Abstract- The paper discusses the conflicts that arise between traditional incentive regulation, where consumers pay a fixed tariff to the distribution company for providing the wire service, and the arrival of distributed generation that alters this arrangement. The Chilean case, where a model company approach is used for tariff building is explained, and how distributed generators are conflicting with the distribution companies as they attempt to connect to their networks. Often, the long distance between renewable power sources and the transmission system, in addition to the small capacity of these distributed generators (DG), renders unprofitable the installation of private lines from the DG to that system. This situation motivates the DG owner to connect the generator to the distribution network. The distribution systems, however, are not usually designed to receive energy at the consumer end. This problem intensifies in developing countries where rural distribution systems are very limited. Thus, when connecting a DG to a radial feeder it is often necessary to upgrade the feeder. The way to make this upgrade coherent with the incentive regulation scheme in place is not evident.

Index Terms— incentive regulation, distribution tariffs, distributed generation.

I. INTRODUCTION

Global warming and environmental concerns have increased remarkably in energy supply discussions throughout recent years. This has augmented the efforts to replace traditional electrical generating technologies with new technologies that pollute less. Therefore, the use of renewable energies worldwide has increased considerably. Along this trend, many countries worldwide are introducing legislation to promote distributed generation that makes use of renewable energies [1, 2]. These efforts aim both to solve the energy supply security and to promote the use of non-polluting energies. However, these efforts have often proved to be insufficient, mainly because of the barriers to entry that arise from the nature of the networks they connect to. It is, therefore, necessary to discover new ways of stimulating the distributors and producers to install this sort of technologies, mainly at the distribution level.

The majority of the present distribution tariff structures and pricing methodologies were developed in the 70’s or 80’s for systems with little or non distributed energy resources and considering completely inelastic demand. They are therefore not designed to promote efficiency in the case of abundant distributed and micro-generation nor in the presence of responsive demand.

Thus, it is difficult to connect renewable energies to the distribution system, given two main reasons. The first is that the old fashioned distribution network is exclusively designed to transport energy from the transmission system to the consumers, with sophisticated incentive regulation tariff schemes, but only considering that unidirectional design. The other reason is the monopolistic muscle of the distribution company when negotiating the connection of the new DG to the network.

Distribution companies in Latin America are assured certain revenues by the distribution pricing scheme, within a benchmark model requesting minimum efficient investment and operation, but are in general reluctant to changes in their top-down supply-demand radial business. They see distributed third party generation within their distribution networks more as a problem than an opportunity, so that future changes in distribution regulation and pricing must be accommodated to overcome that barrier, if micro generation and DG are to be developed.

The Chilean legislation identifies Non Conventional Renewable Energy as the generation means from non conventional renewable sources connected to the grid, such as geothermal, wind, solar, biomass, tidal, cogeneration, and hydro generation up to 20 MW. Recent legislation has set important incentives for this type of generation, forcing a market energy quota of 10% from renewables. Discussions at present even consider 20% for 2020.

II. DISTRIBUTION INCENTIVE REGULATION

Electricity distribution companies, being network industries, aim to transport and distribute electric power from specific points in high or medium voltage lines to end consumers at appropriate voltage levels for industrial and residential use. This activity is organized in public service monopolistic utilities that obtain power supply through contracts with generators. The regulatory challenge is to stimulate an efficient service in distribution, similar to that that would be achieved in a competitive environment [3, 4].
Figure 1.- Cost components of the distribution activity

The characteristics of the distribution activity vary from region to region, depending on the nature of the demand. In Latin America, the main challenge in distribution is one of large growths of demand, annual values around 6 to 8% being common in the region, requiring doubling of capacity every ten years. This, coupled in some countries to the need to extend networks to increase electrification levels, imposes significant challenges to distribution network expansion, different to those faced in North America and Europe. Thus, the need to stimulate efficiency becomes of paramount importance.

To regulate electrical distribution and stimulate efficiency, most Latin-American countries have adopted an incentive regulation approach, using the concept of efficient companies that are adapted to demand and that operate under optimal investment and operations plans. Under this scheme, to force companies to be efficient, the regulator fixes prices according to efficient costs, not necessarily considering actual companies. The actual company will get a normal profitability only if it is capable of emulating the efficient performance, reducing its operating and investment expenditure, thus minimizing the present value of its costs.

In general, this regulation has implied a reduction trend in distribution tariffs. However, it is also becoming a barrier to integrate DG into the distribution networks.

III. THE CHILEAN MODEL COMPANY

Distribution networks are defined in Chile as those whose voltage is less than 23 kV.

The final price paid by a regulated consumer (defined as those under 2 MW) integrates the regulated generation-transmission price with which the generators supply the distributing firms and an added value for the distribution service [3, 4]. The regulated distribution price corresponds to the mean added value by this activity determined from model firms operating in the country.

The regulation mechanism determines its distribution tariffs working with an existing firm that serves as a reference for the construction of a model firm, and such model firm is benchmarked with all the distribution concessionaire firms. Thus, this scheme corresponds to an incentive tariffs model of the yardstick competition type, where the relative performance of the industry is assessed, assuring in theory a specific minimum return to those firms that have a performance similar to the model firm.

A core element to determine distribution tariffs is the dimensioning of the model firm. In the international application of the yardstick competition mechanism, the regulation of monopolistic activities is determined through the comparison of costs and performance of similar firms or mirror firms or the reduced comparison of heterogeneous firms corrected for differences. In the Chilean distribution monopoly regulation model, there is a hybrid benchmarking scheme between different firms. On one hand, group of firms of similar characteristics are compared, identified through typical areas, with a model firm. Then, the performance of heterogeneous firms is compared in an integrated manner, with an assessment of the global adequacy of the industry with a single standard. In the former case and through a theoretical model and through direct comparison, efforts are made to provide the efficiency signal of similar firms and in the latter case efforts are made to produce a horizontal comparison that fits the theoretical model with the average reality of heterogeneous firms.

The electrical legislation determines the distribution tariffs based on the added value for the concept of distribution costs, value that is based in a model firm and that considers the three main components that form part of the distribution business cost: infrastructure and equipment costs, energy and power losses, and operating expenses such as administration, operation and maintenance expenses, determined separately for mid voltage and low voltage networks (Fig. 1).

The components indicated are calculated for a specific number of typical distribution areas defined by the National Energy Commission, with a previous consultation with the firms and a model virtual company is built for each group.

A detailed design of the model company networks is performed, using sophisticated mathematical tools (Fig. 2) [5, 6].
Thus, no assessments, technical or economical, were incorporated into the networks, presently or in the future, and no special consideration was made of DG principle, but no locational sign is used.

Different demand density characteristics (cost-causality made of their potential influence.

The last distribution tariff study was made in 2008 and no special consideration was made of DG incorporated into the networks, presently or in the future. Thus, no assessments, technical or economical, were made of their potential influence.

Standard investment, maintenance and operating costs associated to the distribution are determined by unit of power supplied. The annual investment costs are calculated considering the New Replacement Value (NRV), the facilities adapted to the demand, and a discount rate equal to a real 10% per year. The process to determine the NRV has the objective of calculating the “cost to renew all the works, facilities and physical goods dedicated to provide the distribution service in the respective concessions”. The concept of NRV used by the Chilean legislation to be applied to distribution activities has been a hybrid between the substitution and replacements costs.

Distribution networks are assumed to be designed to supply peak demand condition, so that average cost of the required efficient infrastructure to supply that demand is used for charging calculations. Energy valuations are only needed for the purpose of calculating distribution losses to be paid by demand. As distribution tariffs correspond to capacity payments at peak demand, they are in essence flat tariffs. Regulated consumers are not measured peak demand or timing of that demand. However, medium and large consumers with time-of-use meters are measured their peak demand within the period of peak system demand, and thus receive a time-of-use signal, but just to control their peak.

Distribution tariffs are the same for all those under a given distribution company, a postage stamp payment independent of location. The only differences arise on the density of the area served, rural consumers pay more than urban ones, and these more than those located in highly dense city areas; demand served by underground networks pays more that that served by aerial networks. Demand connected to high voltage networks (from 12 to 23 kV) pays less that that connected to low voltage ones (380 V). The aim is to reflect direct costs associated to different demand density characteristics (cost-causality principle), but no locational sign is used.

The last distribution tariff study was made in 2008 and no special consideration was made of DG incorporated into the networks, presently or in the future. Thus, no assessments, technical or economical, were made of their potential influence.

Open access in distribution exists in principle, both to connect generation and to access non regulated consumers in distribution networks and there is a specific regulation for that purpose, but barriers are faced in actual application in the case of DG. The original focus of the regulation was to provide open access to third party outside generators that would be interested in supplying large non regulated consumers (over 2 MW), located inside the areas being supplied by distribution companies. In the past those customers have been captive of those companies, with which they have to negotiate their tariffs, without alternative suppliers providing competitive prices. Thus, to overcome that restriction, wheeling charges were clearly defined to reach those consumers through the distribution network. The distribution added value calculated for the model distribution company was to apply. This in theory liberates those large consumers from captivity, as they can reach outside suppliers. Nevertheless, it has not implied a relevant migration to outside suppliers, as generators do not like to confront the distribution companies they supply otherwise. It must also be indicated that the figure of marketer or supplier does not exist in Chile, both the line company and the marketer are integrated in the distribution company.

For the case of renewable generator injections, a classification was made depending on where it is connected to the system [1]. The first category is defined as Small Means of Distributed Generation (SMDG), defined as generators with a surplus capacity of lower or equal than 9 MW, that are connected to distribution networks. SMDG were given the right to connect to distribution networks in a framework specially designed to ease the connection process. A second type are the so called Small Means of Generation (SMG) which are generators connected to any of the three transmission systems with surplus capacity of lower or equal than 9 MW. And third, Non-Conventional Generation Means (NCGM) are generators with a surplus capacity lower or equal than 20 MW, which may include combined heat generation, and contains both SMG and SMDG.

In the case of generators that want to connect at the distribution level (at voltages up to 23 kV), the regulation defines a compulsory open access scheme, allowing connection. SMDG generators do not have to pay wheeling charges for the use of distribution networks, unless they make sales to unregulated clients located within the same distribution network. In this last case, the distribution added value calculated for the model distribution company applies.

SMDG only pay the estimated network losses and the extra investment costs necessary to accommodate the introduction of the distributed generator, which considers the additional costs in the areas adjacent to the injection sites and the cost savings in the rest of the distribution network.

Special regulation had to be introduced for the integration of SMDG, since there was no experience in the country connecting generators from third parties to distribution networks. A complete regulated process was implemented, regulating information flows, permits
requests, deadlines and possible litigation. The process has two main phases; the first is to inform the intention of connecting to the network of the distribution company and requesting the technical data concerning the distribution network, so an application for the network connection can be made; and in the second phase the distribution company must state if it agrees with the connection and the possible additional costs incurred because of the connection, but previously discounting possible benefits received from the distributed generator. Further phases exist if no agreement is reached, with a strict supervision from the competent authorities during the complete process.

V. ACCESS DIFFICULTIES

SMG or SMDG which are located in areas distant from important transmission lines, and only near weak transmission lines or rural distribution networks, face the difficult scenario of not being able to exploit their renewable resources, such as small hydro or costal wind, because the required connection facilities. In those cases, either an additional line or the reinforcement of existing transmission or distribution networks exceeds the benefits, often having to reduce the size of the projects in order to fit existing installations. The convenience of implementing more incentives to aid these remote projects is something yet to be studied, since some of these projects are located in very distant areas, where it would be simply unjustified.

Smaller renewable energy, SMDG, has also faced a difficult process of integration to the market due to the required interaction with the distribution company. Often, distribution companies do not welcome generators in their networks, which combined with an important initial information asymmetry, implies long processes before the actual connection can be made. Often more friendly processes can be seen when the energy is sold to the distribution company, smoothing the road since incentives are aligned. All the aforementioned is aggravated by a lack of experience by generation project owners, which results in a delayed connection process.

A first barrier arises with the need to calculate the cost of grid reinforcement. Faced with a growing demand from DGs wanting to connect to the network, the calculation of connection costs for each DG can become an expensive task for the distribution company, a cost that will be transferred to the DG, becoming an entry barrier. Another problem may arise with the case by case analysis of the costs, which is the possibility of discrimination between projects in the absence of a uniform methodology for all cases. The risk is again high that entry barriers may arise.

Those entry barriers can be used by the distribution company, during the negotiations with the DG, to obtain an advantageous contract with the DG, under conditions less favorable than those of the market, for example denying capacity payments.

Another aspect that creates a barrier to entry in negotiating with the distribution company is, as indicated before, the information asymmetry between the DG and the distributor with regards to consumer needs and characteristics of the loads. Nothing forces the distributor to give such information, if it has it. In addition, negotiations also have a great asymmetry, as the company is generally much larger than the DG. To mitigate this, the regulation considers that, given unsolved differences in the negotiations, the Superintendence of Electricity and Fuels is to intervene to solve the problem.

Nevertheless, given the DG size and its often limited experience in negotiations of this kind, it is very difficult to be able to maintain a conflict with the distribution company it wants to connect to. Thus, it is more likely to eventually accept less attractive terms for interconnection. For example, this may occur in the event that the DG is interested in connecting to the network to sell its energy directly to a large consumer located in the concession area. The distributor might not be willing to lose that consumer and its monopolistic position in the network, so it could use the asymmetry between firms to impose conditions to the DG.

5.1 Specific technical difficulties of DG injections

The installation of renewable distributed generation can produce important savings or additional costs to the distribution company depending upon DG penetration [2], and it may also have important technical implications. The most significant technical disadvantages of installing a DG, from the distribution company’s point of view, are:

a) Losses: a DG connection may be detrimental for the distribution company because it may increase its network losses. The increment of the losses is proportional to the DG penetration, i.e., the ratio between the generator power and the power flow in the feeder.

b) Protections: the installation of renewable energy generation in distribution networks produces changes in the power flows and the short circuit currents of the network. This creates problems in the triggering timing of protections. Therefore, when connecting a renewable generator, the distribution company must re-study the location of protections to maintain the security of the system at the required levels.

c) Voltage control: the installation of renewable energy generation can produce undesired voltage rises in some points of the network. Therefore, the distribution company must perform exhaustive studies on the connection of this kind of generator.

These implications condition that the distribution company may be against the connection of a renewable energy DG.

VI. INTERNATIONAL EXPERIENCE

As reported in [2], a great number of countries promote the installation of renewable energy DG in order to diminish the increase of pollution, and define mechanisms to facilitate their connection.
Germany has an economic incentive for DG where the renewable generator does not have to pay an extra charge for improving the power network. The distribution company must report the costs of the improvement within the total costs for the use of the network, which later are prorated amongst all the consumers of the country, with the intention of not harming the consumers who are located in places beneficial for the location of renewable power plants.

In Spain each distribution company is forced to connect the renewable generator that asks for it, but only when the network to which it is connected is able to evacuate the new injected energy. If it is not possible to evacuate the energy, the generator must negotiate the costs of expanding the network directly with the distribution company. The generator finances these improvement costs.

England is the country that has the clearest legislation to calculate the connection of a renewable generator. There exists a governmental regulation that clearly establishes the manner in which to calculate the network improvement costs which are financed by the generator company. It aims at facilitating the connection of this type of generation, obligating them to pay for the connection to their local distribution network, but not for its expansion.

VII. CONCLUSIONS

While incentive regulation has played an important role in stimulating efficient investment and operation of the distribution service in Chile, today has a restrictive approach to distribution development, particularly in facing the growing incorporation of distributed renewable generation. In effect, the effort to design a tariff system, that gets the best of a distribution monopoly, only looks at the activity as a passive top-down supply-demand unidirectional radial business. The distribution company aims at getting the best returns from the defined tariffs and any interference from third parties will not be welcome.

Distributed generation may imply benefits to the distribution company, in reducing losses, reducing investment in transformers, even reducing generation costs, but it implies technical challenges and eventual problems. Thus, barriers of entry are put in front of the incomer which, coupled to financial and environmental restrictions, are deterring expansion of DG in Chile. The renewable quota targets are in risk.

Regulatory changes are to be made if this is to be overcome, recognizing and rewarding the value of DG, and introducing a prorate allocation of network reinforcements to all consumers (along the lines of the German regulation). No recalculation of the distribution added value would be needed, although efficient incentives, along the same lines, should be incorporated for network reinforcements. Further more, new regulations have to be devised, changing the passive distribution activity into a dynamic one, with new technologies and economic models, coupled to active responsive elastic risk-taking consumers, with a growing role of a new load management concept.

VIII. BIBLIOGRAPHY


IX. BIOGRAPHIES

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