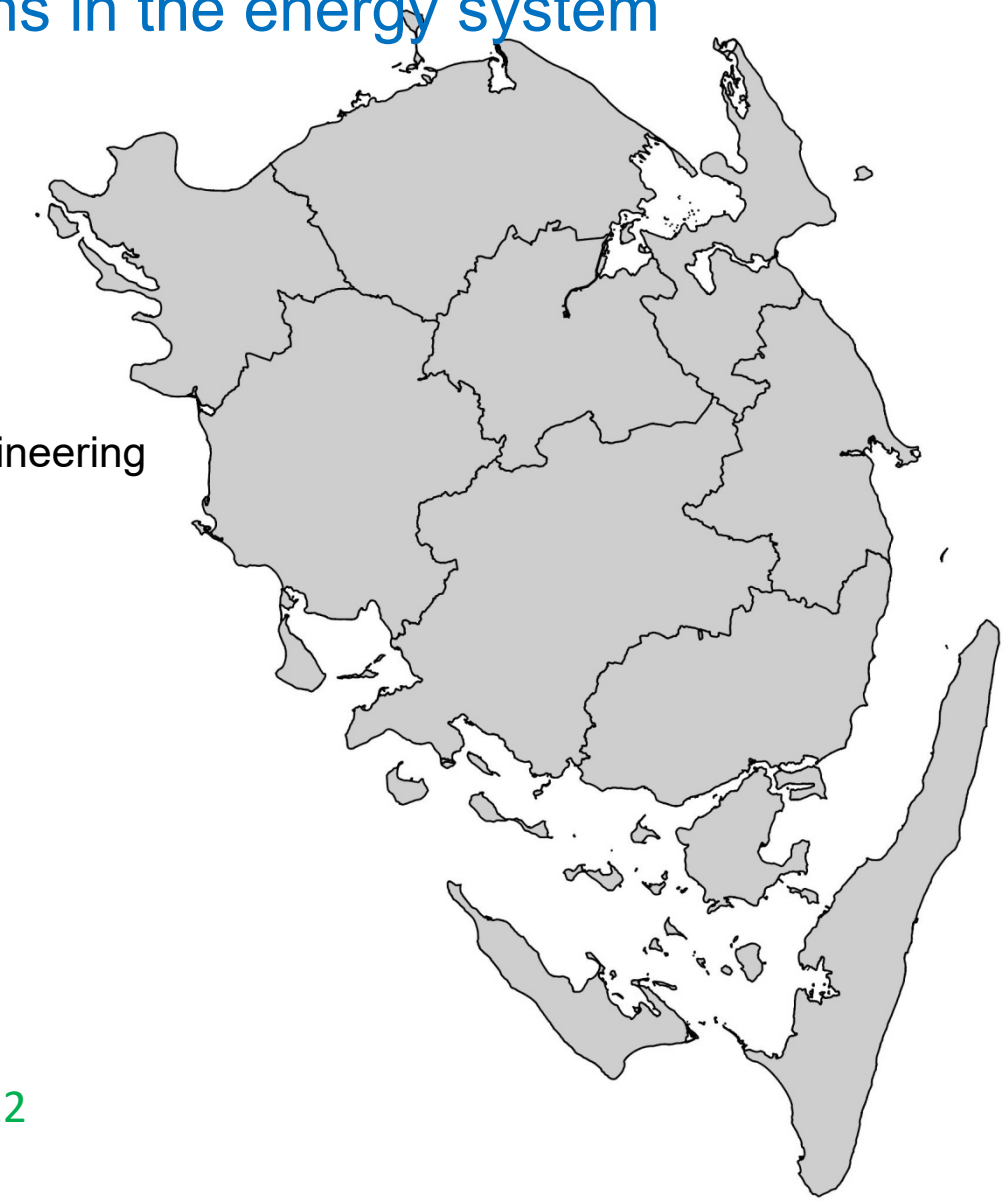
Sector mitigation

- solutions and actions in the energy system



Henrik Wenzel
Professor, SDU Life Cycle Engineering

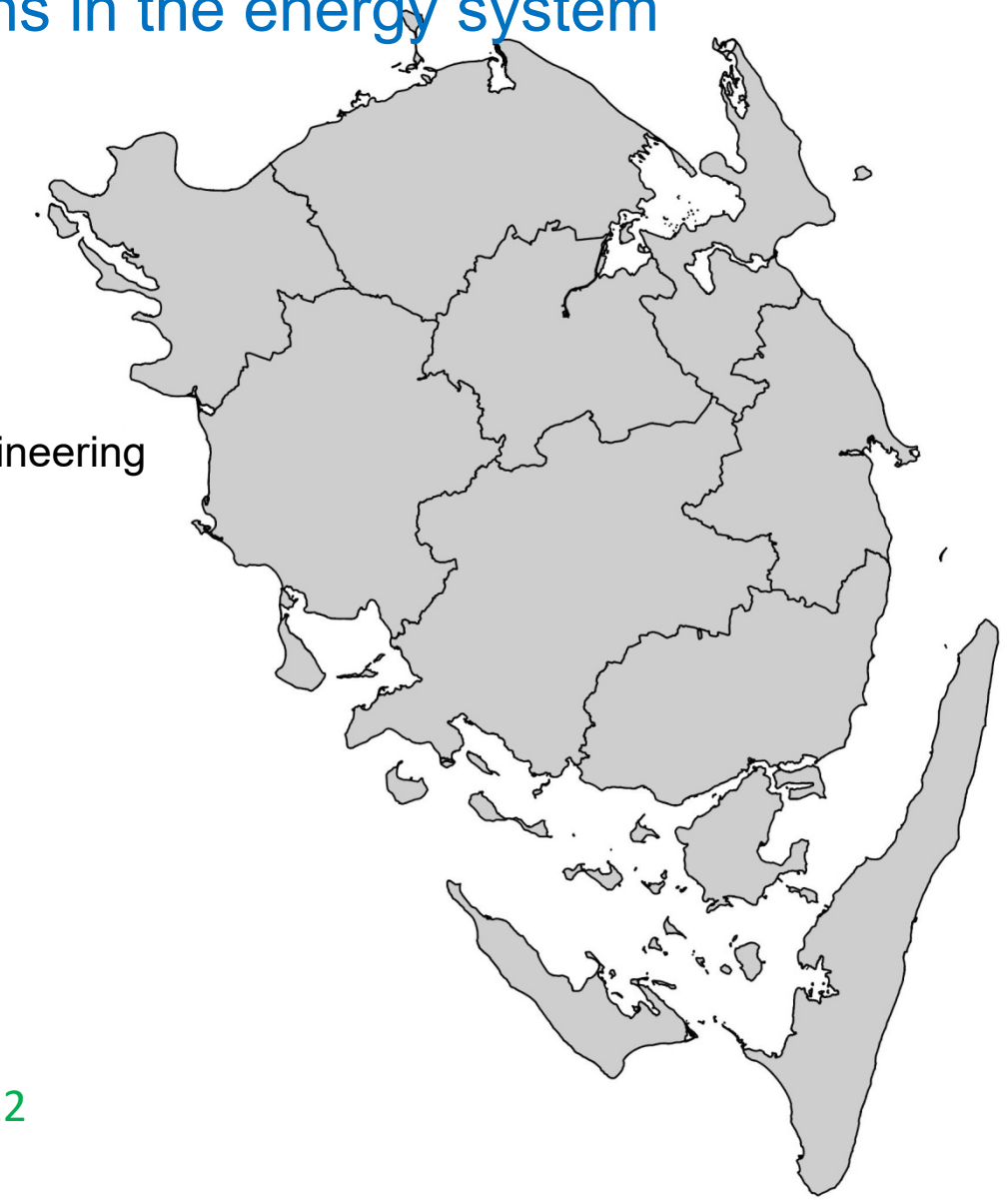
www.sdu.dk/lifecycle

Climate Thursdays
Thursday, October 13th, 2022

SCC
SDU Climate Cluster

Sector mitigation

- solutions and actions in the energy system



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Content

1. The future energy system – the backbone
2. The system integration
3. Some news, updates and perspectives
4. The implications
   - ❑ the carbon balance and hydrogen demand
   - ❑ The cost of transition

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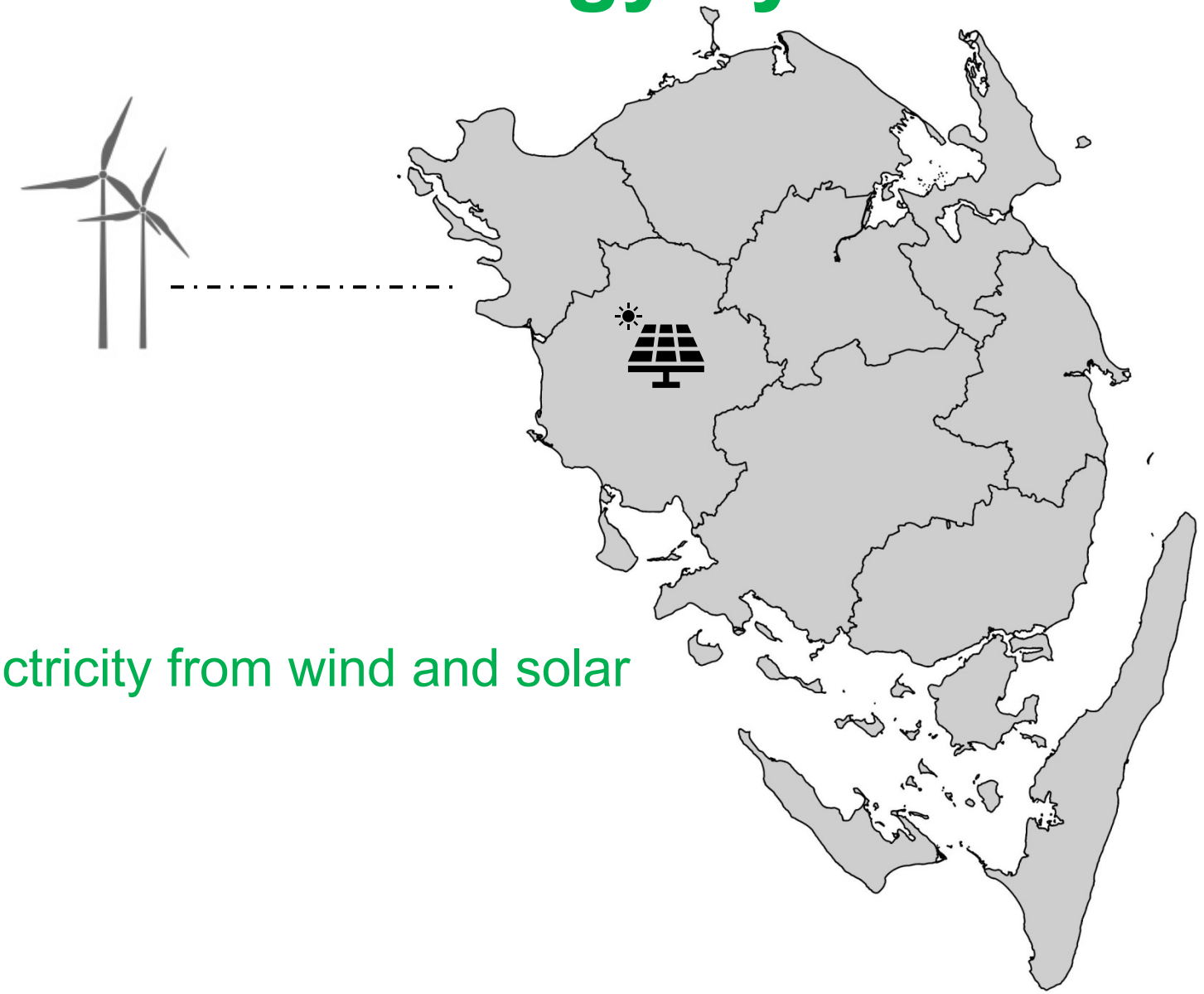
We know how to design the green energy system

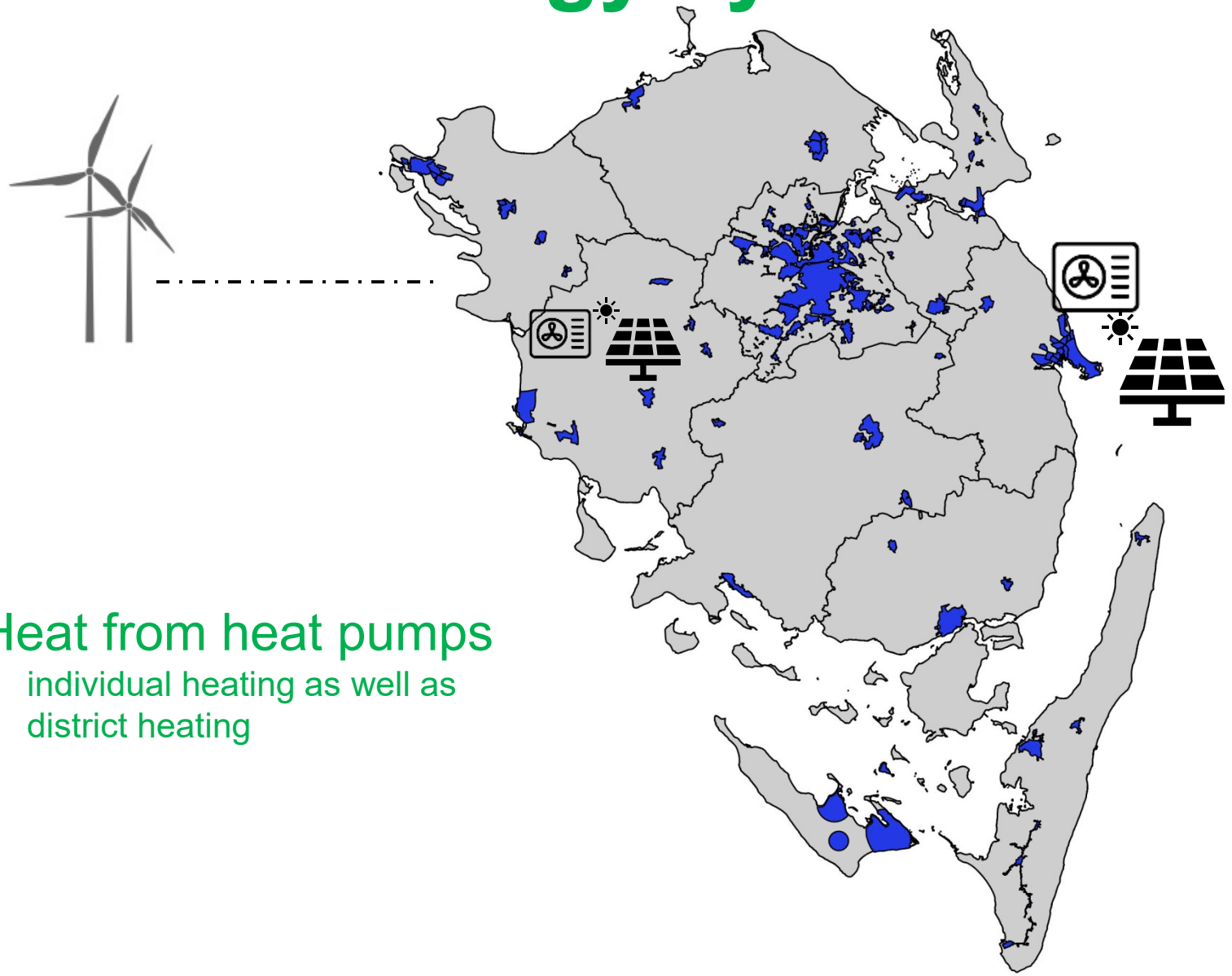
Take a look at this model of the world

The future energy system – the backbone



Electricity from wind and solar

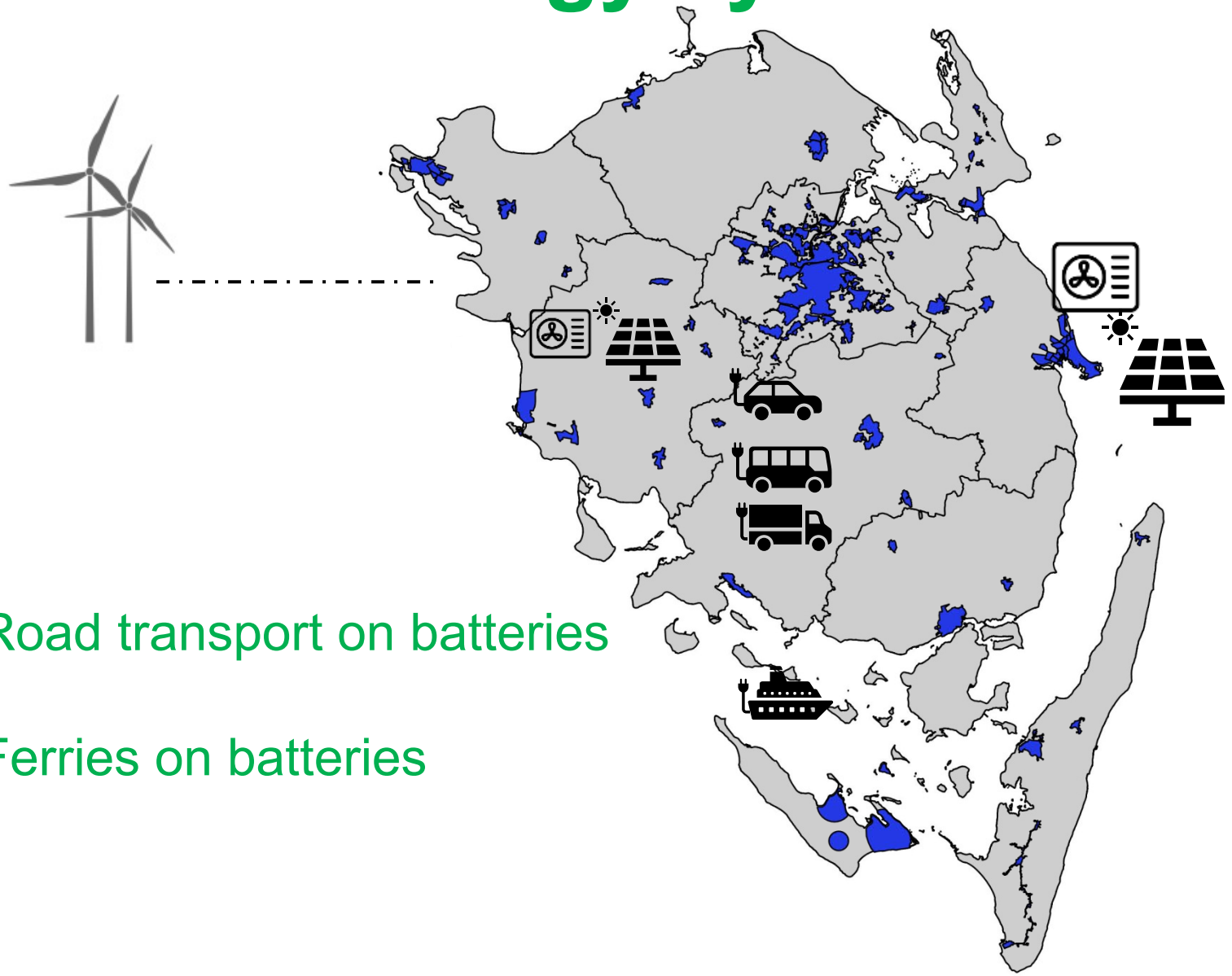
The future energy system – the backbone



Heat from heat pumps

- individual heating as well as
- district heating

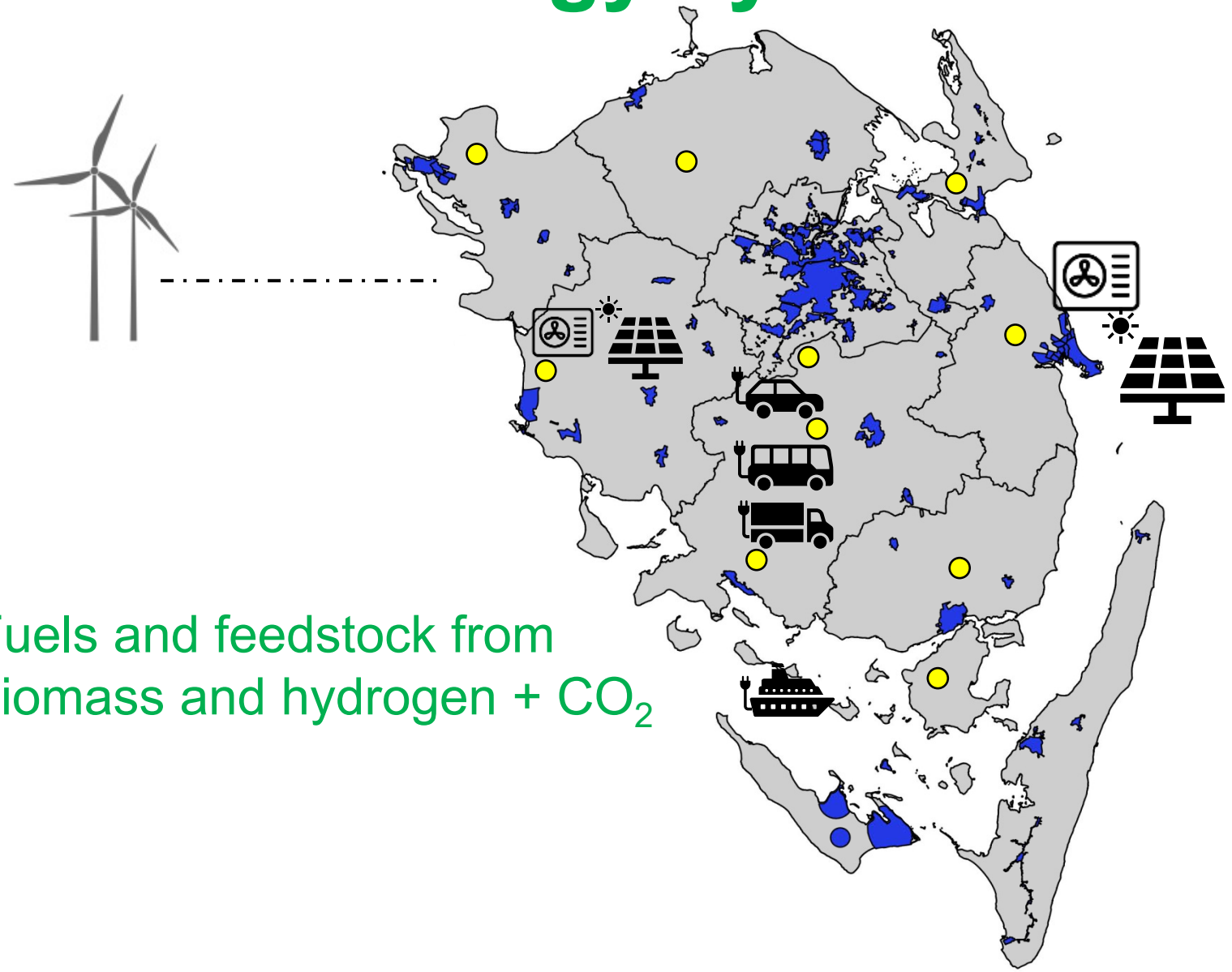
The future energy system – the backbone



Road transport on batteries

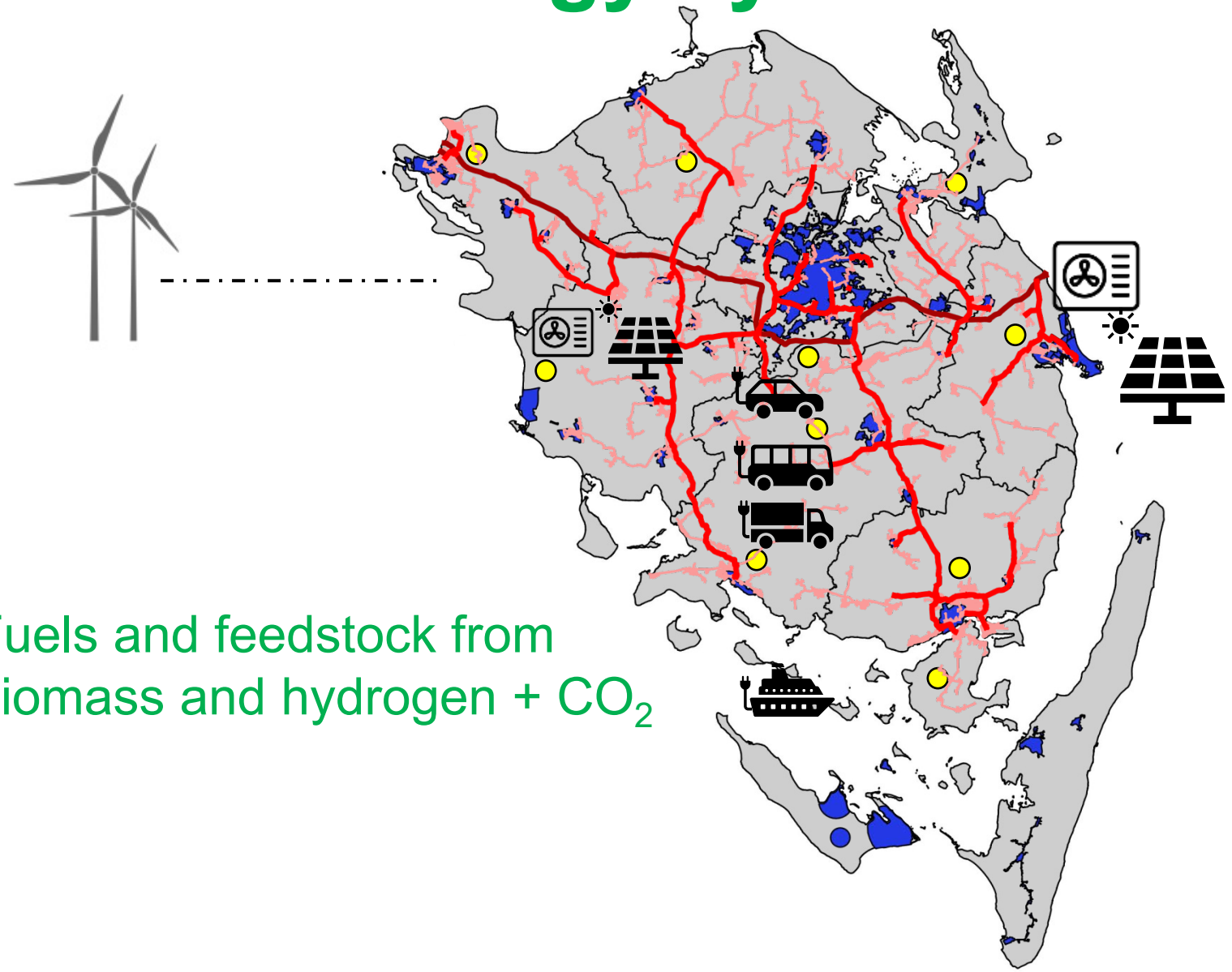
Ferries on batteries

The future energy system – the backbone



Fuels and feedstock from biomass and hydrogen + CO_2

The future energy system – the backbone



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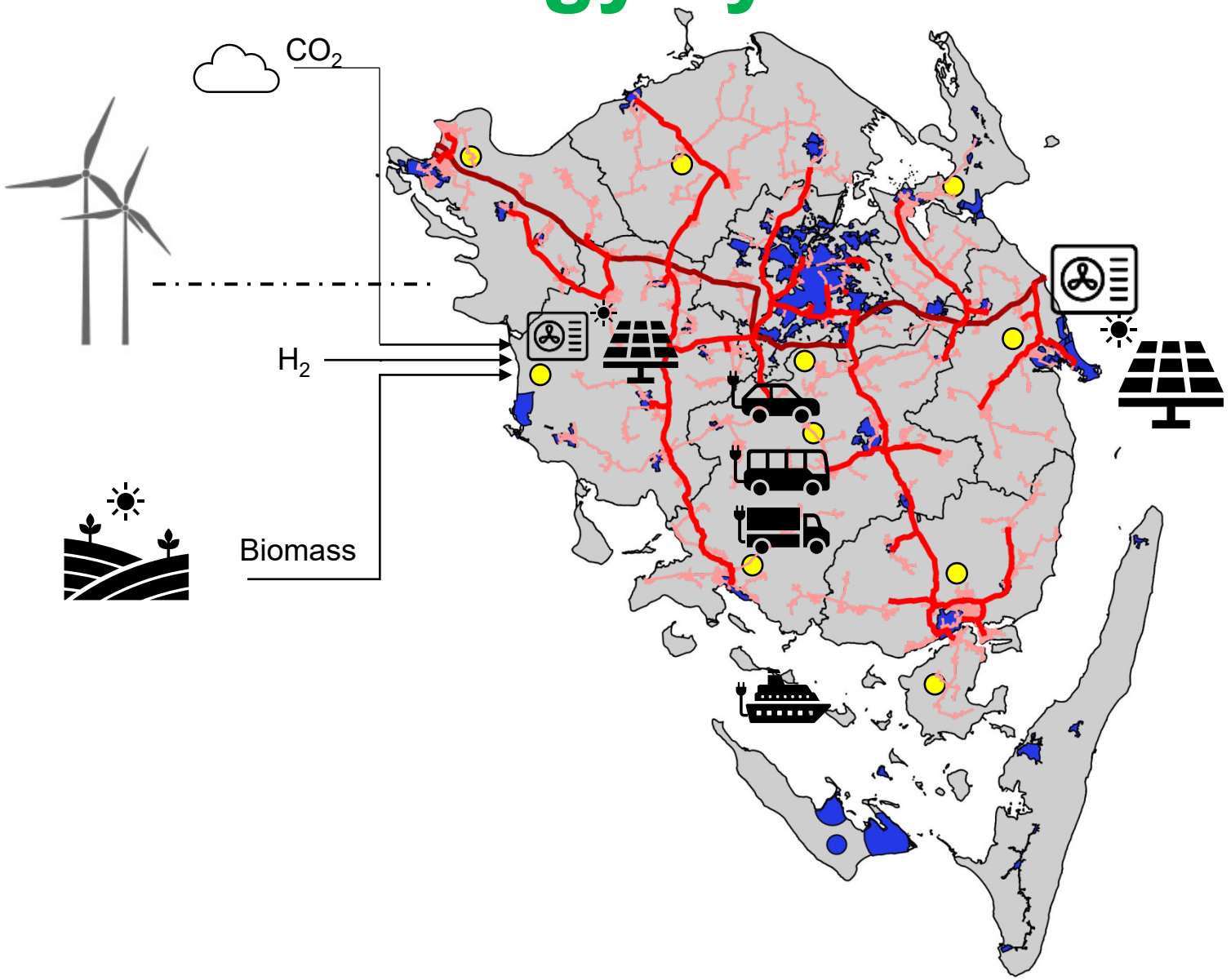

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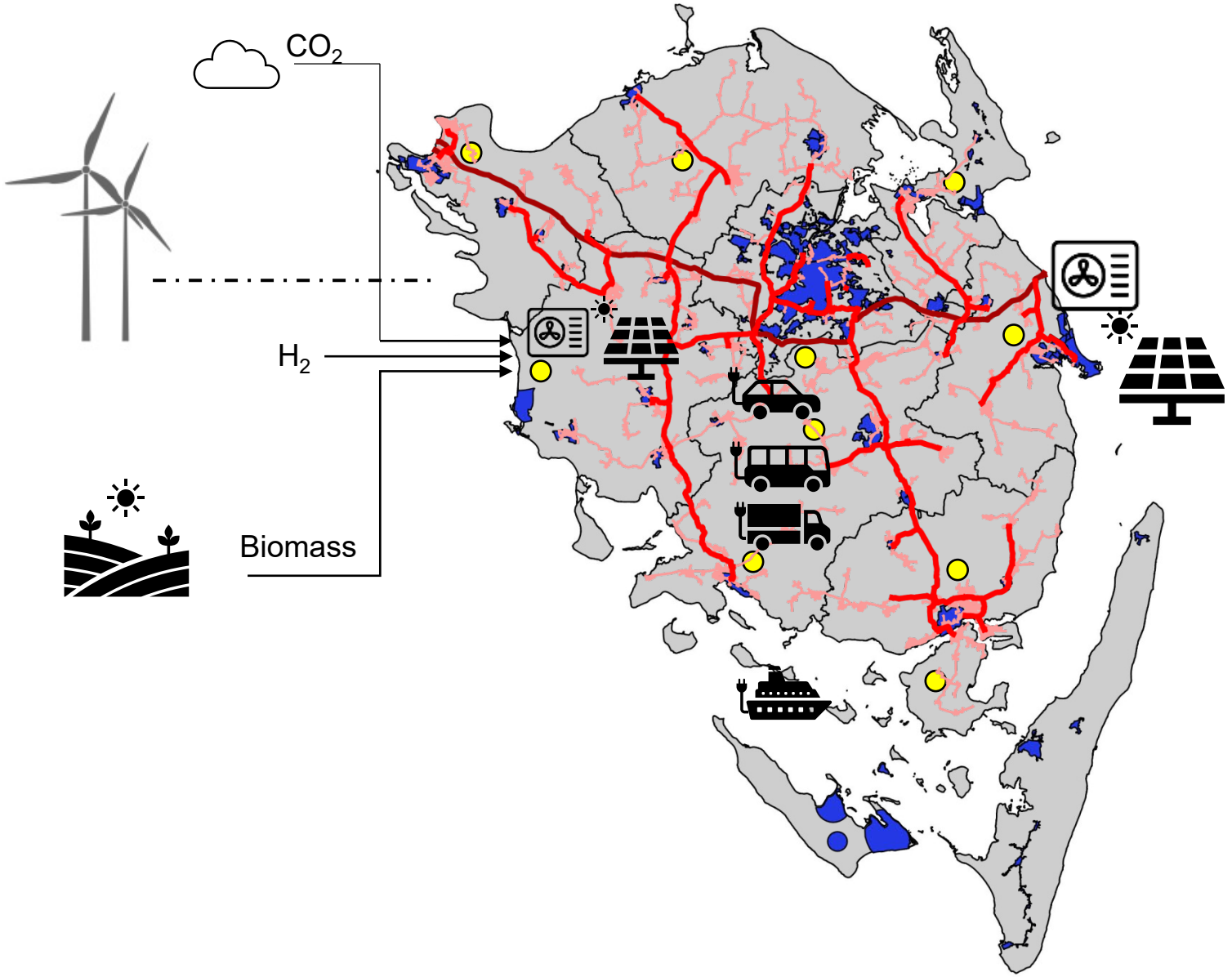
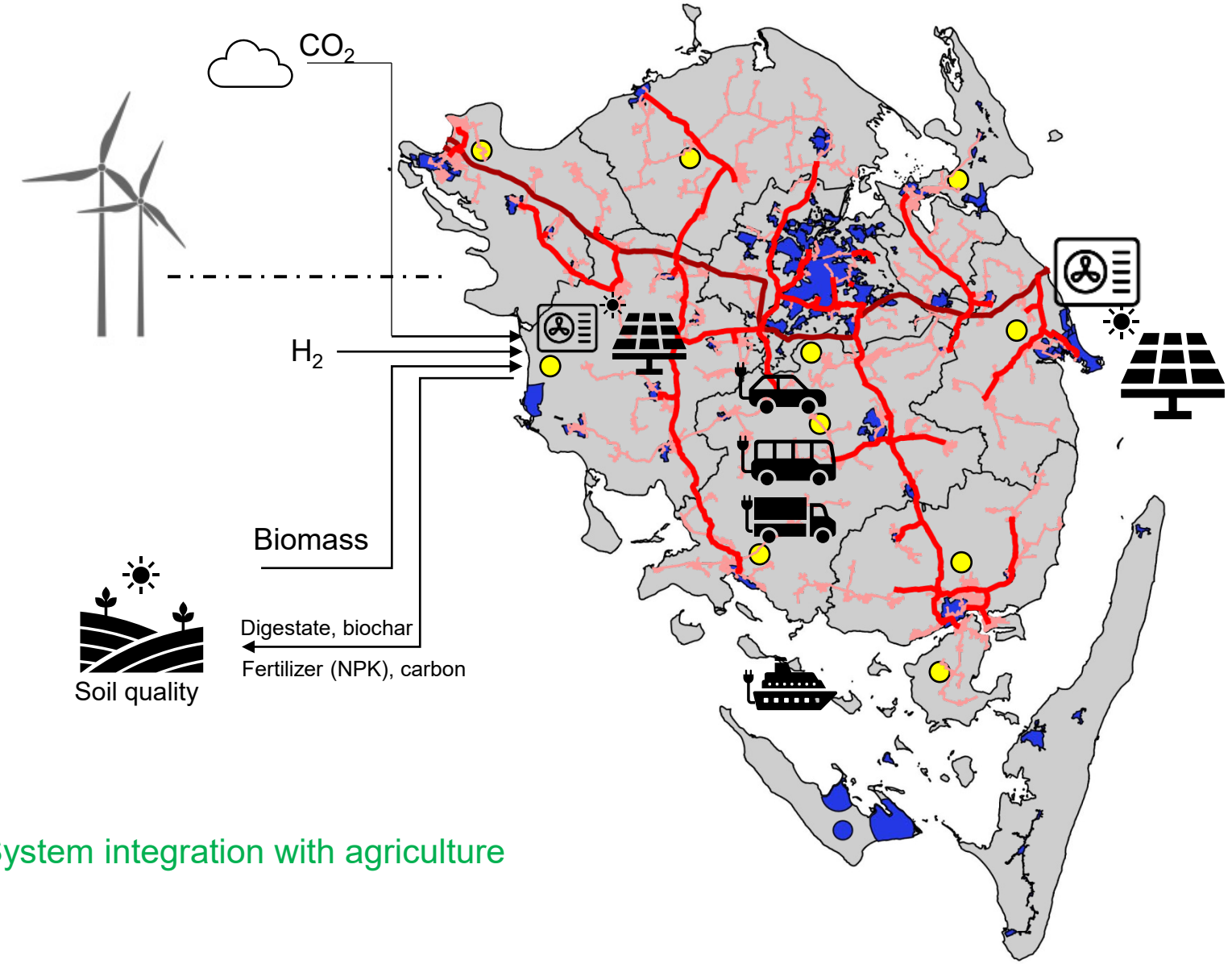
The system integration

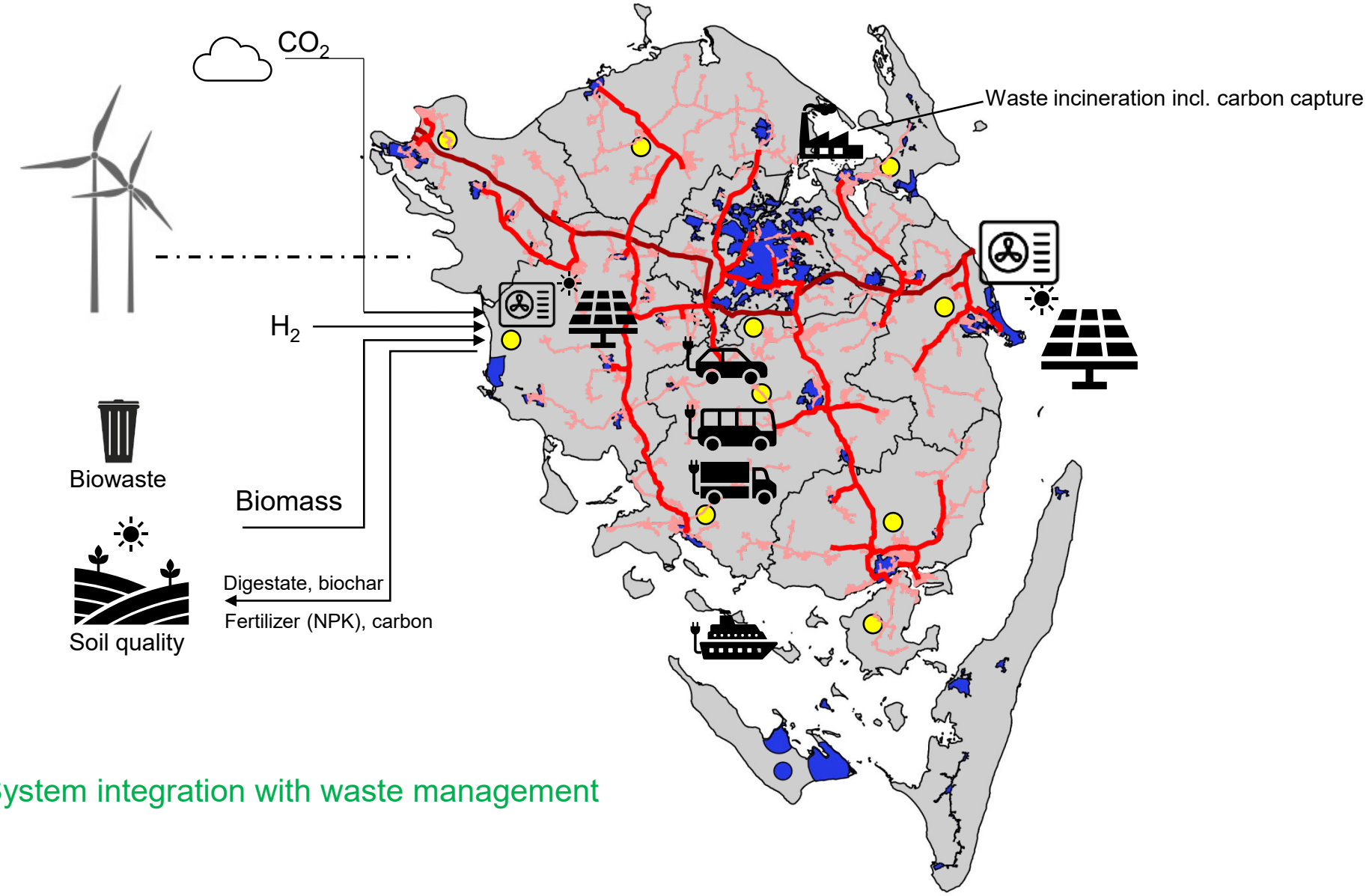


The system integration



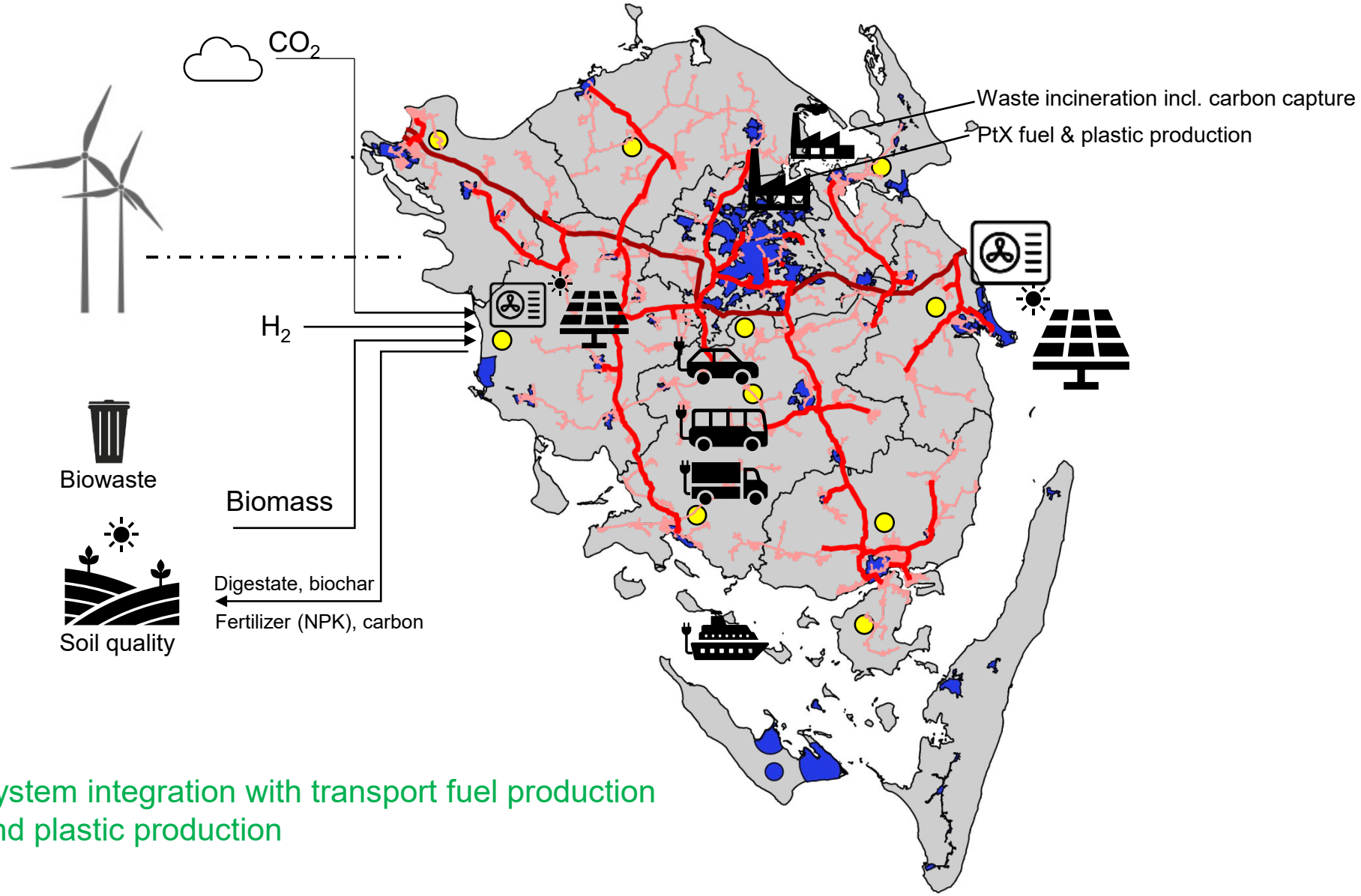
System integration with agriculture

The system integration



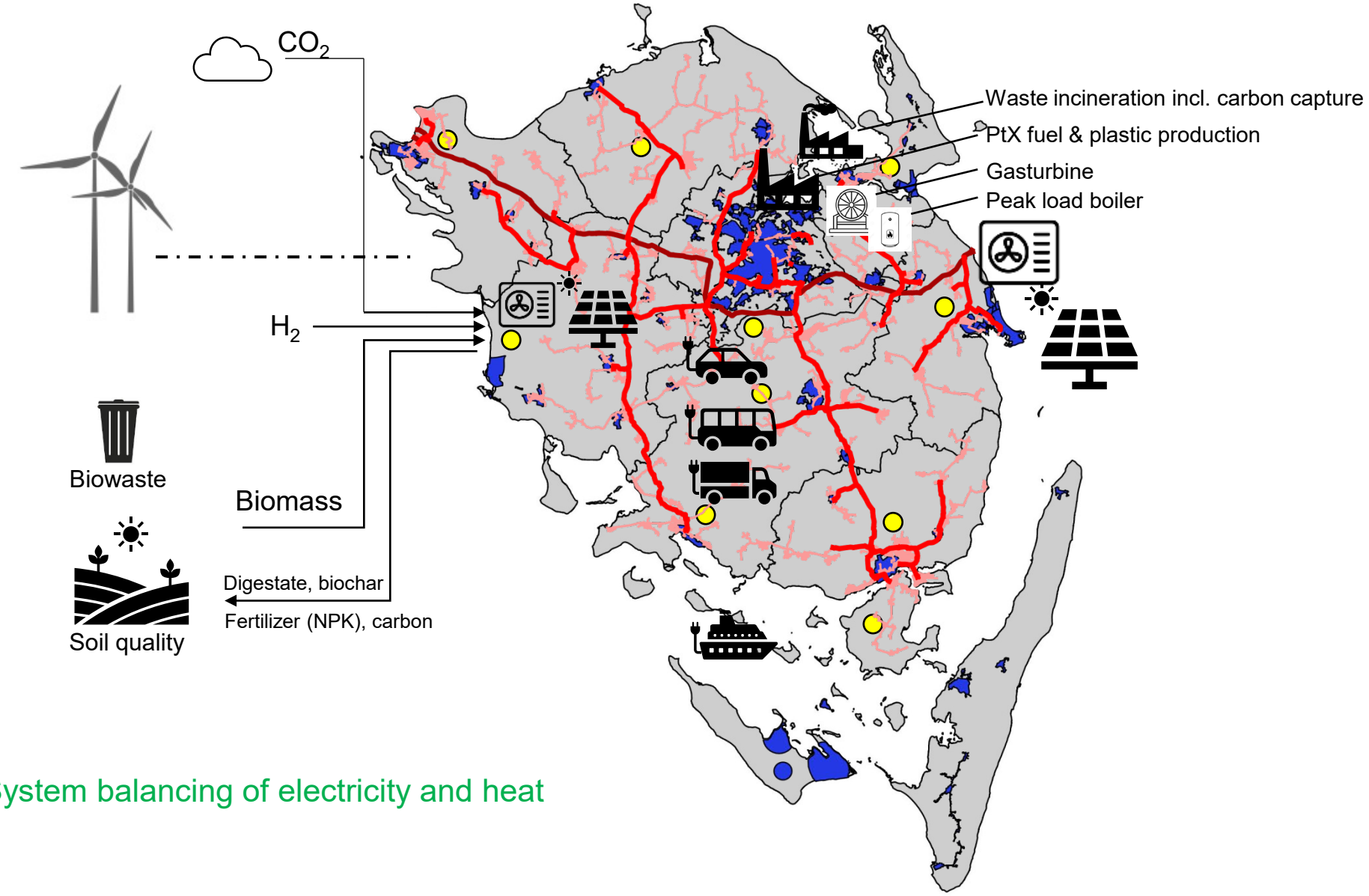
System integration with waste management

The system integration



System integration with transport fuel production and plastic production

The system integration



System balancing of electricity and heat

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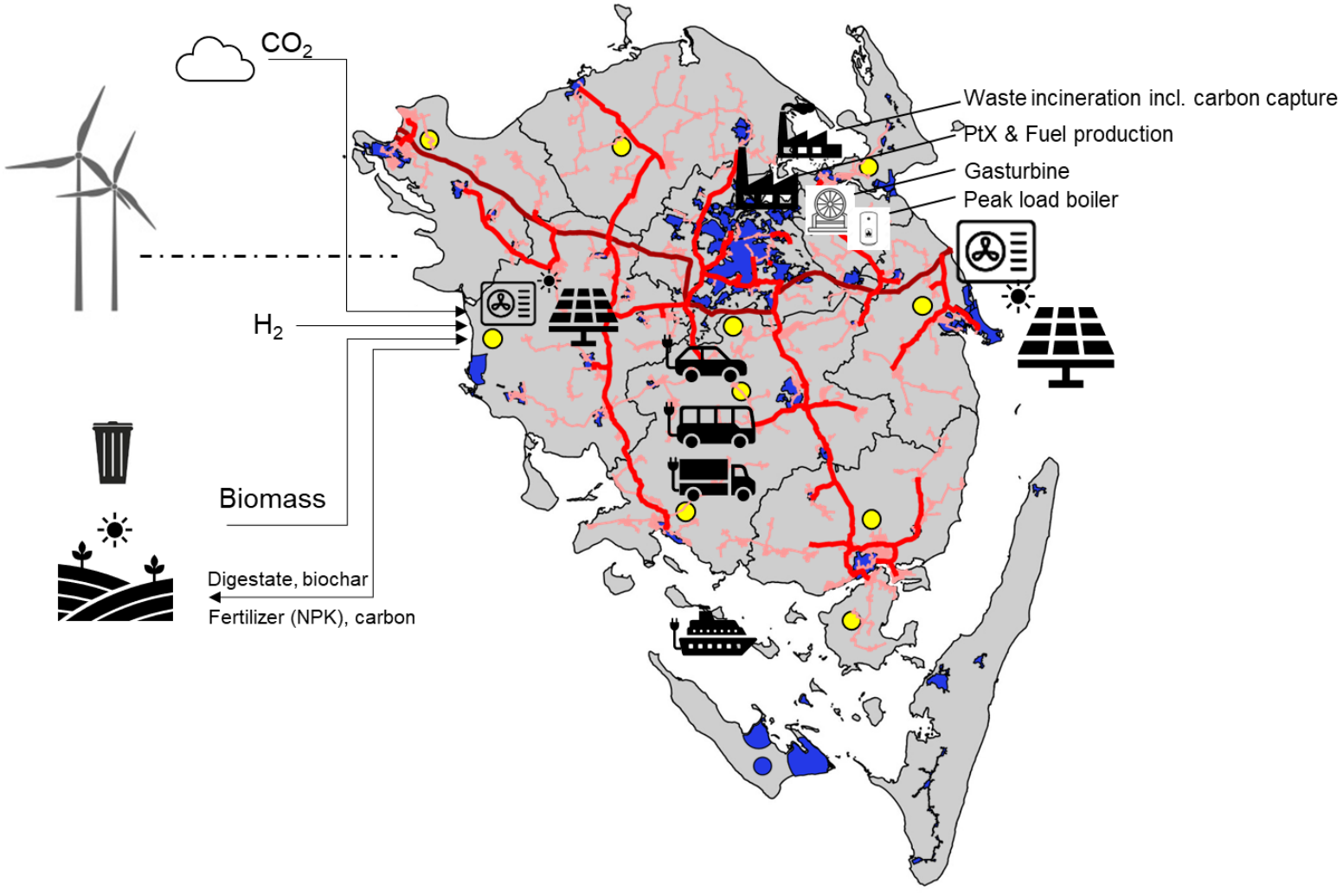
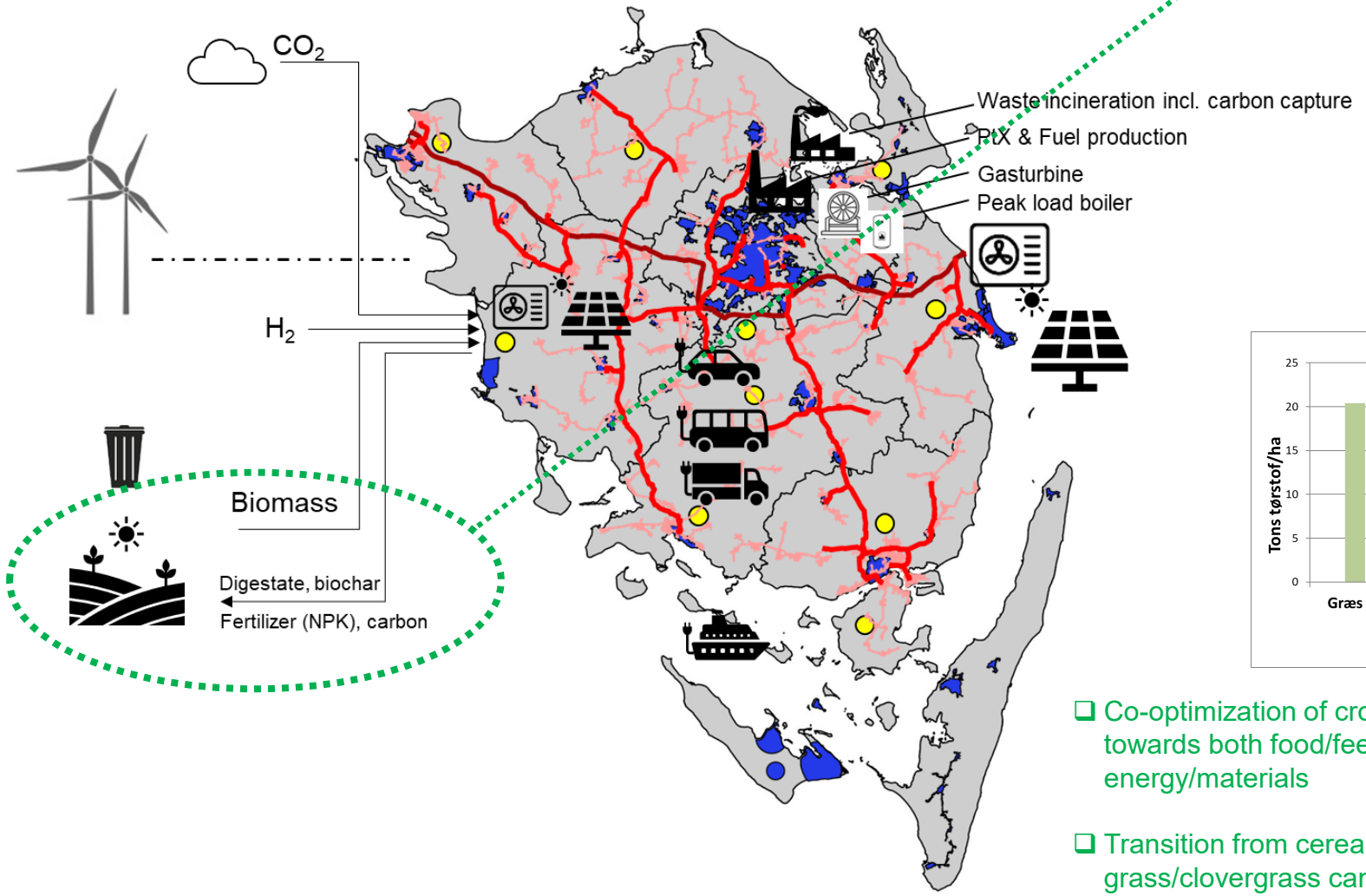
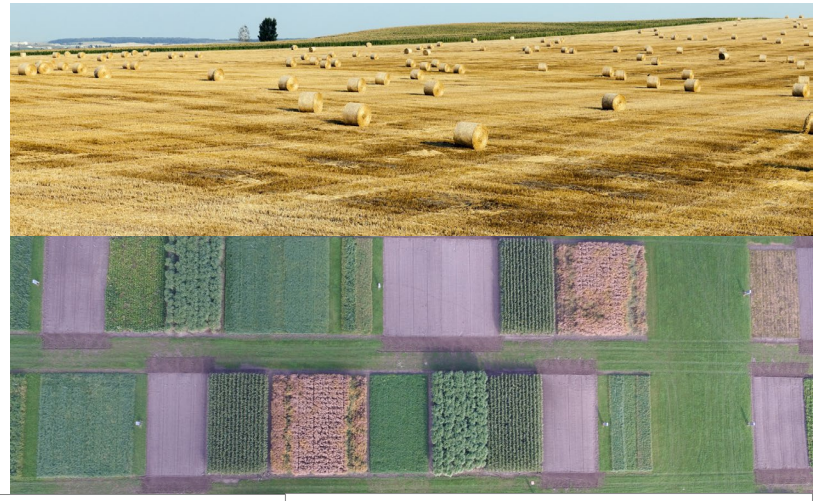
Some news, updates and perspectives

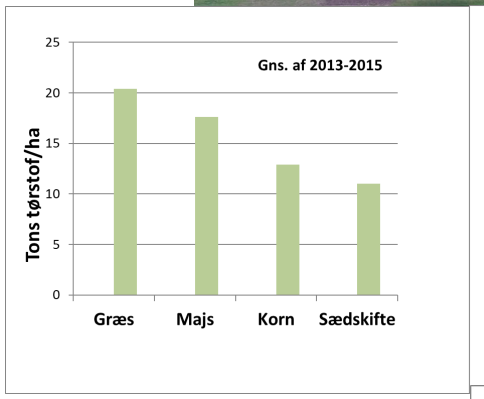


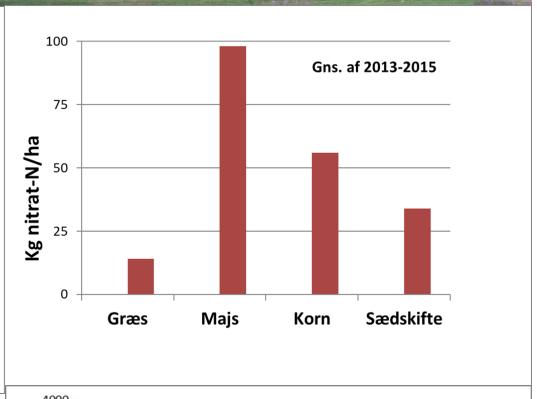
Some news, updates and perspectives

Agriculture and energy/material system integration



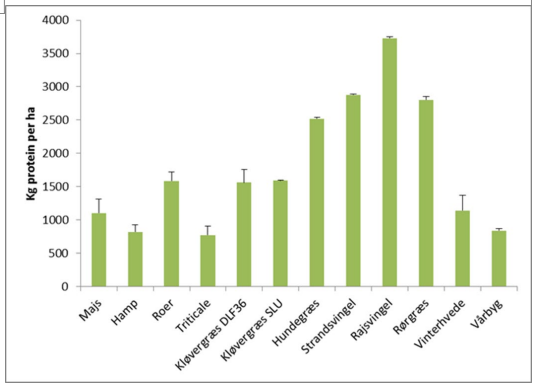






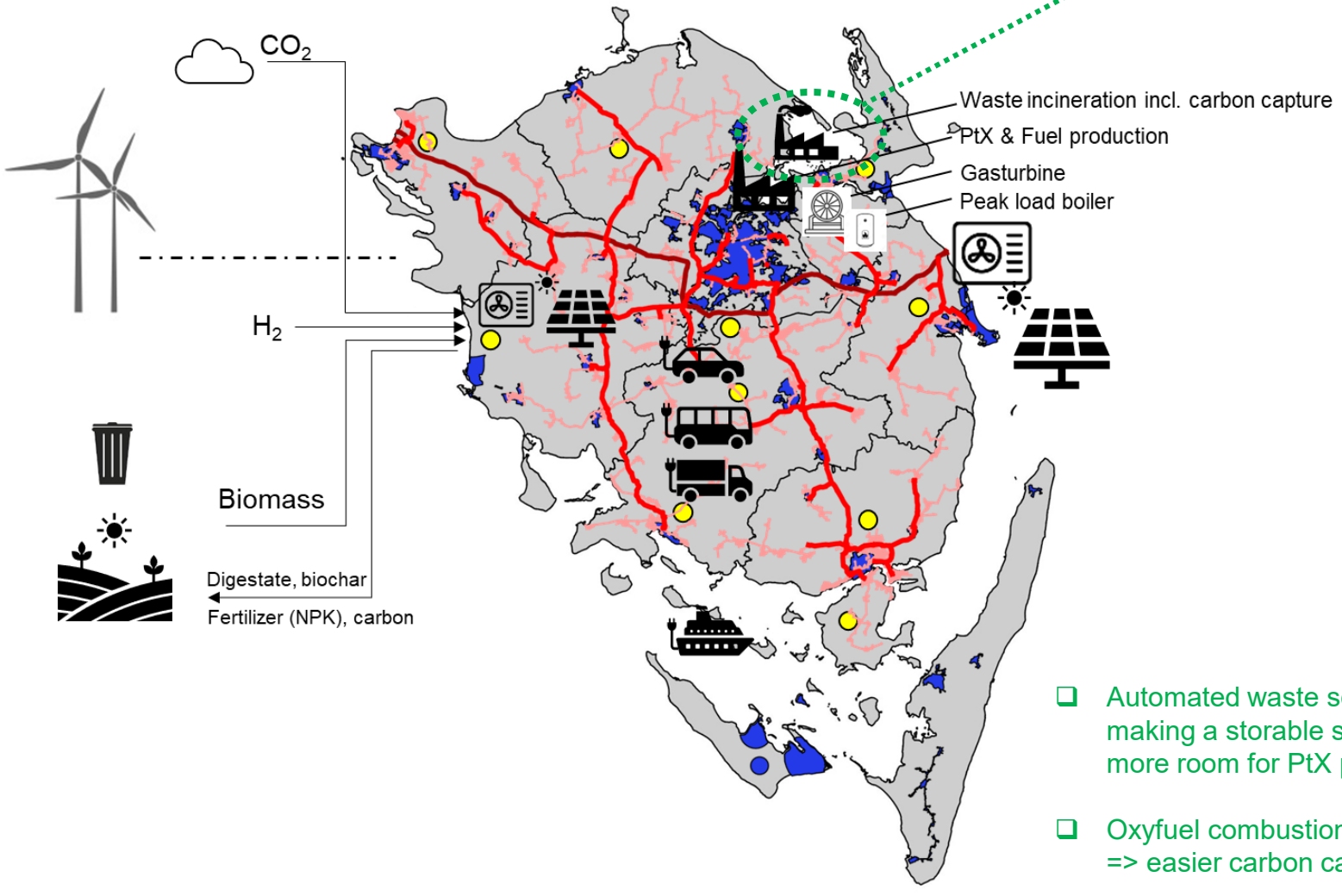
- Co-optimization of cropping schemes towards both food/feed and energy/materials
- Transition from cereals to grass/clovergrass can potentially increase agricultural yields in DK by 50 %

Ref.: Uffe Jørgensen, Århus University



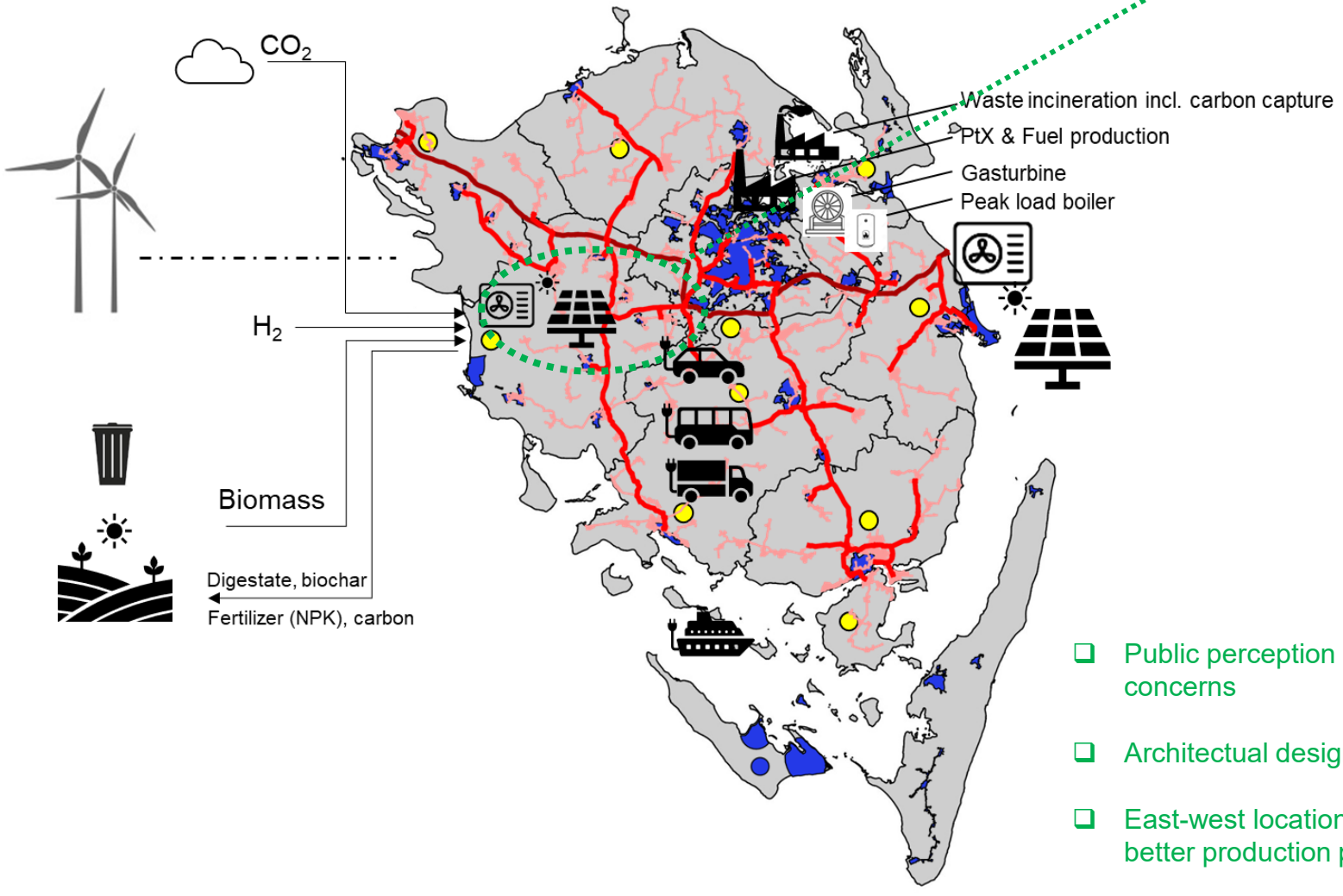
Some news, updates and perspectives

Waste management and energy/material system integration

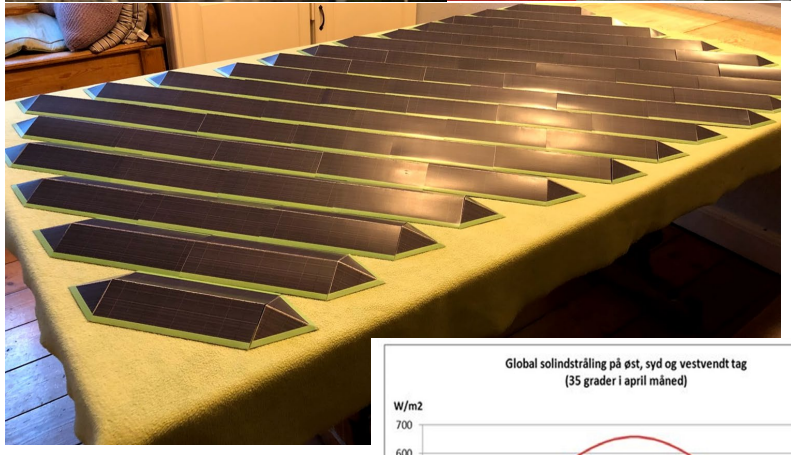


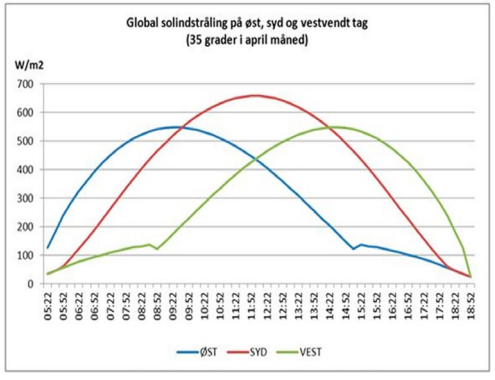
- Automated waste sorting for inhenced recycling and making a storable solid waste (RDF) for winter use => more room for PtX process heat during summer
- Oxyfuel combustion using electrolytic oxygen => easier carbon capture
- Co-production of PtX aviation fuel and naphta for plastic from waste-CO_2 => allow burning the dirtiest plastic

Some news, updates and perspectives



Solar parks





- Public perception & NIMBY are important concerns
- Architectual design
- East-west location much more efficient and better production profile

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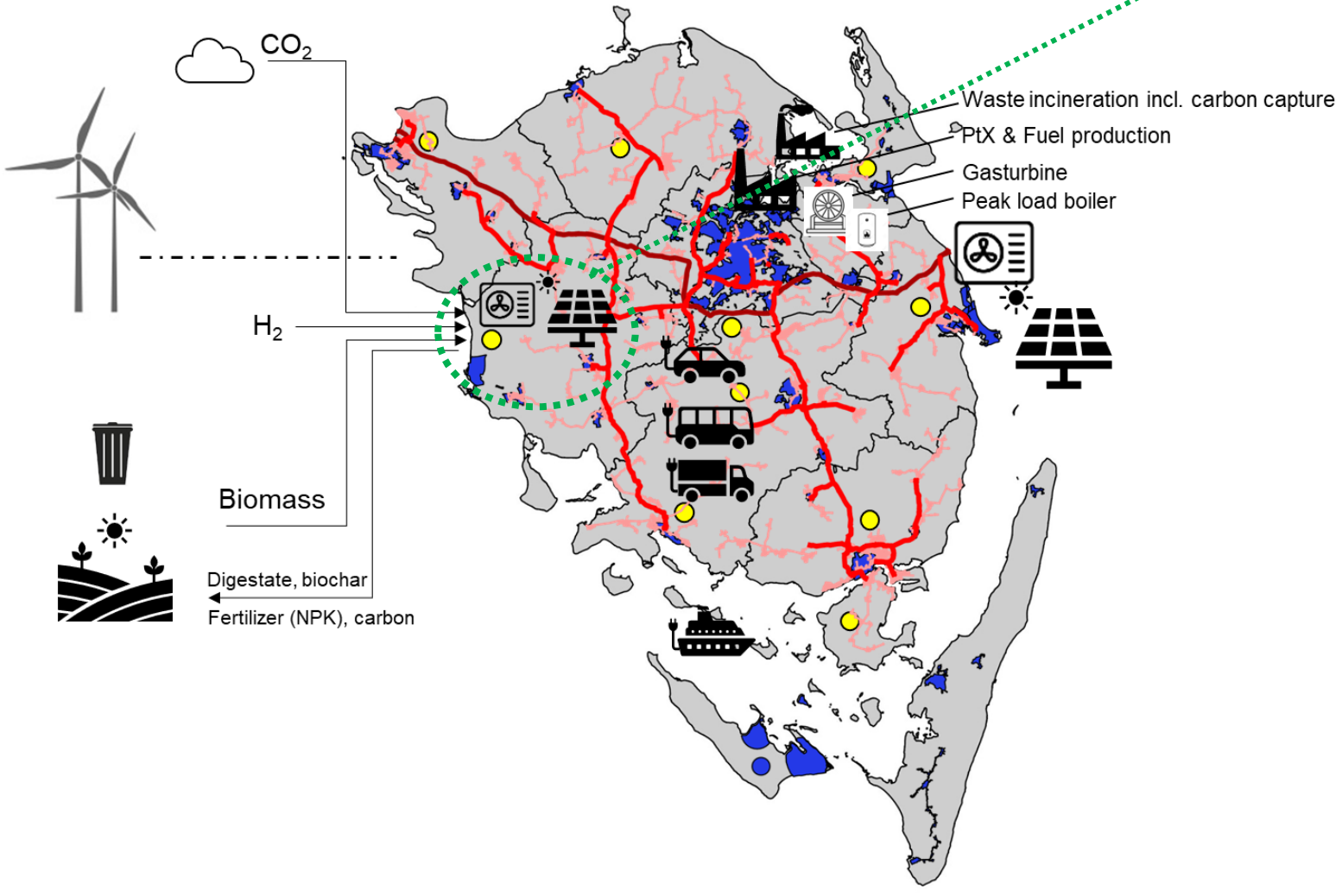
Some news, updates and perspectives

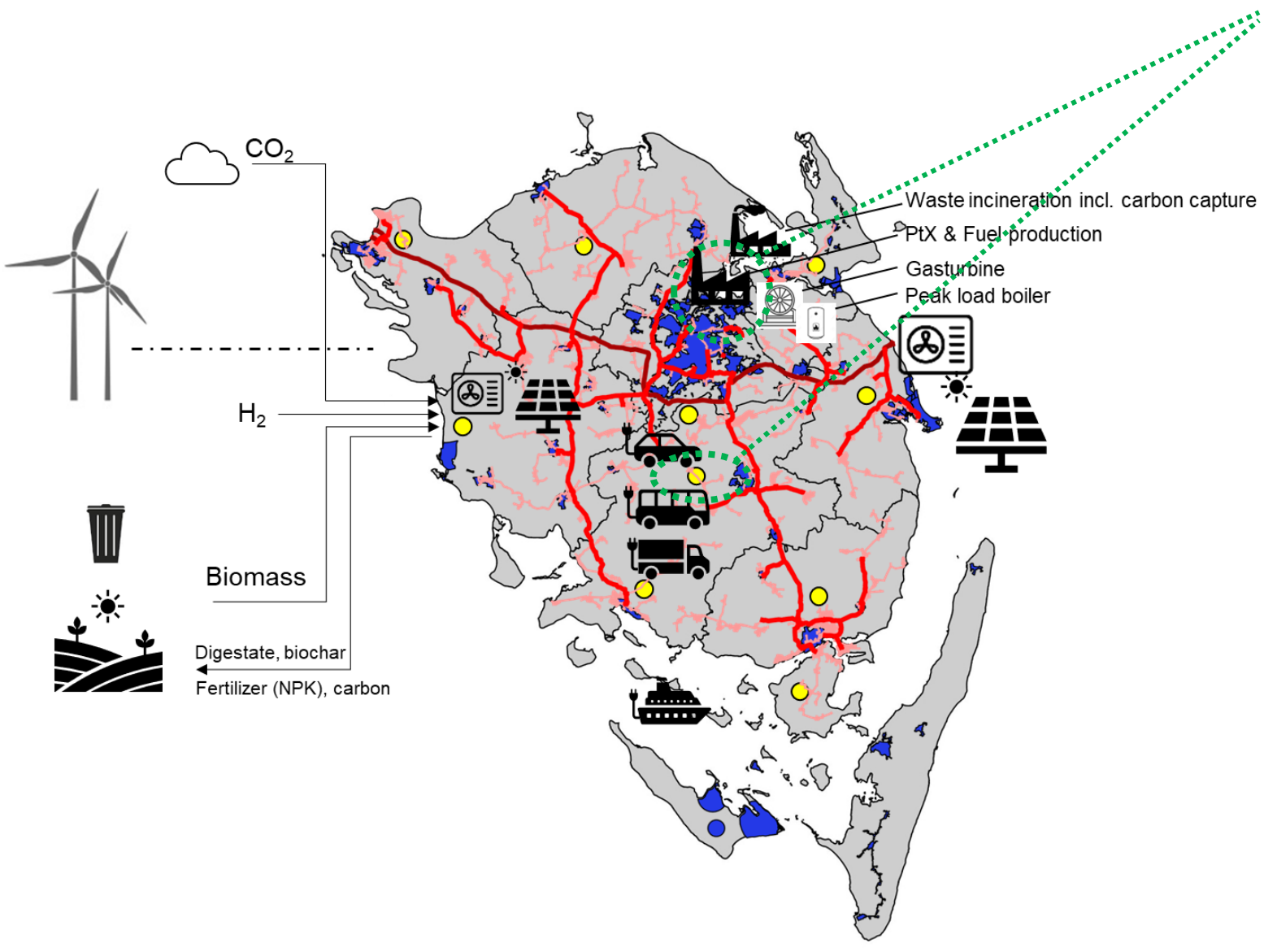


District heating

- Combining solar park, wind turbine(s), large heat pump and maybe also heat storage => cheap and attractive district heating
- Cheaper than individual heat pumps and free from noise in residential areas
- Urgent action needed – at present we are losing future district heating areas due to individual transition to heat pumps in natural gas heating areas

SDU

Some news, updates and perspectives



PtX – bio-methanation of CO_2 with hydrogen

- Nature Energy A/S, Biogasclean A/S, SDU and DTU

Lab scale 2019-2020

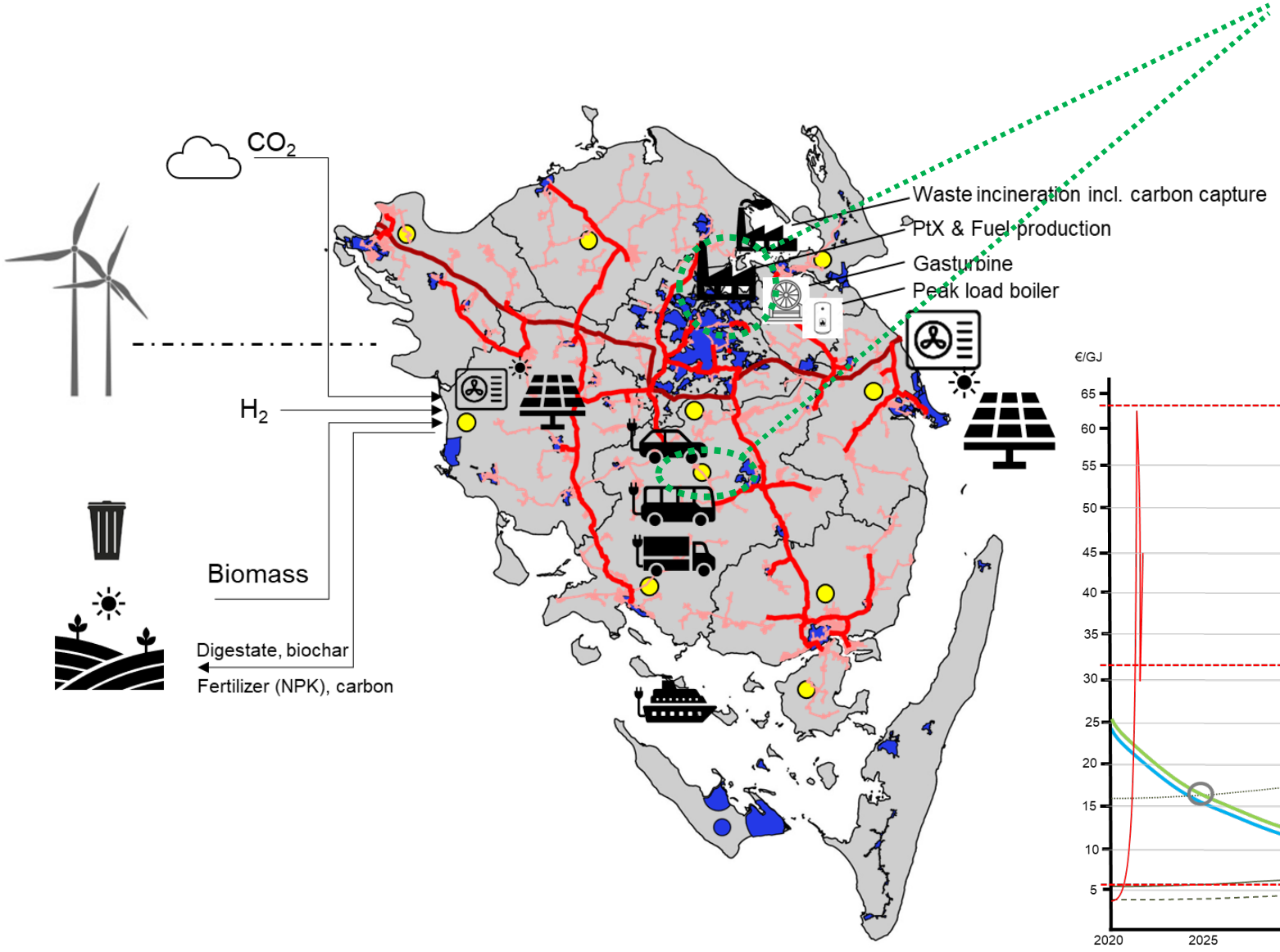
Pilot scale 2021-2022

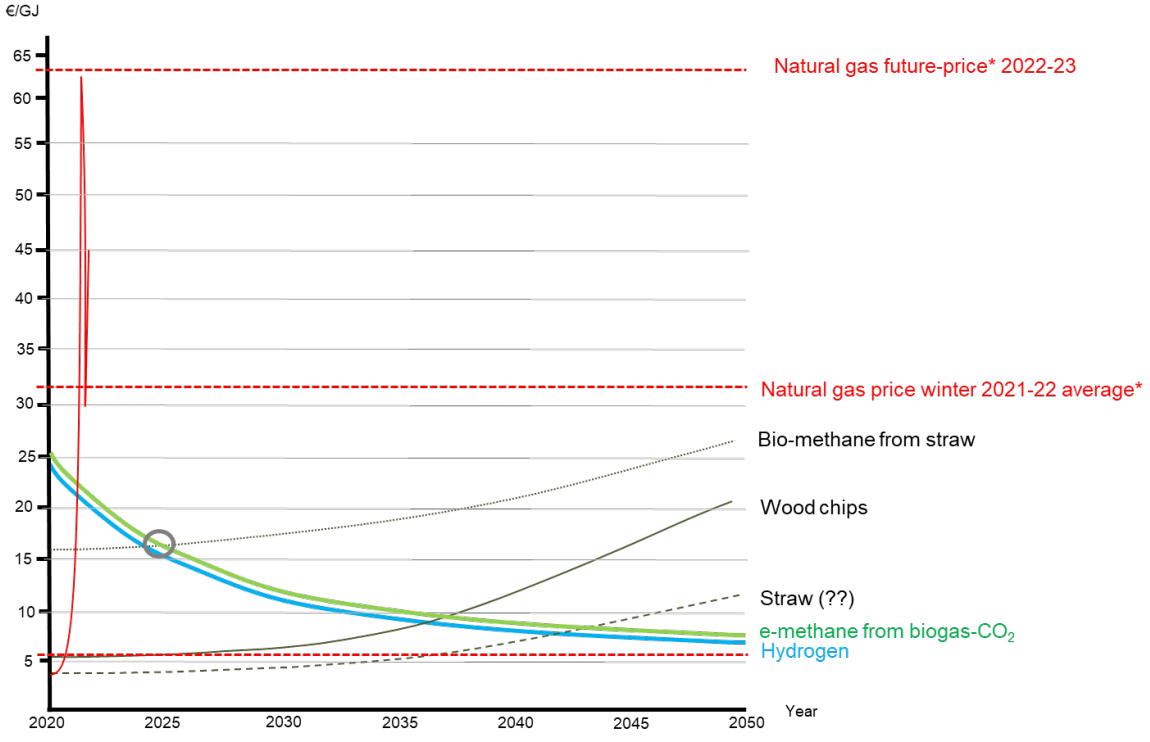
Full scale 2022-2023 and onwards

Some news, updates and perspectives

PtX – bio-methanation of CO_2 with hydrogen

- In 3-5 year, e-methane from CO_2 and H_2 can be made cheaper than bio-methane if hydrogen price forecast is correct, i.e. at 5 DKK/m^3
- This is one third of natural gas future-price 2022-2023





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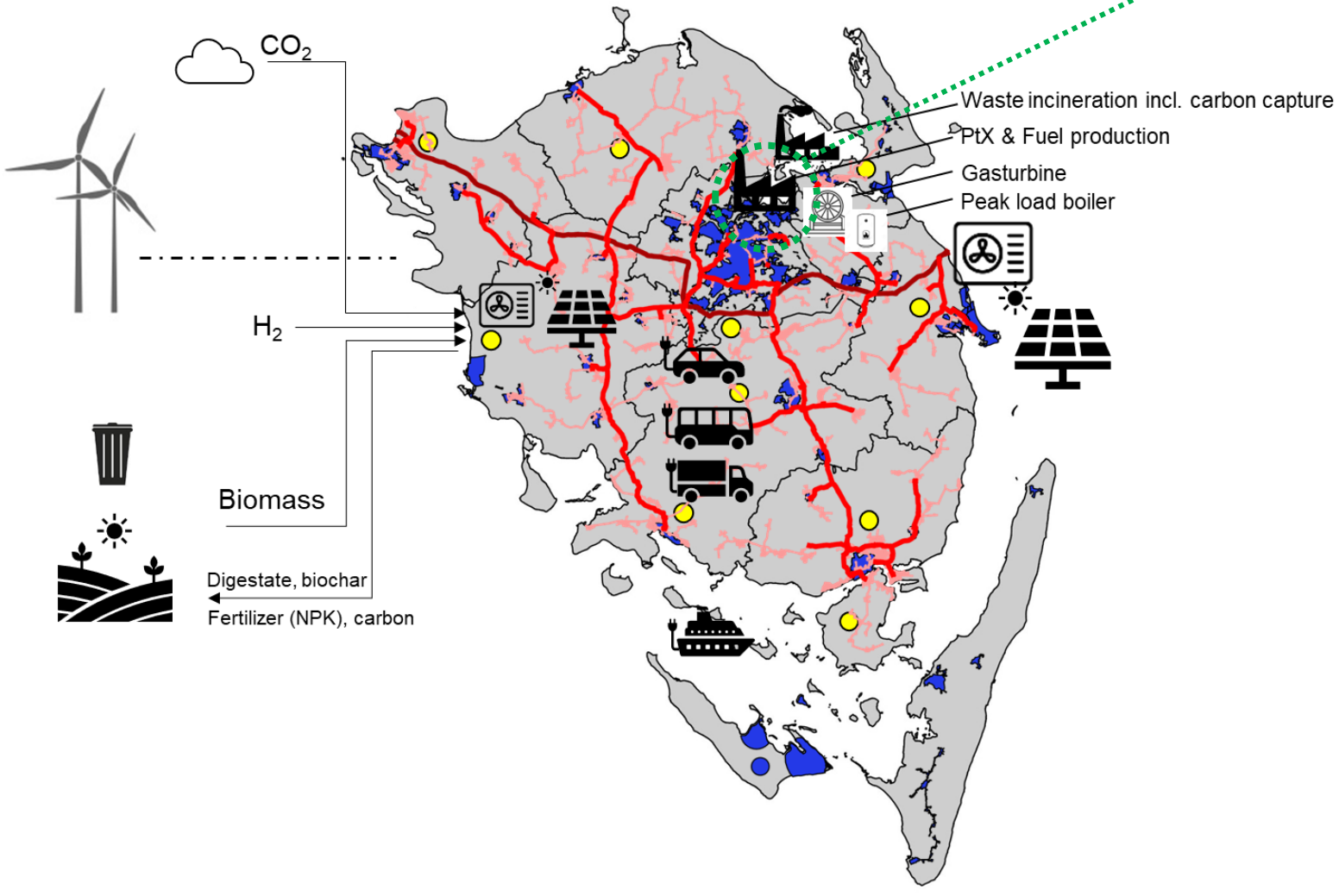


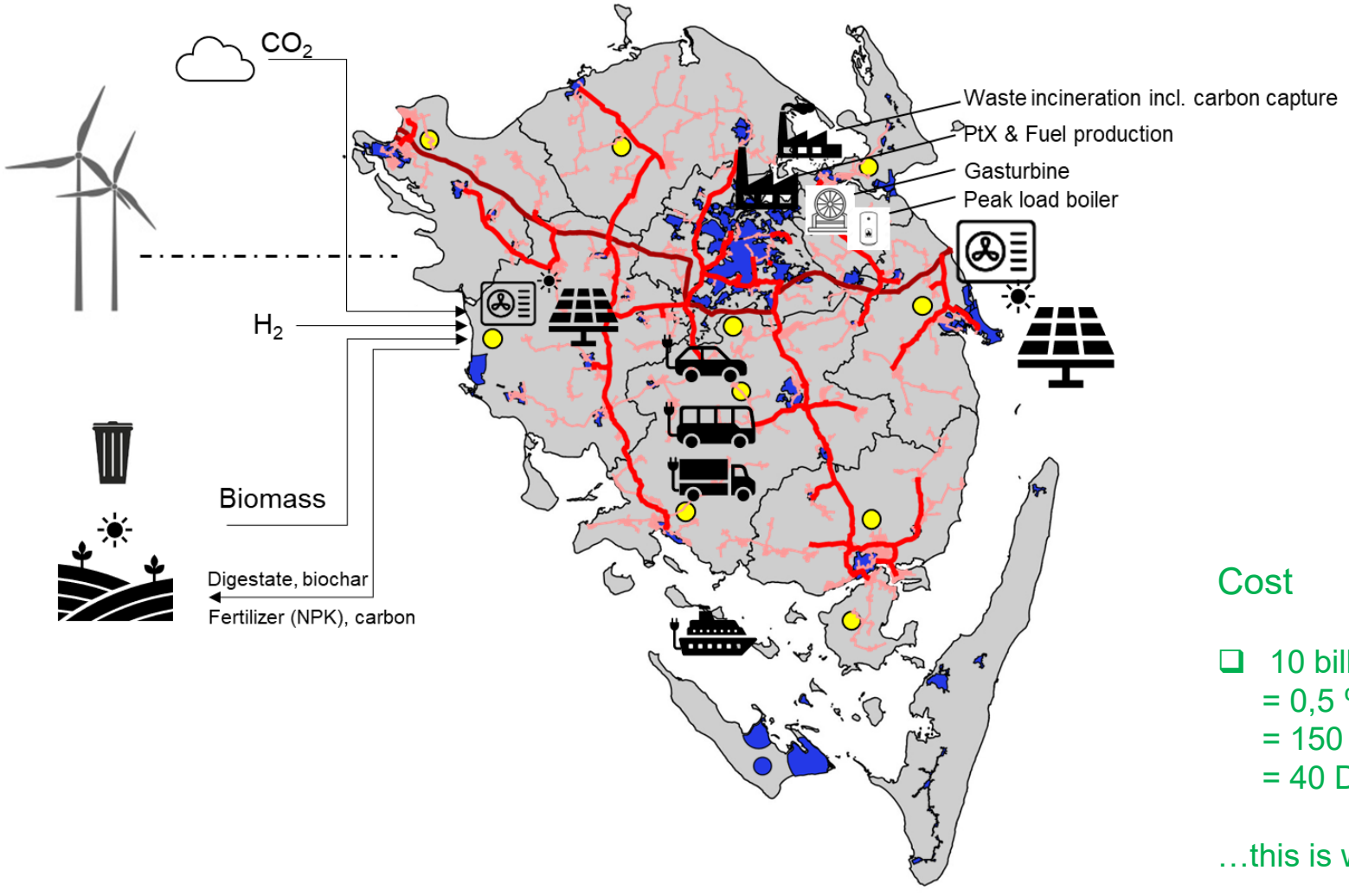
PtX – e-methanol production

- European Energy plant in Kassø predicted in full scale production end of 2023

PtX – jetfuel production

- Arcadia eFuels claims commercial production by 2024 at production facility in Vordingborg

The implications



Carbon balance – example

		All green	Net zero
Biomass	GJ/pers./y	17	17
Hydrogen	GJ/pers./y	35	35
Point source CO_2	Mt/y	7	7
DAC	Mt/y	6	10
Fossil CCS	Mt/y	1,7	1,7
Bio CCS	Mt/y	0	4
Net DK emission	Mt/y	4	0

Cost

- 10 billion DKK extra
  = 0,5 % og Danish GDP
  = 150 DKK/person/month = a Netflix subscription
  = 40 DKK/person/week = a cup of coffee at Starbucks/week

…this is without DAC

Ref.: Danish Energy Agency, 2014

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