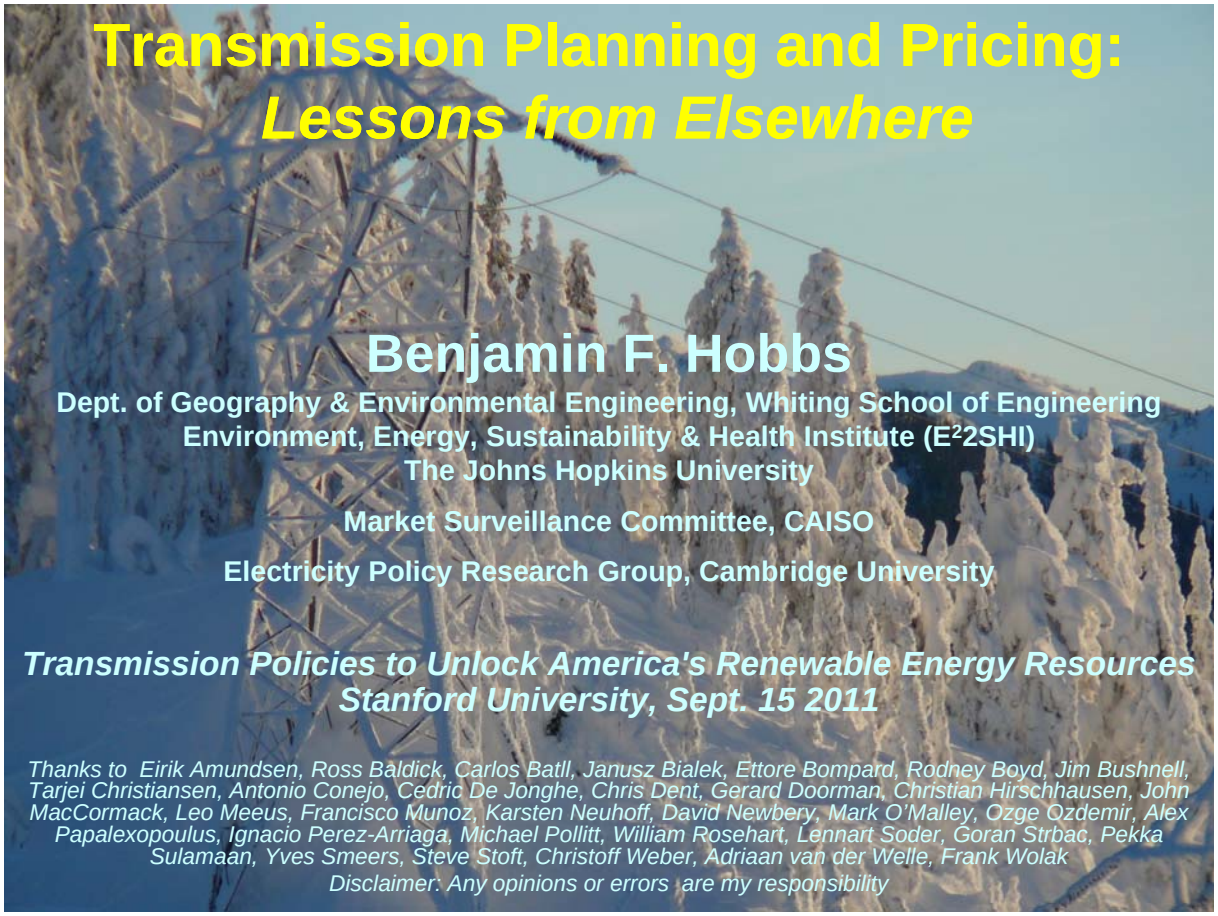

Transmission Planning and Pricing: *Lessons from Elsewhere*

Benjamin F. Hobbs

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Transmission Policies to Unlock America's Renewable Energy Resources
Stanford University, Sept. 15 2011

Thanks to Eirik Amundsen, Ross Baldick, Carlos Batll, Janusz Bialek, Ettore Bompard, Rodney Boyd, Jim Bushnell, Tarjei Christiansen, Antonio Conejo, Cedric De Jonghe, Chris Dent, Gerard Doorman, Christian Hirschhausen, John MacCormack, Leo Meeus, Francisco Munoz, Karsten Neuhoff, David Newbery, Mark O'Malley, Ozge Ozdemir, Alex Papalexopoulus, Ignacio Perez-Arriaga, Michael Pollitt, William Rosehart, Lennart Soder, Goran Strbac, Pekka Sulamaan, Yves Smeers, Steve Stoft, Christoff Weber, Adriaan van der Welle, Frank Wolak

Disclaimer: Any opinions or errors are my responsibility

Outline

EU Technology & Policy Drivers

Transmission to Accommodate Wind

1. **Use of existing assets**
   a) **Within a market**
   b) **Between markets**
2. **Expansion of assets**
   a) **Within a market**
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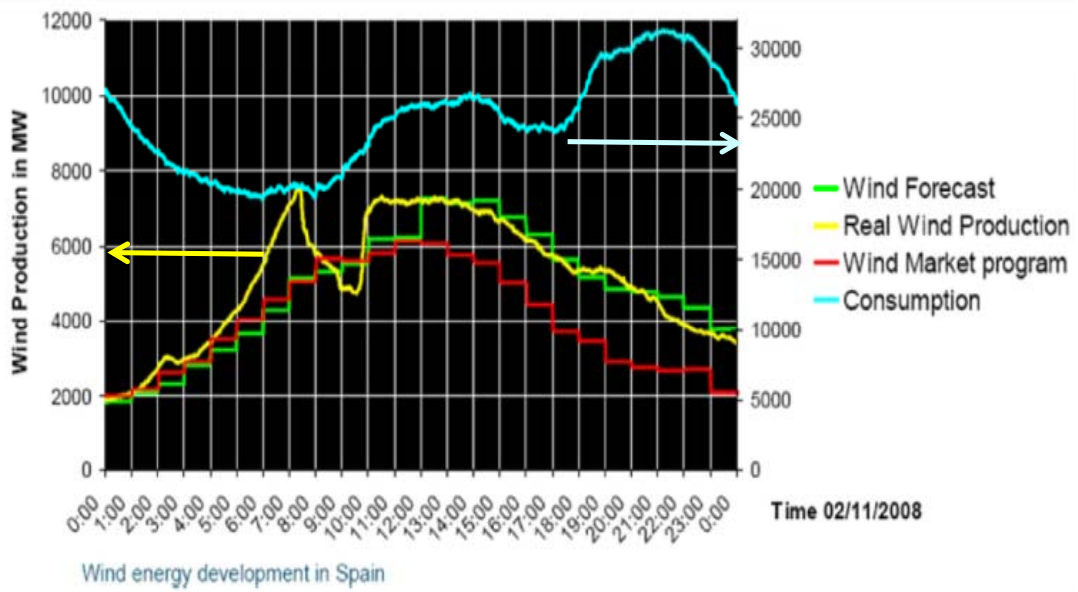
Our Future?

Often Spanish renewables + must run > load

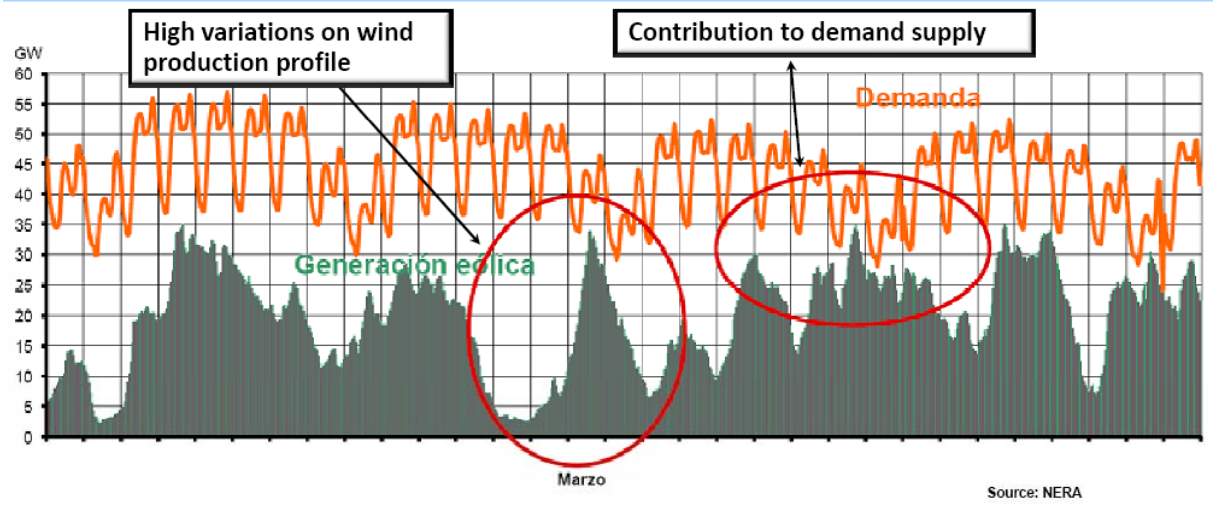


2010: Wind 16% of Spanish electricity
Spillage growing (from .02% → 0.8% in one year)

Source: EPRI, 2010; delaTorre & Paradinas, 2000

2020 Spanish Wind Profile Relative to Load

(de la Torre & Paradinas, 2010)



Fundamental Objectives of Transmission Policy

1. **Minimize cost / maximize net economic benefits**

2. **Minimize emissions & other environmental impacts**

EU strategic goals

nationalgrid
THE POWER OF ACTION

SUSTAINABILITY
- More renewable generation far from loads
- More heating and transport from electricity

COMPETITION / MARKET INTEGRATION
- More long-distance trans-European flows

SECURITY OF SUPPLY
- More optimal resource sharing

Proxy Objectives

- ***These are easy if cost is no object***
- ***Maximizing proxies not same as maximizing fundamental efficiency & environmental objectives***

Source: Kay, 2011

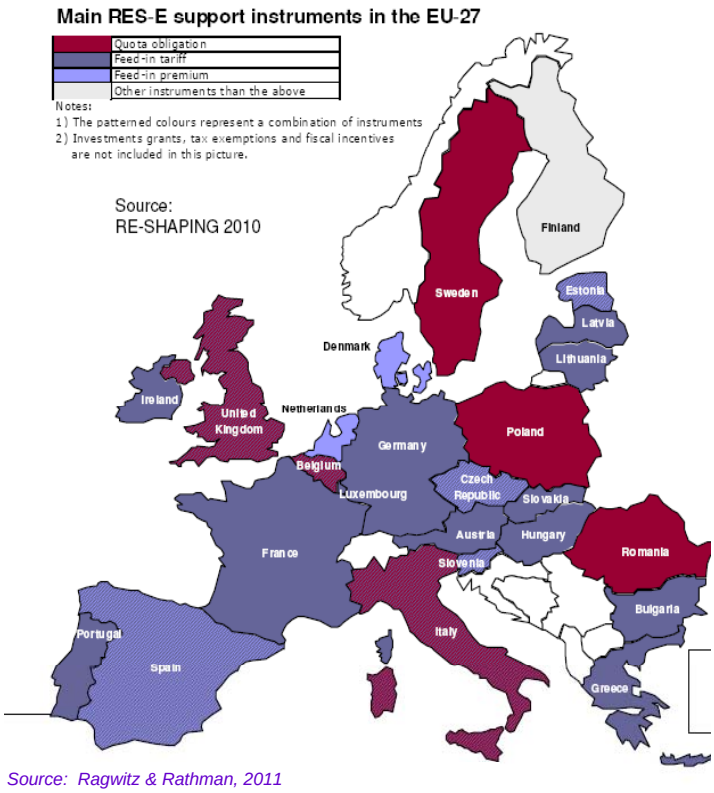
EU Jurisdictional Tension

1. EU Directives drive market opening and rules for inter-country investment and trade
   - E.g., Directive 2009/72/EC (cross border congestion)
2. But country-specific mechanisms to implement renewable goals
3. E.g., "renewable priority" for use of transmission (Directive 2009/28)

   Rationale: "Priority access … for renewable electricity is required … in view of the incompleteness of a liberalised power sector in Europe. The … sector is still dominated by large incumbents in their respective control zones…" (EWEA, 2011)

   - But "priority" is interpreted variously:
     - NL: Can't ramp down, even voluntarily
     - UK: Anyone can participate in balancing market, source blind
     - Germany: Regulator relieved grid of obligation when prices negative
   - EWEA appealed unsuccessfully to EU for more harmonization

Diverse / inconsistent renewable policies



Source: Ragwitz & Rathman, 2011

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1. EU Short Term Congestion Management

a. Within market (usually country)

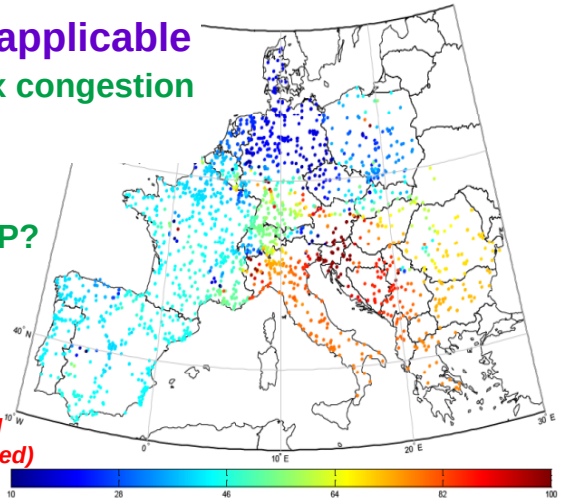
- "Copper plate" fiction for forward scheduling
- (Inefficient) balancing markets in real-time
- Renewable (and CHP, nuclear) have priority
  - Curtailed only if necessary for security
  - Conflicting definitions, Royal decrees

b. Between countries

- Mostly: auction interfaces in path-based system
  - Separate from energy market
- Increasingly: market splitting
  - Zonal prices separate if congestion
  - Transmission price = Δ P
- Inter-TSO Compensation Mechanism based on use of each other's assets

Growing Inefficiency of Copper Plate Assumption

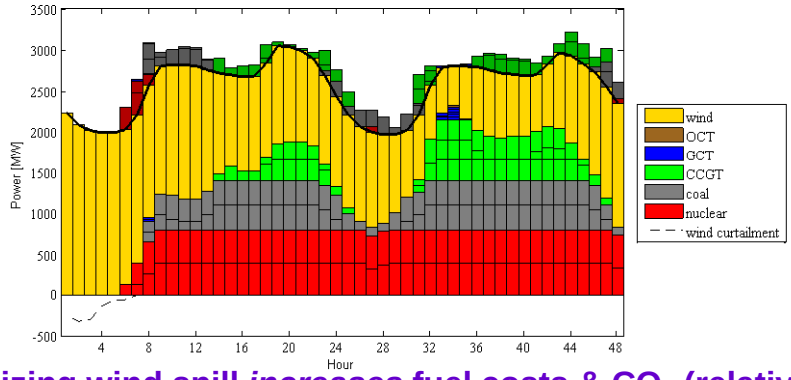
1. Growing congestion costs (UK)
   - £70M (07/08)
   - →£263M (08/09)
   - →£206M(09/10)
   - → £477M(10/11) (est.) (Natl. Grid, 2011)
   - 'Connect and Manage' is explicit/implicit policy in many countries
2. Costs to grow (Strbac et al., 2007)
3. EU denies that US lessons applicable
   - Instead, increasingly complex congestion management proposals
     - NL
     - APX (F-Be-NL-G)
   - Why not the *simple* thing: LMP?
     - Poland



Max Wind Scenario: Geographic representation of nodal marginal prices (from €10/MWh in blue to €100/MWh in red)
(Source: Neuhoff, et al., 2011)

Giving Absolute Priority to Wind Makes Neither Economic nor Environmental Sense

- Can increase ***both*** costs and emissions
  - KU-Leuven stochastic unit commitment (De Jonghe, Hobbs, Belmans 2011):



  - Minimizing wind spill ***increases*** fuel costs & CO_2 (relative to dispatch under 0€/MWh wind bid)
    - 17% reduction in spill possible
    - Per MWh of spill reduction:
      - 0.71 t CO_2 ***increase*** (+1.5% total CO_2)
      - 49 € cost ***increase*** (+1.3% total cost)
    - Assumes no demand elasticity

Giving Renewables Absolute Priority Makes Neither Economic nor Environmental Sense

- **See also:**
  - Analysis of transmission-constrained NW European market (Oggioni et al. 2011):
    - Huge financial costs
  - Simple example (Hobbs 2011)
- **Win-Win possible:** (van der Welle and Joode, 2011; Brandstätt et al., 2011)
  - Give operator flexibility …
  - …while yielding more revenues for wind
  - …and saving consumers money
- ***Example?*** **2009: Germany TSOs no longer have to take wind when prices negative**

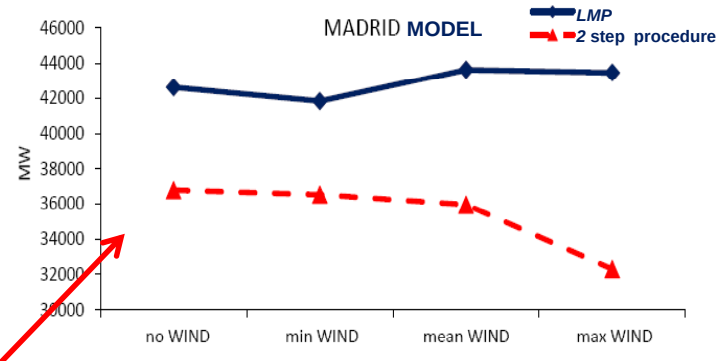
  ⇒ Hours with negative prices fell in 2010

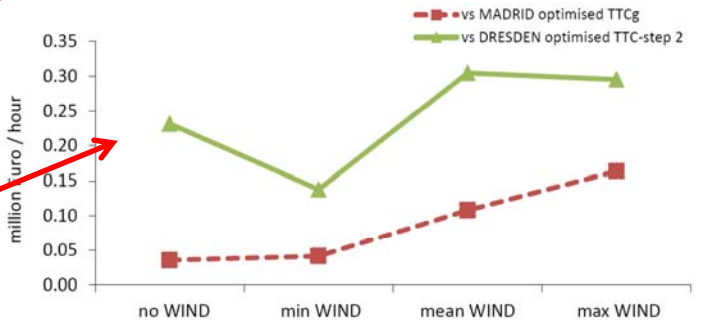
1(b) Efficiency of Full Network (LMP) Markets *vs.* 2-Step "Transfer Capability"-based Intercountry Trade

(Neuhoff et al. 2011; van der Weijde & Hobbs 2011a)

Compared:

- Integrated LMP-based market *versus*
- 2 step procedure:
  1. Guess "MW" transfer capability between countries
  2. Solve energy markets



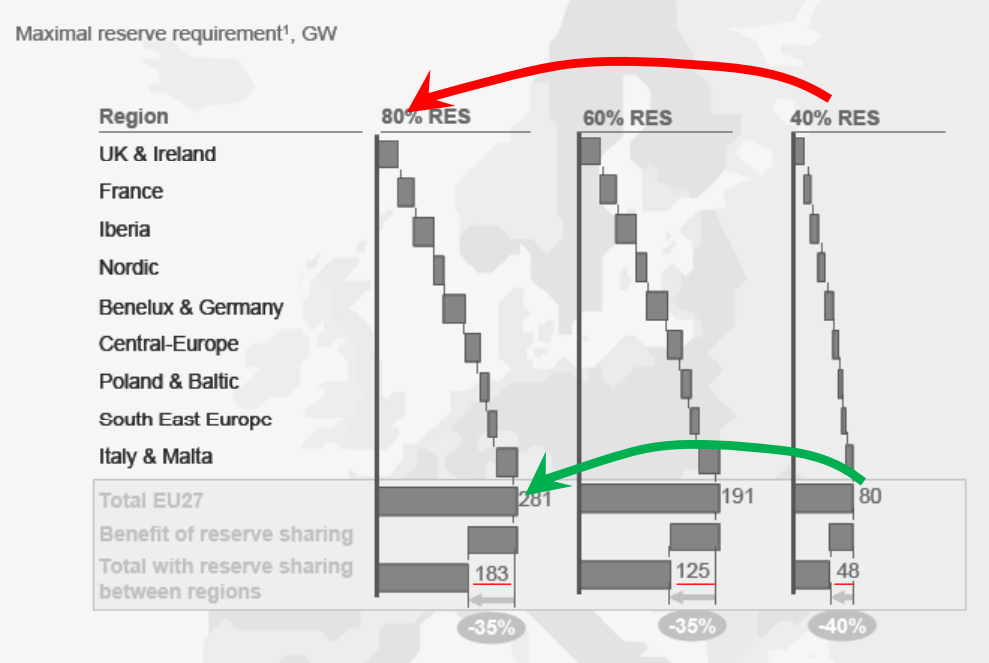


Inefficiency of 2-step procedure

- Less trade
- 1%-4% higher costs
- Same CO_2

Source: Neuhoff et al., 2011.

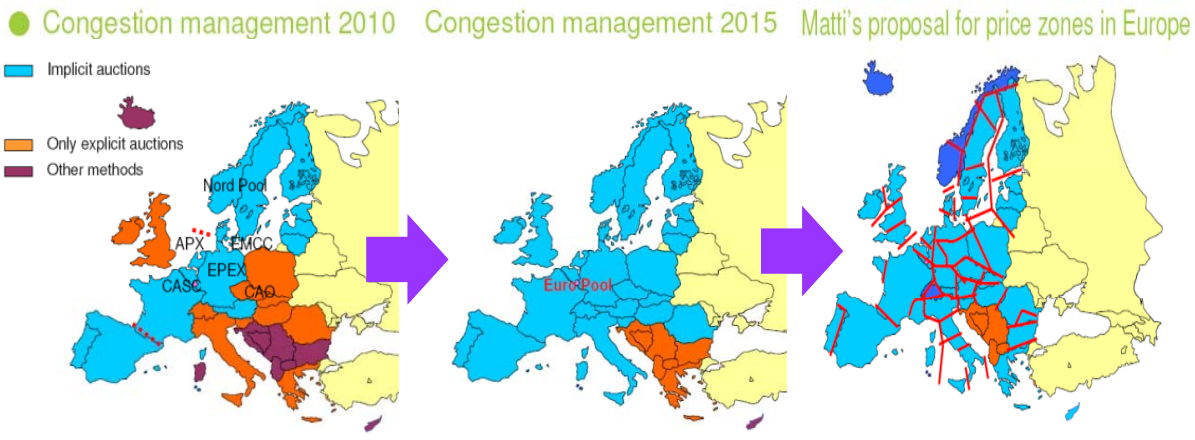
Long Run Benefits of Tight Coordination



1. More wind requires disproportionately more reserves
2. Coordination lowers required reserves by ~35%

(Source: European Climate Foundation 2010, quoted by Perez-Arriaga, 2010)

EU Moving to Tighter Market Integration: Based on Market Splitting/Zonal Model

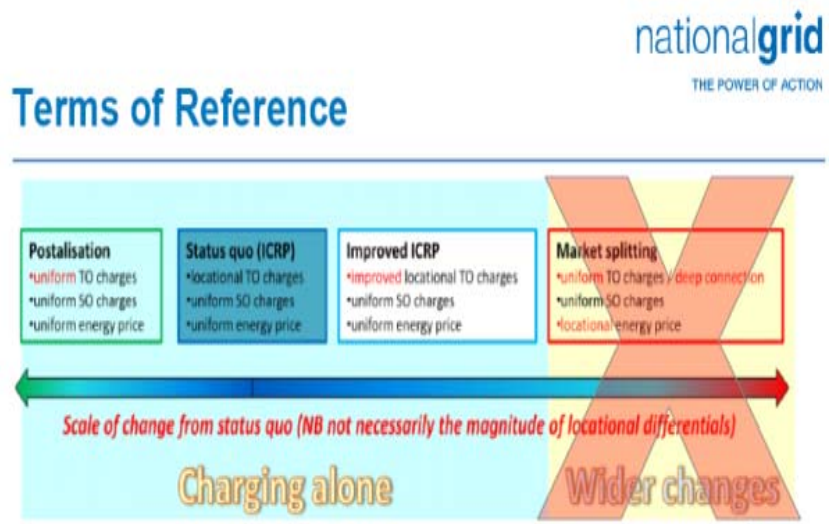


EU Target Model 2014

Source: Supponen, 2010

UK in Denial:
2011 OFGEM TransmiT Project

1. **Consultants recommend move to locational marginal pricing (LMP)** (Newbery, 2011; Baldick et al., 2011)
   - **EU 2014 Target Model will push for more price granularity**
2. **But OFGEM recommends keeping "copper plate" fiction**



The Future?

1. **What or who argues for LMP?**
   - **Consultants**
   - **US experience**
   - **Looming increases in congestion** (Strbac et al. 2007)
   - **Logic: Dispatch subject to *all* operating constraints saves more € in a windy world:**
     - ***Why?*** **It's hard to correct mistakes or respond to outages (gen, transmission) when there are fewer dispatchable resources**
2. **EU pushing for more granularity**
   - **But aside from Poland, no EU institutions favor LMP**
   - **Doubts on LMP benefits vs implementation costs** (Schmitz & Weber, 2011)

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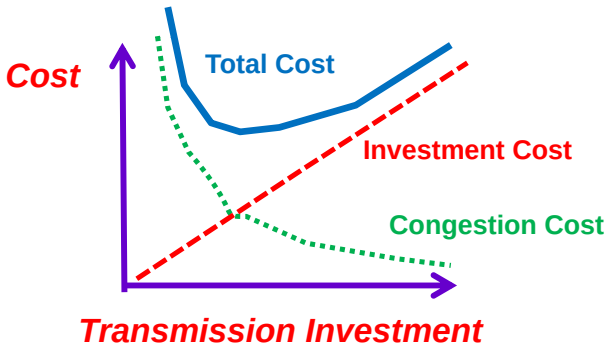
2(a) Transmission Investment *within* Markets

1. **Fundamental tradeoff: congestion vs. investment costs**
   What's optimal?



   – Norway (balanced) vs. Alberta (no congestion)

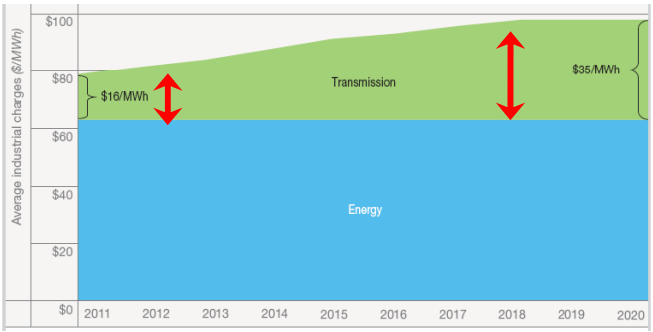
2. **Build costs allocated variously *(see Alex P's comments)***
   – Most countries socialize all (except shallow connection costs)
      ➢ Exceptions: deeper charges in Norway, Alberta, UK
      ➢ Efficiency debated
   – No merchant transmission within markets: Central planning

Alberta

1. Legislature declares Alberta congestion free

- **$14B of transmission investment through 2020?**
  - **Cf. today's book value: $2.1B**
- ***"Building in advance of need & planning for an unconstrained grid provides certainty to … generation projects…. Further, it gives those in other industries the confidence to do business in the province, knowing that power will be there …. Alberta's future prosperity depends upon a reliable transmission system, and a competitive electricity market."*** **(Alberta 2011)**
- **No hearings, no benefit-cost analysis**
- **Why? Pressure from tar sand (not renewable) stakeholders?**

2. Impact on industrial rates:



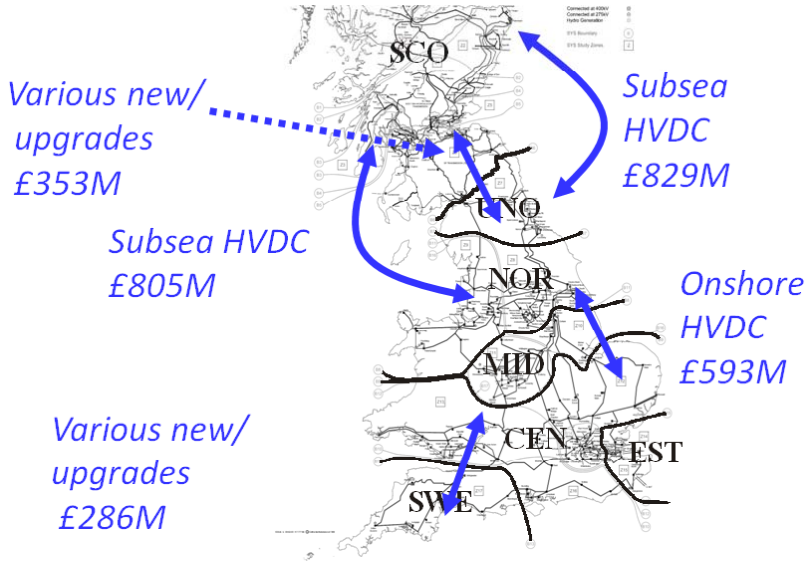
Source: Alberta 2011, Fig. 3

Role of Analysis

- **Policy objectives drive renewable interconnections (DK and Germany)**
  - **Cost/Benefit used for other German lines**
- **UK: simplified congestion avoidance**
- **Uncertainty analysis rare:**
  - **Spanish multiscenario analysis**
    - **EU-wide ten yr plan to include**
  - **CAISO TEAM methodology** **(Awad et al., 2010)**

If "Regret" Could be Large, Consider Risks

- **2 stage analysis** (van der Weijde & Hobbs, 2011b)
  - Separate "here-and-now" from "wait-and-see" decisions
- **Optimal UK here-and-now choices change if consider:**
  - Risk
  - Option of delay



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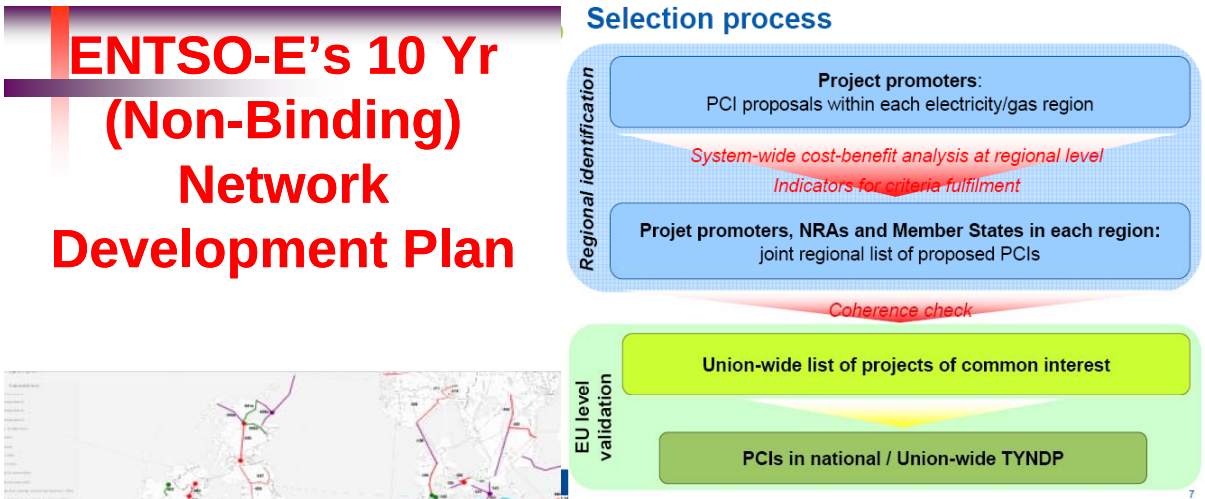
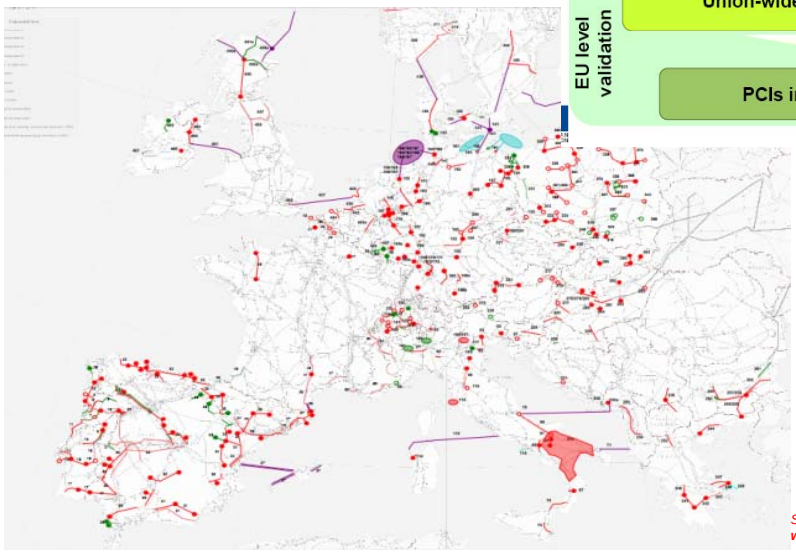
2(b) Between-Country Reinforcements

1. **Worst bottlenecks: borders**
2. **Merchant DC lines in north; less activity elsewhere**
   - **Merchant theoretically inefficient** (Egerer & Kunz, 2011)
3. **EU "Third Energy Package"**
   - **EU"Agency for Cooperation of Energy Regulators"**
   - **Ten Year Plan (European Network of TSOs)**
   - **EU financing arrangements: "Trans Europe Network"**
4. **Same Federal-State tensions as in US**
   - **Admiration expressed for FERC's powers (!)**
   - **EU jawboning sometimes helps**
     - ➢ **Pyrenees interconnector**

ENTSO-E's 10 Yr (Non-Binding) Network Development Plan



Source: Schramm 2011



Source:
www.entsoe.eu/index.php?id=232

42,100 km of new lines needed (25-30B€) in next 5 yr?
(Perez-Arriaga, 2010)

Technology Driver: A Shift in the Wind

Rapid wind growth

Figure 4: Cumulative wind power installations in the EU (MW). Source: EWEA.

Movement offshore

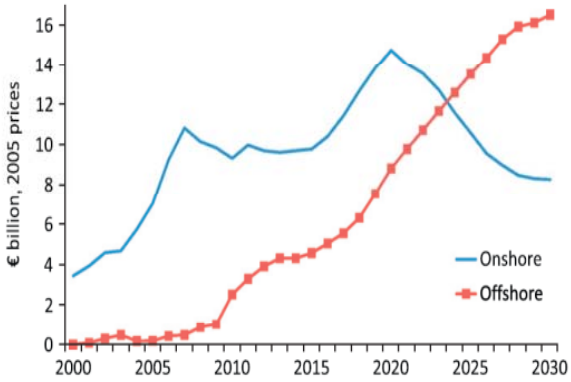


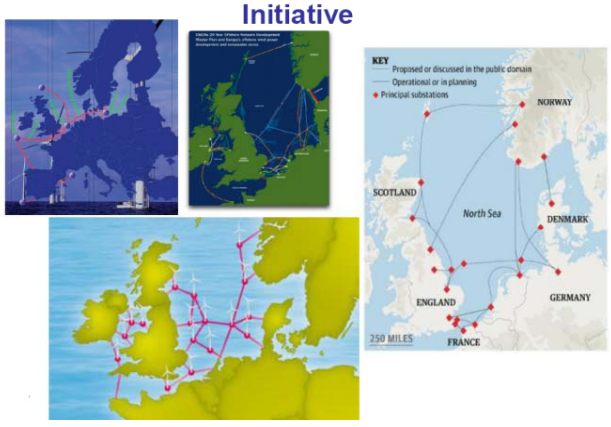
Fig. 1. Predicted wind capacity investments in Europe. Source: EWEA (2009).

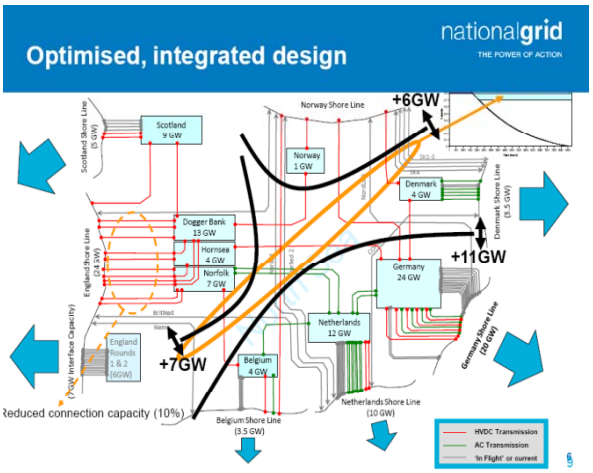
See: Kling et al., 2011; Green and Vasilakos,, 2011

North Sea

- **North Sea Countries' Offshore Grid Initiative**
  - **MoU signed in December 2010 by ten countries**

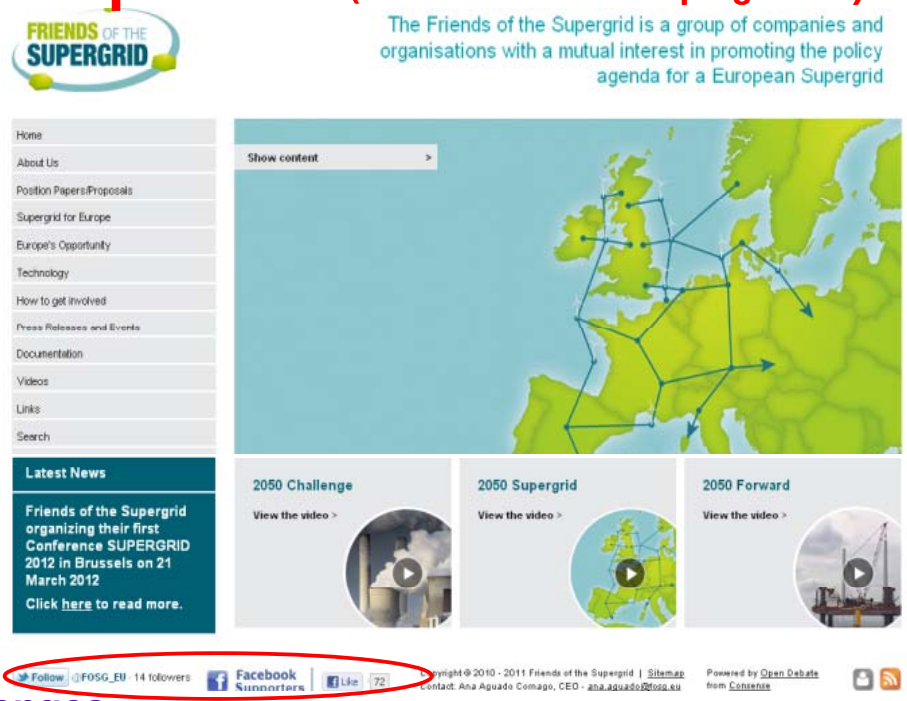
The North Seas Countries' Offshore Grid Initiative





Source: Pandey, 2011; Kay, 2011

SuperGrid (www.friendsofthesupergrid.eu/)



- **Challenges:**
  - **Type & location of renewables?**
  - **Who pays & bears risks?**
  - **Overlay DC, or incrementally improve AC?**

Conclusions for EU (…and us/U.S.!)

- **Increasing congestion**
  - **→ pressure to adopt more granular pricing (ultimately LMP?)**
- **Zero congestion unaffordable**
- **Managing and investing in cross-system transmission is the major headache**

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