A decorative graphic on the left side of the slide, consisting of a complex network of thin, light teal lines forming various geometric shapes, primarily triangles and quadrilaterals, creating a wireframe or mesh effect.

# R&I ROADMAP & FOCUS AREAS TOWARDS A RE-BASED ENERGY-SYSTEM

Cities 5'th General Consortium Meeting

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Energinet, Electricity System Operator

# DISPOSITION

ENTSO-E/G  
TYNDP18 scenarios



1: International Energy Scenarios



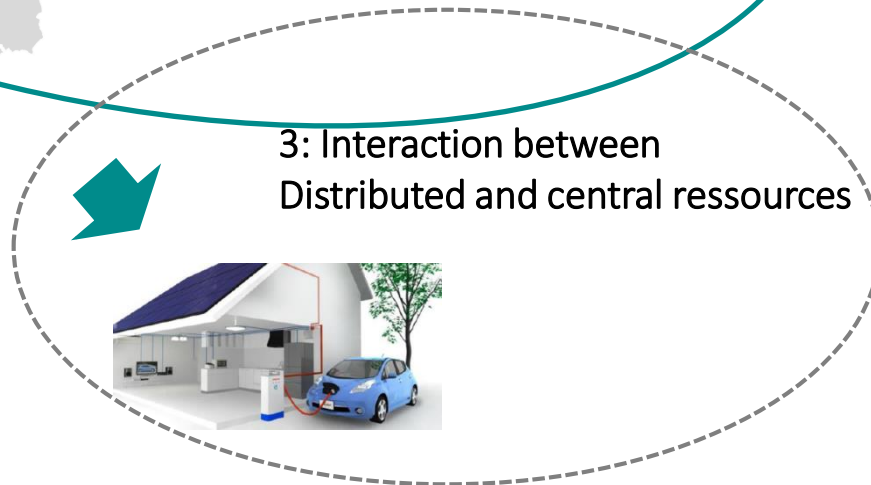
2: System Perspectives for Denmark



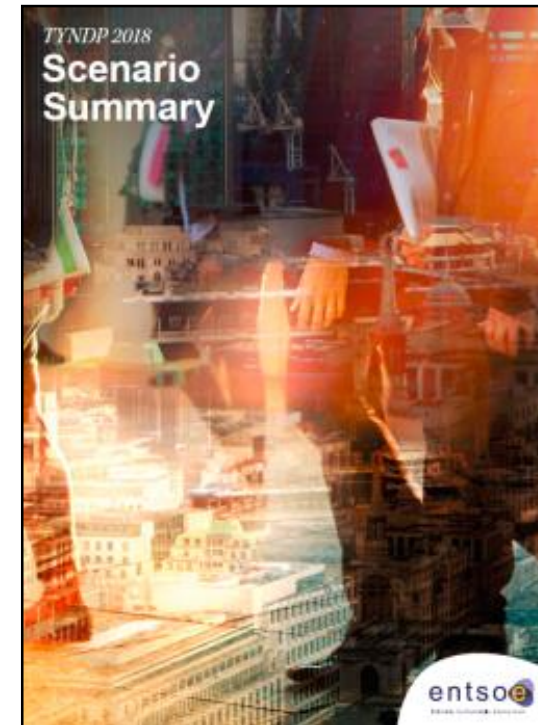
3: Interaction between Distributed and central resources



4: R&I Targets and focus areas



# INTERNATIONAL OUTLOOK – SCENARIOS EU



# INTERNATIONAL SCENARIOS FROM ENTSO-E/G

## Content of the 3 European TYNDP 2018-scenarios



### GCA-scenario (Global Climate Action)

- "On track" with EU current climate targets
- Strong international, green cooperation
- Moderate oil price –high CO<sub>2</sub>-price (IEA 450 PPM)

### DG-scenario (Distributed Generation)



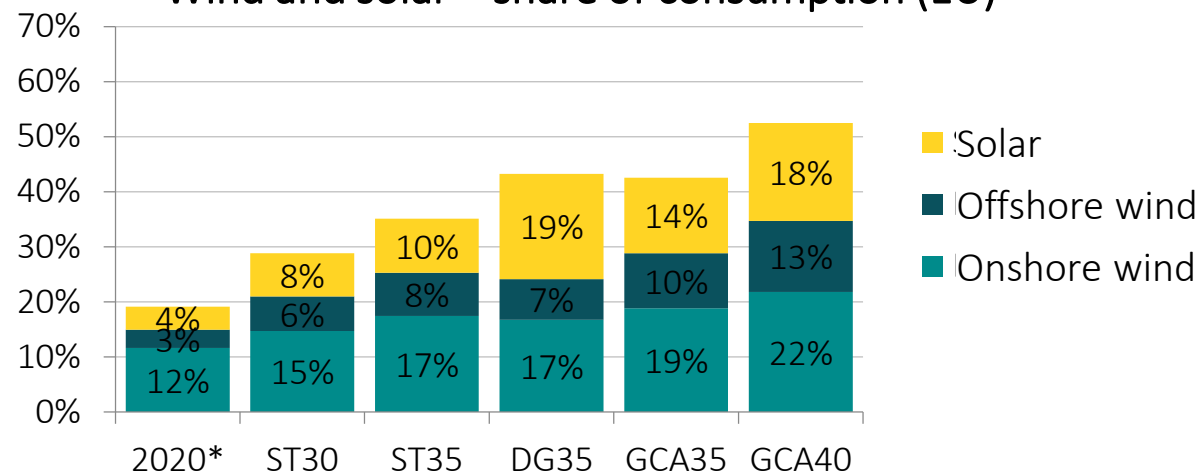
- "On track" with EU current climate targets
- Wide spread local distributed solutions (solar/batteries)
- High oil price (IEA New Policy) – high CO<sub>2</sub>-price

### ST-scenario (Sustainable Transition)

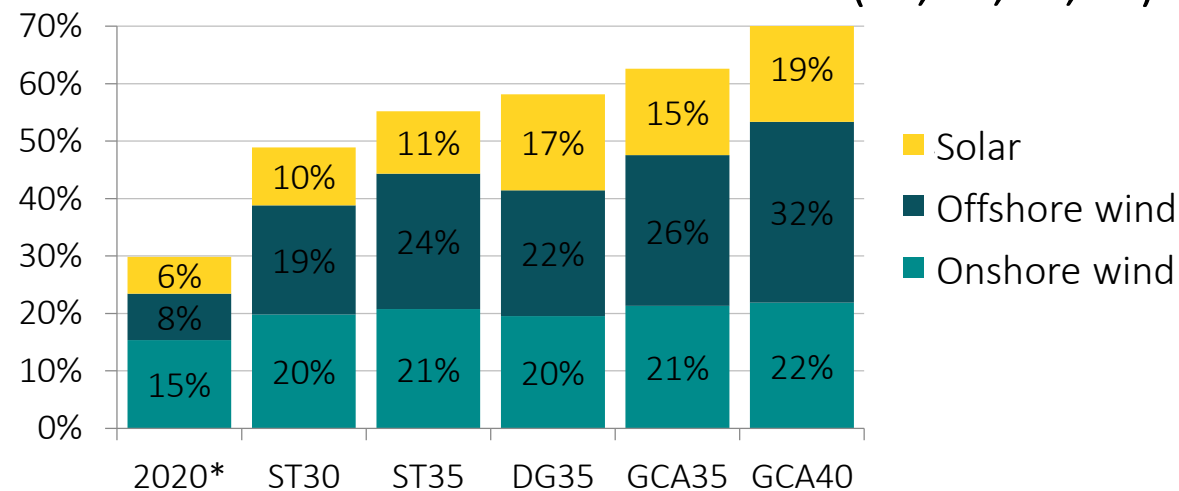


- "Not on track" with EU climate targets
- Low oil and natural gas prices
- Moderate CO<sub>2</sub>-price(IEA Low Oil price scenario)

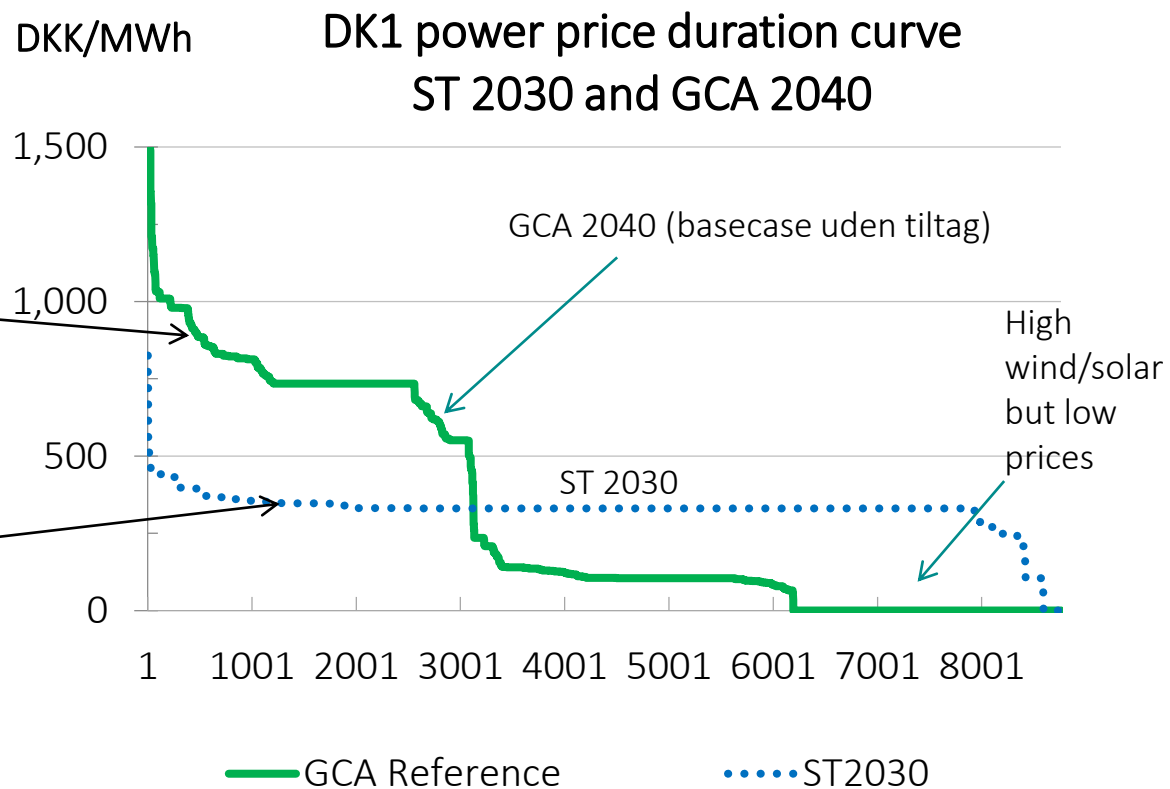
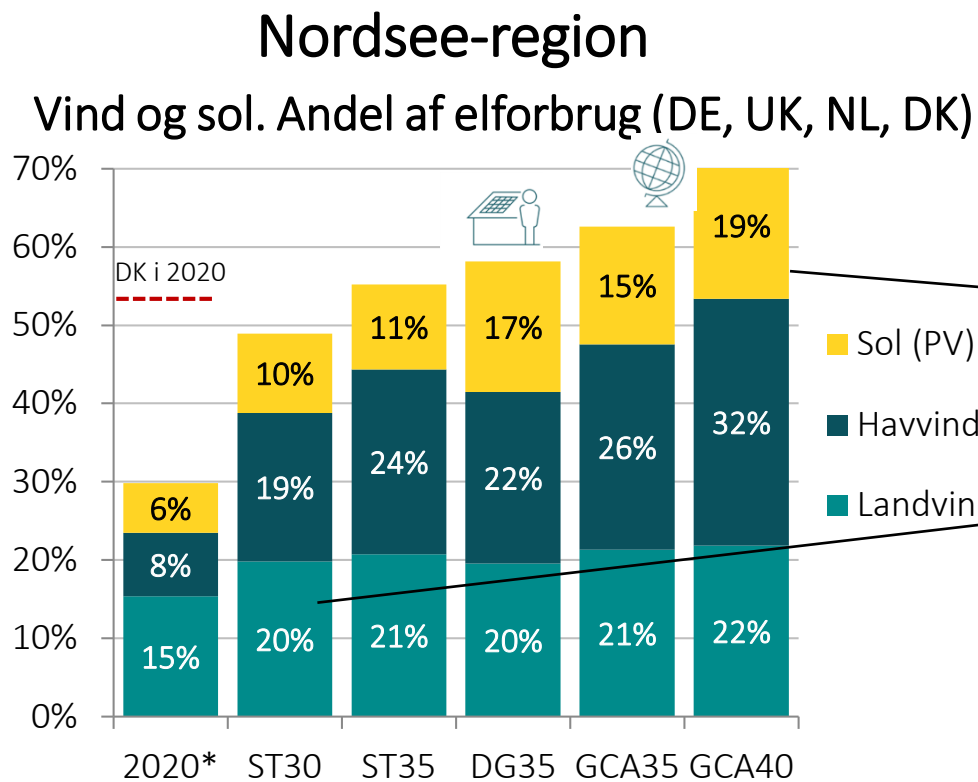
Wind and solar – share of consumption (EU)



Wind and solar share of cons. NorthSea (DE, UK, NL, DK)

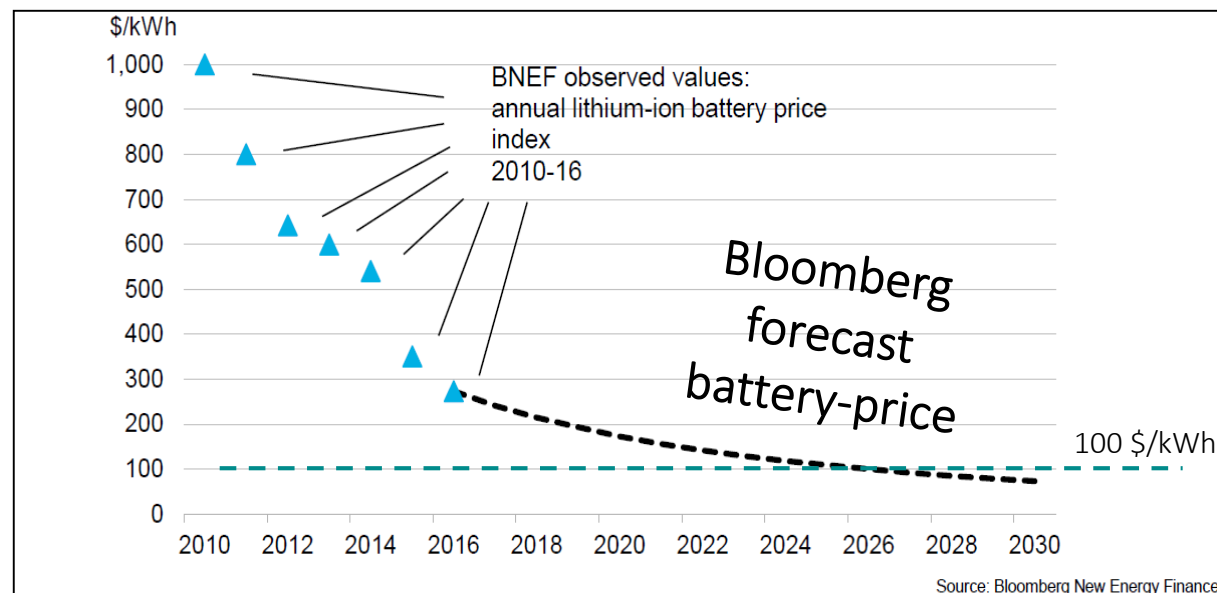


# MUCH MORE WIND AND SOLAR → MORE PRICE FLUCTUATION



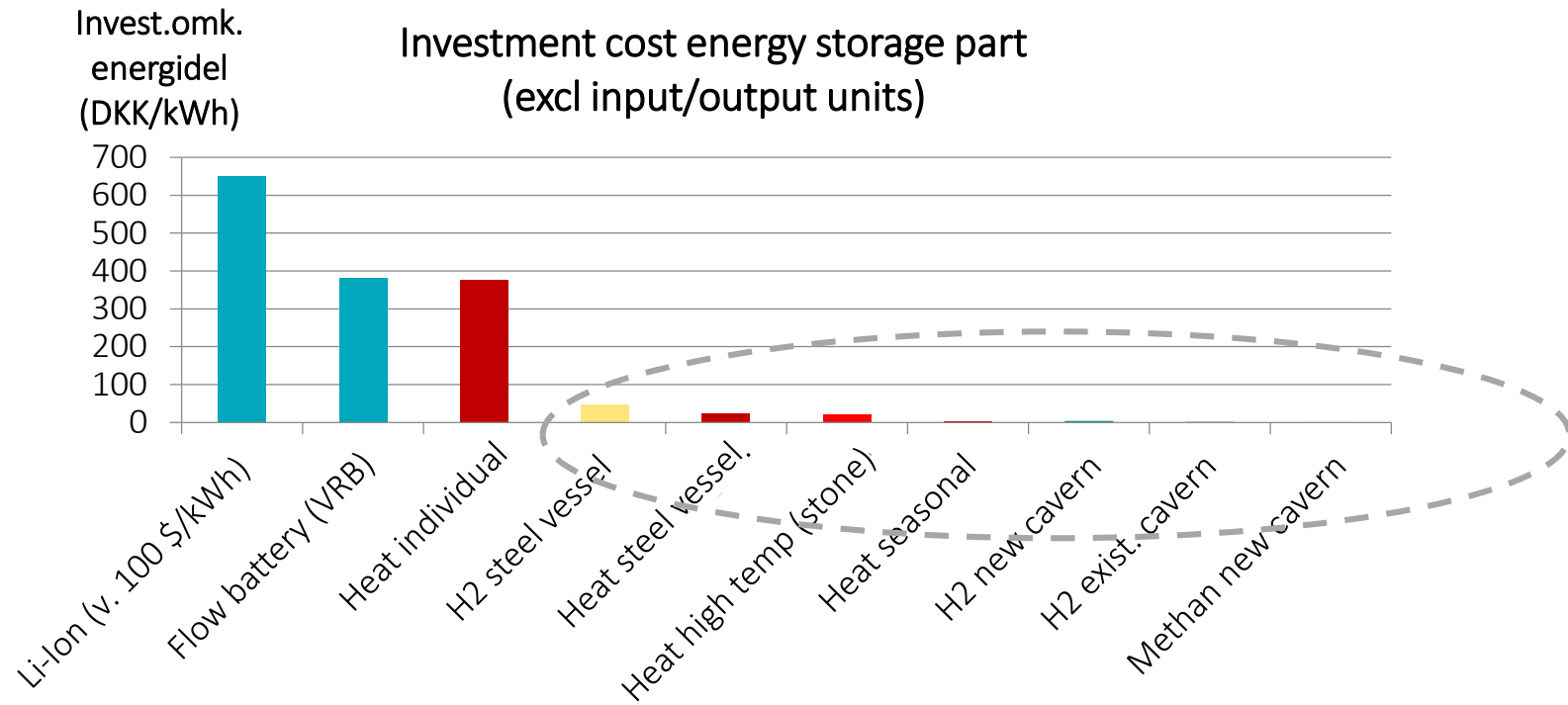
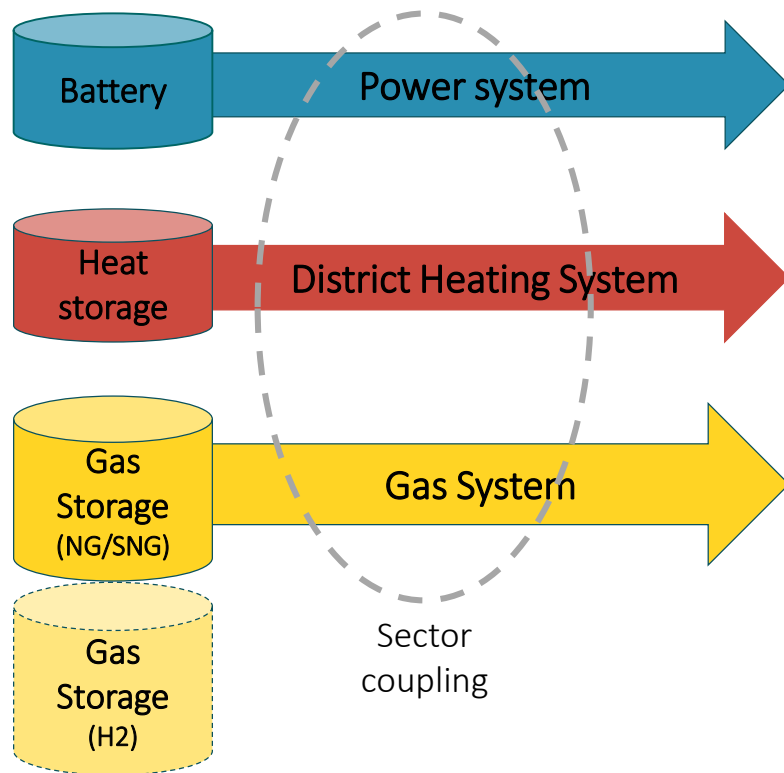
- More hours with zero-price
- Market value of wind/solar below LCOE cost

# COST REDUCTION FORECAST IN LI-ION BATTERIES



*Could batteries solve the  
"North-sea windpower balancing challenge" ?*

# SECTOR COUPLING TO GET ACCESS TO LOW COST STORAGE CAPACITY



- Battery storage is essential for hourly balancing – but too expensive for large scale storage
- Sector coupling to gas and heat can deliver more cost effective large scale storage
- Essential to analyse cost effective sector couplings!

“For all the growth in battery installations that BNEF is forecasting, the total volume of grid-connected batteries by **2030** will be sufficient to meet the world’s power needs **for just 7,5 minutes**” *Michael Liebreich, Bloomberg New Energy Finance, March, 2018*

# SYSTEM ANALYSIS FOR DENMARK





# SECTOR-COUPLING AT LARGE, MEDIUM AND SMALL "PROSUMERS" ENERGINET

Central  
"Energy Plant"



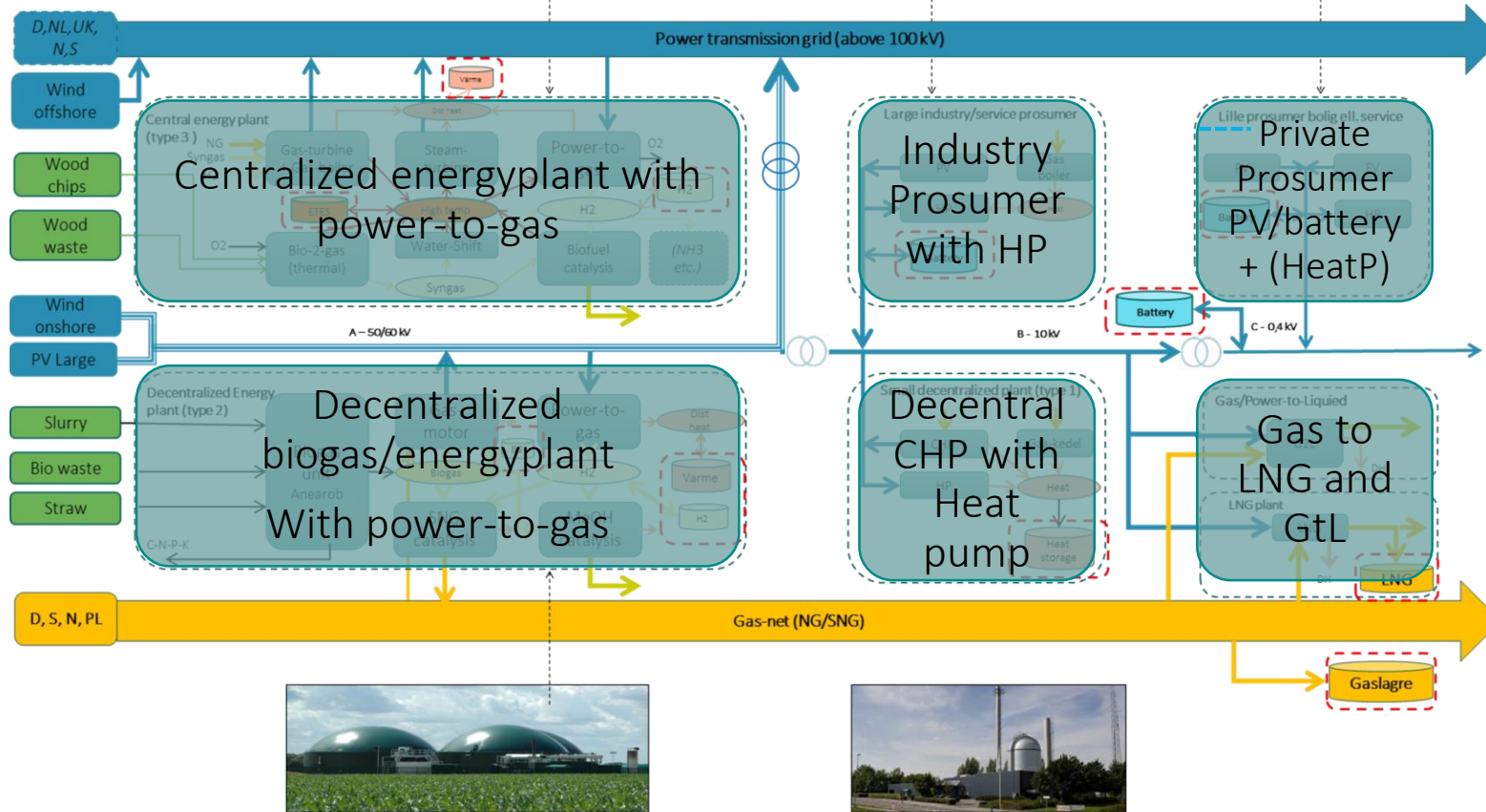
Industry/Service  
Prosumer



Household  
Prosumer



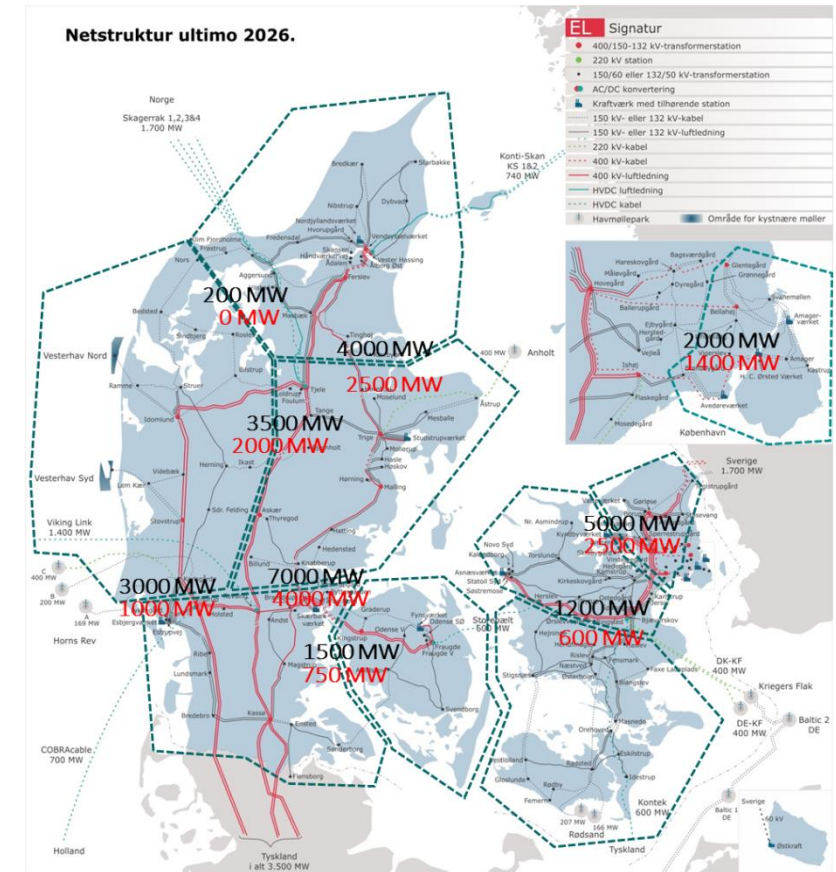
Flexible consumption  
simulated in grid areas  
incl. used as grid reserves



Decentralised Biogas/EnergyPlant



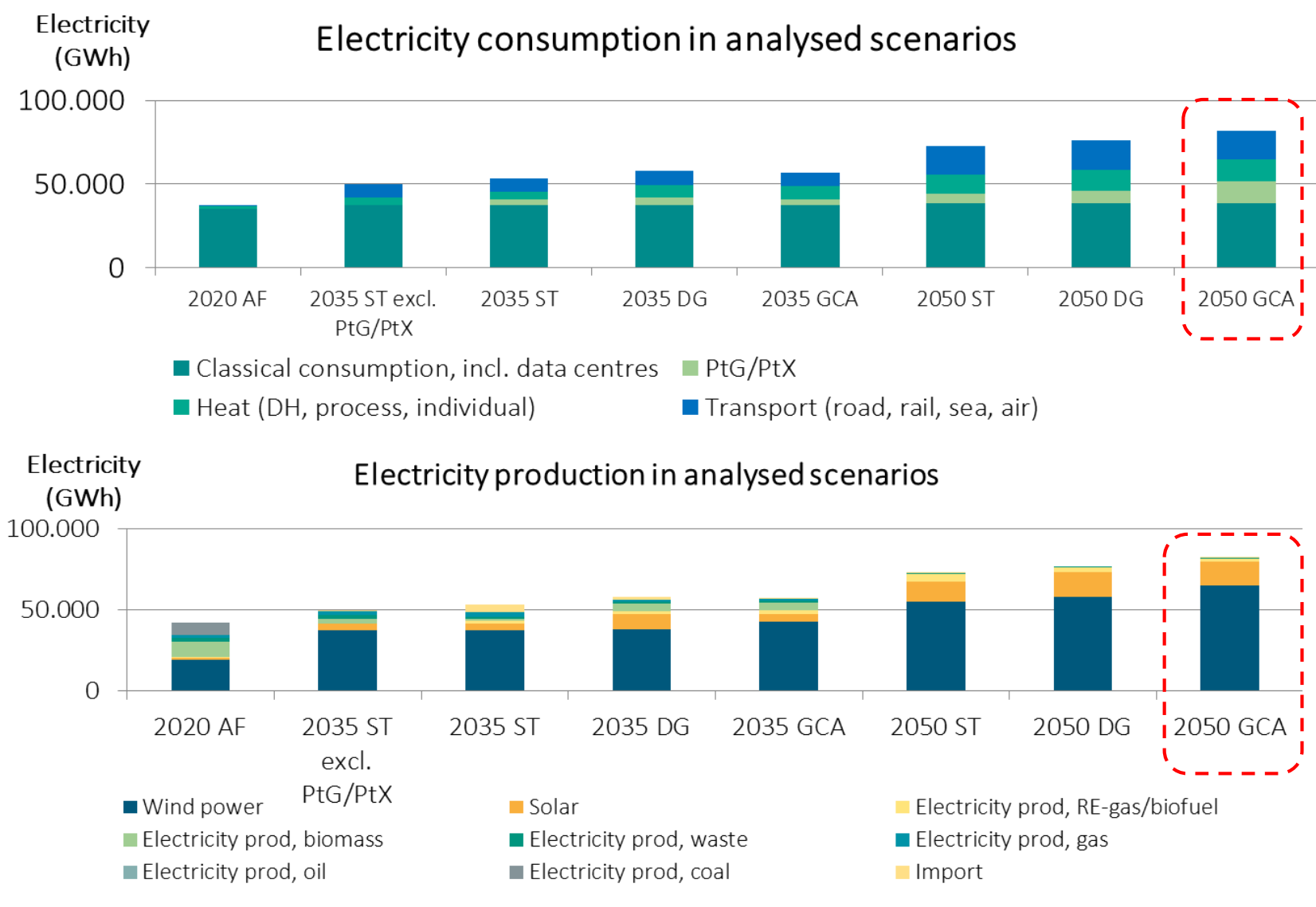
Decentralised CHP



Full grid capacity (physical)

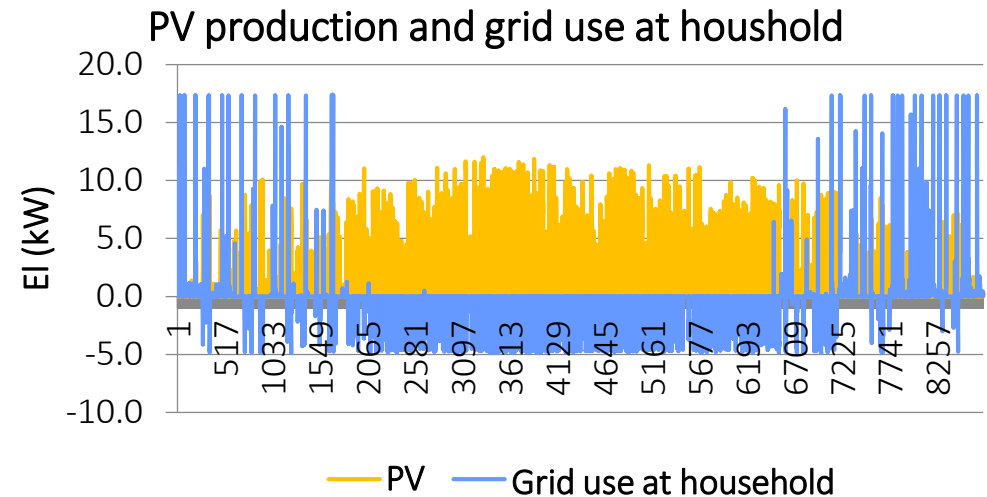
Capacity with N-1 grid reserves constrains

# GCA 2025 SIMULATED ANNUAL ENERGY FLOW



- Consumption doubled towards 2050 – Electrification:
  - Heating
  - Transport
  - PtG/PtX
  - Data centers
- Wind/solar covers (annually) more than 80% of production after 2035 and 95% in 2050
- A very high need for use of flexibility to balance system, ancillary services and enhanced use of grid

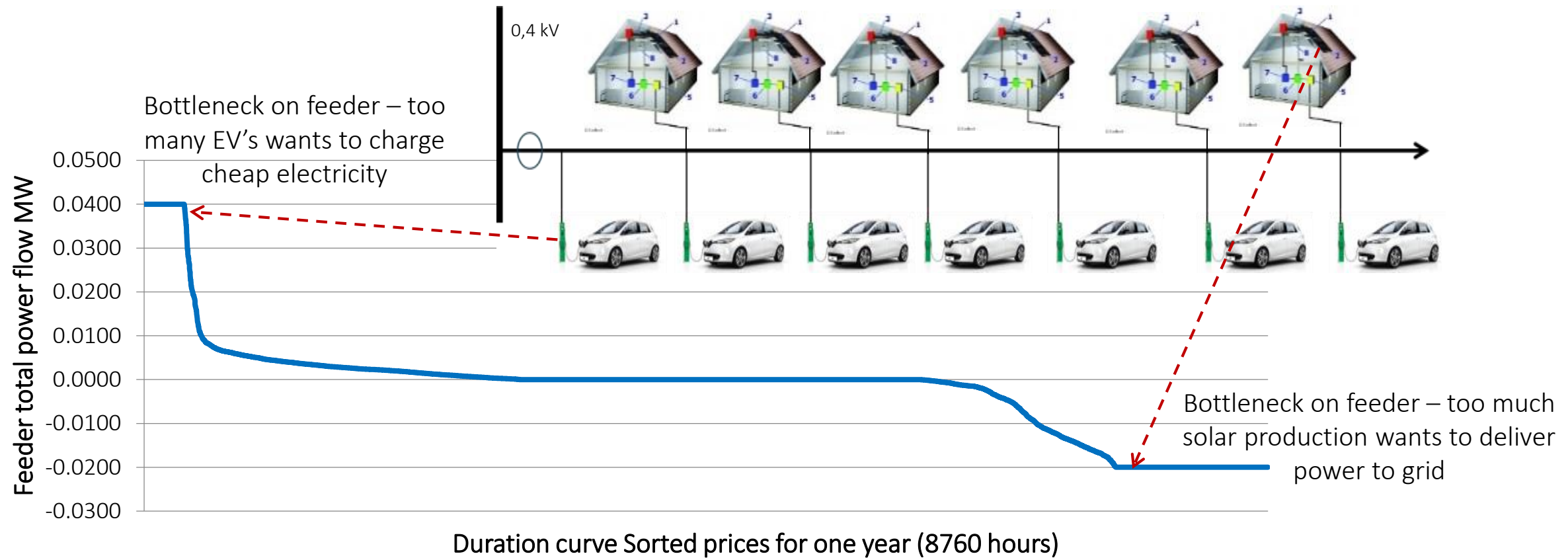
# INVESTMENT ANALYSIS – HOUSEHOLD PROSUMER 2030



		H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
<b>Consumption</b>											
House consumption	MWh	4,7	3,1	3,1	4,1	4,4	4,8	5,0	5,3	5,6	5,6
Electric Vehicle	MWh	5,2	0,0	7,0	5,2	5,2	5,2	3,0	3,0	5,2	5,2
PV	kW	12,0	5,1	12,0	12,0	12,0	12,0	11,7	11,1	12,0	12,0
PV Battery	kWh	23,3	9,2	25,9	24,1	23,9	24,9	12,9	11,2	12,9	13,8

- Investment (least cost optimization)
  - Up to 12 kW PV
  - 9-26 kWh battery
- Import from grid Winter – Export at summer
- Offgrid not economical reasonable
- But what about the grid capacity ?

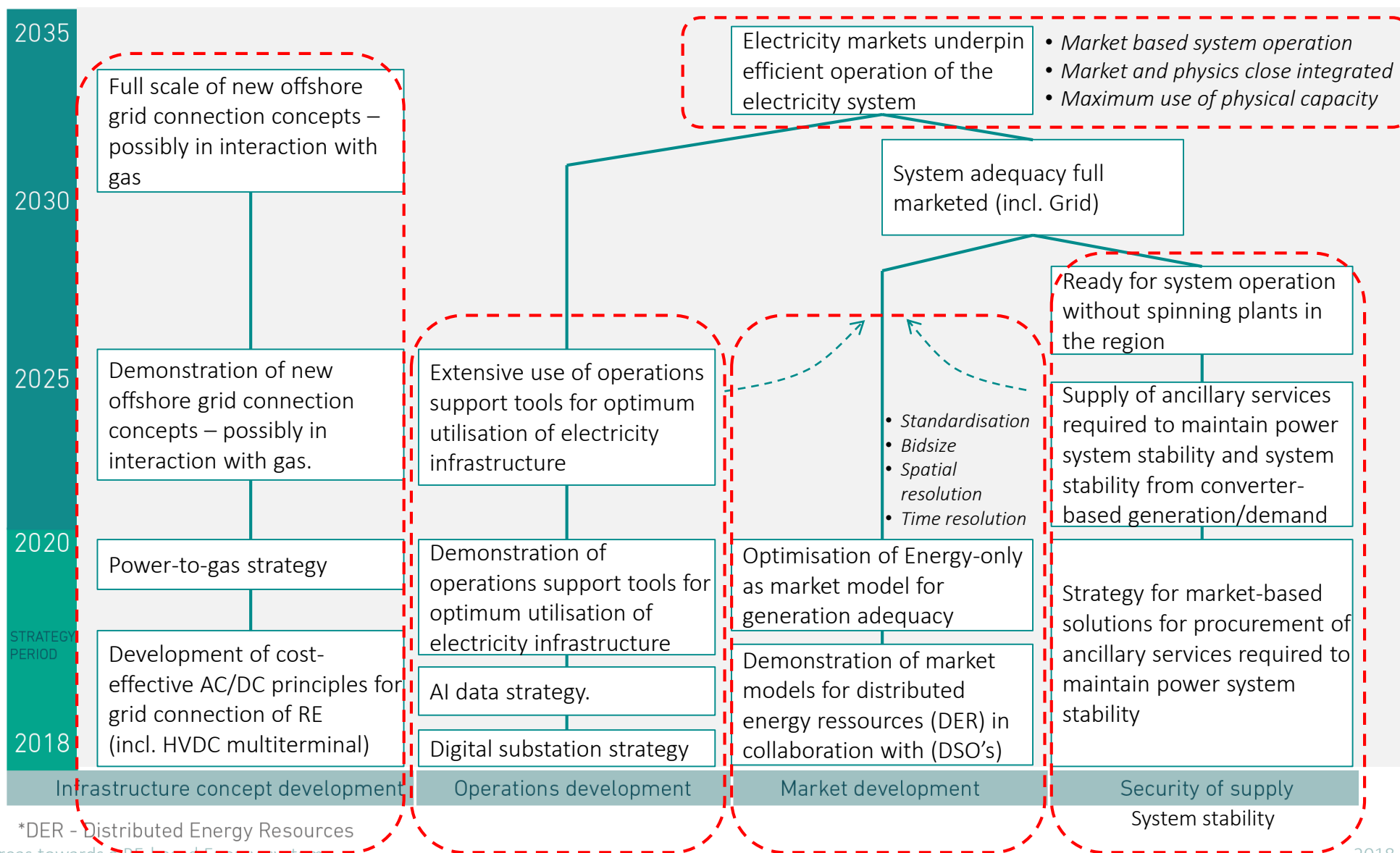
# SIMULATED HOUSES WITH EV, SOLAR, BATTERY (INCL. SMARTGRID)



A need for a SmartNet to control congestion at high net-use (EV charging) and (PV solar production)

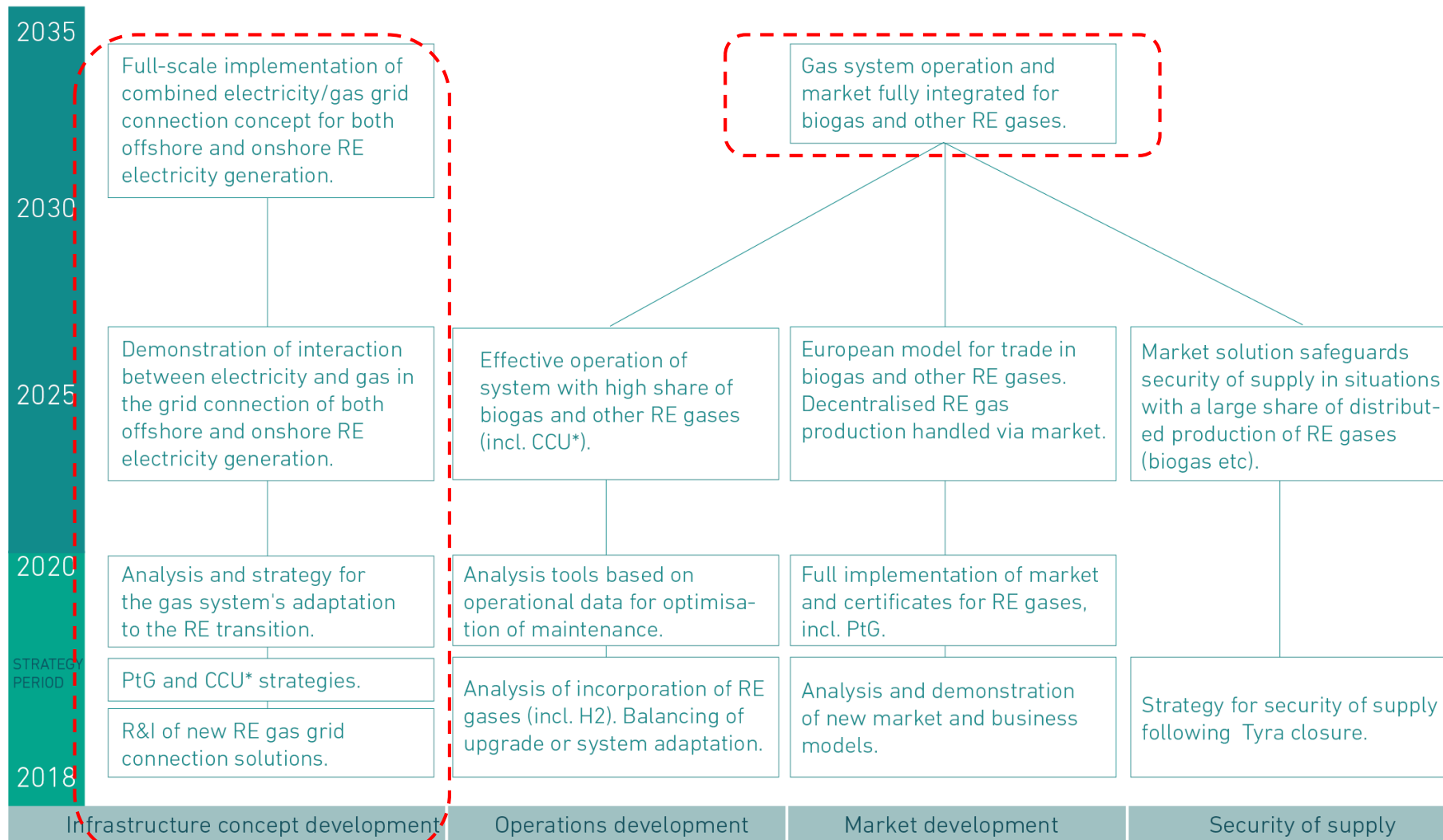
# R&I FOCUS

# R&I TARGET LINES – ELECTRICITY





# R&I TARGET LINES - GAS



\*In this context, PtG and CCU are Power-to-Gas and Carbon Capture & Utilisation (CO2), respectively.



# Tak for opmærksomheden

ENERGINET

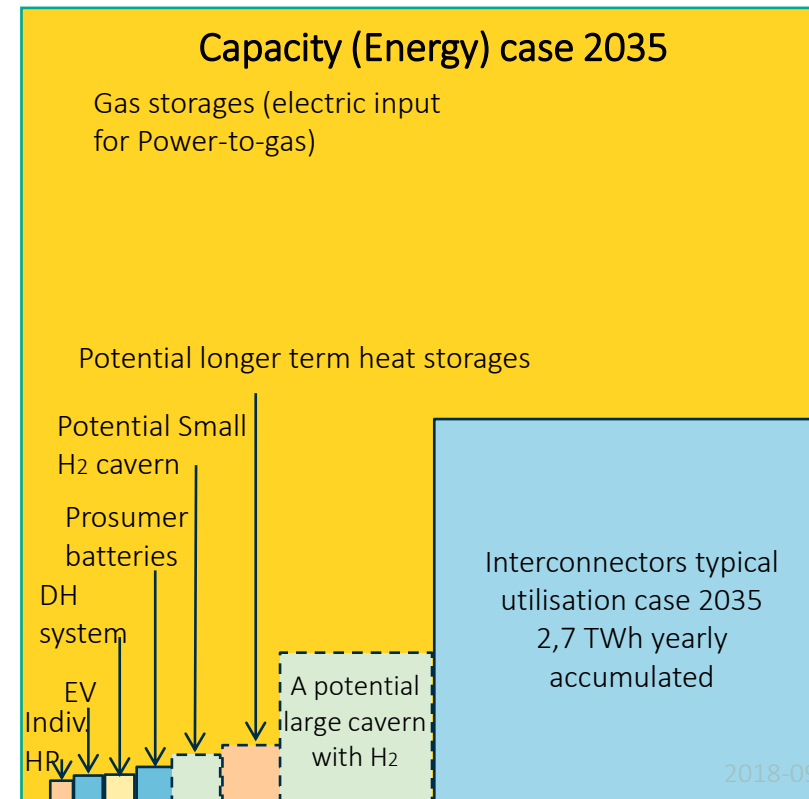
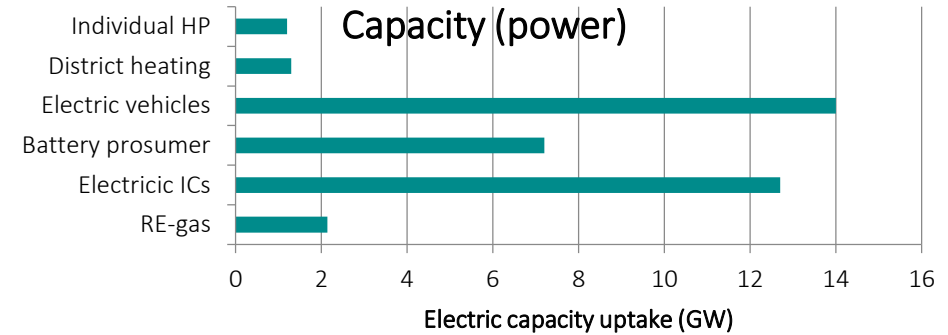
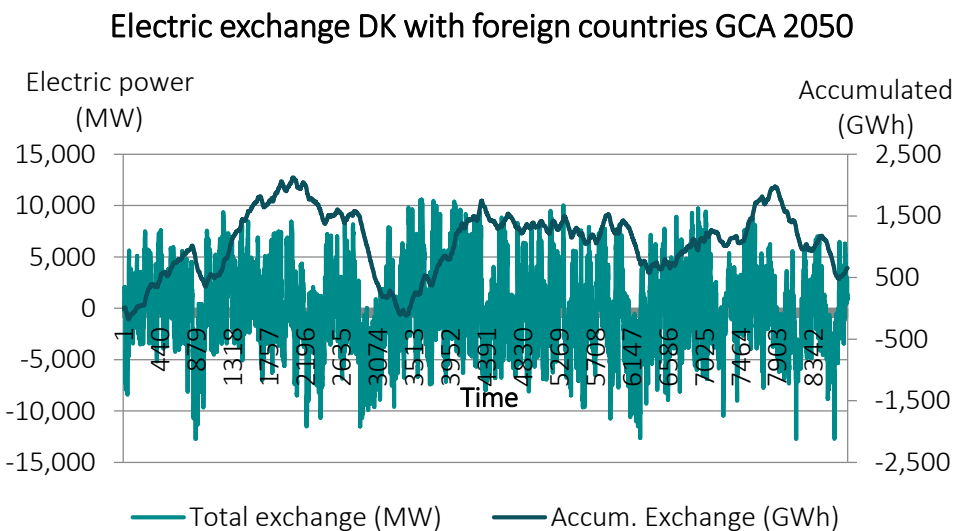
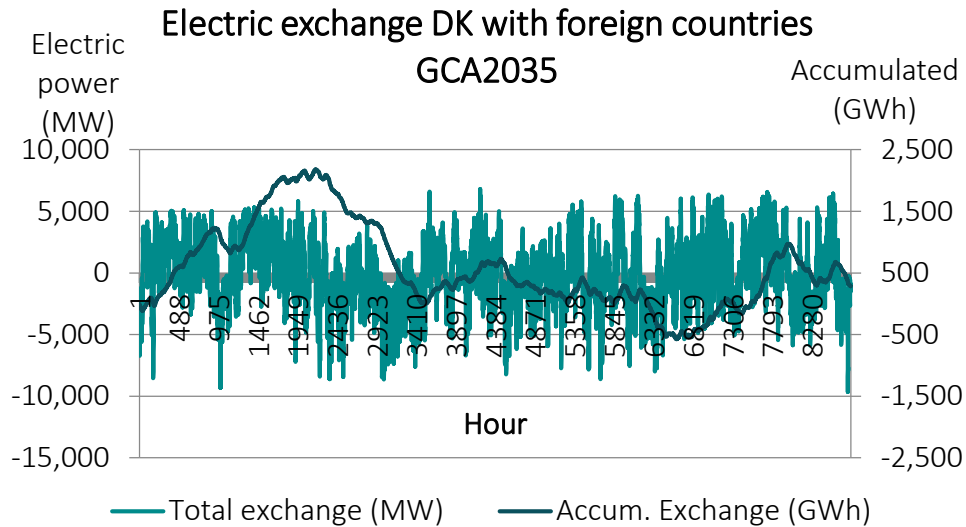
SYSTEMPERSPEKTIV 2035

Perspektiver for effektiv anvendelse af vedvarende energi i  
det danske energisystem på længere sigt

<http://WWW.ENERGINET.DK/sys35>

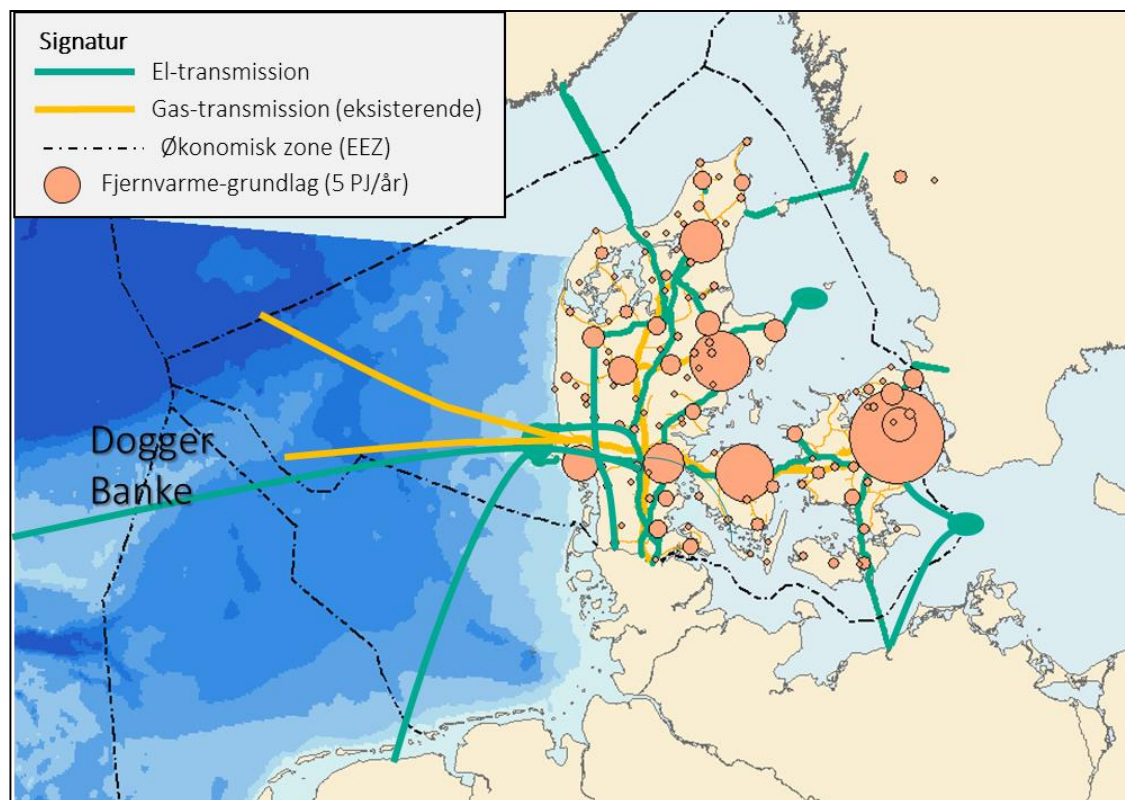


# STORAGE SIMULATION AND CAPACITY



# SECTOR COUPLING IN AN INTERNATIONAL PERSPECTIVE

## Danske Styrkepositioner for sektorkobling



### Electricity

*Competitive prices*  
*High security of supply*  
*High RE-share (RE for PtG/PtX products)*

### Gas

*Gas-grid and cavern storage facilities for RE-gas (H<sub>2</sub>, Syngas, Methan)*



### District heat

*Value of surplus heat from PtX*

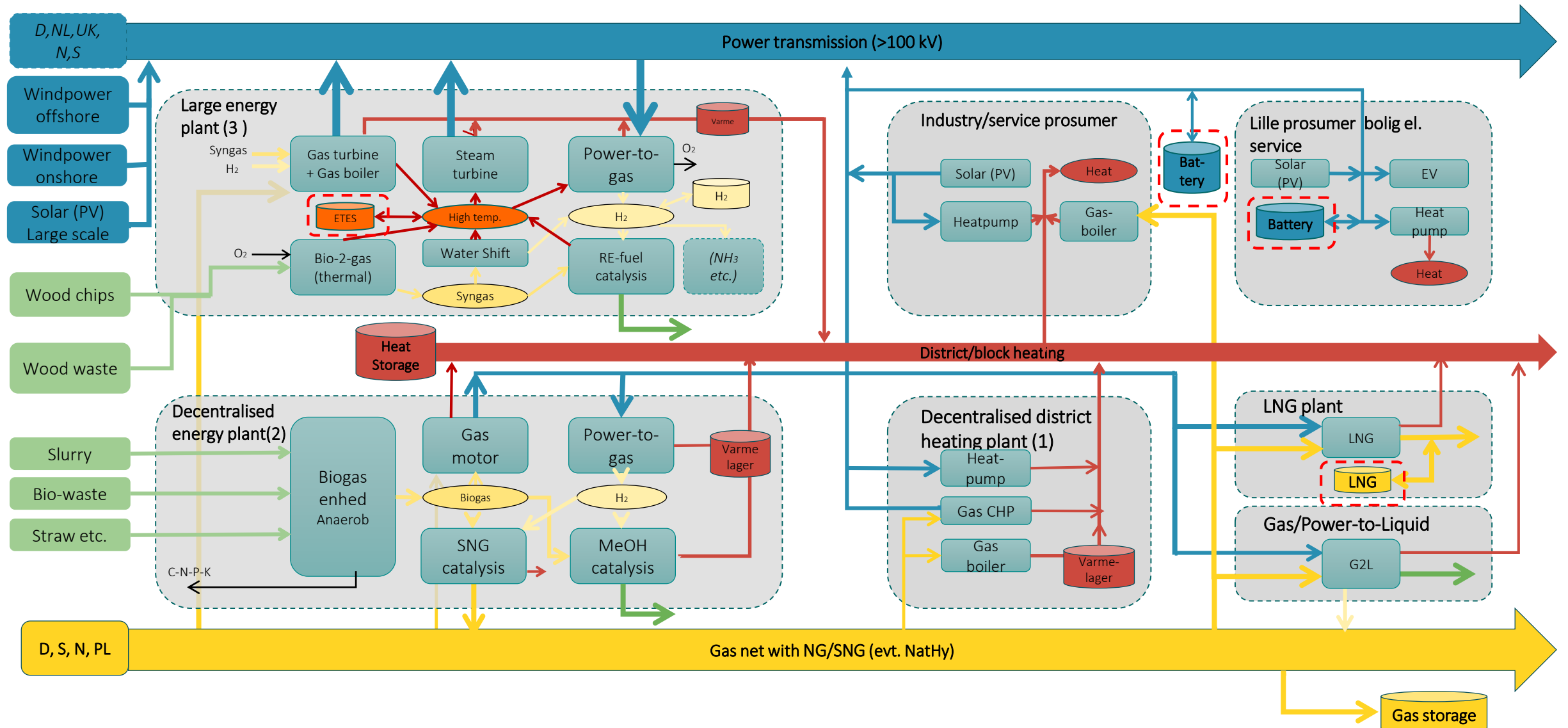
### Bio/Carbon

*Position of strengths in Biomass/biogas (carbon-source)*

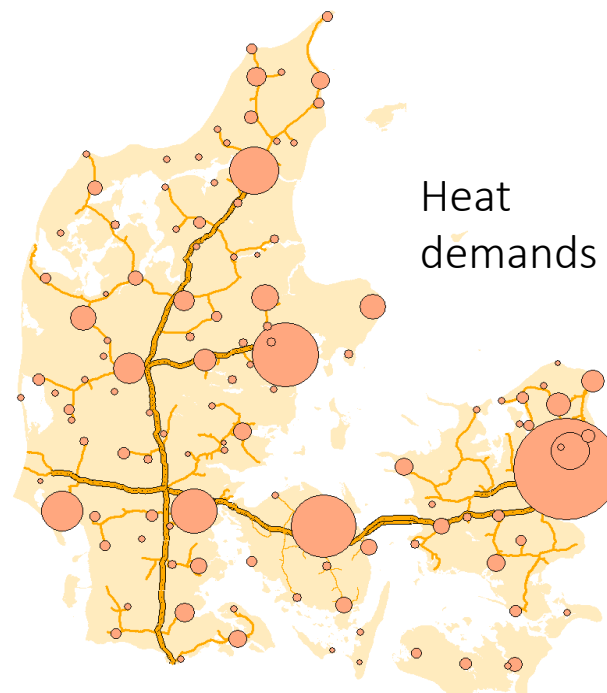
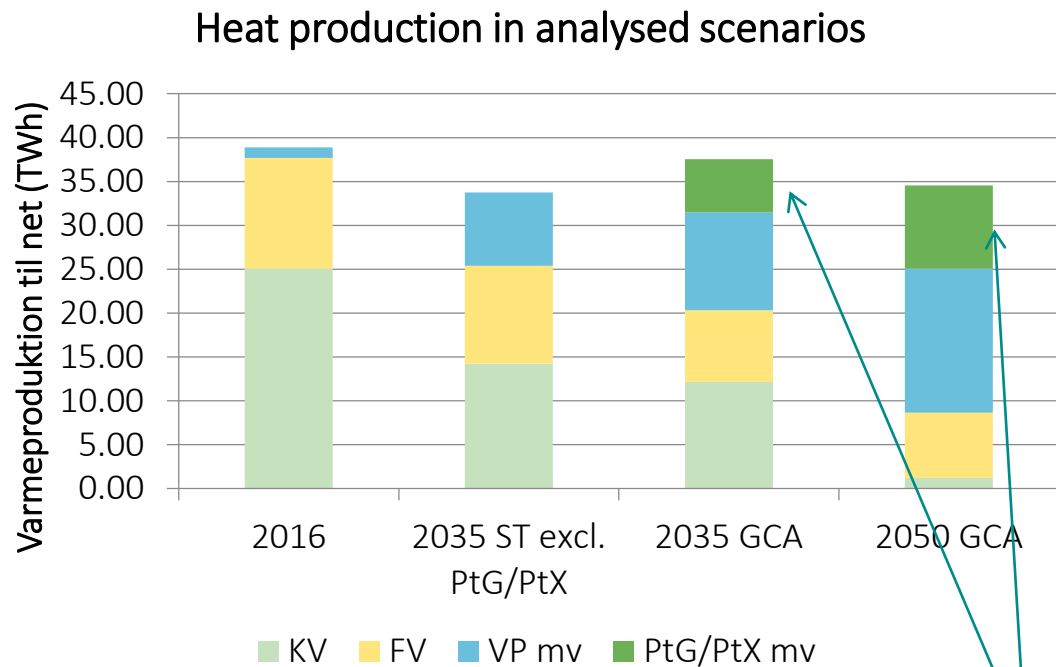
DK positions of strengths for integratoin of North-see RE-potentials in power-gas-heat-fuel systems

Investigation of Dogger Banke offshore PtG (H<sub>2</sub>) with onshore refinery to PtX

# SIMULATION OF SYSTEM AND LEAST COST ANALYSIS



# DISTRICT HEAT-PRODUKTION

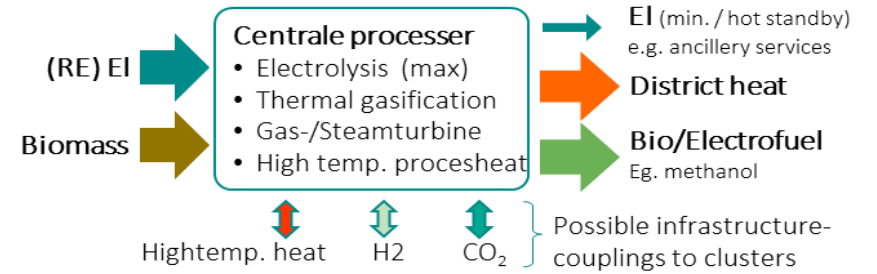


Heat demand can be used for further "refinery" of Northsea power (PtG/PtX).

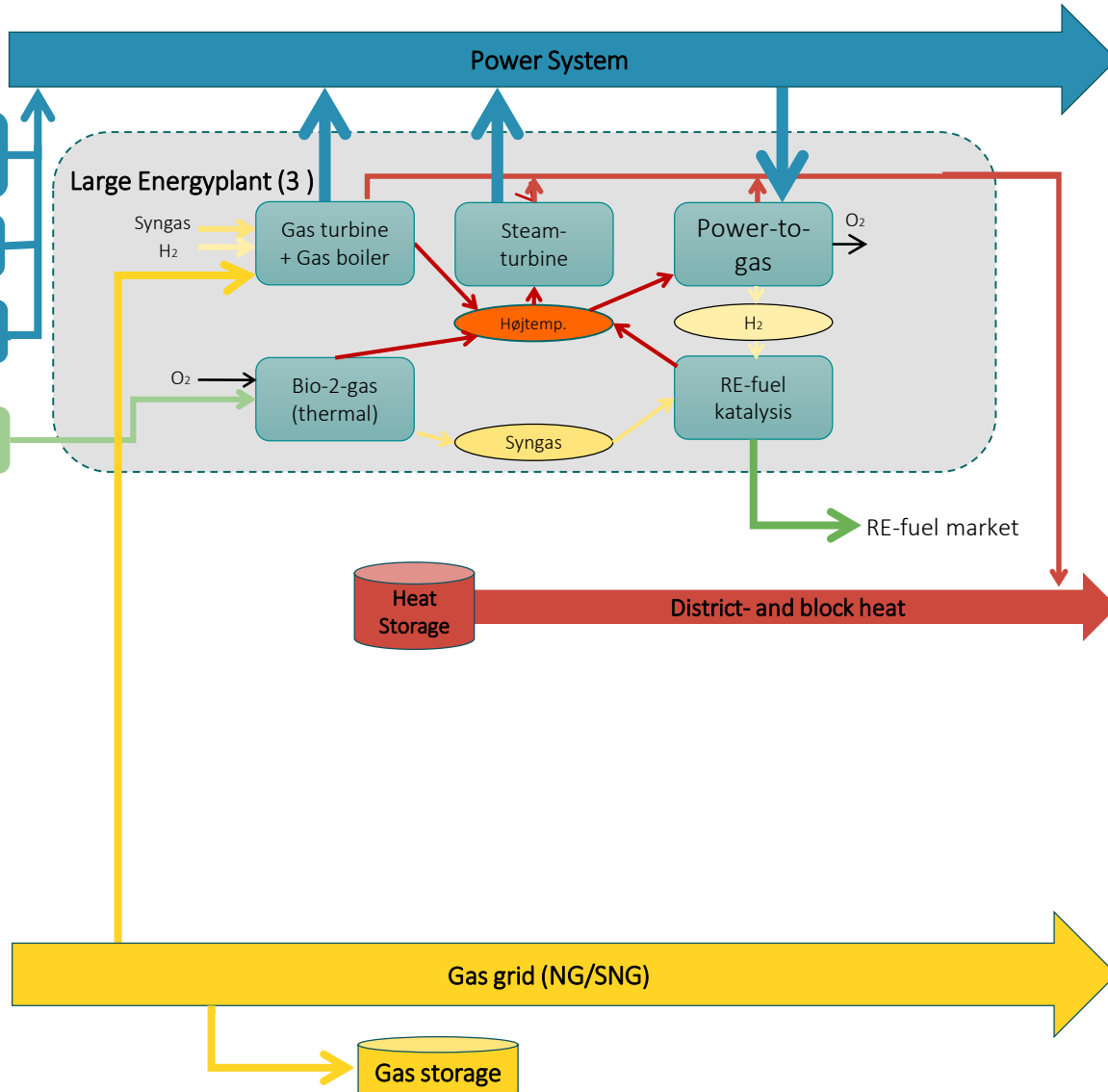
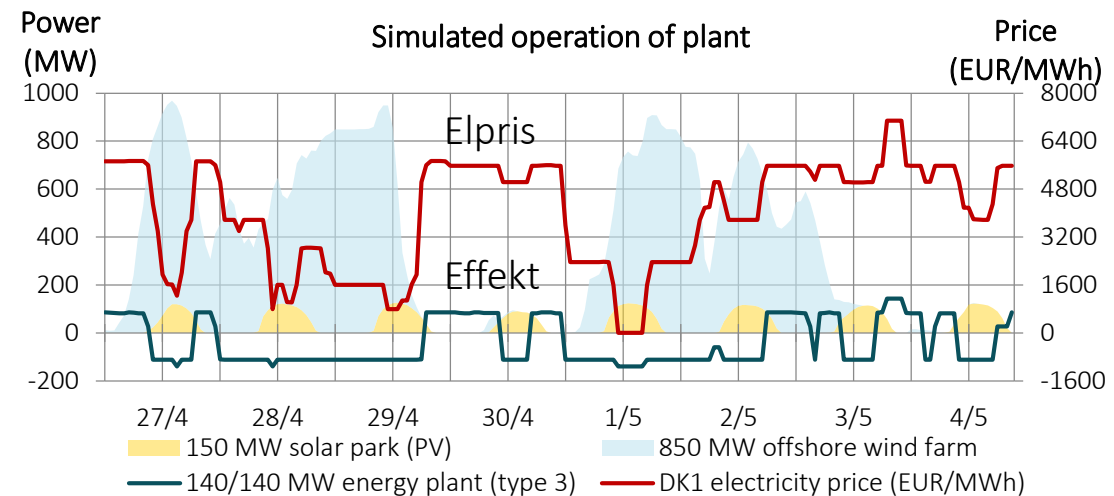
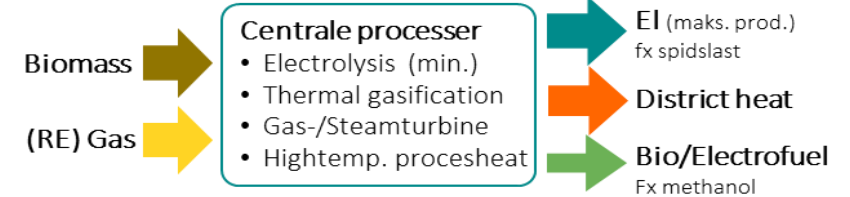
# DRIFT AF EKSEMPEL PÅ STOR PROSUMER

## Principle illustration Energy plant

Operation at low/medium power price (eg 6000-7000 hours/y)



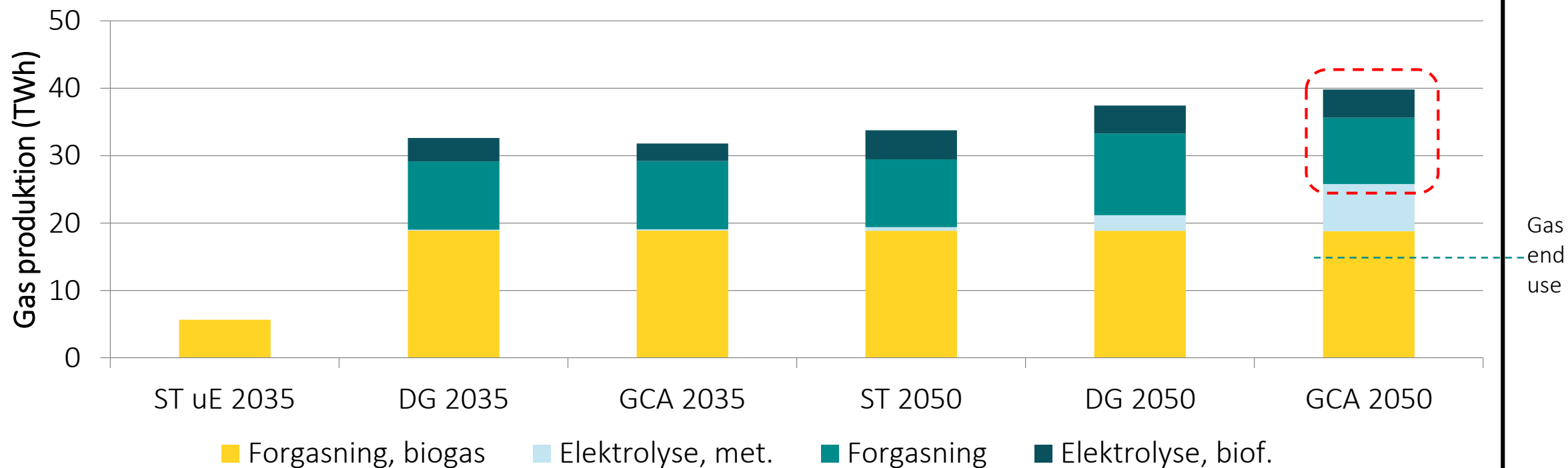
Operation at high power price (eg 1000-2000 hours/y)



# GCA 2050 – SIMULATED ANNUAL ENERGY FLOW



## Gas-production from biomasse and Power-to-gas (PtG)



Coal

Liquid fuels fossil/RE (Gasoline, Diesel, Methanol, DME, etc.)

Aviation