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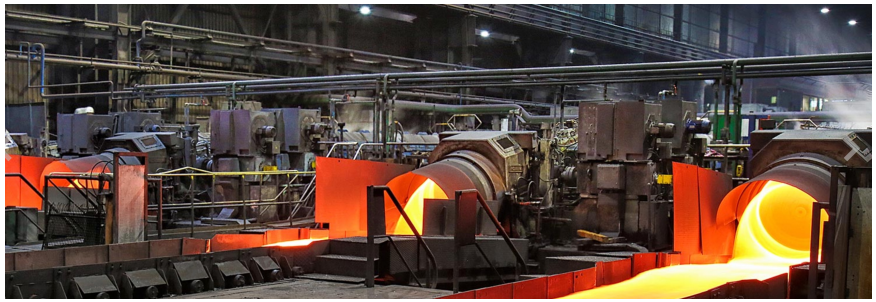

Ansätze zur Dekarbonisierung der stahlverarbeitenden Industrie

Eine numerische Studie

Investitionsbank des Landes Brandenburg ILB

EUROPÄISCHE UNION
Europäischer Fonds für Regionale Entwicklung
www.efre.brandenburg.de

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14. Februar 2022

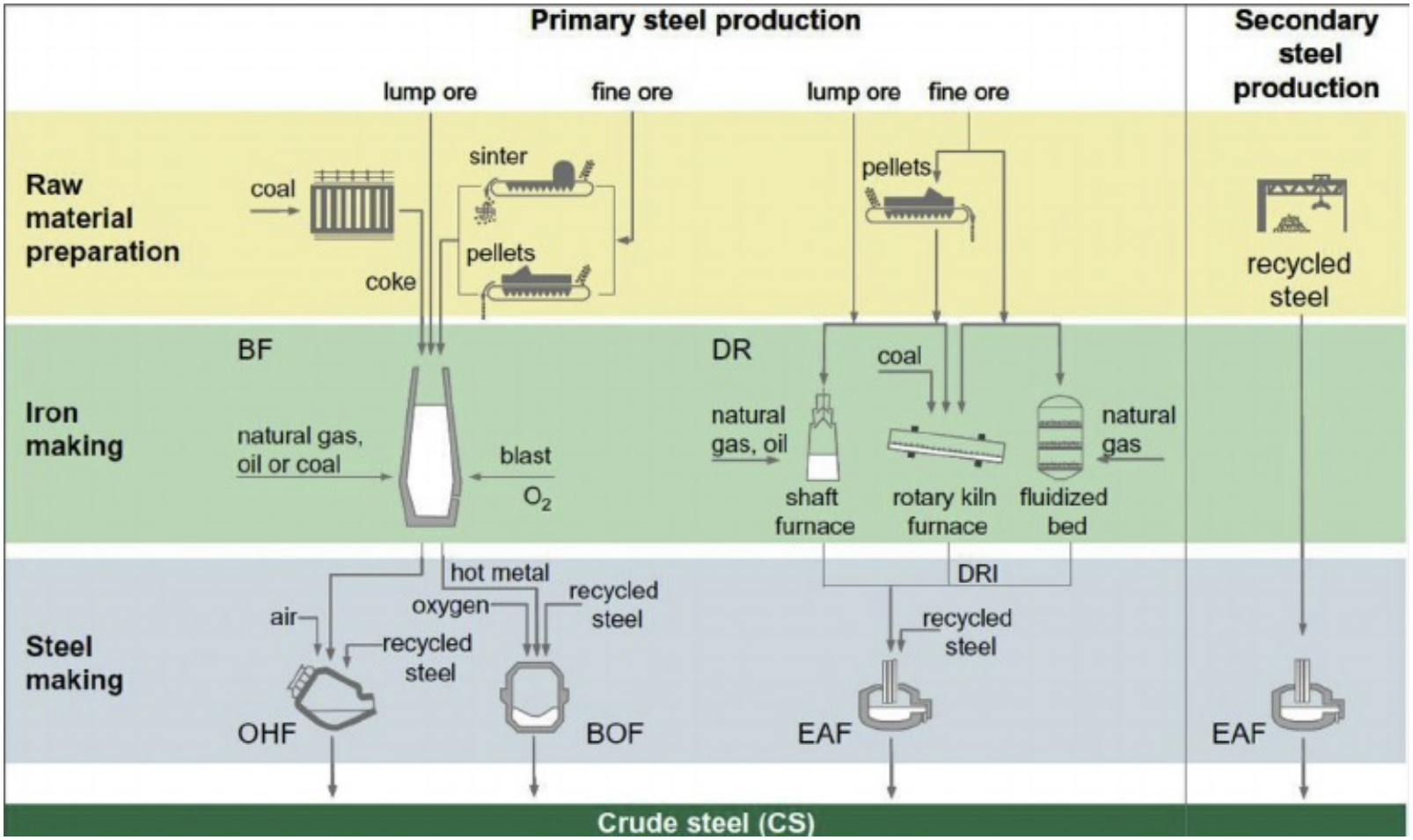
Cleaning up the steel industry

- **the industrial material with the biggest climate impact***
- steelmaking releases more than **3 billion metric tons of carbon dioxide each year**
- steel industry will need to **shrink** its carbon footprint **significantly**

- alternative technology & energymix to steel making:
  - **Primary steel route**
    - Technology: CCS, hydrogen-based, electrochemical
    - Strategiess: greenfy, energy integration
  - **Secondary steel route**
    - Technology: electrone melting of scrape steel
    - Strategies: greenfy, integration

- *24 % of all industrial CO_2 emissions attributed to steelmaking

Cleaning up the steel industry



Worldsteel's contribution to a low carbon future, Worldsteel position paper June, 2014

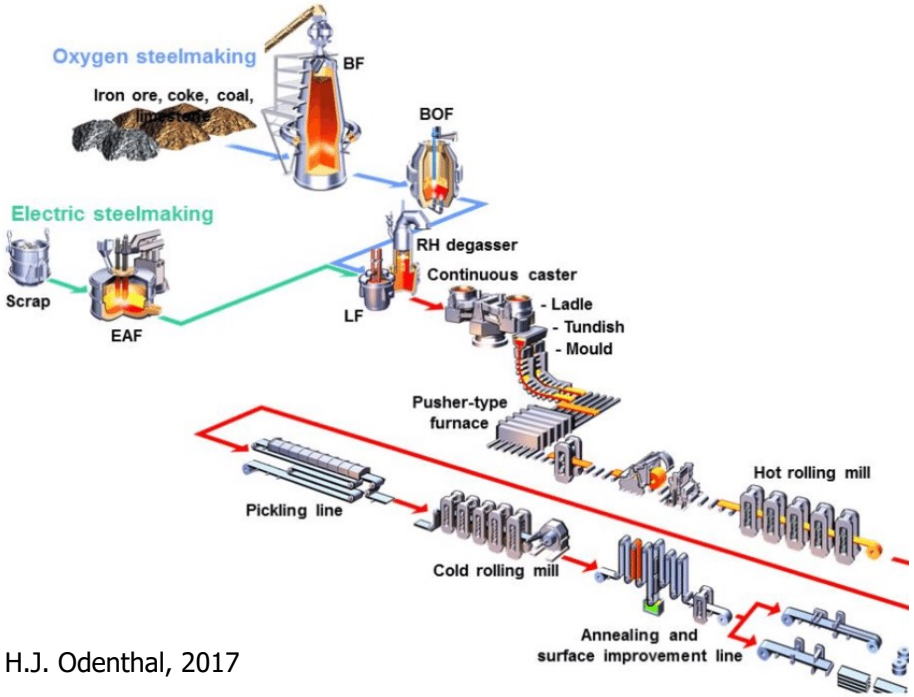
Cleaning up the steel industry

Prognos, Öko-Institut, Wuppertal Institut (2021a)

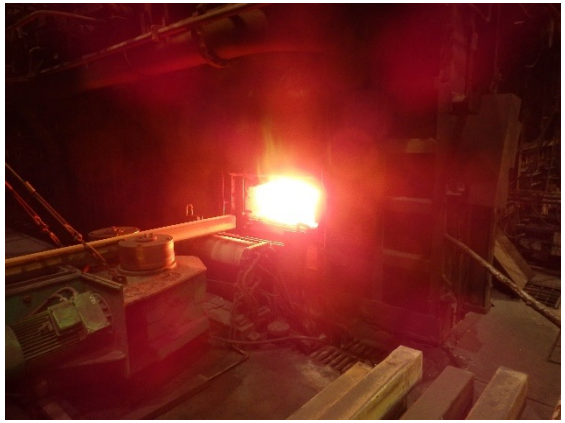
*In der Abbildung ist der Energiebedarf nicht als Endenergiebedarf im Sinne der Energiebilanz angegeben, sondern als Energieeinsatz ab Werktor (unter Ausschluss der Kokereien). Eine Gutschrift für die Erzeugung von Strom aus Kuppelgasen erfolgt hier nicht.

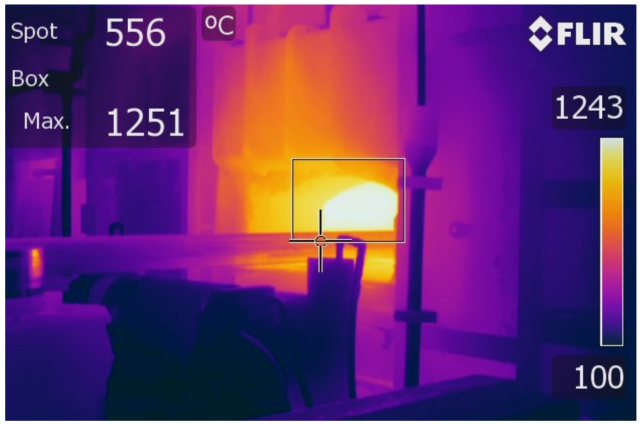
Secondary Steel Route

prometall



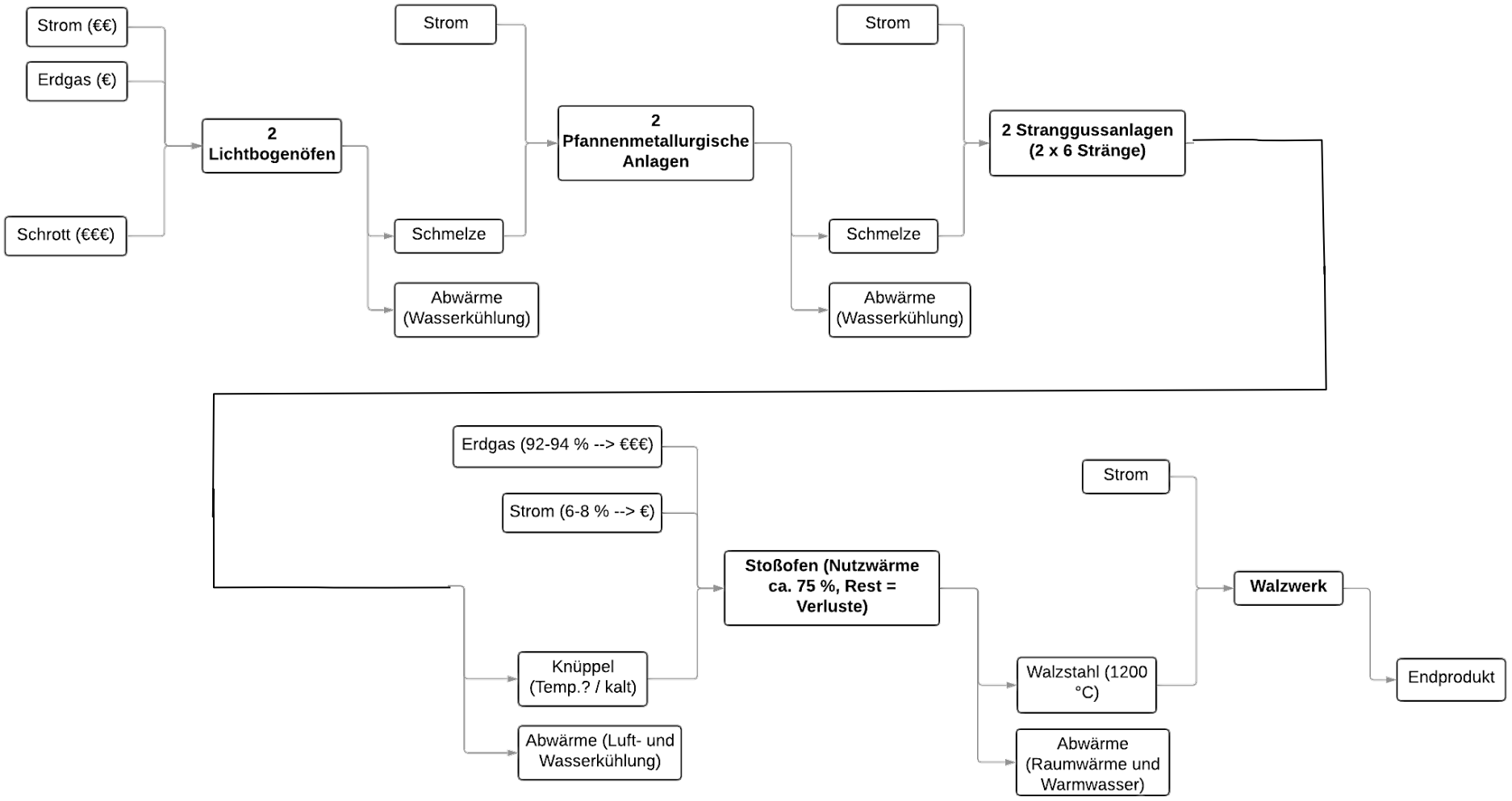
H.J. Odenthal, 2017



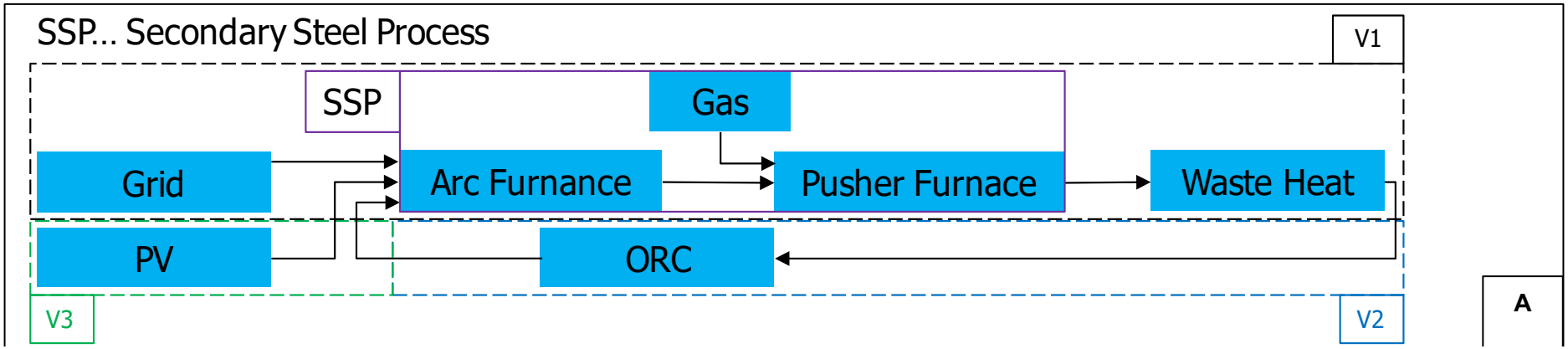


THB, Frank Pinna

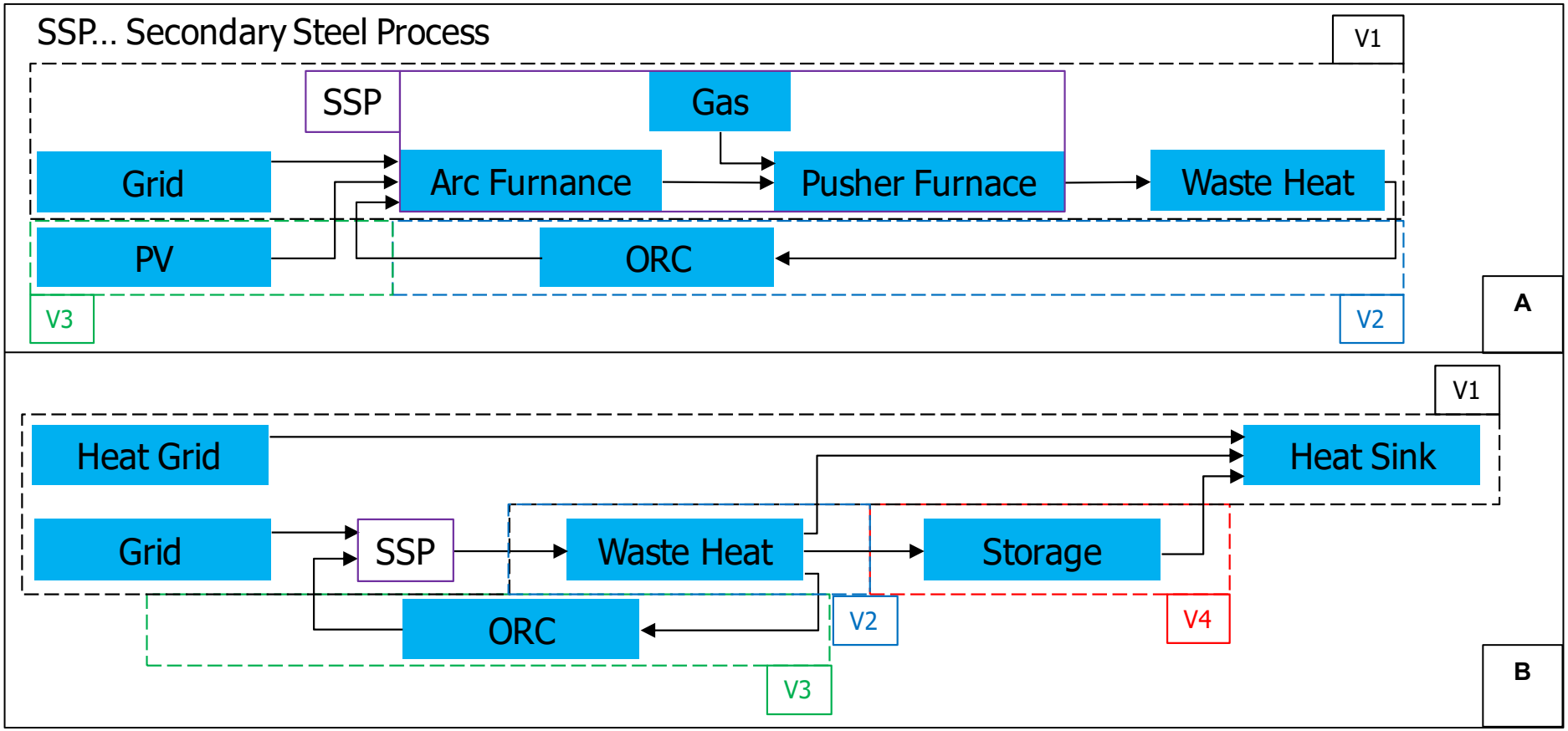
Secondary Steel Process: Flowsheet



Secondary Steel Process: Configuration of Energyflow & -echnologies



Secondary Steel Process: Configuration of Energyflow & -echnologies

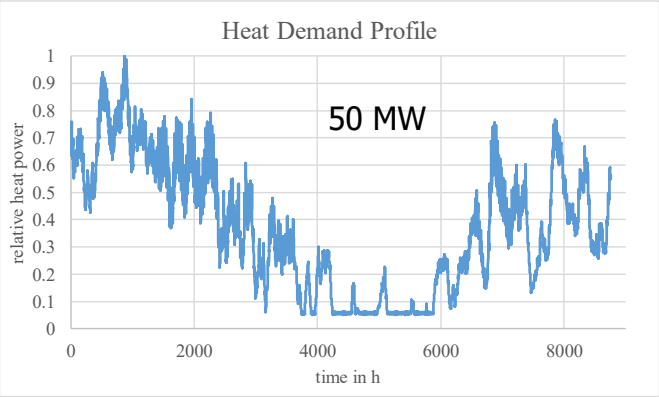


Optimal Configuration of Energyflow & -technologies

Goal:
Identify a configuration of energy technologies and power flows such that annual power supply is cost-optimal

$$\min_{\mathbf{x}\in\mathbb{R}^n} \mathrm{TAC}(\mathbf{x})$$

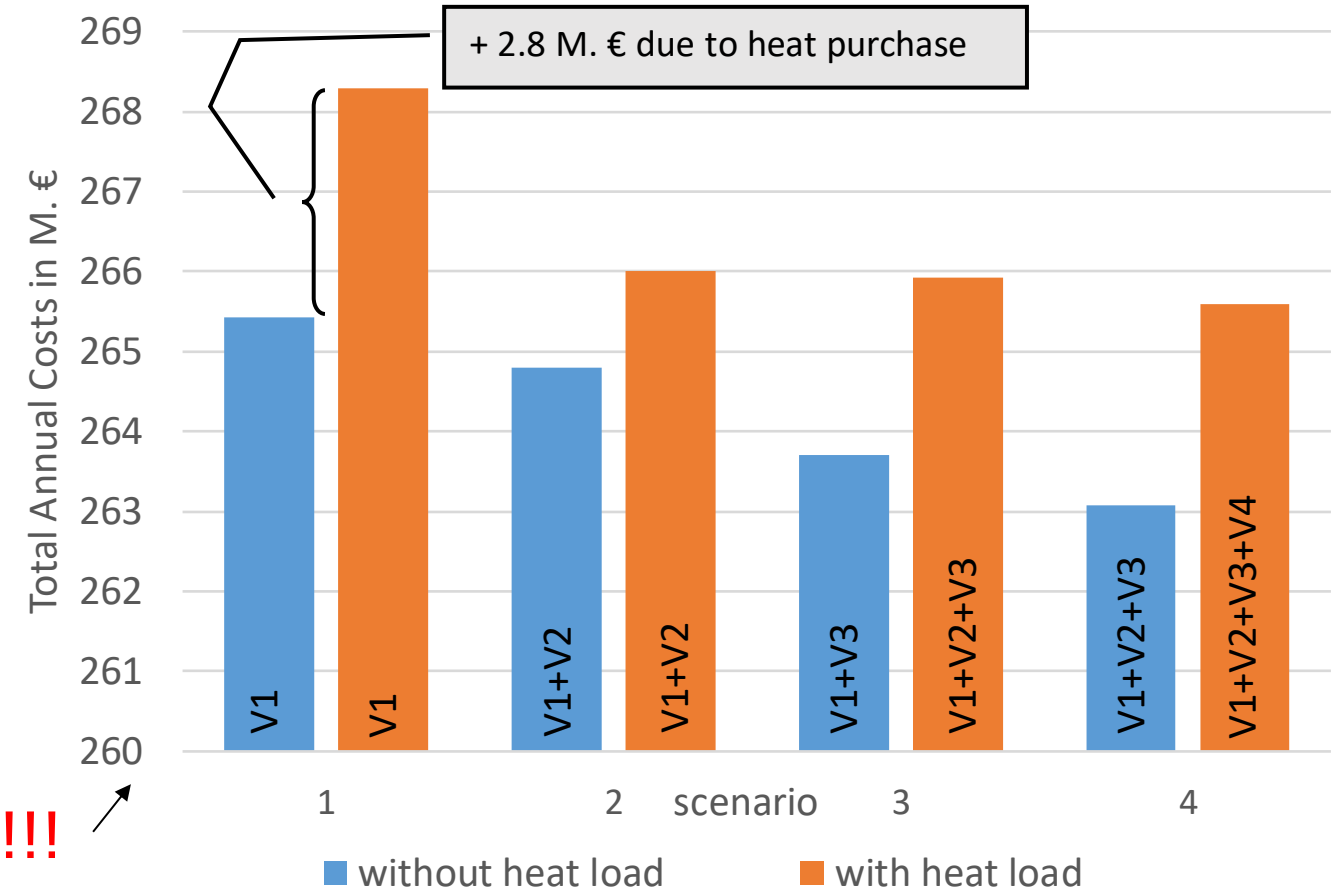
$$\text{s.t.} \quad \begin{cases} \mathbf{h}(\mathbf{x}) = 0 & \{\text{power flows to sinks}\} \\ \mathbf{g}(\mathbf{x}) \leq 0 & \{\text{power flows, techno-econom. parameters.}\} \end{cases}$$



	Legende	Heizlastgang	ORC	PV	Storage	Abwärmeheizung	
Ohne Heizlastgang	Fall 1						V1
	Fall 2		x				V1+V2
	Fall 3			x			V1+V3
	Fall 4		x	x			V1+V2+V3
Mit Heizlastgang	Fall 1	x					V1
	Fall 2	x				x	V1+V2
	Fall 3	x	x			x	V1+V2+V3
	Fall 4	x	x		x	x	V1+V2+V3+V4

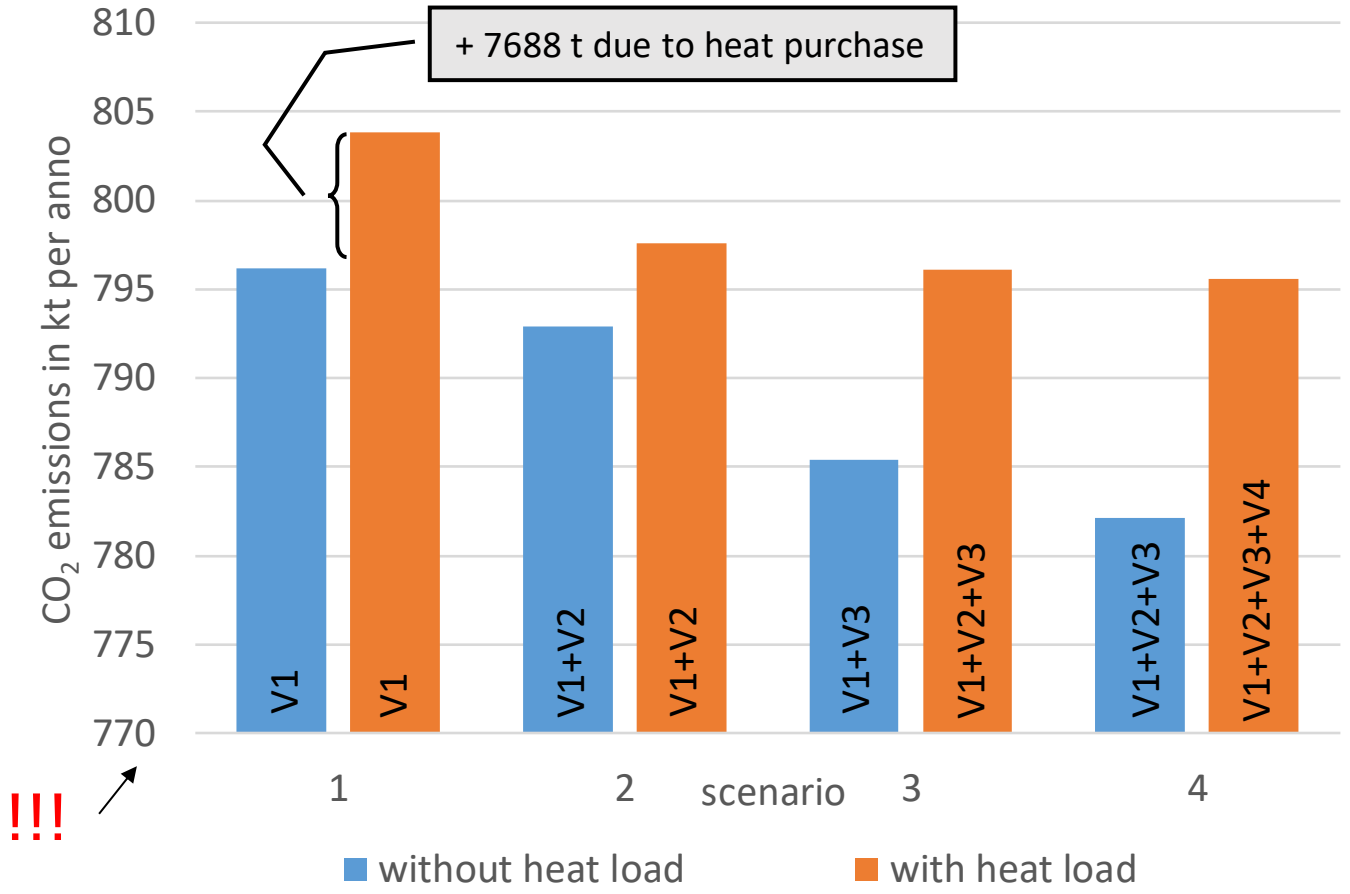
Results: TAC

	Legende	Heizlastgang	ORC	PV	Storage	Abwärmeheizung	
Ohne Heizlastgang	Fall 1						V1
	Fall 2		x				V1+V2
	Fall 3			x			V1+V3
	Fall 4		x	x			V1+V2+V3
Mit Heizlastgang	Fall 1	x					V1
	Fall 2	x				x	V1+V2
	Fall 3	x	x			x	V1+V2+V3
	Fall 4	x	x		x	x	V1+V2+V3+V4

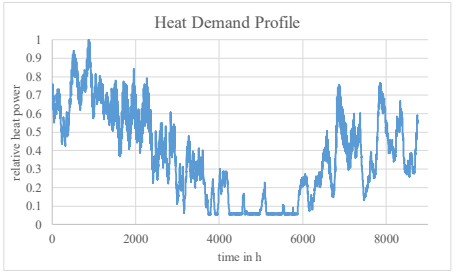


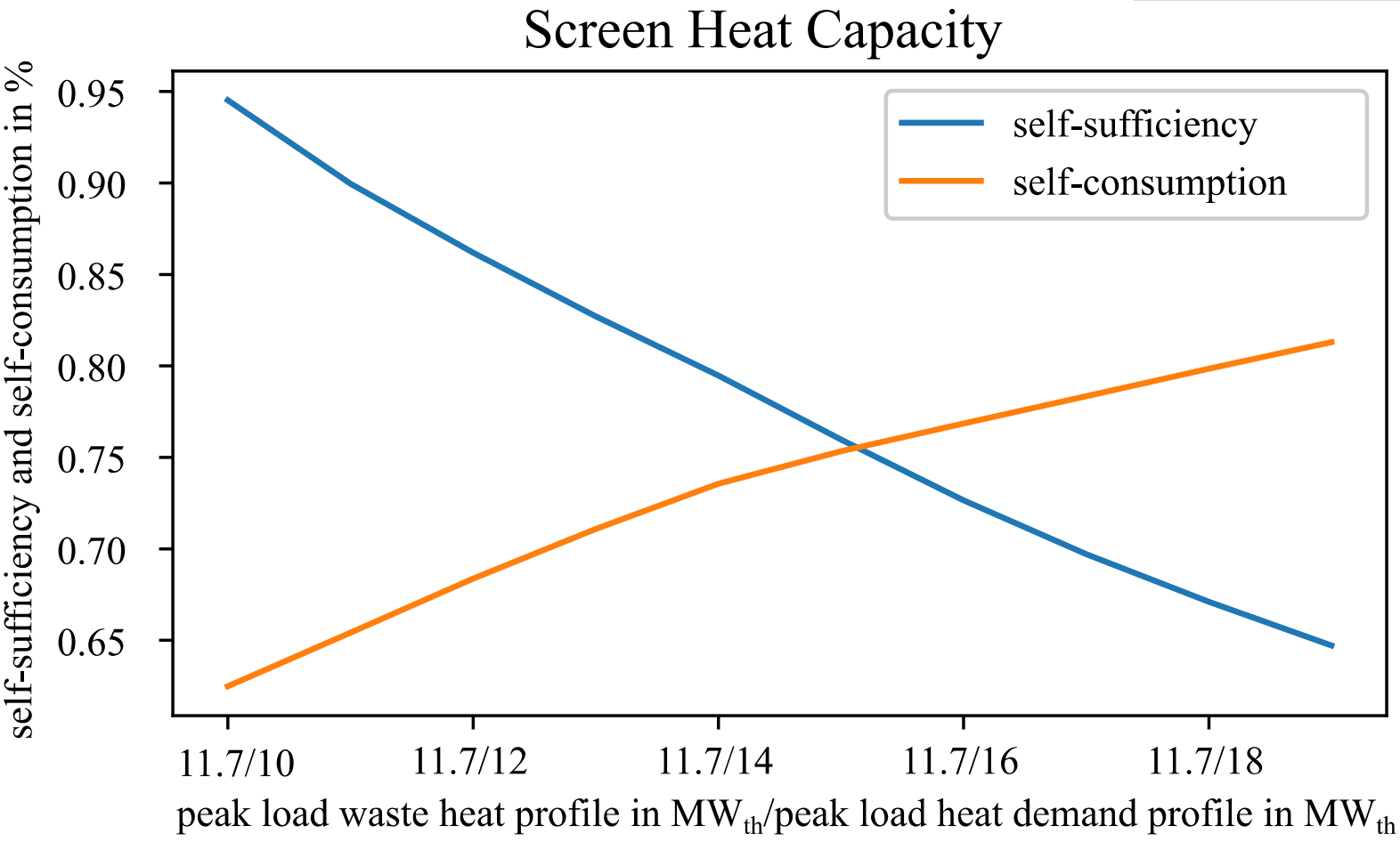
Results: CO_2 Emissions

	Legende	Heizlastgang	ORC	PV	Storage	Abwärmeheizung	
Ohne Heizlastgang	Fall 1						V1
	Fall 2		x				V1+V2
	Fall 3			x			V1+V3
	Fall 4		x	x			V1+V2+V3
Mit Heizlastgang	Fall 1	x					V1
	Fall 2	x				x	V1+V2
	Fall 3	x	x			x	V1+V2+V3
	Fall 4	x	x		x	x	V1+V2+V3+V4



Results: Supply Characteristics Heat





Conclusion & Outlook

- developed process model of secondary steelmaking
- waste heat from the pusher furnace should be recycled and utilized in terms of sector coupling
- integrating the heat demand of a municipality shows that almost a 100 % self-sufficiency with the available waste heat is possible
- under the aspect of sector coupling, this results in an overall monetary and CO_2-based savings potential
- absolute savings effect marginal → need green energy mix in the first place

- include sensitivities
- extend energy price / market model

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Thanks!