EINSTEIN thermal energy industry audit

# Energy Audit Summary Report

## Audit No. 61 - GER08

# DIN Building

## Berlin, Germany


energyXperts.NET
Berlin (Germany) / Barcelona (Spain)

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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: 2010-2011*

*(Date of the visit on site: 14-02-2012)*

## 2.1. General information of the company

| | | |
|---|---|---|
| Company, location | DIN Berlin (Germany) | |
| Sector | Offices, conferences | |
| Turnover | 65 M€ | |
| No. of employees | 570 plus 200 visitors day | |
| Current final energy consumption [MWh] (*) | total | for heating and cooling |
| - local district heating network | 3.503 | 3.503 |
| - electricity | 1.533 | 152 |

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

## 2.2. Description of the building

*a) Activity*

The company has five main buildings areas, which have a total surface of around 46.000 $m^2$ used mainly as offices. For the analysis, the building has been divided according to the current disposition of meter readers for district heating:

– Reader 1: Altbau (1964) and area I (1974-1978): this zone includes the cantine, server room printing workshop, etc. Windows are good standard, but the facade is old and poorly insulated.

– Reader 2: Area II (1974-1978) and Area III (1992): this area gets very warm in summer due to the glass walls.

– Reader 3: Area IV (Humboldt Haus) (1997): this area comprises many conference rooms. Part of the building is rented to other companies. It is better insulated.

All areas are heated in winter. Only some spaces are refrigerated in summer, some of them are cooled the whole year (many conference rooms, the central computer room, etc).

Sanitary hot water demand and hot water for the cantine is needed during the whole year. The building opens from 7 to 20h.

*Figure 1. Zone I and Altbau (grey) and zone III (glass)*

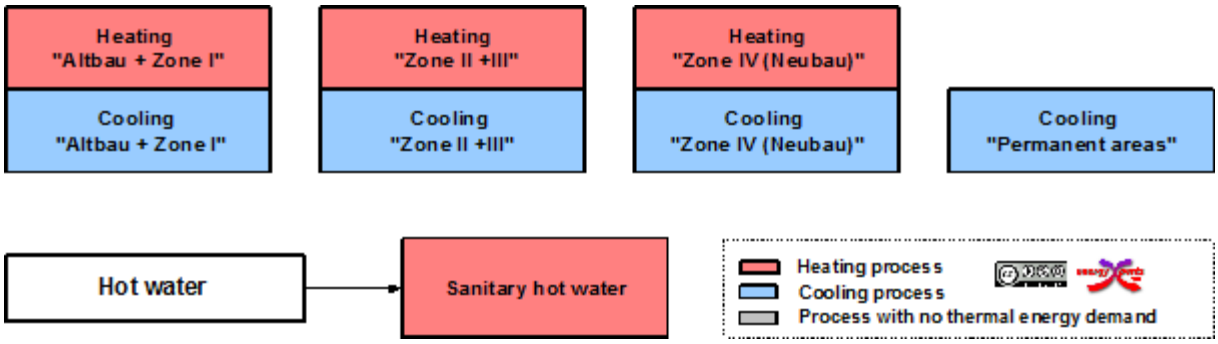


*Figure 2. Overview of heating and cooling demands.*

The highest heating demand corresponds to building IV, while the highest cooling demand comes from zone II and III.

*b) Energy supply system*

Space heating is connected directly to the local city district heating network. Sanitary hot water is generated by district heating as well as electrical boilers (negligible).

Cooling is provided by electrically driven chillers (indirect air cooled).

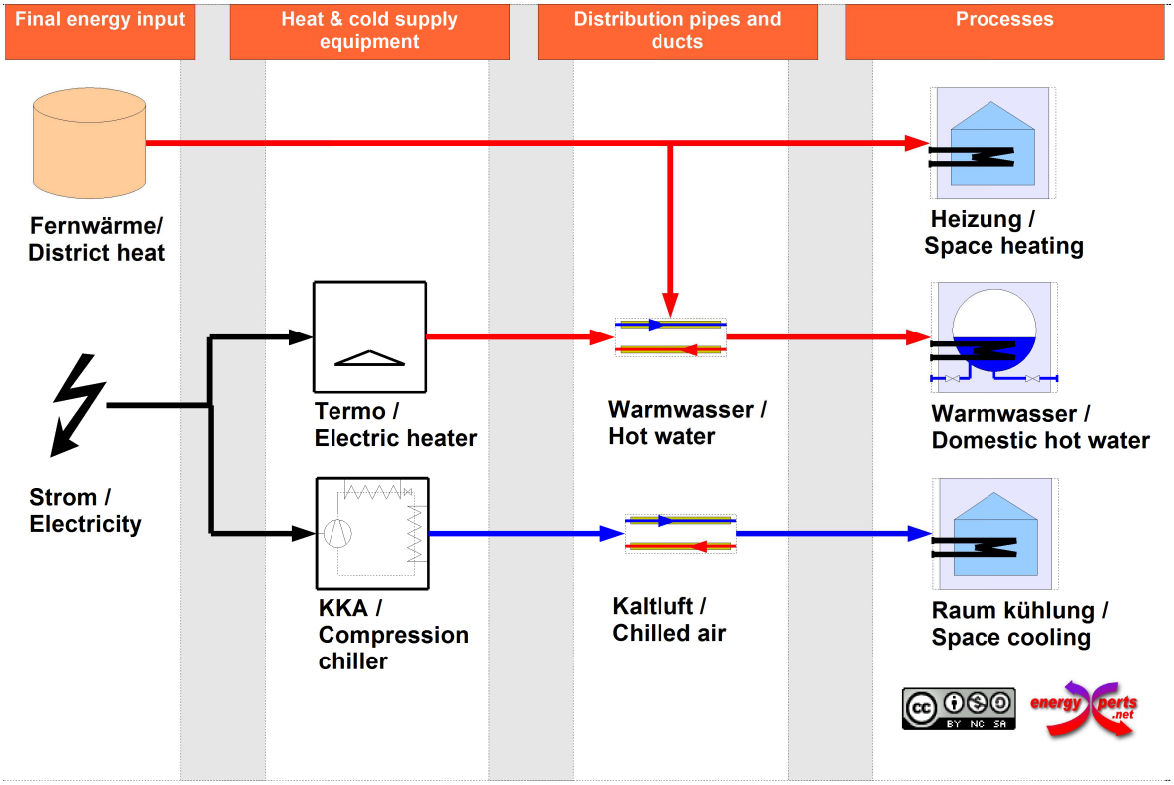


*Figure 3. Overview of the heat and cold supply system*

# 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 and cooling demands.

## 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 |
|---|---|
| HR | **Heat recovery**<br>- Installation of diverse **heat exchangers** (total power 18 kW) to recover heat in the current AHUs (air handling unit) which do not have heat recover yet. |
| HR + ST + AC | **Heat recovery + Solar Thermal + Absorption chiller**<br>- Solar thermal system (Evacuated Tube Collector) 1.000 kW<br>- Absorption chiller (75 kW Kälte)<br>- Measures taken in alternative “HR” |
| HR + CHP | **Heat recovery + Cogeneration**<br>- Cogenerative gas engine (663 kWth / 398 kWel)<br>- Measures taken in alternative "HR" |
| HR + Trigeneration | **Heat recovery + Trigeneration**<br>- Cogenerative gas engine (663 kWth / 389 kWel)<br>- Absorption chiller (150 kW Kälte)<br>- Measures taken in alternative “HR” |

## 3.2. Energy performance[1]

*Table 2. Comparative study: yearly primary energy consumption.*

| Alternative | Primary energy consumption | Savings | |
|---|---|---|---|
| | [MWh] (1) | [MWh] | [%] |
| Present state | 6.125 | --- | --- |
| WRG | 6.066 | 59 | 1,0 |
| WRG + Solar ETC + AKA | 5.839 | 286 | 4,7 |
| WRG + KWK | 5.402 | 723 | 11,8 |
| WRG + KWKK | 5.476 | 649 | 10,6 |

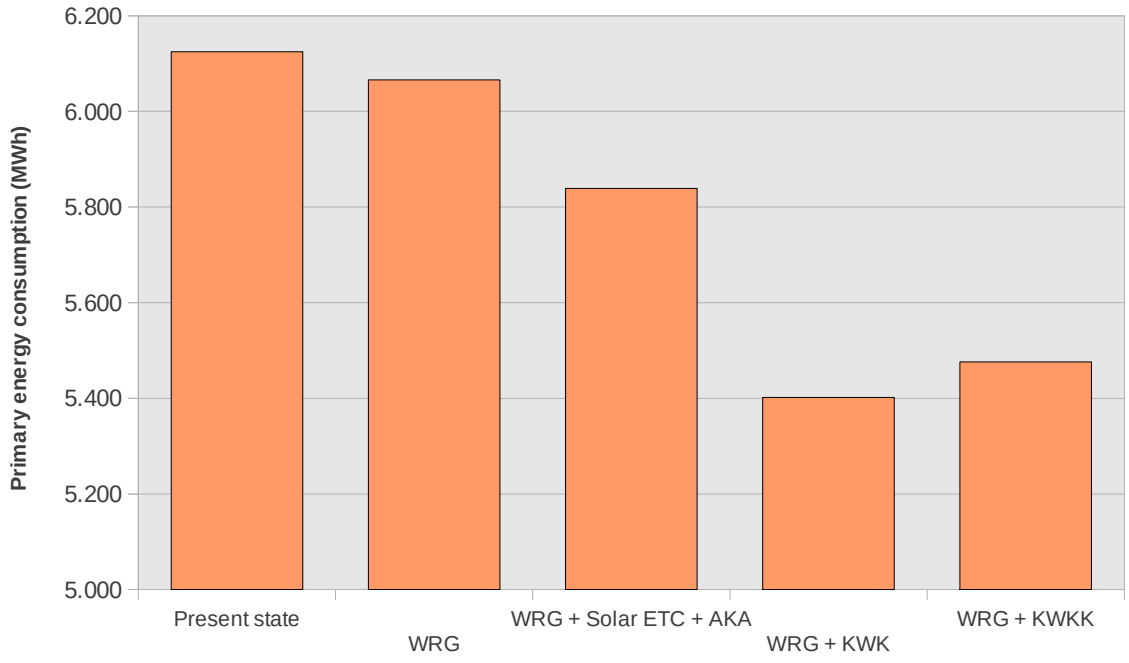


*Figure 4. Comparative study: yearly primary energy consumption.*

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, 1,1 for natural gas and 0,567 for district heat.

## 3.3. Economic performance

*Table 3. Comparative study: investment costs. Estimated co-funding: 30% for solar thermal and 10% for the rest of technologies.*

| Alternative | Total investment [€] | Own investment [€] | Subsidies [€] (1) |
|---|---|---|---|
| Present state | --- | --- | --- |
| WRG | 33.000 | 29.700 | 3.300 |
| WRG + Solar ETC + AKA | 794.563 | 567.294 | 227.269 |
| WRG + KWK | 339.460 | 305.514 | 33.946 |
| WRG + KWKK | 384.460 | 346.014 | 38.446 |

(1) Supposed: 30 % subsidies for solar thermal; 10% for other measures.

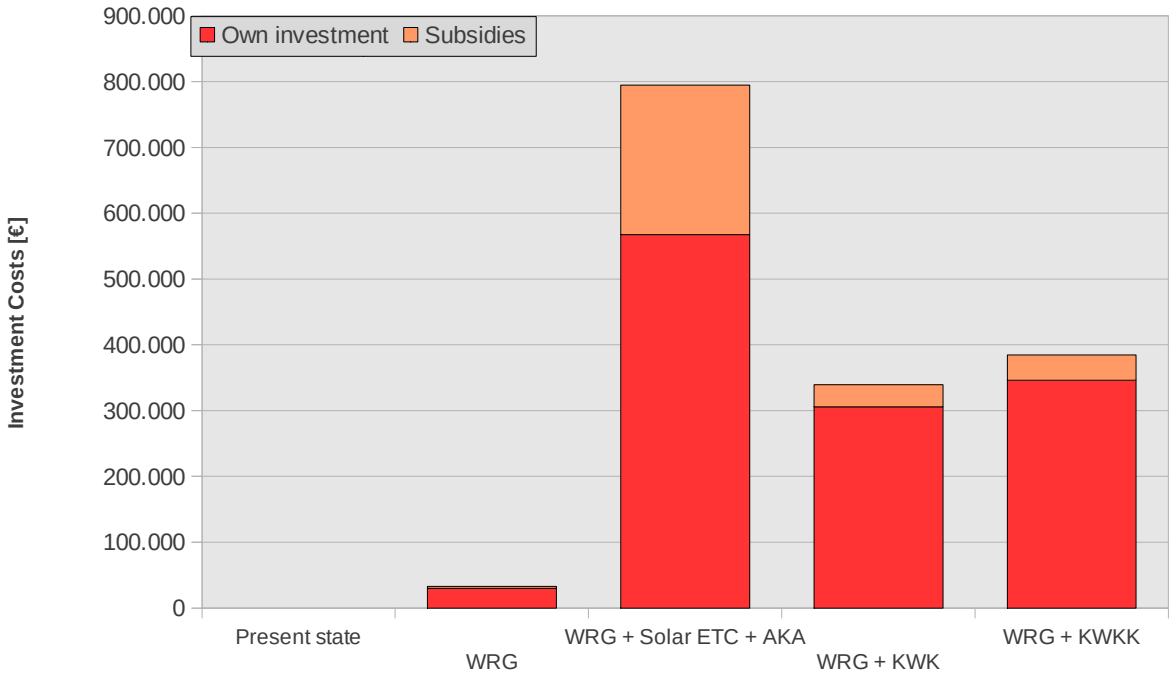


*Figure 5. Comparative study: investment costs. Estimated co-funding: 30% for solar thermal and 10% for the rest of technologies.*

*Table 4. Comparative study: annual costs including annuity of initial investment[2]. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity.*

| Alternative | Annuity [€] | Energy Cost [€] | O&M [€] | Total [€] |
|---|---|---|---|---|
| Present state | --- | 471.563 | 0 | 471.563 |
| WRG | 3.398 | 464.788 | 2.660 | 470.846 |
| WRG + Solar ETC + AKA | 81.810 | 440.948 | 16.285 | 539.043 |
| WRG + KWK | 34.952 | 280.389 | 18.663 | 334.004 |
| WRG + KWKK | 39.585 | 299.286 | 20.257 | 359.128 |

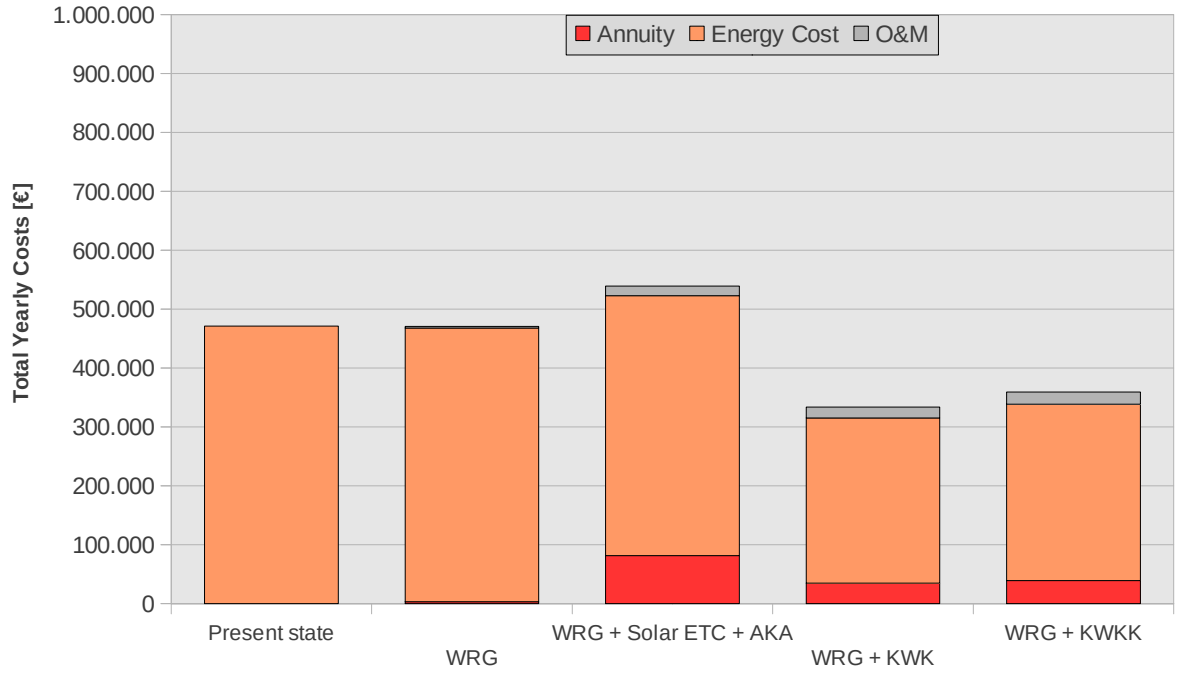


*Figure 6. Comparative study: annual costs including annuity of initial investment. he energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity.*

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: 60,7 €/MWh for district heat, 45 €/MWh for natural gas, 157,8 €/MWh a for purchased electricity, 72 €/MWh for sold electricity.

# 4. Selected alternative and conclusions

## 4.1. Selected alternative

The alternative proposal "HR + CHP" that combines a customized heat exchanger network and a cogenerative gas engine of 398 $kW_e$ /663 $kW_{th}$ 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 trigeneration (combination of the cogenerative plant with an absorption chiller (KWKK) and solar cooling (absorption chiller plus solar thermal system AKA + ST) have been discarded due to lower energy savings. In this case, the compression chiller is more efficient than the connection of a thermal chiller to the district heat, to a CHP or to the solar system.
- the addition of a solar system to the proposed system to generate hot water is an interesting second option that can be taken into account.

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

### 4.1.1. Building optimisation

The scope of the EINSTEIN audit is focussed exclusively on the analysis and optimisation of the supply system of heating and cooling. Nevertheless, the heat demand of the buildings has been analysed in order to detect a possible potential for building optimisation. In Table 5 the specific heat demand for each area is shown:

*Table 5. Specific heat demand [kWh/m2] per building area:*

| | Mwh | % | m² | kWh/m² |
|---|---|---|---|---|
| **Alt + Zone I** | 1106 | 32% | 9.714 | 114 |
| **Zone II + III** | 1511 | 44% | 14.204 | 106 |
| **Zone IV** | 832 | 24% | 12.749 | 65 |

### 4.1.2. Heat recovery

The proposed heat exchanger network uses heat from the air outflow to preheat the air inflow of those AHUs (air handling units) which currently do not have a heat exchanger. (See Table 6). As can be seen from Table 2, heat recovery leads to a saving of 1 % of the primary energy consumption after process optimisation.

*Table 6. List of heat exchangers proposed.*

| Heat Exchanger | Power | Heat Source | Heat Sink | Heat transferred | |
|---|---|---|---|---|---|
| | [kW] | | | [MWh] | [%] |
| HX_AltbauZone1 | 3 | Space Heating Zone I + Altbau | Space Heating Zone I + Altbau | 17 | 17 |
| HX_Zone23 | 5 | Space Heating Zone II + III | Space Heating Zone II + III | 33 | 32 |
| HX_Zone4 | 8 | Space Heating Zone IV (Neubau) | Space Heating Zone IV (Neubau) | 53 | 51 |
| | 15 | | | **103** | **100** |

### 4.1.3. Heat and Cooling Supply

In the new system proposed a cogeneration plant (gas engine) is added to the heat supply system. The CHP plant feeds heat into the existing hot water network. No changes have been introduced in the cooling supply.

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

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

| Parameter | Units | Data |
|---|---|---|
| Type of equipment | - | CHP Engine |
| Nominal power (heat or cold output) | kW | 663 |
| Fuel type | - | Natural Gas |
| Fuel consumption (nominal) | kg/h | 93 |
| Electrical power generated (CHP) | kW | 398 |
| Electrical conversion efficiency (CHP) | - | 0,34 |
| Contribution to total annual heat supply | MWh | 3.105 |
| Relative contribution to total annual heat supply | % | 75 |
| Turn-key price | € | 306.460 |
| Annual operational and maintenance fixed costs | € | 3.582 |
| Annual operation and maintenance variable costs dependant on usage | €/MWh | 4 |

The total and monthly contribution of the new equipment to the total heat supply is shown respectively in Table 8, Figure 7 and Figure 8.

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

| Equipment | USH by equipment | |
|---|---|---|
| | [MWh] | [% of Total] |
| District Heat | 294 | 8,7 |
| **New CHP** | 3.105 | 91,4 |
| **Total** | **3.399** | **100** |

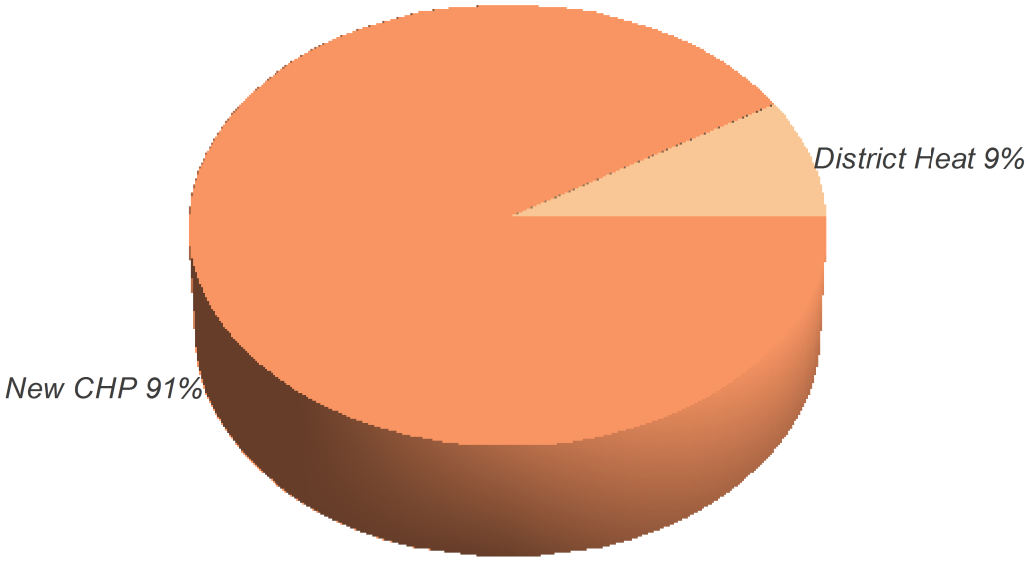


*Figure 7. Contribution of the different equipments to the total useful heat supply (USH) in the company.*

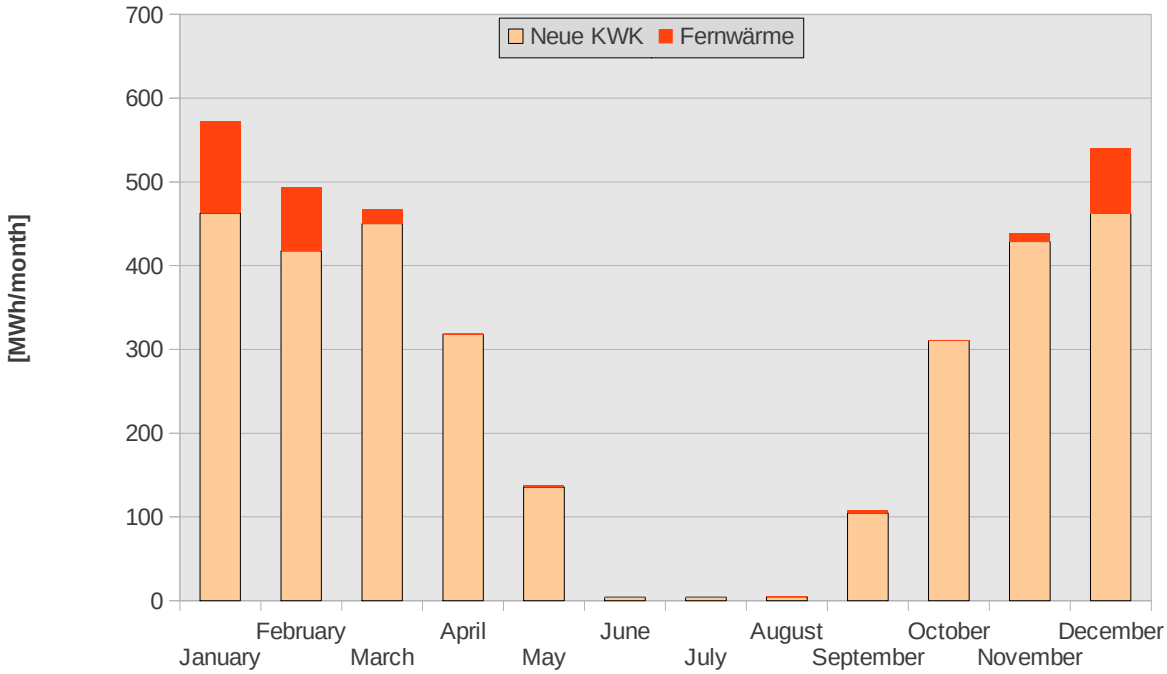


*Figure 8. Contribution of the different equipments to the total useful heat supply (USH) per month.*

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

The following measures are proposed:

- heat recovery: use the air outflow of some of the AHUs to preheat the air inflow
- cogeneration (gas engine) for covering the base load of the remaining heat demand

These measures allow to save 12% of the current primary energy consumption (including primary energy for non-thermal purposes. For thermal purposes only, the savings are 30%), even if in present state heat is drawn from a district heating network already fed partially by CHP. They also save 41% of current energy cost (cost of fuel and electricity, including auto-generated electricity) and leads to a reduction of 29% of the total energy system cost (fuel and electricity, operation and maintenance, amortisation). The total required investment is about 339.460 € and the expected pay-back time is 1,9 years (taking into account the subsidies).

*Table 9. Comparison of the present state and the proposed alternative: saving potential and economic performance.*

| | | **Present state** | **Alternative** | **Savings** |
|---|---|---|---|---|
| Total primary energy consumption (1) | | | | |
| Total | MWh | 6.125 | 5.403 | 12% |
| - Total fuels | MWh | 1.986 | 7.215 | -263% |
| - Total electricity | MWh | 4.139 | -1.812 | 144% |
| Primary energy saving due to renewable energy | MWh | | | - |
| CO2 emissions | t/a | 1.467 | 1.325 | 9,69% |
| Total annual energy system cost (2) | € | 471.563 | 334.004 | 29,17% |
| Total investment cost (3) | € | - | 339.460 | - |
| Pay-back period (4) | a | - | 1,9 | - |

*(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)*