Optimization of green hydrogen supply

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VTT

VTT's P2X-optimization for dimensioning and operational optimization

PtX process unit dimensions are dependent on
- wind (and solar) power
- volatile power market
- green product definitions
- inflexible H_2 demand at customer or downstream process
- optional flexibility in customer's production

⇒ **Model gives cost-optimal dimensions for**
- Electrolysers
- H_2-compressors
- H_2-storages size
- needed renewable power site or PPA-contract
- grid interface, optional battery etc..
- optionally customer's flexible production

Renewable Power (direct or PPA)

Power Market

P2X Optimal Operation and Dimensioning
- Multiple, often conflicting targets
- **GHG (CO_2) emissions & cost of grid** (market) power
- Demand and market price for (green) end products and intermediate products
- **Intermittency and Cost** of renewable power, PPA
- Sales of surplus renewable power, balancing purchases
- **"Green" definition** requirements:
  - CO_2/GHG emissions: direct and indirect
  - Minimum needed share of renewable power
- **Optimal dimensions** of P2X plant dimensions and unit processes, dimensioning of wind power PPA

PtX green products
- Steels
- Fuels
- Chemicals
- Reduction Agents

Side products
Oxygen
Heat
(Steam)

Optimization Case example:

Hydrogen production strategy
for a ”100MW” inflexible industrial load

Data sources: www.fingrid.fi

Inflexible hydrogen production strategy for a ”100MW” load

Industrial steady 2000 kg/h H2 load

To provide 2000 kg/h at EOL, AEL or PEM electrolyser sizes must be 104-122 MW, depending on efficiency.

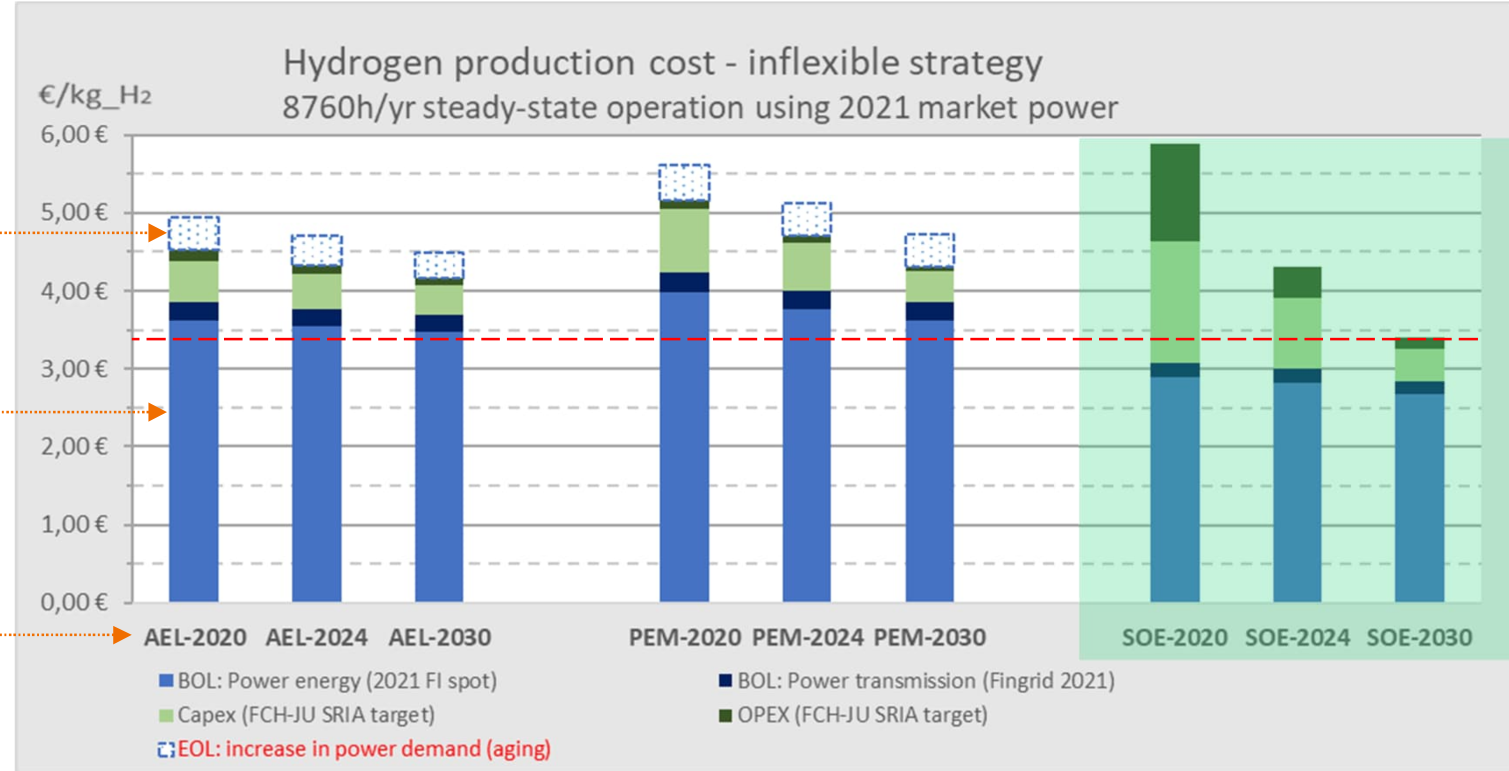
For SOE, this is 93-100 MW.

Stack aging:
Increase of power demand from BOL towards EOL increases the AEL/PEM production costs by 0.21-0.41 €/kg

Average power costs in 2021

ELSPOT FI	72,34 €/MWh
EL gridfee+tax	4,65 €/MWh
Total	76,98 €/MWh

Costs and efficiencies for 2020, 2024 and 2030 according to FCH-JU targets (SRIA 2021)



BOL = Begin of stack life time (0h age)
EOL = End of stack life time (80000h age)

Data sources: www.fingrid.fi; www.nordpoolgroup.com; FCH-JU Multi-Annual Work Plan 2017.

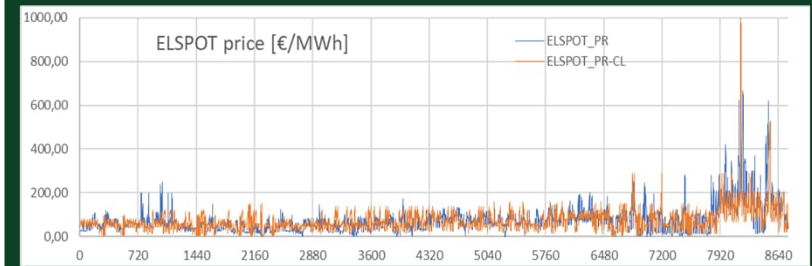
CAPEX related assumptions:
WACC 6%
Optimistic local site costs estimate

Comparison of different production strategies

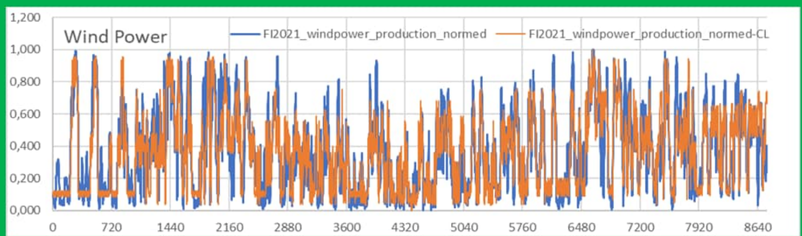
Example industrial case 2030: ”Steady but inflexible large H2 load”

Industrial steady 2000 kg/h H2 load

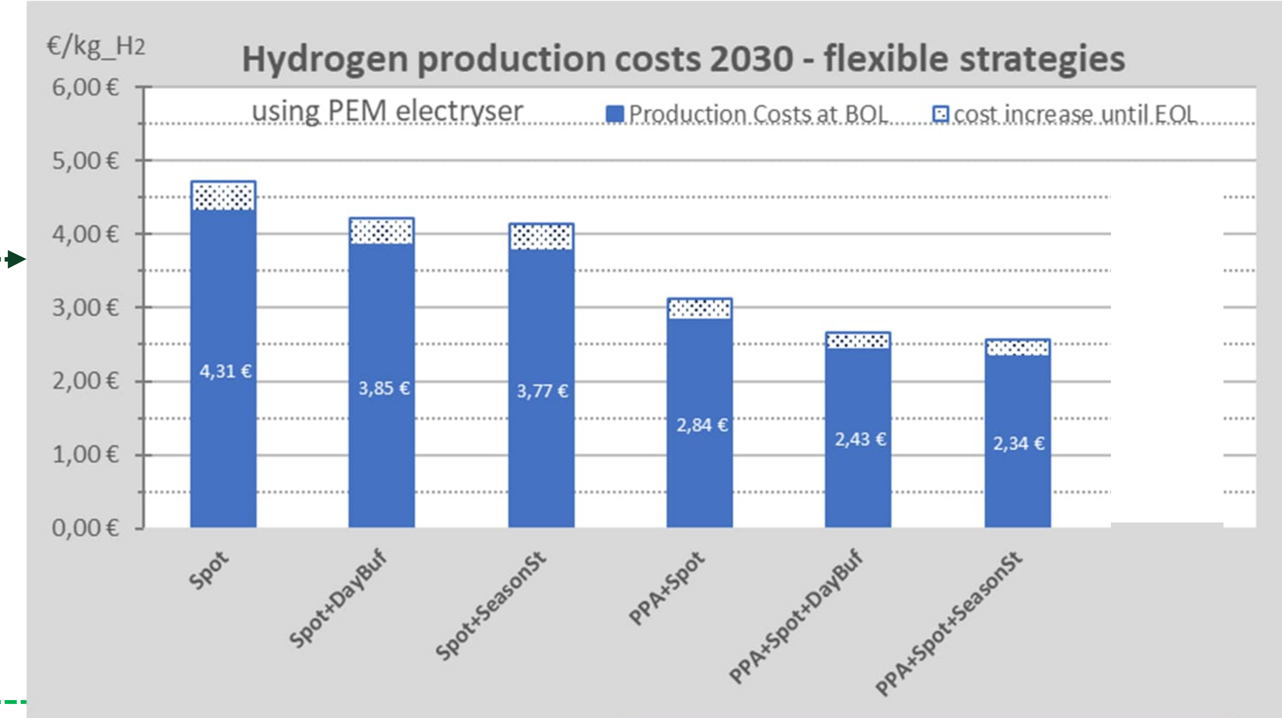
Wholesales Power price (Spot)



Wind power available (PPA)



Load following assumed to be used for adjusting wind power forecasting errors (to avoid balancing costs).



PEM = Proton Exchange Membrane electrolyser, 30bar output, ***optimized size and operation***
PPA = Wind power purchase agreement, ***required size***
Spot = Elspot market power purchases or ***optimized trading***, FI area
DayBuf = H2 intraday buffer storage 30bar, ***optimized size and operation***
SeasonSt = H2 Seasonal storage 125bar, ***optimized size and operation***
BOL = Begin of stack life time
EOL = End of stack life time

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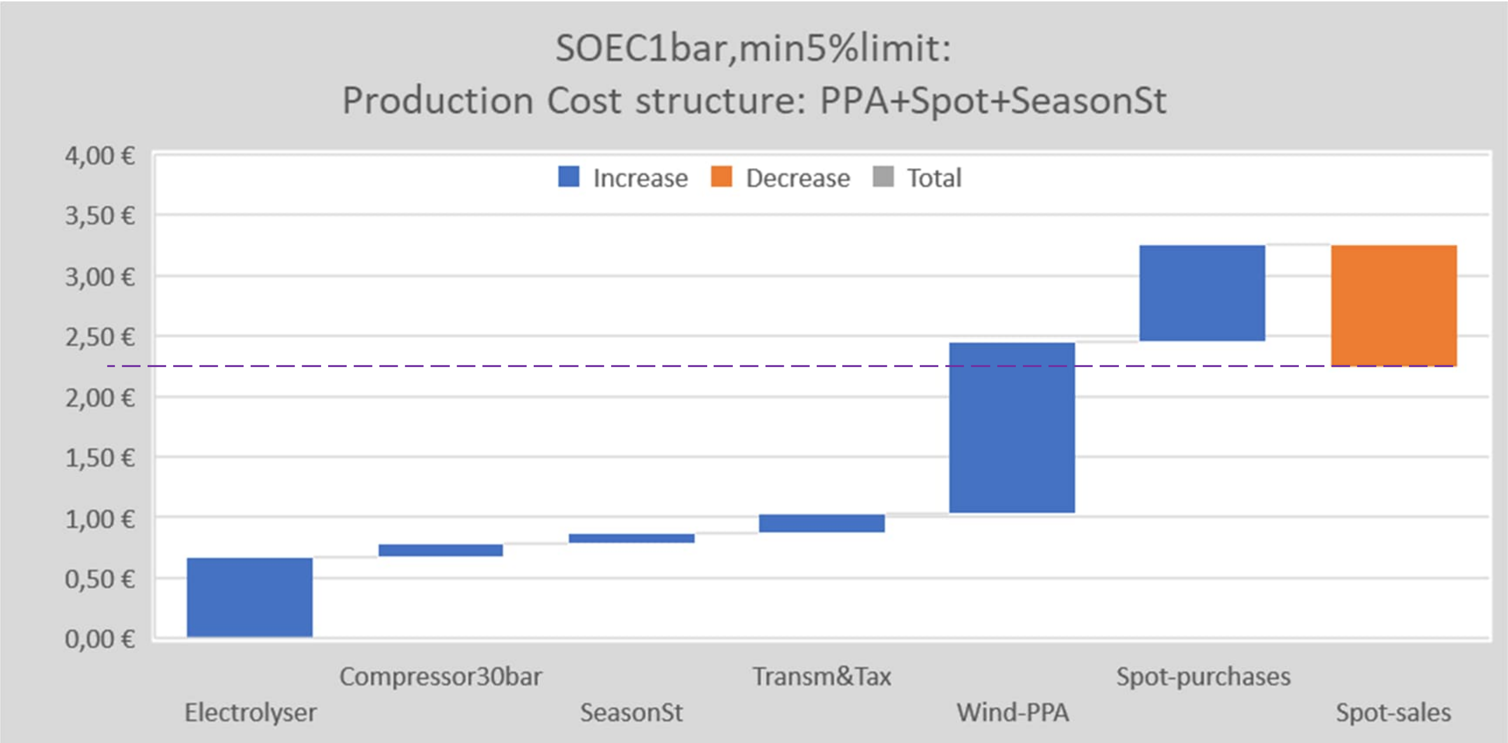
Optimistic local site costs estimate

Performance at optimal *system*

case ”100 MW load”=2000kg/h: Production strategy PPA+Spot+SeasonSt for 2030



SOEC size 91 MW

Wind park size 219 MW

Free steam available

Power used in process	681 GWh	
Wind Power produced	681 GWh	
Wind power own use in process	467 GWh	69 %
Spot purchases	213 GWh	31 %
Spot sales	213 GWh	

PPA = Wind power purchase agreement
Spot = Elspot market power, FI area
DayBuf = H2 intraday buffer storage 30bar
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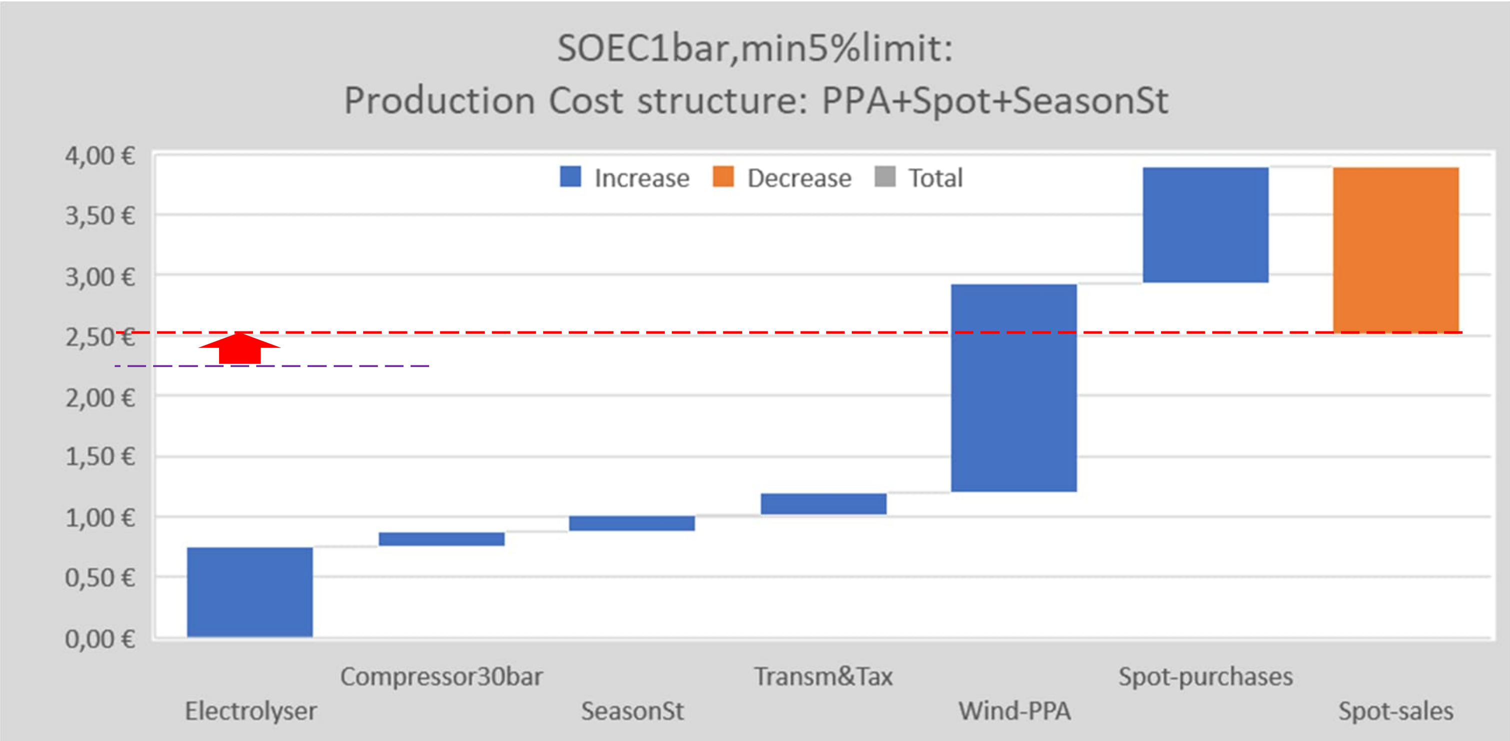

SOEC size 124 MW (+33)

Wind park size 264 MW (+45)

All steam produced from power

Power used in process	821 GWh	
Wind Power produced	821 GWh	
Wind power own use in process	547 GWh	67 %
Spot purchases	274 GWh	33 %
Spot sales	547 GWh	

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