



DANISH MINISTRY OF ENERGY,
UTILITIES AND CLIMATE

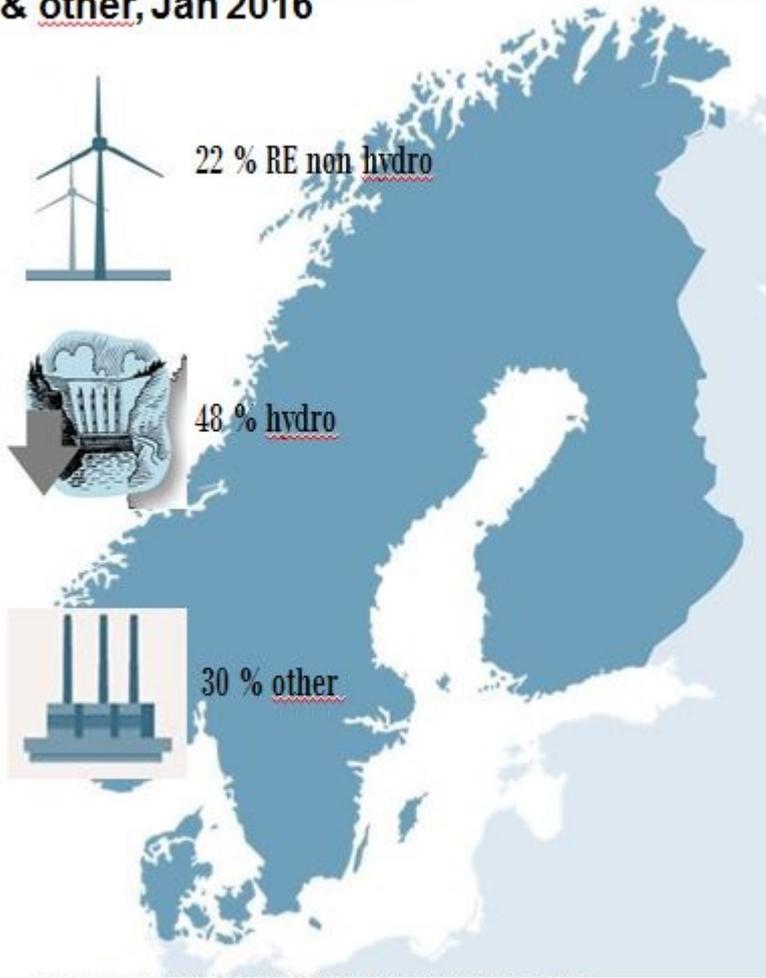
Integration of renewable energy in the Nordic market

*“Decoupling GDP and GHG emissions:
Lessons learned in the Nordic countries”*

COP21 Side Event – Norden & the IEA - 9 December 2015

Why go North? Well, perhaps for a high share of renewables and strong interconnections ...

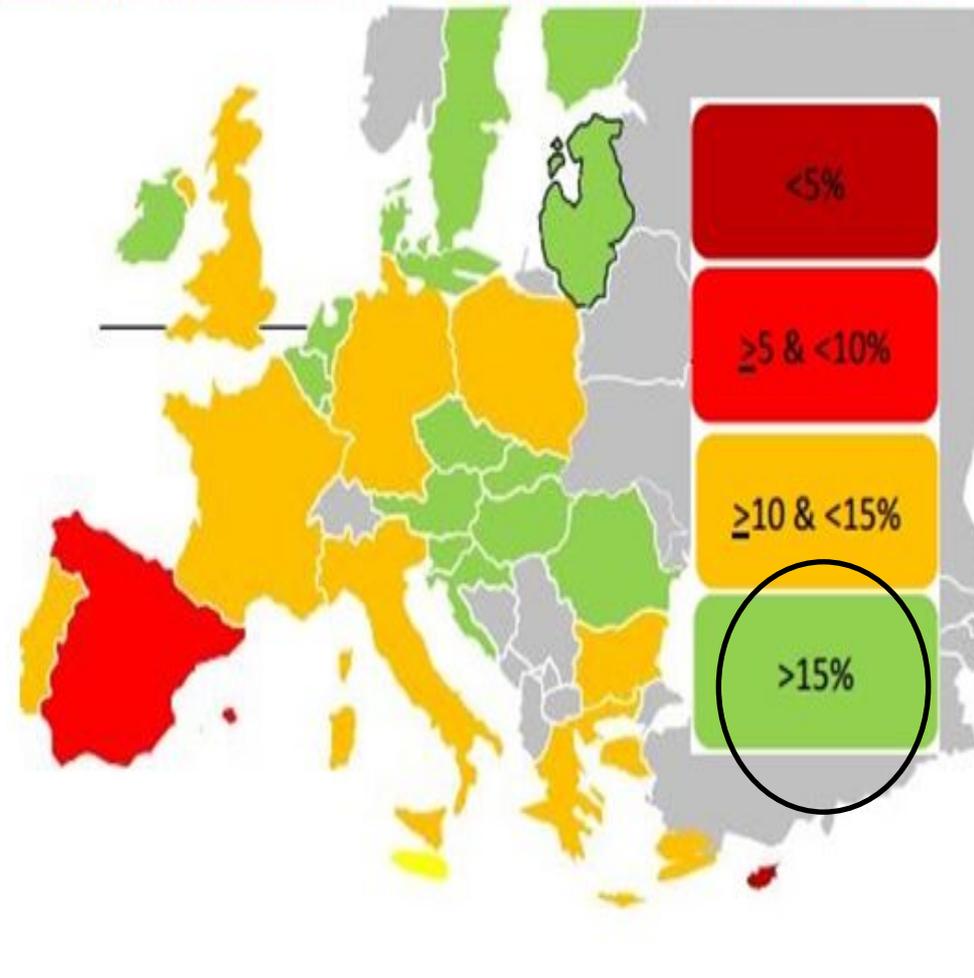
Electricity production, RE non hydro, hydro & other, Jan 2016*



Source: ENTSO-e Scenario Outlook & Adequacy Forecast (2015)

* Expected production mix, example Jan 20 2016 19:00. Excl. non-usable capac.

Interconnection levels in 2020 after implementation of PCI's

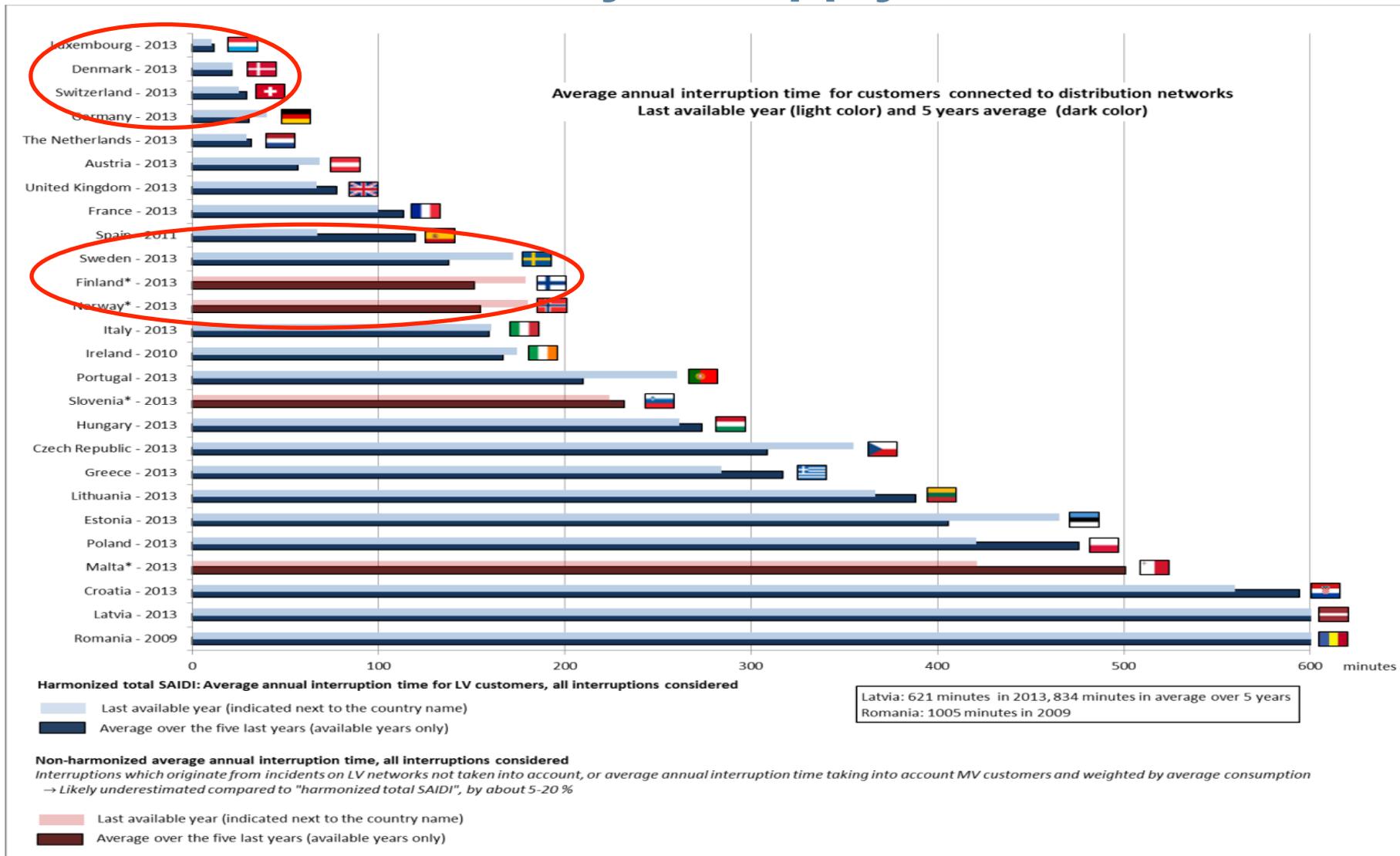


Source: European Commission, COM(2015) 82

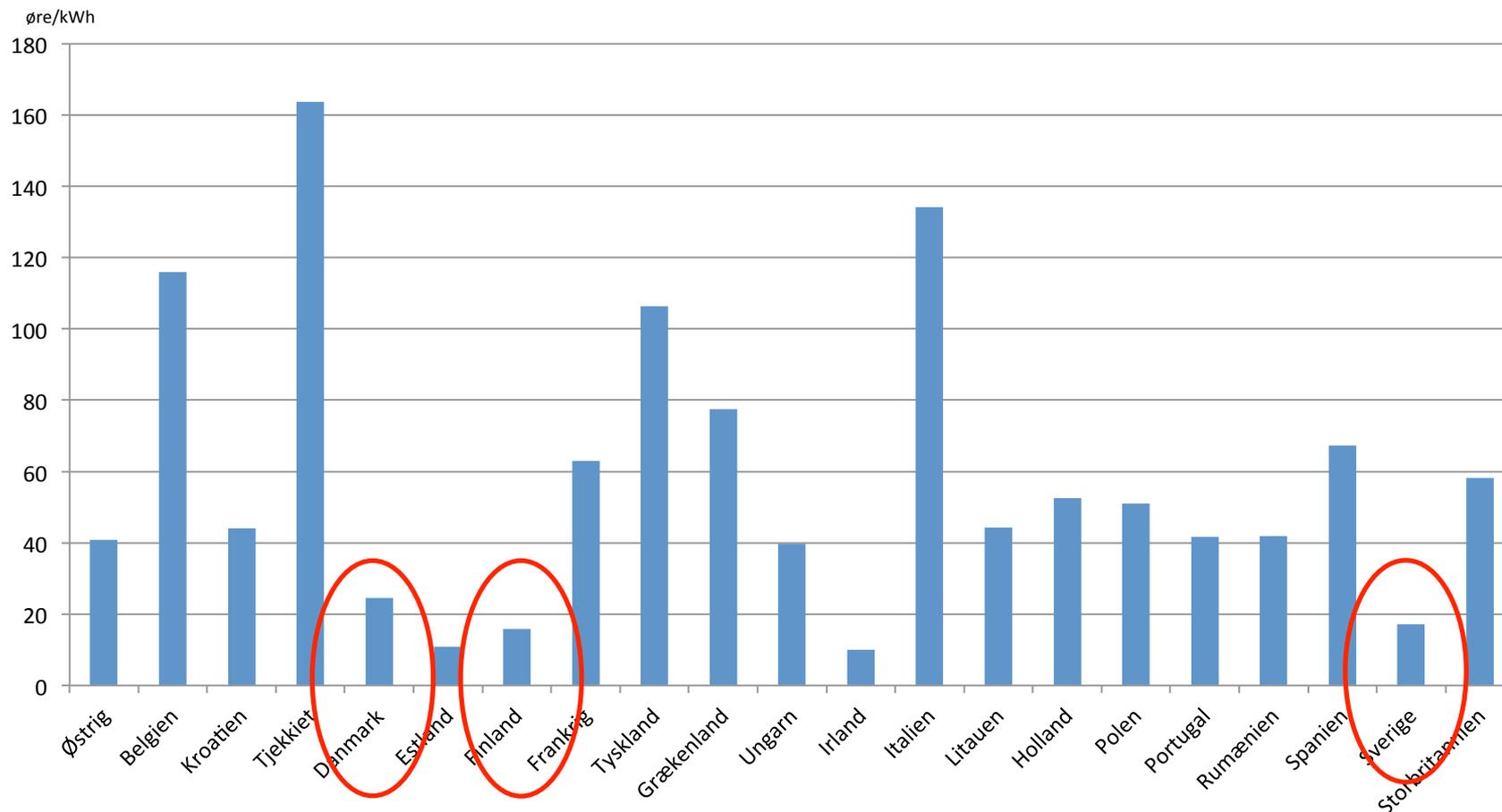


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Or perhaps for relatively high security of supply ...



Or perhaps for relatively low costs pr. kWh of renewable power ...



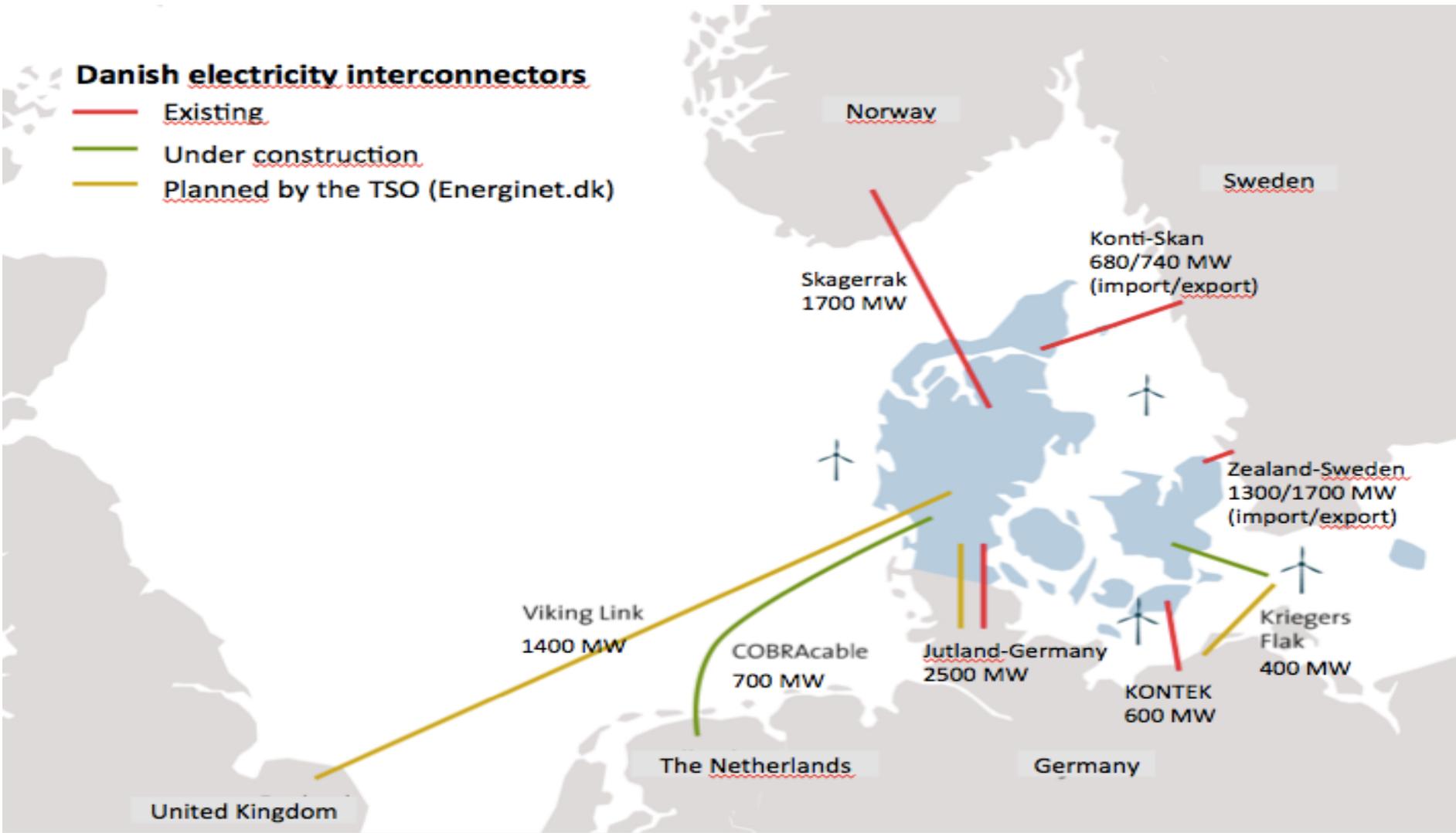
Source: CEER Status Review 2015 report of Renewable and Energy Efficiency Support Schemes (2012 numbers)



How does that work? One example: Approach to interconnections

Danish electricity interconnectors

- Existing
- Under construction
- Planned by the TSO (Energinet.dk)



How does that work? Another example: Power markets (design & forecasting)

Power market

Amount of MWh traded in the power system

Market value / price in the power system

Day-ahead
market

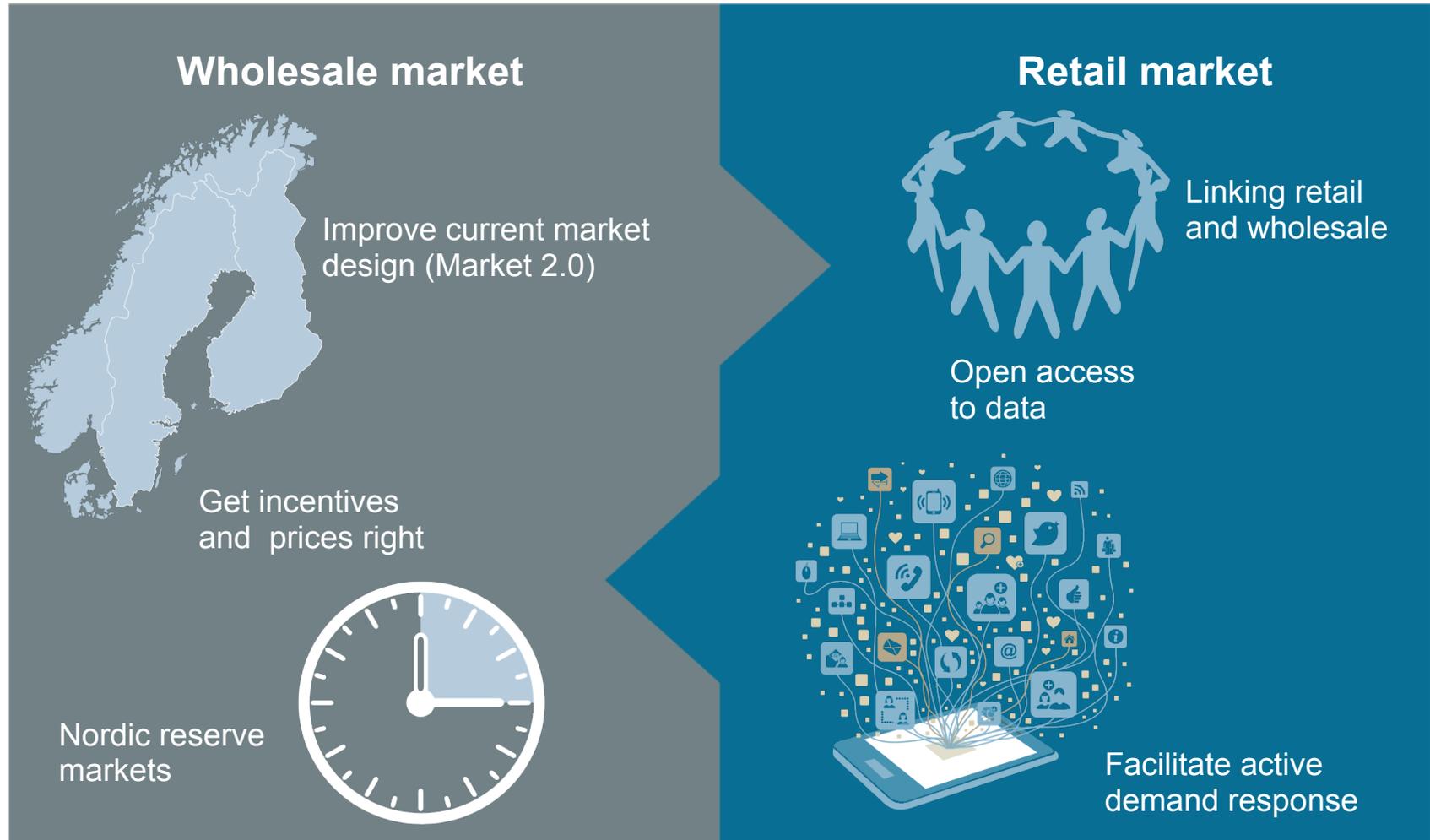
Intraday
market

Reserves and regulating power

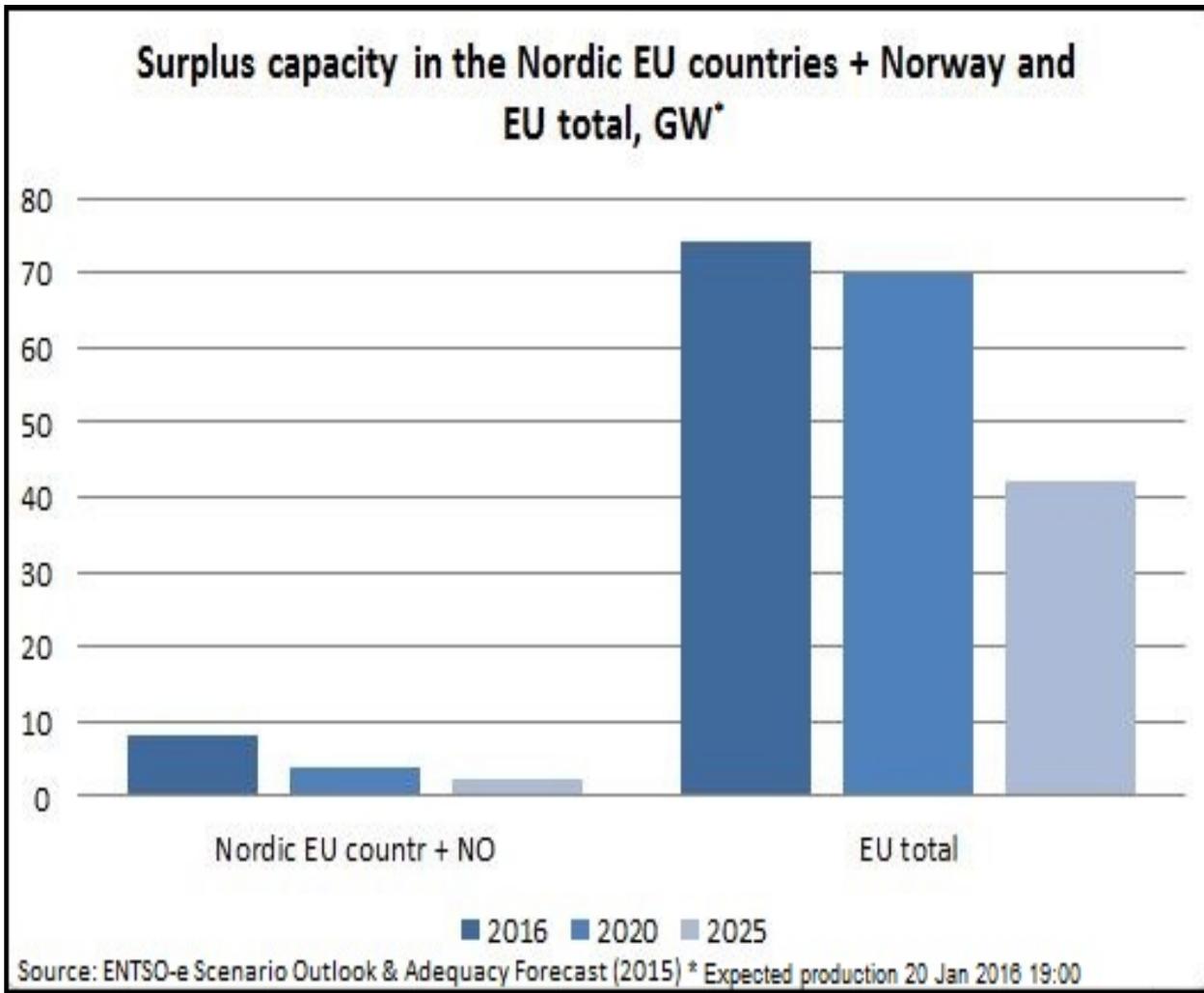
Operating hour



A third example: Further developing the retail market and demand side response



One more: The "elephant in the room" ...



(1) "Hardware":
Increased
interconnection

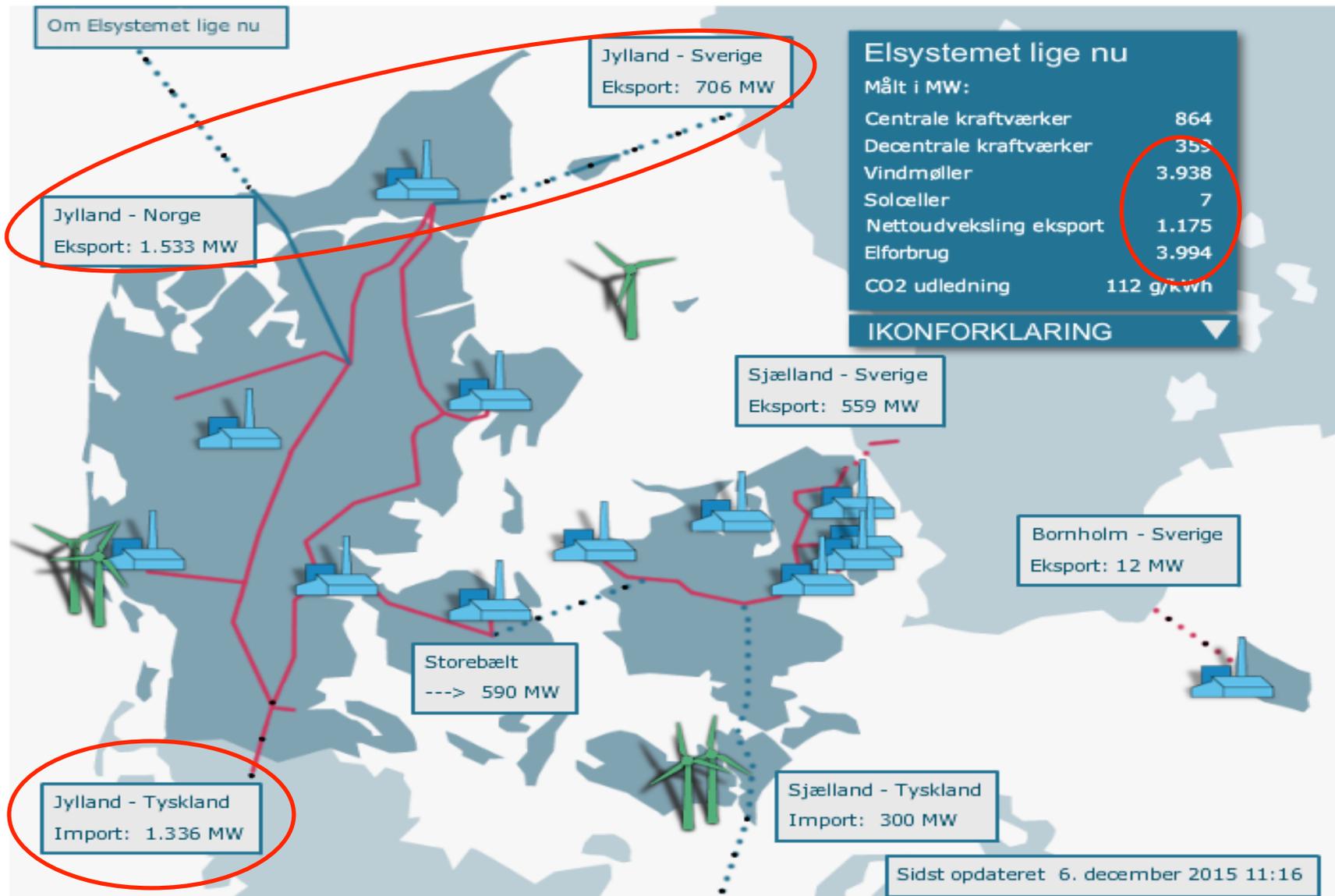
(2) "Software":
Market design
fit for the
transition of the
energy system
of the future

(3) Further
regionalisation
as the option of
choice



The result: Complimentary systems ...

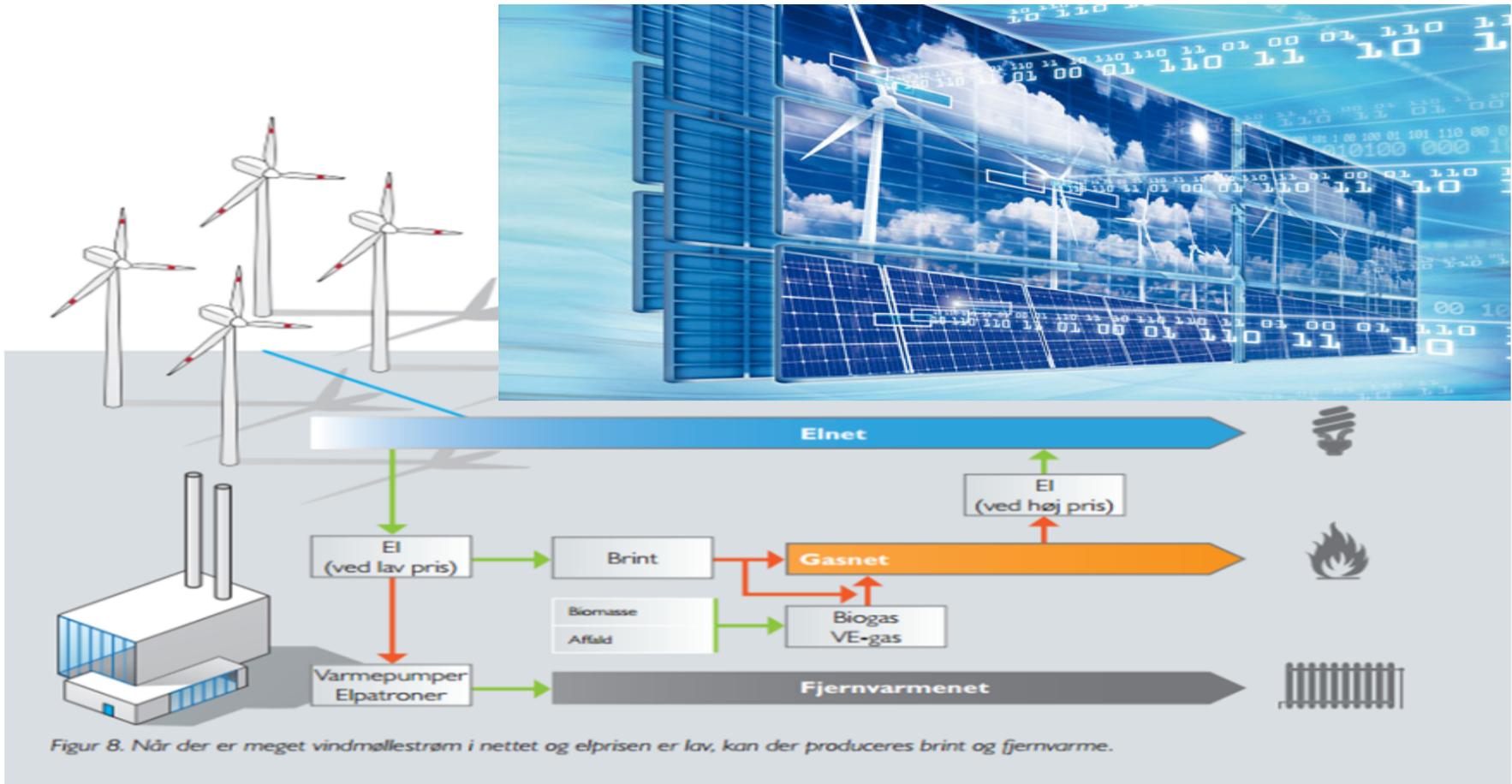
(Denmark - Norway case in point)



The "next frontier" beyond renewables: Energy system integration

4. Smart Energy – vindkraft i fjernvarme- og gassektoren

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Figur 8. Når der er meget vindmøllestrøm i nettet og elprisen er lav, kan der produceres brint og fjernvarme.



Longer-term: Exporting more than the approach?



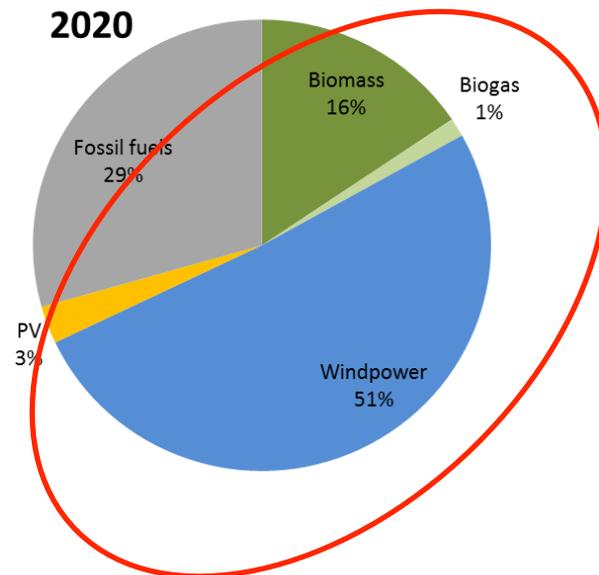
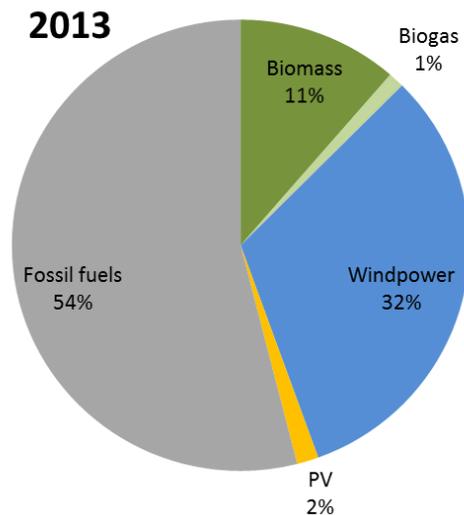
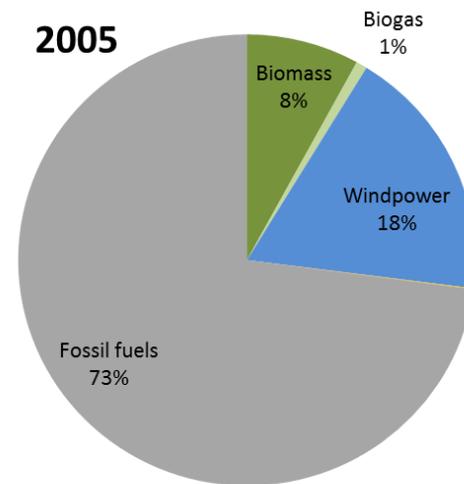
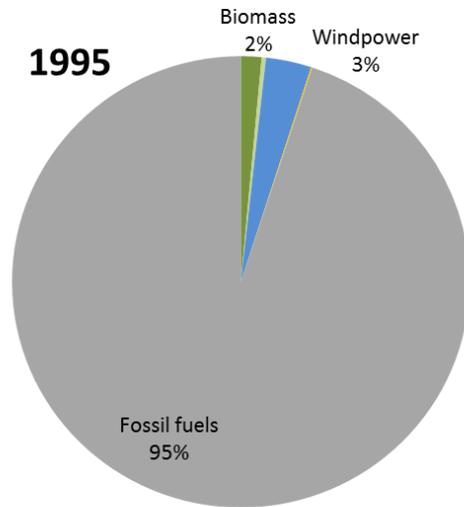
World Energy Outlook 2015

“ ... The cornerstone of this success [*decoupling emissions and economic growth in the Nordic region*] has been **the regional approach to energy and climate policy, including the integrated electricity market** across four countries that has been in operation since 2000. The flexibility provided by extensive physical interconnections has enabled a very high share of variable renewables (such as wind power in Denmark) to be utilized without jeopardizing reliability of supply. **The interconnection among countries enables an optimization of each country's diverse resources ...**

Achievement of a decarbonized future energy system holds **new opportunities for the region, such as potentially providing flexibility and being a net exporter of renewable electricity to Europe**. If interconnections to the continent are expanded sufficiently over the coming decades, as much as 80 terawatt-hours (TWh) could be exported to Europe in 2050 ...”



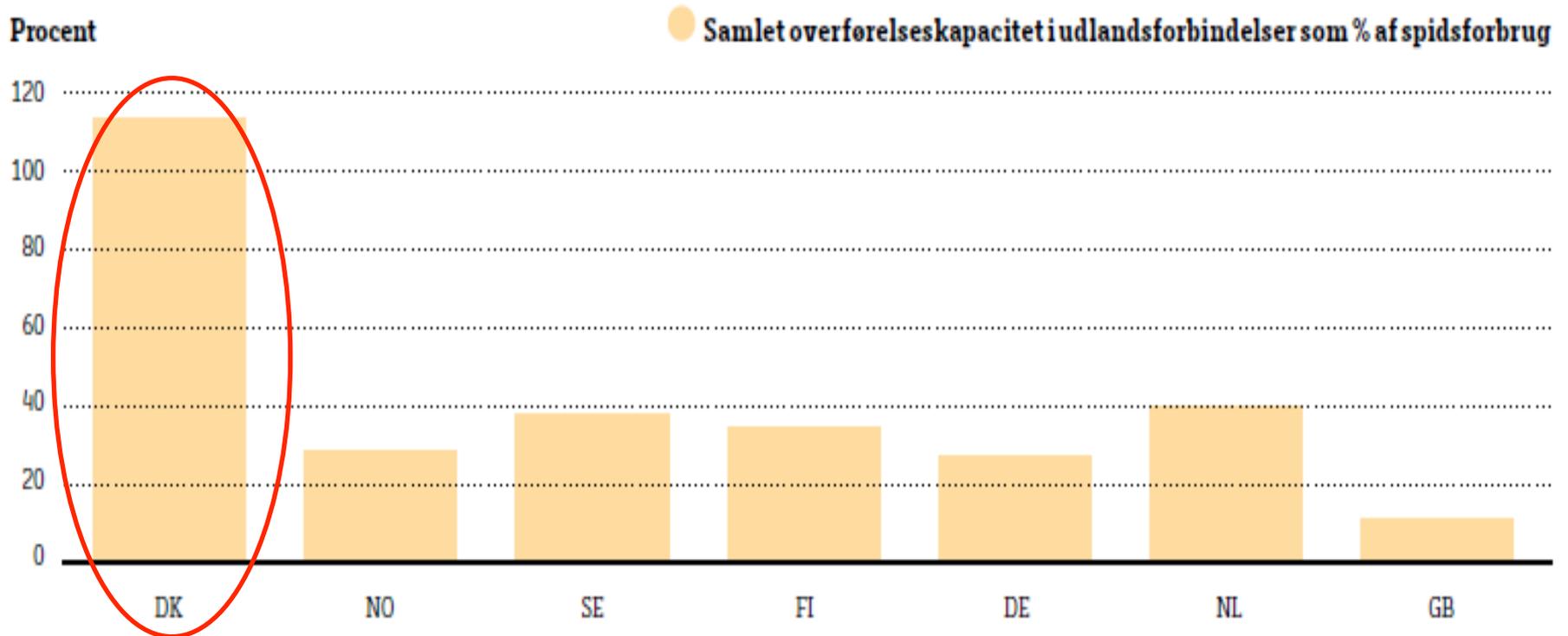
For Denmark: Increasing share of renewables in our power mix ...



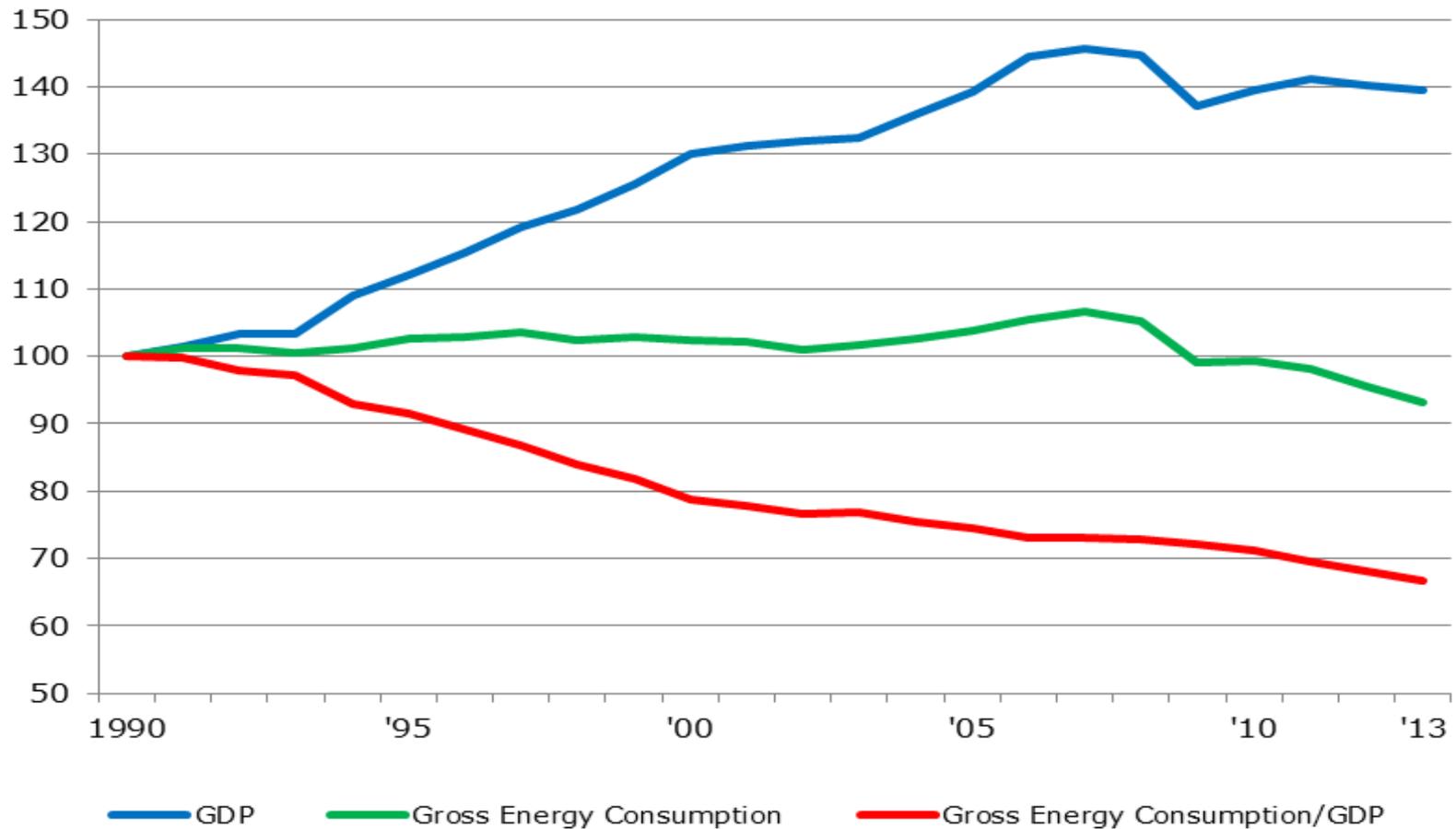
Interconnections relative to other countries

FIGUR 3

Kapacitet i udlandsforbindelser i forhold til maxforbrug 2020.



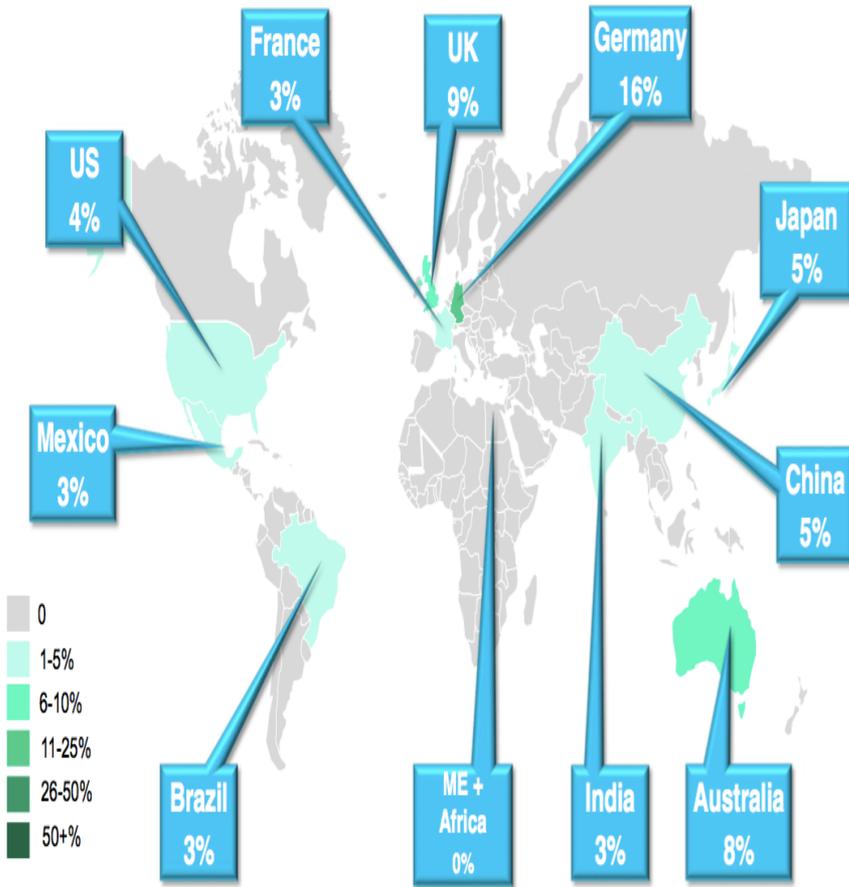
Denmark's energy consumption relative to GDP



The world seems to be moving ...

RENEWABLE ENERGY PROPORTION OF POWER GENERATION- INTERMITTENT ENERGY (WIND & SOLAR), 2014 (%)

Bloomberg
NEW ENERGY FINANCE

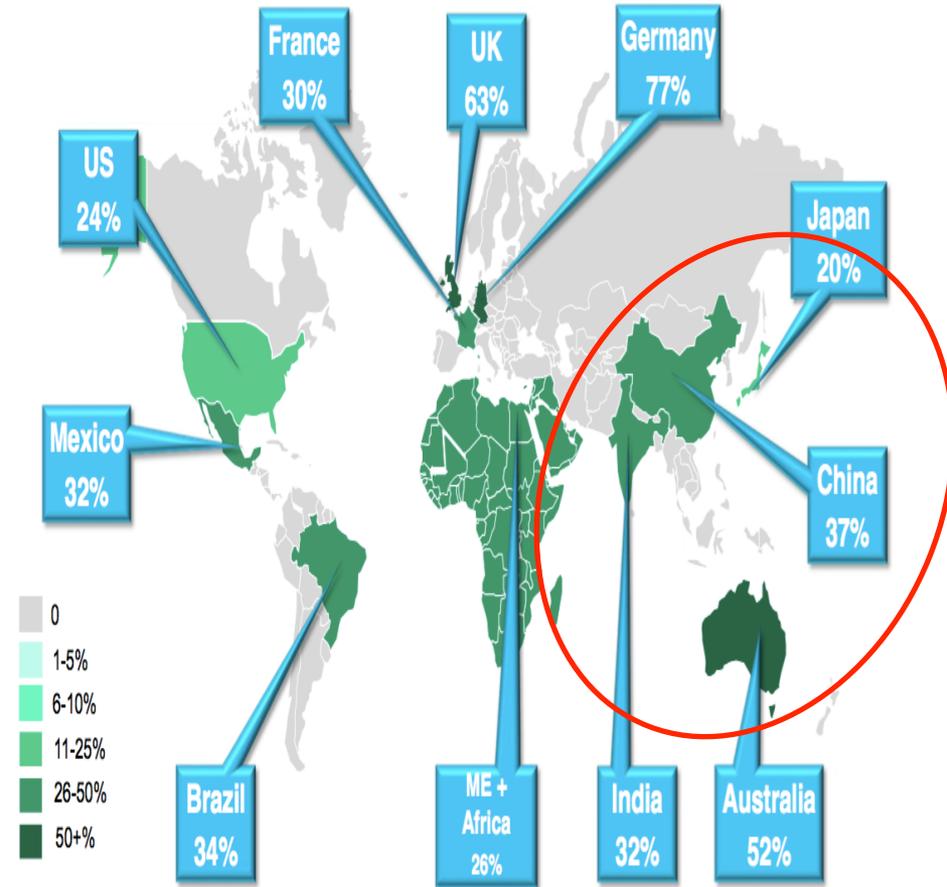


Note: This only shows the combination of wind and solar energy generation. All numbers come from BNEF's New Energy Outlook 2015

Source: Bloomberg New Energy Finance

RENEWABLE ENERGY PROPORTION OF POWER GENERATION- INTERMITTENT ENERGY (WIND & SOLAR), 2040 (%)

Bloomberg
NEW ENERGY FINANCE



Note: This only shows the combination of wind and solar energy generation. All numbers come from BNEF's New Energy Outlook 2015

Source: Bloomberg New Energy Finance



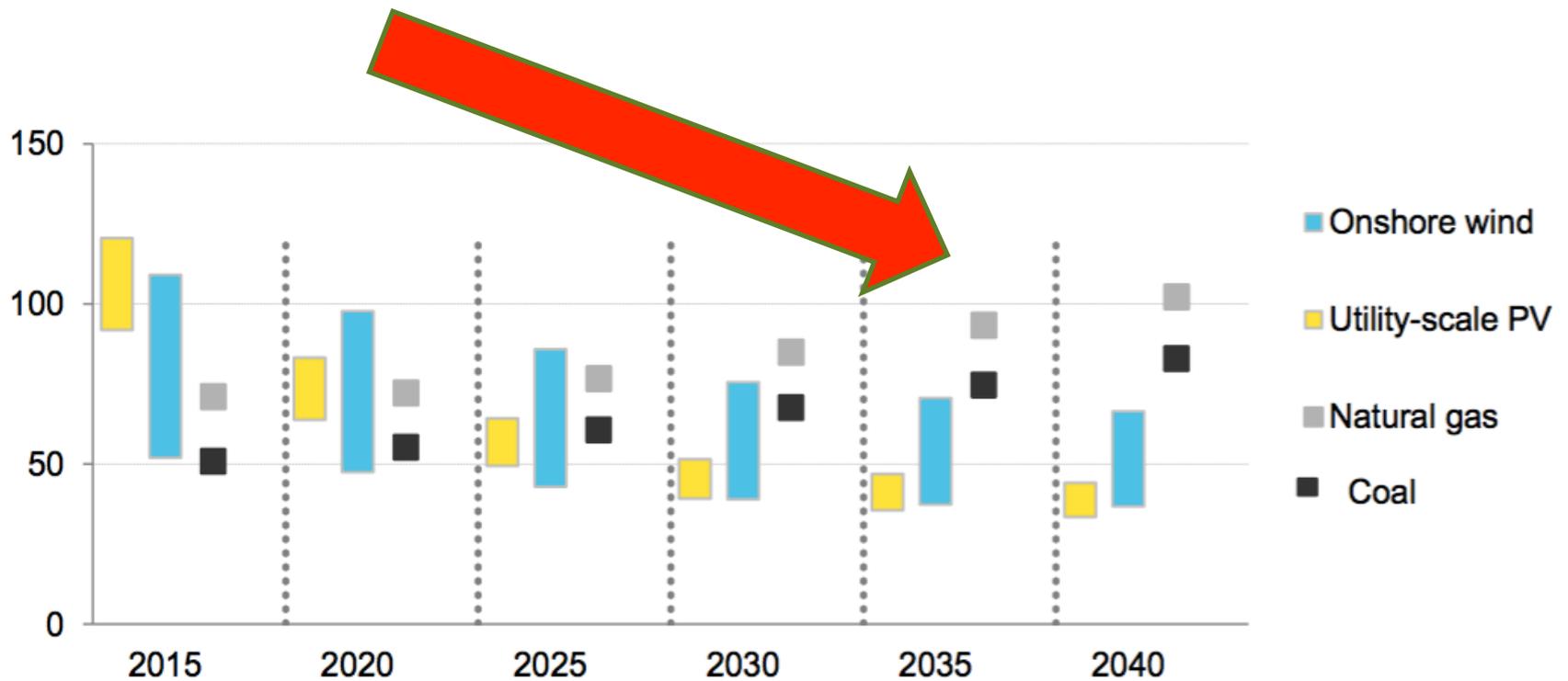
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Future costs of renewables

One example in Asia

INDIA LCOE
(\$/MWH NOMINAL)

Bloomberg
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