Electricity markets: Generation, grids and renewables
Operating and developing reliable electricity systems at least cost

Dennis Volk – Electricity Analyst
Energy Training Week, Paris, 11 April 2013
Agenda

- How to spend 3 hours on electricity?
- The IEA and electricity markets: the bigger context
- Generation and trade
- Grids
- Renewables integration: reliability and affordability
3 HOURS ON ELECTRICITY
3 HOURS ON ELECTRICITY

90 minutes: Q&A and me

50 minutes: groups and Q&A

30 minutes: Bernd

10 minutes: Q&A

30 minutes: coffee
THE CONTEXT
THE CONTEXT – Why electricity matters?

US GDP and power demand growth

- **GDP**
- **Power demand**

- **1980**
- **1990**
- **2000**
- **2010**

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THE CONTEXT – Electricity generation dominates global energy demand growth

Global energy and power demand growth WEO (NPS)

- Power generation
- Energy demand

2010 = 100

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THE CONTEXT – Electricity economics are relevant

Power sector investments until 2035 (WEO/NPS)

16,867 bn USD
43% for grids
THE CONTEXT – Electricity reliability is relevant, too

2003 – Northeast US & Southeast Canada

- Operator is unaware of system vulnerability
- Tree touches one overhead line
- Operator has no real-time awareness
- Blackout cascades – 55 million affected
THE CONTEXT

It is one thing to identify development scenarios,

...but what can we actually do today?
THE CONTEXT – IEA/GCP’s work on electricity markets follows a whole-of-system approach.
THE CONTEXT – ESAP follows common energy policy targets of OECD countries
THE CONTEXT – History of market developments

Shared reserve

Reserve plant

Reserve plant

Shared reserves lead to significant cost reductions

Reserve sharing started electricity flows beyond regional borders
THE CONTEXT – History of market developments

- Cross-regional flows had to be organized
- Organized regions assimilated various suppliers
- Multilateral regions emerged
THE CONTEXT – History of market developments

- **Unilateral price formation** per sub-region initially remained
- Price formation oriented on **cost regulation** per sub-region
- **Regulatory differences** lead to generation imbalances between sub-regions
- Multiple cost regulations replaced by single and competitive **price** formation
- **Grid unbundling** established for facilitating competition and trade
THE CONTEXT – History of market developments

- Unbundling took away the grid from integrated utilities
- Unbundling another step allowing for free trade
THE CONTEXT – Various forms of unbundling
„Integrated utility“

- Generation
- Grids
- Supply

- Generation
- Supply
- TO
- ISO

- Generation
- Supply
- TO & SO

- Generation
- ITO
- Supply
THE CONTEXT – Organized regions

Two-thirds of US electricity demand within organized regions
Further organized regions can be found across the globe.
THE CONTEXT – Institutions, regulations and the value chain support organized markets

**GENERATION**

**TRADE**

- Trade regulations (e.g. frequency)
- Price regulations (e.g. caps)

**RETAIL**

- Structural regulations (unbundling)
- Economic regulations
- Technical regulations
- Specific techno-economical regulations (e.g. EPS)
- Connection requirements (e.g. stability)
- Other
Q & A
GENERATION
& TRADE
GENERATION – How competitive price formation works. The tools for electricity wholesale trading

**Forwards**
- > 90% of physical trades

**Day ahead**
- Residual trades

**Intraday**
- Between 60 to 5 minutes

**Gate closure**
- Real time

Time
GENERATION – How competitive price formation works. Collecting the supply offers (bids)

Supply bids depend on individual units’ OPEX
GENERATION – How competitive price formation works – NYISO marginal pricing as example

- Demand @ night
- Market price @ night
- Our coal plant
- Our gas plant A
- Peak demand @ 95%
- Not dispatched
- Our gas plant B
- Not dispatched
- Not dispatched

Source: Ventyx
GENERATION – CAPEX recovery as part of marginal pricing through infra-marginal rents

- **Infra-marginal rents**
  - IMR: 80 – 35 USD/MWh
  - = 45 USD/MWh

- Our coal plant
- Our gas plant A

Source: Ventyx
GENERATION – Different technologies for different supply tasks

- Nuclear (+++++)
- Coal (+++)
- CCGT (++)
- OCGT (+)

Cost share:
- CO2
- O&M
- FUEL
- CAPEX

Size:
- Nuclear (+++++)
- Coal (+++)
- CCGT (++)
- OCGT (+)
GENERATION – “Energy only” markets work

Generation capacity additions in Germany (to 2015)

<table>
<thead>
<tr>
<th></th>
<th>Additions</th>
<th>Retirements</th>
<th>Net additions</th>
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<tr>
<td>Nuclear</td>
<td>8</td>
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<tr>
<td>Gas</td>
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<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Coal</td>
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<td>0</td>
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</table>

GW
GENERATION – Market-based dispatch

Energy only markets can drive...

• **Transparency** and lower information asymmetry
• Reduced **monopolistic** pricing and/or regulatory **scrutiny**
• Service **quality and competition** for customers
• **Optimization and innovation** to reduce OPEX and CAPEX
• **Individual investment** decisions and less regulation
• Individual decision making for **technology, time and size**
• **Uncertainty** with regard to sufficient dispatch revenues
GENERATION – Market-based dispatch

Various barriers to energy only markets can exist...

- Political / regulatory uncertainty
- Price uncertainty and missing market liquidity
- Undue price caps
- Administered and overly ambitious reliability levels
- Too inflexible pricing and inflexible demand
- System service contribution without cost reflective prices

Unsolved barriers can put an end to energy only markets
Q & A
GRIDS
GRIDS – The backbone of electricity markets. No grid – no power flow!
GRIDS – regulations influence how grids respond

Natural monopolies = Regulations

- Open access
- Non-discriminatory tariffs

- Operational measures
- Infrastructure planning
GRIDS – Delivering power sector policy goals is not for free – grids have an important share
GRIDS – Cost allocation can restore benefits of bundling

"Integrated utility"

"Unbundled utility"
GRIDS – Cost allocation can identify valuable projects

A new line for better trade

or no new line for better system economics

Costs > net benefits!

Ex ante cost allocation roughly commensurate to benefits...

- Provides a foreseeable cash flow for investors
- Identifies projects which bring the added value
- Identifies beneficiaries
- Activates individual market participants to determine project-specific business cases
- Identifies projects which don’t bring the added value

Enhances acceptance from market participants and public
GRIDS – Cost allocation can also improve reliability

1 in 10 events

Extra transmission for 1 in 10 events

Extra costs over 40 years: 1.5 bn €

Lost load over 40 years: 23 TWh

Costs for extra n-1 reliability: 66500 €/MWh
Costs for extra n-1 reliability: 66500 €/MWh

Finding the answers to these questions can allow for...

- Active customer market participation through demand response
- Better cost allocation for reliability investments
- Less infrastructure cost socialization and investment acceptance
- More light-handed regulations for reliability investments

GRIDS – Cost allocation can also improve reliability
GRIDS – New transmission is only one possible solution

- Demand response
- Congestion management
- Dynamic line rating
- Distributed generation
- Storage

Distribution networks
GRIDS – Good reasons against missing acceptance
GRIDS – Planning frameworks have to be open, transparent, comprehensive and consultative
GRIDS – Network operations are the lubricant, but are often a great unknown

Wholesale market

Reliable power flows

Retail customers
GRIDS – Balancing the forecast errors between gate closure and real time

- **Balancing services**
  - Forwards Day-ahead
  - Intraday

- Organized by system operator
- Mostly provided by conventional generators

**Forecast errors**
- Between 60 to 5 minutes
- Gate closure
- Real time
GRIDS – Balancing services remain subject to further improvements

Market-based balancing...

- is based upon undistorted and close real-time marginal prices
- lets generators and demand bid for demand and supply
- remains co-ordinated and netted-out by system operators
- includes costs of network use and bottlenecks
GRIDS – Voltage level stability requirements and its providers

- A regional problem
- Various providers possible
- Often monopolistic
- Creates Reliability-Must-Run (RMR)
- RMR as one market barrier for energy only

Voltage level situations @ n-1
GRIDS – More market-based solutions

More market-based solutions can...

• restore development benefits of integrated utilities
• identify network projects with added market value
• allow for competition against network solutions
• enhance acceptance
• activate demand side’s WTP for reliability investments
• open up new service sectors and reduce RMR
• enhance individual decision making against administration, tough regulation and cost sozialisations
A FINAL WORD ON MARKETS
MARKETS – Will it get cheaper? It depends!

Tariff development for German households

ct/kWh

Negotiated grid access
Regulated grid access

+6%


BNetzA BDEW
MARKETS – Will it get cheaper? It depends!

- Negotiated grid access: +16% increase
- Regulated grid access: +11% increase
- Hard coal price (German border): +6% increase
- Gas import price (German border)
- Taxes

1998 = 100
Q & A
RENEWABLES INTEGRATION
RENEWABLES INTEGRATION – Renewables are inevitable for long-term sustainability

Sustainable global power supply (WEO NPS)

- Other
- Hydro
- Other renewables

<table>
<thead>
<tr>
<th>Year</th>
<th>Other</th>
<th>Hydro</th>
<th>Other renewables</th>
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<td>1990</td>
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<tr>
<td>2035</td>
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RENEWABLES INTEGRATION – No longer a niche player
RENEWABLES INTEGRATION – Inception often comes with layers of “protection” from the market

• Priority dispatch
• Incentives for maximizing generation
• No network cost responsibilities
• 100% feed-in integration and compensation otherwise
• No operational cost responsibilities
• No/limited dispatch capabilities

When market shares rise, these design choices have consequences for the rest of the electricity market
RENEWABLES INTEGRATION – Renewables one factor for new infrastructure requirements

During the next decade...
- 52,300 km new transmission
- +17% network length
- 130 bn € investments
- 80% related to renewables

Towards end of this decade...
- 64,000 km new transmission
- +11% network length
- 50 % related to reliability
- 27% related to renewables
RENEWABLES INTEGRATION – Finding a balance between grid costs and added wind generation

Wind capacity utilisation curve

Capture rate of wind: 90%
Capture rate of wind: 75%
Capture rate of wind: 50%

Wind generation capacity utilisation level (%)

hours per year

1 974 1947 2920 3893 4866 5839 6812 7785 8758

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

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Grid cost allocation supports market-based decision making on location and generation technology.

- Onshore Wind Location A: 50 km, @ 2775 h/a
- Onshore Wind Location B: 220 km, @ 3250 h/a
- Biomass: 475 km, 7500 h/a

LCOE (USD/MWh)

- Share of grid costs on total costs
- Generation
- Grids
- Share of grid costs (right axis)
RENEWABLES INTEGRATION – negative power prices

EEX 2012, week 1

<table>
<thead>
<tr>
<th>Day</th>
<th>Market price (€/MWh)</th>
<th>Wind (GW)</th>
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<tbody>
<tr>
<td>Sunday</td>
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<tr>
<td>Saturday</td>
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Negative prices can reduce conventional generators’ benefits

Generators have opportunity costs while not producing, such as...

- expectations about unrealised sales in the future;
- costs of cycling, shutting down and ramping-up again and
- future supply and balancing obligations (RMR) including penalties for non-delivery.

Negative market prices are a consequence of these opportunity costs
RENEWABLES INTEGRATION – negative power prices

Renewables’ exposure to balancing prices can create market-based solutions and strengthen individual self-management.

Balancing situation in hour 3

- Supply just sufficient to meet demand.
- Close to wind curtailment to avoid light balancing systems.

Available balancing capacity
Share in supply
Balancing demand
Wind
Other

Balancing supply

Spot Price [€/MWh]
RENEWABLES INTEGRATION – Improving balancing markets required to integrate renewables

Clearing in the electricity and balancing markets

- **Forwards**
  - Helps to identify future needs
  - Risk hedging tool

- **Day ahead**
  - Reduces forecast errors
  - Allows for real-time prices
  - Allows active bids, also by RENEWABLES

- **Intraday**
  - Co-optimisation avoids arbitrage
  - Reduces forecast errors

Time

Forecast errors %

- Wind
- Demand

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Q & A
SUMMARY
SUMMARY

- Economies’ dependence on electricity will rise
- Reliability, affordability and acceptance matter
- Markets for efficient generation work, but are sometimes challenged
- More efficient grids are developing under regulation
- Renewables are required for decarbonisation
- Real renewables integration can maintain reliability whilst reducing the system costs during the transition
- Efficient markets are no guarantee for declining prices but can deliver innovation and timely solutions
Where to find more details?

IEA publications under the ESAP

1) “Empowering Customer Choice in Electricity Markets”

2) “Securing Power during the Transition”

3) “Electricity Networks: Infrastructure and Operations” (forthcoming)

4) “Regional Electricity Market Integration” (forthcoming)
Thank you for your attention

For further questions - please contact...

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Q & A