The FutureGas project

- and perspectives for the Danish Energy Policies



Thea Larsen, CEO of

Danish Gas Technology Centre

Vice Chair of The FutureGas Steering Commitee

Agenda

- Introduction
- The Danish energy and climate policies
- The FutureGas R&D project
- Perspectives - the integrated energy system
- Wrap-up and Q&A

Danish Gas Technology Centre (DGC)

- Specialized supplier of R&D, consultancy, measurements, assessments and other knowledge intensive services in the field of gas and energy.
- DGC holds an accredited laboratory to test gas appliances and to make gas analysis, and a Test Centre for Green Gases for analysis of biogas, hydrogen etc.
- Key areas of expertise include gas utilization, green gas production/cleaning, sector coupling/hybrid applications and environmental performance.
- DGC represents the Danish gas sector in various European organisations like Marcogaz, GERG, ERIG etc.
- DGC is an independent company, owned by the gas DSO/TSO, and operating at arm's length of the sector.



The Energy Agenda 2019

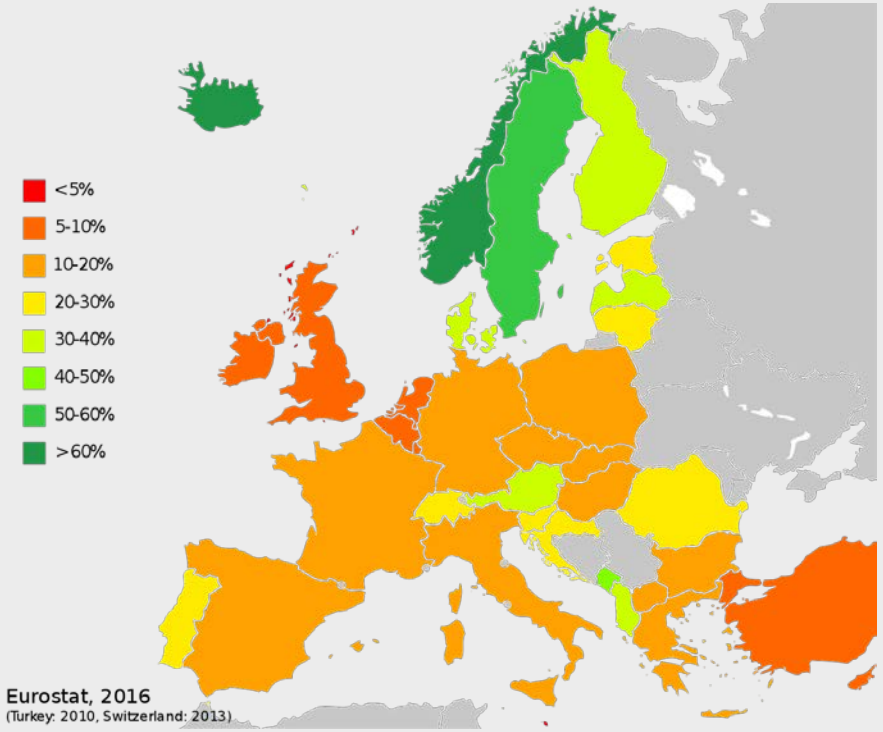
- The Paris Agreement, IPCC Reports, UN sustainable development goals etc

=> CO_2 emission reduction initiatives
  - UN commitments
  - EU targets and regulation
  - National plans with targets, regulation and incentives

- Enhanced by decreasing cost of RE and increasing competition

- High(er) share of fluctuating RE coupled with electrification of energy sector kicks-off increasing need for storage and sector coupling

Share of Renwable Energy in gross final energy consumption



Dan Jørgensen

Minister for Climate, Energy and Utilities
Since June 27th 2019

Goal: 70 % CO_2 reduction in 2030

It is not planned how to achieve the goal.

Denmark must triple the rate of CO_2 reduction to achieve the target.

Initiation of discussions on new climate law started on 3rd September 2019.

New climate law will bring more technologies.



https://kefm.dk/media/12817/klimaminister-dan-joergensen_foto-ulrik-jantzen-3.jpg.
Photographer: Ulrik Jantzen.

Wind power increasingly important

Trends and Strategy

MEGATRENDS:

Subsidy-free wind power

Increasing competition

Digitalization



DanishEnergyAgency

September 13, 2019

Horns Rev 3

Denmark's largest offshore wind farm to date opened 22. august 2019.

Location: 25-40 km from the West Coast
Number of mills: 49 windturbines
Total effect: 406,7 MW

1 turbine, 1 rotation generates enough green power for recharging 1.317 iPhones.

425.000 Danish households will be covered.

25-30 full-time employees



DanishEnergyAgency

September 13, 2019

Page 9

Danish Energy Policy Agreement



The Agreement applies for the period 2018-24

- based on a broad political agreement

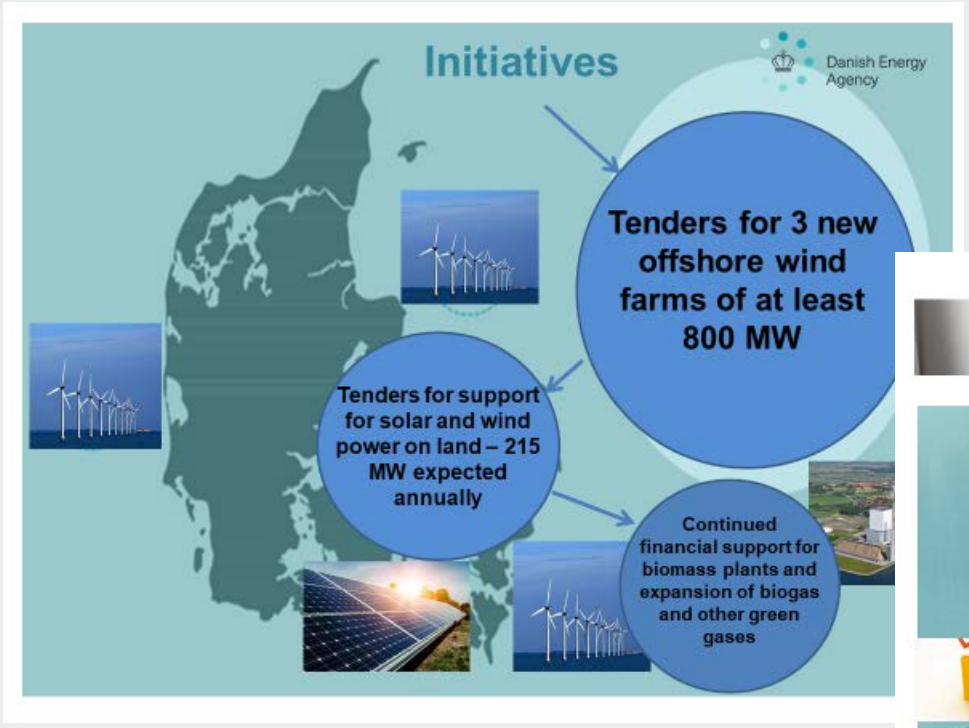
The target is:

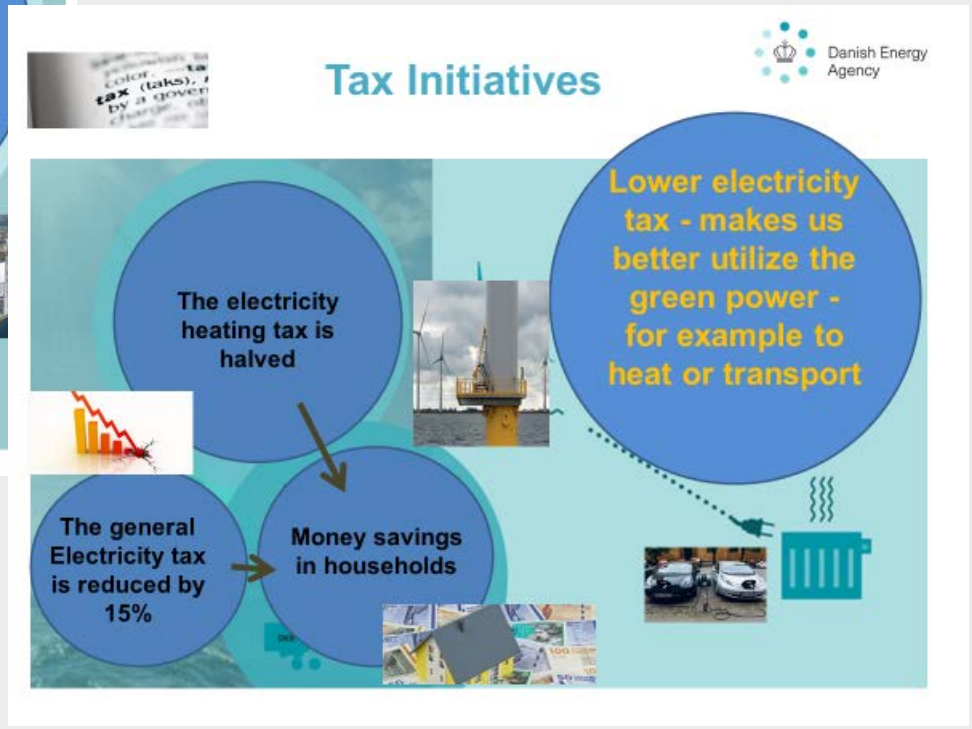
- 55% renewable energy in 2030
- Net zero CO2 emissions by 2050

Principles of the Agreement

- The market shall, as far as possible, conduct the green transition
- The ambition is that the green transition can take place on commercial terms in a few years
- Electricity will be the dominant source of energy

Various initiatives: support, tax, investments





The Danish energy system – power and DH

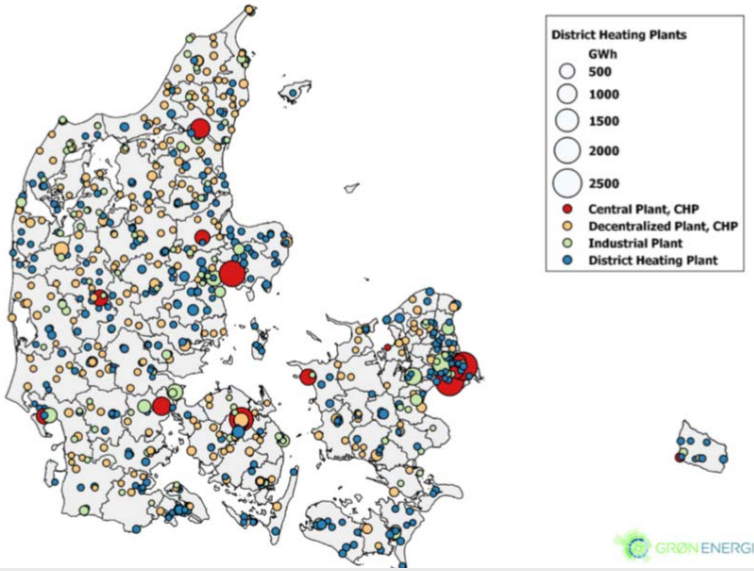
District Heating

Covers 64 % of Danish households

Decentralised and based on biomass, gas, (and coal).

Electric power being introduced.

2035 target: fossil-free production

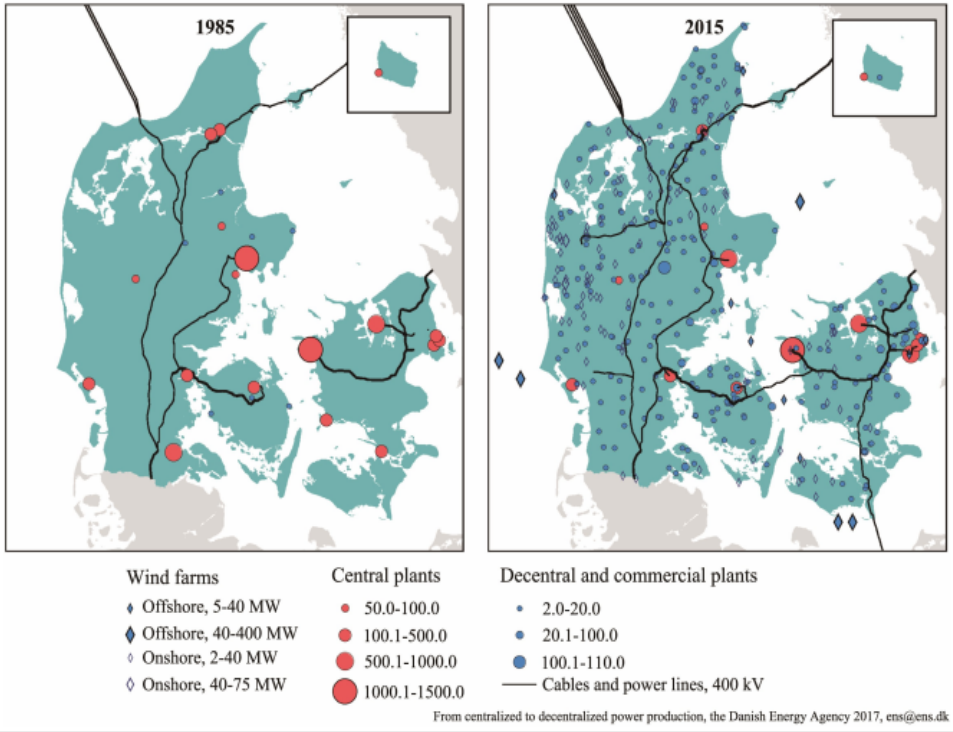


The power system

~ 45 % of power generation from wind and solar power

From centralized to decentralized production

2035 target: fossil-free production



The Danish gas grid

- Gas accounts for 15 % of energy consumption
- Biomethane
  - exceeds 10 % of gas consumption (2019)
  - from waste, manure etc.
  - 33 biogas upgading facilities
  - ~ 30 % by 2023
- Other green gas production is investigated (RD&D work)
- Targets
  - 100 % green gas by 20xx



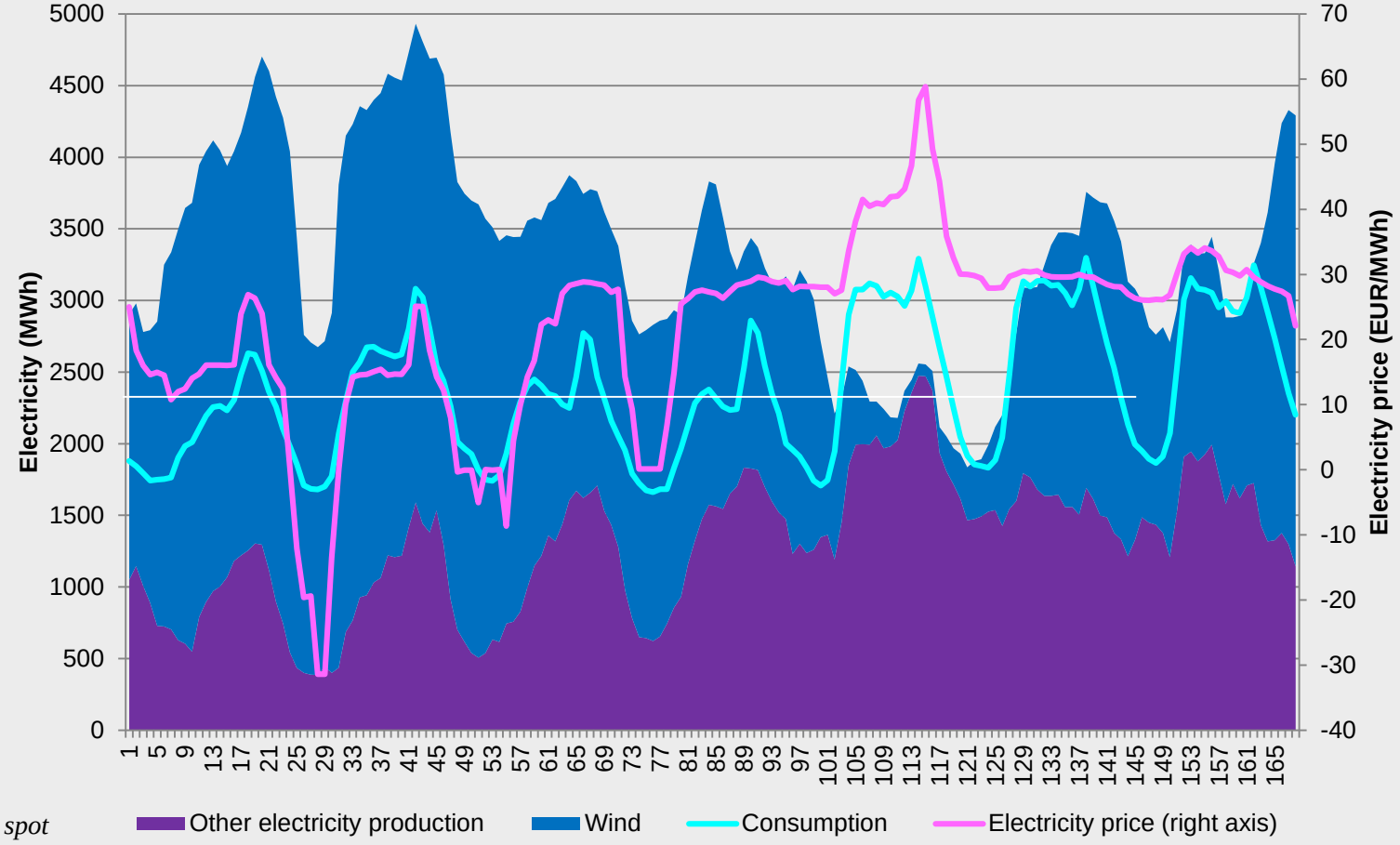
Challenges for the Danish energy system

- Ambitious energy and climate goals
- High content of fluctuating renewable energy
- Decentralization and digitalisation
- Optimal use of power, gas and district heating systems (planning vs. market)
- “Greening” of the transportation and agriculture sectors
- Flexibility required; i.e. balancing, sector coupling and energy storage



Flexibility needs!

Electricity - production, demand and price, for Denmark West. First week in 2015.

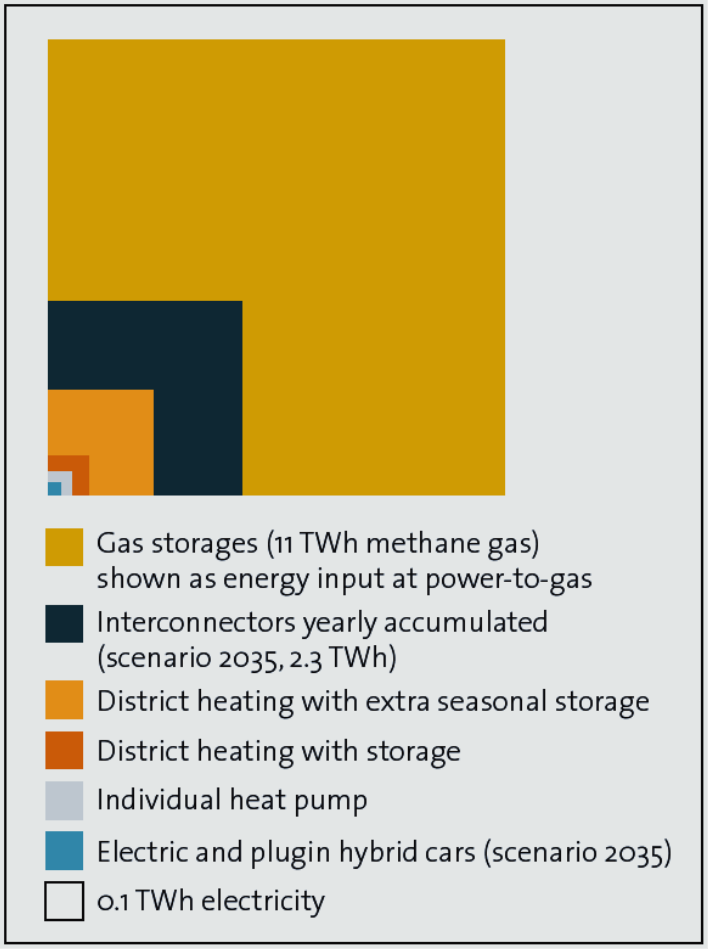


Source: Nordpool spot

Storage and flexibility options

- Huge energy capacity in the gas grid
  ~ 3-4 months total energy consumption
- The gas grid might have an important role to play in the energy transition
- Required: optimized integration and greening of the gas system

	Power	District Heating	Gas	Liquid fuels	Electric vehicles
Flexible power production	√	(√)	√		
Flexible power consumption		√	√	√	√
Storage facilities	(√)	√	√	√	√
Import/export	√		√	√	



Re: DTU CEE and Energinet 2018

The FutureGas project

The aim of the FutureGas project is twofold:

1) *In an energy system context to facilitate **the integration of the gas system** with the power system, the district heating system and the transportation sector taking into account possible synergies*

2) *To facilitate a **cost-efficient uptake of renewable gases**, hereby in the longer term substituting natural gas and fossil fuels*

Period: 2016-2020; www.futuregas.dk

DGC roles:

- WP leaders
- Vice chair of the Steering Committee

Innovation Fund Denmark
RESEARCH, TECHNOLOGY & GROWTH



Integration of gas in the energy system

Power, district heating, transportation …

- **Cost-effective integration of gases based on renewable energy**
  - Biogas, SNG, hydrogen …
  - What are the best utilizations – upgrading/methanation/direct utilisation
- **What are the best utilizations of the natural gas infrastructure?**
  - Could we branch off part of the grid?
- **Utilization of gas in the transportation sector**
  - Expericence from Sweden
- **Modelling of gas**
  - Balmorel, Sifre, development of advanced tools
- **Regulatory issues for gas**
  - Tariffs, taxes …

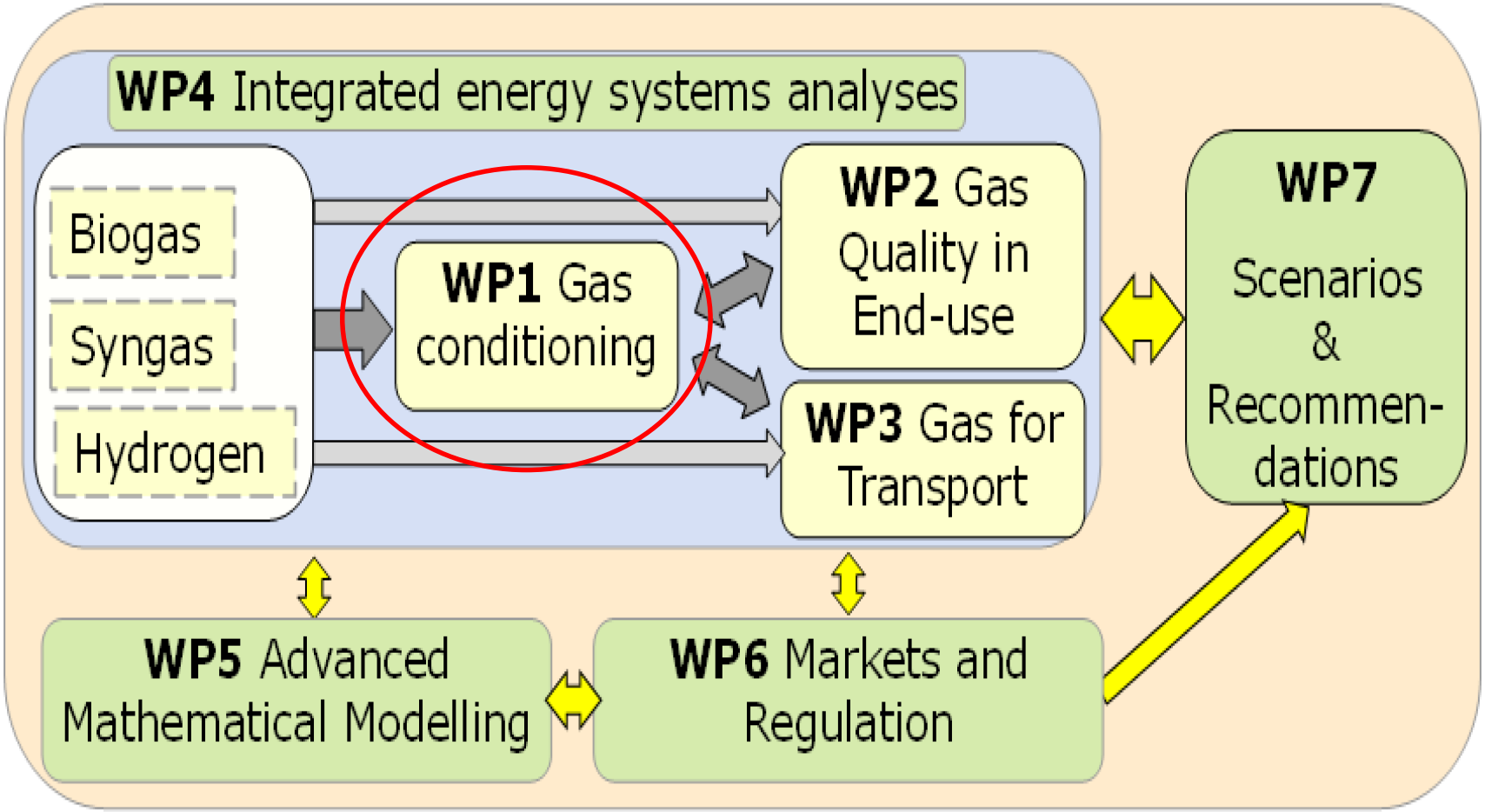
Pivotal questions

1. Is it possible to produce and utilize gas without significant greenhouse gas emissions?

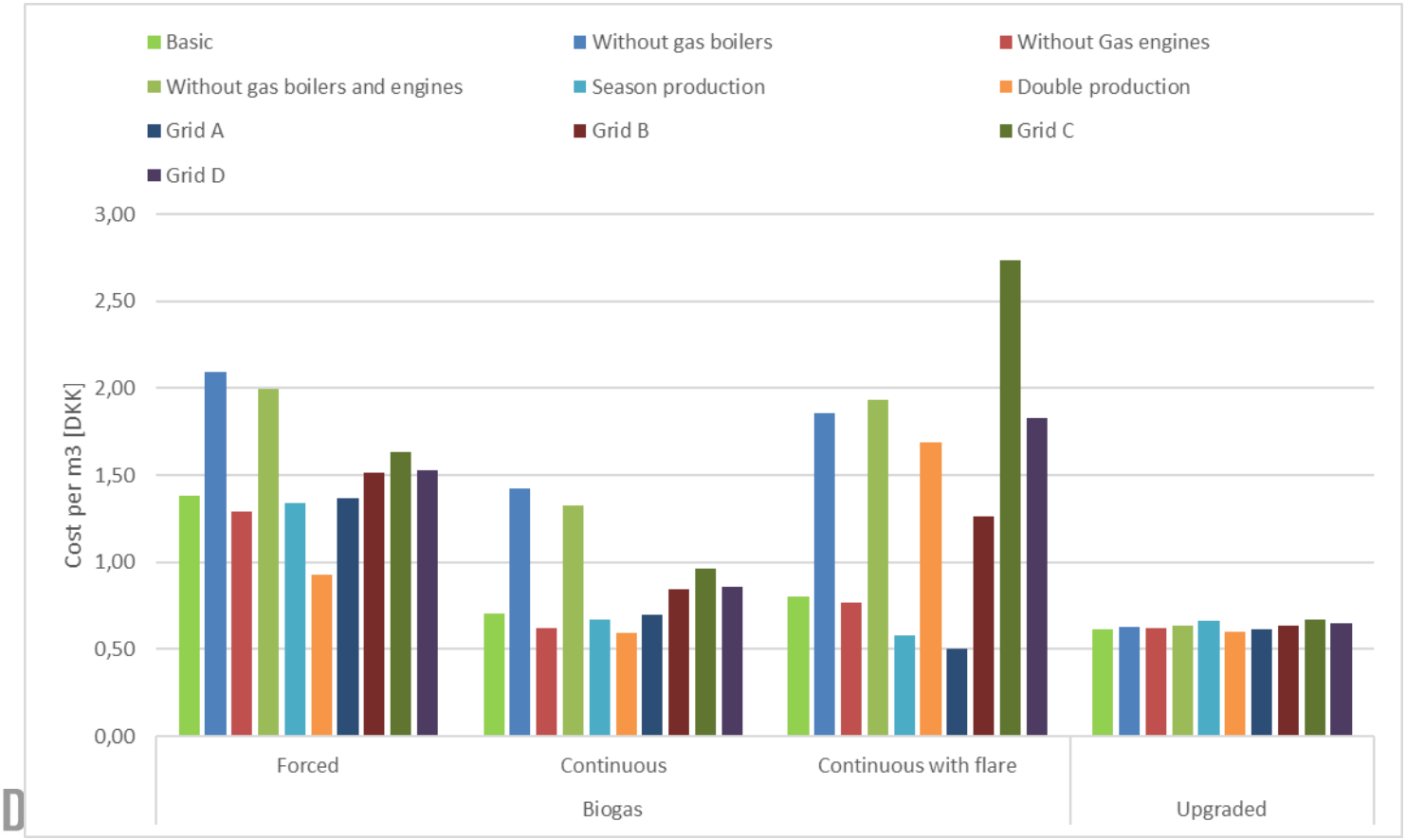
2. How are we going to utilize renewable gas in the energy system?

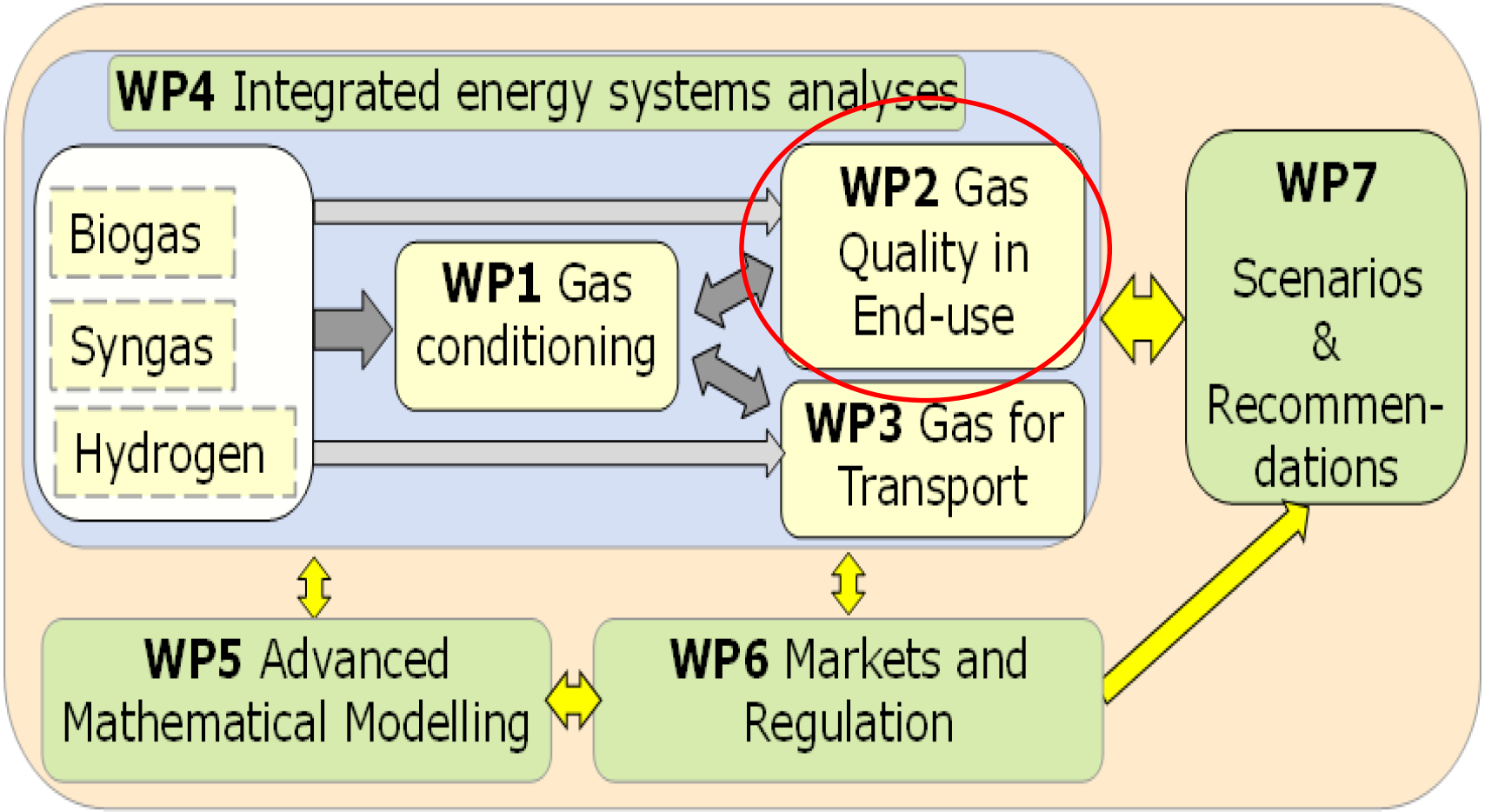
3. … and are we still going to use the gas grid in the future?

4. Which opportunities and limitations does the energy system offer in regard to the future utilization of gas?


WP4 Integrated energy systems analyses
Biogas
Syngas
Hydrogen
WP1 Gas conditioning
WP2 Gas Quality in End-use
WP3 Gas for Transport
WP7 Scenarios & Recommen-dations
WP5 Advanced Mathematical Modelling
WP6 Markets and Regulation

Results from various scenarios




WP4 Integrated energy systems analyses
Biogas
Syngas
Hydrogen
WP1 Gas conditioning
WP2 Gas Quality in End-use
WP3 Gas for Transport
WP7 Scenarios & Recommen-dations
WP5 Advanced Mathematical Modelling
WP6 Markets and Regulation

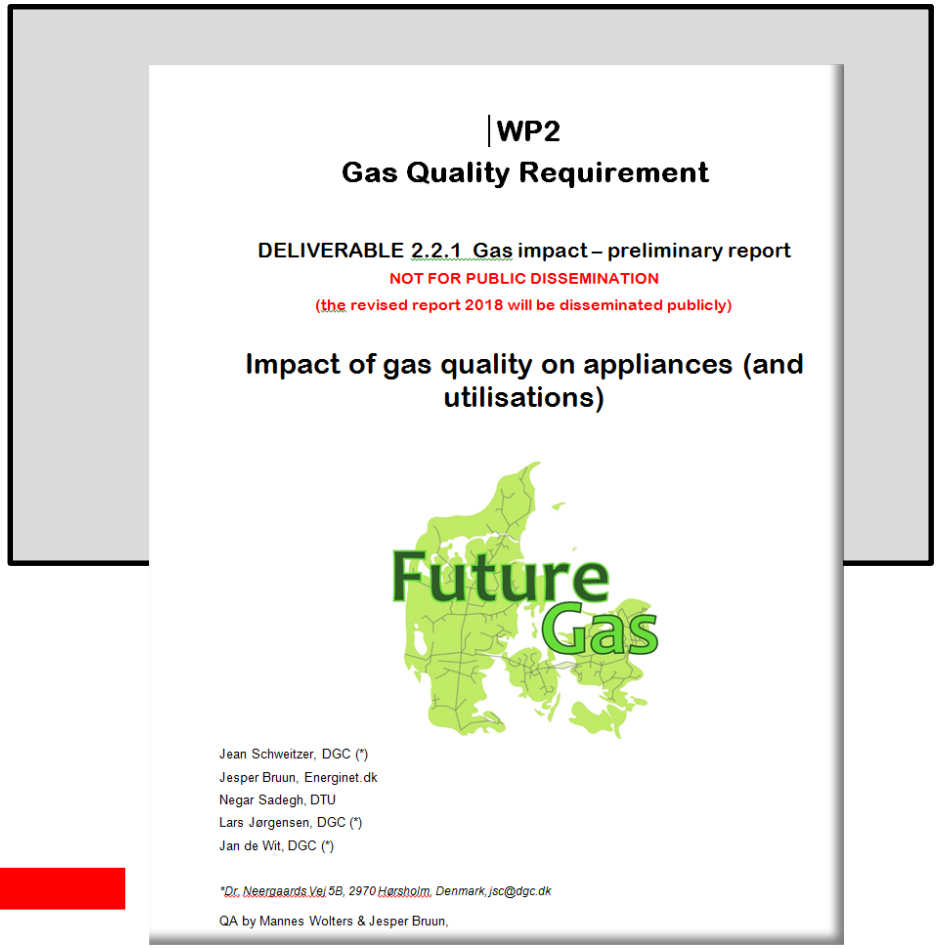
2.2 Analysis of the impact of (future) gas quality on appliances

What are the acceptable variation of gas quality?

Extensive analysis of impact by sector and appliance:

- Domestic
- Commercial
- Transport
- Industry
- Power generation

The report is used for the EU gas quality harmonisation process


WP2

Gas Quality Requirement

DELIVERABLE 2.2.1 Gas impact – preliminary report

NOT FOR PUBLIC DISSEMINATION

(the revised report 2018 will be disseminated publicly)

Impact of gas quality on appliances (and utilisations)

Future Gas

Jean Schweitzer, DGC (*)
Jesper Bruun, Energinet.dk
Negar Sadegh, DTU
Lars Jørgensen, DGC (*)
Jan de Wit, DGC (*)

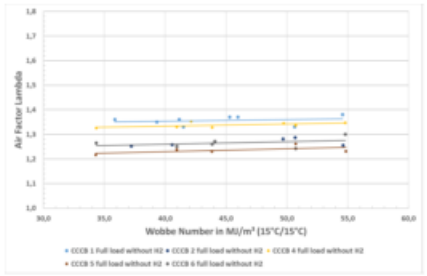
*Dr. Neergaards Vej 5B, 2970 Hørsholm, Denmark, jsc@dgc.dk

QA by Mannes Wolters & Jesper Bruun,

Tests in laboratory

2.3 Tests in laboratory (1)

Collaboration with 5 EU laboratories: Test of combustion control on 6 condensing boilers



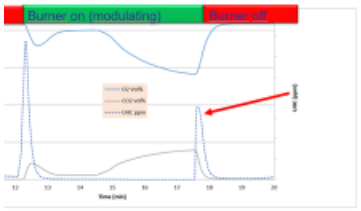
Conclusion:

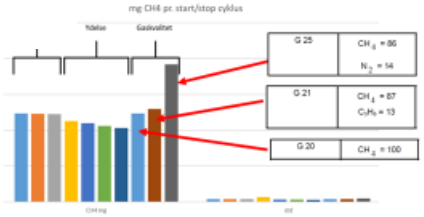
The existing technology enable appliances to maintain the air ratio constant **(and this means it burns gas safely and efficiently with no increase in emissions)** over a much higher range than foreseen in the future.

FUTURE GAS DTU SC/Technical University of Denmark

08-10-2019

ests in laboratory (2) Gas quality and CH4 ions. Collaboration with 5 EU laboratories





RESULTS OBTAINED (1)

1 Understanding of the emissions of CH4 (under start-stop operations)

Main influence factors:
- Nominal emissions
- Start stop frequency
- Gas quality

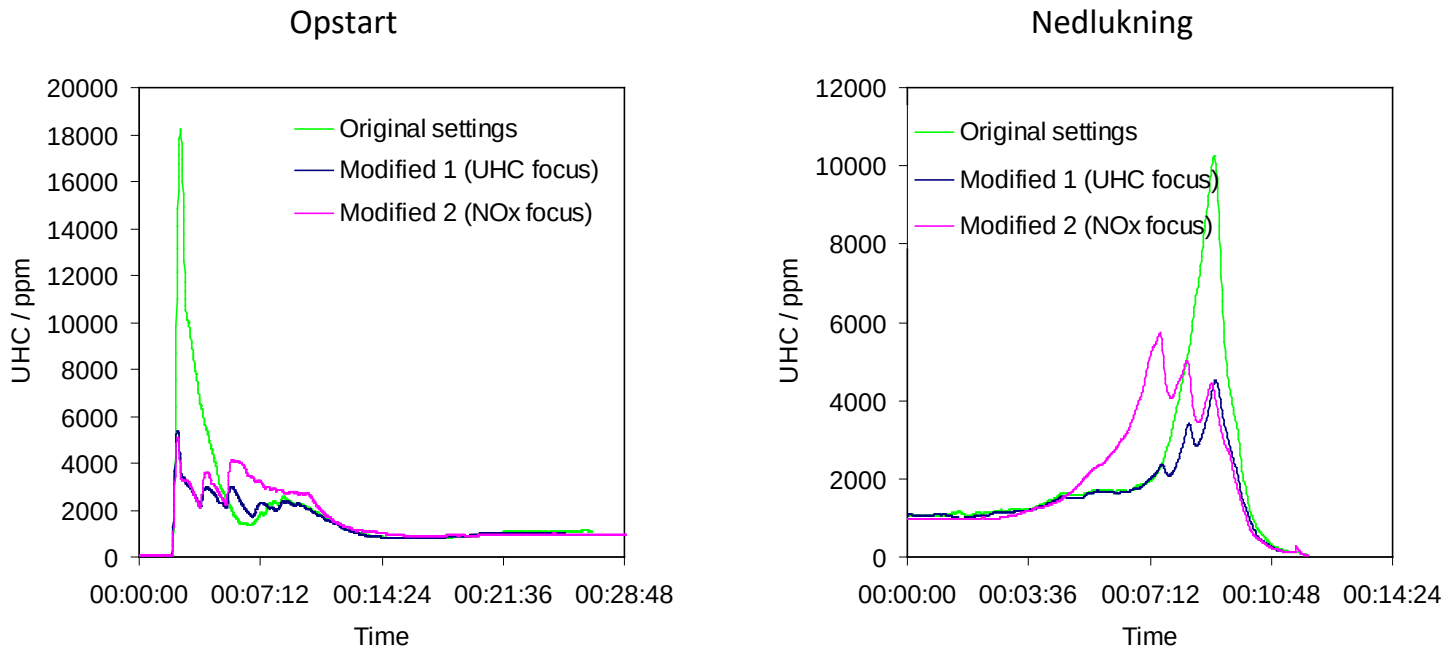
The relative CH4 loss for a DK avg. user is between 0,10% and 0,35%

FUTURE GAS DTU SC/Technical University of Denmark

08-10-2019

Reduction of UHC emissions during start-up and shut-down

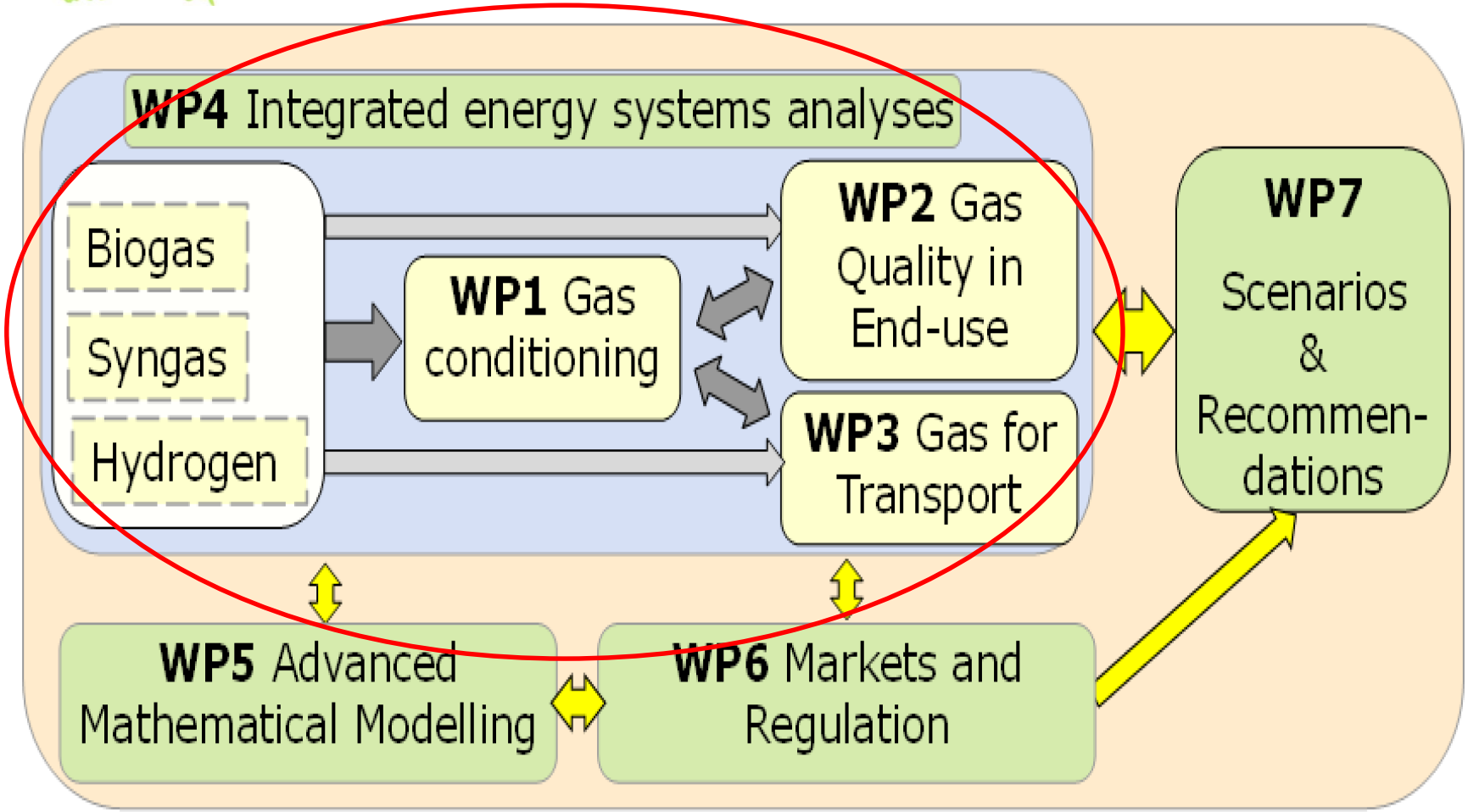
- Experience from gas engines



Source: Faster CHP gas engine start with less emission, Project report 2. DGC report R0710. 2010.

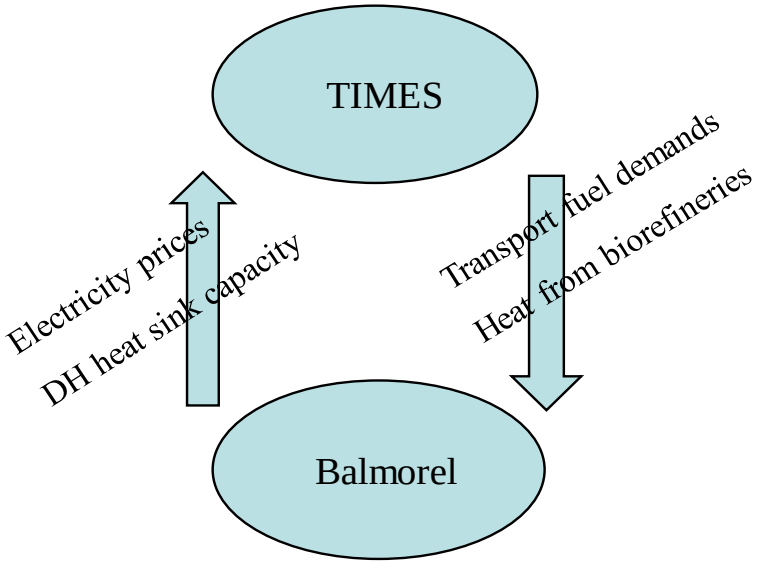
Future Gas

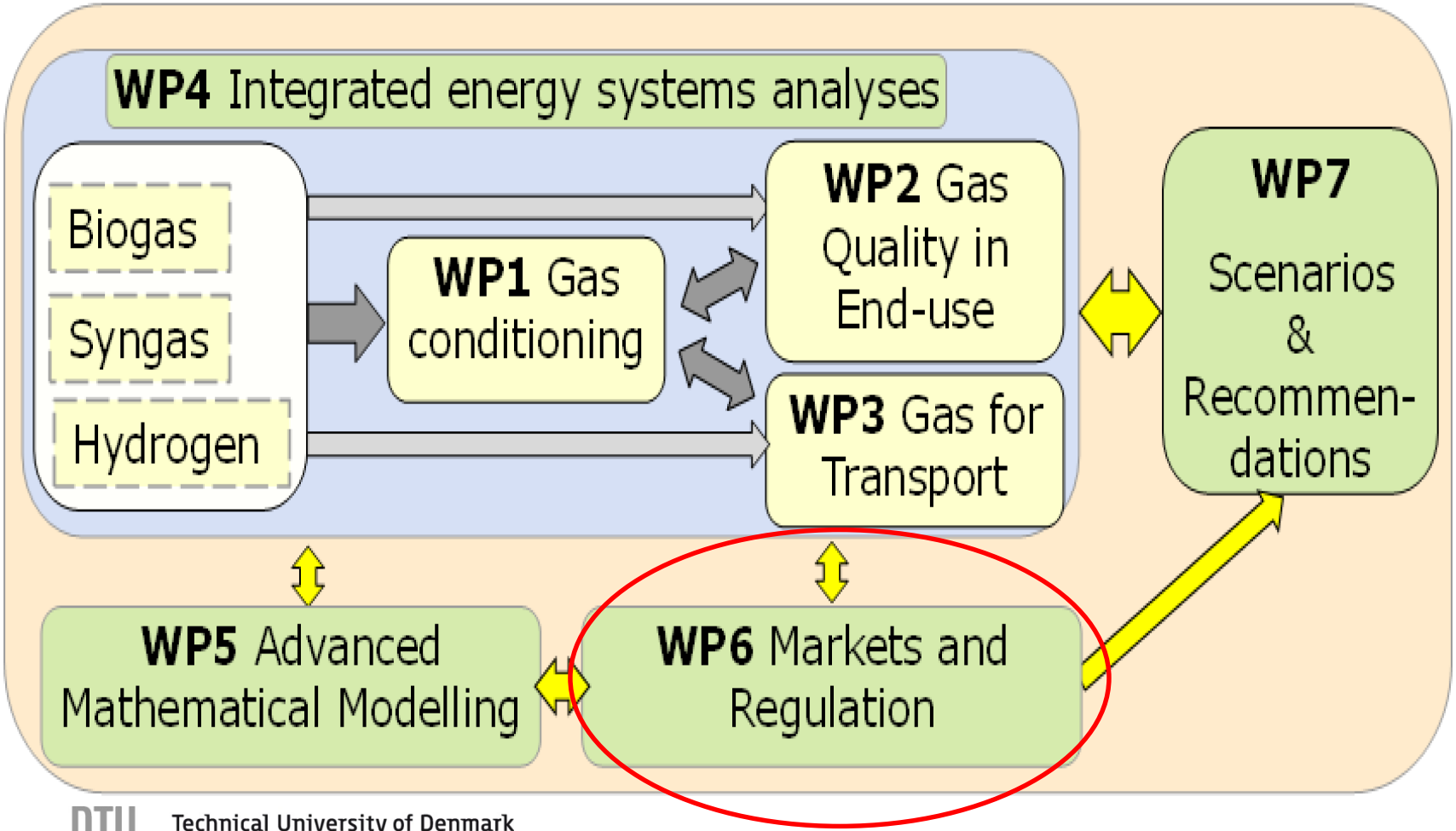
DTU



Model linking with WP4 - Balmorel

- Iterative process
- Data alignment and consistency
  - Wind and solar production profiles
  - Electricity and heat demand profiles
  - Emission limits
  - Resource potentials
  - Technology data
- Convergence in technology mix diffusion is assumed to be the criterion




WP4 Integrated energy systems analyses
Biogas
Syngas
Hydrogen
WP1 Gas conditioning
WP2 Gas Quality in End-use
WP3 Gas for Transport
WP7 Scenarios & Recommen-dations
WP5 Advanced Mathematical Modelling
WP6 Markets and Regulation

Cases in WP6

Contribution to cases	1) Power-to-Gas			2) LNG		3) RE supportmodels - certificates and more		4) Gas in transport		5) Hybrid heating
Partners in WP6	**a**	**b**	**c**	**a**	**b**	**a**	**b**	**a**	**b**	
DTU Management Engineering (DTU-ME)	X	X	X	X	X	X	X	X	X	X
HMN naturgas (HMN)				X			X	X	(X)	X
NGF Nature Energy (NGF)			X		X	X	X	X		
Danish Energy Association (DE)		X	X			X	(X)			X
Danish Gastribution (DGD)	X		X					X		
Energinet	X	X	X	X	X	X	X	X	(X)	X
Danish Energy Agency (DEA)					X	X		X		
Florence School of Regulation (FSR)		X	X	X		X		X		
Exeter University (Exeter)				X	X		X		X	(X)
Delft University of Technology (TU Delft)	X						X	(X)		(X)

1 Power-to-Gas

a) Hydrogen as power storage (Power-to-Gas)
b) Hydrogen sent to the grid
c) Upgrading (Power-to-Biomethane)

2 LNG

a) Large-scale commercial LNG
b) Small-scale, LBG

3 Renewable gases – Certificates

a) An overall market model for the support of renewable gases
b) Green certificates applied together with other tax- or support regulation

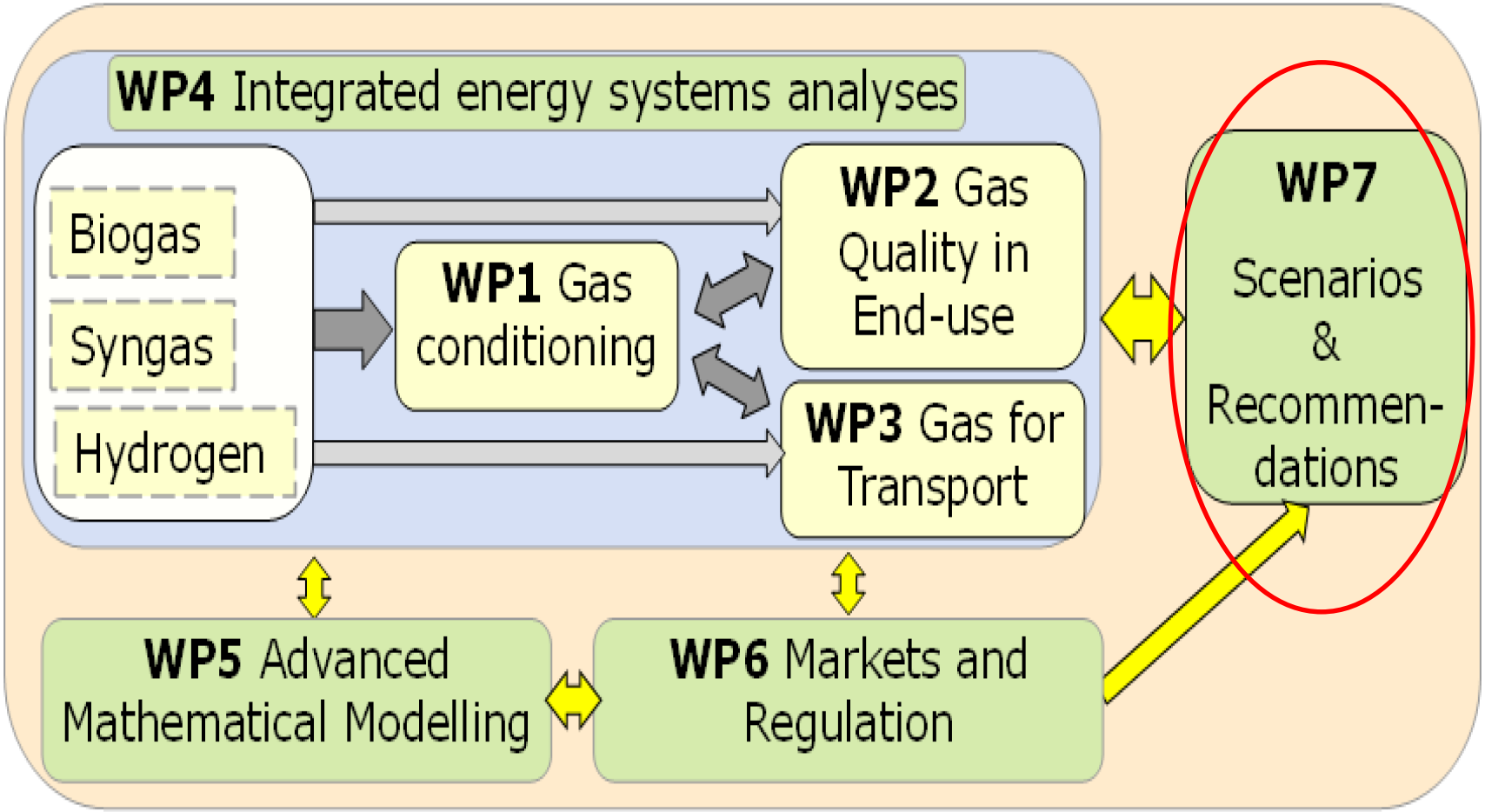
4 Gas in Transport (LNG/CNG)

a) Land transport (blending demands)
b) Maritime transport

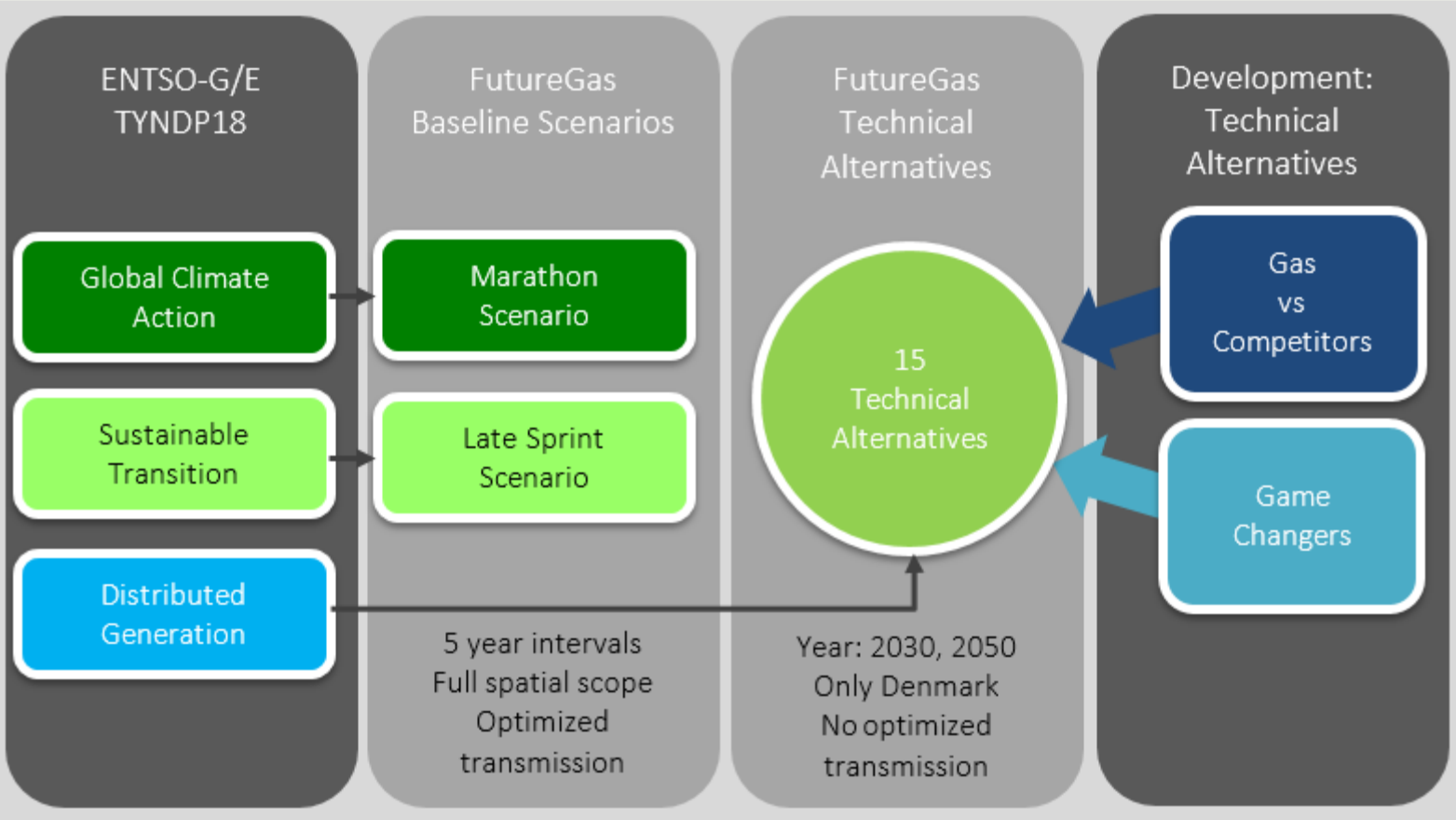
5 Hybrid – electricity driven heat pumps backed by gas boiler

Future Gas

DTU



FutureGas scenario framework



Pivotal questions (1) – and preliminary answers

1. Is it possible to produce and utilize gas without significant greenhouse gas emissions?
   - Gas boilers have low methane emissions – gas engines can be dealt with.
   - Dual-fuel engines today can be problematic.
   - We need to focus on methane leaks.

2. How are we going to utilize renewable gas in the energy system?
   - Are we to inject renewable gas into the gas grid, or are we to use it in another way?
   - Upgrading/methanation is a wise choice.

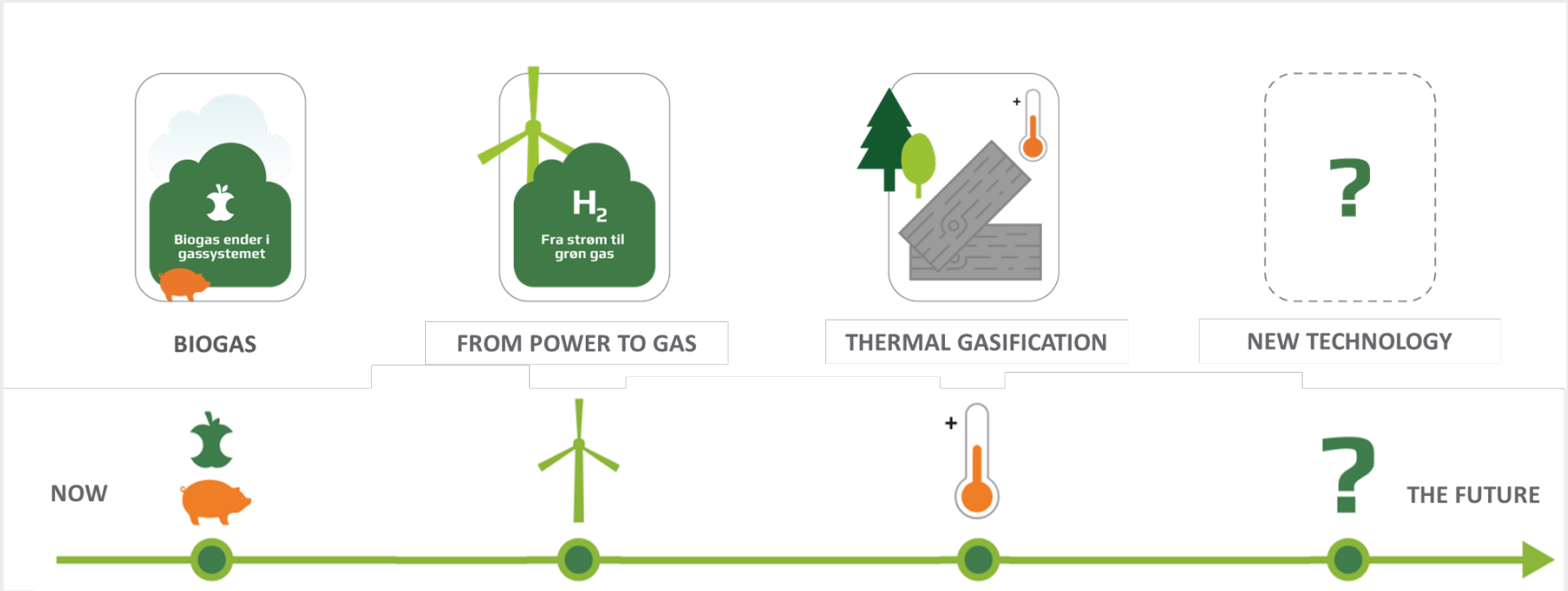
Pivotal questions (2) – and preliminary answers

3. … and are we still going to use the gas grid in the future?
   - Is it possible to utilize the existing grid … or are we to branch off into separate part-grids?
   - Separate grids may be cost-intensive.

4. Which opportunities and limitations does the energy system offer in regard to the future utilization of gas?
   - Our energy models will provide the answers …
   - Biogas, synthetic natural gas and H_2 will all have a role to play.

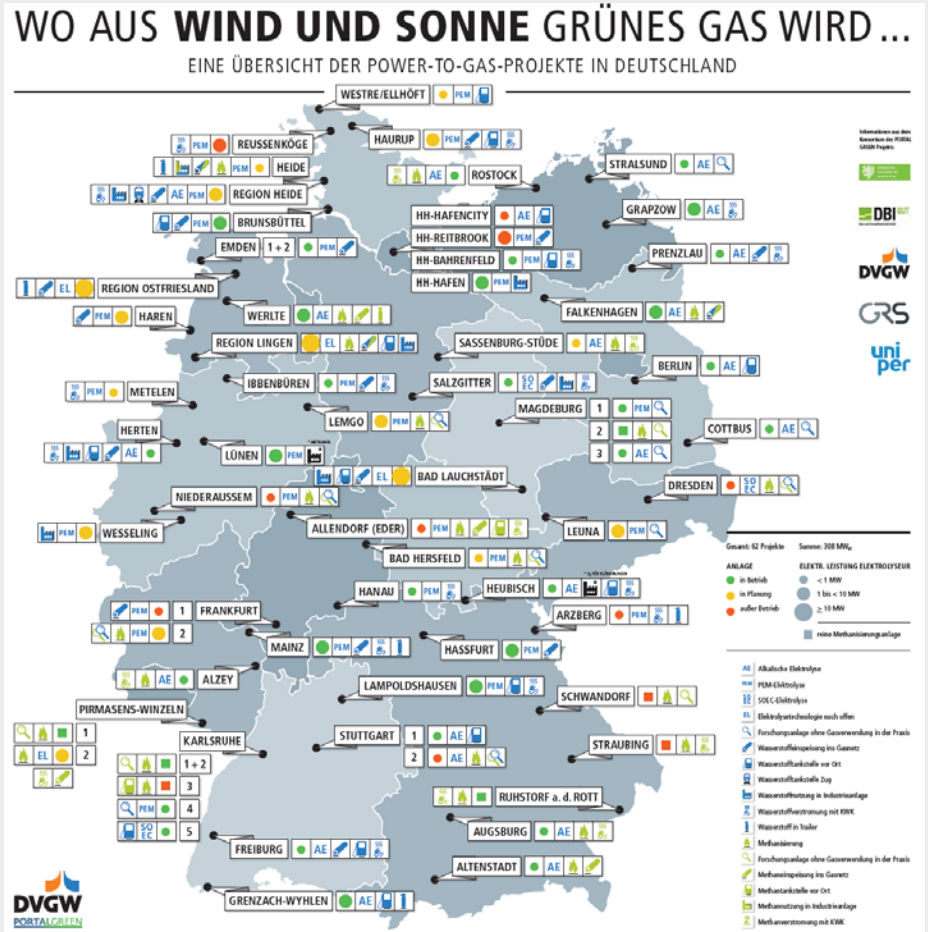
Perspectives - The integrated energy system

Green gas production



Germany to invest in power-to-X

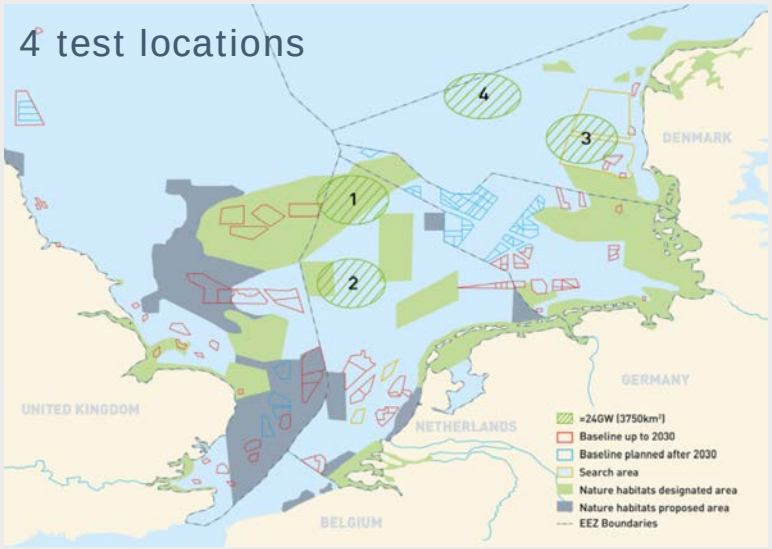
- More than 35 (demo)sites of Power-to-gas/Power-to-X in operation.
  ~ 30 in construction phase.
- Extensive R & D activity
- New plant capacity up to 100 MW
- Hydrogen utilisation
  - Methanized to NG quality
  - Supplied directly as H_2 for industri or transport
  - Blended into the gas grid
  - Processed to liquid fuels



Re: HIPS 2019

North Sea Wind Power Hub

- Vision: 180 GW wind power – in a coordinated roll-out, with minimum environmental impact and lowest cost for society
- Technical solutions are being investigated in the consortium





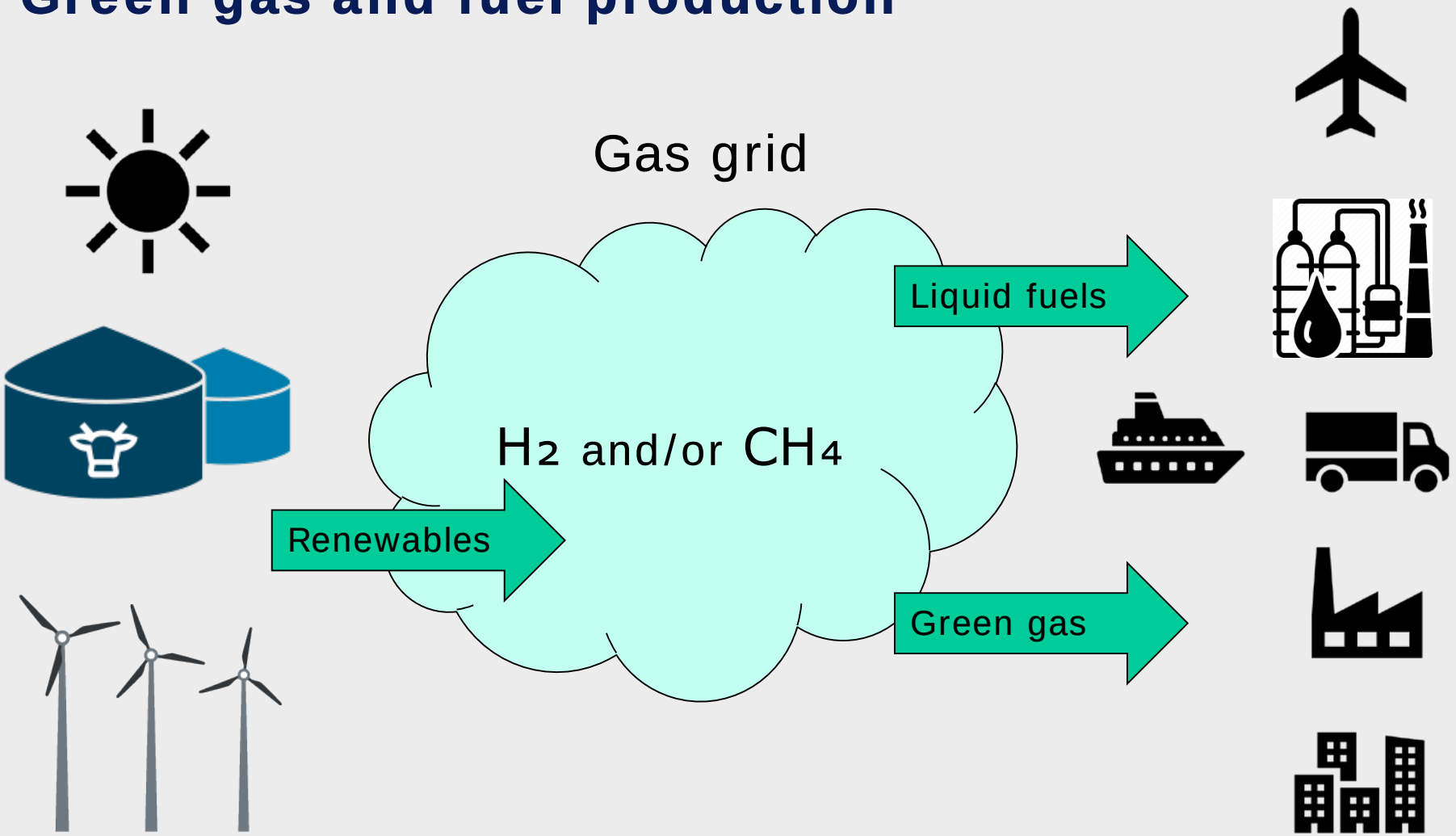
Energi scenario	Power	P2G
2*6GW	2*6GW	x
12GW	12GW	x
24GW	24GW	x
24GW	8GW	16GW
24GW	x	24GW
36GW	x	36GW
36GW	x	36GW

TenneT gasunie ENERGINET Port of Rotterdam

Danish RD&D projects – recent P2X examples

- eSMR-MeOH - Biogas to MeOH by electric reforming
- eFuel – Biogas-to-methane (et. al.) by biological methanation
- Power2Met - Module-based power-to-methanol pilot
- SOEC - Power-to-ammonia pilot
- SOEC - Power-to-methane pilot
- HyBalance pilot plant – Power-to-green hydrogen for industry and balancing services (in operation)
- Avedoere pilot plant – Power-to-methane by biological methanation for gas grid use(in operation)

Green gas and fuel production



Wrap-up and Q&A

- Denmark is on an ambitious path to fossil independence by 2050.
- New energy sources and new use of infrastructure are enablers for a resilient system. The FutureGas project has provided important guidance on how to proceed (technical, modelling and regulation).
- Cross-border connections, sector coupling and storage on many levels are needed.
- A green gas system can be the backbone for the integrated energy services in a fossil-free future.
- Optimal transition requires global (European) targets and a good mix of regulation, market-based subsidies and RD&D.

Extras

Impact - consequences

Danish Energy Agency

55 % of Denmark's energy consumption will be covered by renewable energy in 2030



By 2030, 90 % of district heating is expected to come from renewable energy or waste



The Danish production of green electricity will be able to more or less cover Danish electricity consumption





