Energy Audit Summary Report

Audit No. 52 - GER06

Naturtherme Templin

Templin, Germany

Recreational, cultural and sporting activities

Thermal Bath (Spa)

energyXperts.NET

Berlin (Germany) / Barcelona (Spain)T

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1. Contact data of the auditors

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2. Description of the company (status quo)

Reference year of data/information: 2011

(Date of the visit on site: 23-02-2012)

2.1. General information of the company

Company, location	Templin (Germany)	
Sector	Thermal bath (spa)	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- natural gas	6.353	6.353
- electricity	2.191	87

(*) fuel consumption in terms of MWh lower calorific value (LCV)

Figure 1. Big hall and bath

2.2. Description of the company

a) Activity

The facilities of the company are used for swimming activities. Part of the water is mixed with sole, which is extracted from a 1600m deep borehole at 24 - 28ºC. The main energy demanding processes are:

- Hot water for the pools and pool heating
- Hot water for sanitary uses (showers, etc.)
- Steam in the sauna

- Space heating of different areas (in the modelling, areas with pool and without are differentiated).
- Dehumidification of air in halls with pools: dehumidification is currently done by (increased) ventilation with dry outdoor air, so that dehumidification energy demand is included in space heating demand.

(a) (b)

Figure 2. (a) Big hall with pool (b) Pool and slides

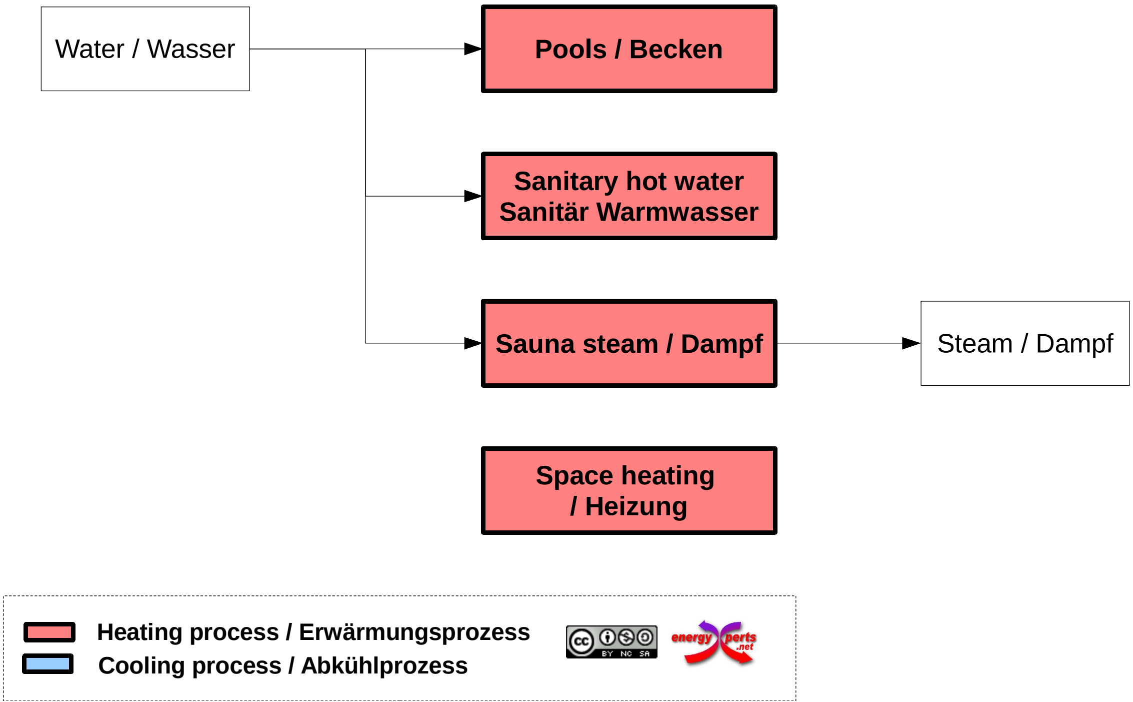

Figure 3. Overview of heating and cooling demands.

The most energy consuming process is the space heating of the areas with pools, which includes the pool heating and the heat demand due to increased ventilation for dehumidification.

b) Energy supply system

The heat used in the company is generated in a hot water boiler that generates hot water at 75ºC, which is distributed and used in heat exchangers to generate hot water for the pools, hot water for sanitary uses and heating of air for space heating. Steam for the sauna is generated in electrical steam generators. See Figure 4.

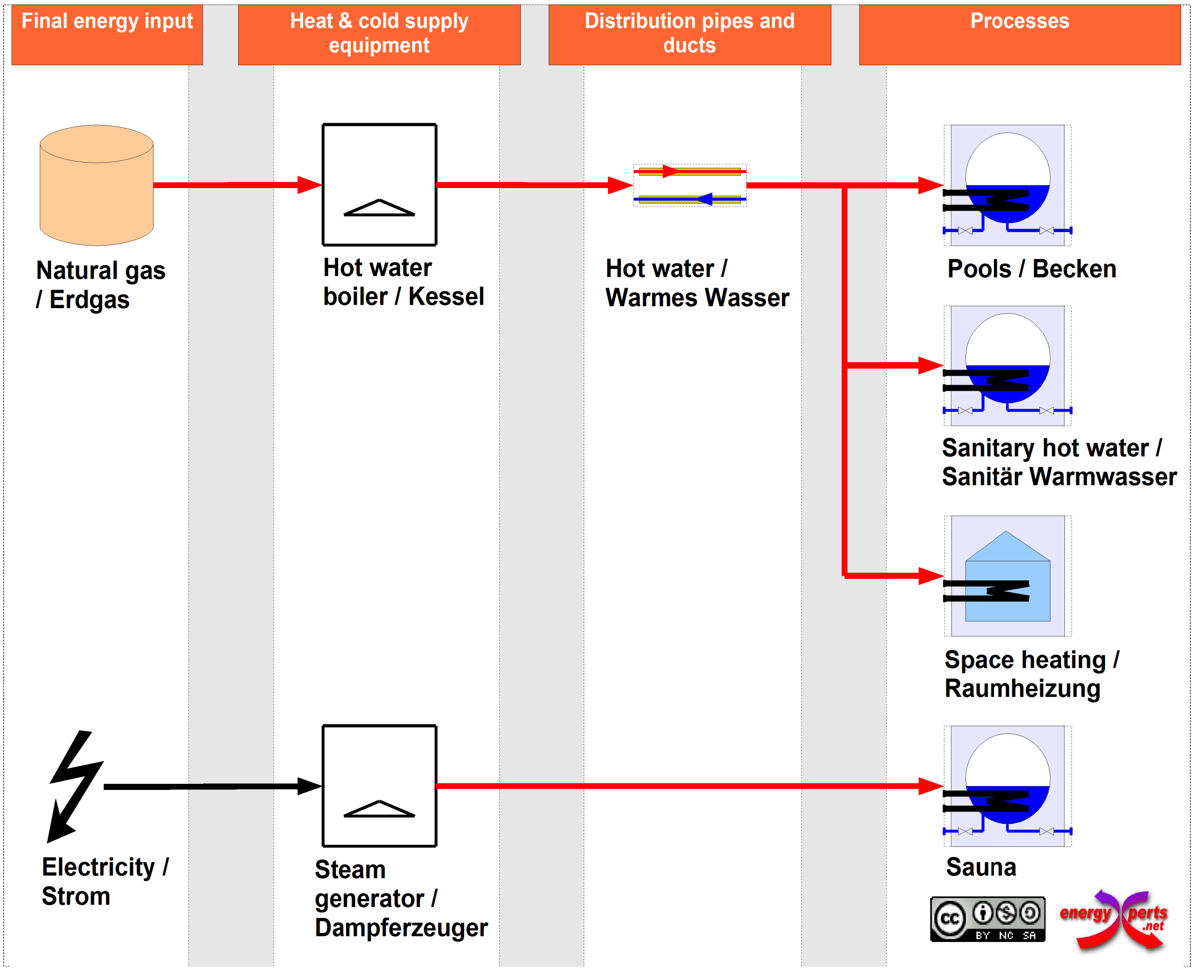

Figure 4. Overview of the heat and cold supply system

2.3. Additional comments

Specific assumptions

The hypothesis listed in Table 1 have been assumed by the auditors:

Table 1. Assumptions made by the auditor

1	Consumption of water for pools and sanitary uses		Constant during the year
2	Average ambient temperature	8,8ºC	Weather data of Potsdam data file
3	Waste water pool massflow	50% of inlet	It has been supposed that massflow of the water of pool (renovation, filtration) that c recovered corresponds to the 50% of th massflow, since some part is evaporated or
4	Temperature of waste water of the pools	28ºC	Estimated
5	Minimal renovation rate	1 volume / hour	Estimated
6	Electricity generated in the CHP		All the amount of electricity generated in th is suposed to be consumed on site.

3. Comparative study of alternative proposals

A comparative study of several technically feasible alternative proposals for energy saving has been carried out. In the following sections the alternatives are first shortly described and then the results of the comparative study are presented.

The scope of the EINSTEIN audit is focussed exclusively on the analysis and optimisation of the supply system of heating and cooling. Building optimisation is not included. It is strongly recommended to carry out a study on potential demand reductions in the building itself (building envelope, lighting, reduction of internal gains) and – in case of modifications – adapt the measures proposed in this study to the then reduced heating demands.

3.1. Proposed alternatives

The technical potential alternatives that have been investigated are listed in Table 2.

Table 2. Overview of the alternative proposals studied

CHP	**Installation of the CHP that the company expects to set up** **Cogenerative engine** (372 kWth / 237 kWel)
CHP + HP	1) Cogenerative engine as in the alternative "CHP" 2) Heat recovery: Installation of a **heat exchanger** (32 kW) to use waste water of pools to preheat inlet water of the same pools. 3) Optimisation of ventilation: - Active dehumidification: cooling air with a **heat exchanger** (143 kW). The transferred heat is used in an electrically driven **heat pump** (200 kW) to preheat water for processes and space heating. - Reduction of rate of air renovation
CHP + AC	Idem to alternative "CHP + HP", but dehumidification is carried out with an absorption chiller (150 kW) instead of the heat pump (200 kW). A heat exchanger is also installed (224 kW)
CHP+ AC +ST	Idem to alternative "CHP + AC" with the addition of a solar thermal system (evacuated tube collectors) of 500 kW.
CHP2 + AC	Idem to alternative "CHP + AC" with the addition of another CHP system (cogenerative motor 372 kWth / 237 kWel)

3.2. Energy performance[1]

Table 3. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh] (1)	[MWh]	[%]
Present state	12.904	---	---
CHP	10.161	2.743	21,26
CHP + HP	8.362	4.542	35,20
CHP + AC	9.168	3.736	28,95
CHP + AC + ST	8.942	3.962	30,70
CHP2 + AC	7.801	5.103	39,54

Figure 5. Comparative study: yearly primary energy consumption.

1 The factors for conversion of final energy (for fuels in terms of LCV) to primary energy used in this study are 2,7 for electricity and 1,1 for natural gas.

3.3. Economic performance

Table 4. Comparative study: investment costs. Estimated co-funding: 30% for solar thermal and 10% for the rest of technologies.

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present state	---	---	---
CHP	194.500	175.050	19.450
CHP + HP	291.300	262.170	29.130
CHP + AC	296.300	266.670	29.630
CHP + AC + ST	678.991	534.554	144.437
CHP2 + AC	490.800	441.720	49.080

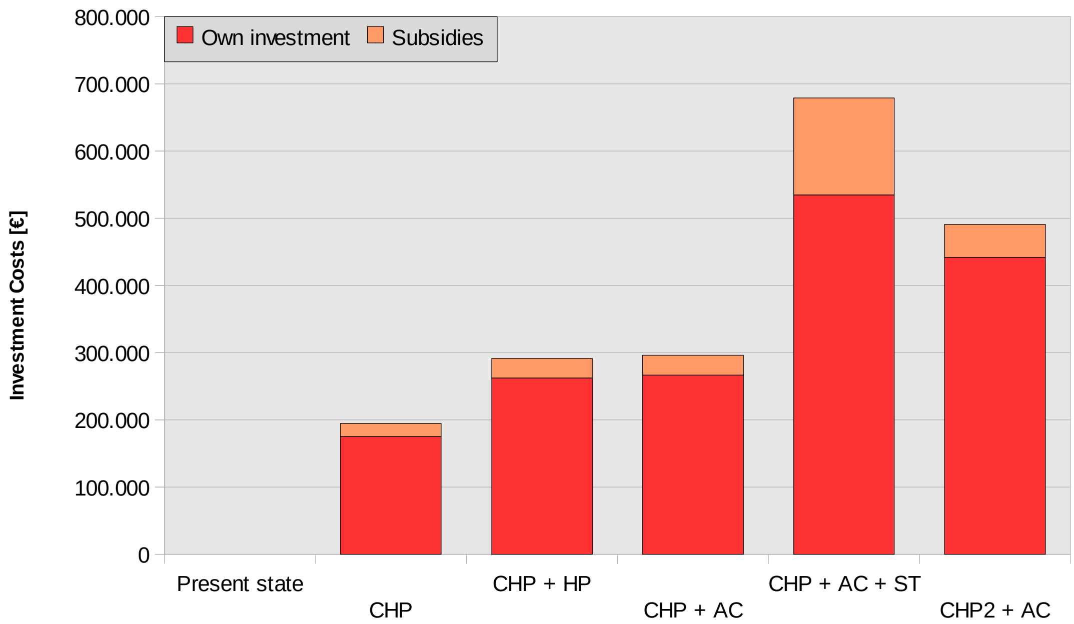

Figure 6. Comparative study: investment costs. Estimated co-funding: 30% for solar thermal and 10% for the rest of technologies.

Table 5. Comparative study: annual costs including annuity of initial investment[2].

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]	Total [€]
Present state	---	557.829	0	557.829
CHP	20.026	327.987	17.648	365.661
CHP + HP	29.993	298.598	18.152	346.742
CHP + AC	30.508	295.695	23.038	349.240
CHP + AC + ST	69.911	294.761	28.140	392.811
CHP2 + AC	50.534	259.808	33.076	343.418

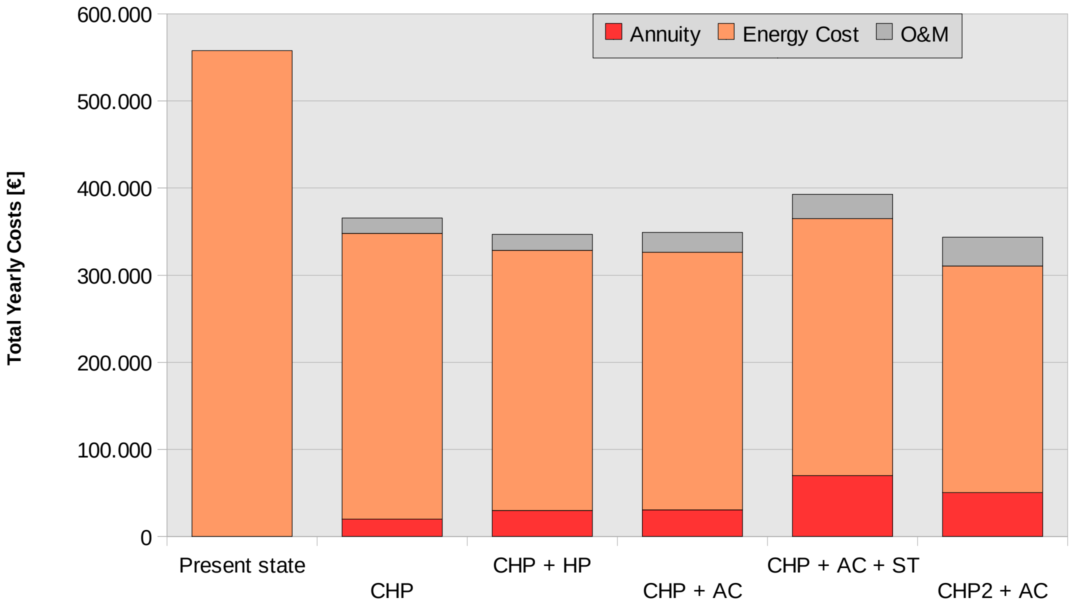

Figure 7. Comparative study: annual costs including annuity of initial investment.

2 Annuity of initial investment: 10,3 % of yearly payments, calculated based on 8 % nominal interest for external financing, 2 % general inflation rate and 15 years of economic depreciation period. Tariffs: 39,69 €/MWh for natural gas, 139,5 €/MWh for electricity, , 21€/MWh of feed-in tariff, 51 €/MWh for sold energy.

4. Selected alternative and conclusions

4.1. Selected alternative

The alternative proposal "CHP + HP" (cogeneration + heat pump) that combines:

- A customized heat exchanger network
- Addition of a CHP-engine
- Optimisation of ventilation system:
  - active dehumidification with a compression heat pump
  - reduction of rate of air renovation
  - use of latent heat from dehumidification by the heat pump to preheat water

has been considered the best option among the previously analysed due to the following reasons:

- high potential of both primary energy and energy cost savings
- the alternatives of combining the CHP plant with an absorption chiller (CHP + AC) and absorption chiller plus solar thermal system (CHP + AC + ST) have been discarded due to lower energy savings
- The addition of a second CHP engine (CHP2 + AC) is an interesting second option that can be taken into account, since the primary energy savings are very high (almost 40%) and the pay-back period is still acceptable.

Figure 8. Waves pool

In the following sections, the selected alternative is described in detail.

4.1.1. Building optimisation

Currently the rate of air renovation is higher than would be required for maintaining indoor air quality, due to the high humidity that reaches the atmosphere of the pool areas. This fact supposes a high additional energy demand to heat the inlet air.

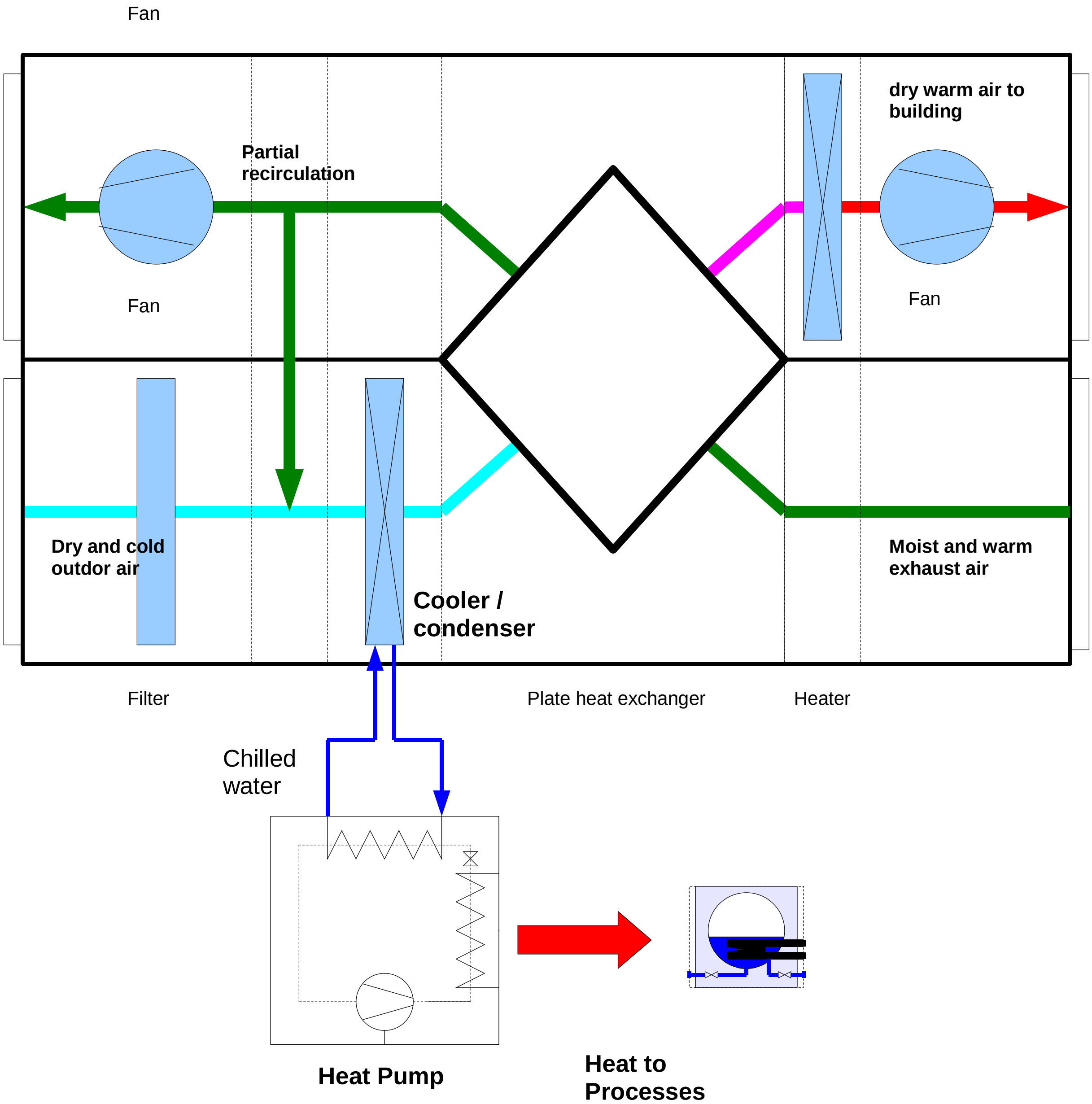

Figure 9. Scheme of the active dehumidification system proposed

In order to avoid this, it is proposed to perform an active dehumidification of air. This process consists in cooling the air down in order to condensate the content of water (dehumidification). After dehumidification, the outlet air is post-heated by heat exchange with the air flow before dehumidification and is then recirculated into the building. Therefore, the intake of cold outdoor air is lower and so is the corresponding energy demand.

Moreover, the latent heat extracted for the condensation of air humidity is used as low temperature heat source for an electrically driven heat pump, that supplies heat to the different processes (hot water for pools, sanitary uses or space heating). See Figure 9 .

4.1.2. Heat recovery

Two new heat exchangers are proposed:

- HX_pools: uses heat from the waste water of the pools to preheat the inlet water.
- HX_HP: uses waste latent heat of dehumidification as the low temperature heat source of the heat pump.

Table 6. List of heat exchangers proposed.

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX_Pools	71	Pool outflow	Pool inflow	104	7,66
HX_HP	143	Dehumiification	Heat pump	1.254	92,34
Total	**214**			**1358**	**100**

4.1.3. Heat and Cold Supply

In the new system proposed a compression heat pump is added to the system for air dehumidification and a cogenerative engine is added to supply heat to the whole system.

The technical specifications of the compression heat pump and the cogenerative engine are given in Table 7 and Table 8 respectively.

Table 7. Technical specifications and economics of the new heat pump

Parameter	Units	Technical data
Type of equipment	-	Compression heat pump
Nominal power (heat or cold output)	kW	200,00
COP	-	4,98
Turn-key price	€	50.000
Annual operational and maintenance fixed costs	€	500

Table 8. Technical specifications and economics of the new cogenerative engine

Parameter	Units	Technical data
Type of equipment	-	Cogenerative engine
Nominal power (heat or cold output)	kW	372,00
Fuel type	-	Natural gas
Fuel consumption (nominal)	kg/h	53,80
Electricity power input	kW	0,00
Electrical power generated (CHP)	kW	237,00
Electrical conversion efficiency (CHP)	-	0,35
Turn-key price	€	194.500
Annual operational and maintenance fixed costs	€	2.150
Annual operation and maintenance variable costs dependant on usage	€/MWh	5

The total and monthly contribution of the new equipments to the total heat supply is shown respectively in Table 9, Figure 10 and Figure 11.

Table 9. Contribution of the different equipments to the total useful heat supply (USH) in the company.

Equipment	USH by equipment	
	[MWh]	[% of Total]
Boiler	772	16,19
Electrical steam generator	87	1,83
New heat pump	1.569	32,90
New CHP	2.340	49,08
Total	**4.768**	**100**

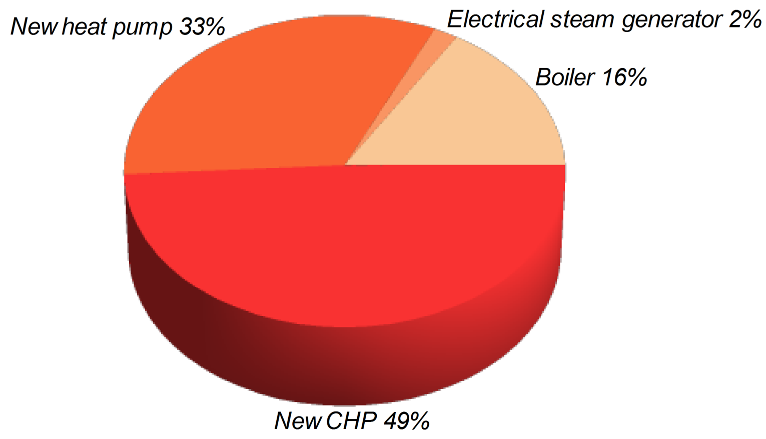

Figure 10. Contribution of the different equipments to the total useful heat supply (USH) in the company.

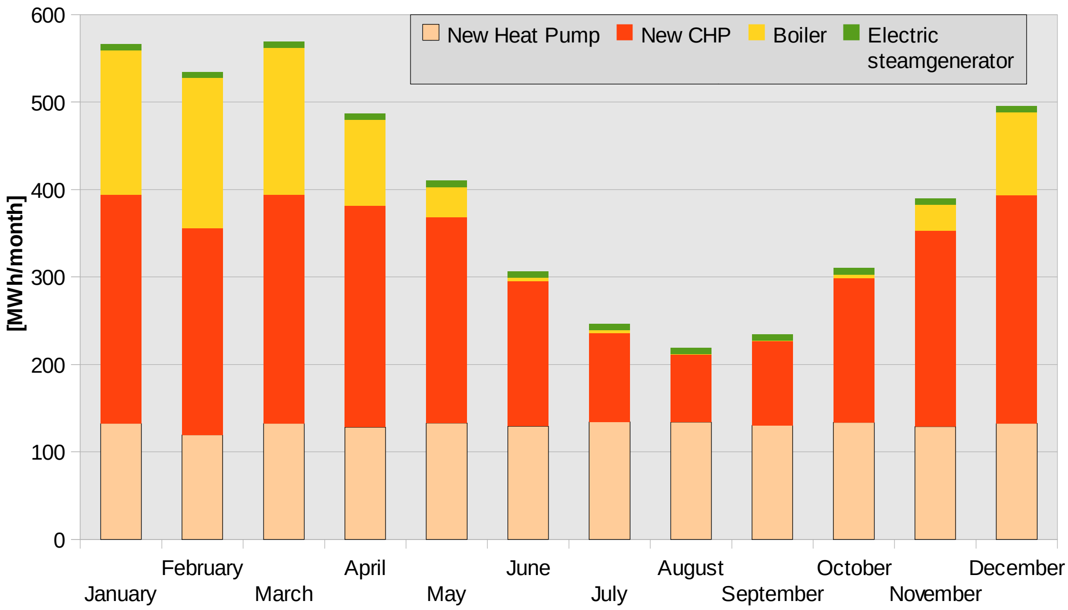

Figure 11. Contribution of the different equipments to the total useful cooling supply (USH) per month.

4.2. Summary: saving potential with respect to present state and economic performance

The following measures are proposed:

- A customized heat exchanger network
- CHP-engine of 237 kWe/372kWth
- Optimisation of ventilation system:
  - reduction of rate of air renovation
  - use of an absorption chiller (45 kWf) and a compression chiller (30 kWf) for active dehumidification
  - use of a customized heat exchanger to use waste heat of the chillers to preheat water

These measures allow to save 35,2% of the current primary energy consumption (including primary energy for non-thermal purposes. For thermal purposes only, the savings are 63%). Their application also saves 46,5% of energy cost (cost of fuel and electricity, including auto-generated electricity) under the supposed scenario of energy tariffs. It leads to a reduction of 37,8% of the total energy system cost (fuel and electricity, operation and maintenance, amortisation)

The total required investment is about 291.300 € and the expected pay-back time for the proposed investment is 1,2 years (taking into account the subsidies). The differential pay-back of the active dehumidification by heat pump (relative to the alternative CHP with only a cogeneration system and heat recovery) is 3,0 years.

Table 10. Comparison of the present state and the proposed alternative: saving potential and economic performance.

		Present state	**Proposed alternative**	**Savings**
Total primary energy consumption (1)				
Total	MWh	12.904	8.362	35,20%
- Total fuels	MWh	6.988	6.242	10,68%
- Total electricity	MWh	5.916	2.120	64,16%
Primary energy saving due to renewable energy	MWh	-	-	-
CO2 emissions	t/a	2.684	1.811	32,52%
Total annual energy system cost (2)	€	557.829	346742	37,84%
Total investment cost(3)	€	-	291300	-
Pay-back period (4)	a	-	1,2	-

(1) including primary energy consumption for non-thermal uses

(2) including energy cost (fuel and electricity bills), operation and maintenance costs and annuity of total investment. It also includes the feed-in-tariff revenue for the electricity produced by the CHP plant and sold to the net.

(3) total investment excluding subsidies.

(4) supposing 10% of funding of total investment (subsidies or equivalent other support mechanisms)