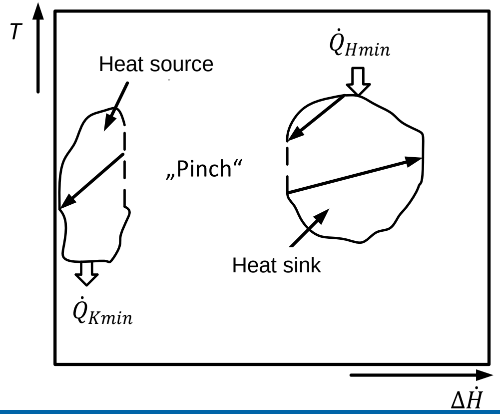
TUBAF
Die Ressourcenuniversität.
Seit 1765.

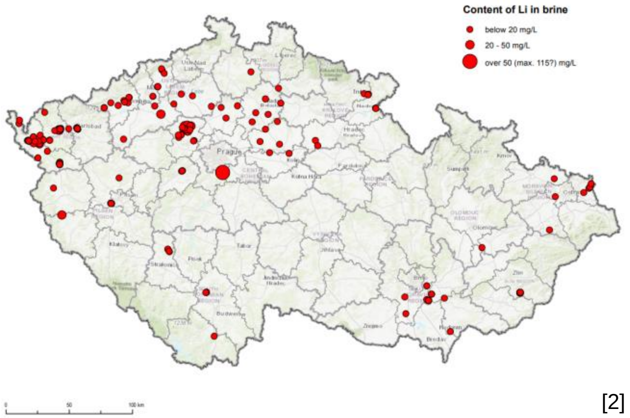
BRINE RIS

technical THERMO DYNAMICS

Utilisation of energy from highly mineralised deep geothermal brines as part of material co-production of minerals

[1]





[2]

Wroclaw, 04.12.2024

Timm Wunderlich, Lukas Oppelt, Kabriil Khajryan, Sebastian Pose, Thomas Grab, Tobias Fieback

Supported by eit RawMaterials Connecting matters
Funded by the European Union

Geothermal potential from heat source to sink

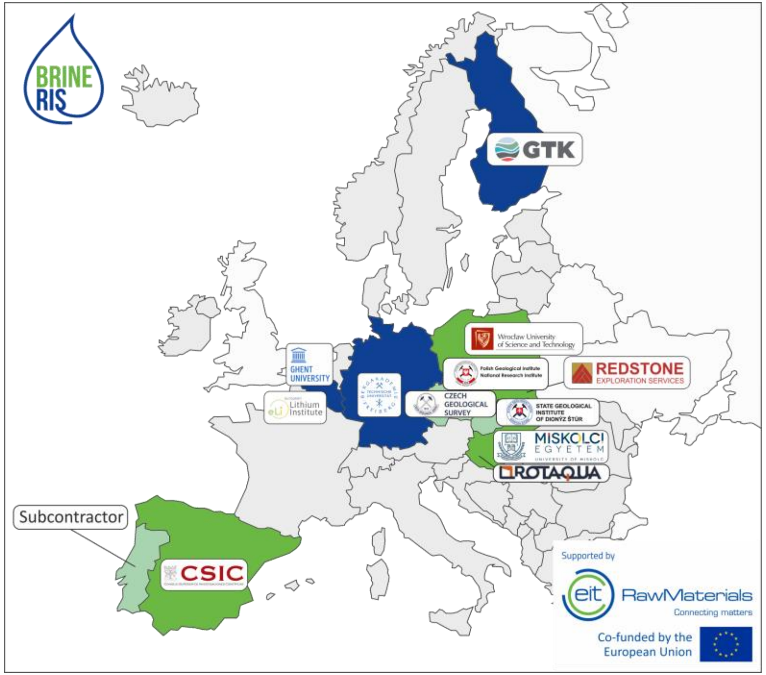
- Collection of a brine database

↓

- Combination of brine recovery processes and utilisation of heating and cooling potentials

↓

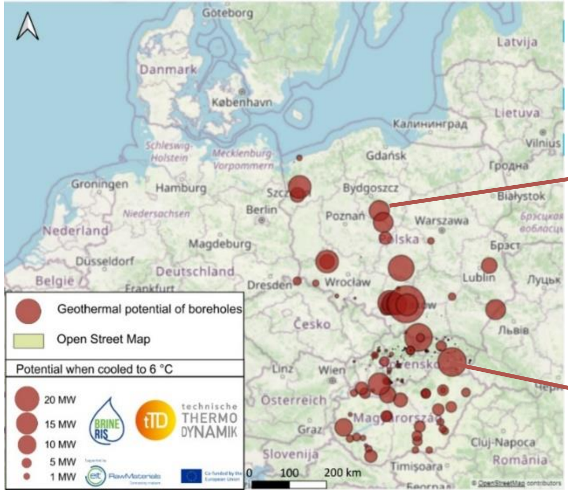
- Forcing ahead with European lithium production

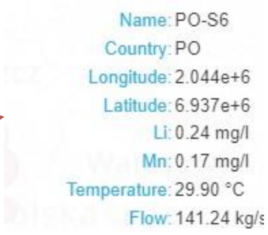


Supported by eit RawMaterials Connecting matters

Funded by the European Union

Geothermal potentials

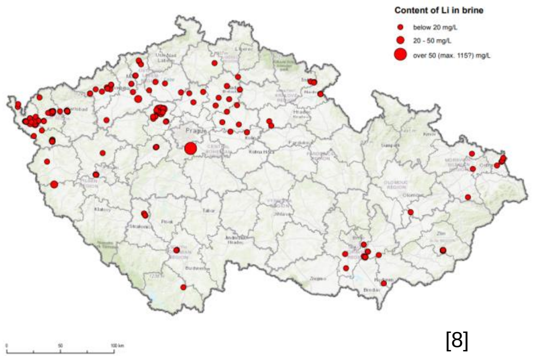




Supported by eit RawMaterials Connecting matters
Funded by the European Union

Example location in the Czech Republic (HP-13)

	value
Lithium content [mg/l]	47,00
Temperature [°C]	10,50
Volume flow [m³/h]	11,09



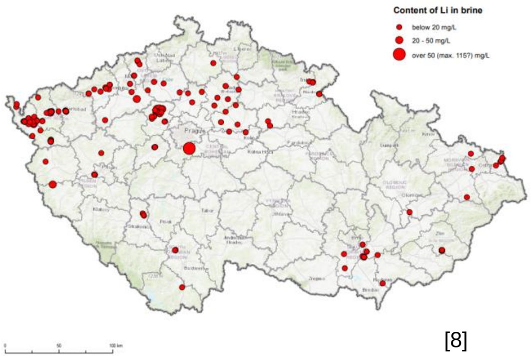
[8]

Mass flow (kg/s)	Heating potential (kW) cool down 5 K	Heating potential (kW) cool down 15 K	Maximum Amount of Heating Energy (MWh/a 5 K)	Maximum Amount of Heating Energy (MWh/a 15 K)
3,67	76,8	0	672,6	0

Supported by eit RawMaterials Connecting matters
Funded by the European Union

Example location in the Czech Republic (HP-13)

	value
Lithium content [mg/l]	47,00
Temperature [°C]	10,50
Volume flow [m³/h]	11,09



[8]

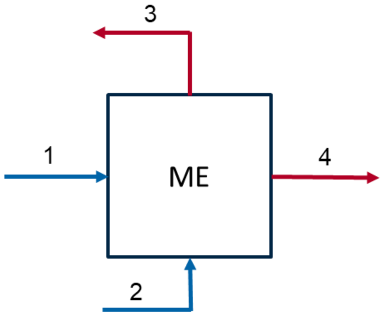
Mass flow (kg/s)	Heating potential (kW) cool down 5 K	Heating potential (kW) cool down 15 K	Maximum Amount of Heating Energy (MWh/a 5 K)	Maximum Amount of Heating Energy (MWh/a 15 K)
3,67	76,8	0	672,6	0

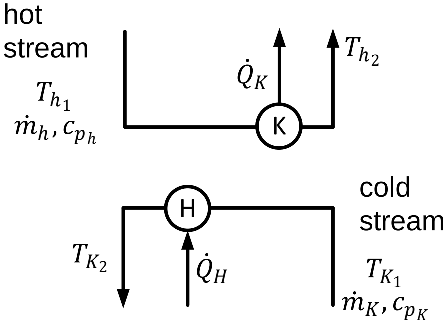
Supported by eit RawMaterials Connecting matters
Funded by the European Union

Wärmeintegration

- Analysis of systems with flows that can heat up or cool down differently
- The analysis using heat integration should provide the following information:
    - Recognise the minimum required useful energy demand
    - Heat integration potential
    - Determination of the minimum heating and cooling requirements
    - Minimum exergy loss

➡ Method: Pinch analysis!

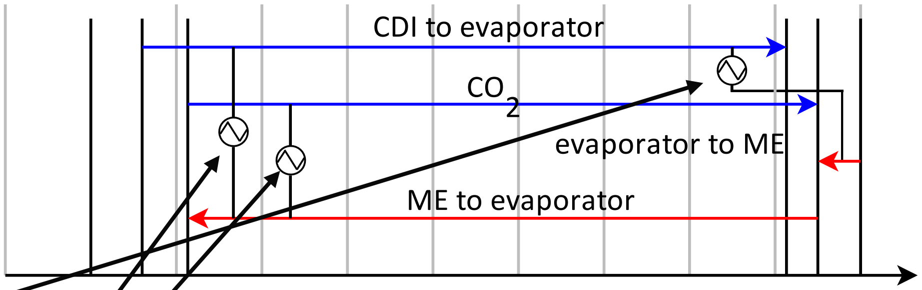




Supported by RawMaterials Connecting matters
Funded by the European Union

Wärmeintegration

- Interconnection of hot and cold flows
- Aim: efficient utilization



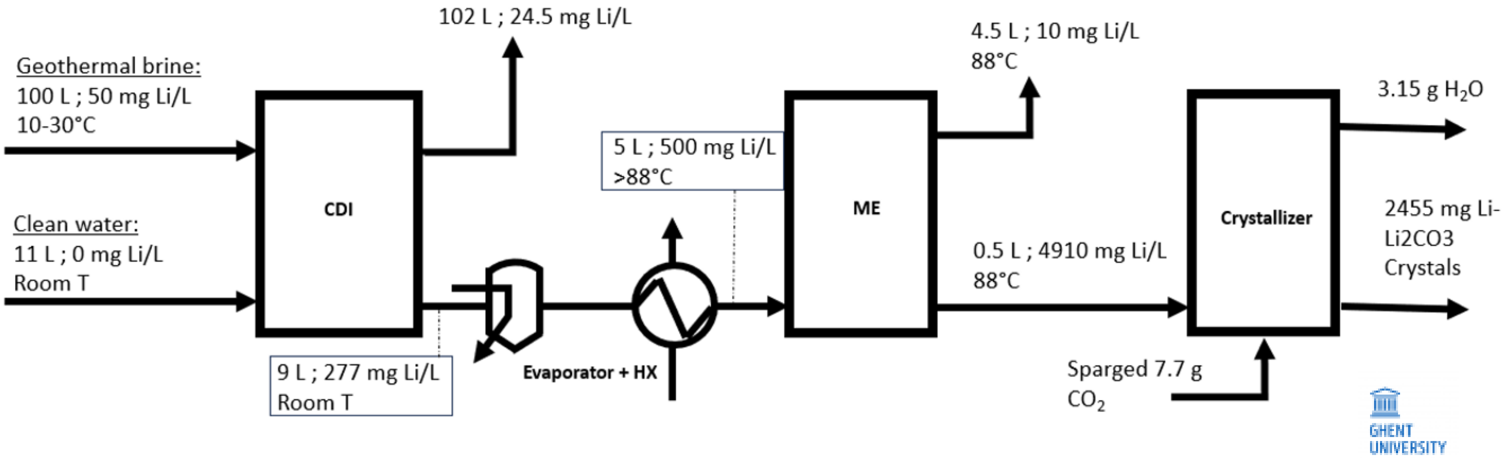
Interconnection flows

- Cool down with 100 °C to 95 °C
- Preheat with 100 °C to 93 °C

- Cool down from 95 °C to minimum
- Preheat with 95 °C to 88 °C
- Prehea with 47 °C to 30 °C

Supported by RawMaterials Connecting matters
Funded by the European Union

Example process of the University of Ghent

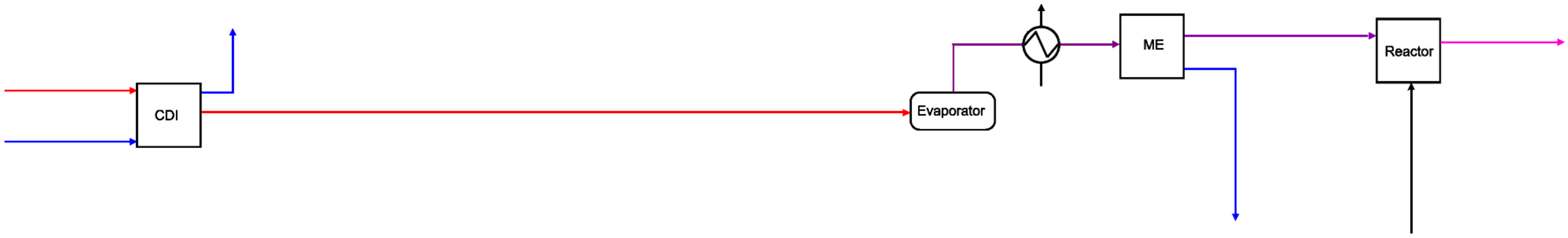


Black box model for lithium extraction, incomplete material flows (2024)

Supported by
RawMaterials
Connecting matters
Funded by the European Union

Starting Situation

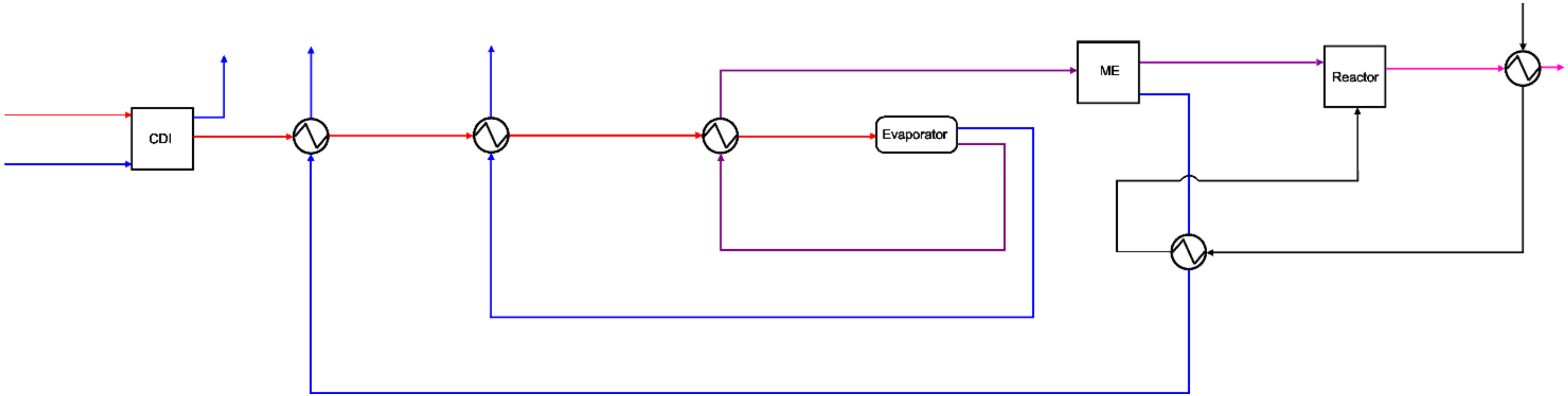
- Integrating the streams
- options after/before each process



Brine solution water concentrated brine CO_2

Supported by eit RawMaterials Connecting matters
Funded by the European Union

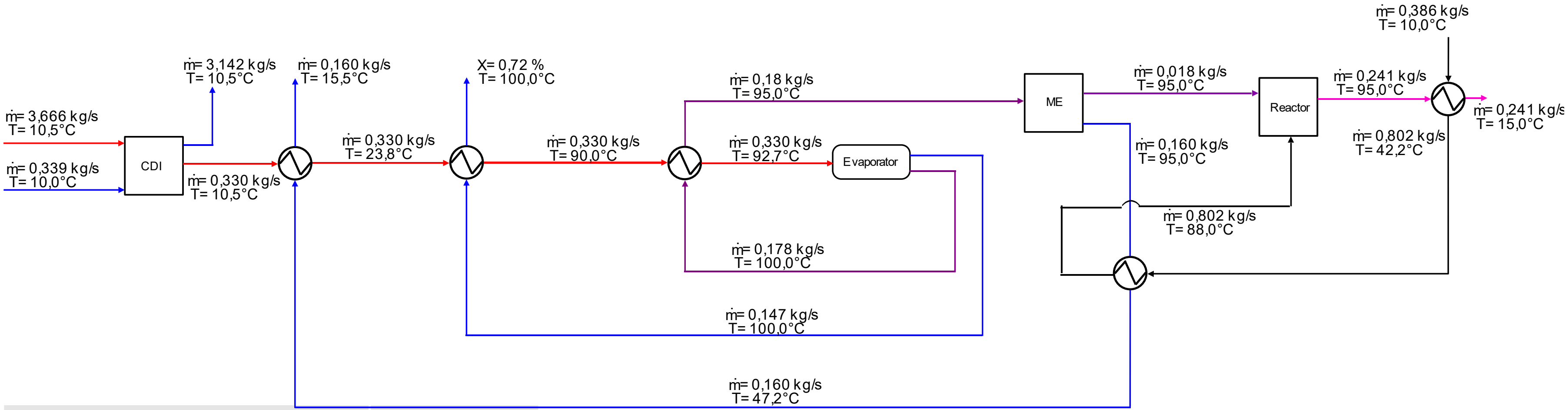
Interconnected Process



Brine solution water concentrated brine CO_2

Supported by
RawMaterials Connecting matters
Funded by the European Union

Process for the location in the Czech Republic

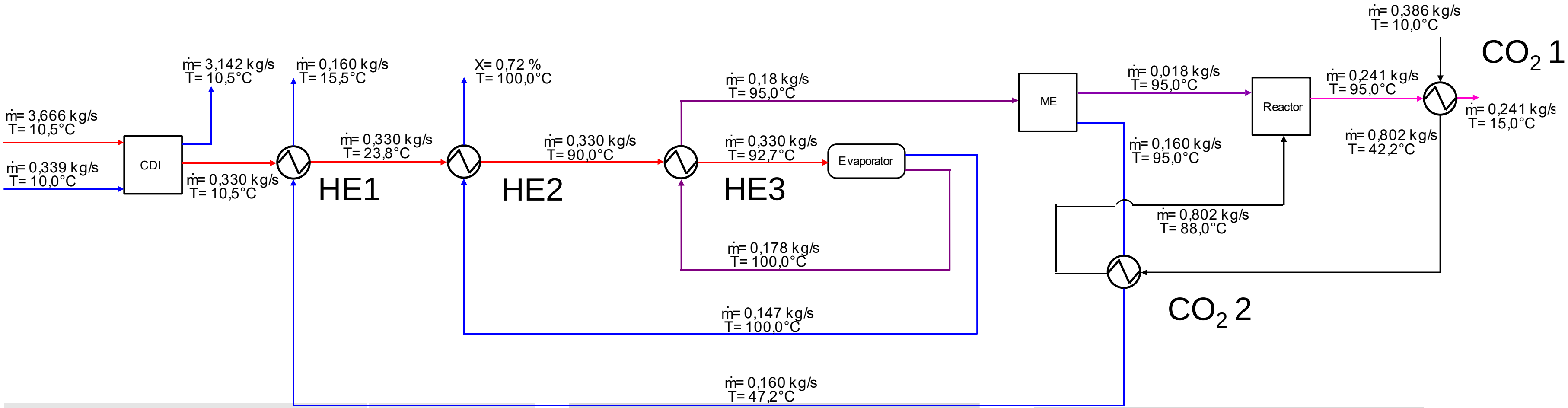


	value
Lithium content [mg/l]	47,00
Temperature [°C]	10,50
Volume flow [m³/h]	11,09

→ Brine solution → water → concentrated brine → CO_2

Supported by eit RawMaterials Connecting matters
Funded by the European Union

Process for the location in the Czech Republic



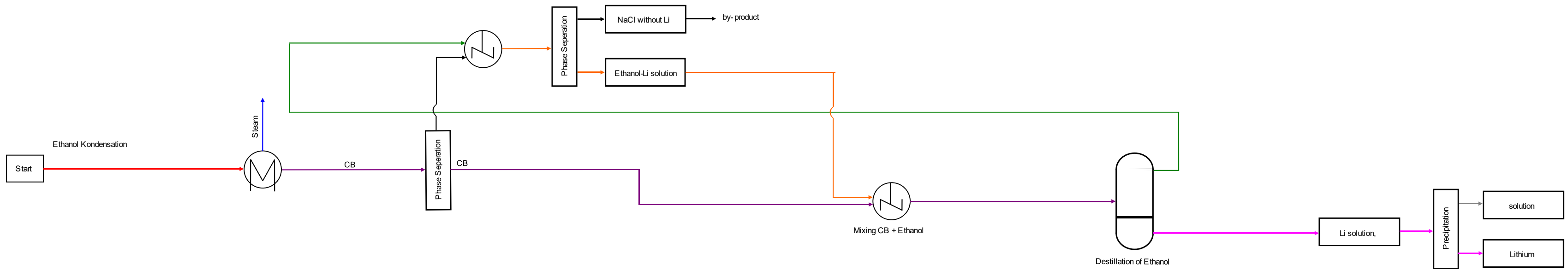
	value
Lithium content [mg/l]	47,00
Temperature [°C]	10,50
Volume flow [m³/h]	11,09

Heat exchangers		
HE brine 1	18,42	kW
HE brine 2	91,54	kW
HE brine 3	3,73	kW

Heat exchanger		
HE CO_2 1	21,77	kW
HE CO_2 2	32,12	kW

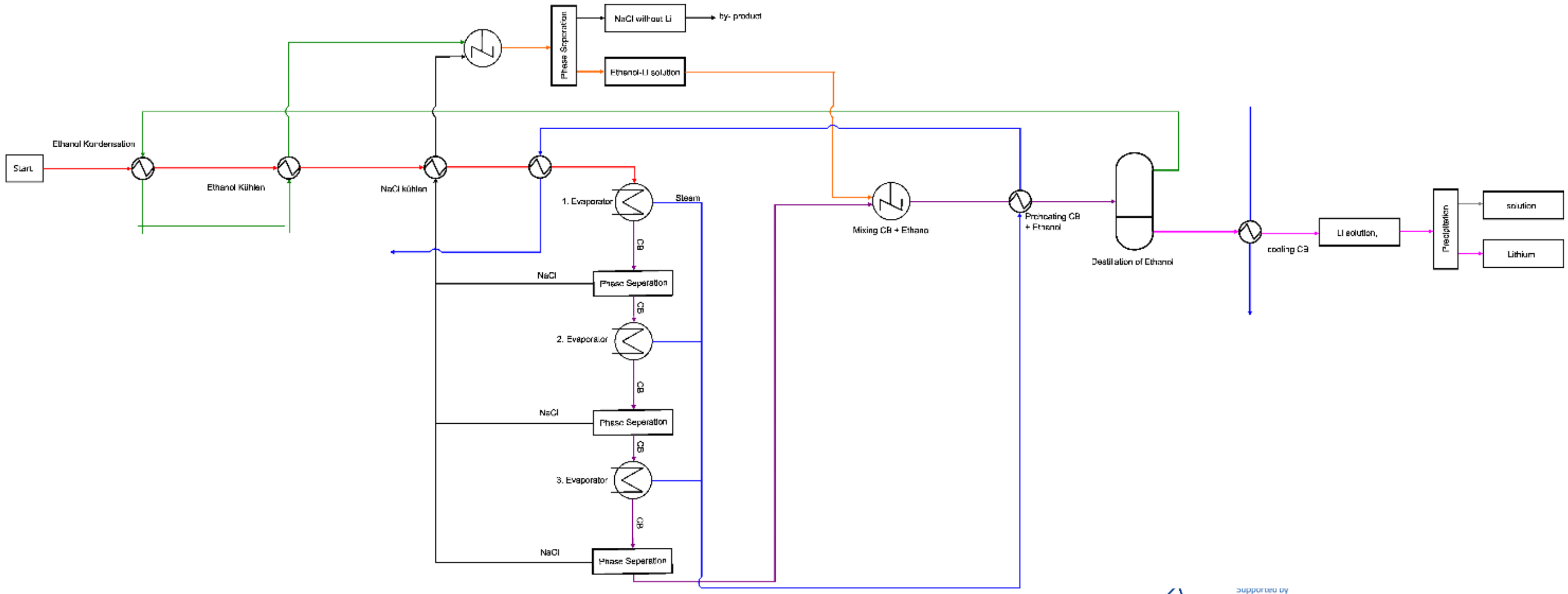
Supported by RawMaterials Connecting matters
Funded by the European Union

Solvent Extraction (SX)



- Evaporation of the brine
- Solid is mixed with fluid
- Mixture of concentrated brine and fluid solution
- Distillation
- Final product

Solvent Extraction (SX)

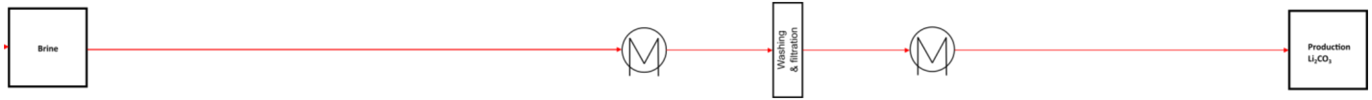


Supported by
Funded by the European Union

Synthetic adsorption

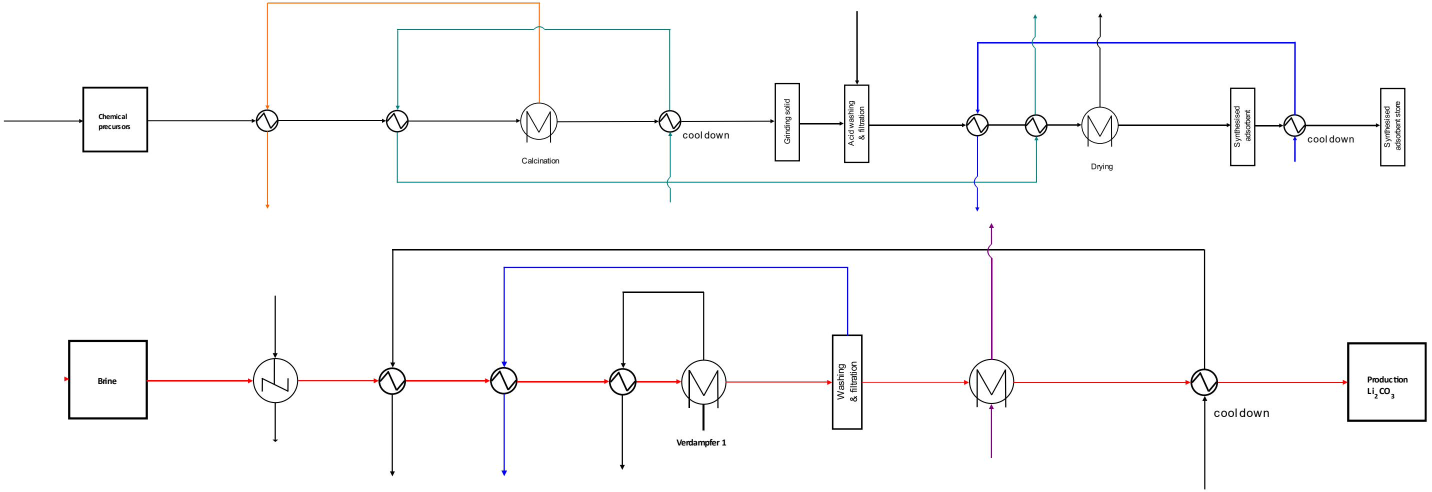
- Production of an adsorbent

- Reaction of adsorbent and brine
- Vaporisation of the liquid



Supported by
Funded by the European Union

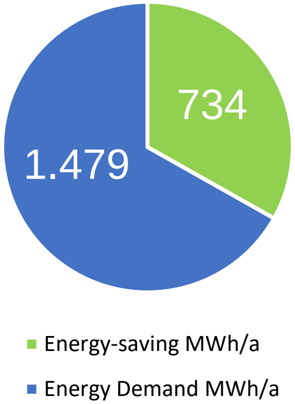
Synthetic adsorption



Supported by eit RawMaterials Connecting matters
Funded by the European Union

Energy demand

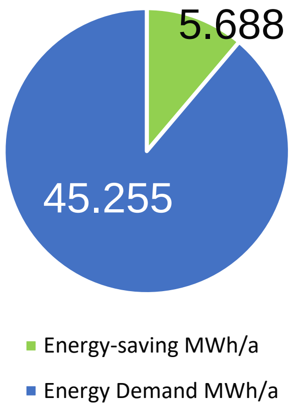
Membrane electrolysis



Total 2.212 MWh/a

Savings 33,2 %

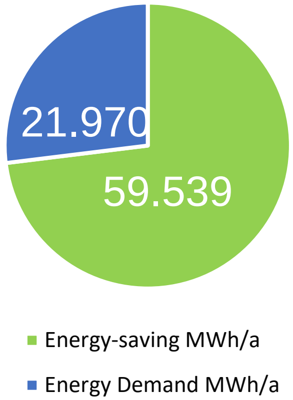
Solvent Extraction



Total 50.943 MWh/a

Savings 11,2%

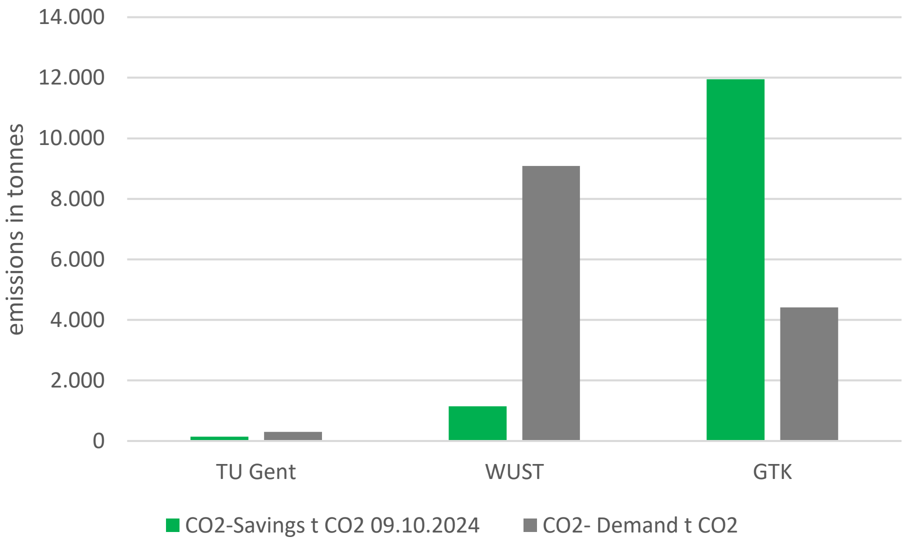
Synthetic adsorption



Total 81.509 MWh/a

Savings 73,0%

CO_2- Emissions



- According to energy consumption, there are clear differences
- The calculation is based on a factor of 200.8 g CO_2/kWh natural gas equivalent

Supported by RawMaterials Connecting matters
Funded by the European Union

Location in the Czech Republic (HP-13)

Figure		Membrane electrolysis	Solvent Extraction	Synthetic adsorption
Energy Demand	MWh/a	734	5.688	59.539
Energy-saving	MWh/a	1.479	45.255	21.970
Energy-saving	%	33,2	11,2	73,0
CO_2- Demand	t CO_2	147	1.142	11.956
CO_2-Savings	t CO_2	297	9.087	4.412
Cooling Potential	MWh/a	270	0,00	0,00
Heating Potential	MWh/a	1.423	30.556	0,00
Lithiumcarbonat	kg/a	≈1.800 (±20%)	≈1.730 (η= 76%) [12]	missing data from the lab

Supported by eit RawMaterials Connecting matters

Funded by the European Union

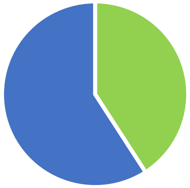
Comparison to 1 kg end product

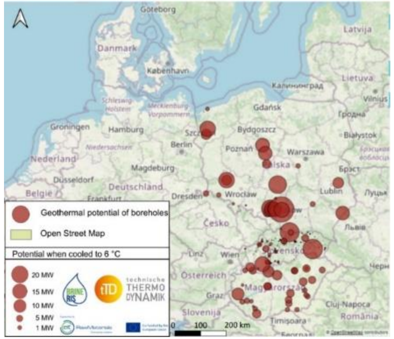
		Membrane electrolysis	Solvent Extraction	Synthetic adsorption
energy/ 1 kg	kWh			
$Cost_{fossil}$ / 1 kg	€			
$Cost_{renew}$ / 1 kg	€			No data available from the lab
$CO_{2\text{-}fossil}$/ 1 kg	kg			
$CO_{2\text{-}renew}$/ 1 kg	kg			

Assumptions Czech Republic :
Gas costs: 0.11 €/kWh
Electricity (not private): 0.21 €/kWh
Electricity (CO2 factor): 107g CO_2/kWh
COP heat pump: 4

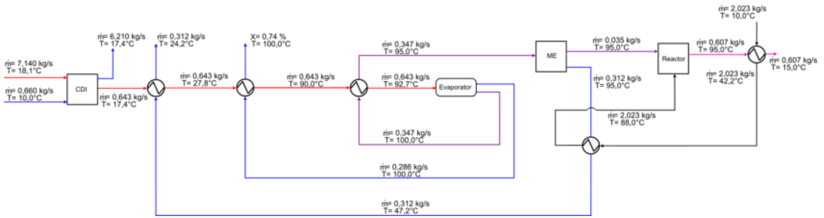
Supported by
RawMaterials
Connecting matters
Funded by the European Union

Conclusion





- Calculated values:
    - Geothermal potential determined
    - Energy savings
    - CO2 cost
    - Lithium available
- Process analysed (processes currently at laboratory scale)
- Lithium production in Europe possible



Supported by

TU BERGAKADEMIE FREIBERG

Lehrstuhl für Technische Thermodynamik,
Gustav-Zeuner-Straße 7, 09599 Freiberg

MBA. Timm Wunderlich
Tel. +49(0)3731 39-3276
Timm.Wunderlich@ttd.tu-freiberg.de

Dr.-Ing. Thomas Grab
Tel. +49(0)3731 39-3004
Thomas.Grab@ttd.tu-freiberg.de

Prof. Dr.-Ing. Tobias Fieback
Tel. +49(0)3731 39-3960
Tobias.Fieback@ttd.tu-freiberg.de

Supported by
RawMaterials
Connecting matters
Co-funded by the European Union