

Economic and environmental considerations for the deployment of VHTHPs in European markets

Kim Högnabba^a, Ron Zevenhoven^a, Tor-Martin Tveit^b, Stefano Vittor^b

Abo Akademi University^a

Olvondo Technology^b



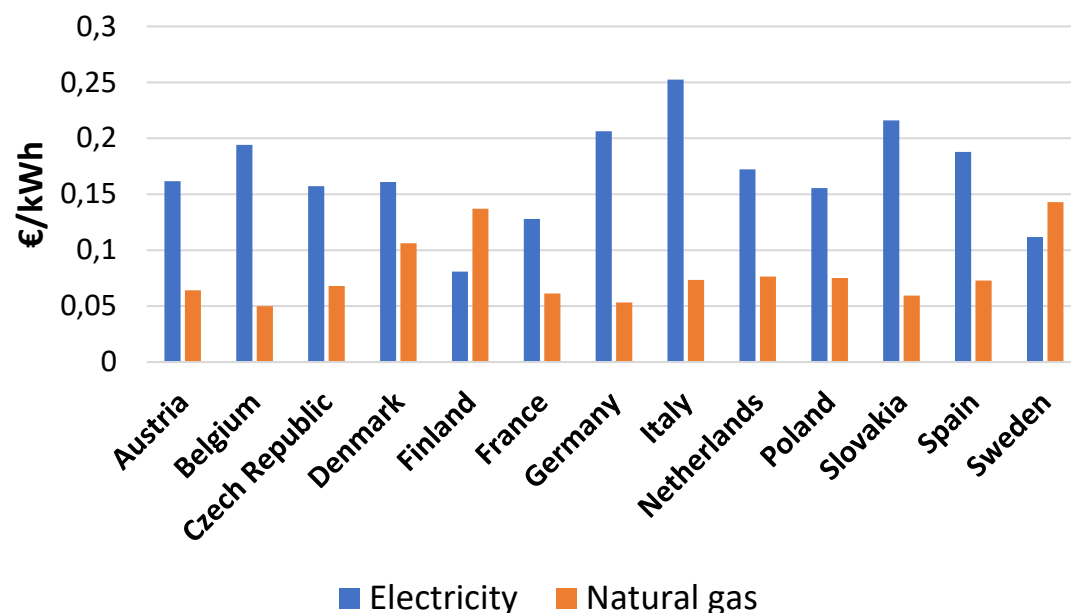
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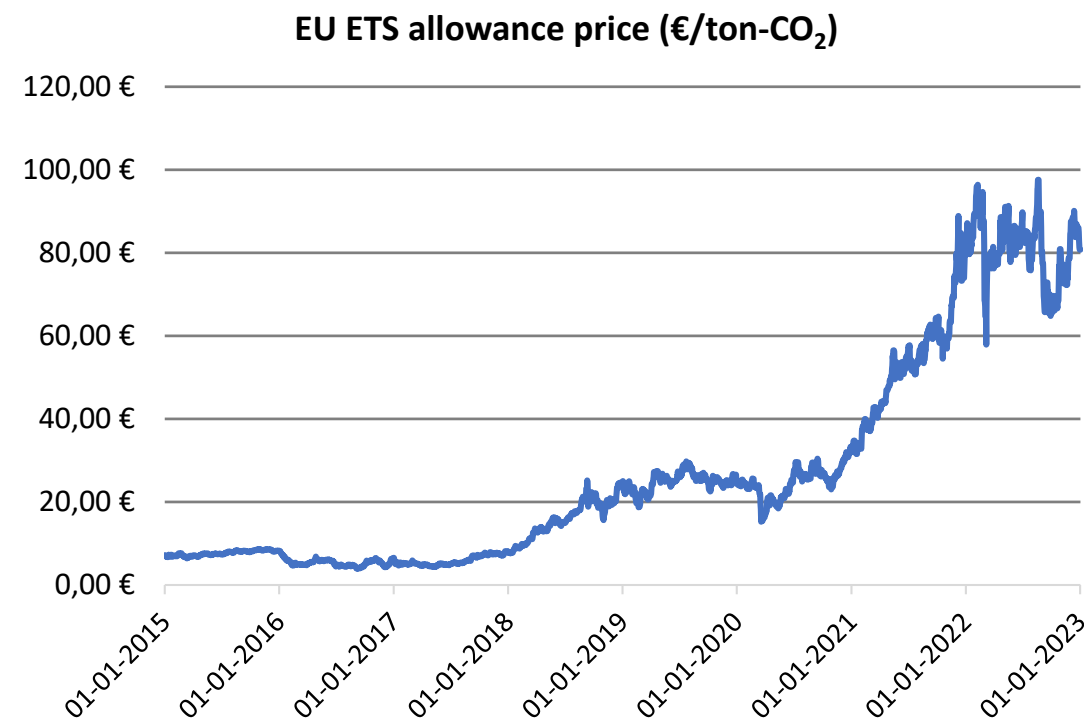
- Briefly outline the current economic landscape for VHTHPs in Europe
- Demonstrate how Life Cycle Assessment (LCA) tools can be utilized to estimate the environmental impact of VHTHPs
- Investigate the feasibility of installing high temperature heat pumps in two case studies

- Cost of investment
- Price of electricity vs natural gas

Energy prices for non-household consumers - first half of 2022

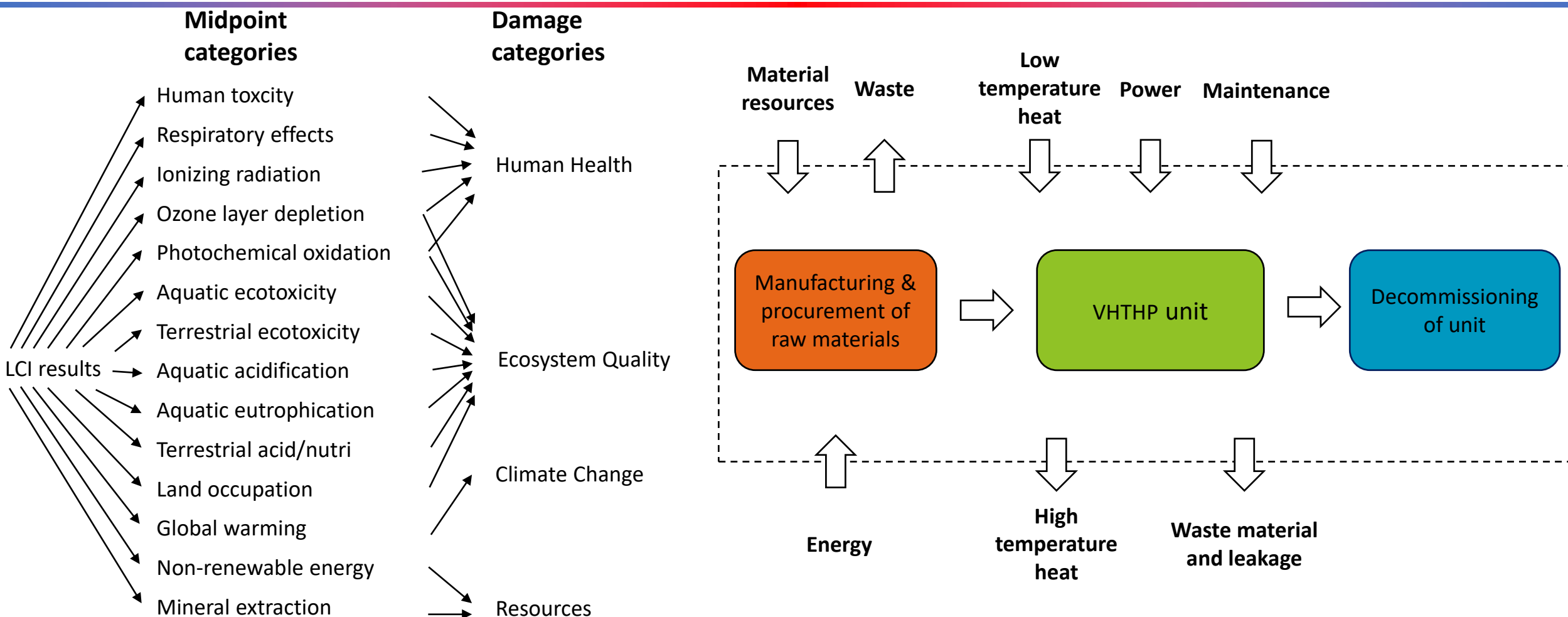


- Carbon pricing mechanisms (taxes, cap and trade)





Quantifying environmental impacts using Life Cycle Assessment (LCA)





Case studies – Background information



- Two breweries in Spain utilizing high pressure steam
- Assumptions
 - LCA assumption: Solar power
 - Electricity price: 70 €/MWh
 - Natural gas price: 27 €/MWh
 - ETS allowance price: 90 €/ton CO₂

	Case 1	Case 2
Hot sink temperature	170 °C (7 barg) 338 °F (102 psig)	162 °C (5.5 barg) 324 °F (80 psig)
Cold source temperature	26 °C, 79 °F (winter) 32 °C, 90 °F (summer)	85 °C, 185 °F
Cold source availability	680 kW	425 kW
Operational hours	6 350 h	5 200 h
Estimated COP	1.8	2.3

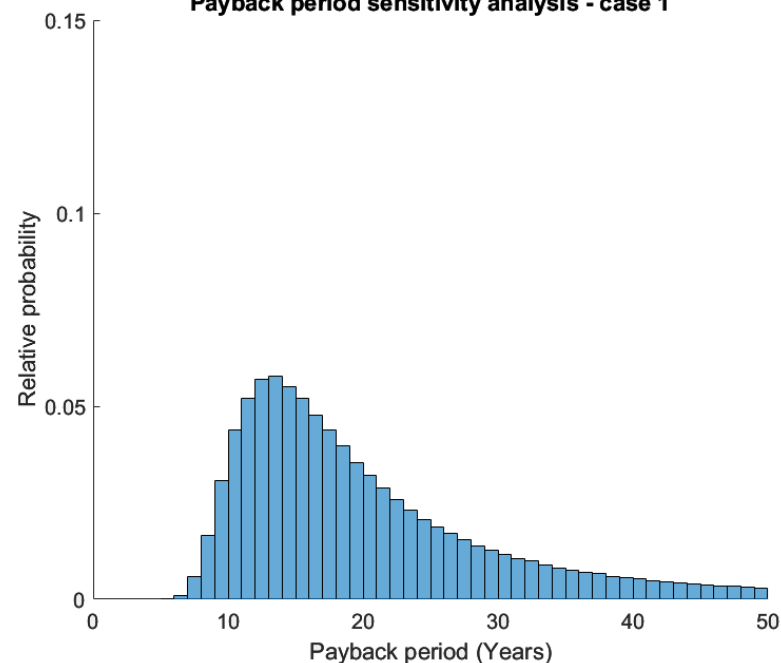
	VHTHP	NG Boiler
Thermal capacity (kW)	750	1 700
Investment cost (k€)	900	76
Maintenance cost (k€/yr)	10	5.5

Median payback periods

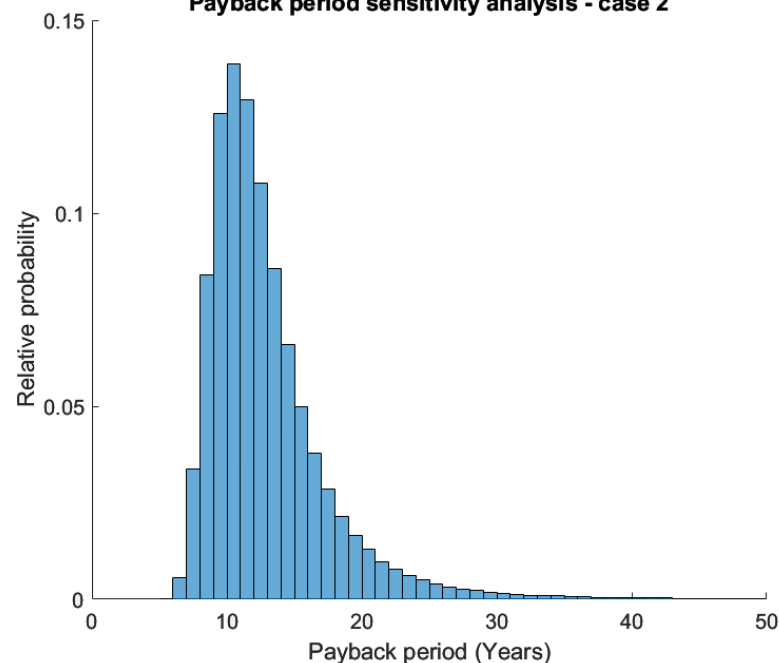
Case 1: 19 years

Case 2: 11 years

Payback period sensitivity analysis - case 1

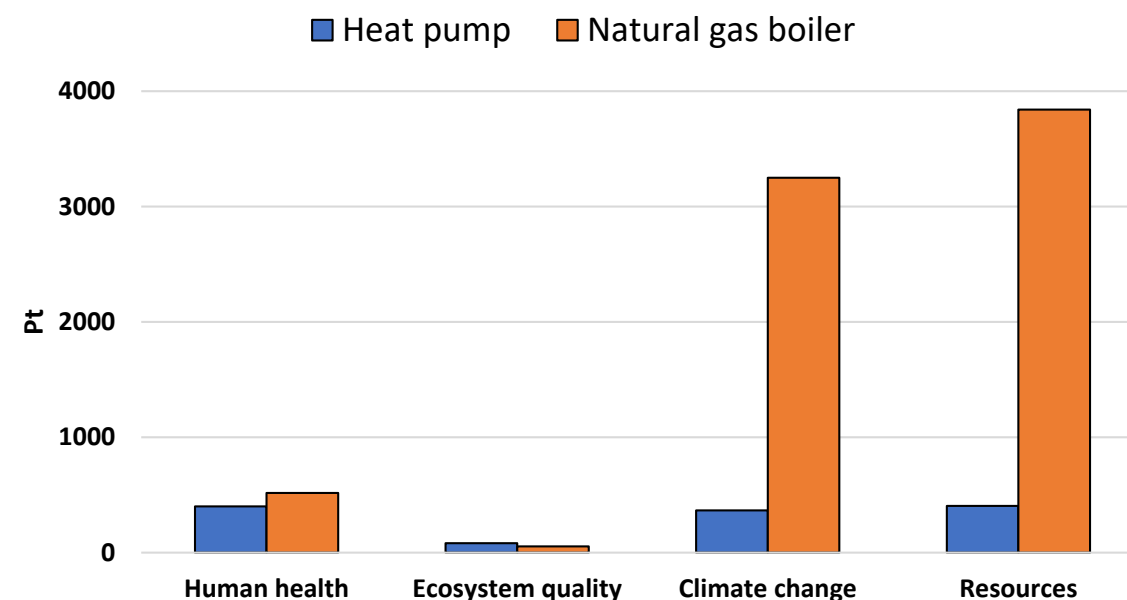
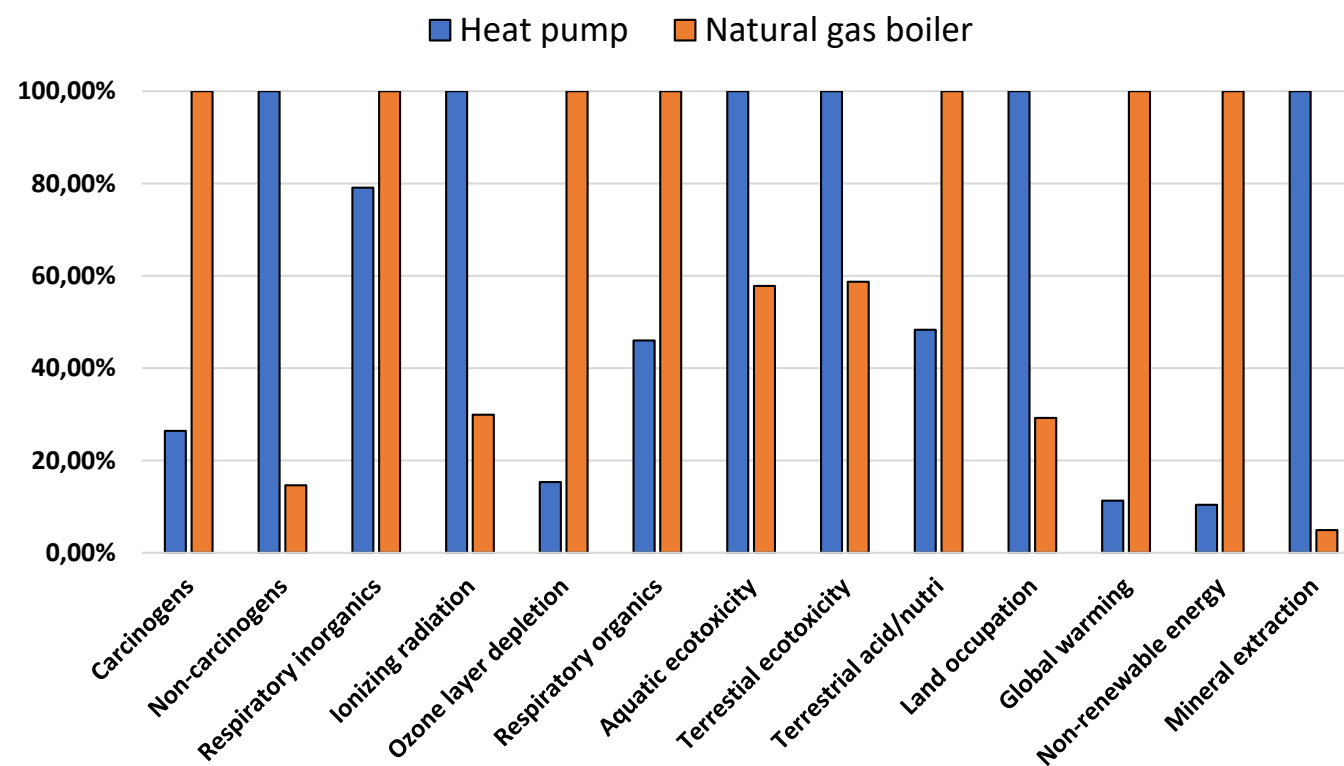


Payback period sensitivity analysis - case 2



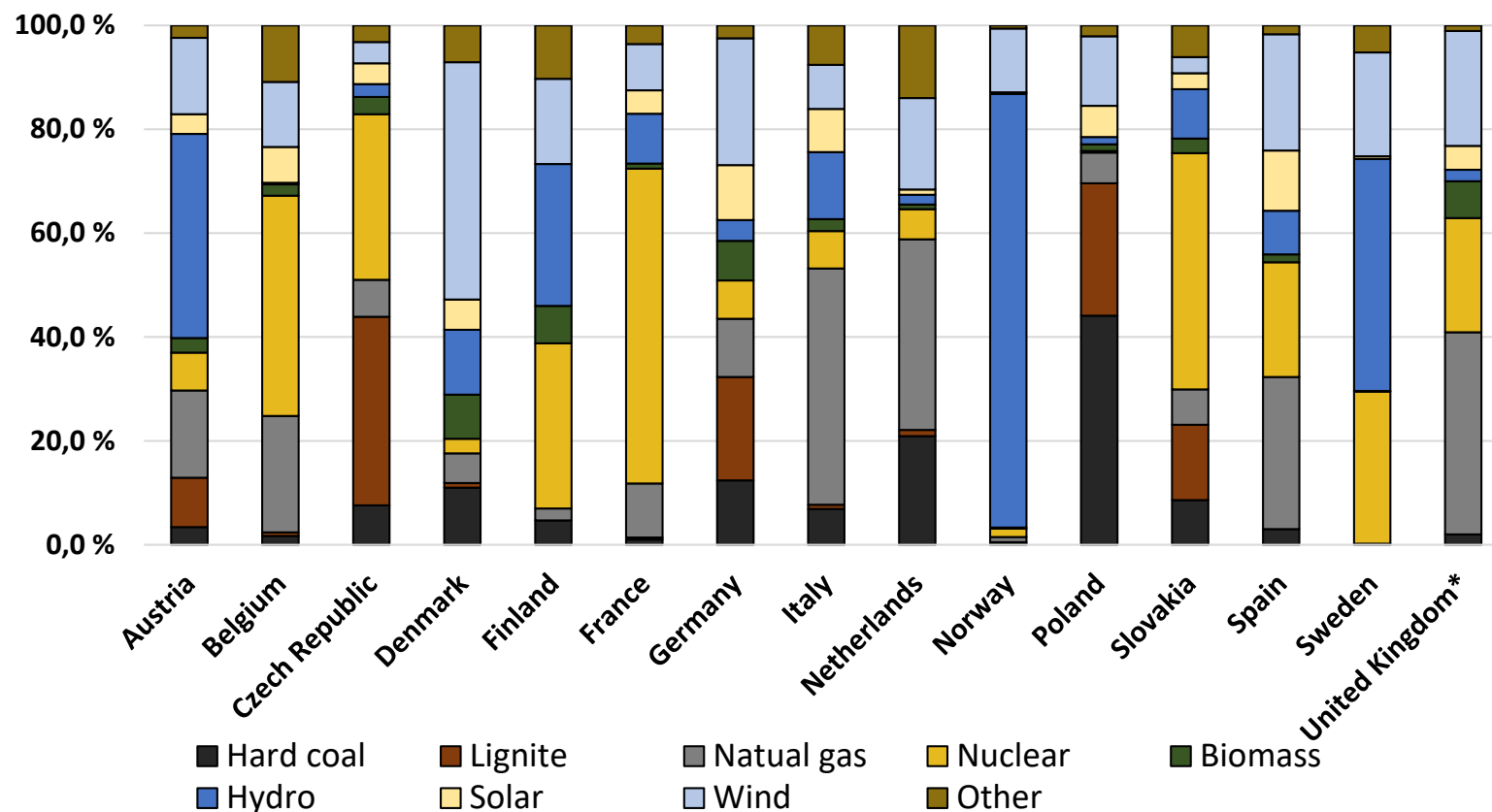
	Case 1 2 VHTHPs	Case 2 1 VHTHP
VHTHP costs		
Maintenance (k€/yr)	20	10
Electricity (k€/yr)	338	109
Natural gas boiler costs		
Maintenance (k€/yr)	5.5	5.5
Natural gas (k€/yr)	261	108
ETS allowances (k€/yr)	183	76
Running cost savings (k€/yr)	91.5	70.5

Midpoint- and normalized damage category impacts for case 1 with a 15-year lifespan utilizing solar power



Method: Impact 2002+

Electricity consumption mixes 2022

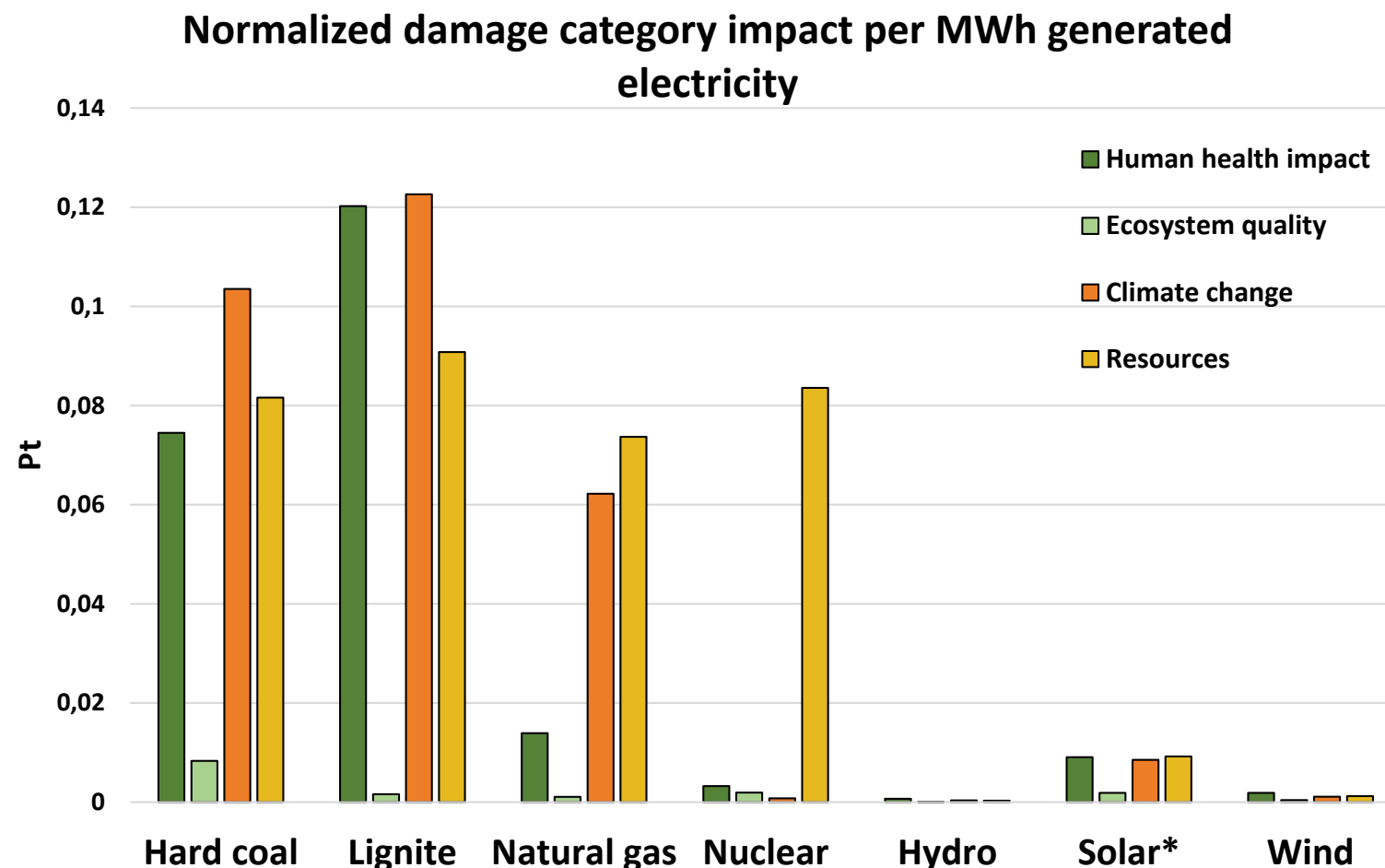


Source: ENTSO-E
*2020

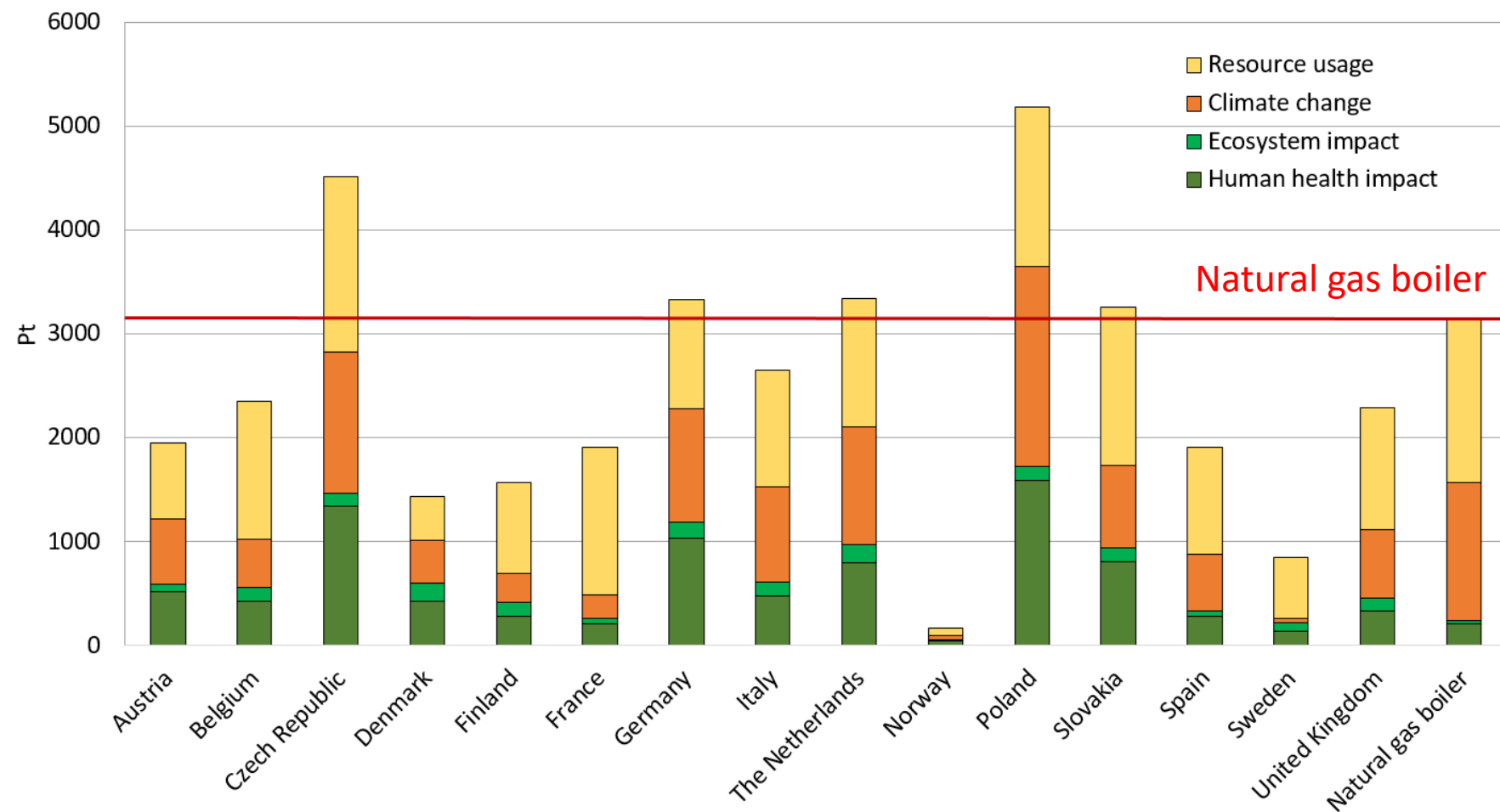
Fossil fuels show a significantly larger environmental impact compared to renewable electricity sources

Source: ecoinvent v3.8

*German climate conditions



Environmental impact of a VHTHP (COP=2.3) using grid electricity and an equivalent natural gas boiler over a 15-year lifespan





Summary



- Carbon pricing mechanisms can play a significant role in determining the economic feasibility of replacing fossil fuel fired boilers with VHTHPs
- The environmental benefit of operating VHTHPs is highly dependent on the electricity mix used and can be quantified using life cycle assessment tools