At the Speed of Light?

Electricity Interconnections for Europe

GOUVERNANCE EUROPÉENNE ET GÉOPOLITIQUE DE L'ÉNERGIE

8

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IFRI
27, rue de la Procession
75740 Paris Cedex 15 – France
Phone: +33 (0)1 40 61 60 00
Email: ifri@ifri.org

IFRI Bruxelles
Rue Marie-Thérèse, 21
B-1000 Bruxelles – Belgium
Phone: +32 (0)2 238 51 10
Email: info.bruxelles@ifri.org

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To Jacques Lesourne

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Executive Summary

Electricity interconnection has become a prominent issue in the news, sometimes even featured as a panacea for the shortcomings of the European electricity market — a panacea that will ensure energy supply and security and pave the way for a promising use of renewables in the future. Its development is, indeed, considered key to the challenge of secure energy supply, a subject of utmost concern for the European Union (EU) especially since the latest —though surely not the last— gas supply interruption at the start of 2009.

Security of supply must be envisaged not only via diversification of routes or suppliers, nor exclusively via the introduction of changes in the energy mix, but also through the improvement of interconnections, both in terms of an optimized use of the existing ones, as well as through the filling—in of the missing links among them.

The present report is devoted to electricity interconnections in Europe, their current state and the projects concerning them. Consistent with political science vocabulary and methodology, interconnection will be viewed, here, as the dependent variable in a complex equation involving historical, geographical, economic and geopolitical factors.[1] Reflecting IFRI's focus on international relations and geopolitics, the author will concentrate on the geopolitics and governance of

1. The terminology originally stems from the discipline of mathematics and statistics: independent and dependent variables are used to distinguish between two types of quantities being considered, separating them into those available at the start of a process and those being created by it, where the latter (dependent variables) are dependent on the former (independent variables).

interconnections. The work is not intended to compete with engineers in 'their' field, nor with economists or regulators — a battle the author could only loose, and that would furthermore be totally outside the scope of IFRI's topics. Some basic understanding of the technical side being nevertheless required, an explanation of certain concepts and practices will be included in the introductory part, based, precisely, on reports and definitions produced by experts and engineers.

The growing public and political interest in interconnections demonstrates the relevance the subject has acquired well beyond the technical and expert circles and justifies, in itself, the existence of this report. Quite possibly, however, after having considered the rather complicated technical fundamentals, the critical observer will find himself still struggling with a compelling question of public interest bearing on this particular field: centralism or federalism? For example: decentralized local and regional grids or a pan-European super grid reflected on regulatory structures? National and corporate interest, lobbying and the exercise of power are intrinsic to this field. More transparency in the debate is definitely a prerequisite for efficient decision making.

The study addresses the following questions:

• *What* is the role of interconnections in the development of a sustainable grid that can emerge from the existing systems, making optimum use of existing generation capacity, ensuring energy security, and offering economies of scales? What is their role in the process of building a different energy concept, one that would address climate change and favor the use of renewables?

• *How* are existing interconnections exploited and governed, and how can their exploitation be improved? Does the EU need more and new interconnections; and if so, where and why, and who is going to finance them?

Part I develops definitions and basic notions necessary for the understanding of the subject. It also addresses the independent variables that influence interconnections (here the dependent variable), and recounts the historical legacies and their enduring impact on today's grid.

Part II is devoted to the EU legal framework and to the complex landscape of governance and its current state of transition.

Part III addresses the management of existing interconnections and the missing links among them, detailing projects and needs region by region, including various dimensions of the relationship between the EU and third countries.

Part IV lays out recommendations for EU and national policy makers.

The conclusions of this study are as follows:

Interconnections can provide the basis for increased solidarity between EU member states. Solidarity means mutual aid in the case of supply disruptions. The practice of solidarity in a well understood common interest requires an appropriate infrastructure, and interconnections are essential to make this happen. Interconnections offer huge potential to improve market efficiency and speed up the move towards a single electricity market. But one must be careful not to overlook the need for improvement within national markets, a precondition for European market integration.

Positions diverge on whether new interconnections are needed or not. Whereas some authors stress the insufficient exploitation of existing links, others complain about poor dynamics in setting up new capacity. Three reports on French interconnections produced by the French regulator Commission de Régulation de l'Energie (CRE) demonstrate that today's existing electricity interconnections are indeed insufficiently exploited — even if positive trends can be noticed as the result of improved governance and increased transparency. On this issue, however, it is very important to remember that for a link to be secure and economical its exploitation must not permanently exceed a 50% level of its physical capacity.

For third countries, interconnection-related interdependence comes with additional benefits such as the convergence of norm and governance. The question about the limits of synchronization, or, to put it otherwise, of an optimal synchronization space, remains unanswered and is political in many ways. Alternatively, the establishment of direct current links is an option. Direct current links, however, do not enhance synchronization, but just join electricity regions without establishing the automatic solidarity predominating today both in the huge synchronous Russia/CIS (Commonwealth of Independant States) area and in the EU as a whole — the United Kingdom (UK) excluded. On the other hand, one can legitimately wonder whether synchronization with Northern Africa via Gibraltar—Ceuta has been the result of a rational choice, considering that it is said to contribute to delaying intra-Maghreb synchronization.

The numerous and fast changes currently taking place in the independent variables affecting interconnections make the present time opportune for exploring: public finance for infrastructure, European governance, the Third Package and 'smart grids' are key words in this context. Smart grids, combined with the use of Information and Communication Technology (ICT), are already widely present in the grid and its management since the 70s (the setting up of computer-based Dispatch Centers is a good example of this). Further improvement needs still be made, however, in distribution to significantly increase energy efficiency. European governance has also made progress through the establishment of the seven electricity regions and the adoption of the Third Package. The financial crisis, in turn, debilitating though it may be, coincides nevertheless with significant fresh commitment by governments to invest in public infrastructure, including energy infrastructure.

A glance at the past can show the effectiveness of such public commitments: the electrification of the US (United States) countryside under Roosevelt's New Deal, for example. With that in mind, it is fundamental to identify and prioritize those projects that can be deemed of European interest, since the increase in public spending unavoidably triggers at once a wave of indiscriminate lobbying for all sorts of ventures, many of them of restricted interest or not important at all. Leaving the flows to the market and making the economically reasonable decisions are thus important goals; distortions from the market game, in turn, must be eliminated with time. This is particularly crucial when one considers that energy infrastructure and energy policy —unlike government administration, for example— are not overhauled every four or five years, but stay on, empirically, for the span of three generations.

The present is a period of intense soul-searching and questioning on matters of energy, and the design of our future energy landscape in Europe is subject to much speculation. The scope of energy efficiency is difficult to anticipate. We ignore the energy mix of the future, but expect the gas demand to keep roughly the same from 2015, and the advent of renewables, and more nuclear. Today's debates confront us with two extreme scenarios —and a number of "combinations" in between— the first one being the traditional model with more nuclear energy (especially the position of France) or clean coal (China), and the second one the 'green model', with the lion's share of electricity generated from renewables by 2050. The idea that the latter could be accomplished via DC links transporting solar energy from the Sahara to the North sounds, today, like science fiction. Conversely, looking back on the present time from the 22nd century perspective, today's coal, gas and nuclear generation units might well appear to our successors as nothing more than a relic from a long-gone past.

Introduction

The European electricity map reveals the concentration of infrastructure in industrial and urban areas, the search for proximity between generation and consumption, the still very prominent East-West divide, and some isolated spaces. It also displays, however, a certain number of cross-border interconnections. The following questions, thus, are in order:

• What is the importance of these lines? Are they sufficient both in number and capacity? Who is in charge of them?

• What is the picture going to look like tomorrow? Are the existing interconnections economically viable?

• Why is it preferable to create interconnections rather than to transport the resources to generate electricity a procedure that is, in general, cheaper?

The advantages of interconnections are as follows:

• they improve the quality of electricity;

• they contribute to the establishment of European norms because they compel the national Transmission System Operators (TSO) in charge of the lines to agree on common standards;

• they develop cross-border capacities and are a conditia sine qua non for an integrated EU electricity market;

• they develop cross-border capacities with third countries and contribute to the development of common standards and the emergence of a European market at large;

• they respond to the challenge of regional congestion management;

- they are an alternative to investment in new capacity;
- they create solidarity among member states and between these and third countries;
- they enhance security of supply;
- they broaden the scope for achieving environmental targets;
- they improve the efficiency of the market by stimulating competition among national operators.

Electricity interconnection, as a process that involves more than one country, is very dependent on the quality of governance. The seemingly simple operation of laying a line from one country to another requires answers to some initial questions:

- Who is to pay for building and maintaining the line? Who is its owner?
- Who is in charge of operational security?
- Who decides on access to infrastructures?
- Who sets the price of the output? And how does the market evaluate the benefits of the line at different price levels?

The European electricity grid, as it exists today, has evolved from local to sub-national, and from sub-national to national grids, having reached, in certain areas, a strong regional dimension. It is important to note that the mere existence of national borders has rarely posed a hindrance to the expansion of electricity grids: in Eastern France, Southern Germany and Switzerland, for example, technical and economic rationales have largely prevailed over national considerations. Logically, the European electricity grid of the future must be regionally organized, since ideas such as selling Spanish solar energy to Denmark, Danish wind energy to Spain, or French nuclear power to Greece would be economically inefficient, losses in transmission high, and governance overly bureaucratic.

The grid also reveals the history of industrial Europe: an intricate tale of war, conflict, cooperation and integration. While pan-European connection dates back to the early 20th century, adverse circumstances of political and technological nature, as well as economic resistance, have hindered progress as much on the optimal exploitation of existing lines as on the setting up of new ones. War in former Yugoslavia and the subsequent political, economic and cultural fragmentation of the territory have not only had an impact on the splinter countries themselves, but also on Greece, Romania, Bulgaria, Albania, and even Turkey. Greece, although a member of the European Community (EC) since 1981, was electrically connected quite belatedly owing to the considerable degree of isolation of the former Eastern Block states that were loosely linked via a Yugoslav interconnection, and only later via a submarine link with Italy.[1] Important EU member states like Spain and Italy are still partly isolated in terms of electrical interconnection. And the East-West divide persists, even if borders have shifted: while Poland was interconnected with the Western UCTE in 1995, the Baltic States —new members since 2004— have still not been so. They continue to be part of the former Soviet IPS/UPS system (Integrated Power System/ Unified Power System), just as Ukraine does except for one small interconnection near Lvov. Moldova remains attached to Russia although two 110 kV lines link it to Romania.

Needless to say, every one of those countries is seeking urgent integration into the Western system partly, at least, so as to decrease dependency on Russia. The highly political dimension of electricity interconnection and the subsequent affiliation with either the Western or the Eastern system is currently epitomized by the Russian government's stern opposition to the alternate current synchronization of Ukraine and Moldova into the UCTE — direct current might be easier to accept, since it does not involve integrated electric governance. This leads straight to the question about the optimum future electricity governance model for Europe: should it be centralized, like the Soviet Central Dispatch Organization (CDO) that used to be responsible for the totality of the communist territory, including Central Europe, or, instead, regional, as it has been emerging to date in the EU? Or yet, would it be rational, in the long run, to have the continent split into an Eastern and a Western system?

1. Greece joined UCTE in 1987. It became interconnected with Yugoslavia in 1972, and later with Italy following the opening of Epire-Pouilles in 2009.

Switzerland, on the opposite edge of the spectrum, is massively interconnected and consequently plays a pivotal role through its participation in the UCTE/ENTSO-E (Union for the Coordination of Transmission of Electricity/European Network of Transmission System Operators for Electricity). However, the fact that the country is not an EU member often requires additional cooperation efforts and constitutes an important handicap to governance.

Turkey, a candidate since 2005, is currently in the process of developing the technical aspects of its interconnection, while it has already, thanks to its link with Greece and Bulgaria, indirectly benefited from the latter's integration with the UCTE. Again in this case, where a direct current link would have helped overcome the de-synchronization with the countries on the eastern border, politics has prevailed over rationality. Turkey's quest for synchronization is, in this sense, a good example of an old-established pattern: electrical integration comes ahead of political integration, not the other way around.

The next question is: should the expansion of a European grid be left to the market? Experience and particularly the missing links show that the markets, if not properly guided, would fail the task. The TSOs would fail as well. Electricity grids and, consequently, interconnections themselves, are public goods, network services very much like telecom or transport routes, and as such need an efficient partnership between private and public instances. To date, the EU is organized into five synchronous areas and a major push is underway towards standardizing the UCTE, an organization considered a benchmark in terms of quality of electricity and good management. On a regulatory level, important changes are currently in progress: the EU's Third Package enhances new institutions and as a result of it, the five existing regional organizations —UKTSOA (United Kingdom Transmission System Operators Association), ATSOI (Association of Transmission System Operators in Ireland), Nordel (Organisation for the Nordic Transmission System Operators) and Centrel (the regional group of four TSOs: CEPS of the Czech Republic, MAVIR of Hungary, PSE-Operator of Poland,

and SEPS of the Slovak Republic)— disappeared by 2009 and constitute now alltogether ENTSO-E.

Europe keeps enlarging; the constant demands to create interconnections with non-member states and regions have led to ambitious interconnection projects with Russia and the CIS, as well as with the yet to be established Mediterranean Ring. The revision of the European Neighbourhood Policy, currently attached to its regional clustering strategy (Union for the Mediterranean, Eastern Partnership), includes electricity interconnection as a prominent issue. And very much as it happened in the early days of European integration, concrete policies, like energy policy, are expected to 'spill over' to regional integration. The exploitation of different pricing levels —cheap in the East, expensive in the West— is as promising to some actors, as frightening for others.

A historical consideration of the sources of electricity generation shows that the 19th and part of the 20th centuries depended on coal, which was then replaced by oil and subsequently completed by gas (1960s) and nuclear technology (1970s). Will the 21st century witness a major transition to renewable sources and a redesigned, much more efficient, ICT-based infrastructure? Is the 100%-renewable perspective stipulated by the European Climate Foundation for 2050 a realistic ambition? If so, what would it all mean for grids that already had to adapt themselves to the nuclear challenge? As environmental concerns over electricity generation grow, so does the interest in renewable energy as a source for feeding both national and European grids. This challenge has translated into the 20/20/20 requirement, by which 20% of final energy is expected to come from renewables by 2020, equivalent to 35% of power generation. Increasing the use of this type of resources directly impacts the nature of the grids: decentralization and adaptation to smaller, intermittent production units will be fundamental steps in a transition that has only just started. Low-voltage lines at a local level will be called to coexist alongside high-voltage European transmission lines. For countries like Germany, to single out just one example, the closing down of nuclear plants in the South and the future generation of electricity through wind power in the North will require a complete review of the existing grids, and introduce significant distances between generation and consumption sites. It can thus be justifiably expected that the electricity grid of the 21st century will be different in size and configuration from the one that was once designed for 20th century conditions. In the new, somewhat perplexing landscape, small, decentralized or even autonomous low-voltage units supplying the immediate neighborhood or village will exist side by side with high-voltage direct current 'super lines' linking countries and even continents, as is already the case between Europe and Africa.

The present study is devoted to electricity interconnections in Europe, their current state and the missing links among them. Taking interconnections as the dependent variable, the independent variables to be defined and discussed are:

- governance and institutions;
- pricing;
- new trends in generation;
- innovation and technical changes (ICT).

The study is organized as follows:

Part I develops definitions and basic notions necessary for the understanding of the subject matter. It also addresses the independent variable factors that influence interconnections as their dependent variable, and recounts the historical legacies and their enduring impact on today's grid.

Part II is devoted to the EU legal layout, and to the complex landscape of governance and its current state of transition.

Part III addresses the management of existing interconnections and with the missing links among them, detailing projects and needs region by region, including various aspects concerning the relationship between the EU and third countries.

Part IV lays out recommendations for EU and national policy makers.

This study draws on research from various individuals and institutes and on reports from organizations such as the European Commission, the European Coordinators and the IEA (International Energy Agency), as well as from the UCTE, ETSO (European Transmission System Operators), ERGEG (European Regulators' Group for Electricity and Gas), national regulators and TSOs, especially the CRE, and major companies. The first transmission development report by UCTE, issued at the end of 2008, has provided especially valuable documentary support for the present research. While this report brings together technical data from the TSOs as well as considerations about their projects and drivers, its scope is analytical. Interviews have been conducted with representatives from CRE, UCTE, ERGEG and ETSO. Two relevant reports on interconnections published by the CRE (2007, 2008) have made of France an excellent case study, especially on the limits of the exploitation of the existing lines. The annex contains not only selected references and definitions, but also regional maps and an overview of existing and projected electricity infrastructure by region coming for the most part from the UCTE 2008 development report.

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The author is, of course, solely responsible for any errors in this study.

Susanne Nies
Senior Research Fellow with IFRI Energy Program,
Head of IFRI Brussels Office

Independent Variables and Legacies

Part I starts by introducing basic notions of electricity and interconnection. The reader in hurry, as well as a technically well-informed one, should thus skip the first section. Section 2 describes the independent variables, id est the factors influencing electricity interconnection as a dependent variable. The third section is devoted to the historical legacies of the electricity grid in Europe to date: the past always matters in the field of energy infrastructure between nations because it sheds light on relation, experience of relation and potential extension or limits of endeavours that belong, per se, to the time frame of 'longue durée'.

Concepts and Definitions

The nature of electricity

Electricity is a unique phenomenon. Halfway between a commodity and a service, it is intrinsically a network-based product. The specificities of electricity are well known and make for its singularity: it is still difficult and costly to store but always expected to be available immediately to meet an ever-changing demand. Storage is currently only possible by pumping water back into the mountains during excess periods in order to make it available for subsequently regenerating electricity. Manifestly, this option is naturally restricted to countries in mountainous areas, such as Switzerland or Norway. Storage on batteries still constitutes a technological challenge given the disproportion existing, for the time being, between the size of batteries and their storage capacity. This is precisely the challenge faced by electric cars, for which battery change or hybrid configurations could be among some of the potential answers.

Electricity moves almost at the speed of light: 273,000 km per second, more slowly —though not considerably— in water (226,000 km/second). The speed of electricity makes it the ultimate straightaway commodity. A problem anywhere can be transmitted everywhere in a nanosecond. An occurrence of this type in Germany at the end of 2006, for example, caused blackouts throughout France and Spain and all the way down to Morocco —although not in the UK, where the continent—island link is a direct current connection and solidarity, both for the good as for the bad, impossible by definition.

Voltage

As far as the optimization of transmission as related to voltage is concerned, the end of the 19th and the beginning of the 20th centuries reveal different approaches, each one attached to different voltage options.[1] Today, the situation is becoming more standardized, with 50-cycle —which corresponds to 220 volts— being used inside of the UCTE and other regional European distribution systems, and 60-cycle —which corresponds to 110 volts— being preferred in the US. Since 1912, the following voltages have been used for distinctive purposes:

AC/DC

A prime governance-related issue in electricity transmission is the choice between the two existing types of current: alternating current (AC) and direct current (DC). DC is the unidirectional flow of electric charge, while AC is the movement of electric charge in periodically reverse direction. The choice between one and the other was the object of a bitter confrontation when electricity grids were first invented: a row

1. Voltage –which would be more correctly called 'voltage difference'–, was historically also named 'potential difference'. The term designates the difference between positions A and B of an electron within a solid electrical conductor.

Table 1. Voltage used since 1912 at various levels

	Urban	Regional	National to international
Medium tension	50 to 90	110 to 220	345 to 500
High tension Over distances of more than 1,000 km (direct current also considered a useful solution)			800 (Canada) 1,100 (China) 1,100 (projected in Japan) 1,200 (projected in India) 1,500 (CIS)

between Tesla (AC) and Edison (DC) came to be known, at the time, as 'the war of the currents'. Today, we witness a differentiation in use whereby DC —which permits to send huge amounts of power from one point to another and to easily control input and output— is roughly used for batteries, solar cells, dynamos and high-voltage direct current (HVDC) lines, and AC is used generically as 'the' form of electricity customarily delivered to businesses and households. Audio and radio signals on electrical wires are also AC. AC presents the additional advantage of allowing for the setting up of meshed grids that interconnect distribution to high-voltage lines.

Summing up, while AC is akin to synchronization, solidarity and interdependence, DC is associated with the setting up of regulated, controlled lines offering manageable input and output but no automatic solidarity. This explains why there is so much debate today about the use of DC as an alternative, especially concerning the enlargement between asynchronous areas.

Grids, AC, DC, HVDC and technical capacity

Electricity grids are made up of transmission and distribution infrastructure. Transmission entails the movement of huge amounts of power throughout a country or among countries, from the generation site to step-down stations in consuming markets. This requires customarily large, high-voltage lines from generation plants to distribution lines via transformation stations. Important improvements have been made to the quality of the lines through the commercialization of polyethylene-insulated cables since the early 1950s and the increasing application since the 1980s of polymer cables. To date, gas insulation of cables and high-temperature super conductors is progressing in the field of research, although the technology is not yet mature.[2] Distribution concerns delivery to the final consumer,[3] and makes use of small, low-voltage lines that look like capillaries, with many branches leading to the end user.

In a simplified way, the differences between AC and DC transmission can be described as follows: AC lines, in the typically European tradition, are overhead lines. These are cheaper than underground lines but have a negative impact on landscapes. In AC lines the power flow is self-adjusting and the system 'self-healing'. In the frequently encountered N-1 case, where one generation unit or one important part of the system goes out of work, AC is capable, in many cases, of repairing the damage automatically. The technical or transmission capacity is determined by two factors: the thermal capacity of the line, and the electrical stability of power system security. In general, exploiting the lines at 50% of their technical capacity is considered the best way of coping with the potential N-1 situation. Nevertheless, each line is specific and belongs to a specific context and it is those two factors that should ultimately determine the capacity up to which a line is charged. DC lines, in turn, are not self-adjusting but present two important advantages: they enable the transport of bulk power from point to point over long distances —which makes them particularly interesting with respect to the future Southern solar projects—, and they act as system stabilizers, because the possibility to calculate their input and output allows them to be used for black starts after an incident. Three companies today hold among themselves the major share in the world market of HVDC technology, and all of them are European: ABB (Sweden), Areva (France) and Siemens (Germany). From an investor's perspective, AC is preferable

2. See for more details: EASAC policy report 11, 'Transforming Europe's Electricity Supply – An Infrastructure Strategy for a Reliable, Renewable and Secure Power System', May 2009, p. 13.
3. See IEA, *Lessons from Liberalized Electricity Markets*, Paris, OECD/IEA, 2005, p. 147.

for up to 200 km of overhead transmission and up to 50 km of sub-sea or underground transmission; in the rest of the cases DC is cheaper. The life expectancy of both AC and DC lines is about 70 to 80 years — more or less like human beings!

Today's European system is characterized by the synchronous UCTE system —with the already mentioned DC exceptions such as the UK, Scandinavia or Corsica— which extends to Africa via a synchronized line linking Gibraltar and Ceuta. The Russia/CIS system is also a huge synchronous area, with a Central Dispatch Organization based in Moscow.

System security and defense plans

The worst nightmare in electricity transmission is the blackout. While a brownout is a drop in voltage in the electrical power supply, a blackout is a total disruption of supply. Reasons are numerous: short circuits, overload, and damage in lines or generation faults. Interconnections and blackouts are doubly linked: an absence of interconnection increases the risk of blackouts as much as poorly managed interconnections do. A continuous overexploitation of the line makes it impossible to cope with overloads. How does risk management deal with malfunctions? Firstly, the setting up of the grid itself needs to anticipate the possibility of incidents and the prime reference for this is the already mentioned N-1 situation. The management of congestion —another likely occurrence— has to ensure that electricity grids are operated in such a way that the technical limits are respected. Thus, as already mentioned above, the overexploitation of lines (at more than 50% of their capacity) has to be avoided. The installation of double or triple lines can be an additional security asset. Ideally, and in order to enhance more system security, there should be many small lines, as Henri Persoz recommends, but in reality this is hardly feasible because of widespread public resistance to what is considered as an impairment to the landscape.[4]

4. H. Persoz, G. Santucci, J.-C. Lemoine and P. Sapet, *La planification des réseaux électriques*, Paris, Editions EDF, 1984, Chapter 1.1, 'Le choix de la section des lignes', pp. 26-29.

The TSOs, in turn, develop defense plans against major incidents that cannot be anticipated. Here, because not all incidents can be avoided, the goal is to limit their consequences. Small incidents, like a thunderstorm or a tree falling on a line, can provoke major and potentially unmanageable ill. In such cases, immediate action is decisive in order to disconnect the deficient area from the rest of the grid and thus prevent the phenomenon from spreading to the entire system in a very short time. That first step proceeds as an automatic response, a feature that has been largely improved by the introduction of Information and Communication Technology. Defense plans depend on the very nature of the grid: if a grid is meshed, like those in the UCTE synchronous area, its frequency is subject to permanent survey so that problems are detected the very moment they occur. In systems like Japan's, where the grid is long and poorly meshed, it is the tension that is surveyed; finally, in areas like the Maghreb, where one country is connected to the other like wagons in a train, surveillance concerns the transit at interconnections.[5]

Two additional imperatives for defense plans are that they do not detect 'wrong' events, and that they do not to react too late. A new challenge to grids today is the unevenness of the input coming from renewable sources, which for the time being has to be balanced out by often redundant traditional generation. The example of offshore wind energy generation in northern Germany may illustrate the problem. The generation of wind energy in Germany is highly profitable because it is heavily subsidized. But the grid in the North is congested and as a consequence the surplus electricity passes West and East into the Dutch and the Polish grids. Instability in those two grids is not a matter of concern for the German TSOs, but it does indeed become a national problem on the other side of the border, for the Dutch and the Polish TSOs. A common approach, as well as European governance, is of the essence in this case in order to harmonize the individual national practices. In the meantime, the synchronous area automatically compensates for the missing capacities.

5. The author thanks François Meslier (EDF) for these insights.

Table 2. Recent major blackouts in Europe and their origin

	Date	Reason/Consequences
France Italy	January 12th 1987 September 28th 2003	Low tension in the grid. Powerline in Switzerland shut off, 95% of Italy was in the dark for several hours.
Greece	July 12th 2004	Low tension in the grid.
France, Belgium (Antwerp region), Spain, Northern Africa	2006	Incident in northern Germany, affecting 10 million citizens including parts of Paris as well as Northern Africa (Morocco) for half an hour.
Poland	January 18th-19th 2007	Kirill wind storm caused interruptions in many lines.
Southern France	October 3rd 2008	Violent thunderstorms led to the failure of the principal line between Marseille and Nice (400,000 kV). 1.5 million citizens were without electricity during the morning. Reason: deadlock in electricity supply originating in the Alpes Maritimes Department.
Poland	January 2008	Overload due to circular flow from wind energy via the German-Polish connector Szczechin, resulting in overload of Polish transmission lines.

Table 2 below lists major blackouts in the last few years in Europe and mentions their reasons. The French, Belgian and Polish examples reveal not only the weaknesses in the German system, but also the interconnection—blackout nexus. The Italian example and the related studies on its origins demonstrate the negative impact of lack of interconnection as well as the need for a European regulator. The question is thus no longer ‘interconnection or not’, but rather ‘interconnection, then how?’. The appropriate response will come from studies that identify the needed links as well as from adequate technical and political governance.

Overhead or underground transmission?

Overhead lines, by definition, must be able to cope with adverse weather conditions. As of late —and partly prompted by the important delays that the establishment of new infrastructure is suffering due to public resistance— a lively debate has erupted on their advantages and disadvantages as compared to those of underground transmission. Price, technological challenges and public acceptance account for the differences between both types. On all three counts, the rates are higher for underground lines.

While most overhead lines work with three-phase alternating current, long-distance as well as underground and undersea lines generally use direct current — with the exception of the already mentioned Gibraltar—Ceuta link. DC requires transformation stations at both ends but offers, as has also been said, the advantages of diminishing losses during transport, allowing for comprehensive control of inputs and outputs and not being bound by solidarity and thus dependency. DC lines are also easier to manage and require no intervention from a TSO, which is definitely not the case for AC lines with their numerous branches and affiliations. The rule, again, is clear: up to 200 km, AC is economically preferable; over 200 km, DC is more advantageous.

Underground transmission, while presenting the advantage of avoiding wind and storm, is a much more expensive option, with the life-cycle cost reaching up to two to four times that of an overhead power line. Thus, common utility ducts that also lodge other utility lines are sometimes used in order to offset in part the price disadvantage. On the other hand, underground transmission emits much less powerful magnetic fields, and requires a strip of only one to 10 meters, whereas overhead transmission requires 20 to 200 meters for safety, maintenance and repair. Until the 1960s, insulation of underground cables running through a rigid steel pipe was accomplished with oil and paper. While polymers have replaced those early materials, many oil and paper cables are still in operation. Currently, opting for underground transmission, even despite its cost, is becoming far more common. However, public resistance to it grows at the same rate as its use increases, putting pressure on public and private entities to seek ways of overcoming that rejection reflex.

Additional obstacles often include ecological or other miscellaneous local concerns, as much as natural impediments. In this context, the case of the recently agreed Spanish-French interconnection through the Pyrenees should be viewed as a real —albeit expensive— breakthrough that put an end to more than 15 years of quarrelling and delays.[6] And if its price is no longer 20 times higher than that of an AC variant, it does still exceed the latter by five times. A similar project was approved in the southwest of France in December 2008. Operators expect the cost of electricity to decrease if underground lines become more frequent in the future.[7] Nevertheless, undergrounding can not be considered a panacea for all. Dominique Maillard, RTE, has very much insisted on the fact that buried lines are exposed to other risks such as floods and are more difficult to repair, with the already mentioned cost factor adding to the list of disadvantages.[8]

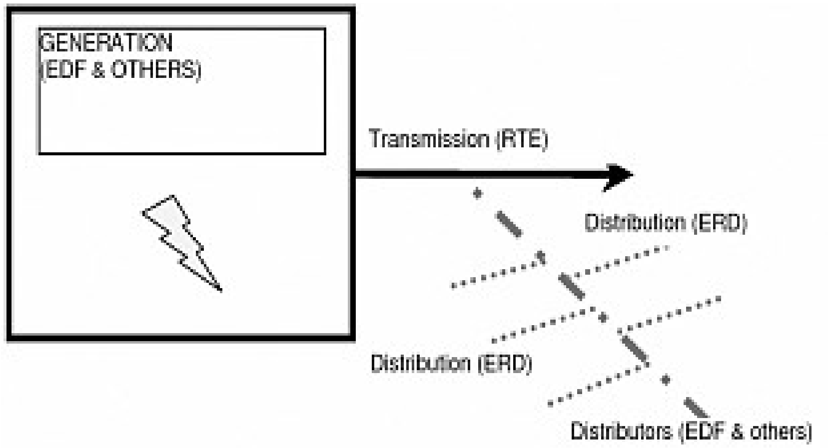
Dependent Variables

The author has identified four independent variables affecting interconnection: governance and institutions, pricing, new trends in generation, and innovations and technological changes. All of those parameters exert strong influence over both the exploitation of existing lines and the setting up of new ones. Presented here as independent variables, those four factors have, in turn, proven to be subject to change themselves and, simultaneously, to entertain significant interaction among each other. Governance impacts on prices, prices impact on technological change, technological change impacts on prices, and so on.

The following sections describe each of the four factors.

6. See the case study in Part III (p. 97).
7. See 'Construction of an underground line over 70 km in order to satisfy environmental concerns', available at: http://www.localtis.info/servlet/ContentServer?c=artVeille&pagename=Localtis%2FartVeille%2FartVeille&cid=1228195724301.
8. 'Investing in Europe's Energy Future', IFRI's Annual Conference, Brussels, February 2009.

Scheme 1. The national electricity grid



Governance and institutions

National electricity governance

The following simplified picture uses France as an example to show the different parts of the system and the operator concerned with each of them. On the generation side, EDF retains an important role but no longer holds a monopoly. RTE, the TSO —itself a subsidiary of EDF—, is in charge of transmission. Distribution, in turn, is in the hands of various distributors, with EDF again being an important, but not the sole operator. The CRE, as pertains to a regulator, oversees the whole process. This simplified explanation also shows the results of liberalization, which has opened up the market through the tool of 'unbundling'. The process of separating power generation, transmission and supply either legally or entirely (ownership unbundling) helps new players arriving in the market to compete, at any stage of the process, with the historical and often state-owned, operators.[9]

9. New package of legislative proposals, known as 'Third Package', with even stronger unbundling rules, from September 2007, endorsed in March and April 2009 by the European Council and the European Parliament, leaving finally three options for unbundling: full ownership unbundling, independent system operator ISO (a separate body to which companies are obliged to hand over the operation of their transmission network while still owning them), and independent transmission operator ITO (a less complete form of unbundling that preserves integrated supply and transmission companies but compels them to abide by certain rules to ensure the two sections of the company operate independently).

Types of exchange and functionality of interconnections

Interconnections may be used for regular, periodical or sporadic exchanges. AC lines automatically lend assistance in case of incidents in neighboring regions, whereas DC lines stay bound to previously established parameters. Regular exchanges add to or even substitute generation capacity in one of the two interconnected regions or countries. This type of exchange is in most cases a one-way operation meant to deal with asymmetric generation capacities, or different pricing levels, on two sides of a border. In the case of periodical exchanges, the interconnection aims to offset sporadic hardships, such as may happen during the winter months. Ideally, southern and northern regions would be interconnected in order for both to benefit from the different climate and comparative advantages of each other with respect to renewable energy generation: solar-based in the South, wind-based in the North, and so on.

Alternatively —just as a joke to apply some humour to a real problem—, countries could agree that the Germans will do their laundry at 12am, the French at 1pm, and the British at 3pm! Realistic changes in consumption habits could, at any rate, be induced by the introduction of ICT into the distribution system allowing customers to have visibility about the more advantageous moments for the purchase of electricity.

Finally, sporadic exchanges occur during specific hardship periods such as blackouts. Each one of the above described situations has to be regulated on a national, bilateral, regional and even European level. The obvious consequence is that synchronization diminishes the autonomy of the national actors.

Synchronizing the grids of country A and country B requires preliminary feasibility studies, carried out by the TSOs and the respective regional or European organization like the UCTE or Nordel, and now, since 2009, ENTSO-E. While the voltage of the line defines the maximum potential load, capacities can be regulated at the two entry points. Thus, depending on the nature of the agreement or in order to address specific imperatives —commercial reasons, for example, or the urgent need of increased supply on one side— the two countries can reduce, increase or stop the flow, always within the limits of the capacity of the line.

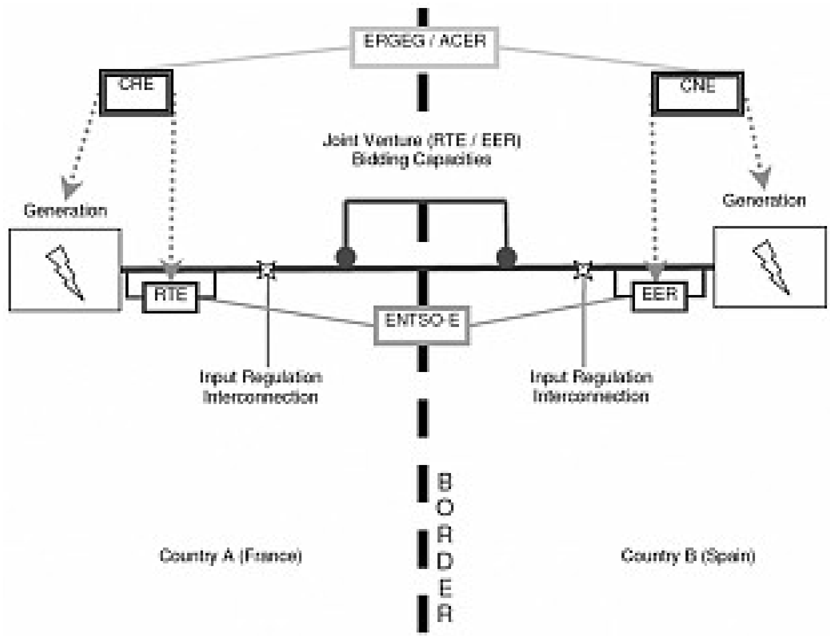
The first phase (Phase A) of any such project consists of drawing up a proposal for a contractual agreement that lays down technical requirements and operational aspects, delimitation clauses from former partners, congestion management procedures, and legal and regulatory conditions. Phase B involves the implementation of the contractual agreement. Phase C includes preparation and tests to be carried out in isolation as well as interconnection tests that must be successfully completed before the grids are effectively connected. Efficient governance on both sides and mutual trust are important prerequisites to the auspicious establishment of any link.

The France—Spain example will also be used to provide an overview of the interconnection process and the multiplicity of players involved in it.

Following the identification of a major congestion area,[10] and under strong EU influence, the two governments agreed to establish a new interconnection between their countries. The French and Spanish TSOs RTE and EER set up a joint venture to finance the works, with some additional funding from the EU. According to the agreement, it will be possible for both TSOs to regulate the capacities of the line at entry through converters that will allow for the exchanges to be scheduled in conformity with mutually established terms. The capacities of the interconnection will be sold 50/50 by RTE and EER, through bidding. In the case of an emergency, it will be possible to increase or decrease the flow, always within the limits of the overall line. Each TSO will be responsible for day-to-day operation and will have a 'red' line available in case there is an emergency on its grid. Both TSOs are members of ENTSO-E which will in turn be responsible for setting network security criteria. At a country level, the national regulators (CRE and CNE) will oversee the entire electricity value chain, in conformity with EU and WTO rules. Linking the electricity grids of two countries is a highly complex process, as much for technical reasons as for the governance aspect of the venture. Several players are involved, as scheme 2 shows.

10. See Part III, p. 97 for further discussion on the French-Spanish interconnection.

Scheme 2. Bilateral interconnection



A clustered set of players

Table 3 provides an overview of the various participants and their mission statements. It does not aspire to be exhaustive and, for the sake of clarity and simplicity, does not mention private actors such as Eurelectric or Medelec, which of course does not mean that the author underestimates their impact on EU electricity governance. The table distinguishes between national and European levels and outlines history, mission and further integration of various organizations. We are currently witnessing an important Europeanization process on the technical front with the merger of regional TSOs (Nordel, UCTE etc.) under the ENTSO-E umbrella. Paradoxically, the national regulators' role has been reinforced. Simultaneously, the regional dimension is also on the rise. All in all, national, bi-national, regional and European levels co-exist, and we could even speculate about the upcoming emergence of a somewhat pan-European dimension resulting from the European Neighbourhood Policy electricity projects.

Table 3. Complex

	Organization	Description
NATIONAL	National TSO	Transmission System Operators (TSOs) are responsible for the bulk transmission of electric power on the main high-voltage electric networks. TSOs provide grid access to the electricity market players (i.e. generating companies, traders, suppliers, distributors and directly connected customers) according to non-discriminatory and transparent rules. In order to ensure the security of supply, they also guarantee the safe operation and maintenance of the system. In many countries, TSOs are also in charge of the development of grid infrastructure. In the European Union, internal electricity market TSOs operate independently from the other electricity market players. They are of very different sizes; in some EU member states there is only one (like Ireland, France), while in others there are several (Germany, UK).
	National Regulators	National regulators were set up to accompany market liberalization, as was the case with the French Commission of Energy Regulation (CRE) in 2000. They are in charge of electricity and gas market regulation (Examples: CRE, BNETZA etc.).
REGIONAL	UCTE	The Union for the Coordination of Transmission of Electricity (UCTE) is the association of Transmission System Operators in continental Europe. Members: 24 countries, with 36 TSOs www.ucte.org:aboutus/members Headquarter: Brussels President: Marcel BIAL
	Nordel	Nordel is the organization of the Transmission System Operators (TSOs) of Denmark, Finland, Iceland, Norway and Sweden.

governance

Mission	Further Integration EU. Level/Development
National TSOs supervise the regional or national grid. One in some countries, more in others. Example: Germany has 4 TSOs, but debate continues over whether it would not make more sense to set up a unified grid. One of the reasons for this move is German fear that an unbundled grid could fall fully into the hands of foreign investors.	Organizations of TSOs: UCTE, Nordel, ATSOI, UKTSOA ENTSO-E (formerly ETSO) Florence Forum. Unbundling with three options reinforced by the EU's Third Package adopted on April 22nd 2009.
Independent, the regulators oversee the market as a whole as well as market access. They control access to grids, market regulation and survey of the market in a period of liberalization. The national regulators have been reinforced by the EU's Third Package of April 2009.	ERGEG ACER Florence Forum The national regulators have been reinforced by the EU's Third Package adopted on April 22nd 2009.
Provides a reliable market base by efficient and secure electric 'power highways'. Through the UCTE networks, about 500 million people are supplied with electric energy; annual electricity consumption totals approximately 2,300 TWh. There was debate on its abolition due to the setting up of ENTSO-E. Ceased to exist on July 1st 2009.	ENTSO-E Pressure to set it up by Third Package.
Nordel's mission is to promote the establishment of a seamless Nordic electricity market as an integrated part of the North-West European electricity market and to maintain a high level of security in the Nordic power system. Nordel's objectives are: – development of an adequate and robust transmission system aimed at few large price areas; – seamless cooperation in the management of the daily system operations to maintain the security of supply and to use the resources efficiently across borders; – efficient functioning of the North-West European electricity market with the goal to create larger and more liquid markets and to improve transparency of TSO operations; – establishment of a benchmark for European transparency of TSO information. Nordel continuously exchanges information with the authorities and the market players, which is important for the evolution of an efficient electricity market. Ceased to exist on July 1st 2009.	ENTSO-E

Table 3. Complex

	Organization	Description
REGIONAL	Centrel	CENTREL is the regional group of four Transmission System Operators: CEPS, a.s. of the Czech Republic; MAVIR ZRt., the Hungarian Power System Operator Company; PSE-Operator S.A. of Poland, and Slovenská elektrizacná prenosová sústava, a.s., or SEPS, a.s., of the Slovak Republic. CENTREL was founded on October 11th 1992 in Prague following significant political changes in all of the above mentioned countries after 1989. These four countries have been collectively referred to as the 'Visegrad Group' since a 1991 summit of the countries' leaders. After the creation of CENTREL, the conditions for membership to UCTE were established. And CENTREL has been a member of UCTE since January 1st 1999.
	UKTSOA	Organization of the four British Transmission System Operators.
	ATSOI	Organization of the Irish Grid.
	BALTSO	BALTSO is the cooperation organization of Estonian, Latvian and Lithuanian Transmission System Operators. The Agreement on Foundation of Estonian, Latvian and Lithuanian Transmission System Cooperation Organisation BALTSO was signed on March 30th 2006 by the representatives of OÜ Põhivõrk from Estonia, Augsts-prieguma Tikls from Latvia and Lietuvos Energija from Lihtuania. www.baltso.eu Headquarters: Vilnius
	IPS/UPS	IPS: Integrated Power System The Integrated Power System (IPS) portion of the network includes the national networks of Ukraine, Kazakhstan, Kyrgyzstan, Belarus, Azerbaijan, Tajikistan, Uzbekistan, Georgia, Moldova and Mongolia UPS: Unified Power System The Russian portion of the interconnection is known as Unified Power System of Russia (UPS) and includes six regional transmission operators: ECO Centre, ECO South, ECO North-West, ECO Middle Volga, ECO Urals and ECO Siberia. ECO East (set up in July 2001) operates in isolation from UPS of Russia. Replacement since July 2008 of its operator RAO UES by Federal Grid Company (FGC UES) Russia.

governance (continued)

Mission	Further Integration EU. Level/Development
As CENTREL electricity network comprises the interconnected systems of its members, the main objectives and tasks of CENTREL are as follows: – to promote efficient use of transmission capacity through the establishment of economic, business, technical and organizational conditions and the provision of mutual assistance which facilitates electricity trading; – to enhance regional cooperation of CENTREL members; – to promote regional interests in the European electricity sector; – to develop transmission systems in CENTREL area; – to promote reliable operation of common system block; – to exchange experiences and improvement of operational conditions of the CENTREL members' transmission systems, including system services; – to exchange information. Ceased to exist on July 1st 2009.	ENTSO-E
Ceased to exist on July 1st 2009.	ENTSO-E
Ceased to exist on July 1st 2009.	ENTSO-E
BALTSO is responsible for: – Initiation, development and implementation of conditions necessary for reliable operation and interconnection of the electrical energy systems of Estonia, Latvia and Lithuania; – maintenance of the process for development of the Baltic transmission system; – initiation, development and implementation of conditions necessary for coordinated and safe operation of the electric energy markets of Estonia, Latvia and Lithuania; – promotion and implementation of cooperation between the Organization and its members on one hand, and energy companies of non-member countries on the other hand; – arrangement of public relations activities related to the Baltic energy system and electricity markets; – initiation, maintenance and development of relations with other relevant organizations and institutions in the Baltic States, in Europe and in the rest of the world. Ceased to exist on July 1st 2009.	ENTSO-E
Decentralized control, by country. Centralized secondary control of frequency by UPS of Russia. Single set of rules/regulations for IPS/UPS regime control is not yet completed. In practice, power balances are coordinated through SO-CDO. Multitude of bilateral and multilateral agreements. Operation based on experience and communication of dispatchers who used to function within the single power system of the former USSR. The system works well; for the last 3 years frequency deviation was in line with UCTE standards.	

Table 3. Complex

	Organization	Description
REGIONAL		CDO: Central Dispatch Organization Eastern Synchronous Area, which spans over 8 times zones and consists of the Independent Power Systems of 12 countries and Unified Power System of Russia. Installed capacity of 300 GW Vast territory leads to: – extensive use of long-distance extra/ultra high-voltage transmission lines; – extensive use of automatic emergency control devices.
EUROPEAN	ACER	See ERGEG Decided by the EU parliament on April 22nd 2009. To be in place at the latest by the start of 2011. Location to be decided among several candidates by the end of 2009: most likely to go to a new member state in Central Europe (Ljubljana, Bucharest, Bratislava). Focus: oversee investment within EU, arbitration. Cross-border issues are very prominent in the tasks of ACER.
	ETSO	Created in 1991, with ATSOI, UKTSOA, NORDEL and UCTE as the association founding members. In June 2001, ETSO was transformed into International Association with direct membership by 32 independent TSO companies from 15 EU member states, plus Norway and Switzerland At the end of 2001, followed the inclusion of Slovenia (full member) and CENTREL (associate members); in June 2003, the Czech Republic; in 2004, Poland, Hungary and Slovakia; in February 2005, the Lithuanian TSO, Estonia, Rumania, Cyprus, Latvia, Serbia, Bosnia Herzegovina, Croatia and FYROM Associate Members. Bulgaria became full member in 2007. ETSO networks now more than 490 million people, with a consumption of electricity amounting to approx. 3,200 TWh per year. It covers more than 290,000 km of HV (400 and 220 kV) lines. Headquarter: Brussels Secretary General: Cecilia HELLNER, former Swedish TSO www.etso-net.org Replaced by ENTSO-E
	ENTSO-E	On June 27th 2008, in Prague, the Chief Executive Officers (CEOs) of 36 European TSO companies from 31 countries signed a Declaration of Intent, as a proactive step ahead of the draft Third Legislative Package, to create a new association: the European Network of Transmission System Operators for Electricity (ENTSO-E), before the end of 2008. The new body was established to cover the needs of the TSO community and in accordance with the principles set out by the draft Third Legislative Package of the Internal Electricity Market. On December 19th the CEOs of 42 European TSOs from 34 countries created ENTSO-E and agreed to propose to the presidents of current TSO associations, i.e. European Transmission System Operators (ETSO), Union for the Coordination of

governance (continued)

Mission
ETSO is responsible for: – inter-TSO compensation – security of supply – tariffs – renewable energies Ceased to exist at the end of 2008.
The establishment of ENTSO-E will further strengthen TSO cooperation in a number of key areas, such as the development of technical and market-related network codes and the coordination of system operation and grid development, with the aim of enhancing the integration of the European electricity market, contributing to a sustainable energy environment and ensuring secure and reliable operation of the European power transmission system. Binding TSO membership in ENTSO-E, as proposed by the EC, is one key to success for the new body and will accelerate the development of common codes, contributing to reliable and efficient pan-European and regional electricity markets.

Table 3. Complex

	Organization	Description
EUROPEAN		Transmission of Electricity (UCTE), Nordel, UKTSOA (UK), BALTSO (Baltics) and ATSOI (Ireland and Northern Ireland), to initiate the necessary procedures to transfer their activities to the new TSO body and to end their respective associations as soon as ENTSO-E is established and the transfer of activities has been accomplished. Headquarter: Brussels (Bd Saint Michel, former Headquarters of ETSO, UCTE) President: Daniel DOBBENI, CEO of Elia, Belgian TSO Elected Secretary General (February 5th 2009) Konstantin STASCHUS
	ERGEG (Euopean Regulators Group for Electricity and Gas)/CEER (Council of European Energy Regulators)/ ACER	CEER and ERGEG are organizations established for the cooperation of the independent energy regulators of Europe. ERGEG was set up by the European Commission (Decision of November 11th 2003, 2003/796/EC) as its advisory body on internal energy market issues. It is made up of the national energy regulatory authorities of the EU member states. ERGEG advises and assists the Commission (DG TREN, DG COMP, DG RESEARCH) on its own initiative or upon request, in particular with respect to the preparation of drafts for implementing measures in the fields of electricity and gas. For example, ERGEG provided significant input to the European Commission in the preparation of its Third Energy Liberalization Legislative Package (adopted in September 2007). One of ERGEG's flagship projects is the Regional Initiatives, which it launched with the Commission's backing in spring 2006, in an effort to speed up the integration of Europe's national energy markets. The ERGEG Regional Initiatives establish seven electricity and three gas regional markets in Europe as an intermediate step in the creation of a single, competitive EU electricity and gas market. ERGEG members are the national energy regulatory authorities of the 27 EU member states. The EU Commission is represented at a high level. The National Energy Regulators of the candidate countries and the countries of the EEA participate in ERGEG meetings as observers. ERGEG is also called CEER/ERGEG. CEER members are the Energy Regulatory Authorities of the EU or the European Economic Area (EEA). Founded in 2000 by ten national regulators, it is based in Brussels. CEER established six working groups, one being electricity. The Florence School and IERN is also part of CEER/ERGEG. Secretary General: Fay GEITONA President: Lord MOGG, former Commission official ACER, the Agency for the Cooperation of Energy Regulators was proposed by the EU Commission, within the framework of the Third package, as a body that should advise the Commission, facilitate national regulators to cooperate and adopt individual decisions on cross-border issues.
	Florence Forum	The Electricity Regulatory Forum of Florence was set up as an initiative of the Commission as a self-regulatory forum in 1998, similar to the Madrid Forum for Gas. The participants are national regulatory authorities, member states, the European Commission, Transmission System Operators, electricity traders, consumers, network users and power exchanges. The Forum convenes once or twice a year, formerly in Florence but now in Rome. The first meeting was held in 1998. http://ec.europa.eu/energy/electricity/florence/index_en.htm Within EU Commission DG TREN.

governance (continued)

Mission
Moreover, ENTSO-E will work with a clear mandate in line with market expectations and in consultation with European Regulators and the Commission. This new environment will enable TSOs to focus on transparent objectives and to speak with 'one single TSO voice' on issues concerning the Internal Electricity Market. ENTSO-E includes three committees for pan-European activities on System Development, System Operation and Market Frameworks, incorporating regional groups under each Committee.
Both organizations pursue the same overall aim of facilitating the creation of a single, competitive, efficient and sustainable internal market for gas and electricity in Europe. CEER and ERGEG share similar objectives and the work and achievements of both are intrinsically linked. Yet there is one main difference in the role of the organizations in relation to the EU and the other stakeholders in Europe's energy sector: cooperation in the framework of the CEER is based on a voluntary agreement among the regulators themselves, while ERGEG was founded by the European Commission in 2003 as its official advisory group on energy issues. Source: www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_ABOUT ERGEG's purpose is to facilitate a consistent application, in all member states, of the provisions set out in Directive 2003/54/EC, Directive 2003/55/EC and Regulation (EC) No 1228/2003, as well as of possible future Community legislation in the field of electricity and gas. The Commission would like to reinforce the role of ERGEG, transforming it into ACER, an initiative contested by Eurelec-tric and ETSO. ACER proposal: Commission Communication of January 10th 2007, An Energy Policy for Europe.
Its role is to discuss the creation of a true internal electricity market, a place where, informally, all the actors come together around the same table. The Forum currently addresses cross-border trade of electricity, in particular the tarification of cross-border electricity exchanges and the management of scarce interconnection capacity.

Investment and pricing

Investment requirements in the electricity sector

IEA forecasts the world's need for electricity investment in transmission and distribution between 2006 and 2030 at a minimum of €4,500 billion, which is equivalent to more than the total forecast for oil and gas together. More than half of that is earmarked for developing and transition countries, with China having already successfully managed electrification in the last years.[11] Most of the investment requirement stems from the industry's double challenge to address climate change and deliver energy security all at once. On this issue, uncertainty reigns on about the different options at hand — more renewable versus more nuclear, etc.

In the EU as a whole, 35% of electricity supply could come from renewable sources by 2020 or 2030; nuclear energy also seems to be gaining ground in a context of growing concerns over climate change and energy security, especially with respect to gas supplies from Russia via Ukraine. The US president, in turn, fixed his own country's ambitions for renewables at 25% of primary energy by 2025.

According to TSO forecasts, midterm investment in the electricity sector will reach around €4 billion per year in the EU until 2013. An increase is then expected before 2023. IEA has estimated the total grid investment needed in the EU at €49 billion for 2001-2010. While cross-border investment currently stays at €200 million per year —a relatively low figure as compared to overall investment projects—, the 32 electricity projects identified as being of European interest will together require €6 billion. This will raise the resulting cross-border investment to €700-800 million, almost four times the current level. The investment requirement for the connection of offshore wind farms is estimated at €0.9 to 1.3 billion per year until 2013, but is then expected to almost double in

11. Quoted from Ed Crooks, Current concerns, *Financial Times*, Energy supplement, October 28th 2008; cited from IEA: 'If in China now 99% of the population has access to electricity, compared to an Asia average of 74%, the level of electrification in India reaches only 60%. In developing countries, distribution losses as well as the theft of electricity remain unresolved problems.'

the long term (€1.7-2.5 billion).[12] As for investment in electricity grids and trans-border lines, it will be primarily undertaken by the national operators. Investment in high tension electricity grids is programmed for a seven— to ten-year period. In recent years, regulatory uncertainty, as well as questions concerning future generation (the role of renewables, CCS, ETS), have set back investment in the grids. In particular, the distance between renewable sources production sites and consumer areas is an important investment challenge, which, according to the Commission, should be dealt with through a European approach. Currently, the various stimulus packages have been leading to more public investment in electricity infrastructure: precisely because of that, it is crucial at this point to privilege the right projects and to avoid investing in infrastructure without a long-term perspective. This may be easy to assess, but not always as easy to execute, given the pressure exercized by lobbies and the uncertainty surrounding the future of energy schemes.

Electricity price

The price of electricity depends on the following seven factors:

- the production cost (depending on the mode of production and the cost calculation method used);
- the transportation cost;
- differing taxes (varying from one EU member state to the other, which partly accounts for the price differences);
- the cost of commercialization (advertising, marketing, customer services);
- the quantity subscribed by a customer (with the largest breach existing between private households and industrial consumers);
- the tension delivered;

12. Source: Dr Wolfgang Kerner, DG TREN B1, Strategic Energy Review and Priority Interconnection Plan, Regulators Electricity Infrastructure Workshop (Brussels, February 23rd 2007). DG TREN.

• the mode and period of consumption (for example, the difference between peak and off-peak rates).

Electricity prices for household consumers are fixed by government decree in 16 EU memberstates (regulated tariffs, like in France), and are not regulated in 11 (like in Germany). As a result, distinctive price regions tied to differences in the above mentioned factors emerge within countries. And prices are very different within the EU, with, for example, a low rate of €0.12 kW/h including taxes in France, and nearly the double in Germany, at €0.22 kW/h, in 2008.[13] In the past, prices used to be subject to significant fluctuations, with France, for example, having experienced decreases between 1997 and 2000 and then important increases since 2001 especially following the rise in production costs and new infrastructure, as well as the obligation to buy renewable energy.[14] The liberalization of the national electricity markets is progressively giving customers the opportunity to switch to another supplier and thus benefit from lower prices for the kW/hour unit and various services, while the tariff for the use of the public grids is, by definition, non-negotiable. In many EU countries, public support and existing subsidies in favor of renewables have translated into competitive prices or tax reduction for users of renewable generated electricity. Nevertheless, a recent report on the consumer markets showed that the EU electricity market is generally considered unsatisfactory and its share in the citizen budget —5.7% on average in the EU-27— much too high. Additionally, consumers hardly ever change operators, even if they have the right to do so, with only 8% in the EU professing to be ready to switch.[15]

Industrial customers, in turn, have three options for purchasing electricity:

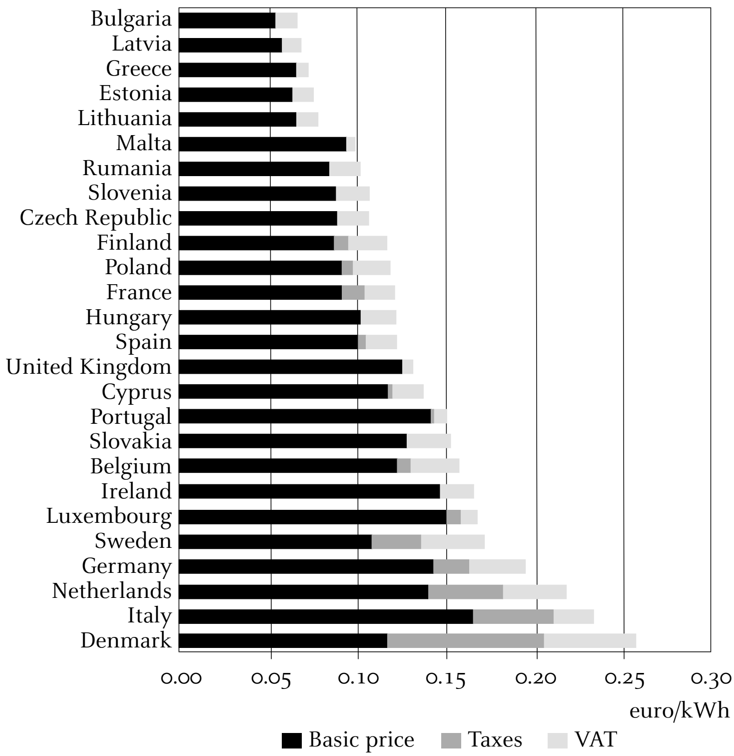
• via organized spot markets (electricity stock markets such as Powernext in France or EEX in Germany, whose prices are publicly available);

13. Source: Eurostat 2009.

14. Source: http://www.environnement.ccip.fr/energie/electricite/tarifs-et-prix.htm.

15. EU Commissioner for Consumer Affairs, Meglena Kuneva, quoted by *Financial Times*, February 2nd 2009: 'Survey sparks EU probe into electricity market'.

Scheme 3. Electricity prices across the EU in 2008



Source: Eurostat[16].

• over the counter (OTC), which means directly from producers such as E.ON and EDF, traders such as Total and Gaselys, or other eligible players or traders such as GFI or Spectron. Since these prices are set via bilateral negotiations, they are less publicly known than those in the first category, but remain subject to estimation by organizations like Platts;

• on the retail market.

On the spot market, a difference exists between the spot prices (for the day ahead) and the forward prices (for the month, quarter or year ahead).

16. For a detailed overview on the electricity prices by type of user in the EU-27 from 1997 to 2008, see Queen detail http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/introduction.

In general, generation capacity in the EU has diminished in the last years, and the volatility of oil and gas prices has had an impact on the price of thermal generation. Finally, liberalization has led the newly privatized companies to integrate investment costs, something that will surely impact the spot prices in the near future. The following picture shows the huge differences in electricity prices across Europe, with the cheapest electricity being available in Bulgaria, and the most expensive in Denmark.

The above described complexity of the national pictures is increased manifold in the case of trans-border exchanges.

Pricing interconnection in the electricity sector

Is the price level differential between both sides of the border an advantage or a disadvantage? Under optimum governance the market should benefit from competitive conditions and lead to lower electricity prices on both sides of the border. Unfortunately, due to flaws in governance and a predominantly national focus on the part of most players, this is not the case today, as the reports by the CRE have demonstrated. On occasions, however, coupled markets like the Franco-Belgian show a high degree of price convergence, which is clearly an encouraging signal.

Not just electricity prices vary across the EU and inside the countries themselves, but the tariff for EU electricity transmission does as well. The Czech EU presidency suggested, in the first half of 2009, the introduction of a single EU tariff on transmission services in order to enhance more cross-border flows.

The electricity flowing through interconnections is either owned by the operators of merchant lines who benefit from temporary exemptions, or is shared by the two interconnecting TSOs who sell their 50% share via auctioning, or as long-term contracts, either monthly or annually. In the second case, the interconnection electricity is sold outside of the regulated electricity markets of the respective countries. Only the non-used volumes of those long-term contracts are made available on spot markets like Powernext or EEX. Their price levels reflect only the leftover volumes rather than interconnection electricity at large. Acquiring long-term capacities is an opportunity for a foreign player aspiring to take position in a given country. The price of electricity sold on the long-term market depends on the quality of the offered product. Quality, in this context, comprises the existence of a secondary market for the onward sale of unused capacity, the procedure of nomination, the financial process, compensation,[17] the quality of the electricity itself, etc. In the case of France and its neighbors, secondary markets have been established since 2001. Excess capacities can thus be either resold or transferred to other players. TSOs are in charge of the highly complex clearing procedure to be accomplished two and one days ahead of use, as well as of the so called 'netting', which is the settlement of obligations between two parties that processes the combined value of a transaction. The day-ahead markets, in particular, tend to experience significant dysfunction, which highlights the flaws of the market itself. Market coupling offers an adequate answer to these problems.

Market coupling

Interconnection and the associated pricing intricacies have led to a new terminology for new methods, presented in brief in the following pages. Market coupling is a promising way of integrating electricity markets from national to bilateral and then onto regional models. The EU has recently witnessed several market coupling projects, with the Northern and the West-Central regions being the most advanced.

Market coupling is a method for integrating electricity markets in different areas. Buyers and sellers automatically integrate the cross-border exchange and no longer need to acquire capacities explicitly. The model has very much been inspired by Scandinavia, which opted from the start for the market splitting paradigm. Market coupling via interconnection can be designed according to a precisely defined contractual architecture, or via the already mentioned joint companies

17. Compensation in case of curtailment of capacities (except in case of 'force majeure') is either based on the initial price of capacity or on the market spread between the energy markets.

or a Common Auction Office. The capacities are purchased by traders, large consumers (businesses), distributors, or European electricity companies. Capacities as well as data have to be submitted to the TSOs, the Auction Office and the national regulators. Investments such as those related to the maintenance of the interconnection are carried out by a joint company.

The technical aspects of market coupling are managed via a technical software tool called the market coupling system (MCS), which is used by the power exchanges in order to calculate cross-border flows and market area prices. Exchanges may be calculated as either price-based, also termed 'close coupling', or volume-based. In the first model, the price calculation is left to the MCS that calculates by combining price and flow. In the second, volume-based flow or 'loose coupling' volumes are additionally introduced into the calculation. The Auction Office is responsible for the calculation of the transborder flows, using relevant data supplied by the TSOs and the power exchanges.

Different auction methods are applied in market coupling, such as:

- explicit auction: the transmission capacity is auctioned separately from the wholesale market. This is the basic method of commercializing interconnection electricity in Europe. It is particularly appropriate for the allocation of long-term capacity rights (sold, for example, at yearly and monthly auctions;
- implicit auction: for day-ahead capacity rights, implicit capacity auctioning goes further and reflects already a certain degree of integration. Here the flow is based on the day-ahead market data from the two interconnected markets. Implicit auctioning reflects much better than explicit auctioning the real prices in the two areas, as well as the cost of congestion. Implicit auction is the common denomination for both market coupling and market splitting.

If market splitting works with just one auction office whereas market coupling links two, in both cases cooperation must ensure that during 24 hours quantities move in the right direction, i.e., towards the higher price area. In both, also, production is stimulated in the lower price area, and production deficits enhanced in the higher price area.

To date, the main market coupling or market splitting projects that have been established are the following:

- the Nord Pool market splitting. The TSOs involved in this implicit allocation of capacities are Energinet.dk, Statnett, Svenska Kraftnät and Fingrid;[18]
- the trilateral coupling of the Netherlands, Belgium and France (TLC). The power exchanges APX, Belpex and Powernext, and the TSOs TenneT, Elia and RTE agreed on a market coupling on November 21st 2006;
- the MIBEL market covering the Iberian Peninsula. The power exchange involved in this market splitting is OMEL, and the TSOs are REE and REN;
- the Italian market, which is split into several internal zones. Congestions between these zones are dealt with through a market splitting solution.

In addition to those existing coupling and splitting solutions, the main projects currently under implementation or under study are:

- Central-West market coupling: Germany will join the coupling between the Netherlands, Belgium and France (target date: March 2010);
- coupling between Central-West and Nord Pool: the 580 km of DC NorNed cable (between the Netherlands and Norway)[19] and the interconnection between Germany and Denmark (EMCC project) are to be managed according to a coupling algorithm. This project is termed multi market coupling (MMC), which precisely designates the link between two already coupled markets. Here, many heterogeneous markets could be integrated. Once the cable successfully opens, the TLC will be enlarged to the Nord Pool system. This last link, however, will be done via DC lines, and will thus not be synchronized.

18. Available at: http://www.nordpoolspot.com/Market_Information/Press-releases-list/Press-Release-no-162006/.
19. This is a project currently uniting the TSO Statnett, TenneT and the power exchanges Nord Pool Spot and APX.

Merchant lines

Merchant lines present an interesting exception to the publicly accessible, 'unbundled' infrastructure. In order to stimulate investment, exemptions were granted in 2003 both for liquefied natural gas (LNG) infrastructure and electricity interconnections.

According to article 7 of the EU regulation 1228/2003 'new direct current interconnections may, upon request, be exempted [...] under the following conditions:

• the investment must enhance competition in electricity supply;

• the level of risk attached to the investment is such that the investment would not take place unless an exemption is granted;

• the interconnection must be owned by a natural or legal person which is separate at least in terms of its legal status from the system operator [...]'.[20]

Merchant lines are generally DC lines, and thus easier to control and to govern then AC lines. The EU regulation was adopted at a moment when the EU was suffering from insufficient regulated investment in interconnection capacity and thus decided to try to offset the trend by granting exemptions —which have to be requested to the EU Commission— for some 20 or 25 years. This means that third parties have no access to the merchant infrastructure within a limited period of time. Nevertheless, until recently, such opportunity was only rarely exploited. A change has intervened only in the last months, partly due to increased public interest and the allocation of new subsidies, including to renewables and appropriate infrastructure. The company IMERA, a frontrunner in the field, recently announced the establishment of two merchant lines called 'Europa Grids': Europa Grid Atlantics, linking the UK, Ireland, France and Spain, and Europa Grid Nord Sea, tying up Scandinavia, Western Europe and the UK.[21] This

20. Regulation No. 1128/2003, Article 2 (7).

21. News Wire, February 2nd 2009, or *Imerapower.com* (Also see the paragraph on Imera on p. 96).

company, which will be subject to more in-depth discussion in Part III of the present work, has specialized in the development of undersea interconnections and the connection of offshore networks, focussing especially on the introduction of renewable energy in the infrastructure. Today's merchant line projects, as a matter of fact, are all HVDC sub-sea links.

New trends in generation

In recent years, the share of electricity generated from renewables has grown rapidly —although quite unequally— within the EU[22] and the trend is likely to continue, especially in light of the already mentioned 20/20/20 objective. Surprisingly, the northern countries produce to date much more renewable energy than the southern ones, including solar energy. This paradox of the North is even truer for the Mediterranean countries.[23] A huge potential in renewables remains unexploited: if hydro-energy is exploited to about 64%, the use of solar, wind, and hydrothermal or geothermal energies is, in turn, still in its very beginning.

Renewable energy would logically be produced far from consumption areas as the renewable resource of water is in mountain regions, near the sea for wind-power, or in southern Europe of North Africa for solar-generated current. This requires major adaptation of the grids, and the extended use of HVDC, especially for offshore wind energy or distant solar. Intermittency inherent in renewables is also an important problem that needs to be solved. For the time being, the introduction of renewables into the grid requires the parallel operation of traditional generation units capable of offsetting irregular input. Currently, there are feasibility studies underway concerning two major projects: the Mediterranean

22. For renewables generation capacity by EU member states, see UCTE Transmission Development Plan Report 2008, p. 15.

23. See 'Méditerranée : une interdépendance énergétique croissante entre nord et sud' (December 11th 2008), available at: http://www.actu-environnement.com/ae/news/interdependance_energetique_mediterranee_6382.php4. According to the study by the Observatoire Méditerranéen de l'Energie (OME), 70% of the renewable electricity generation comes from the Northern Mediterranean, which is paradoxical since the Southern Mediterranean is especially privileged by nature for solar energy generation.

Ring for solar energy, and the northern project for wind energy. Both are discussed later, in Part III. In compliance with the target to in-crease the share of renewables by 20% by 2020, wind will have to represent a third of all renewables by that date. Across the EU, this means that approximately 13% of the total electricity supply will stem from wind, mostly from offshore generation.[24] Northern wind power projects and renewable endeavours in the Southern Mediterranean Ring project, which aims to bring solar electricity to the European market, share common characteristics.

Innovation and technical change

The potential for energy efficiency is very high. According to a report by the EU Commission concerning ICT in the Energy Sector,[25] the potential for improvement, especially in the electricity sector, is considerable: estimated at about 30 to 40% for efficiency increase in generation, at 2% for the avoidance of losses in transport, and at 8% for distribution. The report also refers to the contribution of HVDC lines to energy efficiency. EASAC, as already mentioned, stresses the potential of new cables —like those insulated with gas— and high temperature lines.[26] And it insists on the pioneering role that cities should play, given that more than 50% of the world population is concentrated in them and that consequently 75% of the world's energy is consumed in cities. In this context, an initiative such as the Clinton Foundation's Climate Initiative, known as C40 Cities — Climate Leadership Group, deserves special mention here.[27]

We have witnessed important improvements in the grid and especially in the dispatching and defense plans since the 1980s, and then even more since the 1990s. Nevertheless,

24. G. W. Adamowitsch, 'Project of European Interest, Connection to offshore wind power in Northern Europe (North Sea-Baltic Sea)', (Brussels September 24th 2008). Annual report September 2007-September 2008, available at http://ec.europa.eu/energy/infrastructure/tent_e/doc/off_shore_wind/2008_off_shore_wind_annual_report_2007_2008_en.pdf.
25. Information available at: http://ec.europa.eu/information_society/activities/sustainable_growth/docs/com_2008_241_1_en.pdf.
26. EASAC 2009, p. 13.
27. Available at: *40cities.org*.

insofar as distribution is concerned, the cost of smart metering is still too high for a mass product. The tendency however is towards lower prices, and experts forecast implementation in the next decade.

Research as well as local and regional experience on smart grids clearly demonstrate their value, even if this still remains unfortunately unexploited for the time being.[28]

The term 'smart grid' describes a modernized electricity network that addresses electricity reliability as well as global warming. As digital upgrades of distribution and long distance transmission, smart grids optimize operations, facilitate the introduction of renewables via digital access and delivery control, and reduce CO_2 emissions. Historically, smart grids emerged from early attempts in the 1980s to come up with electronic control, metering and monitoring. Storage of electricity is one of smart grids' objectives. Several projects are currently run at local or regional level, such as Italy's Telegestore project, the first to have networked 27 million homes using smart meters, since 2000. In the US, the city of Austin (Texas) replaced 1/3 of its manual meters with smart meters in 2003. And Boulder (Colorado) recently followed suit, with the completion of a first smart grid project by August 2008.[29] The Third Legislative Package also includes provisions on metering: by 2020, the EU expects 80% of consumers to have access to smart meters.

Legacies: the History of Europe's Grid and Interconnections

The demand for energy and consequently for electricity greatly increases along with economic development and growth. In the context of expansion experienced by the US in the first three decades of the 20th century, demand grew by

28. See communication from the Commission on ICT (May 5th 2008).
29. United States Department of Energy's Modern Grid Initiative report, available at: http://www.netl.doe.gov/moderngrid/opportunity/vision_technologies.htm. See also on the issue: *The Emerging Smart Grid. Investment and Entrepreneurial Potential in the Electric Power Grid of the Future*, Global Environment Fund, 2006, available at: *Centerforsmartenergy.com*.

Scheme 4. Smart grids

Source: http://www.oe.energy.gov/images/smartgrid—diagram.jpg.

12% a year. Until the present financial crisis, we were witnessing similar phenomena in China and India.

Europe is very densely populated, a fact mirrored by its similarly dense and integrated electricity grid, particularly in industrial regions as well as on the borders of the triangle composed by France, Switzerland and Germany. An integrated or interconnected system provides the opportunity for managing grid performance through integration and cooperation between regional and national operators, but also increases the risk of broader blackouts. As a consequence of the proper exercise of this broader grid, the reliability and quality of electricity in Europe have been improved.

A detailed presentation of the historical legacies would exceed the scope and goal of this paper. The interested reader can refer to the impressive research by Thomas Hughes, especially *Networks of Power: Electrification in Western Society, 1880-1930*, which compares electricity development in Chicago, London and Berlin (1983). An excellent historical study was published at the end of 2008 by Lagendijk, *Electrifying Europe: The Power of Europe in the Construction of Electricity Networks*. More national studies have been published on the US —Nye (1990)—, Russia —Coppersmith

(1992)—, and Finland —Myllyntaus (1991)—, to note only some of the most outstanding research. Most countries have been covered by specific regional research.

The first grids in the early 19th century

The following paragraphs summarize main events and steps to-wards an interconnected Europe and are for the most part based essentially on the above cited publications as well as on UCTE reports.

Today's grids, originating in Nicola Tesla's design in 1888, started to spread after 1896. Technological maturity in production and transport was reached only at the end of the 19th century. Earlier grids were localized, with one or two plants providing electricity to a nearby city or small region through a local grid. Those grids were called 'islandized' for the same reason that today we call disconnected countries like Spain or Italy 'electricity islands'.

The first nets, operating with DC, emerged in 1882 in New York, but also in smaller, less important places like the industrial city of Bellegarde, France. Research and improvement efforts focused over the following years on how to avoid transmission losses, and how to stabilize the grids, as blackouts were frequent at that early stage. The introduction of three-phase alternating current allowed for the first time in 1883 to connect a distance of 80 km. Search for the optimal frequency aimed to diminish losses and led to the 50 and 60 hertz paradigm some decades later.

The first high-tension line of more than 100 kV was put into service in Germany in 1912, linking Lauchhammer to Riesa. Again in Germany in 1929, the first double-circuit line was inaugurated, with 220 kV, linking Brauweiler and Ludwigsburg. The US followed with 287 kV (Boulder-Los Angeles, 1932), then Sweden with 380 kV (Harspranget-Halsberg, 1952), the Soviet Union with 525 kV (Moscow-Volgograd, 1960), Canada with 735 kV (Montréal-Manicouagan, 1965), the US again with 765 (Broadford-Baker, 1969) and again the Soviet Union, with 1,200 kV (Ekibastuz-Elektrostal, 1985).

The lion's share of high-tension lines and interconnections operates today with three-phase alternating current. As we have mentioned earlier, the debate on whether AC or DC was more efficient characterized the early years of electricity, and eventually led to the former winning the contest. Nevertheless, underground and especially undersea lines (like the interconnection between France and the UK, IFA, opened in 2000), as well as long-distance lines, favor DC, which, in general, is making a comeback and is now more often considered a serious and reliable alternative for long-distance high-voltage transmission. Since conductors are very vulnerable to temperature, wind, rain, and ice, factors such as materials, but also height and distance between pillars, matter heavily.

The main challenge in the early electrification years was the connection between major production sites (hydroelectricity in the mountains, or coal mines and other fossil reserves) and consumption areas. Surprisingly, efforts at regional cross-border integration and Europeanization were already made in the early years of electrification. Germany, central France and Switzerland constituted the nucleus for the future European grid, following the momentous introduction of higher voltage lines in the aftermath of WWI.[30] Swiss, French and German interconnections linked the German public utility company RWE with Alsace and Lotharingia in France as well as with northern Switzerland in 1926.[31]

Hydroelectricity as well as coal-based electricity production dominated that early stage. The Rhine Valley constituted an impressive early North-South connection, linking the German city of Nordhorn on the Dutch border to the Ruhr city of Trier near Luxemburg. Bludenz in Austria and Frankfurt followed suit, and also an Italy-Switzerland interconnection. Switzerland thus, due to its hydro energy potential as well as to its geographical position, early on became a pivotal part of European electricity networks as an important

30. Lagendijk 2008, p. 42, details on this with tables on exchanges, imports and exports in the early 20s, and a map from 1928, the 'RWE system', drawn by the author from archives, p. 48.

31. Lagendijk 2008, p. 42, Figure 2.1, 'Swiss, French and German interconnections around in 1926', source H. Niesz, L'échange, World Energy Council, available at: *Worldenergy.org*.

transit country for electricity. Governance and organization were critical from the very beginning, since the market itself did not ensure the necessary developments: lack of trust and political factors interfered and continue to interfere heavily with electricity infrastructure projects, very much as they do today with other energy commodity markets such as gas. Global organizations dealing with energy —and more specifically with electricity— eventually came into being, like CIGRE, set up in 1920, UNIPEDE (1925) and the World Energy Council (1924). But others also took part in the debate: among them, the League of Nations through its Committee on Electricity Questions,[32] or the International Labour Organization whose General Secretary Albert Thomas pleaded for public work in setting up infrastructure after the Great Depression.[33] Those organizations attempted to regulate the future regional cross-border interconnections. The 50 Hz current became the standard across Europe, following the norm established in 1918 on three-phase alternating current.[34]

The first pan-European electricity network projects were developed as early as 1929 by Georg Viel and the Swiss engineer Ernst Schönholzer, as well as the German engineer Oskar Oliven.[35] But Belgian proposals from Hymans were met with strong opposition from the national industry, Oliven fled Germany and Thomas died in 1932. The projects were buried, but the idea, as Lagendijk rightly put it, 'had taken root'[36] and would become reality only some fifty years later. Those early debates and proposals about a pan-European grid pondered the following alternatives: either a genuinely European 'super' system (Oliven), or a gradually growing system of more and more interconnected national networks, as other proponents and industry representatives favored. It is interesting to note here that the Soviet Union later undertook the Oliven system by putting in place a highly centralized 'super system' with a Central Dispatch Organization based in Moscow. Awareness of

32. Lagendijk 2008, p. 86.
33. Lagendijk 2008, pp. 90-91.
34. Lagendijk 2008, p. 57 (Extensive information on these developments).
35. Lagendijk 2008, pp. 80-91 (Extensive information on this as well as historical maps of the projects).
36. Lagendijk 2008, p. 103.

the beneficial aspects of interconnections, such as an improved energy mix and mutual assistance, rose inside both camps in the interwar period. Realization of the 'Europe A/Europe B' dichotomy resulting from the rift between the East/South and the West led many of the plans to devote particular attention to East and South electrification.[37] And some authors also suggest not underestimating the Nazi influence on the setting up of electricity infrastructure across Europe — the idea of a Mediterranean ring or even the closure of the Gibraltar-Ceuta straights were already discussed in those days.[38]

Cold War and separate grids

Heavy political interference on the subject of grids became evident again after WWII, with massive meddling from both super powers, the US and the Soviet Union. For example, civil war in Greece made NATO use the concept of 'energy security' and set up a working group on this issue. Europe's division as well as regional integration led to the emergence of four electricity systems: UCPTE, founded in May 1951 very much under the auspices of the US and the Marshall Plan, then Nordel in 1963, Sudel between Austria, Italy and Yugo-slavia in 1964, and IPS/CDO in the Soviet Bloc in 1963, on the other side of the Iron Curtain. In that early period, NATO was also interested in interconnections and set up a special committee dealing with 'war time security and interconnections'. The project, which will remind the observant of NATO's current attempt to play a role in energy security, was abandoned some years later.[39] In fact, the interconnection-security link, or the value of interconnections as a means to tie countries together with the respective alliances, was an important consideration in the aftermath of WWII. Thus, Turkey and Greece became

37. Lagendijk 2008, p. 105.
38. B. Stier, 'Expansion, réforme de structure et interconnexion européenne : Développement et difficultés de l'électricité sous le nazisme, 1939-45', in *Les entreprises du secteur de l'énergie sous l'Occupation*, Denis Varaschin Ed. (Arras, Artois Presses Université, 2006), pp. 289-290.
39. Lagendijk 2008, p. 157, and Special Working Group of NATO, 'The Production and Distribution of Electricity in Wartime', NATO Brussels, cited by Lagendijk.

major targets for the Truman Administration. A specific electricity program for Greece was entrusted to the US Company EBASCO and financed by the OEEC, as part of the International Emergency Program. The US administration believed that 'the electrification project was not just a program for the efficient utilization of the country's indigenous resources, but that it would help to maintain security and peace, attained in 1945'.[40]

Another security case was West Berlin, which turned into an electricity island within the Soviet zone after the Soviet blockade in 1948. Much as it happened with other enclaves, Berlin became electrically independent, with its own power plant dating back to Nazi times and later rebuilt by the Western Allies after the Soviets partly dismantled it.[41]

The Cold War strongly shaped Europe's electricity landscape and reinforced the East-West divide. Nevertheless, some countries played a role as interfaces or bridges through the Iron Curtain: Austria, Yugoslavia, as well as —to a certain extent— Finland and East Germany. Since fast growing European economies required more and more electricity and energy as a whole, lower prices in the Eastern Bloc (due to cheaper fuel prices in the East) made imports from Poland and others particularly attractive, although certainly very controversial for political reasons. The export of unused hydroelectric potential from Yugoslavia to Austria and West Germany was a prominent issue as well, albeit a strongly contested one. Resistance came especially from Germany, influenced by the Hallstein Doctrine that forbade any diplomatic contact with countries that had previously recognized East Germany.[42]

Map 1 shows existing interconnections in 1963. Austria played a pivotal role: interconnected with Czechoslovakia and

40. Lagendijk 2008, p. 160 (Information on Greece and the US electricity program).
41. S. Nies, *Sand in the Works. Enclaves challenging metropolitan States. A comparative study of the governance of enclaves* (HDR, Paris, 2004); published electronically with GRIN and available at: http://www.grin.com/e-book/109517/sand-in-the-works-enclaves-challenging-metropolitan-states-a-comparative; Lagendijk 2008, pp. 160-162.
42. Lagendijk 2008, p. 190 'The Path of Least Resistance: Austria and Yugoslavia'.

Map 1. Existing and planned cross-border interconnections in Central Europe in 1963

Source: adapted by Lagendijk 2008, p. 134 (UNECE, Outline of a Study on the Possibilities of Increasing Interconnection Between Electric Power Transmission Networks in Europe, UN doc, ser; ME/31/64/C.2(A) (Geneva: UNECE 1964).

Hungary, but also with Yugoslavia, it ensured that Greece, which would have otherwise been isolated, participated in the Western European market. East and West Germany were linked via a small transformation station.

Map 2. Yugoslavia in the East West Trade in 1954

Source: Lagendijk 2008, p. 176.

East/West electricity trade during the Cold War

While West Germany remained strongly opposed to East-West trade, Austria, starting with the agreement with Czechoslovakia in 1954, became a platform for it and thus linked the UCPTE and the CDO, the Soviet Central Dispatch Unit. Yugoslavia was also, at the end of the Cold War, deeply involved in East-West trade, as the following map demonstrates. It is particularly regrettable that this asset should have disappeared in the bloody and ruthless wars of the 1990s, and with them too the grid that was taking shape during the Cold War. Without the Balkans war, Yugoslavia, much like Austria does today, could have provided a formidable opportunity for advancing the unification process of Europe after 1989. The map below highlights the connecting role that Yugoslavia played, via Austria.

The setting up of the UCPTE in 1951 was decisive in paving the way for the existence of regional organizations. The entity became a benchmark for other similar organizations that came in the years that followed.

Another crucial element in electricity grid development from the 1960s onwards was the increasing attention paid to environmental issues and NGO concerns, which resulted in important delays in legal approval procedures. The situation has not yet changed, with a new line taking on average around ten years to be legally approved. Thus, installing new generation units continues to be easier than setting up new lines, especially overhead ones.

The first electricity interconnections within the EC were set up in the spirit of favoring mutual assistance in case of technical disruption: they occurred bilaterally, linking two countries or smaller regions (Benelux, France, etc.). Only later, once the security of the system and synchronization were achieved, the ambition of improving the market pricing was put on the agenda where it still remains an important goal.

Bridging the former East/West divide

The end of the Cold War challenged the European electricity grid once again. The main goal was, and still is, to connect the East to the West. Important steps have already been taken in that direction: the setting up of CENTREL in October 1992, uniting the Visegrad states of Poland, Hungary, Slovakia and the Czech Republic, and the synchronization with UCPTE on October 18th 1995, are some examples. The electrical integration of the two Germanys took place one month earlier, in September 1995.

In 2001, the Visegrad states entered into the UCPTE. Simultaneously, the 'westernization' of former East Bloc countries resulted in their progressive disengagement from the Eastern system: as a consequence, formerly existing interconnections, like those established with Hungary, have been out of service for more than a decade, and their state has deteriorated since. It is unclear whether those interconnections could be put back to service again in order to connect IPS/UPS and UCTE. The rights of way, however, are there, which is a positive element.

The relationship between future member states and the EU on electricity issues has been for some time an important concern. The fact that electrical synchronization has empirically preceded political integration and membership, has rendered the UCTE very attractive to many. Turkey, Morocco, Tunisia, Algeria, Ukraine and Moldova have —not surprisingly— applied for interconnection. And again: DC lines, which do not enhance political integration to the same extent, are not considered by most as an equally valuable solution, but just as the 'second best'.

Institutional redesign

Regulatory change, in turn, has progressively led to institutional change. Institutions have at once been designed from 'below' —within member states and at regional level— and from 'above', with the Commission often pursuing different options regarding the same issues. Institutional doubling, naturally, was and still is the consequence. At the same time, institutions have changed and adapted themselves to the new requirements, including the European Commission itself. The DG TREN gained importance and power especially after the Russia-Ukraine conflict in 2006. By the end of 2009, Energy will have been set up as a separate Directorate General, reflecting the newly acquired prominence of energy policy. The UCPTE became the UCTE following unbundling and the separation of production and transmission in many of the member states. UCTE, Nordel, UKTSOA and ATSOI founded ETSO in 1999 in order to harmonize their positions. Eurelectric, the association of the electricity industry in Europe, which was founded in 1990 to represent the industry as a whole, merged in 1997 with UNIPEDE. Institutions moved to Brussels; so did UCTE in 2001. Renewable energies, in the wake of the environmental movements of the 1970s and 1980s, and in answer to the evidence of climate change, have become a widespread concern and have began fundamentally changing the electricity landscape. The newly acquired angst over the future of the environment and the decisions taken at Kyoto and Copenhagen, have also translated into the setting up of new organizations such as Medelec or the Desertec project, DEWI or Dena, to name only some of them.

In 2004, when the EU admitted the eight CEE states as well as Cyprus and Malta, the UCTE stated that enlargement had been 'technically anticipated by the organization', which had integrated those states prior to enlargement.

A Complex European Governance

Part II puts European interconnection governance under closer scrutiny. 'European' does not here mean exclusively the EU, but also the national and regional levels. A large number of players is involved in the process: they will be listed and discussed in the next pages. At this very moment, important changes are underway. The endorsement of the EU's Third Energy Security Package has led to three important institutional changes: the establishment of two European agencies —ACER and the ENTSO-E—, and the reinforcement and homogenization of national regulators.

Interconnections in the Acquis Communautaire

It may be useful to remind the reader here that for the last thirteen years the EU has been engaged on the path of setting up an internal energy market — a process that started in 1996 with the first legislative package. At that time, cross-border transfers were under control of generators, and the prime objective of the First Package was thus to open up the national markets. The picture is very different today, following the emergence of unbundling and the establishment of TSOs, but also the new issue of climate change, which was absent in the agenda of the 1990s. Supply disruptions have been a primary concern ever since the two oil shocks of the 1970s; the gas sector, however, had not known any such hardships until the Ukraine-Russia conflicts in 2006 and 2009. The EU seems resolute to strengthening its energy policy, as is indicated by the huge financial commitment to energy projects, as well as the recent fining of GDF/Suez and E.ON for anti-competitive behaviour concerning the Megal gas pipeline.[1]

Stronger European or regional governance is nevertheless still needed to dismantle some negative legacies from the past. Today's landscape of European organizations dealing with electricity interconnection is highly complex and evolves with the legislative changes. Action is often either doubled or insufficient, due to the particular way in which those structures were set up in the past. Even at the national level, coordination is sometimes difficult. Germany is a prime example, with its four TSOs who must decide unanimously on any new transmission project. It also happens that sometimes the four develop competing projects, including on the subject of interconnections, with highly counterproductive consequences. On occasions, moreover, the four must sit at a table along-side a French or a Belgian TSO, which understandably complicates negotiations further. Bilateralism is highly relevant at the time of setting up interconnections, as was mentioned already in the general overview on market coupling. Bilateralism translates into regionalism, which then allows bi-regional projects to emerge, as with the envisaged link between Nord Pool and Central-West. The Central-West Pentalateral Forum, which comprises Germany, Belgium, France, Luxemburg and the Netherlands, can be considered a benchmark. It was created in December 2005 by the respective energy ministers and progressively integrated —market design, data exchange, etc.— especially since the beginning of 2009.

Given the specific nature of electricity and the high risks that go along with its transportation, appropriate governance is a key factor in —negatively speaking— handling risks and —positively speaking— creating a true European electricity market. Subsidiarity, which means dealing with problems on the appropriate subnational, national, regional or European level, and central regulation, must be reconciled in this respect.

The 10% axiom

The question of interconnections has been on the European Commission's agenda since 1996. In 2002, the Barcelona

1. 'Stepping up the competition crackdown', European Voice, July 23rd 2009, p. 17.

European Council mandated that EU member states set up their interconnection capacity to a minimum of 10% of their respective generation capacity.

Why 10%, and not 5%, or 20%? There is surprisingly no rational answer to the question, which explains the criticism this requirement has been facing.[2] Nevertheless, 10% could be considered a somewhat 'symbolic' quantity: it is easier to understand than eight (which was the first proposal), more important than five, which would be just 'lump sum', and more realistic than 20, which would be perceived as sheer megalomania and an attempt at European overtake.

However, even if the unexplainable 10% axiom deserves criticism, perhaps the figure itself does not really matter, and should rather be considered in its positive sense, as an indication of a certain degree of European commitment towards solidarity and liberalism within electricity markets.

The Second Legislative Package and Regulation 1228: the legal take-off

The legislative starting point of EU regulation on interconnections came with the insight that the European electricity market was far from being completed, not sufficiently liberalized, and dominated by strong national operators. Cross-border electricity exchange was thus envisaged as a means of improving the situation. The consultations, which started in 2000, culminated in 2003 with the Second Legislative Package on the liberalization of electricity and gas markets, comprising Regulation[3] No 1228 'on conditions for access to the network for cross-border exchange in electricity'.[4] Regulation 1228 went into force on July 1st 2004.

2. Comment that there is no reason for the 10%, by a representative of DG TREN, as well as UCTE.
3. A regulation is a legislative act of the EU that enters immediately into force, in all EU member states simultaneously. Regulations are different from directives, which must be transposed into national law and implement measures within established deadlines, based on article 249 of the EC treaty. Regulations are also known by the term of 'European laws'.
4. The full text can be found at: http://www.energy-community.org/pls/portal/docs/36276.PDF.

The objective of the regulation, further amended in 2006, was to 'lay down basic principles with regard to pricing and capacity allocation' (Introduction of the regulation). Regulation 1228 comprises 14 articles covering subject matter and scope: fair rules for cross-border exchanges (Article 1), definitions (Article 2), the inter-transmission system operator compensation mechanism (Article 3), charges for access to networks (Article 4), provision of information on interconnection capacities (Article 5), general principles of congestion management (Article 6), new interconnections (Article 7), guidelines detailing methodology of compensation, (Article 8), regulatory authorities (Article 9), provision of information and confidentiality (Article 10), right of member states to provide for more detailed measures (Article 11), and penalties (Article 12) as well as the Commission Report (Article 14). An annex sets management guidelines. The amendment of December 1st 2006 focussed on the existing mechanism and the improvements to be made, as well as on the introduction of a new regional approach.

Regulation 1228/2003 has also become one of the legal references for the Energy Community of South East Europe (ECSEE), which is a proof of the spillover of EU legislation, especially to countries that are interested in future membership.[5] As a result of the new regulation of cross-border electricity flows, management of interconnection capacity started to shift from priority lists —or pro rata mechanisms (before 2004)— to market coupling.

In January 2007 the European Commission published a priority interconnection plan, as part of the first Strategic Energy Review.[6]

ERGEG'S regional initiatives: from regional to European?

A major institutional and regulatory event for the promotion of interconnection efficiency came somewhere in between

5. See http://www.energy-community.org/portal/page/portal/enc_home/areas_of_work/electricity/Regional_Market/Regulation_1228.
6. See http://ec.europa.eu/energy/energy_policy/doc/12_priority_interconnection_plan_annexe_en.pdf.

the Second and Third legislative packages, with the establishment of ERGEG regions in February 2006, dividing the EU into seven electricity and three gas regions. The seven regions are: Central-West; Northern; France, UK and Ireland; Central-South; South-West; Central-East and Baltic. Each region is chaired by a lead regulator. ERGEG regions do not correspond to historical grids, but represent those territories that, according to ERGEG, should integrate first in order to promote, as a next step, a true European market. France, for example, participates in four regions: Central-South, Central-West, South-West, as well as in the one it shares with the UK and Ireland. The Electricity Regional Initiatives Task Force (ERI TF) within the ERGEG monitors advancements towards regional integration on a yearly basis.[7] The initiative also aims to strengthen market development integration with South Eastern Europe: the latter's electricity market exists under the so-called Athens Forum Process, which is part of the Stability Pact for South Eastern Europe. Reports by ERGEG are presented in the Florence Forum, and commented by ETSO.[8]

According to ERGEG, the emergence of a European electricity market must evolve through regional integration first, which requires common investment projects and adequate funding. Working groups have been set up for each region within ERGEG with the mission to identify important obstacles as well as key interconnections that need to be established. Current developments and especially the advancements in the Central-West region confirm the rationale of the approach: regional integration moves much faster than European integration, or, to put it in the words of Christophe Gence-Creux (CRE): 'This integration —like the setting up of the common centre RTE-Elia— would never have been possible from above'.[9]

7. ERGEG European Energy Regulators Work Programme 2008, Chapter 4.2, p. 37. Electricity Regional Initiatives Task Force.

8. ERGEG Reports Coherence and Convergence, information available at: http://www2.e-control.at/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/2008%20ERI%20Coherence%20and%20Convergence.

9. Interview with Christophe Gence-Creux, April 27th 2009. Christophe Gence-Creux is responsible for the three CRE reports.

Table 4. ERGEG-initiated electricity regions and lead regulators

Electricity Region	Member States	Lead Regulator
Central-West	Belgium, France, Germany, Luxembourg, the Netherlands	CREG (Belgium)
Northern	Denmark, Finland, Germany, Norway, Poland, Sweden	DERA (Denmark)
France, UK and Ireland	France, Republic of Ireland, GB, Northern Ireland	Ofgem (GB)
Central-South	Austria, France, Germany, Greece, Italy, Slovenia	AEEG (Italy)
South-West	France, Portugal, Spain	CNE (Spain)
Central-East	Austria, Czech R, Germany, Hungary, Poland, Slovakia, Slovenia	E-Control (Austria)
Central-East Baltic	Estonia, Latvia, Lithuania	PUC (Latvia)

The Third Legislative Package: institutional design

Approved on April 22nd 2009, the Third Legislative Package —comprising five texts— intends to go further on the path towards gas and electricity market liberalization. But it must be insisted here that in the case of some —and especially the new— member states even the Second Package has not yet been fully implemented; it suffices, for an example, to look at Poland and the particular status of the Jamal gas pipeline.

Energy security and the solidarity quality of interconnections figure more prominently in the Third Package than they did in the previous one, and isolated markets are recognized as being more vulnerable. Also in contrast with the Second Package that changed mostly the national parameters, this one advocates a redesign of the institutions. Interconnections and cross-border electricity exchanges made their way up to an important place in this package despite having been rather overseen in the preceding public debate that focussed very much on 'unbundling' as well as on energy security and climate change. The document stipulates that Directives will go into force 20 days after the publication of the texts in the Official Journal of the EU; subsequently, member states will have 18 months for their transposition into national law.

The blackout of November 4th 2006 clearly demonstrated, according to both the Commission and the UCTE, that national TSO's and regulators had so far failed to cooperate sufficiently. A decision was taken, then, to establish a regulators agency called ACER within the following 18 months — which means by no later than early 2011. It also became clear that regulatory activity had to be streamlined and the authority of national regulators reinforced, especially with respect to the TSOs. The Commission specifically stressed that the different sizes and responsibilities of the national TSOs and regulators constituted a serious handicap to any further cross-border cooperation. Initially, when the directives from December 1996 and June 1998 were converted into national laws, the role of the national regulators had been in fact conceived in a very different way.

Transitions in the Regulatory Landscape

The amendment to Regulation 1228/2003 included in the Third Package triggers complex institutional changes. On the one hand, the regulatory agency ACER is to be set up and the integration of the TSOs within a common organization encouraged, and on the other hand unbundling —with three options— is to be reinforced, separating thus more efficiently the TSOs from the companies. Finally, the national regulator is given extensive powers to oversee the process, including interconnections. The idea of a European regulator dates back to 2003, the date of the Second Electricity Directive, and has since been clarified by another directive concerning electricity market liberalization, in 2007.[10] According to the Parliament and the Commission, the body should contribute to the integration of national electricity markets, a goal that goes far beyond electricity interconnections alone. The European Parliament has repeatedly advocated a strong role for the regulator; the representatives of the member states, however, have been more reluctant to endorse that initiative.

10. COM (2007) 528 final, Brussels September 19th 2007.

The Agency for the Cooperation of Energy Regulators will be in charge of:

• harmonizing access procedures, especially through the elaboration of norms and codes that should eventually be legally binding;

• coordinating the grid through a common mode of exploitation;

• improving the plans and development of the European grid through a ten-year European investment plan, based on national investment and development plans.

In practise, at least in the beginning, ACER will have a more symbolic than real role, and will be especially expected to intervene in cases of arbitrage between national regulators, whenever they cannot reach agreement among themselves.

Why ACER?

The fact that the national implementation of directives, as well as the roles of the regulators, varies widely from one member state to the other, remains a major problem. At the same time, doubt persists over whether a European super regulator would be more efficient than the current group of regulators.[11] ACER's goals and the open questions related to the future agency were described by the president of ERGEG, MP Lord John Mogg, in the following terms: as a Community institution, the agency will be funded from the EU budget, with a projected €9 million a year and some 50 staff to be located in either Romania or Slovakia. Different from ERGEG, which represents individual national authorities, ACER will be working from a cross-border perspective. Its role should be decisive on matters of interconnections and contribute to overcome the lack of interest in setting them up. Mogg insisted, however, on the obstacle resulting from the Meroni principle,[12] a legal instrument dating back to the 1950s.[13]

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11. For an extensive discussion, see Ferron 2006, pp. 140-146.
12. The Meroni principle from 1958 prohibits the delegation of 'discretionary powers' that would amount to a transfer of responsibility replacing the choices of the delegator by those of the delegates.
13. 'ERGEG: EU regulation at a turning point', Interview with Lord Mogg by EurActiv Czech Republic (February 23rd 2009), available at: http://www.euractiv.com/en/energy/ergeg-eu-regulation-turning-point/article-179672.

In turn, ETSO's move towards ENTSO-E is in line with the creation of a European Centre of Networks, an initiative that had also been mentioned in the Energy Green Paper. The Centre is in charge of regulating border exchanges as well as security and compensation. A comparison could be made with another network industry, telecommunications, which in 2002 set up a quite original national/European model and refused to have a super regulator. At the same time, telephone and electricity grids are no longer comparable following the introduction of wireless telecommunication that allows for the coexistence of several networks. Wireless electricity transmission, though possible, would introduce huge risks for vertical transmission — fried planes, fried birds, etc. And vertical wireless electricity transmission —which Japan, for example, is currently studying— could, in turn, only be an interesting project for the future, once isolation methods have evolved to the point of effectively preventing accidents. In addition, electricity, especially because of its system security requirements, necessitates much more central regulation than telecommunications do.

The decisive change: more power for national regulators

The most forceful measure of the amendment, however, is less the creation of ACER than the gradual convergence and reinforcement of national regulators. This fact will surely remind the attentive reader of the apparent paradox of the Lisbon Treaty, which reinforces at once the EU and the rule of national parliaments within the legislative process. The amendment paragraph relating to the national regulator stipulates thus that the power as well as the independence of national regulators must be strengthened. The lack of uniformity and in many cases the weakness of regulatory authority prompted the Commission to encourage the strengthening, and to issue a clear mandate for cooperation on a European level. The proposition also contemplates the increase of the market regulation powers of the regulators, in particular in the areas of monitoring, compliance of transmission and distribution system operators, unbundling, congestion and interconnection management. Regulators will also be in charge of reviewing the TSO's investment plans and of checking the conformity of their proposals with the European-wide 10-year network development plan. The monitoring of network security and reliability, as well as the review of network security and reliability rules, will also be under their responsibility. Transparency obligations must be fulfilled, and regulators could thus force TSOs to publish congestion data from within their countries.[14] Last but not least, regulators will be allowed to take initiative on infrastructure projects, something that is not the case to date.

TSOs anticipate the move: ENTSO-E

In fact, it is the Third Package that should have created ENTSO-E, but the TSOs anticipated the move in order to demonstrate that they did not need central intervention to strengthen cooperation among themselves. To date, the exact distribution of roles between ENTSO-E and ACER is still to be defined. The risk of overlapping, parallel or even contradictory work cannot be excluded. As was already discussed in the historical section, Europe comprises five synchronous areas: UCTE, UKTSOA, ATSOI, Nordel and IPS/UPS. At the same time, organizations like BALTSO (the cooperation organization of Estonian, Latvian and Lithuanian TSOs) and CENTREL are devoted to accelerating integration with the UCTE, which functions very much as a benchmark for Eastern Europe, and also for the Mediterranean region. Integration within ENTSO-E will not lead to the disappearance of the historic regions, simply because those regional electricity zones are based on the historic grids and synchronization. In order to manage specific needs, ENTSO-E will have no other choice but to set up regional departments corresponding to the former UCTE, Nordel, UKTSOA, and ATSOI for as long as the systems are not entirely synchronized.

Where the existing electricity regions follow different technical standards than the members of the region, the sharing of responsibility between the TSOs and UCTE, Nordel, UKTSOA, ATSOI on the one hand, and ETSO or ENTSO-E on the other, works as follows: the national TSOs are in charge of national

14. See: http://ec.europa.eu/energy/gas_electricity/third_legislative_package_en.htm.

Map 3. ENTSO-E members: 42 TSOs, 34 countries

Source: ENTSO-E.

development and operation; national regulators like CRE are in charge of grid access and oversight. Regional organizations like the UCTE must coordinate the TSOs, assess problems such as blackouts, and look into further grid development. ETSO was established by the regional associations at the end of the 1990s with the mission to harmonize compensation between TSOs and to unify actions in order to favor the integration of the European electricity market. Finally, ENTSO-E succeeded ETSO at the end of 2008, yet its mandate and precise definition are still very much under debate.

Open questions remain, as we have said, concerning the relationship between ENTSO-E and ACER, as conflict is inherent between TSOs and regulators, as we witness on a national level. The conflict results mostly from their different roles and the perceptions that each has of the other.

The Commission's redesign 2010: from DG TREN to DG EN

At a political Executive European Level, the growing prominence of energy is clearly reflected in the decision to set up an independent Directorate General for Energy. Consequently, the existing Directorate General for Transport and Energy (DG TREN), which was created by the former Commission President Romano Prodi in 2004 as a merger of two DGs carried out for the sake of efficiency, will be divided again. One of the reasons for it —and not the least of them— is that Director General Mathias Ruete cannot physically attend a transport and an energy council at the same time. At the end of 2008 the Commission president Manuel Barroso announced the creation of a new Directorate General for Energy by November 2009 at the latest, with a staff of 400-500, its own external relations, communications and personnel units. A working group focusing on its concrete design has been set up. Speculation continues, however, over the EU member states' likely push to create a new commissioner post for 'Energy and Climate Change'.[15] Would such a move facilitate energy policies within the Union? To date, energy policy is on the portfolio of several commissioners: DG TREN and RELEX, as well as DG Industry and DG Internal market. For this reason, the Second Strategic Energy Review,[16] an EU 'action plan for energy security and solidarity', released at the end of 2008, was introduced jointly by Ferrero Waldner (Commissioner for External Relations and European Neighbourhood Policy) and Piebalgs (Commissioner for Energy). DG RELEX has in turn made many efforts to play a role in this field, especially in the foreign dimension of energy policy, which is the least defined and less organized field for the time being.

Experts agree that energy policy relating to the Community market is fairly well developed, even if its management remains spread across many institutions, whereas Foreign Energy and Climate Policy is in its early stages, and institutionally not developed at all. In light of important negotiations with producers and transit countries, a redesign is necessary and should come up with the next Commission.

15. Source: EU Observer (December 4th 2008).
16. See http://ec.europa.eu/energy/strategies/2008/doc/2008_11ser2/strategic_energy_review_memo.pdf.

Subsidies, Priorities, Coordinators

The cost of electricity interconnections

An electricity interconnection costs, as estimated by the CRE from experience on the latest established interconnections, an average of €300,000-€500,000/MW for an AC line, and €600,000-€800,000/MW for a DC line.[17] How to finance such important amounts in a situation where electricity border markets are still imperfect, and receipts by the TSOs are not necessarily reinvested into capacities — as is the case with RTE receipts going back into the state budget?

Commission supplementary funding

European subsidies are crucial in this field. The Commission funds TEN-E (Trans European Networks-Electricity) electricity transmission infrastructure projects with a yearly budget of some €25 million (for gas and electricity combined), most of which is spent on supporting feasibility studies. TEN-E is an important label, additionally backed by the European Investment Bank.[18] The EIB has seen its spending on energy infrastructure roughly double between 2006 and 2007,[19] to reach one sixth of its overall budget, or €8 billion a year, whereas the Commission counts on €8 billion for the entire budget period (2007-2013). The EIB complementary funding, which never exceeds 50% of a project's budget, requires that the project be economically viable, technologically functioning, and backed by a capable promoter or consortium. The EIB also generally gives preference to priority projects from the Commission. The bank's strategy is long-term, with a projected return on investment in 40-45 years.

According to the Commission, TEN-E should be replaced by a new instrument: the EU Energy Security and Infrastructure Instrument, one of whose objectives would be to ensure the

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17. CRE, 'Rapport sur la gestion et l'utilisation des interconnections électriques' (2008), p. 10, and footnote 13. The authors state that the price varies largely.
18. Also see the report of MVV Consulting: 'Implementation of TEN-E projects 2004-2006', Brussels, 2007, available at: http://ec.europa.eu/energy/infrastructure/studies/doc/2007_11_ten_e_evaluation.pdf.
19. Interview with Thomas Barrett, EIB director, Action for Growth Instruments, Directorate for Operations in the EU and Candidate Countries (November 14th 2008).

grid's contribution to achieving the EU's renewable energy targets and guaranteeing security of supply, through infrastructure projects within and outside the EU.[20]

The €5 billion stimulus package

On March 20th 2009 the European Council submitted a €5 billion package for infrastructure projects. The finance of energy projects altogether amounts to €3,980 million spread over two years. The funds stem from the re-allocation of unspent agriculture subsidies. They will support clean-coal projects, offshore wind farms, as well as energy infrastructure and interconnections. More precisely, €2,295 million will be devoted to gas and electricity infrastructure, €505 million to offshore wind energy projects, and €1,200 million to carbon capture and storage. The budgetary commitments have to be made before the end of 2010. As for electricity projects, the list of eligible projects comprises the Baltic Interconnection, the Mediterranean —including France—Spain—, the North Sea Area and some small island projects for Cyprus and Malta. Grid integration for offshore wind projects, and especially offshore grids, are part of the proposal.[21] The total amount earmarked for electricity interconnection projects at large is €1,240 million. Certain award criteria such as the requirement of proven maturity by the end of 2010 have been criticized on the grounds that projects meeting that kind of prerequisite will be very limited, if existing at all. The following table, compiled by the author on the basis of the EU Council's decision, presents the eligible electricity interconnection projects to date.

TEN-E and coordinators

TEN-E was launched in the late 1990s with the mission to identify and subsequently promote pan-European priority energy projects. A limited budget of €25 million has since

20. Memo, Second Strategic Review, EU Energy Security and Solidarity Action Plan (November 13th 2008), available at: http://ec.europa.eu/energy/strategies/2009/2009_07_ser2_en.htm.
21. See Council of the European Union 7848/1/09, Brussels, March 20th 2009, for the list of projects.

Table 5. Interconnections and offshore wind grid: EU eligible projects (€1,240 million)

Project	Location of projects supported	Envisaged community contribution (€million)
Baltic Interconnection		
Estlink-2	Estonia, Finland	100
Interconnection Sweden Baltic States, and strengthening of the grid in Baltic States	Sweden, Latvia, Lithuania	175
Central and South East Europe		
Halle/Salle—Schweinfurt	Germany	100
Wien—Györ	Austria	20
Mediterranean	Portugal	50
Portugal—Spain interconnection reinforcement		
Interconnection France—Spain (Baixas—Sta Llogaia)	France, Spain	225
New 380 kV AC submarine DC cable between Sicily— Continental Italy (Sorgente—Rizziconi)	Italy	110
North Sea Area		
Interconnection Republic of Ireland—Wales	Ireland, UK	110
Electricity Interconnection		
Malta—Italy	Malta, Italy	20
TOTAL		910
Small Island Projects	Cyprus	10
	Malta	5

Table 6. Offshore wind projects

Project/capacity	Location of project	Envisaged community contribution (€million)
Baltic-Kriegers Flak I, II, III Building on projects under development, financing aimed at ensuring extra cost for securing a joint interconnection solution 1,5 GW	Denmark, Sweden, Germany, Poland	150
North Sea Grid 1,5 GW	UK, the Netherlands Germany, Ireland, Denmark, Belgium, France, Luxembourg	165

Source: Council of the European Union, Brussels, March 20th 2009, Presidency compromise for financing of the Infrastructure projects put forward by the Commision [...], extracts. Table established by the author.

then been used for feasibility studies. In 2007, the Commission selected 42 gas and electricity priority projects, but only in 2009 an appropriate budget has been set up to move them further: €2.35 billion for gas and electricity interconnections out of the already mentioned €5 billion package. As late as 2008, a significant number of member states had not yet reached the 10% objective.[22] Missing interconnection capacity, missing lines and congestion were identified as the primary reasons. Following the Maastricht Treaty creation of the Trans-European Networks (TEN) —of which TEN-E priority electricity links are part—, a first regulation was published in 2003 concerning their implementation.

A priority plan for interconnections was adopted in March 2006, and European coordinators for those projects were nominated half a year later, in September.[23] EU funding has been awarded to a number of those projects, and the recent gas crisis has reinforced the sense of urgency about some of them. The priority ones comprise three electricity and one gas infrastructure projects that have been in deadlock for quite some time and require particular oversight. To that end, former EU Commissioner for Competition Mario Monti was nominated to coordinate the difficult French-Spanish interconnection project, which had been blocked since 1994. Thanks to his action, the works were finally agreed upon in summer 2008.

Table 7. Projects and coordinators

Project	Coordinator
Power link Germany, Poland, Lithuania	Wladyslaw Mielczarski
Connection offshore wind power Northern Europe	Georg Wilhelm Adamowitsch
French-Spanish Interconnection	Mario Monti
(Nabucco or Southern Corridor, Gas)	(Jozias van Aartsen)

22. Barcelona European Council in 2002, minimum target not achieved: Communication from the Commission to the Council and the European Parliament: Priority Interconnection Plan, January 2007, COM (2006), 846 final.
23. TEN-E guidelines 1346/2006, Annex III.

Existing Lines and Missing Links

Part III is devoted to existing lines and missing links. It presents and analyzes the current situations and projects for various European regions, as well as the large-scale projects for the Mediterranean Ring and the IPS/UPS-UCTE interconnection. The mere existence of the projects does not necessarily imply their (economic) rationality. Especially at a time when increased public subsidies for infrastructure projects coincide with widespread uncertainty about future demand, projects could emerge as the result of misperceptions. The most difficult exercise is thus the assessment of the real and potential needs, both in terms of short, medium and long term supply and of system security and solidarity. To date, insufficient cooperation among the TSOs and the regulators, as well as lack of transparency, hinders progress.

This part is organized as follows: a first section is devoted to the state of interconnections within the EU, following the regional scheme introduced by the ERGEG. The second section analyzes existing projects between the EU and its neighbors, especially the Mediterranean Ring and the IPS/UPS interconnection. Relevant projects in line with the Commission's priority infrastructure concept are examined in each regional section: the French-Spanish Interconnection, the Baltic Interconnection, the challenge of wind generation in Northern Europe and the UCTE's external EU interconnections with Northern Africa and Russia/CIS.

Links within the EU

Evidence from the French regulator reports

According to the already mentioned EU Regulation 2003, regulators should periodically report on management and use of existing electricity interconnections. Despite this obligation, until now only the French regulator CRE has provided such assessments and in-depth analysis in the form of three very elaborated and documented reports, the latest of them published in June 2009. According to Christophe Gence-Creux, the third report could be the last, since the CRE has succeeded in persuading the regions to provide their own reports on the management and exploitation of electricity interconnections from 2009 onwards. The first report of the regions is scheduled to appear by the end of 2009.

The first decisive conclusion from the CRE reports is the insufficient use of existing interconnection capacity. It is important here to distinguish between two different categories of capacity: physical and commercial capacity. The physical capacity represents the electrical potential of a line, which, as was mentioned already, should not be exploited at more than 50% average for system security reasons. The commercial capacity of an interconnection, which takes into account the 50% security parameters and anticipates consumption and production levels, is calculated by the TSO on the basis of the physical capacity. The commercial capacity, identified in these terms, can be used to 100%, and is the reference used, for example, in the CRE reports on the exploitation of the French interconnections. Evidently, one of the immediate consequences of partial commercial exploitation is that it brings into question the likelihood of any new project in the same location.

According to the 2008 report, interconnections with Germany are used to their maximum commercial capacity only 10% of the time on average, with Belgium only 6%, Spain 30%, Switzerland 24%, and the UK only 19%. The only exception to this worrying picture is Italy, where the interconnection capacity is used at 80% — the downside of this, though, is that the grid is close to congestion.[1]

1. CRE Report 2008, p. 11, Table 2.

CRE authors have developed a useful 'market imperfection indicator', which functions as follows: a theoretical revenue based on the price difference between markets is compared with the real revenues on the borders, both for import and export. The results of the CRE reports reveal an important difference between the theoretical and the real revenues, although the comparison of data from one year to the other (between the three CRE reports) shows a positive trend.[2] The authors also identified the economically unacceptable occurrence of electricity acquisition proceeding in the 'wrong' direction, from low-price to high-price electricity regions.

The insufficient exploitation of existing interconnection capacity as well as the imperfection of the markets is explained by the CRE as the result of:

- the difficulty for market players to anticipate price differentials from one day to the next, and also from one month or one year to the next;
- the preference for long term products, which again increases the difficulty for the secondary markets to anticipate next-day prices;
- the unevenness of national markets, both with respect to their different sizes and the number of players, as well as the asymmetry among players.

According to Christophe Gence-Creux, the regulatory context had changed very much in 2006,[3] and is changing again in 2009 following the adoption of the Third Package and the inherent institutional changes that go with it. The reports demonstrated a positive change since 2007 and a continuation of the positive trend in 2008.

EU priorities

EU incentives for linking up both gas and electricity lines, not just within the EU but also between the EU and its neighbors, are particularly strong at the moment. On November 14th 2008, the Commission identified six new priority infrastructure areas:

2. CRE Report 2008, p. 12 Table 3 and paragraph 1.3. Imperfect Market Indicator.
3. CRE Report 2007, p. 7.

• connecting the Baltic area to the EU (gas and electricity);

• bringing independent supplies from the Caspian via a southern corridor (gas);

• increasing LNG capacity where needed (gas);

• complementing the Mediterranean Ring (electricity and gas);

• better connecting Central and South Eastern Europe (electricity and gas);

• developing a North Sea offshore super grid (to connect national electricity grids in North Western Europe together and plug in the numerous offshore wind projects).[4]

These priorities have been translated into EU support within the already mentioned €5 billion package.

Improving links with the EU

The UCTE published its first transmission development plan in the fall of 2008, as was required by the EU. The report presents a survey of investments that UCTE TSOs have either already approved or are still considering. It is organized as follows: the five UCTE regions involving 23 countries are introduced separately; each country is presented individually, with its major problems, projects and internal development; maps and tables for existing and projected infrastructure are organized inside of the five regional areas. Some of the maps and tables are reproduced in this study with the gracious permission of the UCTE. The report should aim to provide a more detailed and critical discussion of the projects; to date, it rather amounts to a mere compilation of information about them, as provided by the TSOs. ERGEG, on the side of the regulators, publishes regular reports on the Electricity Regional Initiative (ERI), presenting the Baltic, Central-East, Central-South, Central-West, Northern, South-West, and France—UK—Ireland regions separately.[5]

4. Quoted from EU Energy Law Newsletter of November 13th 2008: 'Commission adopts the Second Strategic Energy Review and announces TEN-E energy instruments'. http://www.claeys-casteels.com/newsletter/index.php?ucode=F1H2N7N6Q8J0&item.

5. http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_INITIATIVES/.

In the introduction of its report, the UCTE highlights the growing uncertainty regarding the location and the amount of future generation due to the increasing volatility of factors such as energy prices, energy policy decisions on renewables, emission trading schemes and nuclear energy. Both the UCTE and ERGEG complain about the complicated and lengthy legal process of commissioning new infrastructure. The time needed to commission grid equipment is estimated at seven to ten years for overhead lines. Experts and politicians agree that the problem, as has been mentioned before, is often less related to finance than to public resistance or bureaucracy.

Consumption and generation are two interdependent factors influencing grid development. UCTE estimates that consumption will grow by around 90 GW in the next ten years, whereas electricity generation will grow by 220 GW over the same period of time, including some 80 GW to come from wind generation. Before setting up new generation capacity, upgrading interconnections and the internal transmission grids should be the first step. Member states could thus benefit from generation across Europe as a whole. The UCTE estimates the required investment for the next five years at about €17 billion, an amount that would greatly increase if overhead lines where replaced by undergrounding.[6] At the same time, if the latter ends up becoming a generalized pattern, economies of scale will be generated —as has already started being the case— and prices will decrease in the future.[7]

Assessing TEN-E

Before developing the regional picture, this paragraph introduces the identified EU priority projects, the so-called TEN-E (see also Map 8 in the Annex). The map shows identified priority projects that address important congestion on the borders between France, Belgium, the Netherlands and Germany (EL 1); Italy's precarious and isolated situation (EL 2); the similarly isolated situation of the Iberian peninsula (EL 3); the

6. UCTE Transmission Development Plan 2008, pp. 1-2.
7. See ABB Grid Systems, Executive briefing Note 2008: 'Assessing the case for power undergrounding'.

need to connect Greece and the Balkan countries entirely to the UCTE system (EL 4); the need to better interconnect the UK and Ireland (EL 5 and 6); the need to establish a Baltic ring in order to offset the isolation of the Baltic States; and the integration of wind energy (EL 7). Proposed regional electricity priority projects concern the reinforcement of East-West interconnection in Central Europe (EL 8) as well as the establishment of the Mediterranean electricity ring (EL 9).

The vanguard region: Central West

Overview

Belgium, France, Germany, Luxembourg and the Netherlands constitute the Central-West Region, led by the Belgian federal Energy Regulator (CREG). Its ambition is to set up a single regional electricity market. The region represents 1.1 million GWh of electricity consumption, which amounts to approximately 40% of the EU electricity market.[8] Central-West can today be considered a very advanced region in the EU and in Europe as a whole in terms of integration of the markets. Only the Scandinavian States are more integrated electrically. Market integration has been promoted by mergers and acquisitions, like the takeover tentative of the French EDF for the second Belgian electricity company SPE in May 2009.[9] Congestion occurs on the German-Dutch border, with overloads resulting from incoming wind power. The project of a new 60 km double-circuit line is in its permitting phase; the facility could be operational at the earliest in 2013.

Congestion occurs also at the French-Belgian border, due to generation development in northern France. RTE and Elia have launched a study to decide whether to strengthen the existing interconnection or to alternatively build a new line; the chosen option could be operational in 2012/15 at the earliest.

There is also a project underway for a new line between Germany and Belgium, with unclear entry dates, and studies being carried out on grid extension options.

8. Source: ERI Central-West region, on ERGEG website *Ceer-eu.org*.
9. http://www.la-croix.com/article/index.jsp?docId=2373329&rubId=4079.

Towards a regional TSO?

The Central-West region counts five regulators. The very active role that the region currently plays is an encouragement for the other six to follow its example. Year 2008 witnessed major progress in regional integration, with the setting up of a unique auction platform (CASC-CWE), as well as the regional coordination center charged with the control of electricity transfers. Progress has also happened on the management of the French-British interconnection. Market coupling has started in the region on a bilateral level, and looks highly promising. The CRE report 2009 qualified 2008 as 'a year of major advances in the region'.[10]

The opening on February 18th 2009 of a joint coordination office of RTE and Elia was a symbolic step that illustrates the region's role as a leader. Since then, for the first time ever in Europe two TSOs exchange real time information every 15 minutes. The project, named CORESO, came as largely unexpected. In concrete terms, the two TSOs share instruments, data and software, and thus guarantee more system security in the region.[11] In the medium term, a regional TSO might be established. 'Every commitment which leads to the decrease of the number of involved actors should be welcomed', stated Christophe Gence-Creux.[12] The RTE-Elia initiative inspired the German TSO RWE and the Dutch TenneT to manage congestion on the German-Dutch border in a similar way. The same is true for the coordination project allying EnBW Transportnetze AG, another one of the four German TSOs, and Swissgrid: both TSOs founded, in September 2008, a joint coordination venture, CESOC (Central European System Operation Coordinator).[13]

France, included in four ERGEG regional initiatives, has taken, right from the start, a very active role in the process of regional integration; in part, this owes to the fact that CRE is a powerful regulator, very much like the Belgian one — and quite unlike BNetzA, one of the German counterparts, for

10. CRE 2009, p. 5.
11. Interview with Dominique Maillard, RTE, Euractiv.fr, February 12th 2009.
12. Interview by the author (April 27th 2009).
13. http://www.presseportal.ch/fr/pm/100011338/100569414/swissgrid.

example. In the long run, as Gence-Creux explained, the number of coordination centers in the Central-West region, which will surely be set up bilaterally first, will then have to be reduced again, to reach the ideal size of one per region.

As for pricing, the example of the market coupling between France, the Netherlands and Belgium shows that prices have lately been converging more and more for the three markets — a good reason to favor the extension of the market coupling paradigm to the other member states of the region. The Florence Forum, the informal high-level regular gathering on the subject of electricity in Europe, especially devoted its 2008 annual conference to that subject. A project coordination group was set up with the mission to elaborate a mechanism and a schedule for market coupling. If today some ten projects for market coupling are underway, it is obvious that a country cannot engage in more than one market coupling project at a time. It would just not feasible to do so because the contracts to be passed in each case could not be signed simultaneously and in compliance with different sets of parameters all at once.

The merger of Powernext and EEX in April 2009 resulted in the creation of the joint company EPEX spot. A Memorandum of Understanding had been signed by both electricity stock exchanges in the summer of 2008 and a Spot Trading SE had been registered in Paris by September 2008; share exchanges later took place in April 2009.[14] The project, which intends to lay the foundation for a pan-European exchange, already covers Germany, France, Austria and Switzerland, i.e., more than one third of the EU electricity consumption transactions. It is important to note, however, that EPEX spot does not fall into the category of market coupling: in its case, the markets are not linked but function independently, even if the quotations are set up by the joint stock market. One stock market, in fact, can be in charge of a zone including different and not coupled markets.

The process for market coupling, which is independent from the setting up of EPEX, finds an obstacle in the huge

14. http://uk.reuters.com/article/oilRpt/idUKL24689232009 0402.

number represented by the 21 partners around the negotiation table: the TSOs —four for Germany alone—, the regulators, as well as one representative from each of the five governments. 'Too many', according to Gence-Creux, who is not alone in advocating the reduction of partners in the negotiation. On the issue of the German TSO's, he pointed out: 'They present even competing projects, and it is not fair that they are four, but that the other countries have only one TSO in the negotiations.'[15]

Conclusion

All in all, Central-West has to be considered today as a region in the vanguard of its kind, even if Nordel still holds the lead: Nordel started to come up with multilateral grid design as early as 2002 and no other EU region has yet caught up with it on that front. Trilateral market coupling between Belgium, France and the Netherlands is a reality, and the integration of the electricity wholesale markets is on course for Belgium, France and the Netherlands on one hand, and Germany and France on the other. Central-West is the most advanced in terms of interconnection, with road maps, common cross-border capacity calculation, as well as single auction offices. Transparency has been increased by new government mechanisms, as discussed in Part II. The purple marks on Map 11 (see Annex) represent major congestion points, as well as new projects needed to improve system stability, especially with the feeding in of renewables.

Finally, Germany and France intend to increase the power exchange capacity on the Ensdorf—St Avold interconnection — a position that Christophe Gence-Creux questions, stressing that existing capacities are important, but insufficiently exploited. Summing up, Central-West is a strongly interconnected region where the main potential lies with the improved use of existing capacities and the further integration of the markets. As already mentioned, integration here goes much further than in the other electricity regions.

15. Interview by the author (April 27th 2009).

Northern Europe: benchmark, and the offshore wind challenge

Overview

Nordel is, indeed, very much ahead of the other regions in terms of grid integration and common operation and planning. It published its first comprehensive 'grid master plan' in 2002, with a second one following in 2008.[16] The participating countries are Denmark, Finland, Germany, Norway, Poland and Sweden, who integrated very early and are linked to the continent through DC lines, very much like the UK and Ireland. Some of the identified regional priorities are the optimization of the use of interconnections and the cooperation on investment in new infrastructure. A specific regional challenge is the integration of wind energy into the grid. The EU stimulus package, with an important portion devoted to the development of an offshore grid, is a major incentive towards that goal. No direct line exists yet between Germany and Norway, but the coupling of the hydro-dominated Norwegian system with wind electricity from Northern Germany is a promising project for both countries. Nord Link is currently carrying out a feasibility study. The coupling, which is expected to use an HVDC transmission system of 700-1,400 MW, could be operational by 2015. The impetus behind this endeavour is, thus, to ensure system stability as well as security of supply. The link is part of the Baltic Ring project (see Map 9 in the Annex). In order to get the multi-country cooperation on the right track, a European coordinator, Georg Wilhelm Adamowitsch, was appointed in 2007. He delivered his first report on the state of the project at the end of September 2008.[17] In parallel, a European Wind Integration Study[18] (EWIS) was carried out. A second study, undertaken by TradeWind[19] —a European project funded by the EU— was completed by a consortium led by the European Wind Energy Association (EWEA). The latter looks into how 300 GW of wind power can be integrated

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16. Nordel, Grid master plan 2008. Available online at 195.18.187.215/Common/GetFile.asp?PortalSource=1965&DocID+5647&mfd=off&pdoc=1.

17. Adamowitsch, Annual report September 2007-September 2008 http://ec.europa.eu/energy/infrastructure/tent_e/doc/off_shore_wind/2008_off_shore_wind_annual_report_2007_2008_en.pdf.

18. *Wind-integration.eu*.

19. *Trade-wind.eu*.

into an interconnected Europe by 2030. The inherent risks involved in feeding in wind power and circular movements have been demonstrated, especially through the Polish example.

Adamowitsch's role in the early phase of the project concerns bilateral exchanges with national authorities and their integration into the regional project, the extension of the project to Central-West, and the dialogue between wind experts from TradeWind and EWIS on one hand, and the UCTE development team on the other.

The countries of the region, more or less inclined to producing offshore wind energy in the future, are listed here according to the order of importance that they grant to wind energy, on a decreasing scale: the Netherlands, the UK, Norway, Denmark, Germany, Sweden, Finland and Poland. Their approach is predominantly nationally-minded and barely coordinated, but the Kriegers Flak whereby Sweden and Denmark are linked via a sub-sea cable in the Baltic Sea can be considered a benchmark for further development on a European scale: since wind farms profit from varying subsidies and different regulatory systems, the concerned countries have agreed to discuss a common framework for the entire area.

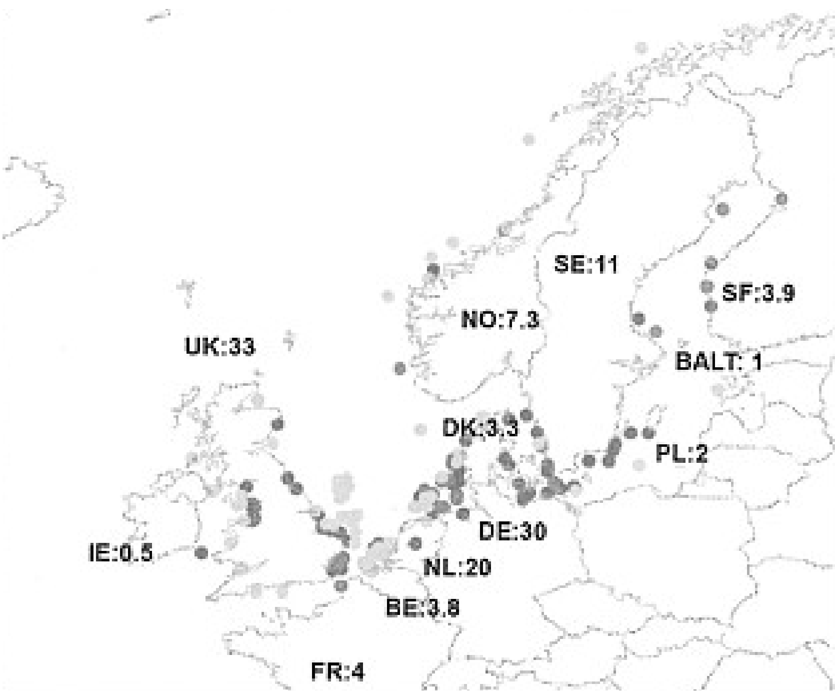
As far as grid development is concerned, member states are, for the time being, focusing on establishing links between wind farms and the onshore high-voltage transmission network. Since today's grid already functions close to the transmission capacity limits and congestion is a huge problem, Adamowitsch stated that adding new links would entail a serious risk of further congestion and even blockage, especially in Germany. Thus, a coordinated approach to the European offshore wind power project not only by the coastal states but by all the EU member states is an important requirement. When visiting the concerned member states, Adamowitsch witnessed an uncoordinated and fragmented approach even inside the states. The UCTE development report from 2008, as well as national studies such as those by the German DENA, very clearly demonstrates the need to upgrade existing infrastructure, add new links, and develop

Table 8. TradeWind scenarios: offshore wind power installed capacities (GW) for 2015, 2020 and 2030 in Northern Europe

	2015	2020	2030
Belgium	0.5	1.3	3.8
Denmark	1.0	1.6	3.3
Finland	0.6	1.2	3.9
France	2.0	4.0	4.0
United Kingdom	6.5	20.0	33.0
Germany	3.0	15.0	30.0
Netherlands	2.0	3.5	20.0
Norway	0.1	0.5	7.3
Republic of Ireland	0.3	0.3	0.5
Sweden	1.8	3.8	11.0
Poland	0.0	0.0	2.0
Baltic States	0.0	0.0	1.0
Total Northern Europe (GW)	18	51	120

Source: TradeWind.

Map 4. Offshore wind scenarios and generation



Source: TradeWind.

interconnections. A working group for onshore and offshore grid development was established by the coordinator in July 2008, with the commitment to meet four times a year. It will proceed from factual grid planning, especially on the Norway—Germany—Denmark interconnection, to solutions on the technical and political levels.

Environmental and local concerns, as we have said, pose an important obstacle to the development of offshore wind energy and to Europe's commitment to developing renewable energies. Adamowitsch has asked for a public debate to find solutions to the major problem of balancing local concerns and European targets.

Imera

Imera is a private company based in Dublin, specialized in offshore grids and HVDC cables, as well as in the 'unlocking of the renewable potential across Europe', via appropriate infrastructure. In February 2009, the company announced, as we mentioned earlier, the setting up of a pan-European electricity grid covering part of the Northern Region via its EuropaGrid North Sea section, and the Atlantic Region, linking the UK, Ireland, France and Spain, via its EuropaGrid Atlantic portion. The announcement came on the tail of the stimulus package proposal by the EU Commission. Imera was set up by its parent company Oceanteam, located in Norway, which possesses a specialized fleet for submarine electricity cables. The fact that it is a small enterprise, independent from big stakeholders in the electricity business, is an important asset for Imera, which has already received the green light from the EU commission for its merchant offshore interconnections linking the UK with Ireland.[20]

EuropaGrid offshore: overview

Imera holds licences for five projects that constitute the foundation of the EuropaGrid: among these are the already mentioned UK-Ireland link, the France-UK link and the

20. Quoted from 'European Commission Grants Imera EU Exemption for East West Interconnections', December 22th 2008.

Table 9. Imera projects

Name	Countries concerned	Cost/Construction Start
EuropaGrid North Sea	Scandinavia, Western Europe, UK	€2.76 billion
EuropaGrid Atlantic	UK, Ireland, France, Spain	€1.65 billion; already started, first cables will be laid in 2010

Belgium-UK link. The company is in the process of raising €100 million in order to finance the development of the first phase of EuropaGrid.[21]

EuropaGrid, through its two branches, was indeed eligible for the EU stimulus package and has additionally been granted the benefits of the 2003 merchant lines exemptions. Imera grids, thus, will be HVDC merchant lines. According to Imera, the EuropaGrid will promote a unique electricity market, and thus increase security of supply and competition and facilitate more efficient electricity exchanges within the EU. In addition, the linking of offshore windmills will favor technological advances that should contribute to solving the problems presented by the feeding in of the wind energy and the need for stabilization.

An analysis of the projects (see Map 9 in the Annex) reveals that the link between Ireland and France is excessively expensive and not really necessary. The links between the UK and Ireland are more or less finalized. Concerning the links between Spain and Portugal on one hand and the one between France and Spain on the other, they would allow for more renewable integration (windmills) in Europe. Nevertheless, their construction should not be expected very soon. Finally, the Eastern part of the grid, especially the Baltic-Swedish link, will be finalized in 2009 and improve the links with the Baltics, together with the already existing Estonia—Finland DC link.

21. Imera is the result of the merger of Imera Power and the Hydragrid business of Oceanteam ASA. Oceanteam is a publicly quoted Norwegian company located in Bergen. *Imerapower.com*. See also 'Imera lance l'EuropaGrid', *Enerpresse* No. 9754, February 4th 2009, p. 2.

Missing links: South Western Europe

Overview

The South-West Region comprises France, Spain and Portugal, and is led by the Spanish Energy Regulator CNE. Just like for the Central-West region, its objective is to set up a single regional market. Annual consumption amounts to 780 TW/h, which represents around 25% of EU-27. The Iberian Electricity Market (MIBEL) was bilaterally set up in June 2007, further integrating the Spanish and the Portuguese markets. An important regulatory convergence followed, and interconnection capacity between the two countries has doubled since. At present, the challenge is to link up MIBEL with France and to analyze the compatibility of the existing rules and procedures.

The CRE 2008 report shows the congestion on the French-Spanish border, with its impact on the Iberian Peninsula as a whole. The interconnection between Portugal and Spain also needs improvement at three points in order to overcome major congestion. Projects are in their permitting stage and should be finalized by 2009-2011. As for the French-Spanish interconnection, which is the subject of the below case study, it should be completed by 2011-2012.

The France—Spain interconnection Baixas—Bescano

One of the most abundantly discussed projects of the last decade has been without any doubt the France—Spain interconnection. An additional high-voltage Hispano-French interconnection was declared an EU priority in 1994, but its accomplishment has been stagnating ever since. At present there are four tie-lines (two of 220 kV and two of 400 kV) linking France and Spain, the last one having been built in 1982. All of them face continuous congestion.[22] Important delays to necessary development have occurred because of local resistance and lack of financial commitment. Additionally, reports from the French regulator reveal continuing significant dysfunction of the existing lines. Eventually, the setting up of

22. UCTE Transmission Development Report 2008: 35 continued, UCTE Regional Forum South-West.

a new HVDC line was approved, singled out for additional EU funding, and meant to be coupled with a high-speed train connection for the sake of economies of scale.

A breakthrough thanks to the European Coordinator

As we said earlier, it was largely thanks to the effective arbitration of European coordinator Mario Monti that the signature of the French-Spanish agreement on June 27th 2008 put an end to years of multi-layer negotiation without result. A first interim report was presented by the chief coordinator at the French-Spanish summit in Paris, in January 2008, and the two governments gave substantial support to the completion of the electricity connection as well as of a gas pipeline.[23] Three information sessions took place, and a final agreement was signed at the end of June 2008.

On October 1st 2008 a joint company called INELFE (Interconnection Electrique France-Espagne) was created, allying RTE and REE (Red Electrica de Espana) with the task to carry out the necessary feasibility studies and the setting up of the line. Creating a joint company charged at once with feasibility studies and construction was considered the best guarantee of coherent choices and the respect of all criteria.

The costs and future profits of the venture are to be shared 50/50. Governments, but also the European Commission, ended up contributing more money than had initially been planned: from the estimated total of €600 million, Brussels will fund €225 million, the rest being shared equally between Paris and Madrid. The strong environmental resistance was finally overcome through the compromise to build an underground line, which made the project cost skyrocket from €600,000 per kilometre to 10-12 times more.[24] The total cost for the underground line is now estimated at between €500 and €750 million, compared to the initial €90 million that would have been needed for the overland line.[25]

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23. Joint declaration by Nicolas Sarkozy and José Luis Zapatero on gas and electricity interconnections, January 28th 2008.
24. *Les Echos*, January 12th 2008.
25. Monti 2008, p. 12.

A route has been defined segment by segment, with the obligation to profit as much as possible from existing infrastructure — be it highways, streets, railroads or some other electricity lines. The route itself must be respectful of the environment of the Pyrenees and even of the regional cultural heritage — and thus specifically avoid crossing an area with important monuments.[26] The agreed-upon route goes the 60 km from Sentmenat and Bescano in Spain to Baixas in France, including a stretch of 8 km through a tunnel in the most mountainous region. The tunnel solution allows for bundling with other infrastructure; in April, word came out about high-level talks being in progress with the TGV project Perpignan-Figueras, again in search of economies of scale and the avoidance of setting up new infrastructure in the area.[27]

Unlike what the initial projects had considered, the French-Spanish line will be a DC line. This means that two converter stations have to be set up on each end of the line, connecting the DC line to the AC grid. Each of the stations, one placed in Baixas and the other in Santa Llogaia (near Figueras), will require an area of some 5 to 10 hectares. Additionally, the already existing converter station in Baixas will be enlarged; on the Spanish side, a new one must be set up. Converter stations of this type already exist and are technically mature — one good example is the IFA 2000 of the French-English interconnection.

Critical assessment

The main reason for the current insufficient use of existing lines in France —as pointed out by the last CRE report— is important congestion within the Spanish Grid that spills over to the bottleneck on the border. Thus, increased efficiency on the existing interconnection via improvements and more transparency on internal congestion

26. See for a detailed discussion of the RTE route, 'Le projet France-Espagne, Point sur le projet de liaison souterraine en courant continu', January 19th 2009, *Rte.fr*.
27. J. Lelong, Languedoc-Roussillon. 'La concertation fait avancer le projet d'interconnexion électrique France-Espagne', in *Les brèves d'actu Web*, April 22nd 2009.

are important steps that should accompany the setting up of the needed new line.[28]

One important point is the fact that the line will be set up as a DC line, and not an AC one, as had been initially planned. What does this change? As mentioned earlier, DC allows for pre-determining a given capacity for the exchange, but does not imply solidarity. An optimum synchronization between two countries relies, thus, on as many AC lines as possible. If the Baixas-Bescano line is set up as a DC line, it will not contribute to improved system security within France and Spain — that is to say, to improved synchronization of the two systems. Nevertheless, as RTE puts it in its report, 'recent technological evolution makes us hope that, in the future, DC lines will start to contribute to an improved performance of the electricity system at large, especially concerning voltage'.[29]

From a short-term perspective, the interconnection is much more important for the system security in Spain (and Portugal) than in France. If the latter is widely integrated with its neighbors, as we have seen in the chapter on the Centre-West region, the Iberian Peninsula is to date poorly connected with the UCTE system and poorly synchronized — with one AC link through the strait of Gibraltar and some other to France. In the medium and long term, however, the interconnection will not only positively impact France, but also the South-West region at large. Renewables and new requirements for grids are a prime issue here. No new lines have been set up since 1982, but projects linking Northern Africa and the setting up of the Mediterranean Ring have gained prominence, as much as the discussion on solar electricity from Southern Europe or Northern Africa. In all of those plans, Spain is an important transit country and will, as such, have to meet better security standards in interconnections. Simultaneously, wind

28. CRE Report 2007, pp. 14-15; CRE Report 200, pp. 43-44. The author states interruptions on 63 days, with, for 2008, only 255 auction days proposed instead of 366. Important amendments to the initially proposed capacities have diminished the value of the interconnection electricity. The author also notes improved use since 2005, especially concerning the decrease of imports from high to low price areas.
29. Report RTE 2009, 'Le projet France-Espagne [...]', p. 7.

Table 10. The Spanish-French interconnection

Border	Project Driver	Expected Effects	Project	Description of Project
FR – ES	The entire interconnection faces a high level of congestion limiting transmission capacity. Constraint on France–Spain border	Limitations on production of wind power energy in the Iberian system. The project aims at eliminating these constraints.	New 400 kV interconnection line on the eastern part of the border. Expected date: 2011	New double-circuit line between Baixas (FR) and Santa Llogaia/Ramis or Vic (ES). AC Voltage 400 kV. Transmission Capacity 2*2 160 MVA (winter). Length Strategy Baixas-Vic 50 km in Spain, 57 in France, or Strategy Baixas-Santa Llogaia 28 km in Spain, 40 in France. Included in the Priority Interconnection Plan (TEN-E Guidelines). A European Coordinator has been appointed by the European Union for this project. TSOs in charge: RTE & REE

Source: The UCTE Transmission Development Report 2008, Annex.

and solar electricity generation in Spain is increasing tremendously and this is opening up new opportunities for supplying the EU markets.

Increase in the use of renewable energies should allow phasing out the very polluting coal— and fuel-based electricity generation, especially in northern Spain.[30] But for this to be possible, interconnections will be fundamental in order to compensate for volatility in renewable generation. Again, as Monti stated, using renewables on a large scale will be impossible without strengthening interconnections in general. And he also stressed that the existing lines faced congestion, a point of view not shared by RTE. According to Monti, in 2007, on 97% of the days the maximum capacity was reached during at least one hour of the day, and exchanges had to be rationed in many cases.[31] The CRE indicated that those limits were due to national congestion in Spain. CRE and the European coordinator converge on the point that the coordination between the two states was far from optimal. Transparency is lacking on both supply and demand.

Conclusion

The setting up of the French-Spanish interconnection, coming after a decade of delays, must be recognized as an outstanding break-through. Another HVDC cable has been committed, and undergrounding seems to gain prominence in Europe at large. Nevertheless, improving the efficiency of the existing infrastructures should not be neglected since it clearly constitutes a critical parallel objective. The reinforcement of the regulators resulting from the Third Package could help the Spanish regulator to improve congestion management within the national borders, and to put pressure on the national TSO.

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30. Report by Mario Monti, 'Interconnection France-Spain' (in French and Spanish) (Brussels, September 2008). According to Monti 2008, p. 8, the gains from closing these polluting plants represent 1.5 million tons of CO_2, which corresponds to some 600,000 cars. Monti based on CESI.
31. Monti 2008 report. See also the earlier analysis of the CESI cabinet, http://ec/europa/ten/energy/coordinators/indexen.htm as well the complete reports and the texts of the French-Spanish agreement.

Central Eastern Europe and the Baltics

Overview

One of ERGEG's regional initiatives concerns the Baltic and the Central-East region. Both are dealt with together here, since the political problems of one and the other are closely linked. The fact that the EU Council sent a note on the Baltic Energy Market Interconnection Plan in June 2009, adopted consecutively by the Council, stresses the urgent need to improve the situation, and the increased awareness towards doing so.[32]

The Baltic region comprises the three former Soviet Republics of Latvia, Lithuania and Estonia, with the Latvian Energy Regulator PUC holding the lead. Consumption represents only 21.2 TWh/year, which is equivalent to not even 1% of EU electricity consumption. In the long run, the Baltic region aspires to become a link between the Central-East and Northern European markets. Key priorities here are the interconnection with the Central-East region, integration into the UCTE system, and transparency and cooperation of network regulators. No congestion is attested in the Baltic region.

As for Central-East, seven countries participate in it: Austria, the Czech Republic, Germany, Hungary, Poland, Slovakia and Slovenia, with Austria's regulator E-control leading the group. The region is characterized by sharp contrasts and huge differences in terms of market development. Here, the border between the 'old' and the 'new' Europe is particularly visible. Transparency and information management are the most important short-term priorities.

As far as concrete projects are concerned, the improvement of the Polish grid, as well as the link between the Baltics and the UCTE, should be considered urgent, especially in the light of rising East-East tension, as demonstrated by the Russia-Georgia war or the Russia-Ukraine gas crisis.

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32. Council of the European Union, Brussels June 8th 2009, 10703/09, Note from General Secretariat of the Council to Delegations, Baltic Energy Market Interconnection Plan-Information from the Commission. ENER 208, 10703/09.

Map 13 (see Annex) shows disseminated purple fields corresponding to:

• system security improvement and capacity increases, which are the impetus for upgrading the existing line between the Czech Republic and Austria by 2008;

• the need to increase the capacity and the feeding in of wind energy, which is the impetus for the setting up of a new line between Germany and the Czech Republic, however not before 2016;

• congestion on the German-Austrian border, which will be offset by a new 380 kV double-circuit overhead interconnection expected to be in service in the beginning of 2017; at the same time, existing systems will be upgraded in order to cope with congestion;

• system security at stake on the Hungarian-Slovak border, where the reliability of the network of both TSOs (Mavir and Seps) has to be improved and interconnections must be established, although this is not expected to happen before 2015;

• aspirations by Germany and Poland to increase power exchange capacities through three projects, including converting an existing 220 kV double line into a 400 kV line after 2015;

• aspirations by Poland-Lithuania interconnection, which is part of the Baltic Ring, to incorporate the Baltic States into the internal electricity market of the EU; the project comprises a new 400 kV double-circuit interconnection together with the back-to-back 1,000 MW station in Alytus and the strengthening of the Polish grid;

• plans by Poland and Ukraine to modernize the existing Rzeszow (Poland)-Kmelnitsakaya (Ukraine) 750 kV line and converter station before 2010;

• plans by Austria and Hungary to install a second system in order to increase transmission czapacity and system security by 2010.

The prime importance of the Polish-Lithuania interconnection

The EU Second Strategic Energy Review of November 13th 2008, mentioned 'the development of a Baltic interconnection plan, better linking the region with the rest of the EU, improving the security and diversity of its energy supply, improving security of supply',[33] as an energy security priority. Especially after the Russian-Georgian war, the perception of the Baltic States overdependence on Russia has become more and more prominent and finding an alternative solution has been placed high on the agenda. EU additional funding has been attributed to that end. The basic Baltic IPS transmission network consists of 330 kV overhead lines and is composed of 59 lines altogether.

In order to provide full and effective control of the electrical ring there are emergency protections and coordinated emergency systems, the most important of which is the emergency protection Ignalina nuclear power plant. The rest of the Baltic IPS transmission network consists primarily of 110 kV lines. The only exception is the Estonian power system, where there is a 220 kV network as well. The fact that the second unit of the Ignalina power plant (a 'Chernobyl' type RBMK, built in 1974) will be closed in 2009, and that the first unit was closed in December 2004, in accordance with Lithuania's Accession Treaty to the EU, creates a major supply problem for the three Baltic States as well as for the Russian enclave of Kaliningrad. Recently, a project for a new plant was adopted, by which a new nuclear power plant will be set up in Visaginas, near Ignalina.[34] At the same time, Rosatom, the Russian nuclear agency, announced the setting up of a nuclear power plant in Kaliningrad.[35] It is clear that only one of the two projects can be constructed and make sense, and that the decision for one or the other has a huge geopolitical impact. Currently, Ignalina produces more than 2/3 of Lithuania's electricity and supplies the neighbors widely as well. Setting up yet another nuclear plant was considered the only solution in order to avoid dependency on Russia. Producing electricity with gas was not an option, as it would have required gas

33. Memo: 'EU Energy Security and Solidarity Action Plan: 2nd strategic energy review', (November 13th 2008), http://ec.europa.eu/energy/strategies/2009/2009_07_ser2_en.htm.
34. See: Enerpresse No. 9816, p. 2, 'Lithuania: Un pas de plus pour une nouvelle tranche' (May 5th 2009).
35. Announcement already made in 2008, http://www.baltictimes.com/news/articles/20316/ and reconfirmed in June 2009. Also rumours about Siemens participation following its divide from Areva.

Table 11. The Baltic Network

Power system	Length of HV lines (km)	Installed capacity of network auto-transformers and transformers (MVA)	Installed shunt reactors (MVAr)
Estonia	1,297.4	2,280	420
Latvia	1,247.9	2,825	240
Lithuania	1,670.4	4,050	150
Baltic IPS	4,215.7	9,55	810

Source: Baltso, http://www/baltso.eu/index.php?id=544.

imports from Russia and further increased dependency. Future plans must keep in mind that any UCTE interconnection of the region and the subsequent IPS/UPS disconnection would put into question the supply of Kaliningrad, a Russian enclave neighboring Lithuania and Poland.

A very long discussion, no results yet

Discussions on the Polish-Lithuanian power link date back to 1992, after both countries broke off from the Soviet system. The Polish power system split from the UPS/IPS at that time and successfully entered the UCTE in 1996, while Lithuania remained in UPS/IPS. Despite years of discussion, we witness little progress. The following steps have taken place: on June 11th 2007 the UCTE received a request for an interconnection with the Baltic systems from Latvia, Lithuania and Estonia. The heads of state of the three countries released a joint communiqué on their decision to fully integrate the UCTE, asked the Baltic TSOs to carry out an exhaustive feasibility study and requested full support from the EU and the UCTE. Finally, they also asked for the cooperation of the Polish TSO. In fact, Poland had been considered one of the main obstacles to integration because of Warsaw's concerns that the cheap Ignalina current —or current from the next nuclear power plant to be set up after Ignalina's decommissioning— might compete with Polish coal-generated electricity.

Environmental concerns (protected natural areas that will be crossed) as well as uncertainty about the chances of success of synchronization were additional causes of anxiety.

On October 30th 2007, a cooperation agreement among the Baltic TSOs was reached, which differed slightly from the first Baltic Ring Study from 1996-1998: the latter had focused on a direct-current line which, according to the study, would be faster to complete and less politically sensitive as there was no UPS/IPS delimitation issue involved. The synchronization project is a priority for the EU, since the setting up of TEN-E and the Second Strategic Review of November 13th 2008. And in summer 2009, a 'Baltic Energy Market Interconnection Plan' uniting eight EU states —Denmark, Finland, Germany, Sweden, Poland, Estonia, Latvia, Lithuania— with Norway as an observer country, was adopted.[36]

A European coordinator

Professor Wladyslaw Mielczarski was nominated European Coordinator in September 2007, and an annual activity report was issued in September 2008.[37] Thanks to him, an agreement between the Lithuanian and the Polish TSOs over the construction of the much discussed power link was signed in February 2008. A joint venture company, LitPol Link, was established and is in charge of the investment plan for the cross-border connection that should be finalized by the middle of 2009. This will allow for construction of the line to begin in 2010. Costs of the transmission line between Elk and Alytus as estimated by the two TSOs are to include €230 million for a back-to-back inverter station necessary to link UPS/IPS and the UCTE[38] as well as €90 million and €600 million for the upgrading of the network of grids in Lithuania and Poland respectively.[39] Ignalina decommissioning funds are going to be used alongside with structural funds.

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36. Communication EU Commission, June 2009, http://ec.europa.eu/regional_policy/cooperation/baltic/pdf/communication/com_baltic_en.pdf.
37. Wladyslaw Mielczarski, 'Annual Activity Report September 2007-September 2008: Poland-Lithuania Link including reinforcement of the Polish electricity network and the Poland-Germany profile', Brussels, September 23rd 2008. http://ec.europa.eu/energy/infrastructure/tent_e/doc/power_link/2008_power_link_annual_report_2007_2008_en.pdf.
38. Back-to-back station: see annex, abbreviations.
39. Data from annual report by the European coordinator, September 2008, p. 5.

On the western side, there are currently two power connections between Eastern Germany and Poland. The Eastern German and Polish operators, VET (Vattenfall Europe Transmission) and PSE (Polish Power Grid), have also come together. Cooperation between Adamowitsch and Mielczarski proved to be particularly useful when circular power flows from wind farms caused major overload damage in Poland in January 2008. Discussions over legal concerns are currently underway between the TSOs and the companies constructing new roads between Berlin and Poznan. The idea is to use the road corridors for the transmission lines, which would allow for some 1,000 MW between both countries.

Considering the entire project, the coordinator has identified today's main challenges to be:

- the necessary support from the respective governments, even more important in Poland where the TSO is 100% owned by the state;
- the increased cost of the back-to-back power station and the technical difficulties of maintaining large electricity flows between the Baltic States and Russia;
- environmental concerns, such as the consequences of piercing through vast lake areas and forests: numerous protests by environmental organizations have occurred in opposition to road construction in those areas;
- the future of the German TSOs: according to the European coordinator, a single German TSO in the place of the four existing ones would help facilitate the project.[40] The European coordinator has also criticized the insufficient progress made towards the reunification of the existing German power systems that currently only allow for limited energy exchange.

These ambitions have been reconfirmed by the already mentioned communication from the Commission in June 2009. It seems that resistance to integration is much more difficult to overcome here than in the case of France—Spain, and the appointment of an EU coordinator has clearly not been sufficient to get out of the deadlock.

40. C. Bryant and G. Wiesmann, 'Berlin pushes for a national power grid', *Financial Times*, October 3rd 2008, p. 4, as well as *Annual Report Coordinator 2008*, p. 9. Any network development in Germany requires the commitment of the four TSOs.

Conclusion

Overcoming the electricity and gas islandization of the three Baltic States remains a key EU objective. This important problem is reinforced even more with the closing down of the last block of Ignalina, and a new plant —be it in Lithuania or Kaliningrad— is not likely to be opened before the end of the next decade. The vulnerability of the three new member states will be increased even further. Slow progress in the UCTE interconnection has made the Northern-Baltic interconnection the most dynamic one of the two. Estlink 1 —linking Estonia and Finland— was set up at the end of 2006 as a merchant line benefiting from the EU exemption of third-party access; a second line, Estlink 2, will be constructed with the help of €100 million from the EU.[41] The construction of a Baltic-Swedish interconnection was decided in April 2009: a HVDC line of some 340 km to be installed by Imera between Lithuania and Sweden. The line, which will receive a €175 million EU subvention, is expected to be operational sooner than the UCTE interconnection line that still requires the preliminary update of the Polish infrastructure.

Synchronization with the Baltic States is not likely to happen any time soon, but it should be considered a top priority project, deserving the allocation of the necessary means both for the upgrade of Poland's national grid and for the interconnection itself. In due time, its accomplishment will provide security of supply and create the material basis for solidarity. Until then, the DC links with Scandinavia can be considered a very positive short-term solution, but not a permanent one.

South Central Europe: islandized, fragmented

In South Central Europe, the islanded situation of Italy and the interconnection with the Southern Balkans are matters of particular concern. Italy's connections are insufficient and congestion occurs regularly not just with France, but also with Austria and Slovenia.

41. Decision taken in February 2009, http://www.fingrid.fi/portal/in_english/news_and_releases/press_releases/?bid=849.

France and Italy intend to offset congestion with an improved line between Trinité Victor in France and Camporosso in Italy. The development of new generation in the Marseille area especially endangers the proper functioning of the existing line. The two countries intend to replace existing lines in order to increase transfer capacity, especially between Albertville in France and Venaus in Italy. An undersea direct line between Corsica (France) and Italy is also under review, in order to further increase transfer capacities. The links between Slovenia and Italy will be upgraded through a new 400 kV substation by 2009 as well as a 380 kV double-circuit line by 2013. The first one is a TEN-E project aiming to connect the EU with the south eastern Balkans.

Austria and Italy intend to overcome border constraints through new lines and the upgrade of existing ones by 2011.

Italy and Switzerland intend to increase their current power exchange by 2020 through a 380 kV line linking Lavorgo (Switzerland) with Morbegno (Italy). The idea is currently under development.

Tunisia and Italy agreed in June 2007 to set up an electricity interconnection, and a corresponding joint venture named STEG was set up to that end. The new 170 km HVDC submarine line between Tunisia and Sicily, with a capacity of 1,000 MW, is part of the Mediterranean Ring project and should be operational by 2011. It will export Tunisian electricity to Italy.

Bottlenecks between France and Switzerland, as well as the movement of future generation capacity in Switzerland, are drivers for new cross-border links between the two countries, with different scenarios being studied.

Links with Neighbors

Interconnections are to a great extent an embodiment of geopolitics at large: much as the EU itself does, the UCTE masters, on its own, a huge amount of soft power and attractiveness, owing to the prestige of its members and to the guaranteed quality of its current.

When an interested candidate applies for UCTE membership, the UCTE passes the application on to the DG TREN for their comments. Once the application has been approved, formal negotiations are engaged with the petitioning country or region in order to proceed to interconnection. On occasions, it is the members of the UCTE, and not the organization itself, who are put in charge of the process. Such is the case with Turkey —another example of geopolitics at work— where the UCTE and the EU prefer, for the time being, to avoid any explicit institutional implication.

Today's map of interconnectedness reveals a certain number of semi-interconnected countries, which means that different parts of their territory are synchronized with one or the other, UCTE and/or IPS/UPS. How does this work, in practise, when the two systems are not effectively linked? Turkey and Ukraine, but also member countries Romania and Poland, belong to this category. In practise, UCTE contracts require that the petitioning country separates the UCTE interconnected part from the rest of the grid. In Ukraine, for example, the electrical island of Burstyn has been synchronized with the UCTE. Two agreements had to be signed to make this possible: the first one —signed by the Ukrainian TSO Ukrenergo and by one TSO representing the UCTE— required Ukraine to comply with the norms of the UCTE; the second one demanded the separation of the Burstyn section from the rest of the IPS/UPS grid. Today, the technical management for the UCTE portion is carried out by the control center in Warsaw, while the IPS/UPS section is controlled by Kiev. Kiev is, additionally, in charge of the maintenance of the Burstyn part, and responsible for the commercial agreements with Hungary, Slovakia and Romania. Again, DC links are an alternative to the complex contractual and technical procedure of synchronization.

Overcome fragmentation: South Central Europe

Overview

In South Eastern Europe, the current situation is characterized by a lack of East-West and North-South corridors in the Balkan region, and important congestion between Albania and Montenegro. The sparse structure of the Balkan network, especially in the former Yugoslavia, deserves special attention. The link between member states Greece and Italy needs to be improved via a second HVDC link. A project is under study but no opening date has been set yet. Croatia and Italy are scheduled to set up their first sub-sea interconnection by 2014. This will be a step of inter-regional importance that will get the insufficiently connected former Yugoslavia linked with the UCTE system, and simultaneously improve the situation of the largely isolated Italy. Romania and Turkey are studying an export project for Romanian electricity that could be operational by 2018: the two countries plan to be linked via a 400 kV HVDC submarine cable connecting Constanta in Romania and Pasakoy in Turkey over a length of 400 km. Again, DC and merchant lines are likely to prevail over cheaper solutions such as crossing Bulgaria.

Institutional reinforcement: the Energy Community

The role progressively being acquired by the Vienna-based Energy Community is good news for the region. The Community was founded in Athens in 2005 and entered into force on July 1st 2006. It counts among its members the successors of former Yugoslavia, Albania, and has observers from both EU and non-EU member states. In dealing with the implementation of the Acquis Communautaire in the field of energy, the Energy Community currently explores the integration of Ukraine and Moldova. The institution was very efficient during the Russian-Ukrainian gas conflict at the beginning of 2009 in terms of co-managing the crisis with the EU and the EU member states. The Energy Community has been, as a consequence, politically reinforced by that crisis.[42]

Conclusion

The electricity infrastructure, not to talk about interconnection, is in its very beginning in large parts of the region. Energy theft is widespread, and national regulators even in new EU member states cannot yet be compared to well-established counterparts in countries such as France or Belgium.

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42. *Energy-community.org* for further information on the institution.

Unrealistic expectations of large EU funding must be curtailed by the acknowledgment that national contribution, as part of the moral codex of electricity infra-structure and grids, is essential. The role of the Energy Community has to be further developed and the spillover of legal standards as well as complementary funding incentivized.

The Mediterranean Ring

In terms of potential for renewables, the Mediterranean South and Turkey are considered a important future source for solar energy — if these reach one day the impressive amount of 200 GW, the grid will have to be reconfigured completely and huge parallel lines will become necessary in order to transport the energy to the North.

The Desertec project

A consortium of twenty German blue chip companies constituted the Desertec project in Munich in July 2009. Led by Munich Re, the project was inspired by the German branch of the Club of Rome, and is backed by the German government.[43] It includes the following companies: ABB, ABENGOA Solar, Cevital, Deutsche Bank, E.ON, HSH Nordbank, MAN Solar Millennium, Munich Re, M+W Zander, RWE, Schott Solar, and Siemens. A Memorandum of Understanding was signed in the presence of high-ranking national and international government officials. The ambitious project is ready to invest some €400 billion on solar projects in the region: this means drafting concrete business plans and initiating the industrial setting up of a large number of networked solar thermal power plants throughout the Middle East and North Africa region (MENA). A limited liability company under German law (GmbH) was to be established by October 31st 2009.

How is this German-initiated project to be considered with respect to the 'Solar Plan' announced in July 2008 within the Union for the Mediterranean (UFM)? In fact, the UFM project,

43. *Desertec.org*.

which intends to set up solar generation of some 20 GW in the region by 2020, with an estimated cost of €80 billion, has been very much the victim of geopolitics so far, and has been paralyzed by the effects of the last Israel-Gaza conflict, and the Israel-Palestine conflict at large. Clearly, the main advantage of Desertec is that the driving force behind it comes from private actors —a highly diversified spectrum of companies from various sectors, NGOs, etc.— and not from politics. From a technical point of view, solar power plants already operate today with a capacity of 500 MW (Spain, USA); others with 1 GW capacity are under construction, and yet others with a 10 GW capacity are in advanced study phase. Nevertheless, from a commercial point of view, solar power requires huge investment, and would be economically viable only after some 10 or 15 years of a plant's operation. This justifies a common initiative such as the German one, which should as soon as possible include French companies like EDF in order to avoid a Franco-German rift on the subject of energy projects in the future.

One main issue still pending is the question of transport. Here we witness a debate on the characteristics and even the feasibility of the grid to be set up. Those in favor of 'small is beautiful' and decentralized infrastructure oppose here the supporters of a new 'super grid'. Hermann Scheer, president of Eurosolar, believes that a 'duplicated current system' with HVDC would entail the risk of concentrating energy distribution in the hands of a few multinational companies.[44] Others advocate a new 'super smart grid', which somewhat reminds us of the huge industrial projects of Soviet times. The debate illustrates again the basic concerns associated with DC and AC, as well as with merchant lines. In addition, access to the resources and revenues for the countries of the region themselves is an important concern. And the fact that the region is far from being politically stable is an additional reminder of the problems and uncertainties that consumer countries currently have to cope with on matters of oil and gas.

44. 'German Blue Chip Firms throw weight behind North African solar project', *The Guardian*, June 16th 2009.

Setting up the Mediterranean Ring

In the medium and short term, synchronization and the improvement of existing grids is on the agenda. On this issue, even if important progress has been made, the synchronization via the 27-km Gibraltar-Ceuta strait has paradoxically proven to be an obstacle to progress in the setting up of links between the Maghreb states. In the case of Turkey, on the other hand, synchronization with the UCTE will oblige it to disconnect from its other partners — not necessarily a wise economic and political decision for Turkey. The author thanks François Meslier, Secretary General of Medelec[45], for important insights concerning the Mediterranean Ring[46] which, according to him, comprises four main systems including Israel, without continuity among them. They are:

• the UCTE, joined by Morocco, Algeria and Tunisia, precisely since the setting up of the Spain— Morocco synchronous link;

• Turkey, since 2000 interested in integrating UCTE and since then engaged in an important upgrading of its system to be followed by a synchronization attempt in 2009;

• the group made up of Libya, Egypt, Jordan, Palestine, Lebanon and Syria, which is currently striving to set up interconnections;

• Israel, which, for obvious reasons of geopolitics and war, functions as an independent system. Only peace in the region could change this situation.

The beginning of synchronization

Since 1997, Morocco, Algeria and Tunisia have synchronously operated with the UCTE via 400 kV AC submarine cables to Spain. In a next step, Libya, Egypt, Jordan, Syria and Lebanon should be connected, through the adaptation of two existing 225 kV lines linking Tunisia and Libya. This interconnection was approved by the UCTE in May 2003 but a

45. Medelec is an industrial initiative and working group, dating back to 1992, termed a 'liaison committee' on the issue of electricity interconnection around the Mediterranean.

46. See especially F. Meslier, 'Evolution of the electrical interconnections around the Mediterranean Sea, due to the Mediterranean Solar Plan', conference March 19th 2009.

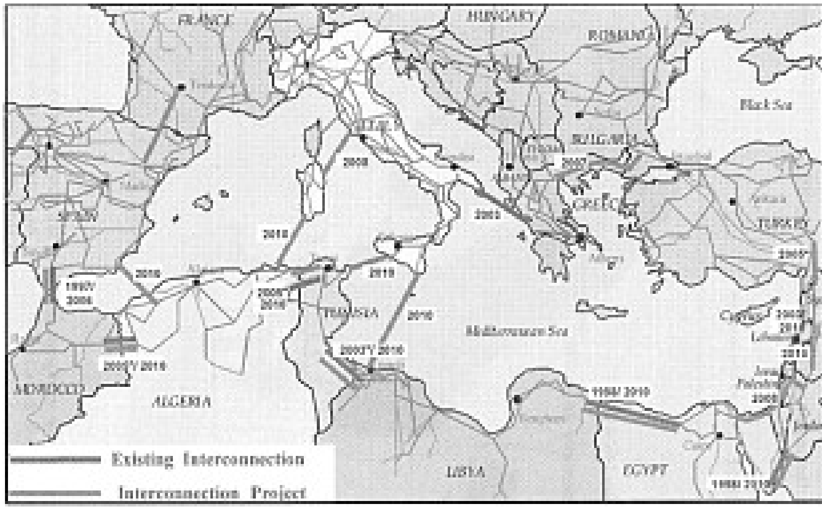
synchronization test on November 21st 2005 failed after seven minutes. For more successful synchronization, the UCTE thus recommended improving generation and regional regulation, increasing the number of generation units, and reinforcing the network. While the partners have already requested a new test, the UCTE established a list of conditions that have not yet been met.[47] The very cause of the problem is the difference among the systems, with a very long but not very powerful Libyan system —more than 2,500 km-long— on the one hand and a very powerful Egyptian system on the other. As Meslier put it, the synchronous Gibraltar-Ceuta link, as well as the chain system tying together the Northern African countries like the wagons of a train, are two serious handicaps for synchronization; they immediately mobilize defense plans for minor reasons.

DC links between Algeria and Spain are under study, as well as direct links to Italy, which would nevertheless be costly; access to the Gibraltar link is considered for the time being as an alternative.

There is shared interest in the interconnection stemming from the potential export of solar power from Northern Africa to Europe, but also potentially of nuclear power. Tunisia aims to 'go nuclear' and expects to open a plant by 2020, after having signed a contract with the French government to that effect.[48] The Union for the Mediterranean (2008) as well as the Barcelona Process established two energy partnerships in that direction: the development of an integrated electricity market, funded with —4.9 million for the period 2007-2010, as well as the MED-EMIP project (Euro-Mediterranean Energy Market Integration Project).[49] France is particularly supportive of the energy dimension of the Union for the Mediterranean. Currently, interconnection within the region is a priority in order to provide a stable regional framework that could, in a second step, be interconnected with the UCTE.

47. Information: Marcel Bial, UCTE, November 2008. Interview by the author.
48. http://www.globalsecuritynewswire.org/gsn/nw_2009 0424_5066.php.
49. *Medemip.eu*.

Map 5. Interconnections in the Mediterranean Ring



Source: OME, 2006.

From bilateral to regional

Bilateral interconnections are the very focus of the Mediterranean Ring project. The fact that, to this date, North African countries export traditional electricity while solar energy, which theoretically has a promising future in the region, is in its early beginnings, is a revealing consequence of insufficient investment and of the relatively high costs of renewables-based generation. The countries of the region, thus, risk privileging traditional generation, which benefits from lighter environmental legislation, to the detriment of solar energy. Besides, electrification is not fully accomplished throughout the region: the mountainous Atlas area, for example, is not connected to the electricity grids. 'Establishing functioning grids in these countries, linking them up, is also a means to make people stay, to prevent them from migrating towards the North, which, again, is in the very interest of the EU', said Marcel Bial.[50]

50. Discussion with the author (December 22nd 2008).

UCTE-Turkey

Electricity interconnection always has, empirically, preceded full membership with the EU. Can one assume that the Turkish case will also be in line with this statement? While only the future will tell, interconnection with Turkey has been progressing since 2005. A study on an interconnection was started in October 2005 and successfully finished by April 2007. The study revealed that interconnection would be feasible under the following conditions:

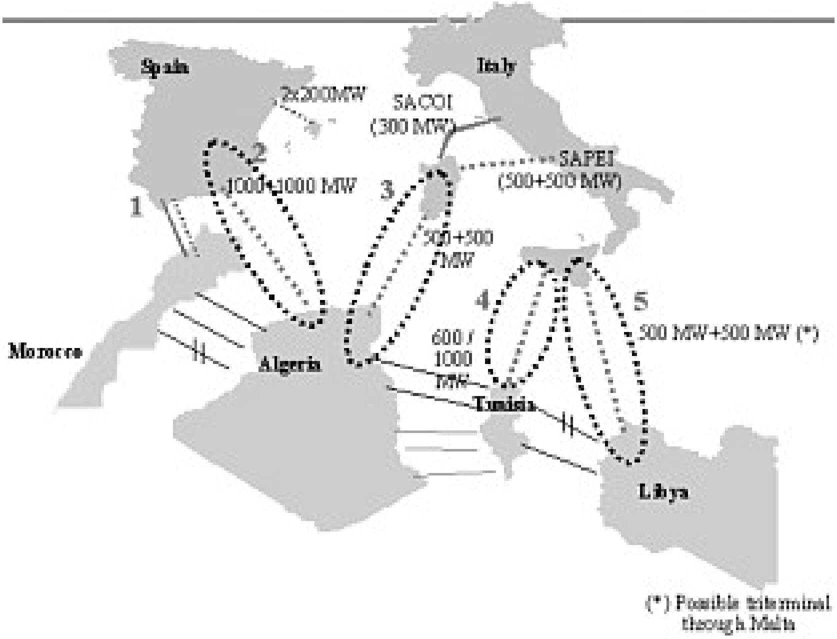
- that the frequency control problem was solved on the Turkish side;
- that a system protection scheme at the boundary was established to manage extreme contingencies;
- that the power exported from Turkey to the UCTE was limited to 500 MW but then progressively went up to 1,500 MW, which is the limit for AC systems.[51]

UCTE interconnection with Turkey progresses, as already mentioned, on a bilateral level: the Romania-Turkey interconnection and the Greece-Turkey lines are clear examples of this trend. It is important to remember, however, that the entire region 'behind' the former Yugoslavia and the Balkans is largely hostage to its fragmented electricity landscape, lack of resources and poor governance. Direct sub-sea lines can offer a certain remedy, but in the long run only the change of the situation in the Balkans will fully integrate countries like Turkey.

Looking at the Turkish borders, the very problem of Turkey, which has numerous synchronized interconnections with its neighbors Iran, Iraq, Syria, Armenia and Georgia, is that synchronization with UCTE will oblige it to turn the existing other links into asynchronous ones. A short— and medium-term alternative to synchronization would be the setting up of back-to-back stations, as was concluded in the UCTE-IPS/UPS interconnection study. But Turkey's aspiration to membership prevents it from accepting that solution.

51. Information from Marcel Bial, UCTE October 2008.

Map 6. HDVC links between Maghreb and Europe



Source: Medelec.

From the Atlantic to Vladivostok: UCTE-IPS/UPS

Interconnection with the former Soviet Union system is an important issue for the EU, as highlighted by various initiatives (listed below in decreasing order of importance):

- the UCTE interconnection with the three former Soviet republics of Estonia, Latvia and Lithuania, now EU members, which has already been discussed before;
- the explicit mention of interconnection as a goal in the Eastern Partnership and its association agreements. Here, electricity standards and interconnectedness are prominent issues;[52]
- current studies on the electricity interconnection with Ukraine and Moldova;
- the UCTE-IPS/UPS interconnection study.

52. Eastern Partnership, EU Council December 11th-12th 2008; K. Longhurst and S. Nies, 'The ENP revisited', *Europe Visions*, Brussels, January 2009, *Ifri.org*.

If the priorities are different in each of the above mentioned cases, the technical problems are common to all. And as for some former Eastern Bloc countries, like Hungary, which used to be interconnected with the IPS/UPS system, the lines themselves would need to be checked in order to assess whether they could be put back to work.

IPS/UPS interconnection: reality and projects

The most fascinating of all electricity projects is, without any doubt, the one born out of the ambitious idea to interconnect Europe and Asia, via the UCTE-IPS/UPS interconnection at large. The thought of it may bring glimpses of utopias such as that of a 'Europe from the Atlantic to Vladivostok' advocated by de Gaulle, and idealistic observers may be ready to accept the challenge and affirm the virtues of its economic opportunity in the long run. The idea of a unified Eurasian electricity market into a single electric space spanning over 13 times zones from the Atlantic to Vladivostok, reaching 800 million consumers (430 million from UCTE and 370 million from IPS/UPS) with 800 GW of capacity, is seen as an exciting prospect on both sides of the former fence. Economic opportunity means also competition and challenge, with, for example, cheaper Russian or Ukrainian electricity competing with EU enterprises. Or even, as some observers put it, interconnection might even result in decreased security of supply and more dependence on Russia who could decide to substitute its gas supplies by electricity and then control this market. Last but not least, unlike the case of the Desertec Solar Plan where new technologies and environment friendly resources are expected to be brought into the EU market, Eurasian interconnection might entail the risk of creating an EU dumpling backyard by producing cheap nuclear electricity, with no regard for environmental risks and security.

The following paragraphs discuss the project, starting by the state of the Russian grid whose technical upgrade is a precondition.

The state of the Russian grid

The Russian electricity grid covers 450,000 km with tensions between 110 and 750 kV. A significant portion works in the 330 and 750 kV segments, a high voltage that is not found within the UCTE. A distinction must be made between, on one hand, the Russian grid (UPS), and on the other the grids of the CIS and Baltic States, collectively called the Integrated Power Systems (IPS). As much as the UCTE grid reflects EU geography and reality and is accordingly strongly interconnected and meshed, the Russian one also reflects the country's geography and industrial landscape: the huge distances between the energy resources and the consumption areas are the reasons why the grid is only partly linked and partly an assortment of very high-tension, long-distance corridors. Russian electricity production currently reaches 210 TWh, with 22% produced with hydro energy, 11% coming from nuclear, and the remaining 67% coming from fossil fuels.[53]

While in the ENTSO system the regulation of demand and supply is a major concern, and businesses as well as individual customers are used to enjoying significant levers —reimbursements in case of damage, for example—, the power of customers in the former Soviet Union is still very weak, not to say close to non-existent. Thus, IPS/UPS —very far from the Western culture concept of 'consumer rights'— continue solving the problem of demand-supply imbalances the same way they used to do it in the past: by simply cutting off customers and, if necessary, entire regions. Southern Ukraine, for example, has been subject to regular disconnection. Consumers have no choice but to accept it.

IPS/UPS's interconnectedness today

IPS/UPS has, to date, the following interconnections with third countries:

- the Finland interconnection, dating back to Soviet times and linking the Soviet system to Finland, quite like the only direct gas link with that country.[54] It has a total capacity of 1,420 MW, and includes four conversion stations in direct current;
- the interconnection with Mongolia;
- the interconnection with China;
- the interconnection with Norway.

53. 'Russia and the interconnected grids of the CIS', Anne-Marie Denis, RTE, Paris, March 3rd 2007, report in French.
54. S. Nies, *Gaz et pétrole vers l'Europe*, Paris, IFRI, 2008, p. 198, Finland Connector, 1973.

As for links with the UCTE grid, IPS/UPS has only one synchronized interconnection in the Lvov pocket at Burstyn, near Mukachevo, in Ukraine. This part of the Ukrainian system is, as already mentioned, separated from the rest of the grid and monitored from the Warsaw UCTE monitoring centre.

Projects

The interconnection projects in progress include Russia on one hand, and separate projects for Ukraine and Moldova on the other. It is obvious that Russia fears being excluded if only the latter were integrated. This explains Moscow's resistance to any synchronization with those two taking place before the long term synchronization at large. Here again, asynchronous DC lines, also for technical reasons, should be considered as alternatives for non-member states. The introductory part on legacies described the Cold War infrastructure. Exploring the technical state of the Cold War interconnections with Hungary, now out of order, to establish whether they could be used again to link the two systems, could potentially reduce investment on lines and help avoid long legislative procedures associated with new infrastructure. This point should be part of the agenda.

Ukraine and Moldova

Ukraine and Moldova requested interconnection to the UCTE in March 2006, through their TSOs Ukrenergo and Moldelectrica. Both countries are today electricity net exporters. The implementation phase of the project is estimated to take seven years. According to the UCTE, the Terms of Reference (ToR) are finalized and have been approved by the partners. Several meetings have taken place with the EU concerning funding, and a call has been made to set up a consortium.[55] But Russia continues being adamantly opposed to Ukraine's interconnection, as it is, in general, to Ukraine's Western integration as a whole. As for Moldova, the EU and UCTE are quite worried about the perspective of a 'second Albania' in the region, an enclave encircled by Romania,

55. Source: UCTE, Marcel Bial, November 2008.

Russia and Ukraine, potentially explosive because of economic decline and the Transnistria conflict. Interconnecting Moldova is an important political task in order to increase stability in that country and prevent it from becoming the poorhouse of Europe. To date, Moldova and Romania are linked via two 110 kW cables, which allows Romania to import cheaper Moldovan electricity.

Russia and the CIS

In 2002, the UCTE received a request from the Russian TSO, on behalf of the CIS and the Baltic States, for a synchronous interconnection of the IPS/UPS power systems with the UCTE. A pre-feasibility study was concluded in 2003, and a second one was launched in 2005 and finalized in December 2008.[56] The second study had to answer the following three questions:

- Is a synchronous interconnection between the UCTE and IPS/UPS possible?
- What are the measures to be taken on each side?
- What are the associated costs?

On the UCTE side, a consortium of eleven TSOs from nine member states participated in the project. On the other side, there was Russia as well as seven companies that had established a joint agreement for the project: Belarus, Estonia, Latvia, Lithuania, Ukraine, Moldova and Central Dispatch Organization (CDO).[57] The project management office has one branch located in Hanover, Germany, and another one at the UCTE in Brussels. Five working groups and €10 million were allocated for a feasibility study that ended up with the endorsement of key conclusions by the study partners on May 5th 2008. According to those, the interconnection was 'feasible upon implementing several technical, operational, and organizational measures and establishing the legal framework as identified in the investigation'. It was acknowledged that the implementation phase would be a long process, and that a

56. *Ucte-ipsups.org* (homepage of the study).
57. For the detailed list see the project UCTE IPSUPS Study, on the UCTE homepage, *Ucte-ipsups.org*.

Map 7. The logo of the UCTE IPSUPS study

Source: Ucte-ipsus.org.

synchronous coupling should be considered as a long-term perspective. In order to achieve the world's largest unified electricity market platform, the construction of HVDC links between the bordering countries may be considered as a medium-term alternative solution. This preliminary system coupling however requires separate investigations.[58]

The feasibility studies further revealed that transfer capacities are limited mainly due to internal congestion in the two systems. Thus, a synchronous coupling would require substantial investment in the transmission grids on the Eastern side. Investment in the IPS/UPS generation and transmission sectors is also required in order to keep frequency fluctuations from generating severe disturbances that would impact on system security. The complex legal and regulatory framework could only be achieved in the long run. This framework has to cover operational and organization issues as well as highly political issues.

58. Key conclusions: http://www.ucte.org/_library/news/2008 0505_UCTE-IPSUPS_Study_Key Conclusions_30April2008.pdf.

Considering these findings, no fast change should be expected to today's situation, due to a lack of investment capacities, legal aspects and various technical problems.

Conclusion

The interconnection with the Baltic States should be considered a first step in order to advance on the path of synchronization while avoiding integrating the systems too early. HVDC lines with back-to-back stations are to be considered as short and medium-term alternatives especially for Moldova and Ukraine.[59] Energy security is an important issue here: the resource-poor EU feels already very dependent on its suppliers, and especially at the mercy of Russia and the transit country Ukraine in terms of gas. A further strengthening of dependency —with the arrival, for example, of cheaper electricity from Russia or Ukraine on the EU markets— is considered by many experts as a huge risk. And this is an even stronger argument, as both countries do not comply with the same rules as the EU in terms of market organization. This said, there should be no obstacle to pan-European market integration once these countries have introduced compatible rules of the game concerning unbundling, competition, etc.

Conclusion: Existing Lines and Missing Links

Summing up, the following problems must still be overcome:

• the poor interconnection —or even isolation— of Italy and the Iberian Peninsula;

• the new risks brought along by renewable energy, especially for Germany;

• the poor state of the grid, poor integration of Central Europe and especially the Baltic States, which also have to bridge the gap between the decommissioning of Ignalina II in 2009 and the start of the new nuclear power plant — whether in Lithuania or Kaliningrad. The Central Europe-East Europe rift

59. http://www.ucte.org/_library/news/081208_pressRelease_UCTEIPSUPS_studyClosingSession.pdf (for the Closing session of December 5th 2008 on the four-year study).

has been particularly visible here, and even more so since the fall of the Soviet Union. Rivalry and resistance are still very present. The idea of a common TSO for the Central European states, in order to favor investment in both electricity and gas, could be a promising idea;[60]

• the hybrid situation of countries who, although having already an islanded UCTE interconnection within their boundaries, still remain separated from the rest of the grid, as was explained in the beginning of this part. This brings along the question as to whether the combined use of AC (synchronization) and DC would not be a long-term solution for some geopolitical contexts such as the common neighborhood area of Russia and the EU;

• the largely incomplete connection between the EU and its neighbors at large. Feasibility studies on the interconnection with the Mediterranean Ring, as well as with IPS/UPS and Turkey have been undertaken, but within the EU Eastern Partnership, UCTE integration of the Ukraine and Moldova remain unaccomplished.

South East Europe has been a major challenge since the Yugoslavian East-West boundary disappeared in the 1990s and several splinter countries succeeded the Federation. The region is clearly the worst-off among the EU neighborhood areas and requires specific efforts to fill in the missing links and overcome extreme import dependency due to insufficient generation. Illegal consumption of electricity is very frequent in the region and makes it difficult to attract investors and companies. Setting up rules and guaranteeing their enforcement is thus the first condition for the region's electric take-off. The higher profile recently acquired by the Energy Community South East Europe with its potential for promoting the regional advances in the field of energy infrastructure is a very positive signal.

Switzerland, a non-member state, continues to play a pivotal role in electricity exchange and is integrated institutionally via the UCTE, but not sufficiently so in an overall governance sense.

60. For the Gas TSO, see proposal of the European Commission, Commission Staff Working Document, January 2009, 'Gas Supply Disruption to the EU: An Assessment', July 19th 2009.

Perspectives and Policy Recommendations

Electrification and electricity grids have been a powerful symbol of development and modernity ever since the end of the 19th century. There is an opportunity again today to bring the subject further into public awareness, as a mirror of modern industrial society. To achieve that will require the optimization of existing infrastructure, the use of the opportunities offered by the information age,[1] the improvement of transborder governance, and the setting up of the obviously missing links.

This part summarizes findings and highlights constraints and upcoming challenges on the subject of interconnections such as the impact of governance and regulation, renewable energies, innovation and smart grids, enlargement and investment. The study concludes on policy recommendations.

Interconnections and the Face of the Grid in the 21st Century

As we said earlier, the European grid reflects the state of European governance as electrical integration is the first step for a country's further integration — economic or political integration, and EU membership. Along the same logic, the European grid's definitive shape —whether it ends up being regional or centralized— will represent a pars pro toto of the EU at large conceived either as a federation or as a nuclear entity.

1. See for an exhaustive presentation of the Information Age: Manuel Castells, *The Information Age. Economy, Society and Culture*, II-III, Cambridge/Oxford, Blackwell, 1996-1998.

The prime objective for the EU electricity market should be the establishment of a sustainable electricity grid: this means an economic, ecological and secure infrastructure that avoids as much as possible unnecessary large scale investment in new generation facilities. Interconnections can be a positive element in this scheme provided that:

• the entire potential of already existing interconnections is fully exploited, both in terms of quantity and price;

• they help substitute generation in using capacities in one country to export them to a neighboring country;

• they help introduce new sources from far away areas, like solar energy from the Sahara;

• they guarantee solidarity, especially in case of natural disasters or politically motivated supply disruptions.

Sustainable grids are a key element to reach the 20/20/20 target. Interconnections, in turn, offer companies the advantage of saving the cost of new infrastructure. They are also in the interest of private consumers who have become increasingly concerned with the potentially adverse ecological impact of infrastructure projects.

Today's AC grid is already extremely flexible and has been technically updated, the distribution part having been left aside for the time being for financial and technical maturity reasons. Progress is to be expected with the introduction of even more ICT[2] and a drop in costs that seems to be already underway.[3] The grid of tomorrow will comprise decentralized small units as well as HVDC lines in the long run and, if the Sahara exploitation is accomplished, also a large HVDC sub-sea system linking the southern and northern shores. The impressive increase in the use of renewable energies for electricity generation, especially and paradoxically in the North, goes along with the challenge of how to integrate that type of energy into the grid. Any solution requires coordination, which so far has proven to be difficult, since traditional approaches and fragmented governance still prevail even at state level.

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2. Bullx, a method of extreme computing, deserves mention here. See www.boursorama.com/infos/actualités/detail (Paris, June 16th 2009).
3. http://www.smartgridnews.com/pdf/TheEmergingSmartGrId.pdf.

Technological progress and innovation is needed to respond to the challenge of renewals, which does not just concern Europe but the world as a whole. Progress is also needed in terms of underground lines, which are likely to become more frequent in the future and are preferable from an ecological point of view. Despite their being much more expensive, their increased use will bring along decreasing costs and economies of scale. Smart grids could also turn out to be a promising concept for the task of increasing transmission efficiency.

Bridging the gap between, on the one hand, the most advanced Information Age sectors such as telecoms and computers, and on the other the very conservative electricity sector, has to be considered a prime challenge, requiring first of all a shift in the institutional paradigm. Financing the change and setting the right incentives for it is a prime Public-Private Partnership (PPP) challenge on a national and a European level.

Interconnections, Politics and Solidarity

Interconnection as a political decision

To set up interconnections is a political decision to the extent that the alternative exists to transport the resources that generate electricity from their source to another site for future electricity generation. The choice of one over the other is not neutral. Interconnections, as we have repeatedly said, present many beneficial aspects, with their potential for solidarity in situations of emergency and disruption being one of the most prominent ones; they do not, however, automatically contribute to an improved market mechanism on both sides of the border — as the CRE reports have shown. We can even witness absurd flows from a higher price area to a lower price region, or the absence of flows in conditions that are largely below the existing interconnection capacities. The improvement of market conditions depends on improved governance as well as on transparency. The EU has gone through tremendous governance changes, and the process is still on course.

The prime role of national regulators

The role of national regulators is crucial for the improved functioning of interconnections.

The Third Package has increased the power of national regulators on the national market. This has been a fundamental step, since congestion does not only occur on the borders, but also inside of the countries. To date, and despite their obligation to do it, the majority of national TSOs do not deliver sufficient data on congestion inside of their countries. The availability of such data is essential in order to deal more efficiently with congestion on the borders and to evaluate the necessity of new infrastructure, including interconnections.

The prime role of regional initiatives

Nordel came up with a multilateral initiative already in 2002, but the move from a bilateral to a regional model is also an option: the Central-West region has moved from bilateral to regional paradigms that in turn have resulted in useful spillover to other regions and could potentially encompass the EU as a whole. Electricity exchange via interconnection, however, will always be regional, limited to some five to seven countries, depending on the number of neighbors of each of the countries involved, and never complete on a European level. It will be limited at least until a new DC grid is set up in parallel to today's meshed system, referring here to the already mentioned ambitious Desertec project.

Institutional change at the speed of light?

The move from ETSO to ENTSO-E is a measure of the accelerated pace of change, as are also the planned creation of DG EN at the end of 2009, the unprecedented establishment of the 20/20/20 goals, and the regulatory changes adopted at the end of 2008 on Energy and Climate. The question remains open as to whether a European electricity market would first require the dismantling of national structures. Unbundling the links between generation and transmission and then integrating them into a true European market is considered by some as the only way to move forward.[4] Does the European electricity market need a 'super regulator' in order to function properly? This issue will be on the agenda for years to come, with a strengthened ACER —'ACER Plus'— as only one among the possible options. Here again, two antagonistic philosophies underlie the current institutional battle: one in favor of the 'federal' approach coming from below, with the ENTSO coordinating the national TSOs in an effort to overcome the narrow-minded national approaches, and another one in favor of a 'Super Agency ACER' centralizing and running the project from 'above'. The concrete performance of each one of these institutions will in time demonstrate which option would be the most efficient.

Missing links within the EU

Part III showed the impressive list of interconnection projects, but also the huge regional differences and a number of missing links that need to be established. Congestion management on a national level has to be improved, and this should be facilitated by the adoption of the Third Package that empowers regulators with the necessary authority to demand that TSOs accomplish that task.

As for the establishment of missing links, today's priorities can be identified as follows:

- East: the inclusion of the Baltic States and the improvement of the weak Polish grid for the sake of improved energy security, as a first step;
- North: a solution to offshore wind energy introduction into the grids and the common management of those flows among the concerned countries;
- West: improvement of governance on the congested French-Belgian, as well as French-German border;
- South: the opening up of Italy via interconnections;
- Southeast: the improvement of the patchwork and islandized structure in the former Yugoslavia, with its impact on other states of the region such as Romania, Greece and Turkey.

4. Ferron 2006, p. 35.

Links with the neighbors

In the EU neighborhood areas, generation sources should be of prime concern, and the current preference for classical generation to the detriment of economically viable renewables, which are abundant in the region, should be offset by government incentives. The Union for the Mediterranean provides a useful forum and instrument for this.

As for the IPS/UPS-UCTE interconnection —a long-term project that has been under study for more than four years now— a fast solution is unthinkable, owing to insufficient grids that require updating, but also to political dissent on the opportunity of the measure. Coupling using HVDC back-to-back stations and the close examination of the out-of-order Cold War infrastructure should be first steps in the right direction.

The UCTE system, now a part of the ENTSO-E, will continue to enlarge and to contribute to homogenization and standardization even outside of the EU membership area. The Mediterranean Ring will be completed and IPS/UPS could then be interconnected. Electricity has a highly symbolic character, equivalent to modernity and progress. Electricity networks as a European public good should thus be regarded as symbols of a successful European integration.

Electrification and development

An estimated 1.6 billion world citizens still lack access to electricity, most of them in sub-Saharan Africa and South Asia, especially in India.[5] In the context of today's financial crisis, the reference to Roosevelt's New Deal reminds us that rural electrification was a huge concern between 1935 and 1950 as much as a significant part of the overall problem. Today, as in the past, modernizing the grids of developed countries and interconnecting them, but also contributing to the electrification of other parts of the world, remains a major concern. The new opportunities resulting from the huge public engagement that is typical of times of global recession should not be left unexploited.

5. Source: IEA, *World Energy Outlook 2008*, quoted by Ed Crooks, Current Concerns, *Financial Times*, Energy supplement, October 28th 2008, p. 4.

Policy Recommendations

The following section offers policy recommendations, viewed as necessary steps to arrive at an improved EU grid as well as improved EU electricity interconnection governance. They are not listed in any order of priority but rather constitute a summary that is a result from this study.

Recommendations on the regulatory and institutional side

1. The four German TSOs must be united in order to homogenize the TSO landscape, diminish the complexity of interconnection governance and avoid parallel projects among them. As a consequence of that, the role of the remaining German TSO would be strengthened.[6] In a more general sense, the coordination of different coupling projects proves to be as crucial as it is difficult to manage: if Germany and Denmark want to engage in market coupling, for example, they cannot do so without taking into account the other countries or regions to which they are already linked: Central-West for Germany, and Nord Pool for Denmark. Since the TSOs do not really coordinate sufficiently today, the regulators have to assume an important role. ERGEG set up a project coordination group during the Florence Forum in November 2008, going in that direction. There is an urgent need to reinforce governance on a European level in order to get projects going.[7]

2. The reports of the CRE have to be considered a benchmark and the upcoming regional reports must not lag back in quality behind those detailed analysis. In a broader sense, transparency on the movements, evaluation, regional breakdown of supply and demand to identify necessary improvements and projects, are the very basis for advancement in EU interconnections.

3. Integration in Central West has to be considered a benchmark. Lessons should be learnt, and integration in the other regions stimulated.

6. http://www.bmwi.de/English/Redaktion/Pdf/options-future-structure-german-electricity-transmission-grid,property=pdf,bereich=bmwi,sprache=en,rwb=true.pdf

7. The fact that the market coupling attempt between Germany and Denmark failed in October 2008 and has not been re-launched ever since, stresses the need for such a common European approach.

4. ACER and ENTSO-E competition has to be avoided, and a clear definition of each one's tasks formulated from the first day of their existence.

Pricing and subsidies

1. The Czech-EU presidency proposal (2009) of a single tariff for EU electricity transmission in the EU should be adopted. The appropriate compensation for third-country access to national grids is clearly a prime issue in improving interconnections in Europe.

2. As for national and EU subsidies, the risk of investing in outdated infrastructure has to be assessed project by project, taking into account provisions concerning future consumption, energy mix and efficient exchanges on the border.

3. The efficiency of merchant lines has to be tested in the years to come. To be declared efficient, they will have to increase competition on the market, and bridge gaps.

New interconnections

New interconnections must be decided on a case-by-case basis, considering the specificities of each border involved, and not as the result of some 'romantic' attachment to the idea of interconnection itself. In order to assess the need for them, the cooperation between TSOs and regulators is as decisive as Public-Private Partnership (PPP). A better fine-tuning of demand and supply, and forward planning, are key elements for moving forward.

EU and neighbors integration via electricity interconnection

1. The IPS/UPS-UCTE integration with Moldova and Ukraine bears an important symbolic meaning and must be promoted. They are also relevant from an economic point of view. Should it be synchronous or asynchronous? If the decision is made in favor of an AC link, its development will have to be accompanied by trust-building measures concerning Russia, and the continuation of the dialogue on the IPS/UPS-UCTE link. Unfortunately today's state of EU-Russia relations is not very promising in this sense.

The renegotiated Partnership and Cooperation Agreement, which will include an energy chapter, could be the appropriate forum for moving further. At the same time, the regional dimension underlying Ukraine's and Moldova's integration cannot be neglected: infrastructure will have to be overhauled both in Poland and in Romania. In the case of Romania, institutions (regulator, etc.) as well will need revamping.

2. Experts agree that energy policy relating to the community market is fairly well developed, even if it is spread across many institutions, whereas the Foreign Energy and Climate Policy is in its early stages, and institutionally not developed at all. In light of important negotiations with producers and transit countries, a clarification of 'who is in charge of what' is necessary.

3. The Mediterranean Ring: the promising Desertec project, a private and mostly German initiative, should be Europeanized, and could become a main driver for the setting up of the Mediterranean Ring portion in Northern Africa/Middle East.

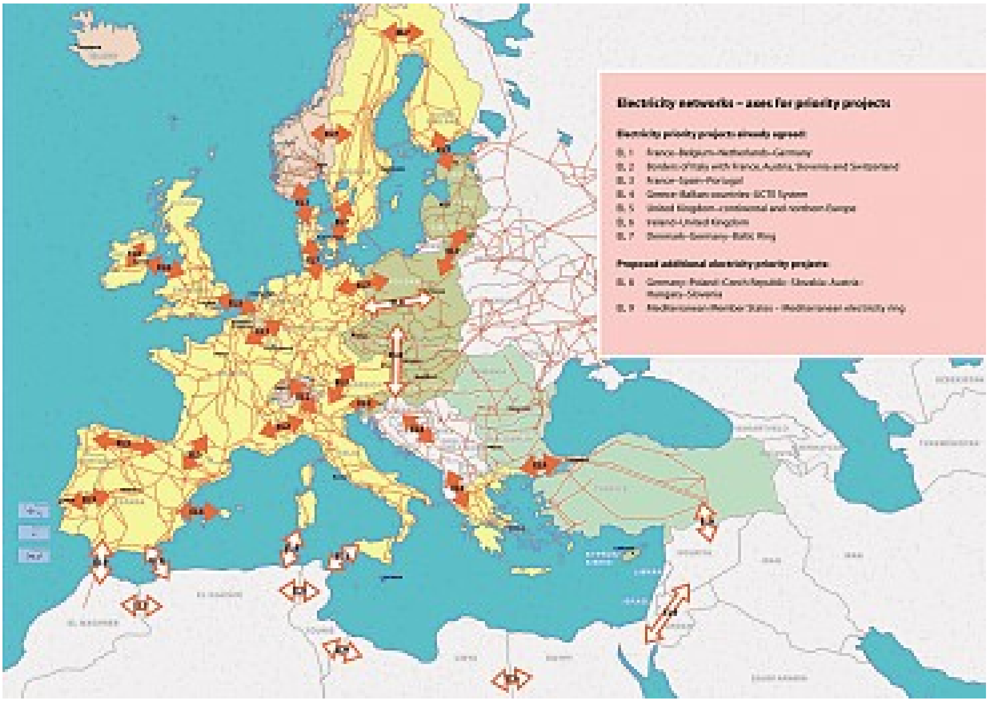
Open Questions

Where are we heading to? The traditional 'nothing replaces hydrocarbon' scenario, the 'more nuclear' scenario, or the 'renewable' one? If a combination of these three is not unlikely at least in the medium term, no one can yet predict what the exact energy mix would be. The answer to this question, however, will ultimately determine the characteristics of the final European grid.

Where do the limits of synchronization lie? Can the political integration aspect be separated from the electricity interconnection issue? Is synchronization necessarily a political issue? What is the role of DC links in the future grids, considering that they are free from risk of chain disconnection down the line?

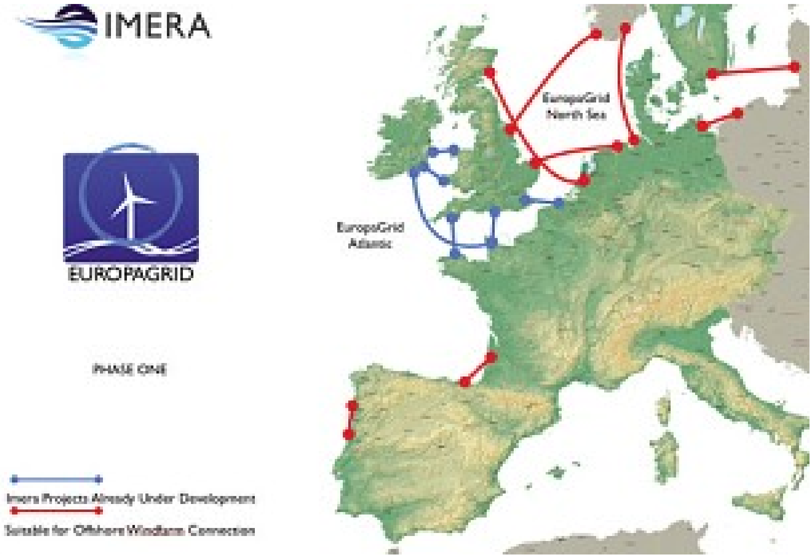
Thus, in the very end, and after an inquiry on complex and technical issues, the reader finds himself confronted again with the very fundamental question of the landscape of energy relations in Europe, and thus the organization of its electricity market. Evolution in this field, unlike electricity, moves hardly at the speed of light.

Map 8. TEN-E Priority Projects



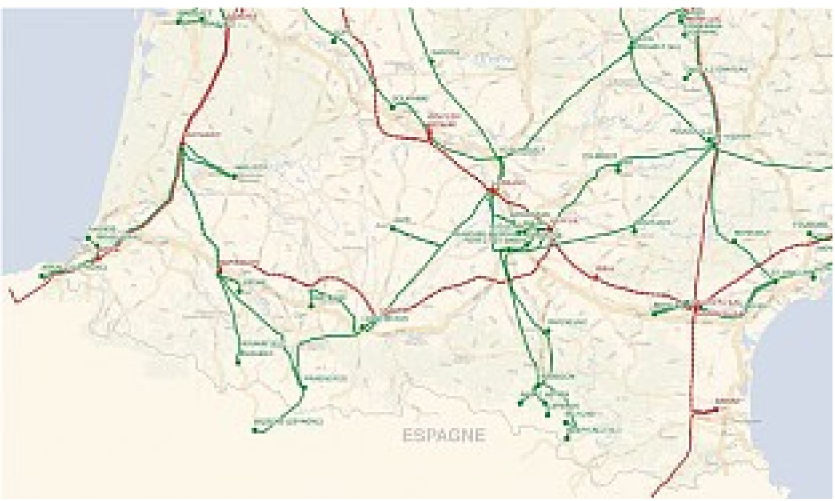
Source: EU Commission DG TREN.

Map 9. Imera Europa Grid



Source: Imera.

Map 10. French high-tension lines near the border with Spain



Note: in red: 400 kV lines; in green: 225 kV lines.
Source : www.liaison-france-espagne.org/pdf/DossierPresentation.pdf.

Map 11. Interconnections of Turkey

Source: Medelec.

Map 12. Regional Forum Central-West

Map 13. Regional Forum Central-East

Map 14. Regional Forum Central-South

Map 15. Regional Forum South-East

Map 16. Regional Forum South-West

Annex

1. Europe's Electricity Regions

ATSOI	Ireland	ENTSO-E by 2009
BALTSO	Baltic States	ENTSO-E by 2009
CENTREL	Continental Central East	ENTSO-E by 2009
IPS/UPS	Former Soviet Union	
Nordel	Northern Grid	ENTSO-E by 2009
UCTE	Continental West	ENTSO-E by 2009
UKTSOA	UK	ENTSO-E by 2009

2. Abbreviations and Definitions

AC: Alternating Current. Usually used for transmission lines: three-phase alternating current. Single-phase AC current is sometimes used in railway electrification systems. The introduction of alternating current followed the 'War of Currents' and is owed to Niclas Tesla

ACER: Agency for the Cooperation of Energy Regulators (to follow ERGEG)

BACK-TO-BACK STATION: Special equipement capable of changing alternating current (AC) into Direct Current (DC) and again DC into AC. Such equipment allows for the connection of two power systems that do not operate synchronously, as UCTE with IPS/UPS

CCS: Carbon Capture and Storage

CDO: Central Dispatch Organization

CEE: Central and Eastern European Countries

CEEC: Committee of European Economic Co-operation, from 1961 OECD

CIGRE: Conseil International des Grands Réseaux Electriques

CMEA: Council for Mutual Economic Assistance (Former Soviet Bloc)

COCOM: Coordination Committee for Multilateral Export Controls

CONGESTION: An interconnection is congested if the net flow on the line —exports and imports— exceeds 99%

CONGESTION MANAGEMENT: A technique of operating electricity grids in such a way that the technical limits are respected. It refers to the principles used to handle the physical flow of power through cuts in the transmission grid, either within an area or between two or more markets

CPTE: Coordination de la Production et du Transport de l'Energie électrique

DC: Direct Current. Losses in direct current transmission are significant and thus require thick cables and local generators; in the early period of electrification this fact limited the size of the grid to a maximum of 2.4 km around the generating plant. Today DC is mostly used in undergrounding, especially sub-sea lines. The DC system set up in the US was invented by EDISON (see AC, Nicolas TESLA, War of Currents)

DEFENSE PLAN: Reaction to an extraordinary situation beyond N-1, requiring the isolation of the incident and a fast appropriate answer

DISTRIBUTION: The final stage in the electricity delivery process before retail to end users. It includes typically medium voltage with less than 50 kV lines as well as electrical substations, transformers, and low-voltage distribution wiring with less than 1,000 V.

DG TREN: Directorate General Transport and Energy. To be transformed by November 2009 into two separate DGs: DG Transport and DG Energy

EIB: European Investment Bank, Luxembourg

ETS: Emission Trading Schemes

ENTSO-E: 36 European TSOs signed on June 27th 2008 a letter of intent in order to set up, before the end of 2008, the European Network of Transmission System Operators for Electricity (ENTSO-E). ENTSO-E will facilitate the implementation of the Third Legislative Package of the Internal Electricity Market. The purpose is to further strengthen the cooperation of TSOs in a number of key areas, such as technical and market-related network codes as well as the coordination of system operation and grid development

ETSO: European Transmission System Operators. ETSO includes 40 TSOs

EURELECTRIC: European Electricity Industry Association

EWEA: European Wind Energy Association

EWIS: European Wind Integration Study

GW/h: Gigawatt per hour

HV: High Voltage

HVDC: High Voltage Direct Current

Hz: Hertz

ICT: Information and Communication Technology

IEA: International Energy Agency (OECD)

IEM: Internal Electricity Market

IPS/UPS: Integrated Power Systems/Unified Power Systems: the Grid of the Former Soviet Union (Russia, CIS, Baltic States)

ITRE: Committee on Industry, Transport, Research and Energy (European Parliament)

JOULE EFFECT: Losses during transmission owed to to resistance and tension

kV: Kilovolt

kWh: Kilowatt hour

LNG: Liquefied Natural Gas

LOW TENSION: 38-230 V

METERING: The introduction of IT elements in the end of the distribution system in order to improve the exploitation of the production in peak and non-peak hours (smart grids)

MPT: Maximum Permanently allowed Tension

MWh: Megawatt hour

N-1: The reference for system security; it means that the system must be able to support losses of one central unit, generator, etc.

NATURAL MONOPOLY: Electricity generation, transmission and distribution has been traditionally considered a natural monopoly. Following liberalization, electricity has come to be considered a commodity, and the setting up of a true electricity market via liberalization a prime challenge and objective. The question nevertheless remains as to whether liberalization will be able to create a real energy market

NORDEL: Scandinavian Grid

SMART GRID: Power grid that delivers electricity from suppliers to consumers using digital technology

TEN: Trans European Networks (set up by the Maastricht Treaty)

TEN-E: Trans European Networks Energy

TPAC: Triple-Phase Alternating Current

TSO: Transmission System Operator. TSOs are responsible for the bulk transmission of electric power on the main high-voltage electric networks. They provide grid access to the electric market players according to non-discriminatory and transparent rules. They are charged with ensuring security of supply via the safe operation and maintenance of the system. In many countries they are in charge of grid development as well. They cooperate in the EU within ENTSO-E as well as within the regional networks, like UCTE or Nordel

UCPTE: Union for the Coordination of Production and Transmission of Electricity (transformed into UCTE with unbundling)

UCTE: Union for the Coordination of Transmission of Electricity: Western continental grid

UNIPEDE: Union Internationale des Producteurs et Distributeurs d'Energie Electrique

WEC: World Energy Council

WPC: World Power Conference

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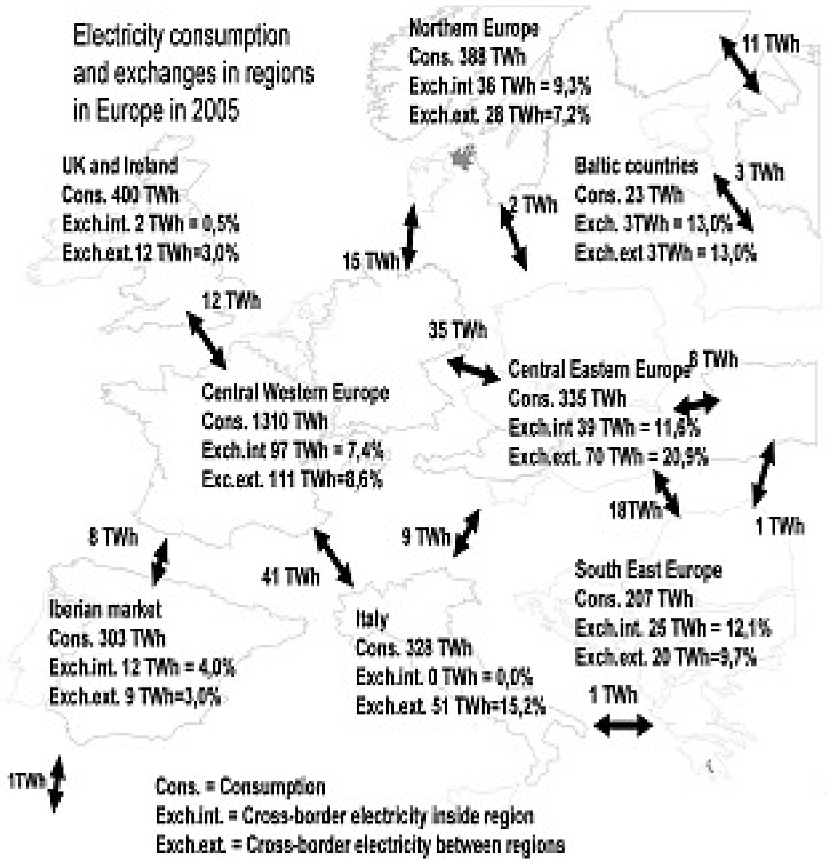
4. Map Electricity Consumption and Exchanges in Regions in Europe in 2005



Source: European Commission, M. Kerner.

5. Interconnections in Europe: Existing Infrastructure and Projects

Central-West

Border	Project Driver	Expected Effects
BE — NL	Congestion on the South and North borders	The three Phase Shifting Transformers (PSTs) shall improve the management of critical situations in the 380 kV grid caused by high North-South or South-North power flows and facilitate allocation of an increased and less volatile interconnection capacity to the market parties
NL — NO	Market coupling Norway—Netherlands	After the project is completed, both Norway (hydro system) and the Netherlands (thermal system) will be able to optimize the use of production capacity
FR — LU	Consumer connection	SOTEL (Luxembourg) has asked RTE for a 225 kV line to feed its industrial consumption in Betvat
FR — BE	Congestion on the 225 kV line between the Lorraine area (FR) and Belgium	The project will increase the electricity transmission capacity between France and Belgium, since congestion constraints will be identified on the 225 kV Moutaine—Aubange circuit due to N-1 contingency on the 400 kV network
NL — UK	Market coupling United Kingdom—the Netherlands	Project will result in enhanced diversity and security of supply for both markets, open access for all market parties by explicit auction and market coupling increase of interconnection capacity and market transparency
LU — BE	Security of supply for the public grid	New interconnection between the Cegedel Net public grid in LU and Elia in BE to improve security of supply for the Cegedel Net grid
DE — NL	Congestion in the area around the German-Dutch border	Overloads due to high North-South power flows through the auctioned frontier between the Netherlands and Germany in peak hours of wind in-feed

Project	Present Status	Expected Date	Description of Project
PSTs (located on the northern border)	Under construction	Spring 2008	Installation of 3 PST 380 kV, 1,400 MVA, + 25 ° / − 25 ° • 1 at Zandvtiet • 2 at Van Eyck. TSOs in charge: Elia
NorNed HVDC link	Construction completed; project in testing phase	2008	New HVDC link between Norway (Feda) and the Netherlands (Eemshav- en), DC voltage 450 kV, transmission capacity 700 MW, length 580 km. TSOs in charge: TenneT TSO & Statnett
Moutaine (FR)—Betvat (LU) 225 kV line	Permitting	2009	Creation of a 225 kV Moutaine (FR)—Betvat (LU) line. TSOs in charge: RTE & SOTEL
Moutaine (FR)—Aubange (BE) 225 kV line	Permitting	2010	The new project will upgrade the existing 225 kV Moutaine (FR)—Aubange (BE) line (installation of the 2nd circuit and replacement of conductors). Studies are being carried out into further increasing this interconnection capacity. TSOs in charge: RTE & Elia
BritNed HVDC link	Intention to construct	2010	New HVDC link between the UK (Isle of Grain, Kent) and the Netherlands (Maasvtakte). Transmission capacity 1,320 MW, length 260 km. TSOs in charge: TenneT TSO & National Grid
New interconnector in the southern section of the LU grid	Under study	2011	New 220 kV line between the substations of Bascharage (LU) and Aubange (BE). TSOs in charge: Cegedel Net & Elia
Line Doetichem (NL)—Niederrhein (DE)	Preparing of permitting procedure	Earliest in 2013	60 km new double circuit 40 kV OHL. TSOs in charge: TenneT, RWE TSO

Central-West (followed)

Border	Project Driver	Expected Effects
FR — BE	Congestions on the France—Belgium border	Constraints appear on the France—Belgium interconnection, due to development in generation in northern France
DE — NO	Interconnection Norway—Germany	Statnett and E.ON Netz are carrying out a study into the first Norway—Germany interconnector. The aim is coupling the hydro-dominated Norwegian etectricity system and the wind and thermal-dominated electricity system in northern Germany
BE — UK	Establish a direct power exchange capability	Create trading capacities by coupling the Belgian grid (Elia) and the British grid (NG)
DE — BE	Establish a direct power exchange capability	New interconnection between the 400 kV Elia and RWE TSO grids in Central-West
DE — FR	Increase the power exchange capacity on the DE—FR profile	Identification of possibilities to improve the Ensdorf (DE)—St. Avold (FR) interconnection

Central-East

Border	Project Driver	Expected Effects
CZ — AT	To increase the (N-1) security and transmission capacity of the existing V 437 Slavetice (CEPS)-Durnrohr (APG) tie line	The project will increase the (N-1) security and North-South transmission capacity at the CEPS-APG interconnection. It will also alleviate severe transmission capacity limitation on the CEPS-APG profile during maintenance
CZ — DE	Increasing power exchange capacity between the Czech Republic and Germany	This project will increase the current power exchange capacity between the Czech Republic and Germany

Project	Present Status	Expected Date	Description of Project
Strengthening of present interconnection or new interconnection project	Under study	2012 – 2015	Study to launch. TSOs in charge: RTE & Elia
NORDLINK	Feasibility study	≥ 2015	HVDC transmission system 700-1,400 MW. Feasibility study performed by Statnett and E.ON Netz.
Under study with National Grid	Under study	Tbd	HVDC link. TSOs in charge: Elia & National Grid
Under study	Under study	Tbd	Investigation of grid extension options. TSOs in charge: Elia & RWE
Ensdorf (DE)—St. Avold (FR) line	Under study	Tbd	TSOs in charge: RTE & RWE

Project	Present Status	Expected Date	Description of Project
V 438: Slavetice (CZ)—Durnrohr (AT) tie-line	Decided, budgeted and prepared on CEPS side. Authorization required on the Austrian side, type of authorization procedure agreed with authorities (starting in 2008).	2008	This project is the result of a bilateral agreement that has been reached between CEPS and APG to improve the existing tie-line by installing the second system. Project participation was agreed to be proportional to the length of the line from the border. TSOs in charge: CEPS & APG
Hradec (CZ)—Vernerov (CZ)—Vitkov (CZ)—Mechlenreuth (DE, E.ON Netz)	Initial negotiations have been launched between the two sides	First planning is due on 2016	It resulted from the discussions between CEPS and E.ON Netz to build a new 380 kV double-circuit overhead interconnection line between Germany and the Czech Republic through two new 400 kV substations.

Central-East (followed)

Border	Project Driver	Expected Effects
AT — DE	Increasing power exchange capacity between Austria and Germany	This project will increase the current power exchange capacity between Austria and Germany
AT — DE	Increasing power exchange capacity on AT—DE profile	Upgrading existing 220 kV grids in southern DE and western AT
HU — SK	Improve the security and reliability of the network of both partners, increase transmission capacity in the North-South direction	Increase the power exchange capacity on Hungary—Slovakia profile. Possible effects will be evaluated by joint studies
PL — DE	Increasing power ex- change capacity on PL—DE profile	Possible effects of this project will be evaluated by joint studies
PL — DE	Increasing power exchange capability on PL—DE profile	Possible effects of this project will be evaluated by joint studies

Project	Present Status	Expected Date	Description of Project
	mutual information exchange of future network development plans. A joint study between E.ON Netz and VE-T on the impact of wind generating plants on the systems is expected to be carried out and reflected in this project		TSOs in charge: E.ON Netz & CEPS. The findings and recommendations of the above mentioned study will be used as a basis for future negotiations between three sides: CEPS, E.ON Netz and VE-T
380 kV tie-line St. Peter (APG)—Isar (E.ON Netz)	Idea / Option	2017	New 380 kV double-circuit overhead interconnection line between Germany and Austria. TSOs in charge: E.ON Netz & APG
Line Oberbachern (DE)—Silz (AT)	Idea / Option	Long term	145 km-long new 400 kV double-circuit overhead line (62 km existing line already designed for 400 kV). TSOs in charge: E.ON Netz & TIWAG-Netz AG
Sajóivánka (HU)—Moldava or Rimavská Sobota (SK) 400 kV double line	Idea, System plan	After 2015	Depending on the decision of both partners, this project will be Sajóivánka (HU)—Moldava or Rimavská Sobota (SK) 400 kV double line. TSOs in charge: MAVIR & SEPS
Krajnik (PL)—Vierraden (DE)	Idea	After 2015	This project is the conversion of an existing 220 kV double-circuit line into a 400 kV line. TSOs in charge: VE-T (DE) & PSE Operator (PL) Financing scheme: not yet decided
Baczyna (PL)—German border (DE)	Idea	After 2015	This is the 3rd 400 kV interconnection between Poland and Germany with reinforcement of Polish internal grid. TSOs in charge: VE-T (DE) & PSE-Operator (PL). Financing scheme: not yet decided

Central-East (followed)

Border	Project Driver	Expected Effects
PL — SK	Increasing power exchange capacity on PL—SK profile	Possible effects of this project will be evaluated by joint studies
PL — LT	Incorporation of Baltic States into Internal Electricity Market (IEM) of European Union	Possible effect should be evaluated by joint studies
PL — UA	Resumption of existing and not used interconnection	It will increase the power exchange capacity on PL—UA profile. Possible additional power flows from PL to SK are expected, caused by power imports from UA
SK — UA	Increasing power exchange capability on SK—UA profile, accommodation of transits / imports of electricity	Possible effects will be evaluated by joint studies, as well as within IPS / UPS study or UA / MD interconnection study (if applicable)
SK — AT	Creating an interconnection line between Austria and Slovakia	Possible effects will be evaluated by joint studies
AT — HU	Increasing the (N-1) security and transmission capacity of the existing tie-line Wien SO (APG)-Györ (MAVIR)	The project will increase the (N-1) security and transmission capacity on Austria-Hungary profile

Project	Present Status	Expected Date	Description of Project
Byczyna (PL)—Varin (SK)	Under study	After 2018	This is a new 400 kV interconnection between Poland and Slovakia with reinforcement of Polish internal grid. TSOs in charge: SEPS (SK) & PSE-Operator (PL). Financing scheme: not yet decided
Elk (PL)—Alytus (LT)	Planning	≤ 2015	This is a new 400 kV double-circuit interconnection between Poland and Lithuania together with back-to-back 1,000 MW station in Alytus (LT) and reinforcement of Polish internal grid. TSOs in charge: subject of decision. Financing scheme: not yet decided
Modernization and resumption of 750 kV Rzeszow (PL)—Khmelnitskaya (UA) OHL and installation of back-to-back 2 × 600 MW converters in the Rzeszow 750 kV (PL) substation	Planning	≥ 2010	The project concerns the modernization and resumption of the existing 750 kV interconnection between Poland and Ukraine. TSOs in charge: Subject of decision. Financing scheme: not yet decided
2 × 400 kV line V. Kapušany (SK)—Mukachevo (UA)	Idea	After 2012	This new project will strengthen the existing 400 kV interconnection between Ukraine and Slovakia with circuit doubling. TSOs in charge: subject to decision. Financing scheme: not yet decided
2 × 400 kV tie-line Stupava (SK)—Bisamberg / Wien SO (AT)	Idea	After 2020	New 400 kV SK—AT double-circuit interconnection. TSOs in charge: SEPS (SK) & APG (AT)
Tie-line Wien SO (AT)—HU border (Györ), 2nd System	Planning phase	2010	Installation of the 2nd system on the tie-line from Wien SO (AT, APG) to the border (both systems have already been installed on the Hungarian side). TSO in charge: APG

Central-South

Border	Project Driver	Expected Effects
FR — IT	Take higher benefit from existing 220 kV Trinite Victor (FR)—Camporosso (IT) interconnection line	The congestion level on 220 kV Trinite Victor Camporosso interconnection line is expected to increase with generation projects in Marseille area, with the result that this line will have to be open most of the time. The project is aiming at alleviating the congestion, allowing for closed operation of this line
FR — IT	Increase of transfer capacity on France—Italy border	The 400 kV France—Italy interconnection re-lies on the only substation of Albertville on the French side; it is made up of a recently constructed double circuit line with big section conductors Albertville (FR)—Rondissone (IT) and an older axis, Albertville (FR)—La Coche (FR)—La Praz Saint André (FR)—Villa-rodin (FR)—Venaus (IT)—Piossasco (IT). The project aims to take best advantage of the existing network and increase the capacity of the latter axis, which limits transmission capacity towards Italy
IT — SI	Congestions on Italian-Slovenian border	Increase the capacity of the current interconnection on the Northeastern Italian border, which has a low level of security and low transfer capacity. The 380 kV Redipuglia (IT)—Divaca (SI) line is particularly congested, limiting power exchanges with Slovenia. TEN-E Project
IT — SI	Congestions on Italian-Slovenian border	Increase the capacity of the current interconnection on the Northeastern Italian border which has a low level of security and low transfer capacity. Low security of supply on the Slovenian network. TEN-E Project
IT — SI	Congestions on Italian-Slovenian border	Increase the capacity of the current interconnection on the Northeastern Italian border that faces a low level of security and transfer capacity. The 220 kV Padriciano (IT)—Divaca (SI) line is particularly congested, especially in N-1 condition
IT — AT	Constraints on Italian-Austrian border	Due to low line capacities on the Northeastern Italian border, there are limitations and congestions in case of Italian power import. The project aims to increase the transfer capacity of this border

Project	Present Status	Expected Date	Description of Project
PST on this line	Under study	2011	Installation of a PST in France or in Italy. TSOs in charge: RTE & TERNA
Upgrade the connection at the Italian-French border	Under study	2012	Replacement of Albertville (FR)—La Coche (FR)—La Praz (FR), La Praz (FR)-Villarodin (FR), Villarodin (FR)—Venaus (FR) and Venaus (IT)—Piossasco (IT) circuits by high temperature conductors is planned. Rehabilitation of a 400 kV line currently out of voltage [Albertville (FR)—Grande Ile (FR)], with high temperature conductors and connection to one existing Albertville (FR)—Rondissone (IT) circuit.
New 380 kV line on the Northeastern Italian border with Slovenia	Pre-authorization phase	2013	New 380 kV double-circuit line between Udine Ovest (IT) and Okroglo (SI). TSOs in charge: TERNA & ELES
New 400 kV PST	Jointly agreed	2009	400 / 400 kV PST in Divaca (SI) substation. TSO in charge: ELES
New 220 kV PST	Under construction	2008	220 / 220 kV PST on Padriciano (IT)—Divaca (SI) Interconnection, in Padriciano (IT). TSO in charge: TERNA
New 380 kV Cordignano (IT)—Lienz (AT) line	Idea	Long term	New 380 kV line between Cordignano (IT) and Lienz (AT). The existing 220 kV Soverzene (IT)—Lienz (AT) interconnection line would be dismantled to minimize the environmental impact. TSOs in charge: TERNA & APG

Central-South (followed)

Border	Project Driver	Expected Effects
IT — AT	Increase of transfer capacity on Italian-Austrian border	In the 2003 TEN-E Study, the possibility of increasing transfer capacity between IT and AT within the Brenner Base Tunnel project was investigated. The GIL solution seems the most feasible, using the planned pilot tunnel of the Brenner Base Tunnel
IT — AT	Constraints on Italian-Austrian border	In order to increase security of supply and transmission capacity between Austria and Italy, a new tie-line at Reschenpass is currently being studied
IT — AT	Constraints on Italian-Austrian border	In order to increase transfer capacity between Italy and Austria, a new link across the Valico del Brennero (Brennerpass) could be renewed.
IT — CH	Cross border Italy—Switzerland	Increase of current power exchange, evacuation of future generation capacity in Switzerland
FR — CH	Cross border France—Switzerland	Elimination of current bottlenecks on the French-Swiss border, evacuation of future generation capacity in Switzerland and increase of current power exchange capacity between France and Italy
FR — IT	Increasing transfer capacity on French-Italian border	In the 2005 TEN-E Study, the possibility of increasing the transfer capacity between Italy and France was investigated. The HVDC solution seems the most feasible, using existing infrastructure corridors

Project	Present Status	Expected Date	Description of Project
GIL Innsbruck—Bressanone	Under study	Long term	New 380 kV GIL interconnection through the planned Brenner Base Tunnel. TSOs in charge: TERNA & TIWAG-Netz AG
220 kV tie-line Reschen-pass	Under study	Mid-term	380 / 220 kV substation directly located at the border and erection of 220 kV connection till Graun and upgrade of the existing Graun—Glorenza line. Additional connection of 110 kV distribution grid in Austria at the new substation. TSOs in charge: TERNA, APG & TIWAG-Netz AG
110/132 kV line Prati di Vizze (IT)—Steinach (AT)	Under study	2011	The project on both sides (Italy and Austria) comprises the upgrading of the existing Prati di Vizze (IT)—Steinach (AT) line, currently operated at medium voltage and the installation of a 110 kV / 132 kV PST in Steinach (AT). TSOs in charge: TERNA & TIWAG-Netz AG
380 kV line Lavorgo (CH)—Morbegno (IT)	Idea	2020	380 kV line between Lavorgo (CH) and Morbegno (IT); different options are on the table. TSOs in charge: Swissgrid & TERNA
Different projects are currently studied	Under study	Tbd	Tbd TSOs in charge: RTE, Swissgrid (& TERNA)
HVDC cable Piossasco (IT)—Grande Ile (FR)	Under study	Mid term	New HVDC under-ground cable interconnection between Piossasco 400 kV (IT) and Grande Ile 380 kV (FR), 1,000 MW. TSOs in charge: TERNA & RTE

Central-South (followed)

Border	Project Driver	Expected Effects
IT — TU	Interconnection line between Italy and Tunisia	In June 2007, an agreement was reached between the Italian Minister for Economic Development and the Tunisian Minister for Industry and Energy, appointing TERNA and the Tunisian company STEG to set up a joint venture to create the electricity interconnection, manage international transits of electricity on the link and launch a bid to build a power plant in Tunisia

South-East

Border	Project Driver	Expected Effects
MK — BG	Establishing East-West Corridor in Southeastern Europe (SEE)	Increase Italy's imports from the Balkans (BG, RO). Strengthen the sparse structure of the Balkan networks. A 400 kV interconnection MK—BG will increase transfer capacities in North–South direction in SEE. This line is also part of the East–West corridor in SEE and creates opportunities for increased power exports towards Italy from countries with surplus power (BG, RO)
MK — AL & AL — IT / ME — IT		
AL — ME	Alleviate congestion in the region	To establish a stiff corridor from GR—AL—ME up to the Adriatic line

Project	Present Status	Expected Date	Description of Project
New HVDC submarine cable between Tunisia and Sicily	Jointly agreed by the Ministries	2011	A new interconnection cable will join the Cap Bon peninsula in Tunisia with Sicily and carry electricity generated by a new power plant in El Haouaria, Tunisia. The plant will generate 1,200 MW, 800 MW of which will be directed towards Italy and 400 towards Tunisia. The submarine cable will be a double cable, 170 km in length, and have a 1,000 MW capacity, 200 MW of which will be guaranteed to the free access share. TSO in charge: TERNA & STEG

Project	Present Status	Expected Date	Description of Project
Stip (MK)—C. Mogila (BG) 400 kV line	Under construction	2008	Length 150 km. TSOs in charge: MEPSO & NEK
Bitola (MK)—Elbasan (AL)—Tirana (AL)—Durres (AL)—Foggia (IT) 400 kV OHL & DC cable Montenegro—Italy is an alternative to Albania—Italy	Under study	2012	OHL length ~ 200 km cable length ~ 350 km. TSOs in charge: MEPSO (MK), ATSO (AL), TERNA (IT) and possibly EPCG (ME)
Tirana (AL)—Podgorica (ME) 400 kV line	Under construction	Third quarter of 2009	400 kV line Tirana2 (AL)—Podgorica (ME) with a length of 157 km (128.5 km on Albanian side, 76 km of which with double the circuit, and 28.5 km on the Montenegrin side). The contract for the construction is signed with Dalekovod Company. TSOs in charge: ATSO & EPCG

South-East (followed)

Border	Project Driver	Expected Effects
HU — RO	Strengthening East-West and North-South corridors	Strengthen the interconnection to the South and increase the transmission capacity
HU — HR		
GR — TR	Northern borders	Alleviate the import limitations from the northern interconnections mainly due to the sparse structure of the Balkan networks
GR — BG		
SI — HU & SI — HR	East border	Connection to new power system and increase of power exchange capability
GR — IT	Increase of interconnection capacity	Increase the transfer capacity between Greece and Italy
HR — IT	Create a subsea interconnection between Croatia and Italy	Create the 1st direct connection between Croatia and Italy, which is of interregional importance for Internal Electricity Market
MK — RS	North-South Corridor in SEE	MK, AL and GR imports from the North are currently limited due to sparse structure of the Balkans networks. The project aims at increasing the transfer capacity

Project	Present Status	Expected Date	Description of Project
400 kV line Bekescsaba (HU)—Nadab (RO)	Under construction	2008	Increase exchange capability between HU—RO. TSOs in charge: MAVIR & Transelectrica
400 kV double line Pecs (HU)—Ernestinovo (HR)	Under construction	2010	TSOs in charge: HEP-OPS & MAVIR
N. Santa (GR)—Babaeski (TR) 400 kV line	Under construction	To be commissioned in 2008	Possible operation for temporary local exchanges with an islanded part of the Turkish power system. Length 130 km. TSOs in charge: HTSO & TEIAS
N. Santa (GR)—Maritsa (BG) 400 kV line	Under study	Tbd	New interconnection line between GR-BG, length 130 km approximately. TSOs in charge: HTSO & NEK
400 kV double line Cirkovce (SI)—Pince (HU) border for connection as Cirkovce (SI)—Heviz (HU) and Cirkovce (SI)—Zerjavinec (HR)	Preparation for authorization	2011	First 400 kV interconnection line between Slovenia and Hungary. The line already exist on Hungarian and Croatian sides. TSO in charge: ELES
Second HVDC link between Greece and Italy	Preliminary study foreseen	Tbd	400 kV DC interconnection. TSOs in charge: TERNA & HTSO
400 kV HVDC subsea cable between Croatia and Italy	Under study	2014	500-1,000 MW. TSOs in charge: TERNA & HEP-OPS
Stip (MK)—Nis (SR) 400 kV line	Under study	2010	Length ~ 220 km. TSOs in charge: MEPSO & EMS

South-East (followed)

Border	Project Driver	Expected Effects
RO — TR	South-East border	Enable the power export to Turkey
RO — RS	Eastern corridor	Increase security of entire interconnection operation
RS — HU	Strengthening the interconnection between HU and RS	Create a new 400 kV line between Serbia and Hungary

South-West

Border	Project Driver	Expected Effects
PT — ES	Portugal—Spain Duero Interconnection	Alleviate the congestion on the 220 kV network in the Duero area
PT — ES	Portugal—Spain Duero Interconnection	Alleviate the congestion in the 220 kV network on the Duero area
PT — ES	Portugal—Spain South Interconnection	Alleviate the congestion that occurs on the existing 400 kV line Alqueva (PT)—Brovales (ES) and low levels of exportation from Spain to Portugal. Besides, the project enables the total integration of Spain and Portugal inside MIBEL

Project	Present Status	Expected Date	Description of Project
400 kV DC submarine cable Constanta (RO)—Pasakoy (TR)	Under study	2018	Length 400 km. TSOs in charge: Transelectrica & TEIAS
400 kV line Sacalaz (RO)—Novi sad (RS)	Under study	2015	Length: 128 km. TSOs in charge: Transelectrica & EMS
New 400 kV line Pecs (HU)—Sombor (RS)	Idea	Tbd	400 kV single line. This project is in very initial stage. TSOs in charge: MAVIR & EMS

Project	Present Status	Expected Date	Description of Project
New 400 kV Duero interconnection Aldeadávila (ES)—Lagoaça (Duero Internacional, PT)	Permitting (almost under construction)	2009	New OHL interconnection line Aldeadávila (ES)—Lagoaça (PT). AC Voltage 400 kV. Transmission capacity 1,690 MVA (winter), length 1 km in Spain, 5 in Portugal. TSOs in charge: REN & REE
Changes in the topology of the 220 kV lines in this area	Permitting (almost under construction)	2009	Changes in the topology of the 220 kV lines in this area. These changes, mainly in the Portuguese 220 kV network, lead to substituting the existing line Aldeadavila (ES)—Bemposta (PT), by a second circuit Aldeadavila (ES)—Pocinho (PT). TSOs in charge: REN & REE
New 400 kV South interconnection Guillena (ES)—Puebla de Guzman (ES)—Tavira (PT)	Under construction (Guillena (ES)—P. Guzman (ES) Defining fnal route (P. Guzman (ES)—Tavira (PT)	2010 – 2011	New OHL double circuit line between Guillena (ES)—Puebla de Guz-man (ES) and Tavira (PT). On the section P. Guzman (ES)—Tavira (PT) initially only one circuit will be placed. AC voltage 400 kV, transmission capacity 1,700 MVA (winter), length 152 km in Spain, 40 km in Portugal. TSOs in charge: REN & REE

South-West (followed)

Border	Project Driver	Expected Effects
FR — ES	Constraint on France—Spain border	The total interconnection faces a high level of congestion limiting the transmission capacity. Limitations on production of wind power energy in the Iberian system. The project aims at eliminating these constraints
PT — ES	Portugal—Spain North Interconnection	Alleviate the congestion on the existing 400 kV line Cartelle (ES)—Lindoso (PT) and low levels of exportation from Spain to Portugal. Besides, the project enables the total integration of Spain and Portugal in MIBEL

Project	Present Status	Expected Date	Description of Project
New 400 kV interconnection line in the eastern part of the border	Defining final route	2011 – 2012	New double circuit line between Baixas (FR) and Santa Llogaia / Ramis or Vic (ES). AC voltage 400 kV, Transmission capacity 2*2 160 MVA (winter), length Strategy Baixas—Vic 50 km in Spain, 57 in France. Or: Strategy Baixas—StaLlogaia 28 km in Spain, 40 in France Included in the Priority Interconnection Plan (TEN-E Guidelines). A European Coordinator has been appointed by the European Union for this project. TSOs in charge: RTE & REE
New 400 kV North interconnection	Under environmental studies	2013 – 2014	New OHL double circuit line between Carteffe—Pazos (ES) and Vifa Fria (PT)—Vifa do Conde (PT)—Recarei (PT). On the section Pazos (ES)—Recarei (PT) only one circuit will be placed. AC Voltage: 400 kV. Transmission capacity 1,700 MVA (winter); length 110 km in Spain (up to Carteffe), 112 km in Portugal (up to Recarei). TSOs in charge: REN & REE

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At the Speed of Light?

Electricity Interconnections for Europe

GOUVERNANCE EUROPÉENNE ET GÉOPOLITIQUE DE L'ÉNERGIE

Electricity moves almost at the speed of light: 273,000 km per second. The speed of electricity makes it the ultimate "just in time" commodity. A problem anywhere can be transmitted everywhere in a nanosecond.

Electricity interconnection is a prominent issue in the news, sometimes even featured as a panacea for the shortcomings of the European electricity market – a panacea that will ensure security of supply, solidarity and pave the way for a promising use of renewables in the future.

The present study is devoted to electricity interconnections in Europe, their current state and the projects concerning them.

The study addresses the following questions:

– *What* is the role of interconnections in the development of a sustainable grid that can emerge from the existing pieces, make optimum use of existing generation capacity, ensure energy security, and offer economies of scales? What is their role in the process of building a different energy concept, one that would be concerned with climate change and thus in favor of the use of renewables?

– *How* are existing interconnections exploited and governed, and how can their exploitation be improved? Does the EU need more and new interconnections; and if so, where and why, and who is going to finance them?

Prominent projects as such as Desertec, the debate on DC or AC lines, or the limits of synchronization, as well as the state of a potential East-West electricity linkage between Former Soviet Union and EU, termed UCTE-UPS/IPS, are discussed in the volume.

The study finishes with recommendations for policy makers.

Susanne Nies is a Senior Research Fellow with IFRI Energy Program and the Head of IFRI Brussels Office.

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