

Technologies, markets and Danish strongholds

ATV meeting: Establishing a National Centre for Energy Storage

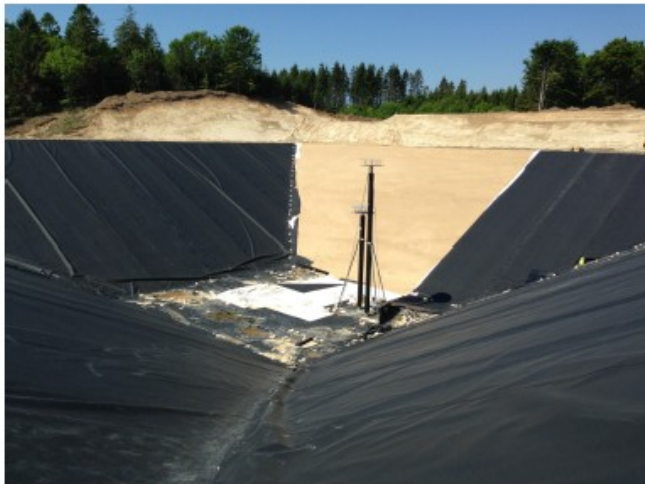
DTU 22nd January 2019

Allan Schrøder Pedersen, DTU Energy



Status and recommendations for RD&D on
energy storage technologies in a Danish context

February 2014



31-01-2014

1

Main authors:

Allan Schrøder Pedersen, DTU
(editor),

Brian Elmegaard, DTU,

Claus Hviid Christensen, DONG
Energy

Claus Kjøller, GEUS

Frank Elefsen, Danish
Technological Institute

John Bøgild Hansen, Haldor
Topsøe A/S

Jørgen Hvid, Rambøll A/S

Per Alex Sørensen, PlanEnergi

Søren Knudsen Kær, AAU

Thomas Vangkilde-Pedersen,
GEUS

Thorkild Feldthusen Jensen,
Rambøll A/S

- Etablering af et Nationalt Center for Energilagring kræver et **solidt videngrundlag**.
- I de forløbne **snart 5 år er der på mange områder sket en væsentlig teknologisk udvikling**. Nye forretningsområder er opstået, og ikke mindst har rammevilkårene ændret sig betydeligt.
- I Europa er der både **nationalt og på EU-plan øget fokus på energilagring**.
- I lyset af de forløbne 5 års udvikling er der derfor brug for en **opfølgende kortlægning**, der revurderer og konkretiserer den fornødne danske indsats på området energilagring og konvertering.
- Kortlægningen bør ske på et **forskningsbaseret grundlag, men samtidig med et fokus på de udviklings- og markedsmæssige udfordringer**, de enkelte teknologier står over for.
- **Hvidbogen kan således blive et væsentligt vidensgrundlag** for arbejdet med at etablere et Nationalt Center for Energilagring.

Content of the updated report

- **Storage technologies**
- **Main trends since 2014**
- **Danish strongholds**
- **Markets and drivers**
- **Applications for energy storage**
- **Conclusions and timeline**

Main trends since 2014

- **Technologies have been developed considerably**
- **Prices have gone down**
- **Business cases have developed to a commercial status**
- **Private companies look to include energy storage in sales**
- **More emphasis on energy storage from consulting engineers**
- **More emphasis from the Danish government**
- **More emphasis from the European Commission**
- **More emphasis from all over the world**

Danish strongholds

Electrochemical energy storage

- Strong industrial status
- Significant activities in universities and technological service organizations

Batteries

- Li-ion technology
 - ❑ Strong knowledge about management and surveillance of Li-ion
 - ❑ Commercial marketing of Co-free Li-ion HV cathode materials

- Strong R&D activities in new battery chemistries, e.g.:

- ❑ Metal-air
- ❑ Flow batteries
- ❑ Na-S and Li-S

Topsoe A/S



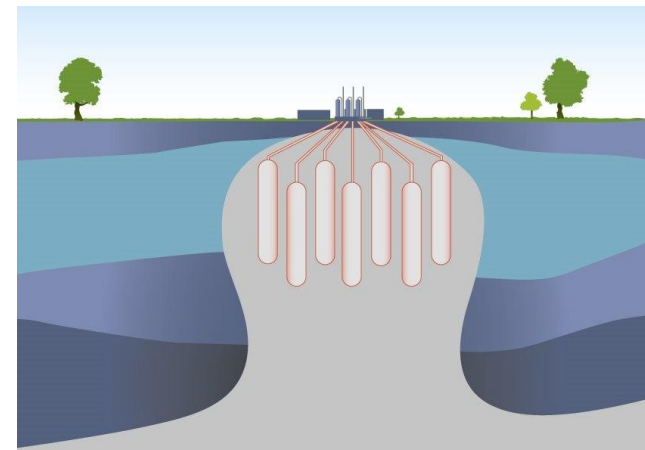
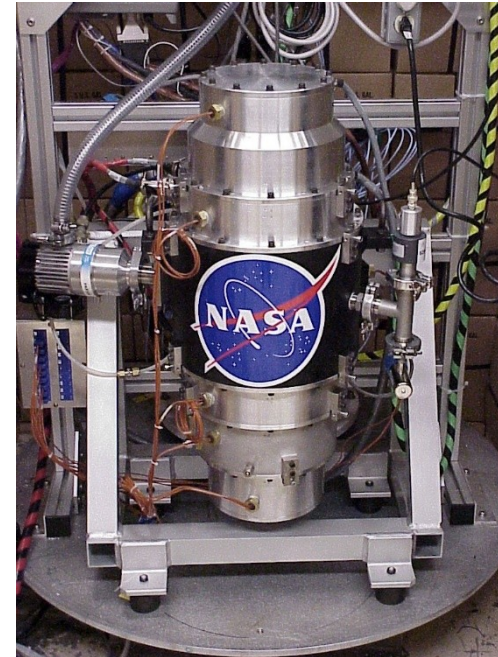
Photos: Ingeniøren



Danish strongholds

Mechanical and thermo-mechanical storage

- Strong status about flywheels
- Strong status within CAES – thermodynamics and **caverns**
- Emerging excellent competences about HT-TES for AA-CAES
- Less experience with other thermo-mechanical energy storage



Danish strongholds

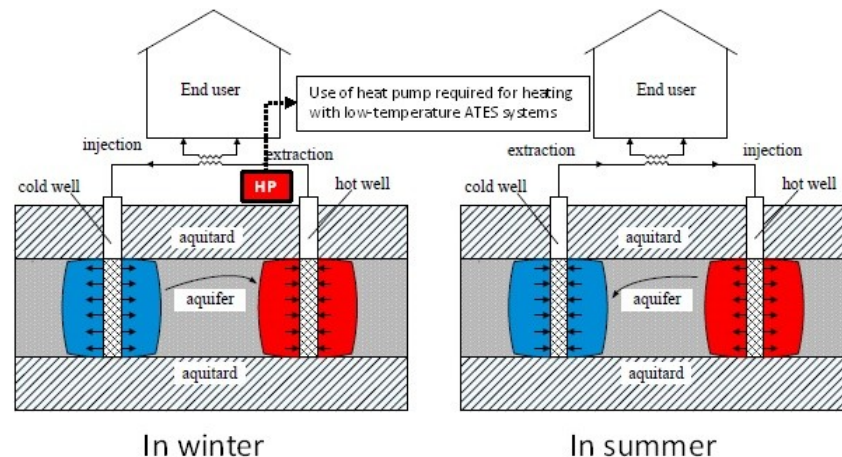
Thermal Energy Storage

- Well-established knowledge about hot water storage in tanks and containers
- Strong knowledge about Pit and Borehole thermal energy storage
- Strong and increasing knowledge about HT-TES in rock beds
- Strong knowledge background for utilizing the subsurface for TES

- ATES already installed
- DATES



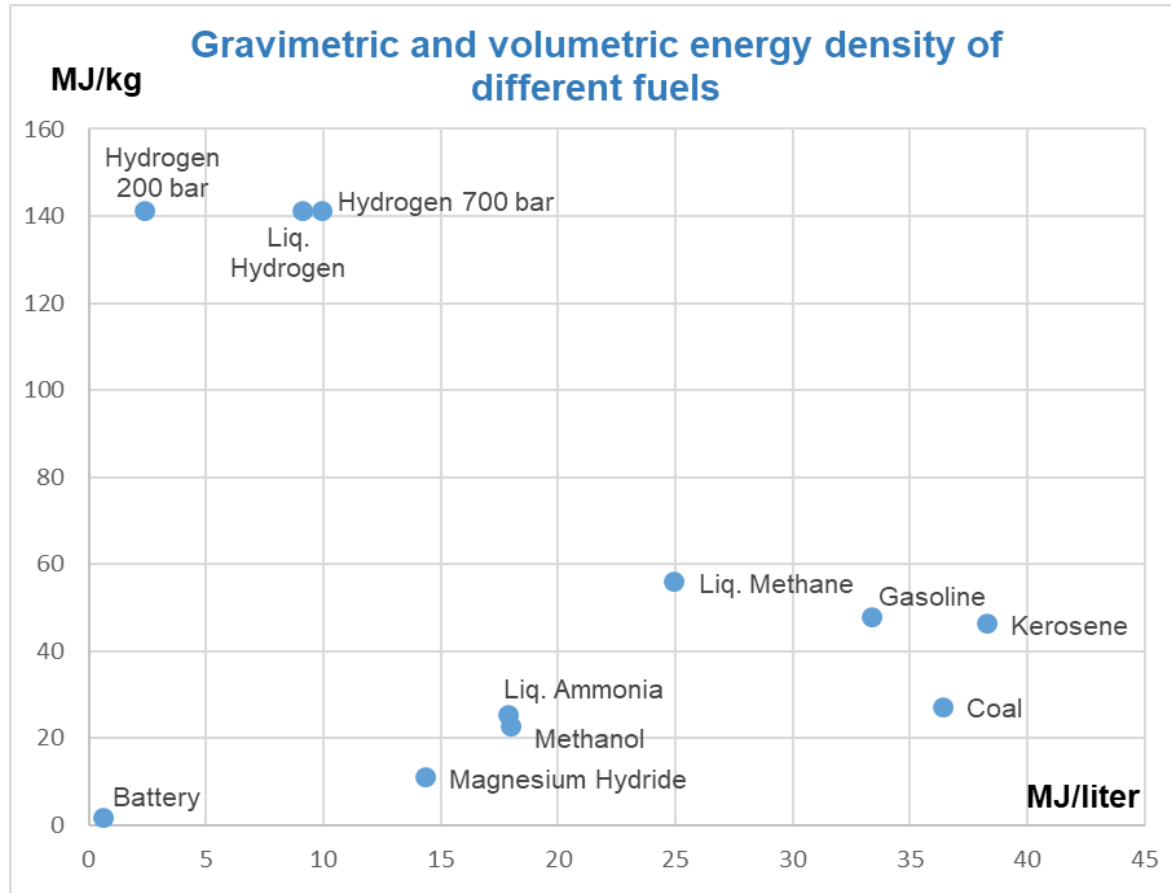
Photo: PlanEnergy



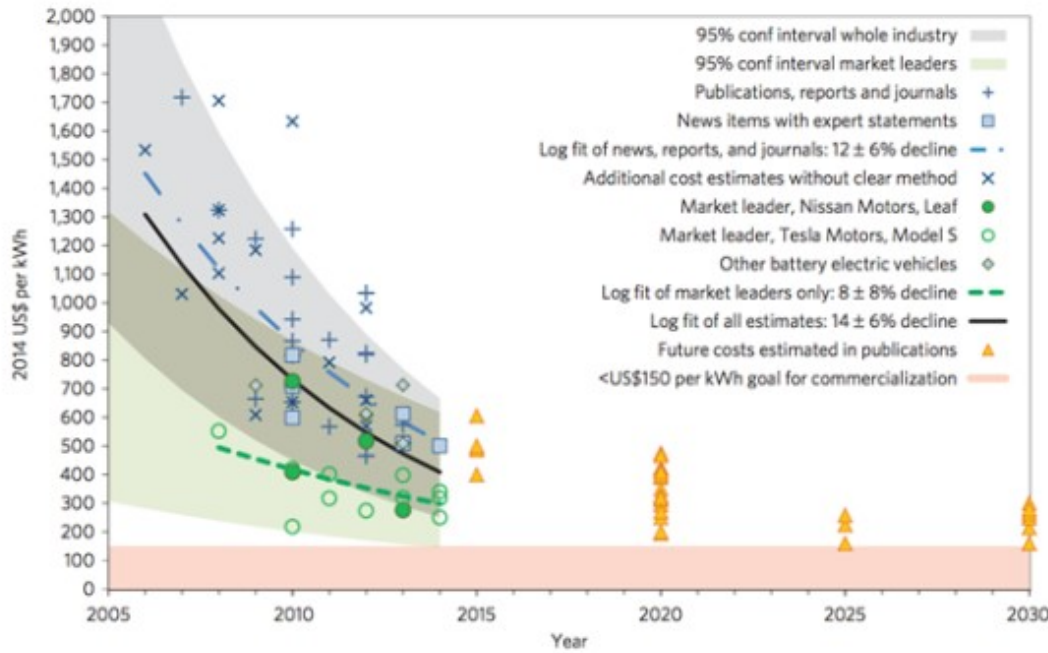
Graphic: The Circonomist

The need for storage

Transport - Grid reliability - Energy supply security



Li ion battery pack prices

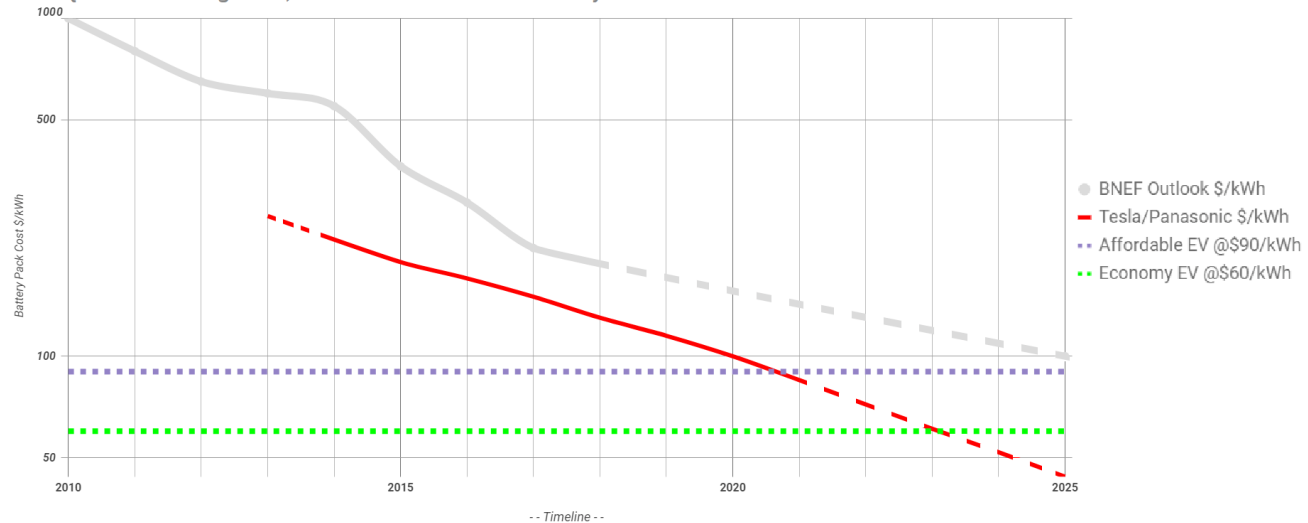


Nature Climate Change 5, 329–332 (2015)

Trend Data for Battery Pack \$/kWh - Tesla vs. Market Average (BNEF research)

{Cost Axis is Log Scale, dashed lines are estimated data}

BNEF Research, 2018



The need for storage

Transport - **Grid reliability** - Energy supply security



100 MW discharge and 80 MW charge, 129 MWh (approx. 75 min full discharge).

Connected to the same 275 kV network connection point as the 300 MW **Hornsdale Wind Farm**.

30 MW and 119 MWh of the battery's discharge capacity is made available to the wind farm operator for commercial operation in the National Electricity Market (NEM).

The remaining **70 MW of battery discharge capacity is reserved** for power system reliability purposes

Profitable? Earned about **800,000 USD in a few days** by responding to a crashed coal plant (loss of 560 MW nearly 1,000km away) in milliseconds .

The need for storage

Transport - Grid reliability - **Energy supply security**

➤ Bulk energy storage: A Long term vision **North Sea Wind Power Hub**



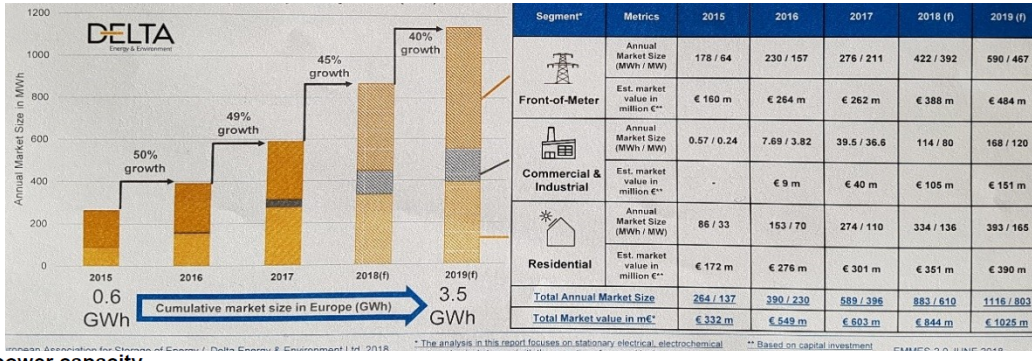
- 12 GW transmission capacity
- CAPEX power transmission: submission E-TYNDP
- CAPEX H2 transmission: estimate consortium

Power transmission		H2 transmission	
Offshore conversion	EUR 9.5B	Offshore P2G conversion	EUR 8.5B
Power cables		Compressor	
Onshore conversion		Offshore Pipeline	



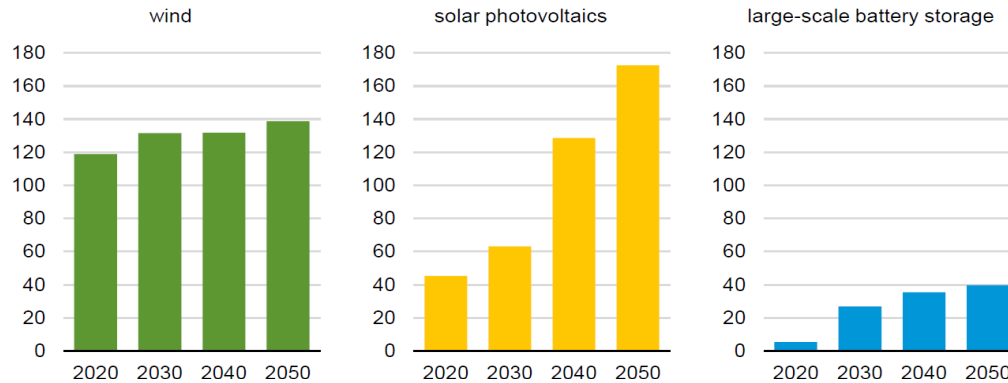
Source: P2G AND THE NORTH SEA WIND POWER HUB, R. Pieters, P2G Conference Copenhagen, Oct 2018

Market forecasts

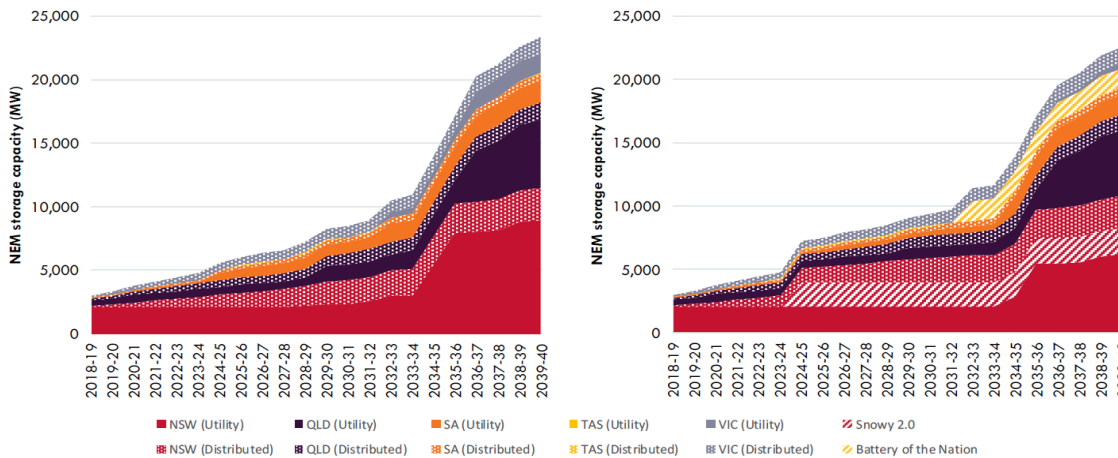


European Market Monitor on Energy Storage (EMMES), EASE and DELTA-ee, June 2018

power capacity
gigawatts



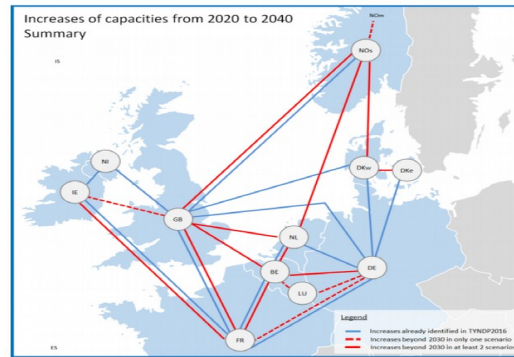
Annual Energy Outlook 2018 with projections to 2050, February 2018, U.S. Energy Information Administration, Office of Energy Analysis, U.S. Department of Energy



Integrated System Plan, Australian Energy Market Operator, July 2018

"Competitors" to energy storage

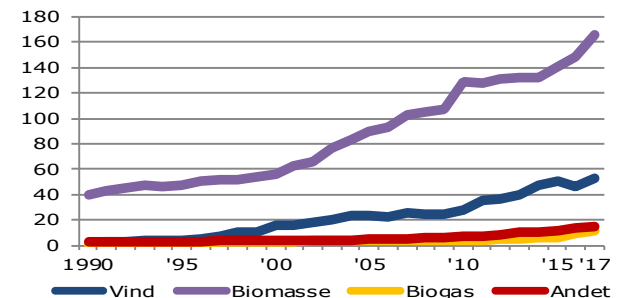
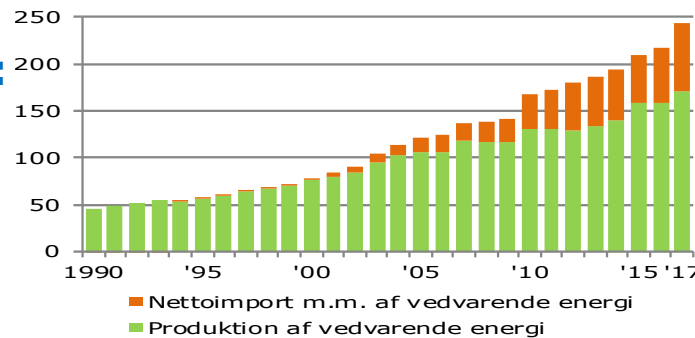
Interconnectors



Biomass

DK biomass potential 2050: 205-245 PJ (ENS 2014)

DK consumption of renewable energy, PJ (ENS)



Virtual storage - Demand flexibility – Demand Side Managem.

□ Being discussed – extent and impact still uncertain



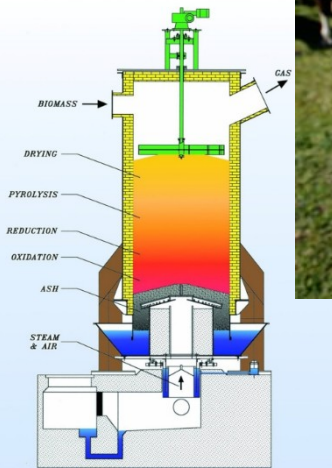
Back up slides

Electrolysis has nice synergy with utilization of biomass

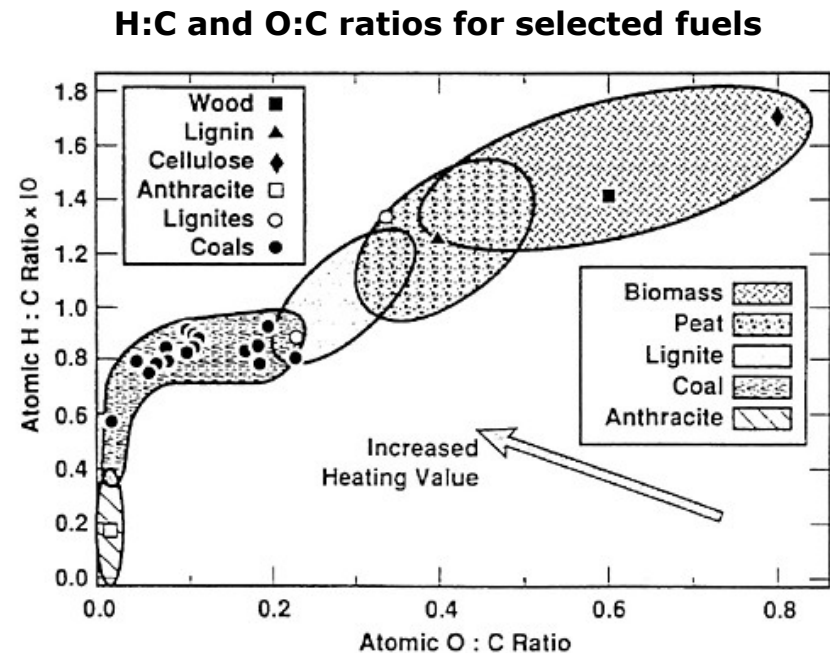
- Gasification of biomass primarily forms mixtures of CO and H₂ (lesser amounts of CO₂ and CH₄)
- Fermentation/digestion of biomass forms mixtures of approx. 60% CH₄ and 40% CO₂ which can be upgraded by methanation of CO₂ with hydrogen



Photo: Mikael Kau/



<http://www.chamco.net/Gasification.htm>



Biogas from waste water

P2G-BioCat

- Cooperation between Electrochea, Hydrogenics, Biofos, NEAS Energy, Energinet.dk, HMN Gashandel, Insero Business Services, and Audi
- Biological methanation at Avedøre WWTP
- 1 MW electrolysis (Hydrogenics, alkaline)

Photos: Biofos and Electrochea

- Gas production implemented 2016

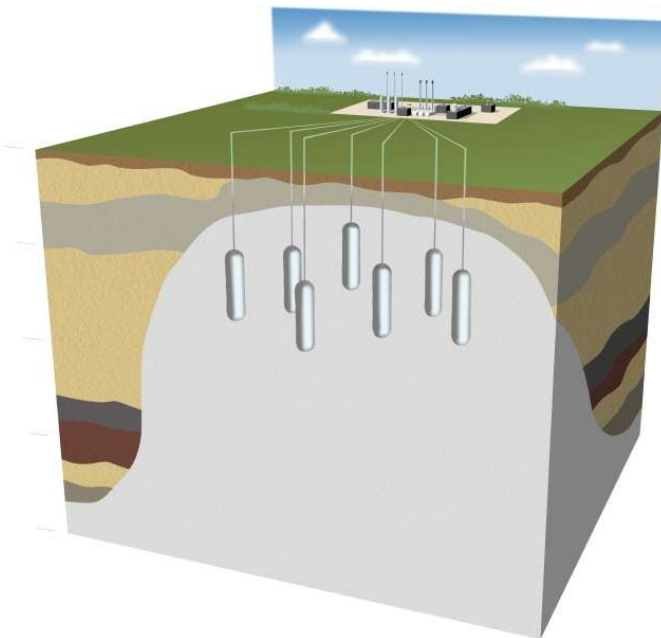


Danish underground gas storage potential

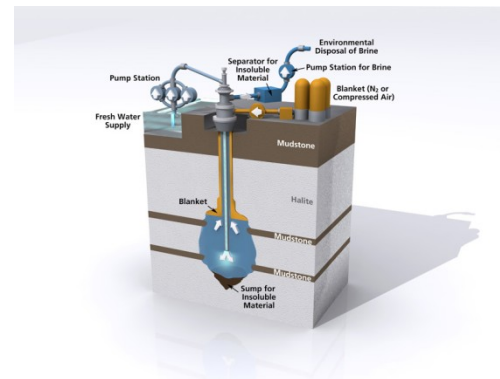
➤ Denmark has suitable geological conditions for salt caverns

Existing capacity:

- 440 mio. Nm³ naturgas
- 5.300 GWh
- DK consumption 2014:
3100 mio. Nm³
- Developed by solution mining



Energinet.dk



www.tunneltalk.com/Technological-developments-Apr11-Salt-cavern-storage.php