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Hydrogen:
An enabler for the transition to a fossilfree island?

Dr Björn Samuelsson, Visby November 28 2024

Gotland – in the middle of the Baltic Sea

- Largest island in Sweden
- 3140 km^2
- 65,000 inhabitants
- Ca 90 km's from mainland Sweden

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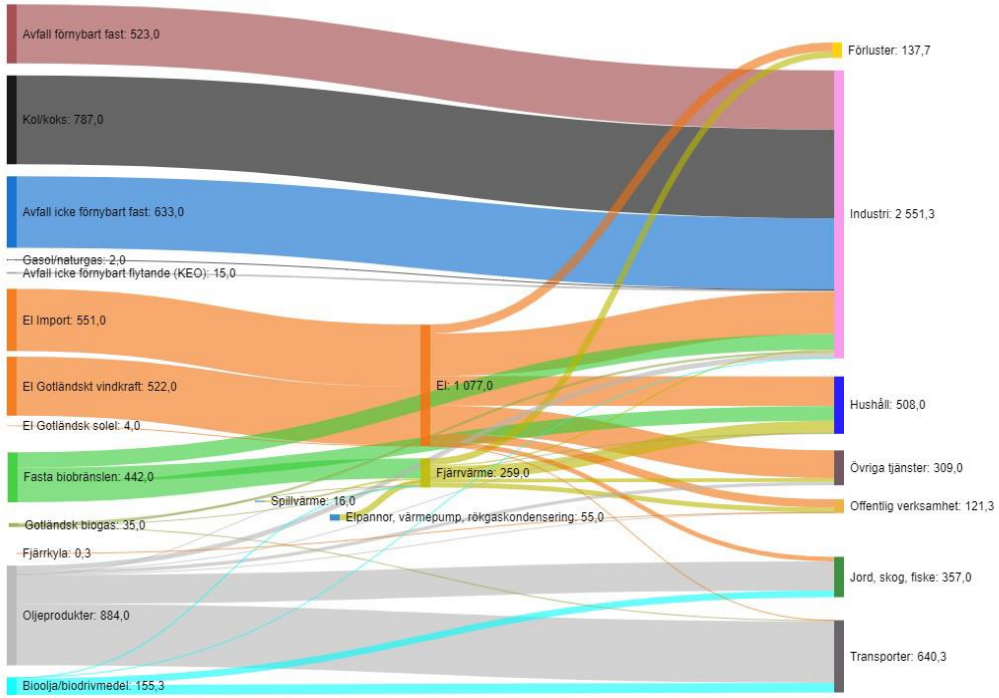
Energy production and consumption

- Electricity consumed: ~ 1 TWh
- 50% imported via cabe from mainland Sweden
- 50% windpower produced at Gotland
- Fossil fuels: ~ 0,9 TWh, (transports 0,6 TWh)
- Good opportunities to increase windpower – large-scale offshore wind farms



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Offshore wind farms

- Offshore wind in the surroundings of Gotland could make the island an exporter of energy…
- But…The government and the military have recently stopped all wind farms in the Baltic Sea

Phase	Location	Commissioned	Production	Capacity
Under development	Baltic Sea, outside Öland and south of Gotland	2030	24 TWh	5,5 GW

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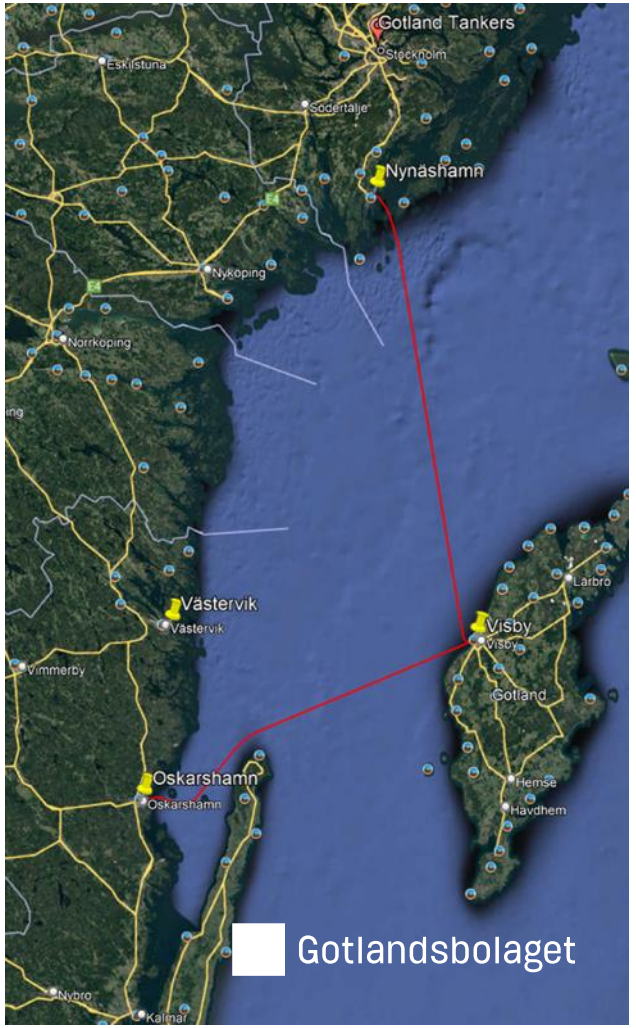
Renewable energy

- Renewable energy production is green, but quite volatile
- Hard to to replace all fossil fuels with battery electrification
- Hydrogen can be an interesting solution to both of these problems!
- Would be beneficial with a large off-taker of hydrogen



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Could we run the ferry on hydrogen?

Present operations

- Distance: 90 nm
- Ferry: Ro-pax, 200m, 1650 passengers, 500 cars (3 ferries)
- Engine: Dual fuel, LNG/LBG, 50 MW
- Speed: 28 knots, 3h15m, 100 MWh per round-trip journey

Hydrogen?

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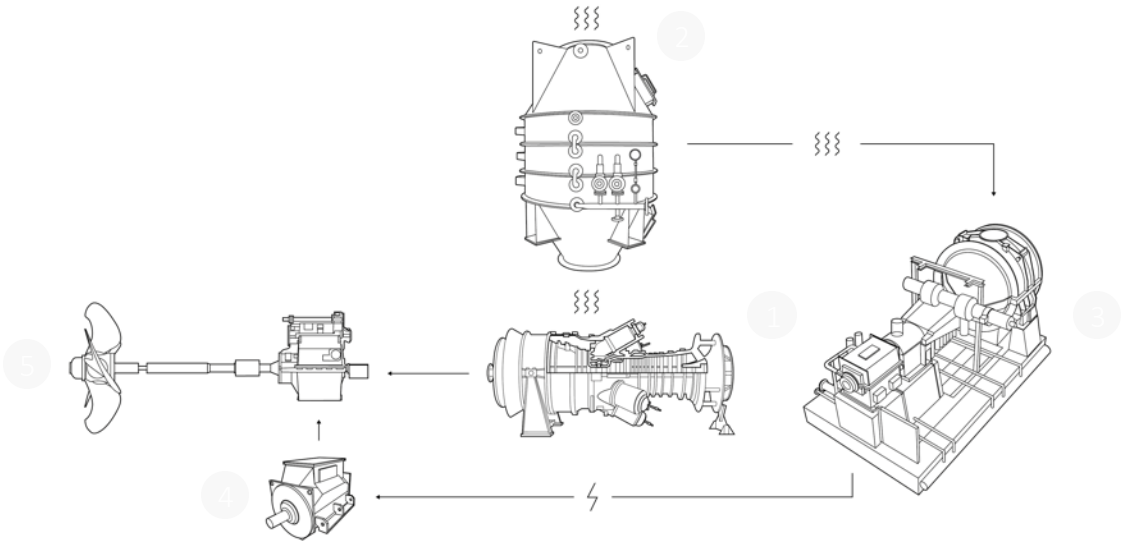
Hydrogen powered ferry

- Gas turbines, in combined cycle with steam turbines
- Long been used in industry, but it is only now that they will be powered by hydrogen.
- A multi-fuel engine; the gas turbines can handle a large variety of fuels
- 24 tonnes of hydrogen stored onboard
- 16 tonnes per round-trip journey
- **Provides a unique opportunity to accelerate the transition of shipping**.



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Hydrogen supply system

- 16 tonnes of hydrogen per round-trip journey
- 20.000 tonnes annual demand
- Requires ~ 1TWh/yr, 200 MW electrolyser
- Hydrogen production on- or offshore
- Pipeline from production to port
- Surplus of oxygen and heat

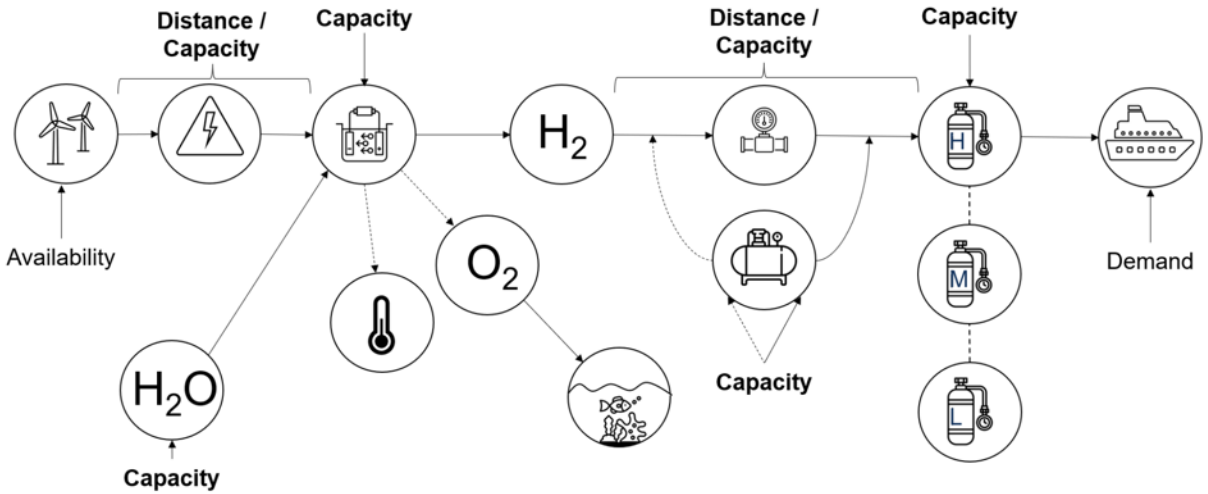

Figure 3: Gotland Ferry system layouts

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Wind + Hydrogen

- Hydrogen and renewable energy production = perfect match
- No need for constant hydrogen production
- Hydrogen production can levelize electricity production to the grid
- Hydrogen production can harness otherwise not used wind/sun
- Large-scale hydrogen storage would further improve the system

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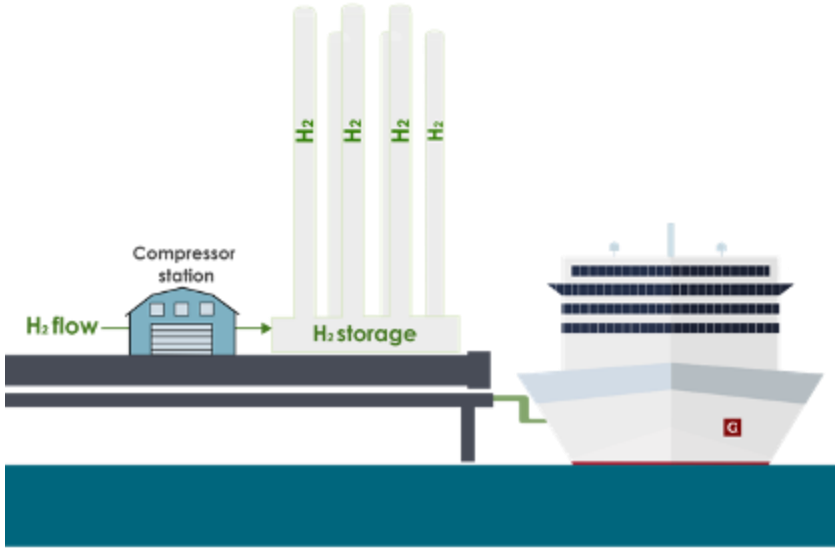
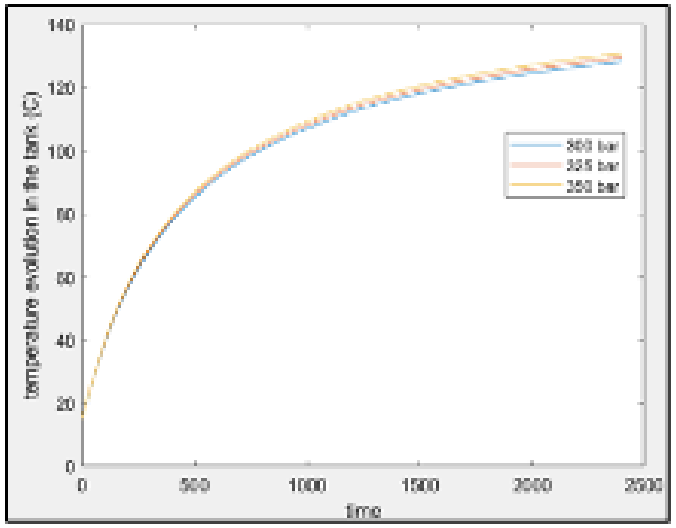
In port

- 16 tons in 45 minutes – approx. 800 m3
- Cascade filling – higher pressure in buffer storage in port
- Temperature will rise – Cooling process necessary
- Requires 50 – 150 tonnes of hydrogen in buffer storage
- Physical space – approx. 2 – 10 000 m^2
- Security and regulatory
- **New refuelling concept needs to be developed**





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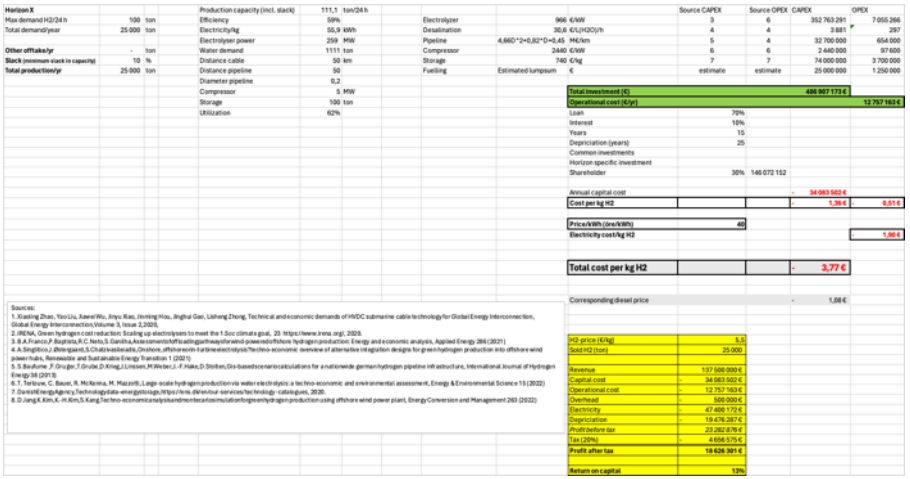
Economy

- Long term: 5.5 €/kg H2
  - ~€1,5/l diesel
- Utilisation rate, electricity prices
- Short term: 10-20 €/kg H2
- Increased CAPEX ferry
- **Need for public support**



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Hydrogen as an enabler for the green transition

- Large-scale production for the ferry system enables other hydrogen soilutions
- Heavy trucks
- Agriculture machines
- Sustainable fertilizer production

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Renewable ⟹ Hydrogen ⟹ Electricty?

- Use hydrogen as energy storage
- Islands with volatile energy production, Wind or solar power
- De-centralized electricity production
- Requires cost-efficient large-scale hydrogen storage
- **Enables a fossil-free renewable electricity system**

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Some challenges

Technical:

- Refuelling and handling in port
- Large-scale storage

Financial/political:

- Support front-runners

Political:

- Support offshore wind farms

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Thank you!

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