 V or 380 / 220 V	Three-phase
76 kW < x < 30 MW	Mid	13,8 kV or 34,5 kV	Three-phase
501 < x > 30 MW	High	69 kV or 138 kV	Three-phase

For alternate current the voltage should not exceed ± 5 % of the voltage level (ANEEL Resolução nº 505). Further the established limiting values (cf. Filho, 2003) for flicker, direct current injection, power factor has to be fulfilled.

Till now just two utilities have developed technical standards for the interconnection of generators at the low voltage level As there is no official technical standard for the installation of the PVS the electrical installation follows the technical standard for electrical installations ABNT NBR 5410.

4. Analysis of the legal framework respective costumer generation – Barriers and Opportunities

The following chapters underline the strength, weakness and the opportunities of the current legal framework towards costumer-generation and DG.

The definition of DG and costumer-generation

Analysis

The general definition of distributed generation is the grid connected electricity supply next to its demand, regardless of its source (Rodriguez, 2002). In Brazil the term distributed generation or decentralized generation is quite new in the legislation appearing the first time the law 10.848 from 2004 (Filho, 2005). But it is used differently depending on the law:

The Decreto n° 5.163 consider distributed generation as the electricity production from hydroelectric with an installed capacity smaller or equal to 30 MW_{el}, biomass, waste and fossil cogeneration plants with an overall efficiency of 75 %. In this definition electricity from wind and photovoltaic are excluded from being distributed generation. In contrast the PRODIST (2010) defines it as any kind of generator of any capacity that are directly connected to the distribution grid or directly to the consumer in parallel or isolated operation.

The term customer-generation appears in the Brazilian law in Resolução Normativa n 83/2004. It applies for the program “Luz para Tudos”. There the costumer generation is only subject to distribution utilities.

Conclusion

The definition of distributed generation given in PRODIST covers the costumer-generation and conforms to the general definition. To win better transparency and understanding of distributed generation it may recommend the use one universal definition for it. For costumer-generation the definition should formulate less restricted.

Market for electricity from DG

Analysis

The Brazilian energy legislation does not foresee costumer generation in the way other countries as Germany, USA or Japan does. DG is constrained by Decreto 5163 Art. 15. The total amount of electricity contracted from DG by utilities cannot exceed 10 % of the load of the distribution utility.

Conclusion

Increase or dispose the limit of distributed generation in the grid.

The OCs and IPs

Analysis

The current law doesn't provide another legal definition for power producers than the OC or IP for the electricity production. Thus costumer-generators are classified in the same way as conventional power generators in case they want to inject electricity to the grid. Otherwise a registration at ANEEL is sufficient.

Concluding from the definition in chapter 4, the OCs may commercialize only the generated excess electricity while IPs must commercialize all its generated electricity. But being an IP is subject to body cooperate. In case of costumer-generators the operator is usually a natural person. So, costumer generators are reduced to produce and inject electricity as OCs coming along with the restrictions and requirements defined in Decreto Federal N° 2.003/96.

Further the current law leaves by theological interpretation the option of own consumption just to OCs. But these have to fulfill some duties. They have to demonstrate that the actual and future electricity produced is used for own consumption. Further, the following information has to be provided to the regulating authority:

- The amount of injected or interchanged electricity and power of OCs connected on the same power bus bar.

- The amount of excess energy purchased by a third party.
- The costs for transmission for the third party purchaser.

This information may be provided easily by estimation. But even then there doesn’t exists a statutorily purchase agreement for the generated electricity with the distribution utilities.

Conclusion

Every household is allowed to produce electricity, as long it does not inject electricity to the distribution grid. The households property line ends at the meter as in Brazil the meter has to be installed at the outside of the property. This means all installations and happenings before the meter belong to the utility operator. Behind the meter everybody may connect a consumer or generator. This leaves various possibilities to run a costumer-generation within current the legal framework:

1. The demand of the costumer has to exceed all time the generation

2. One has to build in a consumer or/and a non-return device

3. The use of electricity storage

Table 1

Type of producer	IP	OC	Just a registration at ANEEL
Purchase	All electricity has to be commercialized	Just the excess electricity has to be commercialized	No electricity injection is possible

However, interviews had shown that as well the injection of electricity is possible for private operators without registration. This was to the facts, that the utilities did not notice the injection, did not care or tolerated the injection, personal understanding of the utility and the operator. Just in one case of all installed PV systems in Brazil the distribution utility asked for additional rework in form of an disconnection switch.

Other possibilities, which need a minimal adjustment of the legal framework, may be:

1. The introduction of a new entity in form as a costumer-generator in the Brazilian legal framework.

2. Adjustment of OC in the legal framework for costumer-generators. This solution makes the easy implementation for net metering or net billing possible. In this case the costumer-generator system could be configured a way that hardly excess electricity is injected to the grid. Furthermore a purchase agreement shall guarantee the purchase of the generated electricity under simplified conditions. This may include a simplified supply of the purchase information for costumer-generators.

Access and usage to the distribution grid

Analysis

In Brazil the legal entitlement to grid connection is ensured through regulated third party access by ANEEL. In general the Prodist and the ABNT give a complete and clear guidance to interconnect generation systems to the power grid. Decentralized generation is neglected or treated legally the same way as central generation (cf. chapter 3).

As described in chapter 3 both parties has to fulfill their task to grid connection. As the details on the task for the request for the connection (cf. Resolução Nº 281/99 Art 6) are not standardized the distribution utility has freedom to set the requirements for interconnection (Filho, 2005, p. 87). As Braun (2010) describes on an example of a distribution utility the requirement for interconnection with the distribution grid are designed for OCs & IPs. The costumer has to provide for example detailed impact studies on the grid of the utility. This makes to interconnection not commensurate hard for costumer-consumers. As well insufficient knowledge within the utilities (Romagnoli, 2005, p.63) and the lack of differentiation of costumer generation systems may lead to additional protection equipment, which has to be financed by the costumer generator (p.50).

The charge for the usage of the transmission and distribution grid is reduced by 50 % for electricity from renewable sources inferior the capacity of 30 MW_{el} in ANEEL Resolução Normativa 77/2004.

Conclusion

The specific requirements for interconnection of distribution utilities should be adjusted in a proportionate way to the standard and need of costumer generation. Fortunately in Brazil it is possible to solve the obstacle of inadequate requirements by a personal talk to the person in charge of the distribution utility.

One problem of costumers is to detect the right technical patterns for the connection to the distribution grid. Further Romagnoli (2005) claims the missing knowledge of the costumers about the norms and regulations. To gain more transparency a best practice should be elaborated that explains to utilities and costumers the essential steps and rules to plan, register, permit, install and connect a costumer generator. This can be achieved by the extension of the Prodist.

In case of further diffusion of DG respective costumer generation it is recommendable that the technical report for access to the grid as mentioned in Prodist is standardized because of the 30 days deadline for the distribution utility to handle in the report.

Register at ANEEL

The registration of generators smaller than 5 MW at ANEEL is simple and corresponds to the practice in other countries. The currently registered plants are listed on http://www.aneel.gov.br/area.cfm?idArea=40.

Case studies on different PV systems

This chapter gives an overview of the installed PV systems in Brazil and presents the experience with grid-connected photovoltaic in Brazil. It will give a general look at the jet-installed systems from 1995 to summer 2010, when the research phase was finished. Due to literature (especially Benedito, 2009) on the different cases as well to site visits and expert interviews with the responsible for the PV system implementation and monitoring, the characteristics of the systems and their state of the art will be presented in following.

Overview on the installed systems

Between the year 1995 and 2010, about 40 grid connected PV systems where installed in Brazil. Actually 36 systems are in operation and accumulating a capacity of 179 kWp. The following table shows basic information on these systems.

Tabelle 2:Currently working PV systems in Brazil

Operator	Number of systems	Installed capacity (kW_p)
UFSC - Labsolar	3	13,34
USP – IEE/LSF	4	16,1
UFRGS	1	4,8
UFPE – Grupo FAE	3	5,18
UFJF	1	31,7
UFPA - GEDAE	1	1,6
UNICAMP– LH2	1	7,5
CEPEL	1	16,32
CELESC	3	4,2
CEMIG	4	19,42
Eletrosul	2	14,3
Tractebel Energia	3	6
IEM - RS	1	3,3
ClínicaHarmonia -SP	1	0,9

GREENPEACE	1	2,8
Residências Particulares	2	3,9
Solaris (Leme -SP)	1	1
Grupo Zeppini	2	17,1
Coca-Cola	1	10
TOTAL	36	179,46

In the ANNEX D one can find the complete list of all systems in Brazil including systems just mentioned in literature but no contact could be found.

Universities and research facilities installed the vast majority of PV capacity. They are responsible for 14 installations. Other 10 (30 %) systems are installed by the utilities, with the technical help of the universities. Private companies maintain nine systems, private persons 2 systems and NGO 1 system. The make 25 % of the installed capacity. The following pie chart visualizes the actual distribution of PV system in Brazil by costumer (nominal and percentage of capacity and allocation).

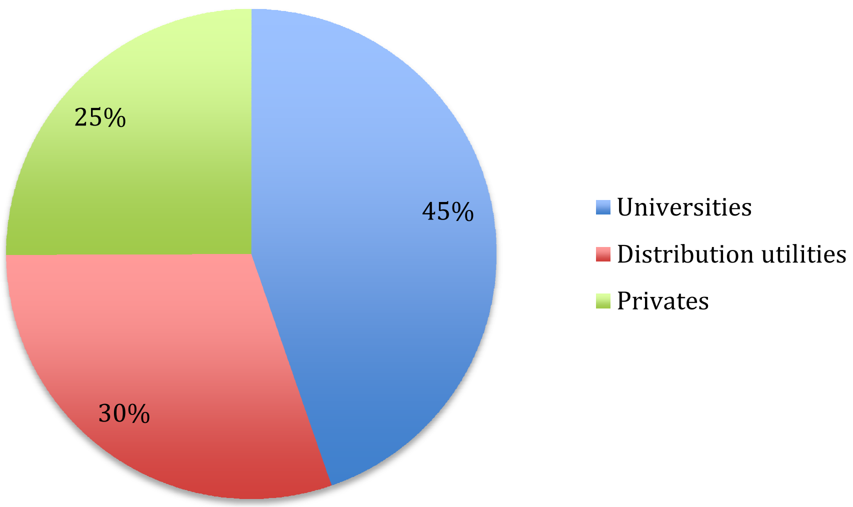

Figure 2: Distribution of the installed capacity by ownership

It is notable that 45 % of the installed capacity is operating in the purpose of research. This as well means that the knowledge in this technology is concentrated in a small fraction of scientist. Brazil has experience in off-grid PV therefore the actual research is concentrating in the operation of different PV technologies under climate circumstances, its behavior and impacts on the grid. An other fact is as many private as distribution utilities are in operation. Even though that the utilities forming as well part of the systems of the research facilities, it shows their small participation and interest in the topic of PV.

Significant progress was made in the development of PV energy in Brazil during the 70s followed by a relatively weak development (Dhere et al.). Since 1992 Brazil experienced further PV projects in research, development and especially rural electrification but not in a proper way for deployment of a long-term PV infrastructure or even industry. This may been showed due to the nationalization index developed by Varella (2009) which shows that PV water pumping equipment is to 5 % and rural electrification systems to 35% installed in Brazil is produced by national industry while the equipment for grid-connected PV systems are imported to a 100% (Varella, 2009).

The experience of R&D institutions

The experience of UFSC

The Federal University of Santa Catarina (Universidade Federal de Santa Catarina) is one of the most experienced facilities on PV. Their PV program is represented by the Laboratório de Energia Solar (LABSOLAR) and the Laboratório de Eficiência Energética em Edificações (LABEEE), it proceeds investigations on grid connected and building integrated PV systems. The experts of the University installed three grid connected systems on the campus and helped to install as well other systems by utilities and private persons (which will be presented as well).

2,0 kWp on the top of the building of Engenharia Mecânica at UFSC

Installed in 1997 this PV system was the first grid connected and building integrated system in Brazil. According to Rüther and Dacorgegio (2000) the installation consists of 68 modules by Solartechnik. The modules are amorphous produced by Phototronics Solartechnik. The system is arranged in four parallel strings with two times 20 modules and two times 14 semi-transparent modules. Every string is connected with a 650 Wp inverter by Würth. Between 1998 and 2005 the average annual productivity of the system is 1,26 kWh/kWp with a capacity factor of 14 % (Rüther et al., 2006). Till the end of survey the system is operating constantly without any technical problems since its implementation.

1,1 kWp at the convention center at UFSC

After the successful connection of the first grid connected PV system, the team of LABSOLAR implemented other PV systems on the campus. An additional 1,1 kWp system started operation in 2000 at the convention center of the UFSC. The purpose of the system is the publicity of electricity generation close at the point of use. The system is working reliable since its installation.

10,24 on the Centro de Cultura e Eventos at UFSC

According to Vaina et al. (2007) the system consists of 80 flexible amorphous modules with each 128 Wp by UniSolar. Nine inverters by Würth provide the alternative current. The average annual productivity is given with 1365 kWh/kWp (Viana et al. 2007) with a resulting capacity factor of 16 %. Besides the good property of the roof and the public importance of the building the system here is installed not only to generate electricity but public awareness.

Figure 3: PV system at UFSC (Zilles, 2008)

The experience FAE – UFPE

The research group FAE – UFPE (Grupo de Pesquisa de Fontes Alternativas de Universidade Federal de Pernambuco) was responsible for the installation of four grid connected PV systems in the northeast region of Brazil since 2000. The three of the four systems, which are still in operation, are presented shortly.

2,4 kWp with battery backup for the Hospital São Luis at Fernando de Noronha

Financed by CELPE/ANEEL – UFPE this system consists of 8 modules each 300 Wp connected to a 4 kW inverter. The system is located at the roof of the hospital. The systems was designed as backup system to ensure the electricity supply for the illumination of the hospital in case of a blackout of the diesel generators which are supplying the archipelago at the moment. Due to eight batteries the system is able to provide autonomously 3,6 kW for 1,5 hours to the hospital. The system is working but failures are occurring. The control panel shows errors and the metallic contacts of the installation are oxidized. This may due to the missing maintenance for the system.

1,28 kWp with battery backup at UFPE

Twenty polycrystalline modules with each 80 Wp and an inverter with 1 kW were installed in 2005 at the campus of UFPE. After one year of operation the system was redesigned. A battery stack was added and a panel of four modules was replaced because two of them suffered physical damage. As well the inverter broke and was replaced by a 4 kW system. After the replacement the whole system was downsized to 1,28 kWp. The goal on this system is the research on the operation of emergency backup systems for electricity. Because of the high demand of the building the system injected no electricity to the grid since its operation.

1,5 kWp of the Restaurante Limpiao

In the year 2007 the group of FAE financed by the MME installed a system for the restaurant Limpiao in the municipality of Piranhas in the region Xingo (Alagoas) at the banks of Rio São Francisco. The systems consists of 12 modules each 125 Wp and is located on a floating construction in the river. The conversion is done by a 1,1 kWp inverter. The choice of the location of the plant was subject to different criteria. So the location was chosen due to sustainability aspects with the aim to strengthen ecotourism in the area. As well the operator of the system had to ensure to maintain its operation (Barbarosa, et al., 2008). The system was designed to cover 50% (=200kWh/m) of the energy demand of the restaurant. In the first month of operation it was detected that the system was over dimensioned. It produced 568 kWh while the consumption was 483 kW (Barbarosa, et al., 2008). As well 192 kWh where injected to the grid of the local distributor. Since its installation the system is working faultless.

16,32 kW of CEPEL

In December 2002 Brazil second biggest PV system was installed at the roof of the CATE (Centro de Aplicação de Tecnologias Eficientes) located at CEPEL (Centro de Pesquisas de Energia Electrica). 80 monocrystalline modules by BP Solar with each 80 Wp are responsible for a peak capacity of 16,32 kWp. Because the mounting of the PV systems directly on the roof had lead to a reform of the cover of the roof, the systems where attached on metal bars as they are uses for two-axis tracing systems (see Figure 4) (Galdino, 2003). The generated electricity is injected to the low voltage grid of the building in three phases of 220 V via six SMA 2,5 kW inverters by SMA. The systems power is low in comparison to the high energy demand of the research centre so that an injection of PV electricity to the utility grid is improbable. The electricity generation of the system is less than 1% of the buildings demand. The operation of the system was interrupted several times for measurements. Galdino (2005) estimated from the disposable data an energy yield of 1290 kWh/kWp and a capacity factor of 14,7 %. Actually four of the six inverters are broken and the system is not working. The reason for the damage of the inverters is expected to be atmospherically discharge, which is higher in tropical regions than in the northern hemisphere. The costs are estimated by Galdino with 300000 BRL (2001).

Figure 4: PV system at CEPEL (Galdino, 2003)

4,8 kW at UFRGS

The Solar Energy Laboratory at the UFRGS (Universidade Federal do Rio Grande do Sul) installed its PV systems financed by the CEEE (Companhia Estadual de Energia do Rio Grande do Sul) in 2004. After the successful testing of 100 Wp modules by ISOFOTON, 48 of the modules where selected and arranged in six panels with 8 modules each interconnected in three strings with each 16 modules. Each string is connected to a SMA inverter with 1,1 kW and each inverter is injecting the AC into one of the three phases of the electrical installation of the building. A detailed explanation of the system is given in Dias (2006). According to Dias (2006) the average energy yield is 1205 kWh/kWp with a capacity factor of 13,8 %.

Figure 5: PV system at UFGRS (Dias, 2006)

31,7 kW at UFJF

In 2005 the - at the moment - biggest PV system of Brazil was connected at the Engineering Faculty of UFJF. Under the supervision of Barbosa 31,7 kWp was installed open space. The installation consists of 264 polycrystalline modules with each 120 Wp by BP Solar. The modules are arranged in eleven strings with each 24 modules (Vinagre, 2005). The electricity transformed in inverters DC-DC and DC-AC. The reason for this research project is to find ways for the improvement the quality of the distribution grid using PV. The goal of the project is to “dominate the technology, develop better controlling and investigation of grid impacts.” The inverter as well the data hubs are developed by the students of the university. Till now the data hubs are in work so that no performance data of the system is available.

The experience of the LSF-IEE-USP

The LSF (Laboratorio de Sistemas Fotovoltaicos) of the faculty for Electronics and Energy (IEE) at the university of Sao Paulo (USP) is researching on photovoltaic till 1998, starting with 0,75 kWp. Till now the research on the field increased, so that now three independent systems with a capacity of 16,1 kWp are working on the campus.

0,75 kW at the LSF

In April 1998 in the environment of the Programma para o Desenvolvimento das Aplicaçoes da Energia Solar Fotovoltaica, financed by the FAPESP (Fundacao de Amparo a Pesquisa do Estado de Sao Paulo, the LSF installed a 750 Wp system at their outdoor laboratory. According to Benedito (2009) the system was designed with the aim to net meter. The system consists of ten times 75 Wp monocrystalline modules by Siemens. The system is connected in series to a SMA 700 W inverter and injects its electricity to 220 V grid of the laboratory.

The utility (EletroPaulo) asked for the installation of an additional transformer after the inverter. That was to guarantee a galvanic isolation and increase the security. As it could be shown that the inverter the transformer was removed (Oliviera, 2002). This demounting of the transformer lead to an incensement of the overall systems performance, because the transformer itself occupied a capacity of 50 W. Oliviera gives the annual productivity with 1429 kWh/kWp. The capacity factor is altering from 15,2 % in winter and 18,3 % in spring and autumn. Actually the system is working faultless by adjusting the contacts occasionally and the cleaning periodically.

12,3 kWp at the Administration building of the IEE-USP

The described system is located at the north front of the administration building of the IEE-USP and was installed in two steps. The first installation was done in 2001 with a capacity of 6,3 kWp (Zilles, Oliviera, 2001). In 2003 the system was upgraded to 12,3 kWp with totally 80 monocrystalline modules by ATERSA and 80 polycrystalline modules by SOLAREX arranged in 8 strings with each 20 modules. The whole arrangement was integrated in the building with the effect that shading of the systems reduces the thermal charge of the building. For the system a detailed monitoring measuring the irradiation, temperature, performance and electrical parameters, was implemented. As described in Macedo (2006) some changing in the configuration took place in the dimension factor of the inverter. It was also shown that the system run with only 11,07 kWp than 12,3 kWp. The energy yield of the system was calculated with 1047 kWh/kWp. As the air condition is connected at 220 V between the two phases, the PV system is. This lead to a reduction of consumption by 50 %. During the weekend little flux is “exported”. Actually the system is working quite well. The only problems occurred were a break down of two inverters due to atmospherically discharge and the superline communication suffered interference, so it had to connect to a filter.

Figure 6; PV system at USP Zilles (2010)

3 kWp at the carport

In December 2004 the LSF installed a 3 kWp system on a car port. The system (see picture X) consists of 60 polycrystalline modules produced by Astrosolar with a nominal capacity of 50 Wp. Twenty modules are connected to a string, organized in two panels with 10 modules in series. Every string is connected to a inverter Sunny Boy 1100 U de SMA with 1 kW. In the first year of operation the systems productivity suffered by failures in the connection of a string with the inverter and by some broken modules.

Figure 7: PV system at USP Zilles (2010)

1,58 kWp GEDEA – UFPA

The GEDEA (Grupo de Estudos e Desenvolvimento de Alternativas Energias) installed in 2007 the first grid connected PV system in the Amazon. The systems is designed in series with 21 modules with each 75 Wp connected to a 2,5 kW inverter. The system is working steadily and has an annual productivity is given with 1296 kWh/kW and a capacity factor of 14,8 % in Macedo et al. (2008).

The experience of the LH2

The modules of the laboratory LH2 of the University of Campinas consists polycrystalline cells by Q-cells. The inverters are by SMA. The system is not optimized and connected before the meter. According to Carmago the process of buying the equipment was the most complicated part in 2005. The interconnection took place 2006 and is operating without any problems. The project was financed by the local distribution utility CPFL and costs 195000 BLR for the PV modules and 30000 BRL for the inverters. The technical installation took one day. The aim of the investigation is the deduction of rules for low voltage interconnection (by knowing the behaviour of hybrid systems) for the utility CPFL. Therefore the electricity quality and the behaviour of hybrid systems as well as its long distance control are observed. As well CPFL needed to experience the inverter safety functions.

Figure 8: PV system at LH2 (Carmago, 2010)

Experience of utilities with grid connected PV

The CHESF experience

CHESF (Companhia Hidroelectrica do Sao Franscisco) was the first institution, which connected PV to the grid in Brazil. The 11 kWp system was operating from 1986 to 1991 in Natal. In 1995 it was transferred to Recife (PE) where it was connected to the utility grid. The system was disconnected in 2001 after problems with the invertors and the degradation was detected. Today the system can be found on the roof of the headquarters of CHESF. The system was composed of twelve strings produced by AEG summing up 10 kWp (500 x 20 Wp). Every string consisted of a panel of 48 polycrystalline modules connected in series. One string (20 x 50 Wp) is of monocrystalline modules by the Brazilian company Heliodinâmica (Oliviera, 2002). The AEG system was connected through a inverter and control system by AEG and the system by Heliodinâmica was connected through equipment by the Brazilian company Varitec at 380 V before the meter. According to Benedito (2009) the company management is thinking of demodulation of the system and to analyze it adequate, as it is the only system in Brazil with a long- term operating experience.

CELESC

In 2003 CELESC (Centrais Electricas de Santa Catarina) installed with the help of LabEEE and LABSOLAR three systems of each 1,4 kW in different regions in Santa Catarina. One system was installed at the companies headquarters the other two were installed in Lajes and Tubarao. All of them where realized in the context of the research program ANEEL/CELESC with the goal to evaluate the feasibility of grid connected PV in Santa Catarina. Every system consist of eleven 128 Wp modules which are flexible and made of amorphous silicon by Unisolar (Rüther et al, 2005). The systems are arranged in two string with 640 Wp and 768 Wp which are connected to 650 Wp inverters by Würth Solar. The goal of utilizing two different configurations was to identify the advantageous system in different climatic conditions. Rüther et al. (2005) showed that the daily productivity ranged from 5,93 to 6,39 kWh/kWp. As well it was shown, that the configuration with 640 Wp achieved more benefit. That because the under dimensioned inverter lead to losses in. The R&D project showed successfully the technical and architectonical viability of flexible amorphous modules under different environmental circumstances.

CEMIG

Cemig (Companhia Energetica de Minas Gerais) installed four grid connected PV systems, two on their own buildings and two at institutions they are cooperating with.

Table 3: Systems by Cemig (Benedito, 2009)

System	Location	Capacity	Characteristics
CPEI/CEFET-MG Programma de communicação	Belo Horizonte	3,24	54 modules by Kyocera KC 60 in 3 strings each 18 modules, connected by three SMA 1,1 kW
GREEN/PUC-MG	Belo	2,05	32 amorphous modules by Unisolar in two strings with

	Horizonte		each 16 modules in serie connected to two SMA 1,1 kW
Escola de Formação e Aerfeiconamento Profissional (EFAP)-Cemig	Sete Lagoas	3,90	Polycrystalline modules by Kyocera and SMA Sunny Boy inverter
Laboratorio Sementes Nativas (LSN) – Cemig	Belo Horizonte	3,00	Monocrystalline modules and SMA Sunny Boy inverter

Till now no data for productivity of the systems are available. According to Benedito (2009) just two of the four systems where equipped with meters for electricity produced.

The systems of CPEI works reliable while the system of Green were reconfigured. Both systems had suffered failures in the monitoring. That is the reason because no data is available.

12 kWp Eletrosul

In February 2009 Eletrosul Centrais Electricas installed a 11.97 kWp PV system at the electrical circuit of the car park of the headquarters in Florianopolis. The system forms part of a joint project of the UFSC and the NGO Instituto Ideal planning to install a 1 MWp on the roof of the headquarters of Eletrosul. The system consists of 88 amorphous modules with 136 kWp in three strings each connected to a 4 kW inverter.

Figure 9: PV system at Eletrosul (2010)

6 kWp Tracabel

In june 2009 Tracabel Energy installed three 2 kWp systems in Florianopolis (Santa Catarina). The systems are located at the Hospital Universitario of UFSC, at the Colegio de Aplicação at UFSC and at the airport Hercilio Luz. Every system consists of 15 amorphous modules with 136 kWp. The annual productivity of the systems is about 1200 kW/kWhp. The systems are pilot projects referring to install major systems in the next years. Tracabel expects to install 1 MWp till 2012.

The experience of private initiatives

3,3 kW Intercambio Eletro Mecanico (IEM) – RS

In 2002 the company IEM got the authorization by the president of the local distributor to connect a 3,3 kWp system at the utility grid. The inverter own islanding system was good enough to meet the security requirements of the utility. The modules are produces by Siemens injecting its electricity via SMA invertors. The idea of the installation was to show the reliability of the systems. Till now the systems are working without problems.

17,2 kW Zeppini Group

The Zeppini Group consists of five sub companies in divergent industry sectors. The oldest company was founded in 1950 specialized in metallic materials. Since the 70s the company is concentrating on environmental technology. In 2006 the Zeppini Energy Z was created for the development of the photovoltaic market. Zeppini Energy Z installed two systems with 14,7 kWp and 2,5 kWp in Sao Bernardo do Campo (Sao Paulo) for the evaluation of the technical feasibility and to gain experience in the technology and the market.

14,7 kWp *at Fundição Estrela*

The system is located at the facade of the Fundição Estrela company building. The facade has an inclination of 106 degree, which makes the system not working in its optimal point of use bus made it cheaper in the investment, better accessible and more visible for the public. Flexible thin film modules are used on a –for this purpose constructed – metal construction of 235 sqm. The modules are arranged in three strings. Two of them has 6 kWp and are each connected to a SMA 6 kWp. The third string has a capacity of 2,7 kWp and is connected to a 2,5 SMA inverter. The system is connected to the 220 V electrical system and consumed by the building itself. The systems productivity was 13375 kWh between June 2008 and April 2009, which leads to a productivity of 910 kWh/kW and a capacity factor of 12,5 % for that period. The invertors' protection system shut down the system automatically several times because of the low electricity quality of the grid.

2,5 kWp at Zeppini Motor Z

At the building of Zeppini Motor Z – the sub-company, which specialized on electric mobility – a carport was equipped with flexible amorphous modules. The system is divided in two strings with each 1,2 kWp and each connected to a SMA 1,1 kW inverter. The systems productivity was 2700 kWh between June 2008 and April 2009 that leads to a productivity of 1080 kWh/kW and a capacity factor of 15 % for that period.

1,9 kWp Solaris

The project office Solaris was found in 1991 and specialized in Photovoltaic. The company installed two grid connected systems with 0,9 kWp at the Clinica Harmonia in Sao Paulo in 2005 and one system of 1 kWp at the Solaris office 2008. Solaris financed both projects with the aim to promote the benefits of PV and the companies' services. The first system consists of 12 times 75 Wp modules by ATERSA in series and an 800 W SMA inverter that is connected to the electrical installation of the Clinica Harmonia. There are no performance data on the system, but personal information affirms the reliability of the system. The second system consists of 8 modules with 130 Wp by ISOFOTON. As well this systems is arranged in series using an SMA 1,1 kW. There are no problems known on this system.

5,7 kWp UruTech/EBEA

The company UruTech – located in Sao Jose dos Campos (Sao Paulo) – specialized in energy solutions for its clients. Two of these energy services were the installation of PV systems for Greenpeace in Sao Paulo and a private building in Sao Paulo (Sao Paulo).

The Greenpeace system was installed in February 2007 and consists of a 40 monocrystalline modules with 70 Wp each by Shell Solar. Two strings with 20 modules each are connected in series to one 3 kW invertors by Xantrex, which is connected at the 220 V. Greenpeace financed the system with the objective of divulgence of renewable energies and the autarkies production of electricity for its headquarters. A monitor shows the performance of the system to the public at the facade. The system works reliable expect shadowing through a tree growing high in the neighborhood.

The other system has a capacity of 2,9 kWp by 70 Wp monocrystalline modules produced by Shell Solar and one 3 kW inverter by Xantrex. Still the system is operating in order.

5. Conclusion and Outlook

The installation and operation of costumer generators in Brazil is possible without any restriction as long no (unauthorized) electricity is injected the distribution grid. In the case of electricity injection of costumer generators the achievement of authorization by following the official proceedings is too complex.

The missing regulatory incorporation of distributed generation respective costumer generation is the fundamental barrier for its diffusion. Especially small PV generators are regarded neither by regulation nor by T&D utilities. The definition of DG applies for industrial generators with a high own consumption rather than for costumer-generators. These industrial generators may act as IPs or OCs, but for costumer generation this would be a far to complex task. The complicated regulation and according to Filho (2005) the different norms between the different distribution utilities makes diffusion of costumer generators difficult (cf. Starrs (2002)).

However, interviews had shown that as well the injection of electricity is possible for private operators. This was to the facts, that the utilities did not notice the injection, did not care, tolerated the injection or had personal understanding with the costumer. Just in one case of all installed PV systems in Brazil the distribution utility asked for additional rework in form of an disconnection switch.

To make the electricity injection practicable and legal, the restrictions in the regulatory framework can be adjusted towards costumer-generation. One option would be a net-metering or net billing for an adjusted form of OCs or the introduction of a new legal entity – the small DG. This opens the possibility of different compensation methods for consumer-generators as Net-Metering, Net-Billing. A feed-in tariff as it exists in Germany and as experts in Brazil demand it would be achievable under the adjustment of the regulations of IPs and might be harder to achieve.

Further a simplification of the connection procedure for costumer-generation is recommended. An elaboration of a separate standard for the interconnection procedure for costumer generators in the Prodist is conceivable. This should happen by ANEEL in collaboration with the participating stakeholders.

Currently some stakeholders demand for an adjustment of the legal framework to DG through the legal framework of Projeto Lei 630/2003. The introduction of this framework doesn’t look promising as the law is discussed since 2003 without any political success. But according to Aneel (2010) a working group on smart grids has been created, which is as well working on possible field of distributed generation and its regulatory framing.

6. ANNEX A

Interview guideline

Forma de Questionamento

Por favor, complete e envie aos cuidados de:

I. <u>Informação sobre o Contexto</u>

<u>Barreiras à implementação de sistemas Fotovoltaicas (FV)</u>

1. Ao longo da experiência com projetos FV, quais foram as maiores dificuldades encontradas?
2. De que forma estas barreiras influenciaram ou atrasaram o projeto?
3. Quais foram as exigências / normas para interligar á rede?
4. Quais outras barreiras foram encontradas durante a interligação?

   a. Barreiras técnicas
   Que tipo/natureza (*por exemplo: equipamentos de proteção adicionais, testes, serviços de engenharia,...):*

   b. Barreiras comerciais
   Que tipo/natureza *(por exemplo: acordo de interligação, contratuais e processuais, requisitos para a interligação, taxas, encargos ou tarifas dificuldades, dificuldades de entrar em contato com operadoras de rede de distribuição, requisitos de seguro,...):*

   c. Barreiras regulatórias
   Que tipo/natureza *(por exemplo: permita local, licenciamento ambiental, limites de tamanho, encargos de transmissão, normas, caderno de encargos,...):*

Lições aprendidas

5. Quais são as lições aprendidas durante o processo de implementação do sistema?

6. Como elas poderiam impactar o futuro desenvolvimento de outros sistemas fotovoltaicos?

II. Informações gerais

Sistema FV:

Localização de sistema FV

Endereço:

Cidade:

Responsável pelo sistema FV

Nome:

Contato:
Tel:
E-mail:

Empresa que executou a instalação

Nome:

Contato:Eng.
Tel:
E-mail:

Distribuidor

Nome:

Sistema fotovoltaico

Potencia total: [kWp]

Modelo dos módulos:

Quantidade de módulos:

Inversor

Modelo: Não informado

Quantidade:

Conexão com a rede
(por exemplo: trifásico, monofásico)
Nível de tensão: [V]

Interligação com a rede
(por exemplo: antes do relógio (Semi in-feed), direto na rede (Total in-feed), sistema isolado)

7. ANNEX B

Interview: CEPEL – Eletrobras

With Mr. Ary & Mr. Galdinho; Rio de Janeiro on 6. August 2010

- The ministry of science and technology (MCT) is running a program for making experience for grid connected PV in six states (Minas Gerais, Sao Paulo, Santa Catharina, Parana, …). The program is running from 2007-10, and is financed with 55 million BRL. Objectives are the implementation of a research network, pilot plants (CTI) and wafers (Cetec) and solar cells (PUC-RS), capacity building, technology prospection and international cooperation. The MCT project has three responsible institutions (e.g. CEPEL for Rio and Minas).
- The interviewee underlines, that Prodist doesn't include any consideration for PV systems. That means that the utility is free to set technical requirements for PV in its norms.
- It is expected, that the MCT project will cause a revision of the actual Prodist in the future to define the technical requirements for PV.
- Besides any incentive program, a new regulatory framework is expected.
- Assuming that Prodist is including rules for PV, the interviewee thinks that, because of cultural reasons, because of economic boundary conditions it is difficult in short and mid term that the consumers would take action and invest in PV modules for recovering the investment through electricity sales to the utility. The return of investment may be too long that consumers feel stimulated to invest.
- The interviewees distinguish between residential systems and systems of juridical persons.
- A further barrier may the fact, that Brazils energy matrix is quite clean through is large hydropower capacity, which is cheap ("Nosotros ya somos renovabels"). Brazil is just using 30 % of its hydropower potential. Other renewable can complement as for example reserve energy. Due to restrictions, the new hydropower plants aren't allowed to take that much space as they used to. That means, that the reservoirs are smaller. To balance the small reservoirs, energy sources in form as RE may be used.

- Though there are no incentives in tender for wind energy generation the prices were competitive. The interviewee assumes that the same will happen with PV.
- With the program “Luz Para Tudos” PV is loosing its driver as a niche market in rural areas. That may harm the diffusion of the technology making PV dispensable under the current circumstances.
- There are no technical barriers for the implementation of PV.
- The energy price has to rise if there would be PV in the energy matrix
- In the case of the CEPELs PV system (16 kW) no energy is transmitted to the grid. The own consumption of the building is far too high (high voltage connection with own transformer). Four inverter had been damaged/burned. The reason is not clear (atmospheric discharge / lightning / or even intern impacts in the grid). The interviewee suspects that atmospheric discharges are more/higher than in Germany. The generation of the system is less than 1% of the buildings demand. 300 000 BRL (2001). Right now not working, about 20 MWh/a.

Interview: EletroSul

Rafael Takasaki Carvalho; Florianopolis, 12.06.2010

- The PV system “Mega Watt Solar” will be connected to the distribution grid from CELESC. All the electricity shall be sold and EletroPaulo acts as an independent producer. It is argued, that the project has about the same capacity as the building and therefore the operation to supply the building is too complicated for CELESC. In “Mega Watt Solar” requirements of the meters are set by the CCEE: exclusive objective is to make the contracts for selling energy.
- The PV system with 11.97 kW was connected on February 2009 at the buildings circuit. It shall reduce the consumption of the building (energy efficiency). No additional technical requirement was needed. The building itself has protection equipment. If the system would be connected directly to the distribution grid, there would be additional requirements to fulfil.
- PV has two possibilities in Brazil: big projects (like that from EletroSul) for Marketing (green labelling) and special clients who want to have a green image. In Rafaels opinion PV penetration never will be such as in Germany because of its costs. Penetration will be just at the consumers level. For utilities it will stay uninteresting except of marketing.
- Before Prodist every project was treated as a single case. Prodist is the first step to unify the procedure of connection to the distribution grid. It set some basic rules for the distributer as well for the generator.
- The law permits the utility to pay the valor de referencia (151 BRL at Celesc). Speaking that the utilities are not obliged to buy energy from DG the utility wont buy the more expansive DG electricity. Net Metering doesn’t work because the utility doesn’t want to pay a higher price
- Utilities wont accept buying a fluctuating energy.
- In the free market “Mercado livre” the highest price would be 200 BRL/MWh (for generators who have 100 % discount in transmission cost)

- It is not forbidden to connect to the grid but small and big producers are treated the same way. The interconnection has to take place at the best global costs. A small generator usually cannot effort an interconnection study. Where you need service as a costumer, the utility has to connect you. But not as a generator.
- "Today a residential consumer is not allowed to feed energy back to the grid, that is a direct barrier." It is just not allowed that a consumer installs anything what is generating more energy then his own consumption." According to the representative from ANEEL (Paulo – Superindendent for regulation of distribution), a change of law needs to take place in this case. The consumer is reduced to design his PV system within the boarders of his own consumption. (In the case that anything is happening on the consumption side there might be additional equipment installed which disconnect the PV system from the grid.)
- R. thinks that a technical norm for interconnection as a consumer at the distribution grid will be form part of Prodist
- In R. opinion the government could open credits to finance PV for the costumers (BNDES + Banco do Brazil + Caixa) at own risk for the costumer. Buying the PV system as any other electronic equipment. There might be a regulation that the utility buys the generated not consumed electricity at a lower tariff.
- R. opinion: The stakeholders have the politics to change law, then the technical details have to be set by ANEEL.
- R. thinks that if everybody would export energy, the economic balance in terms of the concession would brake. Because the utility earn its money with the concessions. That has to take into account during the discussions.
- The distribution utility in Brazil just can consume. Transmission utilities don't buy electricity.
- Some utilities are vertical integrated some are not
- The utility like CELESC makes a tender or take part in a tender and buys at the best price.
- R. Thinks that Brazil has not the need for renewable energies as its energy matrix its already clean. The best diversification for Brazil is Hydro and a few

fossils. The population in Brazil thinks their energy matrix is clean. There is no political pressure using other technologies.

Interview: University Federal of Santa Catarina (UFSC)

With Alexandre Montenegro; Florianopolis on 12.06.2010

- In Brazil is no incentive or feed-in, but there is a working group of the MME.
- The Federal government is interested in small power generation.
- Research is made in small show case projects.
- The discussion about 630/2003 stopped since November 2009.
- A. sees the problem that it is not possible to sell the energy to the utility.
- It is not allowed to inject electricity but is not a problem. One can talk to the utility. The utility has just to be sure, that the grid quality is guaranteed.
- A. says that one can make NM/inject electricity to the grid but at the end of the month the bill has to be positive (if the bill would be negative there is no legislation to make to utility pay for it).
- The government doesn’t want to have PV as a additional corner stock.
- The first barrier is the government, which not interested in a feed-in to develop the PV market. Second barrier are big electricity consumers, respective the share of the costs of a feed-in. Third barrier are the utilities. They know, that they don’t have to make any effort for it, because they know that the government is against feed-in.
- The thermal power producers have a lobby against renewable energies
- Considering grid parity it should be at least allowed to sell electricity to the same tariff
- For the PVs of the UFSC, they just talked with the utilities (but they didn’t register at ANEEL). UFSC followed the security norms from ABNT for electrical installations (in this case generator systems). As there are no specific ABNT norms for PV it is not clear whether other installers use as well the norms.
- With only net metering as compensation mechanism just few people would be interested in PV, but it would be a first step

Interview: Greenpeace

With Élio Vicentini (AES EletroPaulo), Ricardo Baitelo (Greenpeace), Guilherme Araujo (EBES), Eduardo Bomeisel (EBEA); Sao Paulo on 11.06.2010

- No technical problem in interconnection.
- One technical problem is suspected in relation with atmospheric discharge in big systems (or missing protection for atmospheric discharge).
- The costumer had good experience with the utility thus EletroPaulo disconnected the system.
- In the opinion of the costumer a barrier could be formatted by the utility due to too many secret interconnected systems.
- Besides the costs, barriers are missing interest, missing knowledge by a possible costumer how to do the interconnection (many costumers believe, “that PV comes with an battery package as an autonomous system”).
- Point of view of the utility:
    - Technical: Usually the utility has no interest in parallel grid connection of PV systems. Especially if the technique is unknown. As EletroPaulo was informed of the interconnection of the PV system at Greenpeace, the question raised how to protect their line workers. This question was discussed together with the responsible engineer for the installation of the system. The utility made a study, which named the minimal requirements to protect the utility grid in case of an internal problem with the PV system.
    - Regulatory: There is absolutely no legislation referring to feed-in electricity into the low voltage grid of the utility by electricity costumers. The situation is as well confusing to the utility, because they don’t know exactly how to act without no law or regulation.
- The system is connected at the buildings electrical grid and consumes all of generated electricity. The meter is electric mechanic.
- Somebody, who is interested in energy generation and exportation to the grid has to take part a public tender. One is complaining, that this rule is ridiculous for small systems.
- OCs sell their energy to the Camera Comercial de Energia (CEEE). They have to pay charges for the grid and have to adapt the meter. The flux has to

be measured bidirectional and one needs a backup meter. The meters must be accessible by CEEE (via internet).

- The actual legislation is designed for big energy producers.
- The financial boundary conditions in Brazil are not costumer friendly.
- 1 % of the turnover of the utility has to be invested in R&D and in energy efficiency.
- A big barrier is the freedom of the utility to choose what protection equipment shall be used. This can be strategy used to rise the costs of a system.
- During the 90s EletroPaulo was offering the service of maintenance of transformers to other utilities. But after a while ANEEL complained and forbid it.
- The question is: Does one export energy. If not, Prodist doesn’t apply).
- A Meter costs 3000 BRL (quarto quadrants).
- Consumer doesn’t pay charges for the meter. If a additional meter is needed one has to pay.
- One incentive would be to treat PV as system for energy efficiency, especially respective the fact, that one has to consume his proper generated electricity.

Interview: IEM

With Hans Dieter Rahn; Rio de Janeiro on 28.05.2010

- The company IEM had installed and connected at least three PV systems in Porto Alegre.
- One is at the moment under construction. Its capacity is 4 kWp. It is a building intergraded tracked system for a company, which is producing electrical equipment and which want to produce inverters. Modules are 130 W.
- A 3,3 kWp system is under operation since 10 years without any failures.
- The distribution utility confirmed, that its possible to inject electricity as long its operation in not further communicated.
- The utilities want to have an eco-friendly image but “The distribution utility requirements are to high and cost intensive. The additional equipment costs would be the same as the whole system”.
- IEM strategy is to interconnect the plant. Then register at ANEEL and then tell the utility that the interconnection took place. After that the utility can do its measuring.
- IEM also connected a 3,8 kWp PV system for a school (Roof of a car port). The distribution utility was against the connection. But the school had its own transformer as connection point with the utility grid. The interconnection took place because the safety requirements due to galvanic separation through the transformer were met.

Interview: ANEEL

With ???; Rio de Janeiro on 28.06.2010

- At the moment ANEEL is observing the “how to do” for the regulation of residential PV systems due to a working group formatted by the MME aiming at the regulation and policy implementation for smart grids. A sub-working group is working on the adaption of costumer generation with the final objective to create a regulation. The leading principle is the generation for the own demand. Not the importation of electricity to the grid.
- Due to the fact, that the importation to the grid is just regulated to ANEEL 390, separating in OCs and IPs, there is the possibility to connect to the grid without importing electricity)
- In any case of interconnection one has to work with distributor.
- Already incentive are existing in a general mode: Discount of 50 % in the charge of the use of the grid for electricity from renewable energy sources

Interview: University of Sao Paulo (USP)

With R. Zilles; Sao Paulo, 11.06.2010

- A regulation to connect PV to the distribution gird doesn't exist.
- There is Resolução 112/1999 (note: doesn't exist anymore), which said that it is only obligatory to register with only one form: Zilles shows that there is no regulation for PV or Wind. It is possible to interconnect a system smaller than 5 MW and just register it at ANEEL. The distribution utility could buy this energy because 10 % of the energy it purchases could be bought in the free market from distributed generation. The PV system at USP was registered as 112/1999 demanded.
- It is not possible to sell this energy from costumer generation
- Prodist doesn't tell the minimal technical conditions the PV systems have to fulfil respective the distribution utility. There is no definition of the minimal technical requirements for interconnecting a system. Because missing a technical guideline (requirements) the utility can ask for "coisas absurdas" like prohibiting the interconnection systems without isolation transformer. As well there is all undefined, it is possible to interconnect the wrong way, which is harming the system and create additional barriers.
- A certification for invertors is needed. One can translate the IEC standard and introduce it to Brazil. One has to settle the technical standards and provide it to the utility.
- A norm or rule to connect exists but the utility can set its particular settings.
- As it is seen in the Prodist and also for the utilities there is to little knowledge of the technique. There is neither certification for the equipment nor any certification. It is necessary to define the minimal system requirements. A labelling program for PV systems for rural application does exist.
- In the case of EletroPaulo the additional request was just technical and without big effort to realize.
- For a feed in law there is not clear how to meter.
- In the case of Prodist a request to access is necessary. The utility has to condition the access to its grid.

- All systems in Brazil are installed within the electric circuit of the installation. Revering on ANEELs 112/99 one just need to register because one stays within the own electric circuit. If the interconnect is taken place at the utility side there would no benefit generated. But if there would be a second meter which allows to receive a "tariffa premia – tudo bem!", but this doesn't exist in Brazil.
- There may be a feed-in in Ceara
- The responsibility of the consumer stays within the electric circuit (that's why electricity companies don't pay when – for example voltage peaks – consumers equipments are harmed. The consumer has to protect himself with additional equipment).
- Given the structural conditions, one can just generate as much energy as his electrical circuit may support
- The type of meter used depends on the utility. The meters in Sao Paulo are bidirectional electro-mechanic meters but there is a shift to electronic meters. The meters in Sao Paulo are able to net meter.
- The report of the working group on PV of the MME says: There won't be a feed-in Brazil. The MME consider financing pilot projects with the help of BNDES and ANEEL. Zilles was against this, because there are already enough pilot projects showing the feasibility of PV.
- "For Net Metering are no barriers because it already exists"
- "Net Metering is not the adequate form." Z. is in favour of feed-in. But the problem with feed-in (con tariff premio) who will pay the bill. "The actual legislation doesn't permit a feed-in because of the actual tariff structures. Actually it is not possible to pay more than the current tariff. One has to change the law to break with the actual tariff structure.
- In 630/2003 it is proposed to brake with the actual tariff structure. To support DG it is necessary to support the 630/2003. But the ministry itself does not support this law. 630 would prepare the possibility of a feed-in. The 630/2003 is a hybrid out of 18 law projects.
- Actually in aspects of legislation the MME focus in tender. So if there will be a law for PV it will support mainly big projects.

- There are no big technical barriers to connect at low voltage. The law permits to connect, but it is not ready introduce large-scale interconnection.
- In the last 10 years in operation there were just 2 problems: 1. 2 Inverters of 11 had a Problem with EPROM 2. Superline communication suffered interference. So it had to connect to a filter.
- For all systems there was no obstacles by the distribution utility. Just in 1998 EletroPaulo called for isolation transformer. Even though there was already an isolation transformer, EletroPaulo called for an additional one. After 3 month the transformer was disconnected because the new installed inverter already had an isolation transformer.
- The air condition is connected at 220 V between the two phases, the same way the PV system was connected. Consumption was reduced by 50 %. During the weekend little flux is “exported”.
- The first system (800 W) was installed with transformer.
- All inverters are by SMA
- EletroPaulo is interested in PV. They ask for the possibility to connect systems in individual housing projects.
- Advice by Zilles to connect a PV system: 1. Register, 2. Connect, 3. Go to the utility and ask them whether all is done the right way.

Interview: GTZ

With T. Schwab; Rio de Janeiro on 19.08.2010

- In the highly controlled energy sector may exist barriers and opportunities the same time.
- Barriers might be: 1. Transaction costs in Brazil are very high. The process to found a company may took several month. As well the costs of founding a company is really cost extensive due to the reserves. 2. Subsidies as CCC: Tax subsides for diesel. 3. Connection costs for hydro are excluded in the tender. For wind systems they are included. 4. Non consideration of Externalities. 5. Trade Barriers. There is an import tax reduction for technology, which is not produced in Brazil; but if the product can be substituted by other technology the tax has to be paid. 6. Brazil has high discount rates (Banco Central). 7. The capital costs are very high. Especially for small costumers it is hard to receive a credit with low interest rates. In average, the interest rate is high. Just big projects receive cheap credits from the BNDS. The BNDES works primal with big costumers. Especially for small costumers the access to capital is mostly really expensive apart from stimulation via special programs. 8. It is complicated to start a business in Brazil because of red-tape. But more than to start it is complicated to quit it.
- To stimulate the dissemination of renewable energies the ministry is the wrong place to start. It is easier to work with other stakeholders like ANEEL, which may bring suggestions into the ministry.
- There is a certain lack of R&D culture in Brazil. In the case of PV the R&D concentrates on practices level but technological innovative R&D of PV is really costs intensive. Although Brazil had some efforts by industry, research and polices (Prodeem), it never reached breakthrough. This may be because of the difficulties in implementing technology. Further in the case of PV holding a technology advantage is expensive and would need the same effort as for the Atomic program.

Interview: ProNetSolar

With Claudio, Rio de Janeiro on 05 July 2010

- The system was installed in Magé and worked for several years. The education center Instituto Kinder sponsored by Würth built this small PV system for support of the electricity supply. As the education centre lies at end of the distribution line, it often had to suffer electricity shortage. That is why the 12 kWp system (10 x 120 Watt + 7 inverters) was installed. Due to insufficient maintenance after 2 years operation the inverters broke. The education centre CEPEL was contacting the company ProNetSolar to set the system in operation again. ProNetSolar changed the inverters. Now the system is used for educational and research purpose.
- The system propose is education
- According to Claudio, Ampla was approving the PV-system because of its poor electricity supply at the branch line and therefore one less costumer complaining about electricity shortage
- The system is providing nearly 15 % of total consumption, if the system would generate more than it generates, it may had some difficulties with the generators.
- The interviewee had no specific knowledge on barriers of interconnecting because the system was installed before.
- There is no law which says, that it is mandatory for the utility to buy electricity
- It is prohibit installing on grid side of the utility.
- There is no norm for interconnect (not from ANEEL neither from the utility)
- One cannot interconnect with the distribution grid without permission.
- From the moment in which there is a law making it obligatory for the utilities to purchase the generated electricity by costumer generators, Claudio suspects that the distribution utility would put some obstacle requirements on the connection point.
- To the interviewee all the known systems are test systems on university level
- The interviewee does not know any commercial system in Brazil

- Regarding the current legislation the main objective to interconnect is that the meter runs backwards to economise the investment for the PV.
- A problem in the operation of the systems may occur if a fan cools the inverter. Especially in hot areas the system tends to overheat if the fan is broken. Some systems as to be tuned with additional fans with a running all time instead of being temperature regulated.
- In this case the grid synchronized inverter often shut down because of bad grid quality. This may harm the inverter.
- Example of the automotive industry: “ A car constructed in or for Brazil is heavier than the same car for the EU market. That is because the cars for Brazil are reinforced for hold the bad road conditions. A car constructed for the EU market but driven in Brazil is suffering because its layout was not designed for the Brazilian conditions.” This metaphor may be used to describe the conditions in the Brazilian electricity sector. The system – in this case the grid synchronized inverter – need to be more tolerant before shutting down. (As well respective to harm of its equipment)
- The interviewee is in favour of a feed-in financed through a found, which is financed through taxes on the electricity bill.
- The politics in Brazil are in favour of thermal power plants
- In the experience of the interviewee it is from importance to have qualified personal able to design, install and maintain the generation systems. In the case of PV one need able technicians to maintain the inverters. Especially awareness should be on the costumer needs, quality standards and capacity building. The government shall capacitate people for these tasks. That’s why, if the market diffusion may take place, there wont be enough capacity to maintain the systems or install it.
- The interviewee thinks that the utility is not prepared if one want to interconnect to their system
- The modules have reduced taxes. For the modules exist just import tax (18 %)
- Credits in Brazil are expansive or hard to get

Interview: LH2 (Hytron - Tecnologia em Hidrogênio)

With Mr. Camargo, Campinas on 06 Juli 2010

- The systems consists polycrystalline cells by Q-cells. The inverters are by SMA. The system is not optimized and connected before the meter. The process of buying the equipment was the most complicated part in 2005. The interconnection took place 2006 and is operating without any problems
- The project is financed by a utility CPFL and costs 195000 BLR for the PV modules and 30000 BRL for the inverters. The technical installation took one day. The aim of the investigation is the deduction of rules for low voltage interconnection (by knowing the behaviour of hybrid systems) for the utility CPFL. Therefore the electricity quality and the behaviour of hybrid systems as well as its long distance control are observed. As well CPFL needed to experience the inverter safety functions.
- They LH2 asked for the permission/authorization of the utility to interconnect because the utility does not allow interconnecting any source on the low voltage grid.
- The interviewee sees barriers in the regulatory of interconnection. There is no common rule/directive to interconnect to the low voltage grid. Every utility can set its own rules or can act as it like to. The US norm US IEE 1547 should be adapted.
- Biggest barrier in Brazil is the price
- If there would be a compensation method as net metering or feed-in, LH2 sees a barrier in exchange the meters, because the utility has to pay for it
- Opinion: if the inverter fulfils the norm 1547 there is no additional protection needed (excepted a disconnect switch between grid and consumer)
- In his opinion there just PV systems connected to the grid, which are projects from the proper utility.
- Same time: one can connect to its own electricity circuit. The wrights of the utility ends at the meter.
- LH2 experienced PV as easy to handle, reliable, no O&M, and mature technology.

Interview: CHESF

With José Bione de Melo Filho, Recife-PE

Interview via questionary:

Throughout the experience with PV projects, which were the major difficulties encountered?

The lack of a specific legislation.

The lack of appropriate norms for Brazil and the not-adaptation of existing rules of countries that are already developed with the latest technology.

How does these barriers influenced or delayed the project?

They prevent investment in the area because there are no clear rules for the facilities as well as for the comercialisation of energy.

What are the requirements / standards for connecting to the network?

In the case of Chesf, because it is a small system, there were no rules to make the connection.

How did it affect the project?

At the time, almost twenty years ago, there were no impediments, just a standard was adopted with the German experience.

What type / nature of trade barriers there?

The energy produced was never marketed, it was simply injected into the grid.

What are the lessons learned during the implementation process of the system?

Today in Brazil, to start talking about photovoltaic plants, we would have to import almost everything, this would push the price of the plant, but after the first large plant, we are creating a new market for Brazil, not only in a matter of photovoltaic panels but referring to structures, facilities, interconnection with the power network, and other measurements of radiation.

What is the purpose of the PV system?

Private and research.

What is the design of PV system?

Field installation.

Would it be possible to provide a line diagram

As the plant went through a period off, almost all historical plant was lost.

What are the next plans?

In fact we are building a new plant, since the current modules already have an advanced state of disrepair.

8. ANNEX C

Register form ANEEL

Anexo III
FORMULÁRIO DE REGISTRO DE CENTRAL GERADORA

ANEEL
Agência Nacional de Energia Elétrica

1. IDENTIFICAÇÃO

Proprietário

Nome	Telefone ( )	Fax ( )	
Endereço	Município		UF
CNPJ/CPF	e-mail		

Central geradora

Denominação *UTE*		Telefone ( )	Fax ( )	
Endereço		Município		UF
Coord. geográficas: Latitude	Longitude	e-mail		

2. CARACTERÍSTICAS TÉCNICAS DA CENTRAL GERADORA

Usina Termelétrica – UTE

Potência Instalada Total Bruta (kW):	
Nº de Unidades Geradoras:	
Combustível (se aplicável):	

Geradores	Potência (kVA)	Tensão (kV)	Fator de Potência (cos φ)	Potência (kW)	Data de Entrada em Operação
01					
02					

Usina Fotovoltaica - SOL

Potência Instalada Total (kWp):	
Área Total da Usina (m2):	
Número de Arranjos:	
Módulos da Usina Fotovoltaica:	

Arranjos	N.º de Placas por Arranjo	Área do Arranjo (m^2)	Potência de Pico (kW)	Data de Entrada em Operação
01				
02				

Declaro que as informações prestadas neste documento correspondem ao empreendimento em referência e estão de acordo com a legislação aplicável, em especial com o disposto nas Resoluções da ANEEL que tratam sobre a outorga de empreendimentos de geração. Estou ciente de que declarações falsas ou inexatas caracterizam crime de falsidade ideológica (art. 1.299 do Código Penal).

Local__________________________

Data__________________________

____
Proprietário ou representante legal pelo empreendimento

Figure 10: Registration form for ANEEL from Resolução Normativa 390/2009

9. ANNEX D

Overview of installed PV and contacts

PV system	Capacity (kWp)	Operating	Contact	Email
CHESF	11	1995	Prof. Dr. José Bione de Melo	jbionef [jbionef@bol.com.br]
Labsolar-UFSC	2,1	1997	Ricardo Rüther	ruther@ecv.ufsc.br
LSF-IEE/USP	0,8	1997	Roberto Roberto Zilles	zilles@iee.usp,br
UFRJ/COPPE	0,9	1999	Richard Stephan	krauter@coe.ufrj.br
Centro Convivência UFSC	1,1	2000	Ricardo Rüther	ruther@mbox1.ufsc.
Grupo FAE, UFPE (F. Noronha)	2,5	2000	Chigueru Tiba,..Naum Fraidenraich,	'nf@ufpe.br'; 'tiba@ufpe.br'
LSF-IEE/USP	6,3	2001	Roberto Zilles	zilles@iee.usp,br
CEPEL	16,3	2002	Marco Antonio Galdino	marcoag@cepel.br
Intercâmbio Eletro Mecânico H R	3,3	2002	Hans Dienter Rahn	hdrahn@iem.com.br
Grupo FAE, UFPE (F. Noronha)	2,5	2003	Prof. Dr. Chigueru Tiba, Prof. Dr. Naum Fraidenraich,	nf@ufpe.br'; 'tiba@ufpe.br'
CELESC	4,2	2003	Ricardo Rüther	ruther@mbox1.ufsc.br
LSF-IEE/USP	6	2003	Roberto Zilles	zilles@iee.usp,br
Centro de Cultura e Eventos UFSC	10,9	2004	Ricardo Rüther	ruther@mbox1.ufsc.br
LSF-IEE/USP	3	2004	Roberto Zilles	zilles@iee.usp,br
UFRGS	4,8	2004	Arno Krenzinger	arno@mecanica.ufrgs.br
CEMIG	3,15	2004	Sonia Diniz	asacd@pucninas.br
Escola Técnica de Pelotas	0,9	2004	???	???
Grupo FAE – UFPE	1,7	2005	Chigueru Tiba, Naum Fraidenraich,	'nf@ufpe.br'; 'tiba@ufpe.br'
Clinica Harmonia (SP) 1	1	2005	???	harmonia@ harmoniacorpoemente.com.br
Casa Eficiente ELETROSUL	2,3	2006	Engº Rafael Rabassa Morales	???
CEMIG	9	2006	Sonia Diniz	asacd@pucninas.br
UFJF	30	2006	Albilio Manuel Variz	abilio@lacee.ufjf.br
GREENPEACE (SP)	2,9	2007	Eduardo Bomeisel	eduardo@ebea.com.br
Grupo FAE-UFPE N.D.	0	2007	Chigueru Tiba, Naum Fraidenraich,	'nf@ufpe.br'; 'tiba@ufpe.br'
CEFET MG	3,2	2007	Patricia Romeiro da Silva Jota	prsjota@des.cefetmg.br
Lh2 Projeto CPFL	7,5	2007	João Carlos Camargo, Eng. Donadon	donadon@cpfl.com.br João Carlos Camargo
Residência Particular, Recife	1	2007	???	???
Residência Particular	2,9	2008	Eduardo Bomeisel (EBEA)	eduardo@ebea.com.br
Solaris	1,04	2008		solaristecno@uol.com.br

Zepini, Motor Z	2,5	2008	Samir	samir@motor-z.com.br
Zepini, Fundição Estrela	14,7	2008	Samir	samir@motor-z.com.br
ELETROSUL	12	2009	Rafael Takasaki Carvalho	takasaki@eletrosul.gov.br
Hospital Universitário UFSC	2	2009	Ricardo Rüther	ruther@mbox1.ufsc.br
Colegio de Aplicação UFSC	2	2009	Ricardo Rüther	ruther@mbox1.ufsc.br
Aeroporto Hercílio Luz	2,1	2009		leme@leme.com.br
Colégio Estadual Agrícola - CEAGRIM	12	2009	Claudio Cittadino	pronet.solar@uol.com.br
Cemig Sete Lagoas - Mina gerais	3,86			
CEMIG: Belo Horizonte MG	3,41			ecnobre@yahoo.com.br]
Not defined systems				
Vila de Araras –Rondônia	20,5	2001	Ricardo Rüther	ruther@mbox1.ufsc.br
Tractebel Energia	6			
Pedra Branca Palhoca (santa catarina)	6,3			
Porto Alegre	0,6			

10. References

Alderfer R.B., Strrs T.J., Eldridge M.M., 2000. Making Connections - Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects. National Renewable Energy Laboratory. Golden

Braun-Grabolle P., 2010. A integração de sistemas solares fotovoltaicos em larga escala no sistema eléctrico de distribui ção urbana. Universidade Federal de Santa Catarina. Florianopolis. Doctor Thesis

Dhere N.G., Cruz L.R., Lobo P.C., Branco J.R.T., Rüther R. Zanesco, I., Lima J.H.G, 200X. History of solar energy research in Brazil.

Filho, A. S., 2005. Analise regulatoria das condiçoes de interconexao de geração distribuida: requisitos para os procedimentos de distribuição. Universidade Federal de Itajuba. Itajuba

Flick, U., Kardorff v. E., Steinke, I., 2005. Qualitative Forschung: Ein Handbuch

Mayer H.O., 2008. Interview und schriftliche Befragung: Entwicklung, Durchführung und Auswertung. Oldenbourg Wissenschaftsverlag GmbH. München

Rodríguez C.R.C., 2002. Mecanismos regulatórios, tarifários e econômicos na geração distribuída: O caso dos sistemas fotovoltaicos conectados à rede. Universidade estadual de Campinas. Campinas

Rüther R., Salamoni I.T., Montenegro A., 2008. Fontes Renováveis de Energia voltadas à geração de energia para o Sistema Interligado Nacional Brasileiro. Florianopolis

Rüther R., Zilles R., 2011. Making the case for grid-connected photovoltaics in Brazil. Energy Policy 39, 1027–1030

Ruiz B.J., Rodríguez V., Bermann C., 2007. Analysis and Perspectives of the Government Programs to Promote the Renewable Electricity Generation in Brazil. Energy Policy 35, 2989-2994

Salamoni I.T., 2009. Um programa residencial de telhados solares para o Brasil: diretrizes de políticas públicas para a inserção da geração fotovoltaica conectada à rede elétrica. Universidade Federal de Santa Catarina. Florianopolis, Brasil

Solarserver, 2011. Spire to deliver 20MW solar PV module production line to Brazil. Access at http://www.solarserver.com/solar-magazine/solar-news/current/2011/kw12/spire-to-deliver-20mw-solar-pv-module-production-line-to-brazil.html, on 2011-03-25

Tolmasquim M.T., 2003. Fontes Renováveis de Energia no Brasil. Rio de Janeiro: Interciencia: CENERGIA; 2003. p. 281-334

Varella F.K.O.M., Cavaliero C.K.N, da Silva E.P., 2009. A survey of the current photovoltaic equipment industry in Brazil. Renewable Energy 34, 1801-1805

Varella F.K.O.M., 2009. Estimava do índice de nacionalização dos sistemas fotovoltaicos no Brasil. Universidade estadual de Campinas. Caminas

Yang C.-J., 2010. Reconsidering solar grid parity. Energy Policy 38, 3270–3273

Abradee, 2011. Associaction of the distribution utilities. http://www.abradee.org.br/

Prodist 2008a. Procedimentos de Distribuição de Energia Elétrica no Sistema Elétrico Nacional – PRODIST Cartilha de Acesso ao Sistema de Distribuição

Prodist 2008b, Procedimentos de Distribuição de Energia Elétrica no Sistema Elétrico Nacional – PRODIST Módulo 3 – Acesso ao Sistema de Distribuição

Mayring, P. 2006: Einführung in die qualitative Sozialforschung

Kornmeier, M. 2007. Wissenschaftstheorie und wissenschaftliches Arbeiten: Eine Einführung für Wirtschaftswissenschaftler. Ba Kompakt

Bührmann, A. (2002). Das Experteninterview. Theorie, Methode, Anwendung Forum Qualitative Sozialforschung. Available at: http://www.qualitative-research.net/index.php/fqs/article/view/574/1246. Date accessed: 10 Jun. 2010.

Franz, H.-W., Kopp, R., 2004. Betriebliche Experteninterviews. Sozialwissenschaften und Berufspraxis, Available at: http://nbn-resolving.de/urn:nbn:de:0168-ssoar-38198, Date accessed: 10 Jun. 2010.