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Storage market integration, regulatory framework and capacity markets

Hydro Balance User Meeting

18 November 2014, Trondheim



NTNU

Norwegian University of
Science and Technology

Future potential for large scale energy storages

Energy storage can supply more *flexibility* and *balancing* to the grid, providing a *back-up* to intermittent renewable energy.

European Commission, "DG Ener Working Paper The future role and challenges of Energy Storage",
http://ec.europa.eu/energy/infrastructure/doc/energy-storage/2013/energy_storage.pdf

Storages and their

MARKET INTEGRATION

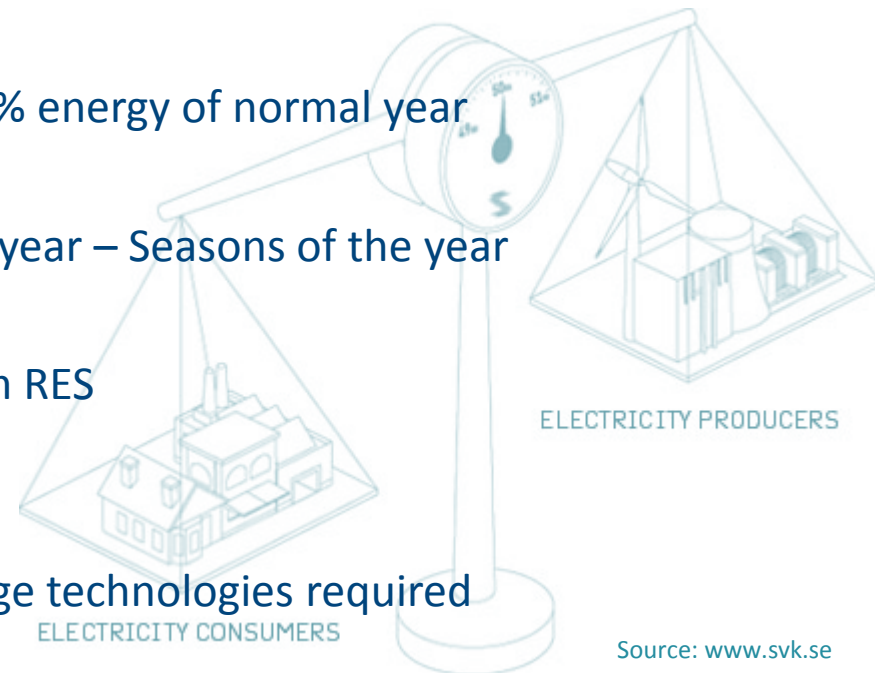
What is meant with **Balancing** the system?

In general:

Assure the *balance* between *supply* and *demand* of electricity on all *times scales*.

- Various time scales (focus on RES):
 - Yearly
 - Wet, windy, sunny year? – up to $\pm 25\%$ energy of normal year
 - Monthly
 - Hydro inflow, wind regimes during a year – Seasons of the year
 - Weekly
 - Days with low / high production from RES
 - Diurnal, Intra-day, Real-time:
 - RES production forecasts

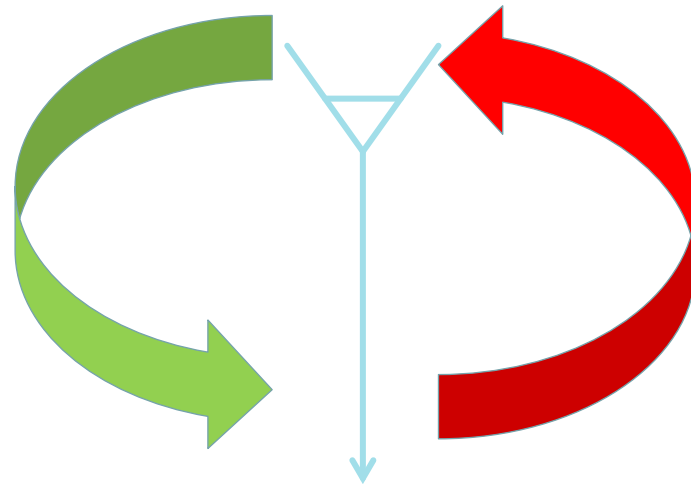
=> Different markets affected and different storage technologies required



Source: www.svk.se

Business models for storages

- Energy storage => arbitrage:
 - Store energy = purchase energy, when energy prices are low
 - Release energy = sell energy, when energy prices are high
 - OBS: Round cycle efficiency => **profit** = $\text{eff}_{\text{round}} * \text{price}_{\text{high}} - \text{price}_{\text{low}}$
 - Size of storage?
- System services:
 - Reserve capacity
 - Balancing energy
 - Black-start capability
 - ...



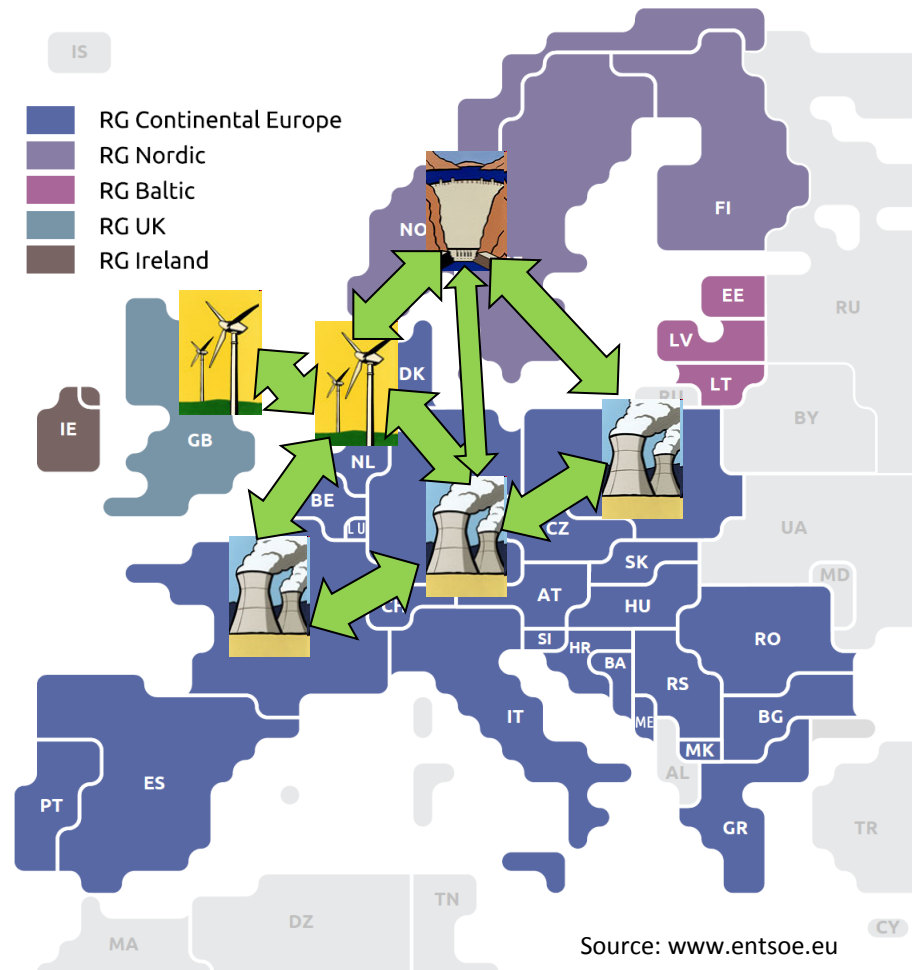
Transmission system

- Geographic location of "big" storages mostly given by landscape:
 - Mountains for pump storages
 - Caverns for compressed air storages

=> connection of storage and production / consumption facilities required

=> transmission system necessary

- Resulting challenges:
 - Additional investment cost for the transmission expansion
 - Potential congestions in the transmission system
 - Losses in the transmission system add up to the round cycle efficiency



Storages and the

REGULATORY FRAMEWORK

European Regulatory Framework

Electricity Directive 2009/72/EC:

- Concept of storage not mentioned

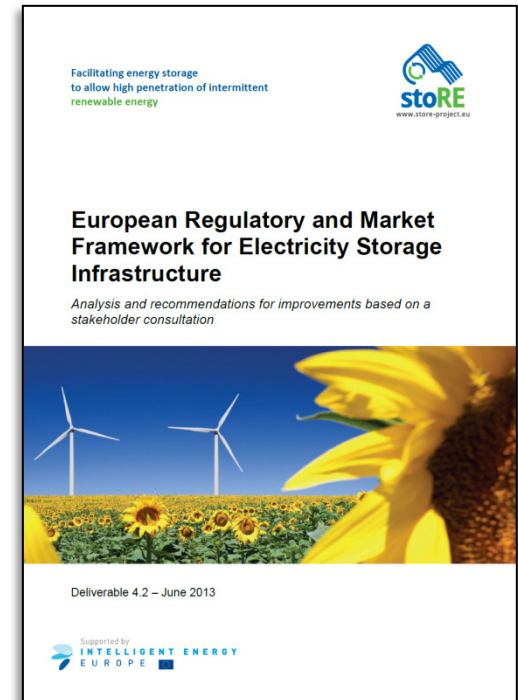
ACER's Framework Guidelines / ENTSOE's Network Codes:

- Electricity Balancing
- Grid Connection
- Electricity System Operation

Guidelines for trans-European energy infrastructure:

- Prominent position together with "transmission assets"
- Potential for financial support for storage facilities
- But: Pump storage explicitly left out from financial support / incentives, as it is a mature technology

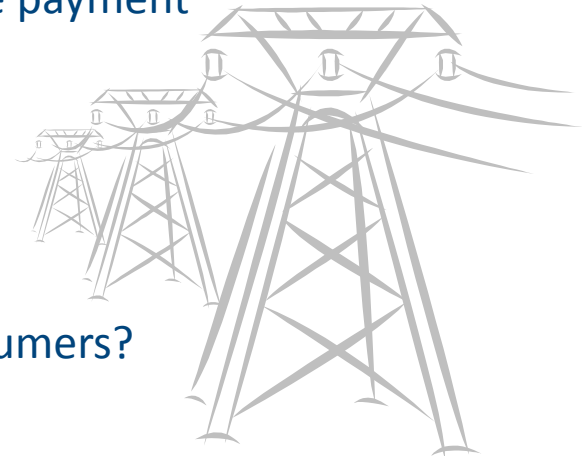
stoRE Project, "European Regulatory and Market Framework for Electricity Storage Infrastructure", 2013,
http://www.store-project.eu/documents/results/en_GB/european-regulatory-and-market-framework-for-electricity-storage-infrastructure



Grid tariffs

Important issue to energy storage operators – potential double payment

- How are storage facilities treated?
 - Production, consumption, as both, different?
- Why should it be treated different than generators or consumers?
 - Most often more price elastic
 - Principle of price causality => is the storage triggering grid investments?
 - Levelling line loading?



Examples for grid tariffs

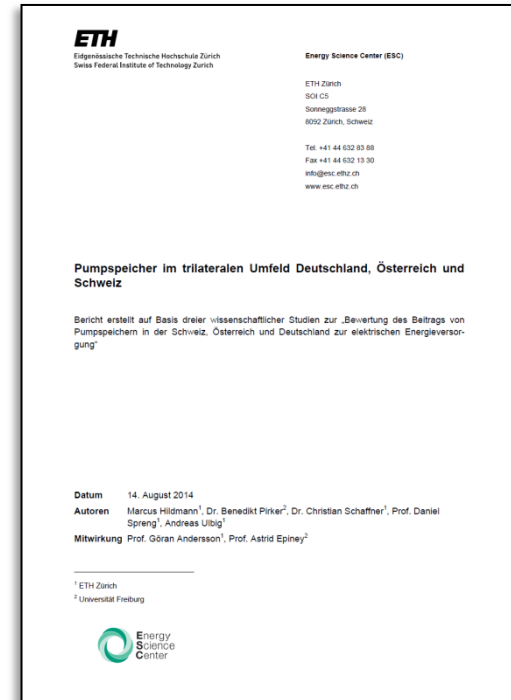
- Norway ¹:
 - Classified as producer and consumer
 - Hourly marginal losses determined, based on expected load flow
=> potential income from grid tariffs
 - Reduction of tariffs in case of high flexibility
- Germany ²:
 - Classified as consumer
 - New storage facilities and pump storage expansions exempted from grid tariffs
- Switzerland ²:
 - Legally exempted from grid tariffs

¹ Statnett, "Sentral nettariffen 2015", 2014,

<http://www.statnett.no/Global/Dokumenter/Kraftsystemet/Tariff%20og%20tilknytning/Tariffhefte%202015.pdf>

² BMWi, "Zusammenfassung der Studie: Pumpspeicher im trilateralen Umfeld Deutschland, Österreich und Schweiz", 2014

<http://www.bmw.de/DE/Mediathek/publikationen,did=649640.html>



Storage capabilities under

CAPACITY REMUNERATION MECHANISMS

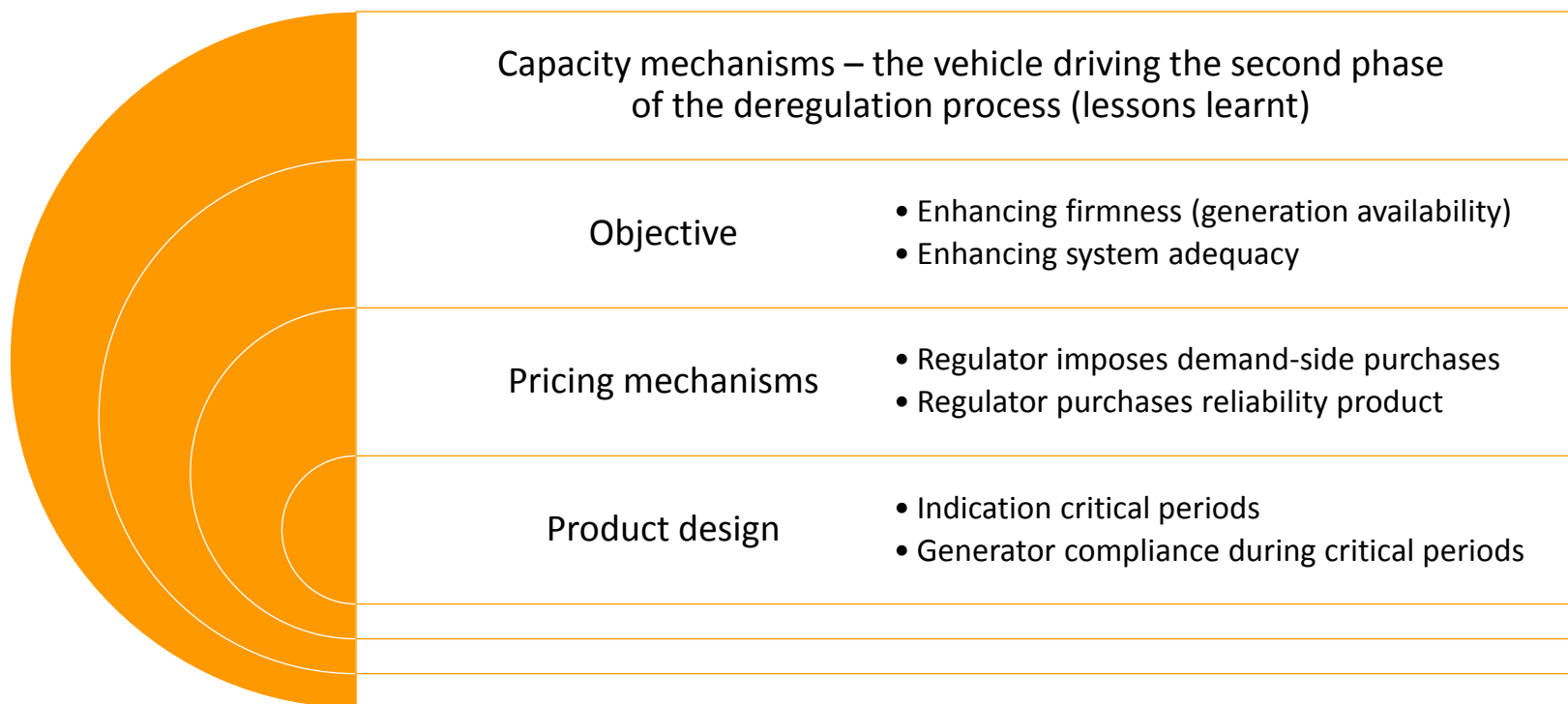
Capacity mechanisms

Capacity (remuneration) mechanisms - **CRM**

- **Requirements** for or **Remuneration** of **installed / available** generation capacity
- Implementation to ensure system adequacy (sufficient generation capacity to cover the peak demand)
- Payments in EUR/MW installed / available generation capacity

Capacity mechanisms

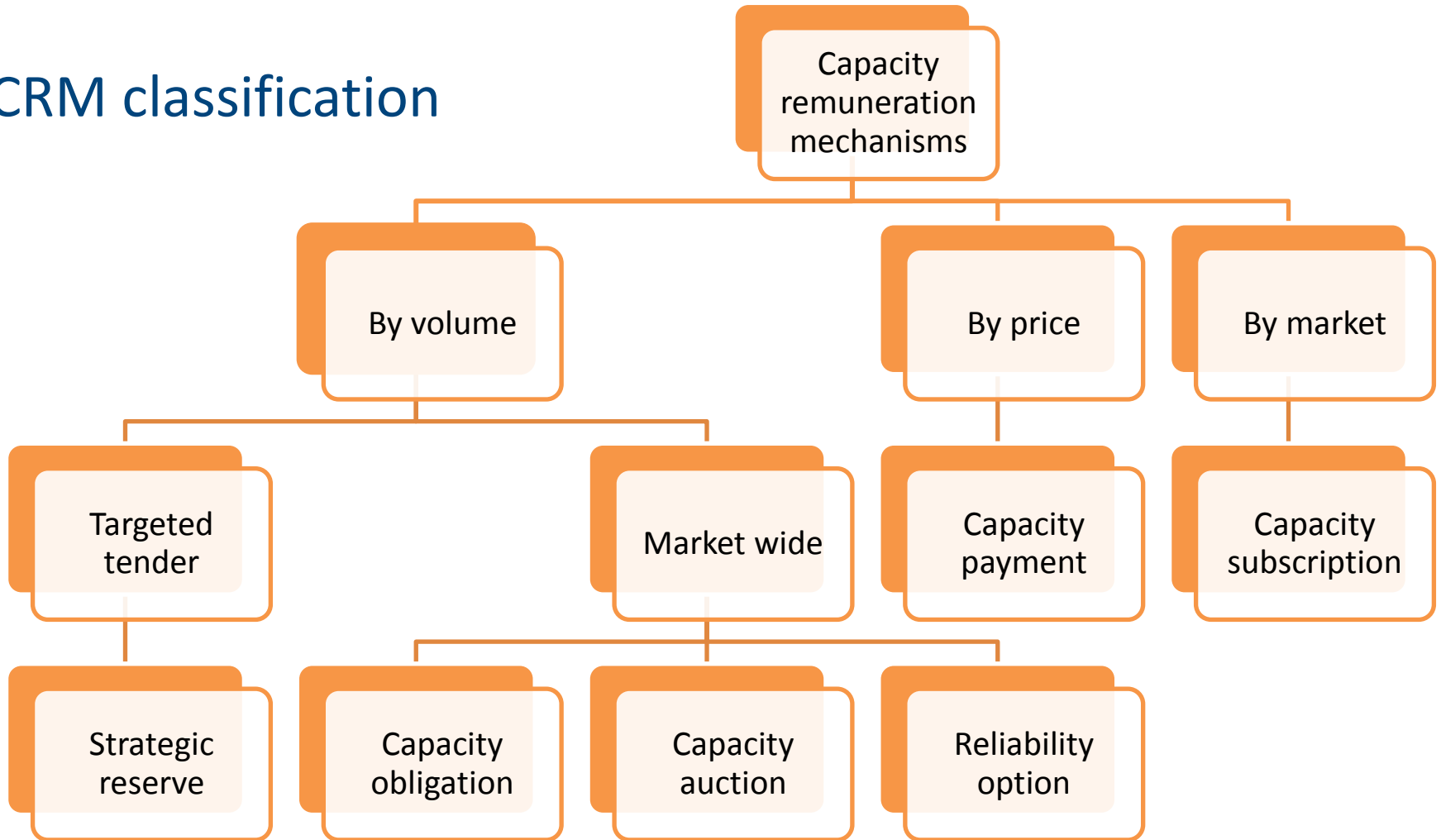
Design criteria



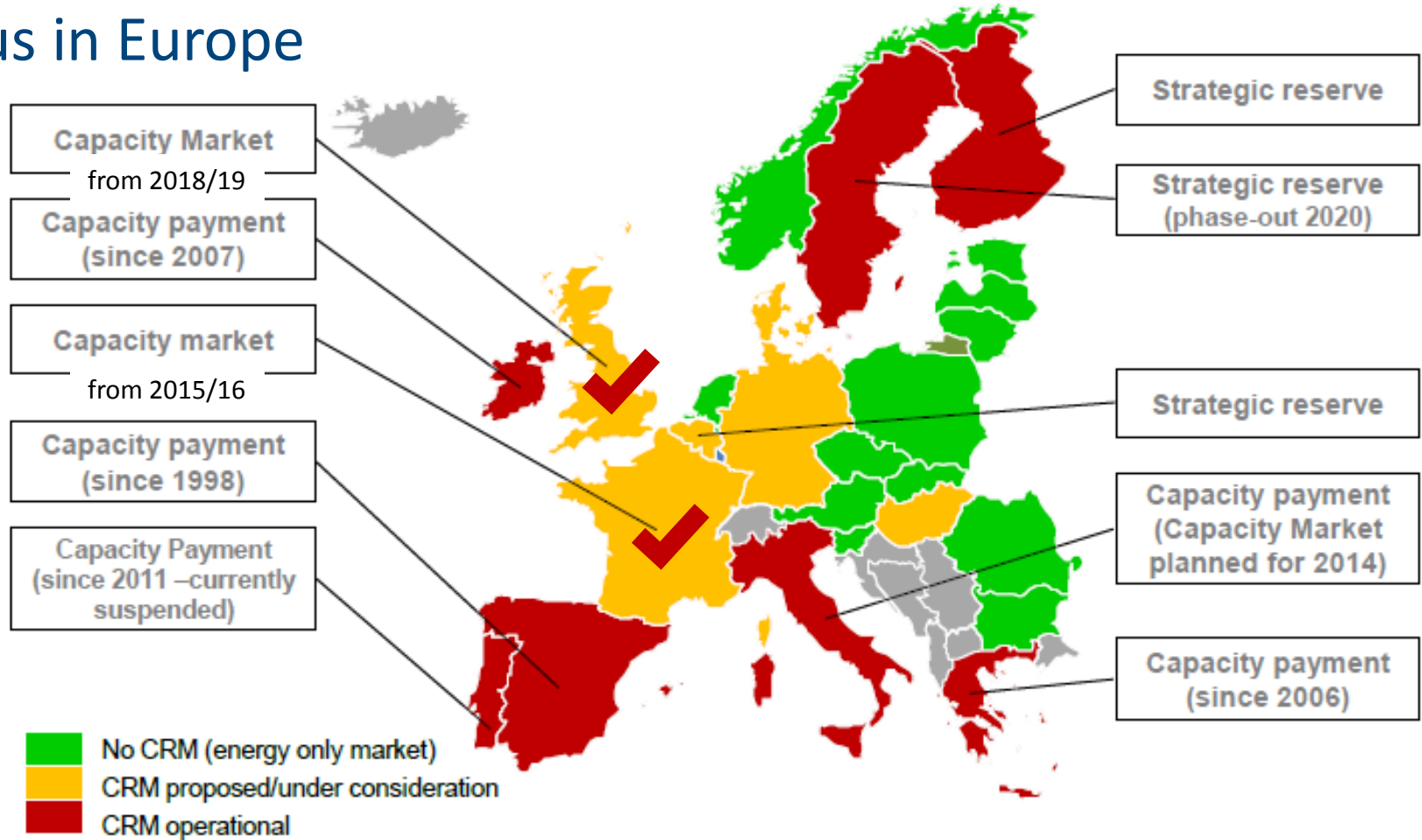
➤ Implicit technology selection through obligation / lag period

C. Batlle, I.J. Perez-Arriaga, "Design criteria for implementing a capacity mechanism in deregulated electricity markets", Utilities Policy, 2008

CRM classification



Status in Europe



ACER, "Report: CAPACITY REMUNERATION MECHANISMS AND THE INTERNAL MARKET FOR ELECTRICITY", 2013, http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/CRMs%20and%20the%20IEM%20Report%20130730.pdf

Renewable energy sources as generation capacity

Key figures from Germany in 2012

- WPP:
 - 29.9 GW installed capacity
 - 45.9 TWh (8.2% of gross electricity production)
- SPP:
 - 32.4 GW installed capacity
 - 27.9 TWh (5% of gross electricity production)

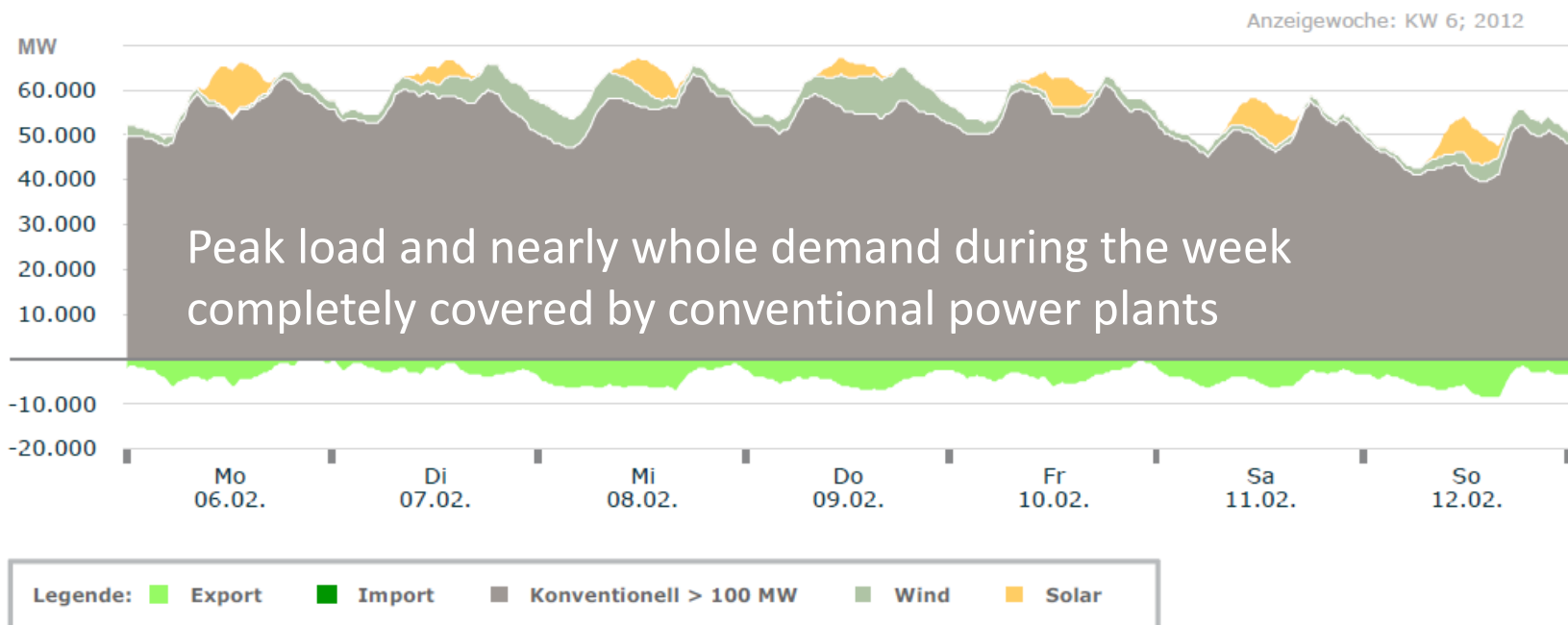
➤ Examples for challenging weeks

Source: Burger, B. "Electricity production from solar and wind energy in 2012",
Fraunhofer ISE, presentation, February, 2013

URL: <http://www.ise.fraunhofer.de/en/renewable-energy-data>

RES challenges

No production from RES

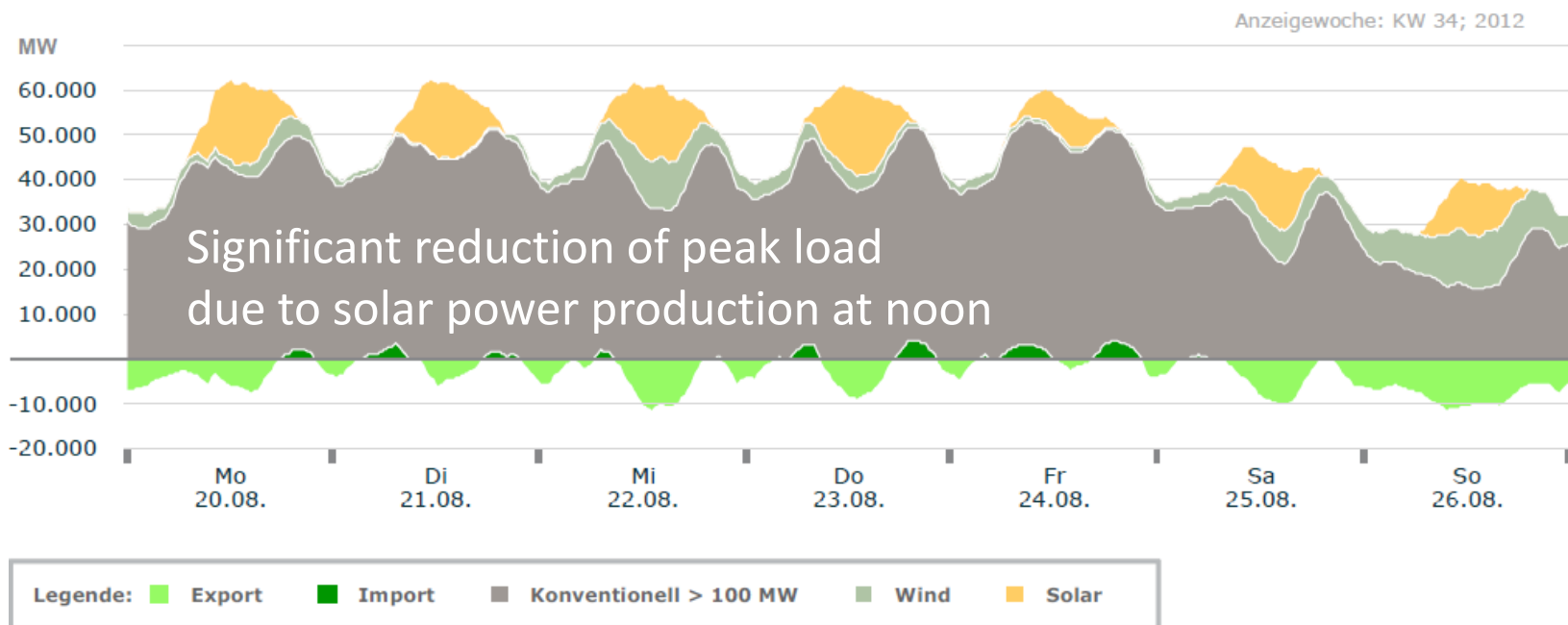


Source: Burger, B. "Electricity production from solar and wind energy in 2012",
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RES challenges

High Photovoltaic production

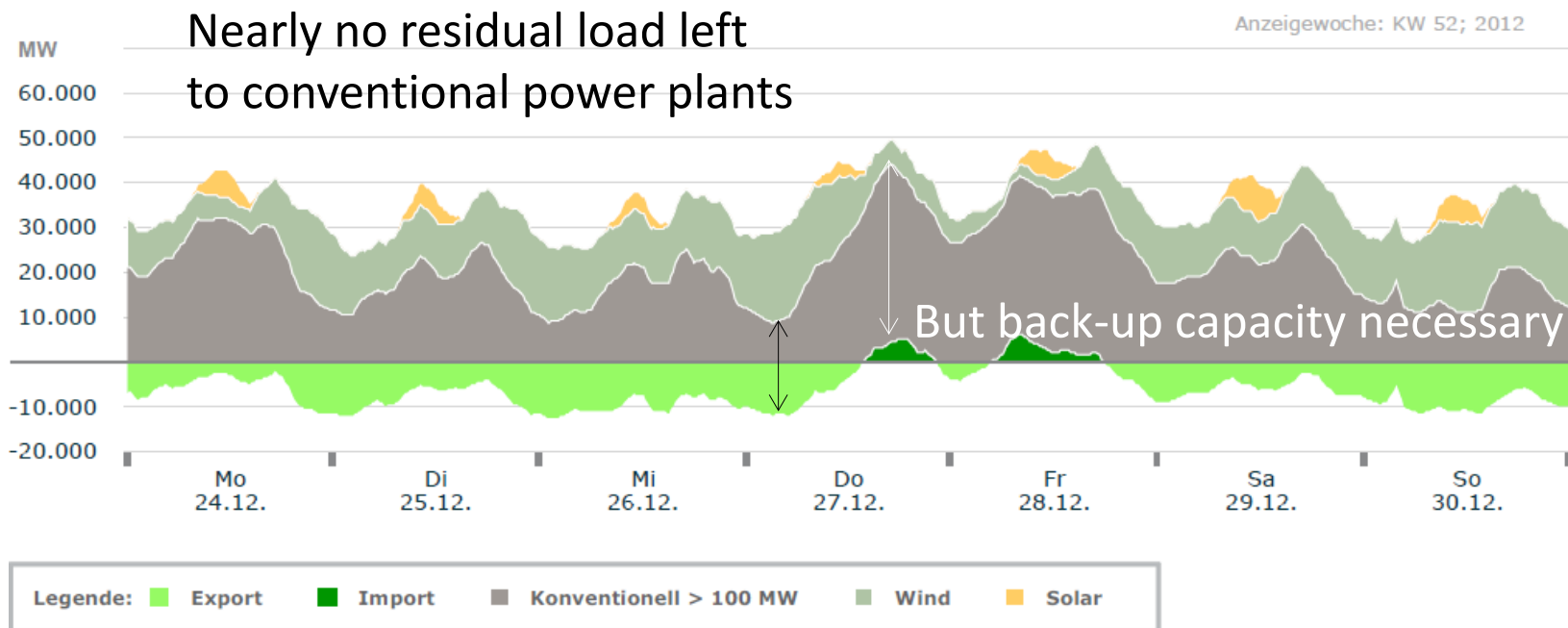


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RES challenges

High Wind power production



Source: Burger, B. "Electricity production from solar and wind energy in 2012",
Fraunhofer ISE, presentation, February, 2013

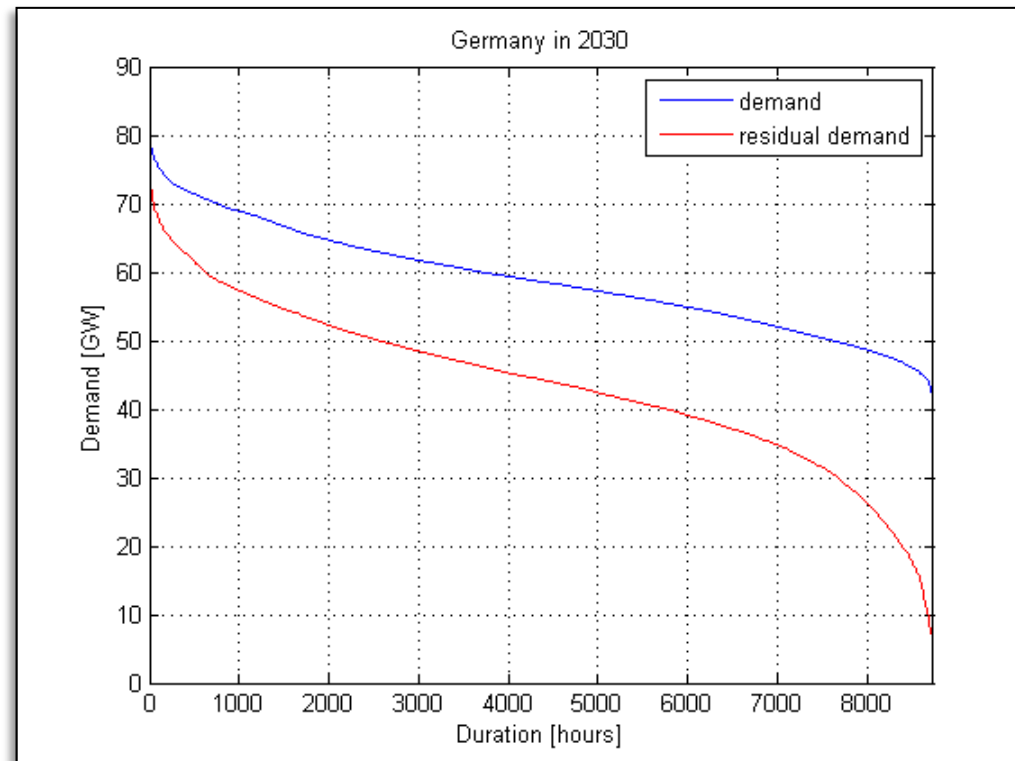
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Renewable energy sources

Challenges for conventional power plants

- Residual demand to be covered by conventional power plants
 - Higher variability of demand
 - Lower utilisation time of power plants
 - But nearly equal size of conventional generation capacity required

=> Call for capacity mechanisms to ensure system adequacy



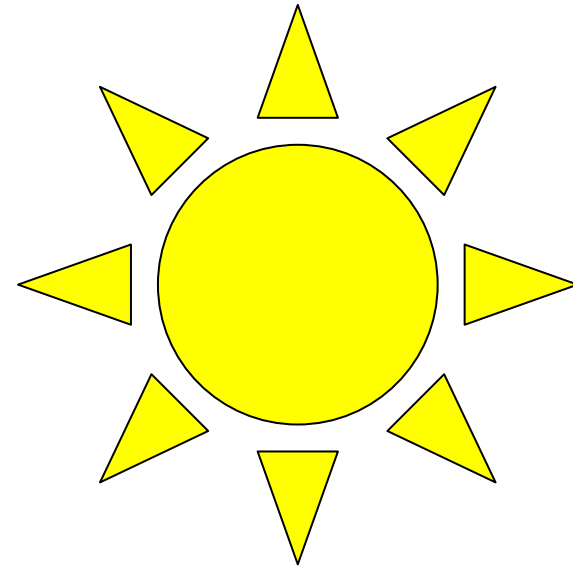
Norwegian hydro power production

In the scope of CRMs

Challenges

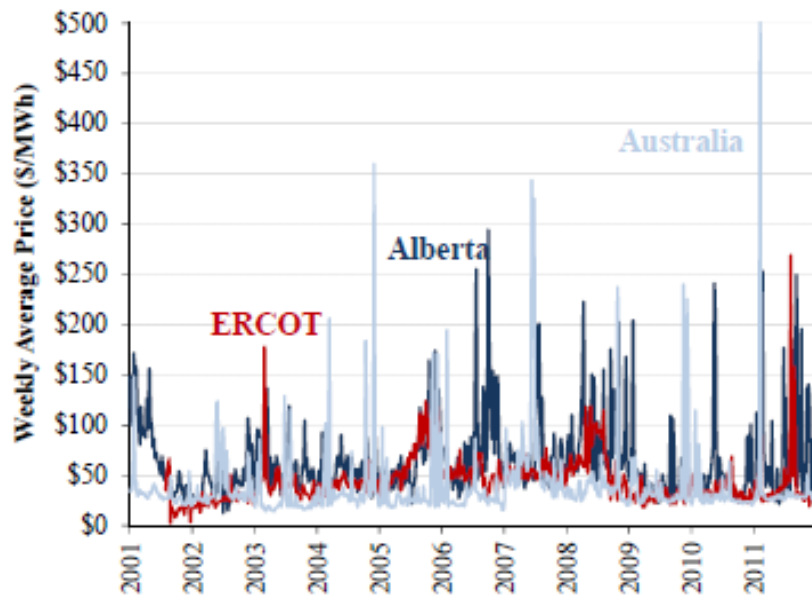


Opportunities

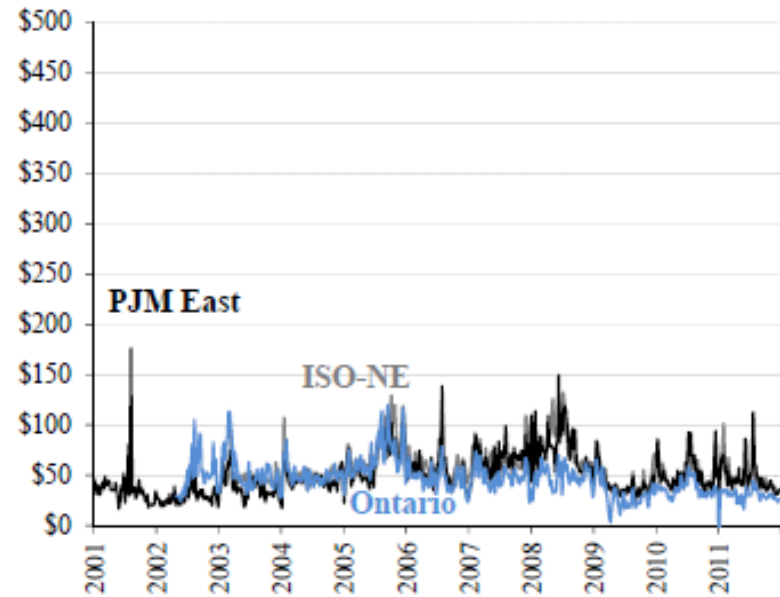


Electricity prices

Weekly average



No capacity mechanism



With capacity mechanism

SOURCE: THE BRATTLE GROUP, "ERCOT INVESTMENT INCENTIVES AND RESOURCE ADEQUACY"

REPORT, JUNE, 2012

Norwegian hydro

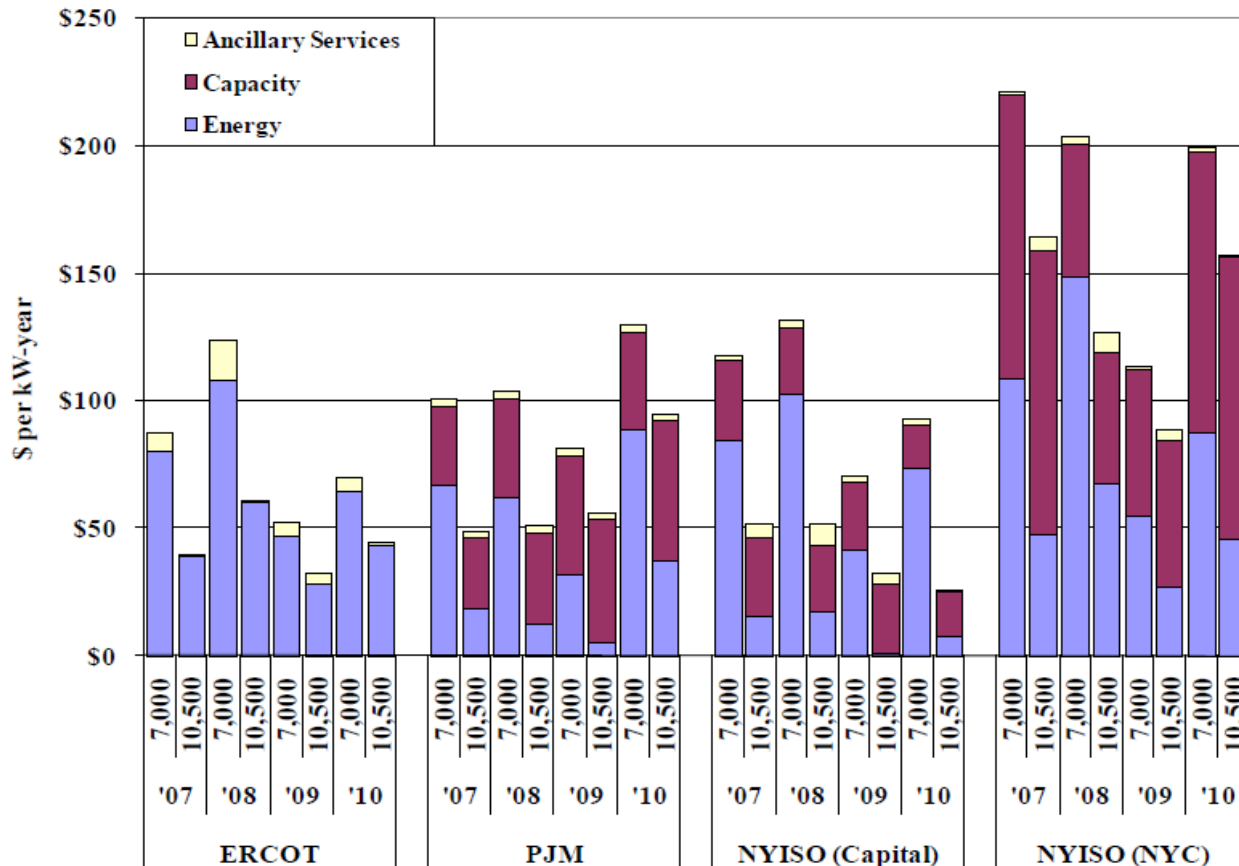
In the scope of CRMs

Challenges

- Reduced average electricity prices in countries with CRMs
- Reduced average electricity prices in Norway (water value defined by exchange prices)
- Reduced income for Norwegian hydro power
- Hydro capacity expansions profitable?

Opportunities

Net revenues for peaking power plants



SOURCE: BARITAUD, M., "CONCEPTS AND EXPERIENCES WITH CAPACITY MECHANISMS",
PRESENTATION, AUGUST 2012

Norwegian hydro

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Opportunities

- Additional hydro power capacity in Norway
- Provision of peak capacity / back-up capacity for RES (if foreign participation is allowed)
- Additional income from capacity remuneration mechanisms to hydro power producers

Norwegian hydro

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But: Reliable transmission capability is required between Nordic and continental Europe

New offshore HVDC cables from Norway

Nord.Link (NO-DE) / NSN (NO-UK) HVDC cables



Permits granted from OED to build HVDC cables
to Germany & UK (13.10.)



Capacity market implemented in UK /
under discussion in Germany



Requirement (of the permits) that cables can
participate in the national CRMs



Technology for a better society