Application for the District Energy Climate Award 2011

1. Cover Page

1.1. name and location of the system

The described energy system of the public utility company is situated in the city of Rosenheim, a town in the German State of Bavaria with a population of approximately 60.000 inhabitants. The city is located close to the Bavarian Alps and lies in between the two major cities of Munich (70 km) and Salzburg/Austria (90 km).
Due to very good location factors Rosenheim has a large variety of businesses. Next to a broad basis of medium sized businesses Rosenheim is also the home of many international companies. All these factors lead to a strong employment market in Rosenheim with a low unemployment rate.
Furthermore Rosenheim is a highly valued holiday area for many visitors per year, due to its outstanding nature with mountains, lakes and forests.
The geographical coordinates are 47° 51′ 0″ North, 12° 8′ 0″ East.

1.2. name of the owner and type of ownership

Owner of the system is the local utility company, called Stadtwerke Rosenheim (SWRO), which operates as a limited liability company. The company is 100% owned by the City of Rosenheim and employs around 320 people.

1.3. Name, address, phone number & email of person submitting the application

Division manger	
Waste-to-energy plant:	Reinhold Egeler
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2. Motivation of Stadtwerke Rosenheim

2.1. Municipal scheme with more than 10.000 users

The public utility company SWRO supplies 43.000 customers with electrical power, about 7.000 customers with natural gas and approx. 620 buildings with a square footage of approx. 1.000.000 m^2 with district heating. Additionally two industrial customers and one hospital are supplied with process steam. For this the SWRO own and run a waste-to-energy plant in central location of Rosenheim. The supply area used to be mainly the city boundary of Rosenheim. Due to the liberalisation of the energy markets (electricity/natural gas) the SWRO also supply customers over longer distances.
The overall demand for electricity in Rosenheim for the year 2010 was 260 GWh. With an own local generation of 79 GWh the SWRO were able to supply one-third of the total demand. A delivery of 121 GWh district heating to end use customers represents a coverage of nearly 20% of the overall heat demand in Rosenheim.

2.2. Expansion of district heating and modernization of the energy plant

A district heating network for the city of Rosenheim is in operation since 1955 which has been expanded regularly with different intensity. In 2008 a expansion program for district heating was implemented with the aim to double the percentage of district heat from 15% up to 30% within the next 10 to 15 years.
Already in 2004 the SWRO power plant was upgraded with a CHP gas engine consisting three motors. To cover the raising district heating demand contracts were signed in 2010 for two more gas engines with an electrical power output of 10 MW and 4,4 MW.

2.3. Reasons for implementation and achievements

The SWRO understand themselves as a primary supplier for the City of Rosenheim. Additionally to a secure allocation of energy comes the responsibility to generate this energy in an ecological efficient way to the best economical standards. With this understanding the SWRO want to support the ambitious targets for climate protection of the german government.
Since the construction of the power plant in Rosenheim (1955) the focus always was on a combined heat and power generation (CHP). Due to changes of the energy markets in Germany and new promotions by law since 2002 the focus became even stronger. In 2004 the SWRO invested 5,7 Mio Euro in highly efficient gas engines of GE Jenbacher with an electrical output of 10 MW. Back then it was the largest investment into a gas engines CHP plant in Germany.
In addition to that in 2007 a large district heating expansion program for Rosenheim was implemented, with the aim to double the heat output within the next 10 to 15 years. This high efficient CHP energy generation in Rosenheim, based on a waste incineration combined with gas engines, is further certified with a primary energy factor of zero. The primary energy factor according to the German Energieeinsparverordnung (ENEV) gives back the ratio of fossil energy input and a weighted electricity and heat output. A primary energy

factor of zero means that no additional primary energy was used for generating district heating.

3. Summary

Since the construction of the power plant in 1955 the SWRO operate a district heating network. The power plant was continuously expanded over the years and optimized in its efficiency. In 1963 a waste incineration was added to the power plant.
To further increase the energy efficiency three gas engines with a total electricity output of 10 MW were installed in 2004. Two more gas engines are currently under construction. Since 2008 the district heating network is expanded largely with the aim to double the percentage of district heating by 2020.
The fuel input for generating heat and electricity is approximately even in between natural gas and waste. The overall efficiency of the Rosenheim generation is just under 70%.
With the delivery of district heat other heat generation is replaced in Rosenheim which would have used fuel oil, natural gas or solid fuels. District heat replaces directly other input fuels and therefore reduces the emissions in Rosenheim. Furthermore the CHP generated electricity in Rosenheim blocks out other electricity generated with inefficient coal power plants somewhere in Germany. On the balance sheet the Rosenheim CHP electricity generation can thereby achieve a CO_2 reduction.
In total a remarkable reduction of emissions by CO_2, SO_2 and especially particles can be achieved compared to no local power generation.

The special characteristic of the Rosenheim concept is the decades long continuity of plant optimization and that all efforts were successful to add value to the local community in combining ecological interest with economical actions.

4. Description of the Rosenheim system

4.1. system history and plant configuration

system history
In the year 1955 the members of the city council in Rosenheim decided to build a combined heat and power plant and to set up a district heating network. With this visionary and historic decision Rosenheim became one of the first cities to focus on a local energy generation.

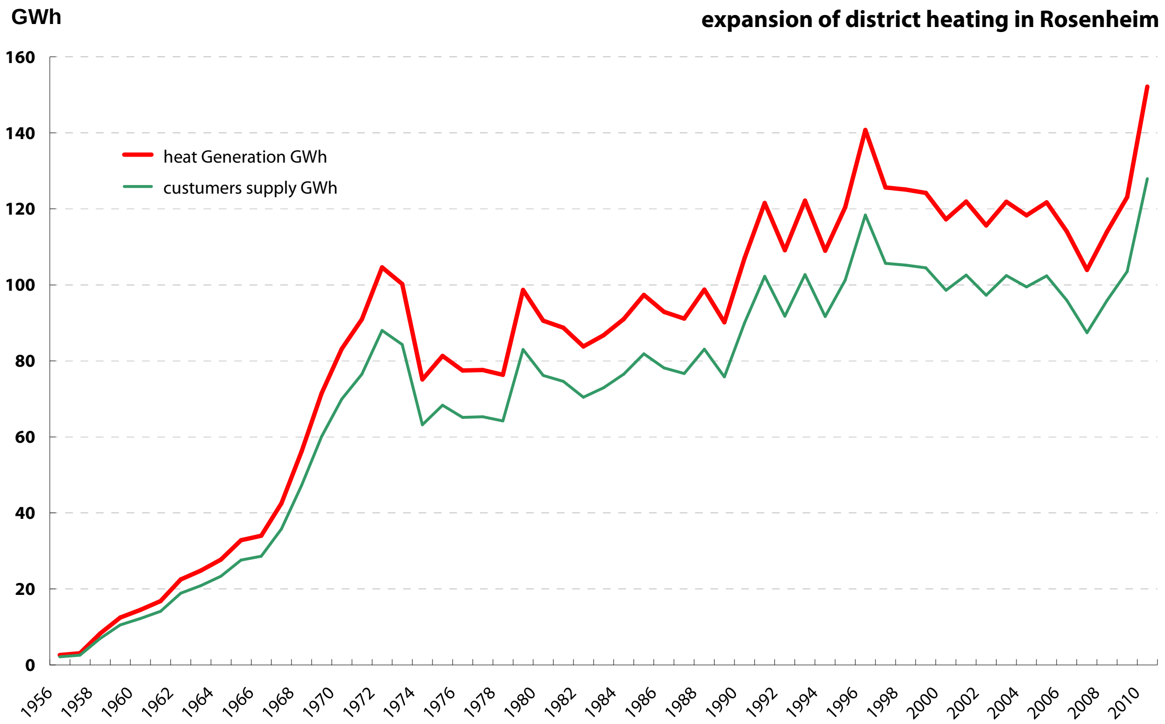

Image 1: expansion of district heating in Rosenheim

Image 1 shows the development of the Rosenheim district heating from 1956 until today. Up to the seventies a large scale expansion was promoted. In the coming years there were always short periods of a smaller expansion. The start of the district heating expansion program in 2008 launched a similar development in expansion like in the start up years.
Different technologies have been used in Rosenheim for generating the demanded heat. It all started with hot water boilers, a waste incineration, and then came steam boilers energizing turbines in a CHP operation. Additionally a gas turbine was in production until 1990. Today the Rosenheim combined heat and power plant consists of two superheated steam boilers, two steam turbines, three gas engines and a waste incineration.

In the past decades also the employed fuels in Rosenheim have changed. From 1956 until 1963 coal and heavy fuel oil have been equally used. In 1963 waste incineration was installed at the same plant site. Since then communal and industrial waste can be utilized into heat and power. In 1974 the firing equipments of the coal fired boilers were converted. Since then mainly natural gas is used as fossil fuel. Since the replacement of the waste incineration in the years 1989/90 on average just over half of the current energy input is originated from municipal waste. With the increasing hours of operating highly efficient gas engines this ratio will slightly lean over towards natural gas again.

Current configuration of production units

The SWRO waste-to-energy plant consists of two natural gas fired steam boilers (superheated steam with 60 bar, 410°C) with an energy output of 20 and 40 tons per hour, one waste incineration plant with a steam output of 30 t/h and a reserve/peak load boiler with a capacity of 38 MW. Additionally the SWRO operates a highly efficient CHP gas engine plant with an electrical output of 10 MW and a thermal power of 9 MW. For optimizing the plants operation, especially the gas engines, a 70 MWh hot water storage tank is installed.

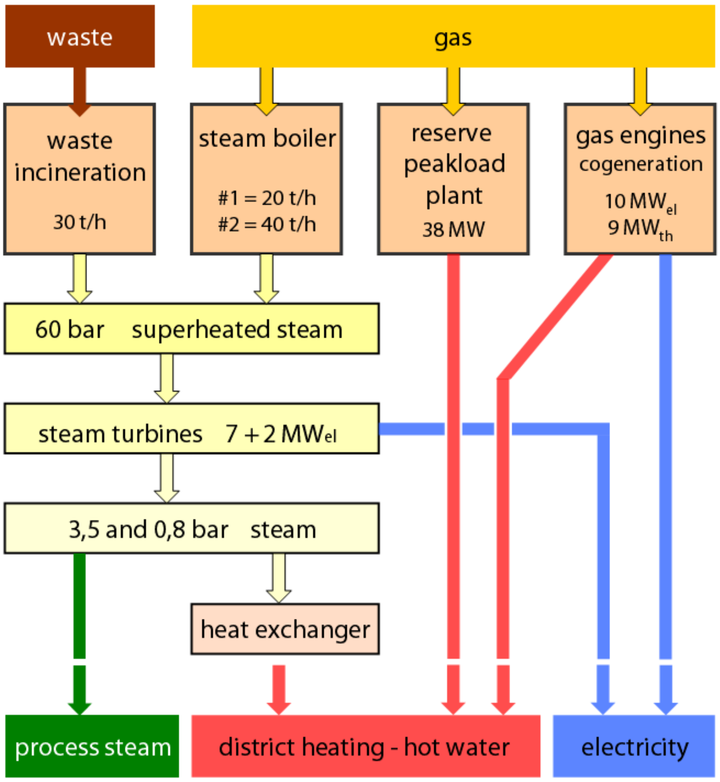

Image 2: plant configuration of SWRO (status March 2011)

Image 2 shows the current plant configuration. The waste incineration and the two steam boilers energize a shared steam bar with 60 bar and 410°C. From there two steam turbines generate electricity. The exhaust steam of the turbines is available in two pressure stages. The 3,5 bar steam is used in the neighboured dairy company. The 0,8 bar steam is used for generating hot water for the district heating and for all internal processes in the power plant.

The gas engines generate combined heat and power. To ensure the supply guarantee and the peak load generation two hot water boilers are held as back up system.

With this plant configuration the SWRO were able to generate 152.000 MWh district heat, 32.000 MWh process steam and 79.000 MWh electricity.

District heating network and number of square footage of building served

Originally the supply of end use customers with district heating was limited to the inner city of Rosenheim, close to the location of the energy plant. As Image 3 shows the district heating network was enlarged over the years. Today the district heating network covers an area of approx. 11 square kilometres, which relates to 30% of the total area of Rosenheim. Alone from 2008 until today the length of district heating piping increased from 51 km up to 74 km, which equals a 45% expansion. In total the SWRO supply approx. 1.000.000 square footage of administration, housing and business buildings.

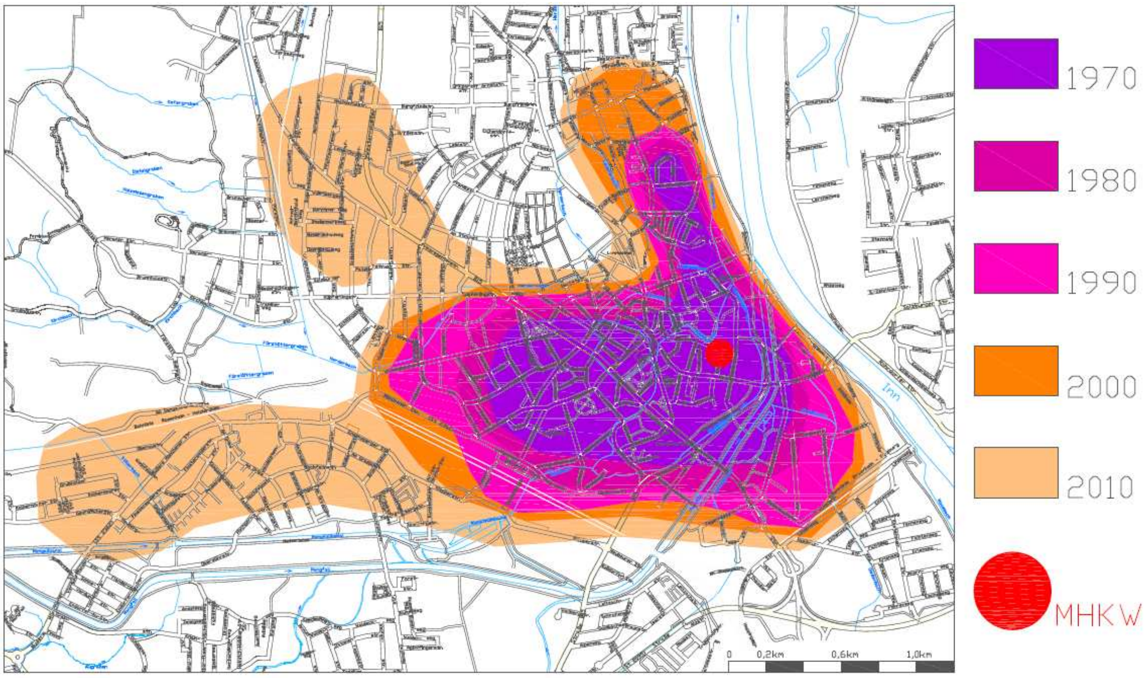

Image 3: Expansion of the district heating grid in Rosenheim
(MHKW is location of the Rosenheim energy plant)

Average age of production and distribution facilities

The current average age of the Rosenheim energy plant is 29 years. The oldest units are a steam turbine from 1956 and a steam boiler from 1962. However its operation hours per year is only 800 hours when the waste incineration is in revision. The most modern unit is the gas engine CHP plant with an age of 7 years. Table 1 shows the complete age structure of the Rosenheim waste-to-energy plant.

	unit	year of construction	age
energy plant	waste incineration	1990	21
	steam boiler K2	1985	26
	steam boiler K4	1962	49
	gas engines 1-3	2004	7
	reserve/peakload plant	1989	22
	steam turbine 2	1956	55
	steam turbine 1	1988	23
Average age energy plant			**29**
Average age of district heating grid			**24**

Table 1: Average ages of the production units and distribution facilities

Single parts of the district heating network from the starter years are still in operation. Due to the expansion, but also because of maintenance and replacements of old pipings with poor insulation allot of piping was renewed. However the average age of the Rosenheim district heating network is 24 years.

4.2. Energy efficiency and distribution of primary and effective energy in the power plant

With the efforts in an ecological and economical efficient energy generation, combined with all the measures done in Rosenheim the plant configuration, as well as the energy input to production and useful energy delivered to end use customers have changed in Rosenheim since 2003. However, the energy input to production stayed the same: only waste and natural gas are used. Image 4 shows the conditions for 2003. In this year nearly two thirds of the energy input to production was waste. The superheated steam from the waste incineration and the steam boilers energized the common turbines generating electricity. Part of the exhaust steam was delivered to end us customers as process steam or used for generating district heat. Only 5% of the delivered heat was generated with the reserve peak load plant.

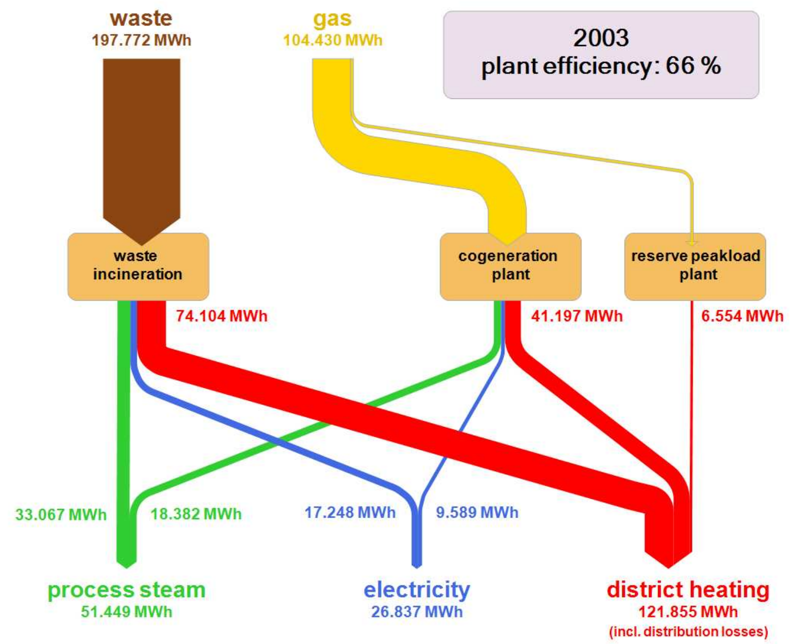

Image 4: energy input and output in 2003

In total an overall efficiency in 2003 of 66% was achieved in the Rosenheim energy plant.

Image 5 shows the energy input and output, as well as the single generation of all available units in 2010. The significant difference compared to 2003 is the implementation of gas engines. Furthermore the generation of electricity and district heating was considerably higher than 2003. The increase of district heating is amongst other things a result of the district heating expansion program. The percentage

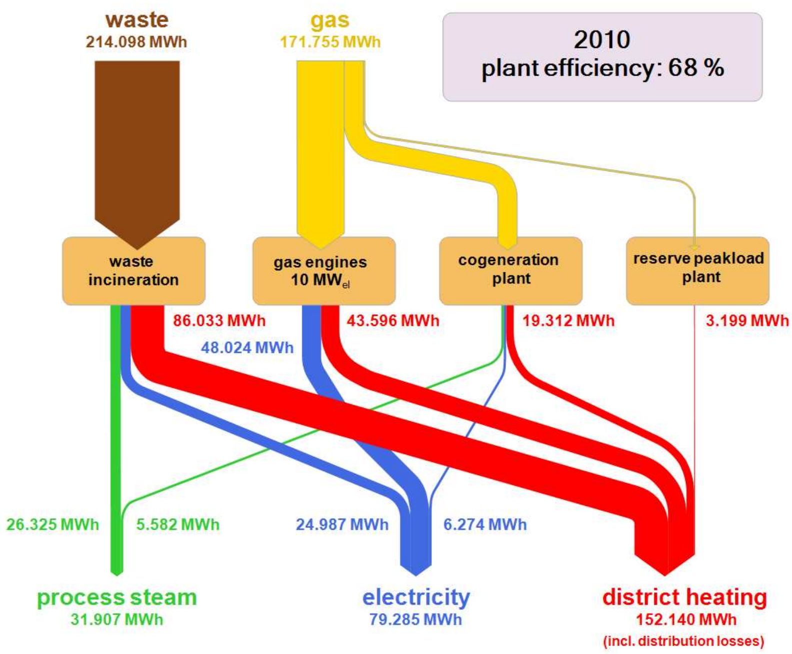

Image 5: energy input and output in 2010

of the reserve peak load plant decreased down to 2%.
The overall efficiency of the energy plant was increased to 68%. That the total energy efficiency is not higher lies in the fact that the gas engines operate also in summer due to economical reasons.

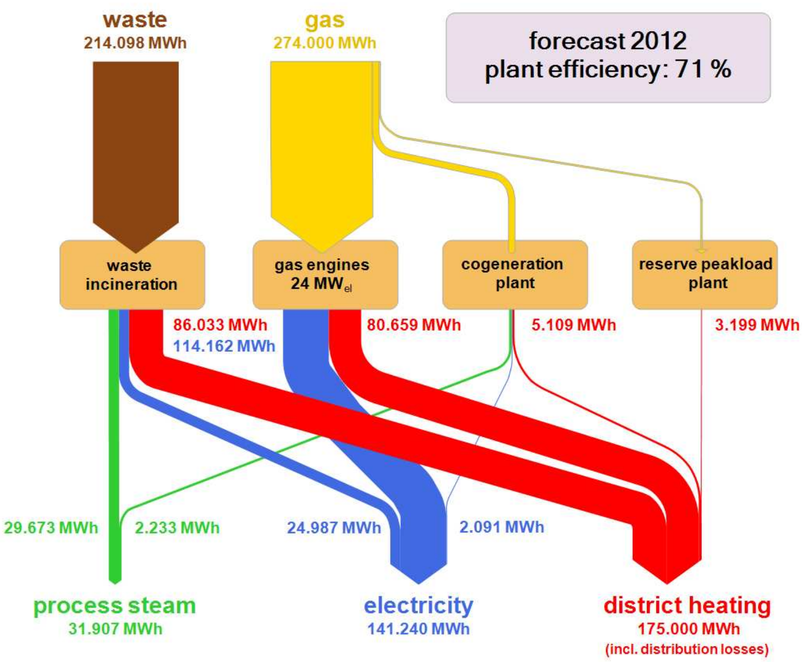

Image 6: energy input and output in 2012

The energy balance diagram of image 6 shows the predictable development for the year 2012. Additional gas engines of 14 MW are under construction at the moment and will be in operation by autumn 2011. The assumption for the further expansion of district heating is bases on already existing contracts. With the new gas engines more district heating can be generated in CHP that the ratio of power generation increases further more compared to the heat generation. The part of the natural gas fired steam boilers will decrease onwards because the unit will be only in use at times of revision for the waste incineration.

4.3. effect of the energy concept on the SWRO emissions

Principle of the replacement of heat and electricity
The calculations for evaluating the economical benefits take as a basis that the demand for electricity and heat is seen separately of its generation. That means that the heat delivered from the Rosenheim energy plant replaces heat which would have been generated with either fuel oil, natural gas or solid fuels in central or single heating installations. The observed balance envelope for heat is therefore the city of Rosenheim.

The same thoughts apply for the electrical generation, with the only difference that the balance envelope is the federal republic of Germany. The highly efficient generated electricity in Rosenheims CHP gas engines replaces electricity produced somewhere in Germany mainly out of brown or black coal. For the calculations of the replacement following thoughts:

Heat demand in Rosenheim and its allocation of primary energy
To calculate the heat demand (heating and water for domestic use) in Rosenheim the SWRO can use their own data of district heating and natural gas delivered to end use

customers. For the year 2009 this was 324.000 MWh natural gas and 111.000 MWh district heating (see table 2, column 1 to 3).
With the help of a geographic information system (GIS) a percentage of 36% for houses and businesses was detected that were not connected to the SWRO district heating or natural gas supply. This means that 36% are heated either with fuel oil or solid fuels or respectively that 64% of the total heat generation is Rosenheim is covered with district heating and natural gas. For estimating an annual amount of fuel oil and solid fuels the same demand average as for district heating and natural gas was used.

The amount of solid fuels was calculated with the emission factors and calculations of Landesamt für Umweltschutz (LfU) from the year 2000. As a result an annual primary energy amount for solid fuels of 30.000 MWh was calculated (table 3, column 1). This number is used for all future years. Further it is assumed that solid fuel is only ligneous biomass like split logs, wood chips or pellets.

With known conversion rates for central heating stations (table 2, column 2) an overall heat demand for the City of Rosenheim as well as the amount of fuel oil can be calculated (table 2, column 3 an 4). With the numbers of primary energy used in Rosenheim a distribution key was estimated for fossil fuels and biomass (table 2, column 3 and 4). This distribution key is used twice in the further estimation. First it is used for calculating the avoided emissions due to district heating and secondly it is used for estimating the total emissions of the city of Rosenheim without a local energy generation and district heating network of SWRO.

Distribution of heat demand in Rosenheim	**primary energy**		**heat demand**		**distribution key**	
	primary energy input of SWRO and city of Rosenheim (2009)	efficiency of generation and distribution losses of district heat	energy demand of heat and water of domestic use (in 2009) in Rosenheim	portion of oil (GIS-data) and solid fuel (36%)	distribution of primary energy without district heat (2009)	
	in MWh	%	in MWh	in MWh	in MWh	%
oil	260.531	76%	-	198.004	260.531	**42%**
gas	324.000	86%	278.640	-	324.000	**53%**
solid fuel / biomass	30.000	70%	-	21.000	30.000	**5%**
district heat	123.000	11%	111.000	-	-	-
sum	737.531	-	389.340	-	614.531	
portion of heat demand	-		64%	36%	-	
heat demand	-		608.344		**-**	

table 2: distribution of heat energy in Rosenheim

The years 2003, 2008 and 2012 were calculated the same way with the same presumptions, except the real supply of natural gas and district heating.

Importance of the displacement of electricity through the local generation in Rosenheim

As mentioned before the electricity generation is independent to the form of its generation. This means locally generated electricity in Rosenheim replaces other german electricity. The question is only which form of German electricity generation was replaced and what emissions could be replaced instead.

Table 3 shows the different technologies of power generation in Germany. In addition it shows which emissions per energy source are set free with each generated megawatt per hour

Electricity generation	German electricity mix 2009		displacement through decentralized generation	
	portion of generation	Emission factor per fuel in kg CO_2/MWh	portion of generation	emission factor per fuel in kg CO_2/MWh
Renewable energy	18%	0	0%	0
nuclear	23%	0	0%	0
Black coal	18%	887	75%	665
Brown coal	25%	1089	15%	163
Natural gas	13%	702	10%	70
others	5%	1272	0%	0
Total emission factor		**587**		**899**

table 3: German electricity generation, portions of energy sources and emission factors

The importance of the displacement of electricity through the local generation in Rosenheim is explained on following example:

If Rosenheim had no local power generation an averaged emission factor for carbon dioxide of 587 kg/MWh electricity had to be used (German Electricity mix 2009).

A local generation in Rosenheim has definitely no displacement effect on nuclear or renewable electricity. A displacement effect would hit regulating and peak load power plant, which means mainly black coal and partly brown coal or natural gas would be replaced. With the portion of generation shown in table 3 (75% black coal. 15% brown coal, 10% natural gas) a new emission factor of 899 kg CO_2/MWh electricity is calculated. This factor has to be offset with the factor of the own generation.

As electricity in Rosenheim is mainly generated in CHP the emission balance is clearly positive. The amount of CO2 reduction is shown in image 7. The light blue columns indicate the situation of no local district heating and power generation. The whole electricity needed in Rosenheim is benchmarked with the German CO_2 faktor, the heat is valuated with 238 kg CO_2/MWh.

With a standard factor for all demanded heat is assumed that the part of district heating is generated with the percentage of natural gas, fuel oil or solid fuels (see table 2, column 6)

The dark blue columns indicate the real situation of power generation at SWRO. The reduction of CO2 is mainly accumulated through the reduction of electricity out of German coal generation. On the other side the SWRO district heat is generated in CHP and therefore has a smaller CO_2 emission that single heating facilities.

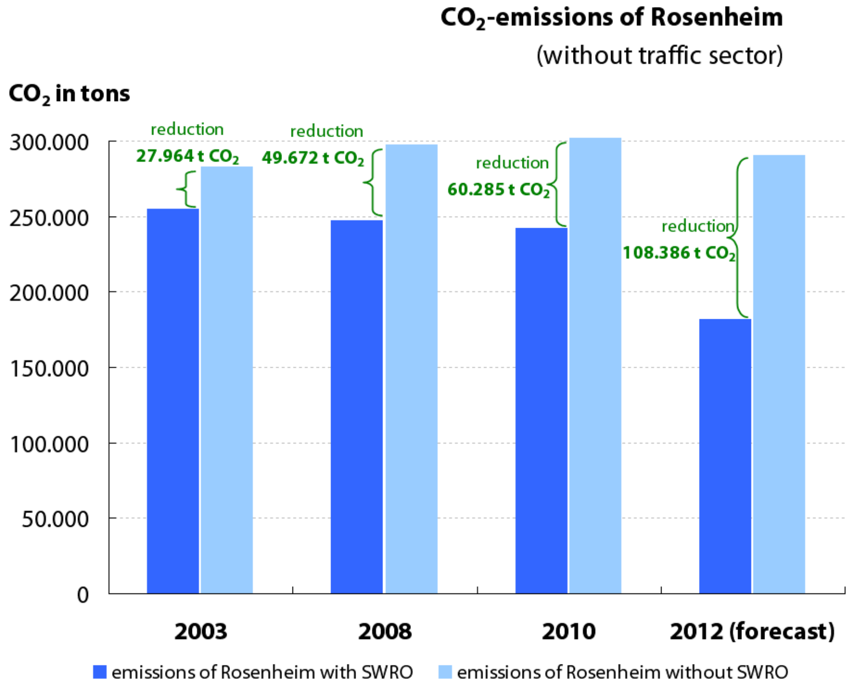

Image 7: CO_2 emissions of Rosenheim and achieved reduction

Already in 2003 a reduction of CO_2 was noticeable. This effect bases mainly on district heating and the biogenic part of the waste, even though the electrical generation was still small.

The improvement compared to 2008 attributes essentially from the expansion of the district heating and the implementation of highly efficient gas engines. An estimation from the Rosenheim traffic sources that approx. 15.000 tons of CO_2 are emitted.

This means that the implementation of new gas engines in 2004 led to a CO2 improvement which are one and a half times higher than all the traffic emissions in Rosenheim.

The further reductions from 2008 to 2010 are caused by the expansion of the district heating.

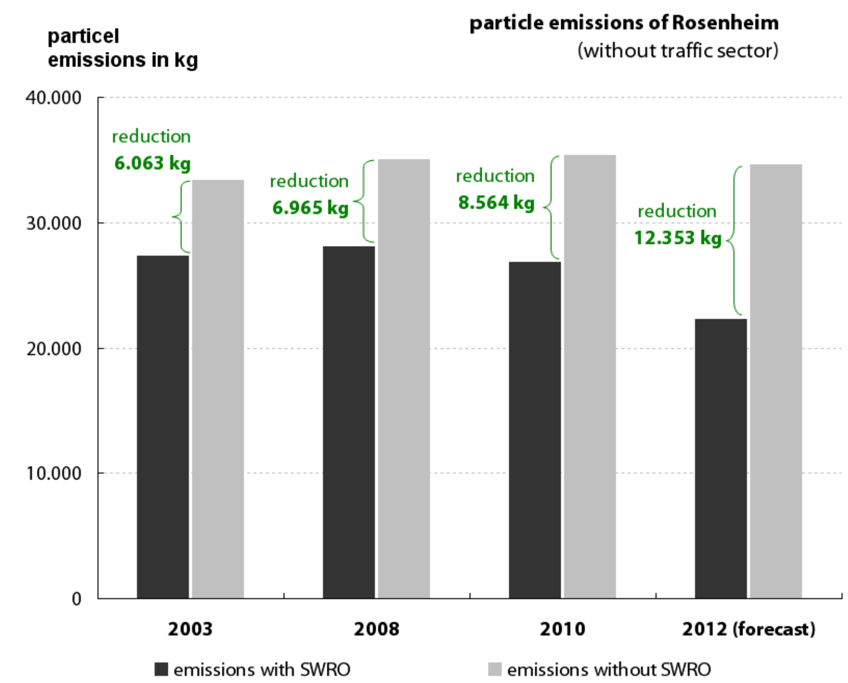

Image 8: particle emissions of Rosenheim and achieved reduction

The continuation of the district heating expansion as well as the new gas engines, which are under construction in 2011, will lead to another remarkable reduction in the future. This is shown in the columns for the year 2012.

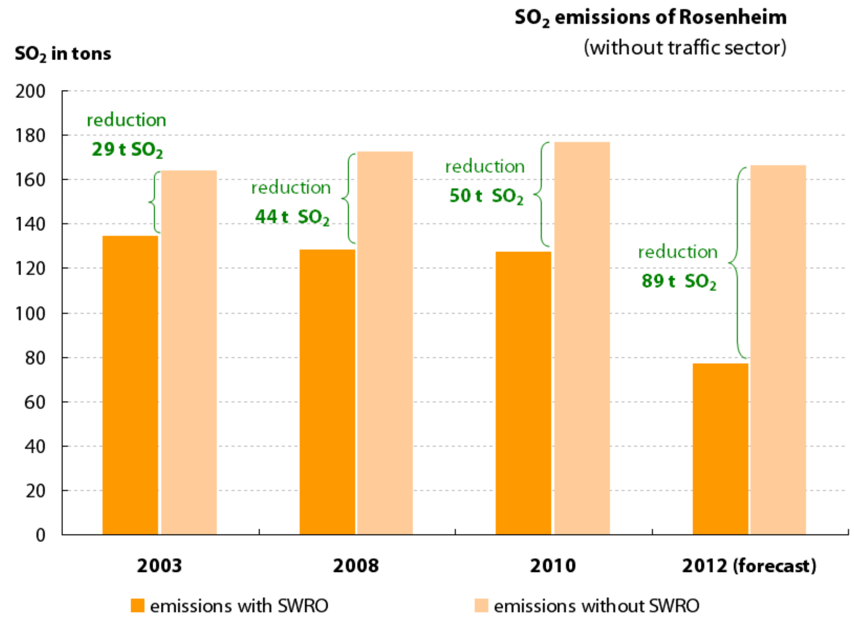

Image 9: SO_2 emissions of Rosenheim and achieved reduction

The same trends are noticeable at the images for sulphur dioxid and particles (images 9 and 10)

The tendencies for nitrogen oxides are pointing in the other direction. Based on emission calculations for Rosenheim it is known that that due to the chimney distribution the NOx impact for Rosenheim is lower than 5%. Nevertheless there is a need for optimization. However a further reduction of NOx cuts down the energy efficiency of gas engines. This means that so far the emissions compete with an optimum of power generation.

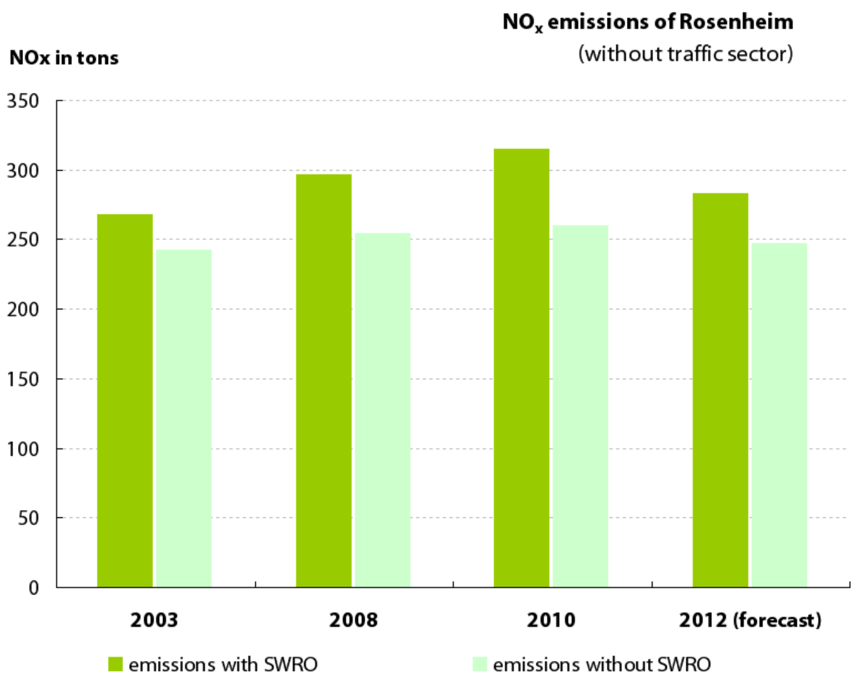

Image 10: NOx emissions of Rosenheim and achieved reduction

Altogether the images show clearly that the CHP generation in Rosenheim combined with a wide expansion of district heating has many ecological advantages.

Since 1997 the Rosenheim waste-to-energy plant is certified according to the Eco-Management and Audit Scheme (EMAS). In line with this audit the water consumption of the power plant was investigated and optimized over the last years. Image 11 shows the declining annual water consumption which is improved clearly in the last years.

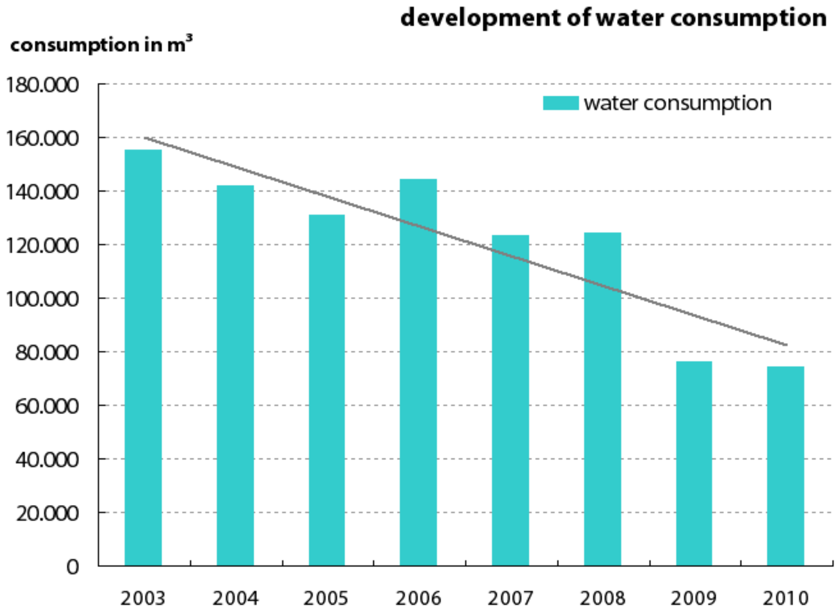

Image 11: development of water consumption by energy generation of SWRO

4.4. What makes our programme outstanding and innovative?

Special characteristics of the measures

The distinctive feature in Rosenheim lies first of all in continuity over decades in a steady advancement and upgrading of ecological and economical useful way of power generation.

Since 1955 the political leaders of Rosenheim always made visionary and highly innovative decisions. These courageous and historic decisions led to the high quality requirements for a further expansion of district heating and a highly efficient operation of CHP gas engines. The implementation of gas engines in 2004 was the first step to tap the full ecological and economic potential. The second step was to establish an expansion program for district heating with the aim to double the connected heat load within the next 10 to 15 years. The third step is the additional implementation of gas engines in 2011. Once again Rosenheim will be a pioneer in this field. The CHP gas engine under construction is not only the largest in Germany at the moment it is also the CHP plant with the highest available energy efficiency of 48% in its power range.
The next step will be an enforced commitment to power generation from biomass. In March 2011 a new energy concept for the city of Rosenheim was introduced. Amongst other things an installation of a biomass gasification plant will reduce the CO2 emission of Rosenheim down to zero until 2025.

As image 12 shows the achieved increases in district heating delivered to end use customers in 2010 have exceeded the former expansion forecasts made in 2008. Therefore it seems realistic to achieve the set goals of the expansion programme. With the investment in additional gas engines, which are under construction at the moment and are planned to be in operation by autumn 2011, the CHP output will be increased from 10 MW up to 24 MW of electrical power. The thermal energy load rises from 9 MW to 20 MW. The main characteristic of the Rosenheim energy system is continuous development since decades, whose targets were regularly adjusted to the ecological and economical conditions of each time. The implementation of the CHP gas engines in 2004 is a good example for this. Back then it was the largest CHP gas engine project in whole Germany, as a newspaper article describes, see attachment 2.

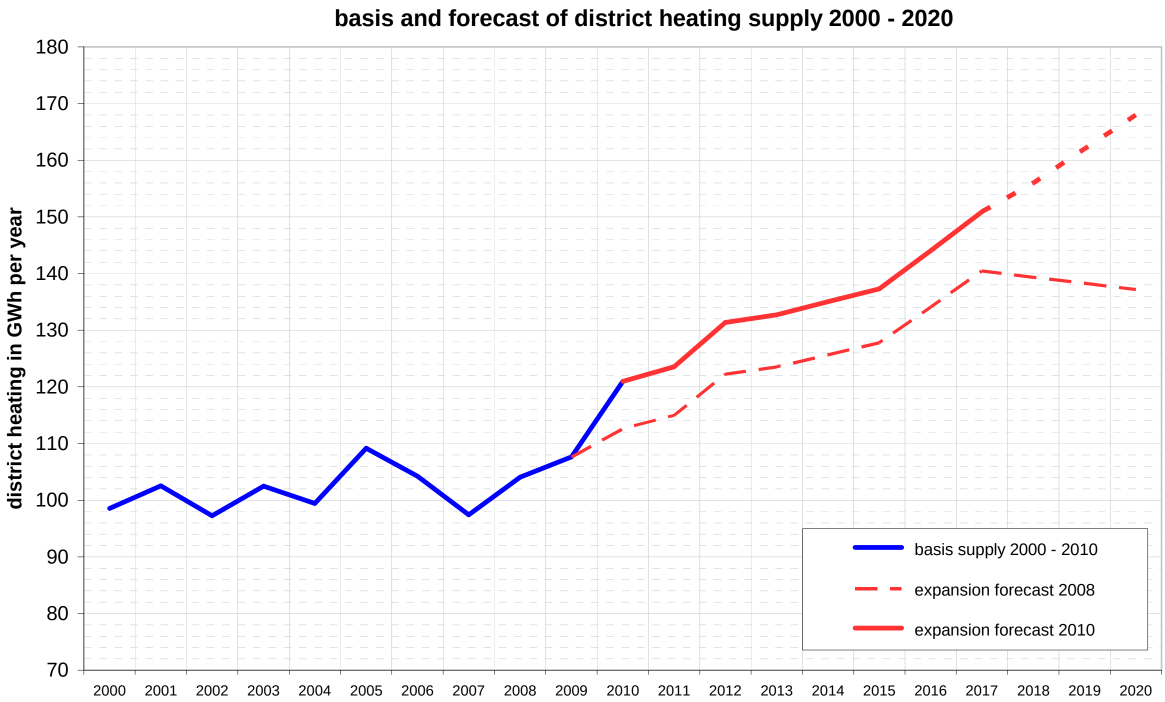

Image 12: basis and forecast of district heating from 2000 until 2020

4.5. Improvement of quality of life

The Rosenheim waste-to-energy plant lies within a 500 metres distance to the city centre. The big advantage of this location is to have only little distribution losses of district heat and process steam due to a short supply length. Furthermore district heating offers attractive advantages compared to stand alone heating facilities, as well as a comfortable way of operation.
Due to a pleasant colouring of the different buildings compared with a extensive plantation of the outside facilities the power plant fits in well into the city and has become a understood part of the cities life. Expensive efforts are undertaken to keep all noise emissions down to a minimum and to make sure that no citizen is disturbed or the acceptance is affected.

The most essential advantage of the waste-to-energy plant for the Rosenheim citizen is the remarkable reduction of the particles. In comparison to the ground level and therefore measureable emissions of stand alone heating facilities and the traffic the percentage of emissions out of the Rosenheim power plant range from 1% to 5% (NO_x). Especially when it comes to the respirable parts of particles the advantages are out of question. Because of the highly efficient flue gas treatment only little amounts of particles are emitted. The immediately effective reduction of particle emission in Rosenheim due to a replacement of fuel oil and solid fuel heaters accumulates to a current rate of 25%, and will be increased up to 35% by 2025.

4.6. What were the challenges we faced and how were they overcome?

The unique challenge of the decisions for the implementation of the gas engines and the expansion program for district heating was the verification, that these measures were not only ecological reasonable and therefore required. On the other hand the measures had to proof their economical meaning.
Basis requirement was that possibilities had to be established to participate in the existing trading platform of the European Energy Exchange, especially for electricity and natural gas. Several arrangements were necessary and actions needed to be done.
With the set up of an own trading department the SWRO were able to participate in electricity trading without any broker in between. Secondary a computer software was implemented to optimize the internal power production and the external power procurement depending on prices for natural gas. On the basis of weather data the software BoFit forecasts the day-ahead demand of district heating, electrical power and natural gas. Additionally it predicts the CHP plants operating hours. Depending on existing contracts with end use customers, current power prices for electricity and natural gas and the demand for heat, electricity and natural gas an optimum of added value can be achieved in Rosenheim.
As a third measure heat storage tanks were installed to decouple the times of electrical power generation with the times of heat generation. With this potential the gas engines are able to generate electricity at times with the highest energy prices. The stored heat can later be used at times with raising heat demand without generating the heat again. This concept has stood its test since several years now and was a fundamental requirement for the economical wise decision of the district heating expansion and the investment into gas engines.

4.7. How was the programme financed?

All mentioned investments and measures were internal financed by SWRO. A nameable contribution to the economic efficiency of the measures provided the Kraft-Wärme-Kopplungsgesetz, a German federal law which covers governmental aid for the expansion and replacement of district heating, as well as a performance fee for all CHP generated electricity.

5. Attachments

Attachment 1: Emission factors

SWRO primary energy	2003 MWh	2008 MWh	2010 MWh	2012 MWh	emission factor CO_2	2003 t CO_2	2008 t CO_2	2010 t CO_2	2012 t CO_2	emission factor SO2 kg/TJ	2003 t SO_2	2008 t SO_2	2010 t SO_2	2012 t SO_2
oil	4.165	2.916	1.886	1.886	0,266 tCO2/MWh *2	1.110	777	502	502	77,0 kg SO2/TJ	1,15	0,81	0,52	0,52
gas	104.430	134.385	171.755	274.000	0,202 tCO2/MWh *2	21.053	27.092	34.626	55.238	0,5 kg SO2/TJ	0,19	0,24	0,31	0,49
waste (tons)	56.351 t	56.794 t	64.169 t	64.169 t	0,373 tCO2/t waste *4	20.991	21.156	23.903	23.903	performance data	1,51	5,24	10,42	10,42
produced emissions					**produced emissions**	**43.153**	**49.025**	**59.031**	**79.644**	**produced emissions**	**2,86**	**6,29**	**11,26**	**11,44**
SWRO effective energy														
steam	51.449	31.399	31.907	31.907	0,231 tCO2/MWh *2*1	11.906	7.266	7.384	7.384	35,7 kg SO2/TJ *2*1	6,61	4,03	4,10	4,10
district heat	109.670	100.874	121.748	150.000	0,238 tCO2/MWh *2*1	26.095	24.002	28.969	35.691	12,5 kg SO2/TJ *2*1	4,93	4,53	5,47	6,74
electricity	36.837	75.004	92.285	161.240	0,899 tCO2/MWh *6	33.116	67.429	82.964	144.955	155,1 kg SO2/TJ *5	20,57	41,89	51,54	90,05
					displaced emissions	**71.117**	**98.697**	**119.317**	**188.030**	**displaced emissions**	**32,11**	**50,45**	**61,11**	**100,89**
					CO_2 reduction	**27.964**	**49.672**	**60.285**	**108.386**	**SO_2 reduction**	**29,25**	**44,16**	**49,85**	**89,45**
energy demand of Rosenheim	**2003 MWh**	**2008 MWh**	**2010 MWh**	**2012 MWh**	**emission factor CO_2**	**2003 t CO2**	**2008 t CO_2**	**2010 t CO2**	**2012 t CO_2**	**emission factor SO2 kg/TJ**	**2003 t SO_2**	**2008 t SO_2**	**2010 t SO_2**	**2012 t SO_2**
electricity demand	248.000	261.000	269.000	250.000	0,597 tCO2/MWh *7	148.056	155.817	160.593	149.250	155,1 kg SO2/TJ *5	139	146	150	140
heat demand	566.000	594.000	595.000	593.000	0,238 tCO2/MWh *2*1	134.675	141.338	141.575	141.100	12,5 kg SO2/TJ *2*1	25	27	27	27
					emission of Rosenheim without SWRO	**282.731**	**297.155**	**302.168**	**290.350**	**emissions of Rosenheim without SWRO**	**164**	**172**	**177**	**166**

SWRO primary energy	2003 MWh	2008 MWh	2010 MWh	2012 MWh
oil	4.165	2.916	1.886	1.886
gas	104.430	134.385	171.755	274.000
waste (tons)	56.351 t	56.794 t	64.169 t	64.169 t
produced emissions				
SWRO effective energy				
steam	51.449	31.399	31.907	31.907
district heat	109.670	100.874	121.748	150.000
electricity	36.837	75.004	92.285	161.240

NOx performance data	2003 t NOx	2008 t NOx	2010 t NOx	2012 t NOx
cogeneration plant	13,40	3,33	3,75	3,75
reserve peakload plant	1,12	0,19	0,26	0,26
gas engines	0,00	39,00	47,45	75,70
waste incineration	59,22	67,00	84,90	84,90
produced emissions	**73,74**	**109,52**	**136,35**	**164,60**
emission factor				
42,6 kg NOx/TJ *2*1	7,89	4,82	4,89	4,89
42,0 kg NOx/TJ *2*1	16,58	15,25	18,41	22,68
175,4 kg NOx/TJ *5	23,26	47,37	58,28	101,82
displaced emissions	**47,73**	**67,43**	**81,58**	**129,40**

particle emissions-factor kg/TJ	2003 kg	2008 kg	2010 kg	2012 kg
1,7 kg PM/TJ	25	18	12	12
0,0 kg PM/TJ	11	15	19	30
performance data	100	181	118	118
produced emission	**137**	**213**	**148**	**159**
0,8 kg PM/TJ *2*1	148	90	92	92
11,9 kg PM/TJ *2*1	4.689	4.313	5.206	6.414
10,3 kg PM/TJ *5	1.363	2.775	3.415	5.966
displaced emissions	**6.200**	**7.179**	**8.712**	**12.471**
particle reduction	**6.063**	**6.965**	**8.564**	**12.312**

energy demand of Rosenheim	2003 MWh	2008 MWh	2010 MWh	2012 MWh
electricity demand	248.000	261.000	269.000	250.000
heat demand	566.000	594.000	595.000	593.000

emission factor NOx kg/TJ	2003 t NOx	2008 t NOx	2010 t NOx	2012 t NOx
175,4 kg NOx/TJ *5	157	165	170	158
42,0 kg NOx/TJ *2*1	86	90	90	90
emissions of Rosenheim without SWRO	**242**	**255**	**260**	**248**

particle emission-factor kg/TJ	2003 kg	2008 kg	2010 kg	2012 kg
10,3 kg PM/TJ *5	9.176	9.657	9.953	9.250
11,9 kg PM/TJ *2*1	24.202	25.399	25.442	25.356
emissions of Rosenheim without SWRO	**33.378**	**35.056**	**35.395**	**34.606**

sources: *1 Bayerisches Landesamt für Umwelt - Emission factors used for not requiring a permit system in Bavaria 2000
*2 Umweltbundesamt (UBA) / Deutsche Emissionshandelsstelle Standardfaktoren (DEHST)
*3 Direct input of performance data
*4 Bayerisches Landesamt für Umwelt
*5 Umweltbundesamt (UBA) "Emissionsbilanz erneuerbarer Energieträger 2009" Emission assessment of renewable energy sources in 2009
*6 Weighted emissions factor explained in chapter 4.3
*7 Avarage of german electricity mix in the last nine years

Attachment 2

E&M 15. März 2005, Seite 21 KWK kompakt

Telefon: 0 30 / 43 60 79 10
Bundesverband Kraft-Wärme-Kopplung e.V.
KWK kommt
Aber nicht von selbst.
Mischen Sie sich ein.
Werden Sie Mitglied.
www.bkwk.de

BHKW DES MONATS

Börsen-Star

Um ein 10 MW-Blockheizkraftwerk, das aus drei Gasmotor-Modulen der GE Jenbacher besteht, haben die Stadtwerke Rosenheim ihr Heizkraftwerk erweitert. Den harten Maßstab für die Wirtschaftlichkeit setzen dabei die Preise der Strombörse.

Die Stadtwerke Rosenheim liefern der südostbayerischen Kommune mit ihren 60 000 Einwohnern sowie ins Umland Strom, Erdgas, Fernwärme und Wasser, kümmern sich um die Abfallentsorgung, betreiben Bäder und bieten Telekommunikations-Dienstleistungen an. Damit ist die GmbH & Co. KG, die sich vollständig im Besitz der Stadt Rosenheim befindet, ein „klassischer" kommunaler Versorger. Das bedeutet aber keineswegs, dass sich das Unternehmen auf die Rolle eines passiven Weiterverteilers beschränkt. So sorgt ein eigenes Portfolio-Management für eine Strombeschaffung zu marktgerechten Preisen.

„Auch mit unserer Eigenerzeugung stehen wir in direktem Wettbewerb mit den Preisen der Leipziger Strombörse EEX", erläutert Reinhold Egeler, Bereichsleiter Müllheizkraftwerk. Die Anlage besteht aus drei Hochdruckkesseln, einer davon ist auf die Verbrennung von jährlich 60 000 t Restmüll ausgelegt, zwei werden mit Erdgas beziehungsweise mit leichtem Heizöl gefeuert. Der in eine Sammelschiene eingespeiste Hochdruckdampf wird in zwei Dampfturbinen zur Stromerzeugung genutzt, an einen benachbarten Da-

Zusatzeinnahmen durch Verkauf von CO_2-Zertifikaten

none-Betrieb geliefert und zur Heißwasser-Bereitstellung für Fernwärme eingesetzt. Strom und Wärme liefert zusätzlich auch ein neues Blockheizkraftwerk, in dem drei von GE Jenbacher stammende Gasmotoren-Module mit je 3 352 kW elektrischer und 3 245 kW thermischer Leistung installiert sind.

Mit der Inbetriebnahme des BHKW wurde die Leistung der Strom-Eigenerzeugung von ursprünglich 16 MW auf 20 MW gesteigert, da gleichzeitig im Heizkraftwerk eine überalterte Dampfturbine mit einer Leistung von rund 6 MW stillgelegt wurde. Die Modernisierung dient der Versorgungssicherheit und ist gleichzeitig ein Beitrag zur Strompreissicherung, resümiert Egeler. In den eigenen Anlagen werden die Stadtwerke, deren Stromabgabe sich auf 250 000 MWh/a summiert, künftig jährlich etwa 80 000 MWh Strom erzeugen, bisher waren es 30 000 MWh/a. Die Wärmeabgabe, die durch Spitzenlast-Heizkessel mit einer Gesamtleistung von 38 MW abgesichert wird, bleibt mit 120 000 MWh/a unverändert.

Das neue BHKW produziert Strom so günstig, das dieser zeitweise auch an der Börse verkauft werden kann, stellt Egeler fest und ist zufrieden, dass sich die Annahmen über die Strompreisentwicklung in der Wirtschaftlichkeitsberechnung bestätigt haben. Im Frühjahr 2003 wurden nämlich von den Stadtwerken etliche Alternativen für die Modernisierung des Heizkraftwerks verglichen. Dabei zeigte sich, dass ein Gasmotoren-Blockheizkraftwerk dank hoher Energieeffizienz und wegen eines günstigen Verhältnisses der Strom- und Wärmeleistung die beste Variante für Rosenheim war. Das höchste Gewicht in der Wirtschaftlichkeit kommt dem elektrischen Wirkungsgrad der Anlage zu, ergab sich aus den Berechnungen.

Dadurch waren die Weichen für ein Grobkonzept gestellt, das von der Münchner ECM Ingenieurunternehmen für Energie- und Umwelttechnik GmbH erarbeitet wurde. Die ECM unterstützte die Stadtwerke auch bei der europaweiten Ausschreibung für das BHKW; die Vergabeverhandlungen wurden von den Stadtwerken wiederum selber geführt.

Die Entscheidung für die BHKW-Module 620 GLC von GE Jenbacher fiel dann konsequent deshalb, weil sie in ihrer Leistungsklasse den höchsten Stromwirkungsgrad haben, unterstreicht Egeler. Vom Lieferanten wurden 43,6 Prozent garantiert, im praktischen Betrieb sind etwa 44 Prozent bei einem Brennstoffnutzungsgrad von 83 bis 85 Prozent erreicht, berichtet Egeler zufrieden. Auch die NO_x-Emissionen der mit Vorkammerverbrennung ausgerüsteten Motoren bleiben mit 350 mg/m³ unter den zugesagten 500 mg/m³. Bei ihrer Wahl ließen sich die Stadtwerke nicht davon abschrecken, zu den ersten Anwendern der weiter entwickelten aufgeladenen 20 Zylinder-Magermotoren zu zählen. „Mit dem ersten Einsatz neuer Anlagen haben wir bereits früher gute Erfahrungen gemacht, auch wenn man dabei am Anfang kleine Nachbesserungen in Kauf nehmen muss", sagt der Kraftwerksleiter.

Der Mitte Januar 2004 begonnene Einbau des BHKW und die Anbindung an das bestehende Heizkraftwerk waren nicht einfach. Untergebracht wurden die Aggregate an dem Platz, den von 1964 bis 1990 die ersten Müllkessel der Stadt Rosenheim eingenommen hatten. Eine knifflige Aufgabe, die die Stadtwerke selber lösten, war die Konzipierung der für das BHKW benötigten Lüftungs- und Schallschutztechnik: Sechs Axial- und drei Radialgebläse transportieren stündlich bis zu 420 000 m³ Luft. Außerdem mussten ein Notkühler mit einer Leistung von rund 11 MW und drei Gemischkühler installiert werden, bevor Anfang Oktober 2004 die Inbetriebnahme beginnen konnte.

Demnächst soll noch ein 500 m³ großer Heißwasserspeicher errichtet werden, damit das BHKW auch bei geringer Wärmeabnahme teuren Peak-Load für die Börse liefern kann. Insgesamt geht Egeler davon aus, das BHKW etwa 5 000 Stunden im Jahr mit Volllast zu betreiben. Damit es keine unerwarteten Ausfälle gibt und um das Kostenrisiko abzusichern, haben die Stadtwerke mit GE Jenbacher einen Vollwartungsvertrag abgeschlossen. Obwohl das Jenbacher-Stammwerk im österreichischen Inntal nur einen Katzensprung von Rosenheim entfernt ist, legt Egeler viel Wert darauf, dass seine Mitarbeiter einfache Wartungsarbeiten selber durchführen können. „Die Mitarbeiter sollen das Know-how aufbauen, damit sie sich mit der Anlage identifizieren", ist er überzeugt.

Bei der Amortisation der für das BHKW investierten 5,75 Mio. Euro helfen die durch das KWK-Gesetz für modernisierte Anlagen garantierten Einspeisezuschläge; sie waren in der Wirtschaftlichkeitsrechnung berücksichtigt. Zusätzlich profitieren die Stadtwerke auch noch vom gerade begonnenen Emissionshandel, denn dank des doppelten Benchmarks – neuen KWK-Anlagen werden CO_2-Emissionen zugestanden, die bei getrennter Strom- und Wärmeerzeugung bei bester verfügbarer Technik entstehen würden – erhielt das BHKW mehr Zertifikate zugewiesen, als für den Betrieb gebraucht werden. „Aus dem Verkauf erzielen wir zusätzliche Einnahmen, mit denen wir nicht gerechnet haben", freut sich Egeler.

Jan Mühlstein

Wo früher im Heizkraftwerk der Stadtwerke Rosenheim Müllkessel standen, liefern nun drei 3 MW-Gasmotoren-Module der GE Jenbacher effektiv Strom und Wärme

Fotos: Stadtwerke Rosenheim

Die Anlage auf einen Blick

Betreiber: Stadtwerke Rosenheim GmbH & Co. KG

Konzept: ECM Ingenieurunternehmen für Energie- und Umwelttechnik GmbH, München

Besonderheit: Elektrischer Wirkungsgrad des BHKW von rund 44 Prozent; Stromverkauf auch über die Börse

Anlage: drei weiterentwickelte BHKW-Module 620 GLC von GE Jenbacher mit je 3 352 kW_{el} und 3 245 kW_{th}

Investition: 5,75 Mio. Euro

Umweltschutz: spezifischer CO_2-Ausstoß von 265 g/kWh_{el} (GuD-Benchmark 365 g/kWh_{el})

Auskunft: Reinhold Egeler, Tel. 0 80 31/36 22 30, r.egeler@rosenheim.de

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Attachment 3

Certificate of primary energy factor of zero for district heating in Rosenheim

INTECHNICA
FUTURE SECURE BUSINESS GROWTH

Zertifikat

Für die Fernwärme- und Dampfversorgung der

STADTWERKE ROSENHEIM
GMBH & CO. KG

am Standort

Färberstraße 47, 83022 Rosenheim

wurde auf Grundlage der Daten des Jahres 2008
nach DIN V 4701-10 ein

Primärenergiefaktor von

$f_{PE,WV} = 0$

ermittelt. Die Wärmebereitstellung erfolgt zu einem Anteil von

98,9 %

aus Kraft-Wärme-Kopplung und der Verbrennung von Müll.

Rosenheim, 20. November 2009

Dr. Reiner Beer

Umweltgutachterorganisation
INTECHNICA CERT GmbH, DE-V-0279

Intechnica Cert GmbH

Aerial view of the Rosenheim waste-to-energy plant

View to north

View to south