TRANSMISSION NETWORKS OR DISTRIBUTED GENERATION?

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ABSTRACT

In this work the planning and design philosophies of Power Systems are discussed, analysing the situation over the past 50 years and the changes that new technologies which involve Distributed Generation (DG) are producing at present.
The influence of these changes on the Transmission conception is assessed and the validity of the natural monopoly conception discussed.
In addition, the importance of adequate regulations is analysed, studying the particular case of Uruguay.

KEYWORDS

Distributed generation (DG), transmission networks, power market regulation.

1. Historical Background

When the Electricity Supply Industry (ESI) began its activity the need for electric energy in a place was, in general, satisfied by municipal companies that installed generators located according to the distribution needs.
The ESI began its history using distributed generation (DG), in other words, generation directly installed in the distribution network, very near to the demand [1]. The generation was planned in order to satisfy demand, with a certain reserve margin for security reasons.

Later on, the increasing electricity demand was satisfied installing huge generation plants, generally near the primary energy sources (e.g. coal mines, rivers, etc.). The great efficiency difference between one big generation plant and a small one, summing up the fact that the reserve margin that had to be taken in the first case was less than if the same power was installed in a distributed way, gave as a result the traditional conception of the Electrical Power Systems (EPS). In other words, an EPS with big generators which energy must necessarily be transported towards the demand using great transmission networks. This development logic has been systematically promoted by the fact that the transmission system costs have been smaller than the profits generated by the economies of scale in generation [2].
Therefore, in essence, the economies of scale in generation and the fact that their amount has been of such volume that surpass the transmission investment costs, have been the determining factors of today's electric circuits topology.

Finally, the economies of scale have not been the only determining factor in the past development of EPS. In nearly all countries, the integration and shaping of monopolies have been a consequence derived from the policy that the best investment size could only be faced by governments and, for this reason, governments were the exclusive owners that controlled the EPS [3].

2. The ESI traditional conception

Nowadays we have an EPS which conformation is the result of a conception that has been in existence for more than fifty years: big generation plants, generally placed far from where the power demand is, and great transmission networks that carry the generated power to the demand sites. In this traditional conception, electricity production inside the ESI consists in a process that has four stages (generation, transmission, distribution and consumption), which is performed with a given order, defining then four levels, as shown in Fig. 1.

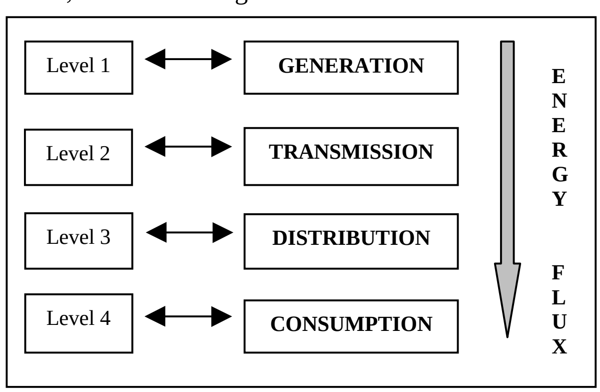

Fig.1. The ESI traditional conception.

2.1 The growth of the system

It is well known that from its early beginnings, the ESI is in a continuos growth owing to the fact that electricity demand grows in a sustained way. This evidently, has produced an increase in electricity generation in a steady way, too.
Inside the traditional scheme of the ESI, the system's growth involves the installation of new generating plants in Level 1 (Fig. 1), in a more or less continuous way, and transmission and distribution network enlargement in a continuous way, too, but with less frequency.
One of the main elements in this development logic is that the taking of decisions comes from a centralised planification generally placed inside a vertically integrated industry.

3. The ESI new conception

The electric market growth, the financial market's development and the accelerated technical progress have made the optimum size in new investments in generation to decrease, in relation to the market's size and to the private financial capacity. As a result, there have appeared new conditions in the generation sector, making it able to be co-ordinated by the market [4].
In addition, the deregulation processes, that have been appearing in the whole world, have made this possible by promoting competence in generation.

A radical change has appeared in the generation costs behaviour in the last decades owing to technological changes. In Fig. 2 thermal plants curve costs are shown over the period 1930 – 1990 [4].

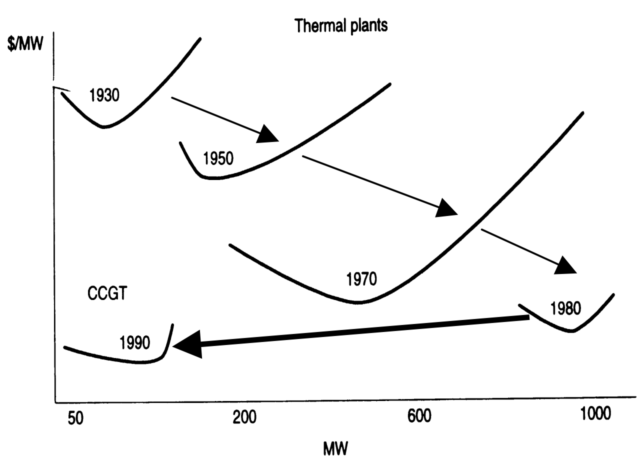

Fig. 2. Generating plants costs curves concerning power (1930-1990) [4].

As it is shown, while until 1980 the MW minimal cost was obtained increasing the generating plant size, towards 1990 a change in this behaviour was produced by obtaining an eminently good point for much less power.

Moreover, if we observe how today's different generation technologies efficiency behave with respect to plant size (Fig. 3), we can observe that for some of the cases, like gas plants, important changes in efficiency are not produced when the generator power varies.

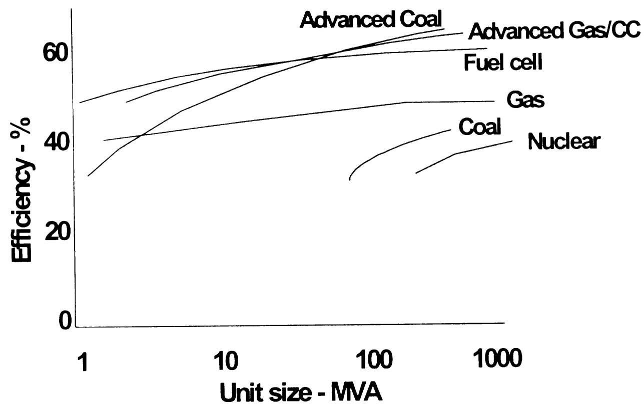

Fig. 3. Efficiency vs. generator power for different technologies [2].

It is important to note that in the past the situation was not this, but on the contrary, the efficiency differences were significant with the variation of the plant's size.
Consequently, the situation has changed with respect to the past. Today there are technologies that allow generation using relatively small sized plants with respect to conventional generation, and with smaller costs per MW generated. This is a technological change that has an appointed strategic importance because the efficiency relation was what in the past dictated the generators' economies of scale. Considering this new situation, one of the basic factors that economically justified the big plants in the past, was lost [4].
A particular interest is revealed in observing these dynamics analogy with those of the informatic systems in the last twenty years, from the mainframe of the '80s to today's "PC networks".

On the other hand, this new size of generators do not need a transmission system because they may be connected directly to the distribution networks, being the energy produced by them consumed directly in the place where it is produced [1]. Therefore, it is not necessary to set any transmission network, avoiding in this way the investment costs that such system implies and the power losses that would be produced if the transport network was set.
Consequently, the tendency is a change in the PES circuits topology.

An evidence of the change that has happened in the generation plant conception can be appreciated in Fig 4, where the average size evolution of those plants in the United States is shown [5].

As it may be observed on the diagram, the generation plants' average size grew up on the 1920 – 1949 period of time at an annual average rate of nearly 5.5%. Afterwards on the following decade the rate increased to a 17%; diminishing then on the later decade. Nevertheless, on the '70s the increase was extraordinarily remarkable, with a peak on the plants average size of 151.1 MW. This time represents the age of nuclear and coal plants.
Starting form the '80s, the appearance of gas technology, together with the end of the nuclear age, produced a complete change on the behaviour that could be observed on previous decades. As it may be seen, the curve slope for this case is negative reaching in 1994 values of less than 30 MW in the average size of generation plants.

In the new conception of the ESI, generation is not exclusive of Level 1 and power flux is not unidirectional like in Fig. 1. On the contrary, we have now a scheme like the one shown in Fig. 5.

In the diagram, we have made distinction between DG and self-generation of energy. The last corresponds to those cases in which a consumer produces electric energy for itself. However, it may be observed that this type of generation may also be considered DG.

In short, there exists evidence that certain determining objective factors of the PES dynamics display strong differences with respect to the past.

3.1 Growth of the system

Inside the ESI new conception, the demand growth can be satisfied in two ways:

- Setting up central conventional generation and enlarging the transport networks.
- Setting up DG.

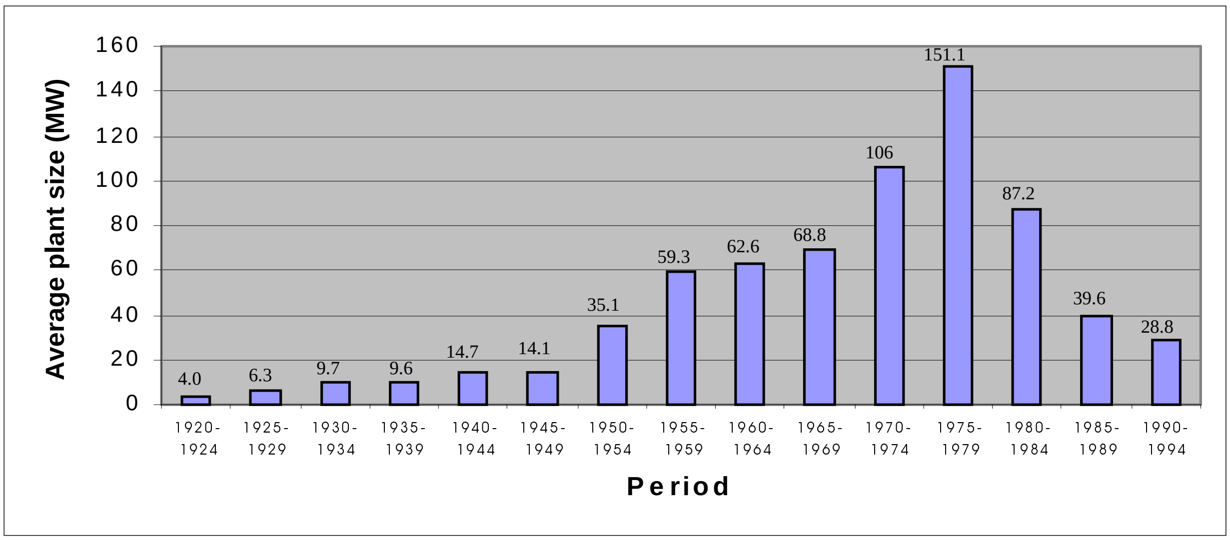

Fig. 4. Generation plants average size in the USA (1920 - 1994). *100 % sampling : 13566 plants* [6].

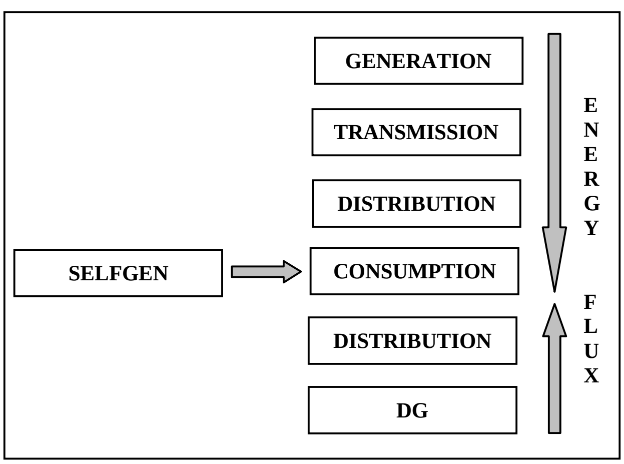

Fig 5. The ESI new conception.

On this new scheme, one part of the demanded energy is supplied by the conventional central generators, while another is produced by DG.

The decision comes up solving a technical-economical problem.
Let us carry out some general considerations.

A big modern plant connected to the transmission network will always be more efficient than a small up to date distributed plant (the scale economies exist when generator dimensions are increased in multiple magnitudes) [2]. Nevertheless, in one of the key magnitudes, the efficiency, the differences cannot be very important, as shown in Fig. 3.
Moreover, if the wish is to power an old generating plant, the associated costs will probably be bigger than if a new distributed generating plant is set up. This is due to the fact that one of the features the distributed generators have is that they are factory produced in a standard way and are afterwards easily set up on site, which notably reduce their cost ("plug and play") [2].

In the options evaluation, the exact costs that must be evaluated are those of the DG plant against the same of the conventional generation plant plus the transport network associated to the latter, as much as in sunk costs, as in maintenance and accumulated losses. As it has already been seen, for the reason of being near to where the demand is, DG does not use the transmission network and thus avoids its associated costs. It is important to note too, that while the global costs of the transport networks construction have increased owing to labour costs and the right of way, esthetic and design constraints, contrarily DG costs have gone down because those plants are made on a standard basis and have a great modularity [2].

In addition to the former considerations, we must take into account that the DG can give additional advantages to the electric systems [6]:

- Reducing losses in the distribution networks.
- Increasing the reliability in the electric energy supply.
- Giving reactive energy control and voltage regulation in the distribution network.
- Generating clean energy using renewable sources (RDG – Renewable Distributed Generation).
- Decentralising and atomising the property in the generation sector, a fundamental characteristic to encourage competence.

As a consequence DG presents several advantages against conventional central generation. Nevertheless, the last decision will have to be the result of a detailed study for the particular case in consideration.

4. Transmission networks or distributed generation? Does it exist a choice?

In spite of the fact that the decision between one or other form to solve the system enlargement for a particular case should involve the assessment of a technical- economical type of problem, the question that appears at this point is: does it exist an option?; in other words, is it possible to choose between one or other of the options, or on the contrary, does it already exist a conditioned option?

Evidently, the imperfections in the market abound in the electric sector. It is enough to observe that the transmission, as well as the distribution are sectors of "great networks" and as such, they are natural monopolies "by definition". Therefore, competence and regulation are activities frankly complementary in this industry but it is the regulation what, in the last instance, will determine the grade of real competence that could exist [3].
Then, in the new ESI of competence, the role played by regulations is fundamental. Regulations must establish fair tariffs systems that recognise the system real costs and profits, and avoid crossed subsidies between the different agents and the existence of direct or indirect restrictions to the coming of new agents [6].

However, what it is seen in several of today's regulations is a traditional conception of the ESI, characterised by the four levels already seen (Generation – Transmission – Distribution – Consumption). With this vision, the new conception of the ESI is disregarded, making tariffs structures to fail in recognising true costs and real profits of DG. Consequently, they make DG to lose competitiveness.

It is already possible to note this situation in the approved regulation for the Uruguayan case on the present time. As a matter of fact, according to article 54 of Decree 22/999 [8] about electricity prices, it is established that tariffs must reflect: wholesale costs, transmission system costs and distribution cost. This is understood as costs of generation, transmission and distribution. Therefore the pattern expresses the conception that all the energy that the distributor uses necessarily passes through the transmission system. Article 72 decrees by law this conception with further details confirming the prejudgement.
In consequence, if a distributed generator sells in the spot market, its fundamental competitive advantage, which is not using the transmission system, will not be reflected because the normative does not make any difference on where the energy that goes to the distributor comes from.
If we start from the principle that it is only paid what it is used and according to how much it is used, the distributed generator that does not transform the boundary node of the distributor circuit to which it is connected in exporter, should not pay any transmission costs.

5. Transmission: natural monopoly or competitive market?

As we have already mentioned and the extensive specialised bibliography shows, the transmission of the PES have been to the present time what we call a natural monopoly. In the processes of regulatory change, in which the electric markets are inserted, the regulations are confronted against the complex task of regulating a natural monopoly.
Particularly, the complexity is also magnified by the fact that technological revolution may develop forces that produce the disappearance or impairment of the "natural" factors that determine the existence of a monopoly.
Regulations must allow the appearance of those forces with the intensity that corresponds to them and not mitigate them with rigid policies that keep the fictitious existence of a monopoly [3,7].
It results then very important to detect and define with precision which is the main factor that makes a company to be listed as a natural monopoly. In theoretical terms,

we must detect what makes that the company's average costs, in the expected production range, be decreasing [9]. This by the side of the offer, while by the demand's side we must detect the reason that makes the captive demand appear for that monopoly.

For the case of the transmission sector, the answers to the former questions have not generated much debate. The fixed costs high impact in front of the variables and the rigidity of those for wide production ranges (kW transmitted) is what makes that average costs be decreasing. Furthermore, these fixed costs are on their great majority irreversible, so they are then sunk costs, that impose restrictions at the arrival of the competition by the offer's side. By the demand's side, as it was explained at the beginning, the whole generation built up by big generators, was set up in the transmission system. Therefore any user that has the intention to sell or buy electric energy needs to be a user of the transmission, in other words it is a captive of it.

On the other hand, the main characteristic of the DG is that it offers a viable and competitive alternative for any user who wish to consume electric energy without being necessarily connected to the transmission system. Due to this fact, the transmission tends to lose its captive demand. Therefore, the transmission loses one of the "natural" factors which makes it a monopoly.
In these conditions, the regulated and isolated determination of the transmission prices tend to lose validity. What is more, if the regulator wishes to fix a price, in theoretical terms, the system must tend to adjust the quantity of energy demanded to the transmission system [9]. In effect, let us suppose that the regulator fixes a high price. Then the energy price at the grid supply points (i.e. boundaries between the transmission and the distribution systems) would rise. This would produce an increase in the DG offer, which would become more competitive, which finally would make to decrease the amount of energy demanded to the transmission system. This mechanism adjust then the amount of energy demanded to the transmission system to the new price.

Evidently, to make this situation effective it results vital that the regulation allows it, respecting the DG key competitive natural factor and not charging transport costs to an activity that does not use that service.

Conclusions

When considering the expansion of the electric system, DG appears like an option to transmission systems.
For each particular case it will have to be decided which of the two options is the best solution from the technical-economical point of view. However, regulations that do not recognise real costs and real profits involved in the electric system and in particular those of DG will make it to lose competitiveness and will distort the EPS efficient development.

The regulations must be flexible enough as to absorb the change of speed imposed by today's technological advance.

For the case of Uruguay, there is no present evidence in the regulations that consider DG. If this situation does not change, DG will probably not develop.

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