Gas Market Council
Malmö 27th November 2018

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Agenda

1. DK development
   - Gas fired heat pumps
   - Hybrid solutions
   - Biogas growth & upgrading

2. Gas quality issues
   - Wobbe standardization work
   - Oxygen
   - Fluctuations - boilers

3. Methane emissions
   - International cooperation
   - Documentation in DK (ongoing)

Danish Gas Technology Centre

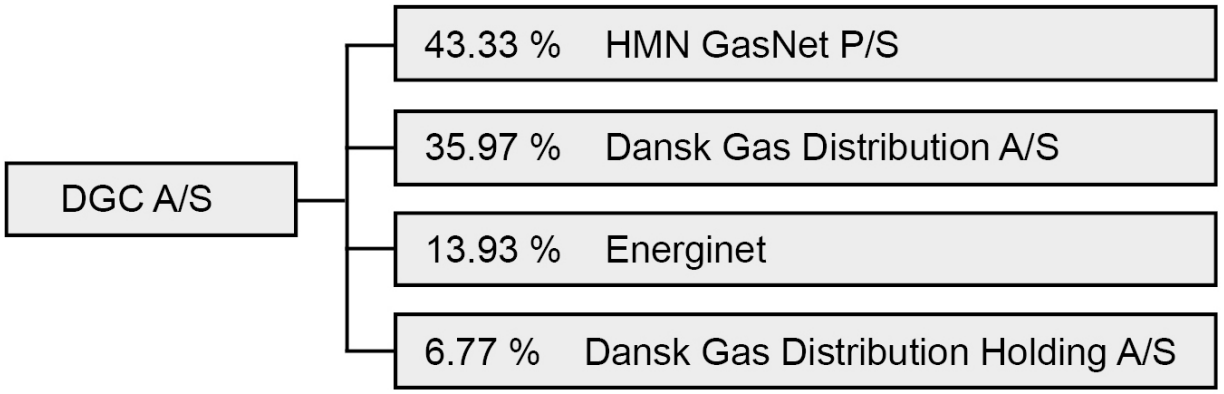
- DGC is a consulting and development organization within energy and environment focusing on energy gases
- DGC was established in 1988 by the Danish gas companies.
- DGC works with all energy gasses: natural gas, town gas, LPG, biogas and hydrogen, but also with combinations of gas and renewable energy.

DGC in Hørsholm and Aalborg

DGC has a local office in **Aalborg**

DGC's main office and laboratory are located in **Hørsholm**, 20 km North of Copenhagen, at the SCION DTU Science Park.

Ownership



DGC ownership structure chart 2018

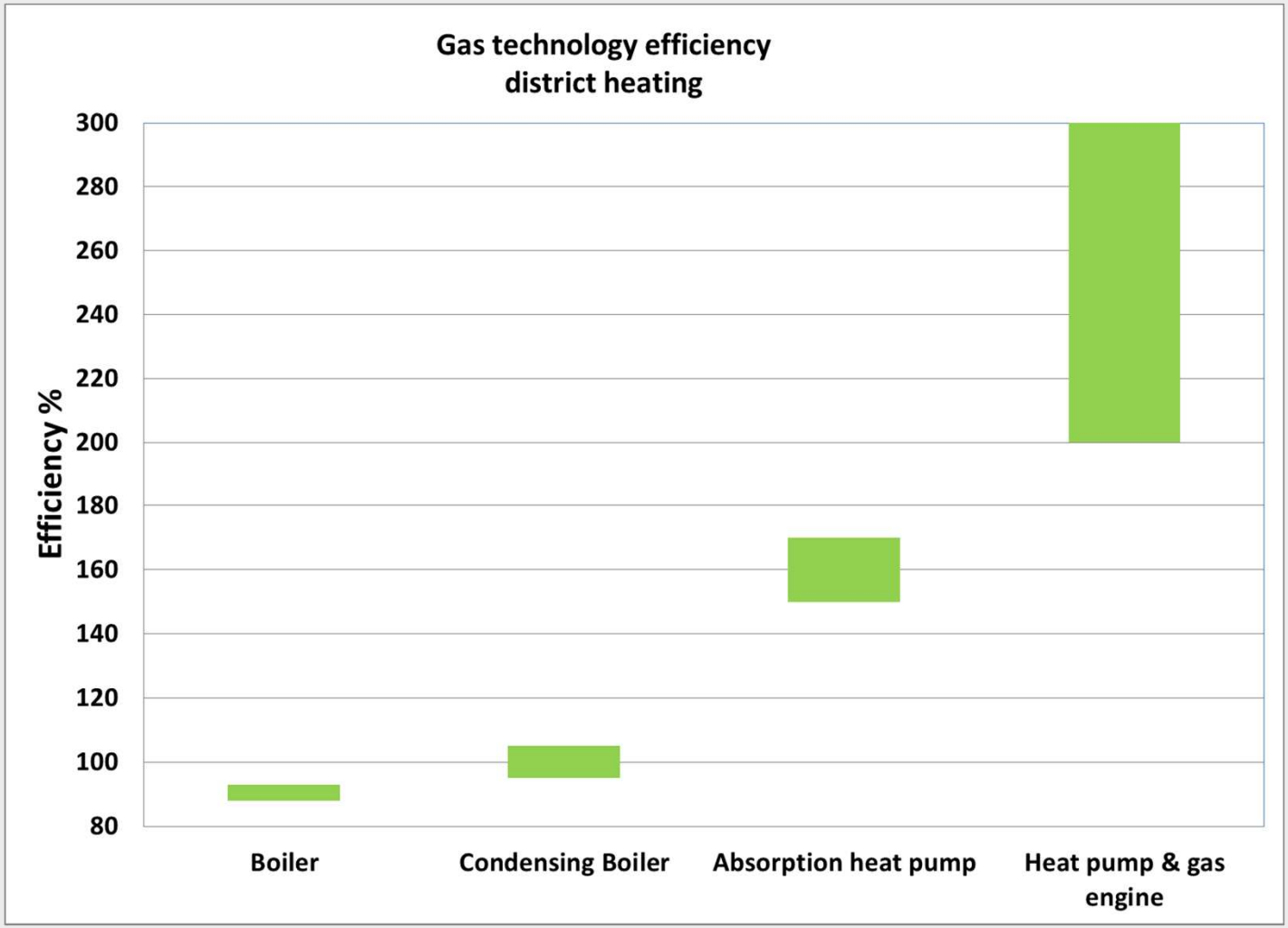
Gas company and DGC R&D

The R&D activities in DGC are application oriented

Why Gas fired heat pumps

- Other technologies challenge traditional gas fired solutions
- 100 % in efficiency is not enough
  - Large power driven heat pumps, tax free biomass gives low cost heat

New technology – high efficiency



Demonstration project

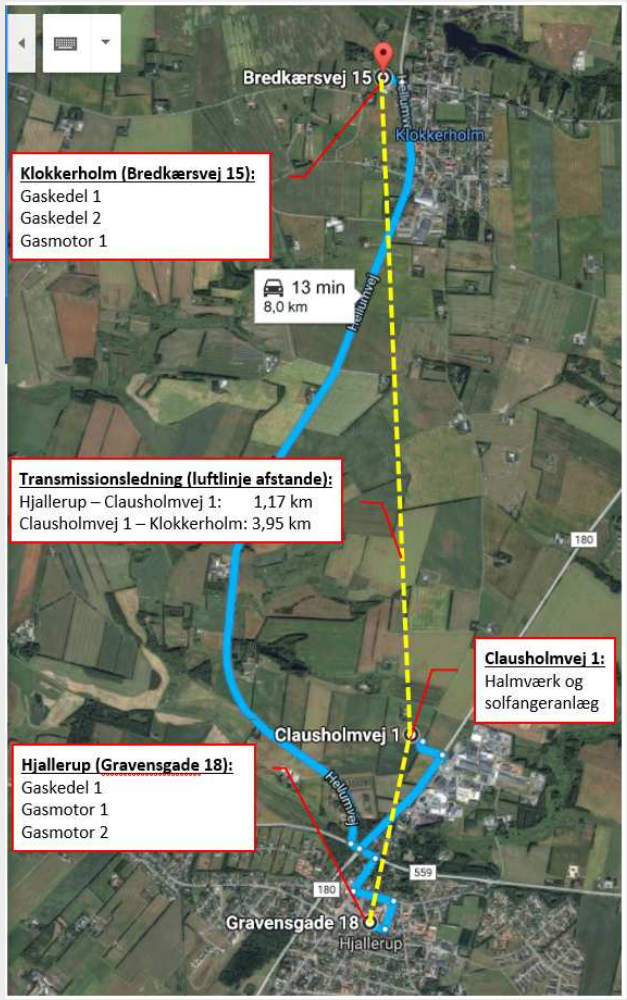
- Objective to demonstrate direct gas fired absorption heat pump in district heating size

- Part 1
  - Technology description and system integration
  - Analyze cost and regulation

- Part 2
  - Installation of demo plant
  - Test, demonstration and documentation
  - Report and dissemination

Hjallerup Fjernvarme

- 3 locations
- Productions facilities
  - Gasboiler
  - Gas engine
  - Straw boiler
  - Solar heating panels
  - Heat pump



Hjallerup Fjernvarme

Hjallerup

Klokkerholm

Clausholmvej

Heat pump installation – Hjallerup Fjernvarme

Why absorption heat pump?

- Lower cost of heat
- Low CAPEX compared to compression heat pump
- Simple and low noise

- For Hjallerup
  - Less heat transmission loss
  - Increased power from solar panels
  - Longer season for solar
  - Savings annually approximately 1,3 mio. DKK./year

New technology – high efficiency – low cost heat

Comparison

- Gas boiler 98 % efficiency

~430 DKK/MWh

- Direct fired absorption heat pump with COP 1,7

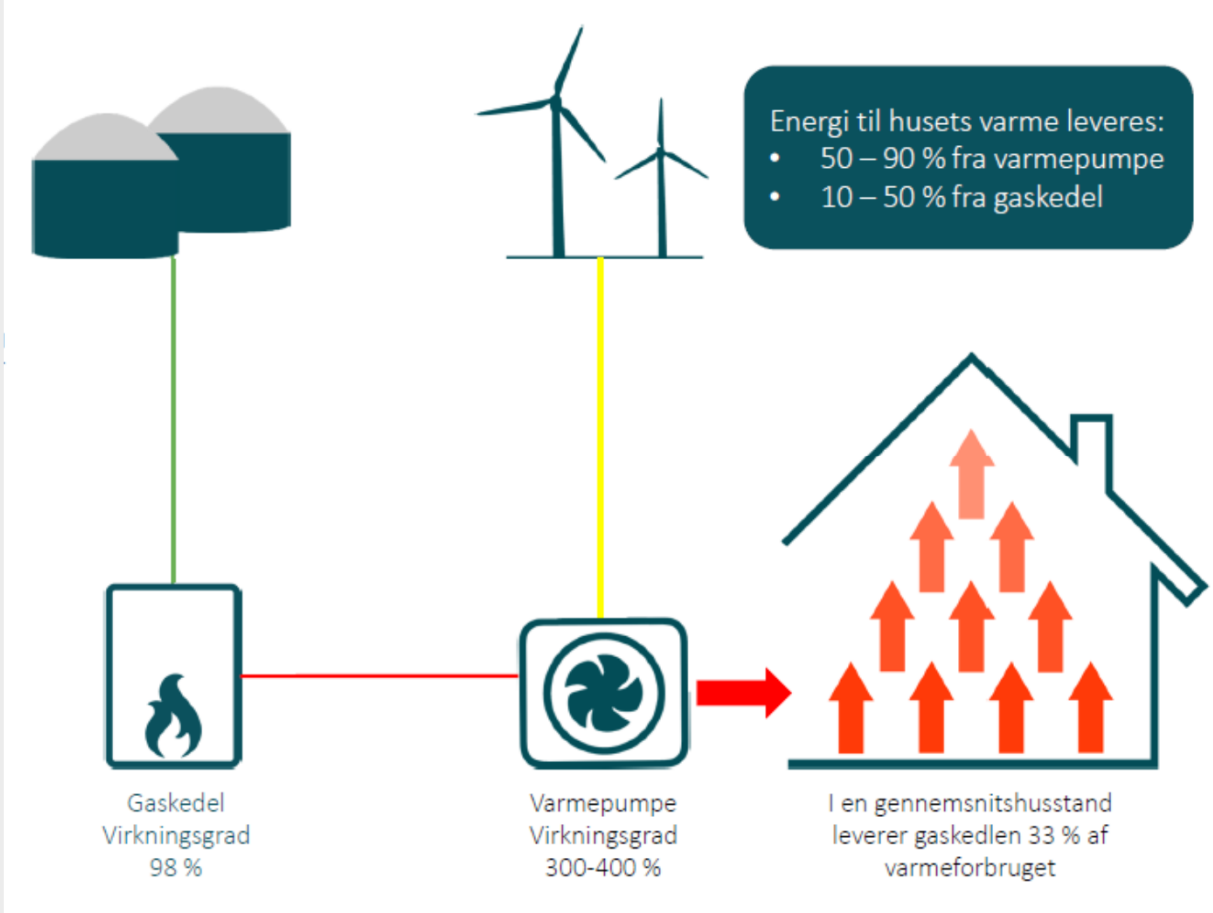
~250 DKK/MWh

<u>As cost using wood chips!</u>

You need a heat source

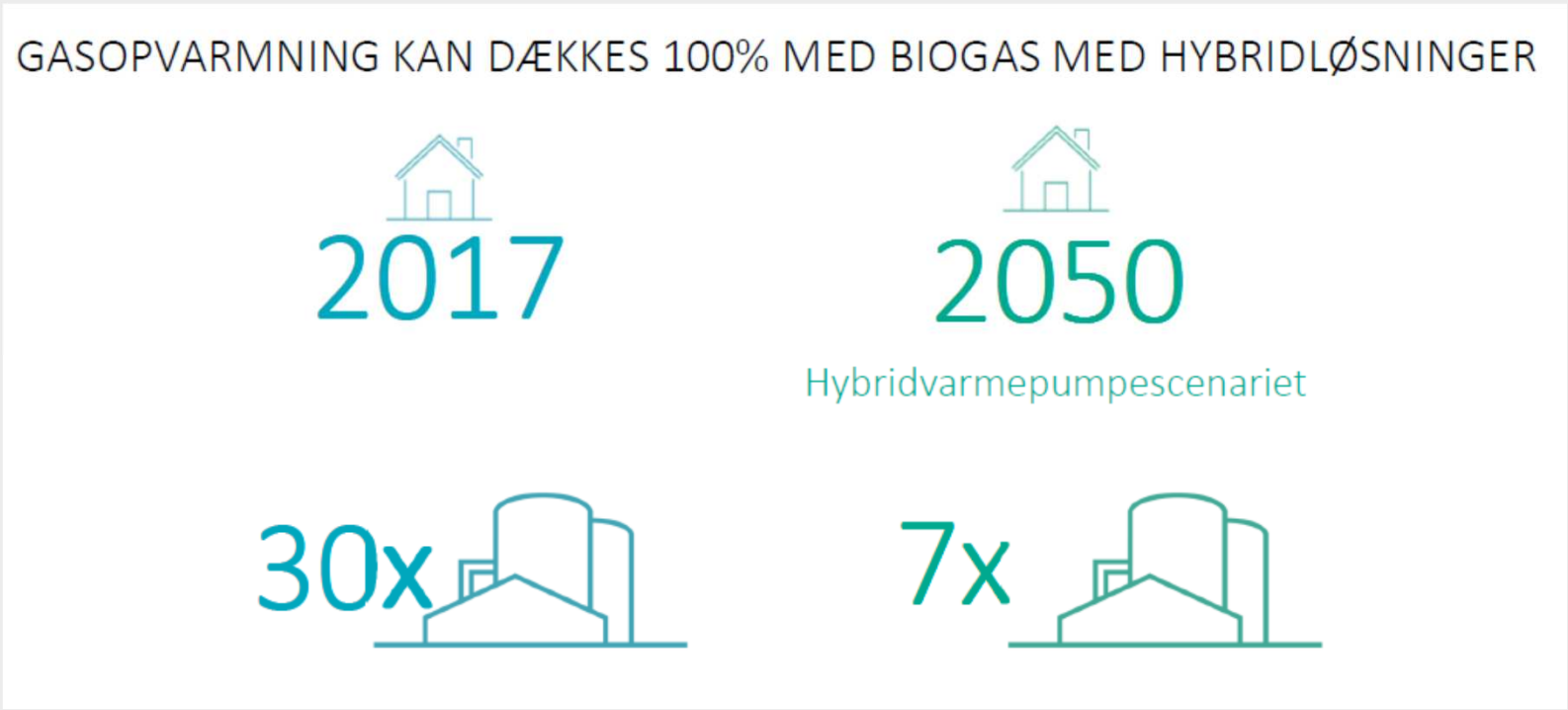
- Waste heat from industry
- Geothermal heat
- Internal sources
  - Cooling flue gas
  - Cooling of water before process (solar, other)
  - Water from sea/lake

Hybrid house heating



Hybridvarmepumper, Energinet, 5. januar 2018 (rapport)

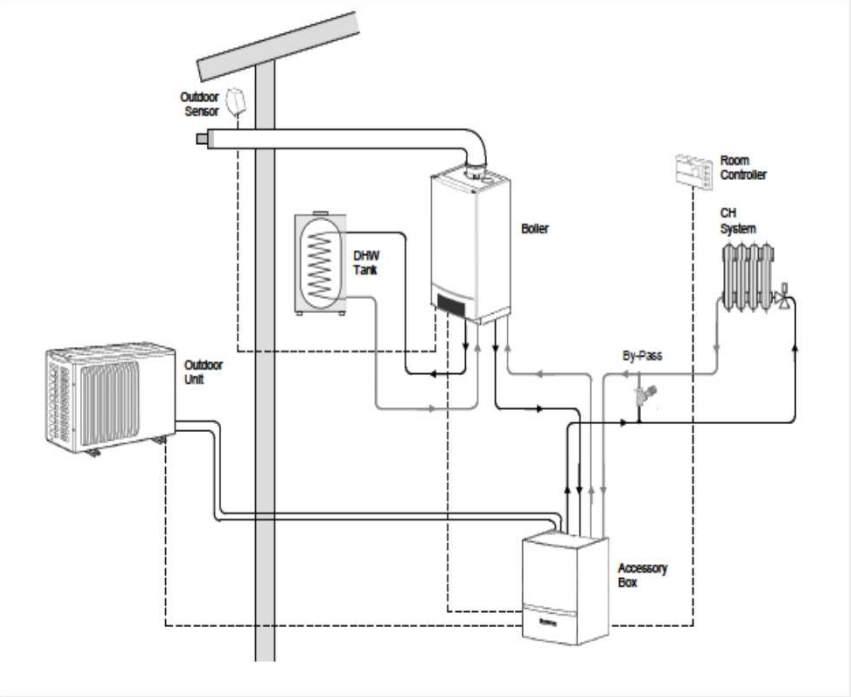
Hybrid, biogas and heating



Hybridvarmepumper, Energinet, 5. januar 2018 (rapport)

Hybrid house heating

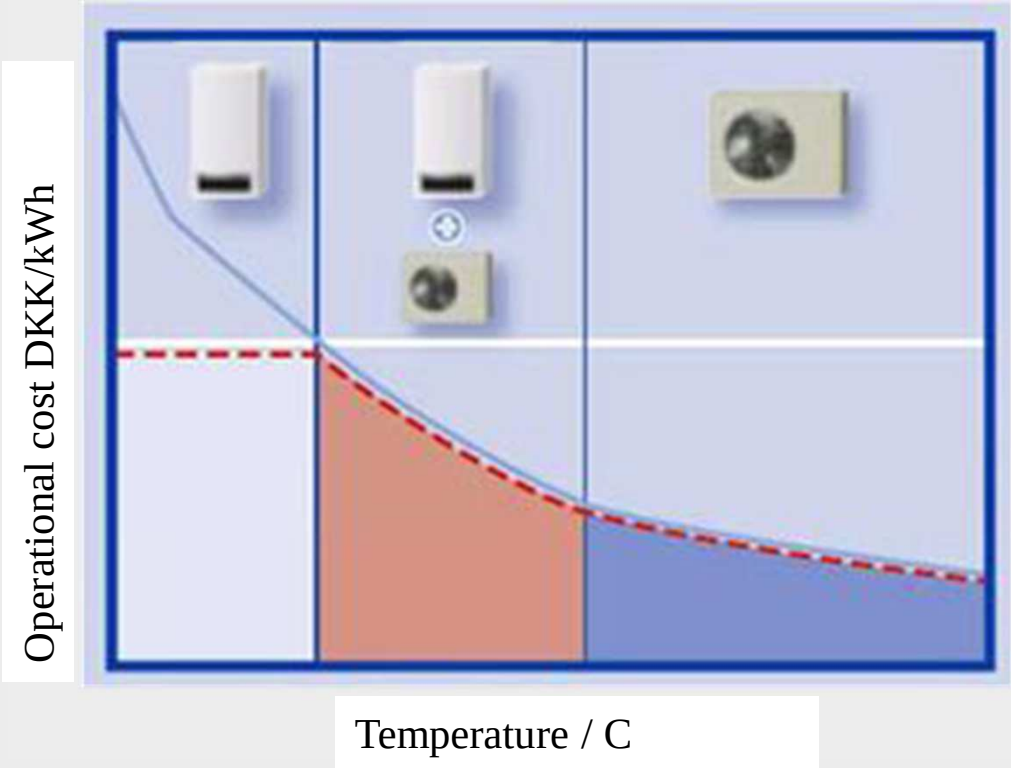
- Heat pump 70 % of house heat demand
- Boiler cower remaining heat demand and hot water production



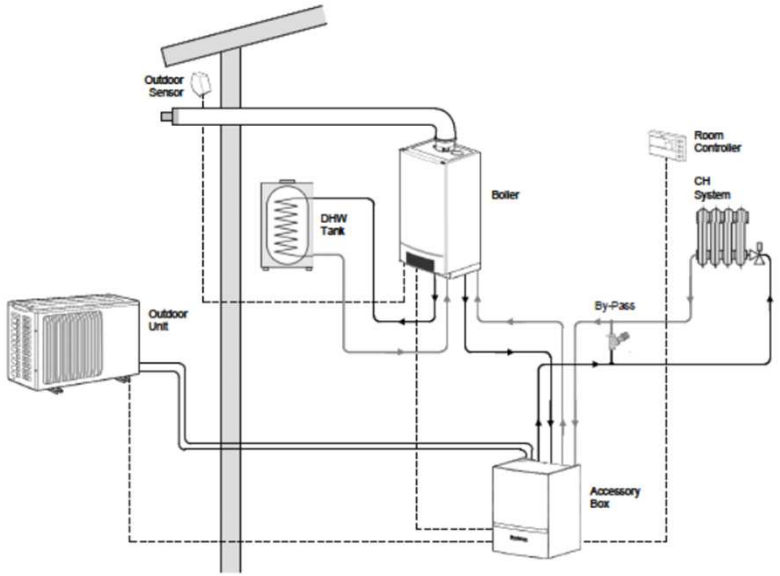
Hybrid heating cost & control

Control parameters:

- Temperature (simple)
- Actual gas- og power cost
- Amount of renewable power in grid

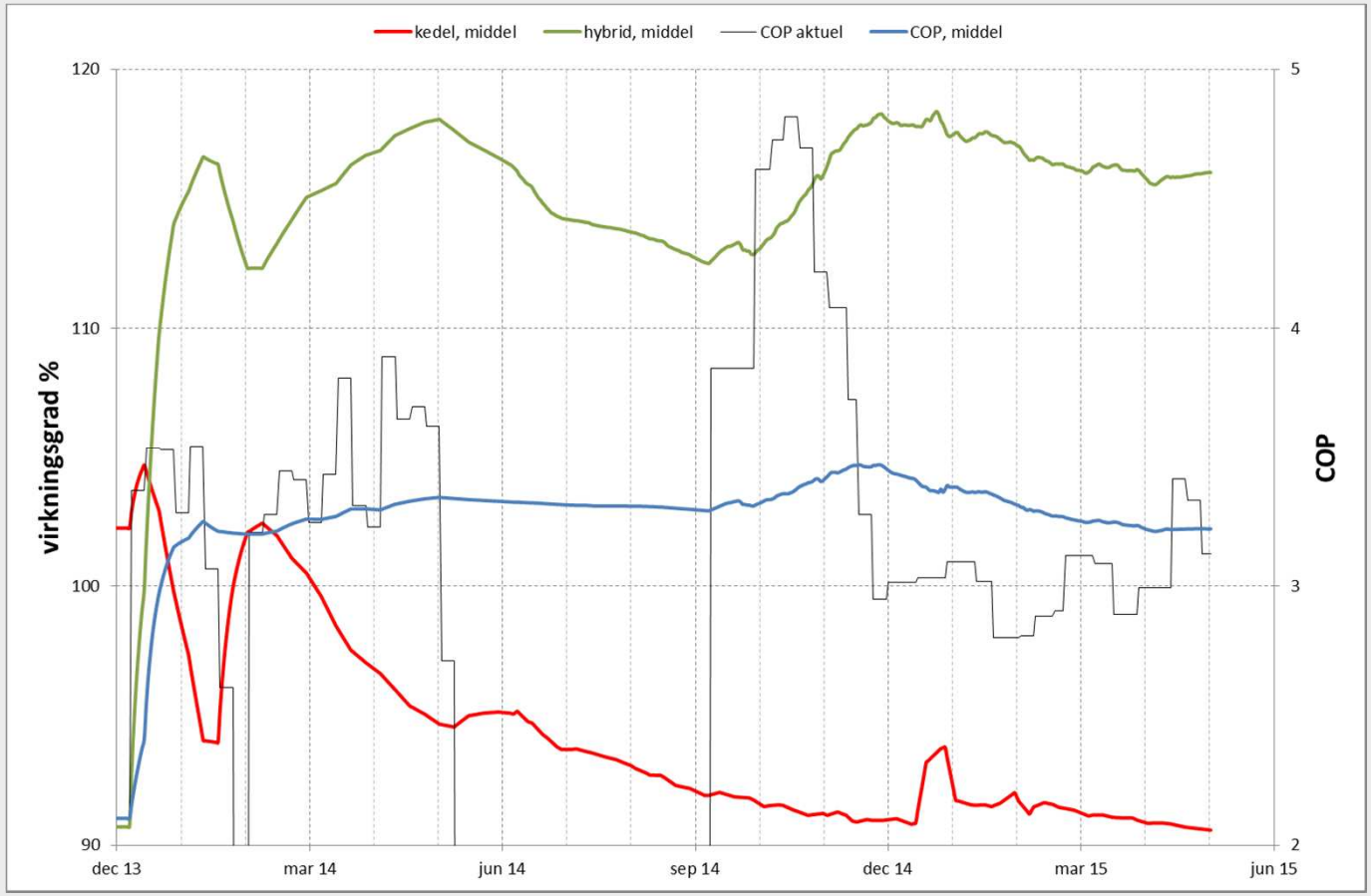


Case – house

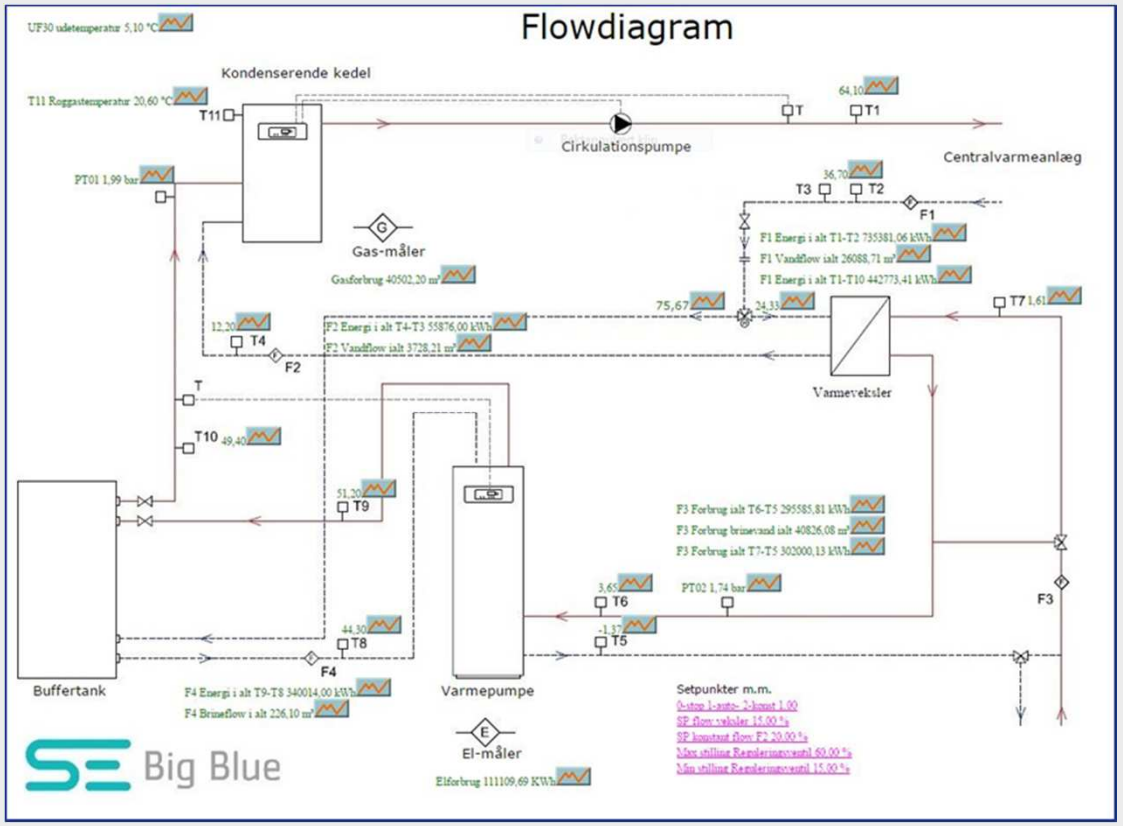


Kilde: DGC/FAU GI/MHG-demonstrationsprojekt

Boiler efficiency and heat pump COP

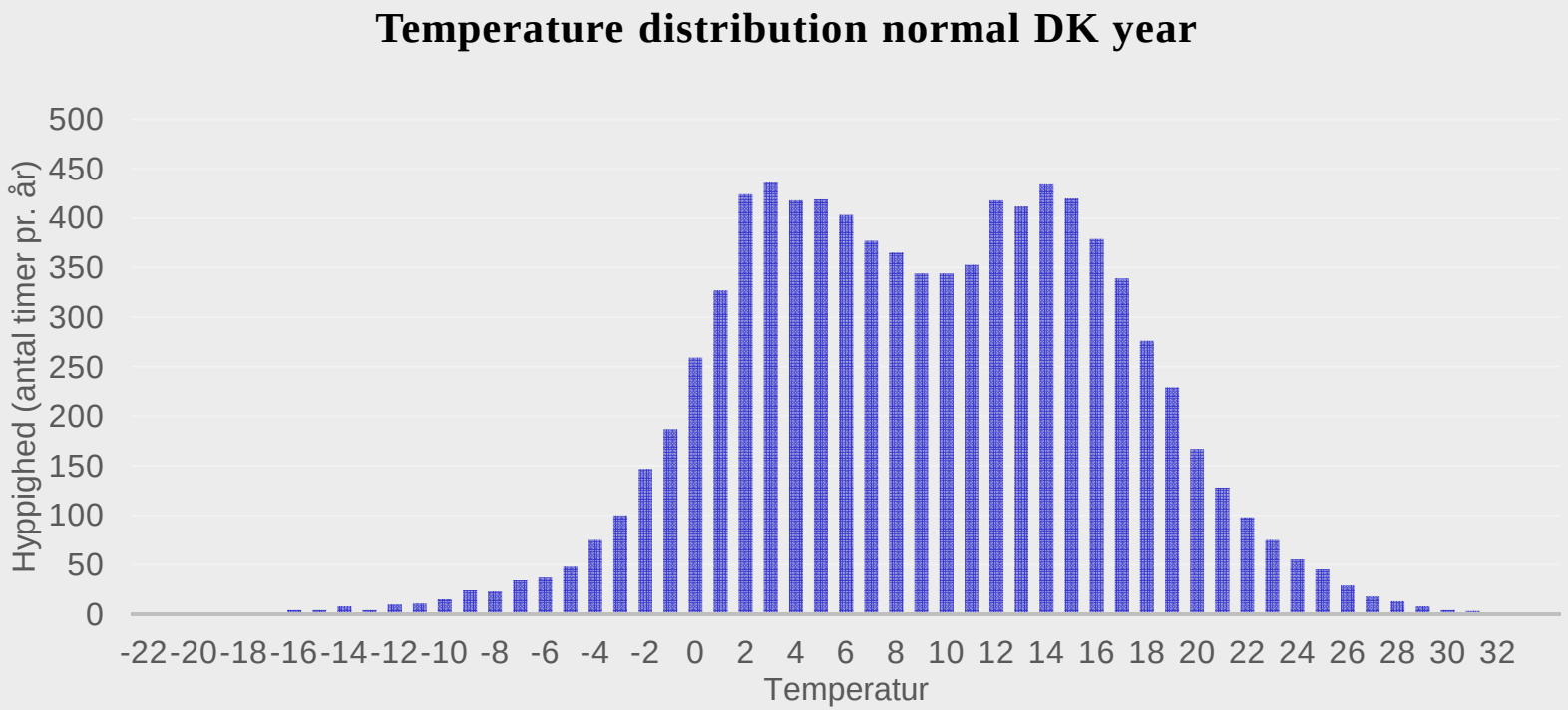


Demo larger hybrid (Ribe)



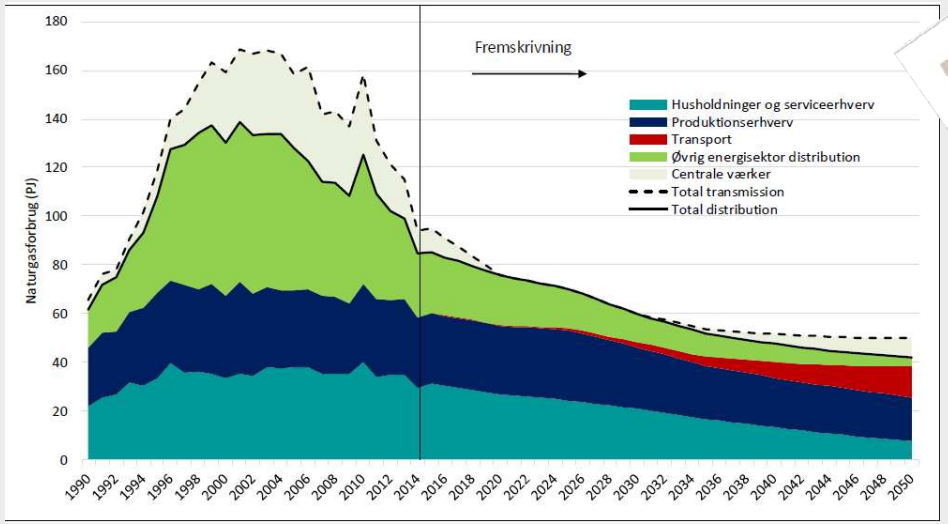
Size of heat pump and boiler

- Cold temperatures are statistically rare, therefore a small heat pump can deliver a large fraction of the heat demand



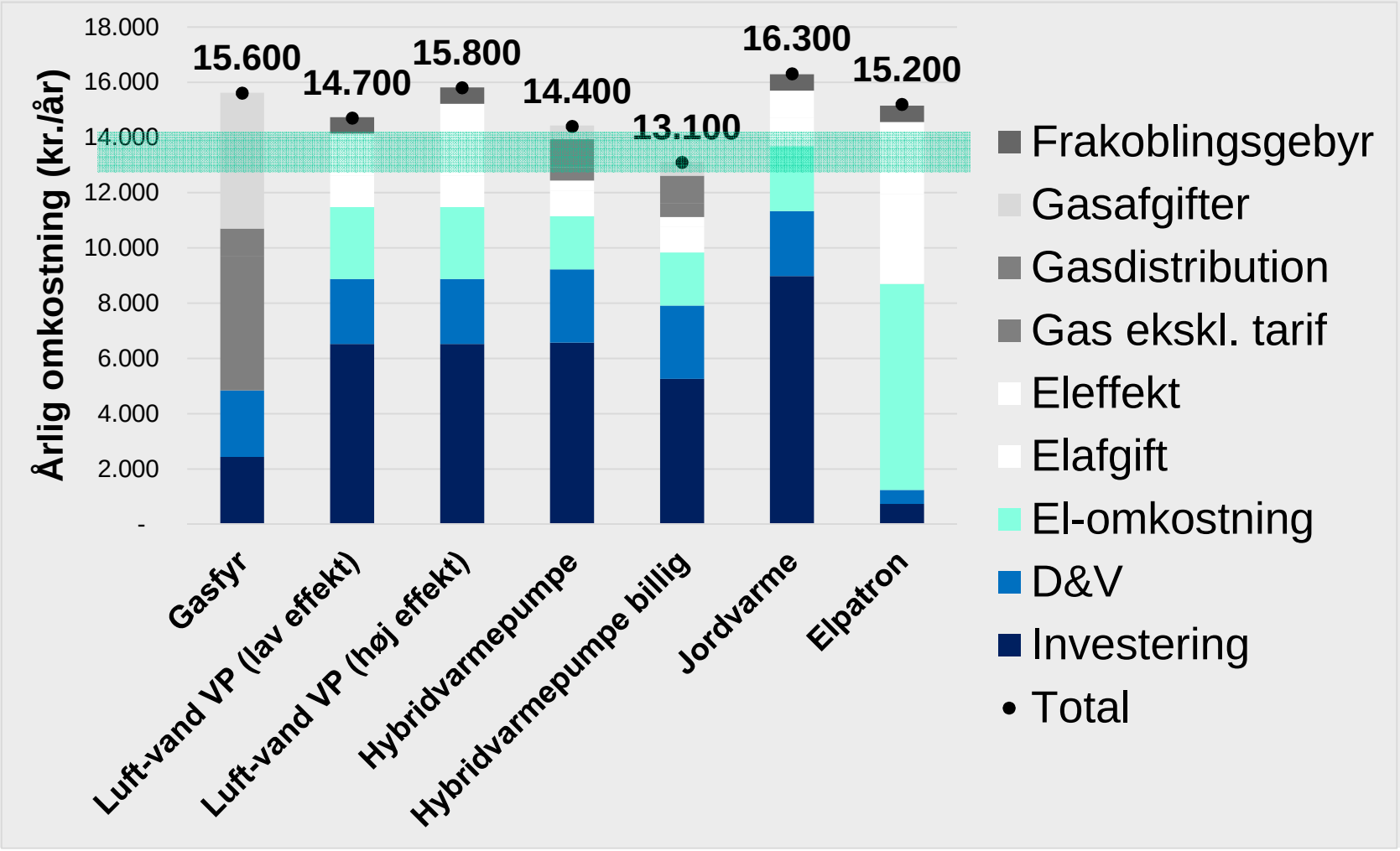
Sceneries for gas customers in Denmark

- Previous analysis

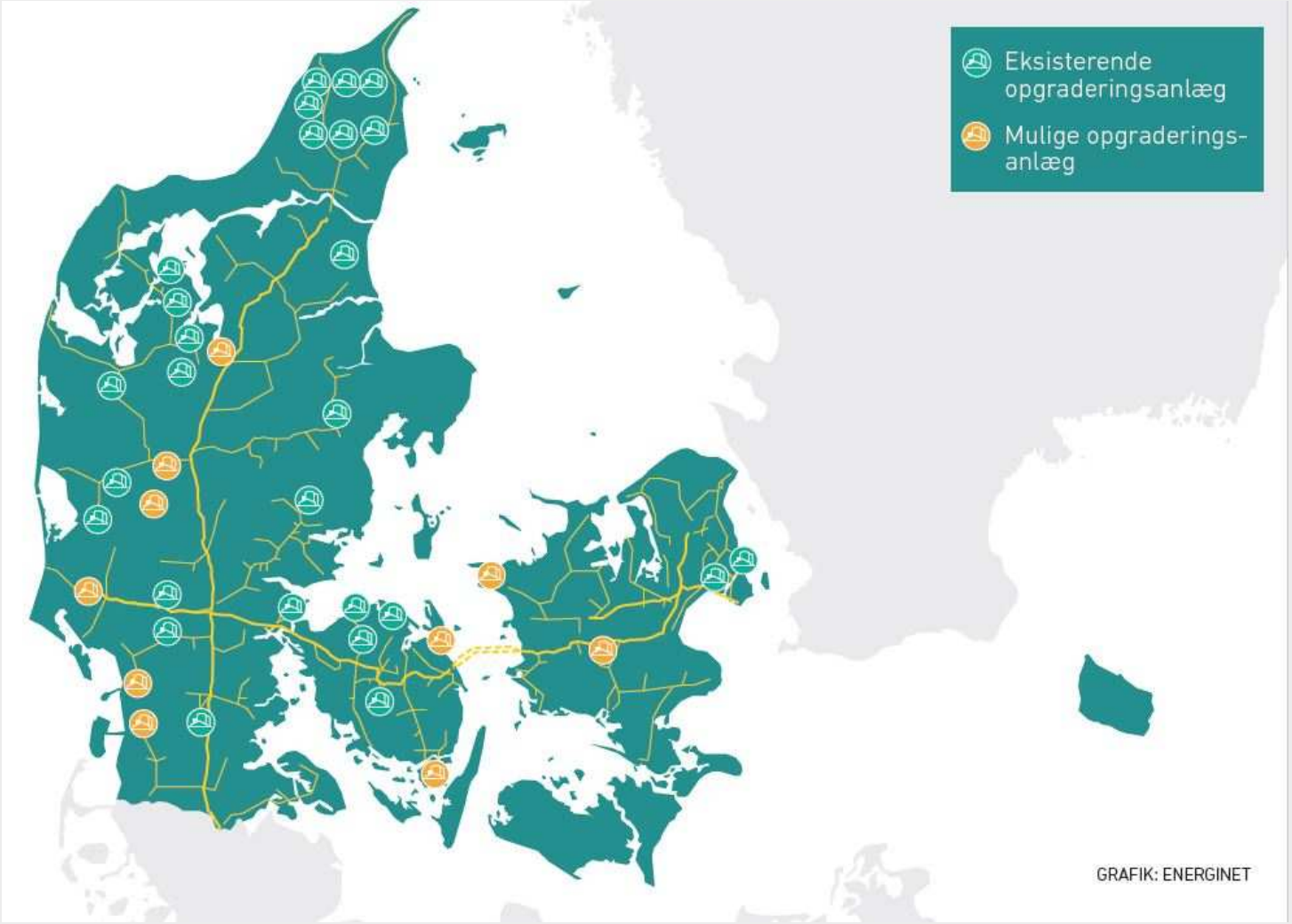


- Expanded with hybrid solutions

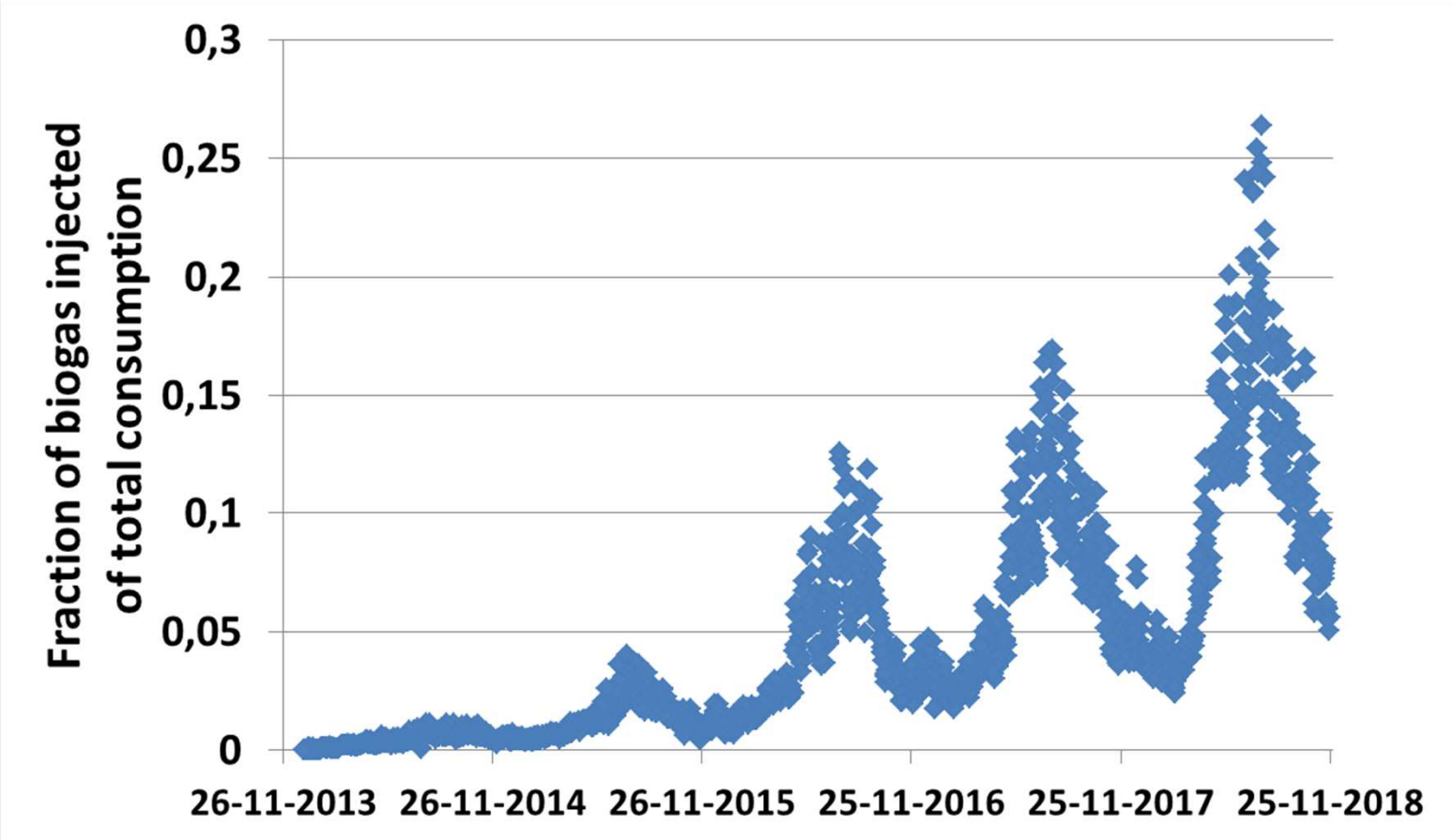
Cost for house heating 2030



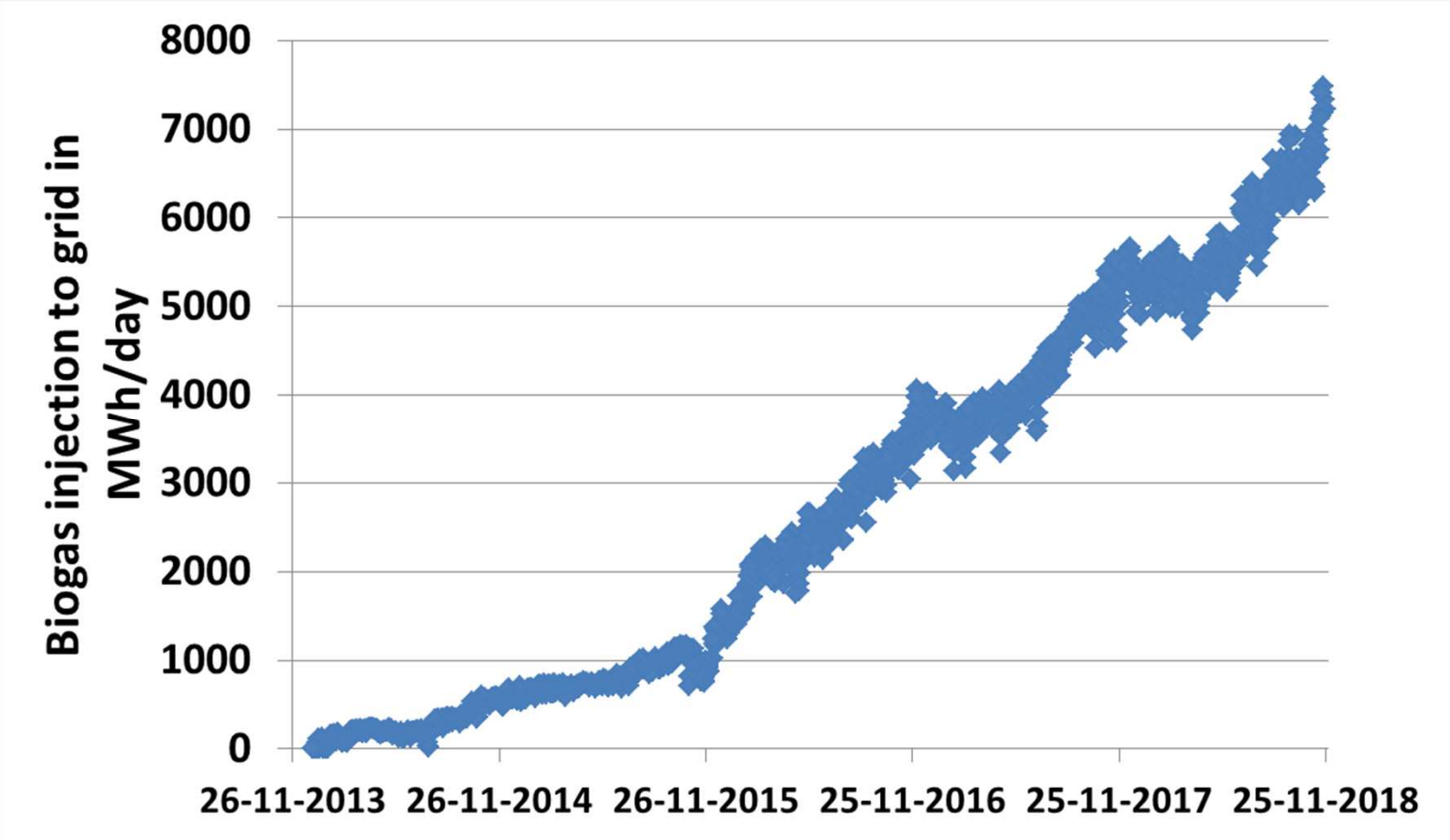
Biogas development in Denmark



Biogas development in Denmark



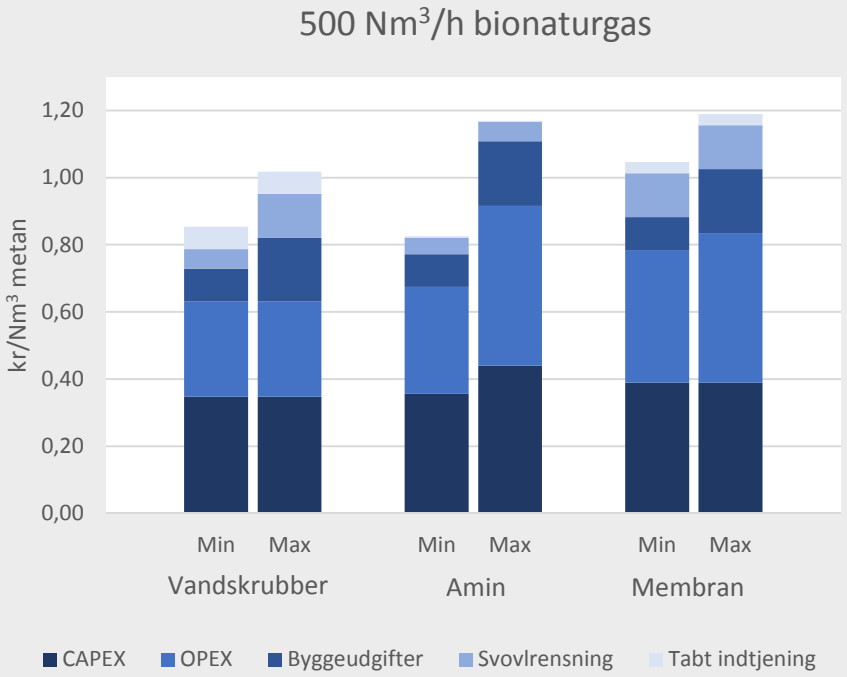
Biogas development in Denmark

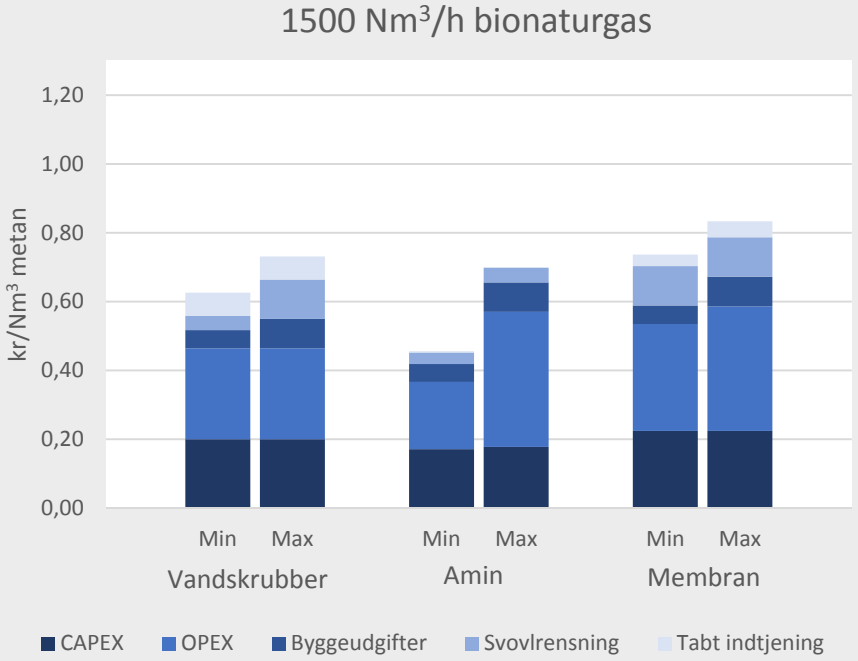


Biogas development in Denmark

- Biogas production expanding rapidly
- Focus is on cost of energy
- Improve production and lower cost

Project results example, upgrading cost



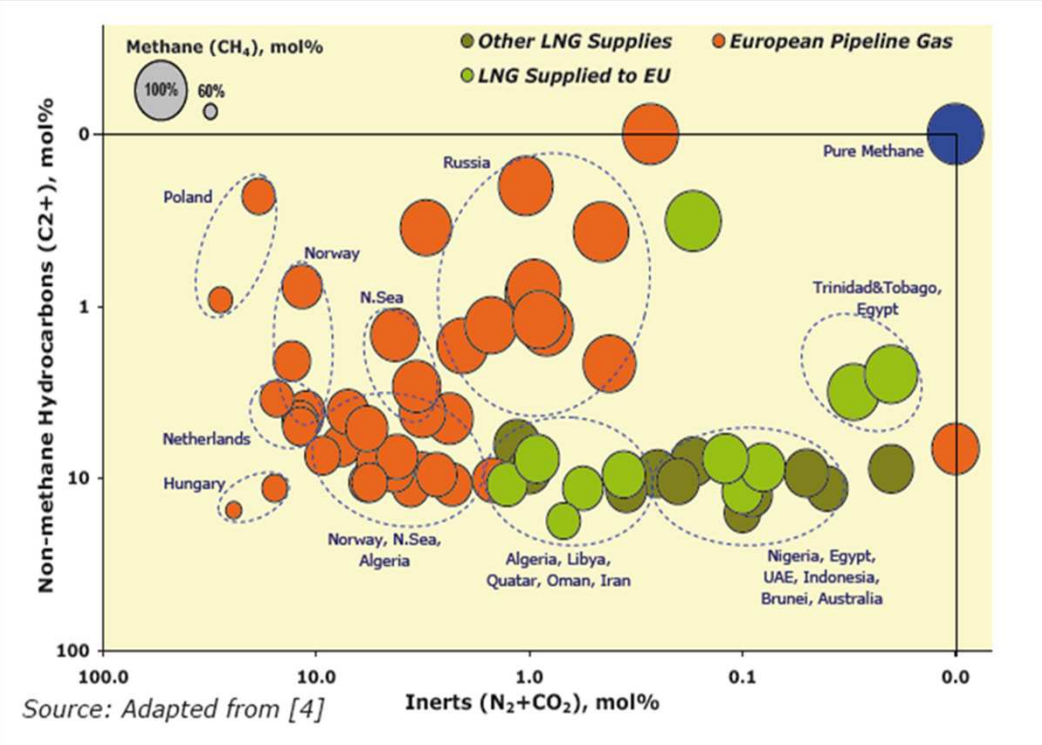


Gas quality issues

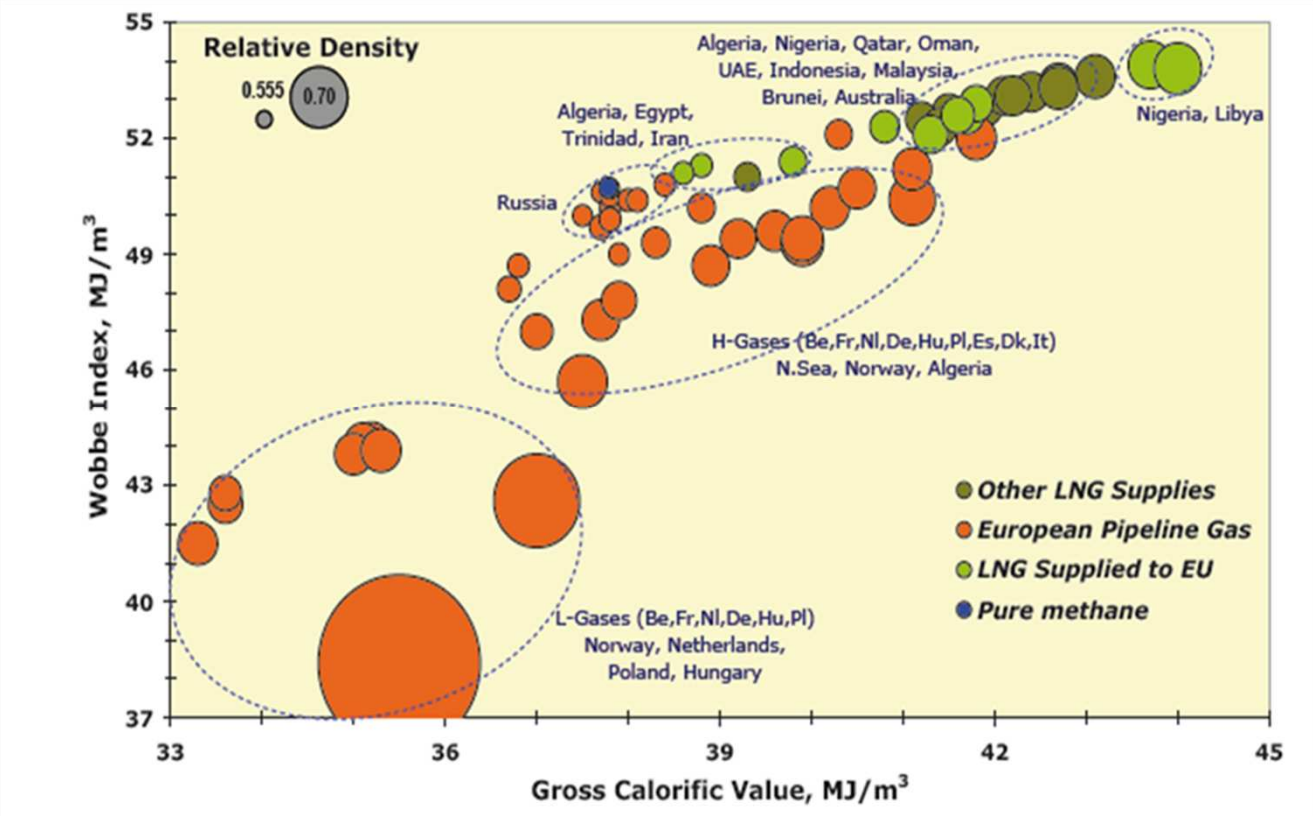
Natural gas

Natural gas is not only CH4, but other components (C2H6, C3H8, CO2, etc….)

Natural gas composition and characteristics depends on it origin



Liquefied Natural Gas for Europe – Some Important Issues for Consideration. JRC B. Kavalov, H. Petri´c, A. Georgakaki



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Natural gas main parameters

Heating value or Calorific value

This represents the energy content of a gas, usually given in units of MJ/m3.

Wobbe Index or Wobbe Number

This is the most widely used interchangeability factor. Wobbe Index is defined with the calorific value and the relative density to air.

Methane Number (MN)

The main parameter for rating the knock resistance of gaseous fuels, which is by function analogous to the Octane Number for gasoline.

Gas quality change potential impact on applications

- Safety
- Efficiency
- Emissions (NOx, CO)
- Operation
- Other (eg. feedstock)

Safety parameters and Gas quality

Possible SAFETY issues related to gas combustion:

CO emissions

Depends on the Wobbe

Flame lift

Depends on the Wobbe

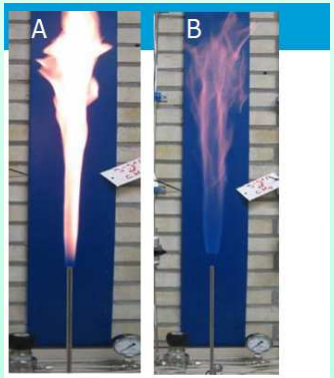


Figure 1: Effect of CO_2 addition on a flame: A - stable natural gas flame; B - Lift when adding CO_2

CO is a major risk for the domestic market. (See next slide)

Most of the appliances safety can be covered by the following parameters:

- ***Wobbe Index***
- ***Density***
- ***H2 content***

Flash back

Depends mainly on presence of H2

Sooting/ Incomplete combustion

Depends mainly on high concentration of heavy hydrocarbons (Wobbe & density)

Picture credit:

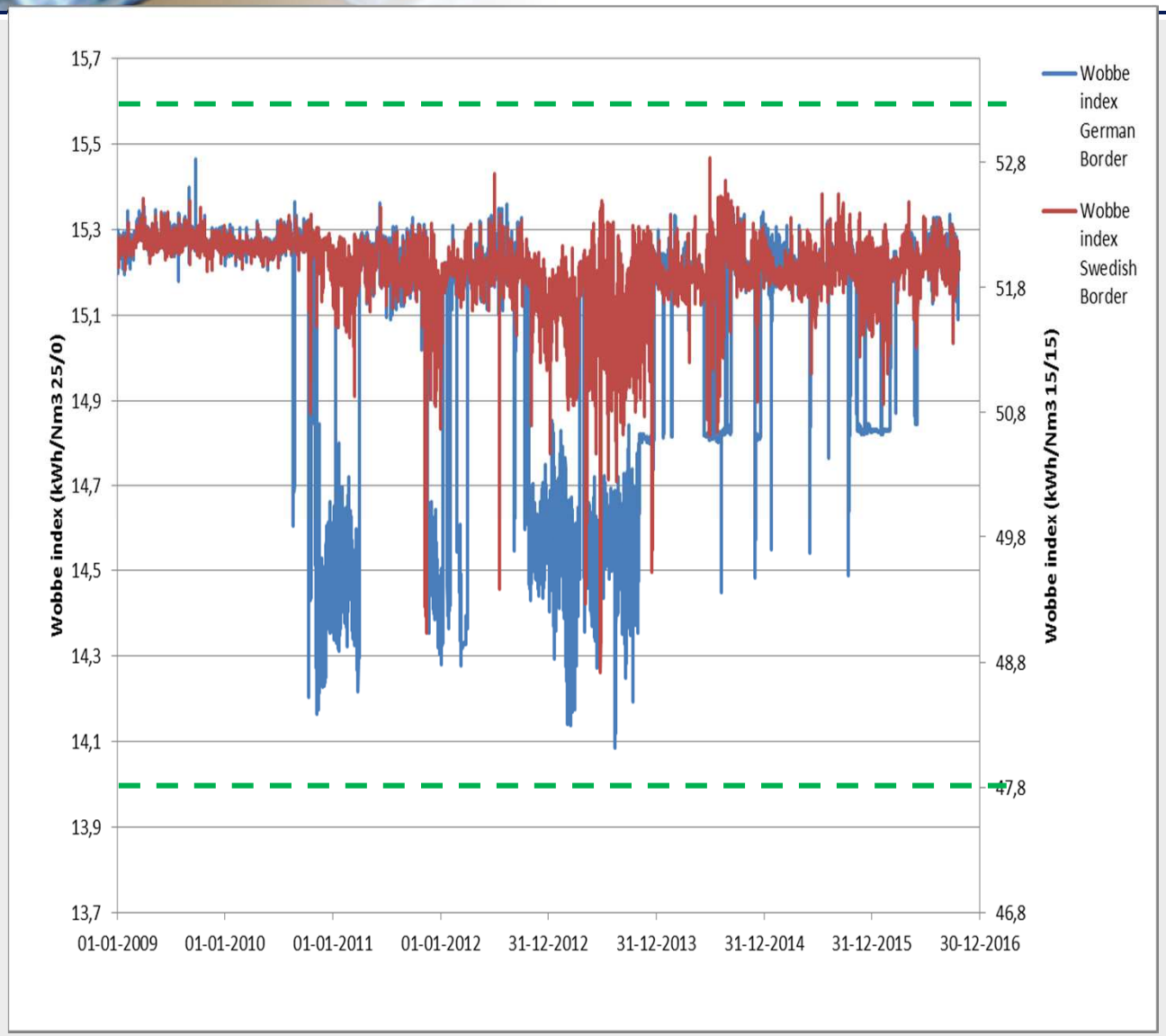
Things to consider for domestic appliances when introducing sustainable gases. Essen, Martijn van, Sander Gersen, Pieter Visser, Berthil Slim, Harmen de Vries, Harry Darmeveil, Gerco van Dijk & Howard Levinsky

Why is CO a main concern for safety

- Most of domestic appliances are installed inside houses
- A very large number (> 200 M in the EU)
- Some are flue less (Combustion products directly evacuated in the room (eg. Cookers, small water heaters)
- Leakage on the flue gas pipe is possible

→ The combustion shall be as clean as possible

→ Changes in gas quality will impact the combustion



Wobbe index variations at interconnection points

The gas quality is never constant

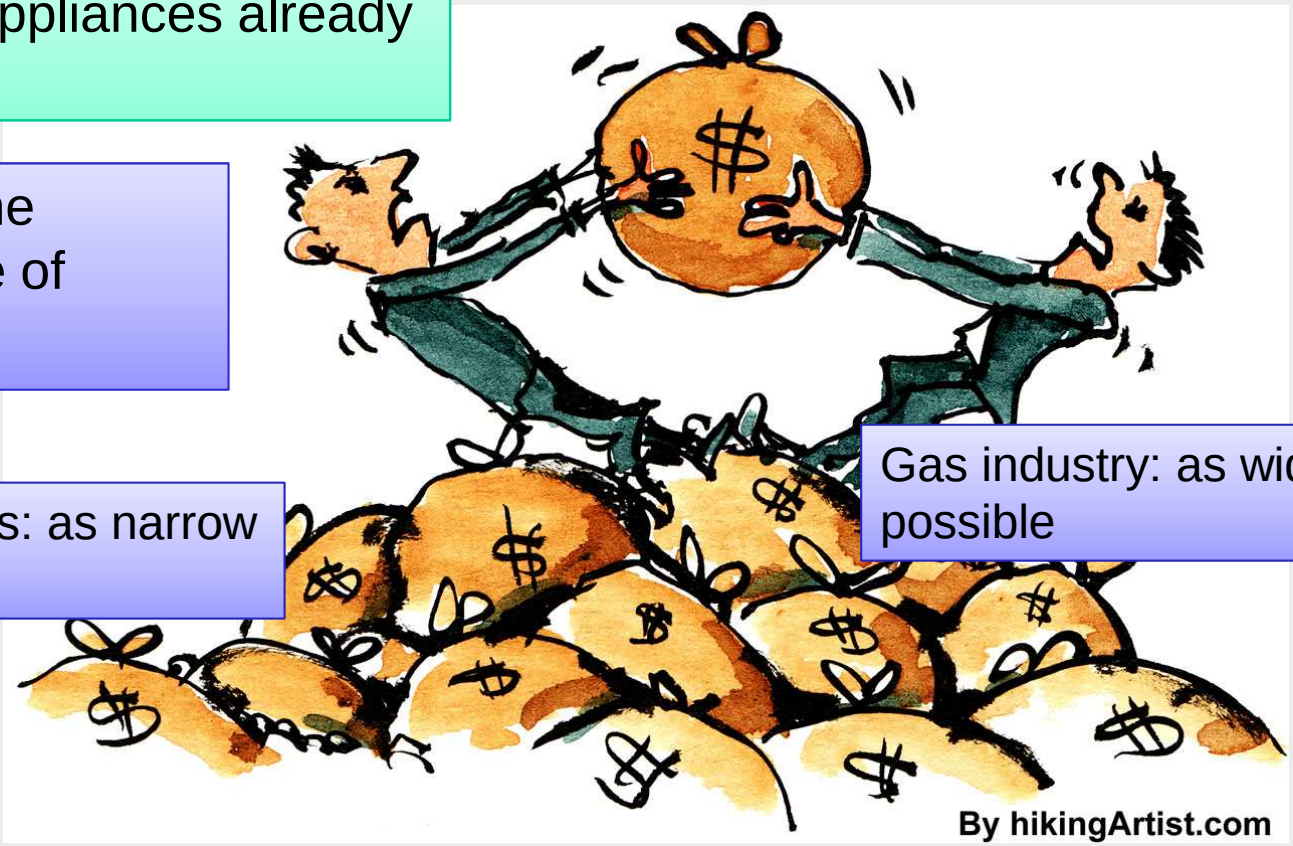
Source Energinet.dk

Why is it so long and so complicated?

27 countries with different supply, different history and a total of 200 millions of small appliances already installed!

What should be the harmonised range of variations?

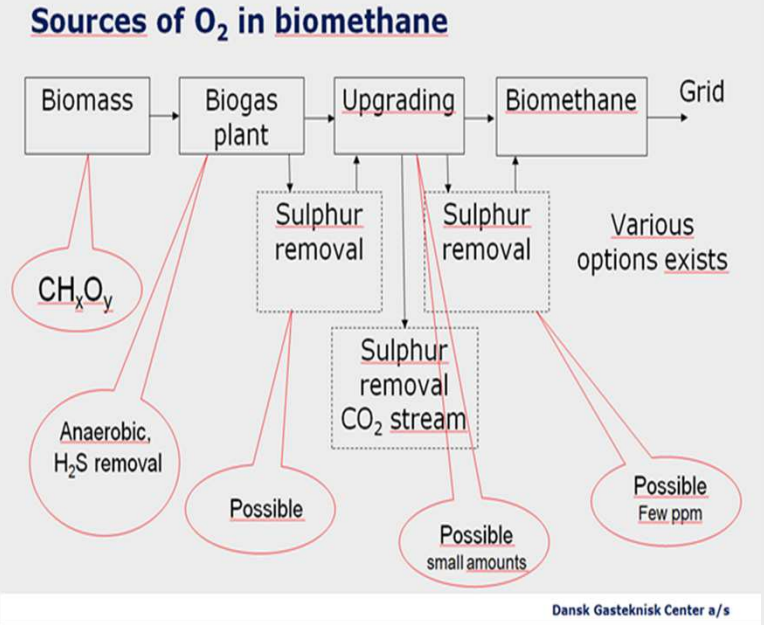
Manufacturers: as narrow as possible



Gas industry: as wide as possible

Oxygen in biomethane

- Surplus oxygen is in biomethane from the de-sulphurisation process of the biogas.
- Removing the oxygen is a technical possibility but will increase the cost (that is already high) to decarbonise the gas

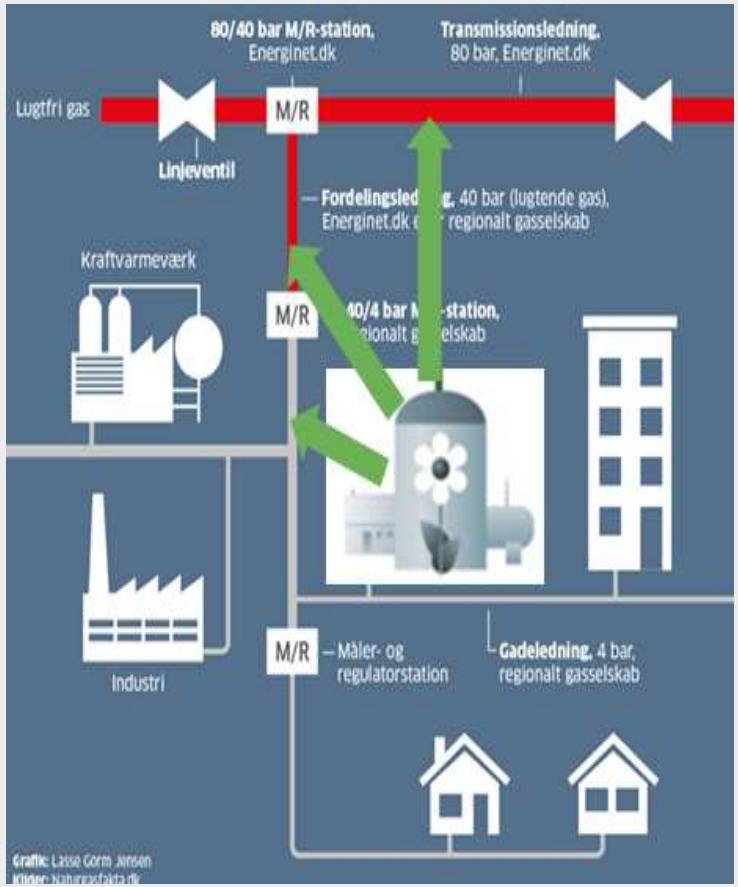


According the GERG project “Removing the technical barriers to use of biomethane in gas networks” (H2020 project), it is economically infeasible to meet the 10 ppm specifications

Consequences of more biomethane

- As more biomethane is injected into the system, bigger amounts will be compressed to higher pressure levels.
- **Oxygen from biomethane will reach many European transmission systems**.
- This may critically limit the operational degrees of freedom of the transmission system operators.

- **This is the time to choose the right path for the future handling of oxygen from biomethane.**



Cen gas quality standard EN 16726

- The standard was published in 2015. O2 limit in the standard EN 16726 was established without taking into account the fact that biomethane injection is rapidly developing in the EU.

- The application of EN 16726 has therefore already created issues because of the injection of biomethane.

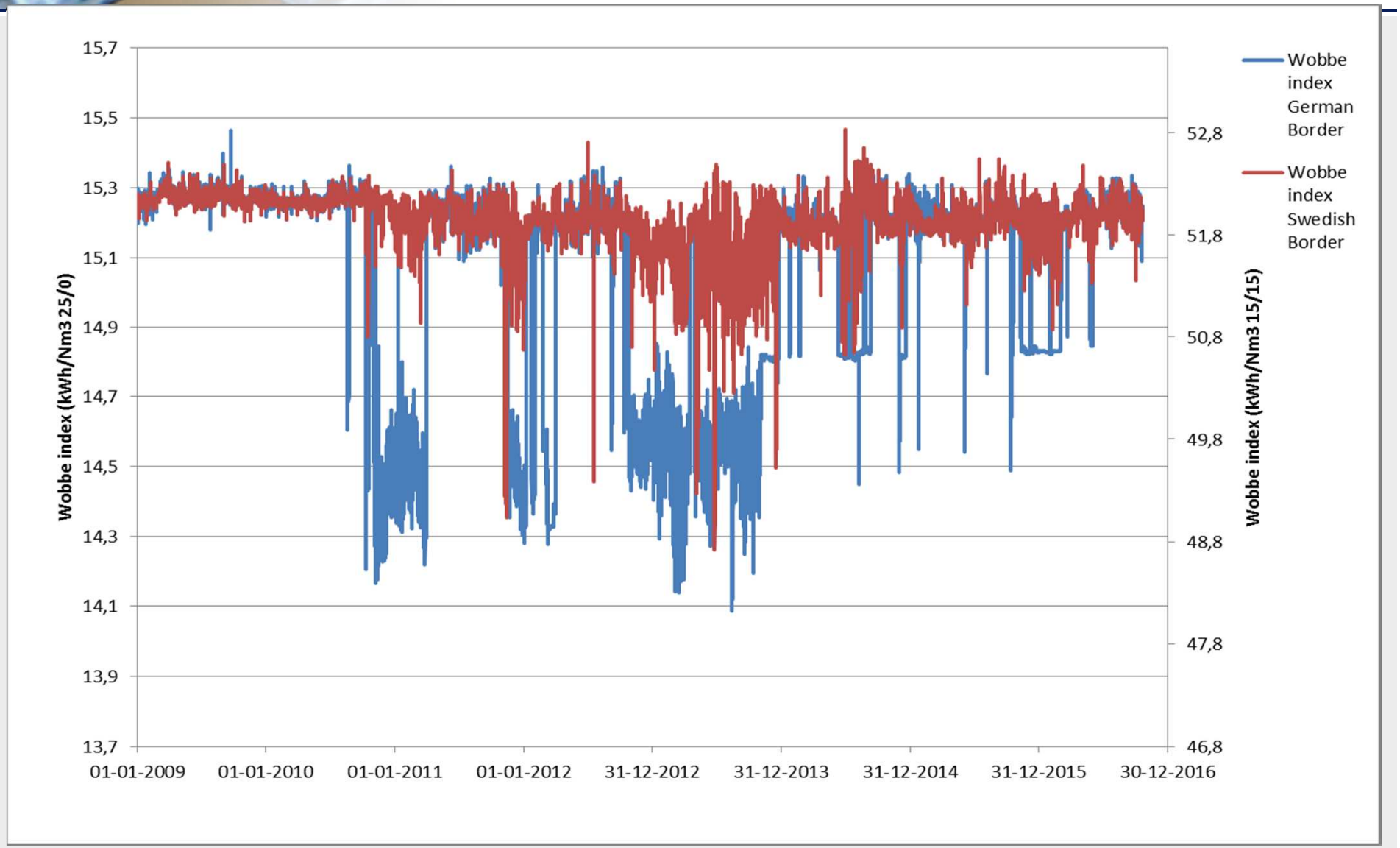
- The current limit (0.001 %) in combination with the wording about sensitive installations **is not compatible with the present market development and an increasing number of countries will be affected by the existing limitation of EN 16726.**

Parameter	Unit	Limits based on standard reference condition 15/15		Limits based on normal reference condition 25/0 (for information)		Reference standards for test methods[d] (informative)
		Min.	Max.	Min.	Max.	
Mercaptan sulfur without odorant (as sulfur)	mg/m^3	not applicable	6[a]	not applicable	6[a]	EN ISO 6326-3, EN ISO 19739
Oxygen	mol/mol	not applicable	0,001 % or 1 % (see below)	not applicable	0,001 % or 1 % (see below)	EN ISO 6974-3, EN ISO 6974-6, EN ISO 6975
	At network entry points and interconnection points the mole fraction of oxygen shall be no more than 0,001 %, expressed as a moving 24 h average. However, where the gas can be demonstrated not to flow to installations sensitive to higher levels of oxygen, e.g. underground storage systems, a higher limit of up to 1 % may be applied.					

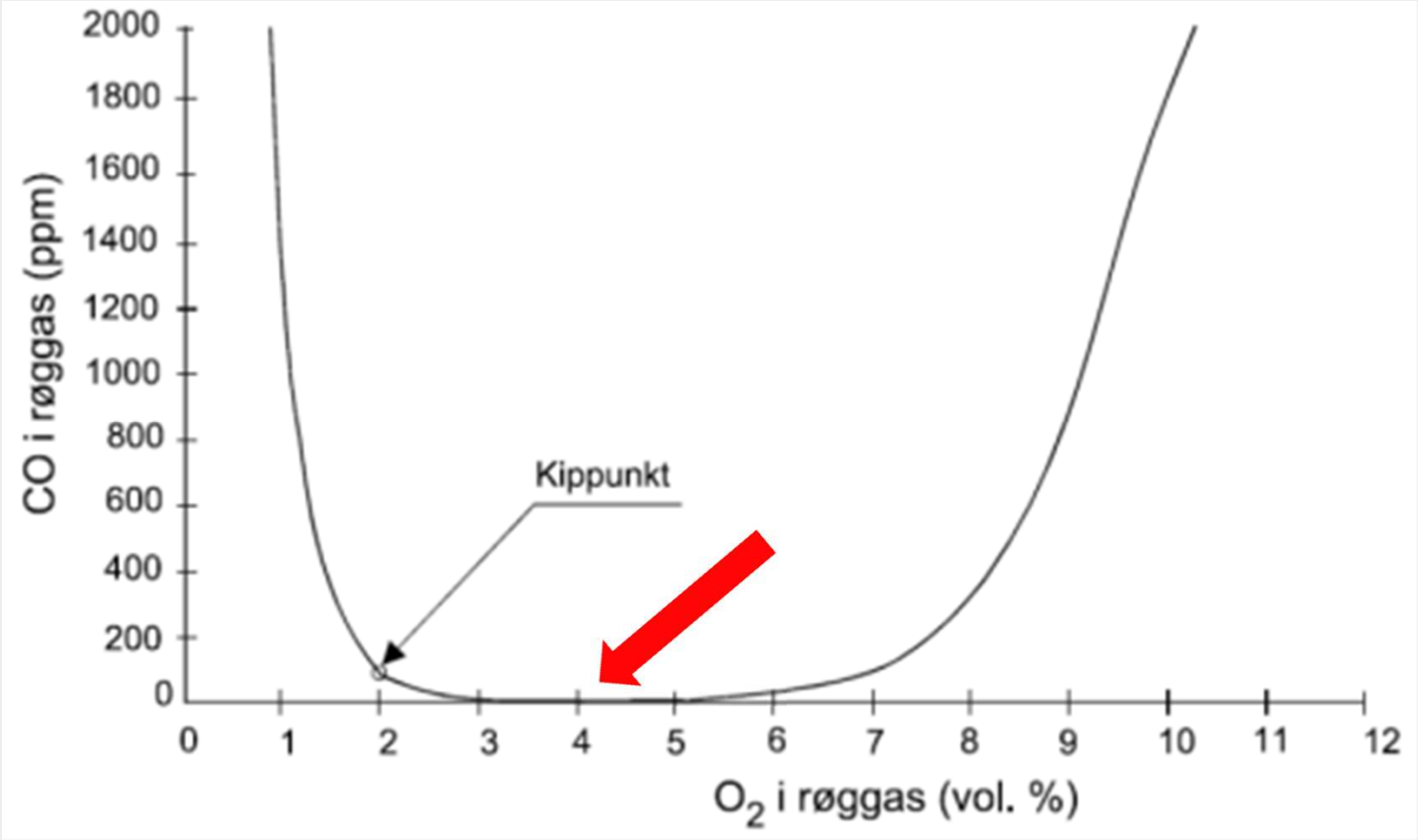
Proposal for action

- Reconsidering O2 value in the standard will considerably help the development of greening of the European gas grid
- **Similarly, to the Wobbe index study, we shall gather and share facts and figures that will allow us to see if an update of O2 requirements in EN 16726 is possible and needed.**
- This would be best done in the frame of the present CEN SFGas GQS activities

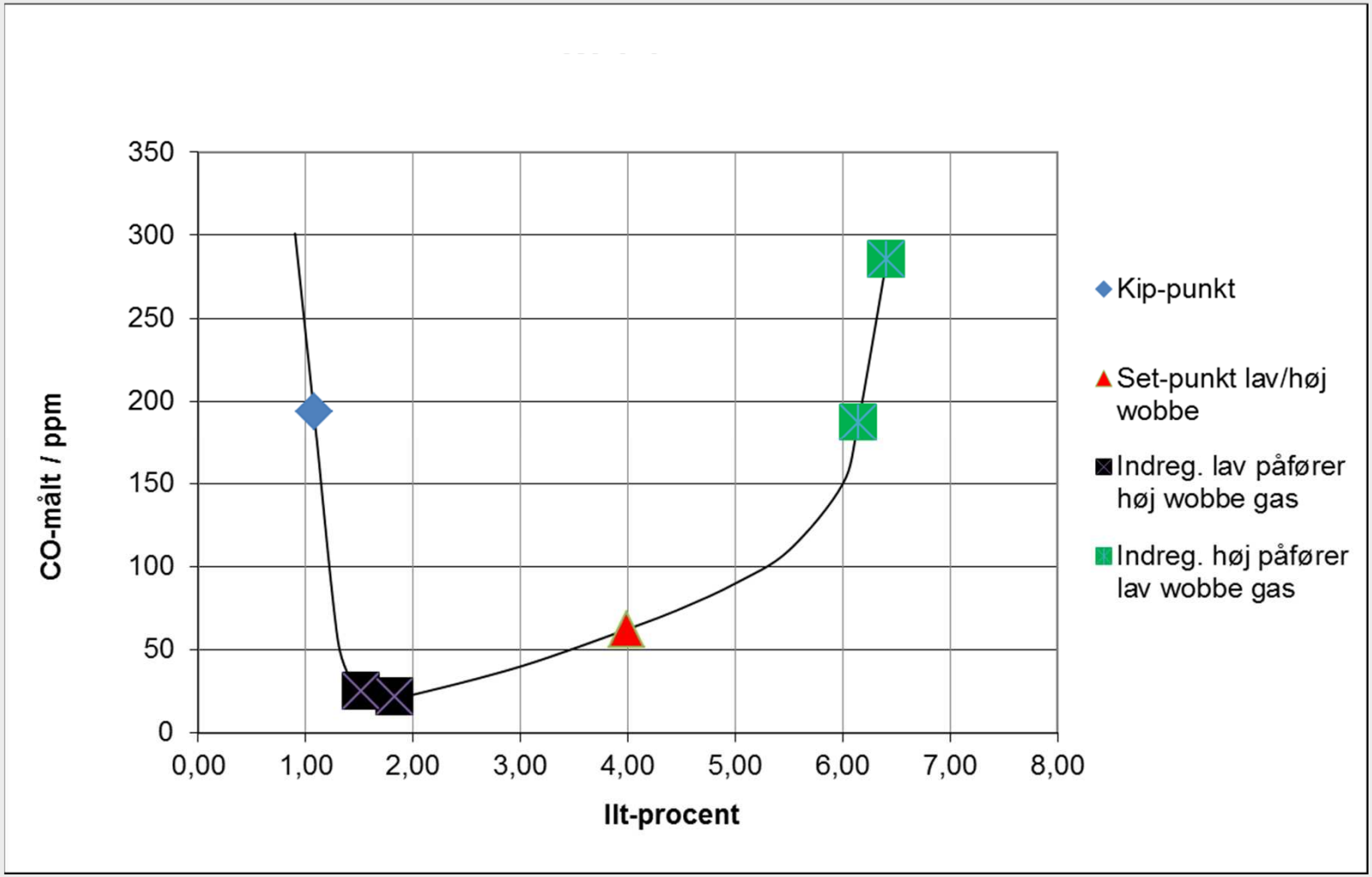
A practical example – forced draught burners


15,7
15,5
15,3
15,1
14,9
14,7
14,5
14,3
14,1
13,9
13,7
Wobbe index (kWh/Nm3 25/0)
52,8
51,8
50,8
49,8
48,8
47,8
46,8
Wobbe index (kWh/Nm3 15/15)
01-01-2009
01-01-2010
01-01-2011
01-01-2012
31-12-2012
31-12-2013
31-12-2014
31-12-2015
30-12-2016
Wobbe index German Border
Wobbe index Swedish Border

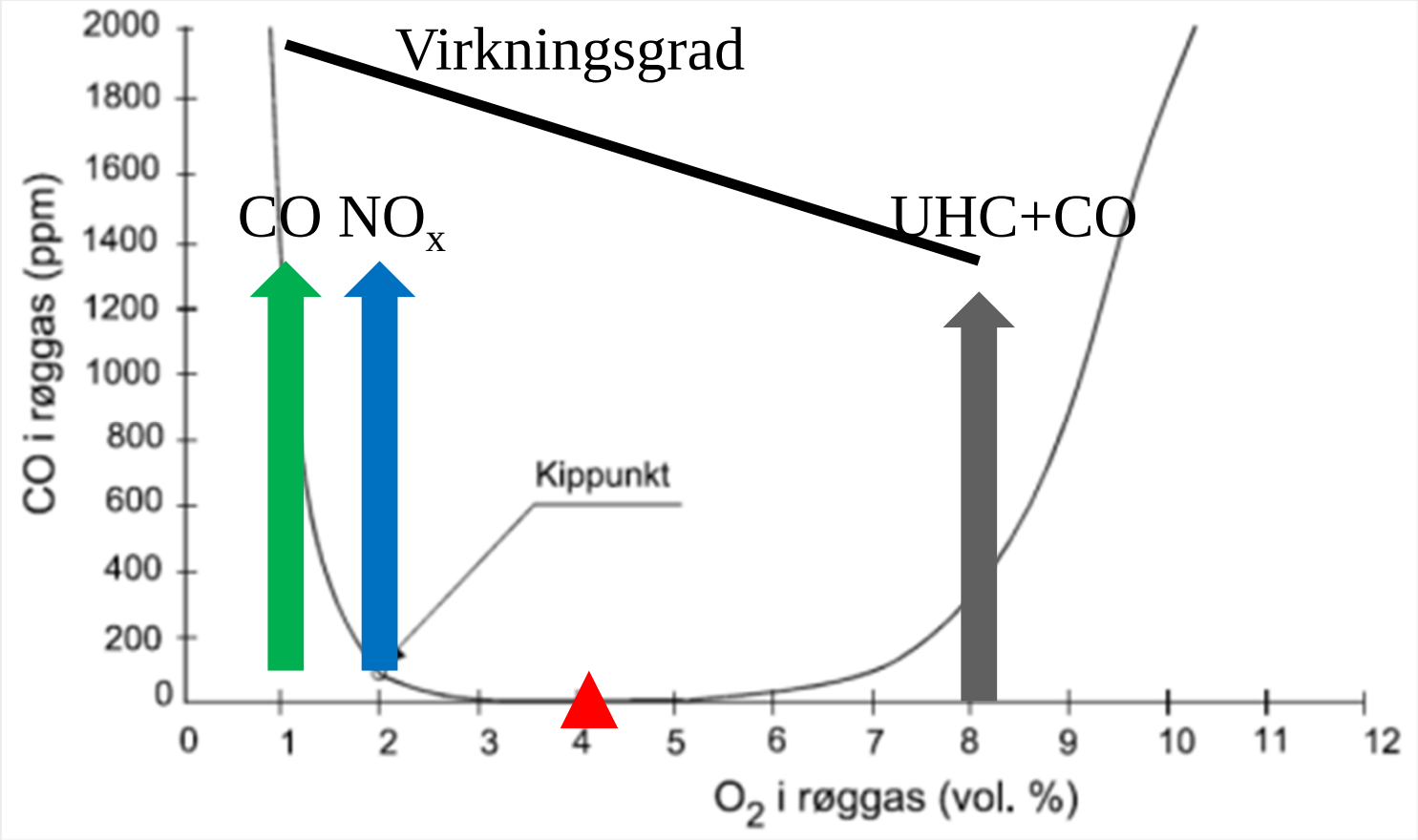
Normal adjustment



What happens with quality variations



Environment and efficiency

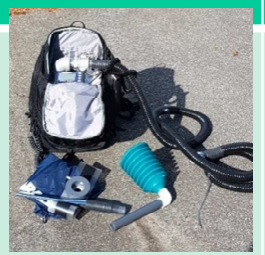


Methane emissions

Methane emissions

- IEA – Is gas part of the future energy mix **?**
  - Gas sector need to show low leak
- EU and UN pressure
- DGC participate in international work Marcogaz
- Quantify leaks in Denmark

Methan measurements

		Advantage	downside	where to use
HI Flow Sampler (source)	 	• Easy • Precise at small sources	• Cannot measure diffusive sources	• Small sources • Quantification single sources
High Volume Sampling with pump and FID analyzer	 	• Measure everything non diffusive • Precise	• Time consuming • Don't do diffusive sources	• Quantification single sources
FLIR Camera (Source - identification)	 	• Quick	• Experienced personnel needed • No quantification	• For identification of sources
"GAS FIND" (Tracer gas measurements)	 	• All sources in one measurement • Combined methane emission quantified	• No source identification • Some uncertainty	• Large installations (Biogas, MR, Compressor stations)
"Sniffer" (Source identification)	 	• Quick • Easy	• No quantification • Must be close	• Identification and security

GASFIND equipment

SUSTAINABLE GAS TECHNOLOGY

GASFIND
Ultraportable Gas Analyzer

Wind-

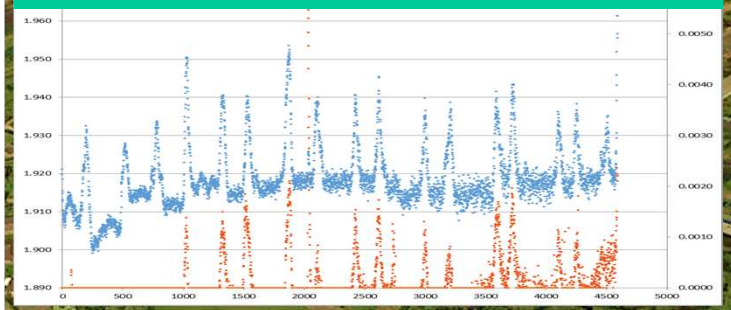
Car, pump, gas sampling, GPS

Tracergas doseing

Results GASFIND measurements

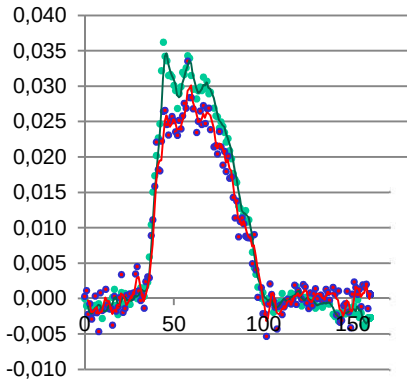
SUSTAINABLE GAS TECHNOLOGY

More runs

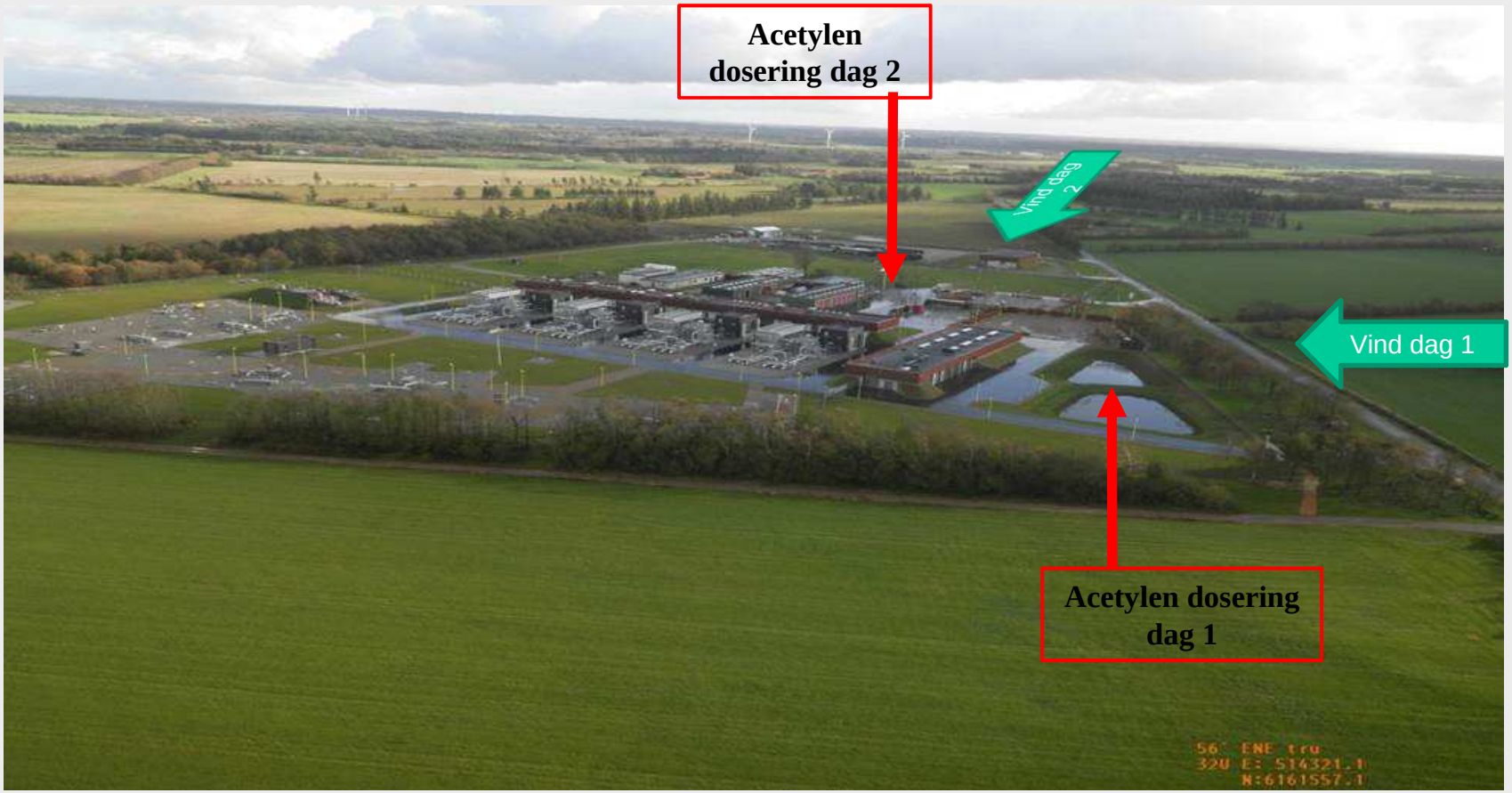


Metankilde

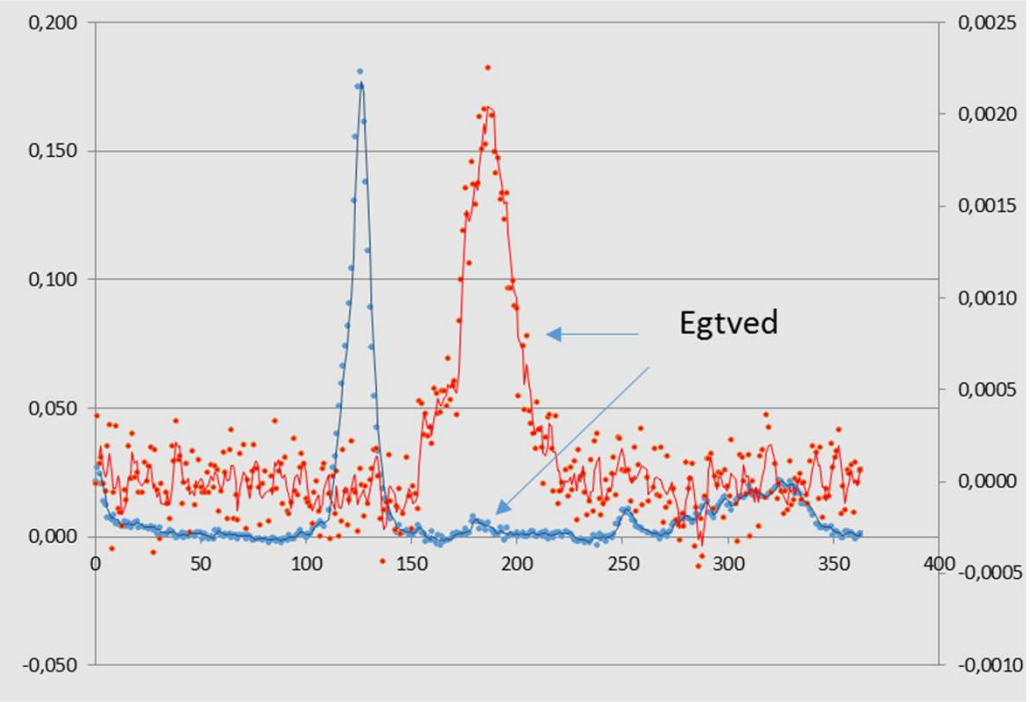
Analyze single run kørsel



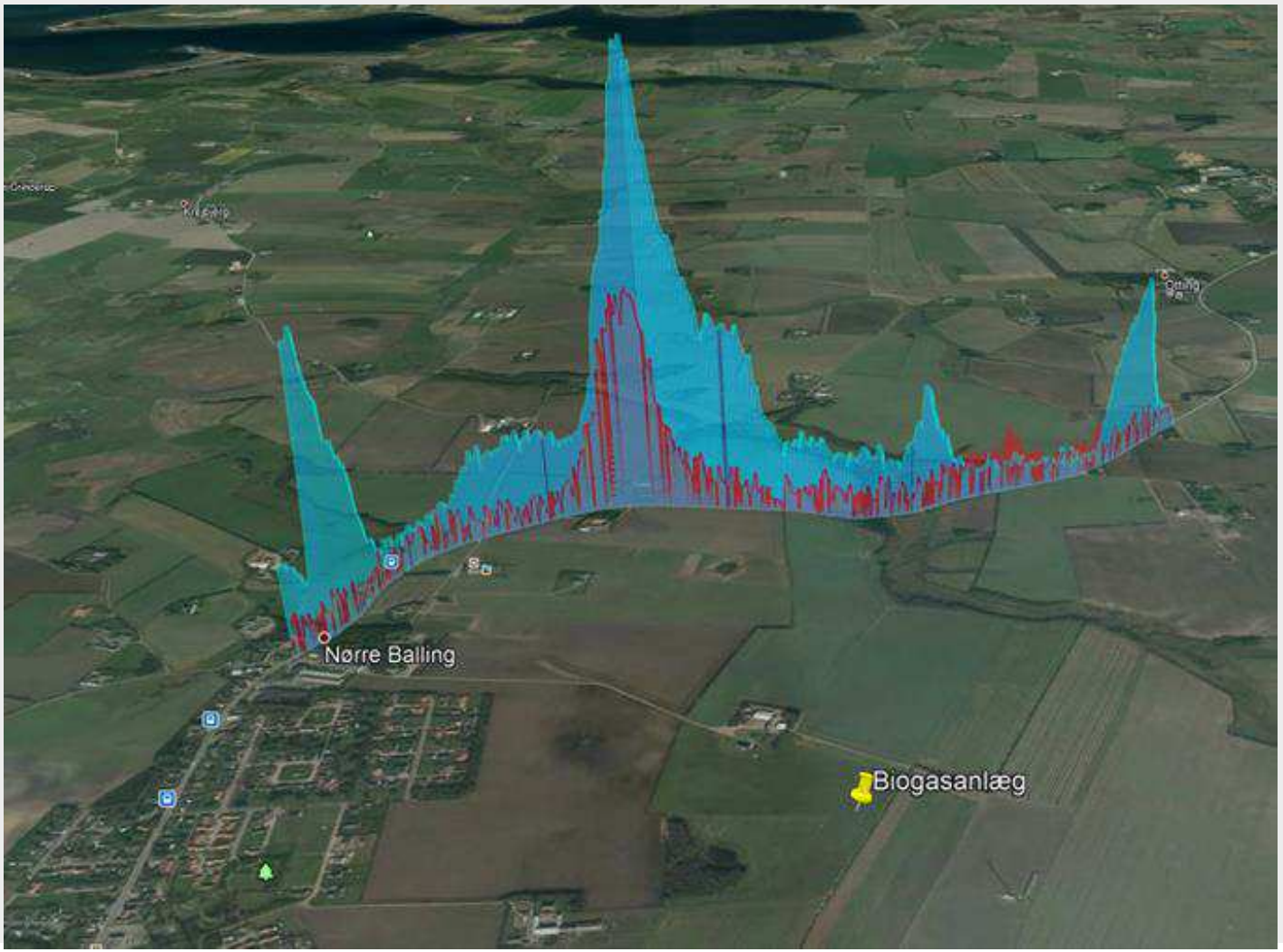
$$\nu = \frac{\int_{t_0}^{t_f} (y(t) - \mu_y)\,dt}{\int_{t_0}^{t_f} (x(t) - \mu_x)\,dt}$$


Acetylen dosering dag 2
Vind dag 2
Vind dag 1
Acetylen dosering dag 1

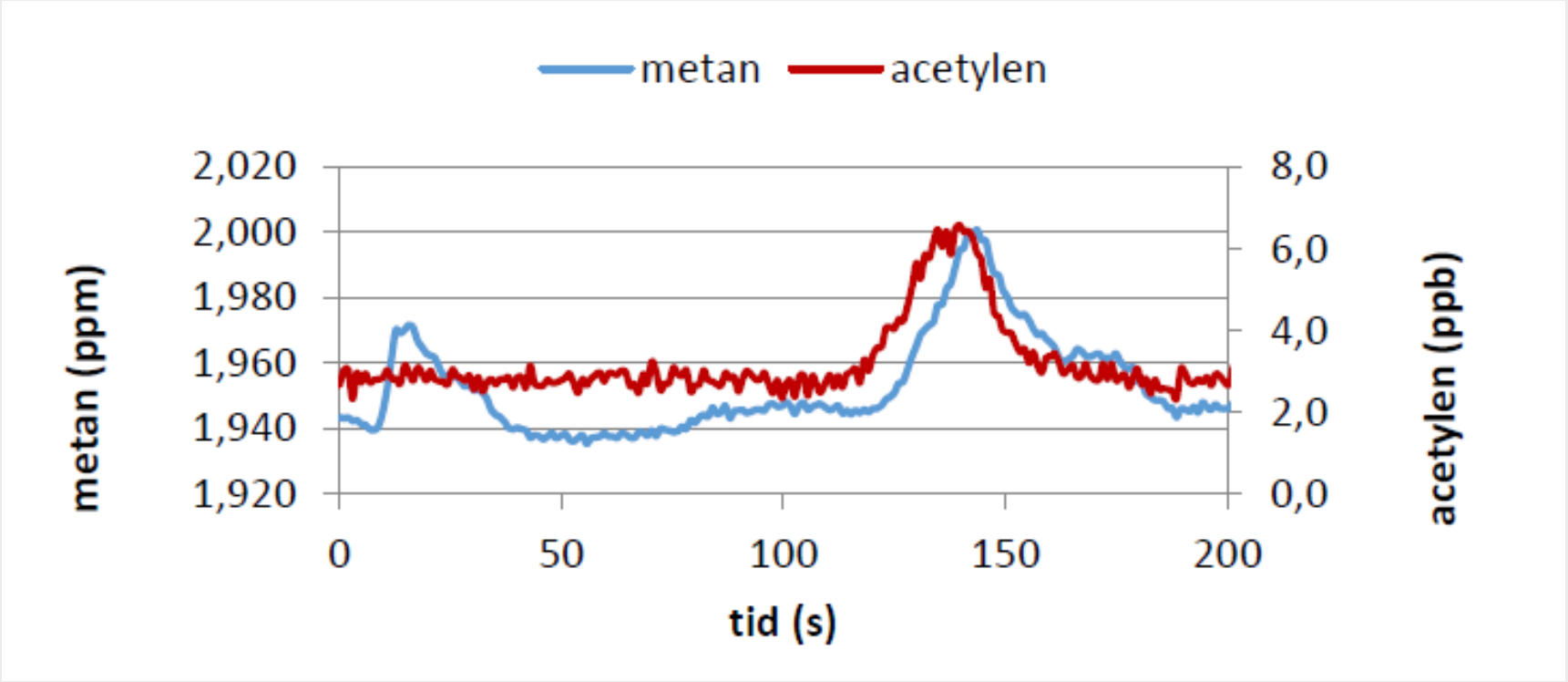
	Runs	kg methane/h	SD
1. day –bleed on compressor 3	16 (8 OK)	5.6	1.2
2. day – normal opertion	22(17 are OK)	1.0	0.3



Biogas sites



Biogas sites



Preliminary results finding gas leaks on grid

- **Measure ppb level of methane in air**
- **Lets do some roads with GPS and methane sampling**

Methane emissions

- Marcogaz result: Loss from transmission and distribution 0,17% of gas sales in EU
- What about production and utilisation?
- Marcogaz writing a draft pre-standard document on documentation of methane emissions from gas grid – give to CEN in June 2019

Thank you for your attention