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“Public service perspectives on reforms of electricity distribution  
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# Public service perspectives on reforms of electricity distribution and supply: a modular analysis

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## Draft Version

### Abstract

The traditional view of electricity distribution is that of a natural monopoly. The EU Electricity directive (2003/54/EC) has required the legal unbundling of distribution networks from the remaining units in the electricity value chain by July 1<sup>st</sup> 2007. However, there is a diversity of unbundling choices of the distribution businesses in Europe (Eurelectric, 2007). This diversity highlights some ambiguities in the natural monopoly status of electricity distribution.

The aim of this paper is to discuss the economic properties of electricity distribution and supply activities. In the light of the current restructuring of these activities, we focus on two principal questions. The first one is whether electricity distribution really has the natural monopoly characteristics as assumed by the literature. The second one is whether there are some interdependencies between the different components of distribution and supply businesses. From an academic point of view, few authors explore the question as to whether electricity distributors are natural monopolies as is typically assumed (Gunn and Sharp 1999), or whether the underlying cost structure of distribution companies indicate a natural monopoly (Salvnes and Tjøtta 1998). Therefore, we propose a new framework for analyzing these questions, which considers the modular properties of the reform of the distribution business (Dubois, 2007).

The first part of this paper discusses the natural monopoly characteristics of electricity distribution and supply activities. While there is not much theoretical debate on the natural monopoly characteristics of electricity distribution (Saplacan, 2007) and on the necessity of regulating this sector, we show that there are several shortcomings in the empirical tests of natural monopoly. The second part of our paper presents the modular framework we employed in order to analyse the reform of distribution and supply businesses and applies this framework to the reforms of electricity distribution in the UK and France, showing that there is room for organization diversity. The third part discusses some policy implications of this modular framework from a public service perspective.

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## Introduction

The electricity reforms initiated by the European directives 96/92/EC and 2003/54/EC have led to organisational changes that have, among others, affected the organisation of electricity distribution and retail businesses. However, while there is an abundant literature on reorganisations in production and transport, including the creation of wholesale markets, few studies focus specifically on organisational changes in electricity distribution and retail. Most of the literature on these activities has focused on the analysis of performances of distribution<sup>4</sup>. Consequently, organisational changes of these activities and their effects on the public service rendered have received little attention.

There is however an interest in studying the efficiency of organisational choices in these activities, as well as their impact on the public service rendered by distribution and supply companies. Organisational changes have to be analysed as the European electricity directives have imposed major changes on electricity distribution. The new unbundling rules have imposed their separation from production and transmission, and also a separation between distribution networks and supply, in order to allow a non-discriminatory access of all suppliers to the final customers. These rules have led to far reaching reorganisations of distribution and supply businesses. New organisational forms have emerged, and their efficiency has not been systematically studied. The public service rendered by these businesses should logically be affected by these reorganisations. Public service issues are debated in the electricity sector (FNCCR, 2004) as well as issues of customer protection (European Commission, 2007). However, the links between reorganisations of electricity distribution and supply and public service concerns have not been analysed.

This paper analyses reforms in electricity distribution and supply and raises the question of their relation with public service issues. The first section criticises the traditional approach on electricity distribution in terms of natural monopoly (Sharkey, 1982). We demonstrate that, in a context of organisational changes of these activities, analyses in terms of natural monopoly are difficult to implement (Salvanes and Tjotta, 1998, Gunn and Sharp, 1999). The second section proposes an alternative analytical framework,

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<sup>4</sup> Cf. For example Filippini and Wild (2000) and Yu, Jamasb and Pollitt (2007)

which decomposes distribution and supply activities in different modules (Baldwin and Clark, 2000). This modular framework is useful for analysing the diversity of organisational choices in different European countries. Finally, the third section discusses the impact of these choices on public service policies. Currently, the organisation of distribution and supply businesses is neither homogeneous nor stable. We analyse how this could affect the public service objectives of maintaining a certain level of quality of supply and of protecting small consumers.

### **1. Electricity distribution: an activity with natural monopoly characteristics?**

The objective of competitive reforms in the electricity sector is to improve the overall efficiency of the sector. However, there are some limitations to introducing competitive mechanisms in some part of the sector. Electricity distribution is traditionally assumed to be a natural monopoly. Therefore, the extent of competition can only be limited. However, since the British reform of 1990, it is well known that some parts of the value chain in distribution and supply can be organized in a competitive manner, while other parts remain monopolistic. Nevertheless, since the beginning of the 1990's, the frontier between monopolistic and competitive activities has evolved. This raises the question of where exactly is the natural monopoly in electricity distribution.

There has been a huge theoretical literature on natural monopoly in network sectors (Lévêque 1998, Joskow 2005) and on the need to maintain some public control over network monopolies (Williamson, 1976, Goldberg, 1976, Priest, 1993). However, the tests of natural monopoly characteristics of electricity distribution have not been properly adapted to the evolution of this activity. Therefore, the question of where the natural monopoly in electricity distribution is really located remains open.

### ***1.1. The theoretical debate on natural monopoly properties and on the introduction of competition***

In electricity distribution, it seems obvious that competition is impossible in some parts of the business. This has been explained by the presence of local electricity networks, which cannot be duplicated at a reasonable cost (Newbery, 1999). These natural monopoly characteristics have traditionally been the justification of a public regulation of these activities (Lévêque, 1998). However, in the 1960's, the failures of regulation have raised a debate on alternatives to traditional modes of regulation, as the one of Demsetz<sup>5</sup> (1968). He argued that, even if scale economies impose a single supplier ex-post, competition is possible through auctioning a right to serve. This way, competition would lead to a price lower than the natural monopoly price, due to the initial selection of the most efficient candidate. In the Demsetz framework, this efficiency was conditional upon a high number of candidates and the impossibility of collusion among bidders.

However, the applicability of this alternative solution has proven limited in the case of network businesses, as demonstrated in 1976 by Williamson (1976). Analysing a real case of auctioning of a long term contract for cable television, Williamson showed that there were important limitations of franchise bidding in the presence of uncertainty and specific investments. Firstly, auctioning for long term contracts is inherently difficult, as the selection of candidates cannot be made only on price criteria. Secondly, long-term contracts are difficult to write since they must allow prices to be changed with the variations of costs and demand. Thirdly, long term contracts are difficult to enforce. For example, they need a mechanism for quality monitoring, where penalties sanction the non-respect of contractual terms. Finally, long term contracts are also difficult to terminate, giving the incumbent company an advantage over potential competitors.

Therefore, franchise bidding in the case of incomplete, long term contracts, differs from regulation only in degree, but not in kind (Priest, 1993). In the case of franchising, a government agency can specify quality and monitor the performance of the franchisees and negotiate price changes with them. Thus, regulation can be seen as an incomplete,

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<sup>5</sup> He argues that “*the theory of natural monopoly is deficient for it fails to reveal the logical steps that carry it from scale economies in production to monopoly price in the market place*” (Demsetz, 1968).

long-term contract in which the firm is guaranteed a fair rate of return and where there is an established procedure for making changes. Consequently, when it comes to network industries, franchise bidding appears superior to regulation for accomplishing the same outcome at lower cost only in an “ideal” world. In practice, incentives for the monopolist to act efficiently are not strong enough, which justifies the need for regulatory agencies<sup>6</sup>.

These results have been applied in most reforms of electricity distribution, where the network part, called “distribution”, has remained a regulated monopoly, while other functions, especially the “supply” part have been opened to competition. This general prescription has also motivated the unbundling of electricity distribution, as imposed by the European Directive 2003/54/EC. However, the different implementation of these unbundling rules and the moving frontier between the “core” of distribution and potentially competitive activities raise the question of where the natural monopoly is located.

## ***1.2. The “maladaptation” of conventional analyses to the evolution of electricity distribution business***

Although the natural monopoly characteristics of electricity distributors have been explored since the 1980’s (Sing, 1987, Mayo, 1984), most of these analyses use cost estimations for integrated distributors. They do not consider the separation between the network activities, which are most likely a natural monopoly, and the supply function, which can be organized competitively. Even recent research on electricity distribution takes this natural monopoly character as given (Kinnunen 2003, Vilijanen 2005, Ajodhia 2006).

The most representative contributions of a new type of approach, which tries to identify the location of the natural monopoly, are Salvanes and Tjotta (1998) with their natural monopoly test of electricity distribution in Norway, and Gunn and Sharp (1999) who analyse the case of New Zealand. In 1987, the Government of New Zealand removed

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<sup>6</sup> The debate over the most appropriate solution to be implemented is still ongoing (Yvrande-Billon 2004). For example, several authors have analysed the potential problems and solutions of implementing franchise bidding (Littlechild 2002, Bajari et al. 2003, Bajari-Tadelis 2001).

their franchises from the electricity distributors to allow them to compete with each other for retail energy services. As a consequence, each distributor got open access rights to construct new lines in any of the other companies' previous franchise areas. Thus, *"the companies responsible for electricity distribution and retailing in New Zealand (were) in fact competing with each other, not just for retail services i.e. energy sale, which was intended, but for distribution services as well i.e. network connection"* (Gunn and Sharp, 1999).

As this type of competition seems contrary to the natural monopoly hypothesis in electricity distribution, Gunn and Sharp (1999) explore this paradox. They consider possible reasons and mechanisms justifying such competition by using a simplified model of a typical New Zealand distribution company. They argue that New Zealand's regulatory regime is such that *"electricity distribution has taken on the two key characteristics of a contestable market (Baumol et al., 1982): no barriers to entry (particularly in the form of sunk costs) and no price response by the incumbent to entry by a competitor"*. However they conclude that, following their model's results, New Zealand's electricity distributors may well be sustainable natural monopolies<sup>7</sup>, even if the light-handed regulatory regime distorts costs and, by removing the franchises from the distributors, has introduced elements of contestability which might allow potentially inefficient competitive behaviour.

These studies are not detailed enough for clarifying the nature of distribution. In the light of the current evolutions of this business, we identify three main limitations.

The first limitation is related to unbundling. The unbundling of distribution from the supply activity has been imposed by the European Directive 96/92/CE and reinforced by the second Directive 2003/54/CE. The aim was to stimulate competition in a sector that has historically been vertically integrated. The two European directives have thus led to a reorganisation of the distribution business and therefore to changes in the cost structure of distribution companies. Salvanes and Tjøtta (1998) do not address the question of unbundling between distribution and supply for their study makes no difference between

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<sup>7</sup> The sustainability condition is that the incumbent can satisfy the whole demand in the market at a combination of output and price that renders entry non attractive for potential new entrants.

them. However, they emphasize that the network infrastructure is the main factor driving the subadditivity of the cost function. Hence, they demonstrate that the distribution infrastructure is a natural monopoly. However, in the absence of separation from supply, the characteristics of the network operation activities remain unclear.

The second limitation is related to the cost structure of distribution companies. An evaluation of their costs should take into account the fixed costs as well as the variable costs, i.e. the cost of capital and operating costs. While Gunn and Sharp (1999) make a clear distinction between supply, as a competitive activity, and distribution, as an electricity delivery activity, their model isn't clear enough on the different types of costs. In particular, neither the asset base nor the fixed nor the variable costs are clearly distinguished. They only consider the operational costs, but these costs are not clearly specified<sup>8</sup>. For the fixed costs, they make a simplification, considering them as independent from the number of clients and from the age of the network<sup>9</sup>.

The third limitation is related to the current transformations of organizational forms of distribution companies. After a first stage of separation between distribution and supply businesses, organizational forms of distributors have continued to change. As a consequence of increased incentives in regulation of distribution activities, network operators externalized some functions related to the operation of their networks. Therefore, new organizational models have emerged in electricity distribution, with integrated network owners operating their networks on the one hand, and disintegrated forms of network ownership and operation on the other hand. For example, in the UK, some network owners, like Scottish Power (Electricity Association, 2003), are also network operators. Others have totally externalised the operation of their network, like the city of London or Eastern Electricity, to EDF<sup>10</sup>. This evolution raises the question whether electricity "distribution" (excluding supply activities) should be further decomposed, some parts of this business being potentially competitive and distinct from

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<sup>8</sup> In particular, these costs are not detailed by categories like for example costs of network equipments, network maintenance, metering, billing, network operation etc. This doesn't allow for a clear comprehension of what they consider as "operating costs"

<sup>9</sup> The age of the network influences the fixed cost of a distributor because it determines the need of renewing parts of the network. Cf. Ofgem (1999) Distribution Price Control Review, Final Proposals, December 1999

<sup>10</sup> [www.le-group.co.uk](http://www.le-group.co.uk)



the “core” natural monopoly business. If this is the case, then analysing “distribution” with a single cost function will no longer be accurate.

These limitations illustrate that the traditional natural monopoly framework is no longer adapted to analyse the electricity distribution and supply businesses, given the fact that they have been subject to extensive reorganizations. Therefore, a more detailed understanding of distribution activities is required to analyse what is at stake in the current transformations of this sector.

## **2. An alternative framework for analysing electricity distribution and supply**

Having demonstrated the inadequacy of the traditional analyses testing the natural monopoly characteristics of electricity distribution, we propose an alternative framework for analysing the reform of this business. It is a modular framework (Baldwin and Clark, 2000), which allows a decomposition of reforms in different interrelated “modules”, with a possibility of organizing each of them in several ways, or “variants”. These modules, are linked with each other by relations of “weak” institutional complementarity<sup>11</sup> (Aoki, 2001, Pagano, 2005). We first propose a modular decomposition of competitive reforms in electricity distribution and discuss the characteristics of these modules (cf. 2.1). We then propose an application of our modular framework to the analysis of reforms in France and the UK.

### ***2.1. The modular decomposition of activities***

The modular nature of competitive electricity reforms can be understood by looking at the technical specificities of electricity. Because of these specificities, markets cannot be created as in classical commodity sectors. Electricity is not storable. It flows on networks that have natural monopoly properties and have the character of essential facilities. In addition, electricity demand cannot be predicted with certainty. As the price elasticity of electricity demand is weak, demand is weakly influenced by its price level.

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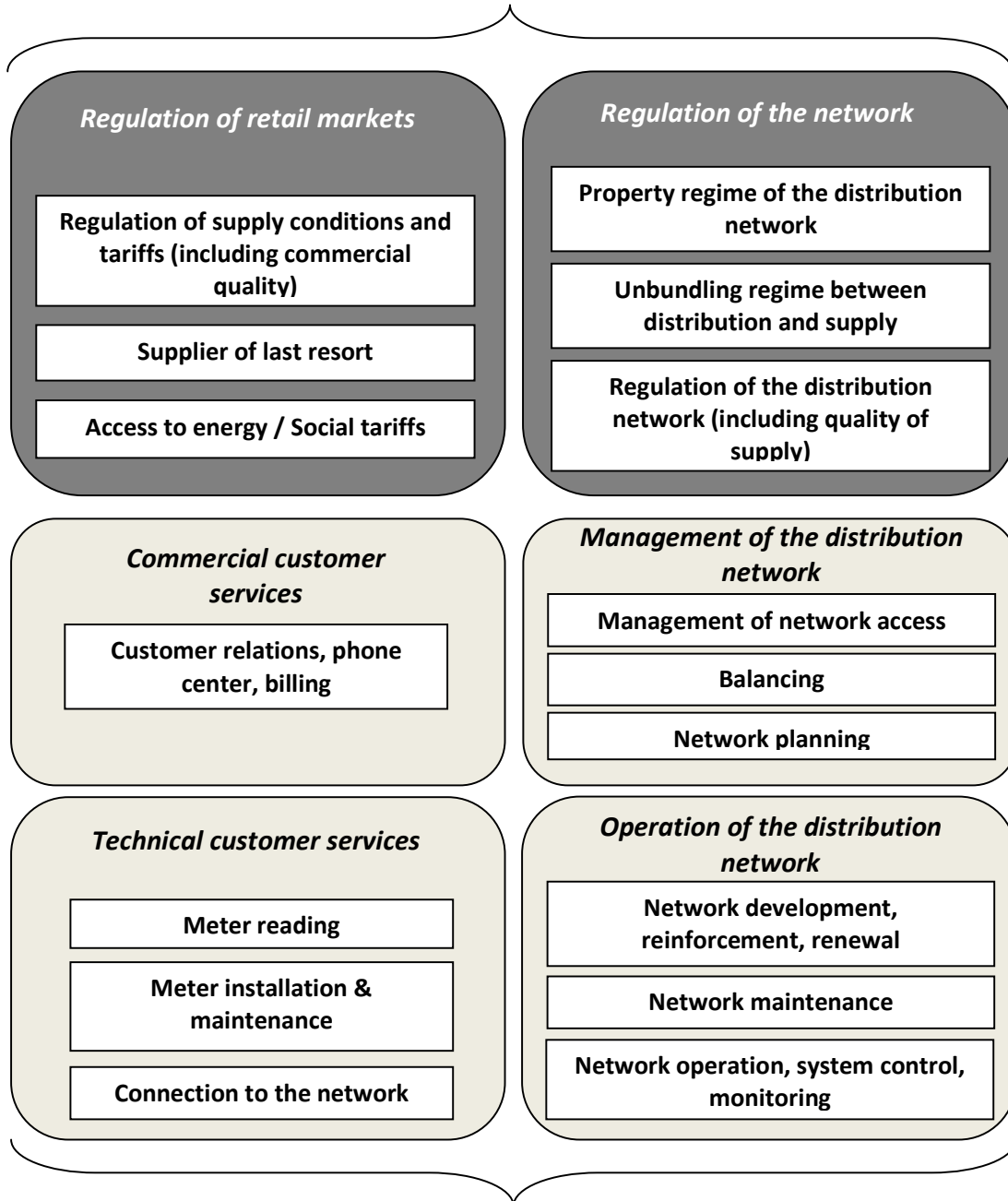
<sup>11</sup> For an application of this approach to electricity reforms, cf. Dubois (2007) and Rious (2007).

Therefore it is difficult to introduce competition in that sector. As discussed in the first section, parts of the sector can be organized in the form of markets, while others remain organized as a monopoly. Because the “market part” and the “network part” are technically dependent one from each other, markets can be created only by splitting electricity transactions in their different components. As demonstrated by Wilson (2002) for wholesale markets, this requires the creation of a sequence of markets, which “simulates” the functioning of competitive markets. Creating retail electricity markets raises similar problems (Glachant, 2005), their specificity lying in the measurement services offered by retailers, who allow the execution of individual transactions.

To analyse reforms of distribution and retail businesses, we split them in different “modules” (Baldwin and Clark, 2000) which can be considered independently one from each other. Each “module” forms a coherent whole and can be organized in different ways. The modules combine to each other more loosely, and are sometimes independent from each other. As interdependencies exist among modules, they can be considered as linked one with each other by relations of “weak institutional complementarity” (Aoki, 2001). Weak institutional complementarity means that one variant of one module fits best with one specific variant of another module, but can also be combined with other variants, but at the expense of the overall efficiency of the system.

One consequence of the weak institutional complementarities between modules is that a variety of systems can exist, as many different variants of modules can be combined together. One possible representation of such a modular organization is given in figure 1 on the next page. This is one possible, though non exhaustive, representation of the modules in electricity distribution and supply as it resulted from several discussions with distribution company representatives (Glachant et al., 2006).

## **TWO REGULATORY MODULES**



## **FOUR OPERATIONAL MODULES**

**Figure 1: a modular representation of reform in distribution and retail**

In our modular representation, we first distinguish two regulatory modules. The first one relates to the regulation of retail markets. It consists in the set of rules established by public bodies (legislator or regulator) to monitor the transactions on retail markets. Even in competitive electricity markets, these rules continue to exist to a certain extent. A first sub-module is the regulation of supply conditions and tariffs. These rules already existed in the formerly regulated markets and they often continue to exist after the transition to competition. For example, the customers who have not switched to competitive suppliers are still benefiting from regulated tariffs and conditions<sup>12</sup>. The second and third sub-modules relate to public service issues. Rules on access to energy stipulate that each consumer has the right to be served, since electricity is an essential service. For certain customers, access to energy is ensured through social tariffs. To allow each consumer to be served in a competitive electricity market, a supplier of last resort can be designated, who is generally the incumbent supplier in a given region.

The second regulatory module relates to the regulation of the distribution network. This module consists in the set of rules established by public bodies (legislator or regulator) to determine the structural characteristics of the distribution business, and the type of regulation imposed to natural monopoly activities. A first sub-module defines the property regime of distribution networks. This sub-module is often inherited from the historical organization of distribution. The property regimes are different from one country to another. For example, in France, the property regime is defined by the “concession contracts” between local authorities and the network operators. According to French concession rules, the municipalities own the networks, although most investments are realized by distribution operators. On the contrary, in Germany, the property regime is totally different, since the network operators also own the networks. A second sub-module relates to the unbundling regime between distribution and supply. Unbundling is considered as an essential condition for truly competitive retail markets (ERGEG, 2007). Unbundling choices of different countries also play an important role for the organizational properties of distribution and retail. Finally, the third sub-module relates to regulation of distribution networks. While in some countries, like Germany, distribution

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<sup>12</sup> For example, the French Senate has recently confirmed the durability of this regime for electricity tariffs, allowing customers to return to the “regulated regime”.

network regulation is only subject to an approval of the regulator based on costs declared by network operators, in other countries, like the UK, distribution activities are subject to incentive schemes.

We then identify four “operational” modules which correspond to the different tasks of distributors and suppliers. Our first operational module relates to the organization of customer services. It concerns all commercial relations with the final customers, including customer relations, phone centre, billing and commercial advice to customers. This module is a non-technical one, as it does not require a specific technical knowledge. It involves relatively frequent relations with the customer.

Our second operational module groups technical services to customers. We distinguish different types of customer services. The service of “meter reading” requires no specific technical skills and it is realised frequently, once or twice a year. The service of “meter installation and maintenance” requires higher technical skills. It is realised with a relatively low frequency. Finally, the service of “connexion to the network” requires a direct technical intervention at the customer’s home, which intervenes with a low frequency, typically when a new house is built and connected to the network.

Our third operational module relates to management of the distribution network. A first task relates to “management of network access”, i.e. giving third parties access to the distributor’s network. A second task is “balancing” of electricity flows and settlement<sup>13</sup>. A third task is the planning of the network. All three sub-modules concern the distribution entity as a whole.

Finally, our fourth operational module relates to the operation of the distribution network. A first sub-module is related to network development, reinforcement and renewal. It is realised according to the decision at the “network planning” level and requires a high level of knowledge of the local conditions, in order to realize the most adapted investments for the consumers’ interests. A second sub-module is network maintenance,

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<sup>13</sup> This task is necessary because of the lack of control of distributors over the electricity flows on their grids. On the one hand, the network operators do not control the consumption flows on their network. And these consumptions are not paid at their “real-time” price. On the other hand, the network operators buy their electricity from the transmission operator at wholesale prices. Therefore, the function of balancing is to “reconcile” the physical and financial flows on the network.

meaning all activities designated to maintaining the actual performances of the network. This requires a certain level of knowledge of the network's local characteristics, as well as a supervision of network conditions in real time. A third sub-module is the network operation itself, including system monitoring and control in real time. This essentially consists in directing the electricity flows on the network. It requires a real time access to information on electricity flows and network configuration.

This modular representation of reforms in distribution and retail is one possible but probably not the only representation. It can be used to explain the diversity of reforms, as different variants of the different modules can coexist one with each other<sup>14</sup>. Consequently, each national reform is a particular combination of different variants of different modules.

However, institutional complementarities between modules exist. Therefore, some constraints exist on the diversity of reforms. We distinguish two types of complementarities. The first one relates to links between regulatory modules and operational modules. For example, the regulation of access to energy and social tariffs influences the management of customer relations. The second type of complementarities exists within the set of operational modules. For example, the module "network planning" is linked with the modules of "network development, reinforcement and renewal", "network maintenance" and "network operation". There are some institutional complementarities among them, due to the fact that decisions within each sub-module influence the other sub-modules. For example, if decisions on network renewal are delayed, this impacts the need of maintenance.

These interdependencies have organizational implications. If sub-modules are separated while strong coordination needs exist between them, the question of coordination becomes crucial. In case of separation of modules, there are risks of opportunistic behavior. For example, in case of a decrease of quality of supply, the responsibility is difficult to locate, as bad quality can result from a bad coordination among them. Therefore, if these sub-modules are separated, some efforts must be devoted to the coordination among them in order to maintain a sufficient level of quality.

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<sup>14</sup> Examples of this diversity of modular reforms in electricity distribution will be developed in section 2.2.

Further developments of this representation are needed to fully analyse their implications on reforms of distribution and retail. In this paper, we use it as a tool to compare different reforms in electricity distribution and retail.

## ***2.2. What limits to organisational diversity?***

Modularity of distribution and retail gives the possibility to combine different variants of modules in several manners. In electricity reforms, there seems to be a huge diversity of organisational forms in distribution and retail, suggesting that our organisational modules can be combined in several ways. The debate on natural monopoly characteristics of distribution suggests that, however, this diversity could be subject to some constraints. We use our modular framework to identify two types of constraints. The first one is related to the local character of distribution activities, what Williamson (1985) calls “site specificity”. If activities have a local character, the possibility of changing their organisational form could be limited. The second constraint is related to the possibility of externalising some activities. These possibilities could be limited by technical interdependencies between modules or sub-modules, which render a strong coordination among them necessary (Aoki 2001). The examples of France and the UK will be used as a basis for discussing the constraints on the organisation of our modules.

### **The local character of the modules**

Two operational modules have an intrinsically local nature, while two others have a less local character. The module of “technical customer services” has an intrinsically local nature. The connection of customers to the network, the meters installation or maintenance and the meter reading are tasks demanding for physical intervention of a distribution company’s employee to the client’s residence. They generally need to be done rapidly. Therefore, these services must be organised on a local basis, as this is the only way to ensure a sufficient level of quality (i.e. rapidity). For example, in France, these activities are in the hand of local distribution units (95 sub-local EDF units exist, each of them being split in a few local units) (Glachant et al. 2006).

The module of “operation of the distribution network” also has a local character, which is a consequence of the geographical specificity of each distribution network. For example, plane or mountain networks have different configurations, as well as rural or urban networks. The characteristics of the demand (for example load density) are also specific to each network. In order to ensure a good quality of supply, a good knowledge of these characteristics is required, as well as a capacity to intervene quickly on the network. Therefore, the tasks of this module also need to be done at a local level.

The module of “commercial customer services” has a less local character since it doesn’t require direct intervention at the client’s residence. However, local centres can play an important role, for example for the most vulnerable customers who go to these centres to pay their bills, or when they experience difficulties of payment. The supplier’s call centres are usually designed for taking calls from large regions, or even for serving at a national level (Glachant et al. 2006). As about the billing activity, it only requires the software programme to calculate each client’s consumption, without any direct intervention, and is also designed for the whole of the clients of a distribution company.

Finally, the module of “management of the distribution network” involves the network planning activity, which requires good knowledge of the demand structure and of the environmental conditions. However, this activity demands for no direct intervention, since it is only a decision process to be transmitted further to the module of “operation of the distribution network” module. Therefore, we consider that it has a non-local character. The balancing and management of network planning have non-local character as well, since they are mainly decisional processes without direct intervention on the network or to the customer’s site.

## **The possibility of externalising modules or sub-modules**

It is difficult to say if a module can be externalised per se. Therefore, to discuss this property we rely on case studies, especially in France and the UK. (1) The module “Technical customer services” can be externalised. For example, in UK, the “Meter installation and maintenance” activities are entirely done by specialised service providers,



while the “Meter reading” is at the charge of the distribution company (Saplacan 2007). (2) The “Commercial customer services” is the core activity of a supplier and thus difficult to externalise. (3) The “Management of the distribution network” could be externalised, module, even if the “Network planning” sub module seems difficult to externalise. However, even the “Network planning” can be externalised. For example, a UK firm, PowerTeam Electrical Services, is specialized in planning, building and developing distribution or transmission networks (lines, high voltage substations etc.). However, this firm also provides activities of the “Operation of the distribution network” module, illustrating the strong interdependencies between these modules. Another example is Citiworks in Germany. This firm is a service provider, emanation of municipal utilities (Stadtwerke), and offers services like “Balancing” and “Management of the network access”. (4) The “Operation of the distribution network” module is the core of distribution business and, when it is externalised, it is externalised as a whole and in generally combined with the “Management of the distribution network”. For example, 24seven, which is part of LE Group, is specialized in supplying network operation services in UK and Germany<sup>15</sup> (city of Kiel). The externalisation of this module remains however an open question.

The previous discussion suggests that there is some place for organisational diversity in electricity distribution. As competitive reforms are concerned with efficiency, the movement towards competition, that has given choice to all EU customers since July 2007, should be accompanied with changes in the organisation of distribution and supply companies in order to improve their efficiency. Indeed, since the first electricity reforms in the UK, several organisational changes have occurred in European electricity distribution.

## **The organisational diversity in European distribution**

In the UK the organisational changes are a consequence of the reform of 1990. Electricity distribution has been split in 14 distributors, and over 18 suppliers<sup>16</sup>. As the UK

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<sup>15</sup> [www.le-group.co.uk](http://www.le-group.co.uk)

<sup>16</sup> <http://www.electricity-guide.org.uk/companies.html>

electricity system is geographically fragmented, the search for efficiency took place at the level of each distributor, in the form of externalisation of some activities. One characteristic of the new organization of distribution was the externalization of meter reading, i.e. a part of our module of “Technical customer services”, which was sub-contracted to independent firms. Thus, some companies have changed their scope of activities, being present in some segments only. For example, London Electricity Group<sup>17</sup> owns and operates the public distribution network of London city and the private networks of Heathrow, Gatwick and Stansted airports<sup>18</sup>, owns the infrastructure for the Channel Tunnel Rail Link<sup>19</sup> (the new rail link from Folkestone to Kings Cross) as well as a 30 year PFI concession for the upgrade and management of London Underground's electrical assets. The same group operates the distribution system of Eastern England, being this time a simple network operator without owning the infrastructure. This group has though a specific “function”, that of a specialized entrepreneur in supplying network operation services.

In France, several modifications of electricity distribution and supply have taken place. As EDF is a distributor of 95 % of electricity in France, it grouped some activities at a supra-local, and even supra-regional level. The French distribution activities have the specificity of having been grouped with gas distribution for several years. Therefore, in the context of the market opening from 1<sup>st</sup> of July 2004 (unbundling of supply and distribution activities, but only for industrial customers) EDF distribution began a process of reorganising its activities. The former organizational form was a multidivisional M form (Ménard, 2004), where short term operational decisions were taken by the local business units and long term strategic decisions were taken at regional or supra-regional level. Starting from January of 2006 the organisation of distribution changed as shown in figure 2 below. The distribution activities are split in two entities, EDF Réseau Distribution (ERD) and EDF Gaz de France Distribution (EGD), which have complementary roles as the EDF distribution network operator (DNO) and are jointly responsible for the overall performance of EDF's distribution activities (Saplacan 2007).

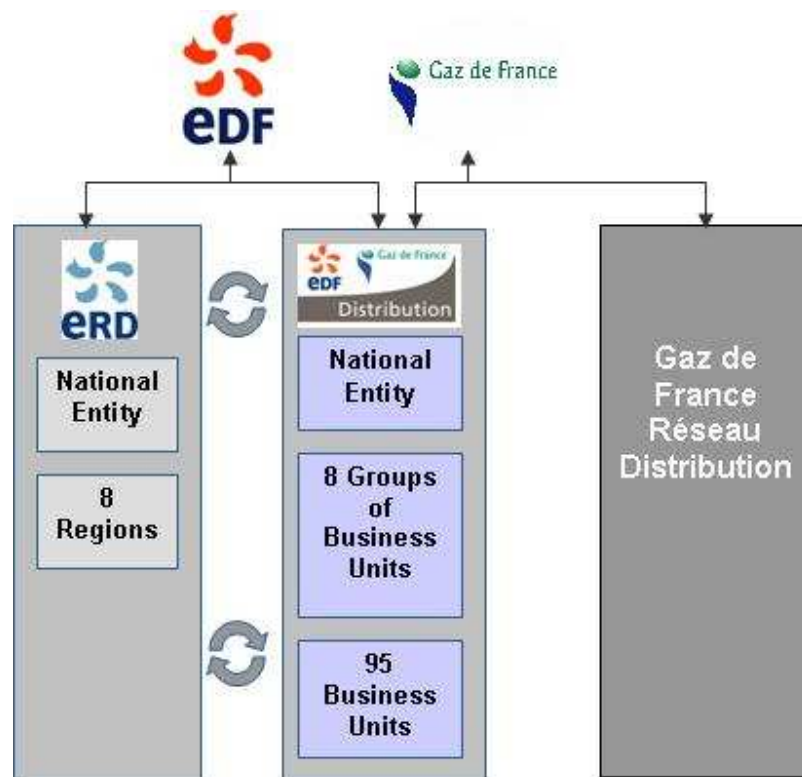
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<sup>17</sup> LE Group is entirely owned by EDF International ([www.le-group.co.uk](http://www.le-group.co.uk)).

<sup>18</sup> For more details see Saplacan (2007)

<sup>19</sup> [www.lpnet.co.uk](http://www.lpnet.co.uk)

The heads of each business unit were in charge of gas and electricity technical decisions corresponding to our module “Operation of network distribution” plus the “Network planning” sub-module, and customer services corresponding to our modules “Commercial customer services” and “Technical customer services”. Starting from January of 2006 it is no longer the case. The head of the local unit is in charge of the current operations, meaning gas and electricity network performances and customer service, i.e. only the “Operation of the distribution network” and “Technical customer services” modules.



**Figure 2: The organisation of EDF Distribution Branch**

Source: <http://www.edfdistribution.fr/130001i/le-distributeur-EDF.html>

The efficiency gains expected by EDF stem from a standardization of local units' activities (harmonized practices and accounts), and from scale economies, some modules like commercial services (telephone centres for example) being grouped in eight regional entities (EGD). Finally, some tasks like maintenance and reparations at the connection with high-voltage transport level or the connection to the high-voltage transport network have been externalised to third parties. Thus, the reorganisation of the French electricity

distribution has been shaped by the possibility of realising efficiency gains by grouping those activities that are not intrinsically local at a higher level.

While the UK is characterised by a functional redefinition of its electricity distribution business and France has reorganised its distribution business in order to realise economies of scale on the modules that are not specifically local, Germany is an intermediary position. On the one hand, large distributors, like E.ON, have progressively reorganised their supply activities to form bigger regional entities. Starting from a pre-reform situation where E.ON was holding participations in regional distribution companies which were operating like independent entities, E.ON progressively increased its share in these distributors. In a second stage, these entities were progressively grouped together in bigger entities. On the other hand, the municipal companies have started to externalise some activities, creating for example a specialised company, Citiworks, who is a service company active on the modules of the management of network access and in balancing management. Thus, the German distributors have adopted different strategies of reorganising their activities, depending on their possibilities to group activities in supra-local units and to externalise some parts of their business.

Modularity changes the way to analyse reforms. As illustrated by different European countries, in practice, it is difficult to draw the line separating monopolistic and competitive activities. And distribution activities can be reorganised in a variety of ways. In a competitive environment, distributors and suppliers adopt new strategies in their search for efficiency. Possible means to improve the efficiency include reorganizing operations when necessary. As shown by the actual practice, some operational sub-modules might be better and/or more efficiently produced by specialized service producers than by the distribution companies themselves. Sharing activities<sup>20</sup> or the externalizing them enables the distributors to increasingly focus on their core business, the managing and operating the network modules. Nevertheless, realizing efficiency gains would require that there are enough external providers in the service markets.

How do these transformations impact the public service characteristics of electricity distribution and supply? That's what the next section tries to explore.

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<sup>20</sup> As the French example shows it, EDF local business units share several activities

### **3. Policy implications of a modular separation of distribution activities**

Before electricity reforms, distribution business has enjoyed the natural monopoly status without having to face the same efficiency requirements as today. Therefore, ensuring that the “public service” was rendered by electricity distribution companies was relatively unproblematic. Service objectives could easily be imposed to the integrated distribution and supply companies, and the financing of the public service was less problematic in that uncompetitive environment.

In the new organisation of the sector, the public service is not automatically guaranteed. In electricity distribution and supply, the re-organisation of activities raises questions on how to guarantee public service (FNCCR, 2004). We here discuss two fields where the best way to ensure public service remains an open question. Firstly, the quality and continuity of supply must be ensured, and this requires some regulatory action. Secondly the interests of small customers, and especially vulnerable customers, must be protected because they will probably benefit less from competition than the big customers. In these two fields, the realisation of public service missions crucially depends on the characteristics of the regulatory modules of the reform.

#### ***3.1. Investing in quality of supply***

One dimension rising from the modular analysis is the quality of supply or quality of service provision (CEER 2001). Service quality is an important issue in electricity distribution and retail and it results from the interplay of several of our operational modules. Consumers are highly sensitive to all aspects of service quality: they value timeliness in dealing with their requests (commercial quality), the reliability of the electricity supply (continuity of supply), and also the characteristics of the supply voltage (voltage quality). Voltage quality (or power quality) is determined by the physical quality

of the voltage waveform<sup>21</sup> (CEER 2001). This dimension is mainly influenced by the “Operation of the distribution network” module. Commercial quality is related to individual agreements between the distributor and the consumers<sup>22</sup>. It is mainly influenced by the “Commercial customer services” and “Technical customer services” modules. Reliability is “*the measure for the ability of the network to continuously meet the demand from consumers*” (Ajodhia 2006). It is mainly influenced by the coordinated functioning of all sub-modules of the “Management of the distribution network” and “Operation of the distribution network” modules. From the three quality dimensions, reliability is generally considered the core value of electricity service provision, since any service interruption temporarily ceases the provision of electricity and therewith directly affects consumers.

Service quality is also influenced by the regulatory modules we defined above. Both theory and empirical evidence indicate that when a regulator imposes revenue ceilings that are weakly related to realized costs, the firm’s incentives to deliver efficient levels of service quality may be lowered (Sappington, 2005; Ter-Martirosyan, 2003). Consequently, the price cap or revenue cap regulations have recently been supplemented by service quality regulation in several European countries (CEER, 2005) in order to protect consumers against quality degradation that might result from the reforms. Quality is regulated through minimum standard requirements (CEER, 2005) as it is difficult to determine a “production function” of quality of service<sup>23</sup> because of the influence of technical choices of the past (Glachant et al. 2006, Ajodhia 2006). Thus, the three dimension of service quality are related to the combined influence of regulatory and operational modules. Distribution service quality failures rising from the coordination of

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<sup>21</sup> For example variations in frequency, fluctuations in voltage magnitude, voltage variations, waveform distortion, etc.

<sup>22</sup> Examples of such agreements are the conditions for connection of new consumers, “installation of measuring equipment, regular transactions such as billing and meter readings and sporadic transactions such as responding to problems and complaints” (Ajodhia 2006).

<sup>23</sup> For example, if a distributor would choose investing in two new substations on a distribution network branch (instead of one) the number of incidents on that branch could be divided by two. Furthermore, adding two automatic remote control switches on each network branch departure, could divide by three the number of incidents. As a result, the number of incidents will diminished by (2 \* 3) and thus, the service interruptions will also be diminished. It is a typical quality of service level enhancement by investing in network components.

operational modules rely on load characteristics of the demand and on the structure of the network infrastructure itself (Doulet 1995).

Investment is the key factor that allows the distributors to continuously respond to the consumers' demand. Thus, in the context of reforms, where price cap regulation and privatisation impose strong incentives to cost reductions (Fumagalli et al. 2007), the firms have more incentives to reduce costs than to enhance (or even keep) the quality level of the service they provide (Hart et al., 1997).

When privatisation is part of the reform, Hart et al. (1997) claim that if quality is not contractible, a private monopolist indulges in excessive cost cuts, and may deliver a lower service quality than a public-sector enterprise. Yet, the same authors argue that the impact of privatization results on quality deterioration is far from having unconditional validity. On the same subject, Fumagalli et al. (2007) show the effects of privatization of distribution utilities in Italy. They underline the influence of managerial behavior on the level of service quality. They also underline that the privatization of Italian electricity utilities has not decreased the quality of supply, although it did not significantly enhance it either. Nevertheless, they find that partly privatized utilities subject to quality regulation maintain higher levels of quality.

When reforms are not accompanied by privatization, like in France, their effects on quality of service are mitigated. In France, local authorities own the network infrastructure, the franchisee network operator being EDF. The French municipalities have defined a model of franchise contract in cooperation with EDF. According to this contract, EDF is responsible for renewing all network parts and for reinforcing the high voltage parts of the network (HTA)<sup>24</sup>. The local authorities are responsible for renewing the low voltage parts of the distribution network (BT). This is coherent with EDF's main interest which is investing in the high voltage parts of the distribution network (HTA) since a supply interruption in this part of the network would affect more consumers than on the BT part. A first reason is that, on the HTA network, one of the network's starting points from the substation will supply at least 1.000 customers, while on the BT network

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<sup>24</sup> High voltage in France is the 20kV distribution network (HTA), while low voltage is the 400 / 230V network (BT)

such a starting point will only supply 40 – 50 customers (Glachant et al. 2006). A second reason is that, on the BT network, most of the incidents appear at the customer's connection level (customer's site) and can be repaired without cutting the line. This could also explain that the network operator can choose to make more frequent interventions instead of investing in this part of the network, thus preferring maintenance over investment. A third reason is given by the way EDF's level of quality is estimated. A same amount invested in the HTA network or in the BT network would not have the same effects over the quality indicators if these ones are a function of number of customers. Investing in an urban area would have a bigger impact on the average value of customer interruptions than investing in a rural area<sup>25</sup>.

In our modular representation of reforms, the reinforcement and the renewal are parts of a same sub-module, the "Network development, reinforcement, renewal". Separating responsibilities in the execution of a sub-module of remaining distribution business would ask for coordination between the entities responsible for each sub-module. As the "production" of service quality and its relation with the amount of investment is hard to evaluate, it could become difficult to designate the responsible for a possible deterioration of the quality of service. Therefore, the role of the regulatory modules is crucial in this configuration where different entities share the responsibility for quality.

To conclude, the regulation of service quality is still an ongoing method to be better apprehended (Ajodhia 2006). Regulating service quality is a difficult task for a number of reasons. Complications derive first from the fact that service quality is multi-dimensional. Second, the ideal level of quality depends on consumer preferences, and these can vary widely. Furthermore, measuring quality can be difficult since consumer behavior can affect the quality of the network (Ajodhia 2006, Doulet 1995). As a result, different means are used to induce regulated firms to deliver the desired levels of service quality in different quality dimensions. When quality dimensions are observable by the regulator, the instruments employed to modify the firms' behavior normally include minimum quality standards and financial incentive schemes (CEER 2005).

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<sup>25</sup> The customer density is higher in urban areas than in rural areas.



### **3.2. *Protecting small customers***

The opening of electricity markets to residential customers in the EU since July 2007 raises the question of whether small customers will really benefit from the market opening. Experiences of countries having opened their electricity markets for residential customers for several years suggest that competition would not benefit to all of them. In the residential market, competition is most likely to benefit to the biggest customers, who are buying both gas and electricity (Mollard, 2007). These customers can benefit from competition by switching to a new dual fuel supplier. Besides this market segment, a large number of customers are less likely to benefit from retail competition. The poorer customers are especially vulnerable. First, they are less prone to switching supplier as they are less informed than other customers and also less attractive from the suppliers' point of view, and less likely to receive attractive competing offers. Second, they are also the most vulnerable to price increases<sup>26</sup>. Therefore, the public service in electricity should be especially directed towards these customers.

The rules concerning customer protection are part of our regulatory module "Regulation of retail markets". In Europe, there seems to be a consensus that a certain level of protection of small customers is necessary in liberalised electricity markets because competition alone cannot ensure consumers' best interests (Commission, 2007). The electricity directive of 2003 provides for the universal right to be supplied with electricity. In addition, the directive gives the Member states additional possibilities of imposing public service obligations to companies operating in the electricity sector. The responsibility of defining the precise public service obligations is thus a national one. We analyse what are the forms taken by these obligations in different European countries and discuss the current practices in the light of our modular framework.

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<sup>26</sup> This is reinforced by the weight of their energy bills in their budgets. In the UK, these customers are therefore a specific target for policies. Customers who have to spend more than ten percent of their income to heat their homes adequately are called "fuel poor".

## The diversity of measures towards vulnerable customers

The European diversity of policies in favour of small customers is a logical consequence of the national specificities regarding electricity distribution and supply. To illustrate this diversity, we briefly present the policies towards vulnerable customers in three countries, France, UK and Germany.

In France, the modular reorganisation of distribution and supply activities has been characterised by the search of economies of scale in the module of “Commercial Customer services” and an organisational unbundling of distribution and supply. The measures towards vulnerable customers are principally directed towards customers with difficulties of payment. Before the market opening, the policies towards these customers were traditionally defined by the electricity supplier EDF and the local authorities<sup>27</sup>. During the last years, several legislative measures have been taken to formalise the protection of customers with difficulties of payment. A decree of the Ministry of economics<sup>28</sup> defines the conditions under which consumers can benefit from a special social tariff (*tarif de première nécessité*, or TPN). Another decree of the Ministry of economics<sup>29</sup> defines the procedure applicable to consumers in difficulties of payment. This decree is complementary with EDF’s internal procedures. In order to avoid disconnections of these customers, EDF proposes a minimum service<sup>30</sup> of energy supply, where the capacity of the customer’s installation is limited to 3 kVA. This procedure is complemented by the action of the municipalities’ social services, which can help the customers paying their energy bills, using funds of the solidarity fund FSL. This brief presentation show how France has developed more formalised mechanisms to help vulnerable customers during the last years. These new mechanisms are involving the legislator and the local administrations, which are now playing a more important role in

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<sup>27</sup> A special fund, the “Fonds Solidarité Energie” existed until 2004. The resources of this fund were used by the municipalities. Since 2004, it has been included in the “Fonds Solidarité Logement”, which is administrated at the level of the Départements.

<sup>28</sup> Décret n° 2004-325 du 8 avril 2004 relatif à la tarification spéciale de l’électricité comme produit de première nécessité.

<sup>29</sup> Décret n° 2005-971 du 10 août 2005 relatif à la procédure applicable en cas d’impayés des factures d’électricité.

<sup>30</sup> This service is called “Service de Maintien de l’Energie” (SME) and it restricts the customer’s consumption capacity. If the customer’s difficulties of payment persist, then his consumption capacity is further restricted, to 1 kVA. This mechanism is called “Service Minimum” (SMI).

addition to EDF. Thus, there is now a more formal regulatory activity in the regulation of supply conditions to vulnerable customers.

In the UK, the market opening for residential customers has started in 1999, leading to a reorganisation of the retail market. Some changes in the regulation supply markets, especially concerning vulnerable customers have been implemented at the same time, although one major change in the supply market occurred in the second half of the 1980s'. At that time, prepayment meters were introduced. These meters give customers a greater control over their electricity bills. The use of prepayment meters has also the effect of reducing the number of customer disconnections made by the suppliers, these disconnections being replaced by "voluntary" self-disconnections of customers. While the introduction of prepayment meters has mechanically reduced the number of disconnections, this does however not solve the problem of fuel poverty, which is very important in the UK. Since 2001, the British government has developed a fuel poverty strategy<sup>31</sup> that aims at reducing the number of "fuel poor" customers until 2010. This is an illustration of the British reform strategy, which consisted in developing competition in the electricity sector, simultaneously increasing the regulatory oversight over this activity, by defining public service objectives for the sector. In addition to these measures, all suppliers propose social tariffs and have developed innovative "social" products to address fuel poverty (Ofgem, 2007).

Finally, in Germany, the measures towards vulnerable customers are neither developed by the distribution and supply companies<sup>32</sup> like in France, nor by the regulator like in the UK<sup>33</sup>. Therefore, the measures towards vulnerable energy customers are mainly implemented by the municipalities. These measures are not specific to energy

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<sup>31</sup> "(...) speedy progress was made on the issue of fuel poverty, with an inter-ministerial group being set up in 1999 and a fuel poverty strategy appearing in 2001, after a consultation process. The goal of this strategy (Department of Trade and Industry (DTI), 2001) was to seek an end to the problem of fuel poverty in vulnerable households by 2010. In broad terms this strategy aimed at improving the energy efficiency of fuel poor households, the maintenance of downward pressure on fuel bills, the encouraging of industry initiatives to help the fuel poor (presumably meaning tariff schemes and payment schemes) and general action to tackle poverty and social exclusion. The progress or otherwise of these policies was to be assessed by a Fuel Poverty Advisory Group, who would publish annual reports on the issues." (Graham, 2006)

<sup>32</sup> With the exception of E.ON Bayern, who proposes a social tariff to customers with low incomes in his area since September 2006.

<sup>33</sup> In Germany, the regulator for energy is only responsible for the control of network access conditions and network tariffs.

consumption, but are part of a larger policy towards vulnerable households (especially pensioners and disabled). Vulnerable customers mainly benefit from payments from the municipalities in order to help them paying their energy bills. For example, in 2006, the monthly payment for electricity (excluding electricity for heating) has been fixed by the federal parliament at 20.74 euro per month for a one-person household (Dünnhoff et al., 2006). In addition to these public measures, some voluntary measures (for example advice to customers) have been put in place at a local level especially by associations.

### **What effect of these measures?**

In France, the objective of the new rules concerning vulnerable customers was to help the customers with payment difficulties. We have no national data concerning customer disconnection and the use of SME, SMI and TPN. However, Sipperec, which groups 80 municipalities in the region of Paris publishes data on the customers with difficulties of payment. The evolution of the number of beneficiaries of different support mechanisms suggests that EDF has made more use of all of these measures (Sipperec, 2007). During the same period, the number of supply interruptions has also increased. The increased use of support mechanisms as well as the increase of the number of supply interruptions between 2002 and 2005 suggests that the reorganisation of EDF's distribution and supply activities has led to a more severe application of the rules to vulnerable customers. However, another explanation could be a general increase of the numbers of vulnerable customers.

In the UK, the effects of the fuel poverty strategy are not so clear. On the one hand, the development of prepayment meters has led to a sharp reduction of the number of supply interruptions, from tens of thousands in the 1980s' to less than 800 in 2004 (Graham, 2006). But a significant proportion of these customers report self-disconnections from the network<sup>34</sup>. On the other hand, the number of "fuel poor" has been drastically reduced between 1996 and 2004, from nearly 6.5 million households in 1996 to 2 million of households in 2004. But a part of this decrease has been a result of overall energy price

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<sup>34</sup> This proportion has been estimated at 24 % (Electricity Association, 2001)

decreases. Therefore, the number of “fuel poor” has again increased after 2004, reaching 3.5 million in 2006 (Energy Retail Association, 2007). However, the effects of the electricity reform on the small and especially vulnerable customers could be limited, due to the parallel development of regulatory policies in favour of these customers.

In Germany, there exists no general evaluation of the number of “fuel poor” customers. The issue of fuel poverty is however an important one, given the large number of poor households<sup>35</sup> and the increase of energy costs. Between 1998 and 2006, the electricity prices for households increased by more than 26 %, while the public payments to vulnerable customers increased only by 7,2 % (Dünnhoff et al., 2006)

### **Customer protection in the context of reorganisations of distribution and supply**

The previous discussion suggests that there exists a huge diversity of measures towards vulnerable customers. However, the process of competitive reform and reorganisation of distribution and supply businesses has been a source of additional threats for these customers who are facing increased energy bills. The effects of reorganisations of the distribution and supply business across Europe have not been examined in the literature. The example of the three countries we examined suggests that an effective protection of vulnerable customers needs a certain development of formal public regulations, i.e. obligations for the companies. But measures towards vulnerable customers also need to be implemented locally, as the treatment of each customer must be a personalised one. This increases the probability of success of these measures, which are sometimes difficult to implement<sup>36</sup> because of barriers to adoption.

The reorganisation of distribution and supply businesses thus raises different questions. One question relates to the strategy of grouping some activities, especially the commercial customer services, within large regional entities. If customer protection

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<sup>35</sup> In 2003, the number of “poor” people was estimated at 11 million (people below a poverty line, i.e. having a revenue below 938 euro per month) (Dünnhoff et al., 2006).

<sup>36</sup> For example, in France, only a part of the potential beneficiaries of the social tariffs (TPN) have actually used them.

requires a certain proximity with customers, will suppliers still be able to adequately propose services to vulnerable customers if they are organised in large regional entities? Another question relates to the relation between technical customer services and commercial services in unbundled systems. The unbundling could for example impact the companies behaviour of disconnecting customers. As the technical entities who disconnect customers for non-payment are not integrated anymore with the commercial services, the number of disconnections could increase due to the “agency relation” that is now existing between the two services. Whether this really increases the number of disconnections has to be examined in practice. If this was the case, alternative methods for dealing with vulnerable customers (prepayment meters, or “intelligent” meters) should be examined further.

This discussion of the potential problems generated by a reorganisation of distribution also raises the question of the appropriateness of basing future customer protection rules on the use of market mechanisms (Commission, 2007). Of course, it is desirable to improve contract structures in order to allow customers to switch their supplier. However, some small consumers could prove unable to fully benefit from competition on the retail markets, and would thus be exposed to future price increases. Therefore, the protection of small customers remains an important question.

The examples of public service policies in quality of supply and customer protection show that separation of monopolistic and competitive activities could bring up coordination issues and divergence in interests of implicated parties. Unbundling of distribution and retail businesses should thus be accompanied by several regulatory measures. First, a careful design of the regulatory modules is needed in order to ensure proper incentives to the network operator to maintain a given level of quality of supply<sup>37</sup> and to ensure public service for vulnerable customers. Second, our modular framework and the actual practice underline the need for coordination between modules and between companies taking part to the distribution activities. Specialized service producers of less specific modules (like “Commercial customer services” module, or the “Metering” sub-

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<sup>37</sup> Cf. Sappington (2005), who suggests to distinguish whether this one is owner or a franchisee. Introduction of competition and regulatory requirements could also induce a more detailed control from the franchisor in the case the owner and the operator of the distribution network are not the same company.

module) or sharing responsibilities for more specific modules (like “Network maintenance” sub-module) might be a way through achieving efficiency, but coordination among modules, including coordination among the parties’ interests should not be left aside<sup>38</sup>. Third, harmonising the regulation principles on these practices would contribute to strengthening the public service dimension of these activities. However, as distribution and supply have strong national specificities, this imposes some limitations on the harmonisation of rules.

## Conclusion

The objective of this paper was to explore the electricity distribution and retail businesses after the introduction of the reforms by focusing on the natural monopoly characteristics of distribution business and on the modular structure of the sector. We have analysed the evolution of the distribution and retail businesses by using a modular framework. This framework has also allowed identifying some potential concerns in the public service obligations like ensuring a good quality of supply for all customers and protecting small customers. Few studies have so far analyzed these issues. We are conscious that our findings are preliminary, and need further empirical validation. Nonetheless, further analyses of the relationships between the organizational evolution of the distribution companies, public service obligations, service quality, ownership, and managerial behavior are needed to shed more light on this relatively unexplored research topic.

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<sup>38</sup> The example of rail industry in UK (Staropoli-Yvrande 2003) shows that pushing separation of activities to an extreme could not bring the expected results, as the separated modules of this industry were reintegrated by the network operators for solving coordination problems that implied too high transaction costs and too many inefficiencies related to the losing too many scale economies.

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