



Flex4RES
Flexible Nordic Energy Systems



FlexEm 2050

Flexible Electricity Markets for
Decarbonized Systems

Eurelectric & FSR
Bruxelles, June 7 2017



Presenters:

Klaus Skytte
Claire Bergaentzle

Klsk@dtu.dk

Energy Economics and Regulation
DTU Management Engineering Denmark

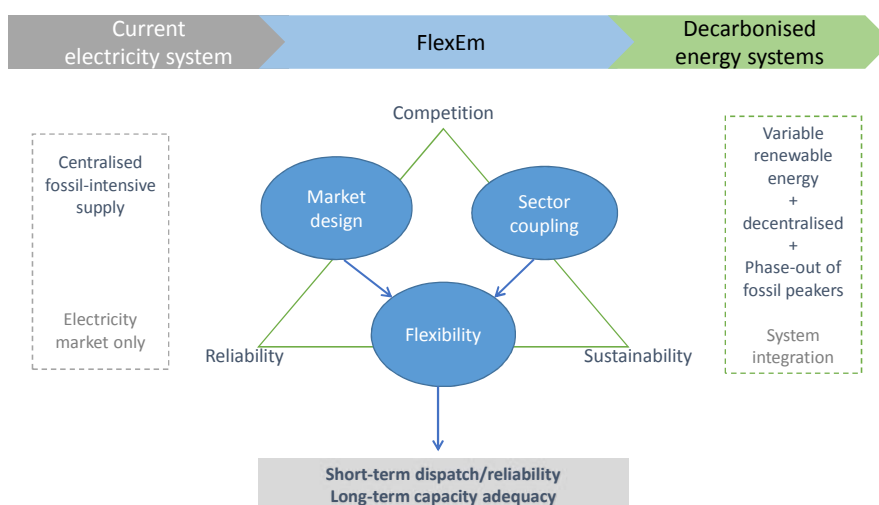


The FlexEM vision

From centralised and fossil-intensive systems to
decarbonised and integrated energy systems



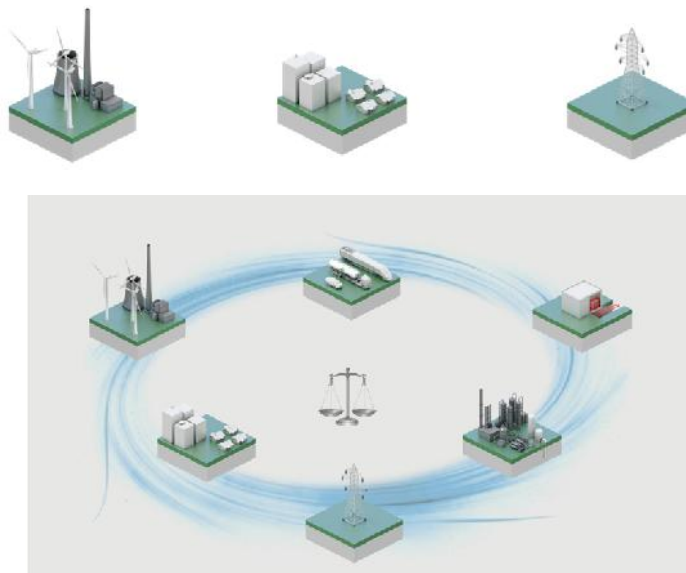
Flex4RES



Flexibility resources



Flex4RES

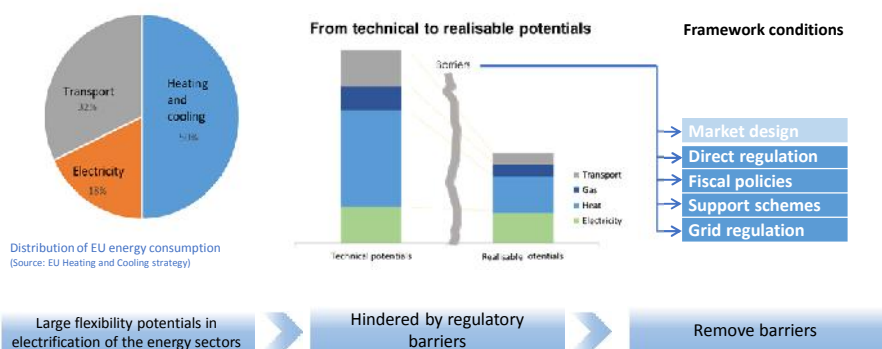


Sector coupling

Electrification as source of flexibility



Flex4RES



Market design



Flex4RES

Regulatory RE-thinking:

Regulation of the future energy markets must take into account the changes in technology mix, market designs, framework condition, and coupling of markets

Make RE market ready

vs

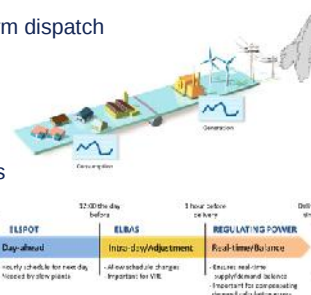
Make markets RE ready

Current market design is well functioning in securing short-term dispatch

Remove barriers to price transmission to market actors

RES from passive to active dynamic generation/market actors

- e.g. act to negative prices + supply system services



Long-term capacity adequacy



Flex4RES

Premium (via operating reserve demand curve)

A higher spot prices that reflects the probability of lost load

⇒ Sufficient revenue for generators

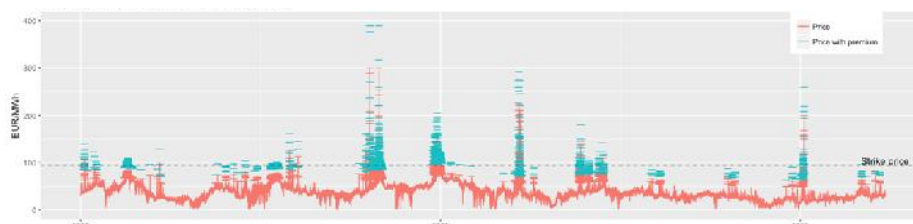
Spot market

⇒ Cost-effective allocation

Reliability options

Swap the revenue from scarcity periods for a risk-free payment

⇒ Acceptable investment risk (cash flow timing)

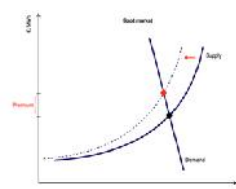


Take away



Flex4RES

- Trend to more market integration and need of more **flexibility**
- Make RE market ready → Markets RE ready
- Start with a well functioning power market/market design.
Then system integration/coupling of markets
- Need for a holistic system approach in order to identify and assess **regulatory and technical pathways** towards coherent energy systems
- VRE and electrified sectors need to become active electricity market actors
- Back-up mechanisms for long-term capacity adequacy



FlexEm 2050

Flexible Electricity Markets for Decarbonized Systems

Presenters:

Klaus Skytte
Claire Bergaentzlé

Energy Economics and Regulation
DTU Management Engineering, Denmark

Klsk@dtu.dk

Eurelectric & FSR
Bruxelles, June 7 2017



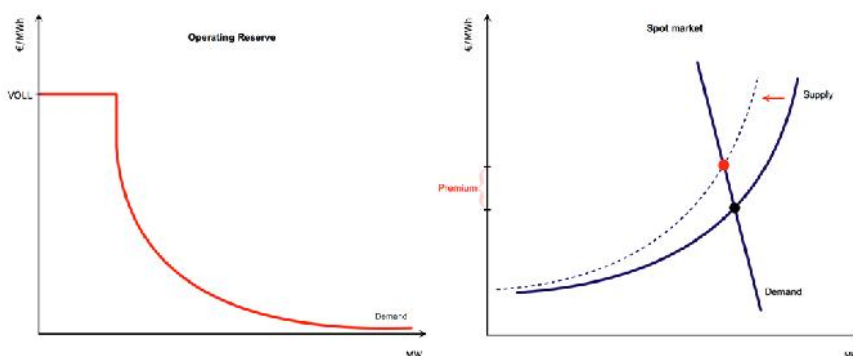
www.Flex4RES.org

Operating Reserve Demand Curve



Flex4RES

The downward sloping *Operating Reserve Demand Curve* determined by the expected value of lost load (i.e. product of **VOLL** and **LOLP**) translates into a price **premium** in the spot market.



⇒ In peak periods, where *probability of lost load* is high the premiums are correspondingly high.

⇒ In other periods, where the probability is negligible, the premiums are essentially zero.

⇒ Improved scarcity pricing

Reliability Options



Flex4RES

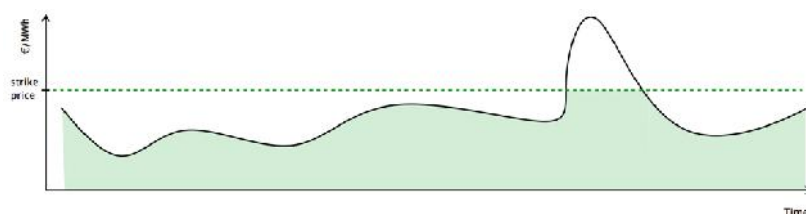
Generators choose either:

Earn the spot
market price

Sell *Reliability
Options*

Income =
 $\sum \text{spot price}$

Income =
 $\sum \text{spot price, when spot price below strike price}$
 $+ \sum \text{strike price, when spot price above strike price}$
 $+ \text{payment for selling reliability option}$



- ⇒ By selling reliability options generators **swap the revenue from few, infrequent scarcity periods with a risk-free payment.** ⇒ Decreases investment risk
- ⇒ Consumers benefit from sufficient capacity / reliability and from a hedge against price spikes.

Sector coupling & electrification



Flex4RES

