EINSTEIN thermal energy

industry audit

Energy Audit Summary Report

Audit No. 48 - DE

Märkisch Edel

Eberswalde, Germany

Food Industry

Industrial bakery

energyXperts.net

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Berlin (Germany) / Barcelona (Spain)
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2. Description of the company (status quo)

Reference year of data/information: 2010

(Date of the visit on site: 18.04.2011)

2.1. General information of the company

Company, location	Märkisch Edel, Eberswalde (Germany)	
Sector	industrial bakery	
Products	bread (full baked and half-baked), cakes	
Yearly production	about 2884 t (bread: 2628 t)	
Turnover	n.a.	
No. of employees	n.a.	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- gas oil	1.908	1.908
- electricity	723	211

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

(a) *(b)*

Figure 1. (a) General view of the production hall; (b) Sales shop.

2.2. Description of the company

a) Productive process

The company Eberswalder Brot- und Feinbackwaren produces the whole sortiment of baked products, producing bread, bread rolls, cakes, pastries, and confectionery.

The dough is either fully baked in the plant, or prepared as (cooled dough or half-baked and then frozen) raw product and then fully baked in the electrical ovens in the sales shops[1].

(a) *(b)*

Figure 2. Ovens (a) continous (Henff-) oven; (b) Stikken-ovens

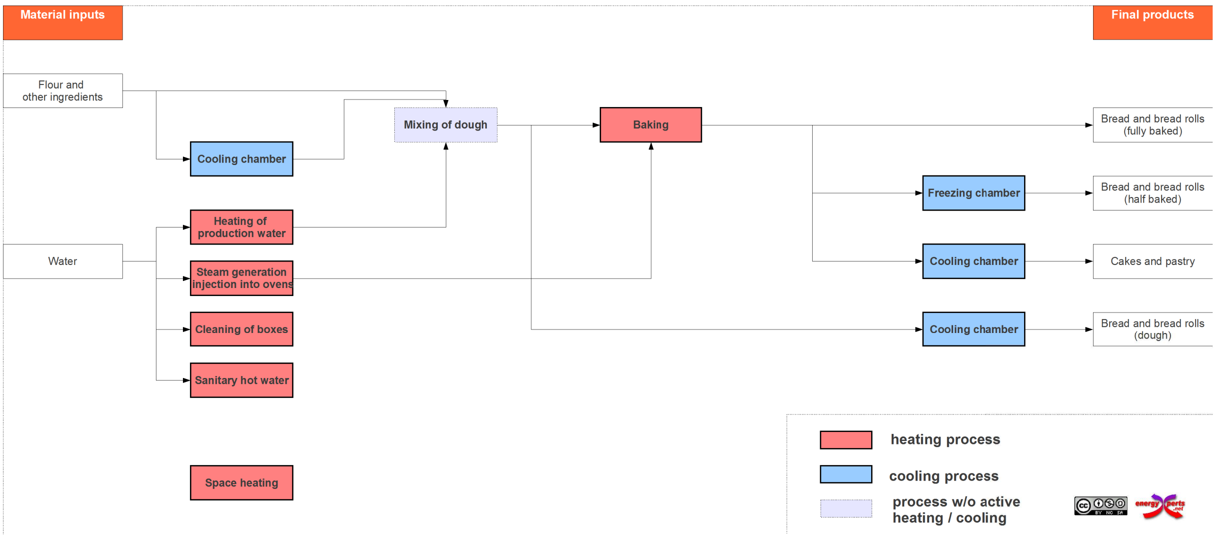

Figure 3. Simplified production flow sheet.

The most energy consuming processes in the company are the ovens (almost 70 % of the heating demand including steam injection)

1 Energy consumption of sales shops not included in the analysis.

b) Energy supply system

The heat used for the ovens is generated in a gas-oil fired thermal oil boiler, and then from this thermal oil circuit steam is generated for vapour injection into the ovens. The five smaller Stikken-ovens are direct fired. Hot water and space heating for offices and the production hall is generated in a separate hot water boiler, and the workshop of the company disposes of an independent boiler.

Cooling for the different cooling chambers is provided by different air-cooled electrically driven chillers.

(a)

(b)

Figure 4. (a) thermal oil boiler; (b) steam generator driven by thermal oil

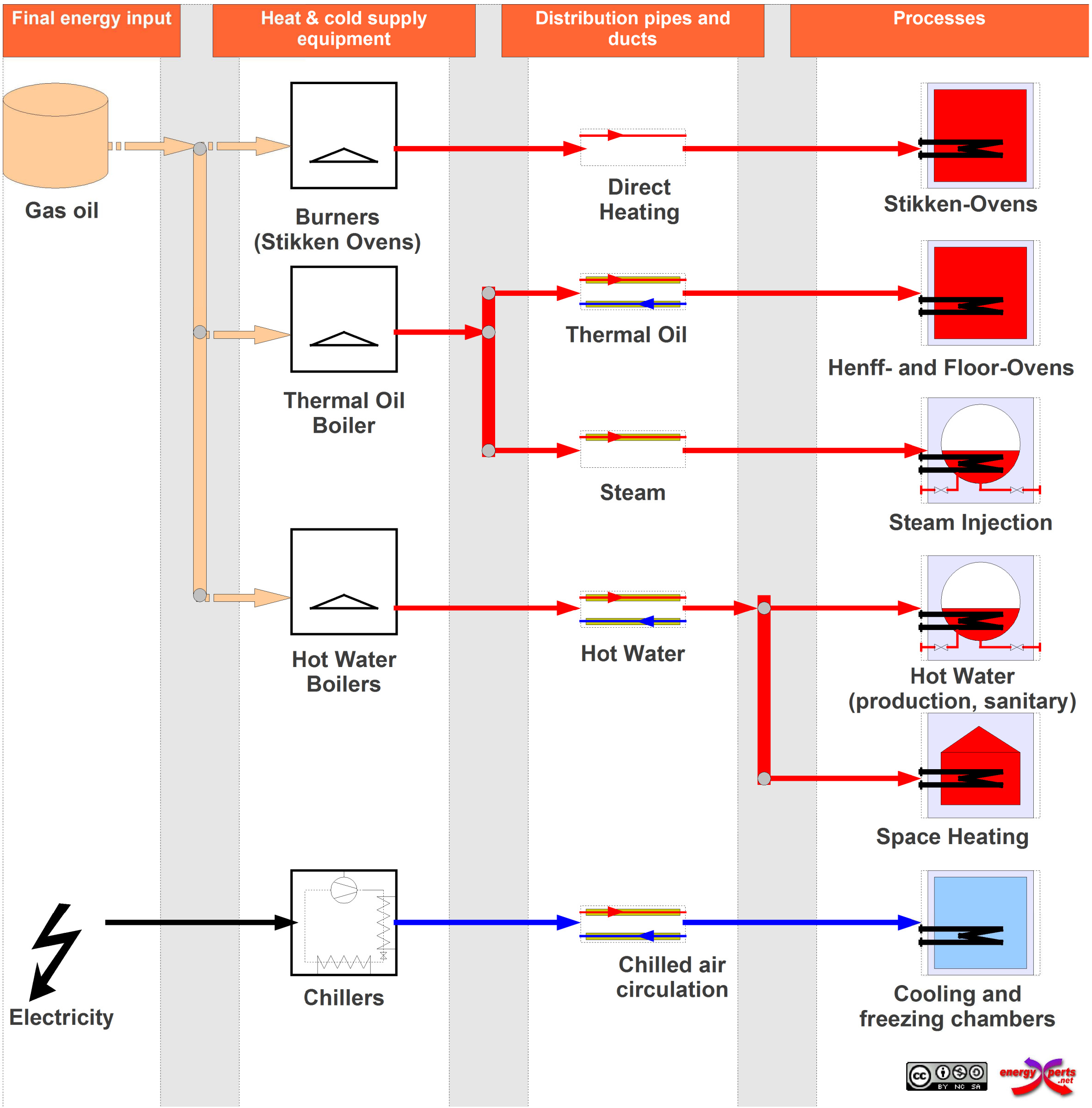

Figure 5. Overview of the heat and cold supply system

2.3. Additional comments

The distribution of the heat demand in the company on the different processes is approximate, based on the available data on product flows and estimated ratios of consumption.

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.

3.1. Proposed alternatives

The technical potential alternatives that have been investigated are listed in Table 1.

Table 1. Overview of the alternative proposals studied.

Short Name	Description
WRG	Heat recovery (Wärmerückgewinnung): 3 heat exchangers for recovery of heat from vapour of ovens (Schwaden, 30 kW), from waste water of the box washer (7 kW) and from the exhaust gas of the thermal oil boiler (21 kW) for preheating of water and space heating.
KWK	Cogeneration (Kraft-Wärme-Kopplung): Gasturbine of 100 kWe / 188 kWth for heating of ovens, generation of steam, hot water demands and space heating. (includes also the heat exchanger network from alternative WRG)

3.2. Energy performance[2]

Table 2. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	4.052	---	---
WRG	3.578	474	11,70
KWK	3.065	987	24,36

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

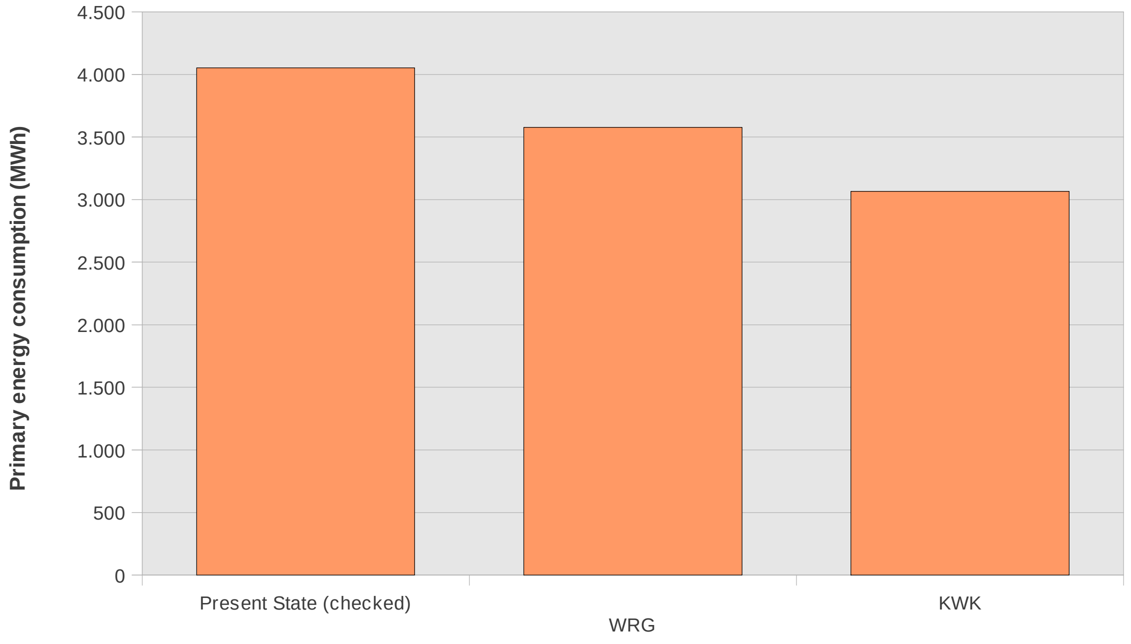

Figure 6. Comparative study: yearly primary energy consumption.

3.3. Economic performance

Table 3. Comparative study: investment costs. Estimated co-funding: 10 % for investment in heat recovery and CHP.

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present State (checked)	---	---	---
WRG	20.000	18.000	2.000
KWK	220.000	198.000	22.000

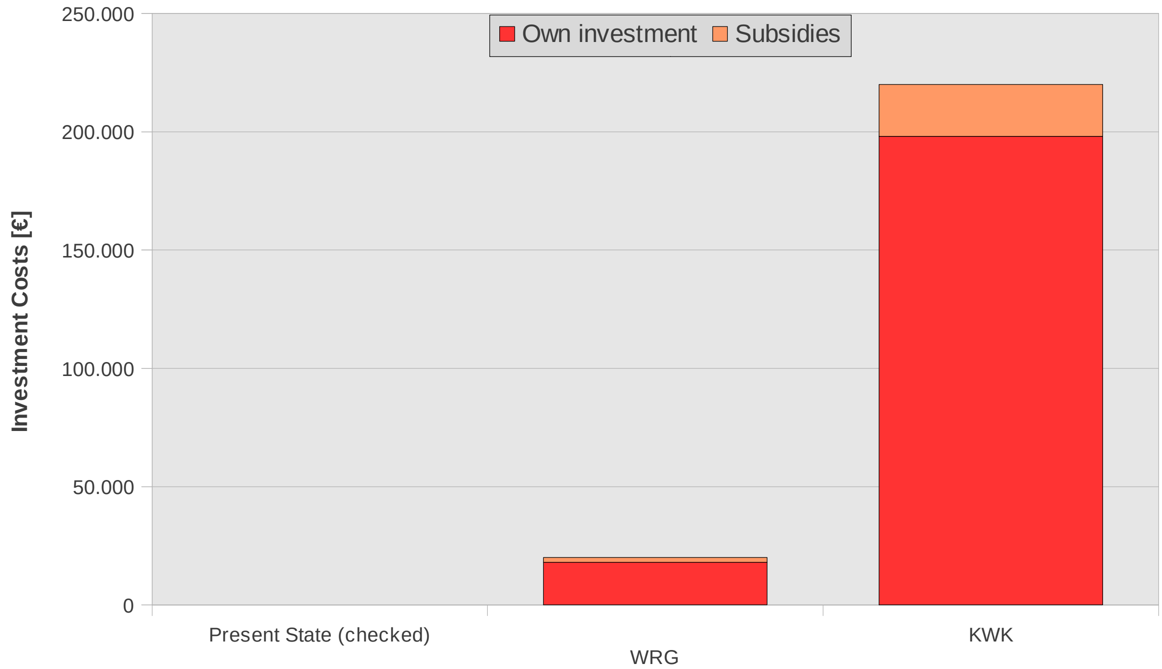

Figure 7. Comparative study: investment costs. Estimated co-funding: 10 % for investment in heat recovery and CHP.

Table 4. Comparative study: annual costs including annuity of initial investment[3]. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity of 21 €/MWh.

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]	Total [€]
Present State (checked)	---	201.297	0	201.297
WRG	2.059	176.186	1.600	179.846
KWK	22.652	114.935	7.650	145.237

3 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 (estimated): 60 €/MWh for gas oil, 40 €/MWh for natural gas, 120 €/MWh a for purchased electricity, 141 €/MWh for sold electricity (feed-in prime of 21 €/MWh).

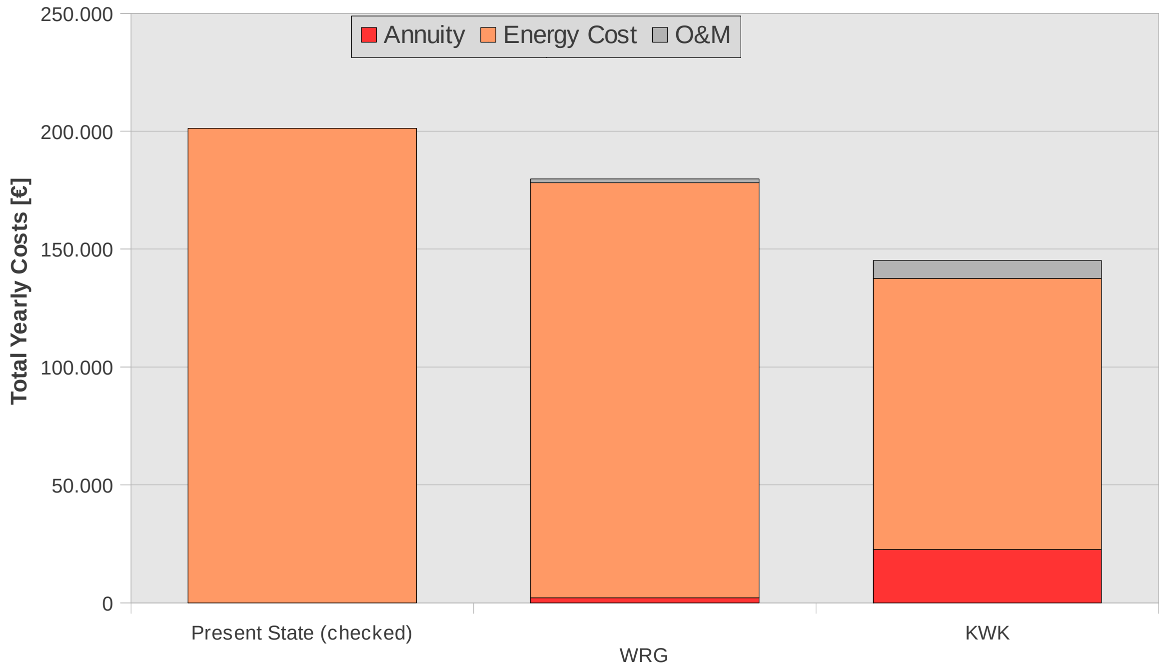

Figure 8. Comparative study: annual costs including annuity of initial investment (see Table 4).

4. Selected alternative and conclusions

4.1. Selected alternative

The alternative proposal "KWK" (cogeneration) that combines a customized heat exchanger network and a cogenerative gas turbine of 100 kW_e / 188 kW_{th} has been considered the best option among the previously analysed due to the following reasons:

- higher potential of both primary energy and energy cost savings
- very good economic performance

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

4.1.1. Process optimisation

The possibility of process optimisation has not been considered in this study as the information available on the existent equipment and on potential alternative technologies is not sufficient in order to carry out this assessment. Nevertheless this might be checked in the future, best before implementing the recommended measures.

4.1.2. Heat recovery

The proposed heat exchanger network consists of 3 heat exchangers for recovery of heat from vapour of ovens (Schwaden, 30 kW), from waste water of the box washer (7 kW) and from the exhaust gas of the thermal oil boiler (21 kW) for preheating of water and space heating (Table 5). As can be seen from Table 2, heat recovery leads to a saving of 11,7 % of the primary energy consumption.

Table 5. List of heat exchangers proposed.

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX Vapour ovens – Box washer	7	Vapour ovens	Box washer	35	11,32
HX Vapour ovens – Production water	23	Vapour ovens	Production hot water	151	48,62
HX Box washer – Sanitary HW	7	Waste water box washers	Sanitary hot water	22	7,06
HX Offgas – Space Heating and HW	21	Thermal oil boiler (exhaust gas)	Hot water and space heating	102	33,00
	59			**310,47**	**100**

4.1.3. Heat and Cold Supply

In the new system proposed a cogeneration plant (gas turbine) is added to the heat supply system. The CHP plant feeds heat into distribution for hot water and space heating. In addition, from the hot exhaust gas of the turbine steam is generated for the injection in the ovens, and a direct heating of the ovens is carried out.

Table 6. Heat and cooling supply equipments . Selected alternative.

Equipment	Type	Heat / cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat / cooling supply	
			[kW]	[MWh]	[%]
New CHP 2	CHP gas turbine	o==Thermoöl (thermal oil)==o o==Direktheizung==o o==Dampfleitung==o o==Warmwasser u Heizung==o o==Heizung Werkstatt==o	188	850	48,92
Thermoölkessel (thermal oil boiler)	steam boiler	o==Thermoöl (thermal oil)==o o==Dampfleitung==o	500	307	17,69
Brenner Stikkenöfen (Burners)	steam boiler	o==Direktheizung==o	390	91	5,21
Heisswasserkessel (hot water boiler)	hot water boiler	o==Warmwasser u Heizung==o	70	43	2,50
Heizung Werkstatt	hot water boiler	o==Heizung Werkstatt==o	18	5	0,30
Kälteanlagen	compression chiller (air cooled)	o==Kühlkammern==o	101	441	25,38

The technical specifications of the new CHP turbine are given in Table 7.

Table 7. Technical specifications and economics of the new CHP gas turbine.

Parameter	Units	Technical data
Type of equipment	-	CHP gas turbine
Nominal power (heat or cold output)	kW	187,50
Fuel type	-	Natural gas
Electrical power generated (CHP)	kW	100,00
Electrical conversion efficiency (CHP)	-	0,30
Parameter	**Units**	**Data**
Turn-key price	€	260000,00
Annual operational and maintenance fixed costs	€	1800,00
Annual operation and maintenance variable costs dependant on usage	€/MWh	5,00

The total and monthly contribution of the new equipments to the total heat supply is shown respectively in Table 8, Figure 9 and Figure 10 while the contribution to the cooling supply is shown in Table 9.

Table 8. Contribution of the different equipments to the total useful heat supply (USH) in the company.

Equipment	USH by equipment	
	[MWh]	[% of Total]
Thermoölkessel (thermal oil boiler)	307	23,70
Brenner Stikkenöfen (Burners)	91	6,99
Heisswasserkessel (hot water boiler)	43	3,35
Heizung Werkstatt	5	0,40
New CHP 2	850	65,56
Total	**1.297**	**100**

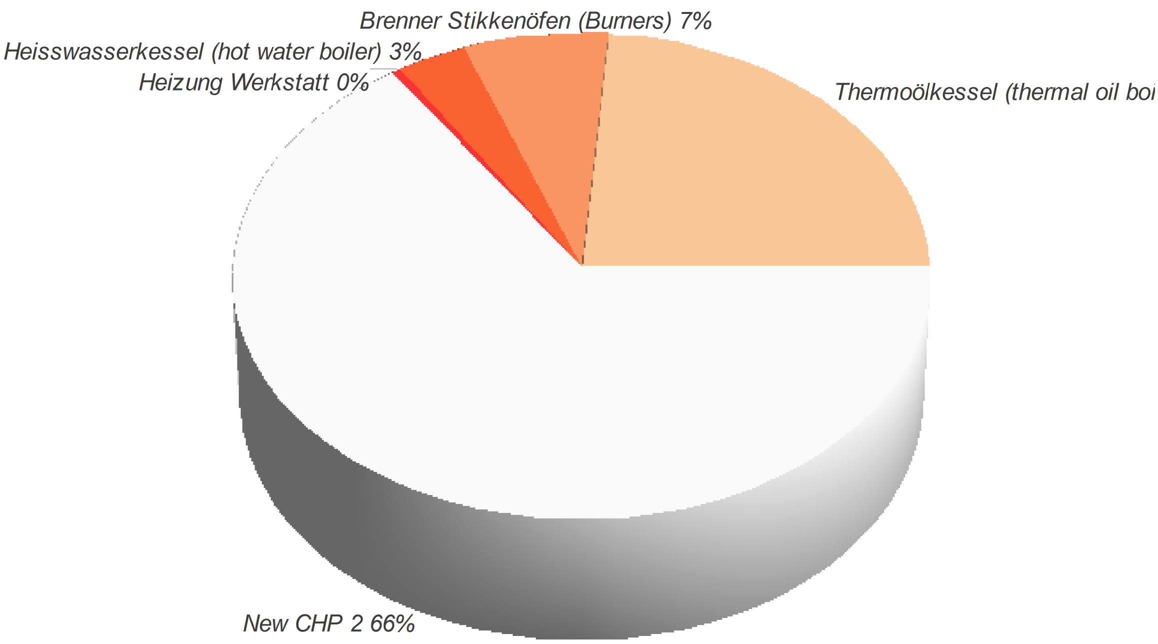

Figure 9. Contribution of the different equipments to the total useful heat supply (USH) in the company.

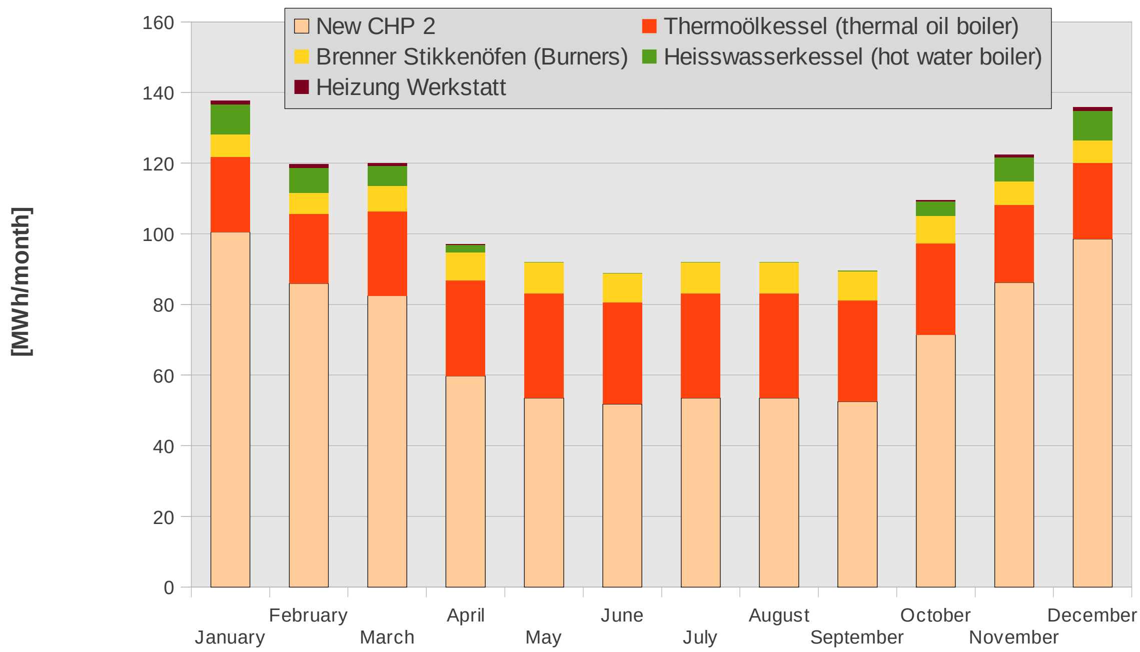

Figure 10. Contribution of the different equipments to the total useful cooling supply (USH) per month.

Table 9. Contribution of the different equipments to the total useful cooling upply (USC) in the company. Estimated data; no breakdown available for different temperature levels / processes.

Equipment	USC by equipment	
	[MWh]	[% of Total]
Kälteanlagen	441	100,00
Total	**441**	**100**

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

The following measures are proposed:

- heat recovery: use of waste heat from vapours (ovens), waste water (box washer) and exhaust gas (thermal oil boiler) for preheating of water and space heating
- cogeneration (gas turbine) for covering the base load of the remaining heat demand

These measures allow to save 24 % of the current total primary energy consumption and 43 % of current energy cost. The total required investment is about 220.000 € and the expected pay-back time is 2,7 years (considering possible subsidies).

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

	U.M.	Present state	Alternative	Saving
Total primary energy consumption (1)				
- total	*MWh*	*4.052*	*3.065*	*24,36%*
- fuels	*MWh*	*2.099*	*2.655*	*-24,57%*
- electricity	*MWh*	*1.953*	*450*	*76,94%*
Primary energy saving due to renewable energy	*MWh*	*0*	*0*	-
CO_2 emissions	t/a	*839*	*678*	*19,21%*
Annual energy system cost (2)	*EUR*	*201.297*	*145.237*	*27,85%*
Total investment costs (3)	*EUR*	-	*220.000*	-
Payback period (4)	*years*	-	*2,7*	-

(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)