Energy Audit Summary Report
Austrian Energy Agency
Audit no.01 – AUT01

Hospital

AUSTRIAN ENERGY AGENCY

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AUDIT no. 01 – AUT01

Hospital, Vienna

1. Data of the auditor

1.1. Contact data of the auditor

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Energy Expert (not Energy Auditor), several energy audits performed (more than 10, each)

Audit date: 19.1.2011

Duration: Several hours on-site for data acquisition and on-site visit

2. Introduction

2.1. Objectives

First objective was to gain data on energy supply and demand in this hospital. The difficulty is that the whole hospital has more than XX buildings and the energy demand is only available on this level. EINSTEIN was tested in one rather simple building where all technologies are used. The second objective was to find energy saving opportunities.

3. Status Quo: processes, distribution, energy supply

Use charts, diagrams, sheets of EINSTEIN as far as possible in all chapters and minimise the necessary explanations, but add descriptive text where necessary to understand what is done in the company

3.1. General info of company

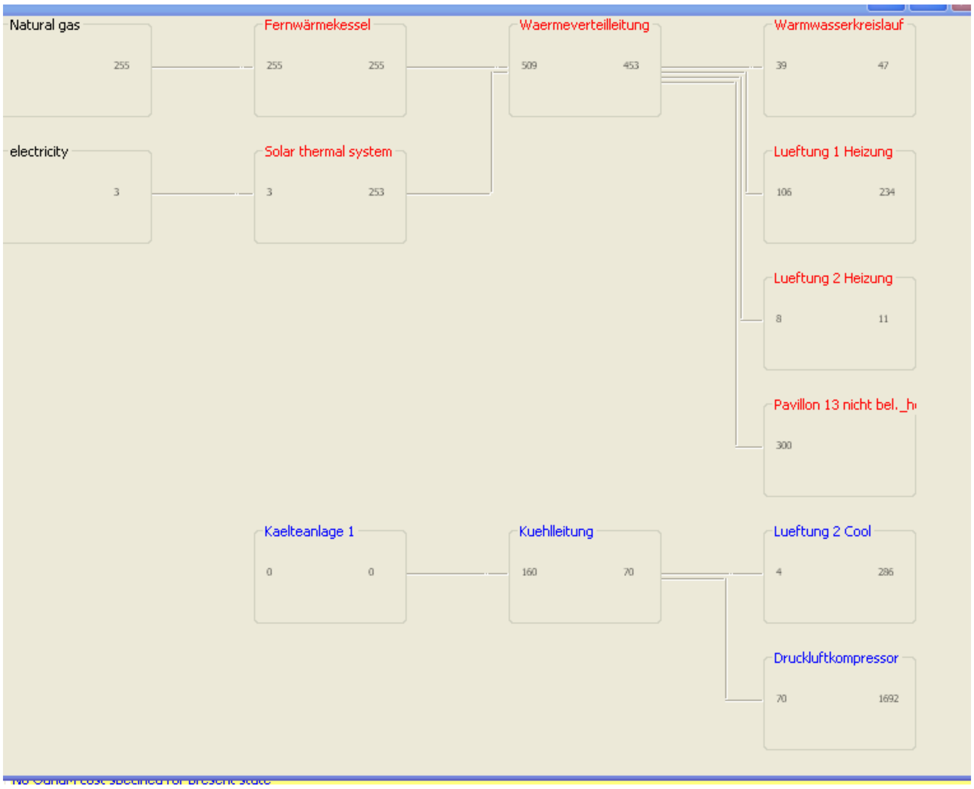
Pavillon 13 is one (out of XX(several) buildings) Hospital, Vienna. It has four floors (with an area of around 700 m² each). The whole "conditioned" area was estimated at 3.200 m². It has 44 beds, several ambulances and therapeutic rooms. During a refurbishment in 2005 the whole HVAC System was modernized. The building is conditioned with radiators, two ventilation systems and a cooling machine.

3.2. Flow sheet of the whole manufacturing side (processes, distribution, energy supply) in form of a block diagram

The main processes defined in EINSTEIN are:

- Heating via radiators of the non-fully air conditioned part of the building, installed power 390 kW.
- Ventilation (incl. heating) of one part of the building (Nass- und Nebenräume),

- o Ventilation, Air conditioning (incl. cooling) of another part of the building (Behandlungsräume) (installed power 170 kW)
- o Hot Water production for the whole building (180 kW), the (cool feed up) water demand was given by 711 m³/a.



Energy Supply:

In reality the hospital is fully supplied by district heat. The nominal heating power was planned for the following power of the relevant heat exchangers:

- o 177 kW for heating of ventilation air flow
- o 390 kW for the heating radiators (for this power it is expected to be too big, as half of the building is now air conditioned)
- o 180 kW for domestic hot water

Data of the district heating demand was analyzed but is not very accurate or realistic. For cooling a chiller is installed (Rhoss, 2005, cooling power: 36,6 kW, R 407/e) (8°C/12°C). For cooling of the ventilation for "Behandlungsräume a heat exchanger with 21 kW power is installed, in addition there are 15 fan coils in the whole building.

3.3. Description of the existing system

- ***Energy Supply***

There is no real estimate for the primary energy consumption as the district heat energy meter is quite unrealistic.
Primary energy consumption, Final energy consumption (FEC) per fuel, final energy demand thermal (FET), useful supply heat (USH), Fuel and electricity demand

- ***Distribution system***

There are two main distribution systems. The hot water pipes (for the radiation heating circuit, for the heating of the ventilation system and for the domestic hot water)
The water circuit for the radiators is around supply line 60°C/return flow of 40°C, the cooling water circuit 8/12°C. The domestic hot water is heated up from 10°C to around 55°C.

- ***Main energy consuming energy processes and buildings***

In EINSTEIN there were the following processes defined:

Ventilation 1 (Nass- u. Nebenräume), Heating:

The air flow is 10.000 m³/h, heating up of ambient air to 24°C/20°C (an average temperature of 6°C was calculated for the mean temperature in the months September through April, a detailed schedule was defined: 6-22 Uhr level 2 (10.000 m³); 22-6 Uhr on level 1 (approx. 6.500 m³/h). For this process already a internal heat recovery exists. (unfortunately no temperature measurement was available for estimating the efficiency of this heat exchanger).

Ventilation 2 (Behandlungsräume), Heating:

The max. air flow is 2.000 m³/h, heating up of ambient air from average 6°C to 24°C/20°C.
The system is switched on from Monday till Friday from 7-18 o clock. On Saturday and it is Sunday switched off. The system is equipped with an variable speed drive but the air flow is more or less constant at 1.600 m³/h. For this process already a internal heat recovery exists.

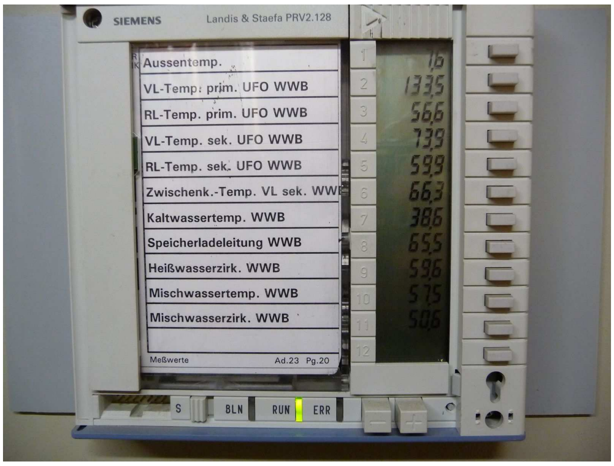
(unfortunately no temperature was available for estimating the efficiency of this heat exchanger)

Ventilation (Behandlungsräume), Cooling:

This air flow is cooled down in the summer time (May, September) to 17°C.
In reality this air flow has to be heated up to 20°C even during the summer period.

Domestic hot water

The heat demand of this process is not directly measured. The water is circulating, but feed in water is measured at 711 m³/a. This water demand is questioned as it is quite low.



Air Compressor

As the room for air compressor is cooled the whole year, this process was added to EINSTEIN (4 kW compressor, 4 h a day running time, 3 kW thermal load)

In addition a building was defined (instead of the radiation circuit)

Half of the building (1600 m²) is heated by radiators. Those radiators are supplied by district heat also. The heating demand was calculated at 200 kWh/m².

Table 1: Total primary energy consumption (PEC) and primary energy consumption for thermal use (PET)

Energy type (fuels / electricity)	PEC		PET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Total fuels	509	30,57	509	97,79
Total electricity	1.155	69,43	12	2,21
Total (fuels + electricity)	**1.664**	**100,00**	**520**	**100,00**

Table 2: Total final energy consumption (FEC) and final energy for thermal use (FET); present state.

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Fernwaerme 0.2	509	56,92	509	99,25
Natural gas	0	0,00	0	0,00
Electricity	385	43,08	4	0,75
Total	894	100,00	512	100,00

Table 3: Useful process heat demand (UPH) by process. Present state.

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Warmwasserkreislauf	39	39	0	0
Lueftung 1 Heizung	106	106	0	0
Lueftung 2 Heizung	8	8	0	0
Pavillon 13 nicht bel._heating	300	0	300	0
Total	**453**			

Table 4: Useful process cooling demand (UPC) by process. Present state.

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Lueftung 2 Cool	4	4	0	0
Druckluftkompressor	3	3	0	0
Total	**8**			

Table 5:. Final energy consumption for thermal use (FET) by equipment (present state).

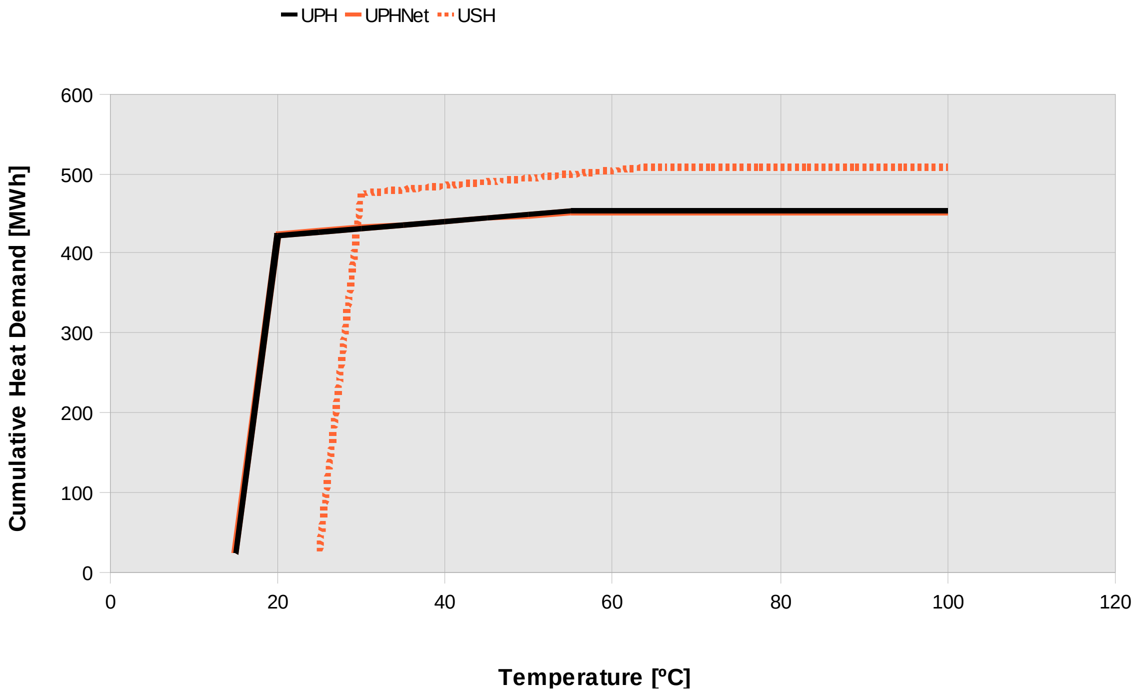
Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
Kaelteanlage 1	Electricity	4	0,75
Fernwärmekessel	Fernwaerme 0.2	509	99,25
Total		**512**	**100,00**

Table 6: Useful supply heat (USH) by equipment; present state.

Equipment	USH by equipment		
	[MWh]	[% of Total]	
Fernwärmekessel	509	100,00	
Total	**509**	**100,00**	

Table 7: Useful supply cooling (USC) by equipment; present state.

Equipment	USC by equipment		
	[MWh]	[% of Total]	
Kaelteanlage 1	13	100,00	
Total	**13**	**100,00**	



3.4. General

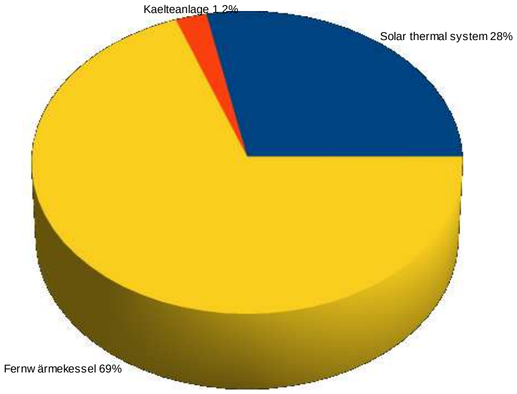
The hospital building visited is part of a big complex with in Vienna, supplied fully by district heat. The exact energy consumption is not known. For the total electricity consumption of the whole building a 24 hours measurement was done and the electricity consumption of the cooling machine was measured during a winter day (outside this project). The temperature levels before and after heat recovery and the flow rates (according to the frequency converter) for the ventilation system were printed out for two days in the "Leitsystem" of the hospital, unfortunately only specific temperatures are in this system, therefore the exact power of the heat exchangers had to be estimated.

4. Comparative study

4.1. Proposed alternatives

Alternative Solar Thermal

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity [kW]	Contribution to total heat and cooling supply [MWh]	[%]
Solar thermal system	solar thermal (flat-plate)	o==Waermeverteilleitung==o	384	147	28,15
Kaelteanlage 1	compression chiller (air cooled)	o==Kuehlleitung==o	37	13	2,44
Fernwärmekessel	hot water boiler	o==Waermeverteilleitung==o	747	362	69,41
Total			**1.168**	**521**	**100**



Alternative CHP

Table 8:. Heat and cooling supply equipment and contribution to total heat and cooling supply

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity [kW]	Contribution to total heat and cooling supply [MWh]	[%]
New CHP 2	CHP engine	o==Waermeverteilleitung==o	93	490	94,05
Kaelteanlage 1	compression chiller (air cooled)	o==Kuehlleitung==o	37	13	2,44
Fernwärmekessel	hot water boiler	o==Waermeverteilleitung==o	747	18	3,51
Total			**877**	**521**	**100**

Alternative 3 Shutting Off of Ventilationsystem

Shutting off the ventilation system on weekends reduces the running time and the total air volume heated up and therefore will reduce the heating demand for the ventilation system no 1.
In present state the UPH for this ventilation system is 106 MWh, in the new proposal only 55.36 MWh would be needed, this means a reduction by 50%.
For the saving calculation below the savings in the electricity demand were not integrated yet!

Overview on alternatives

Table 9: Primary energy consumption: present state and alternative proposals.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	1.664	---	---
New Proposal 1 Solar Thermal	1.516	148	8,88
New Proposal 2 CHP	1.423	241	14,49
New Proposal Reduced Running Time	1.613	51	3

Calculated without electricity savings!

Table 10: Useful process and supply heat: present state and alternative proposals.

Alternative	Useful process heat (UPH)	Savings UPH	Useful supply heat (USH)	Savings USH
	[MWh]	[MWh]	[MWh]	[MWh]
Present State (checked)	453	---	509	---
New Proposal 1 Solar Thermal	453	0	509	0
New Proposal 2 CHP	453	0	509	0
New Proposal Reduced Running Time	401.51	51.5	458	51

Table 11: Environmental impact: present state and alternative proposals.

Alternative	Production of CO2	Highly Radioactive Nuclear Waste	Water consumption
	[t]	[kg]	[m3]
Present State (checked)	294,23	1,93	0,00
New Proposal 1 Solar Thermal	264,72	1,92	0,00
New Proposal 2 CHP	302,96	0,55	0,00
New Proposal Reduced Running Time	284	1,93	0,00

Table 12: Investment cost: alternative proposals.

Alternative	Total investment	Own investment	Subsidies
	[€]	[€]	[€]
Present State (checked)	---	---	---
New Proposal 1 Solar Thermal	218.755	153.129	65.627
New Proposal 2 CHP	62.500	43.750	18.750
New Proposal Reduced Running Time	0	0	0

Table 13: Total annual cost (fuels and electricity, O&M and annuity of investment): present state and alternative proposals.

Alternative	Annuity	Energy Cost	O&M
	[€]	[€]	[€]
Present State (checked)	---	77.319	0
New Proposal 1 Solar Thermal	16.096	68.476	0
New Proposal 2 CHP	4.599	74.116	0
New Proposal Reduced Running Time		74.254	

Table 14: Internal rate of return (IRR) and net present value (NPV) of investment: alternative proposals.

Alternative	Modified Internal Rate of Return	Pay-Back Period	Benefit Cost Ratio	Own Investment	Net Present Value (20 years)
	[%]	[years]	[-]	[€]	[€]
New Proposal 1 Solar Thermal	2,7	20	1,0	153.129 €	2.255 €
New Proposal 2 CHP	3,9	15	1,0	43.750 €	12.535 €
New Proposal Reduced Running Time		0			

5. Selected alternative(s) and conclusions

5.1. Selected alternative

As no (additional) heat exchanger was proposed by EINSTEIN and the payback-time of a CHP and the solar heat system would be much too high, the reduced running time of the ventilation system was calculated and will be proposed as first option.

5.1.1. Process optimisation (written proposals)

For process optimisation esp. the shutting down of the ventilation system during night and weekends (when operation rooms are not used) will have a significant impact on the energy consumption. EINSTEIN was used to calculate the savings by changing the load profile, savings of 50% for the ventilation system number 1 were calculated.

5.1.2. Heat recovery

No additional heat recovery was suggested by EINSTEIN. The main source of waste heat would be the ventilation system, where already heat exchangers are in place. For the second source, the compressed air system, no heat exchanger was suggested as the running time and power is too small.

5.1.3. Heat and Cold Supply

The solar heat system and the CHP were modelled and showed savings between 8 and 15%.

5.2. Comparative study and conclusions

		Present state	**Alternative**	**Saving**
Total primary energy consumption (District Heat)	*[MWh]*	*1.664*	*1.613*	*3*
Allocation of energy consumption	*[-]*			
Share of renewable energy	*[%]*	*0*	*0*	
CO_2 emissions	*[tons/a]*	*294*	*284*	*3%*
Annual energy system cost (2)	*[EUR]*	*77.319*	*74.254,5*	*4%*
Total investment costs	*[EUR]*		*0*	
Payback period (3)	*[years]*		*0*	

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.*
3. *Supposing 0% of funding of total investment (subsidies or equivalent other support mechanisms)*

5.2.1. Energy and environmental analysis

The CO2 Emissions could be reduced by 3% (without electricity demand)

5.2.2. Economic analysis

As no investments would be needed the energy costs could be reduced by 3.064 EUR (only heat demand), electricity savings were not subject to this analysis.

5.2.3. Conclusions and outlook

The results estimated via EINSTEIN are very close the data modelled via excel sheets. The main heat consumer is the heating of the hospital rooms not fully air conditioned.

This analysis was part of a more general energy concept for the whole hospital (including saving opportunities on the electricity side), so the measure will be considered in the energy concept).