Preface

1.1. Electric energy

Energy, which was the basis of the industrial revolution, has had an exponential growth since the birth of industrial electricity at the end of the 19th century. The discovery of the rotating field by Nikola Tesla and the invention of the transformer allowed the expansion of three phases: alternating currents for generation, transmission, and delivery and uses of electric energy in the cheapest way.

At the beginning of the 20th century the development of large electric power grids enabled many countries throughout the world to bring the benefits of electric energy to their citizens, while intensively developing the industrial and tertiary applications of electricity. This growth led to generalization of the use of electric energy in domestic applications and all sectors of industry.

Generation, transportation, transmission and distribution of electric energy were considered to be such strategic operations by most countries that they decided to build them as monopolistic state companies in order to control their development. These decisions and the heavily capitalistic nature of generating and transmission systems led to a vertical integration of electric energy utilities for economic reasons. This is the classic paradigm that for more than a century has allowed the creation of an industry that reached the heights of its power in a slow but constant improvement of the reliability of equipment, the main objective being to ensure the supply of electricity to domestic and industrial customers connected to the grid. The tremendous growth of electric energy consumption during the middle of the last century led to the construction of very large and complex electric power systems (for instance, in the French grid, more than 66,000 MW are flowing at any time in about 1,300,000 km of lines and cables).

Figure 1 shows a schematic representation of these systems.

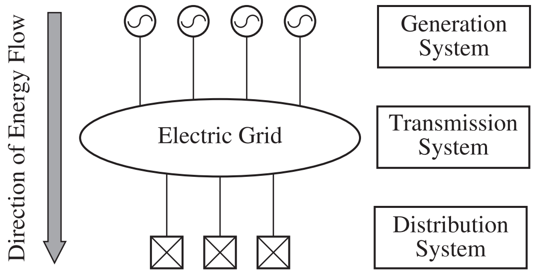

Figure 1. *The historic paradigm*

All electric power systems have been built and operated according to this diagram from the beginning, and for almost all, of the 20th century. Their organization and their operation from generation to the consumer were integrated inside only one, generally monopolistic, private or public company.

The deregulation that started at the beginning of the 1980s introduced a tremendous change by imposing the unbundling of the functions of generation, transmission and distribution. This change introduced a new mode of organization according to a broken up model we shall describe in the next paragraph as the new paradigm.

1.2. The new paradigm

The goal aimed at by the instigators of the deregulation of electric systems has always been to promote a new organization of the electric systems in order to create the conditions of commercial competition among all the stakeholders: the aim is to lower the price of electric energy supply for consumers.

The setting up of new regulations took place in a context where geographic constraints were prominent due to the territorial settlement of power grids that were in fact naturally monopolistic.

However, the new system instituted in the UK at the beginning of the 1990s, and then in the USA, is now installed in almost all developed countries, although with some difficulties of adaptation. As a matter of fact, the systems designed and built on to be operated as an integrated company in a well-defined territory must today be operated on a continental scale without prior modification of the infrastructures of transmission and interconnection.

1.2.1. *The energy system in a deregulated context*

The major functions which must be carried out in order to satisfy consumer demand are the same as previously described but with a different mode of interaction, and they are operated by different actors according to the five essential links described in Figure 2.

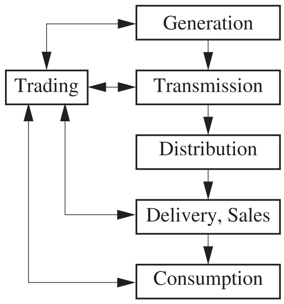

Figure 2. *The new organization of electric systems*

This new organization creates a total hierarchical independence between the producers and the other members of the system. The producers of course are in charge of the generation. They sell to consumers according to several kinds of contracts for short or medium term delivery. The traders are the link between generation and consumption, taking into account the power transmission capacity through transmission and distribution grids.

The power grids must ensure the transmission of energy to the consumers according to the trading exchanges they had with the producers, insuring equitable treatment for all producers. Independent system operators for transmission and distribution grids are in charge of this duty.

This new set of concepts generates not only drastic changes in the economic conditions of the electric system's operation, but also significant technical changes that favor the new technologies with dispersed generation, especially renewable energy technologies that will continue to be the foundation of consumer power.

1.3. Dispersed generation

The economic issues arising from the new regulations incite the big consumers to buy internal generation units in order to smooth the price fluctuations coming from deregulation. They are of course small generation units of limited power, generally connected to distribution grids. These units will be able to control the power imported by the consumer, who will be able to sell his energy on the market by injecting it into the grid if price conditions are favorable. The development of a large number of small generation units from solar, wind, small hydraulic or thermal units, with combined heat and power, alongside classical large generation machines, will superimpose a new phenomenon on the normal operation of the distribution grids: bidirectional energy flow, generally intermittent and random according to wind and sun production.

This phenomenon will create new difficult problems such as the management of these energies while keeping the grid security at the required level.

The new paradigm, which integrates dispersed generation with the economic environment, will lead to a new operation scheme for electric power systems, one that will increasingly be a substitute for the present scheme as described in Figure 3.

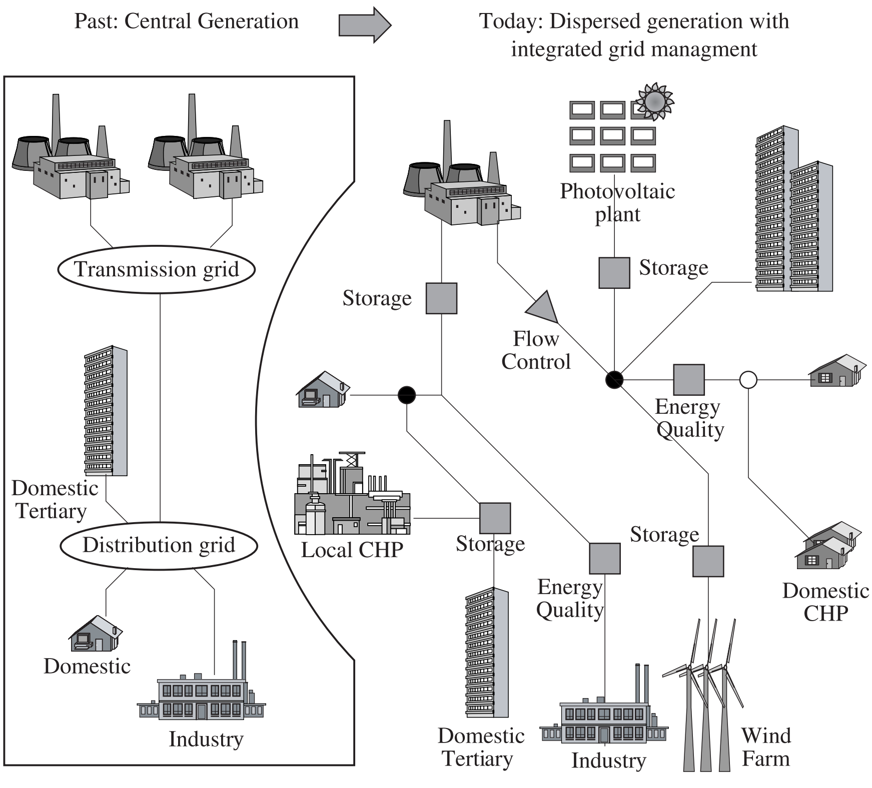

Figure 3. *The new electric power system*

1.4. The new energy generation and management

Independently of these new schemes of grid operation, in the following chapters we shall describe the main characteristics of the emerging generation technologies that will be installed on the grid of the next decades.

In the first volume, *Renewable Energies*, we reviewed the new energy technologies in terms of the types of renewable energy. This second volume, *Low Emission Technologies and Energy Management*, will deal with reduced emission technologies and energy saving.

Volume 1 includes various forms of solar energy such as photovoltaic, thermal and thermodynamic energy conversion.

Wind technologies are in full development today. The chapters dedicated to them describe the state of the art, taking into consideration the question of insertion into the grids of a large quantity of this intermittent energy.

Energy from the sea completes this general view, with a chapter discussing very small hydraulic plants that become of interest when fossil energies become more and more expensive.

We then provide an analysis of geothermal energy, followed by energy from biomass. This entails a full description of biofuels and biogas, and especially energy from wood as a substitute to fossil energy heating.

Volume 2 is dedicated to energy storage, low emission technologies and energy management.

We start with the new generation of nuclear energy, which is presently at a crossroads of its history with these future new generations. It then analyzes combined heat and power generation, by which it is possible to produce heat and electricity jointly as a complement to heat generation in order to improve the efficiency of heat plants. A very careful analysis of the economic conditions of the operation of combined heat and power leads to a description of the economic conditions for which this technology is advantageous.

Energy storage describes the various means and methods of storage in association with intermittent energies like photovoltaic and wind energy plants. Their efficiency and cost are strongly dependent upon their operational facilities and investment costs.

A projection of the use of hydrogen as an energy vector similar to electricity will give readers a comprehensive view of the way to create, store and transport this gas, which is generally improperly considered as very dangerous. Its future using fuel cells as a conversion facility allows us to foresee significant development of this energy vector with a large set of applications.

Finally, we take up the very important subject of energy management, control of energy demand, and energy saving. We describe positive energy houses, low consumption public and domestic lighting, and power moderation by control of the load from the grid.

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