

Digestate and biogas utilisation – practices and perspectives
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Using biogas for CHP and/or transportation purposes in the long run

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Energy policy objectives for Denmark

as specified in the 21st of February 2008 political agreement

- Denmark shall keep on being self-sufficient with energy (national security priority). In the long run (~ before 2100) fossil fuels shall be replaced completely with renewable energy.
- De-linking consumption and economic growth shall continue. Gross energy consumption shall be reduced by 2 % by 2011 and 4 % by 2020 as compared to 2006.
- Renewable energies share of gross energy shall increase from 15,6 % in 2006 to 20 % in 2011 and further to 30 % by 2020.

Priority to biogas

as specified in the 21st of February 2008 political agreement and 16th of June 2009 Green Growth agreement

- Improved feed-in tariff for electricity. All biogas plants now receive a total of **DKK 0,745 per kWh** (or an additional payment of DKK 0,405 per kWh when biogas is used together with natural gas). The tariff is adjusted annually with 60 % of the price index increase.
- As target 50 % of all animal manure is to be utilised for energy production by 2020. This implies a 10-fold increase in using manure as energy source in just 10 years.

How big can biogas become?

- At present biogas contributes 4 PJ or ½ % of Denmark's energy consumption.
- 15-20 PJ in 2020 equals around 2 % of expected gross consumption in 2020.
- The total Danish resources suitable for biogas production could produce 40 PJ per year ~ 5 % of present gross consumption.
- Additional biomass resources can be added – such as energy crops or even sea weeds in the long run.

1st breakthrough: Gaining credibility

2nd challenge: Gaining volume

3rd challenge: Pipeline distribution

4th challenge: Transportation use

- **1st breakthrough - 1990 until now.** Credibility has been gained by stable operation and acceptable profitability due to combined digestion of manure and organic wastes.
- **2nd challenge - from now until 2015.** Volume must be gained from focus on operational efficiency (best practise). In addition financial viability has to be achieved based on a combination of manure and other biomass feedstocks – except organic wastes.
- **3rd challenge - ... before 2020.** How to use the gas grid. Upgrading biogas or downgrading natural gas – or both.
- **4th challenge – biogas as transportation fuel.** Either directly as methane or converted through synthesis – if at all.

Expanding biogas production is the **next major challenge** – while the established CHP-infrastructure is ready to consume the next 5-10 PJ biogas

- Viable production based on manure and energy crops – excluding organic wastes – needs to be demonstrated
- If this production expansion is not successful then perspectives concerning pipeline distribution of biogas or use as transportation fuel become irrelevant

From Centralised to Decentralised CHP

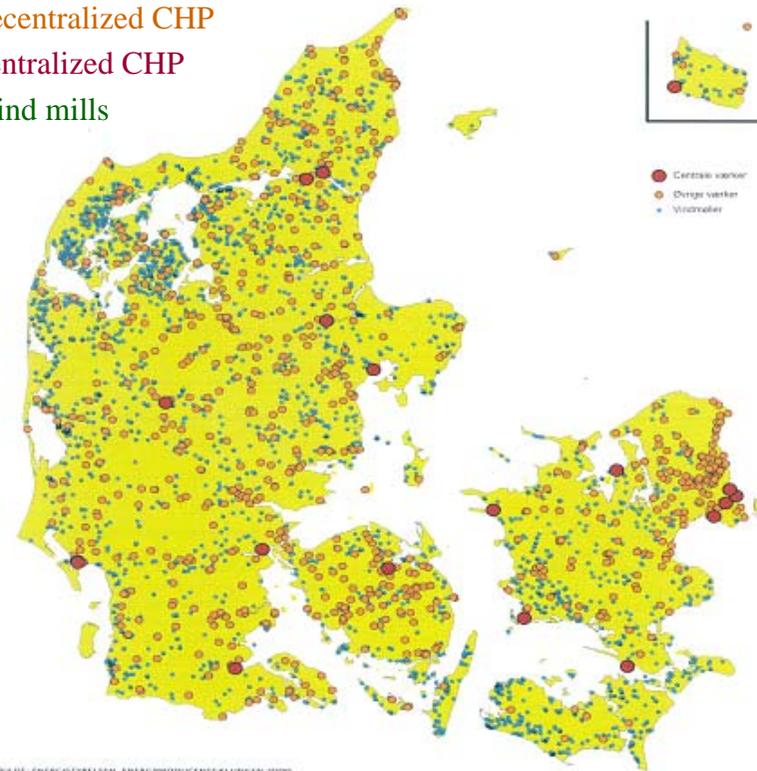
Centralized production in the mid 80's



Decentralized production of today

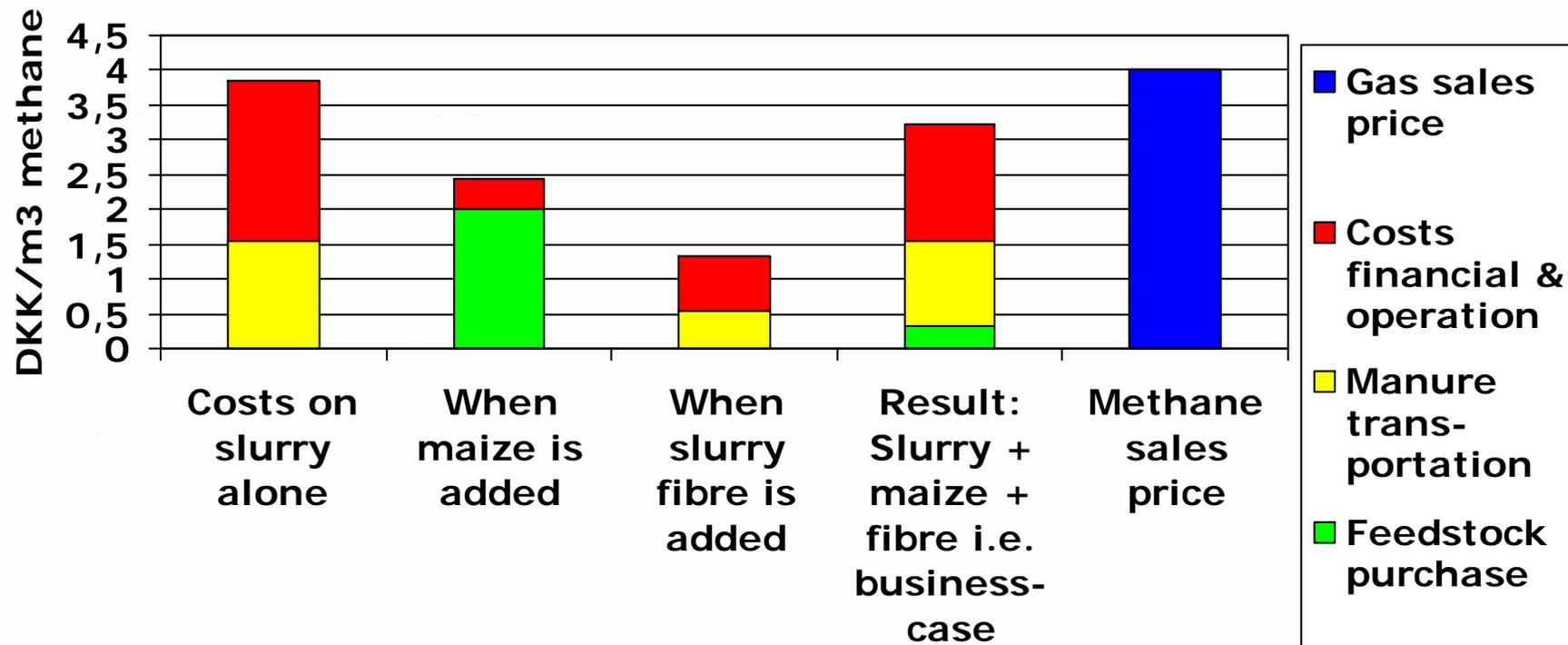
Legend:

- Decentralized CHP
- Centralized CHP
- Wind mills



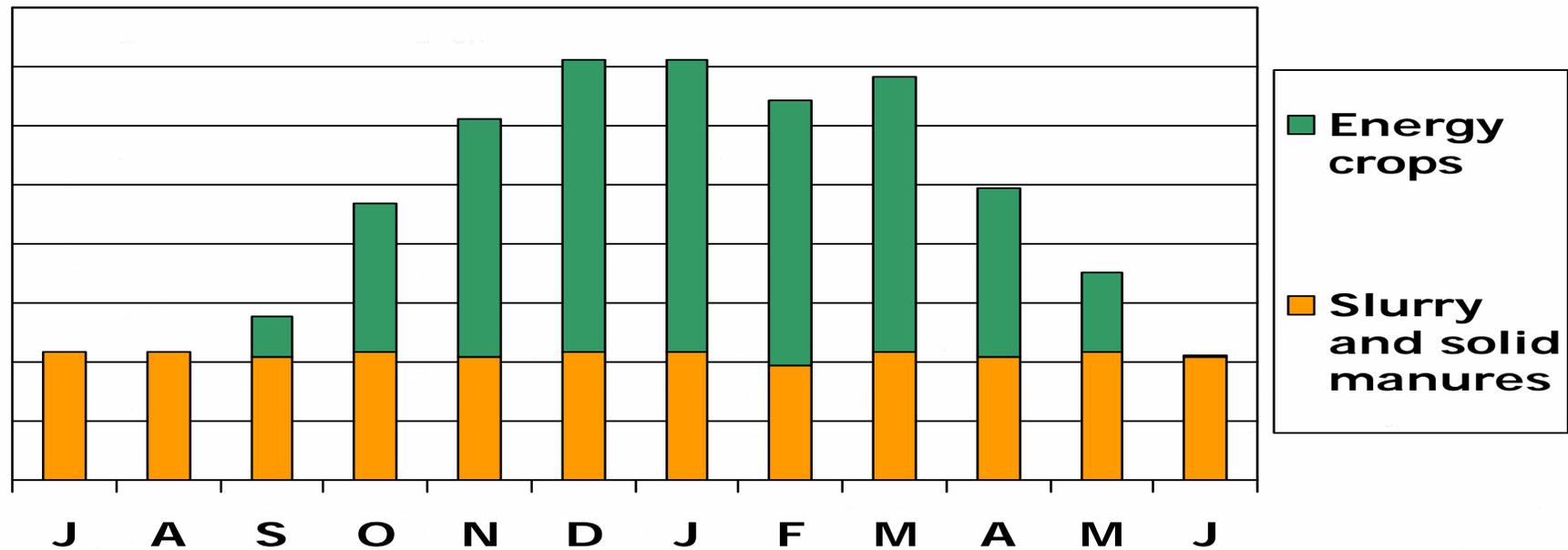
CHP = Combined Heat and Power generation

Business-case: Large scale centralised biogas plants, DKK per m³ methane



Financial viability may be achieved from combining low-costs per m³ slurry handling with enhanced gas production from added feedstocks such as energy crops

Emerging concept: Full coverage of fuel need for CHP by seasonally regulated biogas production



If the concept proves financially viable when biogas may in the long run be able to contribute 50-60 PJ per year or approx. 10 % of Denmark's gross energy consumption

Costs, DDK per m³ methane

Directly to CHP versus opgraded to pipeline quality

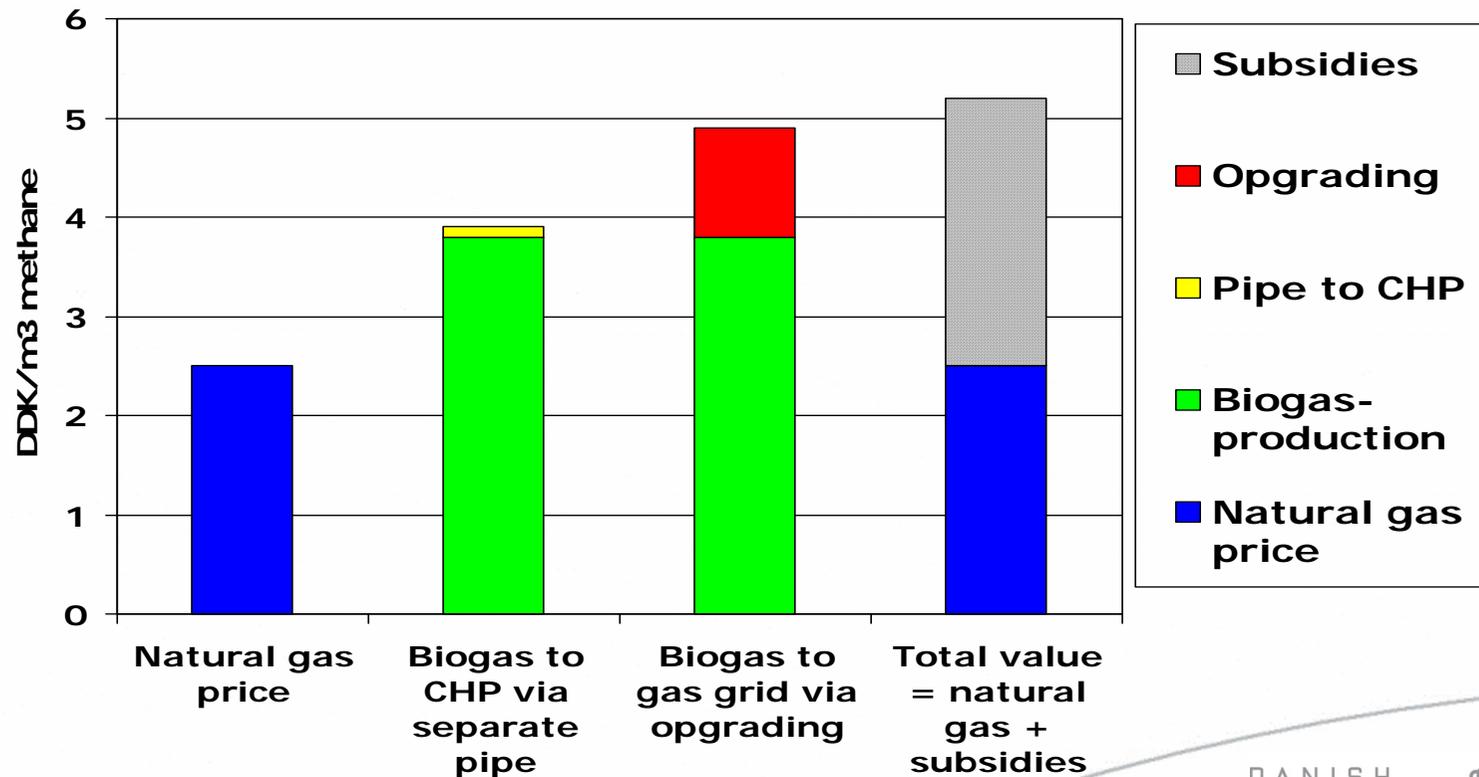
Typical natural gas price: 2-3 DKK/m³ methane

Estimated biogas production costs (large centralised plant): 3,8 DKK/m³ methane

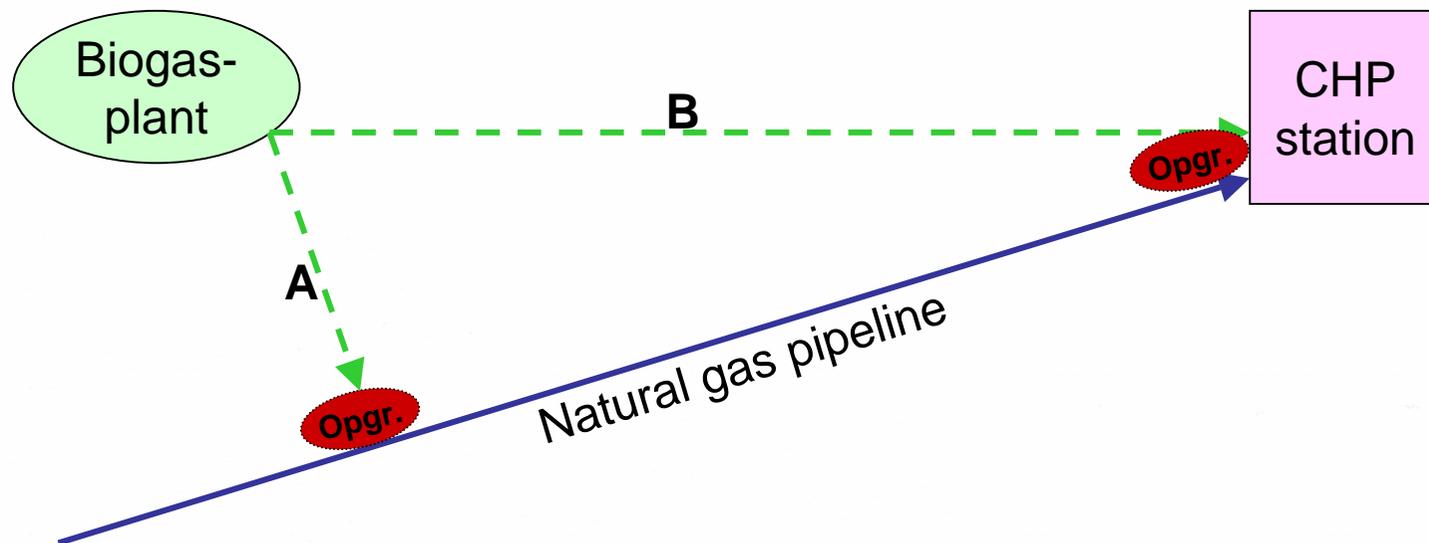
Transporting biogas via separate pipe to CHP-station: 0,1 DKK/m³ methane

Opgrading biogas to pipeline quality (large plant): 1,1 DDK/m³ methane

Total subsidies when biogas is used for CHP: 2,7 DDK/m³ methane

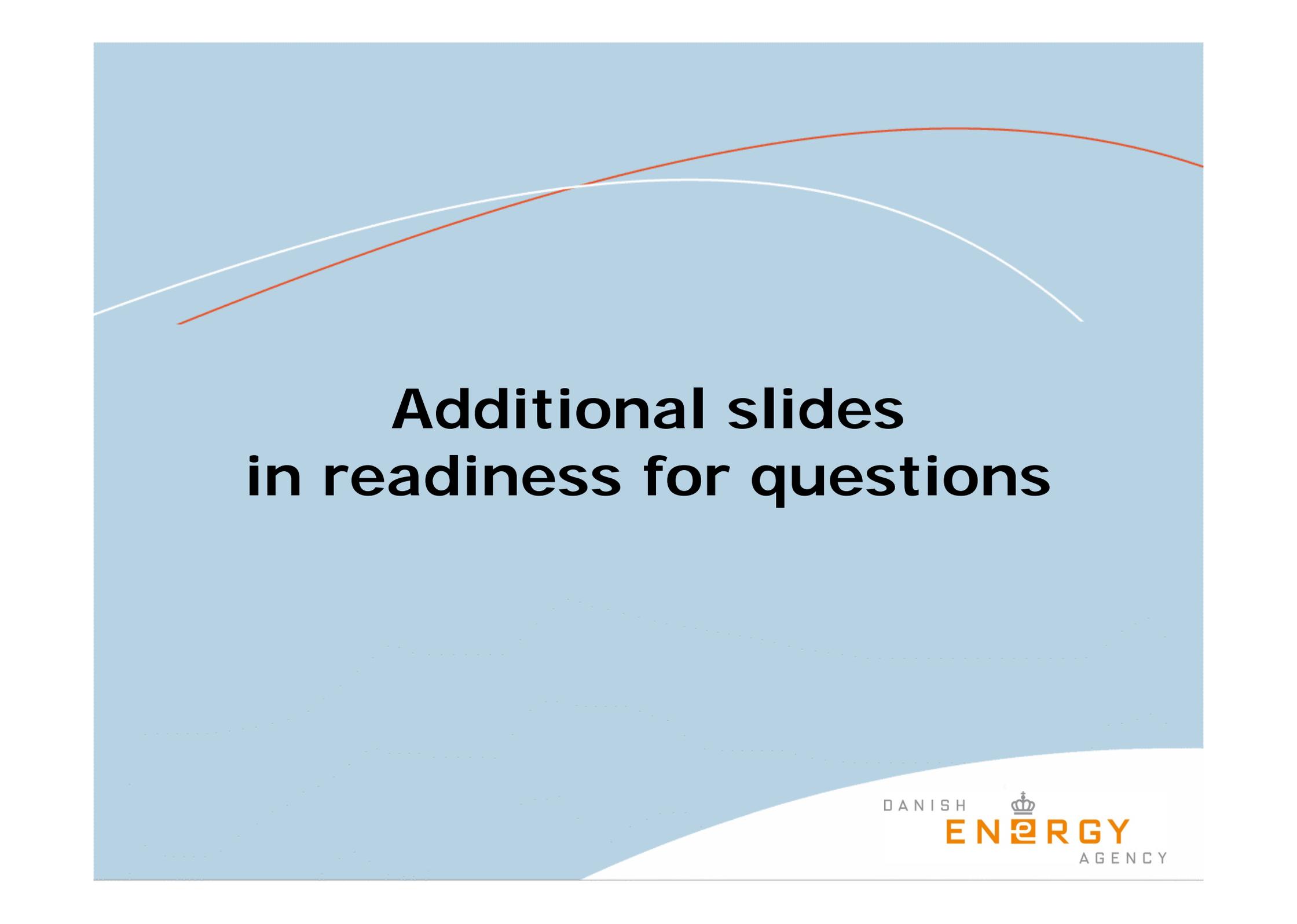


How to get biogas to the natural gas grid, eventually



Thank you for your attention....





**Additional slides
in readiness for questions**

Addressing financial and non-financial barriers

- **Viable business-cases.** Preconditions is discussed in detail. A handful of typical cases is outlined.
- **Reducing preparation time for new plants.** New law shall enable shorter planning periods.
- **Efficient use in the overall energy supply system.** Access to CHP-plants presently running on natural gas. Clarifying and maybe adapting the future use of the natural gas grid for biogas distribution.
- **Existing plants must expand to become more robust.** Smaller plants need to expand to survive.
- **Focus on key important issues is essential.** Past 20 years experiences are to be made operational and more accessible for new projects.

Top priorities for further R&D

- Biological and process control issues. Economically viable ways to improve gas yield especially from recalcitrant organic matter.
- Optimising energy yield and minimising green house gas emissions all the way from the stable through the biogas plant and slurry storage to the final field application.
- Focus on concepts and technical means by which operating costs can be minimised.
- Accurate technical standards to effectively protect neighbours from odour nuisances.
- Long-term strategy considerations: Why are we so focussed on a future hydrogen supply system when we already have a methane option?

20 centralized biogas plant in operation

Capacity: 50-600 m³ slurry per day



Thorsø Centralized Biogas Plant

Slurry tankers is loading 30-35 m³. Diesel consumption typically equals approx. 5 % of the biogas yield from the slurry.



Thorsø Centralized Biogas Plant

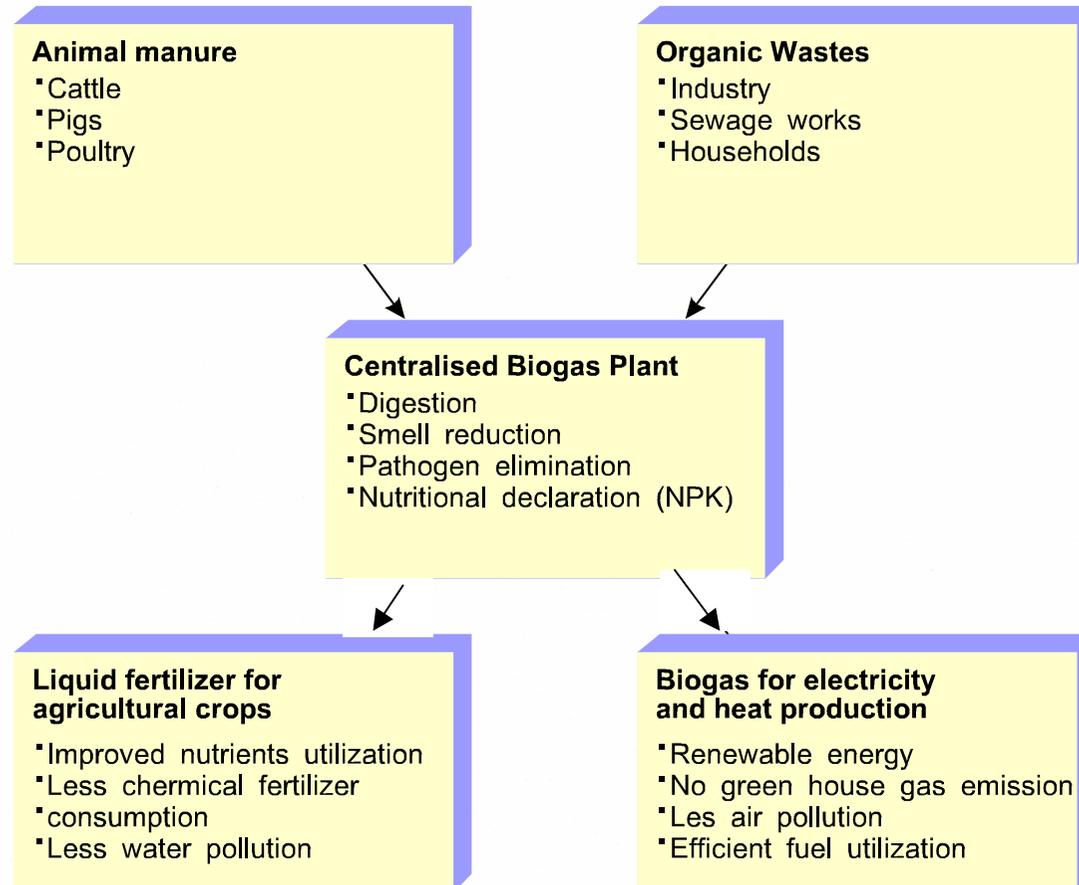
55 single-farm biogas plants in operation

Capacity: 5-50 m³ slurry per day



Orø Single-farm Biogas Plant

The principle features of the centralized biogas plant



Present feedstock mix at Danish Centralized Biogas Plants

Cattle slurry	33 %
Pig slurry	40 %
Other manures	2 %
Subtotal, manure	75 %
Slaughterhouse wastes	8 %
Fatty flotation sludges	6 %
Fish processing wastes	4 %
Dairy, Brewery, Tannery, Pharmaceutical, etc.	7 %
Subtotal, industrial wastes	25 %
Total	100 %

Advantages of co-digestion of manure (slurry) and organic, industrial wastes

- **Enhanced gas production.** High yield per m³ feedstock when organic waste rich in energy is digested with slurry.
- **Efficient digestion.** Co-digestion with slurry makes digestion of wastes stable.
- **Handling.** Solid wastes are turned into pumpable slurry. Fatty wastes mix easily with slurry and fats become accessible to anaerobic digestion.
- **Advantage of scale.** Centralized plants receive wastes from many industries which is more efficient than digesters on each industry.
- **Nutrients utilization and recycling costs.** When wastes are received the farmers take responsibility for the end-use of the product as fertilizer. Due to product uniformity, nutritional declaration and distribution organization the end-result is an all together cheap and environmentally sustainable waste recycling system.

Agricultural and environmental advantages

- Improved fertilizer value
- Full declaration of nutrients
- Free from germs and seeds
- Reduced costs for transportation of slurry
- Reduced nitrate leaching
- Reduced odour problems
- Reduced green house gas emission
- Controlled recycling of organic waste

Agricultural biogas plants fit well with the general transition into efficient use of liquid manure (slurry) as a fertilizer



Application of slurry in winter wheat with trailing hoses



Injection of slurry in bare soil



Broadspreading of slurry is not allowed any more in Denmark due to resulting high ammonia evaporation

N-application in Denmark

