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A multi-factorial decision support tool for integration of small-scale industrial heat pumps and solar PVs into a district heating system

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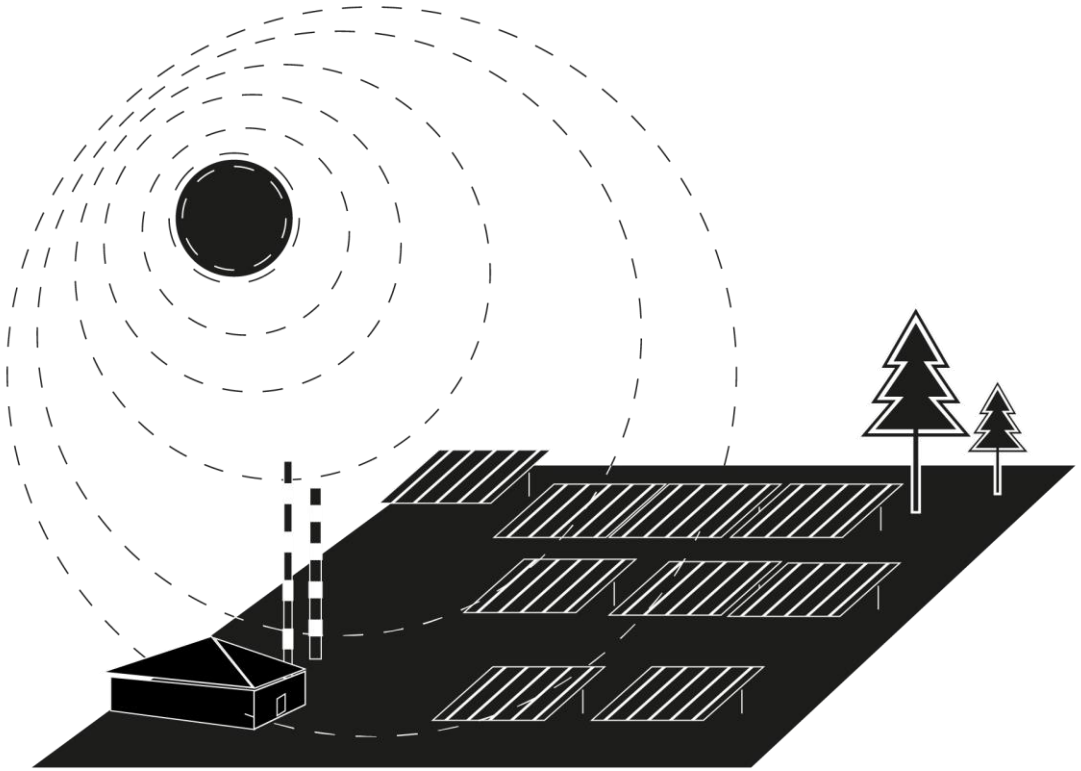
Goal of the research

To analyze possible development scenarios for remote consumers of DH system by implementing multi-generative systems and/or low-temperature heating supply.

The goal is to evaluate the most sustainable scenarios by taking into account the Energy, Exergy, Economic, and Environmental (4E) key performance indicators (KPIs).



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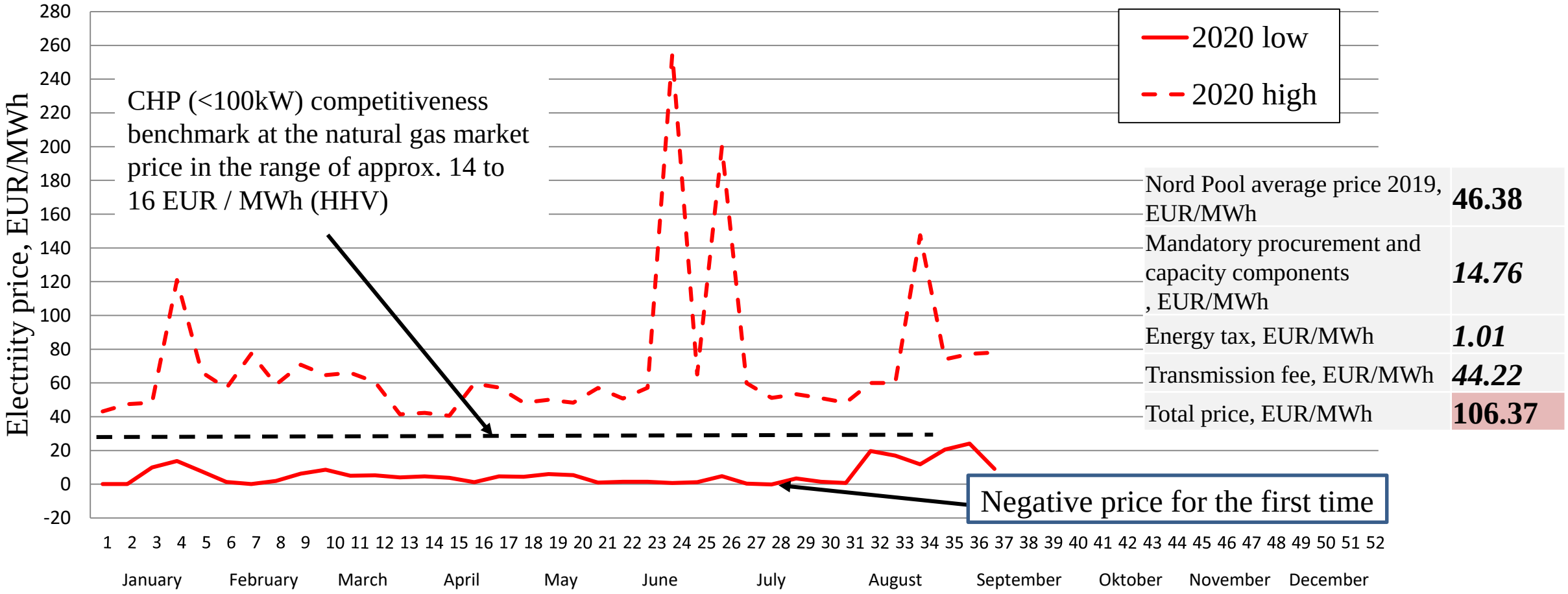
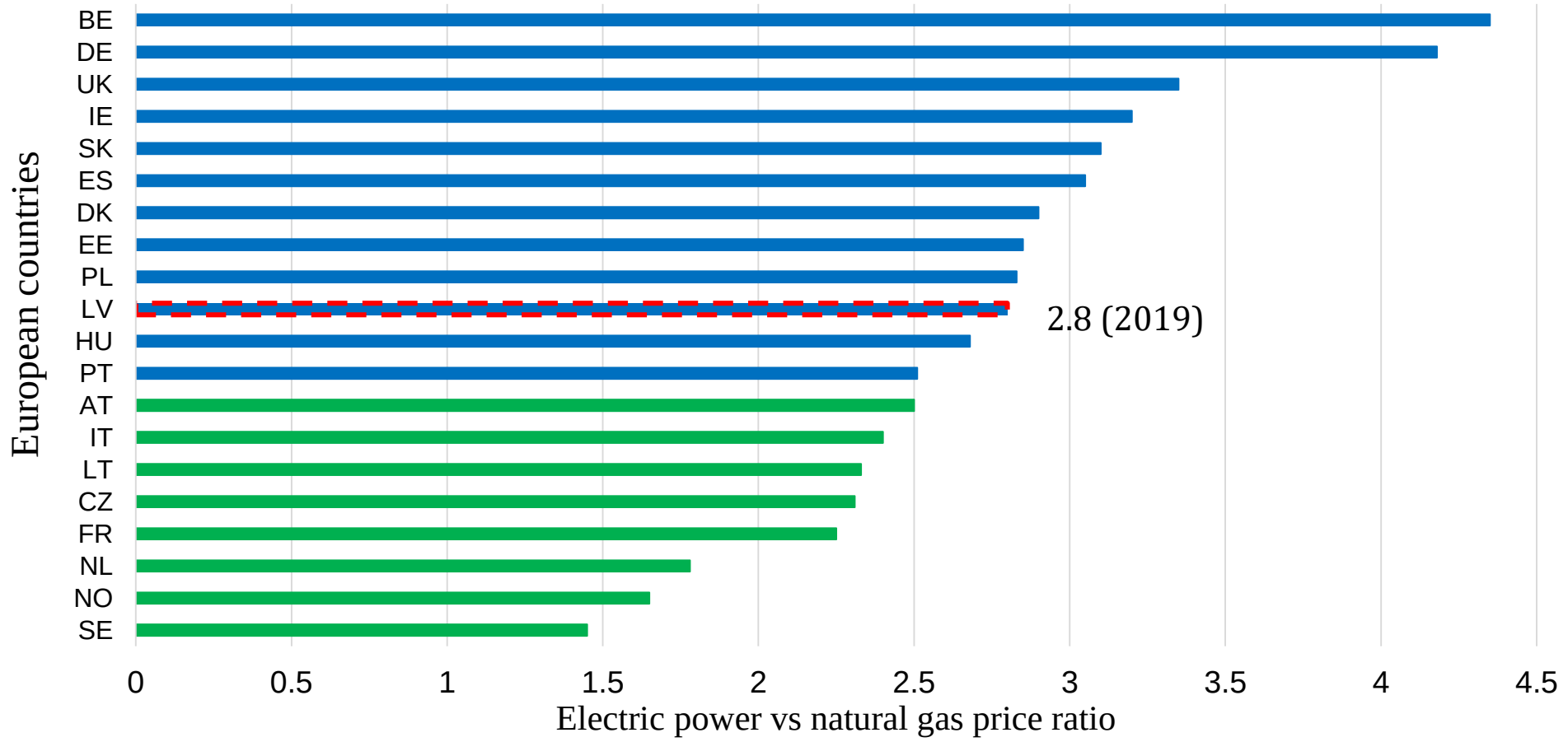
2020 Nord Pool electricity price amplitudes (LV)

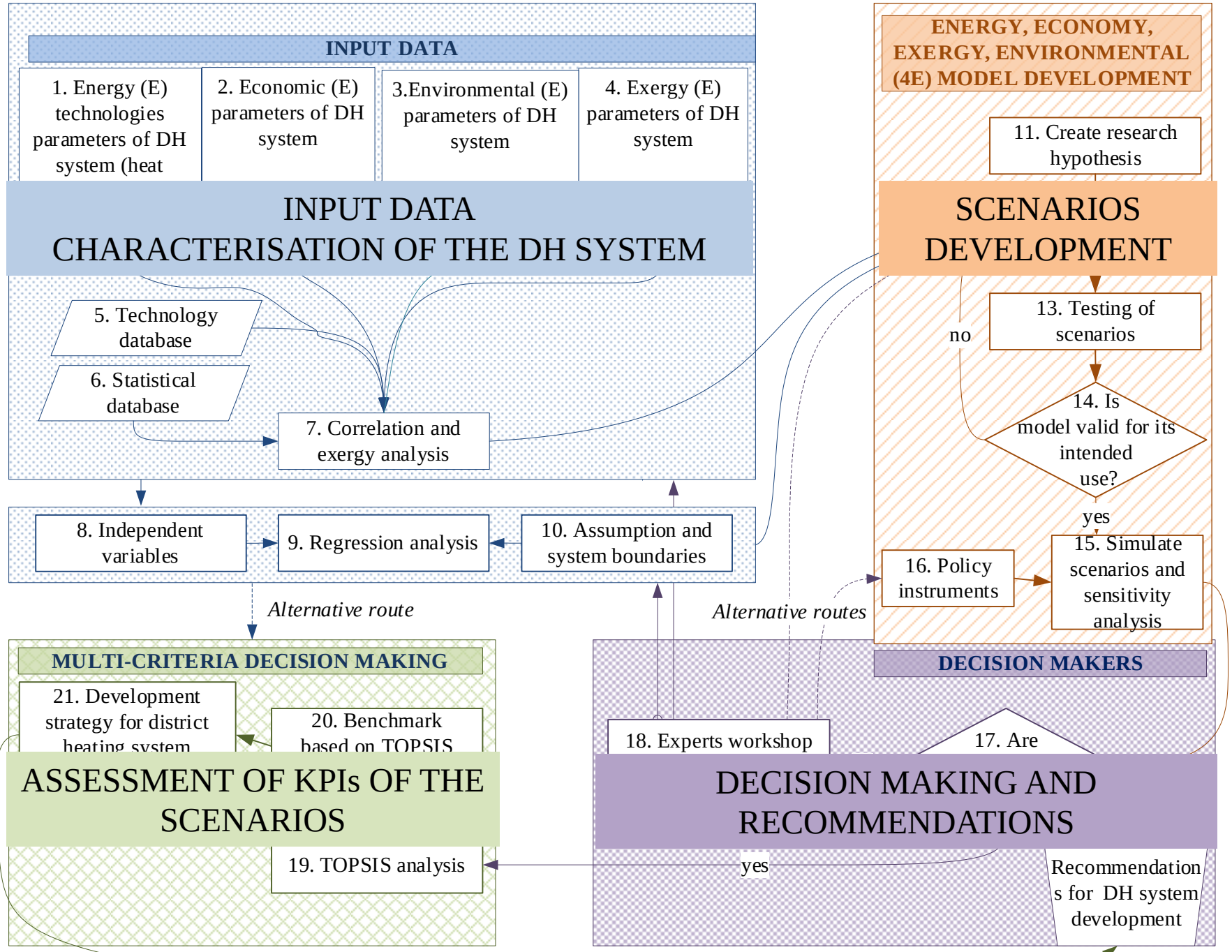


Nord Pool average price 2019, EUR/MWh	**46.38**
Mandatory procurement and capacity components , EUR/MWh	***14.76***
Energy tax, EUR/MWh	***1.01***
Transmission fee, EUR/MWh	***44.22***
Total price, EUR/MWh	**106.37**

Relative price: electric power vs. gas in Europa*

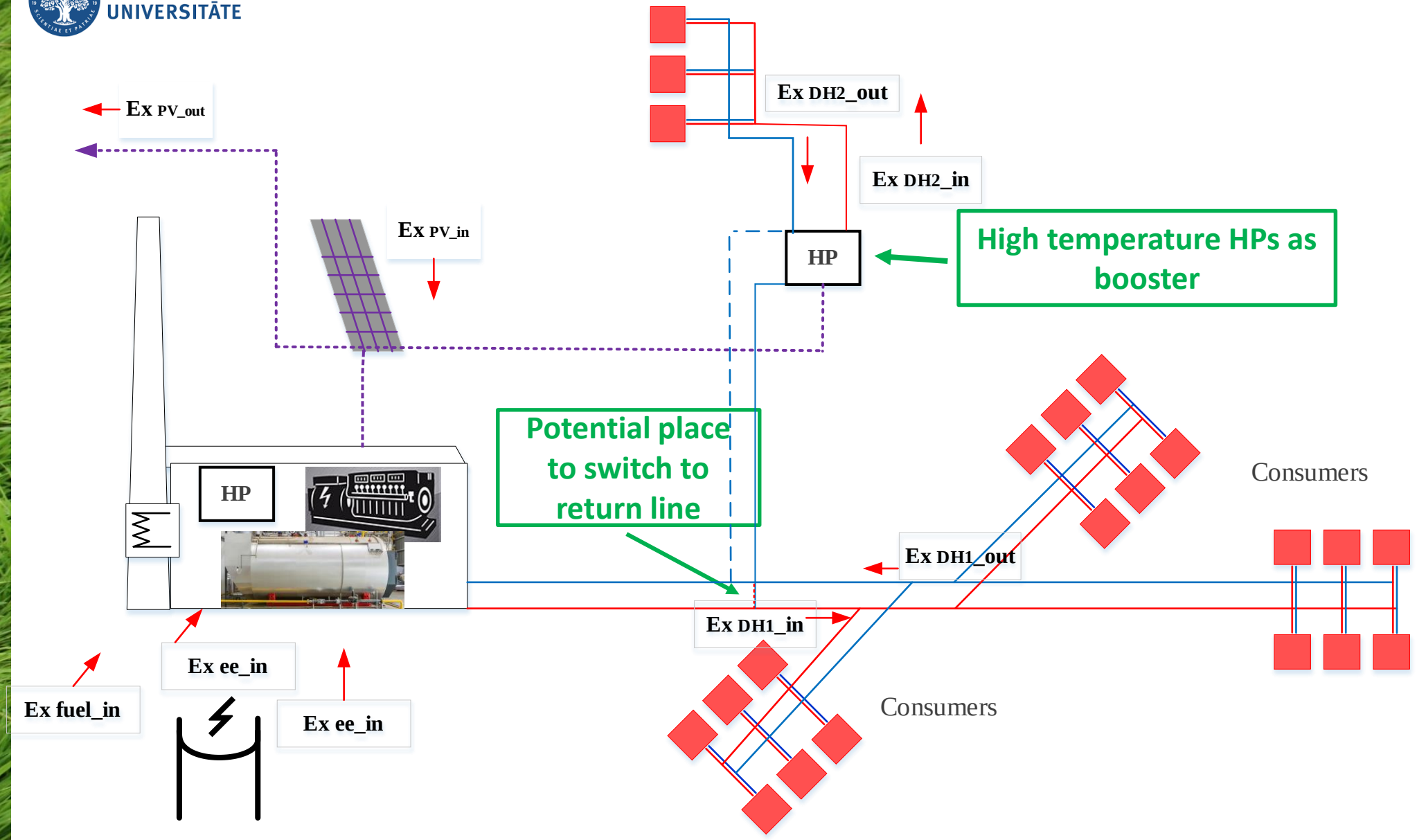


* Webinar: EHPA market report and statistics outlook 2019. Thomas Nowak. Available: https://www.ehpa.org/fileadmin/red/09._Events/2019_Events/Market_and_Statistic_Webinar_2019/20190624_-_EHPA_Webinar_outlook_2019_-_Thomas_Nowak.pdf



Conceptual scheme of methodology

Case study


Ex PV_out
Ex DH2_out
Ex DH2_in
Ex PV_in
HP
High temperature HPs as booster
HP
Potential place to switch to return line
Consumers
Ex DH1_out
Ex DH1_in
Ex fuel_in
Ex ee_in
Ex ee_in
Consumers

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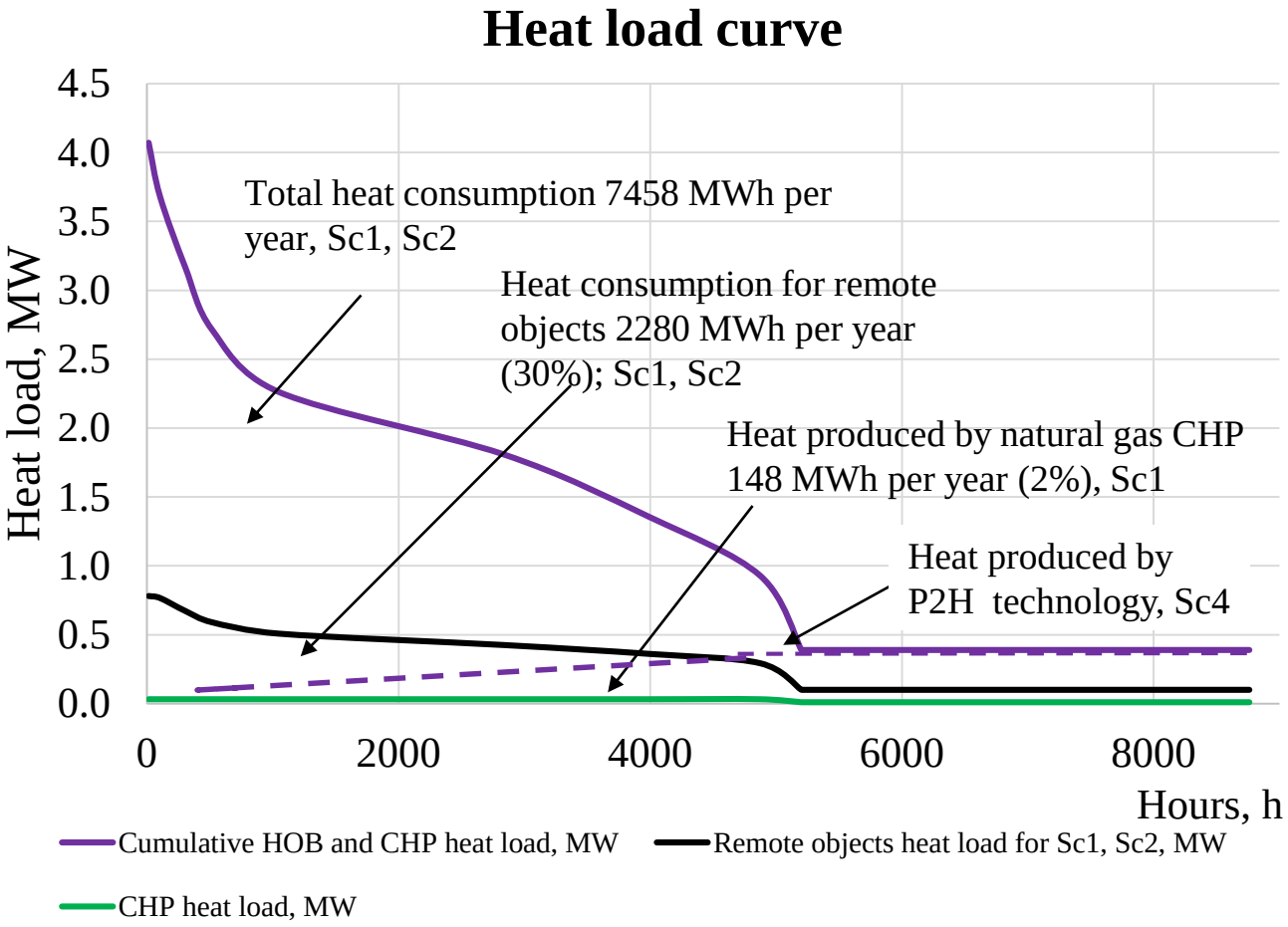
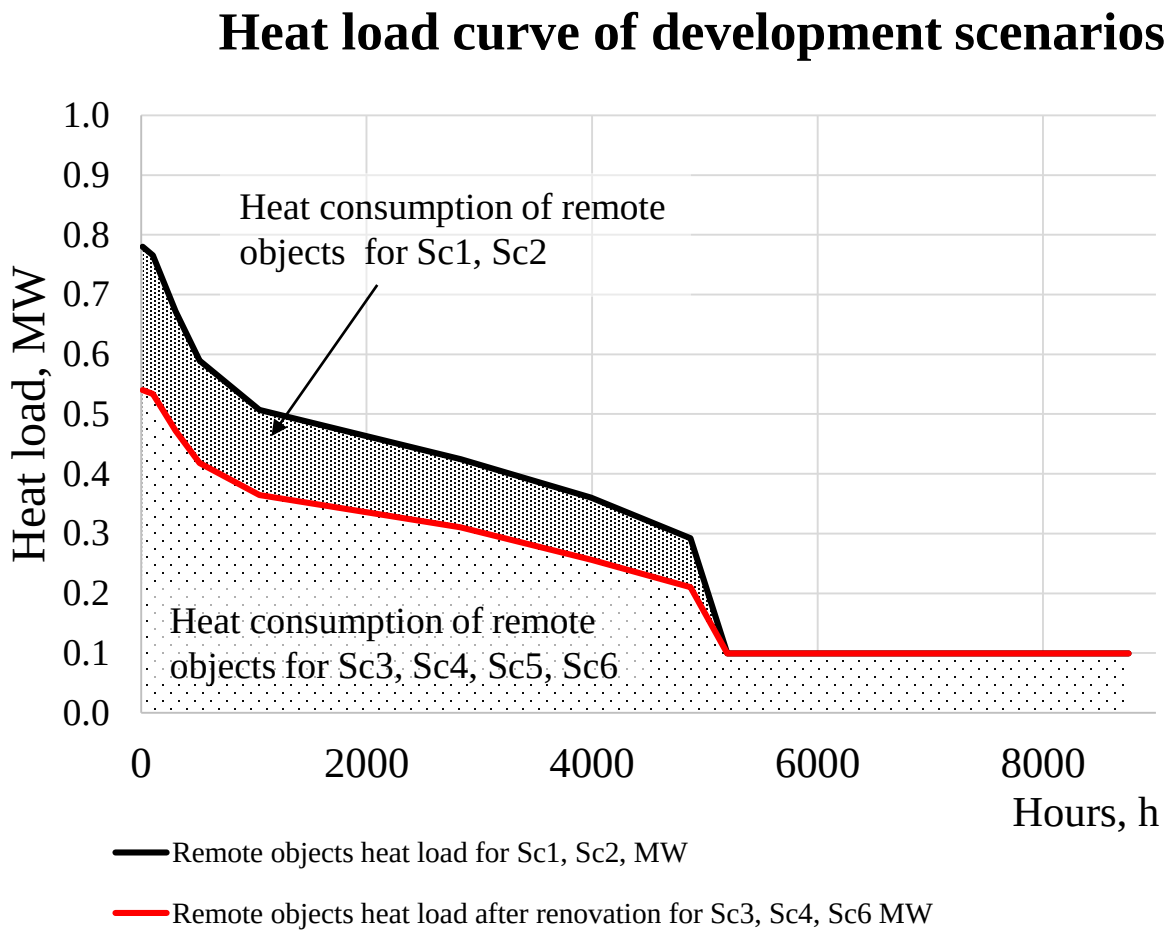
Description of scenarios

Scenario	Main fuel used in boiler house	HP installation as booster	Central HP	PV installation at the heat source	Renovation of remote buildings	Temperature regime (main network) _ after HP
Sc1 (business as usual)	Natural gas (NG)					118/70
Sc2	NG	X				90/60
Sc3	NG	X		X	X	90/60 _ 70/40
Sc4	NG	X	X	X	X	90/60 _ 70/40
Sc5	NG				X	90/60 _ 70/40 low-temp. to remote objects
Sc6	Wood chips	X		X	X	90/60 _ 70/40

Heat load curves of the development scenarios





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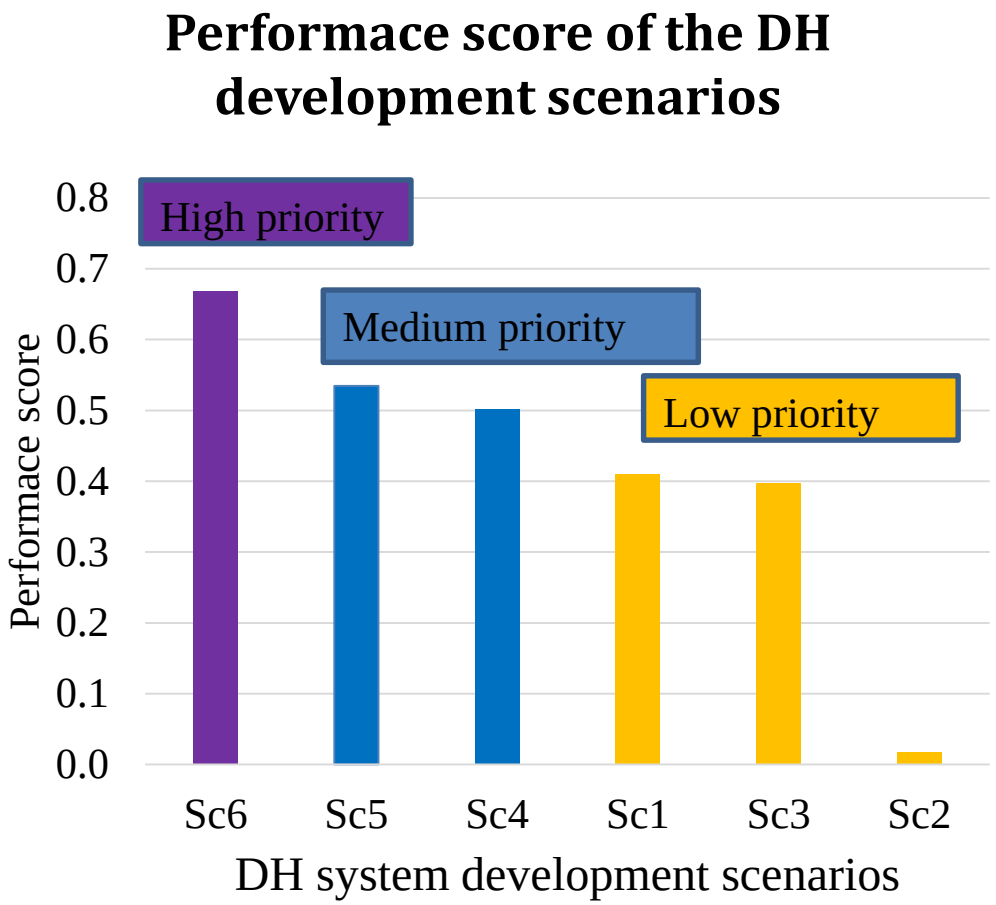
Multi-criteria analysis and results

Dimen-sion	Energy	Exergy	Environ-ment	Economy	
KPI	Primary energy factor, PEF	Exergy efficiency, %	CO2 savings,%	Payback time, years	Levelized costs of heat, EUR/MWh (LCOH)
Objective	**min**	**max**	**max**	**min**	**min**
Sc1	1.27	34.85	0.00	5.80*	34.10
Sc2	1.25	34.48	2.86	21.90	45.01
Sc3	1.24	40.68	9.86	9.13	41.32
Sc4	1.08	**43.48**	17.91	9.20	40.06
Sc5	1.26	42.50	6.94	**2.40**	35.45
Sc6	**0.26**	34.93	**77.77**	4.50	**34.00**



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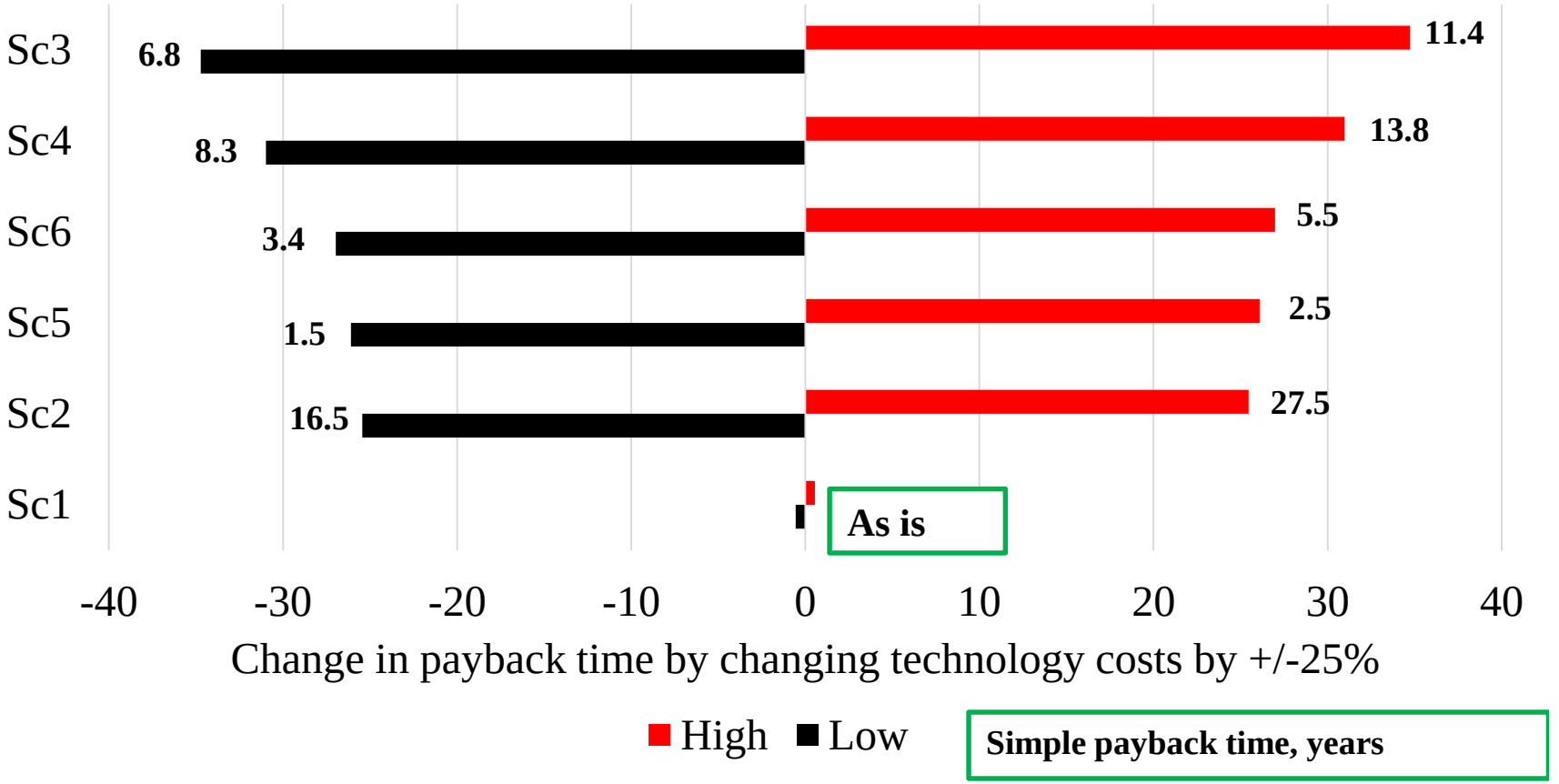
Results of the sensitivity analysis by changing the installed technology costs by +/- 25%



Payback time for Sc3 changed by 4.6 years (40%)

Conclusions

1. The research presents an **analysis and comparison of different development scenarios for remote consumers** by implementation of industrial-scale high temperature HPs that use the return heat water from DH network as the heat source and are coupled with PV panels. As an additional scenario transition of heat supply to low-temperature regime for remote objects is assessed.
2. Energy, exergy, environmental, economy **(4E) model was coupled with multi-criteria analysis** in the research methodology to consider competing targets in different scenarios. **The developed methodology can be applied to other heating systems** if corresponding initial data are added.

3. DH system exergy analysis explicitly shows that **integration of renewable energy source technologies increase exergy efficiency of the system** from 34.85% (existing DH system that used NG boilers and CHP) to 43.48% (HPs coupled with solar PV and P2H).
4. **The most sustainable solution is DH system development scenario that provides biomass boilers integrated with high temperature industrial HPs coupled with PV panels for heat supply for remote consumers.**

6. The distribution losses are more significant for the low heat density area. Therefore, **transition towards low-temperature regime in heat network that distributes heat to remote objects is the second most sustainable development scenario that improves exergy efficiency and payback time of the system.**
7. **Decreased electricity and installed technology costs allows to reduce payback time for approximately 40%** (Sc3 from 11.4 to 6.8 years). It makes the high temperature industrial HP technologies more economically feasible. Financial support from the European funds would facilitate the development of RES technologies in Latvia.

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Transition towards the 4th generation district heating systems starts with small steps

Questions?

Additional information:

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