FLEXIBLE POWER DELIVERY SYSTEMS:
An Overview of Policies and Regulations and Expansion Planning and Market Analysis for the United States and Europe

ISGAN Executive Summary

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Abstract: With the changing dynamics of electric grid systems around the world, decision-makers – both institutional and technological – are facing numerous new challenges to operating, planning, and expanding their systems.[1] New technologies are challenging conventional regulatory regimes and new policies and consumer demands are similarly challenging the currently available technologies. For example, as the demand for cleaner energy sources gains ground all over the globe, technological improvements are necessary to integrate large amounts of variable energy sources such as solar and wind into various electricity systems, while ensuring acceptable levels of reliability and security of the system. Similarly, as consumers engage more with electricity systems, demand profiles and consumer choice, among other demand-side elements, are also challenging our system, providing opportunities for demand-side management and related technologies. In this rapidly changing landscape, regulators and policy-makers must consider how consumer participation and new technologies interact with the market place.

This discussion paper from ISGAN Annex 6 Power Transmission & Distribution Systems Tasks 1 and 2 focuses on achieving flexible power delivery by examining the policies and regulations, as well as expansion, planning, and market analysis for the United States and Europe. This review

[1] Electricity systems integrate technologies, polices and markets across generation, transmission, distribution, and end-users.

looks at how policies and regulations have changed to accommodate new developments in the operation, planning, and market areas of each grid system. Additionally, it highlights certain efforts undertaken to better understand and implement the policy and regulatory changes in these processes as both the United States and Europe work towards achieving a modernized grid system, specifically including the increased deployment and use of smart grid technologies, e.g., synchrophasor measurement technologies, net metering, distributed generation, energy storage, advanced metering infrastructure.

About ISGAN Discussion Papers: ISGAN discussion papers are meant as input documents to the global discussion about smart grids. Each is a statement by the author(s) regarding a topic of international interest. They reflect works in progress in the development of smart grids in the different regions of the world. Their aim is not to communicate a final outcome or to advise decision-makers, rather to lay the ground work for further research and analysis.

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Acronymns and Abbreviations

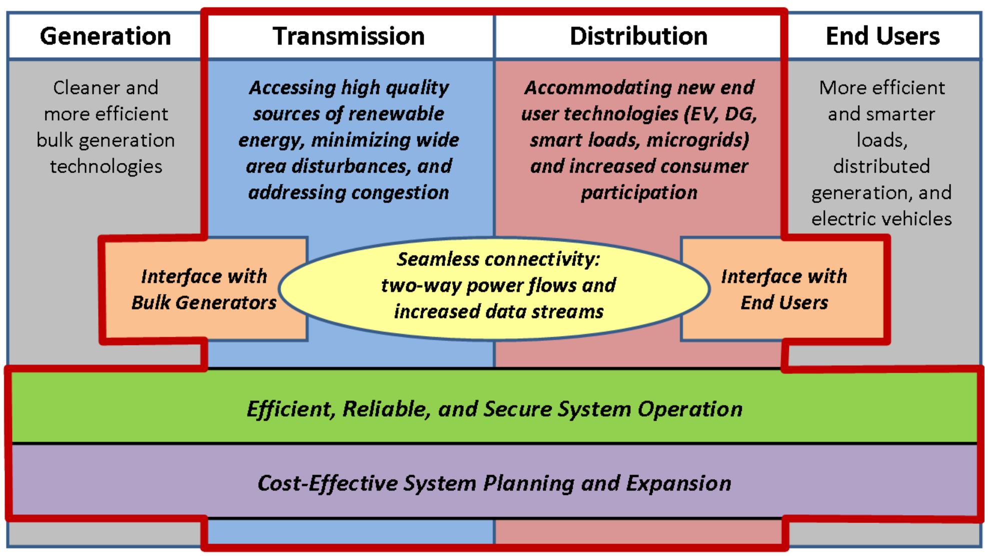
DG	distributed generation
DOE	U.S. Department of Energy
DSO	distribution system operator
EC	European Commission
ENTSO-E	European Network of Transmission System Operators for Electricity
ERCOT	Electric Reliability Council of Texas
EU	European Union
FERC	Federal Energy Regulatory Commission
ISO	independent system operator
IWTP	Interconnection Wide Transmission Planning
NERC	North American Electric Reliability Corporation
PMA	Power Marketing Administration
PUC	public utility commission
PV	photovoltaic
RES	renewable energy source
RPS	renewable portfolio standard
RTO	regional transmission operator
TEN-E	Trans-European Energy Network
TSO	transmission system operator
TYNDP	Ten Year Network Development Plan
U.S.	United States

Executive Summary

THE HOLISTIC APPROACH TO SMARTER ELECTRIC SYSTEMS

ISGAN Annex 6 is working to establish a long-term vision for the development of smarter electricity systems. Flexibility, visibility, and understanding of grid operations are important characteristics that enable deployment of technologies to develop a more modern, smarter electric grid system that can securely, reliably, and resiliently adapt to the panoply of challenges it is likely to encounter in the coming decades. This effort will improve general understanding of smart grid technologies applicable to or influencing system performance, transmission capacity, and operation practices; accelerate their development and deployment; and, promote adoption of related enabling regulatory and government policies.

Addressing challenges such as changes in load profiles, electricity resources, disruptions, and development requires a systematic, holistic, integrated approach that considers not only the enabling technologies, but also the "rules of engagement" that facilitate their deployment. These "rules" include the laws and regulations that govern the electricity system, from generation to end user; the planning, operation, and "grid management" structure and implementation; and, the policy, market, and regulatory approaches employed or considered to enable achieving a smarter grid. As illustrated by Figure 1, across all elements of the "grid space" (outlined in red), it is also important to ensure efficient, reliable, and secure system operation as well as cost-effective system planning and expansion.



Institutional issues and solutions must be considered in conjunction with these technical challenges

Figure 1. Grid space encompasses conventional elements as well as their institutions and other drivers (e.g., markets, policies, regulations)

The United States Electric System

The United States (U.S.) "grid" is a highly complex and dynamic system that operates in connection with Canada and Mexico (together comprising the North American grid). The U.S.

electric system comprises three electrically independent networks—the Eastern, Western, and Electric Reliability Council of Texas (ERCOT) Interconnections—that are connected via direct current (DC) links (see Figure 2). This system is further divided into over 140 control areas responsible for balancing generation and consumption of electricity at all times. The U.S. electric system has no linear or singular operational or management structure.

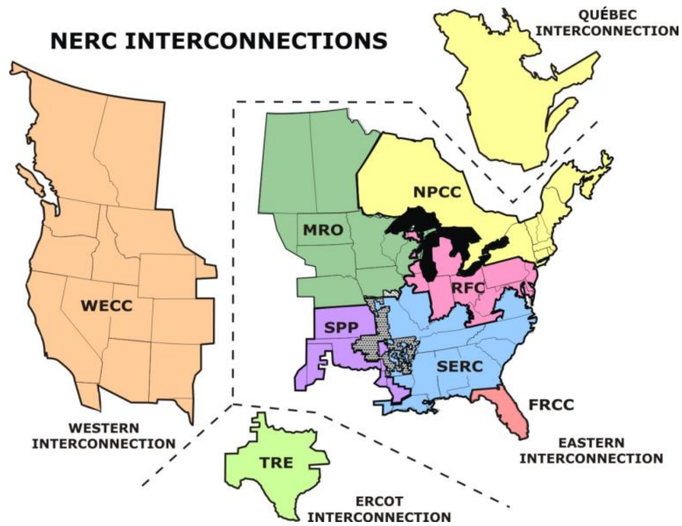


Figure 2. North American Electric Reliability Corporation (NERC) Regions across the North American interconnections

In the U.S., electricity markets and the electricity industry broadly have been undergoing major paradigm shifts over the past few decades. The introduction of open transmission access and restructured electricity markets in the 1990s has led to fundamental changes in ownership structures and planning and operational responsibilities. Because of the national scope of these issues, regional planning and cooperation among all levels of government and interested stakeholders have been encouraged by federal entities, including the U.S. Department of Energy (DOE) and the U.S. Federal Energy Regulatory Commission (FERC). One recent example of this is the DOE-funded Interconnection Wide Transmission Planning process in which five grantee-organizations within the three North American Interconnections in the U.S. have worked to analyze how best to approach the planning and build-out of their transmission systems moving forward.

The European Electric System

Power transmission in Europe is characterized by a high degree of interconnections and inter-area power exchanges, congestion, volatility, and diversity of operating conditions. The power system is subject to the thrust of pan-European market integration and the need to face the variability of renewables such as wind and solar from a system-wide approach, while guaranteeing reliability of supply. The European grid comprises five synchronous areas, 34 countries, and 41 transmission system operators (TSOs) (see Figure 3).

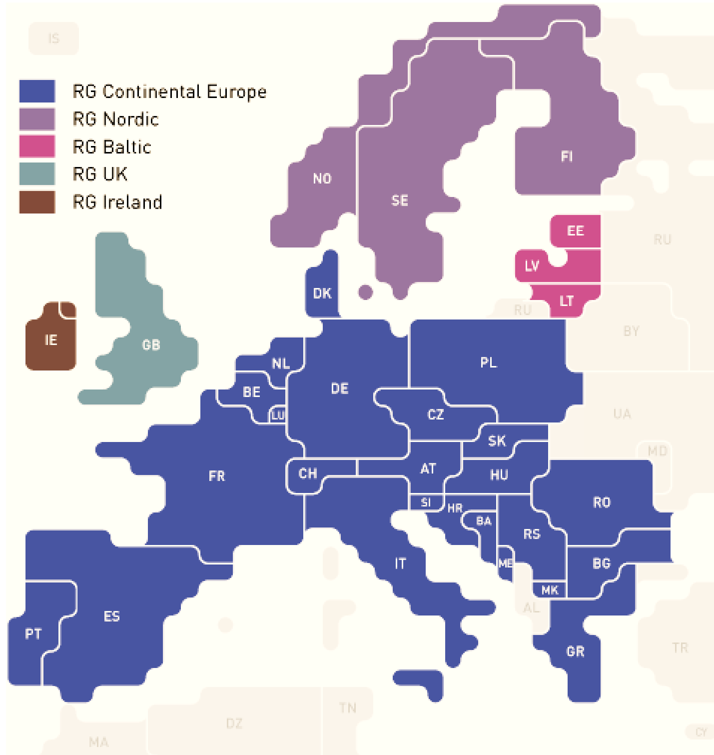


Figure 3. Synchronous zones in Europe

In recent years, electric power systems have been experiencing profound transformations. In the European Union (EU), issues concerning security of energy supply, electricity market restructuring, and environmental constraints represent key drivers for new trends that may have significant impact on the design and operation of the electric power system; this is particularly true for the transmission system. Moreover, and most critically, the European energy sector has been deeply changing as the EU member states decided in 2007 to lay down ambitious environmental targets to be achieved by 2020. Through these efforts, the European electric grids are on a critical path to meet the EU's climate change and energy policy objectives for 2020 and beyond.

Further issues faced by transmission planners nowadays are related to social and environmental constraints to the building (and in some cases even refurbishment) of transmission infrastructure. Aging European grid assets, increased penetration of distributed energy resources, and active demand will play a role in the power system and impact the upstream transmission. The period when generation was considered fully predictable and consumption fully stochastic is evolving to an era where generation becomes partially stochastic and, at the same time, the amount of controllable consumption rises. The combination of all these challenges requires a long and costly technical, market, and regulatory re-engineering process of the European energy system.

REGULATORY AND POLICY ENVIRONMENTS

In both the U.S. and Europe, there are many non-technical factors that drive or challenge the development of a smarter grid through deployment of technologies. Additionally, the hierarchy of governments and cross-border organizations add complexity to the already diverse challenges that are present in each electric system. Strategic measures taken by appropriate authorities can help to define the "rules of engagement" to better enable achieving a smarter grid.

United States Regulations and Polices – Past and Present

Traditionally, in the U.S., local electric utilities, municipalities, or cooperatives were granted a state-protected monopoly under the premise that insulation from competition was necessary to ensure reliable and cost-effective service. Beginning in the late 1980s and early 1990s, electricity regulators in some jurisdictions began experimenting with a deregulated market model. The unquestioned premise that the generation, transmission, and distribution of electricity, in order to operate effectively, must be protected by a legal monopoly no longer has universal agreement.

States and the federal government have separate but connected authorities in the electricity sector. The jurisdictional line between federal and state regulatory authority is not always clear. States have more flexibility within their borders to promote the public interest of both the state and federal governments and to determine how the energy needs of their citizens will be met, e.g., through renewable portfolio standard (RPS) programs. State public utility commissions (PUCs) are the primary regulatory bodies that govern the electricity sector within the borders of their states. PUCs are generally responsible for the retail rates of electricity and the siting of transmission projects. While the federal government is an important player in planning and building energy infrastructure, and can be a driver of innovation, most of the regulatory innovation in energy policy happens at the state level.

In the U.S., two federal entities have primary legal and regulatory jurisdiction over the electricity sector: Congress and the FERC. Congressional legislation has provided the legal authority for federal agencies to regulate and/or support innovation within the electricity sector. The FERC, with jurisdiction over wholesale transmission rates (among other authorities), has undertaken a series of orders to address some of the challenges facing the electricity sector, e.g., increased variable generation, transmission cost allocation, how regions of the electric system are managed, how electricity is traded, and how the electric system is operated and planned.

The overall regulatory framework for transmission planning and cost allocation is in a state of flux, influenced by the changing technological landscape. The FERC issued Order 1000 in 2011, building from previous FERC orders, with two primary objectives: (1) ensuring that transmission planning processes at the regional level are non-discriminatory, efficient, and cost-effective and (2) ensuring that transmission needs chosen via regional planning methods allocate costs fairly to those that receive benefits. Since the FERC issued Order 1000, states have been working to self-organize into qualified regions and submit plans to the FERC for review and approval. Some legal issues and challenges have arisen in connection with regional planning and cost allocation outcomes under Order 1000.

Many electricity markets operate within the structure of a regional transmission organization (RTO) or independent system operator (ISO). RTOs are voluntary associations of utilities that own electrical transmission lines interconnected to form a regional grid and that agree to delegate operational control of the grid to the association. There are six major RTOs/ISOs in the U.S. that serve about two-thirds of the country's electricity consumers.

Entities that do not participate in an RTO or ISO are accounted for under the North American Electric Reliability Corporation (NERC) "reliability regions." RTOs/ISOs play a significant role in overseeing the long-term planning for system operation needs and to coordinate operation of the transmission system.

Electric system infrastructure is often subject to regulation by other federal entities in the U.S. for environmental performance (e.g., generation and transmission/distribution emissions), environmental impact and historic preservation (e.g., for new transmission line construction), endangered species, and wetlands, to name some examples. Moreover, states often have similar regulations that must be complied with to obtain proper state permitting for new generation and transmission projects. These additional constraints add another layer of complexity to the planning and expansion of electric system infrastructure.

European Energy Policies – Past and Present

European energy policy has been based on three "pillars," namely increasing the generation from renewable energy and reducing CO_2 emissions (sustainability), guaranteeing security of energy supply (security), and integrating the European electricity market (competitiveness). In order to achieve these objectives, the transmission grid plays a central role within EU energy policy. In fact, a truly pan-European approach is needed for the planning and operation of electricity infrastructure, especially where a significant cross-border impact is concerned. In 2006, the European Commission (EC) issued the Trans-European Energy Networks (TEN-E) Guidelines document featuring a list of infrastructures recognized as priority projects of European interest. Notwithstanding some improvements in unlocking some TEN-E priority projects of European interest, the situation for the completion of such projects stayed critical.

In order to overcome this critical situation, the EC issued two additional communications in November 2010: (1) the first defined energy strategy in Europe towards 2020 targets and called for a step change in the way energy infrastructure and networks in Europe are planned, constructed, and operated and (2) the second set the creation of a pan-European methodological approach in prioritizing the projects of European interest as a key measure towards EU targets for 2020 and beyond.

To ensure timely integration of renewable generation capacities in Northern and Southern Europe and foster further market integration, four crucial priority corridors of the European power system were identified: (1) Offshore grid in the North Seas and connection to Northern and Central Europe, (2) Completion of the Baltic Energy Market Interconnection Plan, (3) Interconnections in South Western Europe, and (4) Connections in Central Eastern and South Eastern Europe. In addition to these four priority corridors, smart grid deployment and electricity highway development across Europe have been included as priority areas for infrastructure expansion towards 2020 and beyond. The realization that a potential pan-European supergrid is a complex process indicated that can only be considered in a long-term perspective (after 2020), as there are still several techno-economic, technological, regulatory, market, and socio-environmental issues that will have to be properly handled and solved over the years.

In view of fostering cooperation and harmonization in transmission planning and operation, as well as the dialogue between TSOs and institutions (primarily the EC and the regulating bodies), the EC promoted the creation of the European Network of Transmission System Operators for Electricity (ENTSO-E), the body of TSOs at the European level. ENTSO-E comprises 41 TSOs from 34 countries, some of which are not part of the EU.

An important contribution to the identification of common development according to EU objectives was given by the first (pilot) ENTSO-E Ten-Year Network Development Plan (TYNDP) 2010–2020, issued in 2010, extended then in 2012, and to be updated every two years thereafter.

TRANSMISSION OPERATION AND MANAGEMENT

Diversity of grid resources and operational strategies often add complexity to the grid. Understanding these factors and having appropriate visibility into their impacts on grid operation is paramount. Both the U.S. and Europe strive to achieve this through the deployment of smart grid technologies.

United States Electric System Operation

Operating and managing the grid is a multi-layered, complex system-wide task. Operation of the electric system does not happen unilaterally by a single entity, but rather is accomplished across a wide variety of organizations, from the state to the federal level, acting in concert across various functions. Moreover, the U.S. transmission system is managed across a variety of industry standards that vary according to jurisdiction. State and federal entities have jurisdiction over different aspects of electric system operation and management, primarily divided between transmission and distribution.

The distinction between transmission and distribution is one of size and scope. Transmission refers to the transport of electrons at high voltages from generating infrastructure to converting stations (substations or transformers) 100 kV or higher. In distribution systems, electricity is at much lower voltages; typically, the network would include medium-voltage (13 kV to 69 kV) power lines for commercial and industrial customers and low-voltage (less than 1 kV) power lines for residential customers (see Figure 4).

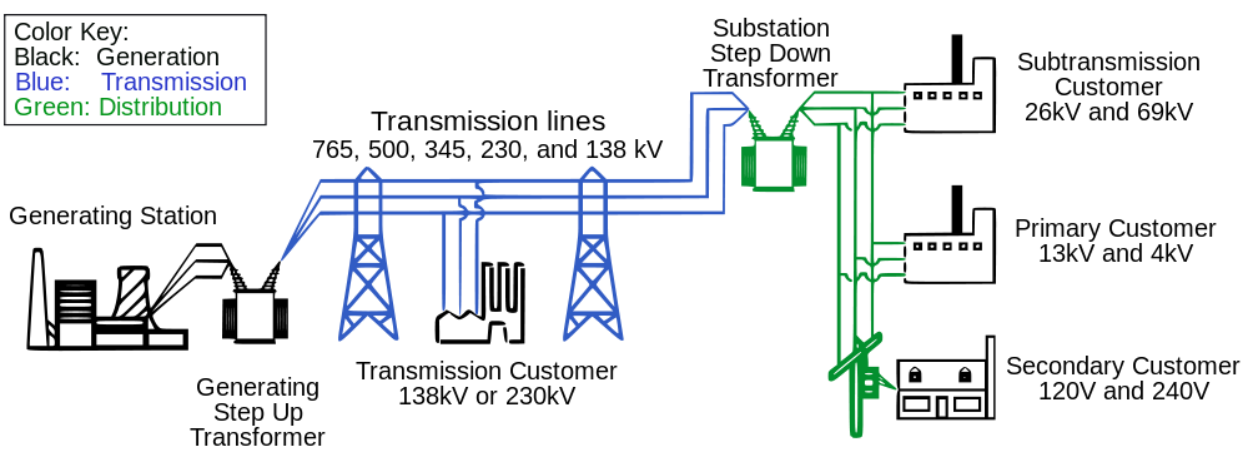


Figure 4. Schematic of the generation, transmission, and distribution system in the U.S.

At the federal level, NERC facilitates 15 reliability coordinators among the eight NERC regional reliability entities. The reliability coordinator ensures that schedules of power delivery are being met and oversees the individual balancing authorities. Balancing authorities are the entities that integrate resource plans ahead of time, maintain load-interchange-generation balance within a balancing authority area, and support interconnection frequency in real-time. Coordination between RTOs/ISOs and the various reliability areas and organizations constitutes the majority of the power flow in operating and managing the bulk power system. However, operating the electric system in the U.S. is a complicated matter.

At the "local" (distribution) level, the owner of the local distribution system is responsible for operation and maintenance and ensures the delivery of electricity to its customers. While the distribution and transmission systems traditionally had clearly defined relationships, their boundaries are blurring. Now, distribution systems entail or encompass broader concepts such as distributed generation (DG) and net metering.

European Electric System Operation

The major challenges of transmission system operation in Europe are due to the extension of the electricity market and to the integration of large amounts of renewables, in particular wind and photovoltaic (PV), and DG. As security limits are tested, jurisdictional issues may prevent optimal decisions from being implemented. For example, the technology and control strategies of DG inherently modify the dynamics of the power system, possibly causing stability problems. Overall, increased TSO/distribution system operator (DSO) coordination is needed, with changes on both the technical and regulatory sides.

However, the complexity of system behavior is increasing, as is the need for inter-TSO coordination. Enhanced analysis tools to assess online the security of the whole system and identify control actions are increasingly needed. ENTSO-E aims to support security of operation by harmonization of operating rules and cooperation among TSOs. Following are some highlights of the emerging issues relevant to operation:

(1) Security implications of the penetration of growing amounts of non-dispatchable renewable energy sources (RES), mainly wind and PV, allow reduction of the consumption share covered by fossil-fueled power plants, introducing a number of criticalities in power system planning and operation. Retrofitting programs of existing PV installations, in order to permit their continued connection to the system in cases of frequency disturbances, have been carried out particularly in Italy and Germany—the countries exhibiting the highest PV installed capacity.

(2) High power flow exchange between areas affecting the stability of operation of the European power system is increasingly dependent on the stability of each of its areas, as disturbances may propagate over wide areas.

(3) Deterministic frequency deviations from the setpoint, occurring around the change of the hour, recognized as a consequence of the market design, as generators change their scheduled output in steps every hour, implying a reduction of power reserves to face sudden power imbalances.

TRANSMISSION EXPANSION PLANNING

Transmission planning and expansion are often connected efforts. Several organizations provide various expertise to address the changing demands on a jurisdiction's electricity system. Understanding and identifying system solutions can be challenging. Scenario analyses help inform these solutions and the optimization of the electric system to address various concerns, including but not limited to reliability, social impacts (e.g., cost and environment), and resource availability.

Current Planning and Expansion in the United States

Transmission planning in the U.S. identifies efficient and cost-effective transmission expansion options. The need to accommodate variable energy resources into the grid in a coordinated and reliable way through cooperation lends itself to regional planning because of the large amounts of transmission infrastructure usually required for such projects. The more that systems can work with other systems across seams in a holistic way, the whole North American grid will be more secure and stable. One successful example is the previously mentioned Interconnection Wide Transmission Planning (IWTP) process through which the organizations are directed to develop 20-year transmission plans. The IWTP process addresses prospective needs of the respective interconnections.

Transmission planning may align along state and RTO/ISO boundaries, as in the case of the states of California and New York. Transmission planning in the larger regional markets spanning multiple states is more complex and implicates both federal and state planning mechanisms.

The DOE is supporting the development and maintenance of several different optimization tools, broadly referred to as the SuperOPF, along with the underlying MATPOWER package, an open-source power system simulation and optimization tool used widely in the power systems field, especially in academia. The unifying themes running through the various SuperOPF-based tools include the simultaneous, explicit modeling of multiple system states, where each state has a full set of optimal power flow (OPF) variables, constraints and costs, a stochastic or weighted cost across the various states, and additional variables, costs and constraints that tie these states together.

The introduction of electricity markets, together with increasing interregional trade and the integration of renewables, has made transmission expansion planning more complicated. Uncertainty about, for example, fuel prices, the location, amount and type of new generation, and electricity demand propogates through planning, expansion, and investment decisions.

Transmission expansion in the U.S. is accomplished through a variety of mechanisms. Transmission expansion is a natural outgrowth of the transmission planning process. The planning process may be seen as the analytical framework by which the actual physical expansion of the transmission network within a given grid system. Analyzing the physical needs of the system requires considering a number of variables that affect the physical and technological makeup of the respective grid components. Understanding and managing congestion is an integral component of transmission expansion. The DOE is required to conduct a triennial national electricity congestion study.

Expansion decisions must keep the grid operating securely and reliably. The ability to make decisions regarding actual expansion and build-out of generation and transmission infrastructure needs lies with the asset owners. While the RTO/ISO has planning authority, as noted above, states have authority over siting of transmission infrastructure. Each RTO/ISO plays a role in the transmission planning and expansion in its respective service area. The RTO/ISO engages in transmission expansion according to analysis of transmission needs and proposed changes to the transmission system as well as develops plans and forecasts for the region's future transmission and energy needs. These organizations make expansion decisions according to the outcomes of their planning processes.

Current Planning and Expansion in Europe

The transmission expansion planning process is a complex task in which the network planners need to handle several uncertainties and risk situations. In the past, before electricity market liberalization, in a centrally managed power system the vertically integrated operator could in general control the whole power system. Now, in a liberalized environment, the TSO, responsible for transmission, shall plan the expansion of its network by minimizing transmission costs (investment and operation), overcome bottlenecks, and pursue maximum social welfare, when requested by specific regulation, while meeting static and dynamic technical constraints to ensure secure and economically efficient operation. Socio-environmental constraints must also increasingly be taken into account in the planning process.

Some important criticalities make the task of a TSO at the same time crucial and very delicate. In fact, changes in future system conditions significantly affect benefits of transmission expansion. Thus, evaluating a transmission project based only on assumptions of average future system conditions might greatly underestimate or overestimate the true benefit of the project and may lead to less than optimal decision making. This can only be taken into account by using different scenarios. Now, it is of paramount importance to consider socio-environmental aspects for a more complete and systematic cost-benefit analysis. In some cases, environmental constraints and social opposition have obliged the transmission planners to reshape the rank of the investigated alternatives.

The European TSOs aim at two main objectives when planning the development of their grid: (1) maximizing system reliability and security of supply and (2) fostering the market to allow an efficient use of generation, thereby minimizing the total costs for the system. European countries have various objectives with their transmission planning. Features like the network planning timeframe, the utilization of deterministic and probabilistic criteria, also with consideration of market issues, are quantitatively and qualitatively compared for some European country systems.

For what concerns cost benefit analyses and market value in the European planning practice, most TSOs, taking also into account the aspects of environmental safeguard, evaluate and rank from the techno-economic perspective several possible alternatives stemming from the planning analyses and which—as a necessary pre-condition—fulfill the priority target of realizing a secure transmission grid. Given the high costs of investments and the long lifetime of the transmission assets, it is crucial to make the right decision at the right time. However, the future evolution is uncertain, and public opposition tends to halt hardly any transmission expansion projects. Comprehensive cost-benefit analysis, accounting for a wide range of benefits and costs, can also reduce the issue of public acceptance while identifying the projects that are of "real" relevance for the European energy policies.

As the availability of renewable electricity sources is continuously increasing, and new and variable generation sources are expected to be developed further away from major consumption sites, electricity must be transported over longer and longer distances and across national borders to be delivered where consumption needs arise. A pan-European network is required to enable integration of TSOs and benefit from the different behaviors of consumption and generation to use, e.g., the wind energy from North-Western Europe, the solar energy from Southern Europe, and the biomass from Eastern Europe.

To this aim, the concept of an innovative "Electricity Highway System" has been introduced. To address these challenges, the e-Highway 2050 research project[2] aims to develop foundations of a modular and robust expansion of the pan-European electricity highway system network capable of meeting future European needs (e.g., energy policy, integrating renewables, international electricity market, and security of supply).

MARKET STRUCTURE AND OPERATIONS

Electricity markets are designed and operated through a variety of mechanisms, often depending on how the electricity system is operated and managed.

United States Electricity Markets

In the U.S., electricity markets are highly complex. There is no national electricity market, and a variety of types of planning and operational paradigms exist in different regions. There are five centralized electricity markets in the Eastern Interconnection, characterized by the existence of RTOs and ISOs, centrally cleared market prices, and various forward and real-time market settlements. The Western Interconnection has only one centralized market.

Despite the range of institutional configurations, there is some consistency in jurisdictional issues. States have jurisdiction over the rates charged for retail power and for siting of infrastructure, including transmission. The FERC has jurisdiction over the rates charged for using a bulk transmission system in centralized markets and independently-owned utility territory. Federal power marketing administrations (PMAs) are not subject to FERC jurisdiction because they are part of the DOE. All FERC-jurisdictional utilities and transmission owners and operators are subject to open access requirements. But, following open access rules does not necessarily mean implementing a centralized, formal electricity market.

Regional centralized electricity market rules and operation are influenced by a variety of factors, including federal statutes, federal regulations, RTO/ISO guidance, stakeholder input, NERC reliability standards, and the forces of competitive markets. Centralized electricity markets are designed and operated by the RTOs or ISOs, along with input from industry stakeholders, and are subject to FERC approval. In general, the trade and transportation of wholesale electricity is regulated or governed by the federal government, while retail sale of electricity is regulated by state-level regulatory authorities. The FERC approves transmission

[2] The e-Highway2050 project is supported by the EU Seventh Framework Programme and is aimed at developing a methodology to support the planning of the Pan-European Transmission Network, focusing on 2020 to 2050, to ensure the reliable delivery of renewable electricity and pan-European market integration.

tariffs, but states regulate consumer tariffs. Four distinct types of markets that typically make up a centralized market are (1) capacity markets, (2) energy markets, (3) ancillary service markets, and (4) transmission capacity markets. Outside of centralized markets, the firm transmission or transmission constraint market allows for open access of the transmission system. The RTO or ISO is an important player in the electricity system in the U.S. because of their power to shape and operate markets across large portions of the country among a diverse set of fuel sources dealing with a variety of geographic and institutional issues. While RTOs and ISOs are not legislative- or rule-making bodies, they implement legislation and rules such as the mandate for the open access transmission system.

European Electricity Markets

As far as the European electricity market is concerned, the European Council announced two ambitious targets in February 2011: (1) completion of the internal energy market by 2014 and (2) no member state electrically isolated from the rest of the EU by 2015. The integration of different national electricity markets toward the European objective of a single internal energy market is clearly a benefit for the whole system, bringing more actors into the playing field, thus increasing cross-border competition and improving the social welfare of the coupled markets.

Until now, the main impact studies and most noteworthy regulatory efforts have been focused on the integration of the national day-ahead market through the progressive enlargement of the market coupling. It is important to notice that the integration of electricity markets closer to real-time, the most critical for the proper functioning of the system, is an important goal to achieve at a pan-European level.

The European market is undergoing an integration process. However, the way the process is implemented will definitely impact the efficiency of the resulting market and also the flexibility of grid operation. The real challenges include the regulatory harmonization of both day-ahead and balancing markets, and the implementation from the methodological and information and communications technology standpoints. In fact, the algorithmic and computational requirements posed by the integrated market problem accounting for all specific rules are very demanding.