Impact of Sector Coupling

Some Exemplary Aspects from Heating and Power-To-Gas

… District Heating

… Coupling of Gas and Electric Grid via Power-to-Gas

EMP-E 2020, 7th October 2020
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A cost optimized scenario for Europe shows that 90% CO_2 emission reduction is achievable with today's available, mature technologies and if the full potential of sector coupling and co-operation is realized.

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warming stripes - global mean temperatures per anno from 1850 – 2018 (source: Ed Harris [1])

Global Challenge	Megatrend	Identified Levers
Decarbonization	Electrification	I Ramp up Renewables
		II Phase-out Fossil in Electricity
	Sector Coupling	III Decarbonization of Decentral Heating
		IV Phase-out Fossil for Central Heating
	Decentralization	V Efficient Space Cooling
		VI Electric & Thermal Storage
	Rise of Flexibility	VII Electrification of Transport
		VIII Alternative Fuels
	Digitalization	IX Efficient ICT

Cost optimized scenario for Europe (integrated multi-modal Energy system)

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~90% CO_2 emission reduction is achievable with today's available, mature technologies and …

… if the full potential of sector coupling and pan-European co-operation is realized

What if not an 'optimal pathway' is pursuit ..

In the case of delayed or excluded low cost decarbonization measures (e.g. from sector coupling; thermal storage), then …

… new technologies (e.g. carbon negative technologies, hydrogen, …) will play a significant role for target achievement

... and this comes at increased costs!

District Heating Grids are economical feasible and will have a growing share … and may provide storage and flexibility options

Heating accounts for about ~47% of final energy demand of the EU

Within the next two decades we have two big challenges for heating awaiting along the transition pathway

- **Replacement of heat obligation from phased-out fossil power plants**
- **Replacement of phased-out of oil boilers in space heating**

Everybody is talking about biomass or 'green' gas boilers for heating or power-to-heat, but District Heating (DH) stands its ground. It is future proof and can ...

… implement heat of **heat recovery from Industry / Commerce**	… district heating networks is essential for heat from heat recovery, geothermal & heat from waste incineration
… implement heat of **heat recovery new opportunities in future**	… e.g. waste heat from data centers, power-to-gas units, etc.
… provide **cheap storage of sur-plus energy & flexibility**	… using power-to-heat and inexpensive thermal storage technologies able to store energy from hours to weeks
… be an **alternative to gas boilers and grid extension**	… natural gas might only a temporary bridge technology on the way from coal to gas to fully decarbonized heating and gas for heating might be next to phase out.
… be gradually **upgraded to Power-to-Heat**	… if heat suppliers (Industry, local power plants) are no longer available or are phased-out; or if an increased share o RES is integrated

From our modeling studies of the pan-European energy system

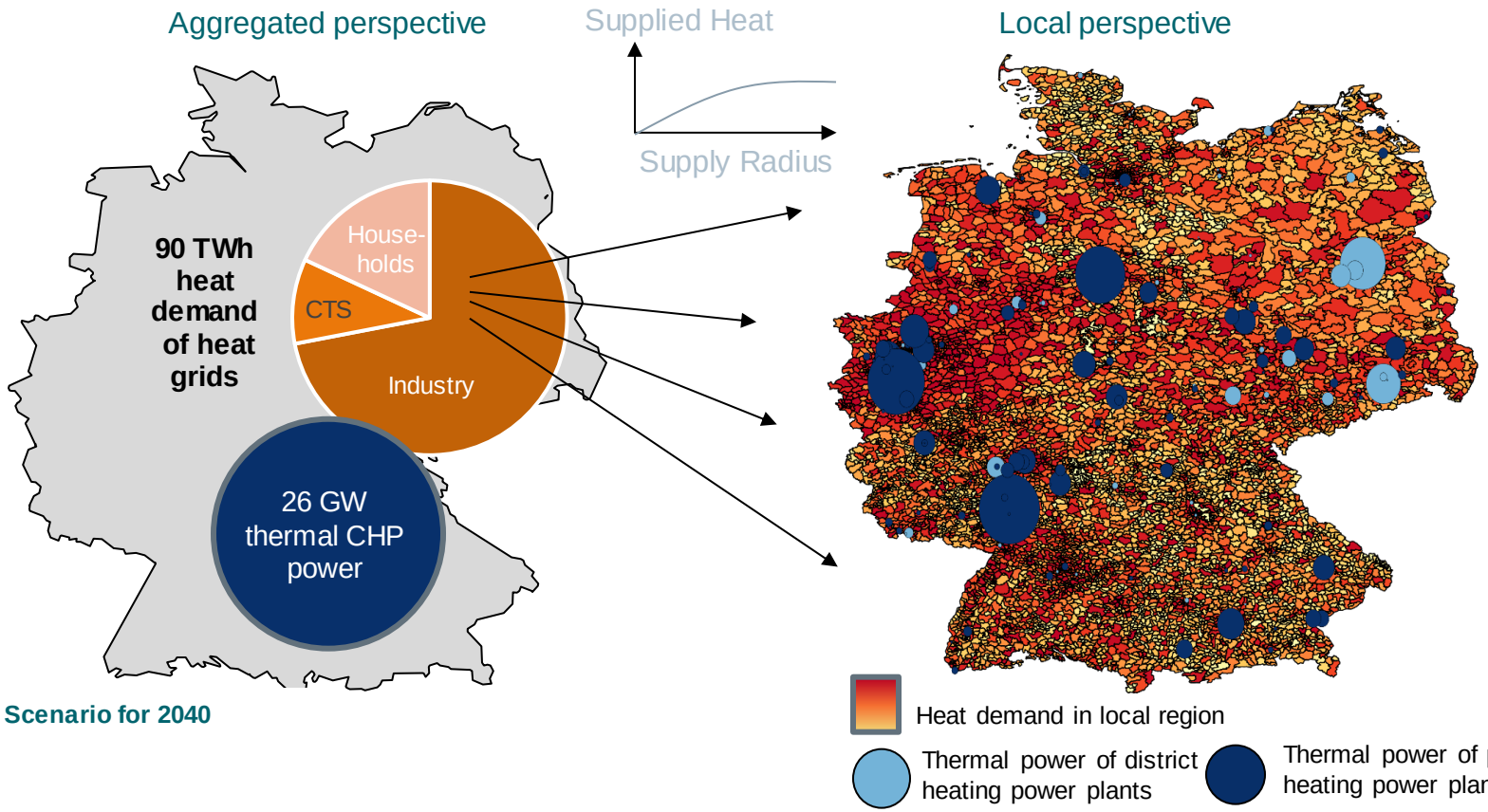
Despite all efforts in savings, e.g. by insulation of housings, district heating is economical feasible and will have a growing share to ~12 .. 15% in space heating and low-temperature heat supply

Matching of new heat suppliers and consumers on regional level is necessary to find feasible replacement for the heat obligation of phased-out fossil power plants

Challenge: Replacement for heat supply after coal phase out in the next 10 to 15 years
- Large District Heating grids supplied by co-generating heat and power plants

Importance of co-generating power plants for the heat supply

- Local dependency of power plants and heat grids
  - → **Matching of heat supplier and consumer necessary**
- ➢ Aggregated perspective may not be sufficient
- ➢ Individual allocation of power plant sites to heating with differentiation in district and process heating necessary



Scenario for 2040

Local heating networks might be an alternative to individual gas boilers or power-to-heat as replacement for oil boilers

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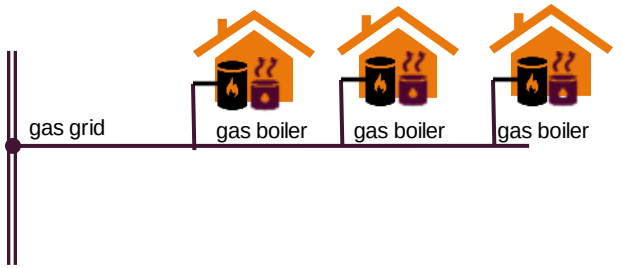
Challenge: In the next two decades many European countries are phasing out oil boilers for decentral heating – what is better, replacement by gas boilers or shift to power-to-heat?

Individual Decentral Gas Boiler
w/ decentral hot water storage

Risk of Stranded Assets

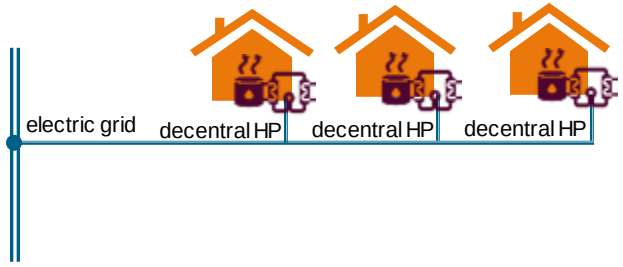


gas grid extension necessary

- **risk of stranded assets** if phase out of fossil gas for heating follows oil phase out
- **no flexibility option** for the local electricity grid
- **no storage option** for the local electricity grid

Individual Decentral Heat Pump (HP)
w/ decentral hot water storage

Individual fast solution;
Limited options to provide flexibility/storage services

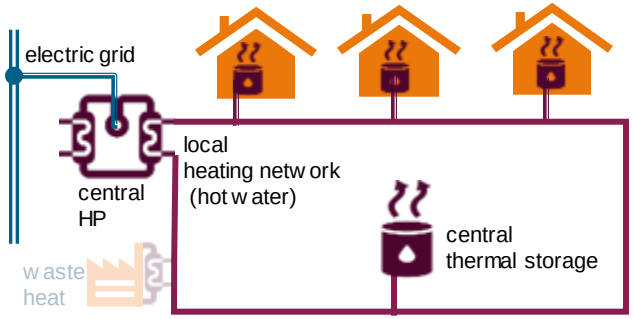


(maybe) extension of the electric grid necessary

- **Limited storage option** for the local electricity grid
- **Limited flexibility option** for the local electricity grid
- but, both only via remote control of many small HPs possible (risk of customer acceptance)
- Risk of cheap but inefficient HPs maybe predominant

Local Heating Network (Hot Water)
w/ efficient central heat pump
w/ cheap central hot water storage,
e.g. 'Pit Storage'

Future proof & implementation of waste heat
Plus option to provide flexibility/storage services to the system



implementation of local heating network

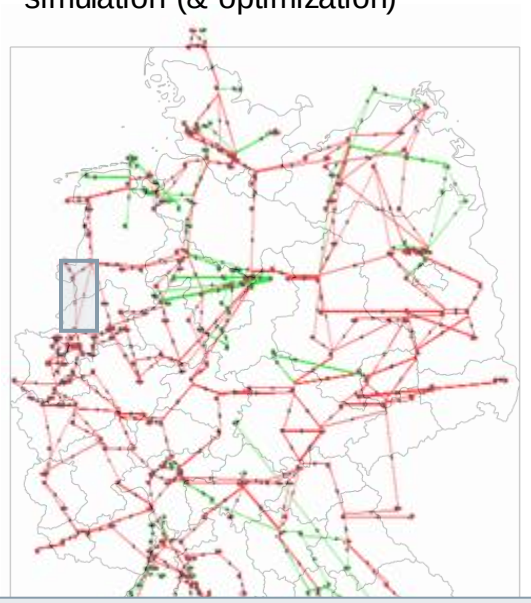
- but no extension of the electric grid necessary
- **provides storage option** for the local electricity grid
- **provides flexibility option** for the local electricity grid
- both options can be controlled by local municipality (less risk of customer acceptance)
- central HP can easily be exchanged, e.g. by CHP, …
- **other heat sources can be integrated in parallel**

Deeper understanding of how much H_2 that we can inject into the gas transport grid as well as of bottlenecks in the gas transportation system

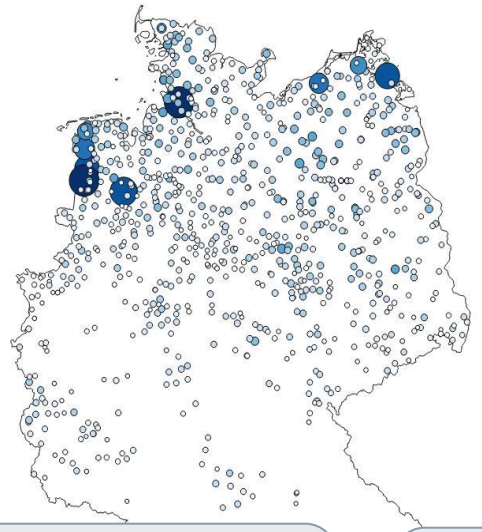
P2G as 'cure' for electric grid issues?

Coupling of Gas Grid Model and Electric Grid Model to assess constraints and limitation from the gas grid

Electric Grid (model) + Location & Operation of Gas Power Plants
simulation (& optimization)



Define Location and Operation Schedule of Power-to-Gas Units



Gas Grid (model) with Location and Operation of Gas Demand and Supply

simulation (& optimization ??)

- Grid Infrastructure Gas and Electric
- Location of Gas Demand and Supply
- Location and Operation of Power Plants
- Location and Operation of Power2Gas
- Location and Operation of Gas Storages

- From existing infrastructure perspective:
  How much H_2 can we inject into the pipelines?
- From newly established services perspective:
  Where should we place P2G facilities?

Output: Feedback to the electric grid & multi-modal investment model

- **Identified Bottlenecks and Infeasibilities**
- **List of Change Requests**

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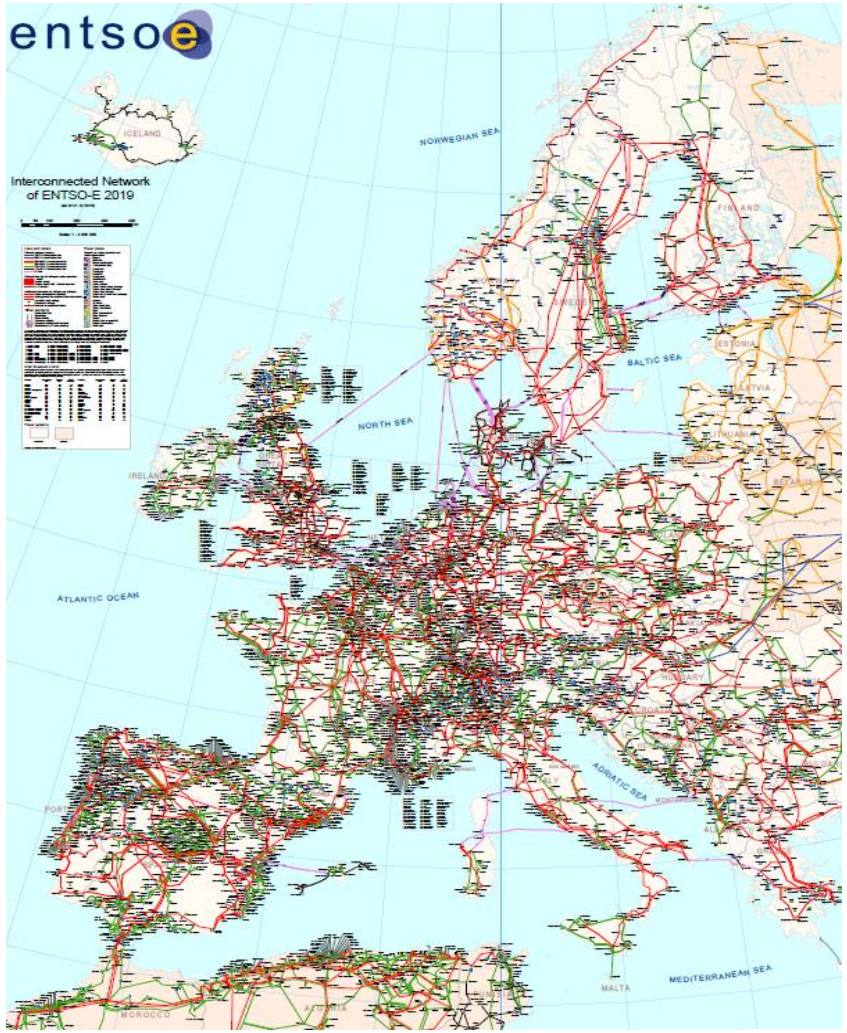
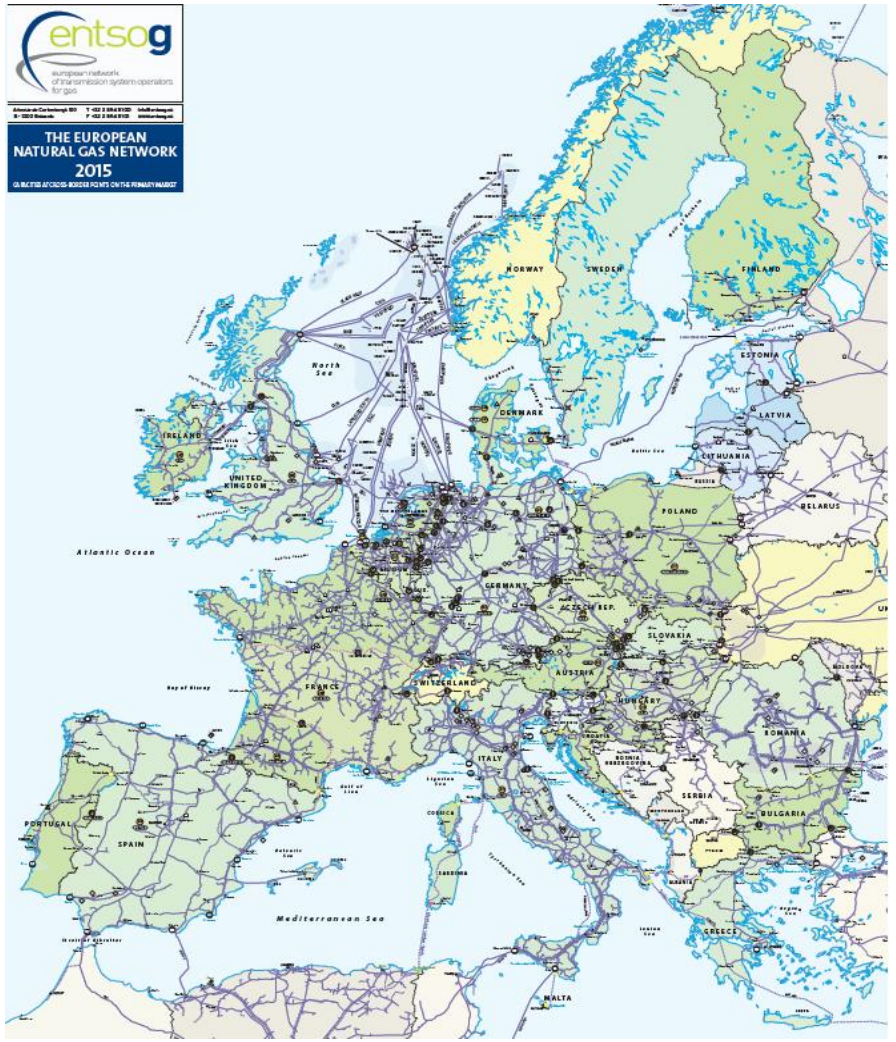
Coupling of gas grid and electric grid models on pan-European scale … is ambitious, but necessary when dealing with power-to-gas



- Location and Operation of power plants
- Location and Operation of Power2Gas
- Location and Operation of Gas storages
- Location of Gas Demand and Supply



Final Key message: Sector Coupling is a cornerstone of decarbonization ... and modelling of integrated energy systems necessary

… find out more about our project

www.plan4res.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773897.

Case Study

Integrated multi-modal pan-European energy concept for achieving COP 21 targets w/ perfect foresight, considering sector coupling of electricity, heating and cooling, mobility, fuel/gas and coupling of gas network and electric grid

www.plan4res.eu/wp-content/uploads/2019/06/plan4res-Definition-Case-Studies-Summary-CS1.pdf

Multi-year, aggregated view → Focus year, disaggregated view

- Multi-modal investment model (EU pathway) — SIEMENS
- Disaggregation + EU commitment model — RWTH AACHEN UNIVERSITY
- Transmission Grid operation model — RWTH AACHEN UNIVERSITY
- Gas Grid operation model — ZIB

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