Heat and power sector

- present and future challenges

ISEE winter school 2017
Chalmers Univ. of Tech. (Göteborg, Sweden)

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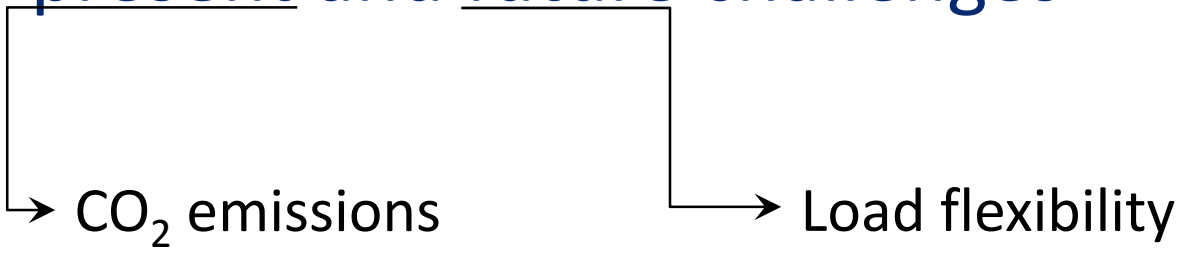
Dept. of Energy and Environment
Chalmers University of Technology

Heat and power sector

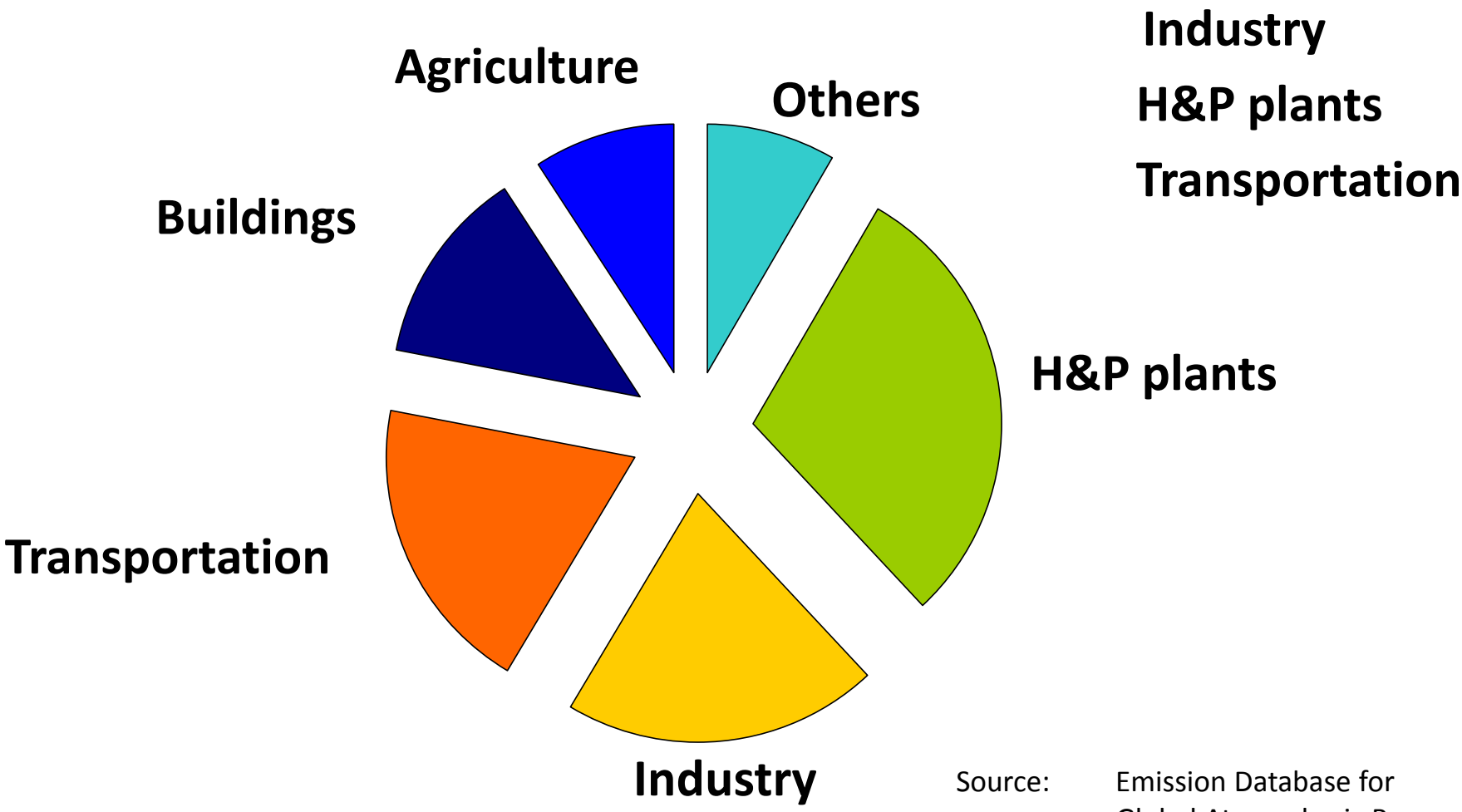
- present and future challenges



Present and future strengths:

It is dispatchable and, optionally, a zero-CO_2 technology

Present challenge: reduction of CO_2 emissions



Source: Emission Database for Global Atmospheric Research

Present challenge: reduction of CO_2 emissions

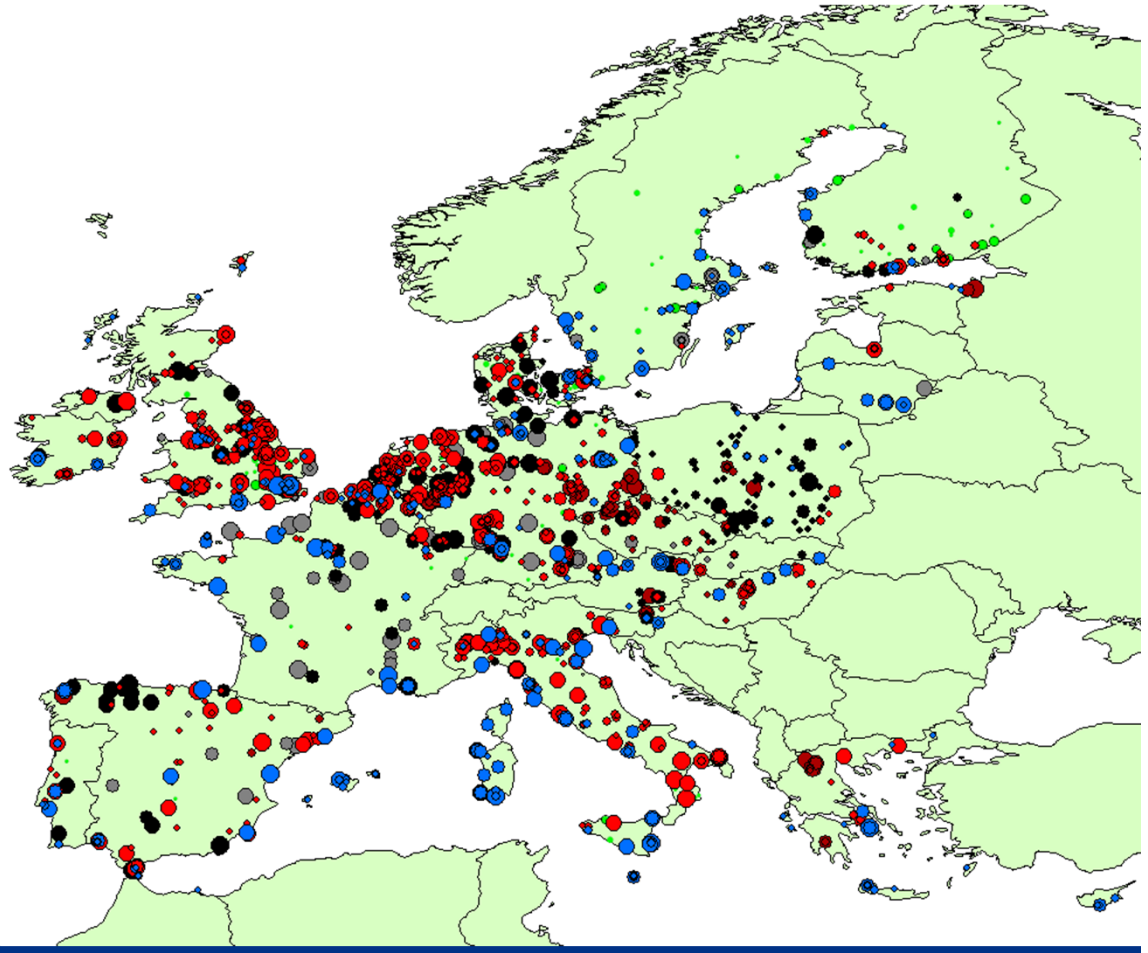
Combustion / Gasification *of* fossile fuel / biomass *with* CO_2 capture

MW/g_{CO2} CO_2-neutral CO_2-neutral/negative

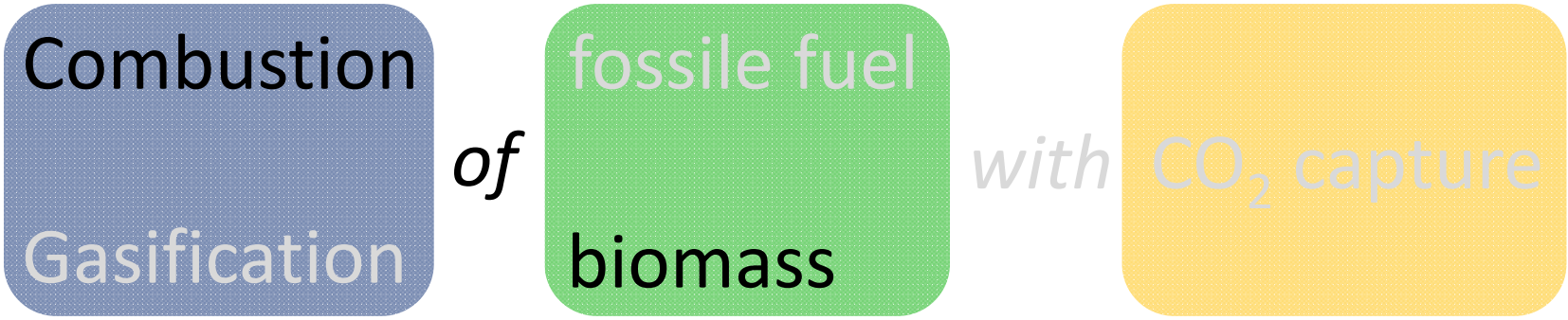
Present challenge: reduction of CO_2 emissions

Current pool of H&P plants

Gas
Coal
Oil
Nuclear
Biomass



Present challenge: reduction of CO_2 emissions



MW/g_{CO2} CO_2-neutral CO_2-neutral/negative

Combustion of biomass

Alholmen (Finland), 265 MWe
Fluidized bed unit, Valmet

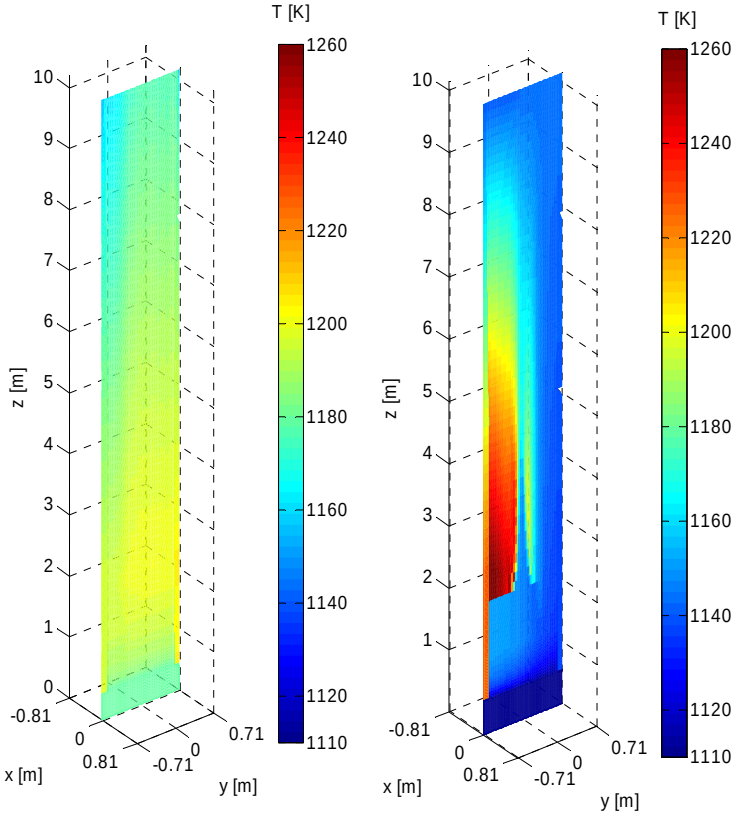
Co-combustion of biomass

Turow (Poland) , 765 MWe, 15% biomass, 85% coal
Fluidized bed unit, Foster Wheeler

Oxygen carriers: the black miracle

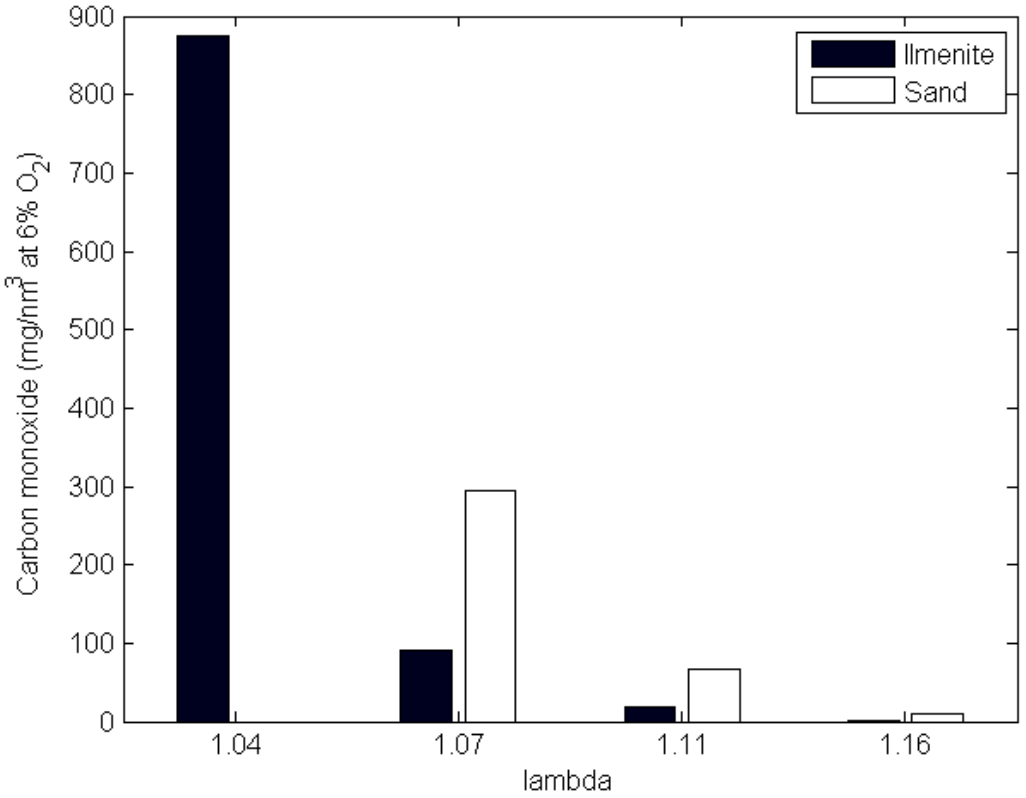
Improved combustion of biomass

OCAC-combustion (patented by Chalmers and EOn)



Coal

Wood chips



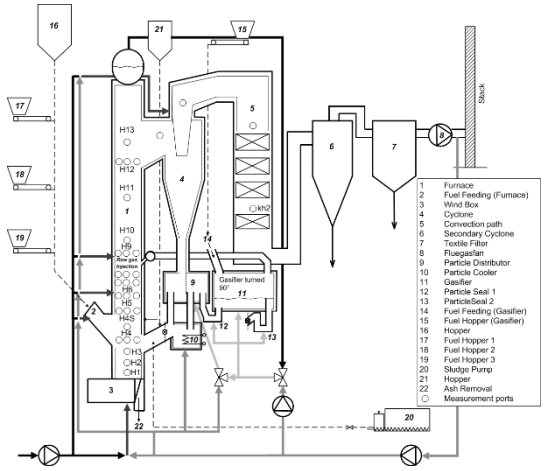
Chalmers research plant (12 MW)

OCAC-combustion of biomass and indirect gasification of biomass

Research from lab to commercial scale

Labscale reactor

Chalmers 12MWth research boiler



E.ON commercial waste boiler 80MWth

Continuous operation since February 2016

2013 2014 2014 - 2016

Present challenge: reduction of CO_2 emissions

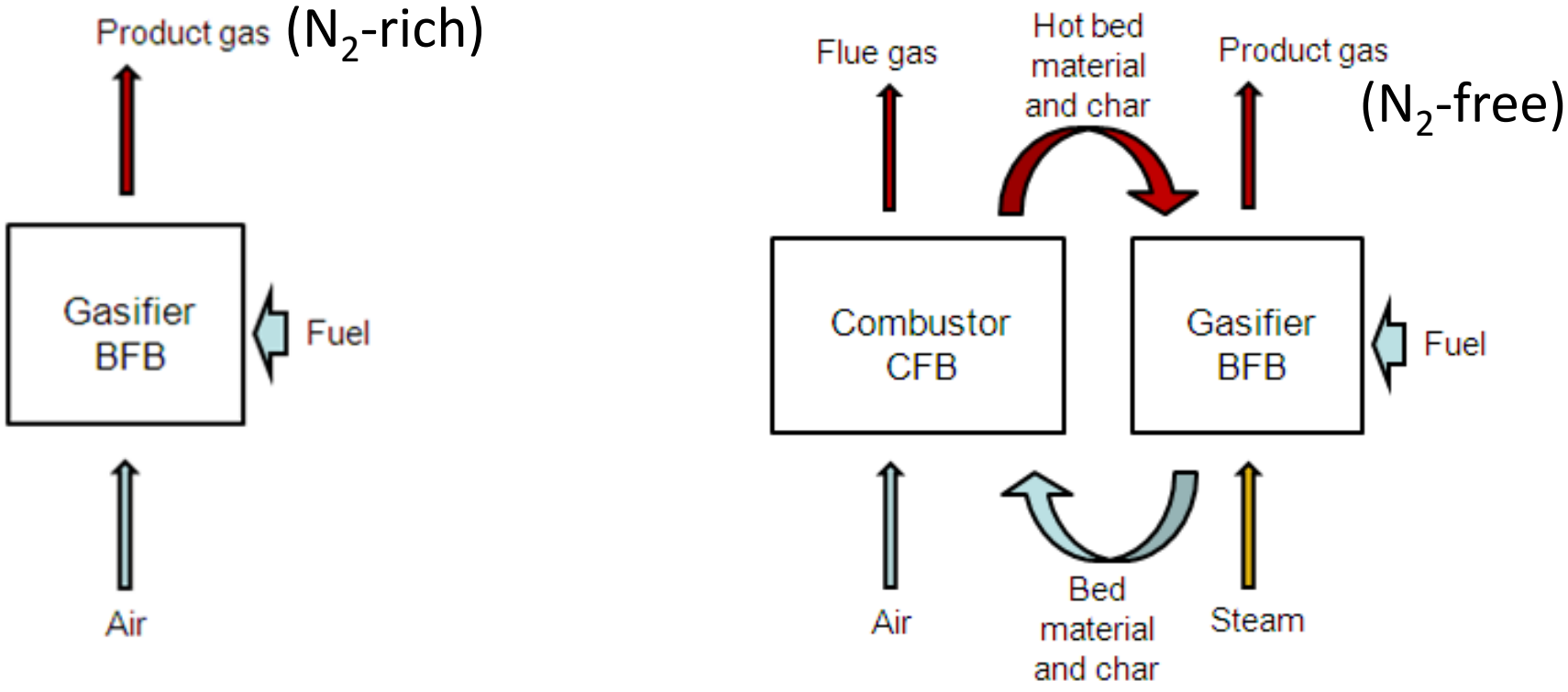
Combustion / Gasification *of* fossile fuel / biomass *with* CO_2 capture

MW/g_{CO2} CO_2-neutral CO_2-neutral/negative

Biomass gasification – a second birth

Improved gasification of biomass

Indirect gasification (commercialized by Chalmers and Göteborg Energi)



Improved gasification of biomass

Indirect gasification (commercialized by Chalmers and Göteborg Energi)

Chalmers lab reactor

Chalmers
2-4 MW Raw Gas
Demonstration Plant

13 Million SEK

GoBiGas Phase 1 Hisingen
20 MW Biomethane Pilot Plant
Göteborg Energi

1400 Million SEK

GoBiGas Phase 2
Hisingen
80-100 MW Biomethane
Commercial Plant
Göteborg Energi

3500 Million SEK

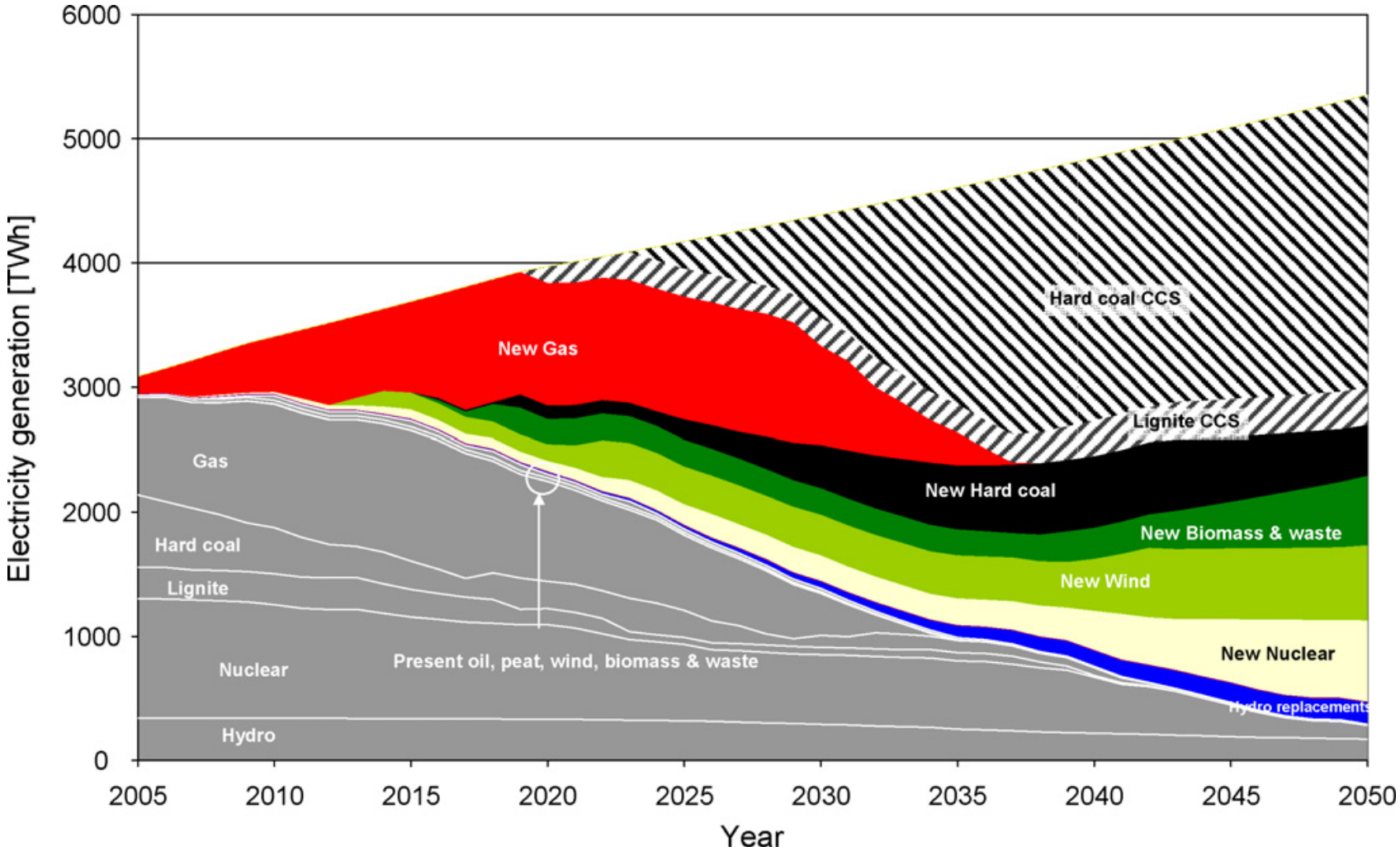
2008 2013 2017

Present challenge: reduction of CO_2 emissions

Combustion / Gasification *of* fossile fuel / biomass *with* CO_2 capture

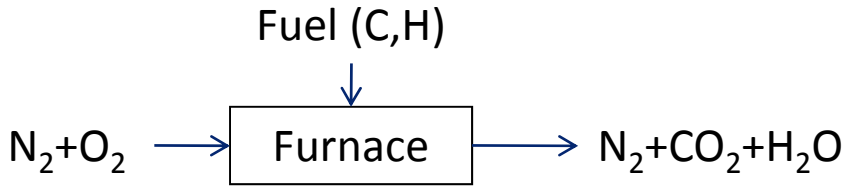
MW/g_{CO2} CO_2-neutral CO_2-neutral/negative

Engineering in the energy field

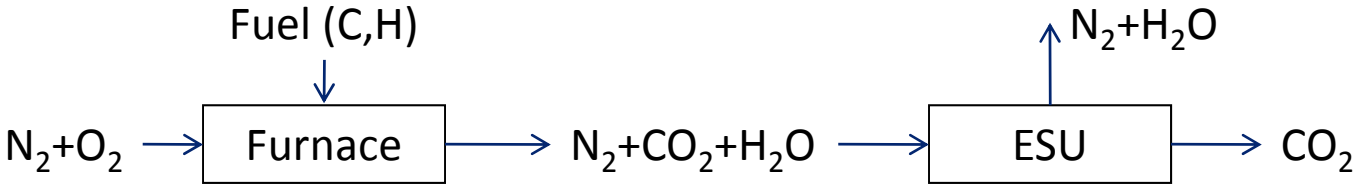


Carbon Capture strategies

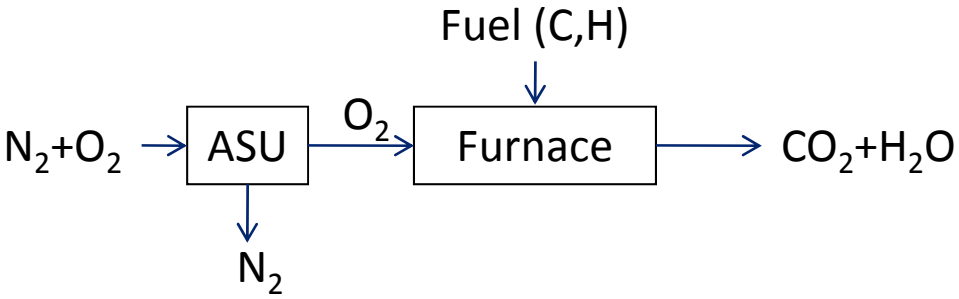
Current Combustion



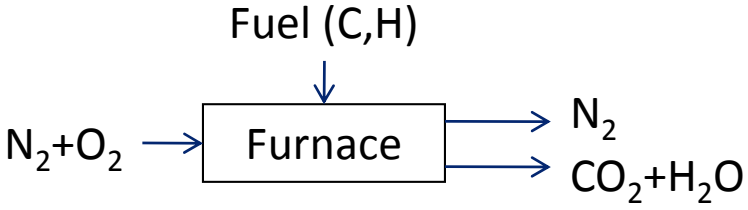
Post-cleaning combustion



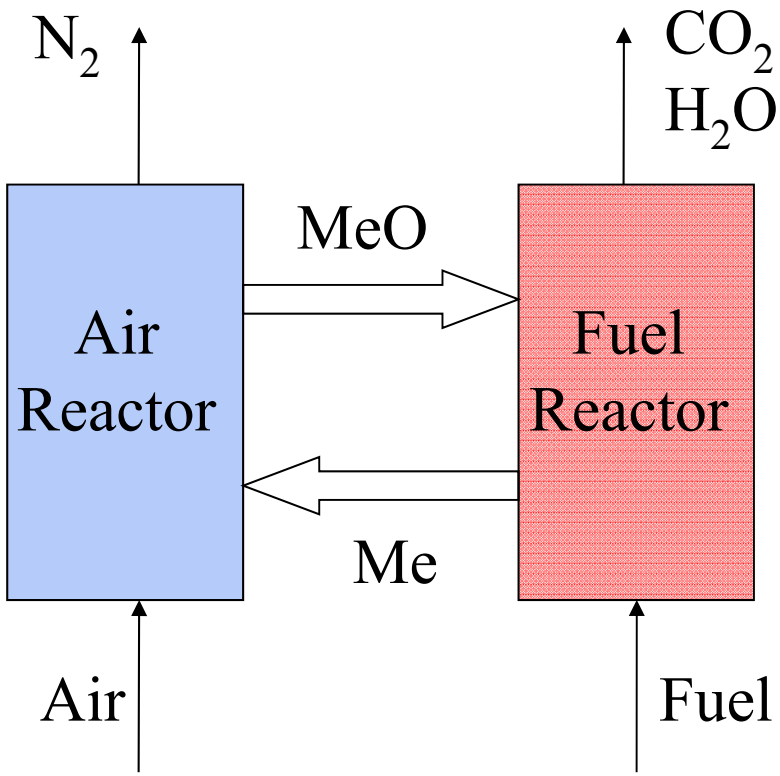
Oxyfuel Combustion



Chemical looping combustion



Chemical Looping Combustion (CLC)



$Me + O_2 \leftrightarrow MeO$

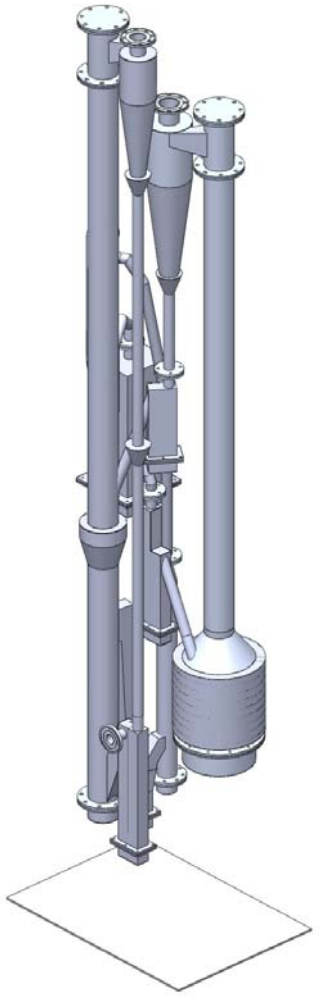
$MeO + fuel \rightarrow Me + CO_2 + H_2O$

Chalmers CLC research

5 out of 10 CLC units worldwide

10 kW (2003)

100 kW (2016)

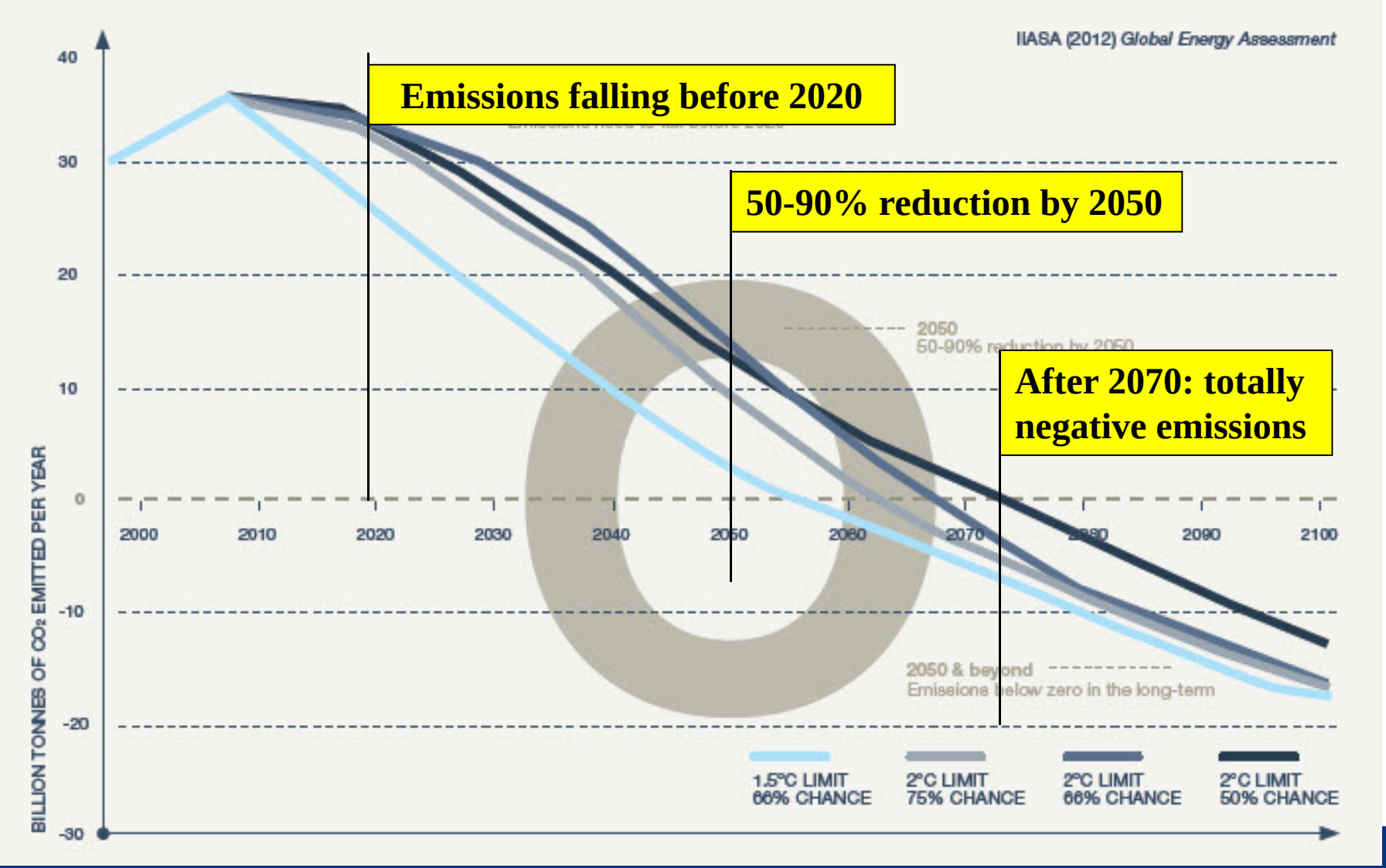


Present challenge: reduction of CO_2 emissions

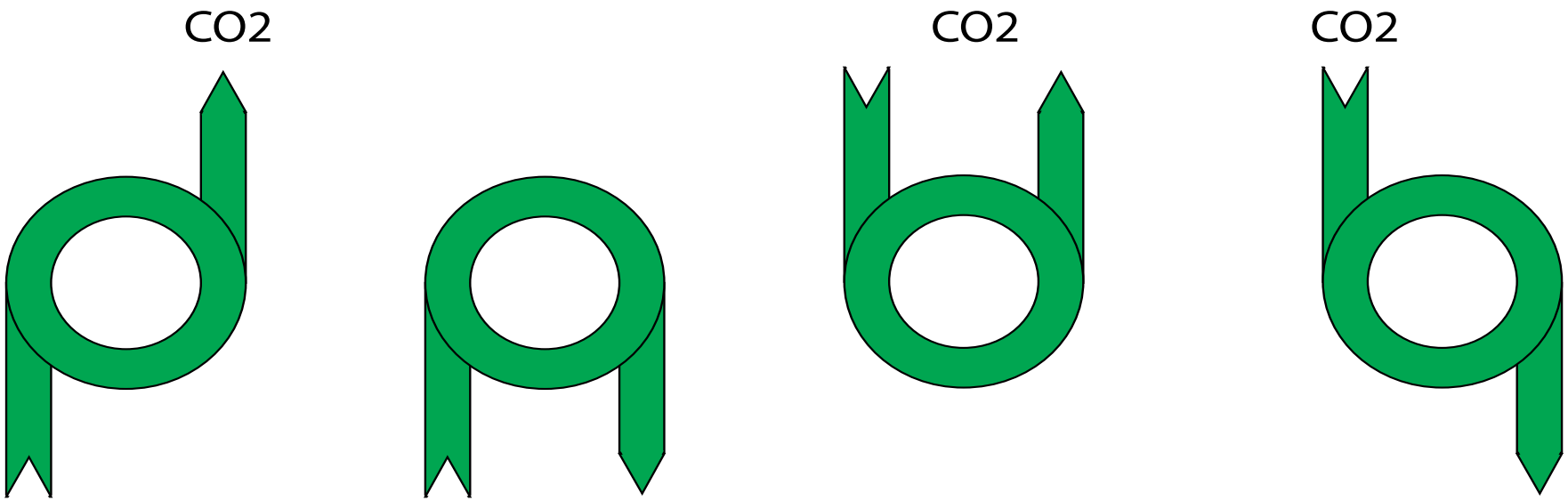
Combustion / Gasification *of* fossile fuel / biomass *with* CO_2 capture

MW/g_{CO2} CO_2-neutral CO_2-neutral/negative

To meet the 2°C target it is not sufficient to stop emissions of CO_2, most likely we need ***negative*** emissions by the end of the century.



ATMOSPHERE



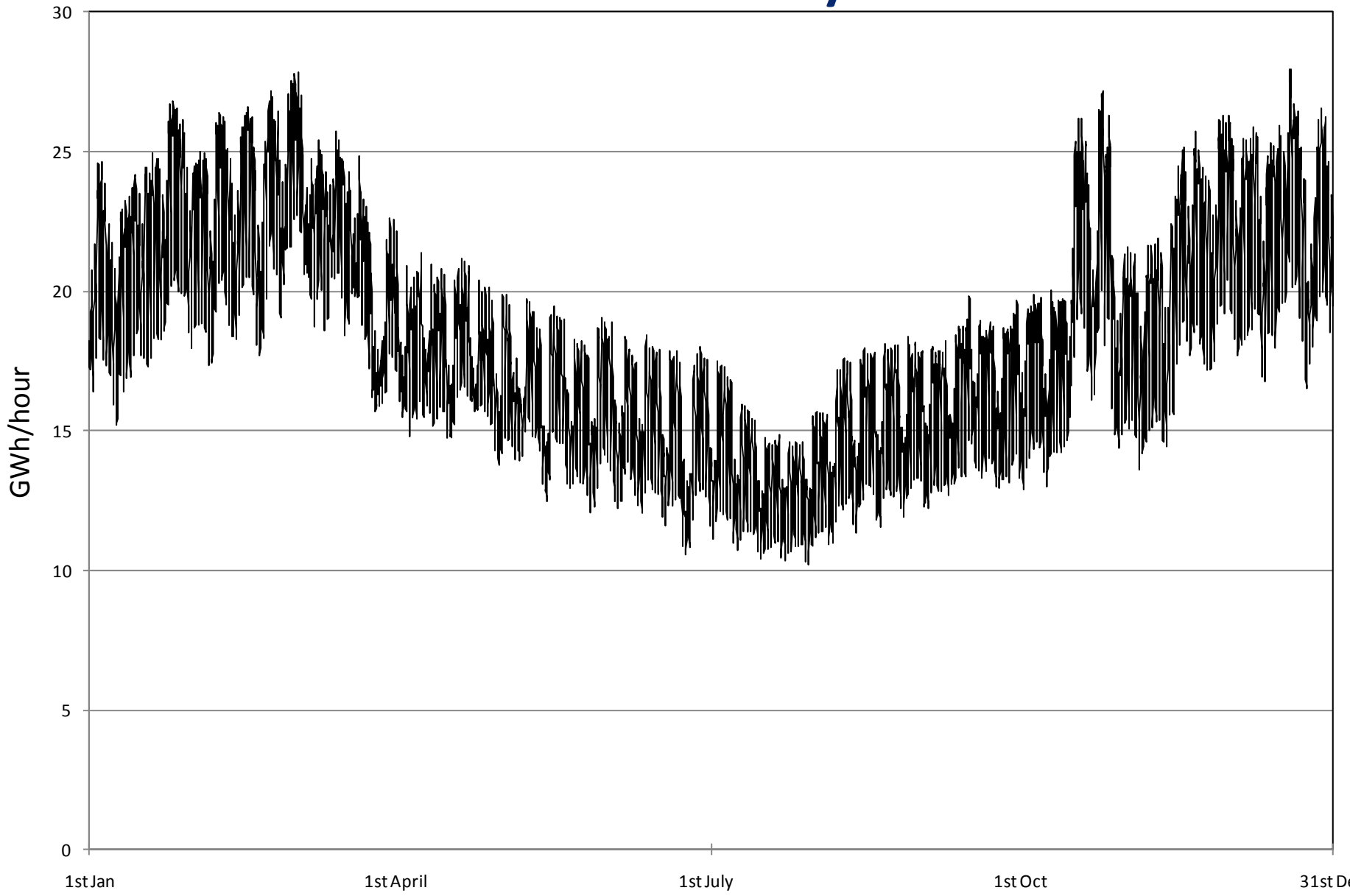
GROUND

Heat and power sector

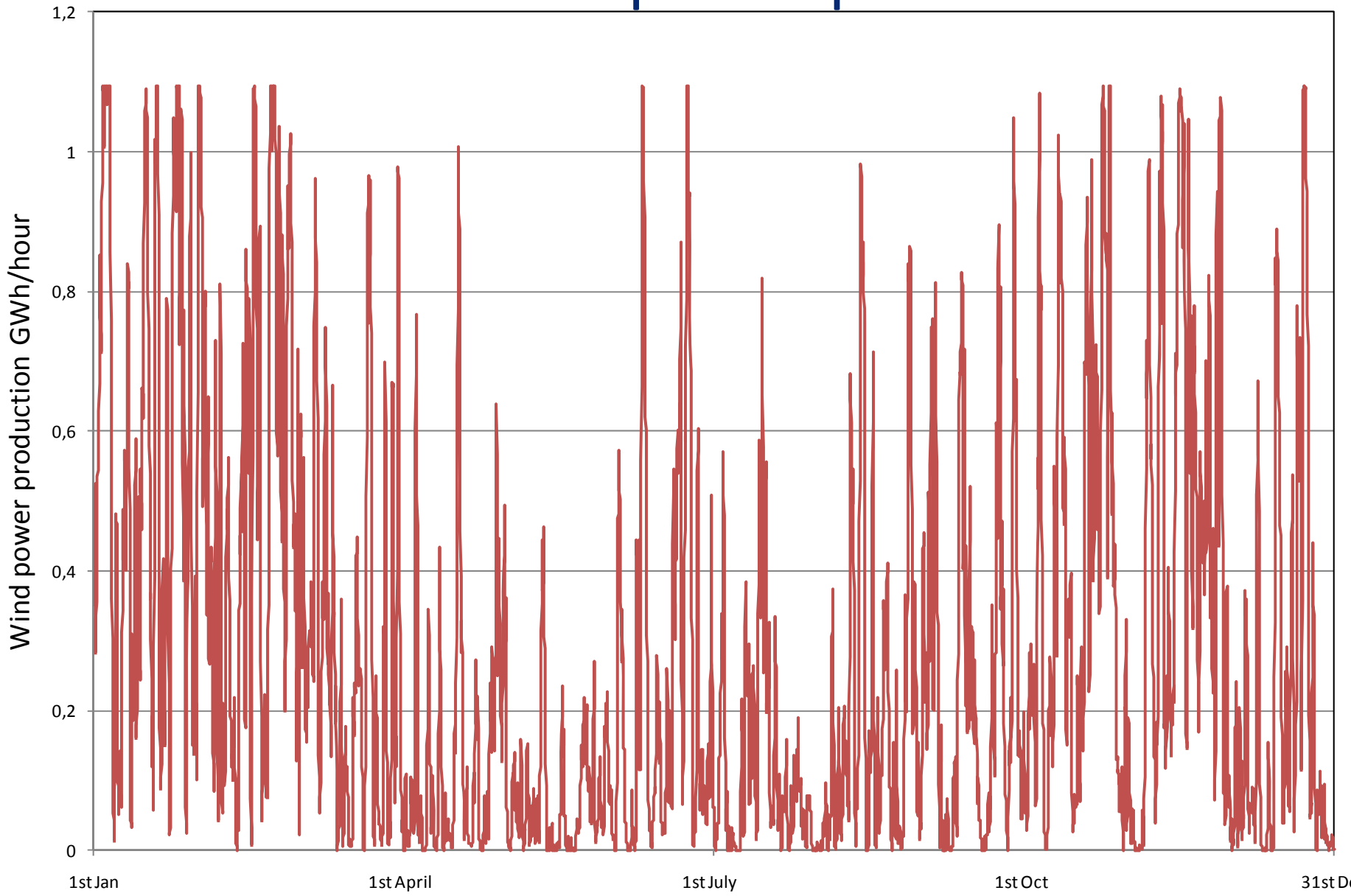
- present and future challenges

- CO_2 emissions
- Load flexibility
  Energy storage

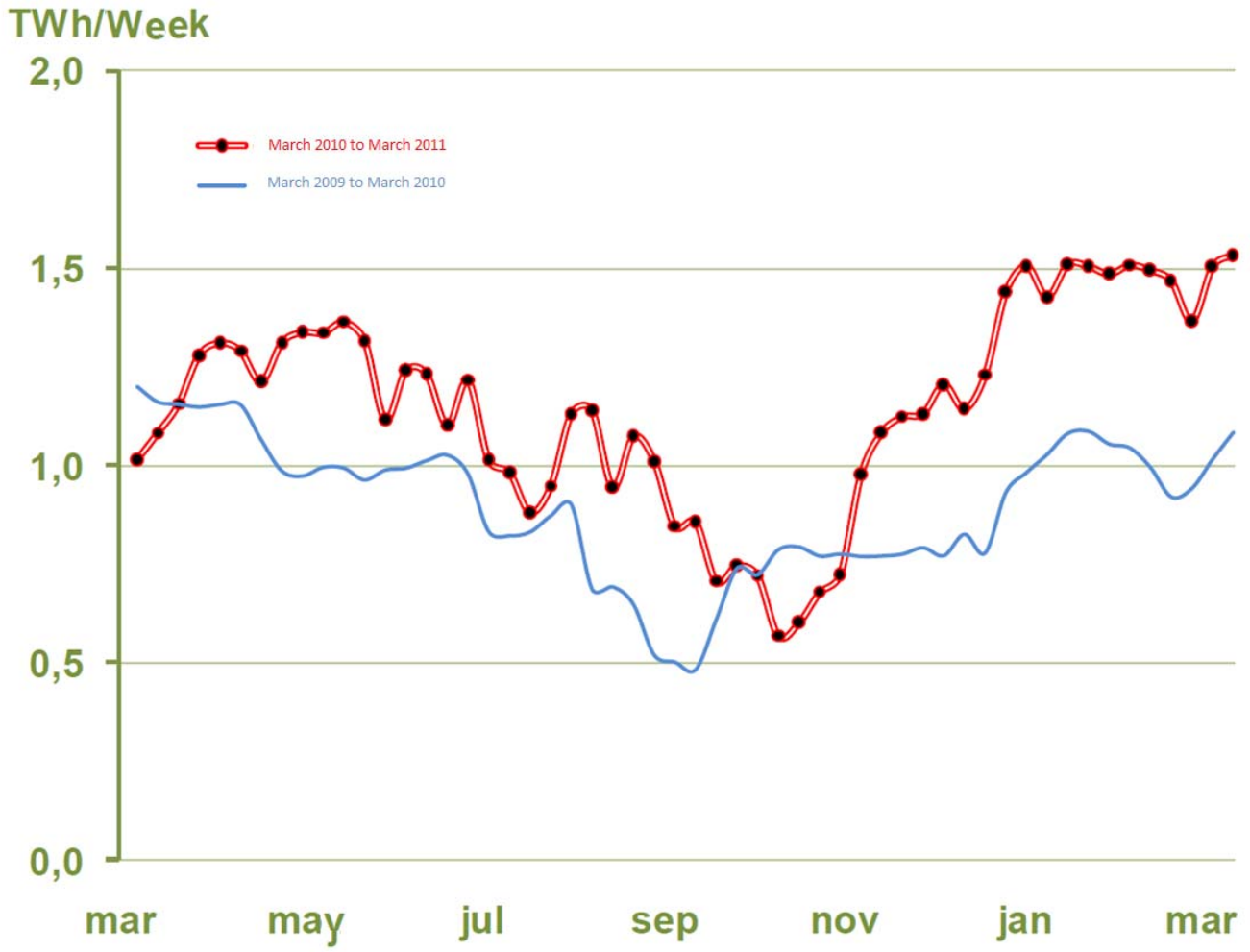
Swedish electricity demand



Swedish wind power production



Dispatch – e.g. Swedish nuclear power



Management of **intermittent power**

Supply

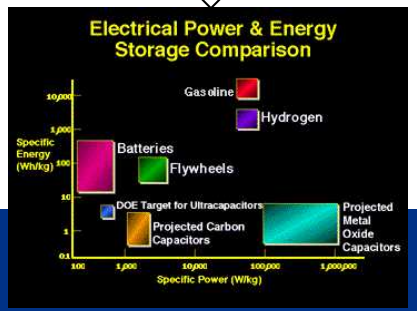
Regulated/Dispatchable

Variable generation

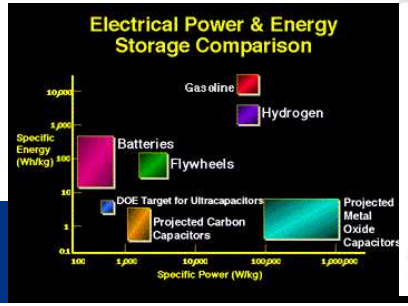
Transmission

Balance

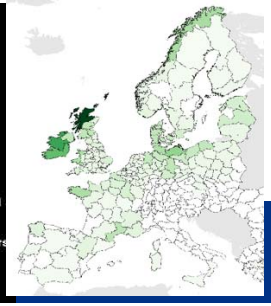
Storage



Storage

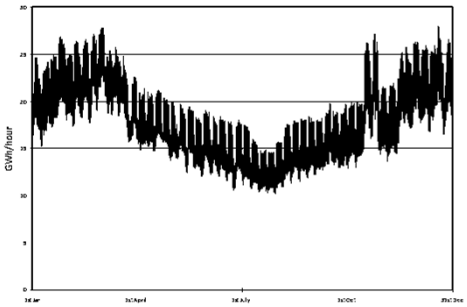


Trade

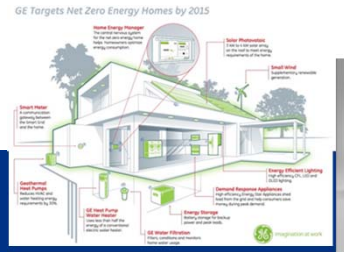


Demand

Load



Management

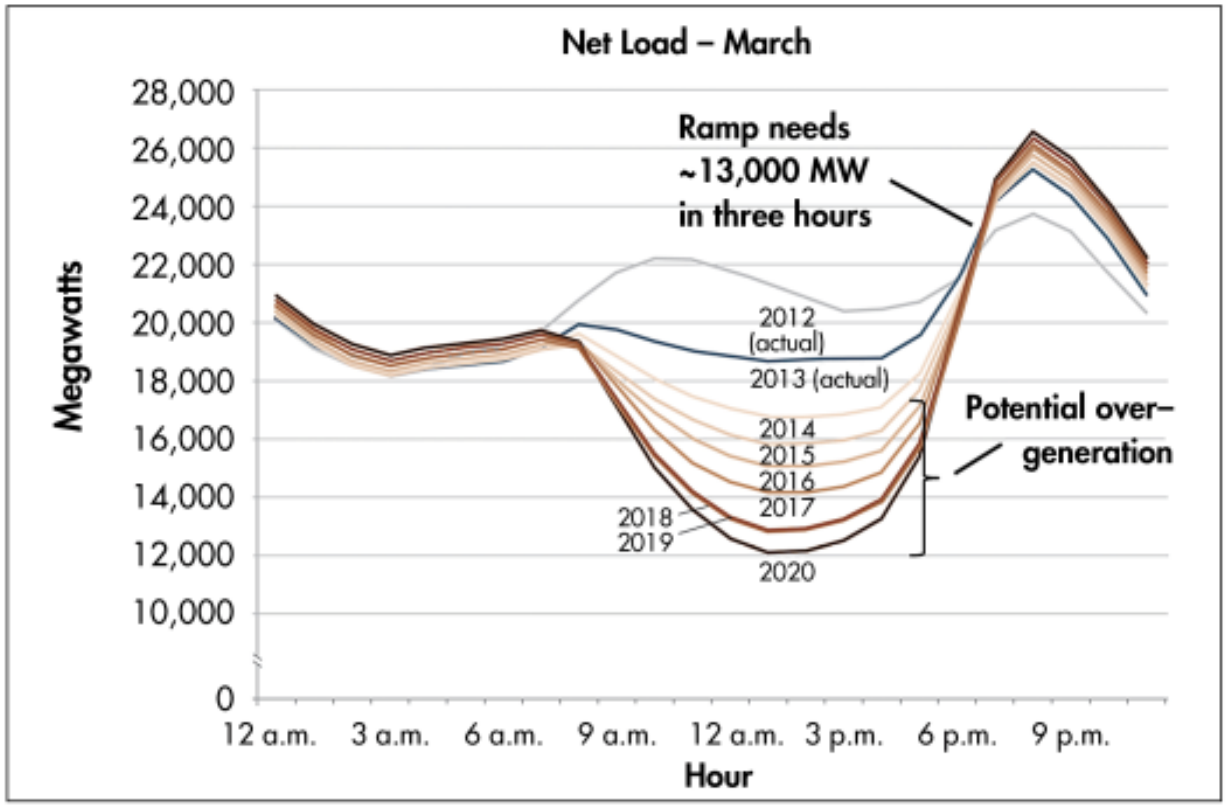


Effect of wind and solar on net load curve

Net load = Demand – Non-dispatchable (wind&solar)

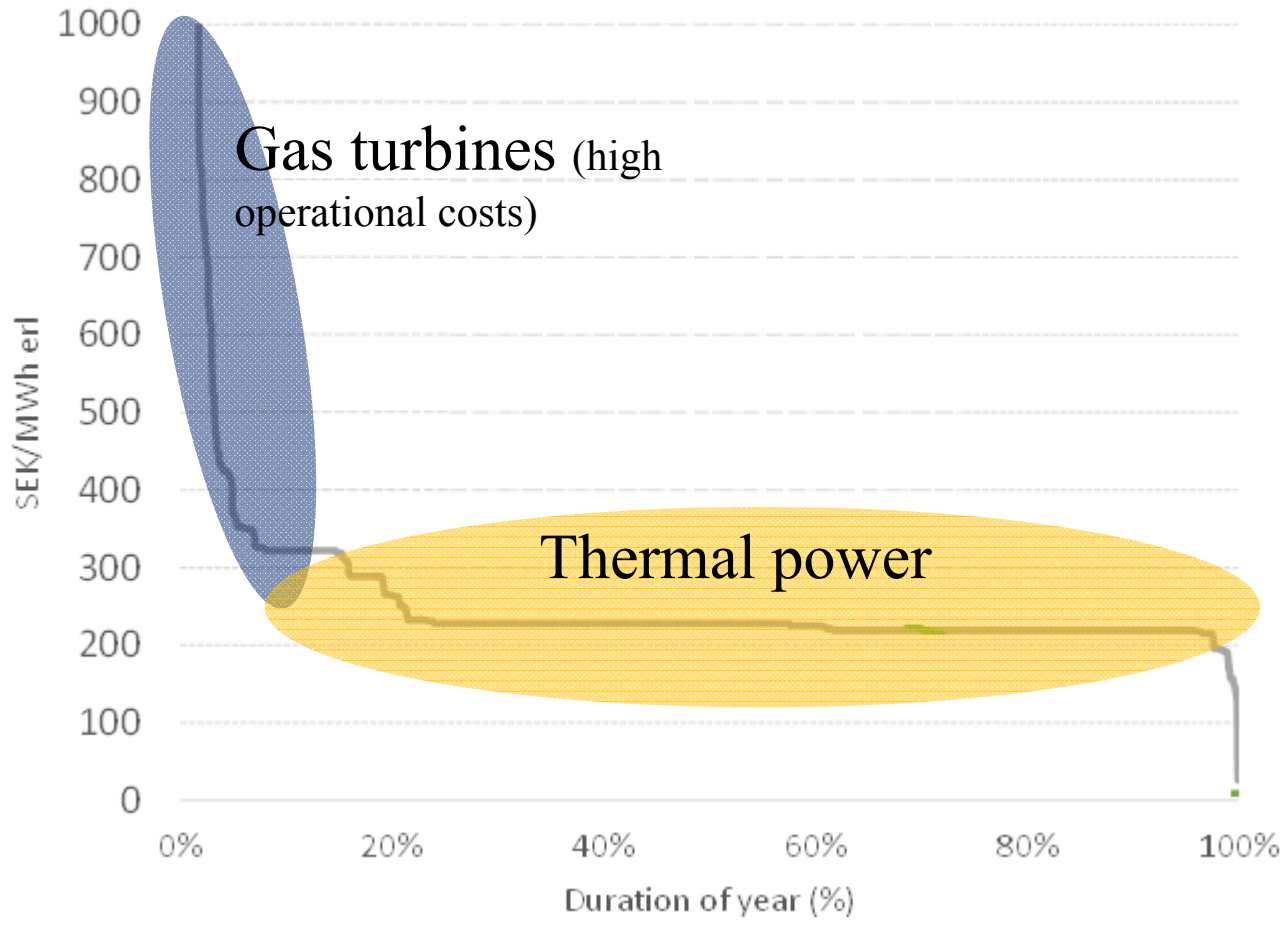
Averaged daily net load curve (intermittency to be added)

Figure 1: Net load on the CAISO system



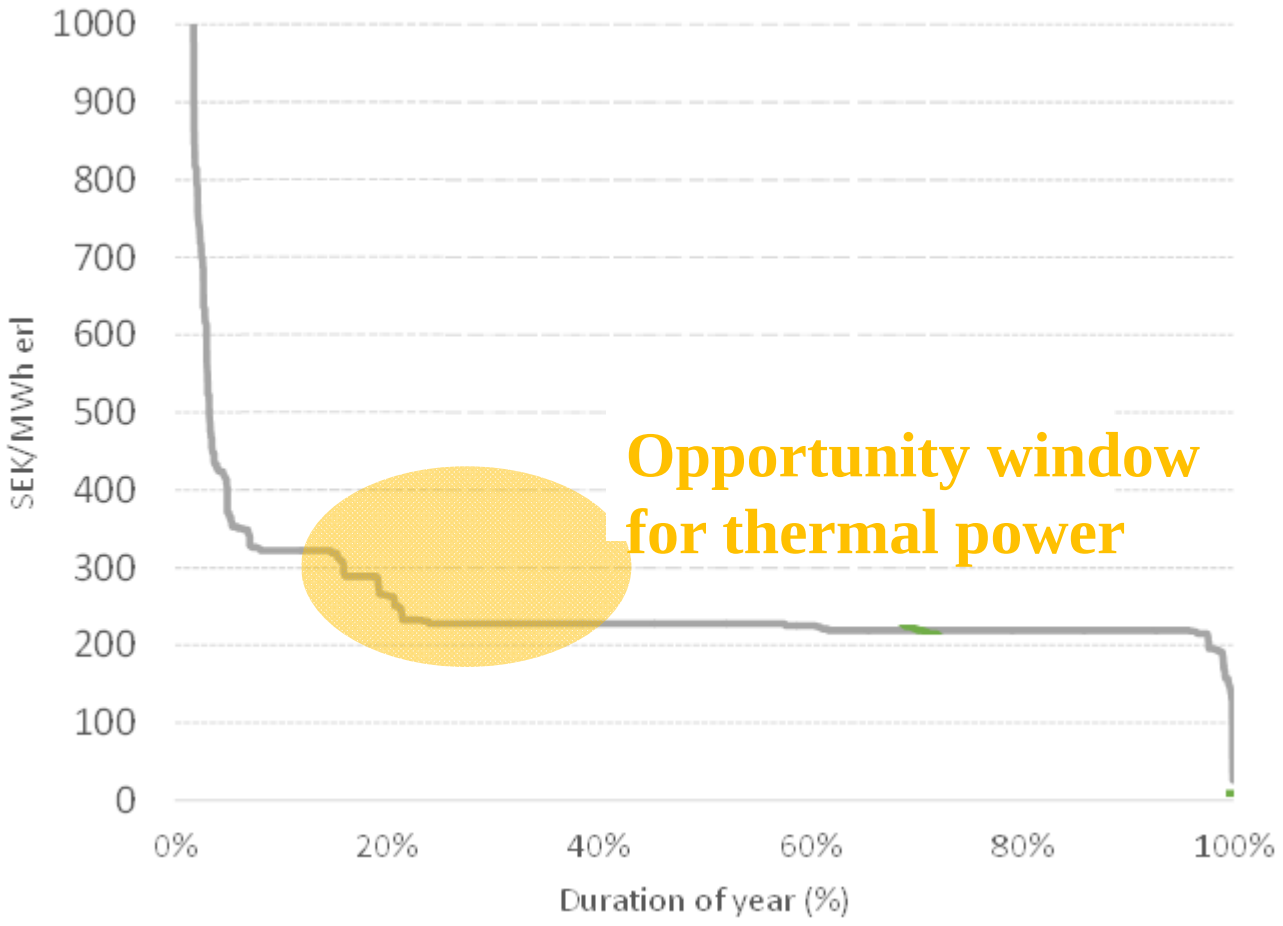
Source: CAISO

Current typical price curve in EU



More solar&wind power (low operational costs)

Higher price variation



renewable,
low-price ho

Flexibility of heat and power plants

Increased wind and solar energy yield a larger share of intermittent and non-dispatchable power generation.

Stronger demands on the operational flexibility of the dispatchable power generation.

Ramp rates

Start-up times

Minimum load

Part load efficiency

Energy storage

Key questions

Will fossil fuels be left on ground?

Are we ready to pay higher power prices?

Is *bridging* pragmatism or an excuse?

Can same demands be set to all countries?