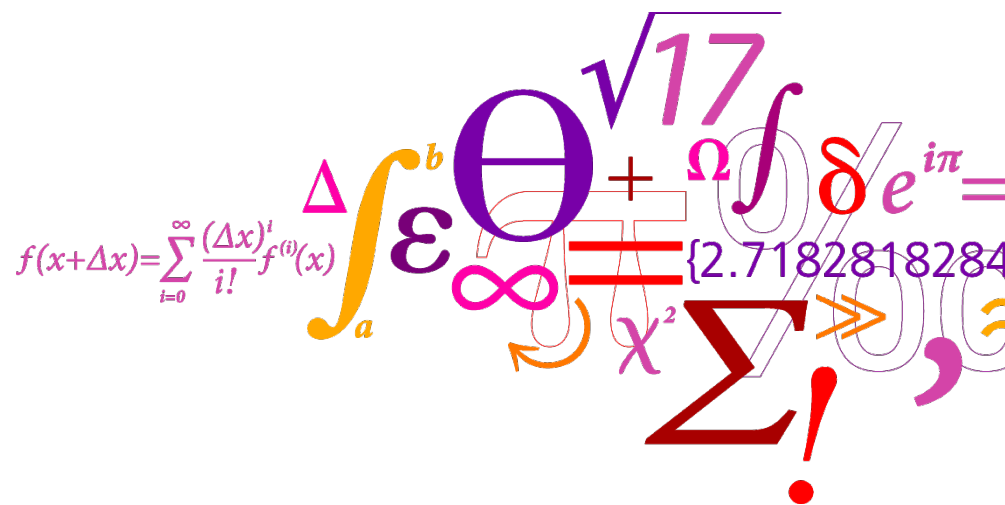


The Future Danish Energy System

- flexibility by system interactions

Professor Poul Erik Morthorst
Systems Analysis Division

DTU Management Engineering
Department of Management Engineering

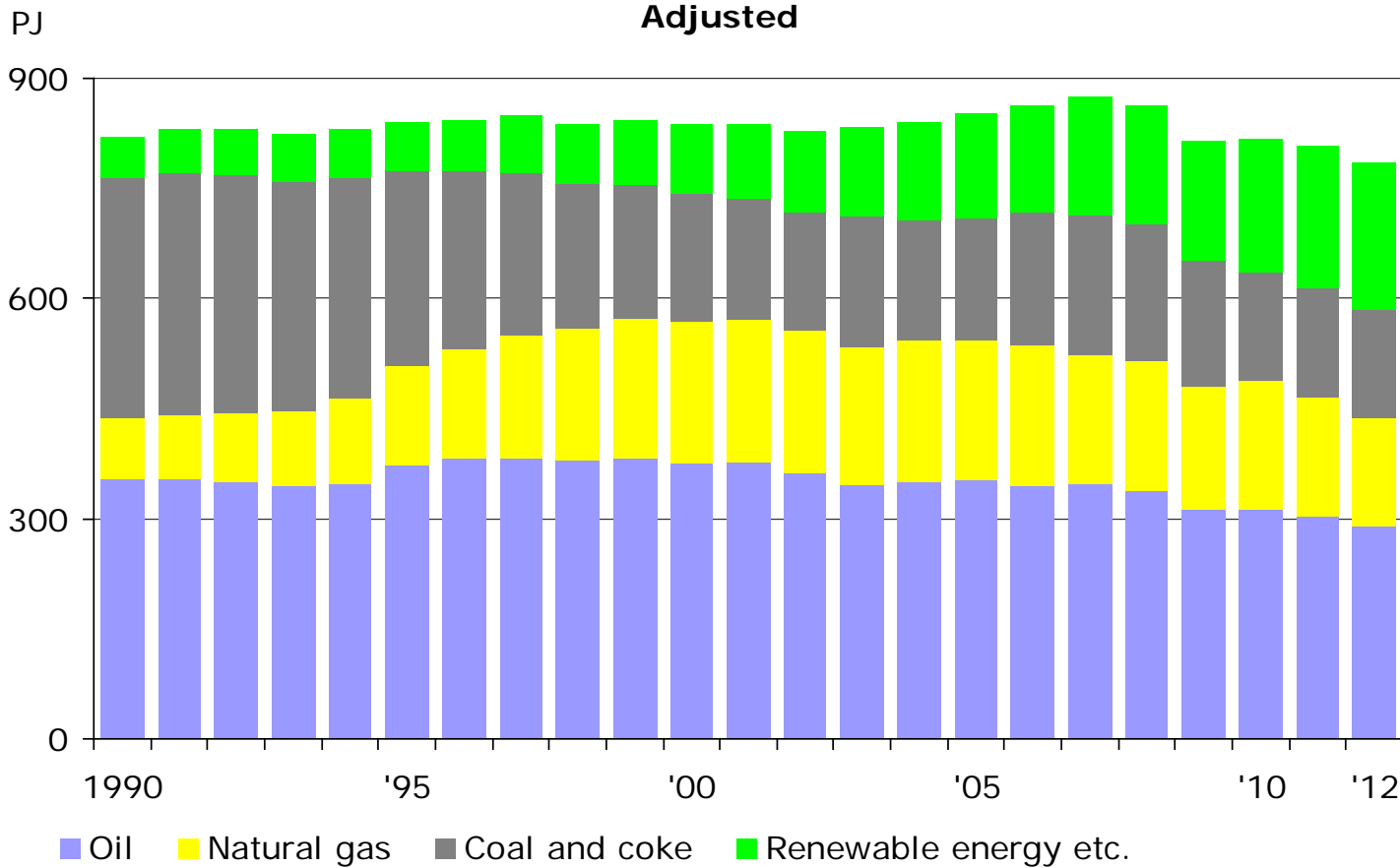


Long term Vision

“ We can both reduce Danish emissions of greenhouse gasses significantly, and make Denmark independent of fossil fuels. This will require a total conversion of the Danish energy system”

- *Danish Commission on Climate Change Policy*

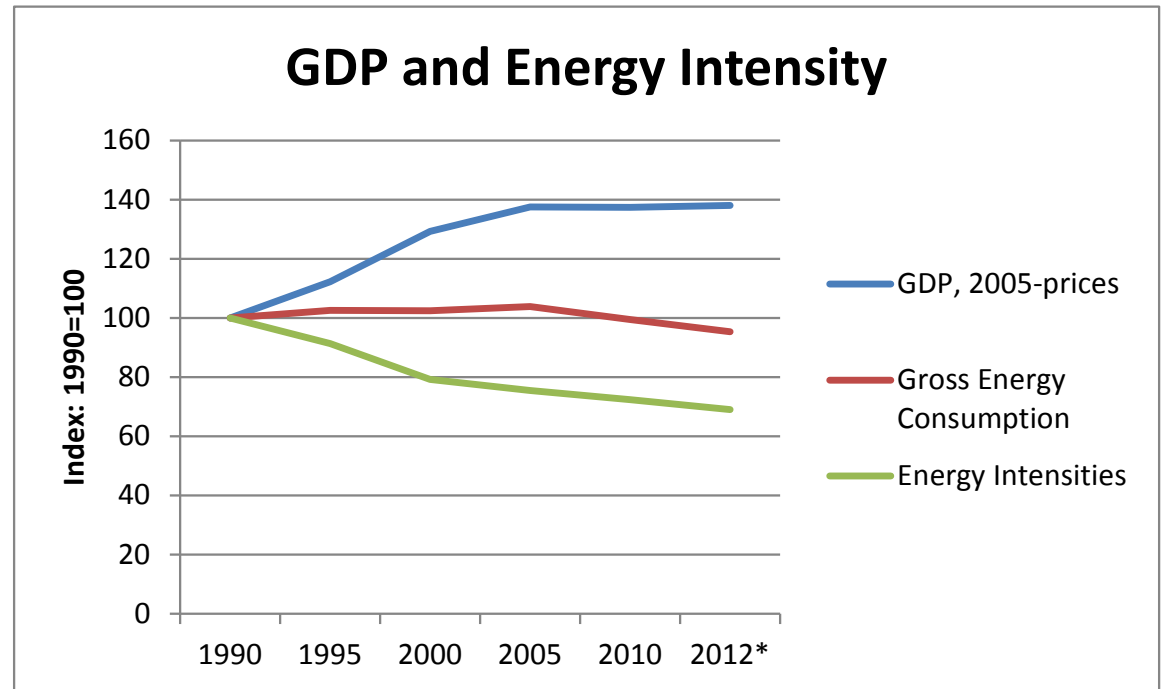
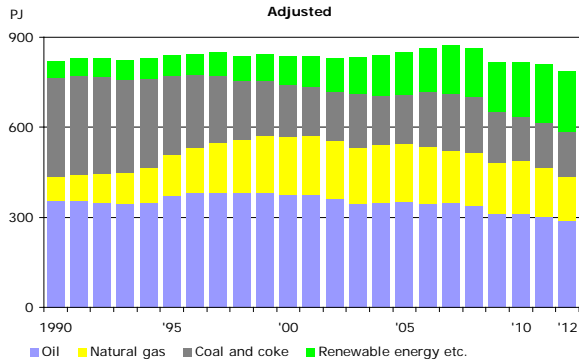
Gross energy consumption by fuel



Source: The Danish Energy Agency

Constant Energy Consumption in spite of strong growth in GDP

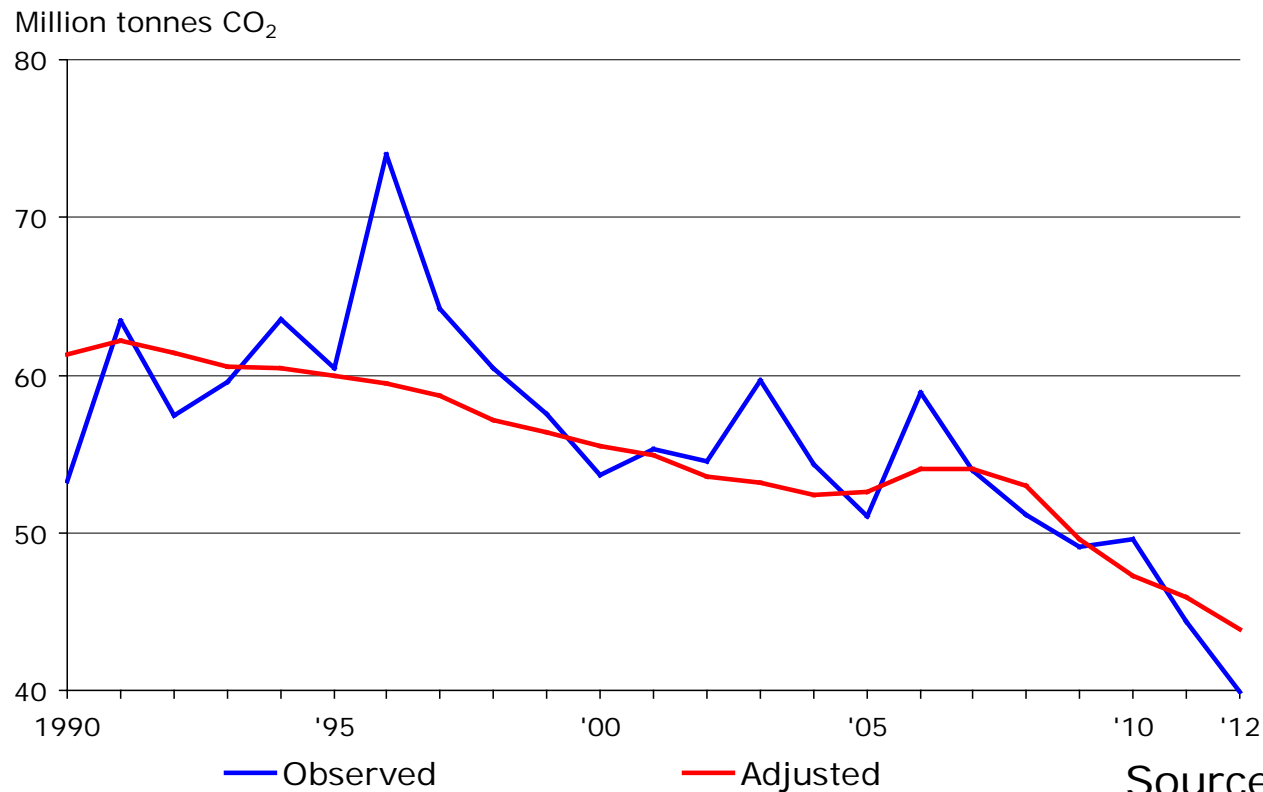
Gross energy consumption by fuel



Source: The Danish Energy Agency

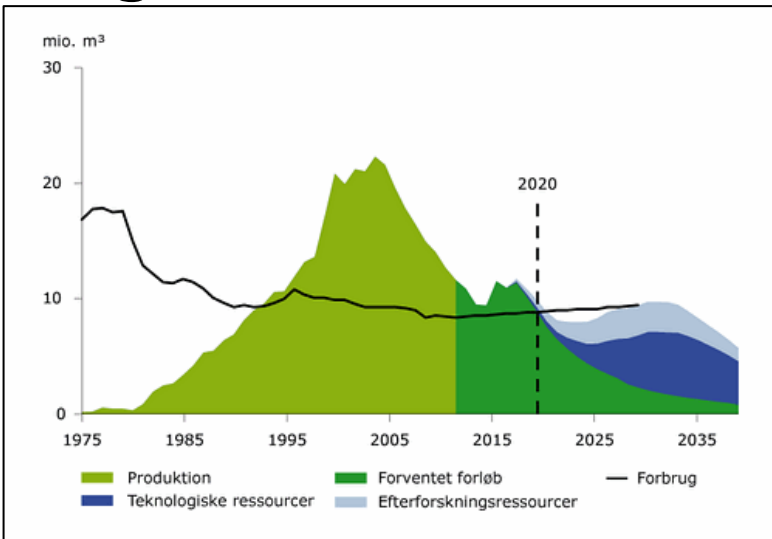
... and CO2 emissions

CO₂ emissions from energy consumption

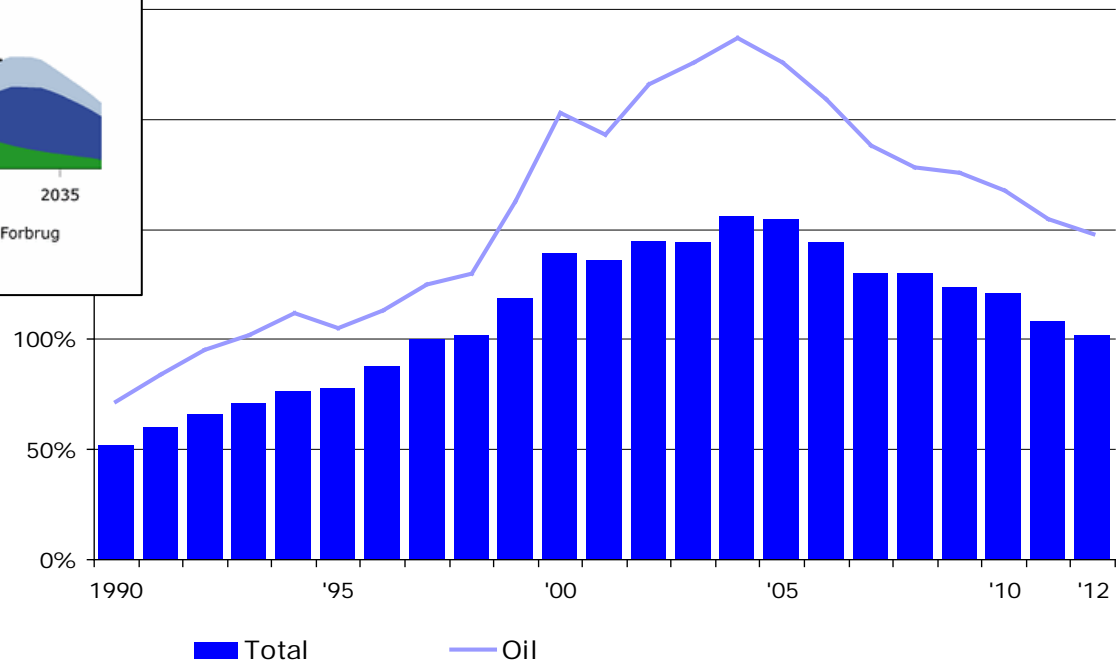


Source: The Danish Energy Agency

Large Domestic Production of Oil and Natural gas



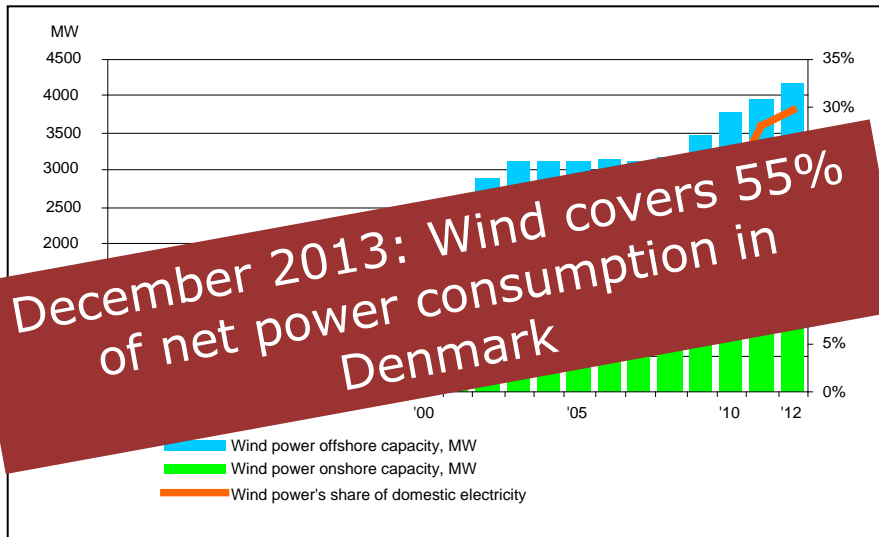
Degree of self-sufficiency



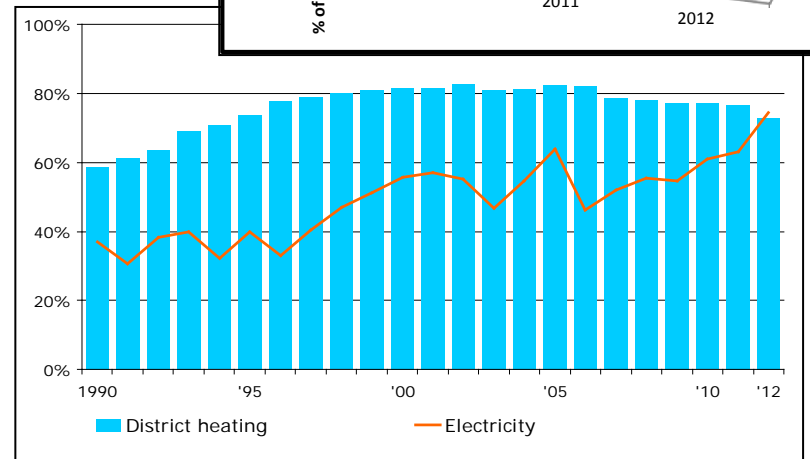
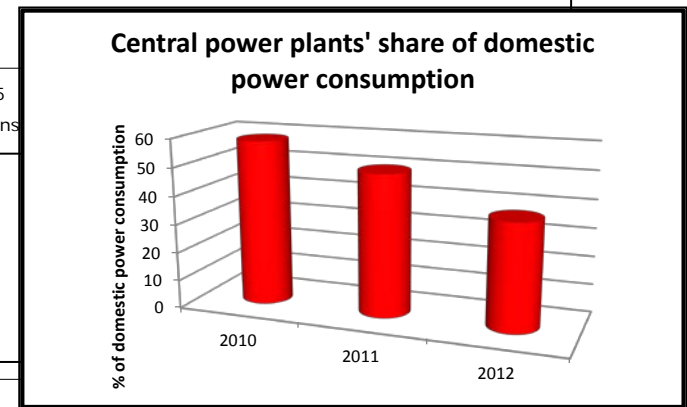
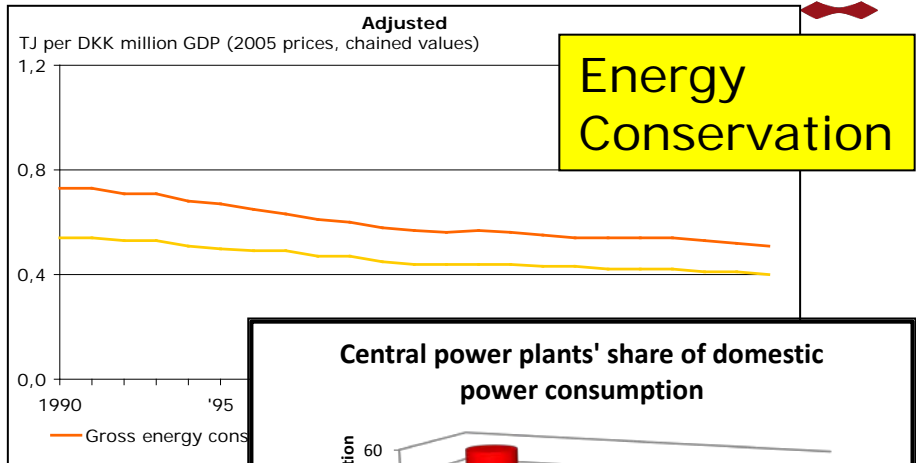
Source: The Danish Energy Agency

Three cornerstones in Danish Energy Policy

Renewables



Combined Heat and Power



Long term Vision

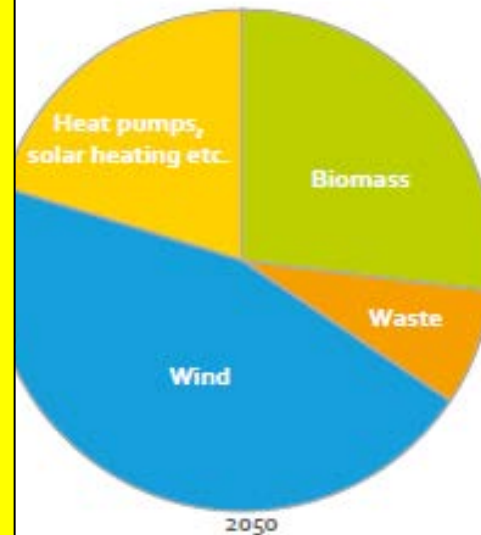
“ We can both reduce Danish emissions of greenhouse gasses significantly, and make Denmark independent of fossil fuels. This will require a total conversion of the Danish energy system”

- *Danish Commission on Climate Change Policy*

Main Future Trends:

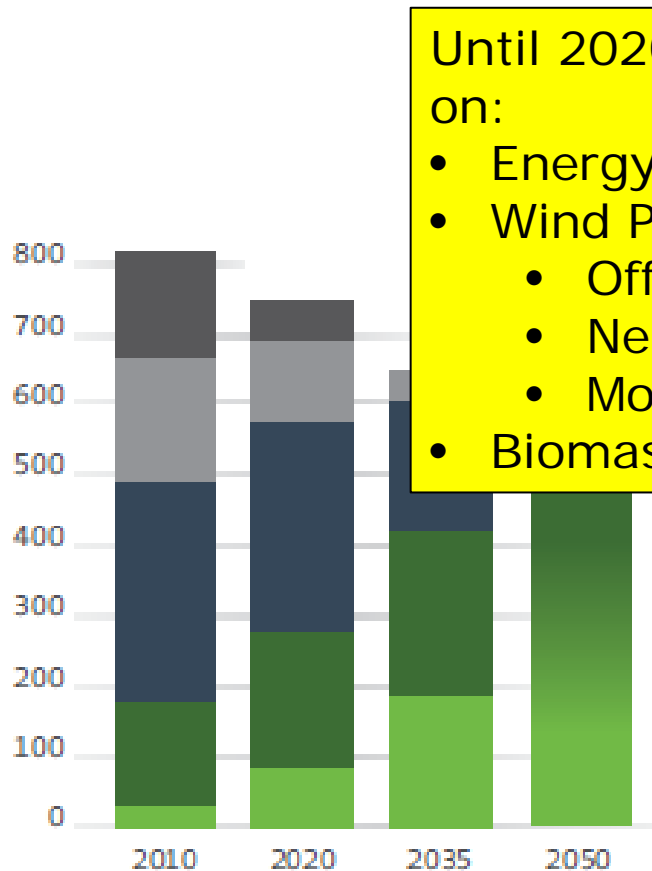
- **An Energy System dominated by electricity**
- **Intermittent sources will have to play a large role**
 - *Wind Power Capacity x 6*
 - *Solar??*
- **The Resource of Biomass is limited**
- **Radical change in transport system**
 - *Electric cars, hydrogen, bio-ethanol.....?*

O.....



Source: Climate Commission

The Government's Energy Plan



Figur 3.8 Anvendelse af fossile brændsler og VE (PJ)

Until 2020 Parliament has agreed on:

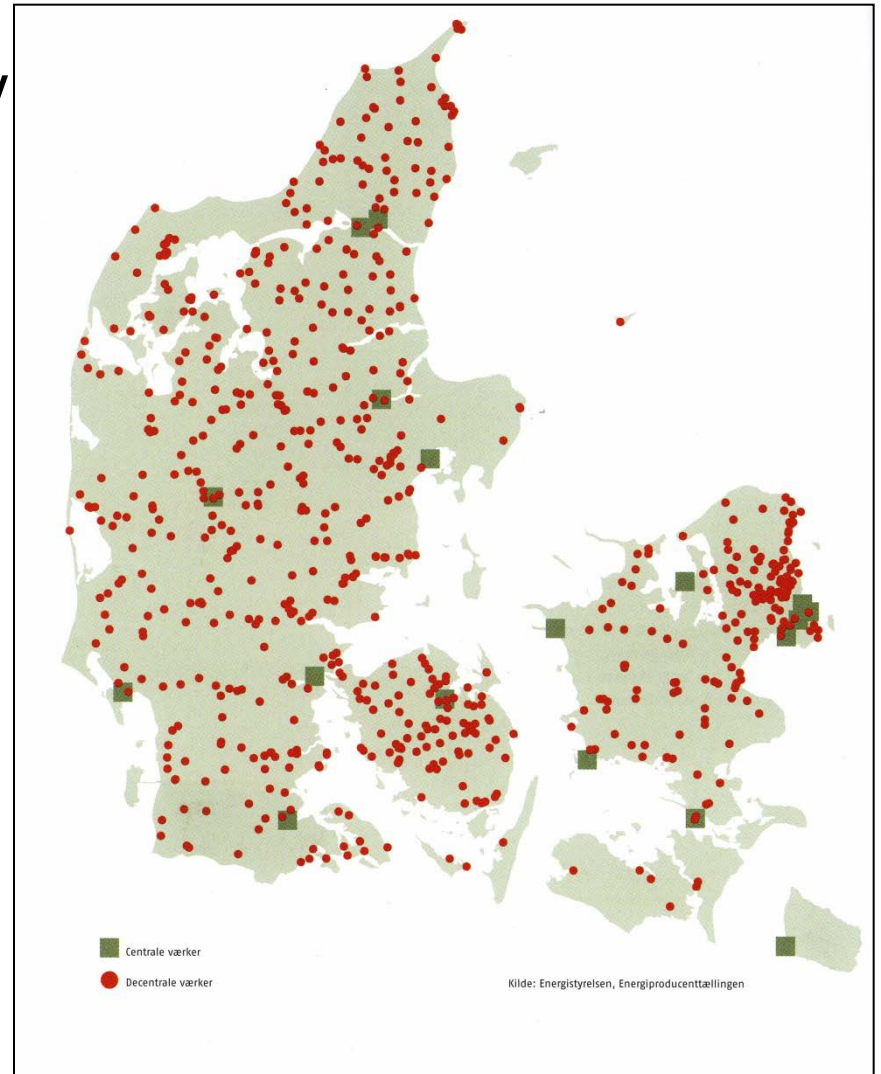
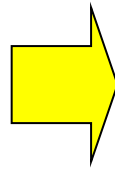
- Energy Savings
- Wind Power
 - Offshore 1000 MW
 - Near Shore turbines 500 MW
 - More Land based 500 MW
- Biomass in central power plants

- **2035:** All heat and power consumption is supplied by renewables
- **2050:** The entire Danish energy consumption is supplied by renewables

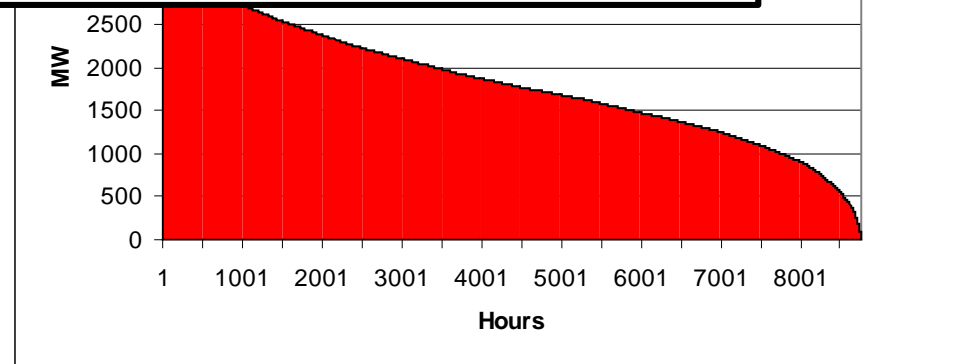
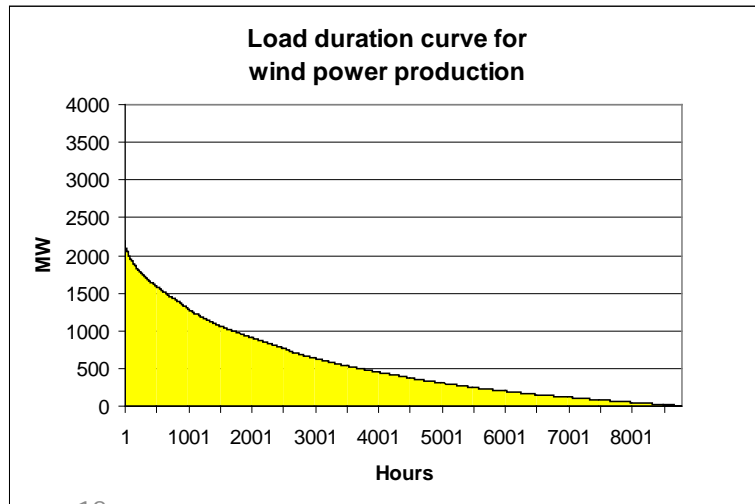
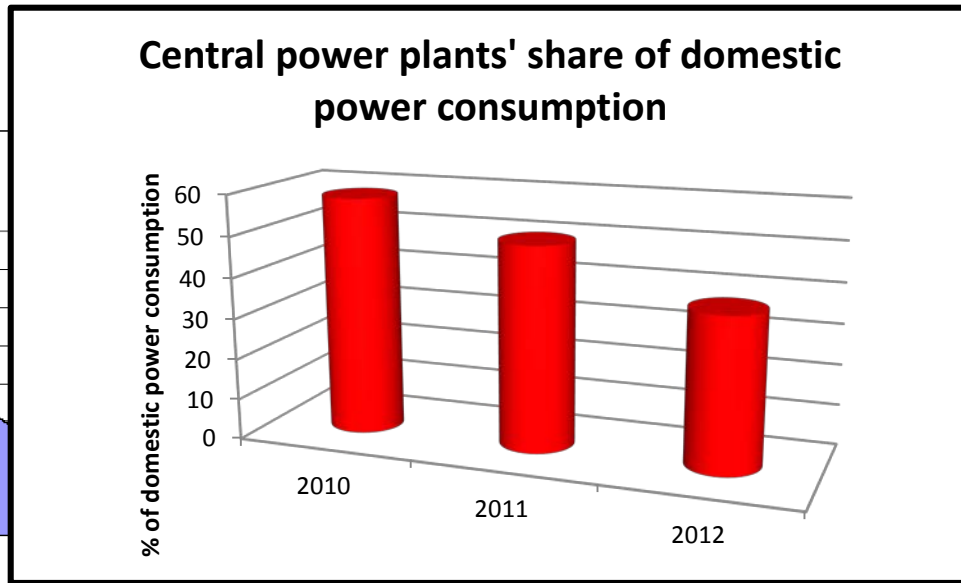
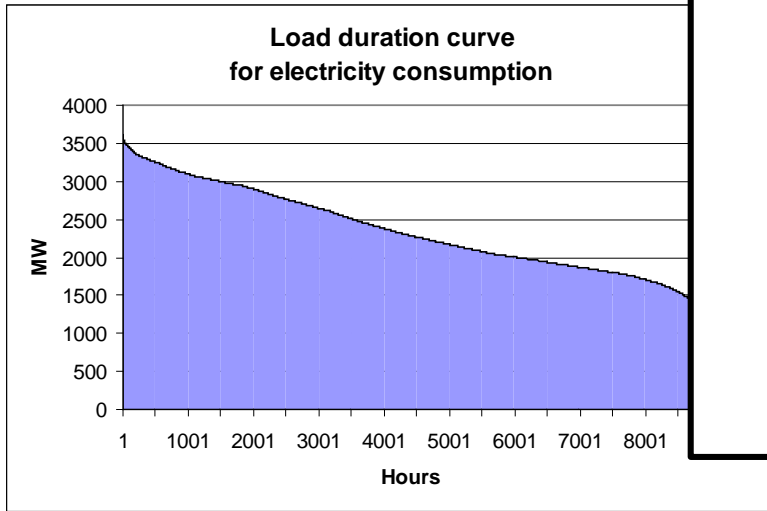
What is the future of our energy system?

Today

1980



This have consequences for the energy system!



Which requirements do we foresee to the power system in the transition phase?

- **Need for balancing wind**

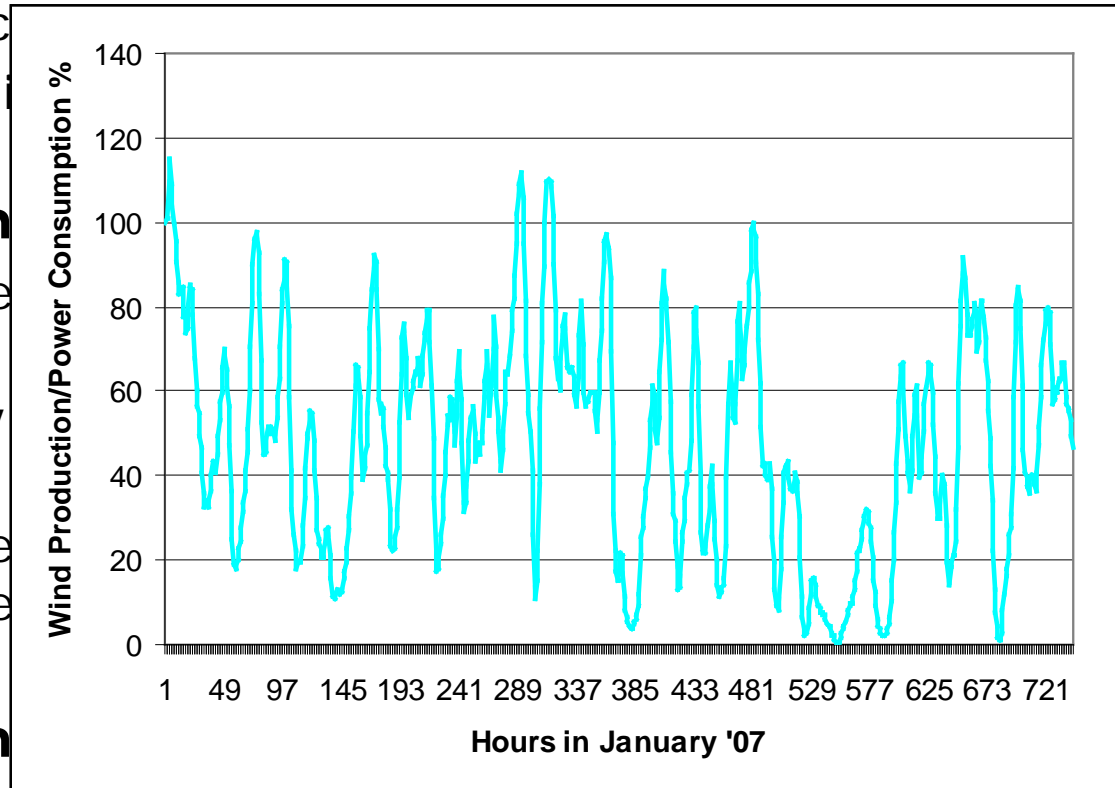
- Interconnectors of
- Balancing power i

- **In periods with**

- Central and/or de biomass or gas?
- Will we politically interconnectors?
- At least one large East and West De

- **Flexibility in en**

- Smart energy



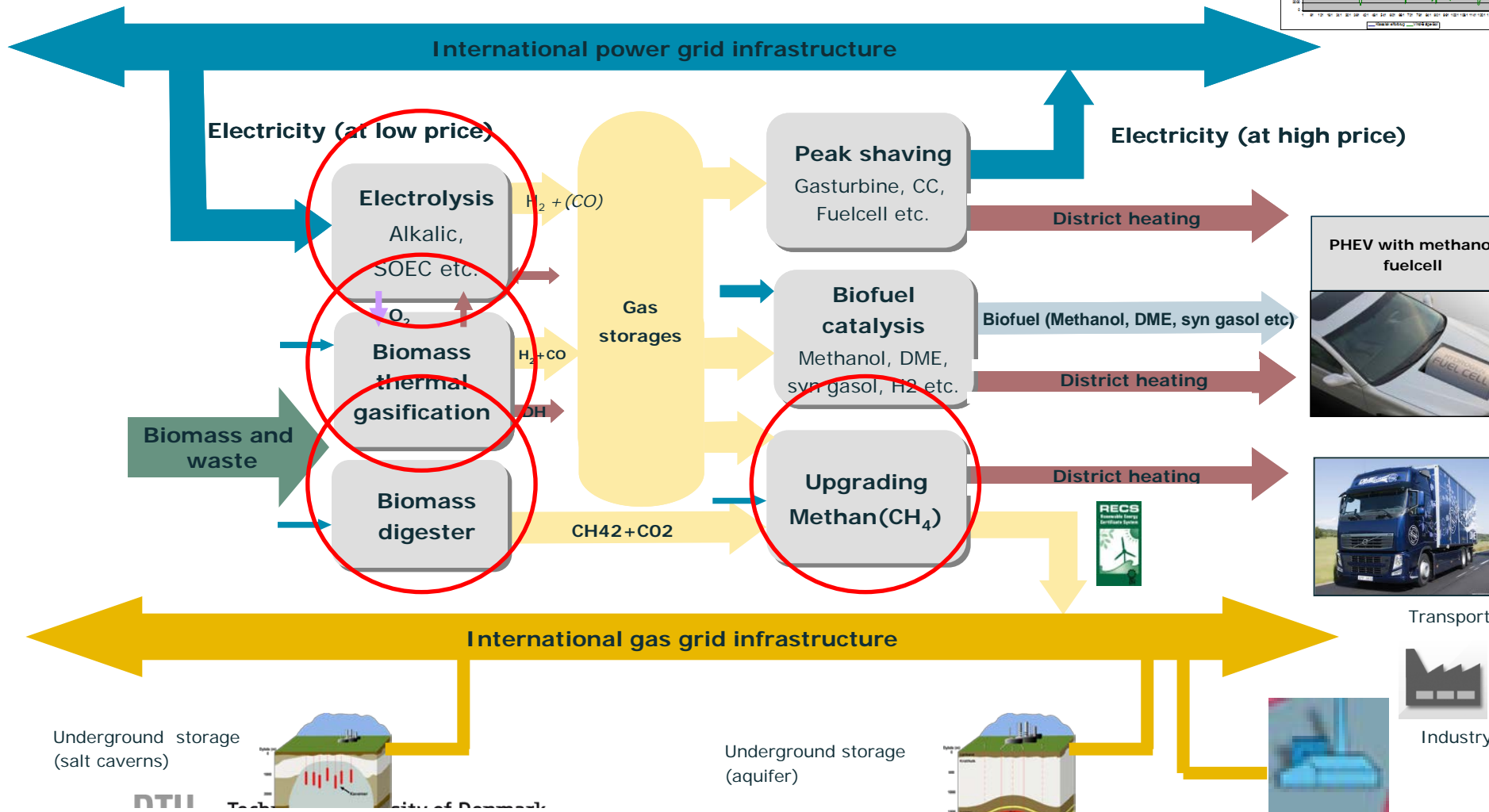
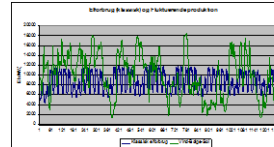
Where will we get the heat from?

- **Without the central power plants we will have a deficit of heat in the big cities**
 - Heat pumps for district heating
 - Geothermal energy
 - Waste heat from industry and incineration plants
- **What about the decentralised power plants?**
 - Solar heating
 - Heat pumps for decentralised use

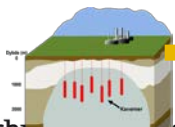
Other needs to be fulfilled in the in the transition phase?

- **Storage facilities might be required**
 - Hydrogen is a possibility
 - Natural gas is probably the cheapest way for longer time storage
- **Reconsider natural gas in combined heat and power after 2035**
 - Could give robustness to the energy system
- **Natural gas is a good substitution for oil in industry and transport**

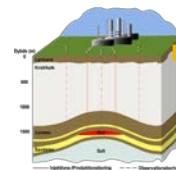
Integration of electricity, heat, gas and fuel-production



Underground storage (salt caverns)

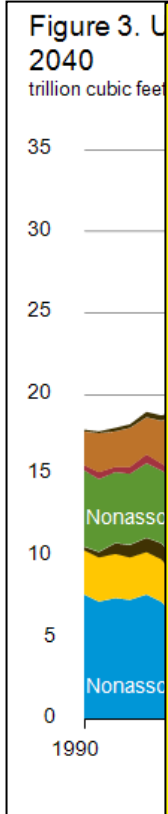


Underground storage (aquifer)



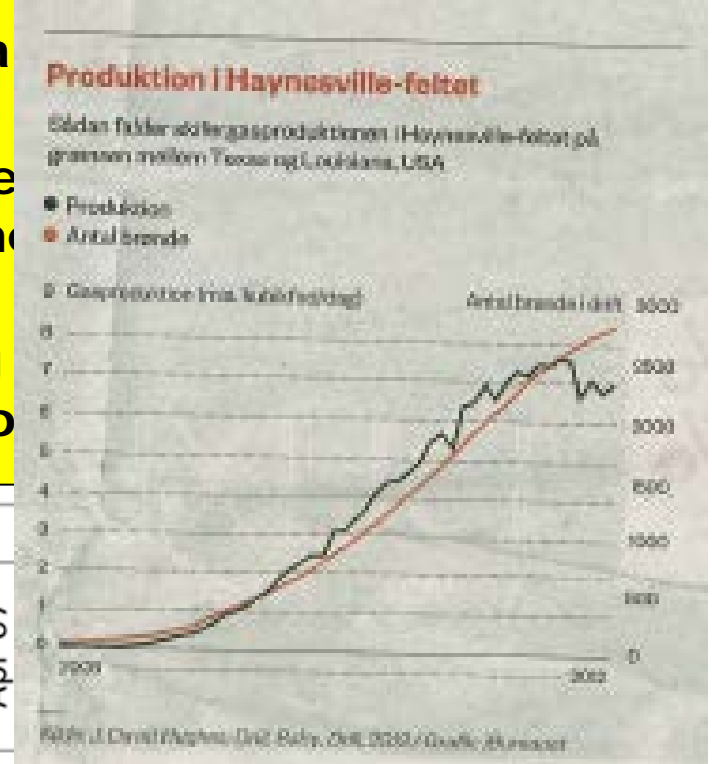
Two Major Threats for the Green Future

- **Too expensive energy supply**
 - Hurt our industrial competitiveness
 - Will shale gas and oil significantly impact Global and European energy prices downwards?

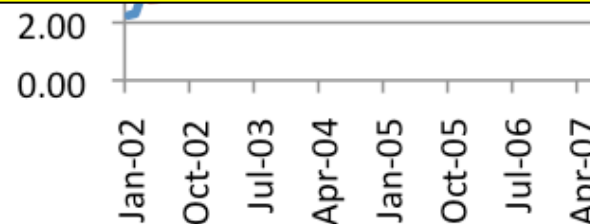


- **Will shale gas be influencing Europe?**
 - Poland experiences are not positive
 - LNG will flow into Europe, but will it have a strong impact?

- **Will US adventure continue?**
 - Upfront investments ta interest rate
 - Is the gas price sufficie continuously generate n investments?
 - Production is declining than for conventional o

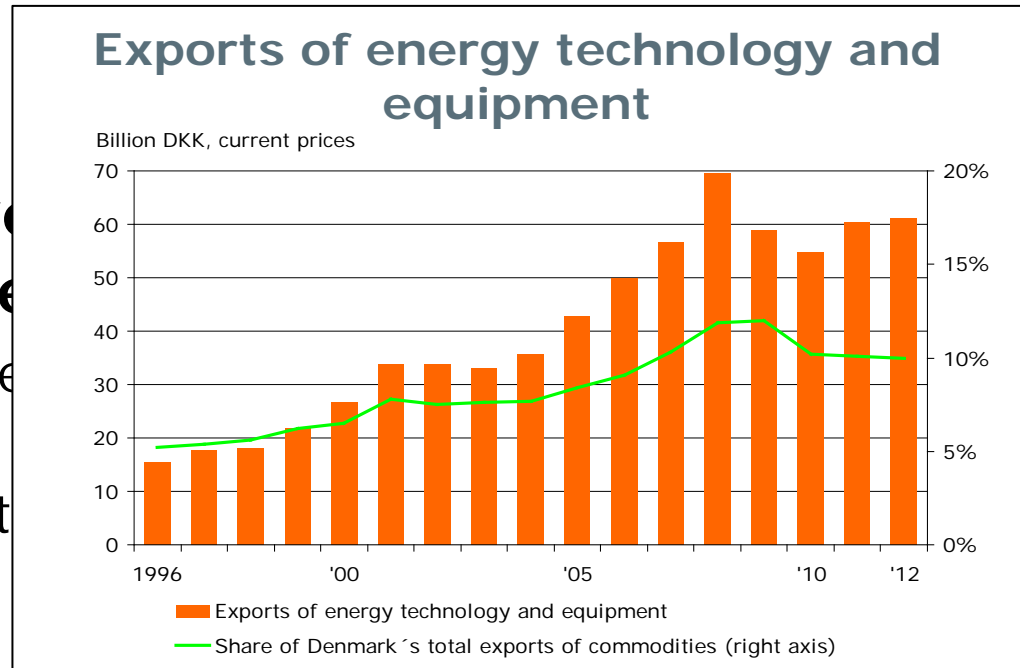


Source: DEA, US



Business Opportunity

- **Leading developer of renewable technologies**
 - Doing very well in heating
 - Good international market



- **The energy system will change drastically over the next 30-40 years**
 - Preconditions are changing – how will shale gas impact Europe?
 - Much higher share of wind than today
 - **It is important to**
- **There might be a**
 - Need for balancing,
 - A flexible fuel in ind
- **Increase energy system resilience**
 - Open up for more use of gas in the transition period
- **New technologies are needed**
 - Fuel cell electrolysis, thermal gasification...
 - Where do we get the heat from? Heat pumps, geothermal, solar....
 - **Complex interactions between power, gas, heat and transport.....**

Uncertainty and Expectation are the joys of life. Security is an insipid thing.

- William Congreve

Thank you for your Attention

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