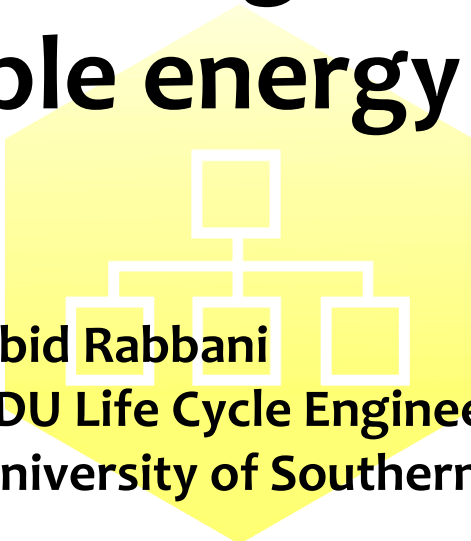
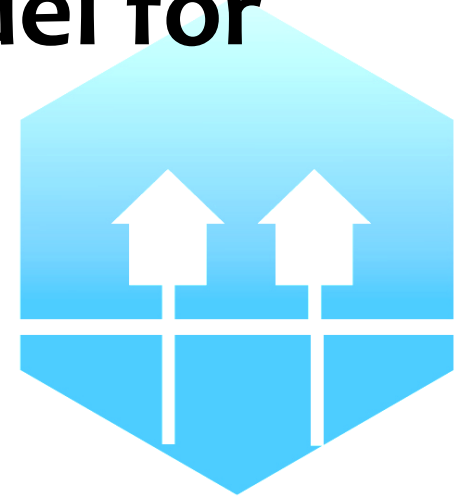


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An integrated gas grid model for upgraded biogas in future renewable energy system



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4th Generation District Heating
Technologies and Systems

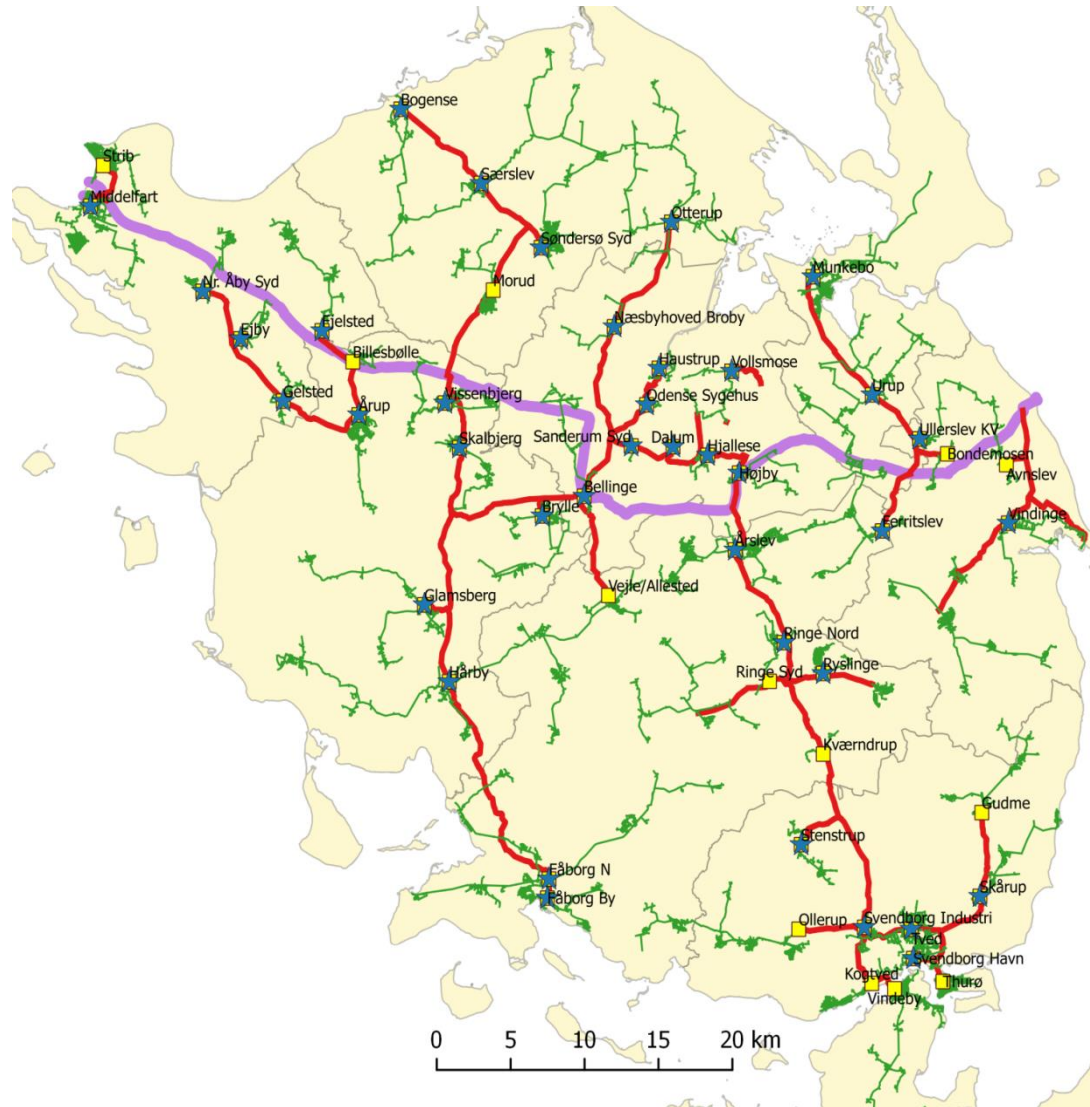
Feasibility study on utilizing natural gas grid for upgraded biogas

- Are there any bottlenecks due to flow capacities of the gas grid?
- Can the low pressure distribution grid be used only for raw biogas and medium pressure grid for upgraded gas only?
- To what extent can these grids balance the supply and demand?
- How much raw & upgraded biogas contribute to the electricity, heat and transport demands?
- How much gas would be exported/ imported? And under what operating conditions?

The Funen Case

- Adequate system size for analyses
- Developed natural gas network
- Could be replaced entirely by biomethane
- Availability of feedstock

Modelling approach:
An integrated grid model in
“SIFRE” tool
Balancing supply and demand for
electricity, DH, Industrial process
heat & transport sector







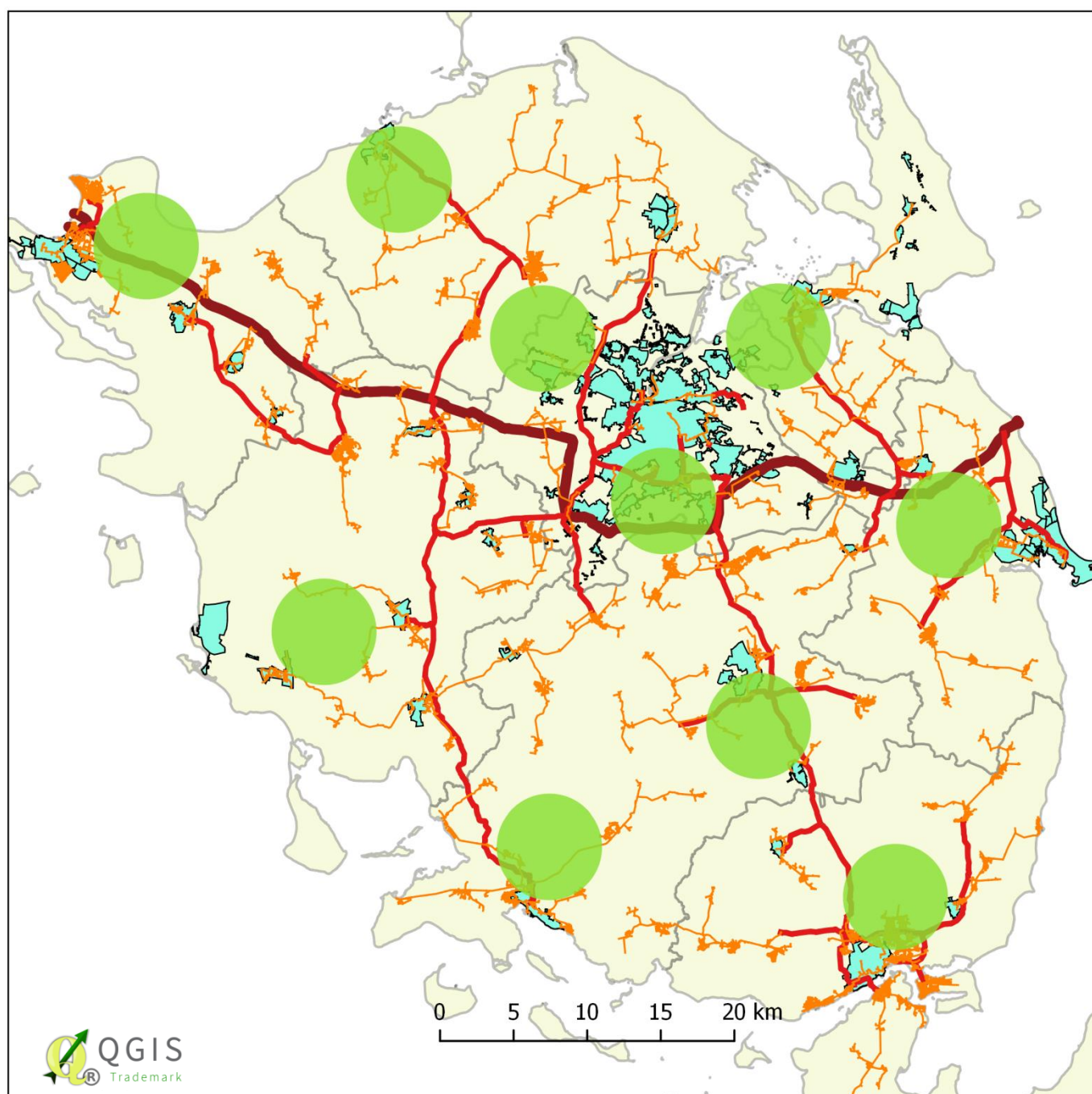
Biogas Plants

Bio-Methane Potential for Fyn

Feedstock	Biogas production (mio Nm ³)	
Manure	2 PJ	86
With Straw	5,7 PJ	214

No. of plants	10
Estimated size of plant	28 mio Nm ³ /y

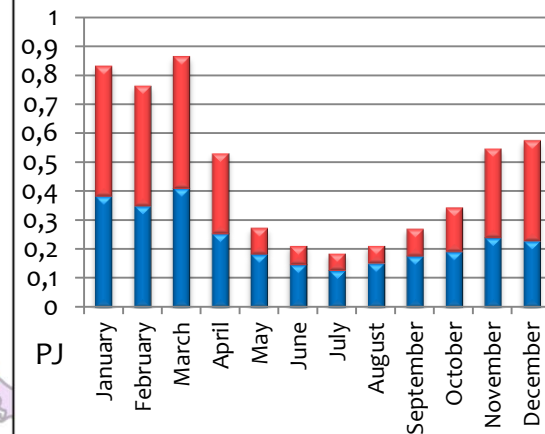
-  DH Networks
-  80 bar pipeline
-  17 bar pipeline
-  4 bar pipeline



Color graduation:
light to dark for % of total energy

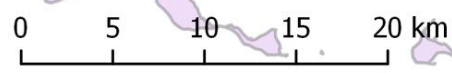
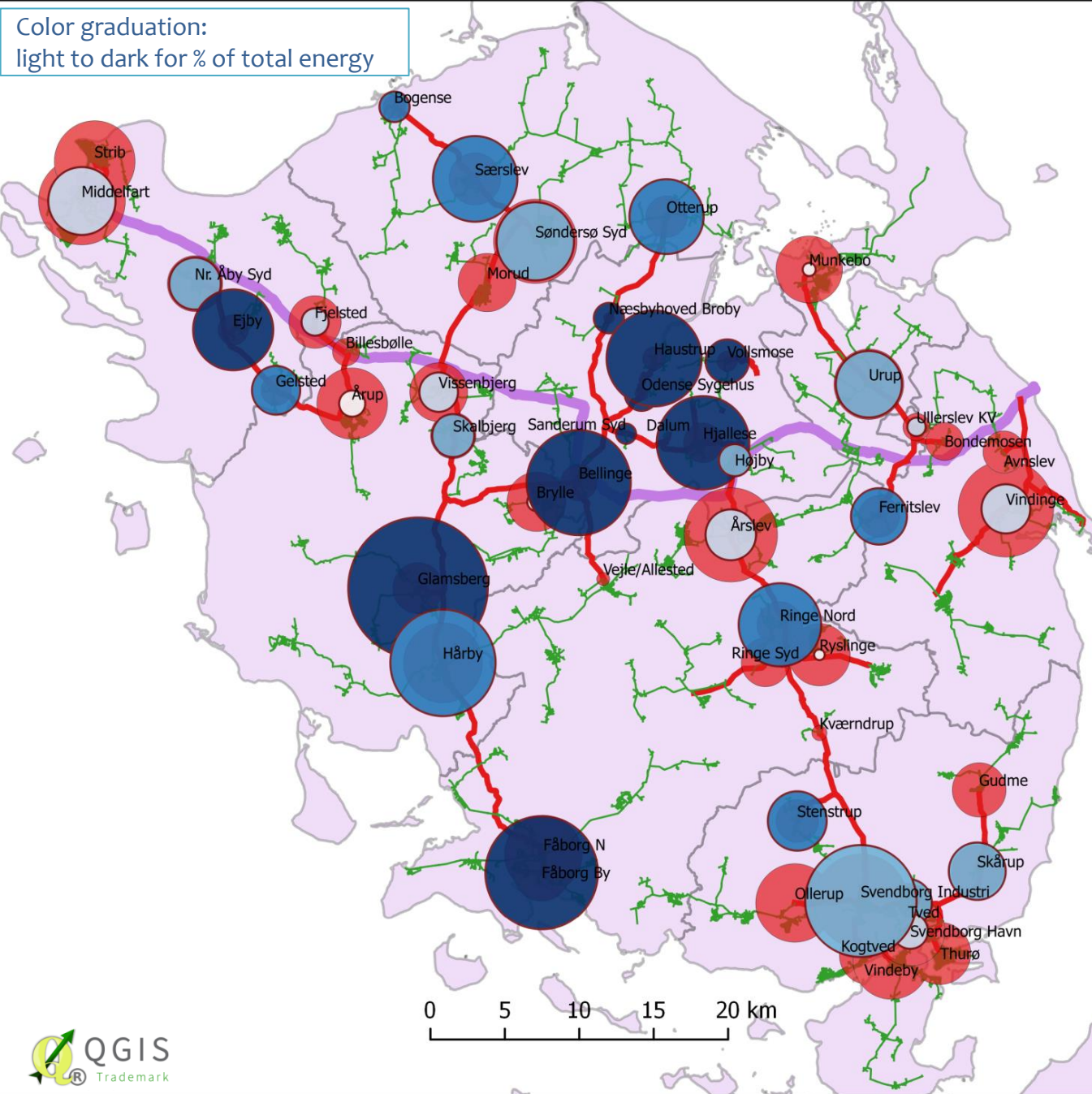
Funen gas demand

■ Large Consumers ■ Small Consumers



Funen gas demand	5,62 PJ
Industrial demand	2,84 PJ
% of total	51%
Convertibility to el.	50-75 %

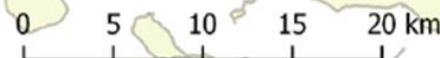
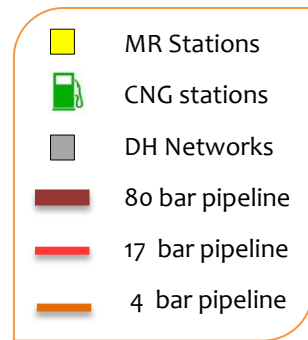
- 80 bar pipeline
- 17 bar pipeline
- 4 bar pipeline



Compressed Biomethane Refilling stations

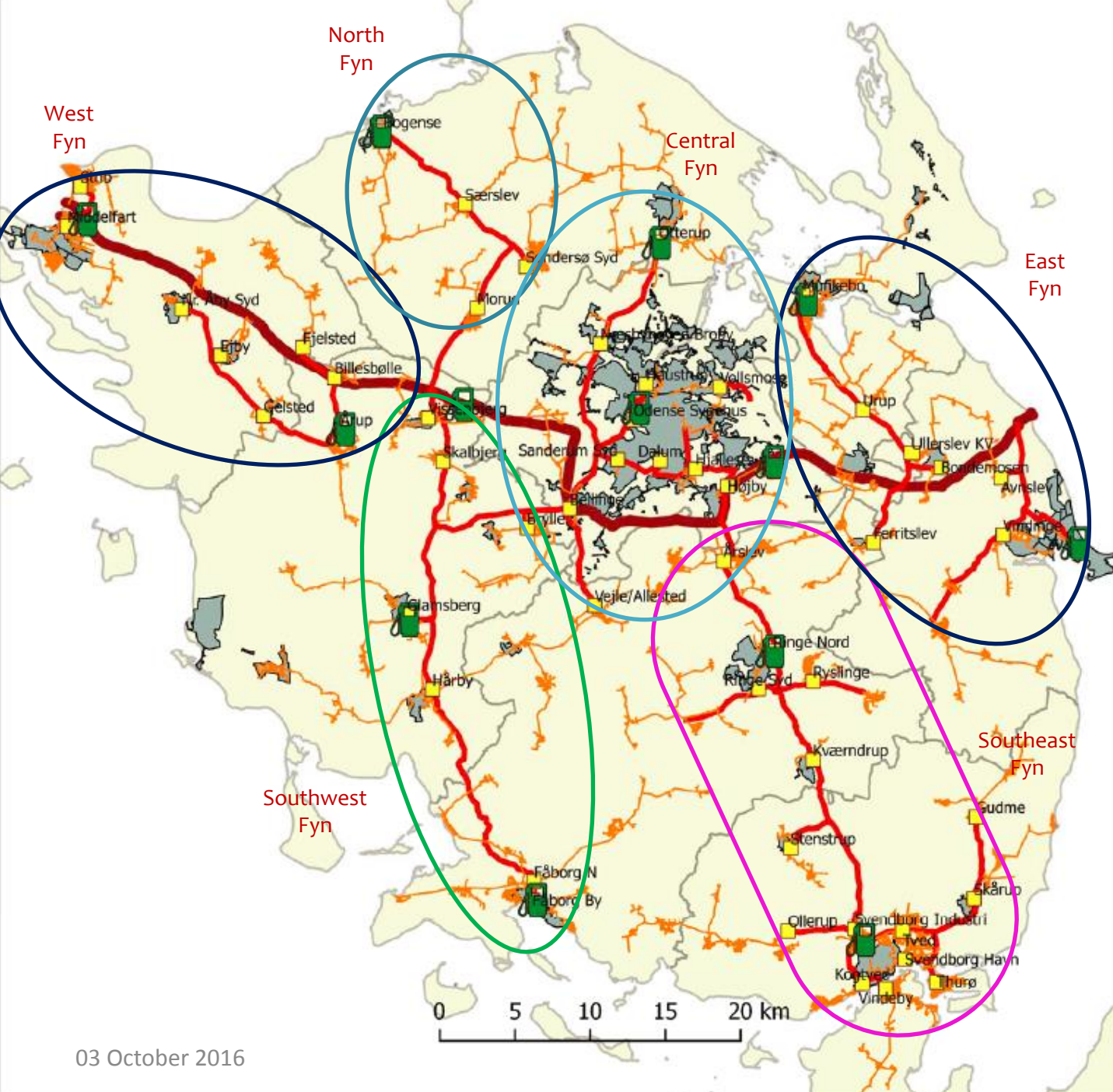
Area	CNG stations	Annual Demand (PJ)	Peak Load (MW)
West Fyn	2	0,38	36
North Fyn	1	0,19	18
Central Fyn	3	0,58	55
East Fyn	2	0,38	36
Southwest Fyn	3	0,58	55
Southeast Fyn	2	0,38	36
Total	13	2,5	

LNG Terminal			
Total	1	2,5	158



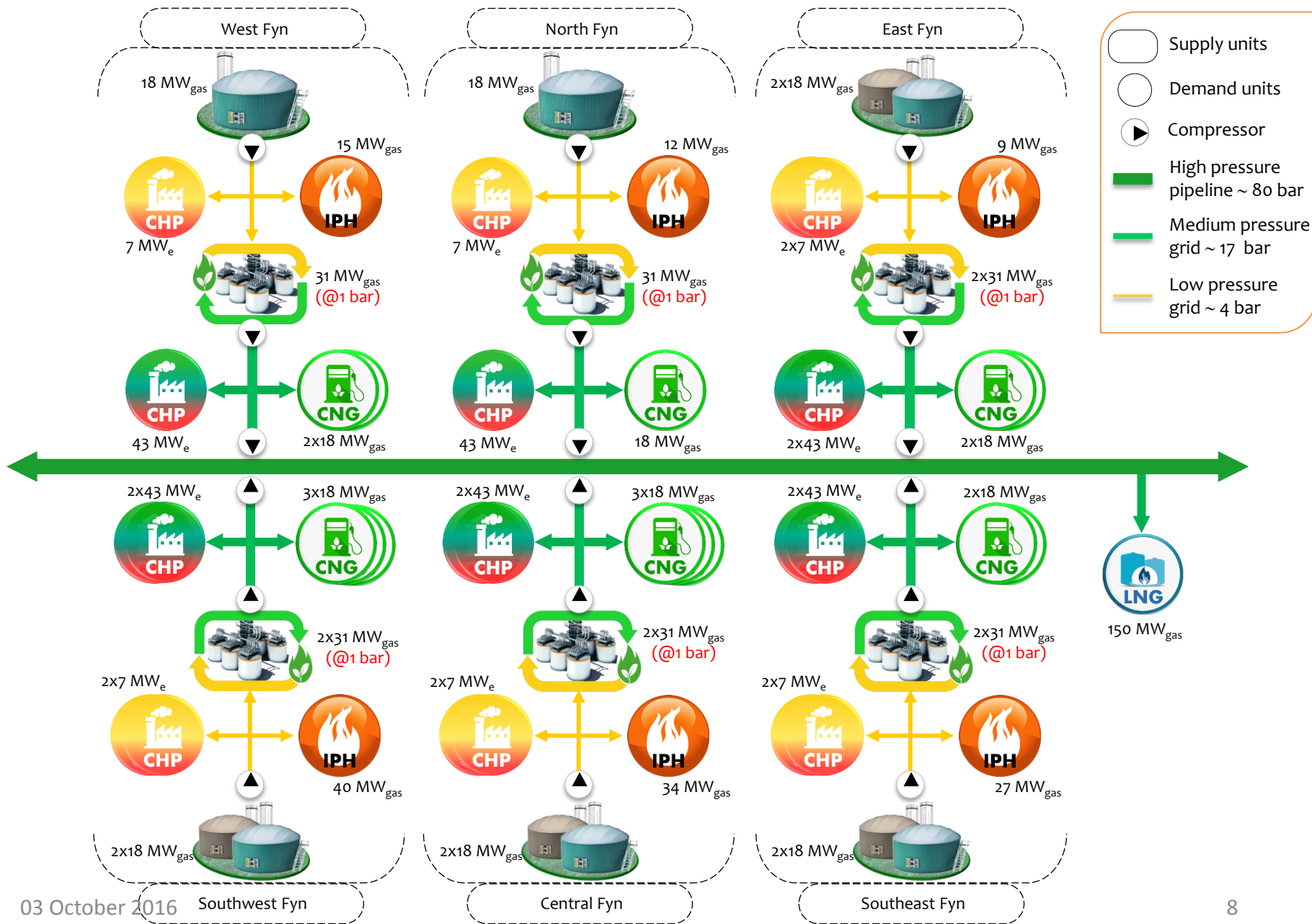
Localized gas grid of Funen

- Total 6 units of supply and Demand
- Each unit mainly consisting of 17 & 4 bar gas grid
- All units connected to 80 bar transmission line
- Different supply and demand characteristics

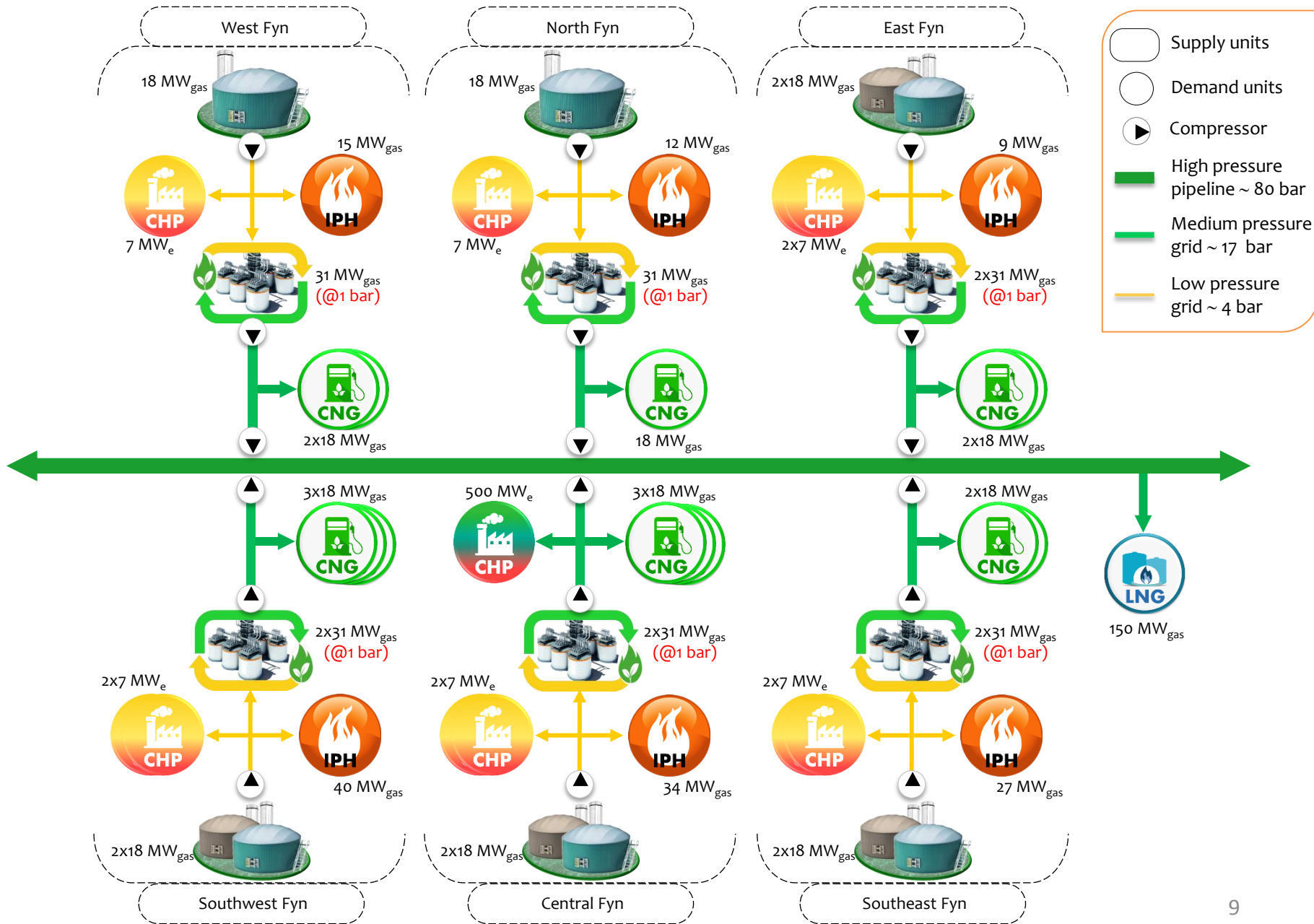


- MR Stations
- CNG stations
- DH Networks
- 80 bar pipeline
- 17 bar pipeline
- 4 bar pipeline

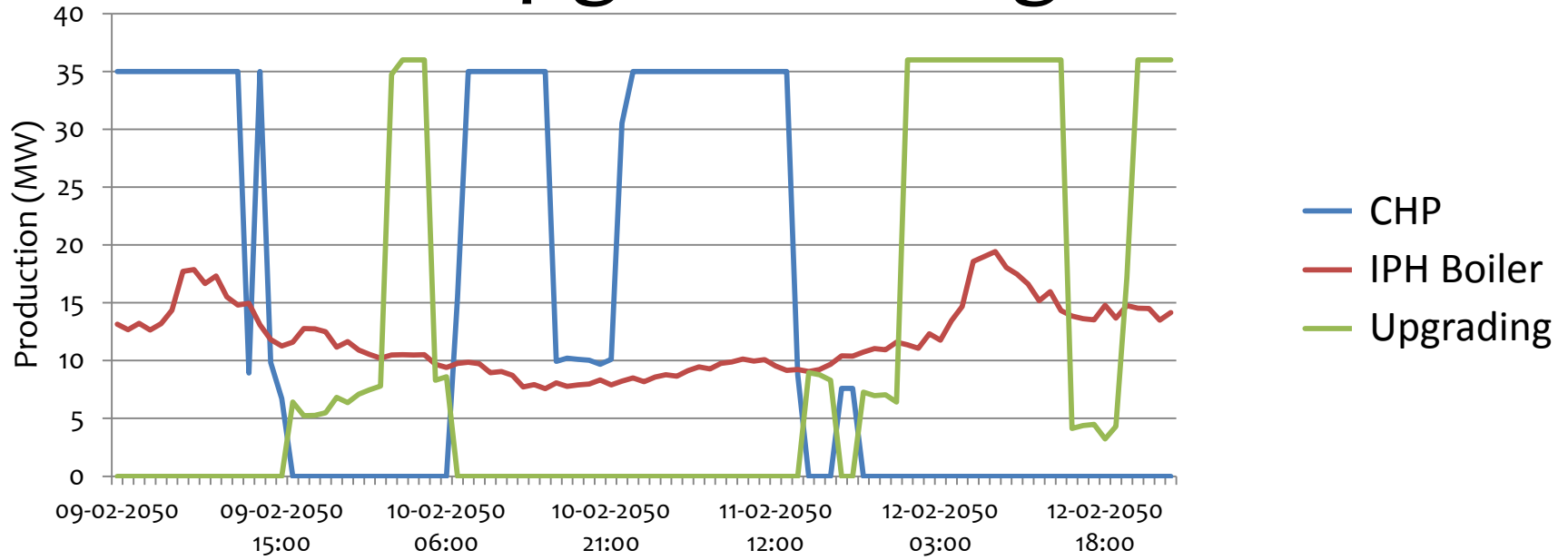
Decentralized CHPs mode with H2 assisted upgrading



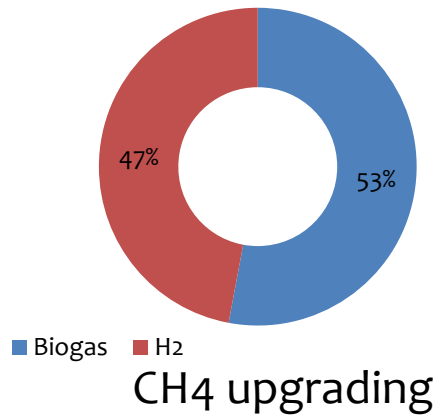
Local biogas CHPs and 1 Central CHP plant



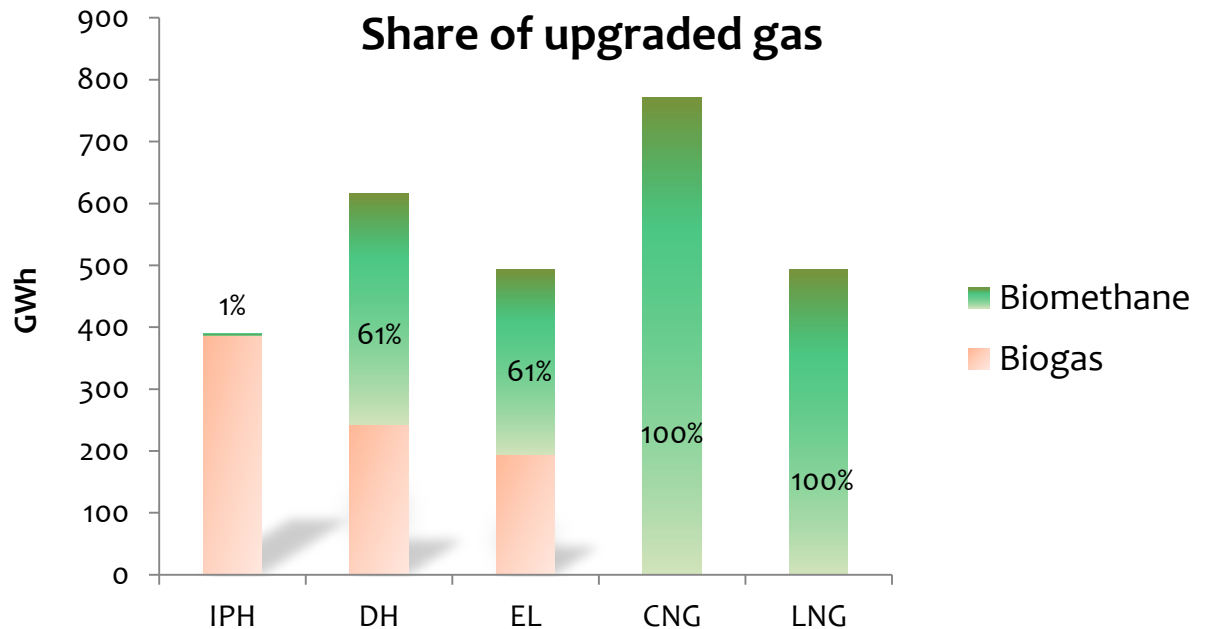
Upgraded biogas



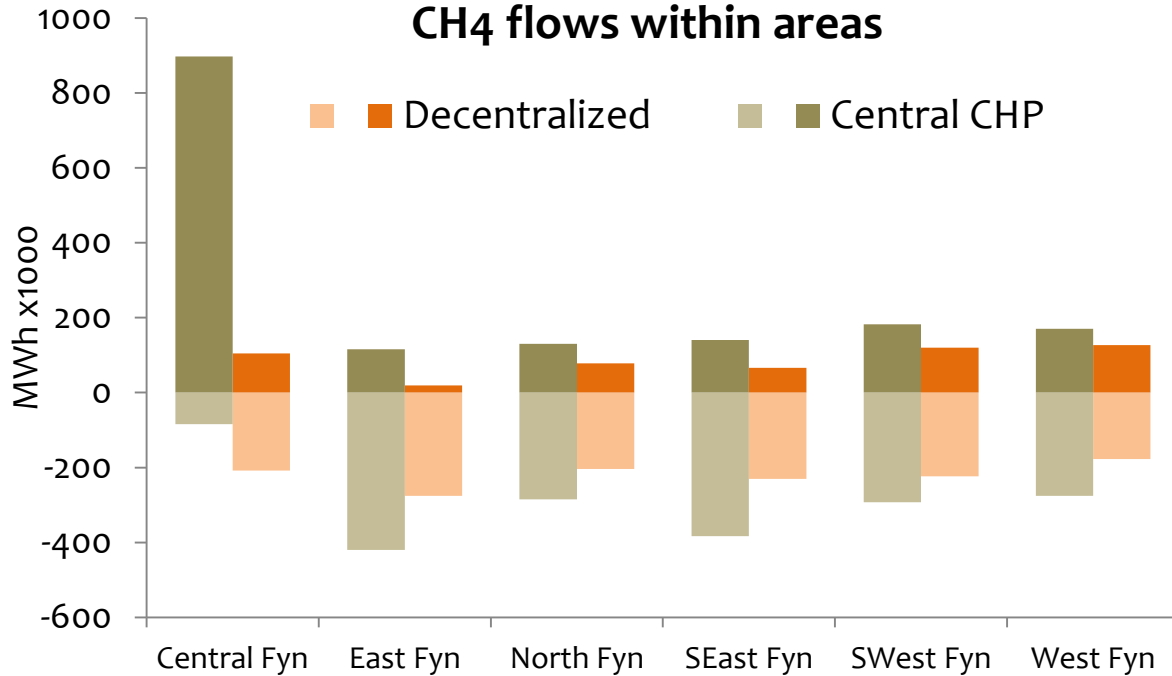
60% biogas upgraded



Share of upgraded gas



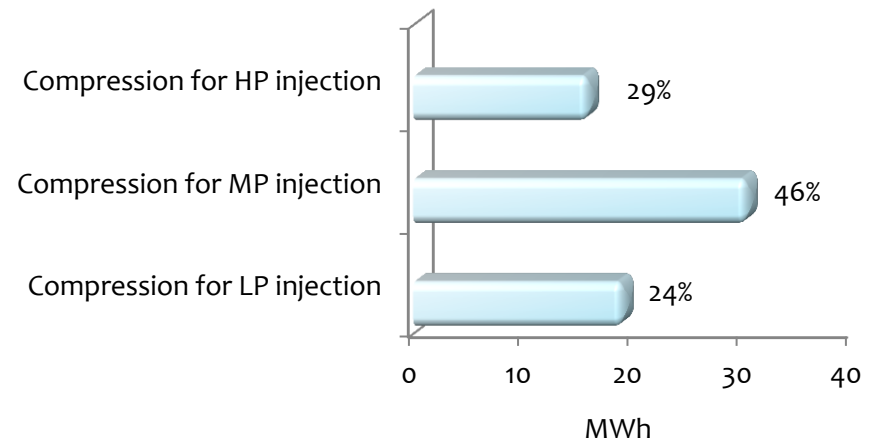
CH₄ flows within areas



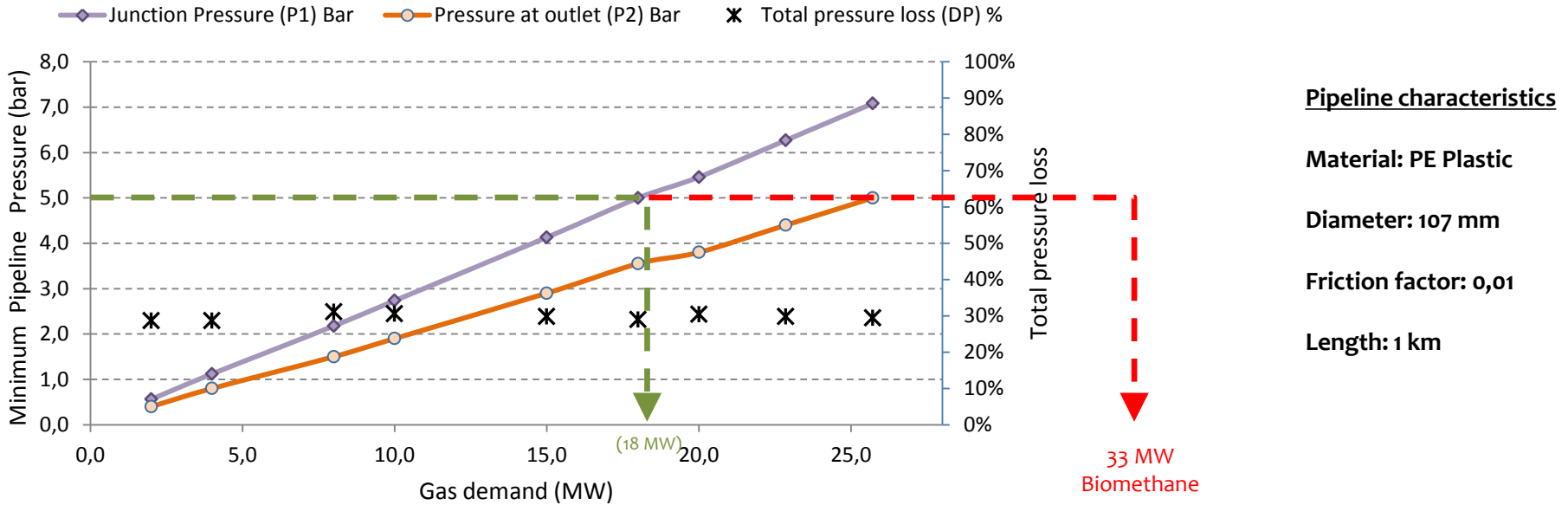
- **Medium pressure grid in stress during Centralized CHP production**

- High consumption in MP grid ~ upgraded gas volume
- Different compression levels depending on the upgrading technology

Electricity consumption of compressors



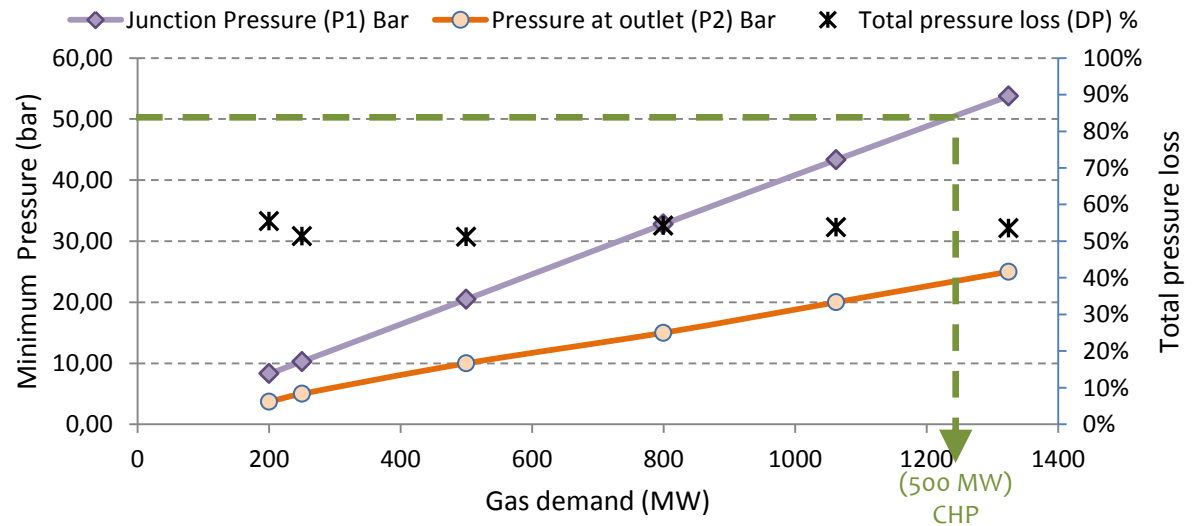
Maximum Biogas Capacity in low-pressure grid



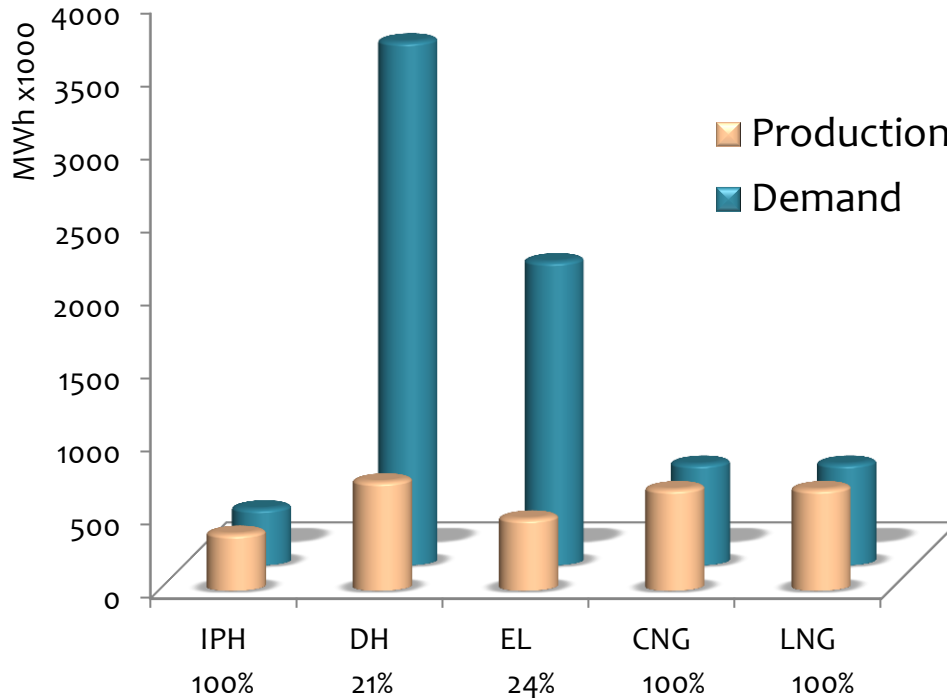
Minimum Biomethane pressures

Pipeline characteristics

- Material: Steel
- Diameter: 312 mm
- Friction factor: 0,015
- Length: 20 km



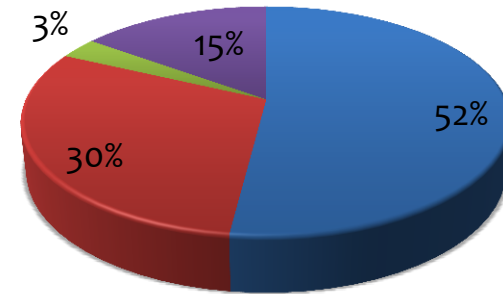
Energy in different sectors



- Though gas import is 15% in volume, import actually occurs 38% of time

- Biomethane grid fully catering to Transport sector

Primary Energy Supply



■ Biogas ■ Electricity ■ Compression ■ Imported Gas

Concluding remarks

- The system is capable of balancing the supply & demand majority of the time
- 60% of biogas is upgraded to biomethane
- More strain is observed on MP biomethane grid
- Improvements through:
 - Optimization of the storages to increase flexibility of upgrading
 - &
 - Operational strategies for compressors to minimize gas imports

Thank you

