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Final report from 14 September 2025

Annex 58 HTHP-CH – Integration of HTHPs in Swiss Industrial Processes

Appendix 7

HTHP Evaluation Tool (MS Excel Tool)

User Instructions

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Contents

1 Introduction

This simple **MS Excel-based economic model** was developed to assess a Go-or-No-go decision on HTHP integration in an industrial site (**Appendix 7, HTHP Evaluation Tool).** The MS Excel File is available for download from the SWEET DeCarbCH Website: https://www.sweet-decarb.ch/decarbonization-tools (HTHP Evaluation Tool_Annex_58_HTHP-CH.xlsx)

2 Assumptions, input, and output parameters

The tool is designed to provide an indication of financial feasibility with limited input information. It assumes that a gas boiler investment is depreciated and remains in place for production redundancy or other purposes (e.g., safety, redundancy, start-up operations, peak load coverage).

It evaluates economic feasibility using **key input parameters,** such as electricity price (c_{el}), gas price (c_{fuel}), operating hours (t), heating capacity ($\dot{Q}_h$), temperature lift between the heat source and sink (ΔT_{lift}), specific investment costs ($c_{inv,HP}$), maintenance cost factor ($f_{maintain}$), interest rate (i), the emissions factors of electricity and fuel (f_{CO2}), and CO_2 tax refund (subsidies) (Table 1).

Output parameters include COP, estimated investment and operating costs, CO_2 emissions reduction ($\dot{m}_{CO2,reduction}$), annual cost savings ($C_{savings}$), and the payback periods (PP).

Table 1: Input and output parameters of the HTHP Evaluation Tool.

Inputs

$\dot{Q}_h$	Heating capacity	kW
ΔT_{lift}	Temperature lift	K
$c_{inv,HP}$	Specific investment costs of HP	EUR/kW
$f_{inv,HP}$	Cost factor for planning & HP integration	-
t	Annual operating time	h/a
$f_{maintain}$	Maintenance factor (on capital costs)	-
η_{fuel}	Efficiency of gas boiler	-
i	Interest rate (discount rate)	-
c_{fuel}	Fuel price (gas, oil)	EUR/kWh
c_{el}	Electricity price	EUR/kWh
$c_{CO2\ tax}$	CO_2 tax	EUR/tCO_2
$f_{CO2,el}$	CO_2 emissions factor electricity	kgCO_2/kWh
$f_{CO2,fuel}$	CO_2 emissions factor fuel	kgCO_2/kWh

Outputs

$C_{inv,HP}$	Investment costs of HP	EUR
$\dot{m}_{CO2,reduction}$	Annual CO_2 emissions reduction	tCO_2/a
$E_{savings}$	Annual energy savings	kWh/a
C_{fuel}	Annual fuel cost savings	EUR/a
C_{el}	Annual electricity costs	EUR/a
$C_{maintain}$	Annual HP maintenance costs	EUR/a
C_{CO2}	Annual CO_2 tax compensation	EUR/a
$C_{savings}$	Annual cost savings	EUR/a
PP	Payback period	a
DPP	Discounted payback period	a

Figure 1 illustrates the cost calculation model, which incorporates the economic calculations, a COP correlation for HTHPs, and specific investment costs to determine the payback period for HTHP integration [1]–[3].

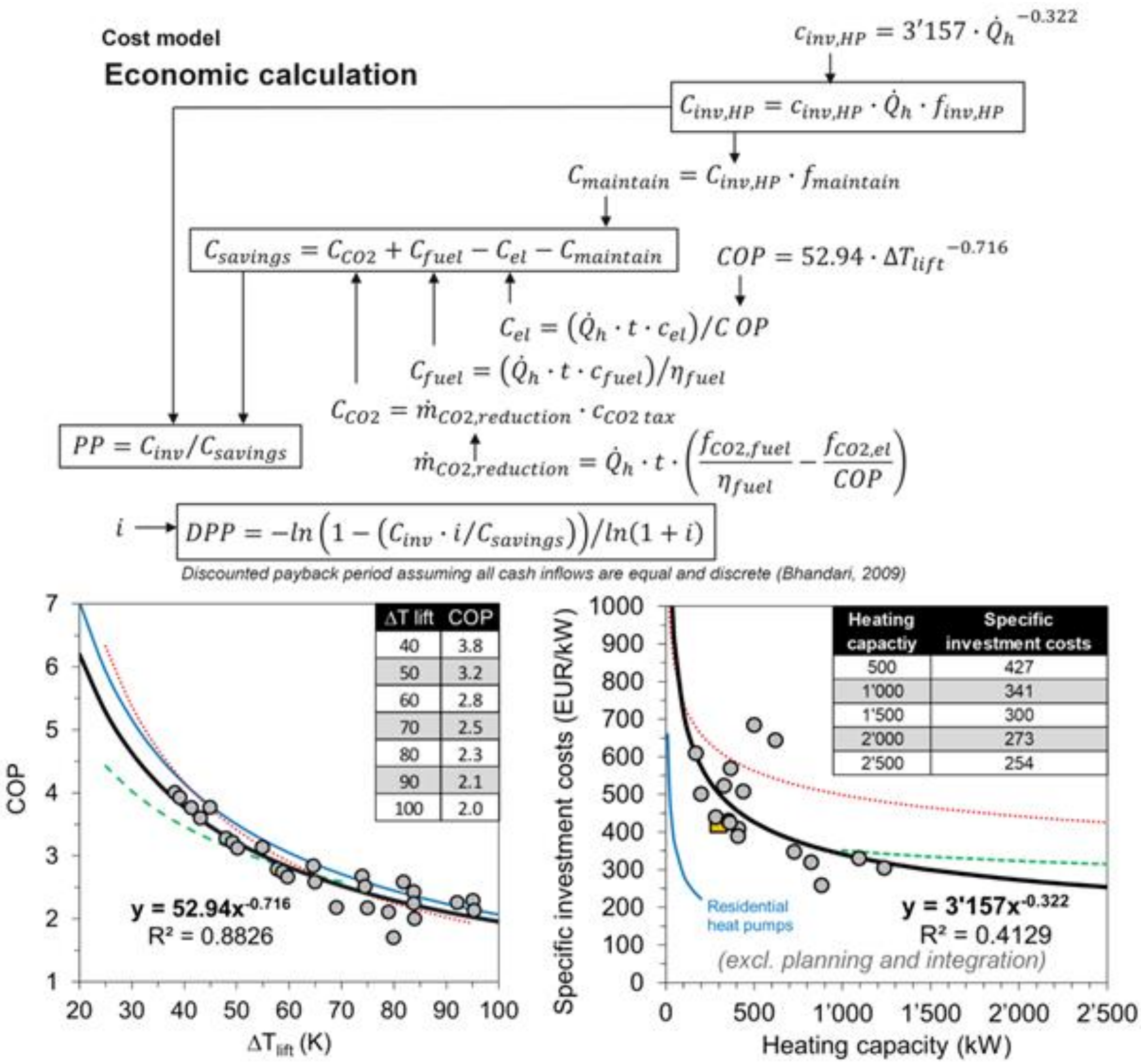

Figure 1: Economic calculation, COP correlation, and specific investment costs to derive the payback period for HTHP integration [1]–[3].

3 Calculation procedure

Step 1: First, the **efficiency** of the HTHP is estimated using the temperature lift (ΔT_{lift}) and a **COP** fit-curve ($COP = 52.94 \cdot \Delta T_{lift}{}^{-0.716}$) derived from quotes from various HTHP suppliers [1], [2].

Step 2: The **investment costs** ($C_{inv,HP}$) of the industrial HTHPs are evaluated based on the **specific investment costs** ($c_{inv,HP} = 3'157 \cdot \dot{Q}_h{}^{-0.322}$) according to price information from HTHP suppliers, the **heating capacity** ($\dot{Q}_h$), and a **cost multiplication factor** ($f_{inv,HP}$) accounting for planning and integration (typically between 1.5 to 4.0 depending on the complexity of integration, e.g., including heat storage, site's electrical installation, piping, hydraulics, etc.) [1], [2].

Step 3: The **annual cost savings** are calculated considering the following:

- **electricity cost** (C_{el}) to operate the HTHP,
    - **maintenance costs** ($C_{maintain}$) of the HTHP using a **multiplication factor** ($f_{maintain}$) on capital cost (typically between 1.5% to 6%, in the case studies, 4% is used) [1], [2],

- **saved fuel costs** (C_{fuel}) (assuming 90% boiler efficiency η_{fuel}), and
- **possible refunds of CO_2 reduction** (C_{CO2}) (e.g., carbon taxes or subsidies).

Step 4: The **payback period** of the HTHP investment is evaluated as a trade-off between the investment costs and the expected **annual cost savings** resulting from the heat pump investment.

Step 5: Finally, the **discount rates** (i) are considered to calculate the **discounted payback periods** (DPP) [4], depending on the investor's risk tolerance (e.g., sector, company size, energy intensity, funding source, new technology, etc.) [5]. Typical discount rates for HP investments range from 5% to 15%, according to reviewed literature [1], [2]. The DPP (discounted payback period) is the period after which the cumulative discounted cash inflows cover the initial investment [4]. The DPP can therefore be interpreted as a period beyond which a project generates economic profit. In contrast, the static PP gives a period beyond which a project generates accounting profit.

4 Results and discussion of HTHP case studies

The HTHP Evaluation Tool was tested on preliminary integration concepts for the case studies of Gustav Spiess (sausage cooking), Cremo (milk drying), and ELSA (CIP process), although further validation is needed for more accurate estimations of the payback periods. The results have been published at several conferences [1]–[3].

Table 2 summarizes the results of the **three case studies**. The calculations yield static payback periods of 2.0, 3.7, and 3.3 years, indicating that HTHP integration would be cost-effective under current assumptions. Overall, the case study examples demonstrate significant annual energy savings of 55%, 60%, and 66%, as well as CO_2 emission reductions of 71%, 75%, and 98%, respectively. The COP varies between 2.0 and 2.7, as shown in the COP-fit function in Figure 1.

The case study **ELSA** has the highest temperature lift of 98 K and consequently the lowest COP, as well as a cost multiplication factor for planning and integration of 3.0, but benefits from a favorable electricity-to-gas price ratio and low specific investment costs due to the large HTHP (economies of scale).

In the **Cremo** case study, the electricity-to-gas price ratio is higher, and the integration factor is 2.0. However, the discount rate is low, resulting in a DPP of 3.9 years. The pinch analysis is a powerful tool to determine the optimal placement of an HTHP, its size, and adequate evaporation and condensation temperatures.

The case study of **Gustav Spiess AG** demonstrates a 98% reduction in CO_2 emissions, as the company benefits from low CO_2 emissions by purchasing nuclear power. Utilizing waste heat from the NH_3 chillers as a heat source demonstrates significant potential in other case studies within the Swiss food industry, where refrigeration machines for cooling food are state-of-the-art.

In addition to the three case studies, Table 2 also shows the results of the payback period for a possible **Reference Case 2023 (Ref)** with a heat source of 50 °C, a heat sink of 120 °C (COP of 2.5), and 1 MW heating capacity, and specific investment costs of 341 EUR/kW$_{th}$. This scenario employs a discount rate of 10%, an average Swiss consumer electricity mix with a CO_2 emission factor of 0.128 kg CO_2/kWh, and a potential carbon tax refund of CHF 92.5/t CO_2 due to the reduction in CO_2 emissions. Electricity and gas prices are based on market data for 2023 [6] (0.15 CHF/kWh PEGAS NCG Year Future and 0.35 CHF/kWh Phelix Year Future, price ratio 2.33, as of December 11, 2022).

Table 2: Results of the case studies ELSA, Cremo, Gustav Spiess, and a Reference (Ref) case with COP, energy savings, investment costs, reduction of CO_2 emissions, and payback periods.

Heat pump conditions	Symbol	Unit	ELSA CIP process	Cremo Milk drying	Gustav Spiess Sausage cooking	Reference 2023 (Ref)
Heat sink (outlet) temperature	$T_{h,out}$	°C	148	120	115	120
Heat source (inlet) temperature	$T_{c,in}$	°C	50	38	50	50
Temperature lift	ΔT_{lift}	K	98	82	65	70
Heating capacity	$\dot{Q}_h$	kW	3,150	940	550	1,000
Fuel prices, CO2 tax, CO2 emission factors						
Fuel price (gas, oil)	c_{fuel}	CHF/kWh	0.13	0.11	0.17	0.15
Electricity price	c_{el}	CHF/kWh	0.18	0.20	0.25	0.35
CO_2 tax or subsidies	$c_{CO2\ tax}$	CHF/tCO_2	0	0	0	92.5
CO_2 emissions factor electricity	$f_{CO2\ el}$	kgCO_2/kWh	0.128	0.128	0.012	0.128
CO_2 emissions factor fuel	$f_{CO2\ fuel}$	kgCO_2/kWh	0.201	0.201	0.201	0.201
CO_2 emissions ratio el/fuel	$e_{CO2\ el/fuel}$	-	0.64	0.64	0.06	0.64
Electricity-to-fuel price ratio	$p_{el/fuel}$	-	1.38	1.82	1.47	2.33
Other input parameters						
Annual operating time	t	h/a	7,200	6,400	3,000	6,400
Efficiency of fuel boiler	η_{fuel}	-	0.90	0.90	0.90	0.90
Maintenance factor (on capital costs)	$f_{maintain}$	-	0.04	0.04	0.04	0.04
Cost factor for planning & integration	$f_{inv,hp}$	-	3.0	2.0	2.0	3.0
Fit curves						
COP ($COP = 52.94 \cdot \Delta T_{lift}{}^{-0.716}$)	COP	-	2.0	2.3	2.7	2.5
Specific investment costs ($c_{inv,HP} = 3'157 \cdot \dot{Q}_h{}^{-0.322}$)	$c_{inv,hp}$	CHF/kW	236	348	414	341
CO2 emissions reduction and energy savings						
Annual CO_2 emissions reduction	$\dot{m}_{CO2,reduction}$	tCO_2/a	3,604	1,002	361	1,105
Annual CO_2 emissions reduction	-	-	71%	75%	98%	77%
Annual energy savings	$E_{savings}$	MWh/a	13,782	4,019	1,214	4,579
Annual energy savings	-	-	55%	60%	66%	64%
Economic calculations						
Investment costs	$C_{inv,hp}$	kCHF	2,230	655	455	1,024
Annual fuel cost savings	C_{fuel}	kCHF/a	3,276	735	312	1,067
Annual electricity costs	C_{el}	kCHF/a	2,055	533	155	886
Annual heat pump maintenance costs	$C_{maintain}$	kCHF/a	89	26	18	41
Annual CO_2 tax compensation	C_{CO2}	kCHF/a	0	0	0	102
Annual cost savings	$C_{savings}$	kCHF/a	1132	176	139	242
Payback						
Discount rate	i	-	0.10	0.02	0.05	0.10
Payback period	PP	**years**	**2.0**	**3.7**	**3.3**	**4.2**
Discounted payback period	DPP	years	2.3	3.9	3.7	5.8

Figure 2 shows a **Sensitivity Analysis** of the Payback Period (PP) for the **Reference Case 2023 (Ref)**. All input factors of the model were individually varied from -25% to +25% (factor 0.75 to 1.25), while the other parameters were kept constant. The sensitivity analysis reveals that the payback period is strongly sensitive to changes in electricity and fuel prices, as well as the temperature lift of the heat pump.

Favorable conditions for HTHPs include higher fuel prices, longer operating times, a lower fuel CO_2 emission factor, a higher CO_2 tax, increased heating capacity, and lower electricity prices. In addition, an increasing CO_2 tax, along with subsidies and possible CO_2 compensation through the European Emission Trading System (ETS), increases the financial incentives for HTHPs. On the other hand, low gas and high electricity prices create unfavorable conditions and are significant barriers to investment in industrial HTHPs.

As seen in the lower diagrams of Figure 2, the payback period is strongly determined by the electricity-to-gas price ratio. Above a price ratio of 2.7, the payback period exceeds 10 years. In addition, the payback period is strongly influenced by the temperature lift, which determines the COP and, thus, the operating cost of the HTHP and the avoided fuel consumption.

For fixed energy prices and temperature lift, the cost multiplication factor for planning & implementation leads to significant uncertainty in quantifying the payback period. The cost multiplication factor depends on the complexity of the HTHP integration and can only be properly determined after a thorough analysis of the project and indicative price quotations for the entire heating system implementation.

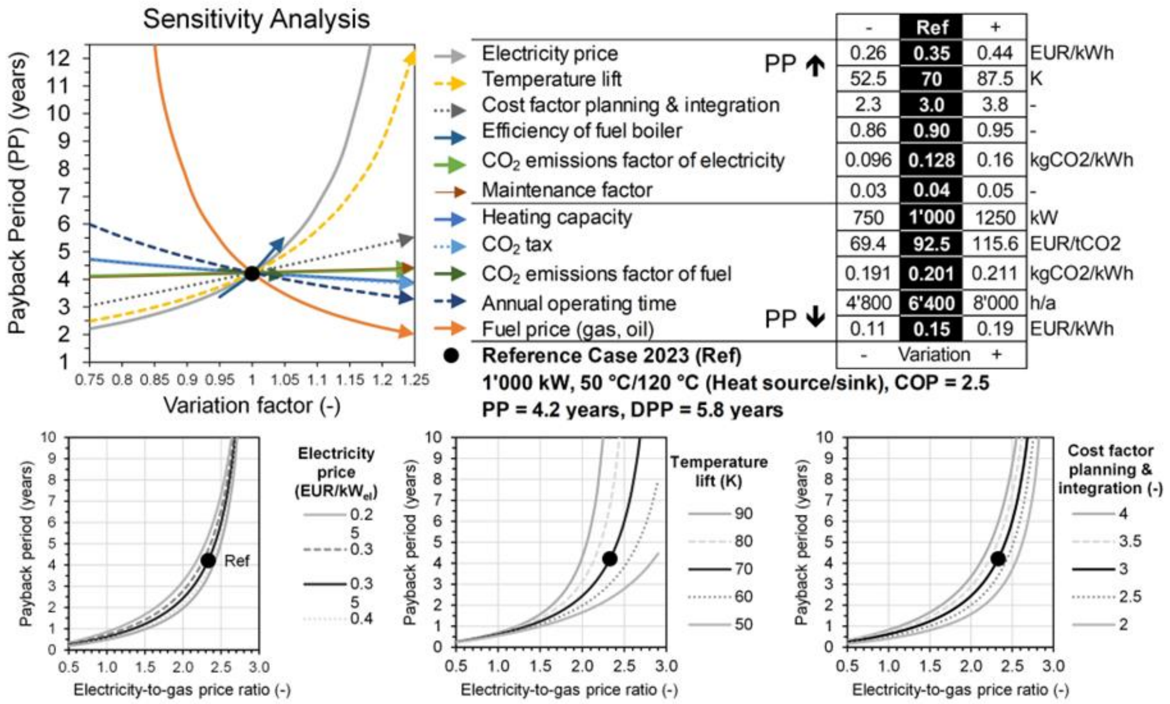

Figure 2: Sensitivity analysis of the payback period for a Reference Case 2023 (Ref) at 50 °C/120 °C heat source/sink, 1'000 kW heating capacity, and an electricity-to-gas price ratio of 2.33. The graphs below illustrate the impact of electricity price, temperature lift, and cost factor planning & integration on the payback period as a function of the electricity-to-gas price ratio.

5 Conclusions

This simple HTHP Evaluation Tool supports the pre-assessment of economic feasibility for integrating HTHPs. It identifies key cost drivers through sensitivity analysis and has been validated with conceptual case studies at ELSA, Cremo, and Gustav Spiess.

The results show substantial annual energy savings (55%, 60%, and 66%) and CO_2 reductions (71%, 75%, and 98%), with payback periods of 2.0, 3.7, and 3.3 years, highlighting strong potential for cost-effective integration. Profitability is favored by electricity-to-gas price ratios below 2.7 and temperature lifts of less than 70 K, while high temperature lifts, low gas prices, and high discount rates pose challenges.

Future work includes applying the tool to further case studies, refining end-user-specific integration conditions, and integrating advanced heat pump models that consider refrigerants, compressor efficiency, and cycle design.

6 References

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