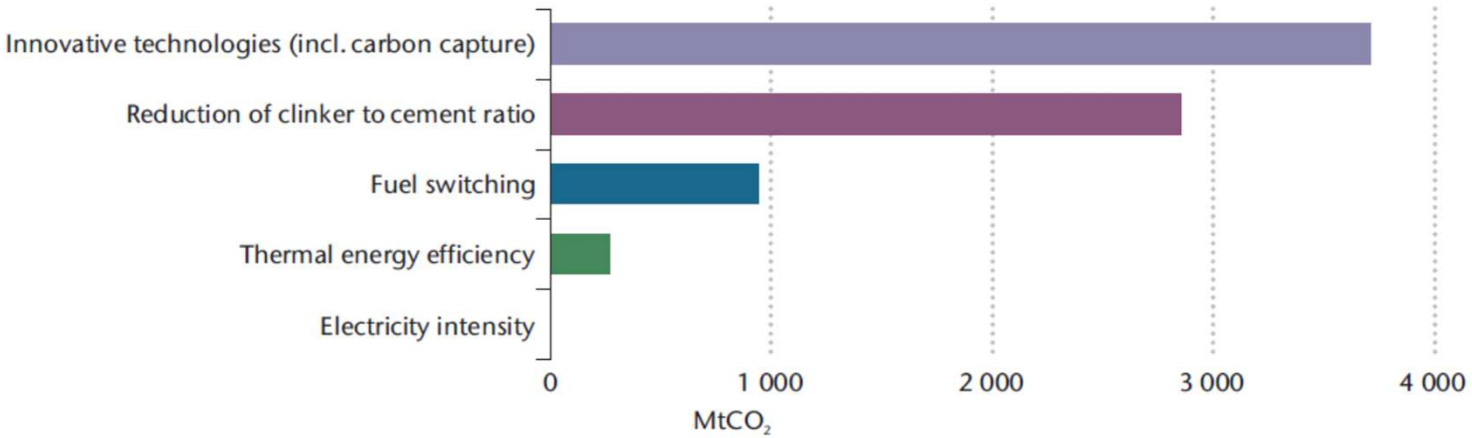
Climate change solutions utilising local symbiosis

Several solutions are needed for CO_2 reduction in the cement industry

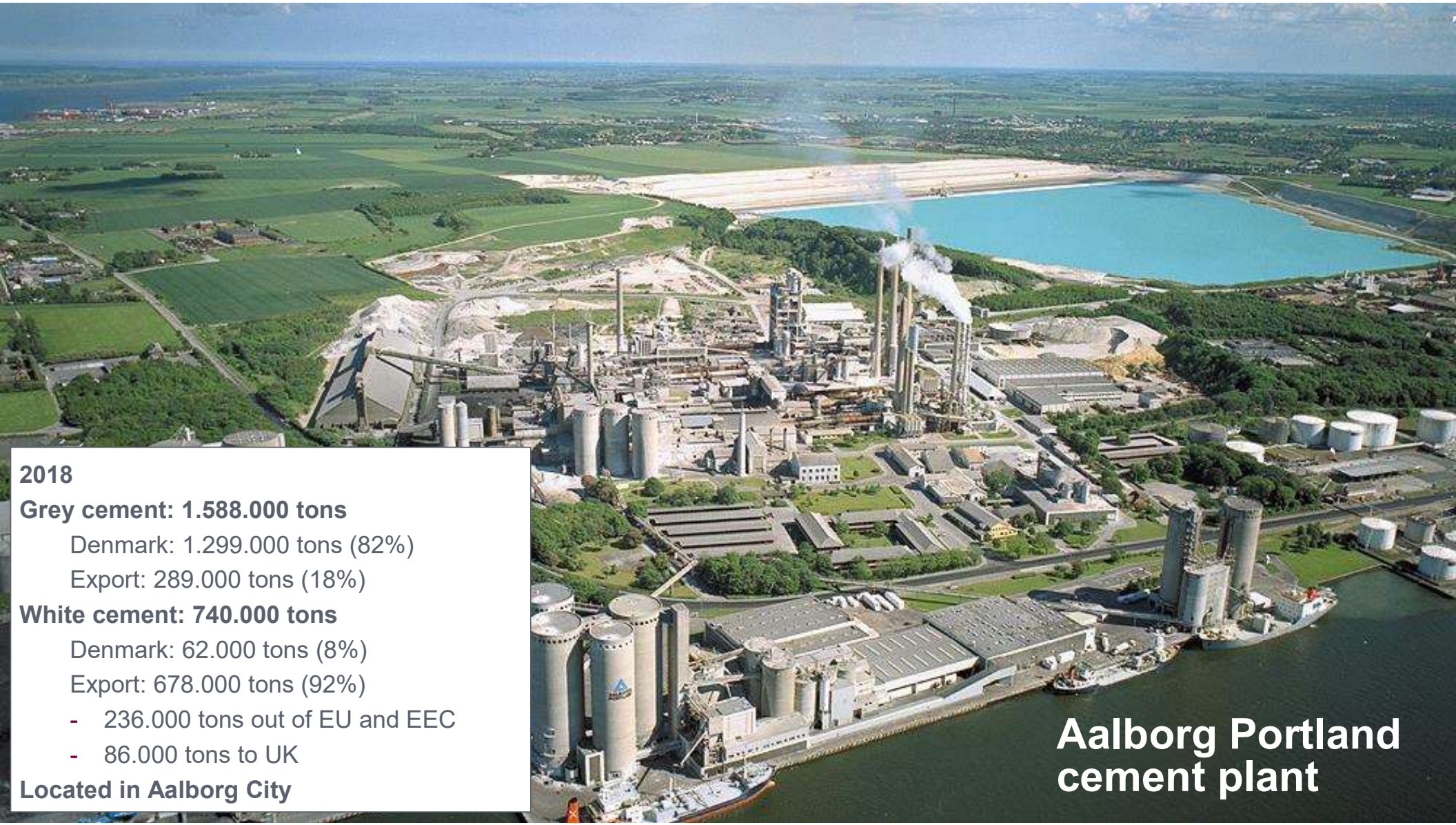
- **Carbon capture** and storage or utilisation
- Reducing **clinker content in cement**. Clinker is the intermediate product produced in a cement kiln
- **Symbioses** may enable cost-effective and sustainable solutions by combining CO2 reduction in the cement production with production of sustainable liquid fuel



Note: Cumulative CO_2 emissions reductions refer to the period from 2020 to 2050 and are based on the low-variability case of the scenarios.

Technology Roadmap. Low-carbon Transition in the Cement Industry. IEA/CSI (2018)

cementirholding
CALTAGIRONE GROUP
Concretely Dynamic



2018

Grey cement: 1.588.000 tons

Denmark: 1.299.000 tons (82%)

Export: 289.000 tons (18%)

White cement: 740.000 tons

Denmark: 62.000 tons (8%)

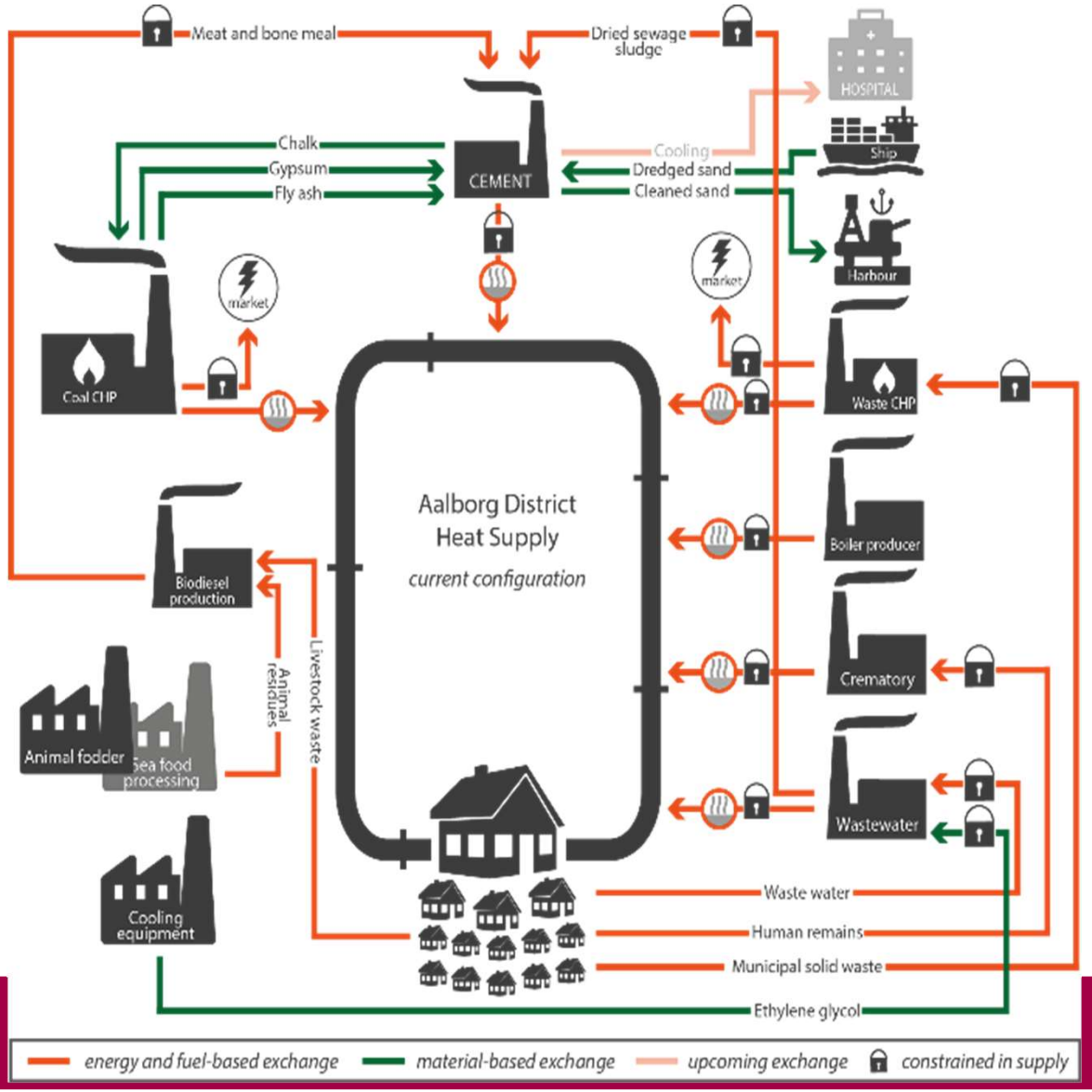
Export: 678.000 tons (92%)

- 236.000 tons out of EU and EEC
- 86.000 tons to UK

Located in Aalborg City

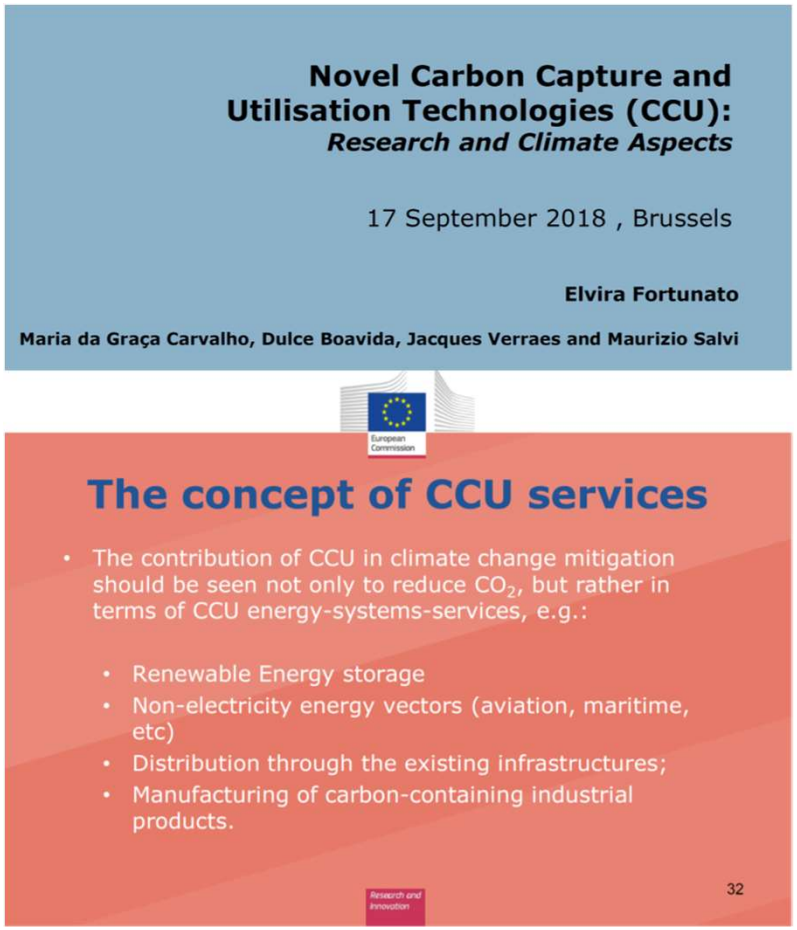
Symbioses are already well developed in the Aalborg area

- **Existing symbioses**
  - Industries supply surplus heat to district heating
  - Cement plant supplies limestone slurry to the power station which use it for desulphurisation and returns it as gypsum to be used in cement
  - Fly ash from the power station is used in production of cement and concrete
  - Sand from harbour dredging is used in the cement production
- **Future symbioses**
  - Supply to district cooling from the lake in Aalborg Portland limestone quarry
  - Establishment of heat storage at Aalborg Portland
  - Production of methanol using CO_2 supplied by Aalborg Portland?

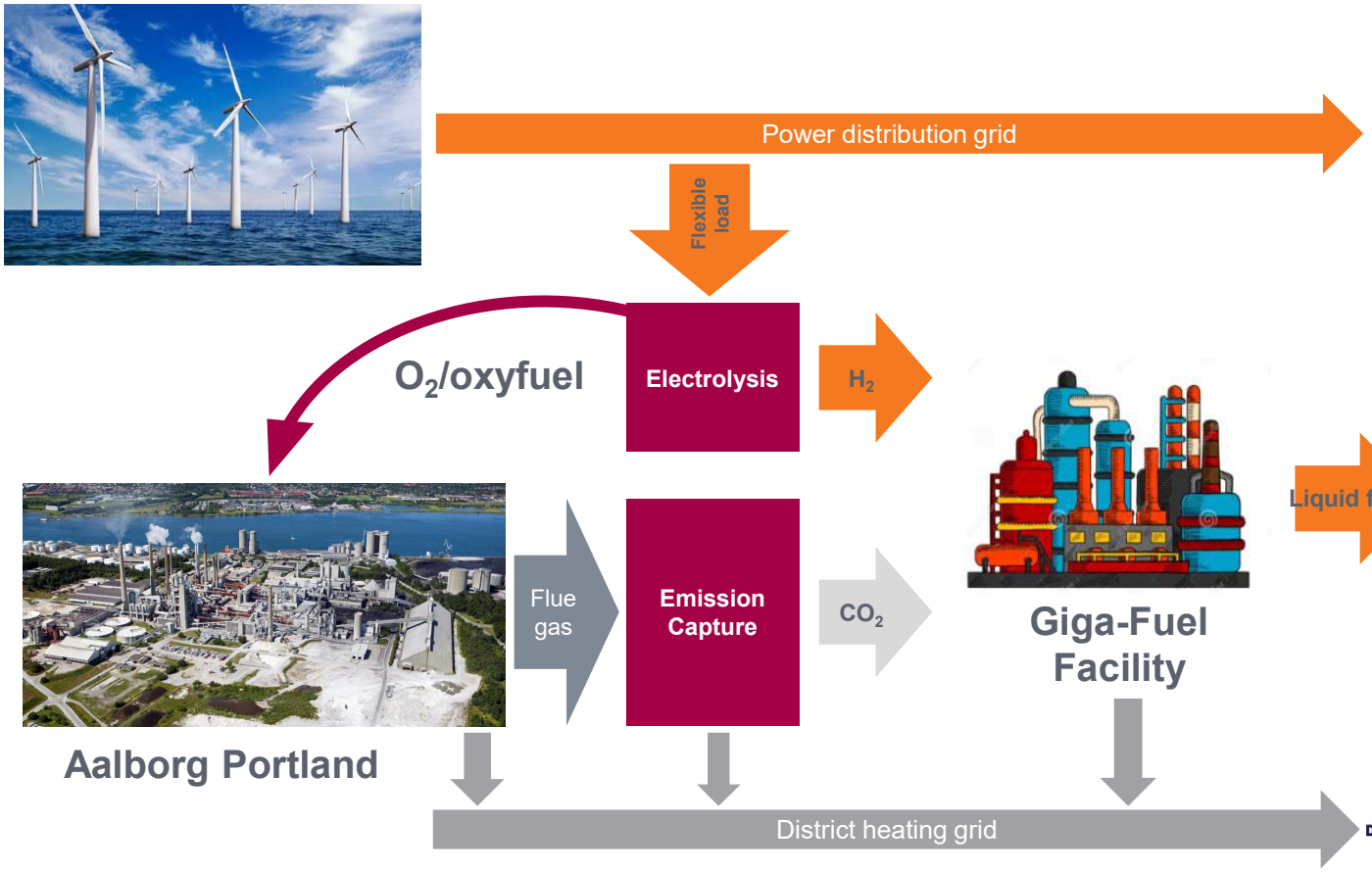


CCU has multiple roles in a renewable energy system

- Carbon Capture and Utilization in power-to-methanol can lead to **significant CO_2 reductions**
- Just as important, it can **facilitate the integration and use of renewable energy resources** that would otherwise not be possible due to bottle necks in the electrical grid.
- In Denmark alone more than **30 GW offshore wind resources are stranded in the North Sea** as it cannot be absorbed in the electrical grid
  - This huge potential can only be utilized via power-to-X technologies and methanol represent a valuable end or intermediate product.



Aalborg Giga-Fuel: Conceptual idea by Aalborg University



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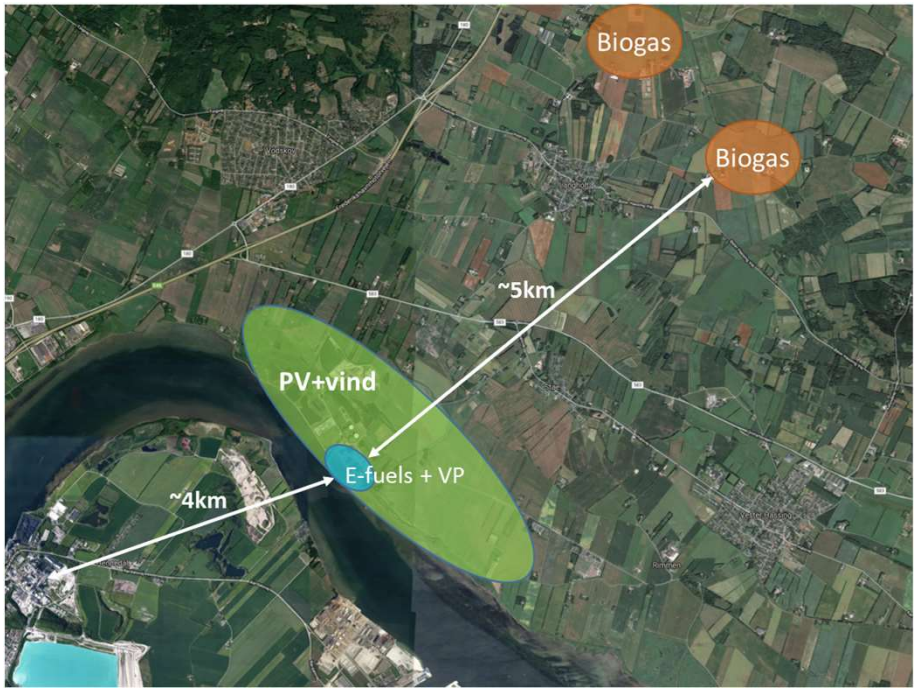
Phase 1 realization of demo-project

Aalborg is ideally suited for a light-house project showing a whole city running on renewables

- Complete infrastructure is already available
  - Large CO_2 source (about 2.0 mio. tons)
  - District heating grid (6000 + TJ/year)
  - Electric grid connections (150 kV and 400 kV)
  - Industrial harbour
- Large-scale demonstration of methanol technologies manufactured in Aalborg
  - 100 MW electrolysis -> 100 mio. liter methanol
  - 800 GWh of renewable electricity stored
  - 100.000 tons CO_2 recycled



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Reducing clinker content in cement using calcined clay-limestone technology

FUTURECEM

- Clay with high content of certain **clay minerals** are suitable for reduction of clinker content in cement after calcination
  - **Calcination** is done by heating suitable clay to 700-800°C and grinding it to the size of cement
- **Synergy** between limestone and calcined clay enable **higher strength** and **larger clinker replacement** than using only calcined clay
- This technology has potential to close the gap after fly ash and slag
  - Possible global CO_2 savings in 2050: 400 million tons
- To get the full benefit, a low CO_2 clay calciner must be developed
  - A clean, renewable fuel will optimise CO_2 saving potential

Discussion with potential partners is under way. The consortium will comprise

- **Aalborg Portland** Owns and operates the carbon capture plant
- **Aalborg University** R&D partner on complete integrated system and towards the energy system
- Experienced supplier of the carbon capture plant
- Owner of the wind turbines possibly as a joint venture with the methanol synthesis plant.
- Owner of the methanol synthesis plant
- Owner of the electrolyser
- End-user of green methanol as fuel for ships and green plastics
- Partner related to grid integration and operation strategy

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Costs of demo and full-scale project

- **Phase 1 demo project**

• Clay calciner	40 mio. EUR
• Wind turbines (12x4,6 MW):	70 mio. EUR
• Carbon capture (100 kT/yr):	25 mio. EUR
• Electrolysis (100 MW):	70 mio. EUR
• Methanol plant:	30 mio. EUR
• Construction:	20 mio. EUR
• 10 yr. additional OPEX:	20 mio. EUR
• **Total investment:**	**275 mio. EUR**

60% funding for OPEX+CAPEX is sought for

Remaining financing is expected to be from private funds

Full-scale plant

- Investment: **1.5-2.0 billion EUR**
  - AP investment in carbon capture: 160 million EUR
- Production of 1.3 million tons methanol
  - Use of **2 million tons CO_2**
  - Capture price: 30-40 EUR/tons CO_2
  - Electricity demand for methanol production: **12 million MWh**

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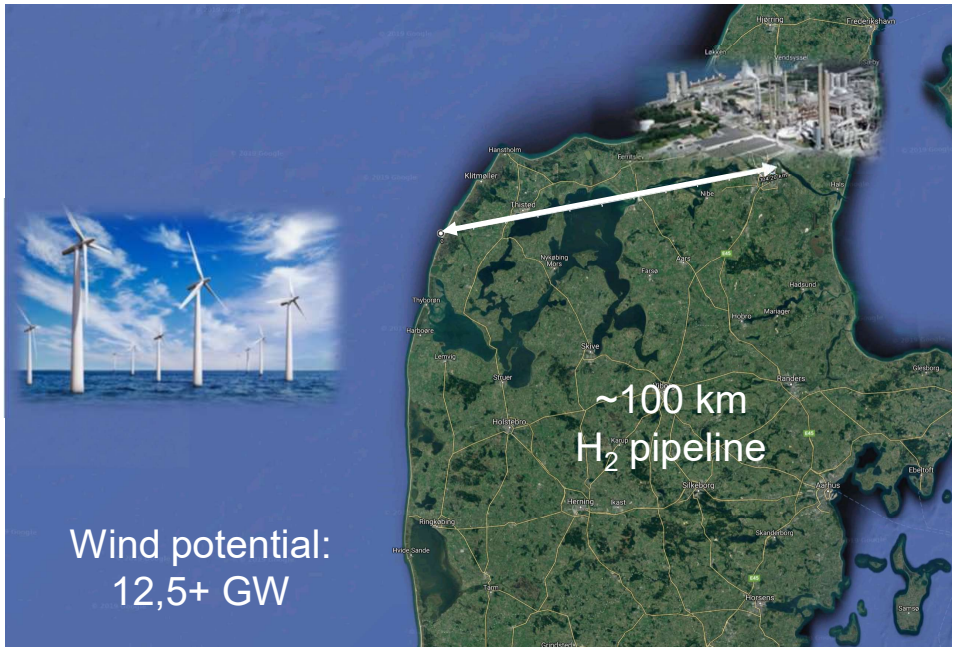
Long-term, full-scale implementation

- Enormous **off-shore wind** potential, 12,5+ GW
  - Only about 3 GW can be absorbed in the electric grid
- The full-scale **Giga-Fuel Factory**
  - Electricity from 3 GW off-shore wind for water electrolysis and fuel production in Aalborg
  - 2,000,000 tons of CO_2 recycled
- **60% of Denmark's aviation fuel** consumption!
  - The market for green fuels driven by political targets for CO_2 reduction
  - Danish and EU legislation must allow carbon recycled fuels (CO_2 from cement, biomass, waste)
  - Questions of CCU from cement plant CO_2 regarding ETS, EPD and LCA must be resolved



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