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South-East Europe Electricity Roadmap

Challenges of massive RES-E integration to the grid - TSO

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SEERMAP training
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Tirana, Albania

- Ensuring system security under liberalized market circumstances
- Challenges from connecting massive RES-E resources to the grid
- Managing increased flexibility needs and costs
- Network planning and development to support RES-E integration

Under any market model the transmission system operator has a central role

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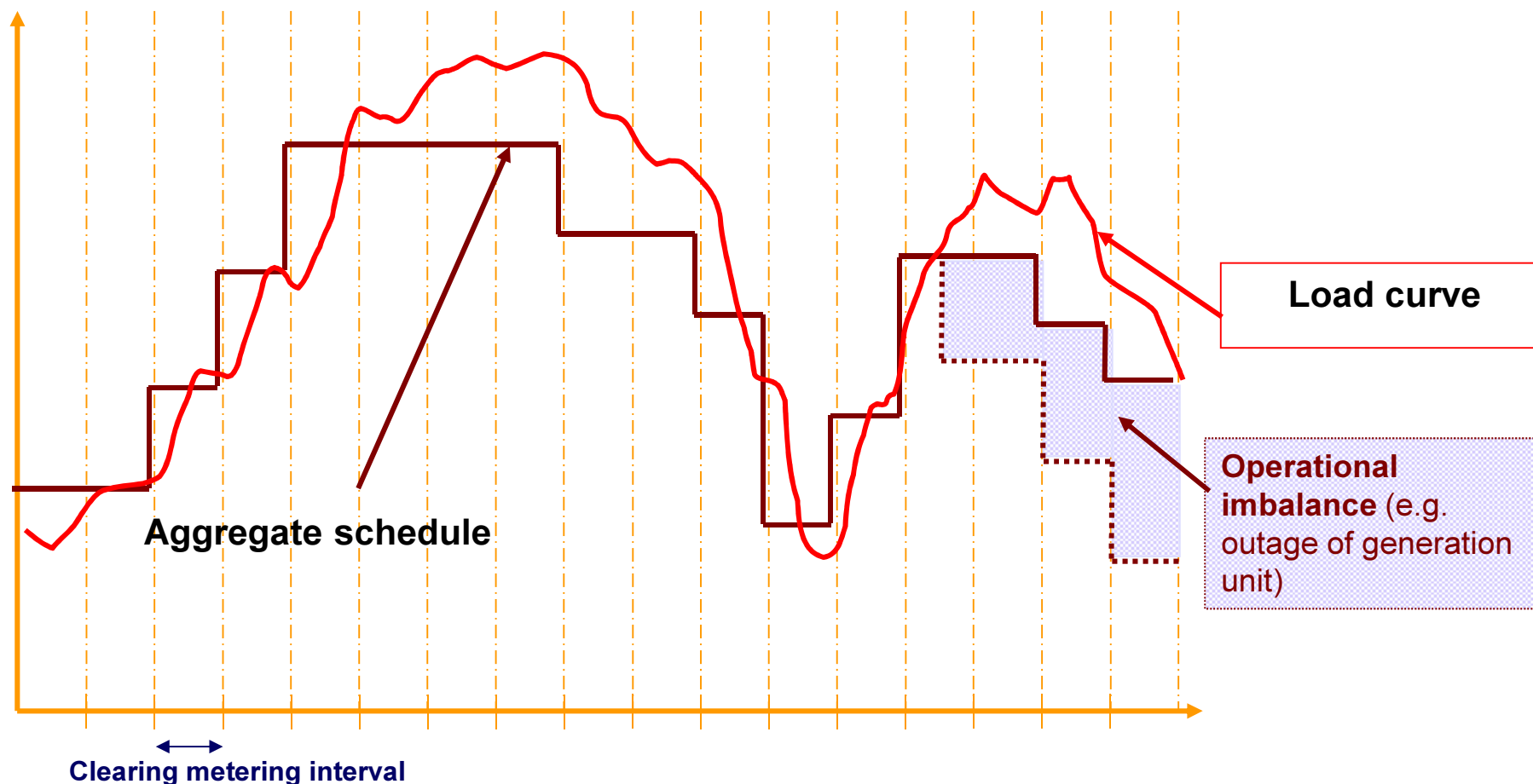
Takes care over system security and balance, otherwise...



The origin of the balancing responsibility of the TSO: potential for system imbalance

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$$\text{Balancing energy} = \text{Load curve} - \text{aggregate schedule} - \text{operational imbalance}$$

System balancing before unbundling and market liberalization

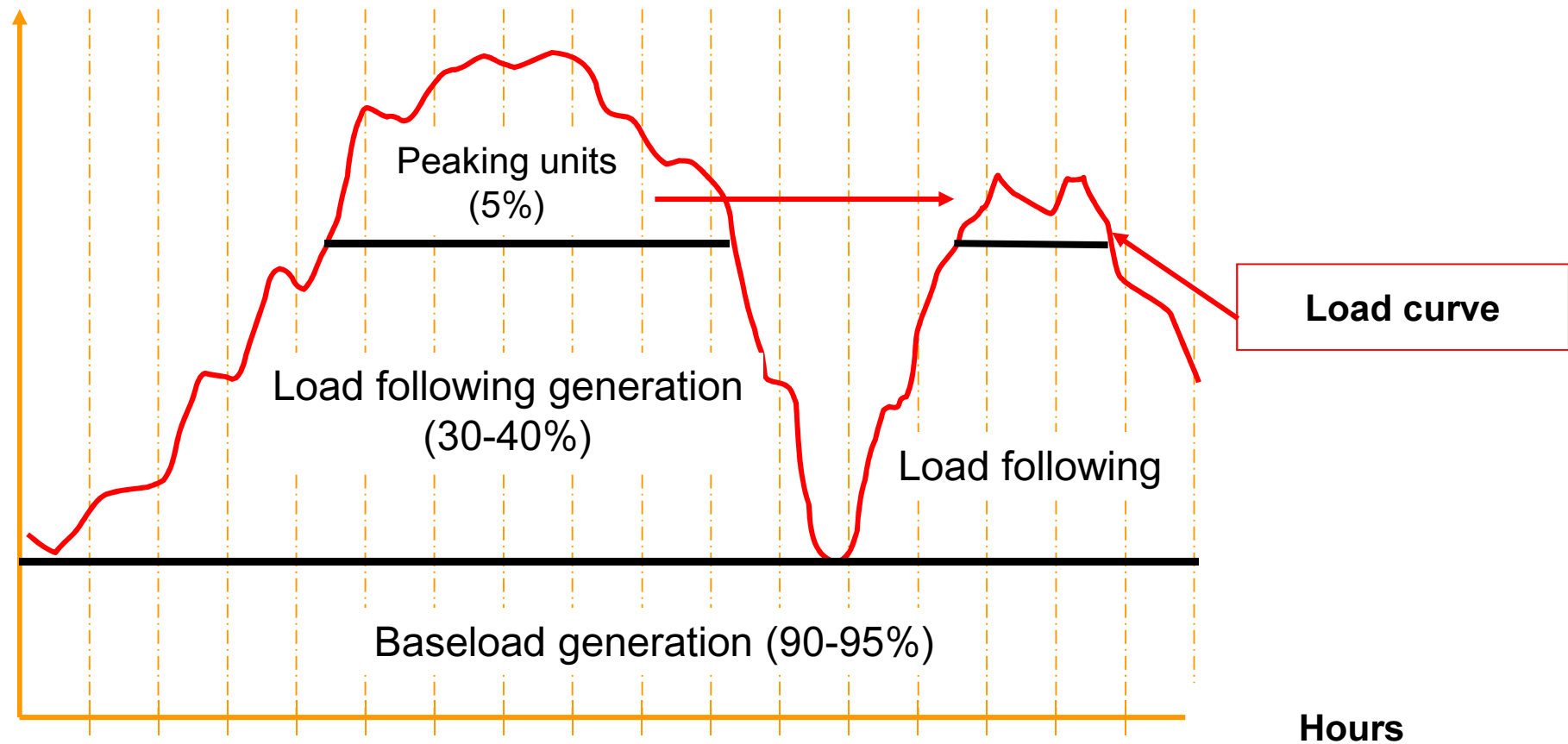
- Before market liberalization the vertically integrated utility (VIU) provided system balancing by relying on its own demand forecast and generation portfolio
- Regulating capacities were built and centrally dispatched by the VIU
- Balancing and related system reserve costs were recovered by bundled regulated tariffs
- Utility focus on system security but less on related costs

System balancing by a VIU by its own generation

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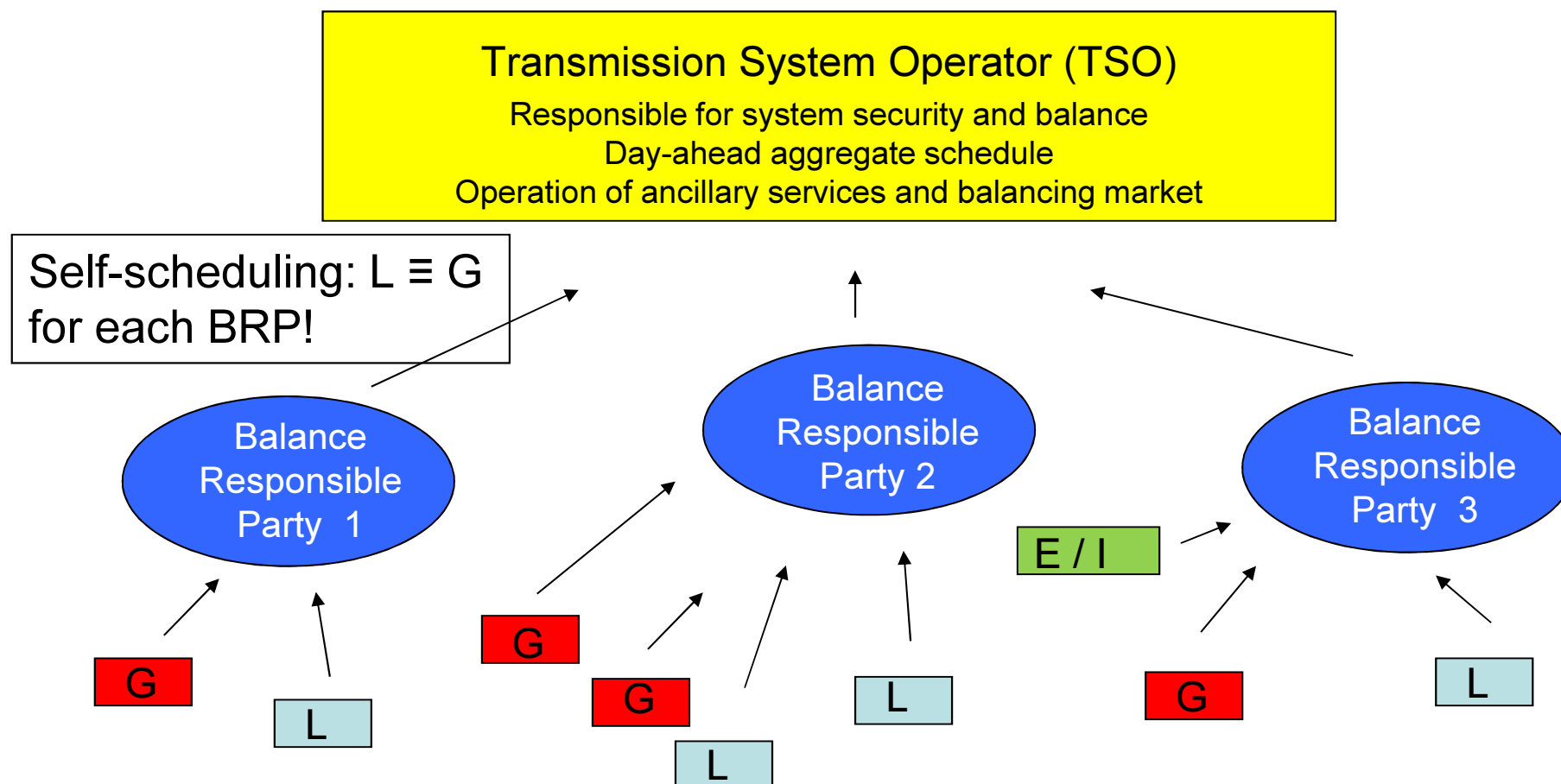
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Generation /
load, MW



Hours

The big change for the TSO after unbundling: decentralised load and dispatch scheduling



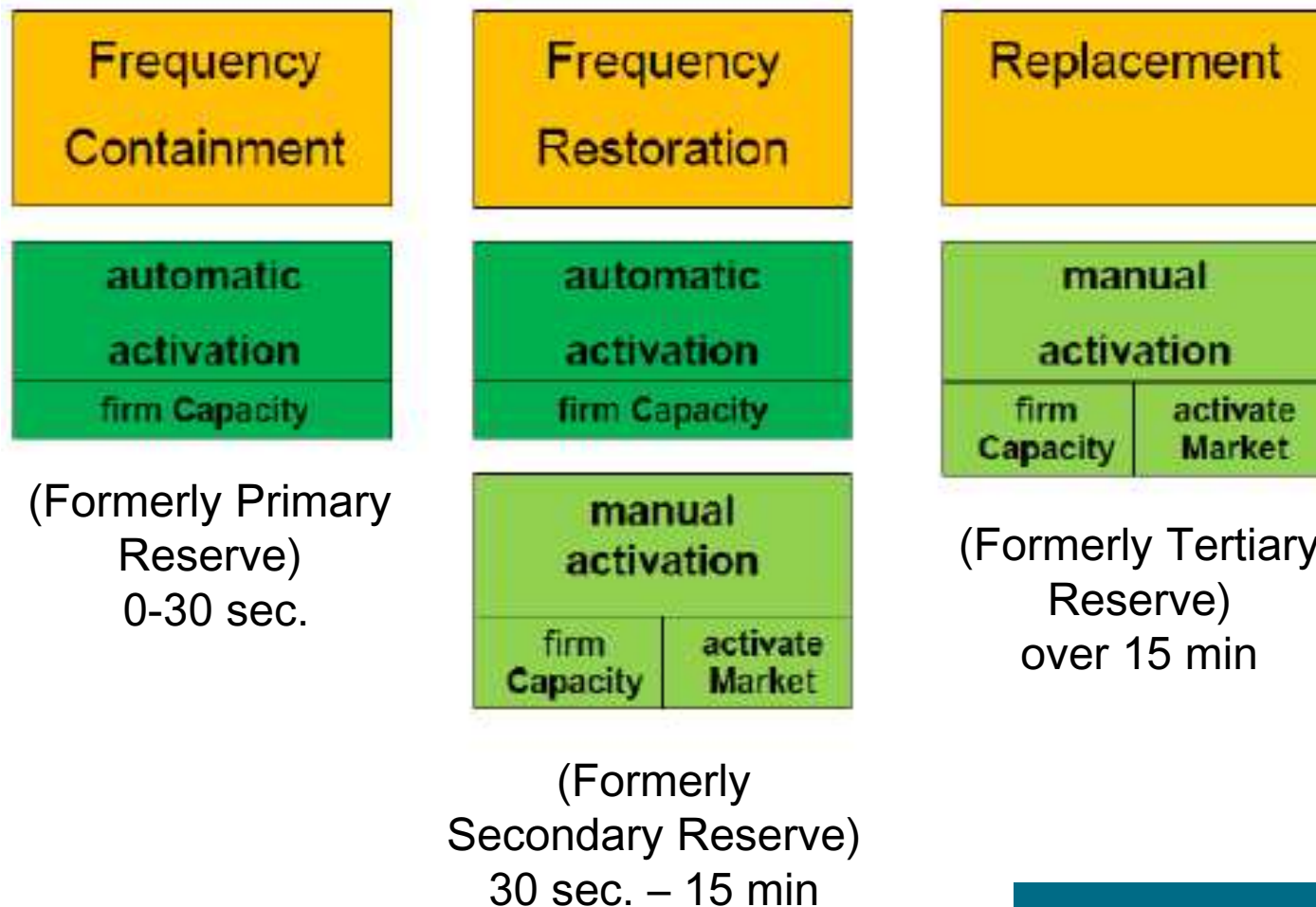
Need for separate ancillary services products / market emerges

Balancing and ancillary services provision after unbundling (market liberalization)

- Unbundling and the introduction of competitive markets required that balancing and ancillary services be clearly defined and monetized.
- Markets have been created for several ancillary services in order to minimize the cost of maintaining system reliability
- Also a separate balancing market is created to meet customers' balancing energy needs
- Pricing of these services might be market based or regulated, depending on the level of market concentration

- Ancillary services are some reserved services, controlled (owned or procured) by the TSO, for keeping a balance between supply and demand, stabilizing the transmission system and maintaining power quality.
- Two main characteristics of the electricity system that need to be regulated:
 - Frequency
 - Voltage
- Types of ancillary services
 - **Frequency regulation by maintaining a constant balance between generation and load using active power reserves**
 - Voltage and reactive power control
 - Black start capability: ability to restart a grid following a black-out
 - Islanding capability

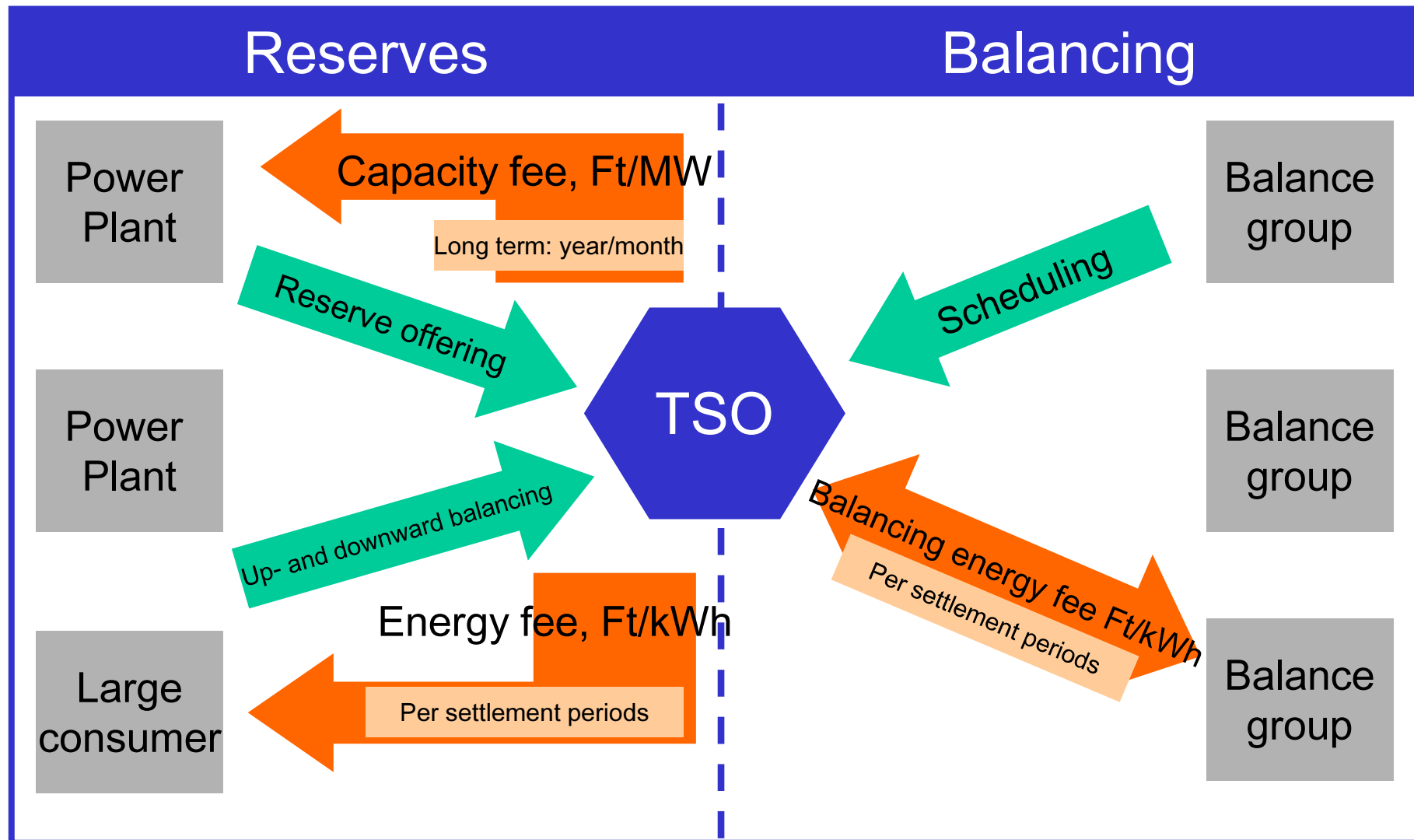
Active Power Reserves for frequency regulation



The link between the balancing process and active power reserves procurement by the TSO after unbundling

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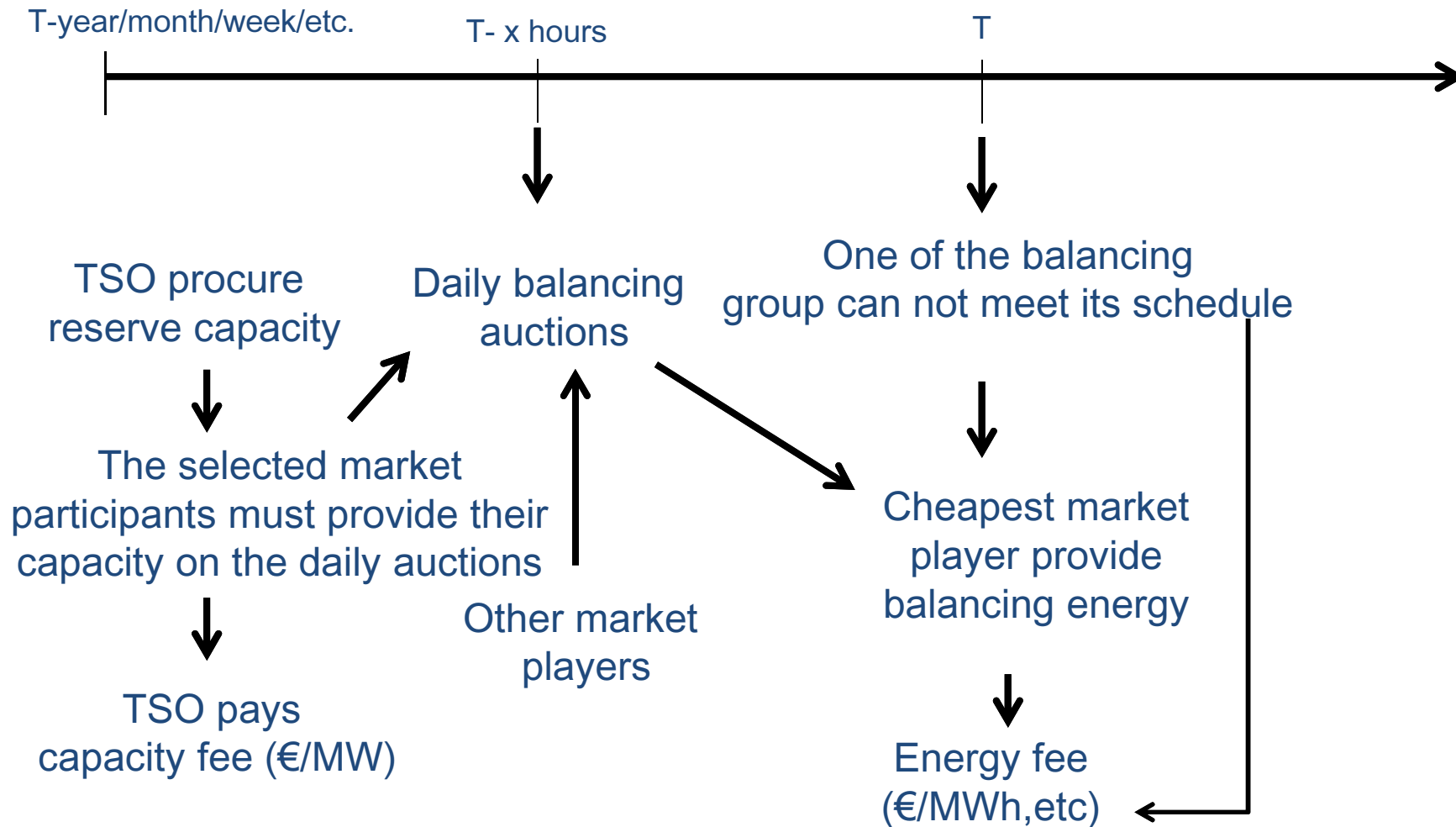
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- On these markets the TSO buys an option from accredited market players to dispatch them at a given time to increase or decrease their generation (or consumption) with a given amount.
- Demand side of the market: the TSO is a single buyer; the amount and composition of the needed regulation reserve is defined by the TSO.
- Supply side of the market: mainly power plants; sometimes a few large customers that are able and willing to decrease or increase their consumption for short notice.
- Regulatory reserve prices are either regulated or market based

- On these markets the TSO supplies balancing energy to system users / balance groups that can not meet their schedules.
- Demand side of the market: producers, customers or their aggregators (balance groups) that can not meet their production or load schedule in a given hour
- Supply side of the market: usually the TSO is the central provider of balancing energy; however, the balance group responsible often offers for its members balancing energy options
- Balancing energy prices are either market based or regulated

Balancing market operation and its relation to the regulation reserve market - Hungary

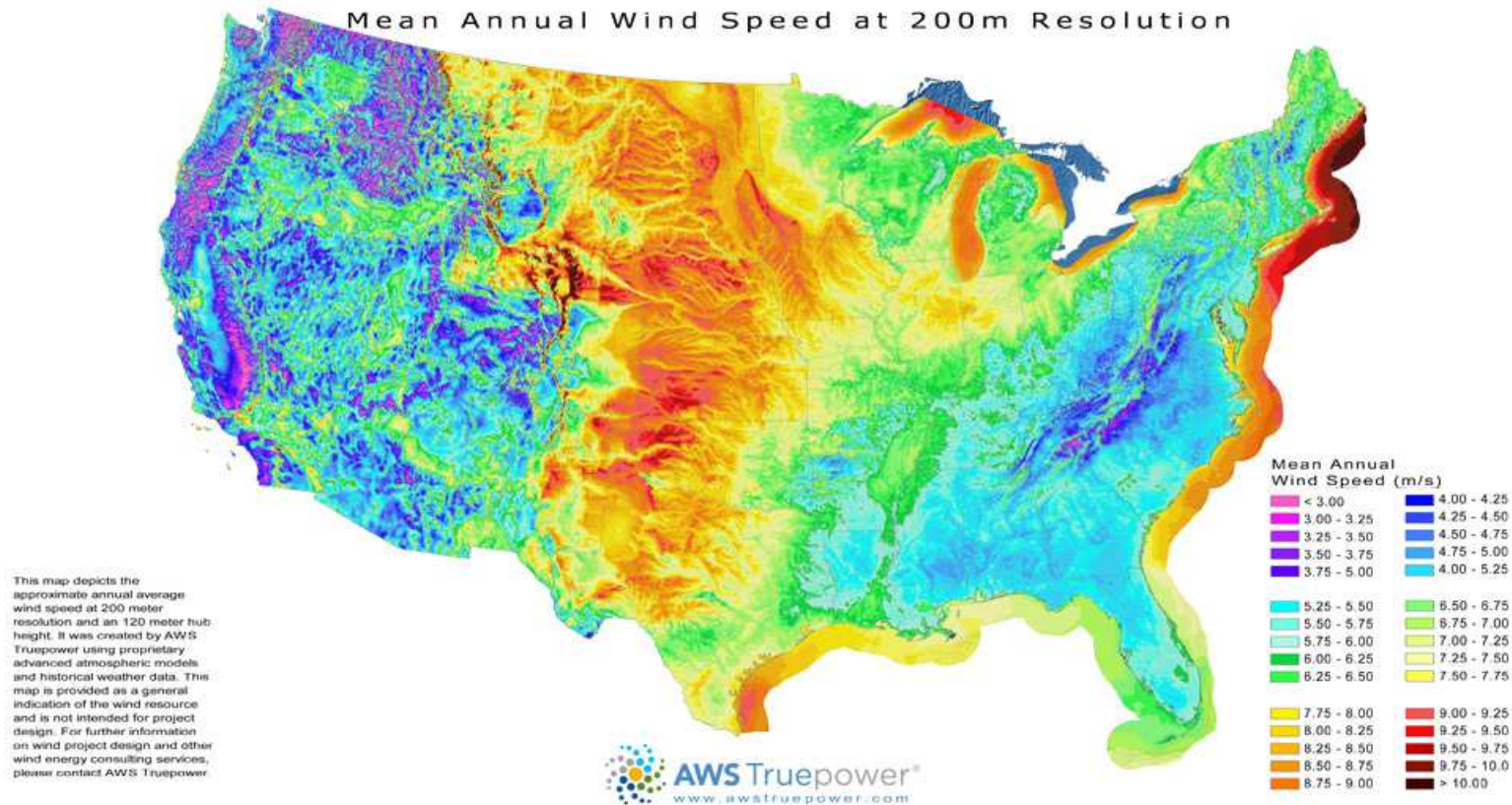


- Ensuring system security under liberalized market circumstances
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1. Is there a problem here?

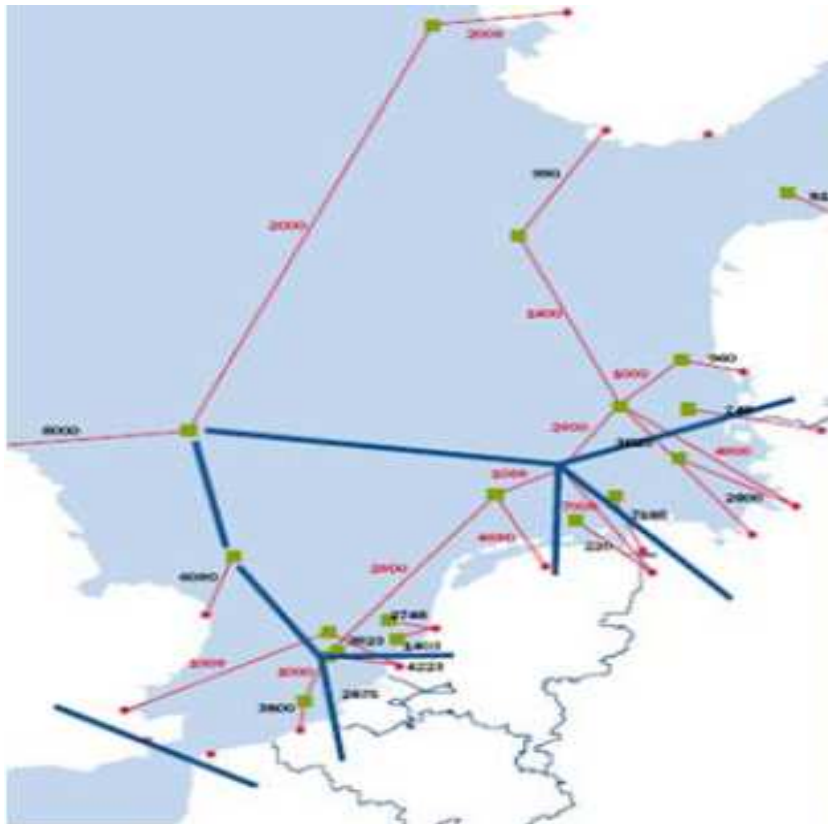
WIND RESOURCE OF THE UNITED STATES

Mean Annual Wind Speed at 200m Resolution



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RES-E potentials for the EU: North Sea wind, North Africa solar



**Integrate offshore
wind generation**



**Integrate RES-e from EU
and non-EU countries**

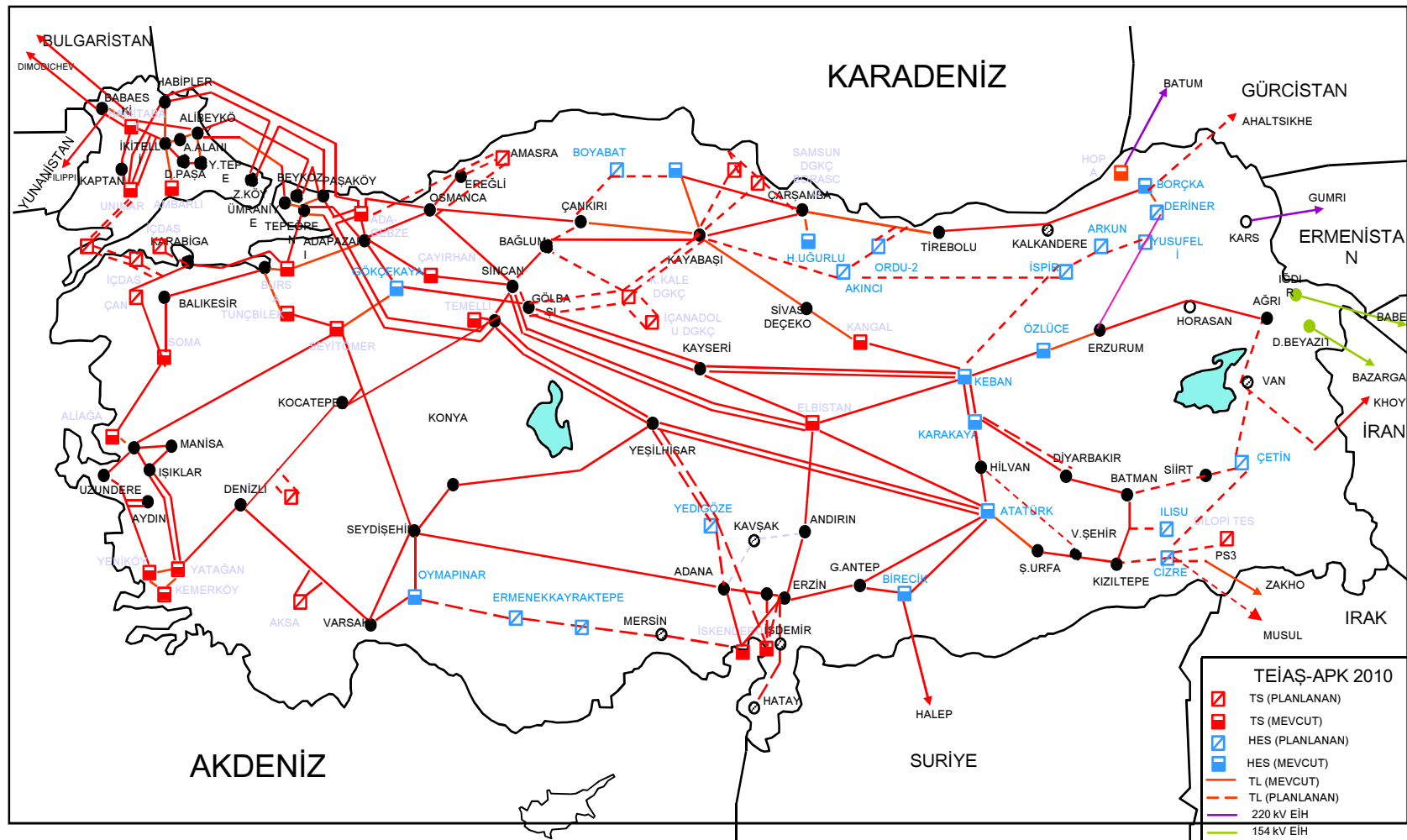
Problem 1: distance from load

- High quality RES-E resources often located far from load centres
- Connecting high quality RES-E requires massive investment into new HV transmission
- Questions:
 - Who should pay for the costs of connection?
 - Is there any reason to socialize the connection cost for some new market participants?
 - Should the cost of connection depend on the location of the connection point?
 - What to do with excess demand for connection at a connection point (substation)?
 - How to establish priorities for new connection?
 - How to plan for the expansion of the grid?

400 kV network - Turkey

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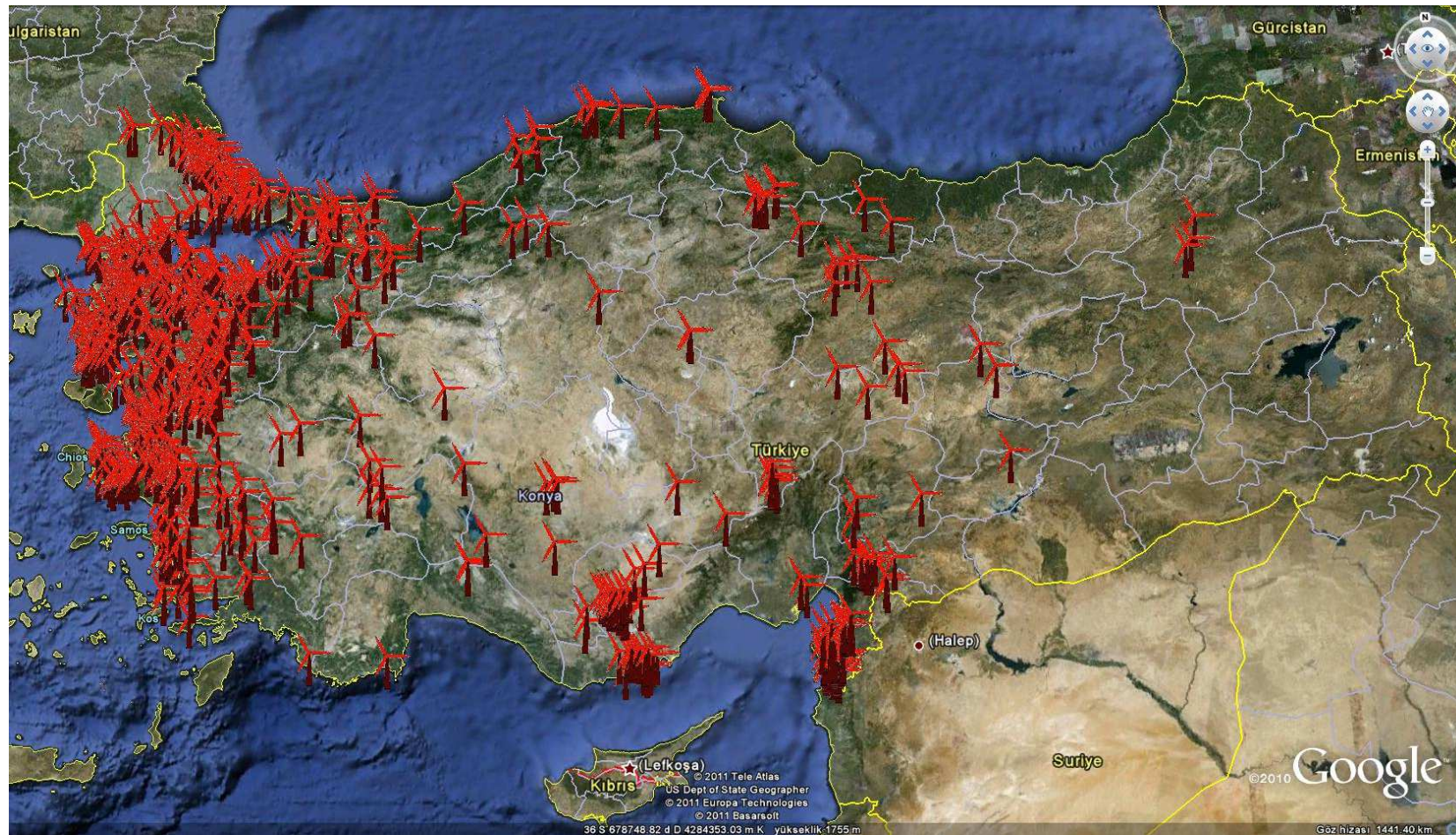
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Location of wind license applications – Turkey

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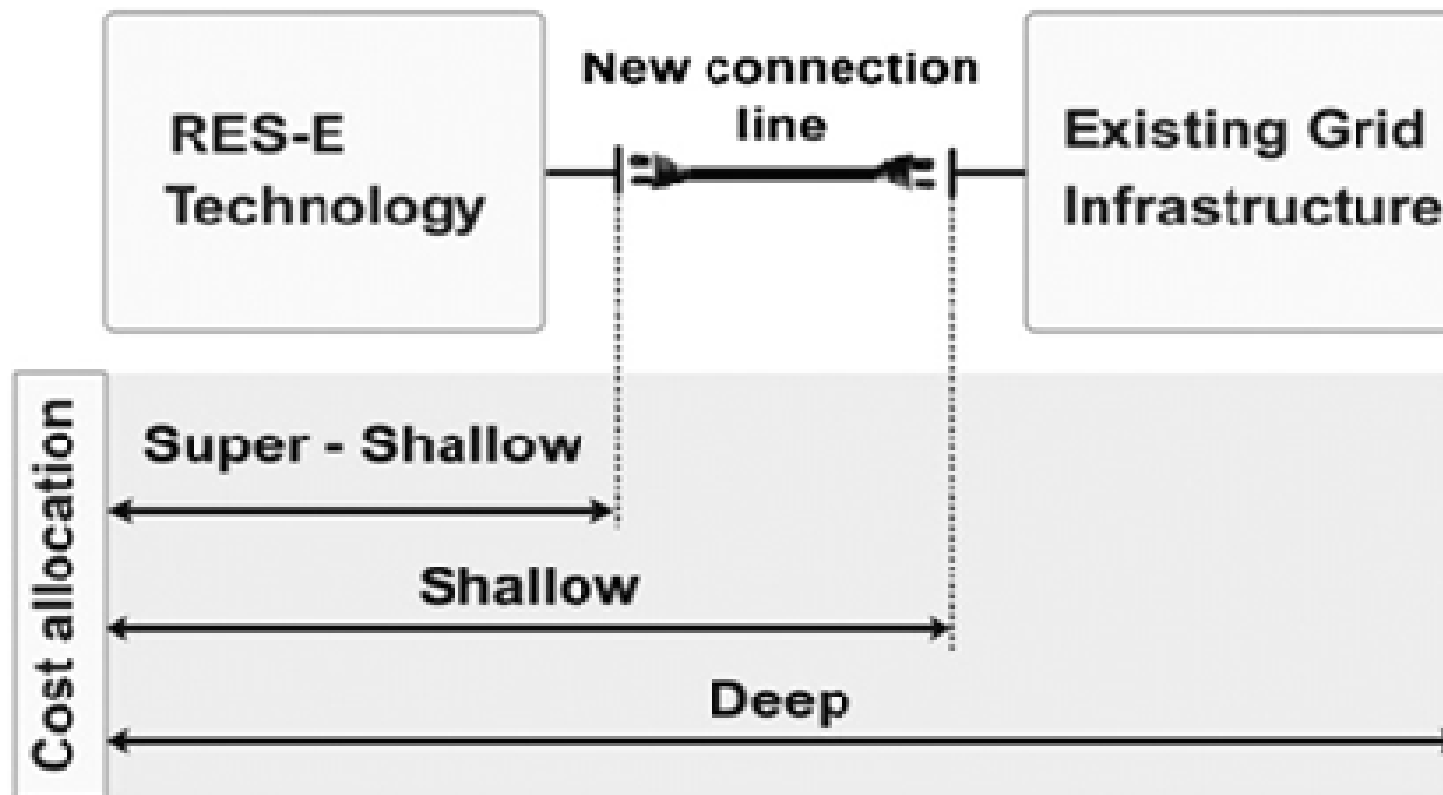
Solar radiation map – Turkey

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Connection cost allocation example



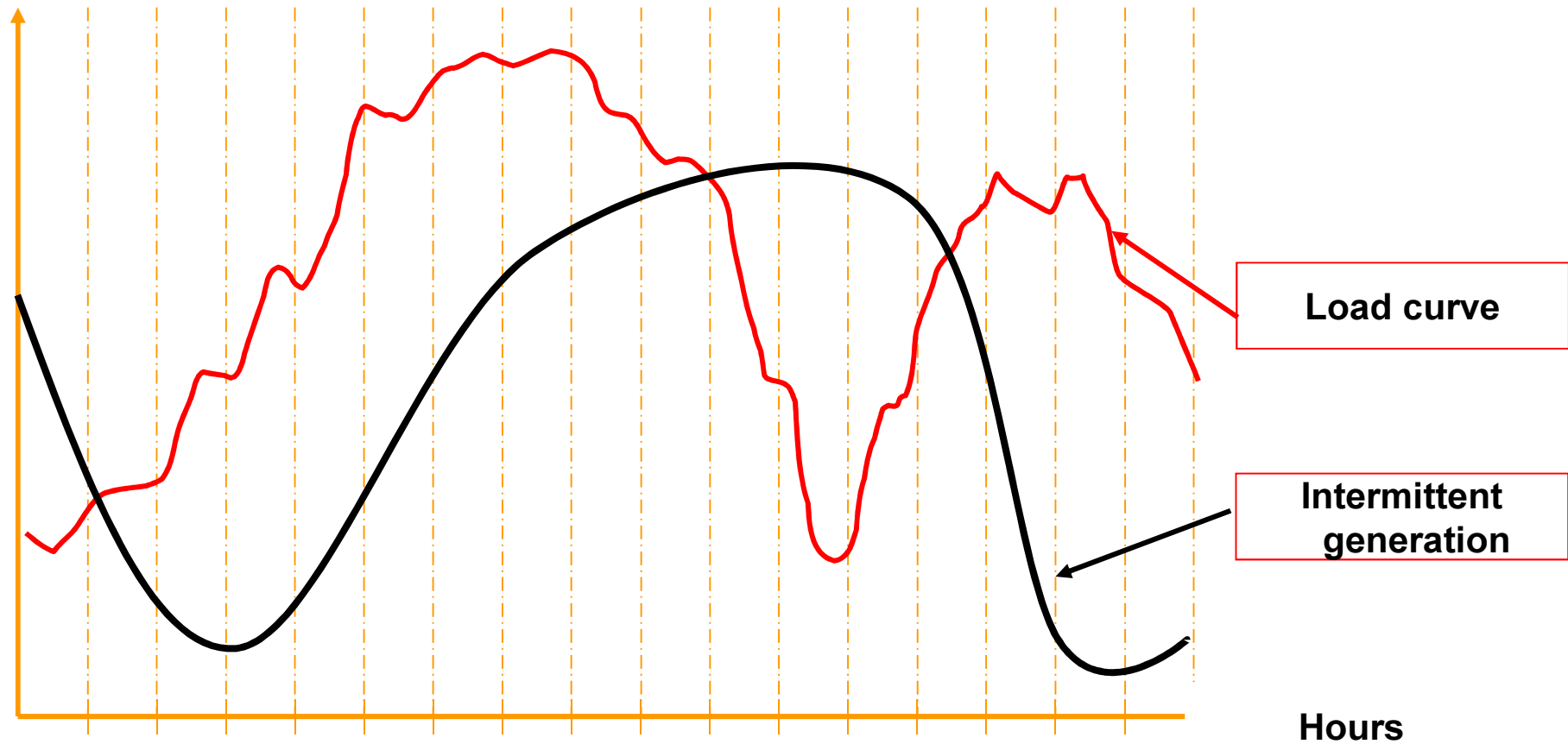
Source: Swinder (2008)

Germany: 100% socialisation of the cost of connecting
North Sea offshore wind

2. Is there a problem here?

Generation /
load, MW

Residual load = system load – intermittent generation

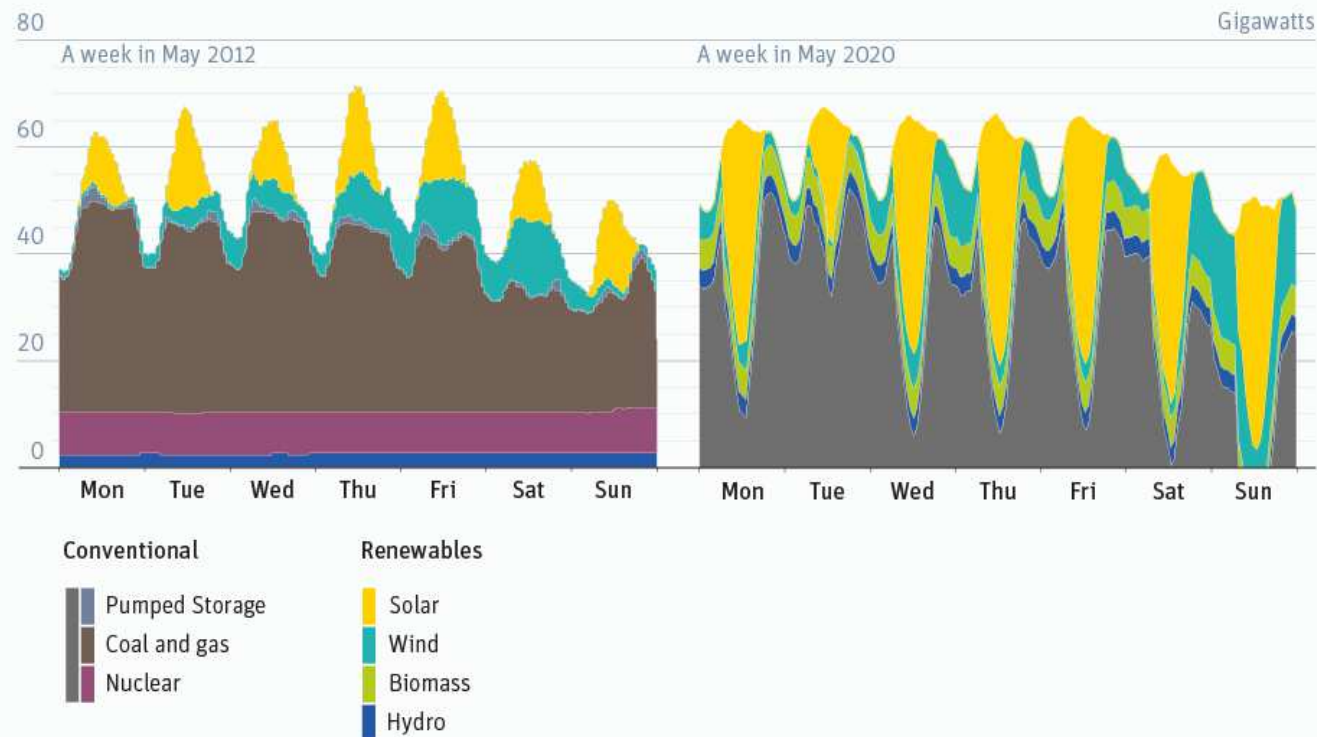


2. Is there a problem here?

Renewables need flexible backup, not baseload

Estimated power demand over a week in 2012 and 2020, Germany

Source: Volker Quaschnig, HTW Berlin



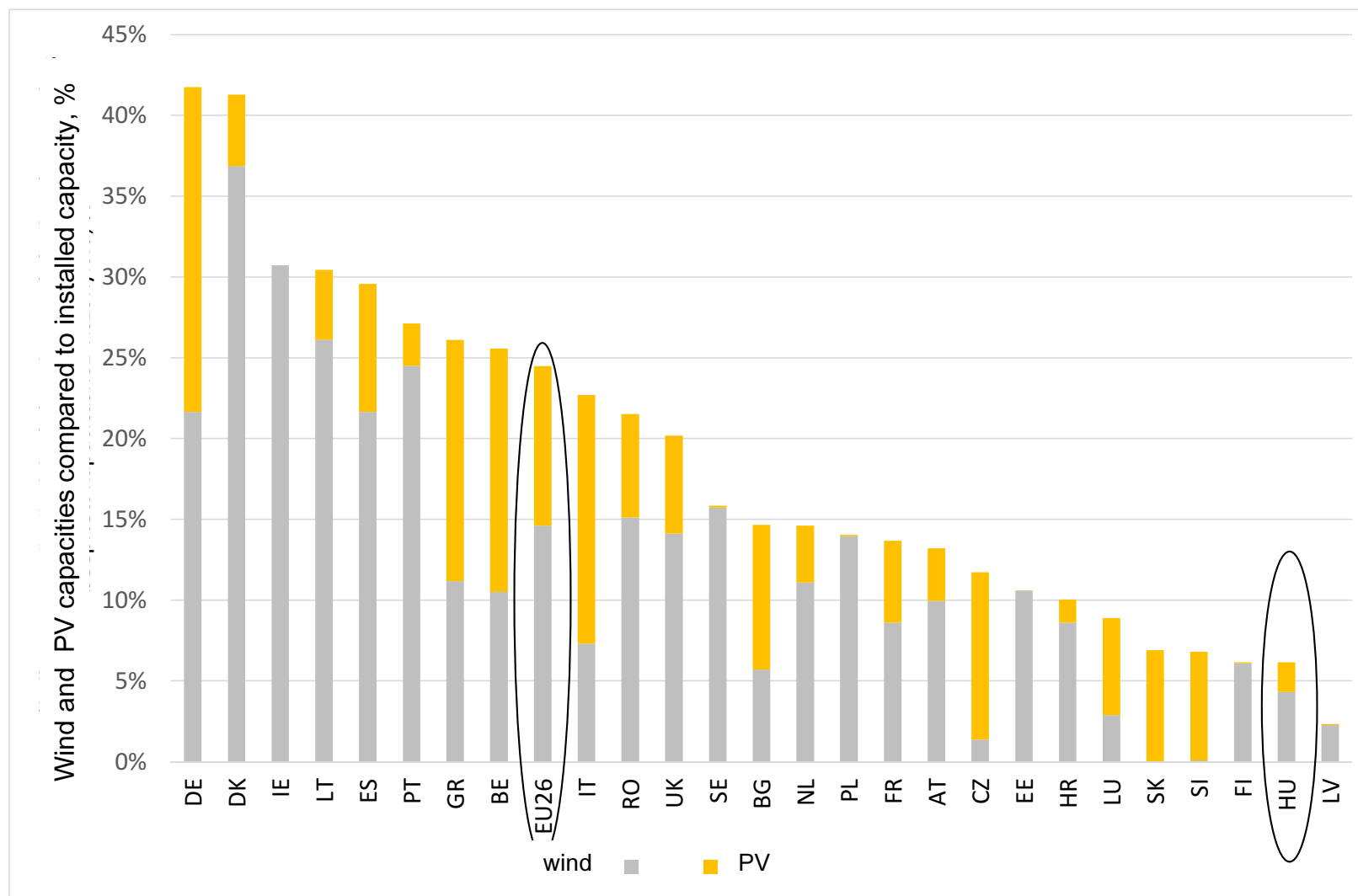
German Energy Transition

energytransition.de



Volker Quaschnig, 2010

Share of intermittent generation in installed capacity, EU, 2015



Problem 2: increased demand for system flexibility

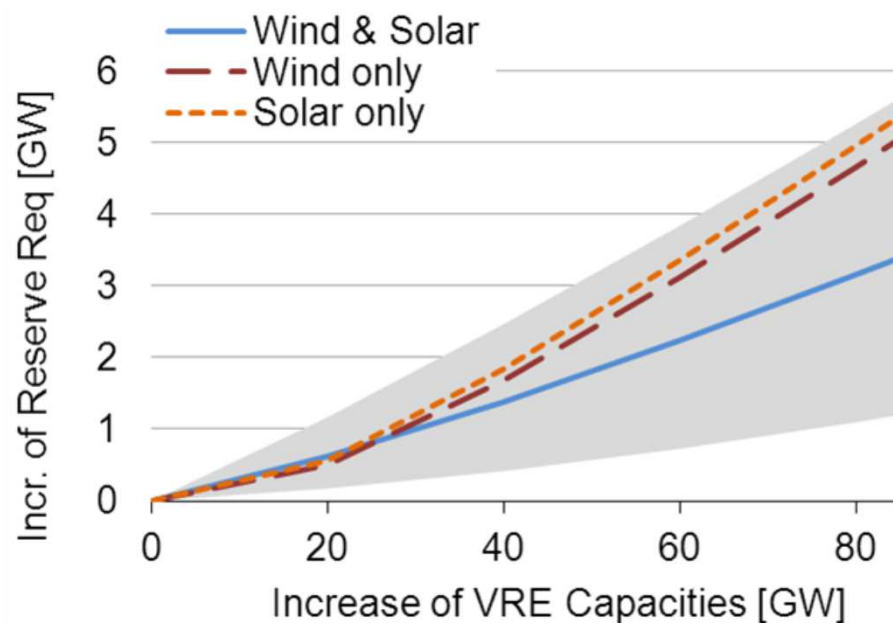
- As intermittent renewables penetrate, the residual load to serve by conventional generation decreases and becomes volatile
- Financial viability of conventional generation deteriorated
 - Reduced utilization rate (natural gas)
- Negative electricity wholesale prices appear
 - High cost of down regulating conventional units (nuclear, coal)

- What to do when intermittent generation (IG) falls well below system load?
- What to do when intermittent generation (IG) far exceeds system load?
- Which market participants can best help me (the TSO) keeping system security?
- How to discover the cost of flexibility providers?

Relationship between intermittent capacity and reserve needs?

Literature

1% increase in installed intermittent capacity
Implies 0.01-0.08 % additional reserve



Source: Ziegenhagen, 2013

Germany

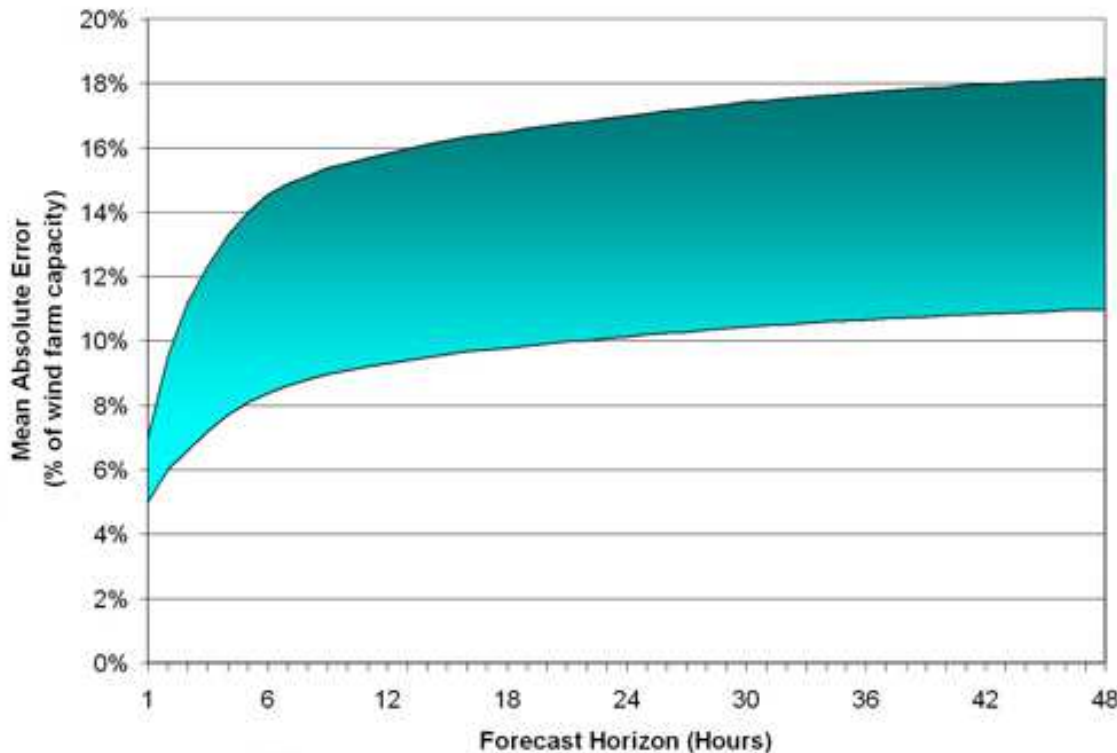
Change in installed intermittent capacities and reserves between 2008-14



Source: Hirth – Ziegenhagen, 2015

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Reducing demand for flexibility: gate closure, intraday markets



Source: Madsen (2005)

- Wind forecasting improves close to real time -> allow gate closure close to real time -> reduced need for balancing and additional reserves

- Main flexibility providers:
 - Flexible generation – CCGT
 - Demand – response
 - Storage
 - ...?
- Remuneration:
 - unlimited price spikes?
 - capacity remuneration mechanism (CRM)?
- EU proposal: CRM only if
 - regional inadequacy proved
 - CRM should be open for cross-border participants

Electricity balancing markets to be integrated cross-border

- Currently in Europe most balancing activity is carried out on a national level.
- In order to start a harmonization process in 2012 September ACER published the Framework Guidelines on Electricity Balancing in which Target Models of Balancing Energy has been framed
- ACER has proposed a gradual process
 - integrated market for all types of balancing energy within 6 years after the entry into force of the Network Code on Electricity Balancing (NC EB) which is currently under revision by ENTSO-E
- The main advantage of the integration of balancing market is that larger markets allow the different resources available in Europe to be used in a more effective way. This brings down the balancing costs and enhances security of supply.
- The NC EB would like to encourage a greater number of parties to offer balancing services including demand side response and intermittent sources → higher number of market players → more competitive balancing markets

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Network upgrade financing models 1 – Merchant or private lines

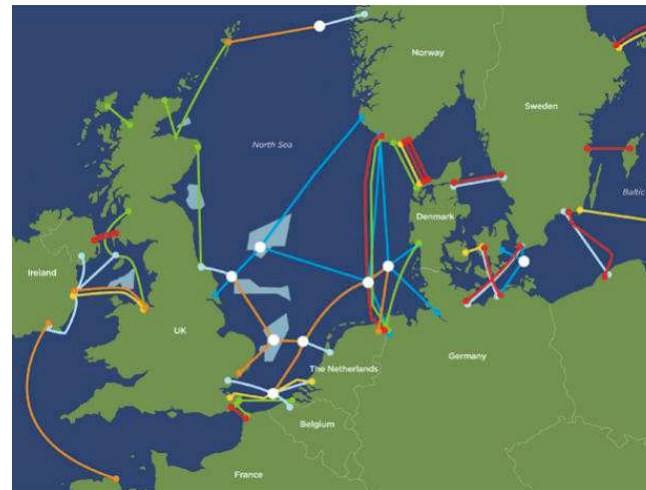
- Exclusive use of capacity by developers
- No (or negotiated) third party access - no regulated access tariff
- Line pays back from the price difference between the markets it connects



Estlink

Network upgrade financing models 2 – Public purpose lines

- Main rule: **regulated third party access (rTPA)**
- Line pays back from regulated tariff set by national regulator(s)
- In case of new major infrastructure development: Commission / ACER might provide exemption from rTPA



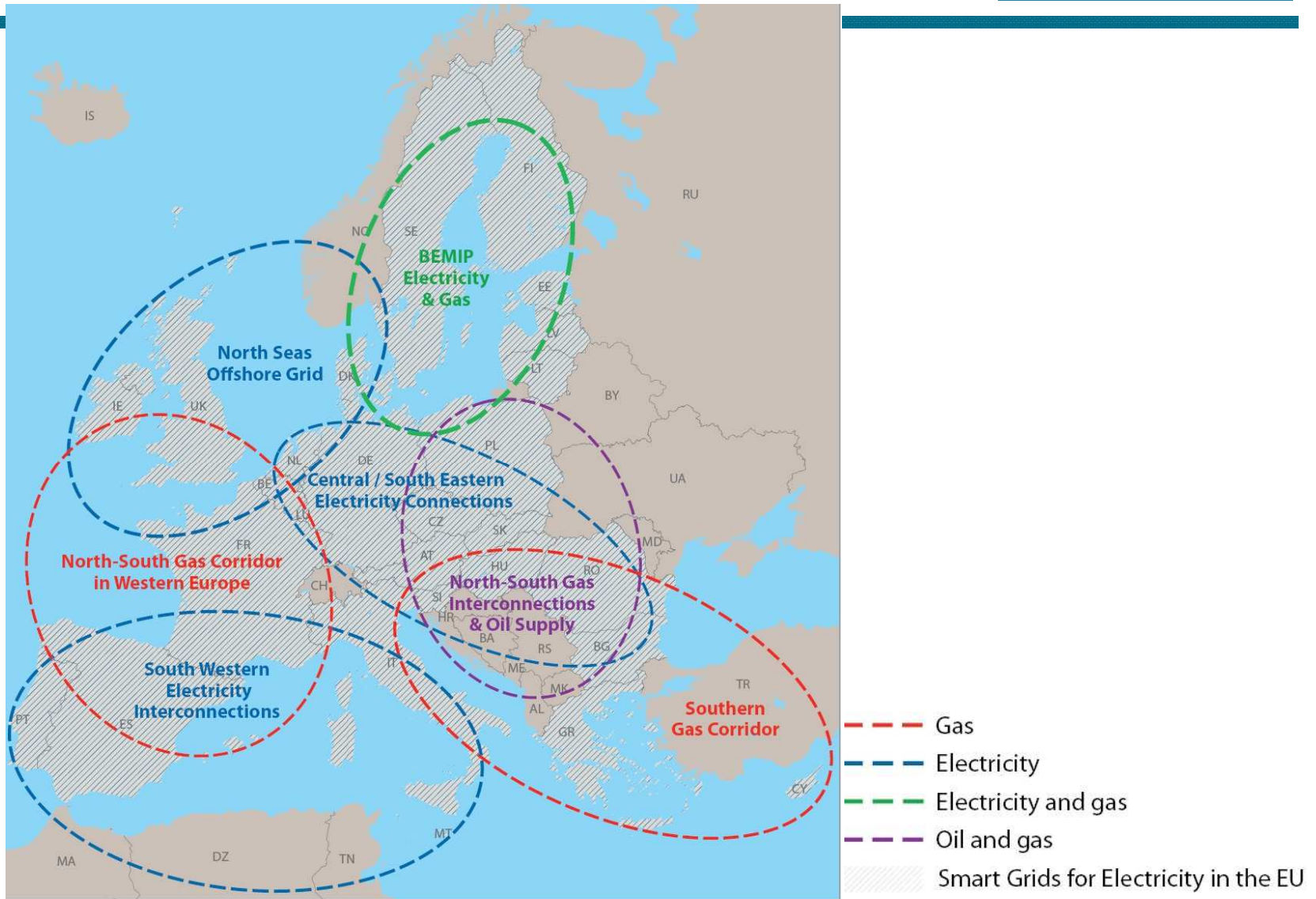
North Sea
offshore grid

- Problem: missing infrastructure to support full EU internal electricity market integration
- EU response:
 - TYNDP by ENTSO-E
 - Regulation 347/2013 on developing trans-European energy infrastructure development
 - Connecting Europe Facility (5 Mrd Euro)
- Main measures:
 - Projects of Common Interest (PCI) selection process
 - Decision supported by system-wide Cost Benefit Analysis
 - Cost sharing: Cross Border Cost Allocation based on benefit distribution

EU Energy corridor development priorities

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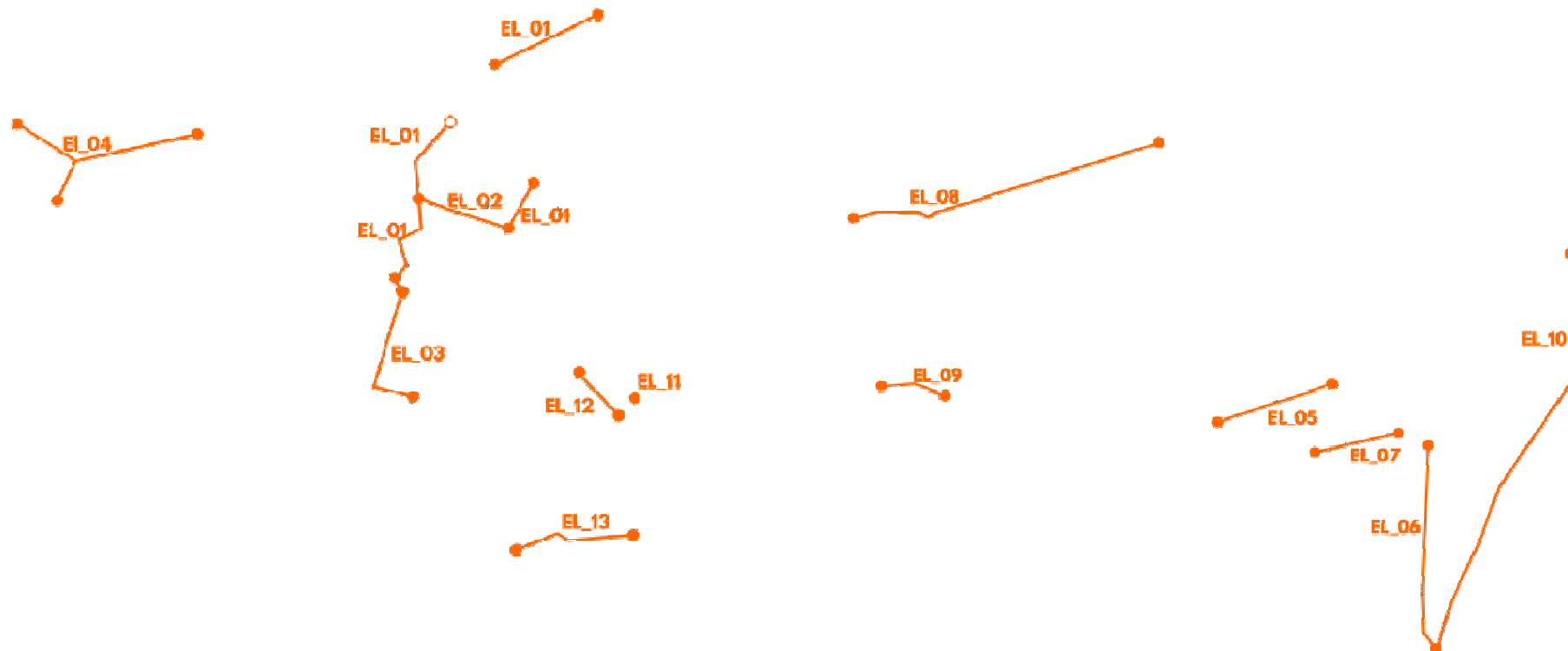


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Proposed Projects of Energy Community Interest (2016)

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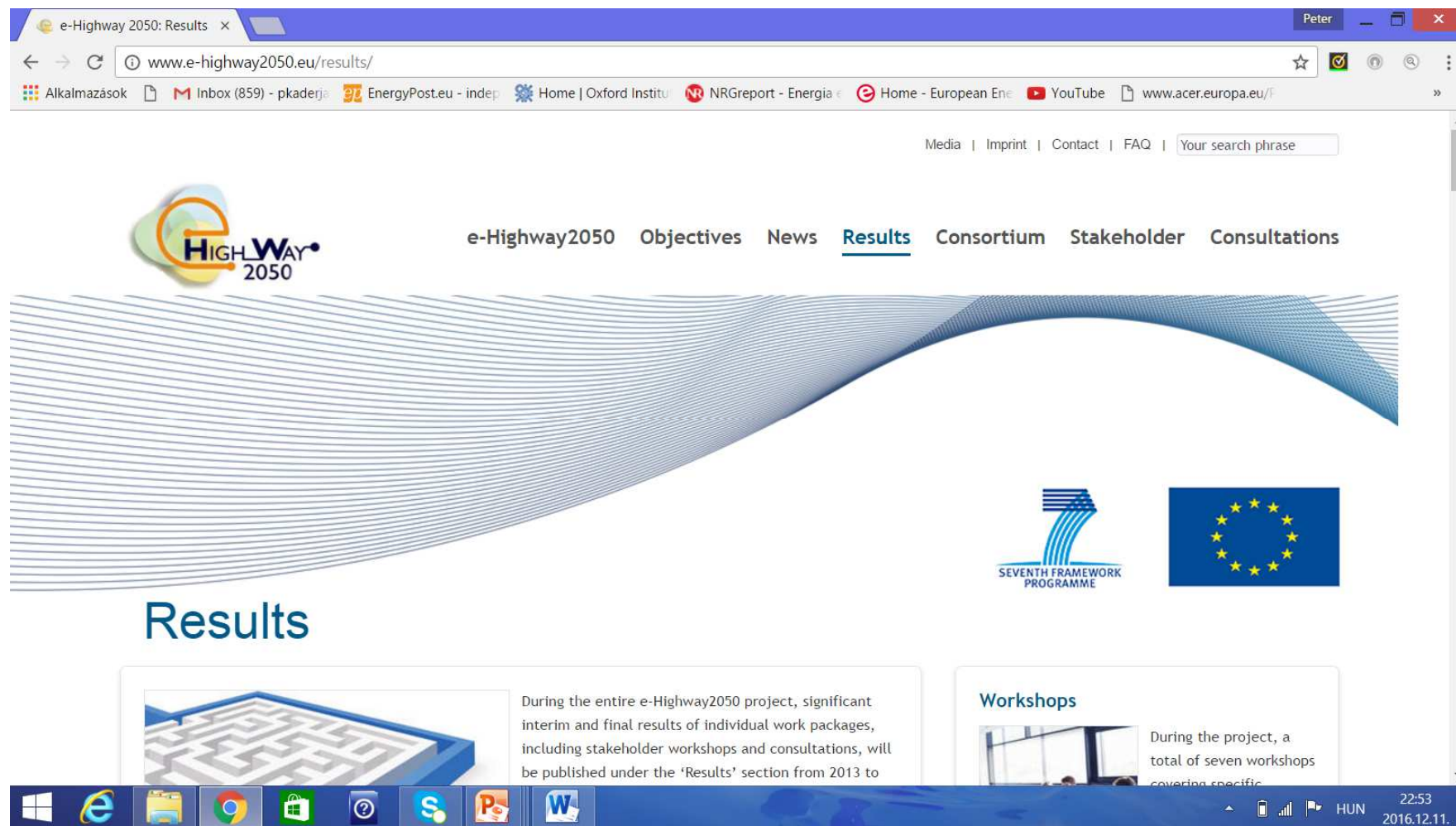
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E-highway 2050

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The screenshot shows a web browser window displaying the 'e-Highway 2050: Results' page. The browser's address bar shows the URL 'www.e-highway2050.eu/results/'. The page features a navigation menu with links to 'e-Highway2050', 'Objectives', 'News', 'Results' (which is underlined), 'Consortium', 'Stakeholder', and 'Consultations'. Below the navigation menu is a large graphic of a blue wavy line. To the right of this graphic are logos for the 'SEVENTH FRAMEWORK PROGRAMME' and the European Union flag. The main heading 'Results' is prominently displayed. Below it, there are two sections: 'Workshops' and 'Results'. The 'Workshops' section includes a photo of a workshop and text stating 'During the project, a total of seven workshops covering specific...'. The 'Results' section includes a photo of a maze and text stating 'During the entire e-Highway2050 project, significant interim and final results of individual work packages, including stakeholder workshops and consultations, will be published under the 'Results' section from 2013 to...'. The Windows taskbar at the bottom shows various application icons and the system clock indicating 22:53 on 2016.12.11.

e-Highway 2050: Results

www.e-highway2050.eu/results/

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e-Highway2050 Objectives News Results Consortium Stakeholder Consultations

Results

SEVENTH FRAMEWORK PROGRAMME

Workshops

During the project, a total of seven workshops covering specific...

During the entire e-Highway2050 project, significant interim and final results of individual work packages, including stakeholder workshops and consultations, will be published under the 'Results' section from 2013 to...

22:53 2016.12.11.

Appendix

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Basic characteristics of reserve procurement and balancing in Hungary I.

	Primary	Secondary	Tertiary
Who can provide reserve?	Domestic and foreign power plants, traders, consumers – accreditation is needed	Domestic and foreign power plants, traders, consumers – accreditation is needed	Domestic and foreign power plants, traders, consumers – accreditation is needed
Needed capacity	TSO declares	TSO declares	TSO declares
Procurement method	Yearly auction	Multistep auction: yearly/quarterly/weekly auctions	Yearly auction
Contract type	Yearly Market maker	Yearly Market maker, Yearly option contract	Yearly Market maker, Yearly option contract
Form of payment	Capacity fee	Capacity fee + energy fee	Capacity fee + energy fee

Basic characteristics of reserve procurement and balancing in Hungary II.

- Multistep auction:
 - First step: procurement on yearly/quarterly/weekly auctions
 - Second step: usage according to the result of day-ahead auction
- There are two types of contracts:
 - Market maker (dominant form)
 - The market player must provide its capacity on the daily auctions at a non-higher price than defined in the contract
 - The TSO must accept it
 - Option contracts (for the market players who do not get an offer for a market maker contract)
 - The market player can make an offer on the daily auction
 - The TSO can accept it
- Because of the characteristics of the market maker contracts, the importance of the option contracts is not so significant, and the daily auctions only play role in the defining of the mobilization order and the balancing energy fees.

The cost of the procurement of reserves in 2009-12

Categories		Years							
		2009		2010		2011		2012	
		Average quantity [MW]	Total cost [million Ft]	Average quantity [MW]	Total cost [million Ft]	Average quantity [MW]	Total cost [million Ft]	Average quantity [MW]	Total cost [million Ft]
Primary (+/-)		40	1 122.1	40	1 162.3	40	1 634.0	40	1 822.9
Secondary	Upward	340	13 423.6	301	11 747.7	310	19 714.9	257	26 085.2
	Downward	-	-	172	19 037.7	145	15 957.8	137	12 120.3
Tertiary	Upward	524	13 490.3	464	23 534.7	455	24 807.6	500	11 758.0
	Downward	-	-	77	1 476.5	-	-	-	-
Black Start			115.3		151.5		119		186
U/Q			15.3		18.0		91.8		45.7
Sum			28 169.6		41 937.5		46 209.6		52 018.1

Source: MAVIR data

- The total cost of securing system level reserves has escalated
- The costs of BS and U/Q (Voltage and reactive power control) are negligible
- Secondary and tertiary reserves have the largest share (~96%) → TSO launched auctions from 2013, sharp price decrease!