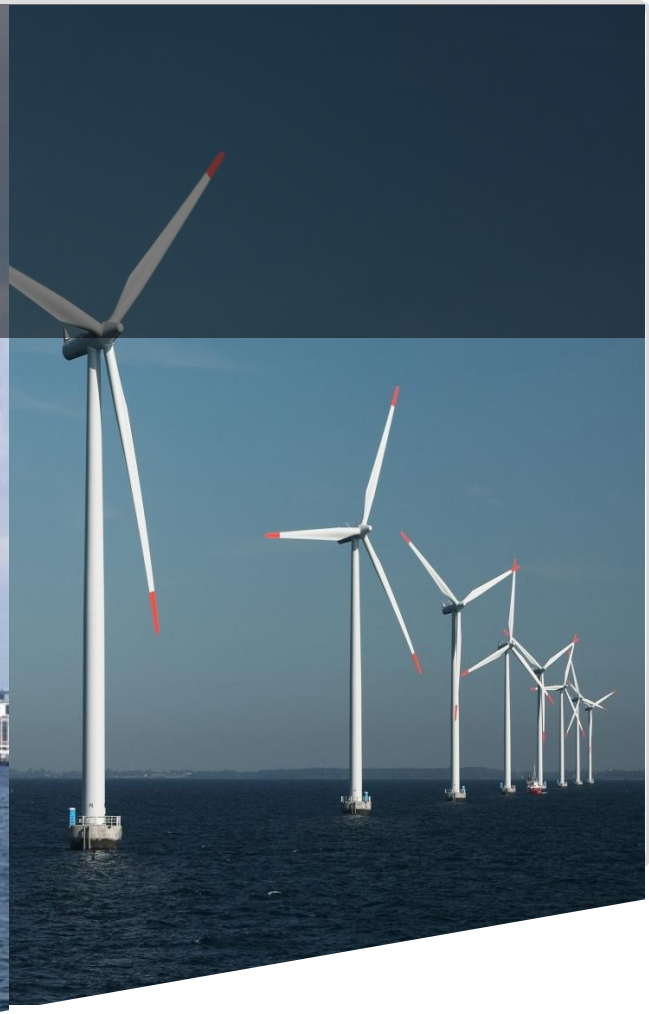
Natural gas power production – now and in the future

Rudolph Blum, Head of R&D, DONG Energy Power

Soul October 19, 2011



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Main data

- DONG Energy is the biggest energy company in Denmark.
  The state owns ~75 % of the shares.

- DONG Energy is a merger of several energy companies and has the complete value chain from oil and gas exploration and production, over electricity production to electricity and gas distribution.

- In 2010, the main production and sales figures were :
  - Oil and gas production: 24.4 million boe
  - Electricity production: 20.2 TWh
  - Electricity sales: 10.4 TWh
  - Electricity distribution: 9.1 TWh
  - Gas distribution: 11.4 TWh

- Number of employees: 5,900

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Electricity production capacity by 2010

- **Total fossil fuel-based operating capacity: 5,300 MW**
  - Hereof gas-based: 1,680 MW
  - Gas-based under construction: 50 % of 870 MW

- **Wind power capacity**
  - Operating: 1,060 MW
  - Under construction: 1,290 MW

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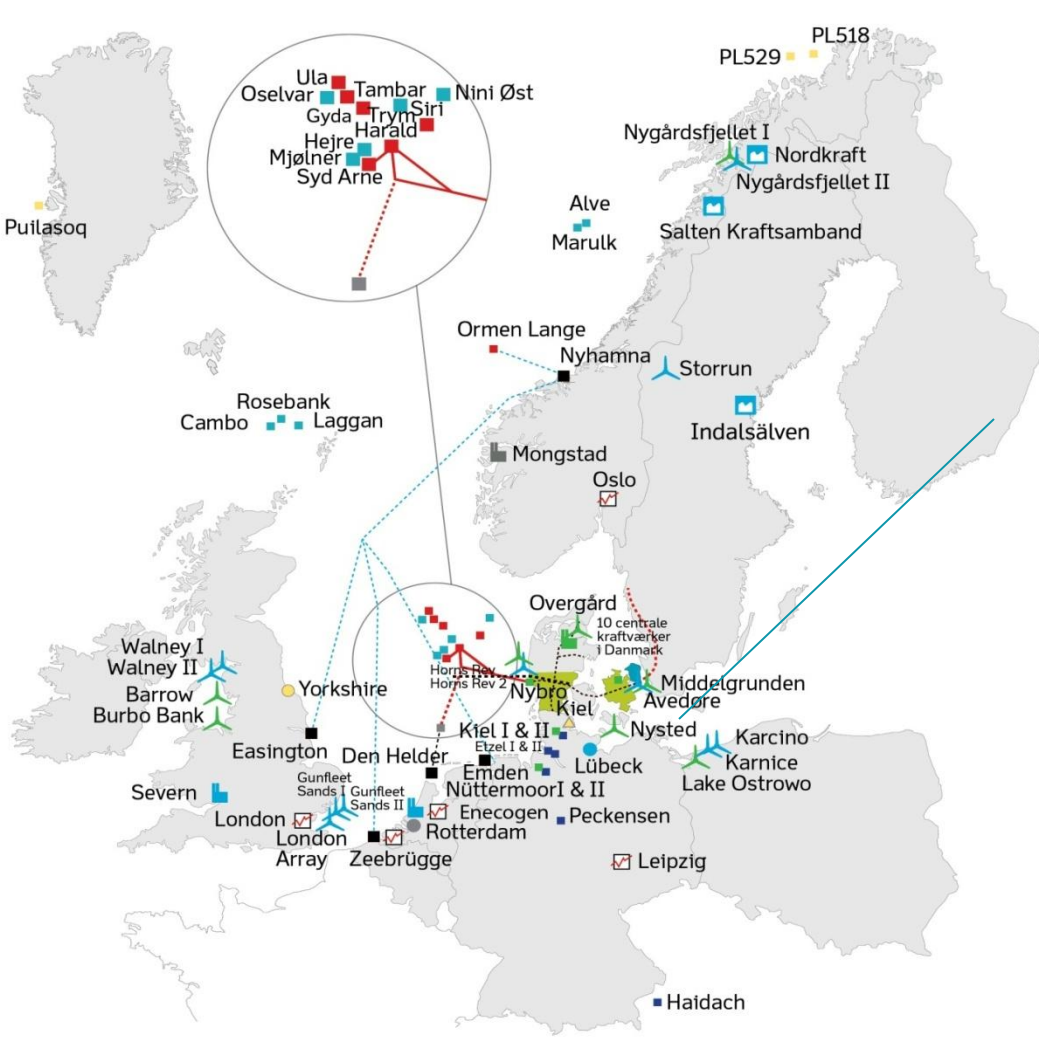
DONG Energy is an integrated energy company

- with activities across the entire energy value chain



Exploration and production areas of oil and natural gas

Natural gas pipeline owned by DONG Energy

Natural gas pipeline owned by others

Natural gas pipeline partly owned by DONG Energy

Gassled natural gas transmission system partly owned by DONG Energy

Oil pipeline owned by DONG Energy

Hubs

Natural gas distribution

Natural gas storage

Heat and power production

Heat and power production project under development

Power production project under development

Wind power

Wind project under development

Electricity distribution

Hydro power - partly owned by DONG Energy

Stadtwerke Lübeck partly owned by DONG Energy

Energy exchange

DONG Energy offices

Carron Engineering & Construction - subsidiary fully owned by DONG Energy

DONG Energy pipelines GmbH - subsidiary fully owned by DONG Energy

Liquefied Natural Gas (LNG) terminal, partly owned by DONG Energy, project under development

Producing oil/natural gas field - partly owned by DONG Energy, DONG Energy is licence partner

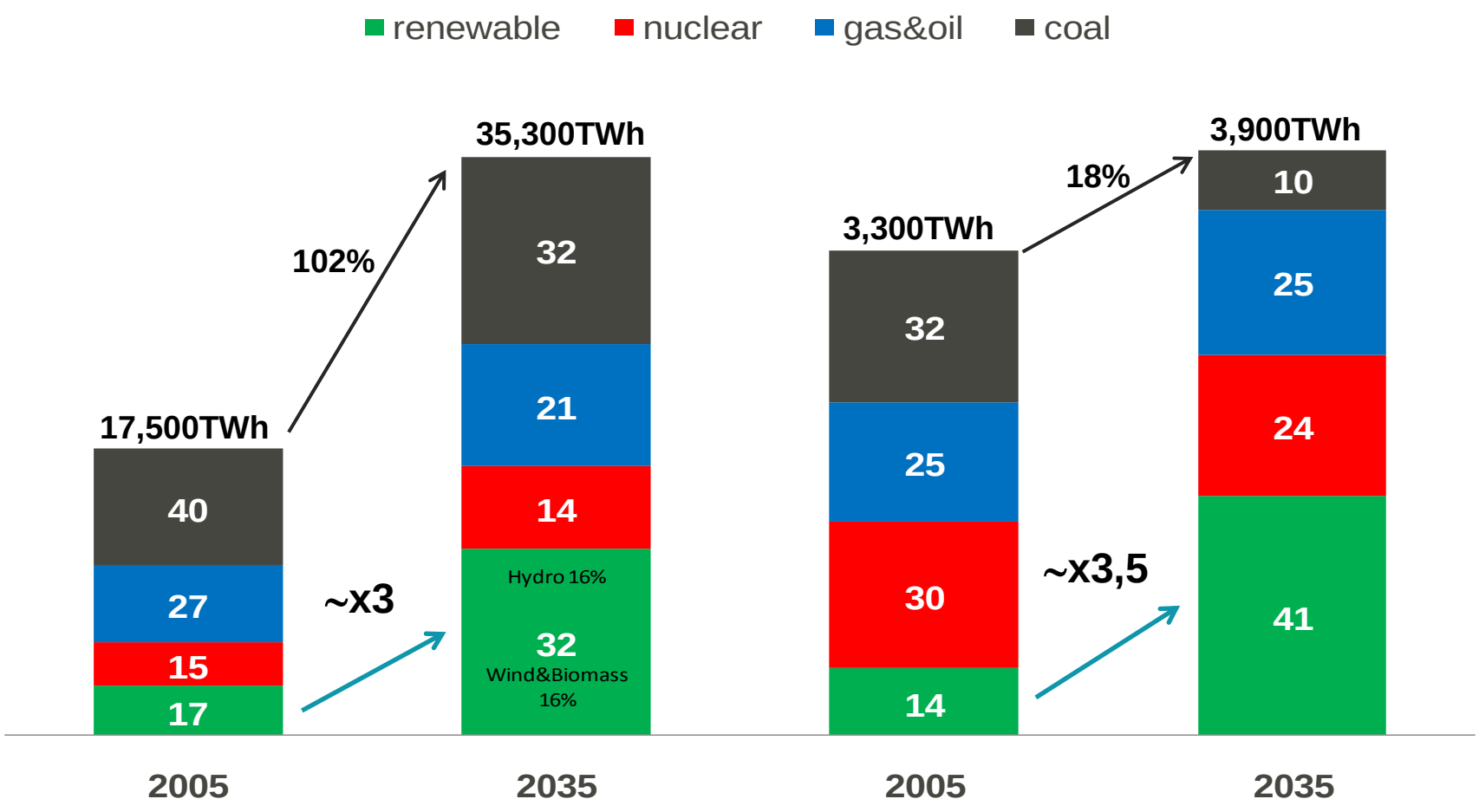
Producing oil/natural gas field - partly owned by DONG Energy, DONG Energy is licence operator

Producing oil/natural gas field - owned and operated by others

[1] Under construction, commissioning expected in 2010

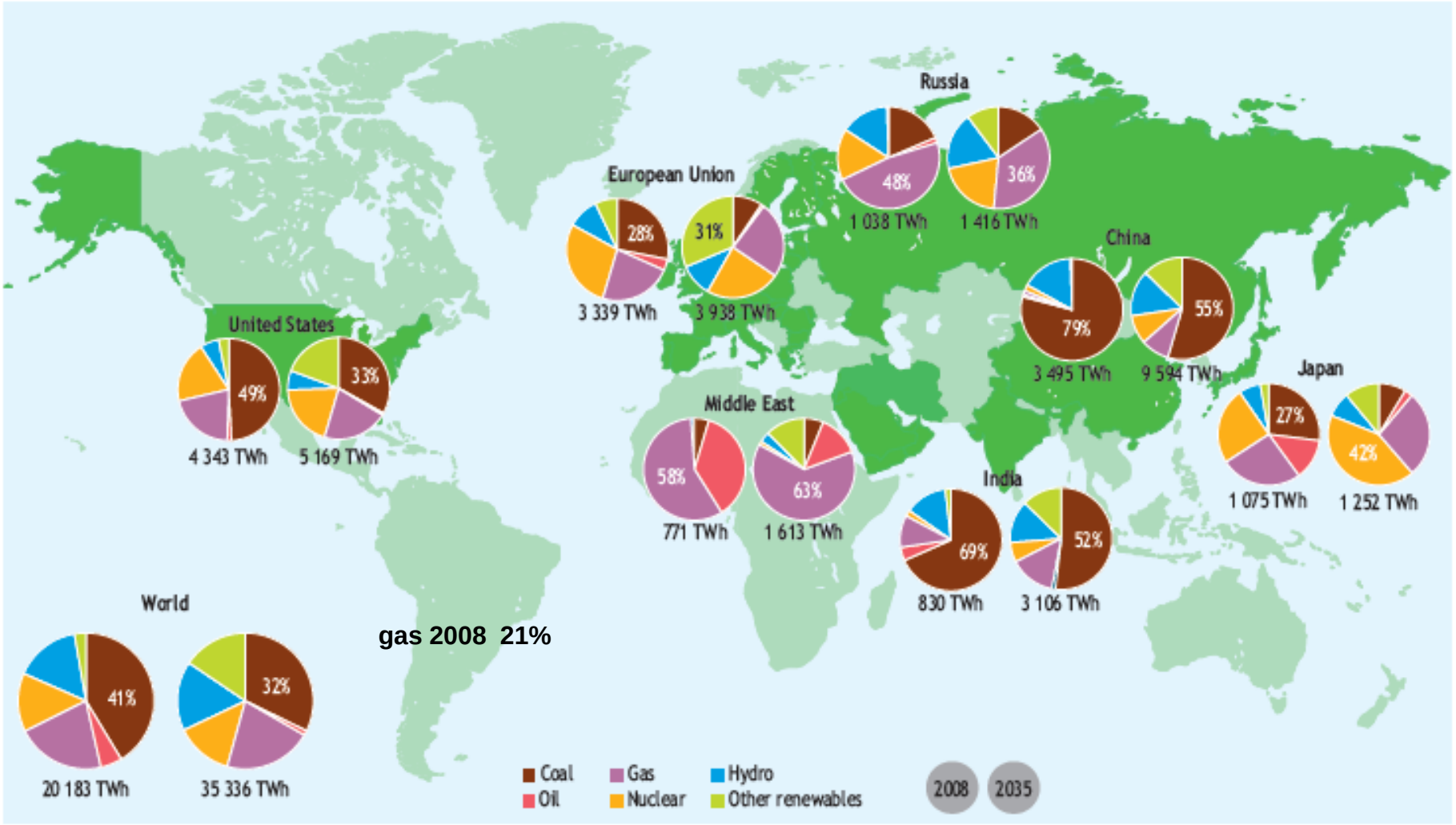
[2] Awaiting final investment decision

Primary energy sources for electricity generation 2005-2035



Source: IEA 2010

Electricity generation by fuel and region - IEA 2010



Present keywords for fossil-fired power plants

- High efficiency is the key word for clean thermal power plants because
  - it reduces the overall consumption of primary energy
  - it generally reduces the emissions
- Good load following capability
- CHP, district cooling or symbioses with industries lead to substantial improvements of the utilisation of the primary energy and cut CO_2 emission.

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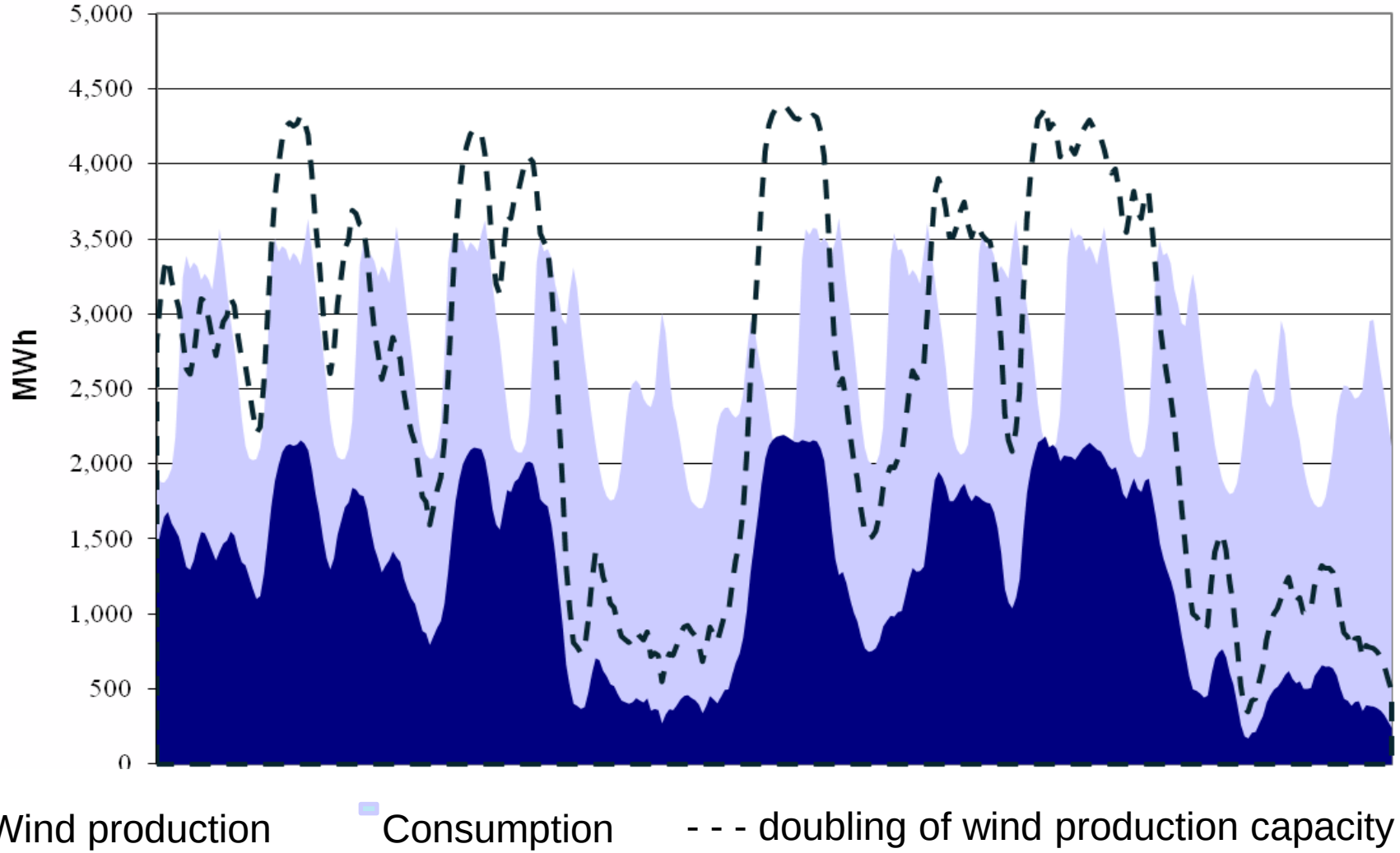
Wind production and consumption in Western Denmark December 2006 and by doubling the wind production capacity



Source: Energistyrelsen; EWEA; Energinet.dk

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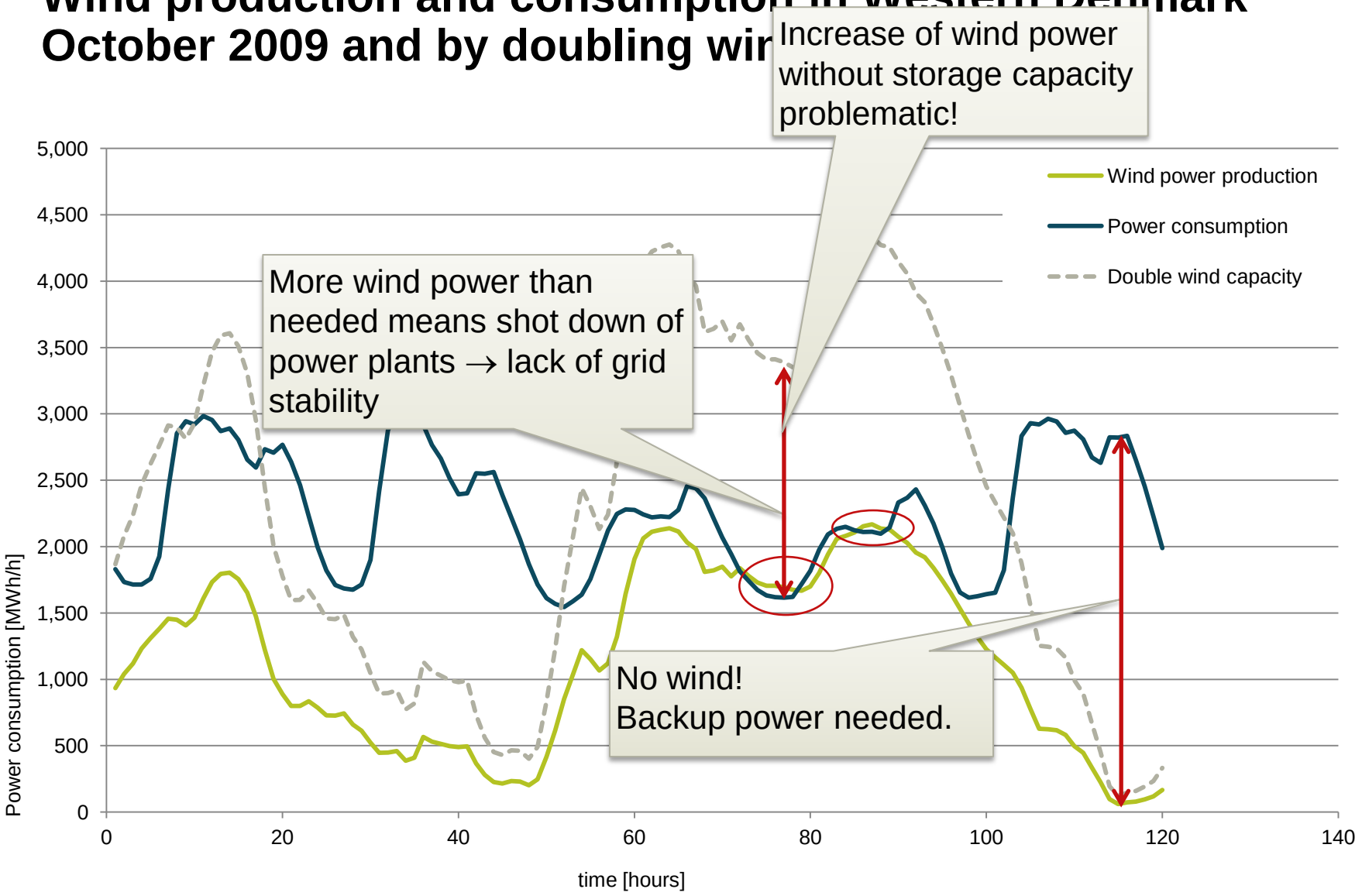
Wind production and consumption in Western Denmark October 2009 and by doubling wir



Source: www.energinet.dk

Future keywords for fossil-fired power plants in Northern Europe

- Long periods (up to 1-2 weeks) where need for back-up power for a real high percentage of wind and solar power exists.
- Low investment costs due to few full load operating hours.
- Extreme flexibility due to fluctuations in renewable energy regarding
  - Load following
  - Minimum load
  - Short start/stop times

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Challenges in the future electricity system
Renewable Energy – unbalance

- To obtain a high percentage of wind and solar energy an excess amount of nominal power must be installed.
- This leads to unbalance with periods with excess power production and other periods with need for back-up power.
- Such unbalance will be on time scales ranging from minutes over hours to days and weeks.
- This situation creates a strong need for flexibility and storage capacity for electricity.
- Long-term unbalance (several hours, days and weeks)– lack of electricity cannot be counteracted from storage facilities, but thermal production technology must be used.
- As the amount of full load hours will be low CAPEX have to be low whereas a higher OPEX can be foreseen.
- This makes a gas turbine solution advantageous.

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Characteristics of GT power plants – now and in the near future

- Single cycle GT enables an efficiency up to 46 % - low capex
  - GE
- Combined cycle GT has proven efficiencies above 60% - medium capex
  - Siemens
- Development of single cycle GT combined with steam injection calls for efficiencies up to 58% in the future – low capex
  - GE and Europe Turbine

Gas turbines are an efficient thermal generation concept for the future.

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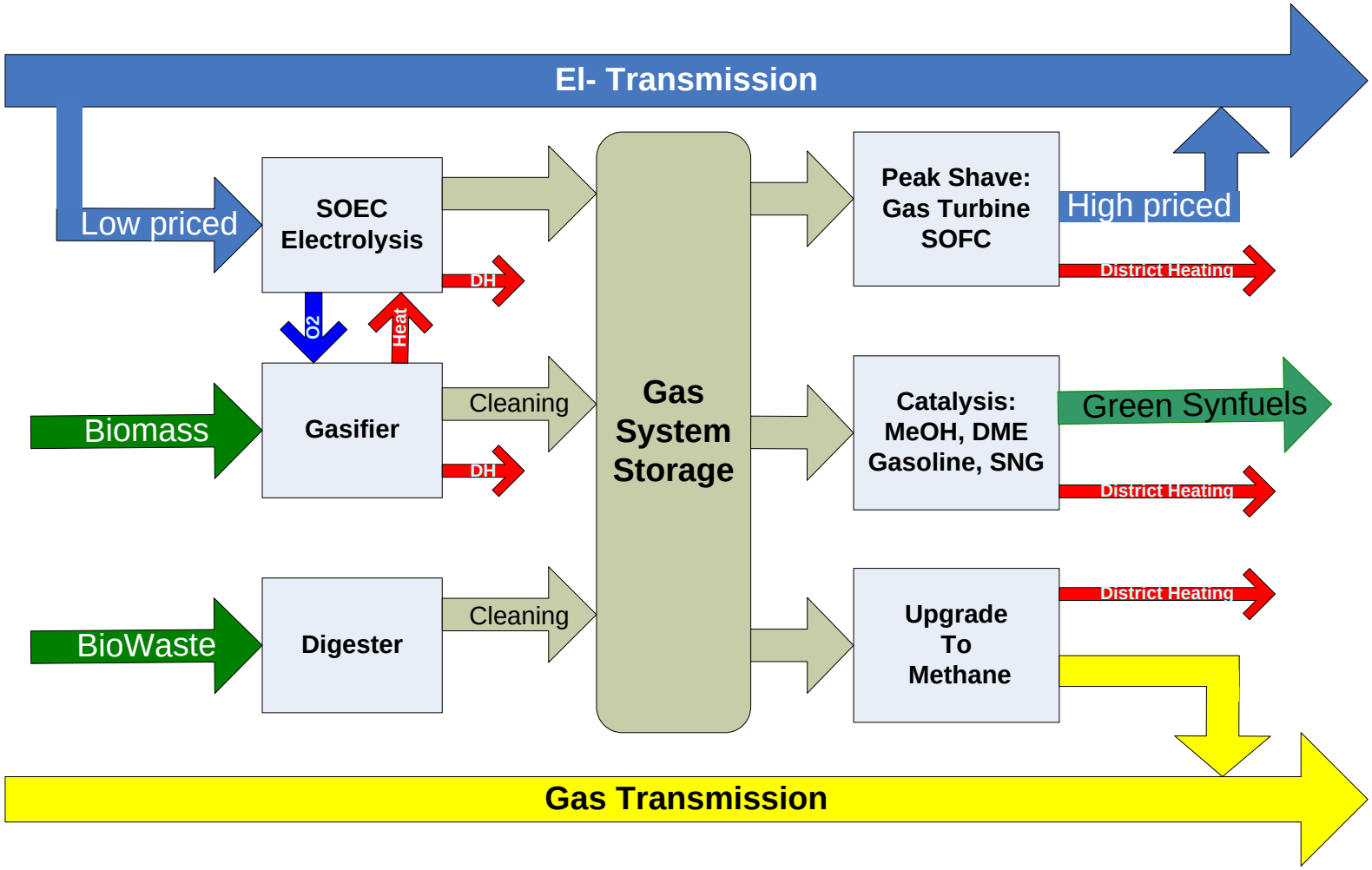
Govermental vision for a fossil fuel-free Denmark in 2050
The wind scenario



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Production of green gas

A: Upgrading of biogas *)

- CO_2 removal and injection into the N-gas network
- Upgrading of H_2 and CO_2 to methane

B: H_2 produced through electrolysis *)

C: Gasification of biomass and upgrading of CO/CO_2 and H_2 to methane

D: Combination of B and C

*) A and B under development in Denmark

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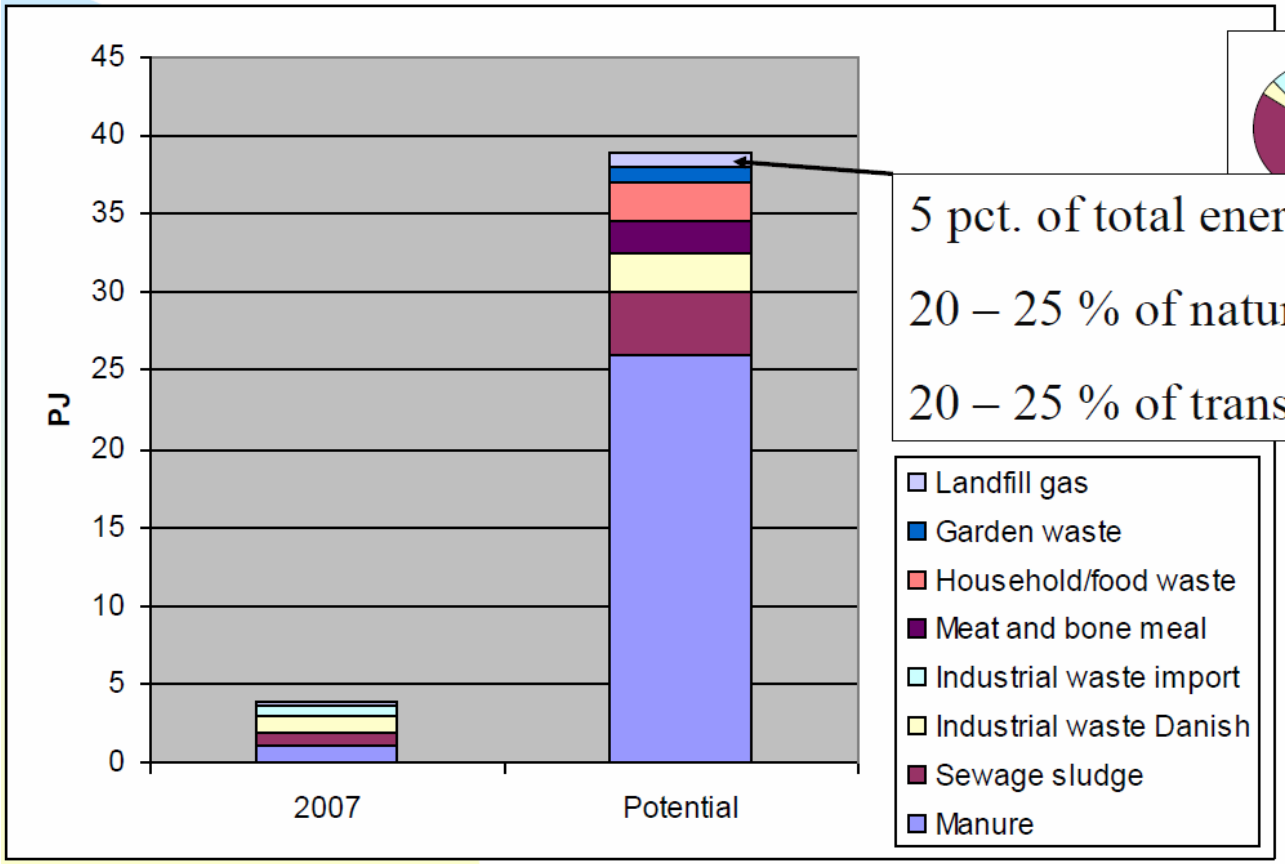
Biogas – production and potential



Danish Biogas Association

Kilde: Energistyrelsen

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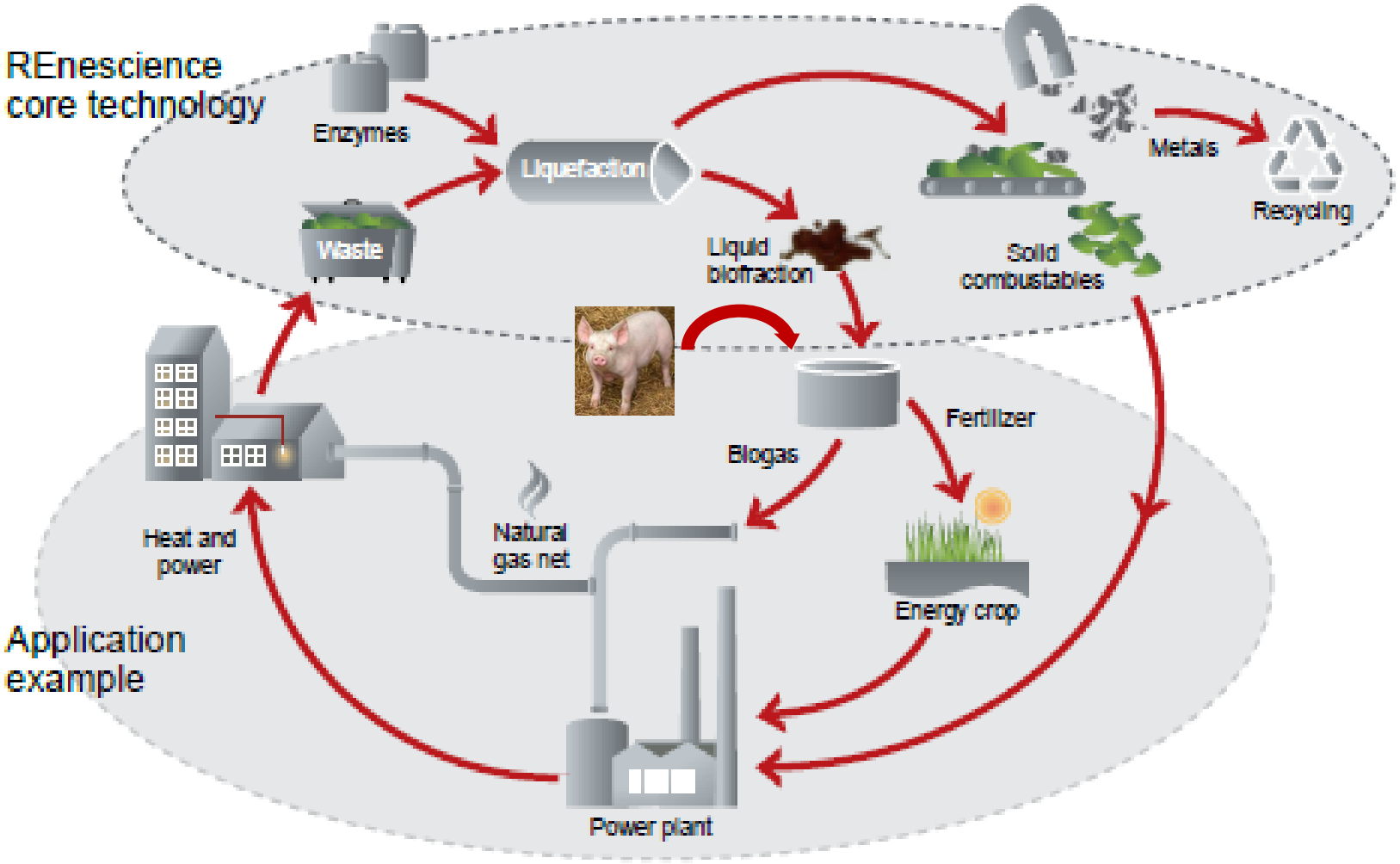
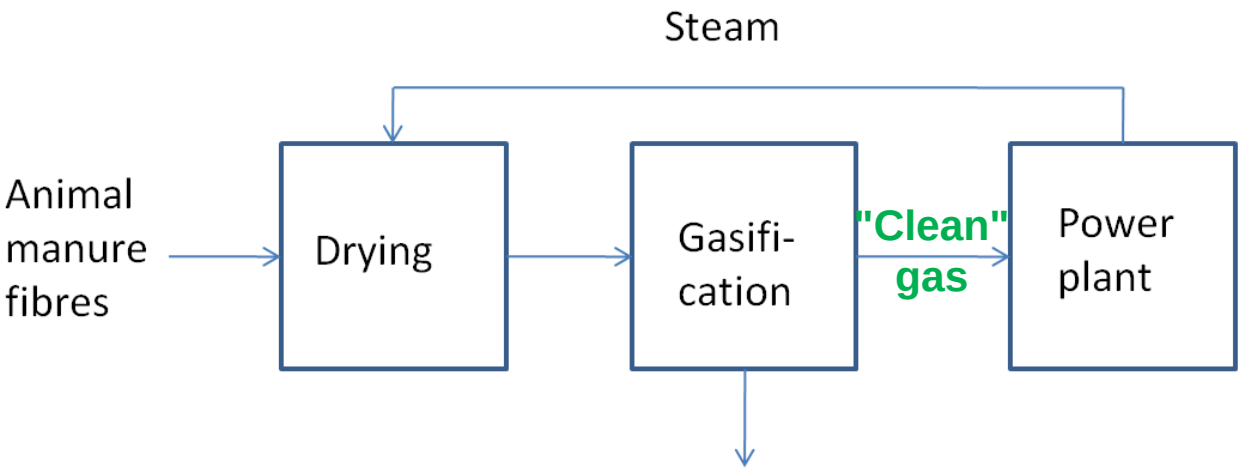
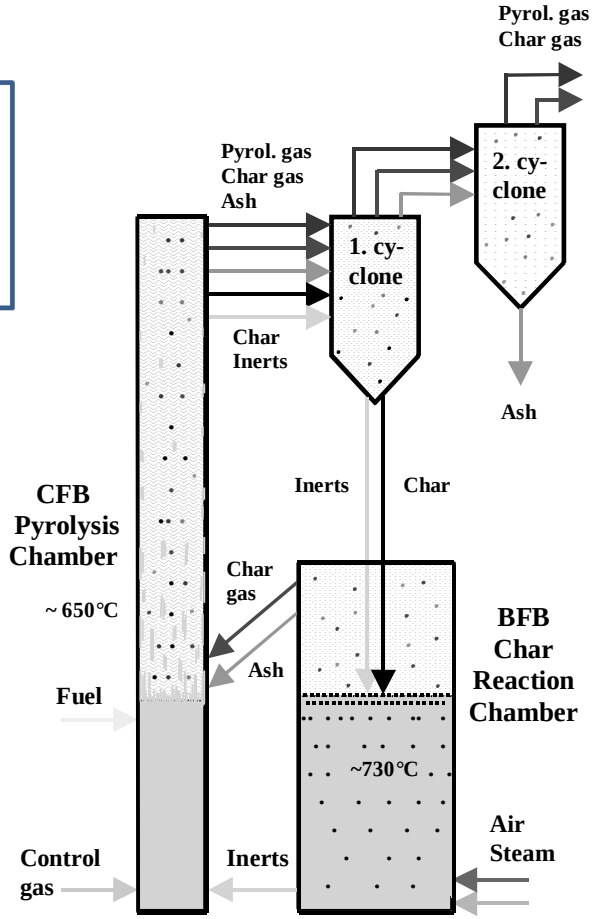
Biogas production based on animal manure combined with municipal waste



Low-temperature CFB gasifier for thermal pretreatment of straw, animal manure fibres and other difficult biomasses



Ash containing 95% of the valuabled minerals



500 kW test plant at DTU 2005
Stable operation with straw, no agglomeration

5 MW demonstration plant in operation
since 2010 linked to a DONG Energy power plant

Further optimisation including gas upgrade through R&D activities planned for the next three years

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Green Natural Gas – Development of the SOEC technology

- Surplus of electrical energy can be transformed to storable SNG
- SNG is catalysed under >10 bar pressure from a ‘green’ synthesis gas consisting of H_2, CO and CO_2. The CO_2 will be provided from biomass gasification and/or fermentation of biofuels. The CO and H_2 are generated by solid oxide electrolysis of CO_2 and steam.
- SOEC operating at 800 °C implies an efficiency of 3-3.5 kWh/Nm^3 H_2 which is 20-25 % more efficient than traditional low temperature electrolysis.
- SOEC cost is expected to be low when fully developed in the future as high volumes of the stacks will be demanded also by fuel cell applications (SOFC).

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Storage capacities – use of existing caverns

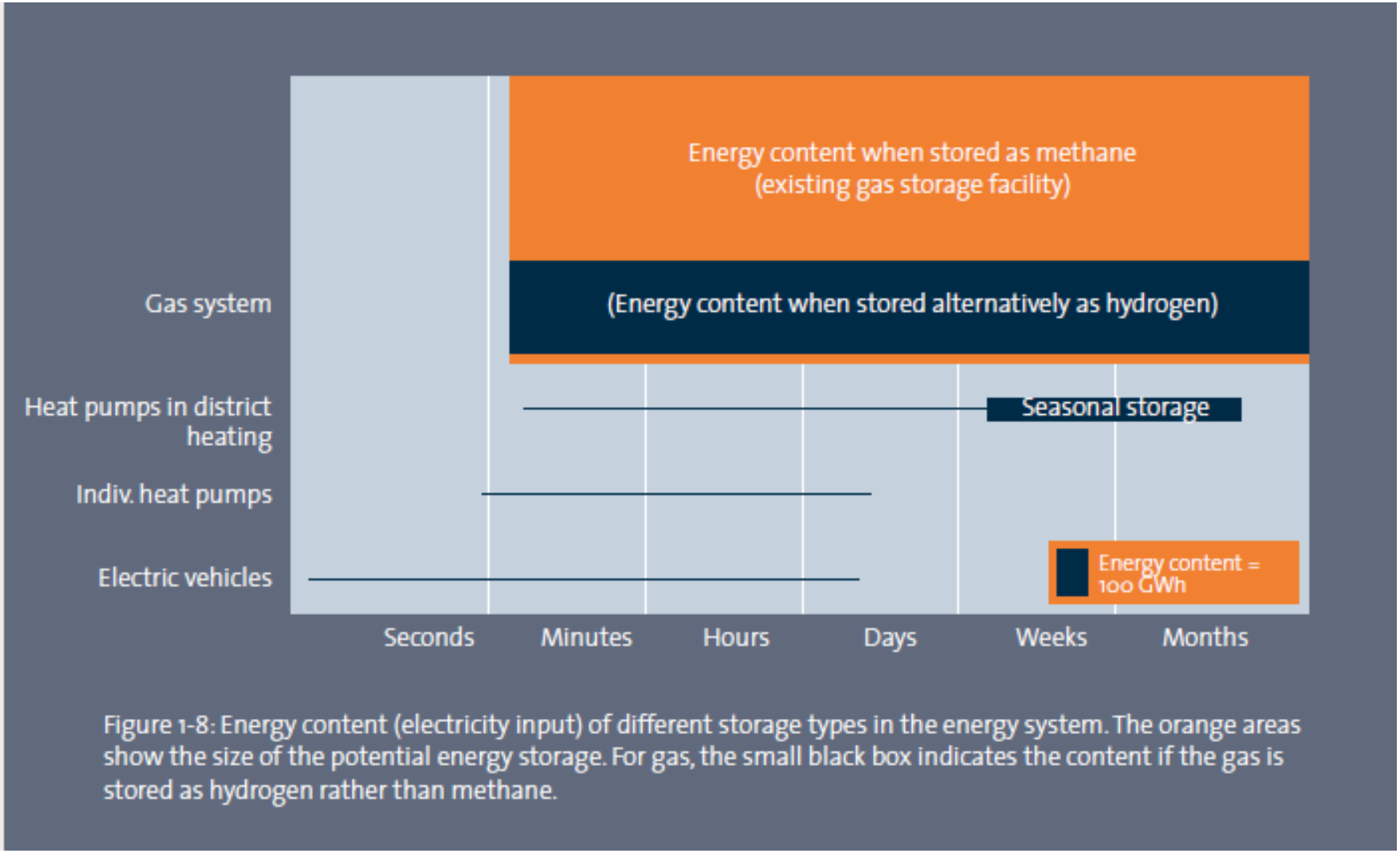

Figure 1-8: Energy content (electricity input) of different storage types in the energy system. The orange areas show the size of the potential energy storage. For gas, the small black box indicates the content if the gas is stored as hydrogen rather than methane.

Source: energinet.dk

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Conclusion

"*Does electricity power the gas industry?*" Yes - because

A vaste development of unpredictable renewable energy production capacity calls for:

- flexible and high efficient back up capacity
- low capex
- low CO_2 emision

Gas turbines can fulfil these requirements to day and enables a relatively easy transformation from fossil gas to green gas for the future by using biomass and renewable energy based gas refining technologies.

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