Decarbonizing Swiss Industrial Sectors by Process Integration, Electrification, and Traditional Energy Efficiency Measures

Presented by
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SCCER EFFICIENCY OF INDUSTRIAL PROCESSES

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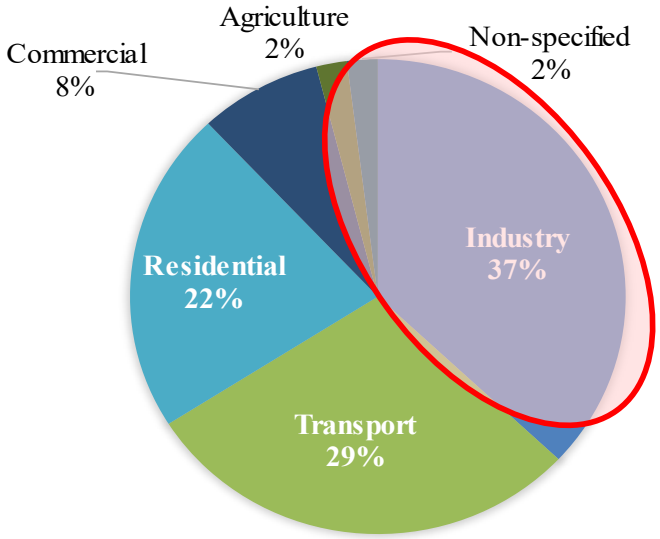
Outline

- Introduction
- Process heat integration
- Process electrification
- Sector- and system-specific EE cost curves
- Conclusions

Introduction

- Global industry: **>1/3rd** of global final energy demand
- Key strategies → renewables & energy efficiency (EE)
- Rate of EE increase still **very low** *(IEA 2016)*
- Heterogeneity and complexity of processes → **EE indicators, a challenge** *(IEA 2016)*
- Limited research on EE opportunities in **high value-added** ind. sector *(Järvinen 2017)*

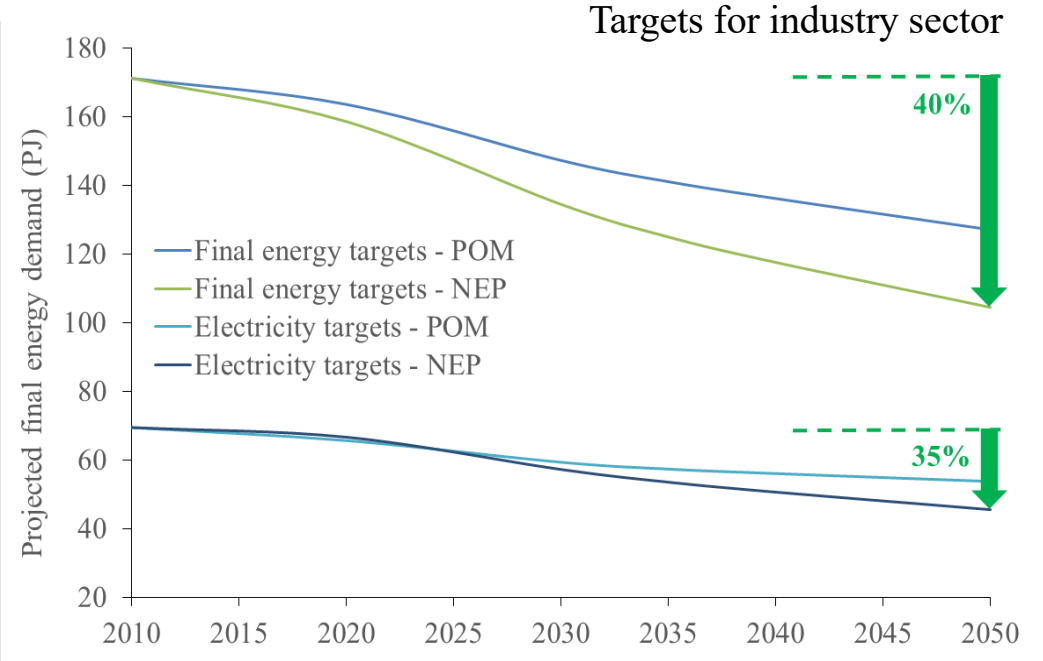


Global final energy demand in 2015
(IEA 2017)

Introduction – Case of the Swiss industry

- Paris Agreement → essential to:
  1) assess current state of ind. sectors **by country** *(EU 2016)*
  2) identify **high-impact areas and EE measures** *(IEA 2016)*

- Transition from traditional to **high-value manufac.** *(SWI, 2017)*
- Energy strategy 2050



Prognos (2012)

- CO_2 levy & elec. grid surcharge (KEV) → **real experience data**

Central research question and goals

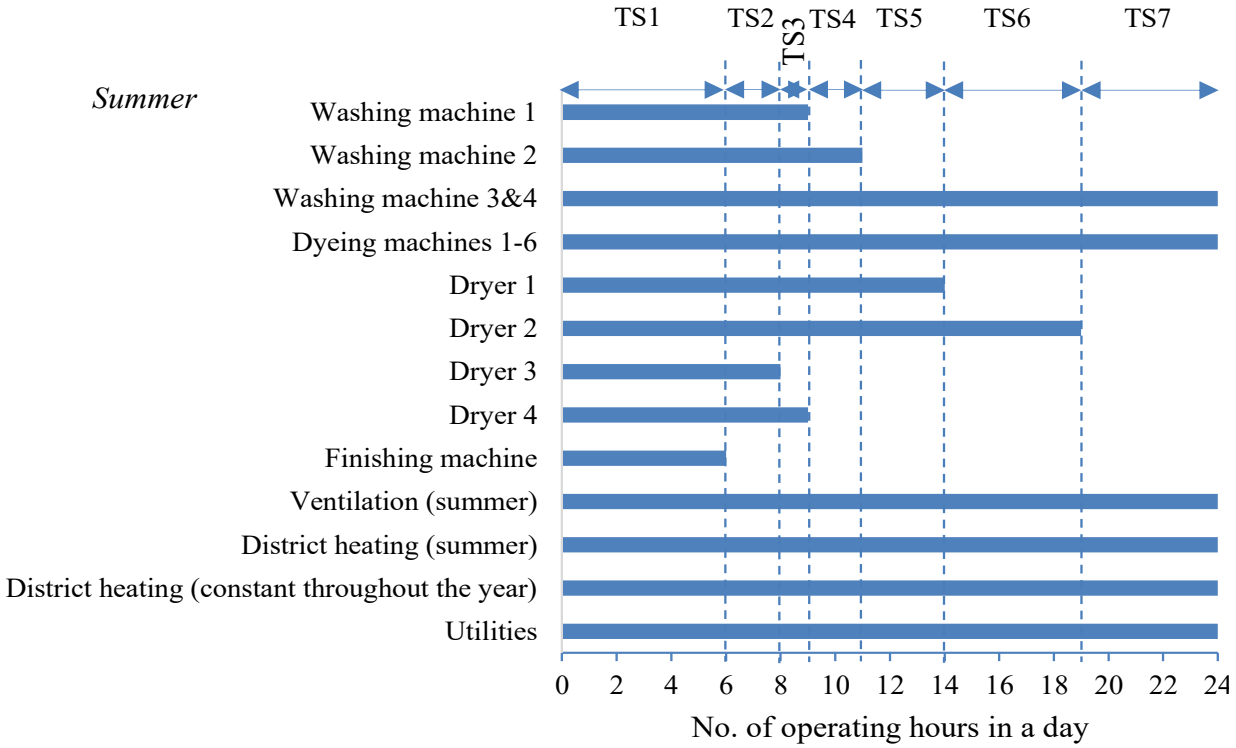
What are the economically viable energy efficiency improvement opportunities in a high value-added industry sector?

- Develop a **bottom-up model** for techno-economic assessment of energy saving potentials in Swiss industry (sectors and industrial systems) based on **real experience**
- Evaluate the **economic viability** of existing and **emerging innovative EE measures**
- Identify which **parameters influence** the economic viability of the EE measures and to which extent

Heat integration in multi-product batch process

- Pinch analysis → A micro-level case study on heat integration in a textile plant

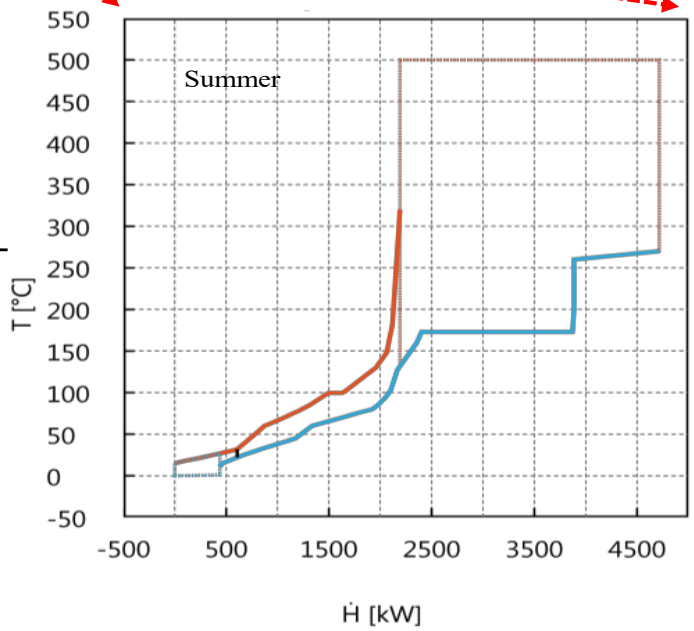
- Manufactures several high value-added fabrics in batch-mode



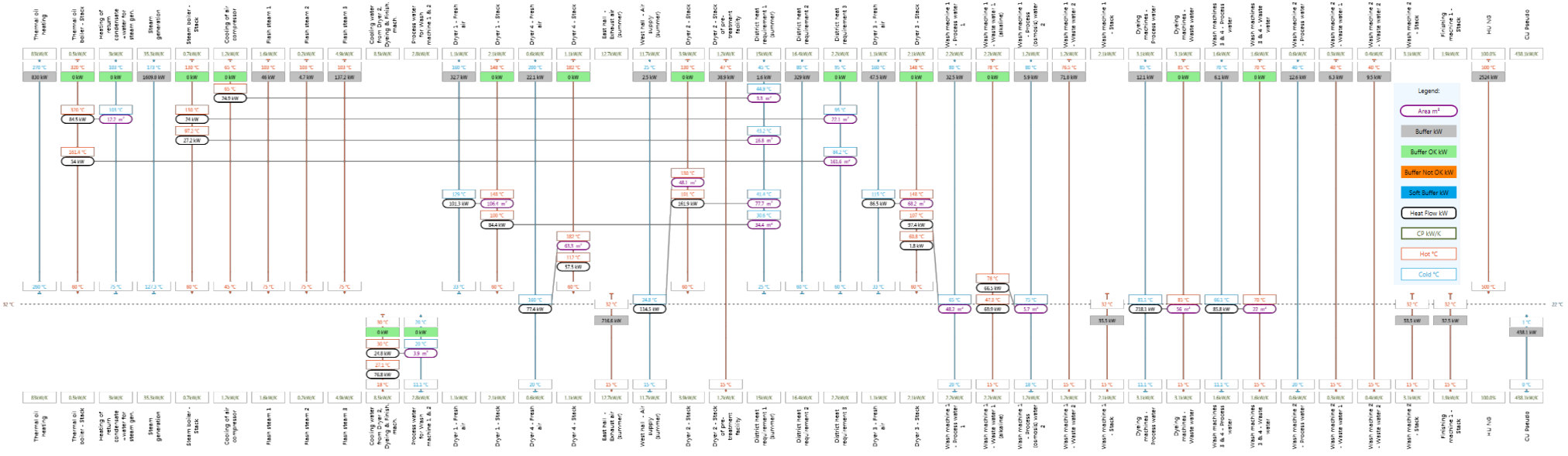
- **Approach:** First optimize for **Direct heat recovery (DHR)** and then for **indirect heat recovery (IHR)** using **thermal energy storage (TES)** → Software tool: PinCH 3.0

Results of the pinch analysis for summer

Time slices	Pinch temp.	Max. heat recovery	Heat transfer area	No. of units	Hot utility	Cold utility
hours	°C	kW	m^2		kW	kW
0-6	27	1754	1399	52	2524	438
6-8	27	1754	1367	51	2524	406
8-9	27	1568	1161	49	2576	406
9-11	27	1272	1000	37	2570	324
11-14	27	1265	965	30	2564	261
14-19	27	1079	822	28	2616	261
19-24	27	785	618	25	2911	240



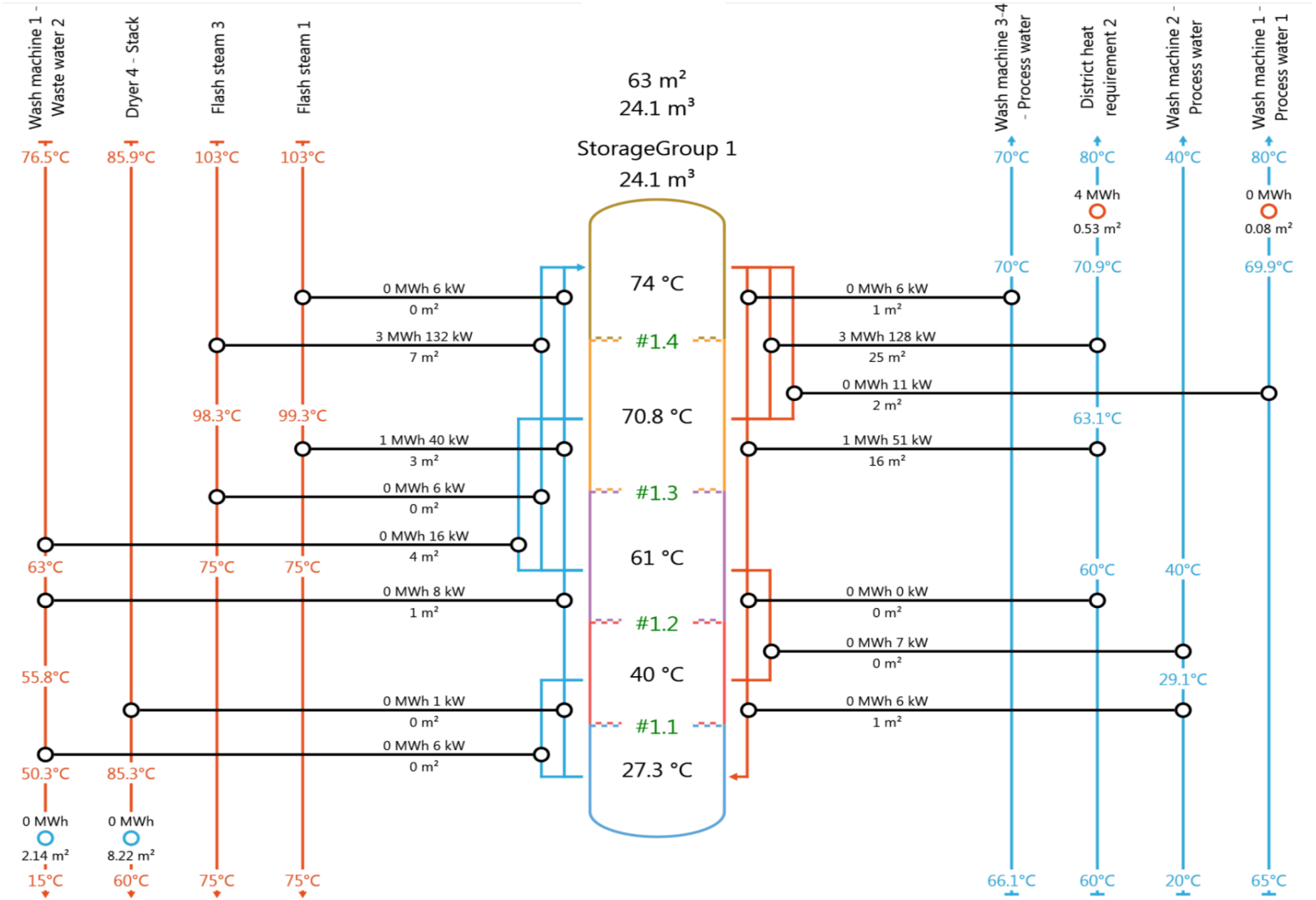
Heat exchanger network design for DHR



Time slices hours	Design HR kW	HT area m^2	No. of units	% of max. potential
0-6	1333	750	16	76%
6-8	1333	750	16	76%
8-9	1149	634	14	73%
9-11	1005	565	12	79%
11-14	1005	565	12	79%
14-19	820	424	10	76%
19-24	543	298	8	69%

DHR = 85 GJ/day
= 25% of the daily thermal energy demand of the overall process

Heat exchanger and storage network design for IHR



IHR = 17 GJ/day
= 5% of the daily thermal energy demand of the overall process

DHR + IHR
= 102 GJ/day
= ~30% of the daily thermal energy demand of the overall process

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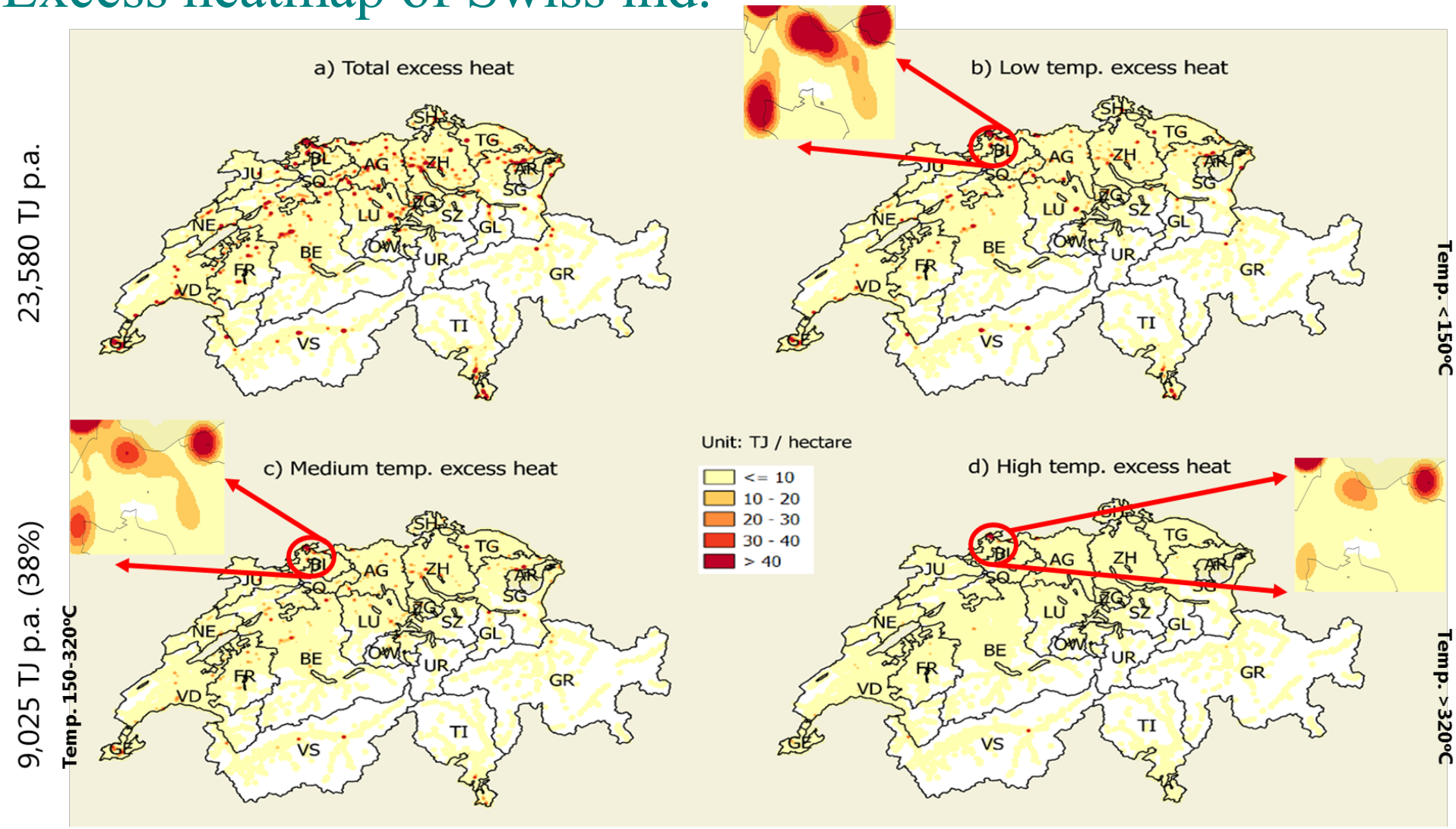
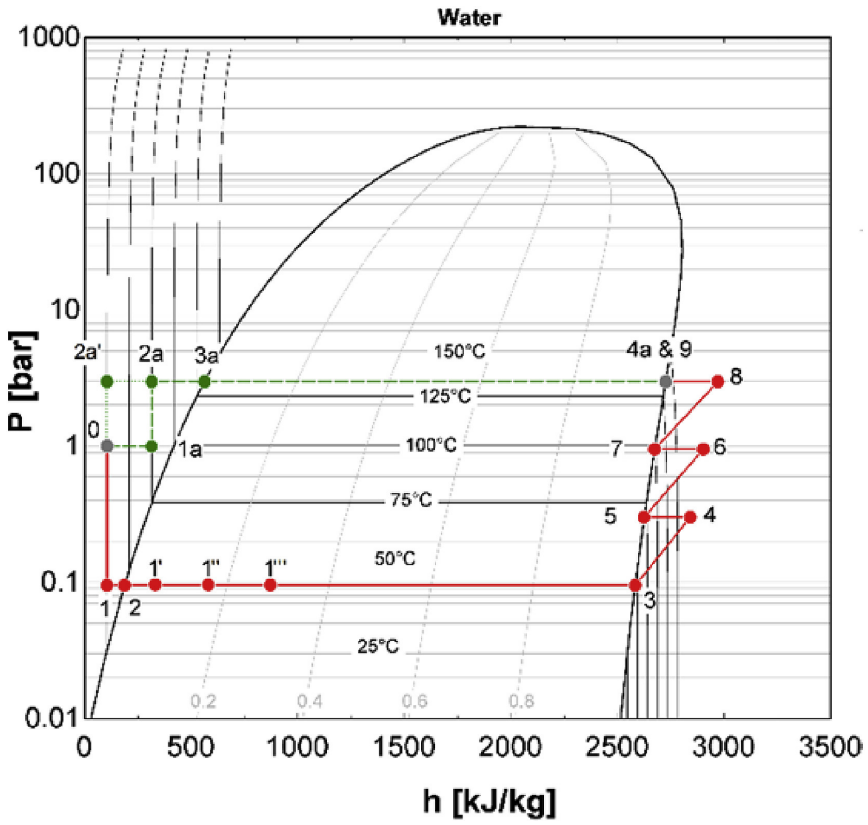
Excess heatmap of Swiss ind.

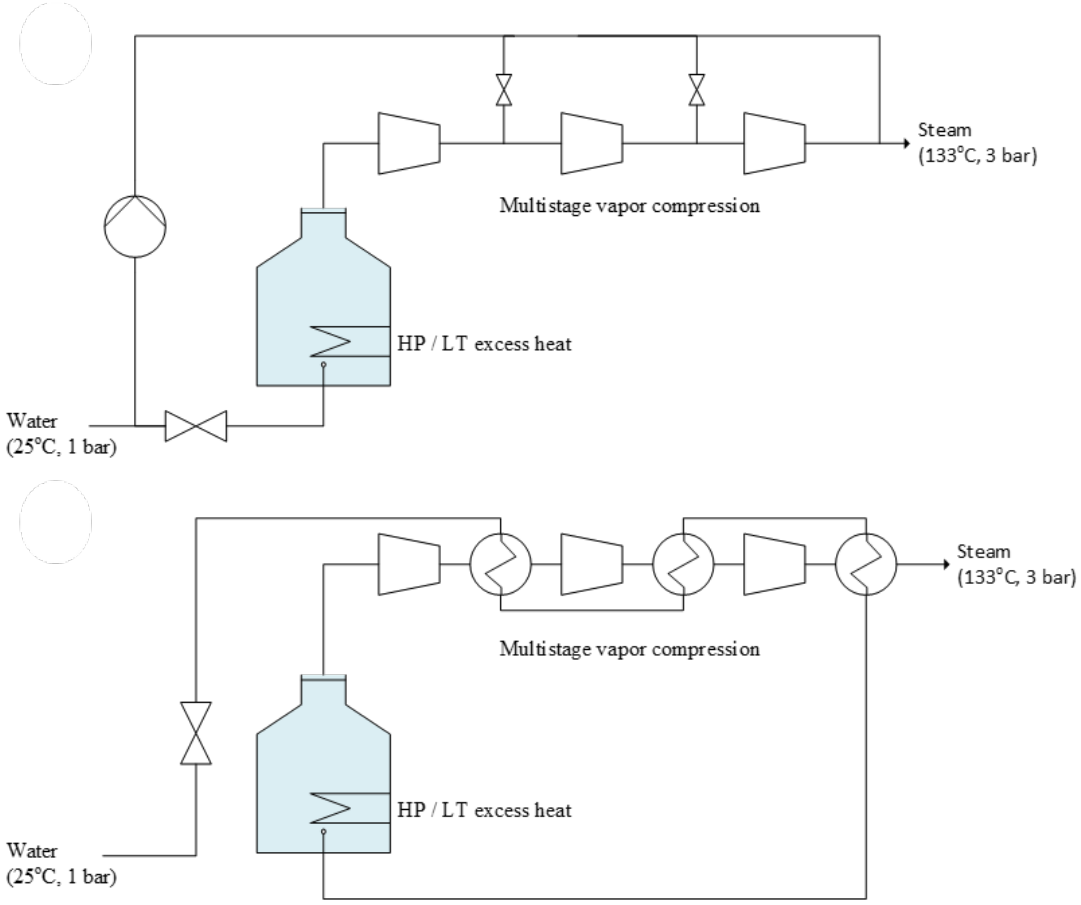


Process electrification - Low pressure evap. & vapor comp.

Pressure enthalpy diagram (Bless et al. 2017)

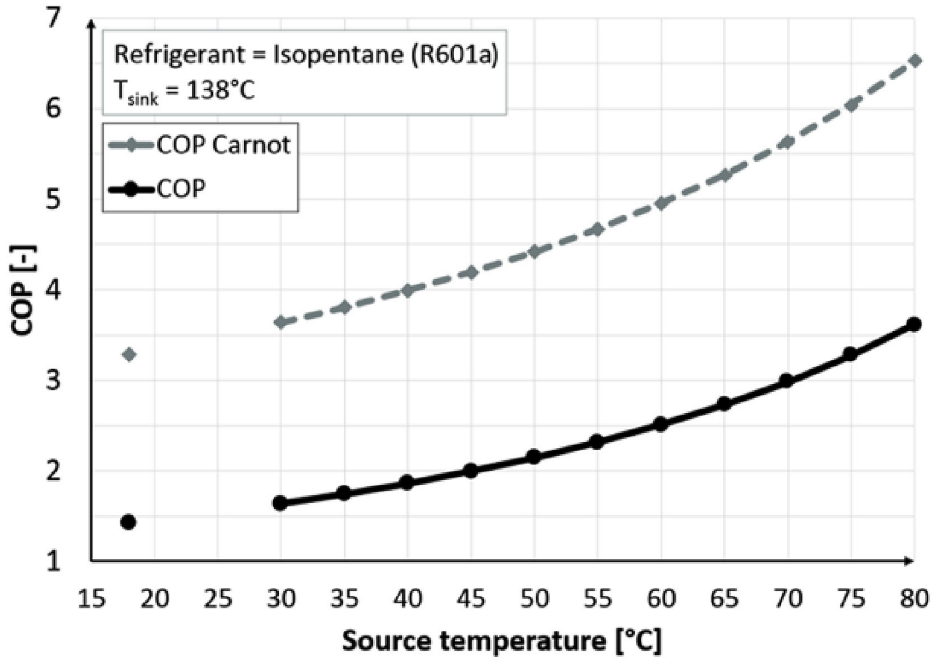


Schematics of steam generation by LPE&VC

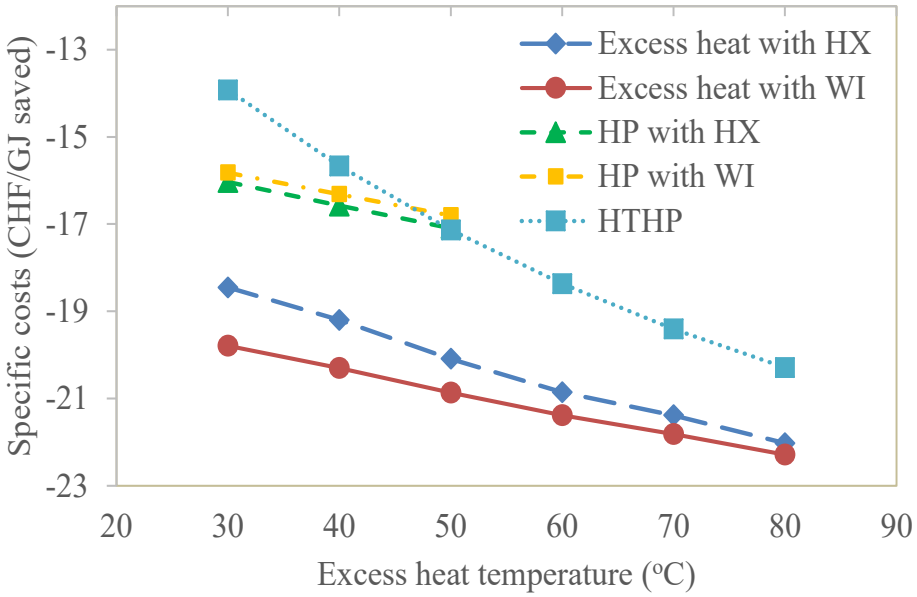


Process electrification - HTHP and economics

High temp. heat pump – HTHP (Bless et al. 2017)

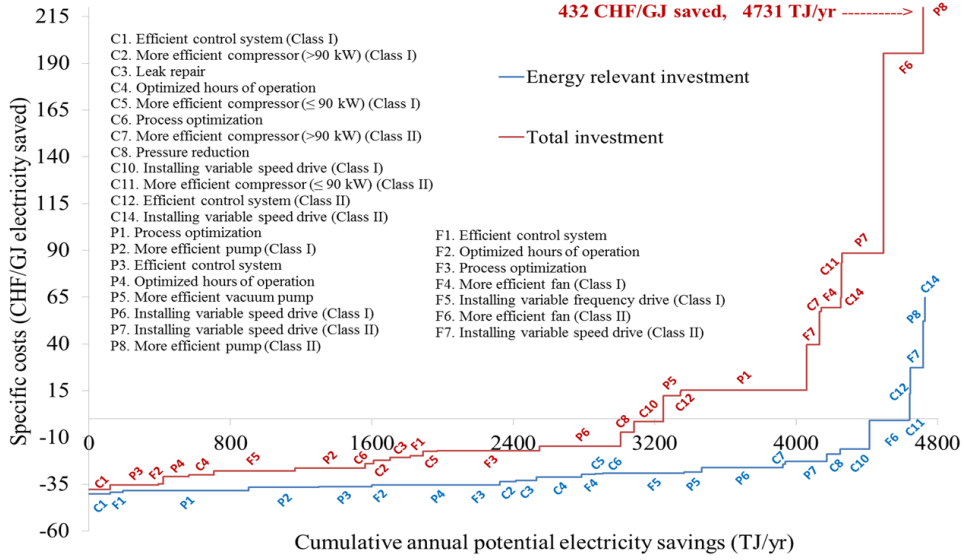


Specific costs for steam generation technologies

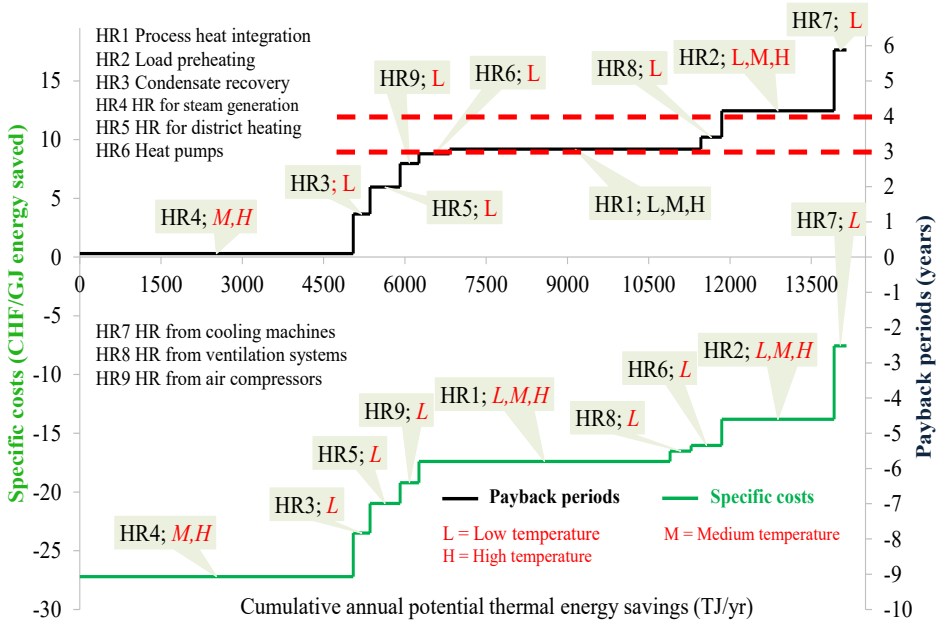


Sector- & system-specific EE cost curves

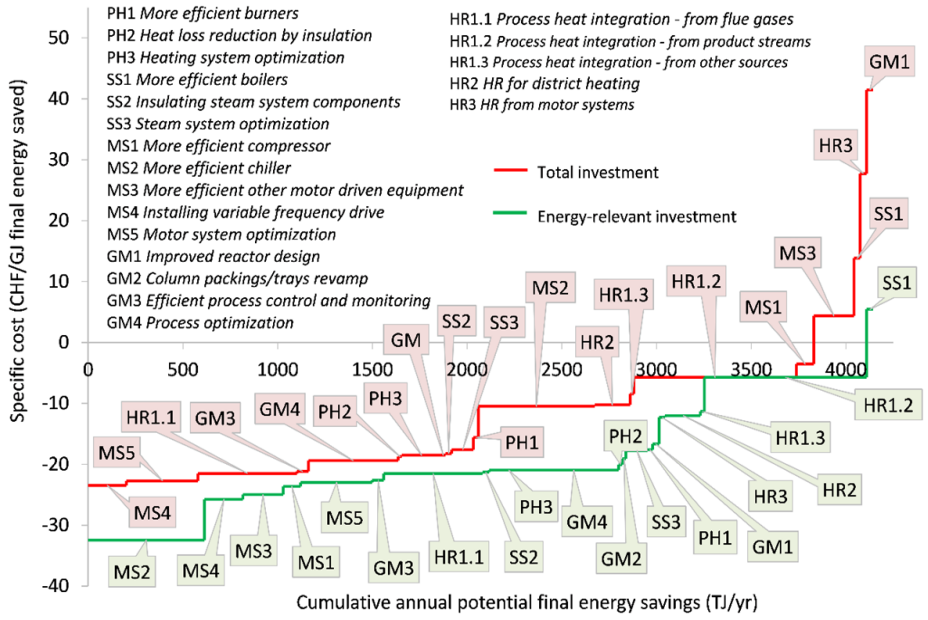
Motor systems → EIS = 17%



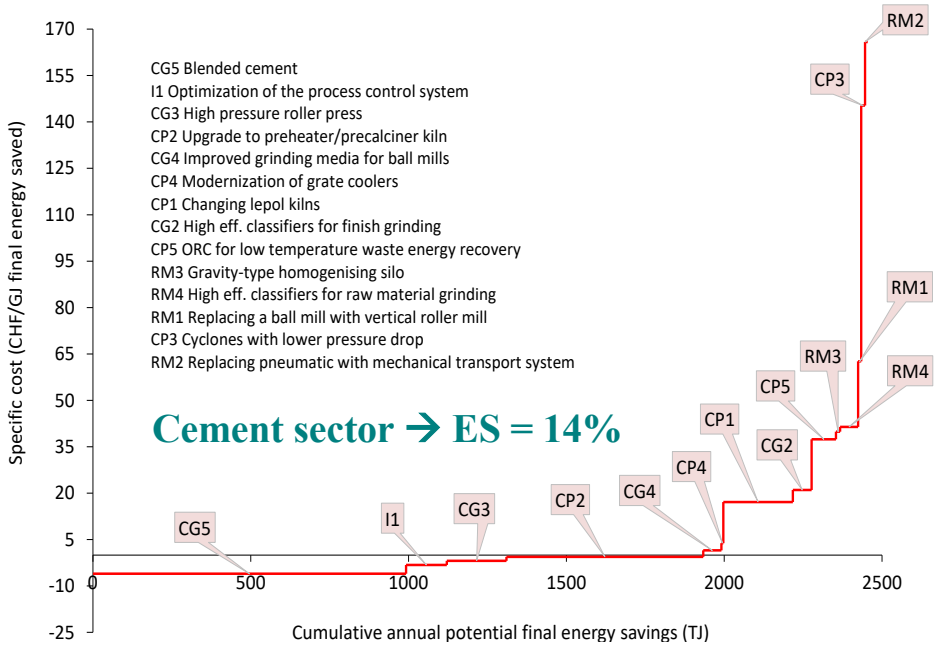
Process heat systems → HS = 24%



Chemical sector → ES = 15%

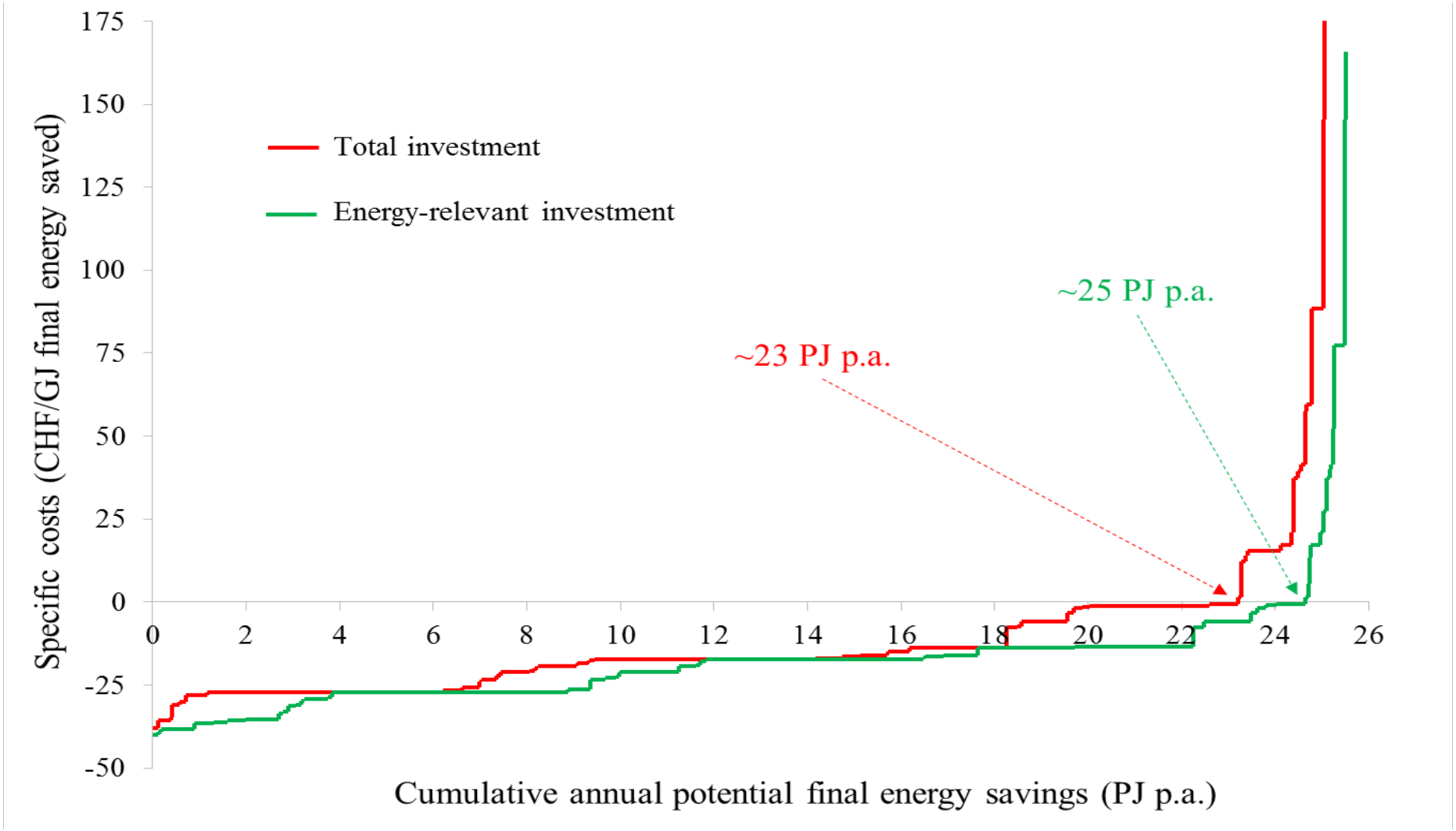


Cement sector → ES = 14%



EE cost curve for the overall Swiss industry

No. of measures = 64



Contribution to ES 2050 targets

	Overall potential identified	Overall economic potential	Contribution of the economic potential to indicative targets	
			2035	2050
Final energy savings				
Total inv.	22%	**19%**	**57%**	39%
Energy rel. inv.		21%	82%	56%
Electricity savings				
Total inv.	17%	**13%**	**53%**	41%
Energy rel. inv.		15%	65%	50%

For more details

Doctoral thesis

- M.J.S.Zuberi. Improving energy efficiency in Swiss industrial sectors: status, emerging technologies and trends. Thèse de doctorat: Université de Genève (2019) - Sc. 5369.

Publications

- M.J.S.Zuberi, D.Olsen, P.Liam, B.Wellig, M.K.Patel. *"Heat integration of a multi-product batch process by means of direct and indirect heat recovery using thermal energy storage"*. Applied Thermal Engineering (2020) 167, 114796.
- M.J.S.Zuberi, M.Santoro, A.Eberle, N.Bhadbhade, S.Sulzer, B.Wellig, M.K.Patel. *"A detailed review on current status of energy efficiency improvement in the Swiss industry sector"*. Energy Policy (2019) 137, 111162.
- M.J.S.Zuberi, M.K.Patel. *"Cost-effectiveness analysis of energy efficiency measures in the Swiss chemical and pharmaceutical industry"*. International Journal of Energy Research (2019) 43, 313-336.
- M.J.S.Zuberi, F.Bless, J.Chambers, C.Arpagaus, S.Bertsch, M.K.Patel. *"Excess heat recovery: An invisible energy resource for the Swiss industry sector"*. Applied Energy (2018) 228, 390-408.
- M.J.S.Zuberi, A.Tijdink, M.K.Patel. *"Techno-economic analysis of energy efficiency improvement in electric motor driven systems in Swiss industry"*. Applied Energy (2017) 205, 85-104.
- M.J.S.Zuberi, M.K.Patel. *"Bottom-up analysis of energy efficiency improvement and CO_2 emission reduction potentials in the Swiss cement industry"*. Journal of Cleaner Production (2017) 142, 4294-4309.
- M.J.S.Zuberi, M.K.Patel. *"The importance of additionality in evaluating the economic viability of motor-related energy efficiency measures"*. Energy Efficiency in Motor Driven Systems (EEMODS'17), Rome, Italy (2017).

THANK YOU!!!

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