Engineering, Economics & Regulation of the Electric Power Sector

ESD.934, 6.974

Session 22
Module K

Regional electricity markets

Case example: EU Internal Electricity Market

Prof. Ignacio J. Pérez-Arriaga

Readings *(1 of 2)*

- T. Jamasb & M. Pollitt, "Electricity Market Reform in the European Union: Review of Progress toward Liberalization & Integration", CEEPR Working Paper 05-003, 2005
- J. Sierra & I. Pérez-Arriaga, "Energy Policy in the European Union", IEEE Power & Energy Magazine, Sep/Oct 2009
- ETSO & EuroPEX, "Development & implementation of a coordinated model for regional and inter-regional congestion management ", April 2008

Readings *(2 of 2)*

- Florence School of Regulation, "A study on the Inter-TSO compensation mechanism", research paper, Oct. 2005
- Slide presentation of Project SIEPAC & design of the Central American Electricity Market
- The World Bank, "Building Regional Power Pools: A Toolkit" *<Should anyone propose a toolkit to design regional markets in developing countries and use NordPool as an example?>*

The EU Internal Electricity Market (IEM)
Objectives & challenges

- The objective
  - An operating Internal Electricity Market (IEM) where electric energy is delivered at the lowest cost that is compatible with a satisfactory quality of supply & environmental sustainability
- The challenge
  - How to implement it, taking the initial existing situation as the starting point

4

Specific issues in regional electricity markets

5

Markets integration
An international trend

- Regional markets integrating several national markets are becoming a common practice all over the world
- Economic efficiency and security of supply
- Relevant international experiences:
  - European Union (IEM, including NORDEL, MIBEL, SEM), ISO/RTO markets in the US (after Standard Market Design), Central America (MER), South America (MERCOSUR and the Andean market), Australia, South Africa, Mekong, Nile, etc.

6

Market integration benefits

- Higher **efficiency** and *(hopefully)* lower **environmental costs**– Efficient and environmental friendly generation replaces less efficient generation
- Increase **power system security**: larger systems are more robust against system contingencies if control areas are well coordinated
- Increase **security of supply**: primary energy sources are more diversified
- Increase **competition** in generation and supply
  - Wholesale market (increase size of the relevant market)
  - Retail market (higher possibilities to choose supplier)

7

Regional institutions and regulation

- Political willingness and compromise among governments
- Legislation at the top level: Treaties, Directives,…
- Creation of Regional Institutions or Associations: Energy Regulators, Transmission System Operators (TSO), Power Exchanges (PX),…
- Regulatory principles for regional integration
  - Transparent and non discriminatory regulation
  - Competition as market driver
  - Free energy exchanges using transmission interconnections
  - Free third party access to networks
  - Harmonization of national regulations to meet regional agreements and legislation

8

Key elements in the design a regional market

- Long process with continuous political support
- Key issues with several maturity stages:
  - Development of regional market legislation and harmonization of national legislations
  - Creation of regional market institutions
  - Development of required interconnection capacities
  - Market mechanisms to reserve interconnection capacity and joint congestion management procedures
  - Transmission cross-border tariffs
- **Single market paradigm**: the outcome of the regional regulation should approach as much as possible a sound regulation for a single system of regional dimension

9

Objectives for a regional electricity market

- A market really encompassing the **entire region**
- A **truly competitive** market in electricity & gas
  - For energy, capacity, ancillary services & retail markets
  - Efficient free entry & investment
  - Efficient cross-border trading
- Acceptable **security of supply**
- Efficient & non-discriminatory **electricity prices** that foster regional competitiveness
- The regional market as a key component of a **sustainable energy model** for the region

10

Design of a regional electricity market
Regulatory challenges (1)

- **Market structures** suitable for competition
  - Insufficient interconnection / Horizontal concentration / Vertical integration / Diagonal integration / Incomplete market opening / Barriers to entry & to switching supplier
- Adequate **guarantee of supply** in primary energy sources & generation investment
- Adequate rules to share the common **transmission** network
  - Investment, access & pricing issues
- Efficient & non-discriminatory electricity **tariffs & prices** all over the region

11

Design of a regional electricity market
Regulatory challenges (2)

- **Sustainability** of the energy model ➔
  - Radical support of renewable energy sources
    - Efficient financial mechanisms
    - Incorporation of a large volume of **intermittent & non-controllable** energy sources in system operation
  - Aggressive policy of **energy saving & efficiency**
- A minimum level of **harmonization**
  - Previous items / CO2 emissions trading / market rules for cross-border trade / promotion of renewables / balancing mechanisms / market information / other

12

Design of a regional electricity market
Regulatory challenges (3)

- Any feasible implementation scheme cannot ignore two critical facts
  - In the medium term (at least) **there is a limit to harmonization**: for instance, the EU IEM encompasses 27 countries with different regulations & pace of liberalization, with several functioning PEXs, etc.
  - the **laws of physics** in system operation

13

But let's start from the beginning…

The struggle to establish a EU energy policy

Some basic data & trends

- Evolution & current trends (1990 to 2030)
  - **Liquid fuels** (38% in 2000): absolute growth, slight reduction in %. Transport is key
  - **Natural gas** (23% in 2000): absolute & % growth
  - **Solid fuels** (18% in 2000): absolute & % reduction; possible change
  - **Nuclear** (14% in 2000): absolute & % reduction. Debate
  - **Renewables** (6% in 2000): strong absolute & % growth
  - **CO2 emissions**: trend to increase after 2010
  - **Energy intensity**: diminishing steadily
  - **Energy dependence**: 45% (1990) to 68% (2030)

15

Towards a EU energy policy *(1 of 3)*

- After much indecision, the EU has recently established important regulation
  - Inspired by sustainability & with the classical objectives of security, economy & environmental concern
  - Reduction 2020/1990 of CO2 emissions by 20% *(30% if international consensus)*
  - Improvement of 20% of efficiency in consumption
  - Target of 20% of renewables in final energy consumption *(approx. 40% of electricity production)*
  - Implementation of the GHG Emission Trading Scheme, more than 10 Directives & Regulations approved in 2009, standards for appliances, sustainability criteria for biofuels, instruments to support clean technologies, etc.

16

Towards a EU energy policy *(2 of 3)*

- Creation of new institutions with EU-wide reach
- Agency for Cooperation of Energy Regulators, ACER
  - Framework for national regulators to cooperate
  - Regulatory oversight of the cooperation among TSOs
  - Individual decision powers *(without normative decisions)*
    - Exemption requests for infrastructure assets
    - Regulatory regime concerning cross-border infrastructure
    - Specific decisions when established by any Guidelines under comitology procedure
  - General advisory role
- European Network of TSOs, ENTSO

17

Towards a EU energy policy *(3 of 3)*

- Still contradictions & obstacles exist
  - The need for consensus in "energy matters"
  - Member States have exclusive competence on the technology mix
  - Latent conflict between two opposing models:
    - "liberal" (more competition, market integration, collective security, multilateralism)
    - "nationalistic" (more traditional regulation, self-sufficiency, national security, national champions, bilateral relations)
  - Potential lack of maturity for an integrated management & a common foreign policy
  - Ambiguity in nuclear energy, insufficient interconnection policy, weaknesses in competition law & institutions

18

A cursory review of a few topics of relevance for electricity markets

The topics

- Who is in charge?
- Compatibility of markets & public energy policy
- Regional initiatives: A seamless EU IEM?
- Transmission network expansion
- *Other topics not covered here: new paradigms in system operation, EU competition enquiry, energy R&D, the EU approach to "smart grids"*

20

Who is in charge?

(the story of the Inter-TSO payments)

Development of cross-border trade regulation

- Progress has been difficult with so many institutions & viewpoints, lack of effective decision-making procedures & no clear sense of direction

  ➔The overall approach might work, but very slowly

- A **case example**: Inter-TSO payments
  - Countries compensate one-another for the utilization of their networks
  - A procedure is needed to quantify "network utilization"
  - The net balance of compensations & charges for each country is added to its total network cost from which transmission tariffs are computed
  - The national network charge gives access to the entire EU

A little history *(1 of 4)*

- First EU Electricity Directive (1996)
  - Ambiguous. Transmission charges could be negotiated or regulated. Scarce progress in market implementation
- National independent regulators take the lead. The Florence Forum is born in 1998
  - The concept of the "single system paradigm" & complete EU-wide access with just local network charges plus inter-TSO payments is agreed
  - But, how to implement it? Initial consensus results in a provisional & highly questionable method *(March 2002)*
- Creation of ETSO, CEER, EUROPEX, EFET, etc.

23

A little history *(2 of 4)*

- The ensuing debate
  - An endless debate to decide on a more sound & permanent method. How to reach a decision? Proposals by ETSO & some regulators. Positions aligned with national interests. Gridlock
- 2003 Directive establishes minimum requirements on
  - Network access, creation of wholesale markets, unbundling of activities, installation of new generation, consumer eligibility, role of regulators, etc.

24

A little history *(3 of 4)*

- But 2003 Regulation does not provide specific implementation criteria on
  - Harmonization of transmission charges, cross-border tarification, network congestion management, handling of long-term contracts, interconnection reinforcement ➔ *little guidance to solve the Inter-TSO compensation problem*
- Creation of ERGEG & extension of UE
  - Comitology with even more actors. Hopeless gridlock of regulators & TSOs with new proposals under request of EU Commission. Nobody is really in charge with executive power

25

A little history *(4 of 4)*

- 2009 Electricity Directive & Regulation
  - Creation of ENTSO & ACER
  - Still no executive power by ACER to approve regulation, & ENTSO has no regulation competence, but at least there will be institutions with true EU-wide mission & scope, & the technical capability & adequate internal procedures to produce meaningful proposals
- & now the presentation of the current approach *(which is conceptually sound)*...

26

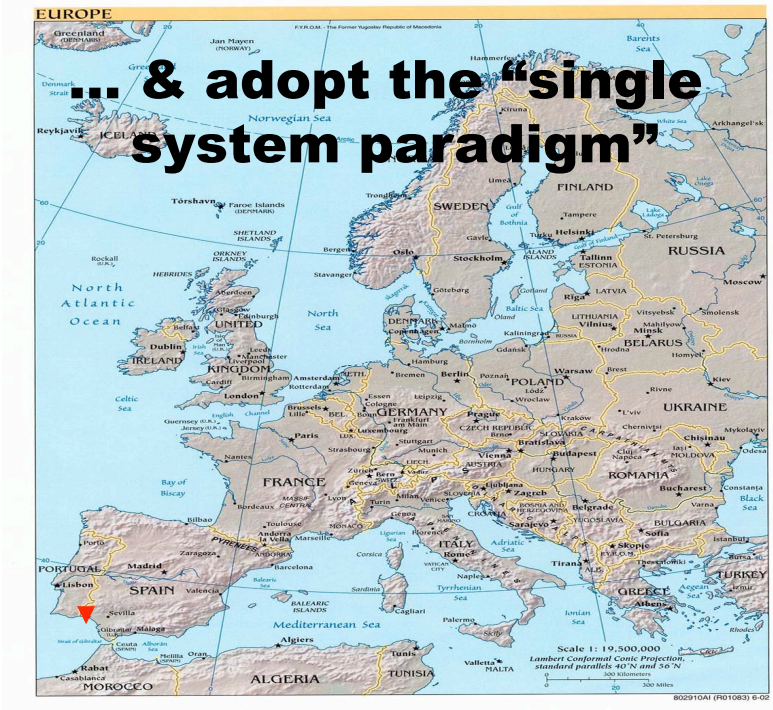
What is an acceptable cross-border trading scheme?

- The "obvious" approach is wrong:
  - Treat each cross-border transaction CBT as a local generator or demand that is placed at the corresponding border node ➔ this leads to tariff pancaking & lack of coordination in transaction management
    - economically inefficient
    - an obstacle to international trade

➔ back to the basics

27

Abandon this mental model …



Cross-border tarification

"Single system paradigm" for transmission network pricing ➔

- Local connection charge (G, L) provides access to entire EU network
  - charges are independent on the commercial transactions
  - some transmission tariff harmonization should be achieved

30

Cross-border tarification

- **Implementation**
  - Pan-European access with local G & L charges
    - Implemented since March 2001
      - An initial export fee was applied & eliminated two years later
  - Inter-TSO payments to compensate for external network use
    - A crude temporary scheme was adopted in 2001. The initial disagreement on the appropriate method to measure external network use, how to determine its cost & how to allocate the charges still persists

31

Cross-border tarification

- **Implementation** *(cont.)*
  - no cross-border tariffs, but inter-TSO payments
  - with the net balance of inter-TSO payments each country modifies its internal G & L tariffs
  - Note that the final G & L tariffs are not transaction-based *(& this is how it should be)*

32

Inter-TSO payments

Computation

- **Step 1.** Determine the **compensation** that is due to each country/TSO on the basis of the external use of its network & standard network & energy costs
- **Step 2.** Determine the **charges** to be applied to each country/TSO because of its responsibility in the extra costs of other countries
- **Step 3.** Application of the **net balance** of compensation & charges of a country/TSO to its internal network users

33

How to make markets & public energy policy compatible?

Some important questions

- In the context that can be anticipated of strong sustainability & security oriented policy measures
  - How to improve / redesign market regulation to facilitate that these policies reach their objectives efficiently?
  - How to make these policy measures compatible with the functioning of electricity markets?

See the special issue of The Energy Journal "The future of electricity: Papers in honor of David Newbery", 2008, for a detailed elaboration on these issues

36

First, indicative planning

- What is intended to accomplish? *(national & supranational energy policies require long-term analysis with sustainability criteria)* ➔ **indicative planning** (IP)
  - The IP procedure is meant to characterize meaningful energy development paths that meet any prescribed high level *(sustainability & others)* targets, in order to facilitate political decisions
  - Note that, once one path is chosen, IP
    - is more than just **prospective** analysis *(find what could happen)*
    - has **normative** character *(identify what has to be done to make sure that a future with some desirable features happens)*

37

EU Electricity Directive, 2009

Art. 2: "… In relation to security of supply, energy efficiency/demand side management and for the fulfillment of environmental goals and goals for energy from renewable sources, … Member States may introduce the implementation of long-term planning, taking into account the possibility of third parties seeking access to the system."

Art. 7.2: "Member States shall lay down the criteria for the grant of authorisations for the construction of generating capacity in their territory. In determining appropriate criteria, Member States shall consider: … (j) the contribution of the generating capacity to meeting the overall Community target of at least a 20 % share of energy from renewable sources in the Community's gross final consumption of energy in 2020... and (k) the contribution of generating capacity to reducing emissions."

Art. 10: "Member States shall implement measures to achieve the objectives of social and economic cohesion and environmental protection, which shall include energy efficiency/demand-side management measures and means to combat climate change, and security of supply, where appropriate. Such measures may include, in particular, the provision of adequate economic incentives…"

38

Regulatory challenges *(1 of 2)*

- **Choice of instruments** to develop & deploy **clean technologies** (electricity generation & energy efficiency & conservation, ECE) to meet IP targets
  - Use **market prices** *(of energy, emissions, green or white certificates)* with as much internalization as politically possible
  - **BUT** while full internalization of sustainability implications is not achieved ➔ use **additional regulatory instruments** *(quotas, standards, incentives, cross-cutting policies)* while trying to minimize market distortion

39

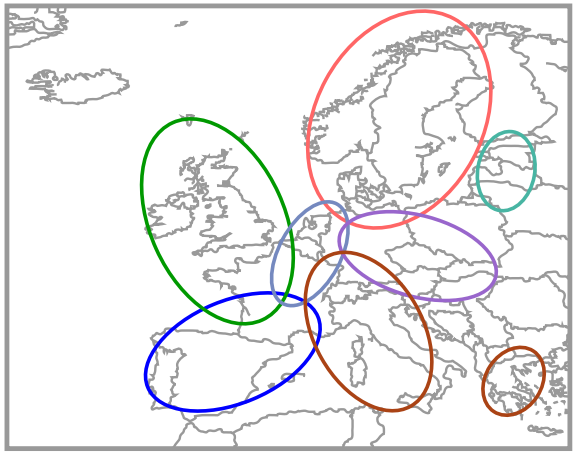
Regulatory challenges *(2 of 2)*

- Choice of instruments to make possible a **clean technology mix** in electricity generation
  - **Nuclear**: if politically acceptable, it might need some regulatory commitment to reduce financial risks
  - **Clean coal (CCS)**: presently only viable with regulatory support *(until sufficiently high & stable CO2 prices exist)*
  - **Renewables**: same; support scheme should depend on level of maturity of technology, cost & rules for integration in the market *(which affect the economic viability of other plants)*
  - **Peaking plants**: economic viability strongly depends on regulation of security of supply & intermittent generation

➔ *Reduced, but still significant, space for the market* 40

Regional initiatives: Towards a seamless EU IEM?

The electricity Regional Initiatives



Region	Lead regulator
Central-West	Belgium
Northern	Denmark
UK and Ireland	Great Britain
Central-South	Italy
South-West	Spain
Central-East	Austria
Baltic	Latvia

Central West
Northern
UK & Ireland
South West
Central South
Central East
Baltic

Image by MIT OpenCourseWare.

From RIs to a true EU IEM

- The magnitude of the challenge is worth noticing: coordinated congestion management at EU-wide level
- 7 Regional Initiatives (RIs) were created to remove barriers to trade & achieve a high level of harmonization just among neighboring countries
  - with the expectation of integrating the RIs into a single EU IEM later
- The success has been very limited so far & the progress very slow

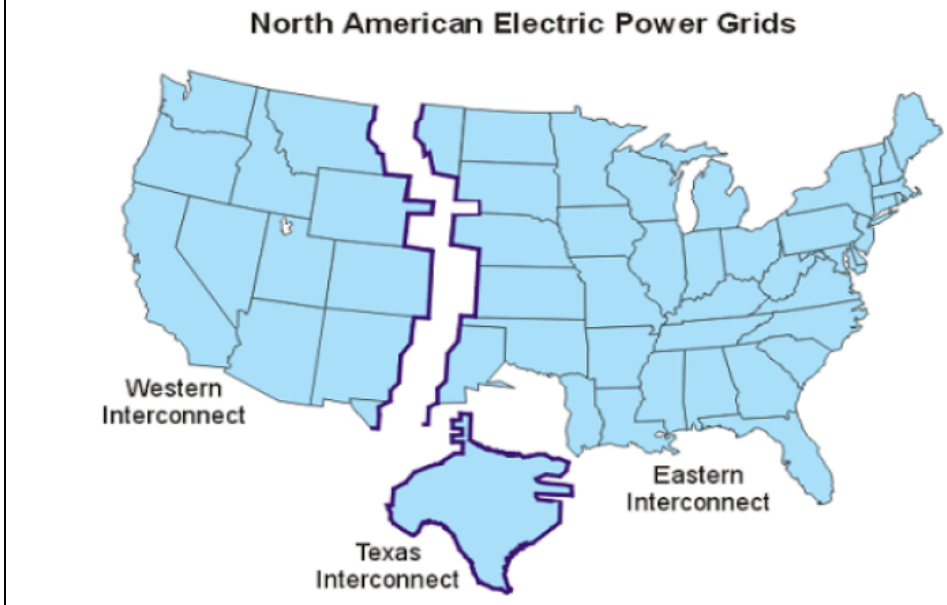
43

The Internal Electricity Market (IEM) of the EU

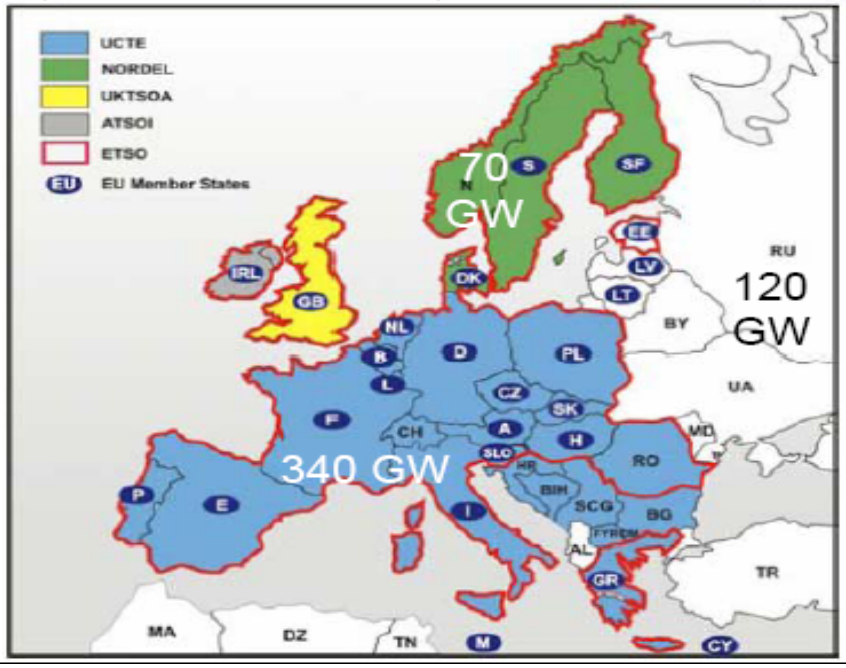
US & EU: a basic comparison

- EU-27 & IEM
  - 4,3 Mkm2, 493 Mhab, 11600 b€ GDP
  - 741 GW installed capacity
  - 3309 TWh/year
- *(Installed capacity, annual production)*
  - Germany (124 GW, 620 TWh)
  - France (116 GW, 578 TWh)
  - UK (81 GW, 398 TWh)
  - Italy (85 GW, 304 TWh)
  - Spain (70 GW, 294 TWh)
- USA
  - 9,8 Mkm2, 300 Mhab, 13200 b$ GDP
  - 1076 GW installed capacity
  - 4200 TWh/year
- *(Installed capacity, annual production)*
  - PJM (164 GW, 763 GWh)
  - MISO (127 GW, xxx)
  - ERCOT (80 GW, 290 TWh)
  - California (55 GW, 240 TWh)
  - NY-ISO (40 GW, 167 TWh)
  - NE-ISO (31 GW, 134 TWh)

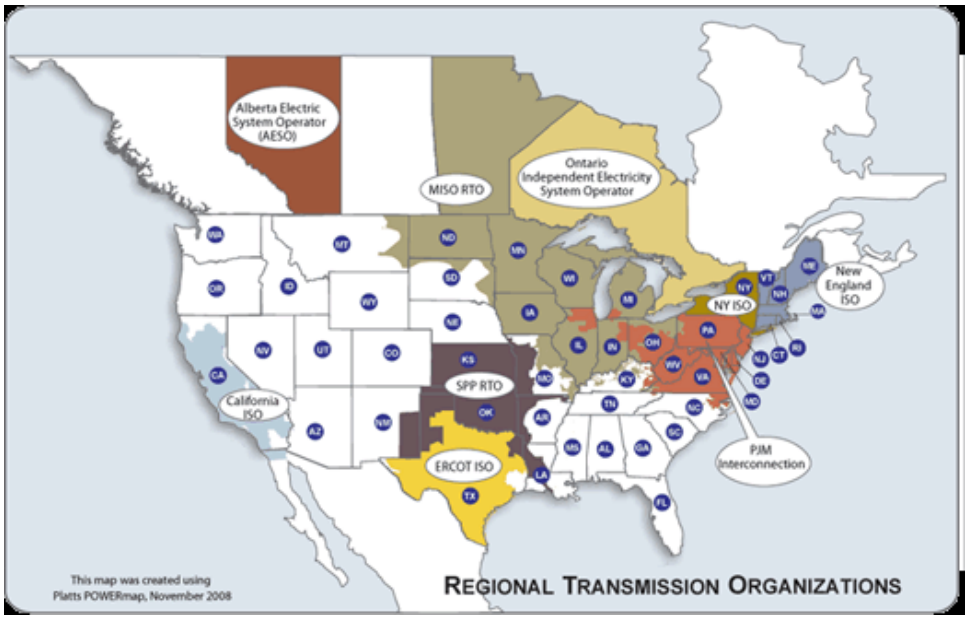
45

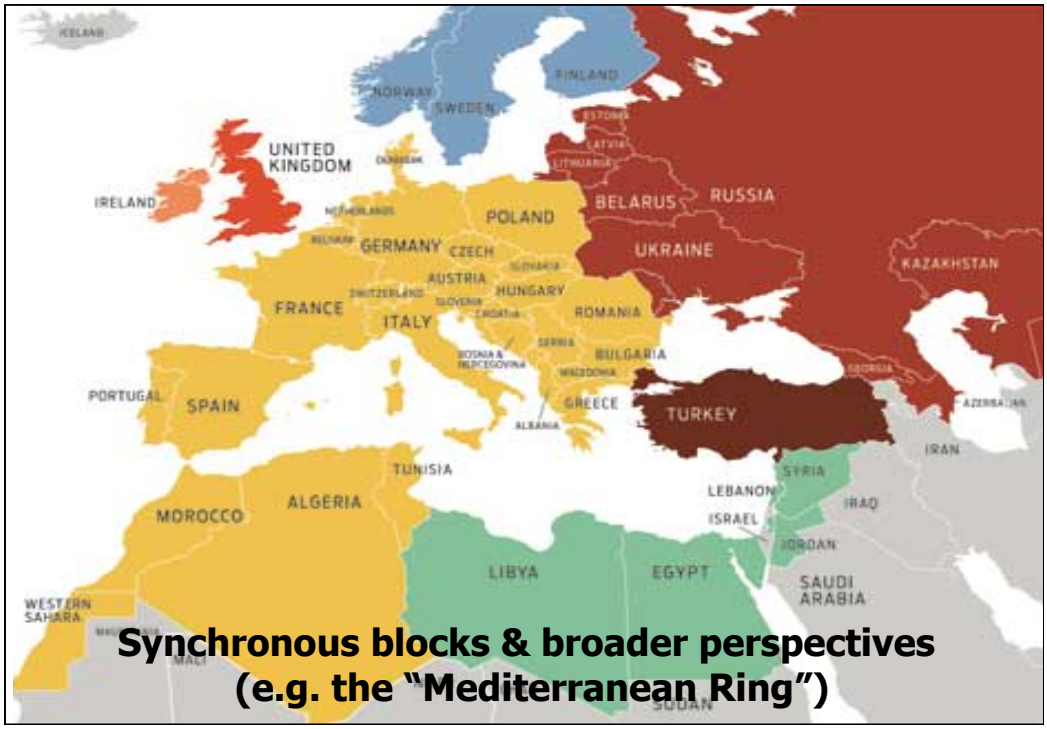


Synchronous subsystems in Europe



US & Canada Regional Transmission Organizations





Synchronous blocks & broader perspectives (e.g. the "Mediterranean Ring")

Tasks being addressed by the RIs

- Coordinated transmission capacity calculation & utilization of a common network model
- Towards a regional single auction platform, with harmonized rules, IT interface & products for medium & long-term allocation
- Towards a market coupling model for the day-ahead timeframe
- Towards an intra-day mechanism, possible based on continuous trading
- Integration of balancing markets
- Integration of transparency requirements

The way ahead *(1 of 3)*

- Conceptually, LMP, locational marginal pricing *(nodal energy pricing)* would the ideal solution
  - It is widely used in the USA, but only at RTO level
  - Generalized LMP does not seem to be a viable solution in the EU in the medium term
- Although the incremental contributions of mini-Fora and RIs have been meager, they have been probably useful in helping to create some conceptual consensus
  - Much coincidence now between ENTSO & EuroPEX, as shown in its recent joint report with a very limited range of alternative designs

The way ahead *(2 of 3)*

- Need for top-down guidance at this point
  - According to the 3rd package, this should result from ACER establishing some guidelines, ENTSO developing the corresponding network codes following the guidelines, ACER verifying that the network codes are in compliance with the guidelines, ACER sending the network codes to the Commission for approval.
  - The RIs can be useful in some aspects of the implementation process, since it is true that in some issues it suffices with adopting decisions at regional level, better adapted to the specific local situation and with no further implication at the broader EU level (decentralized RI implementation of some measures of just RI scope)

The way ahead *(3 of 3)*

- What can be done while ACER becomes operational?
  - ENTSO & EuroPEX in their joint report propose a "Market integration design project", with a technical body and a political one *(the Steering Forum)*
    - A "project" avoids creating any additional institutions *(given that adequate ones have been already created in the 3rd package)* but it allows continuing activities and making progress
  - Some EU Power Exchanges (PEX) have already started merging (German EEX & French PowerNext) or establishing advanced PEX coordination schemes (France, Germany, Belgium, Netherlands, Nordel plus Portugal & Spain)

Other actions at EU level

- EU Commission has focused on regions where progress was slow & on priority European projects
  - The Priority Interconnection Plan (PIP)
  - A revision of the Trans-European Energy Network (TEN-E) guidelines.
  - A High Level Group was set up to speed up progress in the South West electricity region
  - EU coordinators for key energy infrastructure projects
  - 3rd package contains a provisions to enhance market integration; harmonize the powers and independence of regulators at a national and EU level; increase transparency; & provide for effective unbundling

Transmission network expansion

The challenge…

- Despite the large geographical dimension of the EU IEM & open transmission access, there are **not very significant transfers of electricity** between regions
  - The interconnections between regions are frequently weak
  - Typically there are no major surpluses / deficits
  - Generation technologies at the margin are frequently similar
- **This situation will probably change** with massive deployment of renewable generation, either internal or external
- A comprehensive approach to **transmission expansion has been lacking**, as well as the institutional capability for an effective implementation

56

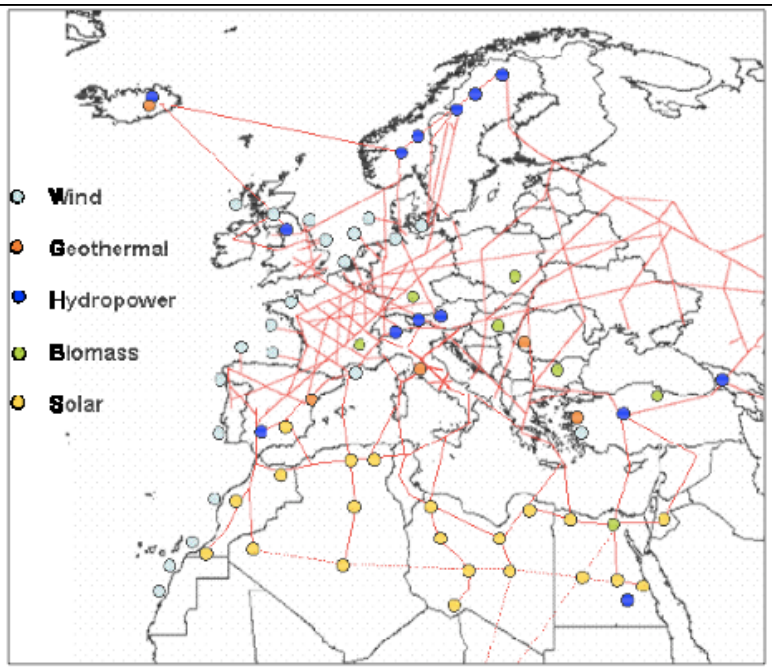


Figure 2: Vision of an EUMENA backbone grid using HVDC power transmission technology as "Electricity Highways" to complement the conventional AC electricity grid.

...the sound regulatory approach

- Transmission capacity expansion must be based on comprehensive planning studies, in principle encompassing the entire interconnected system
- Responsibilities for planning, authorizing, siting & pricing should be clearly assigned
- Pricing & remuneration of transmission should be transparent, low risk & convey efficient locational signals
- Provide effective open transmission access
- Adopt an advanced approach to system operation that properly addresses intermittency with state-of-the-art technology, integrating demand response & storage

58

… some conflicting views

- Large very-high voltage "overlays" *(multiple major additions)* **versus** incremental network development
- Global broad planning perspective **versus** comprehensive utilization of local resources *(typically with associated local side benefits)*
  - Transmission expansion creates asymmetrical benefits & costs
- Pros & cons of extending the scope of the tightly interconnected system
  - Increment of efficiency
  - Reduce impact of intermittency
  - Security of system operation

59

… and the EU regulatory response

- Electricity Directive & Regulation, July 2009
  - Establish the participation of TSOs, collectively (ENTSO) & individually, the regulatory authorities, collectively (ACER) & individually, the Member States & the concerned stakeholders
  - Non mandatory EU-wide transmission expansion plan prepared by ENTSO */European Network of Transmission System Operators)* & ACER *(Agency for the Cooperation of Energy Regulators)*
  - Mandatory national transmission expansion plan prepared by national TSO & approved & enforced by regulator

60

EU Electricity Directive & Regulation, 2009

Art. 22. ***Network development and powers to make investment decisions.***

"Every year, transmission system operators shall submit to the regulatory authority a ten-year network development plan based on existing and forecast supply and demand after having consulted all the relevant stakeholders. …The regulatory authority shall consult all actual or potential system users on the ten-year network development plan in an open and transparent manner."

"When elaborating the ten-year network development plan, the transmission system operator shall make reasonable assumptions about the evolution of the generation, supply, consumption and exchanges with other countries, taking into account investment plans for regional and Community-wide networks."

Article 8(3)(b) of Regulation (EC) No 714/2009: "The ENTSO for electricity shall adopt: …a non-binding Community-wide ten-year network development plan, (Community-wide network development plan), including a European generation adequacy outlook, every two years…"

61

EU Electricity Directive & Regulation, 2009

Article 8(11) of Regulation (EC) No 714/2009: "The Agency (ACER) shall provide an opinion on the national ten year network development plans to assess their consistency with the Community-wide network development plan. If the Agency identifies inconsistencies between a national ten-year network development plan and the Community-wide network development plan, it shall recommend amending the national ten-year network development plan or the Community-wide network development plan as appropriate."

Art. 22. ***Network development and powers to make investment decisions (cont.)***

"The regulatory authority shall examine whether the ten-year network development plan covers all investment needs identified during the consultation process, and whether it is consistent with the non-binding Community-wide ten-year network development. …The regulatory authority may require the transmission system operator to amend its ten-year network development plan."

"Member States shall ensure that the regulatory authority is required to take at least one of the following measures to ensure that the investment in question is made…"

62

Is this response enough?

- Institutions of European dimension *(ENTSO & ACER)* are responsible for developing transmission expansion plans of EU dimension
  - However, final decisions are left to national regulators & TSOs
  - And mandatory criteria for expansion are based just on reliability
- Critical issues (authorizations, siting, remuneration *(Art. 22.7 & 22.8 of Regulation)*) are still open & cost allocation implicitly results from the Inter-TSO payment mechanism

63

Thank you for your attention

ESD.934 / 6.695 / 15.032J / ESD.162 / 6.974 Engineering, Economics and Regulation of the Electric Power Sector

Spring 2010