OPTIMAL ENERGY CONCEPT FOR DECARBONISATION OF SEA-BUCKTHORN PROCESSING PLANTS

M.I. Roldán*[1] and R. Kansara[1]

[1]Institute of Low-Carbon Industrial Processes, German Aerospace Center, Walther-Pauser-Straße 5 – 03046 Cottbus (Germany)

*Corresponding author e-mail: maria.roldanserrano@dlr.de

1 INTRODUCTION

The industrial sector accounts for 37% of the total global energy consumption and for a quarter of global energy system CO_2 emissions (1). Therefore, the decarbonisation of the industrial sector plays a key role for the achievement of the objectives defined in the 2030 Climate and Energy framework of the European Union (2).

2 OBJECTIVE

Optimal decarbonisation concepts adapted to the industrial site integrate renewable sources and storage systems while minimising investment and operating costs (3). In this work, an optimal energy supply system is defined for the decarbonization of a sea-buckthorn processing plant located in Herzberg (Germany).

3 METHODOLOGY

1. Analysis of the industrial process:

- Gas boiler and steam generator
- PV plant: 55 kW_p

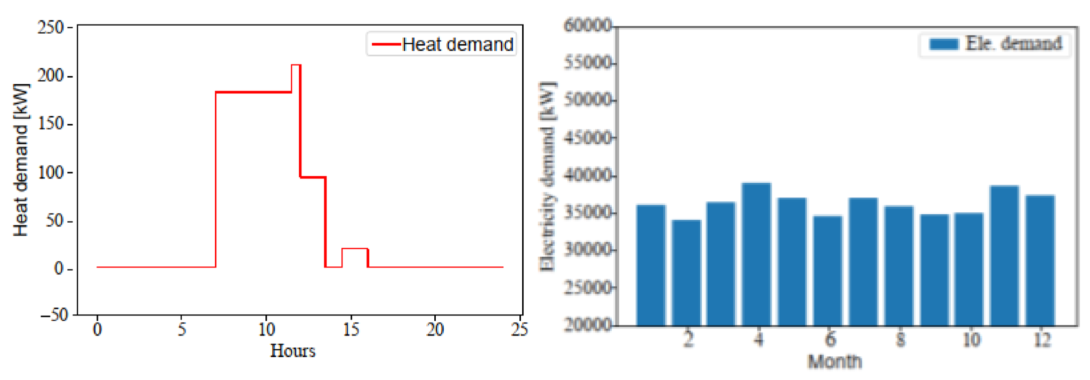

Fig 1. Daily heat demand and yearly electricity requirements for operation with steam.

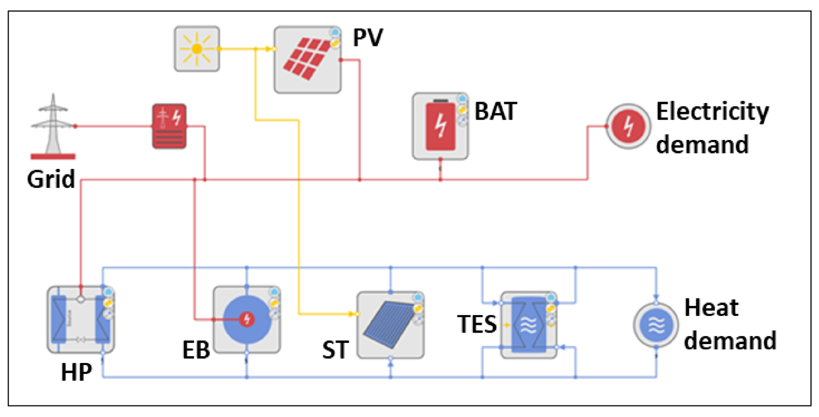

Fig 2. Decarbonisation concepts: cases 1 and 2.

2. Decarbonisation energy concepts:

- Renewable sources (solar radiation)
- Energy conversion components: PV plant (PV), solar thermal (ST), heat pump (HP), electrical boiler (EB).
- Storage systems: battery (BAT), thermal storage (TES).

Case 1: Components for heat supply connected to the process. Air as HP heat source.

Case 2: Components for heat supply connected to the process. HP with geothermal heat source at 32°C.

Case 3: Case 1 with ST used only for TES charging.

Case 4: Case 3 with TES used only as HP heat source.

3. Modelling of energy concepts:

- Concept digitalisation using a commercial optimization tool
- Implementation of an in-house operational logic
- Definition of operating and economic parameters for each component (electricity price = 16.75 ct/kWh)
- Coupled structural and operational optimisation.

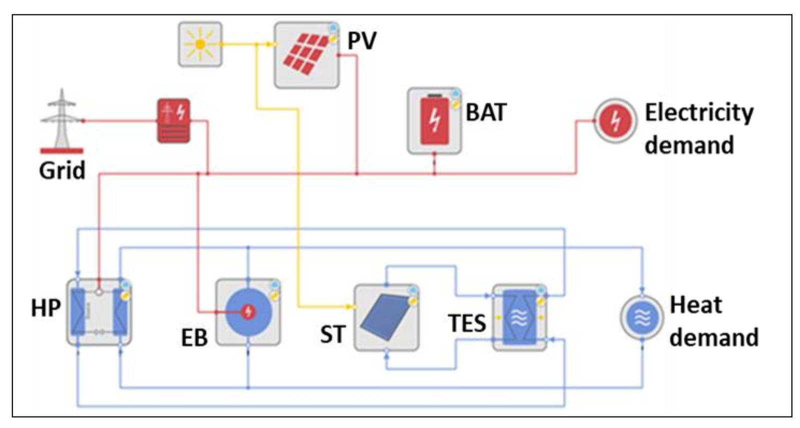

Fig 3. Decarbonisation concept: case 4.

4 RESULTS

- **Structural optimisation:**

COMPONENT SIZING	CASE 1	CASE 2	CASE 3	CASE 4
HP (kW)	140	140	155	70
EB (kW)	40	40	24	177
TES (kWh_{th})	150	158	130	145
BAT (kWh)	0	0	0	0
ST (m^2)	75	75	75	75
PV (kW_p)	190	190	190	190

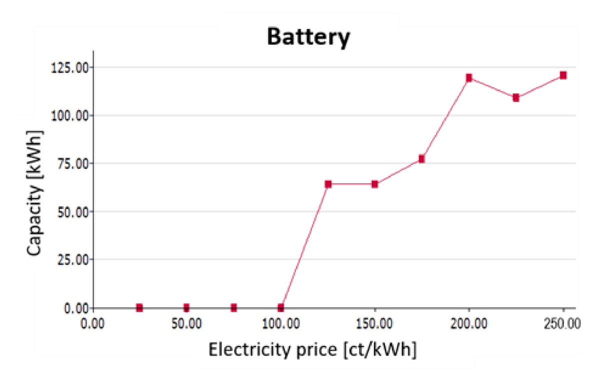

Fig 4. Battery sensitivity analysis.

- **Operational optimisation:**

PARAMETER	CASE 1	CASE 2	CASE 3	CASE 4
Operation costs (T€/year)	115	109	116	146
CO_2 emissions (t/year)	147	140	148	187
Investment (T€)	289	299	290	280
Payback time (year)	5.8	5.2	6	17.6

Analysis of the working fluid for the reference case

PARAMETER	STEAM	WATER
Operation costs (T€/year)	161	154
CO_2 emissions (t/a)	226	113

CONCLUSIONS 5

- Operation with water instead of steam as working fluid shows a 15% reduction in the process heat demand that leads to a 5% reduction in operation costs and CO_2 emissions.
- The most appropriate decarbonisation concept for the industrial site achieves a reduction of 25% in operation costs and 31% in CO_2 with an investment of 288.7 T€ and a payback time of 5.8 years.
- Battery integration is not profitable for electricity prices up to 100 ct/kWh.
- This analysis can be applied to other industrial processes and locations with adapted techno-economic parameters and operational logic.

REFERENCES

(1) International Energy Agency, “Tracking industry”, (2023).

(2) European Union, “EU Climate Target Plan 2030: Key contributors and policy Tools” (2020).

(3) Carmona, https://doi.org/10.3390/ pr11010018, (2023).

AKNOWLEDGEMENTS

This research was funded by the European Union’s Horizon Europe project SINNOGENES (Storage innovations for green energy systems), under Grant Agreement No 101096992.