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ELECTRICITY TRANSMISSION AND EU RULES FOR ENERGY SECTOR [*]

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ABSTRACT

This paper first discusses features of the Third Energy Package" of EU legislation regarding electricity transmission system operators (TSOs), which has been in place since 2009. The Package envisages three different types of TSO organization: full ownership unbundling (OU), independent system operator (ISO), and independent transmission operator (ITO). The question of economic efficiency of the three possible settings occupies much of researchers' attention. Here we argue that the results of basic economic analytical models depend critically on whether the regulatory function is deemed efficiently executed, or not. Next, challenges posed in front of TSOs by rapid decarbonization of power systems are briefly discussed, too. The main conclusion is that the answer to a question which of the three types of TSO organization from EU regulations is economically most efficient depends on quality of regulator's performance, which itself cannot be deemed (as often is in the literature) perfectly efficient.

1. INTRODUCTION

Reorganization of electricity system that has been going on since about two decades can be viewed in a light of deregulation doctrine which has been prevailing in western public policy ever since eighties. In electricity systems there are opportunities for competition in generation, wholesale trade, and retail. The networks are generally considered natural monopolies, and probably no one ever contested that fact. Yet, there have been quite a few debates about what should be the way to organize network operators. This question,

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of course, is not that simple and the answer often depends on one's personal views. Economic science has not yet offered a clear solution, as complexity of the problem is tremendous. It is hard to model complicated economic systems with simple theoretic models. It may be even harder to define more complex models. The literature is anything but unisonous about which of the organizational models from the 3rd Package electricity directive[1] is the best from the standpoint of either allocative, cost, or technical efficiency.

In this work we will first give an overview of contemporary economic literature on transmission system operator organization, with an inevitable conclusion that there is no clear conclusion about economic superiority of any of them. This will shift our attention to the area of policy choice. Since neither of the models can be firmly identified as the best, seemingly there is more maneuver space for political decision-making regarding that point. However, in most of the theoretical works we had read there is an underlying assumption, which cannot be firmly supported, that the regulatory system is perfect, meaning that it works as it is (theoretically) supposed to. Thus, assuming that the regulatory system *is not doing the job in the best possible way* in any of the three above mentioned aspects, the ownership unbundling model would emerge as probably the least problematic canonic model among the three from the 3rd Package's catalog, given the current EU circumstances in the electricity sector. However, the topic still deserves closer attention.

2. LITERATURE REVIEW

In the contemporary literature on the 3rd Package institutional framework for TSOs the researchers take several different approaches to the issue. The three are most important:

– Authors like Leveque, Glachant, Saguan, Rious, Pollitt, Bolle, Breitmoser, Brunekreeft and others analyze economic aspects of TSO designs, trying to identify which of the three is optimal regarding social cost-benefit. They usually try to rationalize the debate, however, this proved not to be too easy because the phenomena studied in their works are quite complex and consequently, the economic models employed were too coarse to give way for clear-cut conclusions.

– Some authors, e.g. Thomas, who is one of the most active, try to prove that the European Commission (EC) has not been successful in proving and justifying its course of action, which originally aimed to retain the owner-

[1] European Community (2009b).

ship unbundling (OU) solution as the only one legally allowed. Therefore, supposedly, the EC should not have favored the OU and forced the network owners to divest their historic assets neither by the law, nor by rigid antitrust enforcement. However, one can object to such an argumentation that legislatures are bound by constitutional limitations only and that they really do not have to *prove* their cases in a way court procedure would require.

– Finally, there are authors, for example Willis, Diathesopoulos, and others, who analyze relevant European antitrust case-law which influenced processes around formation of contemporary EC policies regarding transmission system operation in an ex-post manner. They are important for understanding of the logic of EU antitrust law enforcement that can be expected in future cases, since apparently the EC tends to use this legal tool to foster implementation of the rules.

An extensive analysis of the influence of TSO institutional arrangements on overall social benefit can be found in Pollitt's works[2]. He compares five institutional settings regarding their social cost-benefit: (i) Independent TSO (equivalent to OU from the 3rd Package); (ii) Legally unbundled TSO (equivalent to 3rd Package's ITO); (iii) Independent System Operator (equivalent to ISO from the 3rd Package); (iv) Hybrid ISO/TO operation (where both ISO and Transmission Owner are fully unbundled), and; (v) Traditional vertically integrated utility (VIU). These five arrangements were compared across a number of aspects: (1) effects on market competition; (2) ease and efficiency of regulation; (3) privatization aspects; (4) security of supply; (5) transaction costs of unbundling; (6) cost of capital and investment costs; (7) synergy and focusing effects; (8) double marginalization; (9) probability of foreign takeover; and (10) risk of voluntary government intervention. Pollitt concludes that the full OU is the best possible solution regarding overall social cost-benefit but for cost of capital as a fully unbundled operator as relatively small part of a system can lose a portion of its credit rating. He also refutes conclusions of other authors[3] that the LTSO is the optimal arrangement. He notes that in the jurisdictions with most successful electricity sector reforms (New Zeeland, Victoria & South Australia, Chile, Argentina, Nordic countries, UK, New York, Texas, PJM) system operation has been independent from generation interests, without exemption. On the other hand, countries with slow and unsuccessful reforms (France, Germany, California) had not made the system operation fully independent. An apparent advantage of the LTSO option in achieving better transmission investment adequacy and lower cost of capital

[2] Pollit (2007a); Pollit (2007b).

[3] Bolle and Breitmoser (2006).

may as well be diminished or nullified by difficulties in regulatory oversight of a bundled structure and discrimination issues linked to it. As Pollitt notes, this could be a significant problem especially in less developed EU states as their regulatory authorities may not be sufficiently mature, yet. Further, if legal unbundling itself were implemented in a correct manner, the mutual ownership effects would be questionable. Therefore, the whole concept of LTSO may be questionable, too (that is, if the real political goal was not to actually obstruct the market reform). As regards regulatory oversight, OU and hybrid ISO/TO may require notably more effort from regulators than e.g. state-owned VIUs or LTSOs due to bigger information asymmetries and more market transactions. Moreover, vertically integrated utilities require rather an anti-trust monitoring than regulation, especially if private. To conclude, Pollitt prefers full unbundling of the TSOs as the socially most acceptable institutional arrangement.

The French school of power system economists tries to introduce more rationality into otherwise aflame EU-wide discussions about optimal TSO design by taking a new institutional economics approach. Glachant and Rious[4] perform a modular analysis of TSO organization with respect to three basic modules each TSO has to have: (i) short-run network externality management (i.e. dispatching with congestion management); (ii) network development (i.e. long-run congestion management), and; (iii) coordination with neighboring TSOs. Leveque *et al*.[5] discuss criteria to compare transmission organizations. Assigning different weights to the five factors ((1) transaction cost savings; (2) incentive regulation implementation; (3) conflict of interests issues; (4) nondiscriminatory network access, and; (5) advantages of regional integration), they rank the three standard 3rd Package's solutions for different circumstances. They conclude that the full OU is most the best solution where cost savings and correct price signals for investments are crucial. This is the case where the transmission system is well connected with neighboring networks while internal network suffers from congestions. Note for example that quite a number of South-East Europe countries can fit very well into this category[6]. The ISO solution is most suitable for situations where internal networks are sufficiently developed but there is a need for more complex regional inter-TSO coordination due to insufficient interconnection capacities between individual control areas. The authors conclude that the European Commission, when ranking the options included into the 3rd Package directive[7], valued the cost-savings and right investment signals the most. They argue that the EC should proceed

4 Glachant and Rious (2007).

5 Leveque, Glachant, Saguan and De Muizon (2009).

6 Sabolić, Grčić (2010).

7 European Community (2009b).

with efforts to finally accept and legally enforce a unique institutional form for TSOs as the coordination between the systems would certainly be more efficient if all the systems shared the same organizational rules. The important message from this group's works is that in different conditions different institutional settings may be most appropriate. They also, pretty much as the EC, consider the ITO arrangement the weakest as it comes to TSO task fulfillment in reformed power sector.

Brunekreeft[8] performs a social cost-benefit analysis of the ownership unbundling with an emphasis on German TSOs. He studies three groups of potential effects across a few scenarios on welfare: (i) effects on market competition; (ii) effects on interconnection investments, and; (iii) effects on costs due to a loss of vertical synergies. He reports that: (1) In most scenarios the welfare change is positive but very small in a relative sense. (2) Effects on interconnection investments are surprisingly small, which is explained by the fact that, actually, vertically integrated utilities in countries which are either big importers or exporters need interconnections, and therefore, they do not have an interest in stopping TSOs from building new ones. On the other hand, (3) Brunekreeft found the vertical synergy loss effects very small, too. All in all, the OU solution is found to have slightly positive welfare effects. The author makes no attempt to compare the OU with other arrangements.

Balmert and Brunekreeft[9] try to analyze so-called deep-ISO variant of organization by posing the resolution of conflict between investment decision making and risk taking to the center of their attention. They argue that investment tendering (where private parties would be able to invest in transmission assets) would resolve this conflict. However, their conclusion is not really substantiated, and the question of private investments itself is too complex to be answered without much theoretical work or experience. This model is not yet clearly identified as a potential future canonic solution in other authors' works, either.

Bolle and Breitmoser[10] compare ownership unbundling (OU) and legal unbundling (ITO) and conclude that legal unbundling leads to lower final electricity prices, i.e. to lower total costs in the system. However, one of the underlying assumptions of their model was that in legal unbundling setting double marginalization is completely avoided. Yet, it can be at least partially eliminated in cases of vertically unbundled systems, too, by designing multi-part tariffs. After all, the present EU law requires tariff separation as obligatory.

8 Brunekreeft (2008).

9 Balmert and Brunekreeft (2009).

10 Bolle and Breitmoser (2006).

Nardi[11] analyzes empirically effects of ownership unbundling on transmission capacity investment and quality of service by comparing on the one hand, countries with any kind of unbundling in place against the ones with no unbundling at all, and on the other, countries with ownership unbundling against all other countries. As regards capacity investments the OU seems superior to other arrangements. When it comes to quality of services, it turned out to be better in group of countries with any kind of unbundling than in those without it. However, the systems with OU seemed to be worse off than the others, although Nardi notes that this result was not statistically significant.

As regards criticism towards the European Commission's past attempts to pass the OU as the only legally allowed option, there certainly has not been a lack of journal papers, analyses, political manifests, and all sorts of public activities aimed against the EC's policy orientation. We will cite here only one author as a representative of this class. Thomas[12] analyzes, more-or-less, semantics of the EC's policy papers, working documents, press releases, and, finally, pieces of legislative acts, to argue that the Commission had not sufficiently investigated and attested the grounds for its political action aimed at obligatory ownership unbundling. However, strictly speaking, the Commission was here merely a drafter of legislation. Had the European Parliament wanted to have the case scientifically or professionally *proved*, it would have certainly asked the Commission to produce some harder evidence. *But it had not*. And of course, the Parliament can pass a piece of legislation even (in a principal) on its whim, as long as the Treaty provisions are not breached. *The policy needs no proof.*

Pielow and Ehlers[13] analyzed the question of *constitutional grounds* for obligatory ownership unbundling. They analyze relevant provisions of constitutions of Germany, France and Netherlands, addressing the issue of basic freedoms of ownership and capital movement, although they never questioned the Commission's right of legislative initiative, nor general constitutional rights of legislators to limit certain general freedoms when public interests are on stake. Certain countries may have some constitutional obstacles in that regard, however, the example of France shows that these are basically not fundamental and that pragmatic solutions can be found. (For example, the French Constitution of 1958 required public services to be supplied by publicly owned companies but it did not specify *which* these services are. This was the basis that made possible privatization of Gaz de France in 2004.)

[11] Nardi (2009).

[12] Thomas (2007 a,b,c,).

[13] Pielow and Ehlers (2008).

There is an interesting piece of work on the relation between *corruption* and TSO unbundling[14], with an econometric analysis of a relation between Transparency International's *Corruption Perception Index* (CPI) and the level of unbundling modeled as a five-level variable. The main statistically significant conclusion is that lower degree of unbundling goes with lower CPI (i.e. higher perception of corruption). Moreover, newer EU member states have averagely lower level of unbundling. Interestingly, higher GDP per capita is associated with lower levels of unbundling. Although these results are quite intriguing, one can find some methodological problems here: First, the relation of CPI as a *perception* indicator and *true* level of corruption may be problematic in an international context as the same CPI may in the reality mean very different situations in different countries with considerably different relevant cultural backgrounds. Further, the GDP-unbundling relation may be affected by the fact that quite a few very large and high-GDP countries, like Germany and France, had at the time lower levels of unbundling.

Knyazeva, Knyazeva and Stiglitz[15] do not engage specifically in electricity transmission industry at all (in fact, they analyze international telecommunications industry from 1987 to 1999 and check the plausibility of the results by analyzing a multi-sector sample of European privatization deals from 1989 to 2006), but they investigate an aspect of *ownership change* influence on accessibility of external financing, which is quite important since an alleged detrimental influence on financial positions of both former VIU and new TSO has been one of the *main arguments of ownership unbundling haters"* in some countries in Europe. In newer EU member states there have been attempts to stir up emotions in political arena around the evil of privatization, too.

The conclusions of Knyazeva, Knyazeva and Stiglitz are: (i) Full privatization is more likely to happen in industries with weak performances; in states with higher fiscal deficits; in states with a legal system of non-French origin; and in larger and wealthier states. (ii) Access to external financing (bank crediting) has an important positive impact on future profits, investments and growth. (iii) Performance changes in years around the ownership change are not very sensitive to past financing limitations of public sector. (v) Company performances have better prospects to advance in the future if the privatization is done later due to the effect of learning an optimal privatization design in given circumstances in the sector. (vi) Maturity of capital market in a given state is important factor regarding success of privatization. (vii) Newly-privatized companies have higher information asymmetries (i.e. less reputation: they are

[14] Van Koten and Ortmann (2008).

[15] Knyazeva, Knyazeva and Stiglitz (2009).

less known to the business community). Since costs of debt are less sensitive to information than costs of equity, the access to bank loans is essential. Effects on operating performances are more evident in later years after privatization, though. (viii) Performances of privatized companies *are not better (nor worse)* than of the ones that stayed under state ownership. The lack of government guarantees can increase capital costs on grounds of higher risks, especially in early years following privatization. Effects of ownership change (or non-change) to company performances *were statistically equally insignificant* in both examined groups.

To sum up the conclusions stated above, and to translate them to the electricity transmission industry, *the ownership change itself is not all that important*, meaning that it cannot be used as a key argument *pro et contra* either of the TSO institutional arrangements. The arguments of state v. private ownership *are not very important, either.* What matters is the availability to external sources of capital, which is not more specifically related to the electricity transmission business, than any other one.

The last group of works we want to discuss here sheds light on the ownership unbundling subject from the standpoint of antitrust law, policy and jurisprudence, focusing on energy sector cases[16]. A great importance of it stems from the fact that antitrust litigations can perhaps be sees as one of the most powerful tools the Commission uses *de facto* to enforce its policy goals. Willis and Hughes conclude: (i) The Commission *does have a right* to order ownership unbundling in non-merger proceedings, too, as a structural measure in individual cases, after a thorough economic analysis, adhering to the principle of *proportionality* of the measure in relation to the nature and extent of the breach. (ii) The Commission is *likely to be able to defeat* any legal challenge based on arguments that it has infringed the European Convention on Human Rights[17],[18], or the principle of subsidiarity[19], provided that the unbundling remedy is proportionate to the breach of the EC antitrust law, as the Commission has already won a number of cases in courts where it commanded divestiture as a structural remedy under Art. 82 of the Treaty. Further, there were cases in which the Commission acted under Art. 81 of the Treaty by approving firm's commitment to *voluntary measures* taken to avoid expensive, long lasting and risky litigations.

16 Willis and Hughes (2008); Diathesopoulos (2010).

17 Council of Europe (1953), Protocol 1, Art. 1, the right of peaceful enjoyment of his/her possessions.

18 Article 295 of the Treaty (European Community (2002), national property rights).

19 Article 1 of the Treaty, European Community (2002).

For example, on 26 Nov. 2008 the Commission adopted a decision on commitment addressed to E.ON for two *suspected* infringements of the EU antitrust law (manipulating the wholesale energy market by withholding, and buying system reserves favoring its affiliated generation plants). To avoid litigation, the E.ON had to commit to divest: (i) 5.000 MW of installed generation capacity; (ii) the high voltage grid together with the system operation activities. These were the first cases ever in which a company agreed to sell *very substantial* amount of assets to avoid antitrust proceedings the Commission intended to start. For a brief exposure of this milestone antitrust case can refer to Chauve *et al*.[20].

3. CAN OPTIMAL TSO INSTITUTIONAL ARRANGEMENT BE IDENTIFIED?

From the literature review one can conclude that, probably, there is *no firm evidence* that any of the 3rd Package's canonic forms is the best from the social cost-benefit point of view. Moreover, the old arrangements themselves, like full vertical integration or legal unbundling within a VIU group, cannot be in a theoretically sound way regarded as neither better nor worse from these three. The reason for this lies in a fact that the TSO-related economic phenomena are too complex and dependent on too many variables, many of which being specific for a given electricity system with its unique inherited features. Therefore, they cannot be emulated by simple and comprehensive theoretic models. Complex models, on the other hand, cannot be employed because they would require much wider statistical samples within each of the modeled structure, and longer time series than presently available.

Thus, our conclusion is that the very *organizational form* itself cannot be too important and it certainly cannot be *the* most important thing to take care of, provided each of the organizational settings is executed in a correct manner. But then, the problem is how to achieve this correctness itself.

When companies are totally independent, as in the OU case where former VIU and new TSO have different owners, all that is more-or-less important are normal strategic interactions between firms, requiring only a relatively mild ex-post control over possible collusive practices. An ISO arrangement requires more regulatory engagement, while ITO may pose truly big challenges in front of the regulatory system as a whole. One of the main characteristics of the TSO design-related literature is that the analyses have been performed under an assumption of regulatory efficiency. Yet, this assumption might prove not to

[20] Chauve *et al*. (2009).

be too strong. For example, Ugur[21] concludes from his analysis of ex-ante and ex-post indicators of regulatory quality and their relationship with market outcomes in three liberalized network industries (telecoms, gas, and electricity) of the EU-15 countries that the design of European market institutions is *not* optimal and that it may be conducive to regulatory ineffectiveness or outright regulatory failure.

While Ugur's work is of a practical kind, which is very important for getting a picture on true regulatory quality around Europe, we can refer to two seminal theoretic works on regulation, too. Stigler[22] formulates his famous theory of regulatory capture following an econometric analysis of *effectiveness* of regulation. Peltzman[23] made a sort of generalization of Stigler's theory by modeling a regulator as an agent which tries to maximize *its own utility* (and *not* necessary society's) by choosing certain equilibrium mix between popular and private political support. In an earlier work by Stigler and Friedland[24] the *effectiveness of electricity utility regulation* throughout the USA in the pre-World war II time was studied. It was econometrically calculated how the explanatory variables (total population in cities larger than 25 thousand inhabitants; price of fuel; percentage of hydro generation; per capita state income; and dummy variable for presence of regulation in a state) influence average revenue per kilowatt-hour. Influence of regulation proved to be *statistically insignificant* in all analyzed years. Further, the relation between regulation and rate structure (the ratio between household and business tariffs) was studied. Finally, the effects of regulation on long term equity performance were investigated. In both cases regulation had statistically insignificant influence. (These findings certainly contributed to Stigler's theory of regulation of 1971.) Stigler and Friedland explained their findings essentially by informational asymmetry (in today's vocabulary).

Not many economists today oppose to these basic theories and their more advanced later versions. Yet, for some reason, in many theoretical analyses regulatory system is being *assumed* efficient, while seemingly *it is not* by the *very nature* of regulatory process. Thus, it is methodologically problematic to assume regulation was perfect while at the same time regulatory imperfectness has been theoretically undisputed since decades.

Taking this basic fact into account may certainly change the otherwise hazy situation regarding the choice of optimal TSO institutional arrangement by

21 Ugur (2009).

22 Stigler (1971).

23 Peltzman (1976).

24 Stigler and Friedland (1962).

identifying the *models less dependant on regulation* more desirable. It is well known that either total ownership unbundling or total vertical bundling are the settings least dependant on regulatory action. Since the 3rd Package *commands* vertical unbundling in one of the three canonic ways, obviously, not much maneuvering space is left, at least not in countries where regulatory institutions are still considerably weak. Such countries are often characterized by a joint state ownership over the regulator, the VIU, and the system operator (either directly or indirectly), which may complicate relations between these agents (e.g. for the ITO case these relations would be: state-regulator; VIU-ITO, VIU-regulator and regulator-ITO) to a further level. If a *political goal* was to have electricity transmission system operated independently of either generation or supply activities, and the European Parliament and Council *did make it a goal* by adopting the 3rd Package, then, having in mind that a non-negligible degree of regulatory failure is by the nature quite probable, the full ownership unbundling would presumably fit best into this political framework. It is worthy to note that American economists (and politicians) strongly favor wholly independent system operation, too[25]. Given American tradition in policy pragmatism, as well as the fact that the whole idea of electricity market reform had originated in the USA, this is certainly something to take into account, too.

Unfortunately for politicians, theoretical economic analysis cannot provide a firm proof that either of the TSO models is the best. If it could, there would be less debating over the issue. However, unfortunately for the EC's critics, the politicians successfully created a sufficient amount of political will needed to pass the legislation that clearly prefers the OU model. As the 3rd Package appeared in a democratic process, it is a demonstration of political will and thus does not have to be even economically justified, let alone proved. This is an elementary fact overlooked by quite a few authors, as we argued above.

4. TSOS' ROLE IN ENERGY POLICY IMPLEMENTATION

4.1. FORMULATION OF THE POLICY PROBLEM

Energy mix problem in electricity generation becomes more and more important throughout the World for two main reasons: emissions of carbon dioxide should be lowered because of global warming concerns, and fossil fuels need to be gradually replaced by alternative available energy sources as the fossil fuel reserves are limited. In electricity generation these two goals are to be achieved by two kinds of actions: implementing new generation plants that

[25] See e.g. Joskow, (2003).

use renewable energy sources like wind, solar or geothermal power, and making industry and living less energy-intensive by all sorts of energy efficiency improvements, for instance investments in better thermal isolation of homes, fostering development of distributed generation aimed at lowering energy losses in networks (at some expense in generation efficiency, though), producing better electrical machinery that would spend less energy for the same functionality, etc.

The European Commission adopted a policy of reaching twenty percents of total energy consumption from renewable sources until 2020[26]. This policy has been turned into law: the Renewables directive[27] sets out this goal as a firm obligation for the EU and also specifies individual national targets which took into account specifics of each member state. Moreover, until 2050 the electricity generation should be 96-99 percent carbon-free[28]. The fact that today's technology still does not allow for full competitiveness of renewable sources as compared to conventional ones *does not automatically remove* a need to gradually change the organization of the industry so that renewable sources become able to compete *in electricity markets* with a minimized state intervention (and minimized or, ideally, abandoned subsidy schemes). This is, naturally, not attainable in the short term.

Thus, the main *political* goal in the electricity sector for the decades to come should be formulated as follows: The renewable sources *must* eventually become an integral part of electricity markets, and they *must* be subjected to the same market forces and price incentives. This is a precondition for the transition from fossil fuel-dominated system to a green one. One can rightfully fear that governments, prescribing various subsidy schemes that effectively isolate renewable sources from market signals, will gradually introduce a lot of market distortions by sustaining these schemes for a long time. Although one cannot really dispute the need for a state intervention in the beginning of the decarbonization process, there are questions of how well the intervention has been thought through, and are the mechanisms for government's pull-out in place, or at least prepared.

[26] European Commission (2010).

[27] European Community, (2009a).

[28] European Commission, (2011).

4.2. ECONOMIC CHALLENGES IN FRONT OF THE GENERATION-TRANSMISSION HALF OF THE SYSTEM

In this section we will concentrate on issues specific for generation and transmission. The main assumption is that the biggest challenge in front of transmission business is how to adopt a large sum of new (intermittent) renewable sources in relatively short time in an economically viable way and, yet, not jeopardize reliability of electricity supply. In that context, issues relevant for transmission and for generation are hardly inseparable.

Transmission networks as they are today had been built mostly to meet different type of requirements than the emerging ones. Historically, the grids had been planned to enable transmission of energy from domestic generation plants to domestic consumers (mostly on national level), aiming at electrical self-sufficiency. Cross-border capacities had been built for technical purposes (security of network operation) and they usually had been too small to be able to carry significant energy flows. System reserves had been planned and built to satisfy the regulation needs of electricity system mostly comprised of easily fossil fuel-fired, nuclear, and hydro plants on the production side, and quite predictable load and prediction tools appropriate for relatively slow-changing load profile on the consumption side.

The greenification of the electricity system, combined with market reform, brings more complex challenges in front of networks and their operators. As regards market reform, transmission systems are expected to become more interconnected to allow for serious energy transfers across national borders. This is, for example, in line with the European electricity sector policy[29]. However, execution of the policy goes together with many practical problems and possible misunderstandings.

One of the most prominent blunders is that every cross-border congestion is by definition bad and that it must be rooted out at any cost[30]. Another very popular blunder is that new interconnections would solve all the problems regarding "free" electricity trade (that is, a trade not influenced directly by government's heavy regulatory rules and oversight), as they are needed to compensate for large-scale unevenness of generation plant geographical distribution and, maybe more important, growing unevenness of geographical distribution of large wind generation plants across the internal European market. At the same time, the problem of insufficient capacities for ancillary services, especially secondary and tertiary regulation, which are necessary to have to enable larger pen-

[29] See European Community (2009 b, and c).

[30] It apparently follows from European Community (2009c).

etration of intermittent renewables, is being constantly undervalued for some hardly understandable reason.

Although challenges that TSOs face in the greenification process may seem technical in their nature, they are not. In fact, there are huge *business challenges* that will soon need to be efficiently managed by TSOs. When, for instance, operators say that they are getting a hard time when they have to operate the system with a substantial percentage of intermittent wind power production, this usually does not mean that they do not know how to run it, but rather that they do not have sufficient regulation resources. As regards congestion management, it is solvable with still relatively cheap investments in transmission lines. However, the problem with regulation (physical balancing in the real time) does not go away with energy transferred through the transmission lines. It remains within the domestic system which must bear the burden of regulation.

Fast regulation can be provided only by certain types of conventional power plants, which are technologically capable of this: hydro plants with reservoirs, or with pumped water storages, or otherwise by natural gas-fired plants, provided the latter are connected to a gas transmission system which itself is balanced.

Thus, the increase in regulation capability of the power system is inevitably associated with hefty investments in the *conventional generation* sector. By the currently prevailing political will, the generation industry must be *unbundled* from the transmission business, leaving TSOs essentially helpless when it comes to new regulation plant investments. Since that is so, *the only way* to make increase of overall regulation capability possible is to make the regulation power plant investments attractive enough for potential investors. This is equivalent to say that the society *must commit* to "free" electricity market mechanisms and give up the state intervention in the electricity sector. Namely, an inrush of intermittent generation (notably, wind and solar) itself changes the economics of power system in a way that it lowers the market value of energy, *ceteris paribus*, and simultaneously increases the investment risks, especially for peaking plants[31]. The state subsidies which isolate renewable sources from market risks certainly do not help the situation.

However, the only way to phase out state subsidies is to make new renewable sources economically competitive with classical ones. Technology development can bring renewables still closer to classical plants regarding overall long run incremental costs, on the one hand. On the other, enormous externality costs of pollution, which are still largely avoided, should be paid for by the in-

[31] Steggals *et al*. (2011).

dustry. Naturally, these new costs (CO_2 emission costs being the most famous of them all) will be transferred towards the final customers, and again, they will have to start paying.

One of the problems encountered in small power systems is the night load minimum (e.g. Croatian system with about 3.100 MW of peak load can be considered small; the night minimum is about 1.400 MW). At least all coal-fired and nuclear plants (if any) have to fit into this modest range. Moreover, recent strong political and legislative trends gave advantage in network access to renewable sources[32]. Thus, in most of the countries large wind farms already have preferential treatment as compared to fossil fuel and nuclear plants. In such circumstances it is not hard to imagine a situation where a larger new plant (say, 800 MW coal-fired, or 1.000 MW nuclear) would be simply too large to be squeezed into a tight generation schedule unless shipping a substantial percentage of produced electricity abroad, especially during the night.

For that reason, investors in large (and usually more efficient) generation units would be forced to ship the excess energy abroad, especially during the night time. This can increase investment risks as selling an energy that nobody currently needs may lower its prices considerably (even to negative values, as several times during 2009 on the German market). If there is no coupling with the foreign markets to sell, the investor would have to bear risks of cross-border charges, too. All these risks diminish as the market is bigger (with more players and more energy to exchange), i.e. more liquid. Connecting to international markets increases liquidity, decreases risks, and usually enables usage of various financial hedging devices.

Further, there occurs a question of *system reserves*, especially the tertiary reserve. A system operator has an obligation to keep available as much tertiary reserve capacity as big the largest generator inside its control area is. Suppose an investor wants to build a new 1.000 MW nuclear plant with a single generator in a control area with e.g. 3.100 MW peak load. Let the largest existing generator in such a system have 300 MW of installed power. Thus, local system operator has to keep 300 MW of tertiary reserve. After new nuclear plant is built, the operator would have to get additional 700 MW of tertiary reserve.

It is self-understood that in a bigger system it would be much easier and cheaper to obtain larger sums of tertiary reserve *and* the problem of the generator unit size would not be that drastic as in small systems. These are the reasons why it is economically better for system operators *themselves* to be a part of a larger system. Generators would benefit, too, because diseconomies of running in a small system would naturally decrease. Or, to put it simpler: *system*

[32] European Community (2009a).

operation itself exhibits economies of scale. Transmission system operators and electricity system as a whole profit from including more control areas into a centrally operated system. Therefore, state policies should foster mergers of control areas beyond national borders instead of discouraging them. Yet, at least regarding this point, European states have not shown too much rationality, so that exploiting the system operations economies of scale like in the USA still seems decades far away when it comes to the EU or Europe in a wider sense.

Regarding European policy towards ancillary services *trade*, apparently there is none. Otherwise, if anybody took care about this important detail, the European Commission would not effectively prevent cross-border trade of non-dispatchable services as it did in the Regulation on network access for the cross-border exchange[33]. Since the cross-border capacity allocation rules are based on forwardly traded scheduled capacities (except for the remaining capacities available for intra-day (real-time) allocations), and since capacity reservation is forbidden (except for technical purposes related strictly to security of system operation) they apparently prevent non-schedulable services, such as reserve power, to be traded over national borders, although ancillary service trade is obviously useful and beneficial.

The question of competitiveness of renewable sources is not by any means simple nor one-dimensional. In Joskow[34] the author argues that the currently used methods of comparison, the levelized cost being the most frequent one, do not produce realistic results in comparing classical with renewable technologies, and make the green technologies look more attractive in an economic sense than they realistically are. The levelized cost methods sum all the capital and operating costs during the plant's life cycle and divide it by the quantity of energy it will produce in this time span. The idea of the calculation is to enable comparison between total long-run production costs per unit of generated electricity. Joskow shows that, since such studies have an underlying assumption that the economic value of the energy produced in all types of plants is the same, the results are misleading.

Electricity can take a number of marketable forms, so one cannot speak about the electricity as a single product. Instead, one can think of separate energy and reserve power markets such as base-load, peak-load, night base load, day base load, spinning reserve, secondary regulation, tertiary reserve, island operation, black start, etc. (for more information see[35]). In this context, as an ap-

[33] European Community (2009c).

[34] Joskow (2010).

[35] Stoft (2000).

proximation Joskow identifies two main groups of generating plants: dispatchable and non-dispatchable. While dispatchable plants can easily adjust their generation power to a desired level that is derived from economic dispatching and system security criteria, the non-dispatchable cannot. In other words, dispatchable generators can work (and make money) when ever needed, while the others cannot. If by a political force the non-dispatchable sources were given a legally established precedence in network access, they would incur additional costs of system regulation. In any case, the energy produced in non-dispatchable generators has significantly lower economic value. For this reason, more accurate models for comparison of concurrent electricity generation projects will have to be developed. Regarding only the renewable electricity technologies, geothermal plants are the nearest to the goal of being competitive with coal, combined-cycle natural gas, or nuclear plants, and this is because of their inherently dispatchable character. Wind farm technology is probably the next in line, while solar thermal and especially solar photovoltaic technologies may have to wait somewhat longer to become truly competitive[34].

The economic factors that will certainly help renewable technologies to become competitive in time even without state subsidies are as follows:

- the hydro potentials will eventually become mostly utilized, so there will be no significant potentials for further construction of hydro plants; as power consumption will inevitably increase, these natural resources will gradually become more and more scarce;
- the prices of fossil fuels (oil, natural gas, coal) will inevitably keep increasing for their reserves will gradually come to their ends (though, coal reserves will probably last quite longer than gas and oil);
- the carbon emission reductions will become tighter in time as a consequence of increased political determination to significantly slow down the pace of human-induced global warming; therefore, the prices of carbon emission rights (or their tradable financial derivatives, to be more precise) will also keep increasing;
- in order to combat increasing carbon emission prices the companies might start investing in carbon capture and sequestration technologies (should they become truly efficient with affordable prices); this will be just another manifestation of carbon emission reduction costs which will additionally burden both capital and operating costs (since these technologies increase fuel consumption, which in turn may also contribute to further fuel costs increases, too).

From today's standpoint it is hard to tell when the above listed costs will become significant enough to draw true normalized costs of renewable and clas-

sical electricity sources nearer to each other. However, one should note that it is not only a drop in renewable plant costs that will happen – rather, it is an increase in classical plant costs, too.

5. CONCLUSIONS

The most important strategic challenge in front of transmission system operators is large-scale adoption of renewable sources, many of them with intermittent production characteristics (i.e., with unpredictable temporal variability), into transmission systems. This assumes the systems must be upgraded both in the physical domain and in the domain of the management philosophy. Regarding physical upgrades, the new transmission systems must become able of evacuation of considerable amounts of energy from many new renewable generating plants. They have to become able of transferring large-scale energy flows between macroscopic geographical areas with uneven distribution of new renewable plants. Nevertheless, this is merely an economic problem of network investments which may prove to be still relatively modest.

Transmission operation is a regulated business which must be sufficiently funded to be able to fulfill its tasks. It seems that increased need for so-called ancillary services would put operators to a financial stress because the society (and regulators, too) would probably expect transmission tariffs not to increase (too much). Therefore, there will be pressures to reduce costs related to assets and labor, to make more room for additional costs associated with real-time system running. However, a combination of higher percentage of intermittent generators and lower asset-related spending could bring system reliability (i.e. short-term security of supply) nearer to a dangerous level. This in turn could pose new organizational challenges before management structures of the operators.

Regarding the economics of power system related to the process of system greenification, which has a profound influence on transmission business, the main policy goal should be to abandon the philosophy of subsidies towards the green sources as soon as possible. Renewable generation definitely must become an integral part of electricity market. While the subsidies are justified in the beginning of the greenification, so that the process can successfully start after many decades of ignoring the external costs related to environmental pollution, which made clean energy sources uncompetitive in comparison with the classical ones, once the levelized costs of the two become comparable the renewable sources will have to assume a role in normal power markets, which includes forward trades, real-time (spot) market settlements (called *balancing*), including balance responsibility measured by normal spot prices. In other words, one day renewable sources must become just another market partici-

pant offering their products and services on organized or non-organized markets, following the same market rules, and receiving the same price signals, as any other market player, regardless on technology they implemented for production of electric energy.

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