

Security of supply and renewable energy in the light of the opening of electricity markets to competition

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1. Introduction

This article analyses the problem of electricity security of supply and the development of renewable energy (RE) in the light of the opening of markets to competition. It takes into consideration both developed and developing countries. It attempts to identify the advantages and disadvantages of competition and analyse market dynamics. The problem is very complex, notably due to technical constraints, and is topical since the electricity crises of California and Brazil.

The article is organised in the following manner: first we define the problems of electricity supply security, RE development and market organisation. Using Schumpeter's approach, we bring to light the postulates of the neoclassical paradigm that inspired the pioneers of market reorganisation. In point 3, we discuss the concept of risk, which orientates our analysis. Then, in point 4, we analyse the problems of security and RE development in a market which tends to competition. Point 5 presents the measures destined to face such problems. We evoke rational use of energy (RUE), which should be developed in parallel to RE. Points 6 and 7 respectively analyse hydroelectric systems and the development of new renewable energy (NRE) in the perspective of distributed resources (DR). We provide illustrations taken from Brazil and Norway's experiences, followed by conclusions.

2. Problem

Electricity systems, both monopolistic and competitive, are judged severely on the security that they provide. This is based on prices, quantities and quality of supply. In the short term, it is given by the instantaneous equilibrium between supply and demand and the networks' stability. In the long term, it implies the diversification of supply sources and the constitution of a well balanced portfolio. Thus, it creates a utility for renewable energy (RE) and rational use of energy (RUE), in order to face the problems posed by fossil fuels and nuclear energy¹.

New renewable energy (NRE), such as wind power and solar are relatively heterogeneous. Some technologies are already profitable. Some sources are predictable, such as tides, while others are random. The specificity of NRE also lies in their rhythm of penetration into the

* We thank the Federal Office for Education and Science for its support, as well as Luke Gueriane, student, for his assistance.

¹ European Commission (2001), *Towards a European strategy for the security of energy supply*, Green Paper, Luxembourg.

market and the reduction in the production costs, depicted by their learning curves. This raises several problems with regards to security and the opening of markets to competition².

Hydroelectric plants with storage provide a flexible source of energy. They provide an important role for network stability and are able to compensate for the variability in generation of certain RE, like wind power. Hydroelectricity does, however, present substantial seasonal and annual variations. As is the case for NRE, investment is capital intensive, so much so that in the beginning of the opening of markets decision-makers began to ask whether hydroelectric installations represented stranded investments³.

In monopolistic environments many Northern countries over-dimensioned capacity⁴. They considered costs incurred by electricity surpluses to be lower than those incurred by deficits. Furthermore, they attempted to reach a high degree of energy independence, by avoiding having to resort to importations and use of non national resources. Certain countries launched highly ambitious nuclear programs⁵. NRE were often neglected. Economic efficiency was not the primary concern of electricity companies. This does not mean that they were unable to obtain satisfactory results.

On the other hand, in several developing countries electricity companies didn't carry out the necessary investments due to the inefficiency of public companies, inappropriate tariff systems, public debt, as well as the macroeconomic risk. It should be pointed out that in certain cases the annual deficits of loss-making public enterprises far exceed the budgetary provisions for health and education⁶. Market tensions are expressed by frequent black-outs.

With the opening of markets to competition and vertical de-integration, priority is given to economic efficiency. In the opinion of market opening supporters, efficiency guaranties security. Opponents point out that the market's invisible hand can be electrocuted. Certain studies foresee reductions in investments and weakening of reserve margins. They also await a "rush for gas" at the cost of diversification of supply sources. Other studies are less sceptical. For example, Martin raises that "With the emergence of a new organisational model, other technological orientations gain importance: such as small thermal stations that burn wood and waste, combined heat and power, wind power, photovoltaics and above all gas turbines"⁷.

The security problem was in all likelihood underestimated by the market opening pioneers, who had been inspired by neoclassical models. In fact, in such models equilibrium is assured in an almost automatic and instantaneous manner. In order to question the pertinence of the neoclassical paradigm, it is useful to recall Schumpeter, who brings to light the problem of

² Lachal B. (1999), Spécificité des énergies renouvelables, in Lachal B., Romerio F. éd., *Quels systèmes énergétiques pour le XXI^e siècle ? Production*, Université de Genève, Collection Energie, Environnement, Société, p. 21-36.

³ Romerio F. (2002), European electrical systems and Alpine hydro resources, *GAIA*, 3, p. 200-202.

⁴ In some cases, investment has nonetheless been paralysed by regulatory constraints related to pricing or the environment (Joskow P.L., Schmalensee R. (1983), *Markets for power*, The MIT Press, Cambridge MA, p. 6).

⁵ Romerio F. (CUEPE) (1998), The risks of the nuclear policies, *Energy Policy*, 26 (3), p. 239-246; Romerio F. (2005), *Nuclear energy, an option for sustainable development ?*, Investing for Sustainability, 5th SESSA Conference, Universidad Pontificia Comillas, Madrid, May 19-20.

⁶ United Nations Development Programme (UNDP) (1996), *Human development report 1996: Economic growth and human development*, Oxford University Press, Oxford, New York, p. 83.

⁷ Martin J.-M. (2000), Le changement des technologies de l'énergie : genèse, modalités et hypothèses explicatives, in Bourgeois B., Finon D., Martin J.-M. (éd.), *Energie et changement technologique, Une approche évolutionniste*, Economica, Paris, p. 52.

disequilibrium⁸. He writes: “once equilibrium has been destroyed by some disturbance, the process of establishing a new one is not as sure and prompt and economical as the old theory of perfect competition made it out to be” (p. 103). Even if Schumpeter could not have imagined the consequences of disequilibrium on an electrical system, the neoclassicists have not grasped the dynamics of disequilibria on goods and services markets.

Schumpeter does not believe in perfect competition that he qualifies as an “entirely imaginary golden age” (p. 81). He defends the idea that competition is a process, which is more realistic, notably in view of possible oligopolistic reconfigurations of the electrical sector. From his point of view, the existence of oligopolies can facilitate investment and innovation. He raises the question of risk coverage as follows: “Long-range investing under rapidly changing conditions... is like shooting at a target that is not only indistinct but moving-and moving jerkily at that. Hence, it becomes necessary to resort to such protecting devices as patents or temporary secrecy of processes or... long-period contracts secured in advance” (p. 88).

Innovation – new products, technologies, markets, forms of industrial organisation – represents a fundamental impulsion for “the capitalist engine” (p. 83). It is fundamental for security in the long term. Furthermore, innovation can help fight dominant positions, even if in the electricity sector this may be more difficult. One must not lose sight of the entrepreneurial figure, defining strategies, not accepting to follow passively the spot market price fluctuations.

Schumpeter underlines that one must judge a system’s efficiency with time, “through decades or centuries”. He writes: “A system... that at every given point of time fully utilizes its possibilities to the best advantage may yet in the long run be inferior to a system that does so at no given point of time, because the latter’s failure to do so may be a condition for the level or speed of long-run performance” (p. 83).

For neo-classicists, regulation is to overcome market failures and help reach the ideal situation of perfect competition. For Schumpeter, it is useless and counterproductive, due to the absence of information, the regulator’s capture, rent-seeking groups, etc. This criticism is pertinent if we remain on economic field. It is contestable when we are confronted by extra-economic realities, as is the case with physical systems such as electricity. We can however, envisage the creation of regulatory references in order to stimulate certain processes, in a Schumpeterian spirit. For example, defining technological strategies that raise companies’ creativity and that orientate innovative activity in directions seen as socially beneficial, as proposes Martin⁹.

In brief, while monopolies can as easily bring over-dimensioning as under-dimensioning of electrical equipment, competition creates a risk of under-dimensioning. Neither monopoly nor competition alone assures an adequate diversification of supply sources. This particularly concerns NRE. The specificities of RE offer real term advantages and disadvantages to the management of electricity systems. The market is characterised by imperfect competition and disequilibrium. Regulation becomes necessary if we consider the extra-economic realities.

⁸ Schumpeter J.A. (1950), *Capitalism, socialism, and democracy*, Harper, New York. On these issues, cf. De Marchi N., Blaug M. eds. (1991), *Appraising economic theories: studies in the methodology of research programs*, E. Elgar, Brookfield; Robinson C. (2000), Energy economists and economic liberalism, *The Energy Journal*, 21(2), p. 1-22.

⁹ Martin J.-M. (2000), Des politiques technologiques mieux adaptées, in Bourgeois B., Finon D., Martin J.-M. (éd.), *op. cit.*, p. 432.

3. Approach

We broach the subjects of security, renewable energy and the opening of markets to competition in terms of “risk”¹⁰. Risk refers to the possible apparition of an event provoking negative consequences. However, we often expose ourselves to risk in the hope of obtaining an advantage. In many cases, we can choose between several types of risk, which brings us to study relative risks. Risk must be identified then managed.¹¹

Risk is defined by a hazard and the consequences of its occurrence. The hazard represents the probability of occurrence of the event. It is characterised by its nature and in some cases by its magnitude. Some hazards are independent of human will; others can be influenced by different types of measures. The hazard’s occurrence affects either totally or partially the elements at risk. Such elements consist in populations, economic activity, infrastructures, etc. In order to evaluate losses of elements at risk, we can take into consideration vulnerability. It is expressed by the fact of being prone to or susceptible to damage. We can also introduce the concept of capacity, i.e. the fact of being prone to or susceptible to recovery. Interactions between vulnerability and capacity can lead to “creative destruction” phenomena. The occurrence of some hazards can provoke disasters. At the root of the disaster, we can also find a strong vulnerability coupled with a weak capacity. We are therefore confronted by major risks that can lead to extraordinary losses.

Risk is a complex function of time and space. The hazard can appear in an almost instantaneous manner or relatively slowly. It can bear short, medium and long term consequences, on a local, regional or global scale. It can cause instability and irreversibility. The estimation of hazard, vulnerability and capacity can be surrounded by high uncertainty margins. In order to understand these phenomena, one must study physical, technological, economic, social systems, etc., which can be extremely complex.

It is possible to reduce risk by adopting measures that allow the lowering of the hazard’s probability of occurrence, weakening vulnerability or reinforcing capacity. A weaker vulnerability and greater capacity allows a much greater tolerance of the presence of hazards.

We suggest an analysis of the risks related to electricity prices, tensions between supply and demand and supply quality in the short, medium and long term. These risks are caused by a number of hazards that are linked to the following elements: climatic conditions, economic fluctuations, production and transport costs, equipment and raw material availability, green energy and pollution rights availability, speculative behaviour, technological progress, life style changes, political decisions and regulatory measures. The risk’s amplitude depends notably on the vulnerability of the elements at risk: poor market design, poor regulatory conception, unstable political and regulatory frameworks, weak price elasticity of supply and demand, low reserve margins, low levels of supply diversification, very energy intensive economic growth, unsatisfactory equipment, strong uncertainties surrounding evolutions in key economic parameters, poor financial capacity, high externalities, presence of public goods and free riders, insufficient effort in R&D, socio-political conflicts. Strong disruptions of an electrical system can provoke major risks. California’s electricity crisis provides a well known illustration.

At present, the global evaluation of risks related to electricity supply can only be carried out using a qualitative approach. In fact, we are confronted by multiple phenomena concerning

¹⁰ Romerio F., *A concept of risk for the understanding of energy problems and their environmental and social implications* (forthcoming).

¹¹ There is also the problem of subjective attitudes towards risk that are not covered in this paper.

society, politics, technology, the environment, etc., that are extremely difficult to measure and bring to a common denominator. However, inevitably partial, more precise quantitative analyses are extremely useful for decision making.

4. Analysis

a) Market, price, investment

In the course of a day or a season, wholesale prices can undergo strong fluctuations around a rising or falling trend. Volatility is very high. As stated by Boucher, Ghilain and Smeers, “Power prices stand out even in comparison with several commodities that are notorious for a high degree of price volatility (such as natural gas)”¹². In some cases, we can have rationing prices. In other cases, prices can fall below variable costs. These fluctuations aren’t limited by consumer reactions as price elasticity of demand is very low and these prices are not usually passed onto final consumers.

Investment returns that depend on the frequency and durations of supply-demand tensions are perhaps too low to encourage new investments. The problem of reserve margins is particularly delicate, notably due to the low rates of equipment’s use. We can imagine the apparition of a cyclical movement¹³. In fact, when the market is strained, prices rise. In principle, companies invest and we have new entries. When there is over-capacity, companies are incapable of covering fixed costs, sometimes even variable costs, and they no longer invest.

If companies are in a position to practice market power, they can attempt to provoke deficits in the aim of obtaining higher prices. This can lead to delaying investments, capacity retention, and perhaps even provoking bottlenecks in networks. The problem becomes particularly delicate when peak and reserve equipments are controlled by one or two companies that can, in this respect, profit from a monopolistic or duopolistic situation¹⁴. “It is the relatively inelastic demand for electricity, compounded by a general lack of storage that makes electricity markets so vulnerable to the exercise of market power”¹⁵.

b) Competition, diversification and innovation

The opening of electricity markets to competition penalises investments that are capital intensive, present long pay back periods, aren’t very flexible and entail relatively high levels of risk. This could orientate investment towards combined-cycle gas turbines (CCGTs) at the cost of supply diversification, notably in countries that are already highly dependant on fossil fuels. By “diversification”, we mean the creation of a well balanced portfolio, consisting in different sources of energy that are as little correlated as possible¹⁶. Projects that are negatively correlated with other sources of national income, that is, projects that tend to pay off in adverse circumstances, represent an insurance against adverse states of nature¹⁷.

¹² Boucher J., Ghilain B., Smeers Y. (1998), Security-constraint dispatch gives financially and economically significant nodal prices, *The Electricity Journal*, Nov., p. 54.

¹³ Ford A. (1999), Cycles in competitive electricity markets : a simulation study of the Western United States, *Energy Policy*, 27, p. 653.

¹⁴ Green R., Newbery D.M. (1992), Competition in the British Electricity spot market, *Journal of Political Economy*, 100 (5), 929-953.

¹⁵ Boucher J., Ghilain B., Smeers Y. (1998), *op. cit.*, p. 54.

¹⁶ Stirling A. (1994), Diversity and ignorance in electricity supply investment: Addressing the solution rather than the problem, *Energy Policy*, 22, 195-216.

¹⁷ Dasgupta P.S., Heal G.M. (1979), *Economic theory of exhaustible resources*, Cambridge Economic Handbooks, p. 386.

The search for high, almost immediate returns and lower risk could paralyse innovation. However, in some fields this hypothesis seems to be contradicted by facts. An illustration of such can be provided by the development of DR, as we will see in point 7.

It is not possible at present, to predict the effects of an oligopolistic type organisation of the electricity sector with regards to investment and diversification. Nelson and Winter argue that “An oligopolistic structure has the potential of combining the best aspects of competition and pluralism and of R&D benefit internalization. But such a structure also has the potential for combining the worst features of monopoly and competition”¹⁸.

c) Vertical de-integration

De-integration of electricity generation, transport, distribution and supply, is aimed at avoiding competitor discrimination and cross-subsidization. It is a legitimate approach, but might discourage investment. Finon shows that in France they tried to limit de-integration in order to “defend the possibility of reinvesting in new electro-nuclear units”¹⁹. De-integration can also cause problems related to the co-ordination of different functions of the electrical system. For example, the incentive for the utility to go beyond the meter may be cancelled out.

d) Public goods and free-riders

Security – as opposed to electricity supply – can be seen as a public good and present the problem of free-riders, which is also often mentioned in literature on NRE. Abott states that the principles on non-rivalry and non-exclusivity characterise investment in security²⁰. He states that “any expansion in capacity designed to meet growth in demand not only reduces the risk of blackouts for those being supplied from the new plant but also reduces everyone else’s risk at no extra cost. This means that security is non-rival in public good terms. Security of supply also appears to be nonexclusive in that it is difficult to exclude people from benefiting from that...” (p. 31-33). Therefore, electricity market prices may not sufficiently reflect security’s social value and discourage investment.

This analysis is not shared by all experts. Robinson for example raises that security is an important attribute of any good or service so markets will tend to supply it to the extent that it is required by consumers²¹.

e) Market and institutional weaknesses in developing countries

Stiglitz points out that “Market failures are particularly pervasive in less developed countries”²². Pollitt stresses that “For privatization to work in many of these countries,

¹⁸ Nelson R., Winter S. (1982), *An evolutionary theory of economic change*, Harvard University Press, Cambridge MA, p. 390.

¹⁹ Finon D. (2003), Les incitations à l’investissement dans les industries électriques libéralisées du Nord et du Sud. La nécessité d’arrangements institutionnels adéquats, in *Energía, Reformas Institucionales y Desarrollo en América Latina*, Universidad Nacional Autónoma de México (UNAM), p. 354.

²⁰ Abbott M. (2001), Is the security supply of electricity supply a public good ?, *The Electricity Journal*, August-September, p. 31-33. Also Lieb-Doczy E., Börner A.-R., MacKerron G. (2003), Who secure the security of supply ? European perspectives on security, competition, and liability, *The Electricity Journal*, Dec., p. 12.

²¹ Robinson C. (2000), Energy economists and economic liberalism, *The Energy Journal*, 21(2), p. 13-14; cf. also Rochlin C. (2004), Resource adequacy requirement, reserve margin, and the “public good” argument, *The Electricity Journal*, April, p. 52-59.

²² Stiglitz J.E. (1989), Market, market failures, and development, *American Economic Review*, p. 202.

attention will need to be paid to the re-building of fundamental institutions such as property rights, competition authorities, and stock markets and so on²³.

In such conditions, it is very difficult to assure investment in electrical infrastructures and to find necessary finance sources. There is also the problem of corruption, often nourished by companies situated in Northern countries²⁴. The IEA points out that mobilising the capital needed to build power plants and to add sufficient transmission and distribution capacity may prove an insurmountable challenge for some developing countries²⁵.

f) Summary

One must acknowledge the supply risks related to competition. There are many hazards and they are not always controllable. Vulnerability can be high, as we have noticed in several countries. In developing countries, it is particularly important due to the weaknesses in markets and institutions.

Disequilibria between supply and demand are market intrinsic characteristics. We may assist in their amplification. They manifest themselves as, for example very high or very low spot prices, over and under-investment cycles of an unpredictable duration, or as inadequate supply portfolios. It is important to understand the dynamic character of market phenomena, their paths, convergent or divergent, and the processes that can worsen disequilibria or lead to new disequilibria. The problem of NRE is particularly delicate, due to technical and economic constraints.

A halt to investment, weak diversification, insufficient innovation, can induce greater tolerance to imperfect competition, market power and notably the presence of oligopolies. On the other hand, speculations destined at creating artificial price rises, attract competition. In the same manner, lacks in coordination of the electric sector favour re-integration projects, whereas crossed finance and competitor discrimination, the opposite.

In the point that follows, we present the measures aimed at facing supply risks, based on market organisation and regulation. A parallel with risks incurred by monopolistic organisation is presented in the conclusions.

5. Measures

a) Energy and power

Wholesale markets only allow the remuneration of the energy actually supplied. It is difficult in such conditions to secure a return on reserve equipments. Regulation markets determine a price for this kind of service. However, the problem of volatility also characterises these markets. Futures allow an insurance against volatility, but do not present a solution to the investment problem as these markets are currently still thin beyond six months. Medium and long term contracts allow to hedge against the problem of investment and diversification to a certain extent²⁶. In the other hand, they create rigidities that cause other disadvantages.

²³ Pollitt M.G. (1997), The impact of liberalization on the performance of the electricity supply industry: An international survey, *Journal of Energy Literature*, 2, p. 16-17.

²⁴ We often cite the example of Westinghouse which allegedly paid Marcos US\$ 80 million to get the contract to build a nuclear plant.

²⁵ IEA (International Energy Agency) (2004), *World energy investment outlook, 2003 Insights*, Paris, p. 366.

²⁶ Borenstein expresses a more shaded view: "Long-term contracting is an important part of the solution to the fundamental problem of electricity markets, but it does not "solve" the mismatches between supply and demand. It just prevents large fluctuations in electric bills when those mismatches occur. It can, however, be used to pay for excess or standby capacity by assuring that the generating companies receive payments sufficient to cover their capital costs even if demand turns out to be low and some of the capacity does not get used" (Borenstein S.

The application of capacity payment or of capacity requirement principles represents a possible response to this type of problem. The reserves would thus be remunerated independently of the energy actually supplied. In the case of the capacity payment, the regulator sets a price for capacity and lets the market determine the amount of capacity available. In the case of the capacity requirement, the regulator sets the amount of capacity that has to be available and lets the market determine its price²⁷. These instruments may lead to strategic behaviours. The IEA points out that “There may be incentives in the short run for gaming the rules, for instance, by manipulating the availability of plants to increase revenue”²⁸. Another concern is the interaction among systems with and without capacity mechanisms, which may lead to distortions.

A more interventionist approach would be the definition of “security of supply obligations” (SSOs) by regulators that force system operators or market operators to ensure a sufficient reserve through appropriate investment or contracts. Pérez-Arriaga points out that “This approach... may seriously interfere with the proper functioning of the market”²⁹; he also criticizes “the breakdown of the market into two different parts: the competitive market and the units under the control of the system operator as strategic reserve units”.

We can also envisage obligatory licences for investors and operators, aimed at assuring market transparency, notably regarding security and diversification of supply source portfolios. Newbery points out that “Licence conditions are important as they specify the information that must be made available to the regulator to monitor conduct”³⁰. The regulator, on his side, should carry out perspective studies of market evolutions and make public references on this subject.

b) New renewable energy (NRE)

NRE can be promoted through a system of guaranteed purchase prices (feed-in system), competitive auctions or Tradable Green Certificates (TGC)³¹. With the first system, electricity companies are forced to purchase electricity from NRE producers situated in their activity zones, at a price fixed by authorities, guaranteed for a certain period. The risk for the investor is very low. Incentives to lower costs are insufficient, unless they are accompanied by progressive reductions in prices. However, the system may be very costly in subsidies and encounter acceptability problems. Despite the latter, it has already known an incontestable success in terms of installed capacity.

The second system entails an auction organisation for a given quantity of NRE; competition is based on price per kWh; offers are classified in rising order until the auctioned quantity has been reached. There is an obligation to buy the production. The investor must bear a relatively

(2002), The trouble with electricity markets: Understanding California’s restructuring disaster, *Journal of Economic Perspectives*, 16, 1, p. 203).

²⁷ Definition of payment and capacity obligation is based on the concepts of “value of lost load” (VOLL) and of “loss of load probability” (LOLP).

²⁸ IEA (International Energy Agency) (2002), *Security of supply in electricity markets: Evidence and policy issues*, Paris, p. 20.

²⁹ Pérez-Arriaga I.J. (2001), *Long-term reliability of generation in competitive wholesale markets: A critical review of issues and alternative options*, Instituto de Investigación Tecnológica (IIT), Universidad Pontificia Comillas, Madrid (www.iit.upco.es).

³⁰ Newbery D.M. (2002), Problems of liberalising the electricity industry, *European Economic Review*, 46, p. 923.

³¹ Finon D., Menanteau P. (2003), La promotion de l’efficacité énergétique et des énergies renouvelables dans des marchés libéralisés : le besoin de nouveaux cadre incitatifs, in Lachal B., Romerio F. éd., *L’énergie, controverses et perspectives*, Université de Genève, Collection Energie, Environnement, Société, p. 259-274.

high risk. The incentives to reduce costs are high. Nevertheless, this system has given disappointing results³².

With the TGC system, we impose obligatory quotas of use of NRE to electricity companies. These companies have the choice of either producing these quotas themselves, buying them off an NRE producer or purchasing certificates. These certificates are diffused by NRE producers, who in this way remunerate their production through sales of electricity produced at market prices on the one hand, and on the sale of green certificates on the other hand. We can consider a regular and progressive increase in these quotas. The competition between producers is expected to lead to a fall in price of green electricity. This system allows electric companies to comply with their obligation in a flexible manner. However, the green certificates' volatility could undermine fuel price stability, which is one of the system benefits ascribed to increased penetration of NRE into electricity markets. A certain number of solutions have been proposed in this respect. For instance, when yearly renewable generation exceeds annual demand, banking could provide a mechanism to transfer the aggregate renewable energy credits supply into future years, giving market participants a way to capture the value of renewable generation that otherwise has no immediate value³³.

The integration of variable supply sources such as wind, into electrical systems raises the problem of reserve creation that must be able to compensate for any reductions in production. The cost of these reserves depends on the energy's contribution to peak demand³⁴. It is endured by the system operator if we adopt the guaranteed price system. In TGC's case, price fixing rules for imbalances between anticipated and real flows can penalise variable energy sold on the market³⁵. In order to overcome this problem, we can envisage a reduction in these penalties, a reduction in the gate closure time³⁶, a diversification of production sites allowing to take advantage of profusion and compensate for meteorological uncertainties, the creation of well diversified technology portfolios and, last but not least, improvements in weather forecasts.

The TGC system may penalise NRE, which are not yet mature, in front of more established technologies. On this subject, Jensen and Skytte point out that "A green certificate system has to include devices to account for initial differences in technological and economic performance among renewable based technologies. Neglecting these differences could harm the further development of promising alternatives that are still in an infant stage of development. A kind of quota system... could be considered as part of the green certificate system, in order to provide fair chances to the whole range of technological variety..."³⁷.

³² Mitchell C. (2003), The evolving relationship between liberalization, the regulator and renewable energy development in the UK, 1990-2002, in Lachal B., Romerio F. éds., *op. cit.*, p. 299-305.

³³ Chupka M.W. (2003), Designing effective renewable markets, *The Electricity Journal*, May, p.52.

³⁴ In this respect Grubb expresses a balanced judgement: "... while it would be an exaggeration to describe capacity concerns as a non-issue their economic importance has certainly been greatly exaggerated. Variable sources are valuable primarily because of their fuel savings and - like all other baseload plants - cannot be justified primarily in terms of capacity needs..." (Grubb M.J. (1991), The integration of renewable electricity sources, *Energy Policy*, September, p. 677).

³⁵ Shuttleworth G. (2002), Hot topics in European electricity: What is relevant and what isn't, *The Electricity Journal*, Oct., p. 36.

³⁶ For example, on the Scandinavian market, if offers were made in a 6-12 hour gap in advance (instead of the current 12-36 hours), this would lead to a 30% reduction in adjustment costs (Menanteau P., Finon D., Lamy M.-L. (2004), Coûts et prix de l'intermittence des énergies renouvelables dans les marchés électriques libéralisés, *Revue de l'Energie*, 554, p. 87).

³⁷ Jensen S.G., Skytte K. (2003), Simultaneous attainment of energy goals by means of green certificates and emission permits, *Energy Policy*, 31, p. 63-71. On the interactions between green certificates markets and CO₂ emissions markets, cf. Jensen S.G., Skytte K. (2002), Interactions between the power and green certificate

c) Demand

Another angle of attack of the security problem is represented by the rational use of energy (RUE), which contains energy efficiency programs (EEP), demand side management and demand side bidding³⁸. Furthermore, developing RE without taking measures from RUE can lead to wasting resources. One must recognise however, that the results from investments in demand side management are often very volatile.

Price elasticity of demand can be stimulated by appropriate pricing systems, as well as by the development of advanced metering and control switching technologies. Higher price elasticity makes it easier to avoid strategic behaviour on behalf of companies possessing any kind of market power. Demand side management must take into consideration the fact that security needs, as well as risk aversion levels, are not the same for all consumers. Different customers place different values on not being disconnected. It has been suggested that these variations could form the basis of a pricing and disconnection policy where customers who value continuity of service the most would pay a higher price for their supply in order to be disconnected last³⁹. Green and Pardina remind us of an equity problem that may be present in this respect, notably when applying the Ramsey rule, which implies that “luxury uses of a commodity would face relatively low prices, while essential uses should face higher prices”⁴⁰.

Energy efficiency can be promoted by Energy Service Companies (ESCOs) that are in charge of developing projects in this field, taking full responsibility for their proper functioning⁴¹, in the frame of Energy Performance Contracting (EPC). With EPC, the ESCO is paid for by the savings due to the installed equipment. For large energy users, energy efficiency should be a market product of its own, implemented through EPC. However, smaller customers, for whom the implementing of performance contracts is too expensive, should be subject to a public benefit charge, i.e. a levy that is devoted to DSM.

d) Summary

There are different incentive and regulatory measures concerning investment, diversification and innovation that allow a reinforcement of supply security in the short, medium and long term. One must also take into consideration measures adopted in a spontaneous manner by operators in the electricity sector. Many companies possess strategies on different time scales. Their efforts have unfortunately been short circuited in the eyes of public opinion by predatory, even criminal behaviour (notably ENRON).

These measures allow a reduction of vulnerability, and in some cases avoid the occurrence of certain hazards. The risk however cannot be cancelled out completely. The problems

markets, *Energy Policy*, 30, p. 425-435; Jensen S.G., Skytte K. (2003), *op. cit.*; Morthorst P.E. (2003), A green certificate market combined with a liberalised power market, *Energy Policy*, 31, p. 1393-1402.

³⁸ Energy efficiency programs (EEP) seek to reduce loads, regardless of the time-of-use; demand side management (DSM) does not necessarily lead to consumption reduction, but rather focuses on shifting load from peak to off-peak times, shaving peaks, etc.; demand side bidding (DSB) allows the consumer to be paid a market price for withdrawing load, when required by the market operator, in a similar way that generators are paid to supply.

³⁹ Strbac G., Kirschen D.S. (2000), Who should pay for reserve, *The Electricity Journal*, October, 32-33.

⁴⁰ Green R., Pardina M.R. (1999), *Resetting price controls for privatized utilities. A manual for regulators*, The World Bank, Washington D.C., p. 5-6.

⁴¹ Didden M.H. *et al.* (2003), DSM in a competitive European market: Who should be responsible for its implementation ?, *Energy Policy*, 31, p. 1307-1314.

mentioned above show this clearly⁴². Because of the complexity of electrical systems and the technical constraints, such measures can even increase certain risks. In some cases, for instance that of demand management, we can only aim for hoped advantages at the price of greater risk.

These measures should not intend for a perfect equilibrium through extreme regulation. This would result in paralysing market dynamics in the vain hope of creating what Schumpeter referred to as an “entirely imaginary golden age”. Disequilibrium that must be apprehended in time can even create the dynamics necessary to avoid slipping into crisis. For example, it may incite companies’ creativity. A certain degree of imperfect competition can subsist in this respect, even if the adoption of the measures evoked makes imperfect competition less necessary to assure investment.

We look at this reflection in more detail in the conclusion, after analysis of RE in the two points that follow. We provide some examples taken from Norway and Brazil’s experiences⁴³.

6. Hydroelectric systems

a) Generation

The plants with daily or seasonal reservoirs play a very important role in terms of security of supply and network stability in that they enable modulation of output according to daily and seasonal consumption fluctuations. Hydro generators can respond to system variations within seconds, so that imbalances do not cause major operational problems.

However, hydroelectric production depends on precipitations, snow coverage, as much so that it can fluctuate considerably from one year to the next. The problem not only exists for run-of-the-river plants, but also for storage plants. Furthermore, hydro plants are energy-limited, i.e. they are unable to generate permanently at the maximum capacity because the total energy available, water, is limited. The determination of their firm capacity may become a very controversial issue⁴⁴. One must also take into consideration constraints in networks provoked by strong variations of hydropower production, which have repercussions on transmission requirements.

b) Price

The flexibility of hydro plants allows the concentration of production at times that prices are high. The real option approach may be particularly interesting in this case. In fact, as pointed out by Frayer and Uludere, “Under a real options approach, increased uncertainty (e.g., more-volatile electricity prices) translates into a larger options-based value”⁴⁵. The creation of a

⁴² Reminder: price volatility, market heterogeneity, too short time scales, contract rigidity, distortions caused by interventionist measures, reductions in costs of NRE, production variability, uncertainties of demand management, risk aversion, etc.

⁴³ Brazil opened its electricity market to competition in 1995, in the aim of attracting private investment. Norway opened its market in 1991 in a situation of overcapacity. Brazil encountered an acute electricity crisis in 2001. On the other hand, in Norway we can observe a relatively slight reduction in the electricity systems reserve margins. In both countries, production is almost exclusively hydroelectric (Romerio F. (2002), *op. cit.*; Ferraz C., Romerio F. (2003), Réorganisation des marchés, sécurité des approvisionnements et ressources hydrauliques. Comparaison des expériences brésilienne et norvégienne, in *Energía, Reformas Institucionales y Desarrollo en América Latina*, Universidad Nacional Autónoma de México (UNAM), p. 401-413; Ferraz C. de M. (2004), *Le marché de L'électricité au Brésil : ouverture à la concurrence et régulation*, Mémoire de Diplôme, DEAMAP, Genève).

⁴⁴ Vazquez C., Rivier M., Pérez-Arriaga I.J. (2002), A market approach to long-term security of supply, *IEEE Transactions on Power Systems*, 17 (2), p. 350.

⁴⁵ Frayer J., Uludere N.Z. (2001), What is it worth ? Application of real options theory to the valuation of generation assets, *The Electricity Journal*, October, p. 40.

regulating power market may increase the value of options. This type of market exists in Norway, where supply and demand bids determine the price for regulation, i.e. supply of up and down regulation services are cleared against the need for these services in order to create a market balance⁴⁶.

If electrical systems are dominated by hydro plants, the market's volatility is very high since prices reflect and amplify meteorological hazards. Norway for example, has very low prices in humid years and very high ones in dry years. In Brazil, price distribution in each month is much skewed. "Simulations... show that there is a probability of 70% that prices in a given month are below average and a probability of 40% that they're actually zero. In contrast, there are a few simulated scenarios where spot price exceeds \$300/MWh"⁴⁷.

The marginal cost structure of a hydro system is presented as follows⁴⁸: during wet and peak periods, the marginal cost of providing extra capacity; during wet and off-peak periods, zero; during dry and peak periods, the marginal cost of providing extra capacity plus extra storage capacity; during dry and off-peak periods, the marginal cost of providing extra storage capacity.

The integration between hydro and thermo-electricity allows alleviating oscillations in prices thanks to their complementarities. For instance, the risk of extreme price volatility in Norway owing to low inflows is dramatically reduced in an open trade system. Furthermore, Norwegians are able to afford a relatively high price for peak-load export⁴⁹.

In general, we consider it as difficult for hydroelectric companies to come to agreements or to retain capacity in the aim of manipulating prices due to the variable character of precipitations. Furthermore, we could allow regulators to impose the maintenance of minimum reserve margins in dams. Halseth and Olsen point out that "cartel co-ordination based on pure non-cooperative strategic behaviour seems neither easy to establish nor easy to sustain in a hydropower system"⁵⁰. Bushnell is slightly more prudent: "While strategic behaviour can have a very large impact on the redistribution of water within a month, the implications of market power for the shifting of hydro energy between months appear to be less dramatic"⁵¹. It is possible that market power may be underestimated in hydroelectricity's case considering improvements in prevision systems and dam filling.

c) Investment and diversification

Price volatility deters investment in hydro plants, which are particularly capital intensive. The rate of use of the reserve capacity represents an additional source of uncertainty to investors. In Brazil and Norway, we observed that spot prices (Nord Pool and MAE⁵²) make it difficult

⁴⁶ Skytte K. (1999), The regulating power market on the Nordic power exchange Nord Pool: an econometric analysis, *Energy Economics*, 21, p. 296.

⁴⁷ Kelman R., Barroso L.A.N., Pereira M.V.F. (2001), Market power assessment and mitigation in hydrothermal systems, *IEEE Trans. Power Systems*, 16(3), p. 358.

⁴⁸ Turvey R., Anderson D. (1977). *Electricity economics. Essays and case studies*, Baltimore, The Johns Hopkins University Press, p. 321.

⁴⁹ Halseth, Snoen (2000), Trade and competition in the Nordic context, in Magnus E., Midttun A. eds., *Electricity Market Reform in Norway*, MacMillan, London, p. 177-178, 189.

⁵⁰ Halseth A., Olsen P.I. (2000), Competition and market power, in Magnus E., Midttun A. eds., *op. cit.*, p. 90.

⁵¹ Bushnell J. (2003), A mixed complementarity model of hydrothermal electricity competition in the Western United States, *Operations Research*, 51 (1), p. 92.

⁵² The MAE (electricity wholesale market) was dissolved in 2004 and replaced by the CCEE (Chamber of electrical energy commercialisation).

to make new investments profitable. Pinto Jr.⁵³ underlines that the opening to competition did not succeed in reviving investment into Brazil's production⁵⁴. Amundsen and Bergman point out that "Norway and Sweden have experienced a considerable increase of demand in recent years, while there has been almost no construction of new production capacity"⁵⁵. In fact, new installation cost prices, including gas turbines, are above the market average. Kåberger even argues that in Scandinavia, nuclear reactors have been kept in operation despite annual avoidable costs exceeding the income available from selling electricity at average spot market prices⁵⁶. Environmental legislation contributed in the slowing down of investment in hydroelectricity and gas. Until recently, investment projects in gas turbines in Brazil were neglected due to electricity prices and the uncertainties surrounding gas importation prices.

The most competitive alternative to the run-of-the-river plants is represented by the combined cycle gas turbines (CCGTs), which provide base-load electricity and heat at very competitive prices. The pay-back time, as well as the time to plan and build a new plant, is relatively short⁵⁷. By contrast gas turbines (GTs) are less worthwhile as replacements for storage plants, because of high capital and operating costs, due to low capacity factor (5-10%) and high heat rates⁵⁸. It should be emphasised that the Hydro – GTs/CCGTs comparison involves several quite unpredictable factors, in particular the price of gas, heat use and CO₂ emissions taxes. Land and environmental problems can present further constraints that can favour one technology over another.

d) Externalities

Internalisation of external costs generated by hydroelectricity production can penalise this energy source, but external benefits can add to its competitiveness. In particular, we should take into consideration the environmental nuisances that ensue when residual flows in rivers and streams are reduced below certain limits. Compulsory civil liability insurance aimed at more comprehensive disaster coverage than in the past is another possible penalising factor for hydroelectric energy.

External costs' internalisation due to combustion of fossil energy and nuclear fission makes hydropower generation more competitive. In principle, a tax on CO₂ has a positive impact. Concerning the risk of major accident in nuclear power plants, it is not directly comparable with the risk of collapse of the reservoir or of crumbling of ground at its interior⁵⁹, as sometimes stated. In both cases, the probability of accident is very low. In the case of hydro plants, we are however confronted with damages, certainly very significant, but caused by

⁵³ Pinto Jr H.Q. (2003), Les problèmes des réformes structurelles et institutionnelles inachevées : le cas de l'industrie électrique au Brésil, *Revue de l'Energie*, 544, p. 103-111.

⁵⁴ This brought President Lula's government to take up measures aimed at reconsidering planification in the medium and long term, the short term following of supply conditions, the reorientation of sale and purchase contracts in the long term, the establishment of fluctuation reserves (Ferraz (2004), *op. cit.*).

⁵⁵ They also notice that "This may be seen as a positive sign as it was generally accepted that there had been overinvestment in this sector prior to the introduction of the new Energy Acts". (Amundsen E.S., Bergman L. (2003), The deregulated electricity markets in Norway and Sweden: a tentative assessment, in J.-M. Glachant, D. Finon, (eds.), *Competition in European electricity markets : A cross-country comparison*, Edward Elgar, Cheltenham and Northampton, p. 120 and 131).

⁵⁶ Kåberger T. (2003), Environmental labelling of electricity delivery contracts in Sweden, *Energy Policy*, 31(7), p. 636.

⁵⁷ Pfeifenberger J.P., Hanser P.Q., Ammann P.R. (1997), What's in the cards for distributed resources ?, *The Energy Journal*, Special Issue on Distributed Resources, p. 1-2.

⁵⁸ Hughes W.R., Parece A. (2002), The economics of price spikes in deregulated power markets, *The Electricity Journal*, July, p. 34.

⁵⁹ For instance, the rupture of the Fréjus reservoir (France), December 12, 1959, provoked 400 deaths; the crumbling of ground in the Vajont reservoir (Italy), October 9, 1963, provoked 2000 deaths.

water. In the case of nuclear power plants, on the other hand, we are confronted with radio-elements which have relatively little known carcinogenic, mutagenic and teratogenic effects.

Since the beginning of the process of opening electricity markets to competition, we have been assisting in the diffusion of “green labels”⁶⁰. It would be in the operators’ interest to invest in the hydroelectric plants in order to meet a set of environmental criteria, even though in doing so there is a slight rise in production costs. The labels should be granted only to environmentally benign facilities⁶¹. It is useful to remember that their definition raises controversy. Some experts suggested that their attribution should only be to the existing plans, because the most environmental damage of hydropower arise when power plants are built, as well as to the small scale hydroelectric plants, because they are less ecologically harmful. Furthermore, large hydro plants should not be included in this procedure, since they are already competitive. However, many studies show that small plants are at least as harmful per unit of electricity produced as the larger ones. Operation of existing plants can be very damaging for the environment. Alternative solutions may be available. New hydro plants can be less harmful to the environment than other technologies.

e) Summary

Hydro plants provide a flexible production if they are equipped with reservoirs but they face with meteorological variations. Market price volatility can present an interesting opportunity to hydroelectric companies. At the same time, they can prevent investment into new production units. The creation of regulating markets or measures concerning capacity may improve their returns. It is of an extreme importance to create portfolios containing complementary technologies. Hydroelectricity is subject to competition from gas turbines, especially CCTGs. Thanks to the reserves it provides, it can help in the development of NRE whose production is variable. An important stake is hydro plants adequacy for green labels. Hydroelectricity’s future is also in the hands of the institutional framework surrounding it, such as concession systems, which we are unable to analyse in this paper as they depend on national specificities⁶².

7. Distributed resources and new renewable energy

a) Definition, origin and perspectives of DR

By “distributed resources” (DR), we mean decentralised production units going from a power of a few kW up to 25 MW, i) linked to low, medium or high voltage networks, ii) part of a low-medium voltage micro-network, or iii) operating in an isolated manner. Depending on the technology, these plants can provide peak, intermediate or base-load. The energy can be of fossil or renewable origin. We may have cogeneration. The interest of DR should be evaluated in comparison to centralised solutions. Before developing DR, one must analyse DSM and energy efficiency potential, as it may be more economical and safer to act upon demand rather than supply.

At the origin of DR, there is the technological progress and the opening of electricity markets to competition. This is coherent with the theory of Thomas P. Hughes, for whom a

⁶⁰ About consumer protection issues, labelling in particular, cf. Vaughn K.I. (2001), A modern Austrian approach to economic regulation, in Midttun A., Svindland E. eds., *Approaches and dilemmas in economic regulation, Politics, economics and dynamics*, Palgrave, New York, p. 127.

⁶¹ Käberger (2003), *op. cit.*; Truffer B., Markard J., Wüstenhagen R. (2001), Eco-labeling of electricity – strategies and tradeoffs in the definition of environmental standards, *Energy Policy*, 29, p. 885-897.

⁶² Cf. for example the case of Switzerland and Norway, who adopted laws on water concessions respectively in 1916 and 1917 (Romerio F., *Hydroelectric resources between State and Market in the Alpine countries*, in Wiegandt E. (ed.), *Mountains : Sources of water, Sources of knowledge*, Kluwer, London, forthcoming).

technological system means both a technical core and an organizational structure⁶³. Technological progress has allowed the development of units of a few kW or MW that efficiently use fossil fuels (notably natural gas) or that exploit renewable energy. As for market reorganisation, it can favour DR in different ways, in the adoption of the third party access principle, in encouraging independent production, even auto production, in pushing producers to find flexible solutions and in allowing consumers to choose their suppliers, the type of energy, security levels, etc...

DR development perspectives are interesting, however “The Economist’s” optimism, when talking of an “electric revolution”, is probably an exaggeration. The terms “decades” and “visionaries” in the two quotes that follow moderate its view: “in a few decades time, the notion of micro-power unit in energy home and office may even have come to fruition”; “Visionaries see a future in which dozens, even hundreds, of disparate micropower units are linked together in so-called microgrids”⁶⁴.

b) Implications for the electricity market

DR may have a significant advantage over central power stations in that it is closer to end users and sized more appropriately for their electric and thermal requirements⁶⁵. As raised by Willis and Scott, DR “is tailorable to the electric power user’s needs”⁶⁶. In particular, it offers a greater choice to consumers and can respond to security needs in a diverse manner.

DR can provide particularly interesting solutions to meet the needs and capacities of local communities in the South. Sokona, a representative of ENDA-Third World, points out that “Only programmes of community management which are integrated and sustainable (in town or rural areas) can satisfy the needs of all, and particularly the poor population. These programmes can take into account the natural and technical resources of the region, the human capacity, the financial resources and the environmental constraints”⁶⁷. The IEA shares the same point of view: “In rural areas in developing countries, where financial markets will require time to grow, the development of community-based micro-credit programmes could play an important role in financing small-scale, distributed power generation projects, including solar photovoltaic and mini-hydro”⁶⁸. DR may well offer original solutions at a time when President Lula’s government, in Brazil, has just initiated the “Light for All” program to be completed by 2008⁶⁹.

By raising autonomy levels with regards to the market, DR allows a reduction in customer exposure to price volatility and market power. Finon, Johnsen and Midttun point out that in Norway “The answer to the price-hike challenge may... not only come from the centralised energy system itself, but also from supplementary decentralised approaches, both with respect to reducing peak power demand-side and increasing volume on the supply side”. They

⁶³ Thue L. (1995), The formation and development of the Nordic electricity regimes, in Kaijser A. and Hedin M. (eds.), *Nordic energy systems. Historical perspectives and current issues*, Science History Publications, Canton Mass., p. 11.

⁶⁴ The dawn of micropower, *The Economist*, August 5th, 2000, p. 18 and 77.

⁶⁵ Pfeifenberger J.P., Hanser P.Q., Ammann P.R. (1997), What’s in the cards for distributed resources ?, *The Energy Journal*, Special Issue on Distributed Resources, p. 6-7.

⁶⁶ Willis H.L., Scott W.G. (2000), *Distributed power generation*, Planning and evaluation, Marcel Dekker, Inc., New York, p. 577.

⁶⁷ Sokona Y. (2003), Widening access to rural energy services in Africa: Looking to the future, in Lachal B., Romerio F. eds. (2003), *op.cit.*, p. 196.

⁶⁸ IEA (International Energy Agency) (2004), *op. cit.*, Paris, p. 94.

⁶⁹ http://www.mme.gov.br/programs_display.do;jsessionid=8CDF7F212CFF3010A0023473129B6958?prg=8.

mention in particular a wave of investments in small-scale hydro, carried out at the local level⁷⁰.

DR, like auto-generation, is a substitute for electricity transportation services. This has the effect of weakening the network's natural monopoly. It has the potential to increase competition in the supply of electricity and thereby support the process of liberalization.

With vertical de-integration, there remains the problem of who finances the investments in DR. The consumer himself? The network managers who opt for DR, given its economic advantages and regulatory directives? Market operators investing in DR in a spontaneous manner after having carried out profitability calculations?

c) Economic evaluation

DR's competitiveness depends on the cost of electricity generated by DR *versus* the cost of electricity delivered by the central network; the value of any electricity injected into the network; the charges for services provided to/by the local network, to provide voltage support, to relieve congestion, to reduce losses; the value of other services that DR can offer, including electric reliability. Without thermal applications, it is more difficult to supply the base and intermediate-load at a competitive price. Several studies believe that the largest potential market segment is for DR designed for peak-load or peak shaving operations⁷¹. The creation of a micro-network allows reduction in costs per kWh compared to the isolated solution, since we take advantage of the profusion factor, possible size effects, as well as a greater flexibility in choice of production units.

Flexibility represents a fundamental attribute of DR in an environment characterized by economic, regulatory and political uncertainty. In fact, investments in small decentralised plants may be staggered through time, in "digestible" amounts, with consideration of evolution and uncertainty. Uncertainty represents an element in favour of DR. Feinstein, Morris and Chapel stress that "Leaving uncertainty out of a planning analysis systematically undervalues DR alternatives"⁷².

The transport pricing system influences DR's profitability. The adoption of postage-stamps, independently of distance and congestion, does not provide the right incentive in this respect. A relatively low discount rate applied to network investment, related to the fact that it represents a regulated sector, can also penalise DR.

d) Security problems

DR can represent an attractive measure to maintain or increase reliability for customers. Investment problems in large power stations and high voltage network can be overcome by this method. However, DR may require an increase in the sophistication of the control framework. As stated by Cardell and Tabors, "until such control is implemented, there could be unexpected and undesirable consequences of installing multiple distributed generators in existing distribution systems"⁷³. DR also raises new challenges for electric system development as it has to be incorporated in load forecasts.

⁷⁰ Finon D., Tor Arnt Johnsen T.A., Midttun A. (2004), Challenges when electricity markets face the investment phase, *Energy Policy*, 32, p. 1360.

⁷¹ Pfeifenberger J.P., Hanser P.Q., Ammann P.R. (1997), *Op. cit.*, p. 1.

⁷² Feinstein C., Morris P.A., Chapel S.W. (1997), Capacity planning under uncertainty: developing local area strategies for integrating distributed resources, *The Energy Journal*, Special Issue on Distributed Resources, p. 92.

⁷³ Cardell J., Tabors R. (1997), Operation and control in a competitive market: distributed generation in a restructured industry, *The Energy Journal*, Special Issue on Distributed Resources, p. 114.

Unfortunately, DR can equally promote local renewable energy, such as photovoltaic or wind plants, as it can fossil energy, notably cogeneration. Even if the latter presents a balance sheet relatively favourable to centralised power plants, in terms of conversion efficiency and emission levels per kWh⁷⁴, the development of fossil energy is not desirable. The measures envisaged to promote NRE (point 5.b) are applicable to DR nonetheless, including some adaptations if there are no high voltage network connections. It is however useful to define responsibilities that were listed above in the last paragraph of point b). Finally, there is the problem of the natural variability of NRE production, as well as the coordination of power and heat production in the case of cogeneration.

f) Summary

Thanks to its decentralised nature DR favours market dynamics. DR can respond in diverse manners to end-user needs, particularly in security matters, and provides investors with flexible solutions. To local communities, it allows the conception of projects adapted to their needs and their capacities. The opening of markets to competition should provide a fertile territory for these technologies spread, for which progress is still under way. The development of DR does however raise new challenges, notably in the field of system control. There is the risk that gas technologies develop on a local level instead of NRE. The promotion measures for NRE should be adapted to DR's characteristics. From this point of view, responsibilities must be outlined and perhaps even a license system created.

8. Conclusions

Electricity supply is confronted by many risks of economic and extra-economic nature. The perfecting of market design and regulation, as well as operators spontaneous initiatives, don't allow risk erasure that to a certain extent represents a vitality factor to the economy. Markets are characterized by dynamics where disequilibria are the rule and can lead to both positive and negative effects.

We must particularly avoid apparitions of disequilibria that provoke major risks for the society. From this point of view, one must seek out points of agreement between market operators and regulators (including network managers). In the medium and long term, the problem may take the form of a potential energy crisis brought about by the depletion of fossil fuels or their freeze due to environmental impacts. In the short term, there is the question of electricity crises that manifest themselves as blackouts or by sudden price rises. It is essential that NRE are developed in the future. DR can offer interesting flexible solutions. The electric market reforms and the technological progress seem to boost NRE and DR.

Compared with a monopolistic situation, the opening of markets to competition modifies the spectrum of risks related to electricity supply. In principle, it is not possible to determine whether a system which tends to competition is superior to a monopolistic one in this respect⁷⁵. This is mainly due to the complexity of electricity systems and their historic roots. Only case studies and notably the analysis of the particular combination between regulation, market and business dimensions⁷⁶, allow verifying specific exposure to risk and potential risk management.

⁷⁴ Habay P., Pariente S.D. (1999), The emergence of distributed generation in a liberalising European electricity market, *Revue de l'Energie*, 508, p. 402.

⁷⁵ In a monopolistic system, risks and particularly major risks are related to the use of rent, technological choices (including NRE), cost control, consumer treatment and the coordination of the totality of activities.

⁷⁶ Glachant shows that the electric reforms are determined by the combination of these three dimensions, and that this explains why there is such a potential for diversity (Glachant J.-M. (2003), The making of competitive

Abbreviations

CCGTs	Combined-Cycle Gas Turbines
DR	Distributed Resources
DSB	Demand Side Bidding
DSM	Demand Side Management
EEP	Energy Efficiency Programmes
EPC	Energy Performance Contracting
ESCOs	Energy Service Companies
GTs	Gas Turbines (peak)
NRE	New Renewable Energy
RE	Renewable Energy
RUE	Rational Use of Energy
SSOs	Security of Supply Obligations
TGC	Tradable Green Certificates

electricity markets in Europe: no single way and no single market, in J.-M. Glachant, D. Finon, (eds.), *op. cit.*, p. 8).