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Validity assessment of the waste heat integration into a district heating system: Case of the city of Riga

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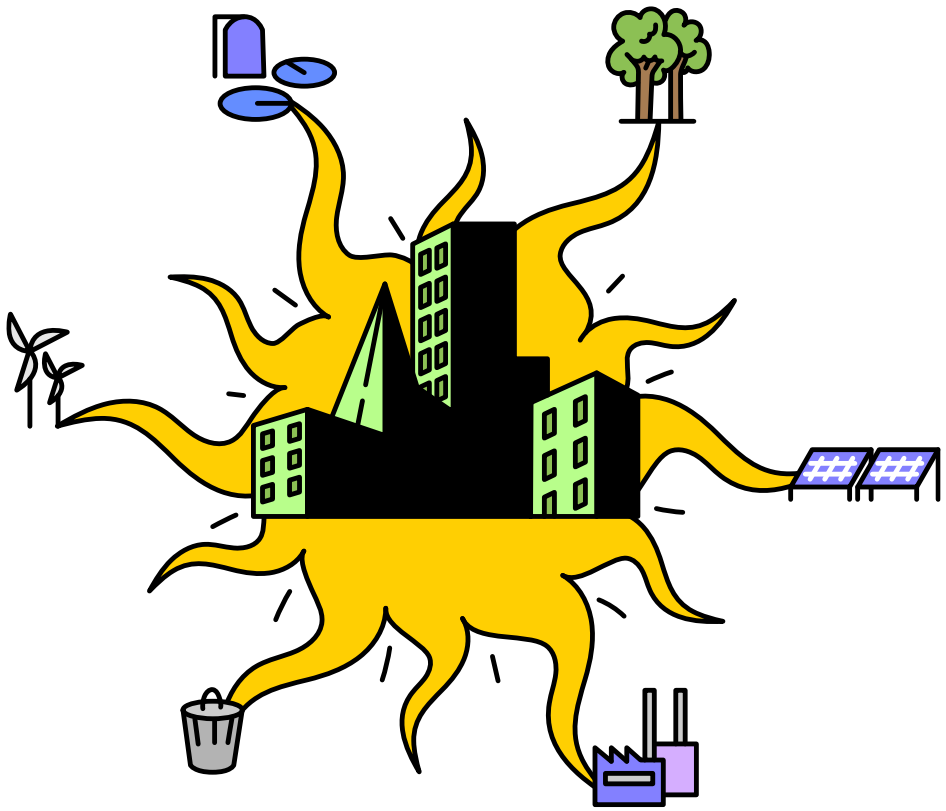
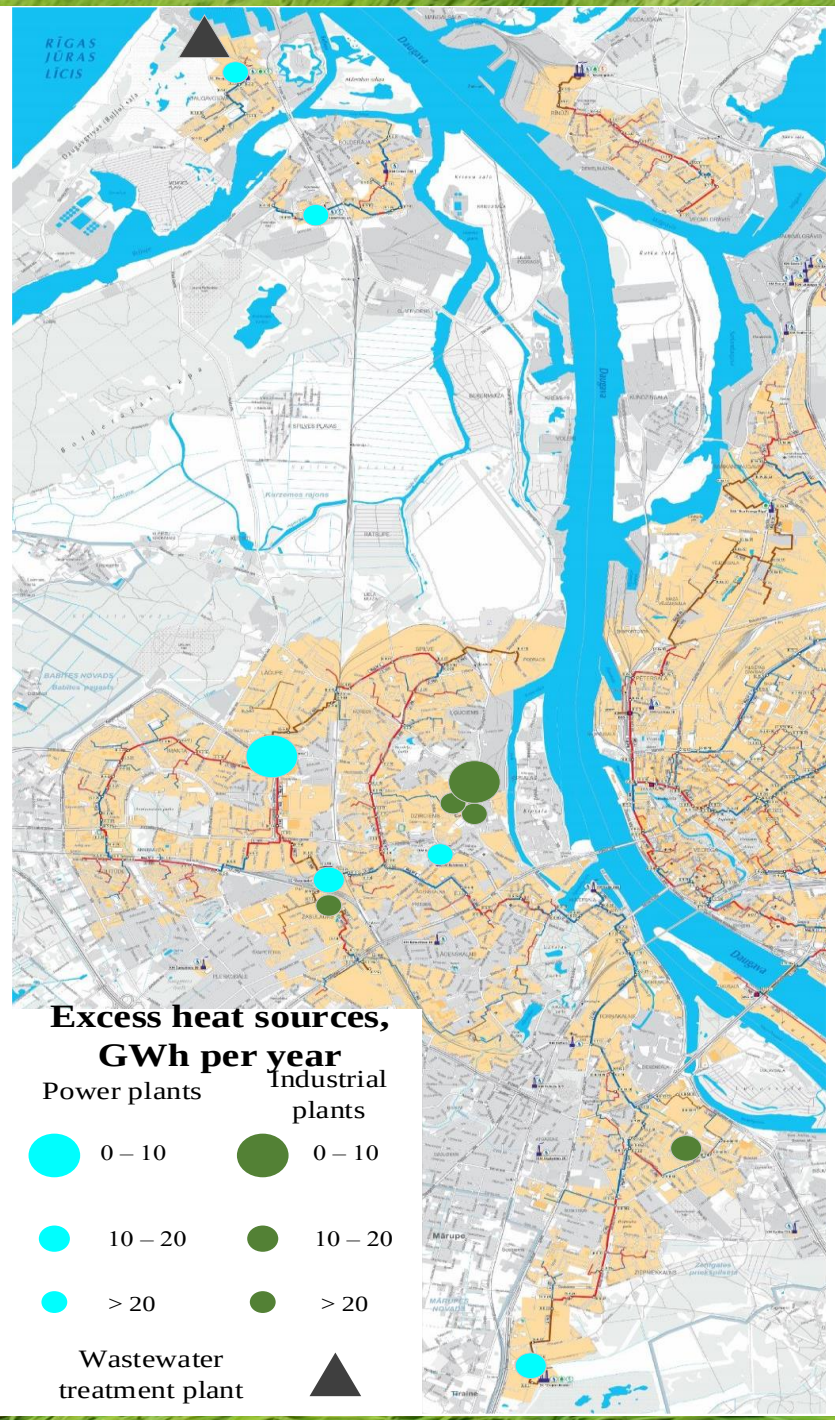
Aim of the research

To build a decision support tool that facilitates assessing, whether integration of excess heat into the DHS allows to achieve carbon-neutrality and transition towards the sustainable energy system.



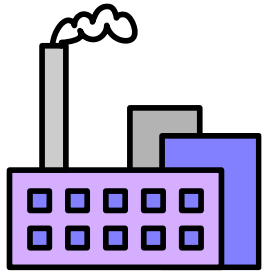
Case study

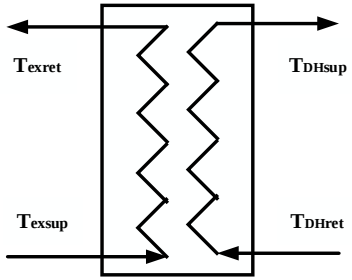

RĪGA
RĪGAS JŪRAS LĪCIS
JŪRMALA
ČARNIKAVAS PAGASTS
ĀDAŽU PAGASTS
GARKALNES PAGASTS
STOPIŅU PAGASTS
BABĪTES PAGASTS
MĀRUPES PAGASTS
BALOŽI
SALASPILS


Excess heat sources, GWh per year
Power plants
Industrial plants
0 – 10
0 – 10
10 – 20
10 – 20
> 20
> 20
Wastewater treatment plant

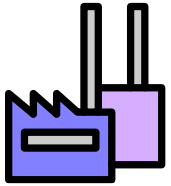
Estimation of excess heat source potential

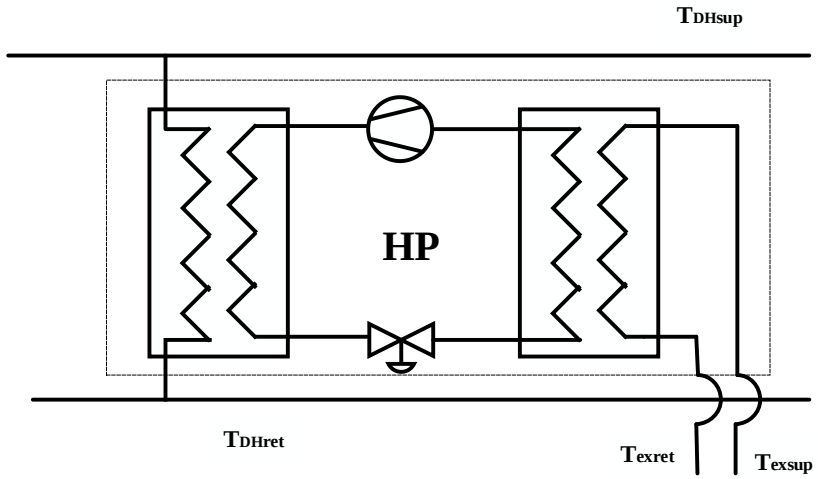
- **Industrial plants (50 ^{0}C,T<150 ^{0}C)**



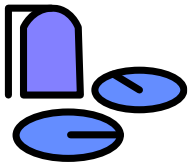


- **Power plants (T<200 ^{0}C)**





- **Wastewater treatment plants (10 ^{0}C<T<20 ^{0}C, Δ5 ^{0}C)**



Structure of the model and selected scenarios

Energy sources

Fossil fuel

Natural gas

Renewable energy sources 50%
Business as usual
Sc1

Waste heat 50%
Waste heat priority
Sc3

Technologies

Accumulation

Existing

NG boiler

Biomass boilers

CHP 75%
CHP priority
Sc2

New

Solar collectors

Large scale heat pumps

Wastewater heat pumps

Heat exchangers & heat pumps by excess heat

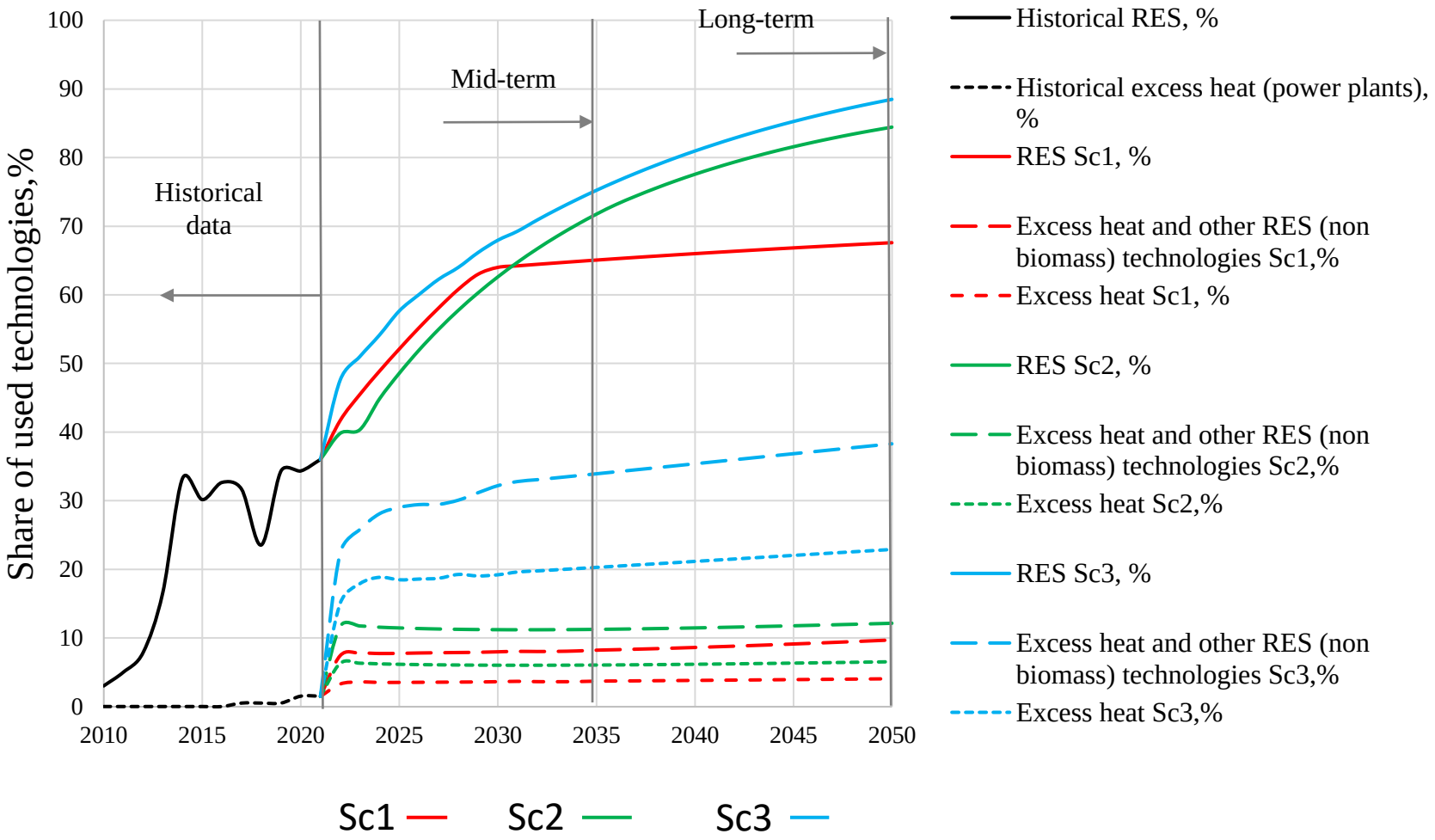
Efficiency improvements

1. Heat losses decrease from 11.5 to 8.5%
2. Heat demand decreases by 20%*

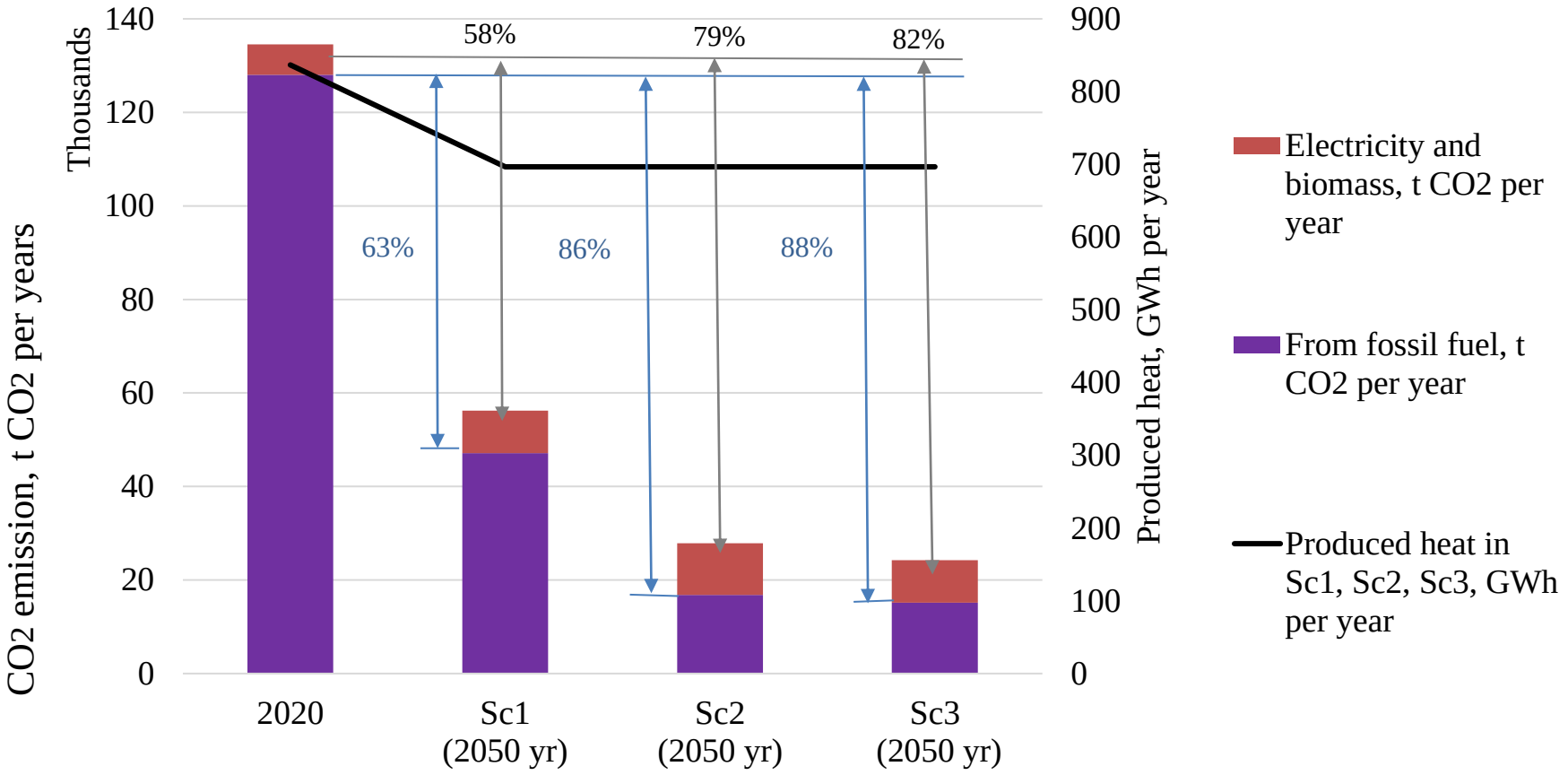
*EU Reference Scenario 2020. https://ec.europa.eu/energy/data-analysis/energy-modelling/eu-reference-scenario-2020_en

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency determines that an **efficient district heating and cooling system** is one that is using
(a) at least 50 % renewable energy,
(b) 50 % waste heat,
(c) 75 % cogenerated heat, or
(d) 50 % of a combination of such energy and heat.

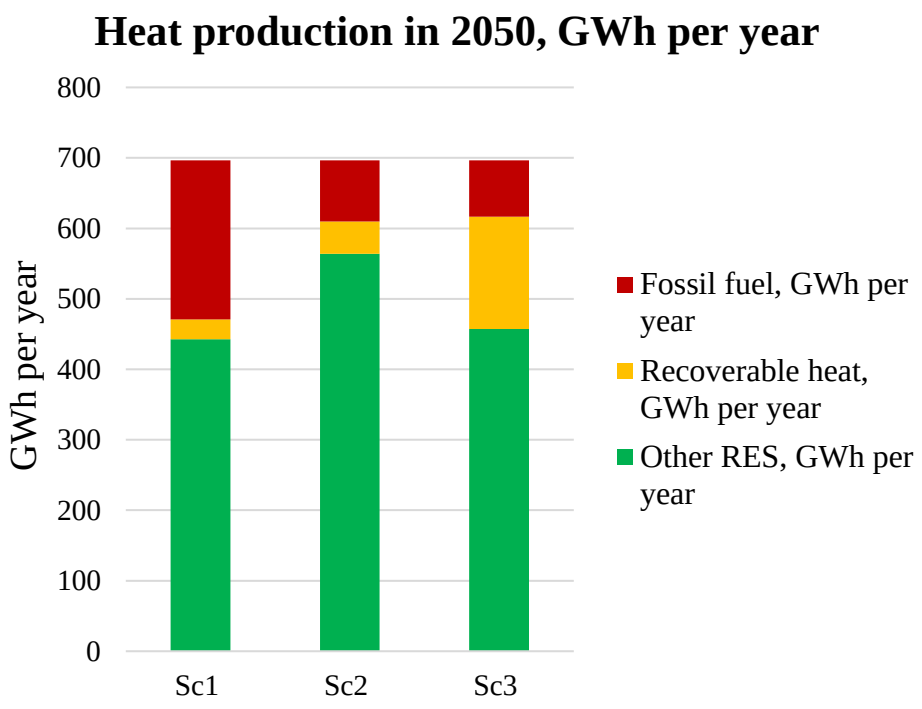
Share of used technologies in different development scenarios

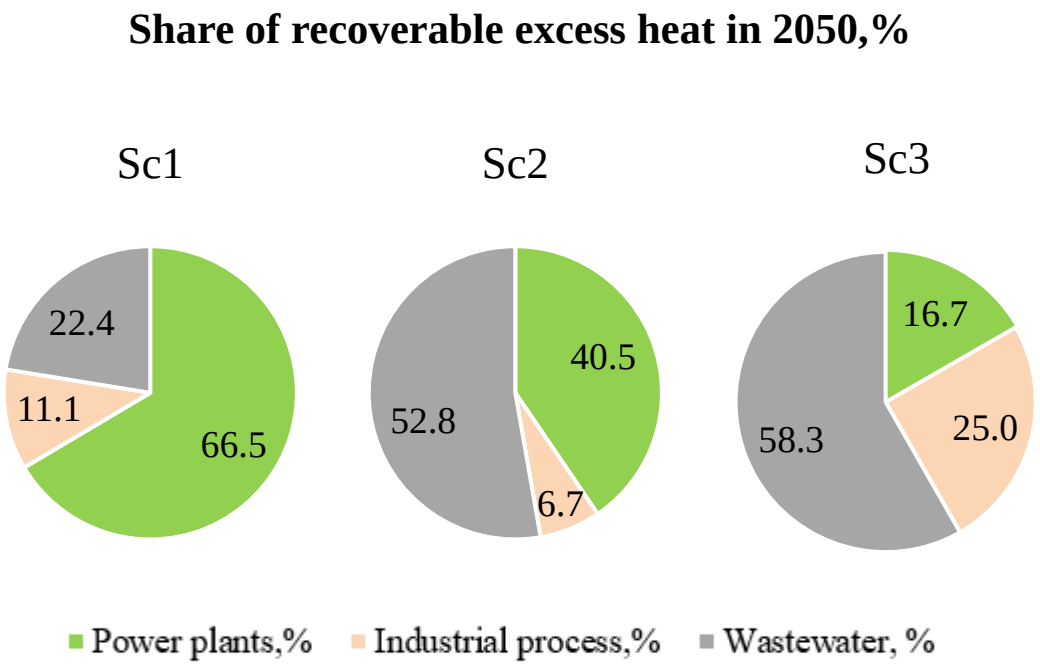


CO_2 emissions



Results of heat production in long-term

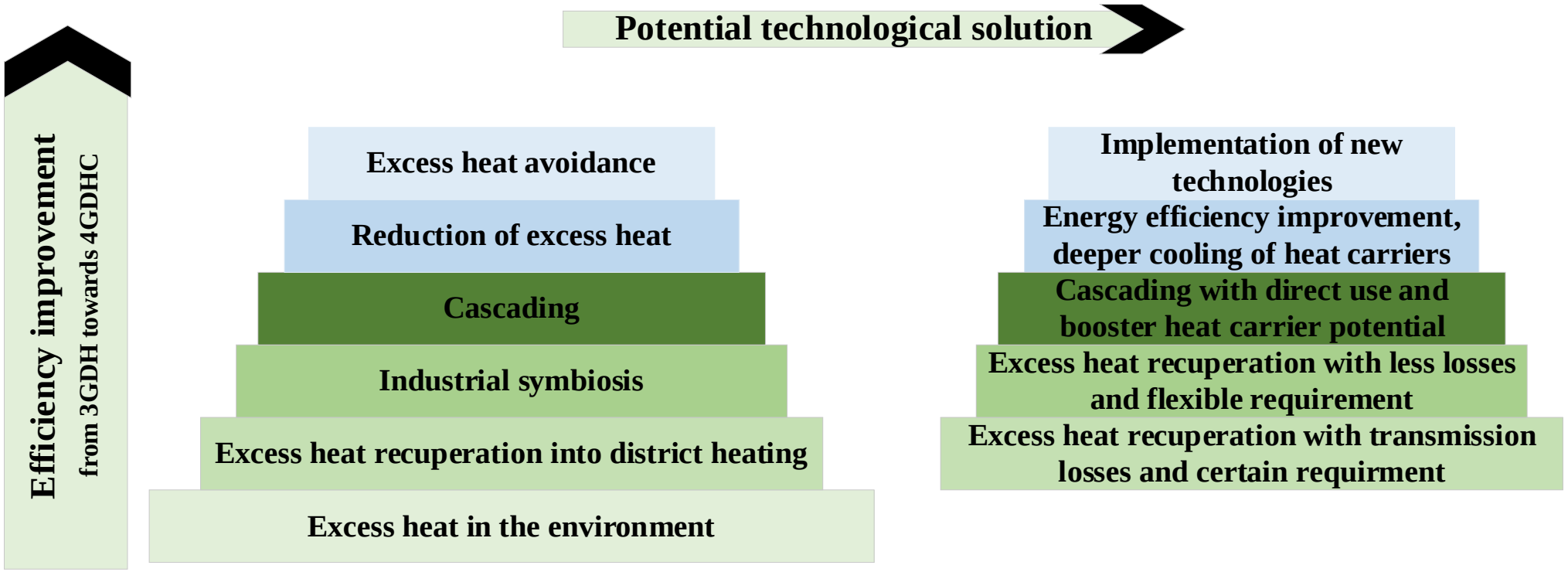




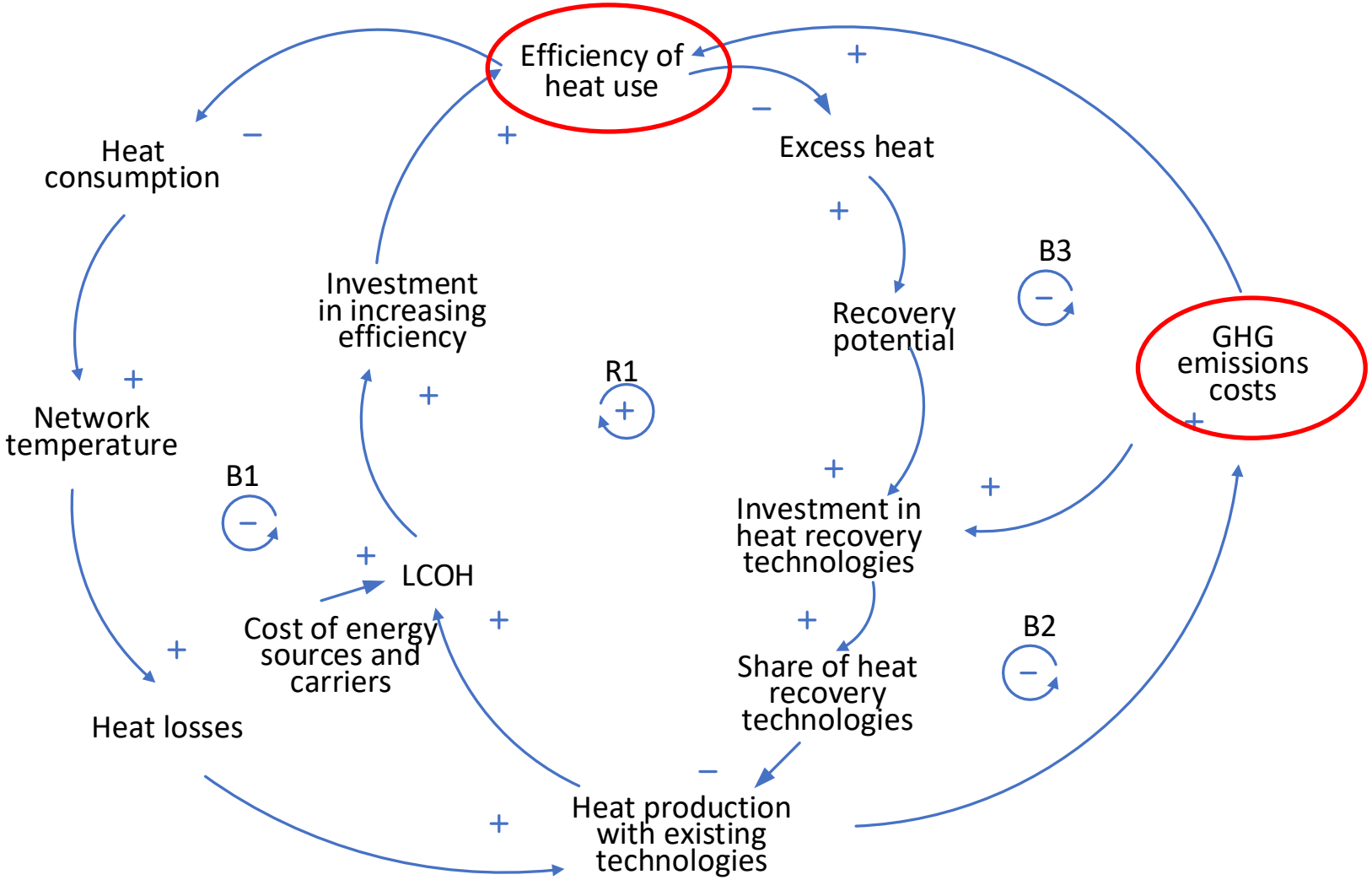
Selection of indicators

Key performace indicators		2020	2050		
			Sc1	Sc2	Sc3
Energy	Primary energy factor	0.90	0.58	0.38	0.33
	Ratio of fuel consumption (consumed heat/produced heat), MWh/MWh	1.09	0.94	0.89	0.63
	Recovered energy share, %	-	7	9	31
Environment	CO_2 savings,%	-	58	79	82
Economy	Avoided emissions costs, EUR/t CO2	-	120	430	343

Concept of the excess heat recovery hierarchy



RESULTS
Causal loop diagram



Conclusions

1. Excess heat integration into DHS has a potential for minimizing the primary energy consumption. In Riga, the primary energy factor can be reduced by 56%.

2. Excess heat integration into the DHS is a straight path towards carbon-neutrality of cities. In the current study, the integration of excess heat allows to decrease CO_2 emissions by 82%. The most sustainable scenario is Sc 3, which includes excess heat integration into DHS and allows to achieve the recovered energy share up to 31%.

3. Developement of additional technologies that increase the flexibility of the DHS is necessary to achieve full carbon neutrality of Riga – e.g. Power-to-Heat technologies based on zero-carbon electricity.

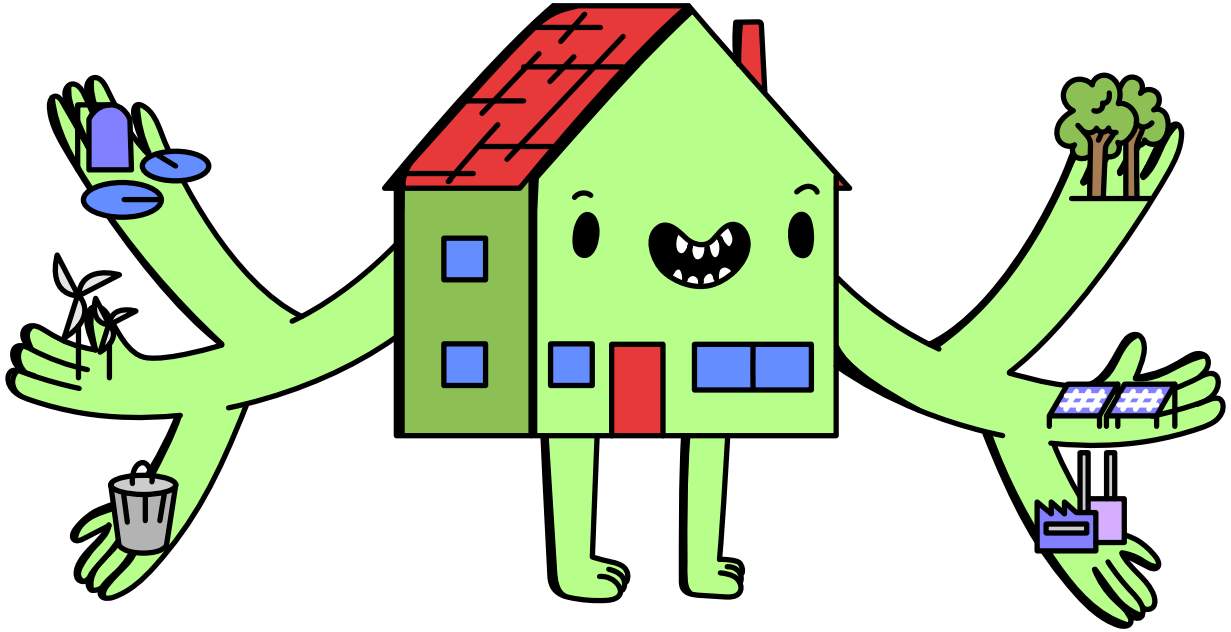
4. The developed decision support tool can be applied to other heating systems if corresponding initial data of waste heat, RES potentials and Power-to-X technologies are added.

Conclusions

5. An innovative «Concept of excess heat recovery hierarchy» is presented and described by key performance indicators. Analysis of indicators allows to assess primary resource conversion process and technologies applying the circular bioeconomy and carbon neutrality principles. E.g. the ratio of fuel consumption decreases from 1.1 (in 2020) to 0.6 – that is important from circular economy point of view.

Acknowledgements

This research has been supported by the European Regional Development Fund within the project No. 1.1.1.2/VIAA/4/20/604 “Decision Support Tool for Decarbonisation Assessment of District Heating Systems (START)”.



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