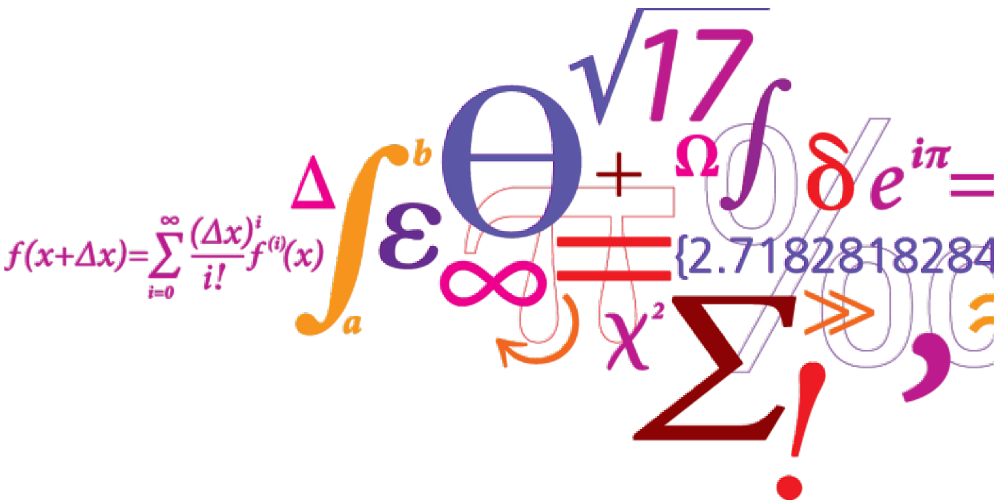
Renewable energy
Why and how - Challenges and solutions

Nordic5Tech winter school
Gothenburg



Lise-Lotte Pade
February 8th 2017

DTU Management Engineering
Institut for Systemer, Produktion og Ledelse

Today's plan

- Who am I?
- Why renewable energy?
- How?
- Challenges and solutions

Who am I?

- Associate Professor at DTU Management Engineering

- Energy and environmental economist
  - environmental regulation of the energy sector and climate policy
  - development and deployment of renewable energy technologies
  - energy markets and integration of renewable energy
  - energy demand and savings

- Teaching
  - Energy economics, markets and policies
  - Macroeconomics

- Heads of studies
  - Sustainable energy
  - ISEE Nordic5Tech Wind and solar track DTU

Renewable energy - targets and policies

- Denmark:
  - 50 % renewable energy in electricity production in 2020
  - Fossil free electricity production in 2035
  - Danmark 100 % fossil free in 2050

- EU's 2020 targets
  - 20 % renewable enegy in the energy production
  - 20 % energy savings relative to 2005
  - 20 % reduction in CO2 emissions relative to 1990
  - 10 % of the fuel consumption in transport shall consist of bio fuels

- EU's 2030 targets
  - 40 % reduction in CO2 emissions relative to 1990
  - ~ 27 % renewable energy in the energy production

Why targets for RES, energy savings and bio fuels in transport?

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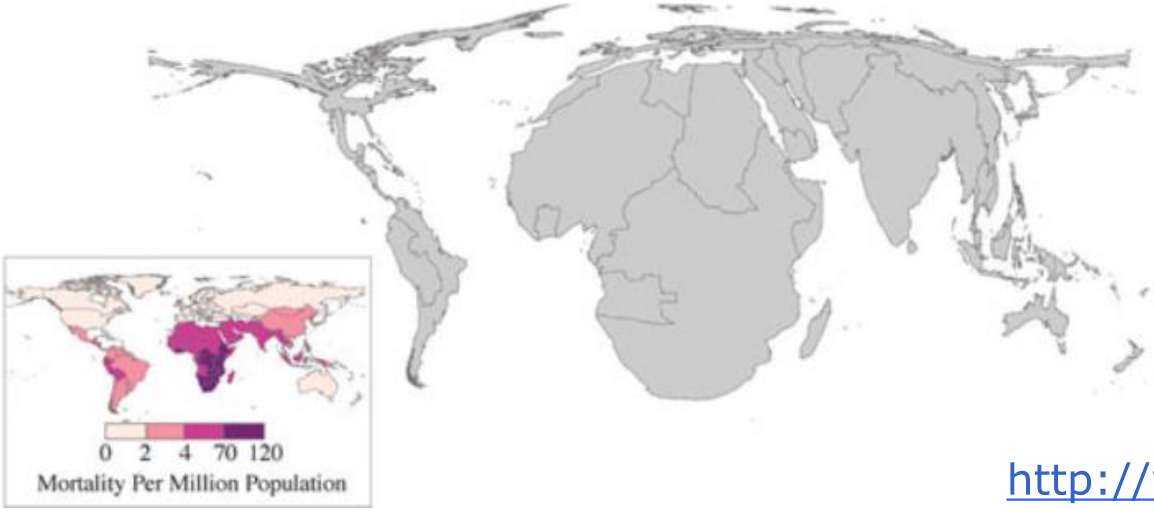
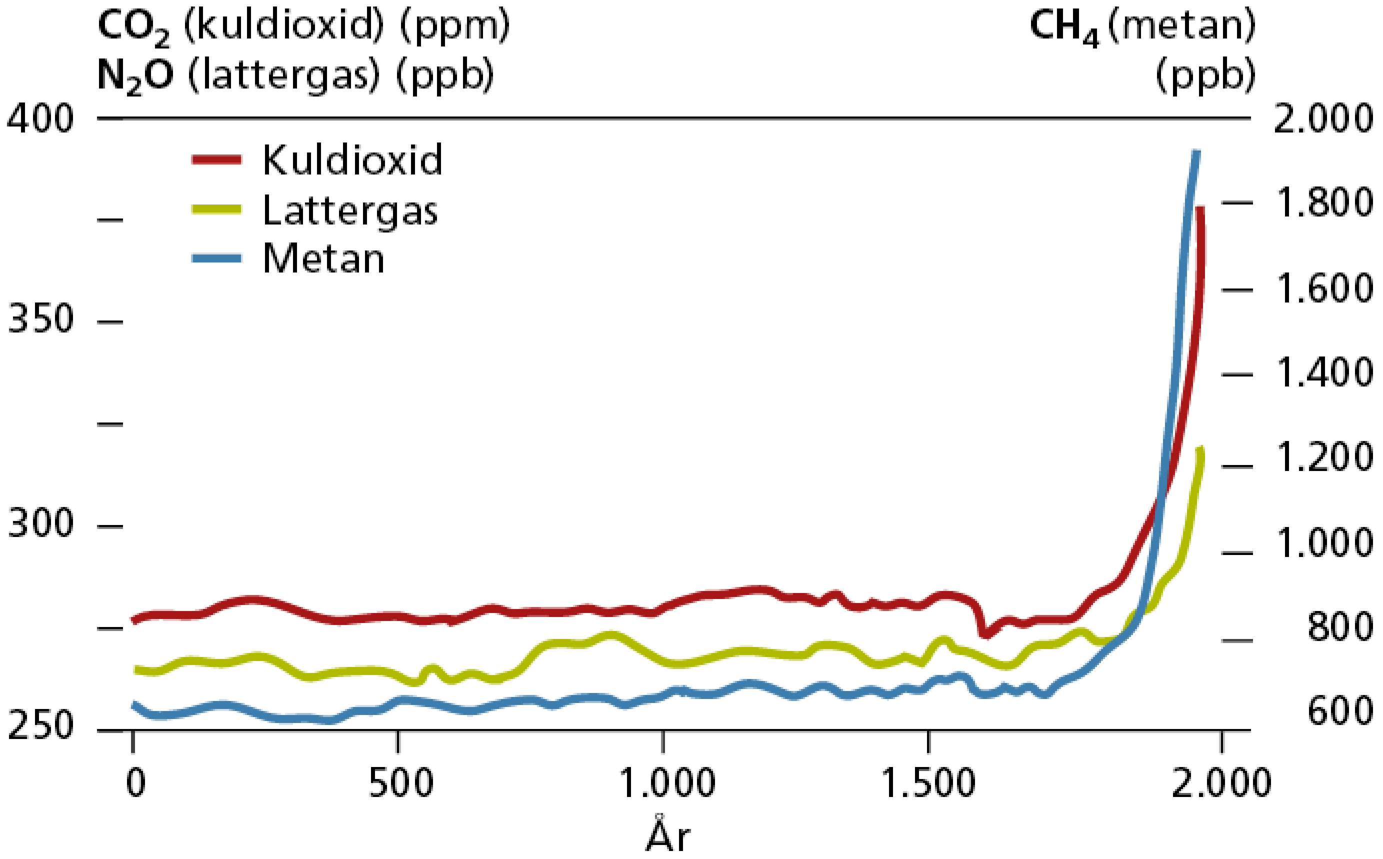
Globale warming
- contribution



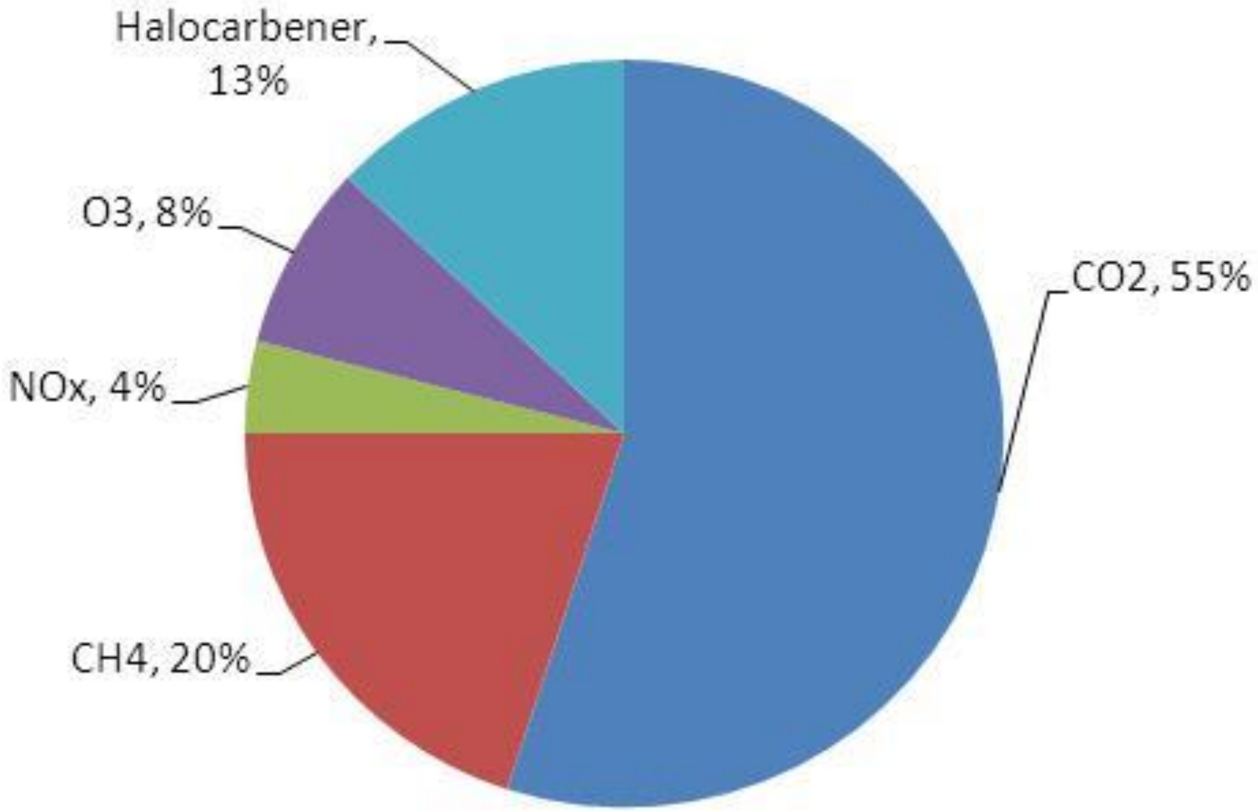
Globale warming
- consequence

http://www.news.wisc.edu/14419 (2007)

Why targets for RES, energy savings and bio fuels in transport?

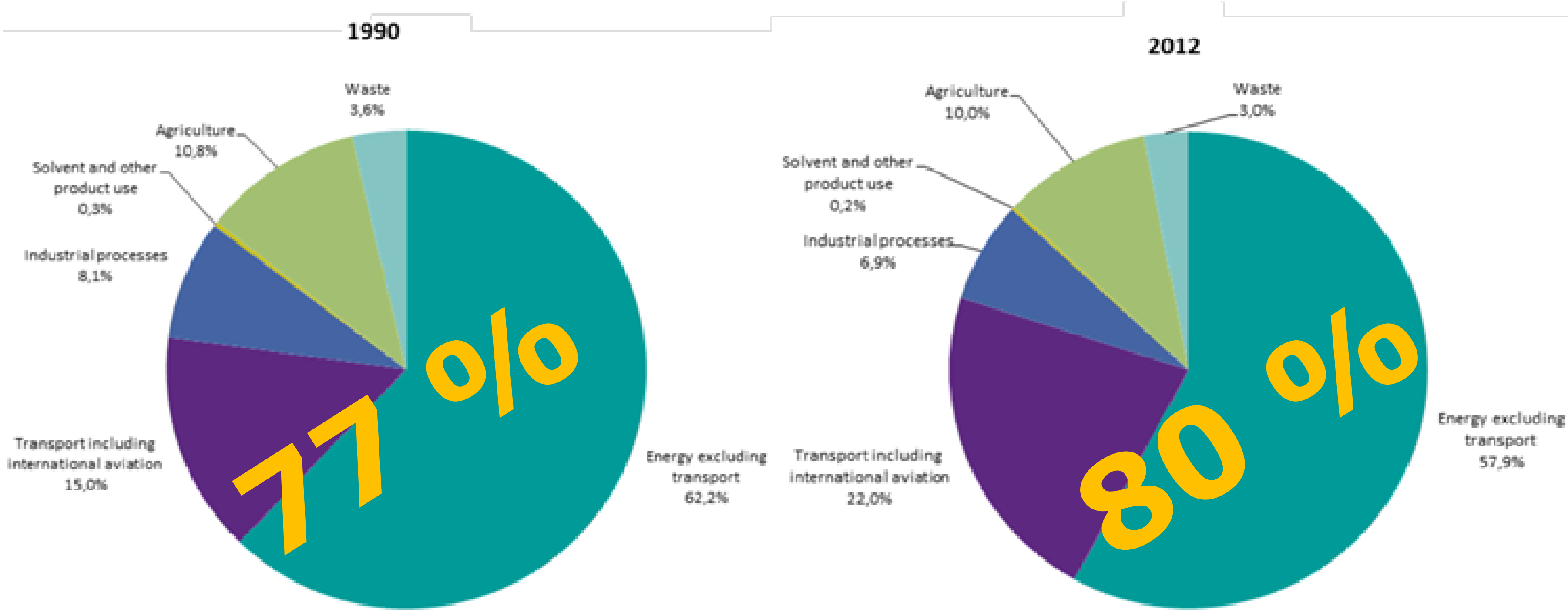


Why targets for RES, energy savings and bio fuels in transport?



Why targets for RES, energy savings and bio fuels in transport?

Fordeling af drivhusgasser i EU



Source: Eurostat (env_air_gge), European Energy Agency, European Topic Centre on Air and Climate

Policy instruments
- how to reach the targets

- Carrot

- Stick

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- Command-and-control

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Policy instruments

- How to reach the targets?
  - Stick
    - Taxes
    - Tradable quotas

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Policy instruments

- How to reach the targets?
  - Stick
    - Taxes
    - Tradable quotas
  - Carrot
    - Support schemes

Policy instruments

- How to reach the targets?
  - Stick
    - Taxes
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  - Carrot
    - Support schemes
  - Command-and-control
    - Quotas

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Stick...

- Taxes
  - tax on fossil fuels
    - $\Rightarrow$ more expensive to use fossil fuels
    - $\Rightarrow$ incentive to reduce consumption of fossil fuels
      - fuels with smaller CO2 content
        - » e.g. from coal to gas or RES
      - become more efficient in the fuel consumption
        - » increase energy efficiency

  - the regulating authoruty does not directly control the actual CO2 reduction achieved
    - if the reduction is too low, the tax has to be increased

Stick… II


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- Tradable quotas (EU ETS)
  - some or all consumers of fossil fuels are granted a certain amount of quotas (the right to emit CO_2)
  - the owners of quotas have the right to trade

    ⇒ if it is cheaper for one emitter to reduce his CO_2 emission compared to another emitter, the two emitters can trade.

    ⇒ the one with the high reduction costs can buy qoutas, thereby increase the amount of CO_2 to emit and hence reduce less.

    ⇒ the one with the low reduction costs can sell quotas and reduce more.

    ⇒ a market is developed => equilibrium price

    ⇒ whether the emitters wish to buy or sell depends on the reduction costs relatiave to the price of the quots.

  - the regulating authority directly controls the actual CO_2 reduction achieved

Carrot

- Investment support
  - direct support for the investment
  - reduced prices on necessary inputs
- Variable support/operation support
  - support for the output/product
    - electricity or heat
  - tax exemptions

Carrot II - Variable support/operataion support

- Price baseret support
  - the investor receives a higher price for the for output (electricity or heat) end than the market price
    - a fixed price in a certain amount of years (FIT)
    - a fixed supplement on top of the market price per unit sold (per kWh) in a certain amount of years (FIP)
    - netmetering for households - the electrity meter runs backwards
  - the regulating authoruty does not directly control the actual CO2 reduction achieved
    - if the investmenst in RES are lower than anticipated, the level of support must be increased.

- Quantity based support
  - Tendering
    - the regulating authority determines where and how much of which kind of RES to be developed
    - investorers bids a price
      - tendering is typically combined with a FIT

Carrot II - Variable support/operataion support

- Quantity based support - cont.
  - Tradable green certificates/vedvarende RES quota system
    - electricity distributers are obliged to make sure that a certain share of the electricity they are selling comes from RES.
    - producers of RES energy get certicifates corresponding to the amount of RES energy they produce.
    - the certificates are sold to the elecitricity distributers

    $\Rightarrow$ a market is developed => equilibrium price
  - if there are too few certificates

    $\Rightarrow$ the price on certificates increase

    $\Rightarrow$ the incentive to invest in RES increase

    $\Rightarrow$ the amount of RES increase

- the regulating authority directly controls the amount of RES invested.

Policy instruments - quantity and technology control

	CO2 tax	EU-ETS	Inv. sup.	FIT	FIP	Netmetering	Tendering	TGC
	Stick	Stick	Carrot	Carrot	Carrot	Carrot	Carrot	Carrot
Quantity control		X					X	X
Technology control			(X)	(X)	(X)	(X)	X	(X)

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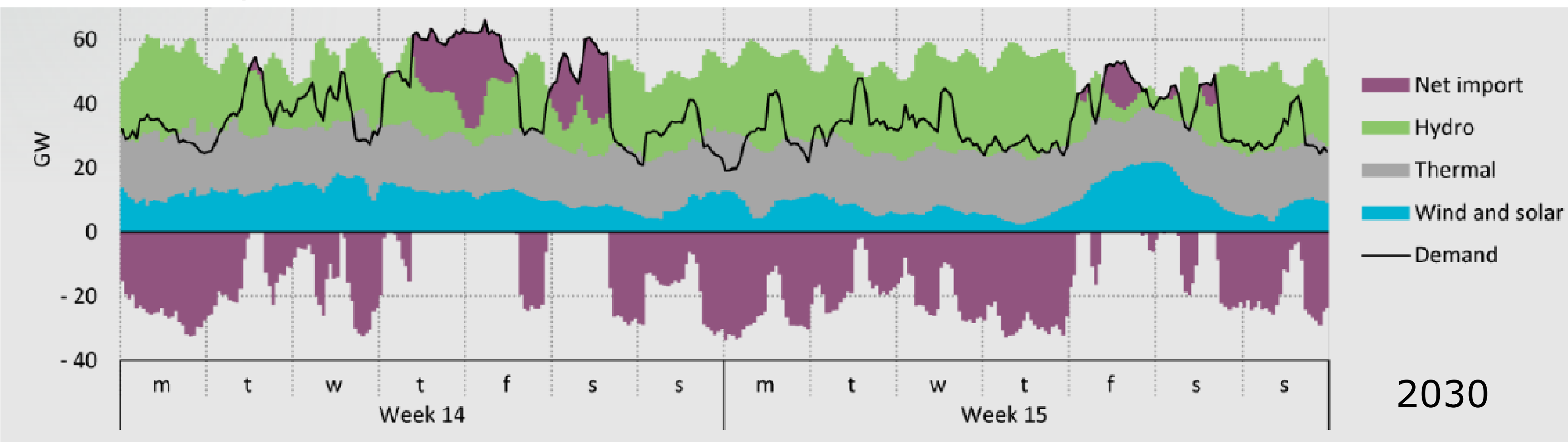
Command-and-control

- Prohibition
  - E.g. no oil furnace in new houses in 2017
- Command
  - Technology (e.g. end of pipe technologies)
- Targets
  - Quotas - non-tradable

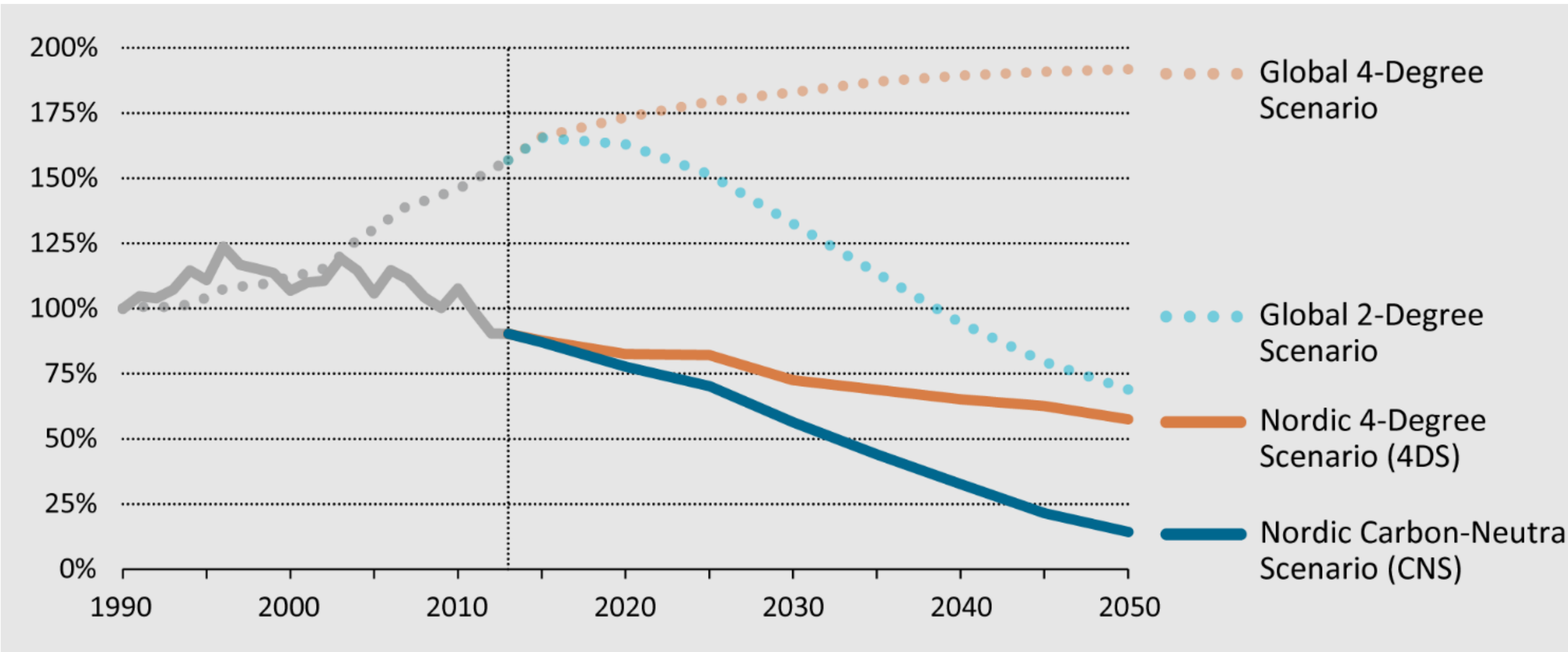
- Control costs
- Increased costs of achievement
  - Re. tradable quotas

Challenges of renewable energy

- We produce electricity when
  - the wind is blowing
  - the sun is shining
- We consume electricity when
  - we cook
  - do the laundry
  - we produce
- For the good 'electricity'
  - supply = demand
- Storage of electricity?
  - Yes
    - Batteries
    - Heat

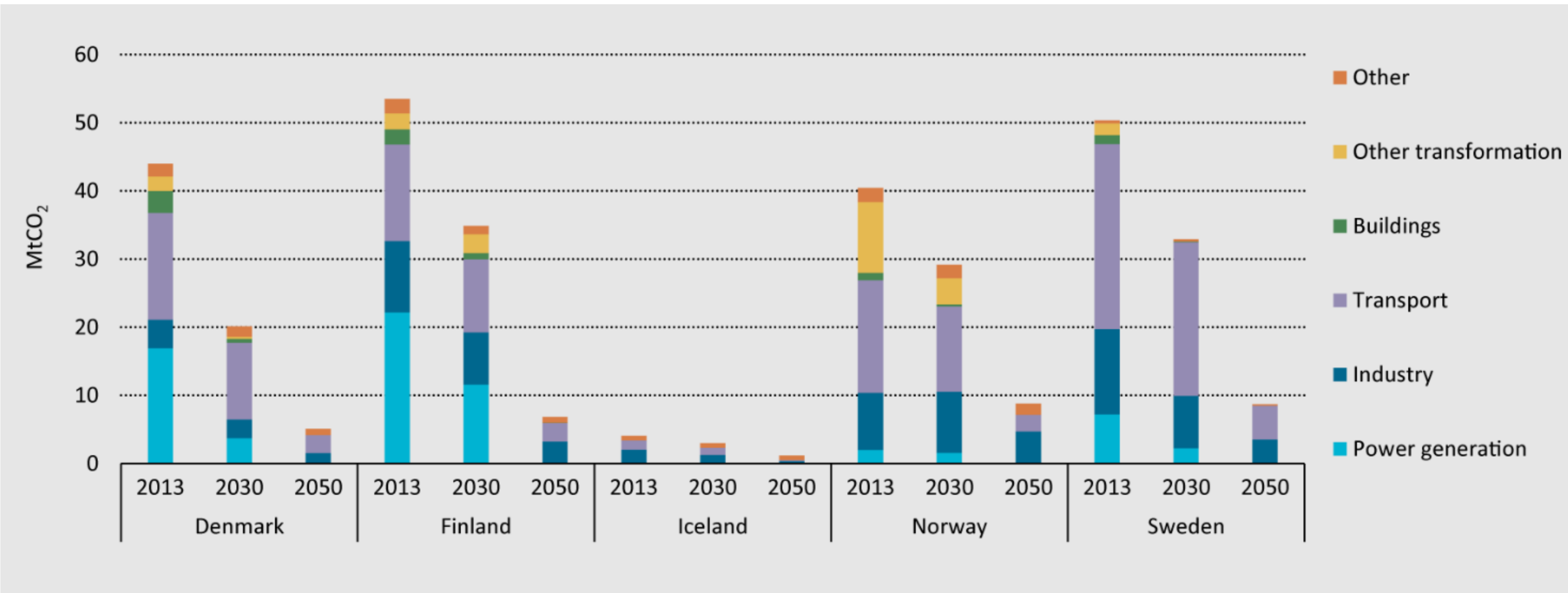


Nordic Energy Technology Perspectives



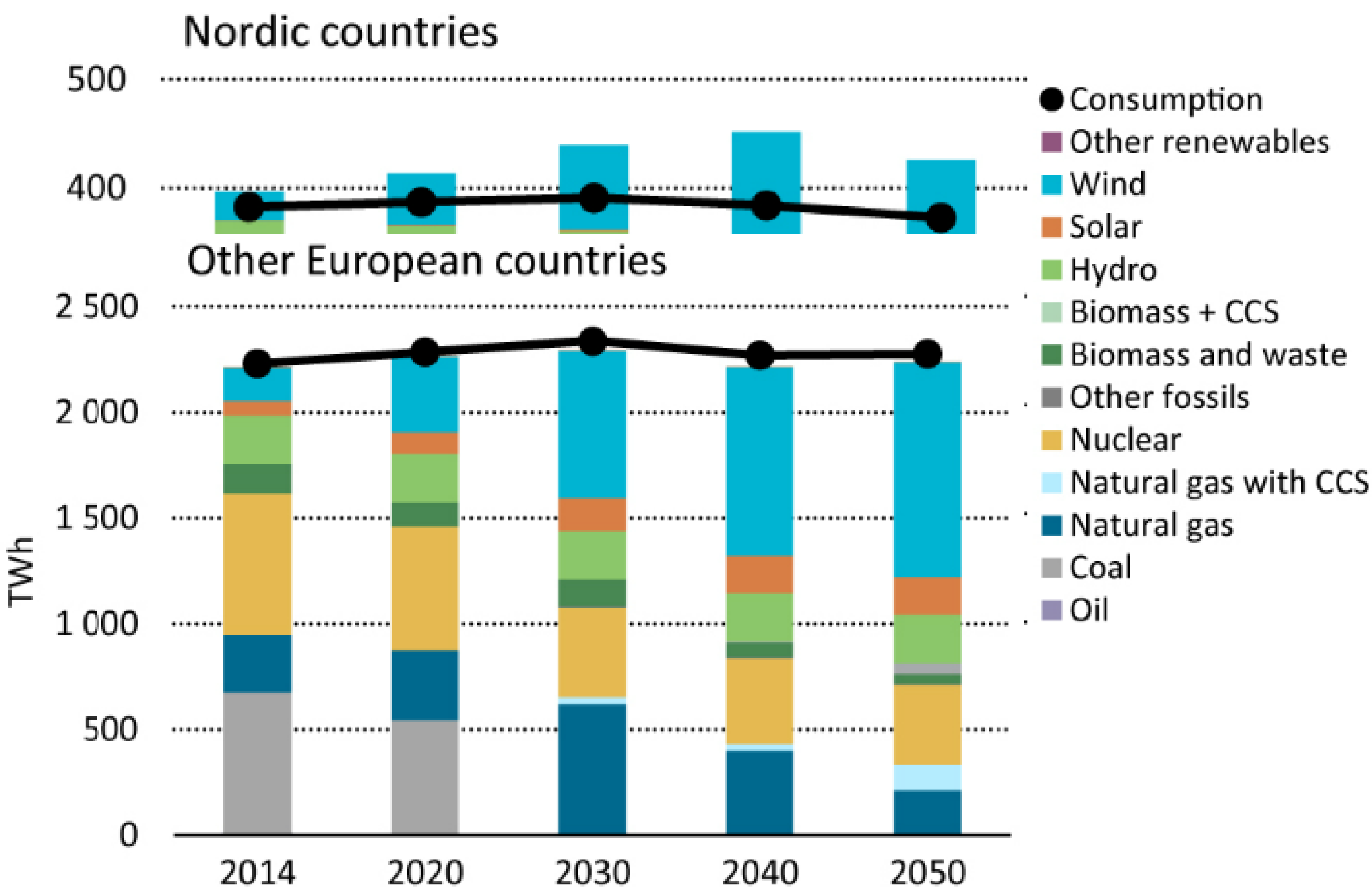
Nordic Energy Technology Perspectives

CO2 emissions on sectors, 2013, 2030 og 2050



Nordic Energy Technology Perspectives

Electricity production in the Nordic countries and other European countries



Nordic Energy Technology Perspectives

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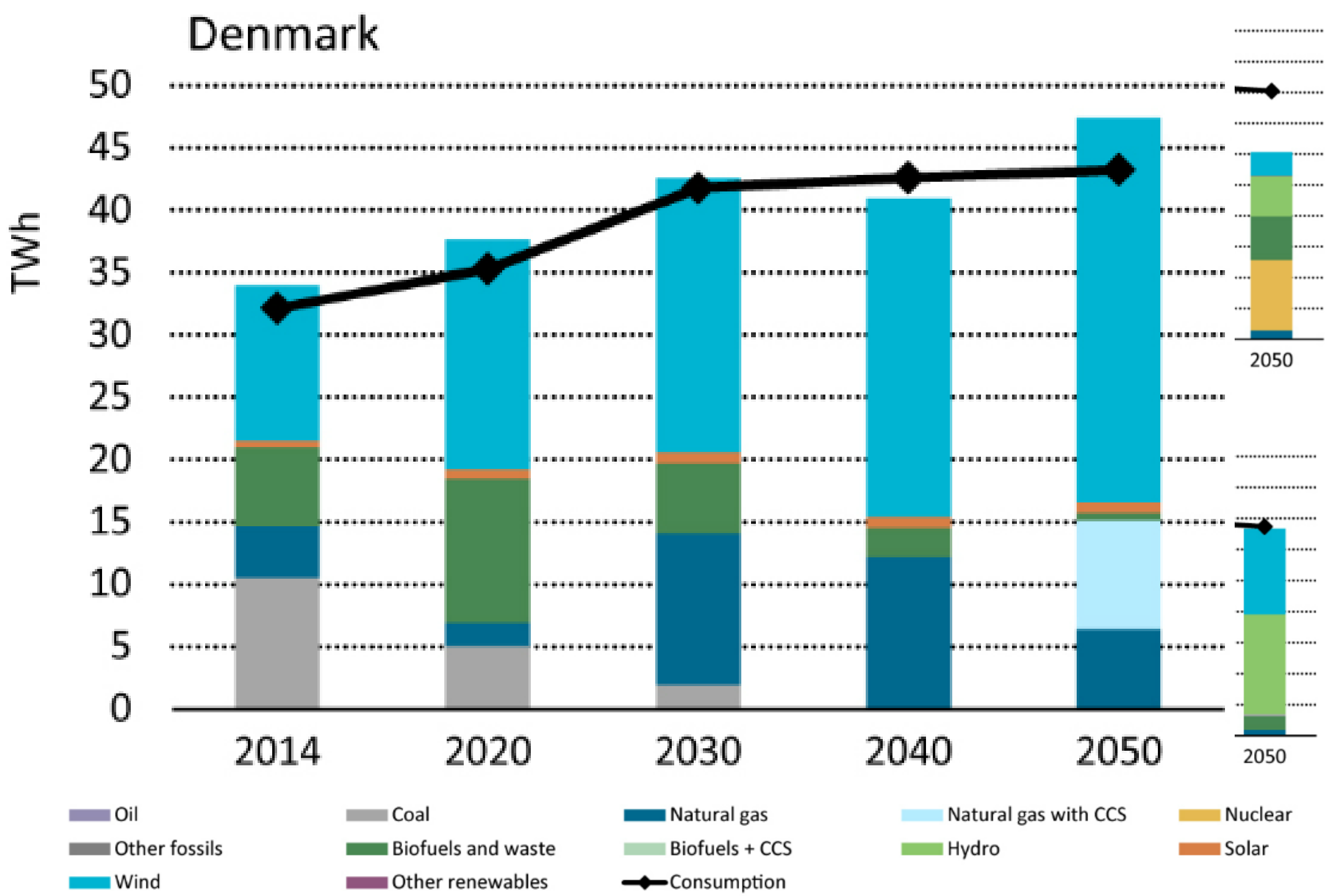
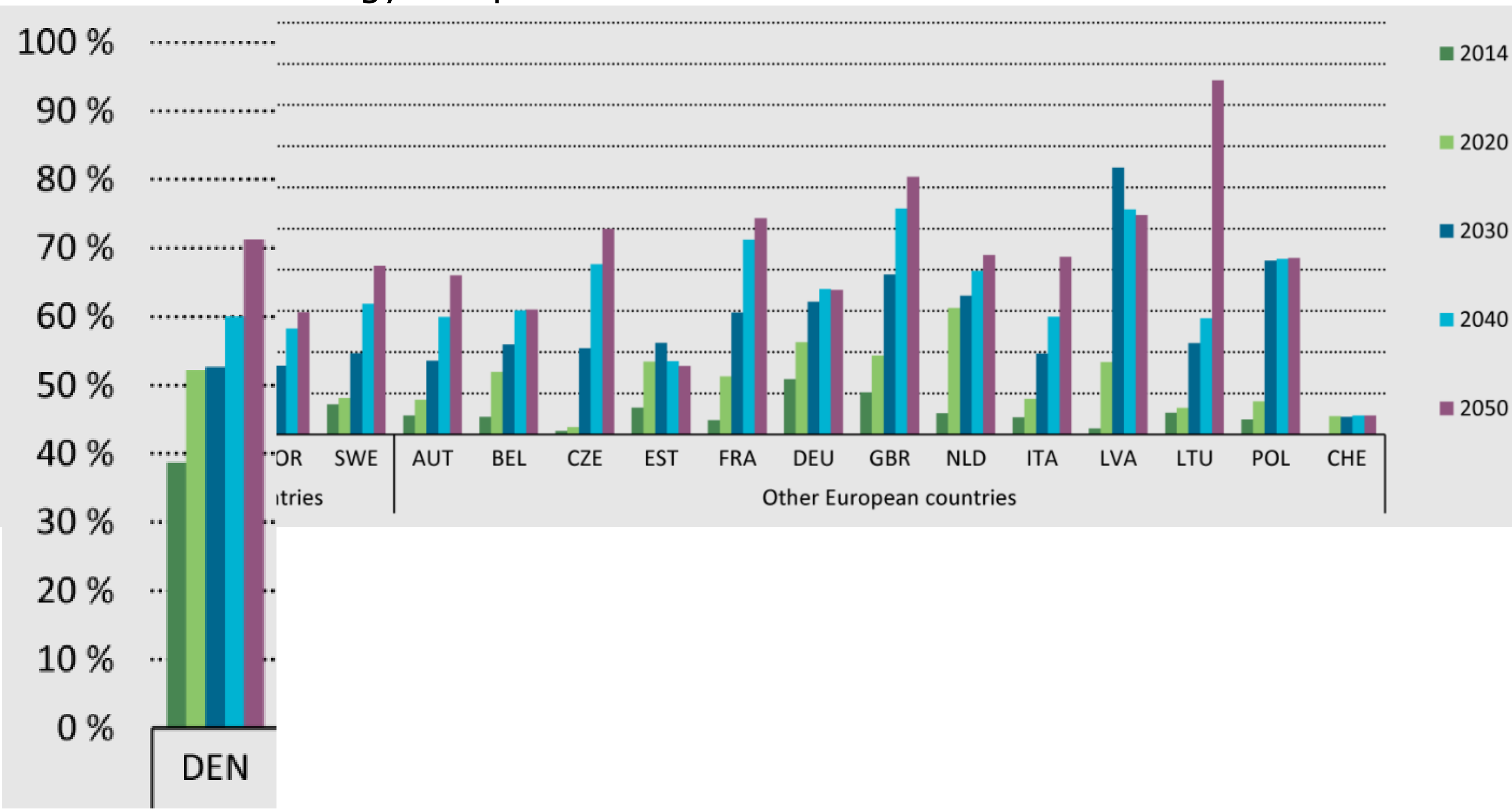


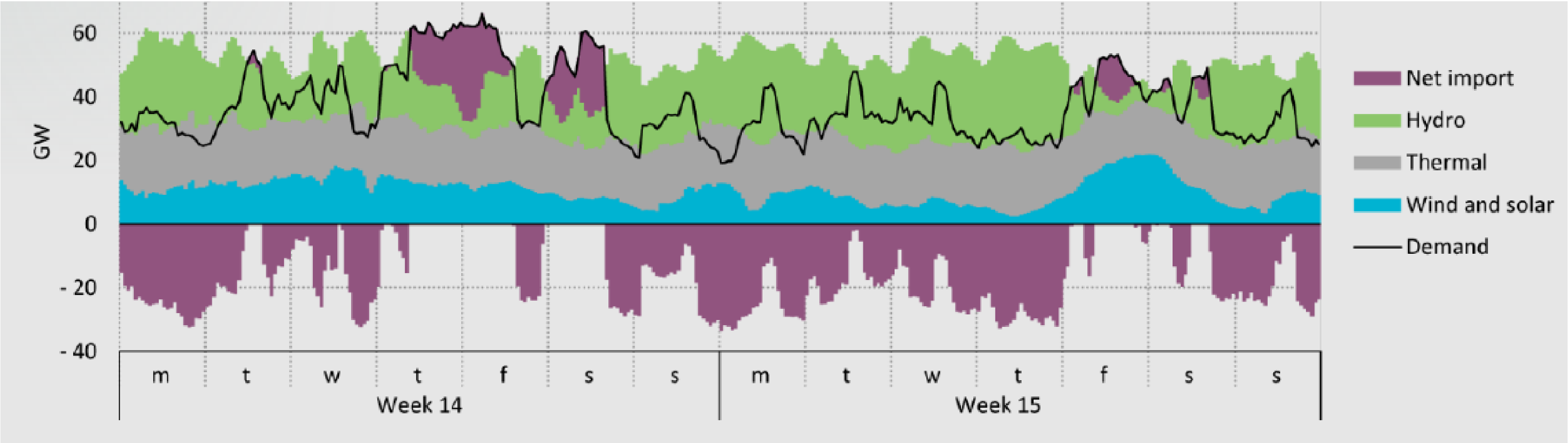
Nordic Energy Technology Perspectives

Share of wind energy compared to demand

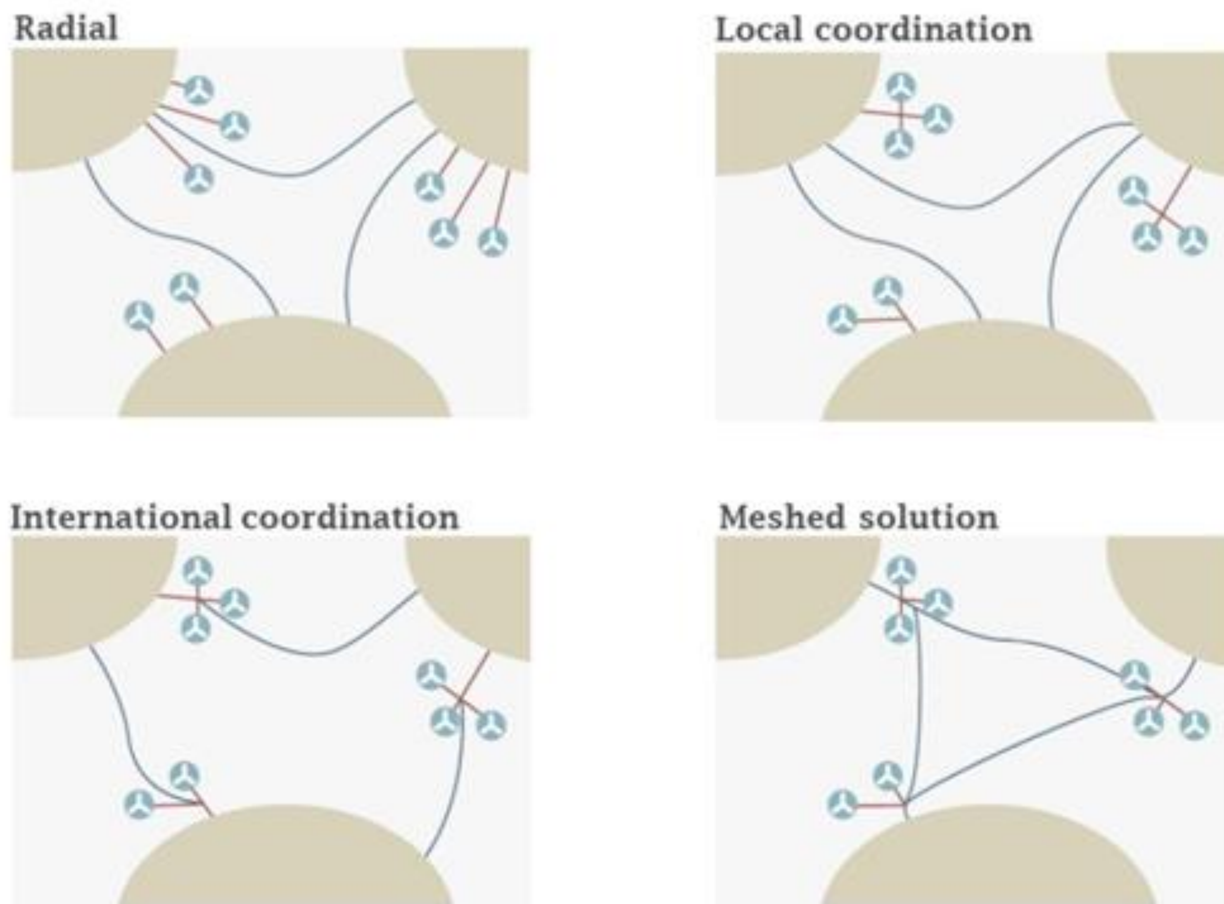


Solutions

- Dispathcable renewable energy
  - Bio fuels
  - Biogas
  - Hydropower
- Flexible demand
  - Demand response
- Interaction with the other energy types in the energy system
  - Heat
  - Transport
  - Heat pumps
- Interconnection with other countries/systems

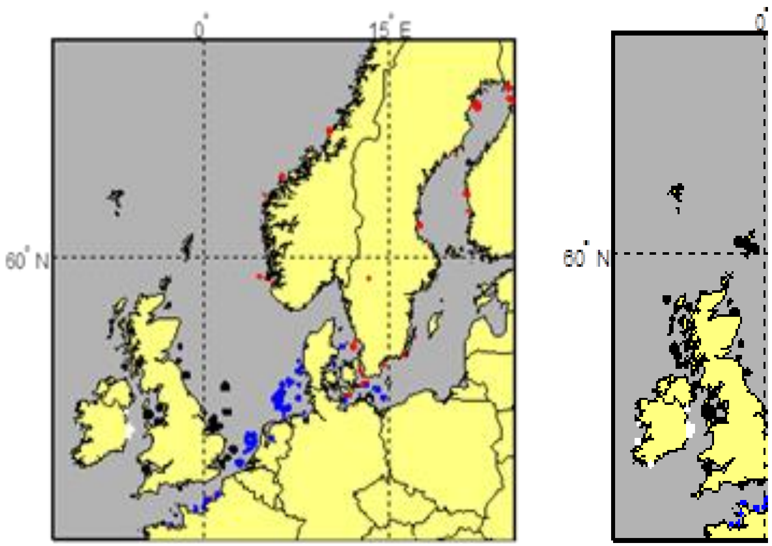


Solutions - grid connections



Solutions - grid connections

- Massive offshore wind power will a
  transition towards a future sustain
  - energy storage
  - coordination between the elect
    systems
  - offshore grid development



Location of offshore wind power plants in detailed scer
and 2030 (right) developed in the EU TWENTIES proje

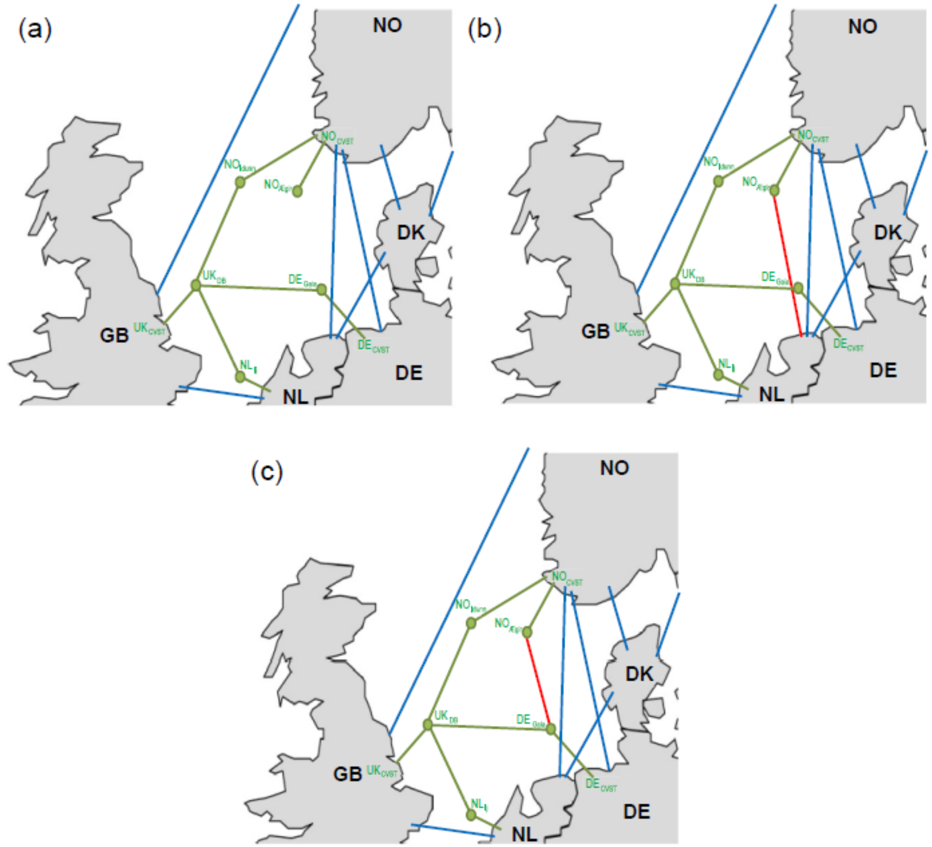


Figure 16.14 Proposed offshore grid alternatives. (a) Case A, (b) Case B and (c) Case C.
Source: Farahmand, H., Jaehnert, S., Aigner, T., Huertas-Hernando, D., 2013. TWENTIES Task 16.3. Nordic Hydro Power Generation Flexibility and Transmission Capacity Expansion to Support North European Wind Power: 2020 and 2030 Case Studies. SINTEF Energy Research, D 16.3.

Solutions - grid connections

- NSON projects
  - Denmark, Germany, Netherlands, Norway and UK
- Baltic integrid
  - Partners from
    - Denmark, Sweden, Germany, Poland, Latvia, Estonia, Finland

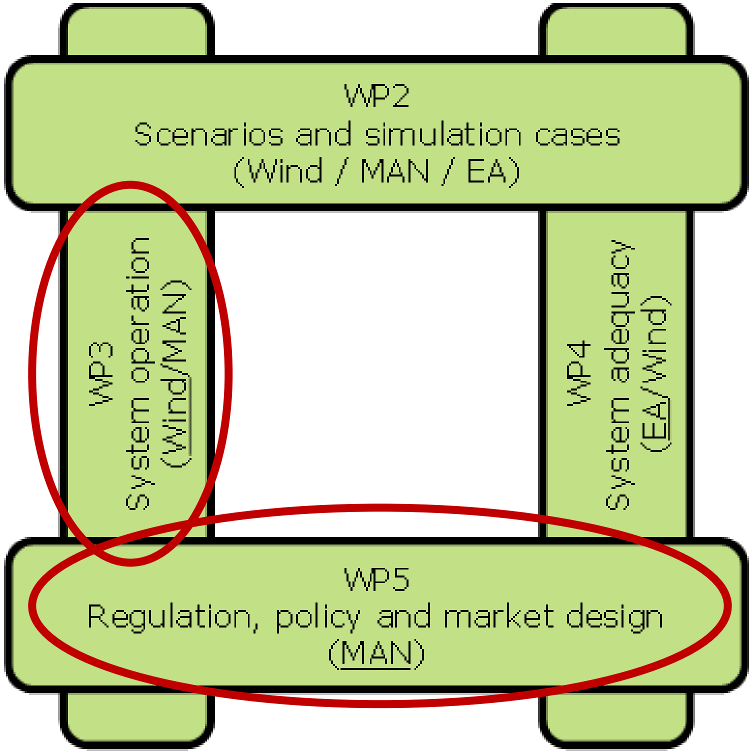
- Basically:
  - Which is the best option for grid connections in the North Sea and the Baltic Sea respectively?
  - How are we going to achieve that?
    - Effect on the variability and uncertainty of variable renewable generation
    - Balancing and need for reserves
    - Influence on the electricity markets and coordination with other energy systems
    - The scale and architecture of the offshore grid
    - Policy instruments

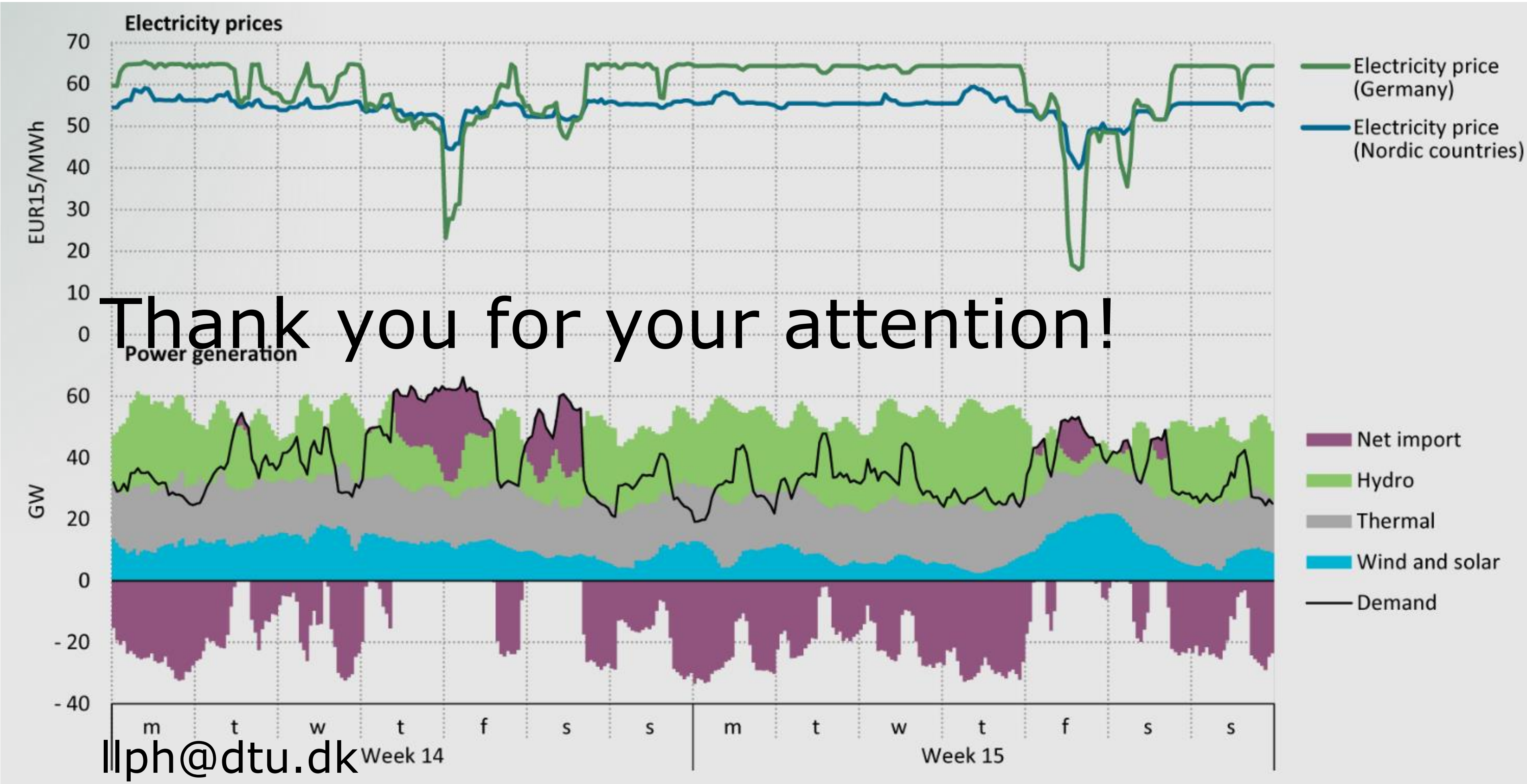
Solutions - grid connections

NSON-DK

- System costs
- Market balancing
- Control of reserves

- Instrument's and market design's impact on the offshore wind power and grid development.
- Necessary policy design for achieving the relevant offshore development
- Description of the market design necessary for the relevant offshore development





Thank you for your attention!

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