MSc Program
Renewable Energy in Central and Eastern Europe

Solar Heat in Austria
Potentials, regulatory framework and business environment

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Affidavit

I, **ALEXANDER BAUER**, hereby declare

1. that I am the sole author of the present Master´s Thesis, “SOLAR HEAT IN AUSTRIA, POTENTIALS, REGULATORY FRAMEWORK AND BUSINESS ENVIRONMENT”, 71 pages, bound, and that I have not used any source or tool than those referenced or any other illicit aid or tool, and

2. that I have not prior to this date submitted this Master´s Thesis as an examination paper in any form in Austria or abroad.

Vienna, 30.10.2010

Signature

Abstract

Solar energy is for free and inexhaustible. These seem to be the optimal conditions to solve all the problems of energy supply.

The focus of this work is on an existing district heating plant in Trumau, in Lower Austria, based on biomass, which will be analysed and supplemented with solar heat. The local conditions of solar radiation will be described. These conditions are the base of the available solar energy.
The solar output, the expected heat demand and the equipment investments will show the economic reasonableness.

At the beginning of this master thesis, the natural conditions of solar radiation will be described. In this respect, the special conditions for Austria will be analyced and evaluated.

Further on, the current situation in Austrian will be demonstrated.
The political goals, the existing guidelines and support mechanisms.

In this respect, important questions are:

- Where are active solar collectors used?
- What kind of technology is mainly used?
- What kind of feed systems exist?

In order to answer these technological issues, the essential technologies will be described and the differences concerning the diverse applications will be analyced.

At the end of this work, the process value will be shown.
Also the development of energy costs will be handled and pictured.

At least, the current situation in Austria will be resumed and the most important items to force the usage of solar heat will be accosted.

Several of the very important measures will be pointed out, in connection with the political guidelines and new or adapted feed systems.

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1. Introduction

1.1 Motivation

The global energy demand is still increasing. This development will take us to the limit of adequate supply of fossil fuels.
The expected impact will be dramatically increasing prices for gas and oil.
This will influence the economic systems all over the world.

The economic growth rate will decrease in many parts of the world due to all the negative consequences of our prosperity.

So, our aim has to be to substitute fossil energy sources by renewable energy to avoid the scenario drafted above and to phase down the addiction to fossil energy sources.

In my opinion, solar energy is one of the most important technologies to increase the share of renewable energies in the over-all energy demand, especially in Austria.

My vested interest in this item is founded on my business. Since 2005, the author have been responsible for the department “Energiemanagement”.
The authors company deals with the planning, building and operating of local heating and cooling systems.
In respect to this, the enterprise wants to raise the share of renewable energies. The main focus lies on biomass and solar heating.

1.2 What is the core objective of this master thesis?

Obviously, our current structure of energy production and energy supply based on fossil fuels is one significant reason for global warming and all the consequences thereof.

Based on the professional experiences of the author in many various items of energy supply and production of heat and electricity, it is clear that the use and the development of renewable energy systems will be a very important part of energy supply in the future.

Solar heating seems to be a substantial contribution to end our addiction to fossil fuels.

In this master thesis, the main market situation in Austria will be described and an example for solar heating will be shown in detail. Where two renewable "systems", district heating based on biomass and solar heating can be a reasonable extension.

At the end, there should be a clear picture of a possible market development mixed with a concrete example of solar thermal application.

1.3 Structure of work

The core issue of this paper is the usage of solar heat combined with district heating systems based on biomass.
The potential in Austria concerning solar radiation, based on literature and different studies.

The most important current political guidelines provide an overview of the political goals and will establish an understanding of the expected market development. Particularly, regulation regards to subsidies and promotions of the government.

Further on, it will be shown, where solar heat is, should be and can be used, on the Austrian market. It is assumed that solar heat can be used in a wider range than it currently is.

According to the field of application, different technologies will be described.
As a consequence, the advantages and disadvantages are documented.

The focus lies on an existing biomass district heating plant, which should be supplemented by solar heat.
The main questions are:

- What is the current situation and what kind of development is expected for the future?
- What is the day to day demand over a whole year period?
- How large can the solar input be?
- What is the space requirement?
- What kind of technology should be used?
- Will the economic efficiency be improved?

Based on the example above of integrating solar heating in an existing BDH and the other topics mentioned, an overview of the right and important preconditions to promote solar heat in Austria will be given.

2 Solar energy

2.1 Natural conditions of solar radiation in Austria

For understanding the availability of solar energy, we need to know the conditions of the natural solar radiation.
Especially the local solar radiation in the area of the DHP is an important precondition for the planned solar thermal plant.

Aberrant from the truth, the current opinion is that the energy content of solar radiation in Austria is low, too low to use solar thermal energy efficiently. However, as can be seen in figure 1 below, there is a high potential of solar energy in big areas of Austria.

For the local amount of energy that can be gained annually by solar radiation, parameters like the average amount of sunshine hours per year as well as the population size have to be taken into consideration.

Main criteria for the optimal energy yield are also orientation, tilt angle and the alignment of plants.

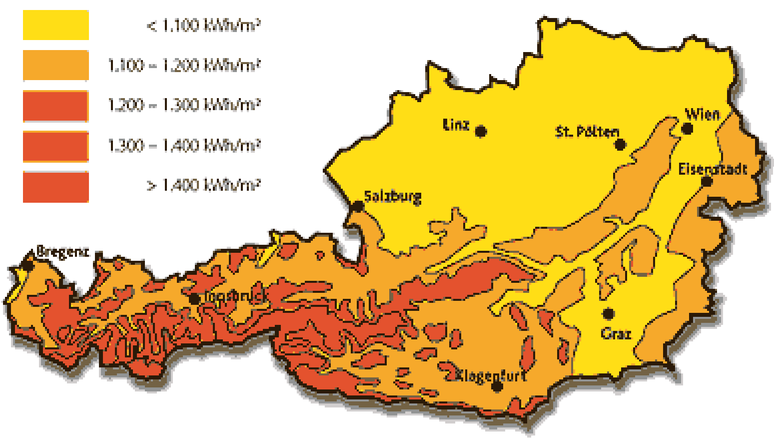


Figure 1: Solar radiation in Austria (kWh/m²) (ASSA, 1985)

85% of the solar radiation reaches Austria from March until October.
In Austria the average solar radiation is app. 1.100 kWh/m² per year. In higher regions the solar radiation is nearly 1.400 kWh/m². So there is enough solar radiation to operate solar systems in an efficient way. (Austria Solar)

3 Current situation on the Austrian solar thermal market

3.1 Political goals

Based on the energy and climate measures that were taken by the EU in December 2008, Austria must increase the share of renewable energy in the energy volume to 34% till 2020.

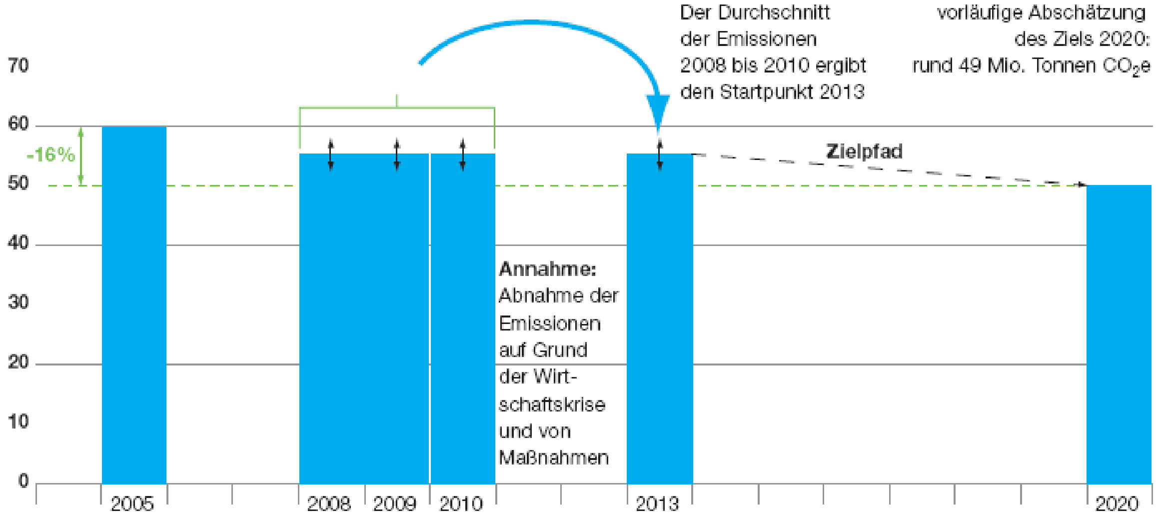


Figure 2: CO_2 reduction until 2020 (Austrian Energy Agency)

The most important issues in this respect are “energy efficiency” and the resulting energy savings, as well as the readiness for use renewable energy sources.

A precondition to reach the goal of a 34% share of renewable energy is the stabilisation of energy consumption.

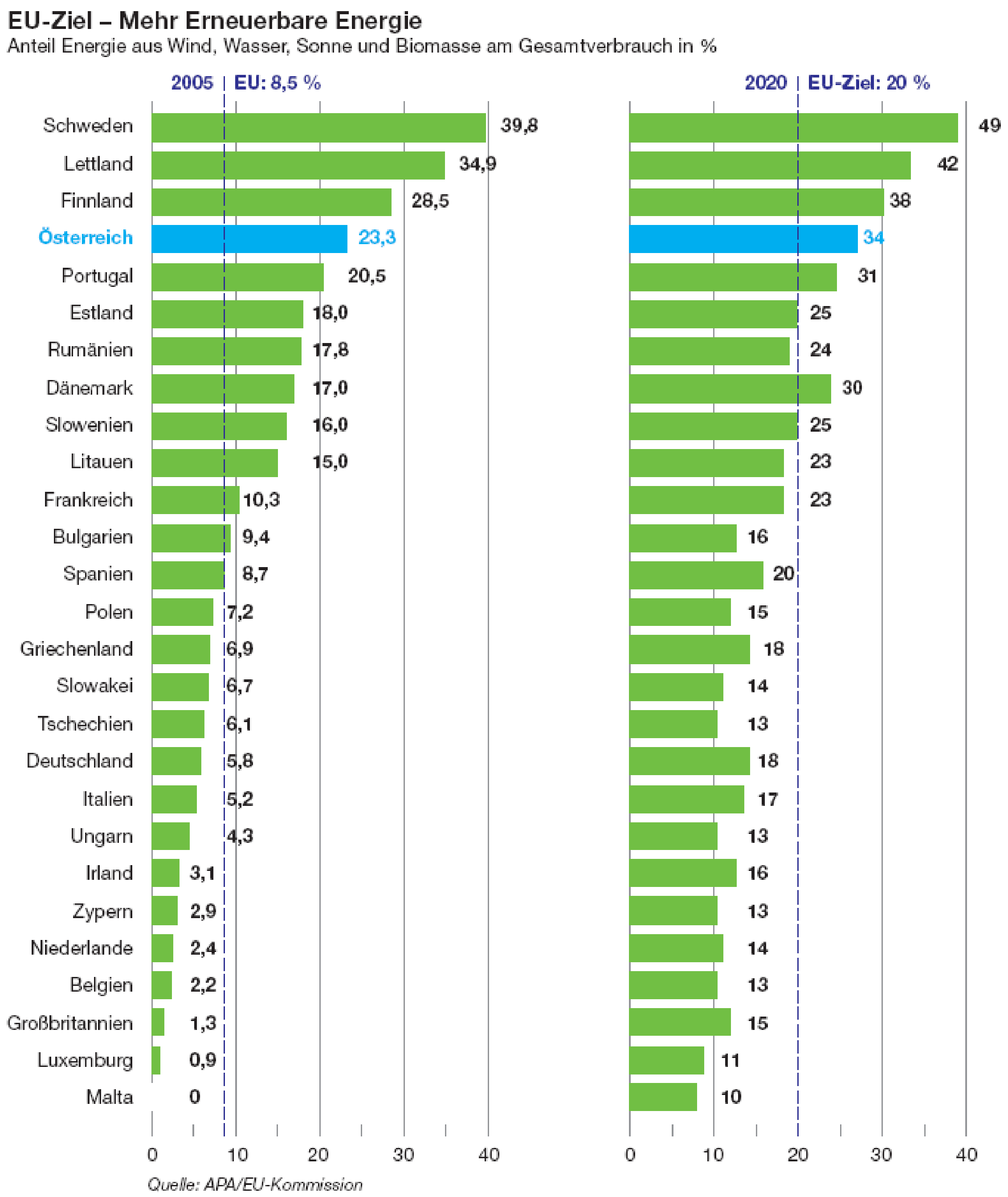


Figure 3: Share of renewable energy goals of the member states (APA, European Commission)

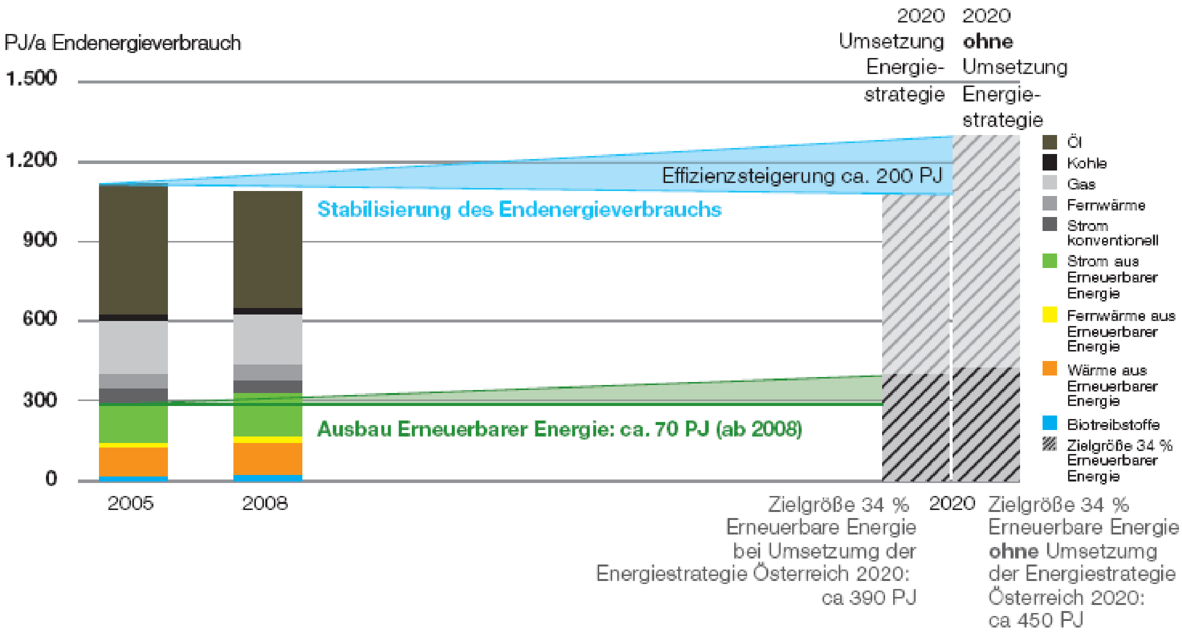


Figure 4: energy consumption PJ/a (Austrian Energy Agency)

3.2 Guidelines, support mechanism and regulations

The development of our energy systems is being approached in various documents of the European Commission and other institutions of the EU.

Examples for this are:

- The support of electricity from renewable energy sources (7.12.2005)
- A European Strategy for Sustainable, Competitive and Secure Energy (Green paper, 8 March 2006) Renewable Energy Road Map (Commission Communication, 10 January 2007)
- Adapting to climate change: Towards a European framework for action (White paper, 1 April 2009)
- Directive on the promotion of the use of energy from renewable sources (23 April 2009)

The European Union’s objective is to increase the share of renewable energies all over Europe to 20%.

Electricity production is, beside heat production, of prime importance. Technologies like combined heat and power or district heating are being approached. The goal to reduce climate change as well as its negative effects or possibly avoid them completely is more important than anything else.

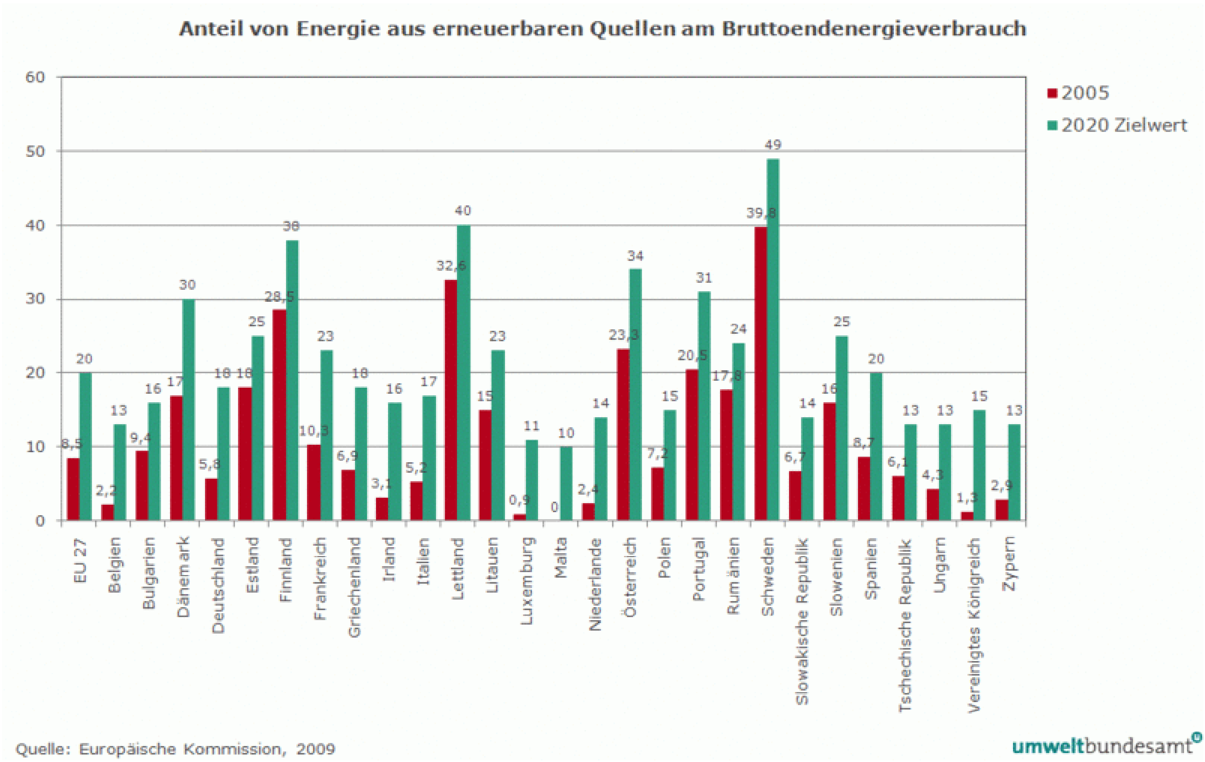


Figure 5: Share of renewable energy in Europe 2020 (Federal Environment Agency)

Varied country-specific regulations, legal requirements and action plans of the EU member states are derived from these „guidelines“ of the EU. More specific measures will be derived from them, concluded and in the most favourable case they will be enforced for individual states in countries that have a federal state order like Austria does.

Hereinafter, essential examples of „documents“ that regulate the application of renewable energy sources, especially that of solar heat in Austria, are being quoted.

- Green Energy Ordinance 2010 (Ökostromverordnung 2010)
- Austrian Energy Strategy 2010 (Energiestrategie Österreich 2010)
- National Renewable Energy Action Plan 2010 (Nationaler Aktionsplan erneuerbarer Energien 2010)

In 2008, the share of renewable energies in total energy consumption in Austria amounted to 29%. According to the Directive 2009/28/EC for renewable energies, this share should increase to 34% in Austria until 2020. How this goal can be achieved, is currently being worked out in the Austrian Energy Strategy 2020 (Energie Strategie Österreich 2020). The national goal is to stabilise the total energy consumption, based on the consumption of 2005 (1.100PJ).

In the context of the energy and climate change package, Austria has committed itself to reduce green house gas emissions in all sectors that are not subject to emissions trading by 16% until 2020, as well as to increase energy efficiency by 20%. (Federal Environment Agency)

3.2.1 Support mechanism

The current funding guidelines distinguish between:

Private investment

Multi-storey public housing

Industry and commerce

Funding is being granted on a state and federal level. Furthermore, individual funding is continually being offered by federal states and municipalities.

In the private housing sector (one-family house, townhouse), solar systems with a collector surface of 6m² for hot water supply are funded with € 600 to € 1,700 from the state. Additionally, € 2,920 can be set off against tax liability as “additional expenses” (federal funding).

Solar systems with a collector surface of 15m² for the assistance of the heating system are funded with € 1,050 to € 1,350, depending on the federal state as well as the plant efficiency. Moreover, "additional expenses" in the maximum amount of € 2,920 can be set off against income tax. (solarwärme, 2010)
In the multi-storey sector, funding is being provided in each federal state. Referring to this, new buildings as well as subsequently built solar systems are being funded.

Generally, a distinction is made between funding through direct grants and through subsidised housing, whereas subsidised housing is possible for new buildings as well as renovation work.
In concrete terms, this means that funding comprises the following types of support:

- Refundable annuity grants (including interest)
- Non-refundable annuity grants
- Promotional loans
- Interest subsidies
- Direct grants
- Housing allowances

Direct grants range from 30% to 50% of investments, based on different calculation methods.
Housing allowances are mostly granted in connection with promotional loans.

For a better understanding, a concrete example for Lower Austria is cited below.

The direct grant for solar systems is a non-recurring grant that basically is 30% of investment costs. However, the maximum amount for hot water preparation is € 1,500 and € 3,000 for the support of heating systems. These maximum amounts can be increased by € 400 for every additional apartment, also using the solar system. At the same time, certain technical requirements have to be fulfilled. Plants for hot water preparation have to include a collector surface of at least 4 m² and a warm water tank with a volume of 300 litres. In case of heating system support flat-plate collectors of at least 15 m² or vacuum collectors of at least 12 m² and also a warm water tank with a volume of 300 litres have to be used.

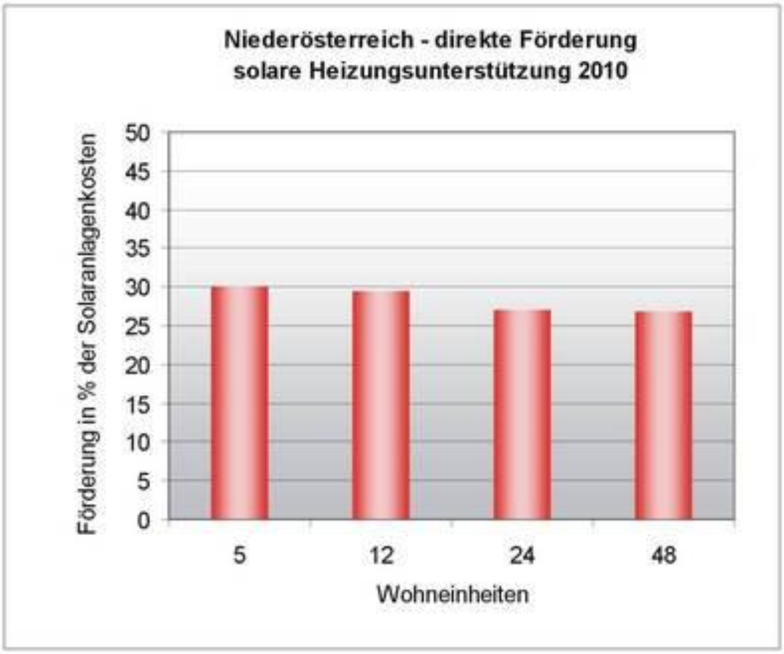


Figure 6: Grant-in-aid funding Lower Austria (solarwärme, 2010)

Funding for new buildings is provided in form of a state loan through refundable and non-refundable annuity grants, allocated with the help of a points system. New buildings can reach a maximum of 100 points.
Dwelling redevelopment of at least 500 m² is rewarded with funding for redevelopment investment, as long as the redevelopment costs are less than € 1,000/m². Should the costs exceed this amount, one has to apply for funding for new buildings. For the subsequent installation of a solar system only, reconstruction costs of 30% are taken as a basis. An annual percentage of 6% thereof form a non-refundable grant with a 10-year-term. In Lower Austria, a combination of funding through direct grants and new building or redevelopment is not possible. (solarwärme, 2010)

A special funding system is also provided for hotels and guesthouses by federal (KPC) and state governments. This topic will not be commented on further in this thesis.

In table 1, all funded projects in the commerce and industry sector, starting with the year 2002 are listed.
As can be seen in table 1, an average of approximately 30% of all investment costs that are environmentally relevant are being funded.
Processing and payment are carried out by the KPC (Kommunalkredit Public Consulting).

Table 1: Solar thermal grants for industry and trade (Faninger, 2007)

Grant solar thermal for industry and trade						
Kommunalkredit						
year	2002	2003	2004	2005	2006	2002 - 2006
number of solar stations	148	228	255	405	857	1.893
environmentally relevant investments	4.254.948	10.047.906	7.040.108	12.583.662	27.149.989	61.076.613
grant (EURO)	1.241.359	3.019.811	2.076.272	3.547.174	7.429.588	17.314.204
collector surface (m²)	6.794	16.242	11.211	20.129	44.607	98.983
grant/EURO/station	8.388	13.245	8.142	8.758	8.669	9.440
grant/EURO/m² collector surface	183	186	185	176	167	179
grant of any. relevant investments	0,29	0,30	0,29	0,28	0,27	0,29

Concerning grants for solar thermal systems in combination with biomass local heating systems, there are no clear regulations.
It may be assumed that projects submitted for grants are assessed individually by the grant provider responsible and that suitable amounts are released.

Coupled solar plants are funded by the KPC within the context of environmental support, if the plant's overall profitability will be increased.
The basis is the so called de minimis funding (all de minimis fundings can amount to a maximum of € 200,000 for one business in the course of three fiscal years). The funding rate is 25% of environmentally relevant investment.
(KPC, 2009)

Finally, it should be noted that an economic implementation of solar thermal projects without grants is virtually impossible, due to the current market conditions,
In this respect, all forms of grants that are currently available for these systems are essential preconditions in order to increase the use of solar thermal systems.

Additional consequences can be found in the conclusion at the end of this thesis.

3.3 Application areas of solar thermal systems

Solar heat is mainly used for hot water production and water heating. The collector surface is usually rather small in this case. Normally, the collectors are mounted on the roof of the house.

In the majority of cases, the solar thermal equipment is combined with a second heating station, which is gas, oil or biomass operated.
Owing to the climate conditions in Austria, the daily demand on hot water and heating cannot be covered without a storage system.

In exceptional cases, hot water storage tanks are used, covering the heat demand for the period with low solar radiation.
However, the investments that have to be made for this system are very high and you also have to accept the disadvantage of storage losses.

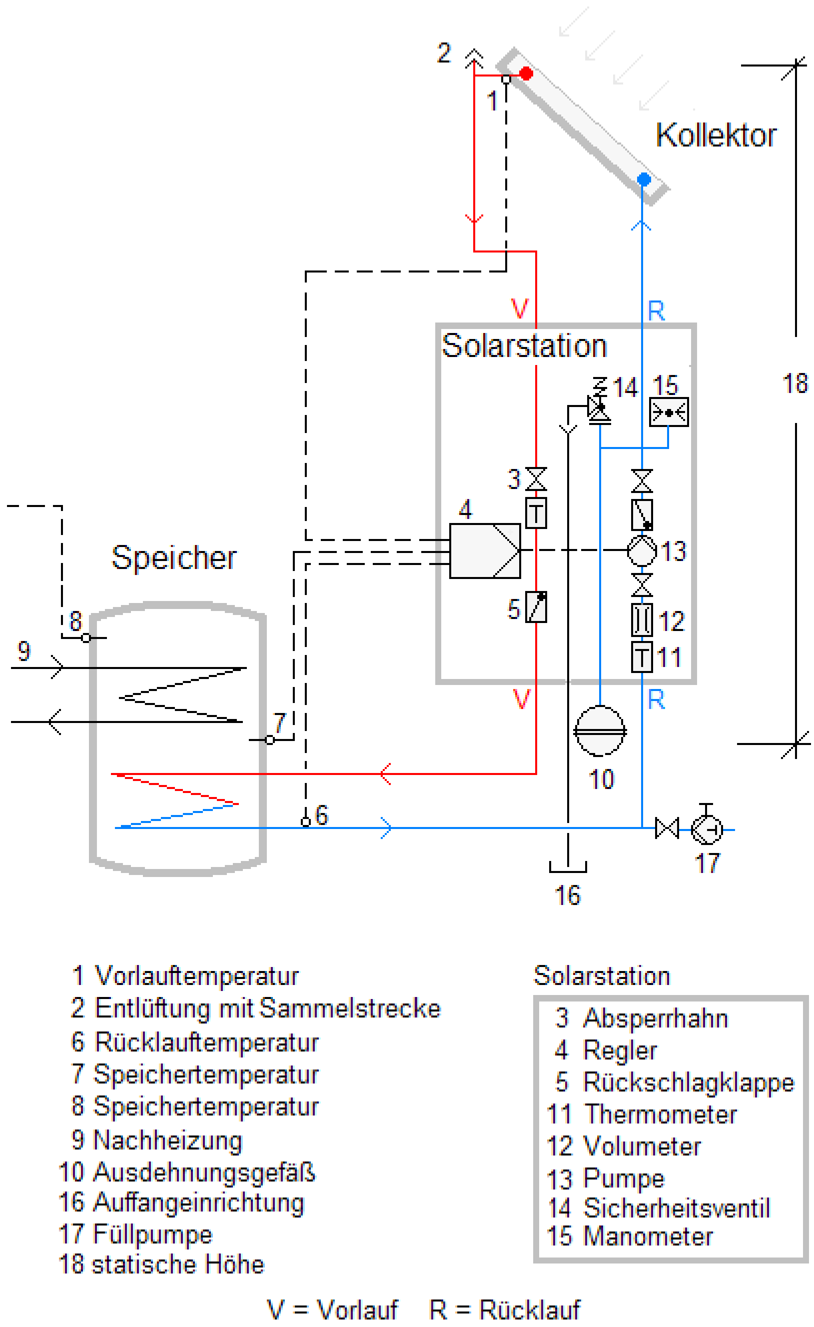


Figure 7: Typical diagram of a solar station (Energiecomfort 2010, internal document)

Solar thermal system is also used for industrial and commercial processes.

A short time ago, there were only a few examples where solar thermal energy was used for industrial and commercial processes and also for the heating of production halls.

The amount of collector surfaces that were mounted until 2004, have a total area of 148 million m² with an installed power of approximately 104 GWh. Most of this produced energy was needed for heating warm water, for space heating and for the heating of pools. (energytech)
As shown in figure 8, solar thermal power is mostly used in the food- and beverage industry, in the textile- and chemicals industry and in the simple processes of washing and cleaning, e.g. in car wash sites.

The reason for this frequent use, are the levels of temperature which are needed for the listed branches. The temperature needed ranges from 30° C to a maximum of 90°C. Therefore, flat-plate collectors are used in most cases. This type of collector has a good efficiency in this temperature range. (energytech)

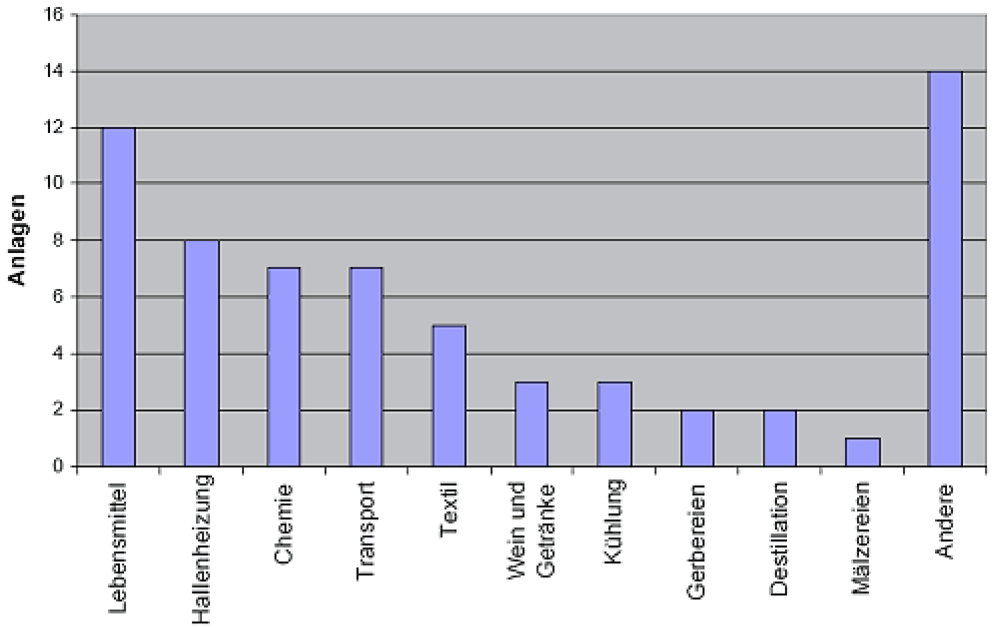


Figure 8: Solar thermal plants in different industrial sectors (energytech)

Figure 9 shows the main applications of process heat. Additionally, the temperature range and the types of collectors as well as the analysed systems are listed.

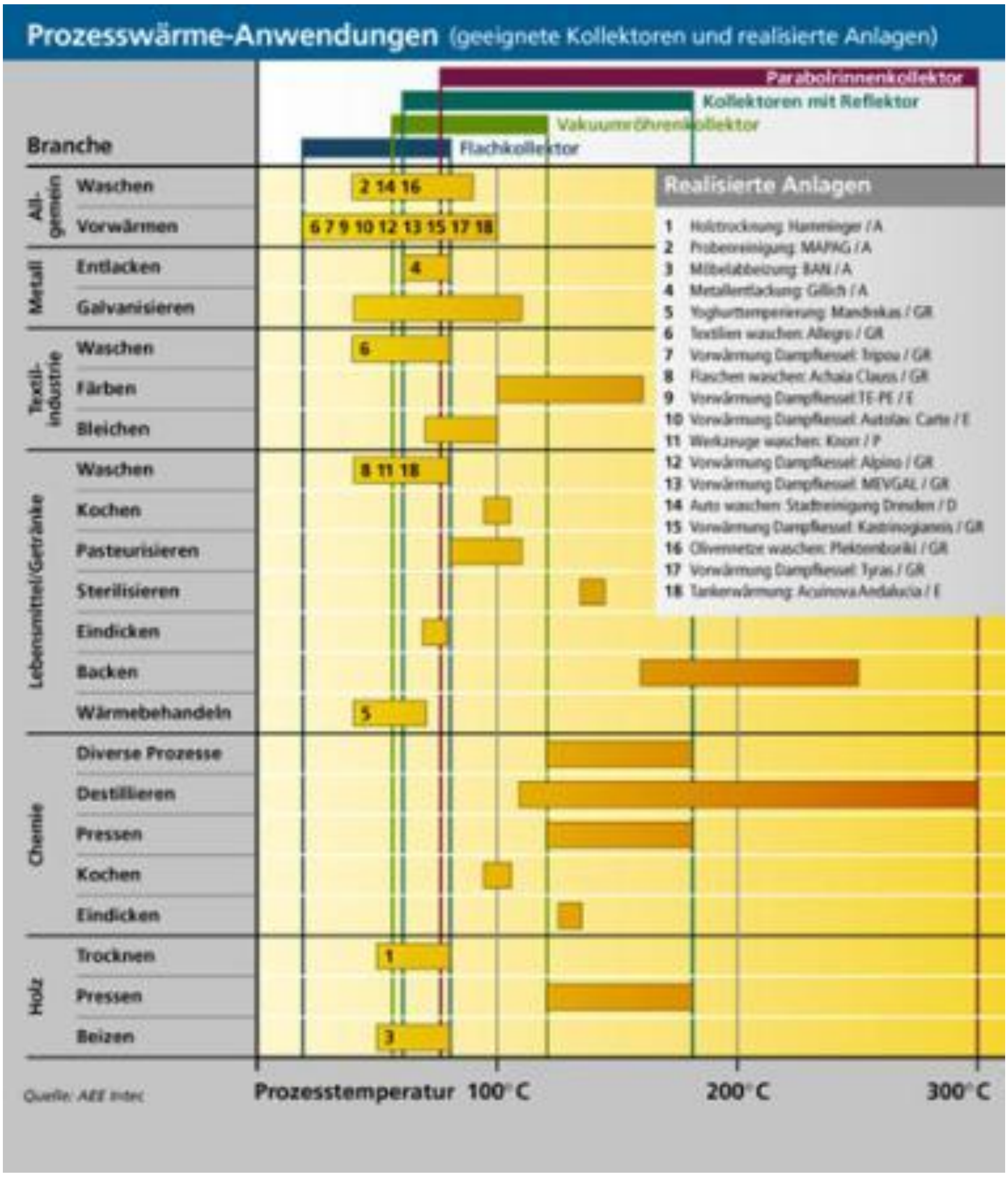


Figure 9: Applications of process heat (AEE INTEC)

In conclusion, it can be said that solar thermal energy can mainly be used in the private sector, for one-family houses or multi-storey housing.

The application in this sector is especially accelerated by recent grant systems, which will be dealt with at a later stage.

Furthermore, solar thermal energy is used more frequently in the industry sector, especially when it comes to process heat. In this area, the focus is mainly on low-temperature energy uses. The food industry as well as the chemical industry rank first.

The use of solar thermal energy in connection with central heating systems, particularly in connection with district and local heating, has started app. 15 years ago.
A large part of this work focusses on a concrete example that is presented in great detail.

In addition to all the above mentioned sectors, the use of certain existing technologies is essential for an optimum energy yield and optimum efficiency.

Which kinds of technologies are available at present will be covered in the following chapter.

3.4 Technologies being used

3.4.1 Flat-plate collectors

Flat-plate collectors have a flat collector surface that is pointed at the sun.

Figure 10: Construction of a flat-plate collector (gas- und solarheizung)

The cover and the absorber are meant to transport solar energy in the best possible way to the transmission medium, which is in most cases water mixed with anti-freeze. Copper tubings are used in most cases as absorber.
The collectors' performance is mainly determined by the collector surface, the collector glass as well as the glass coating and the insulation.
In most cases, the cover is made of safety glass with a high degree of transparency for the short wavelength spectral range and for losing the least possible radiation.
Flat-plate collectors can operate until the temperature reaches 80° C with a good efficiency. The maximum efficiency is 80%.
As shown in figure 14 the efficiency decreases when the difference between the carrier medium's temperature and the ambient temperature increases.

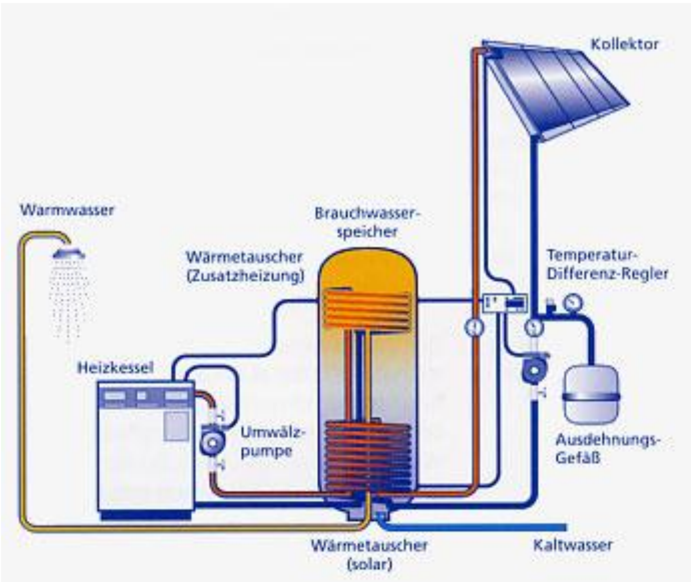


Figure 11: Structure of a solar thermal station with flat-plate collectors (Loth)

3.4.2 Evacuated tube collector

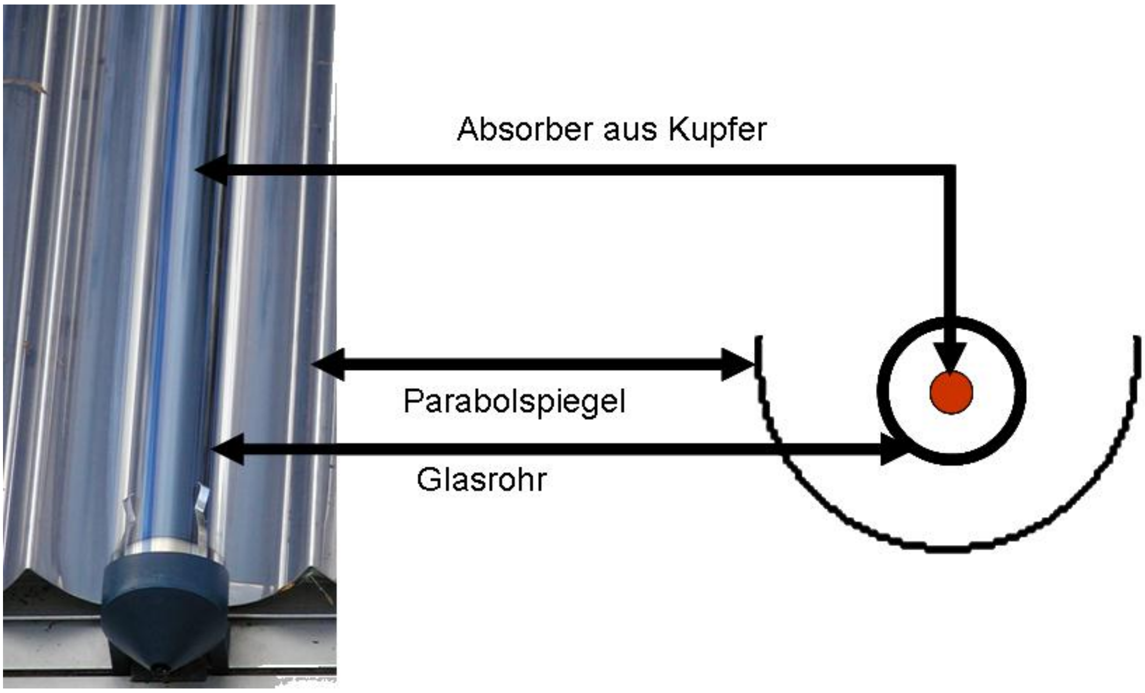


Figure 12: Structure of an evacuated tube collector (de.academic.ru)

The glass being used has to withstand all conditions, caused by the vacuum.
The flat-plate collector's insulation is replaced by a vacuum.
The thermal efficiency of evacuated tube collectors ranges between 64% and 80% maximal efficiency. Due to the special structure of the vacuum collector, temperatures of more than 100° C are possible. Hence, vacuum collectors can be used and are used in the process heat sector in particular. Moreover, these kind of collectors provide space saving mounting because of the possible rotation around the condenser tube and the higher specific output.

3.4.3 Collectors for pool heating

For the heating of pools, high temperatures are not necessary. However, large quantities of water have to be heated.
In most cases, black plastic hoses on black plastic mats are used, the pool water flows through them.

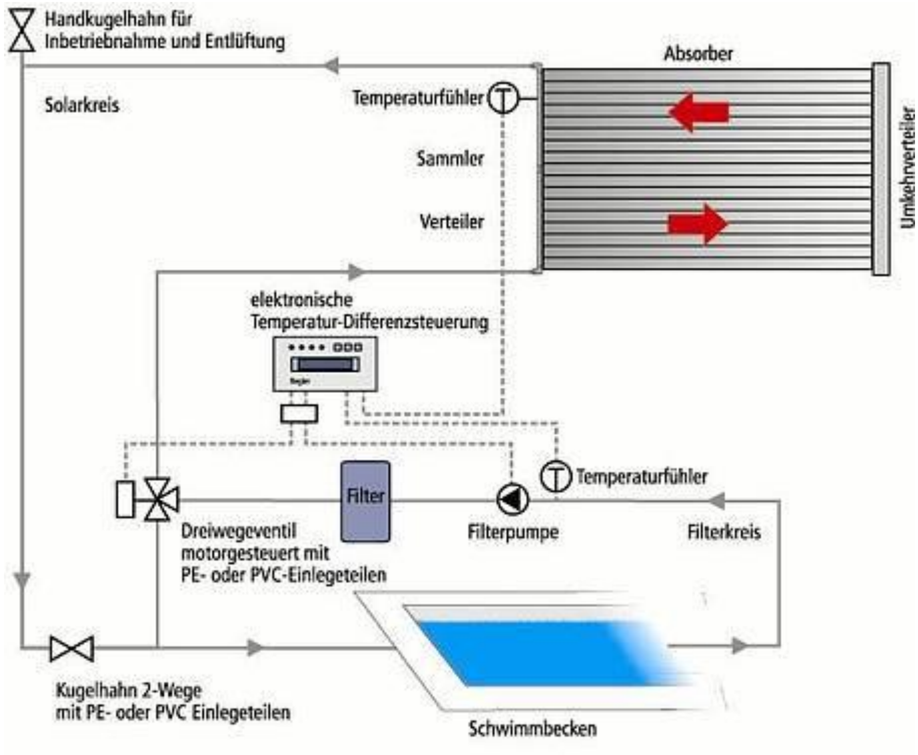


Figure 13: Diagram of a solar thermal station for pool heating (solar l klar.de)

As demonstrated in figure 13, the plant’s structure is fairly simple. The pool’s absorbers work up to a maximum temperature of 50°C. As shown in figure 13 an efficiency rate of much more than 80% can be achieved.
However, the efficiency decreases rapidly when the difference in temperature increases.

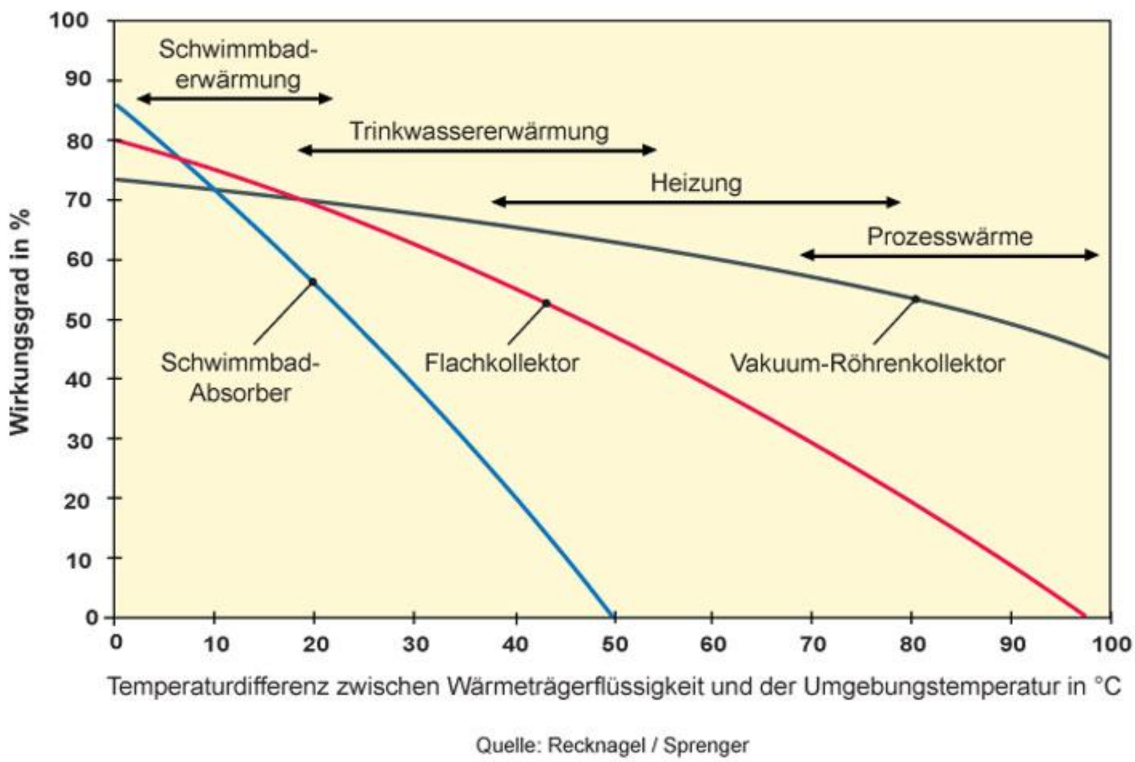


Figure 14: Efficiency of different types of collectors (iwo, 2010 Recknagel/Sprenger)

In addition to the above mentioned collector types, there are also several „special versions" that allow for a higher temperature range for special application.
These special constructions are usually connected with higher manufacturing costs.
Those technologies, which are not very common yet, will not be mentioned again in this paper.

3.5 Existing district heating plants combined with solar thermal plants

The political will in Europe, to replace fossil fuels by renewable energies has led to a change of the energy market and supply structures. The goal of this new energy policy is to prevent climate change or at least to reduce it. Furthermore, problematic dependency on only a few states or regions with according sources of fossil fuel shall be reduced.

In this context, district or local heating based on biomass have become more and more important in Austria.

The combination of district and local heating with solar thermal energy has only increased in recent years. Apart from environmentally relevant aspects, the economic optimisation of biomass local heating is of prime importance.
The goal of supplementation with solar thermal energy is to optimise inefficient summer activity that has a low heat requirement. Ideally, a major part of the heat requirement can be covered by solar energy during this period.

In the year 2000 there were about 20 solar-assisted biomass district heating plants with a collector surface of 225m² to 1.400 m² per plant and a total surface of approximately 12.000m². At present, the largest solar-assisted biomass district heating plant with a collector surface of 1.295m² and a storage volume of 120m³ is located in the National Park Hohe Tauern in Winklern (Carinthia).
(University of Klagenfurt & AEE INTEC, 2000)

Another example is the biomass local heating plant Eibiswald in Styria, which currently has a collector surface (1.150m²). The Nahwärme Eibiswald Gen.m.b.H was founded in 1991. In the year 1992, the first parts of the network were built and in 1994, the boiler house came on stream. The thermal solar plant was built in 1997. The thermal solar plant was designed with the help of the solar simulation programme SHW (Streicher et al. 1998). The goal was to cover the solar energy demand during summer.

Figure 15: picture of district heating system Eibiswald (energytech, 1998)

Figure 16 shows the plant's hydraulic diagram. The buffer storage can be charged up to two different levels and is also supplied by the biomass boiler. A special characteristic in this respect is that, due to an air-water heat exchanger, the collectors can be used for the drying of the biomass during excess time in summer.

This kind of additional heating with fossil fuels (oil) serves to cover peak loads during summer. (energytech, 1998)

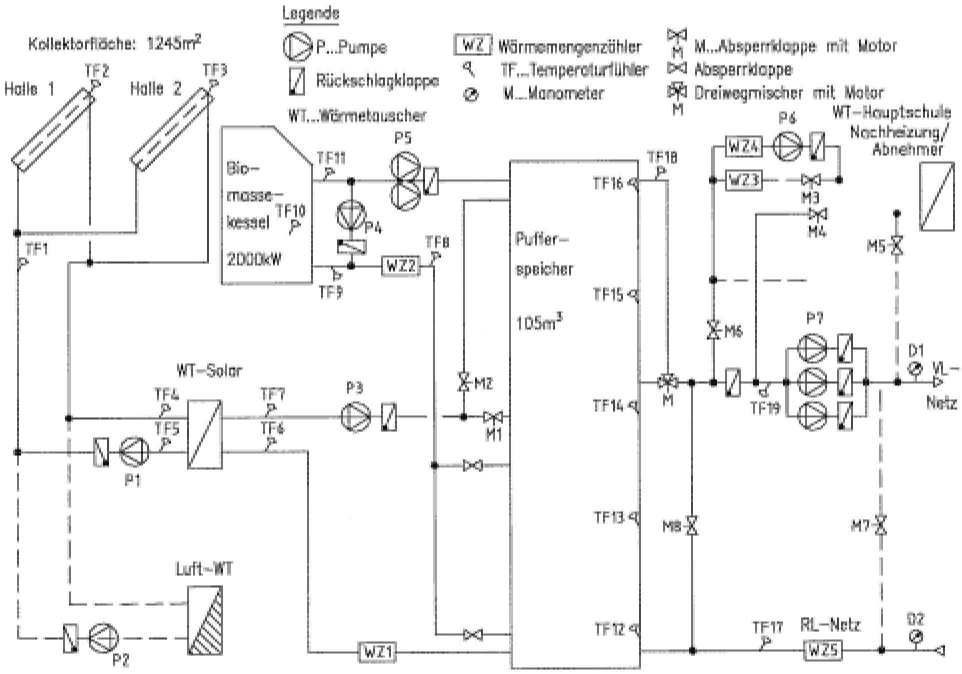


Figure 16: Technical diagram of the biomass solar station Eibiswald (energytech, 1998)

The plant's parameters are as follows:

Heat supplied to the grid:	4500 MWh
Consumers' consumption:	3650 MWh
Heat supplied by biomass boiler:	4040 MWh
Heat supplied by oil boiler:	105 MWh
Heat supplied by solar plant:	516 MWh
Specific collector yield:	415 kWh /m²/a (gross collector surface)
Annual grid losses:	20%
Heat supplied to the grid (July, August)	125 MWh
Grid losses (July, August)	65%
Coverage provided by solar heat during the months of summer holidays	90%
Total annual provided by solar heat:	8%

Subsequently, different major technical systems and storage concepts will be covered.

3.5.1 System and storage conceptions

There are three different system and storage conceptions that are most widely used: short-term and long-term heat storage tanks. Short-term heat storage tanks can temporarily store solar heat for one or two days and are mainly used for the preparation of hot water.
The share of solar heat of the total heat demand (hot water and space heating) is limited to approximately 10% to 20%. The generally opposed parameters of the high

solar yield in summer and the low solar heat in winter, and of the low heat requirement in summer and the high space heating demand in winter is compensated for by long-term storage systems. The covering of the total demand through solar heat can be up to 70%.
(University of Klagenfurt & AEE INTEC, 2000)

	Short-term storage system	Storage system for one week	Long-term storage system
Solar thermal energy for	Hot water	Hot water and space heating	Hot water and space heating
Share of solar energy	10 to 20%	30 to 40%	40 to 70%
Collector surface per unit	2 to 4 m²	4 to 10 m²	10 to 40 m²
Water storage space per m² of collector surface	50 to 70 l/m²	200 to 400 l/m²	2000 to 4000 l/m²
Costs of solar thermal share per m² of heated area	20 to 25 €/m²	30 to 50 €/m²	90 to 150 €/m²

Figure 17: Comparison of different systems (University of Klagenfurt & AEE INTEC, 2000)

Based on the above mentioned systems, an existing biomass local heating network will be analysed and interpreted concerning the supplementation or combination with solar thermal energy.

4 Solar thermal heat in addition to district heating

4.1 Description of the existing DHP Trumau

The project development on this biomass plant began in the year 2006.
In figure 18, the plant's functional principle with a heat grid is shown in an easy and clear structure.

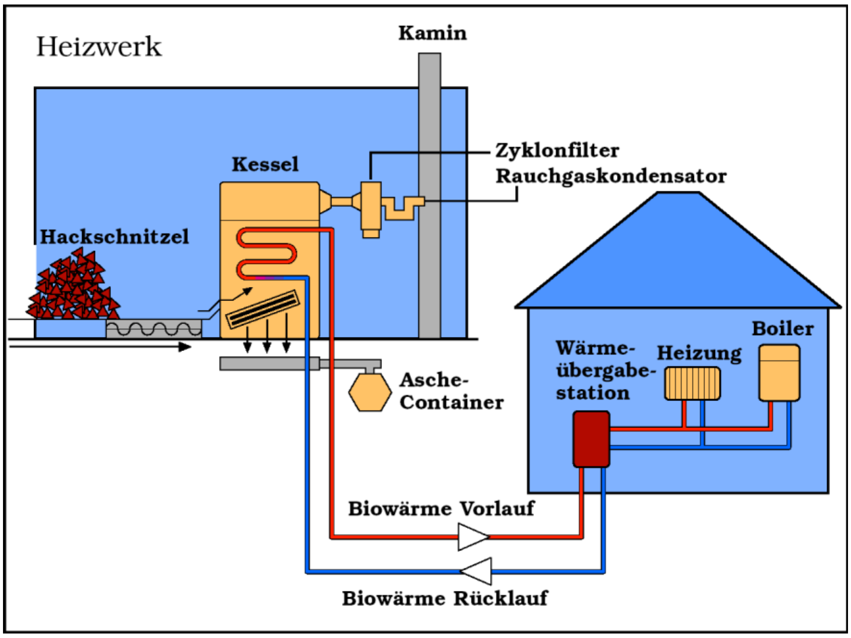


Figure 18: Functional principle of the district heating system

The initial situation was defined by the following basic conditions:

In the municipality, there were a lot of new buildings and redeveloped buildings. The building developer Gebös has been represented through many buildings and therefore, had a great interest in the establishment of this kind of heat supply. The main route for the network was located on public land.
The location of the boiler house was decided on rather quickly, due to the planned construction of a sludge drying plant. It was located right next to a wastewater treatment plant.

In addition to detailed preliminary examinations and many coordination meetings with the municipality of Trumau, a feasibility study was carried out in 2006. The supply of approximately 50 buildings was the basis of the feasibility study, whereas the subject of sludge drying was essential for the project's development.
In the wastewater treatment plant (covers a total of 7 municipalities), approximately 1.200 tons of pressed wet sludge are produced per year. The goal was to reduce the relatively high disposal costs. In order to achieve this goal, a sludge drying plant was planned in combination with a biomass plant and it was finally built in the course of this project. In this drying plant, nearly all the water contained in the wet sludge, with a water content of approximately 85%, is extracted with the help of a belt dryer at a temperature of approximately 100° C. In this respect, around 1.000 MWh of heat energy are needed every year. Afterwards, the dried sludge is taken away and then it is burnt.

Figure 19: wet sludge

Figure 20: dry sludge

The total power requirement for all the connected buildings amounts to 5 MW.

After the approval of the plant's construction through the necessary committees, the ground-breaking ceremony took place in October 2006 and marked the official start of construction.

In fact, the construction of the plant started in April 2007, after having received the federation's (KPC) and Lower Austria's release of funds.
The first application for funding was submitted on March 31, 2006. A subsequent submission was made on January 19, 2007.

In autumn 2007, the first buildings were already supplied with the heat of the biomass plant. Starting in autumn 2008, the plant became fully operational and currently supplies about 30 buildings with an annual total energy demand of approximately 5.000 MWh. It is located right next to the wastewater treatment plant in Trumau. The total area (built-up area and storage area) is about 3.000m².

The investment volume was around. € 3.9 million.

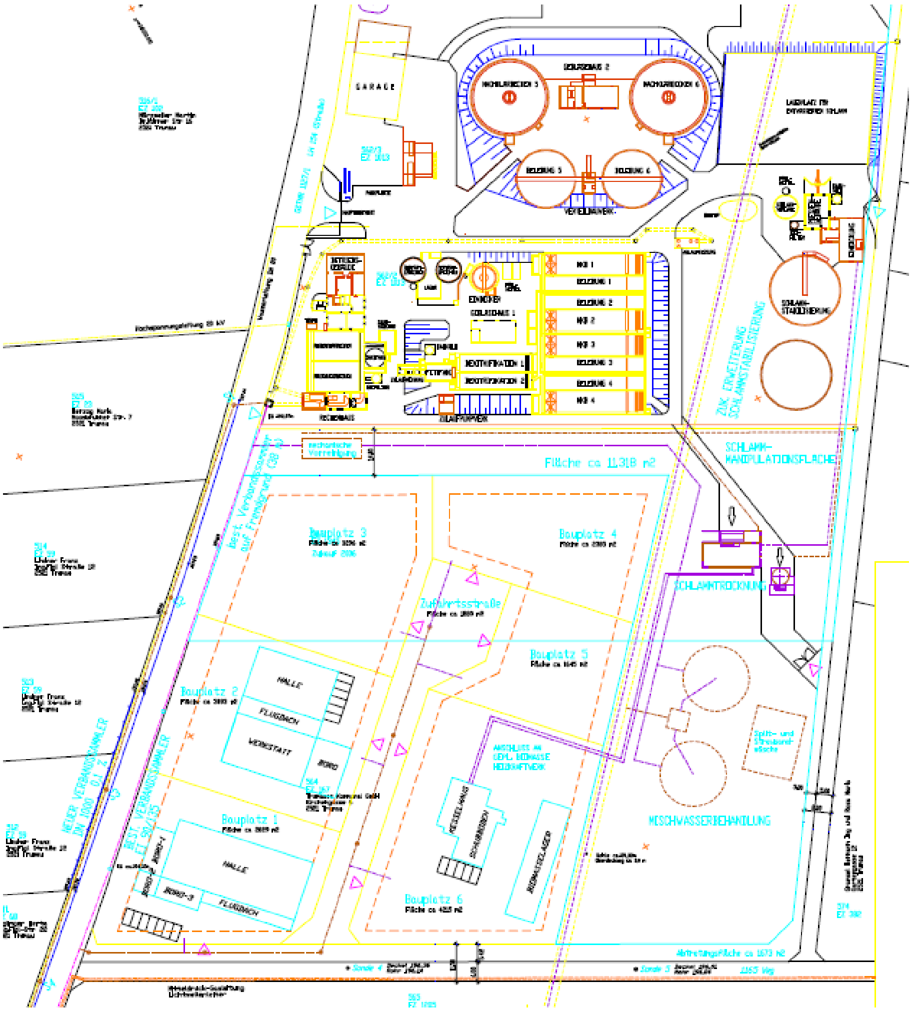


Figure 21: Site plan Trumau

The contributions accomplished by our business in order to realise this project include:

- Planning of the entire plant, including the network
- Processing of funding
- Construction of the heating plant, including storage
- Construction of pipeline network, including house connections
- Construction of sub-stations for the houses
- Construction supervision
- Initial operation
- Management of the actual operation of the plant.

4.2 Heat demand

The recent total amount of energy produced per year is approximately 5,000 MWh. When the plant is running at full capacity, an annual amount of energy of 8,000 to 9,000 MWh can be expected.
In this respect, especially new converted buildings (from floor heating to central heating) are connected to the grid.

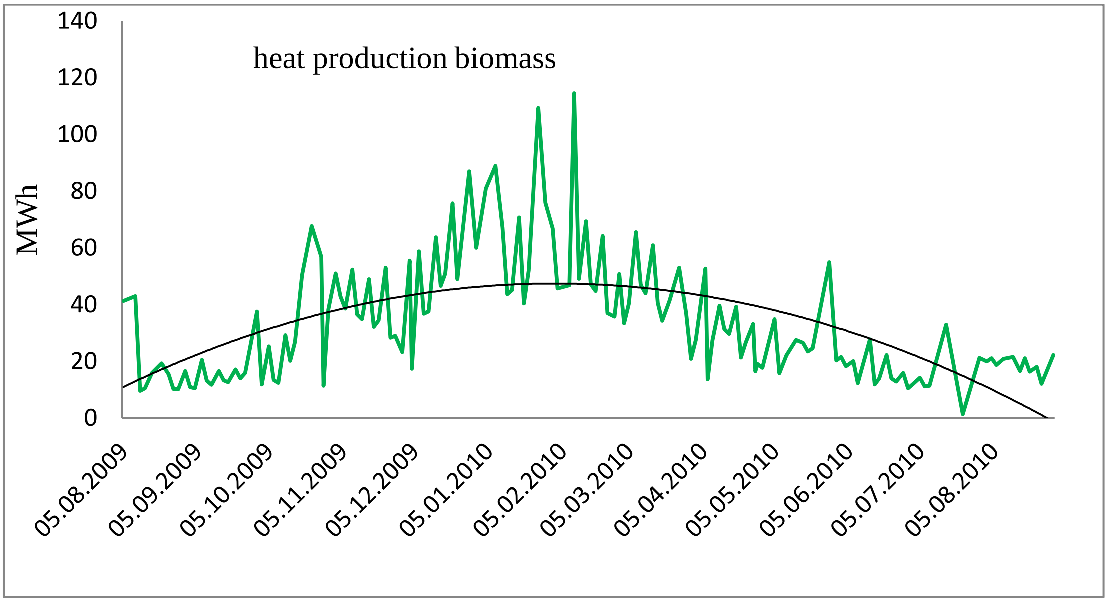


Figure 22: Heat production biomass

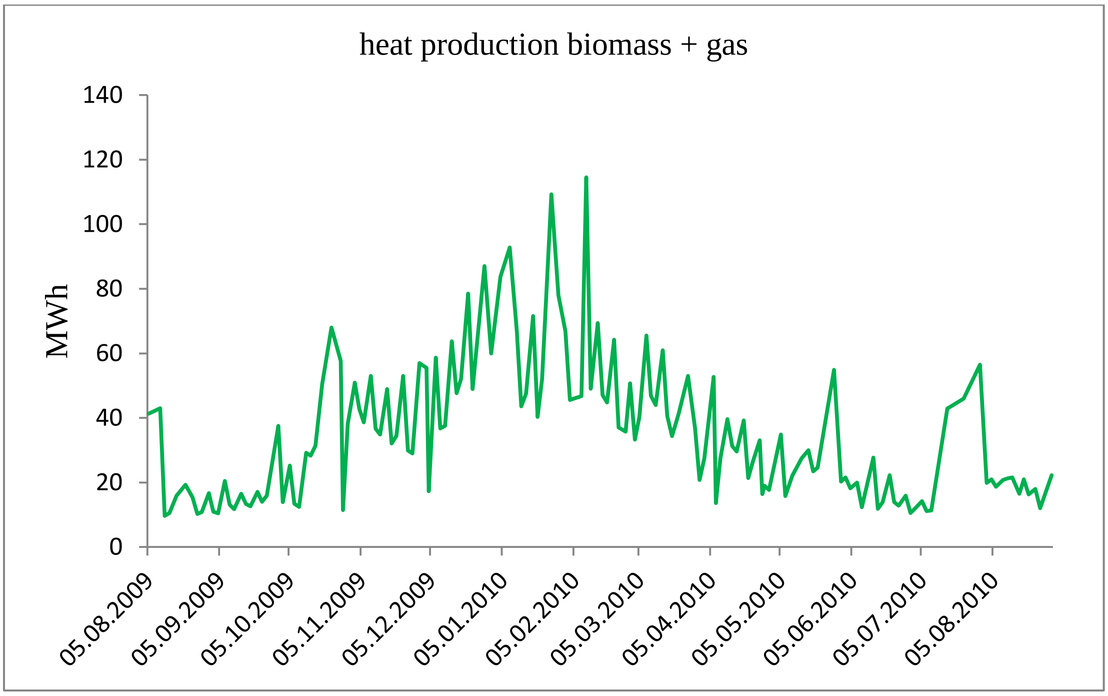


Figure 23: Heat production biomass + gas

4.3 Installed capacity

The installed capacity currently amounts to 2 MW biomass boilers and 4.5 MW gas-fired boilers. The gas-fired boiler is used as a failover and to cover peak loads.
As a result, the aim is an interruption-free supply of the connected buildings all year long.
In figure 24, the biomass boiler, including the heat exchanger and parts of the flue gas cleaning are illustrated.

Figure 24: Boiler plant incl. heat exchanger and parts of flue gas cleaning

The plant has been designed in a way that, in case of full extension, a maximum of 5% of fossil fuels must be used in order to cover peak loads.

The established flue gas cleaning consists of several stages. The bottom ash, a result of the combustion process, is transported to a through chain conveyor via the grate. The flue gas is purified from fine ash and dust particles in the multi-cyclone. Subsequently, the glue gas is additionally purified from fine dust with the help of an electrostatic precipitator.
The fine dust is also being gathered in a tightly sealed container and is disposed of properly.

4.4 Grid losses

Grid losses mainly depend on the grid length, the connection density as well as on the tube design.
In this case, an established high-quality product, ISO Plus, is being used.
The grid losses are around 16 W/lm based on the used technology and the laying.
The pipe length is around 5.200 m.

The grid losses approximately are 1,300 MWh/a. This heat loss is, as it were, a base load over the whole year.

4.5 Grid water volume

The grid's length is approximately 5.200 m. That means, the length of the flow pipe and return pipe is 10.400 m in total. The root (pipe diameter) of the pipe exiting the heating plant is 100 mm.
The diameter of the individual house connections is 40 mm. The grid's water volume therefore amounts to 82.000 litres, in other words 81 m³.

The grid's flow temperature is about 95 °C und the return temperature is about 65° C The difference between flow temperature and return temperature therefore amounts to 30° C.
The plant is designed for this temperature difference and provides the highest efficiency possible in this temperature range.

In summer, the flow temperature is lowered to approximately 80° C, according to the clients' needs and the contractual provisions. This measure helps to accordingly reduce grid losses.

4.6 Fuel mix

As already mentioned above, the goal is to limit the use of fossil fuels, in this case gas, to a maximum of 5% of the total demand per year.

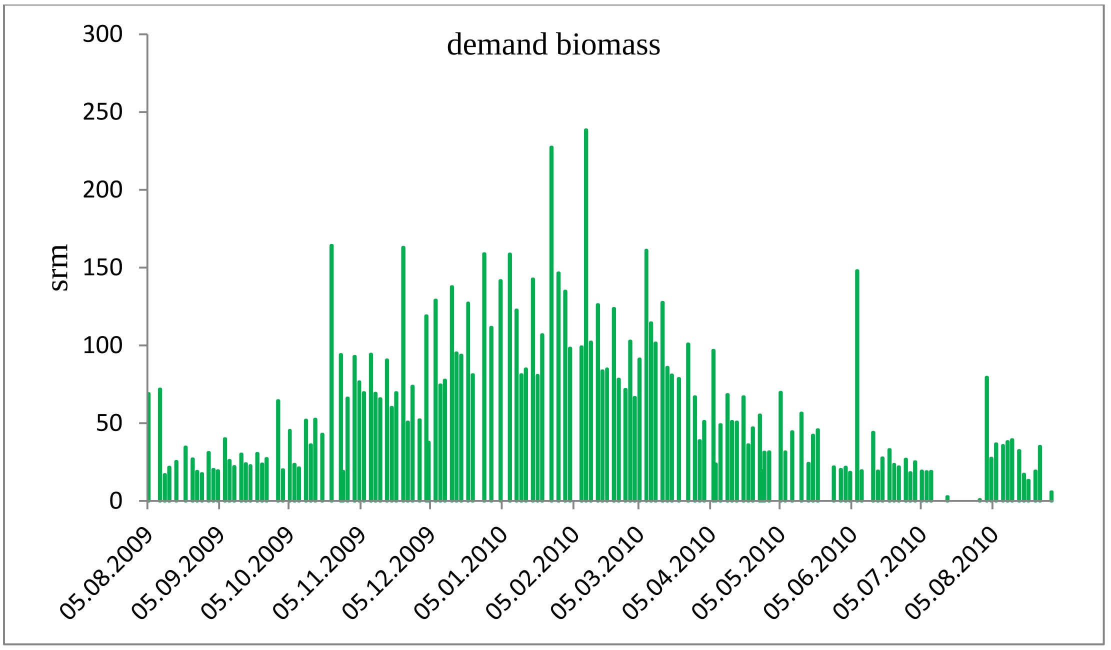


Figure 25: Demand biomass (srm)

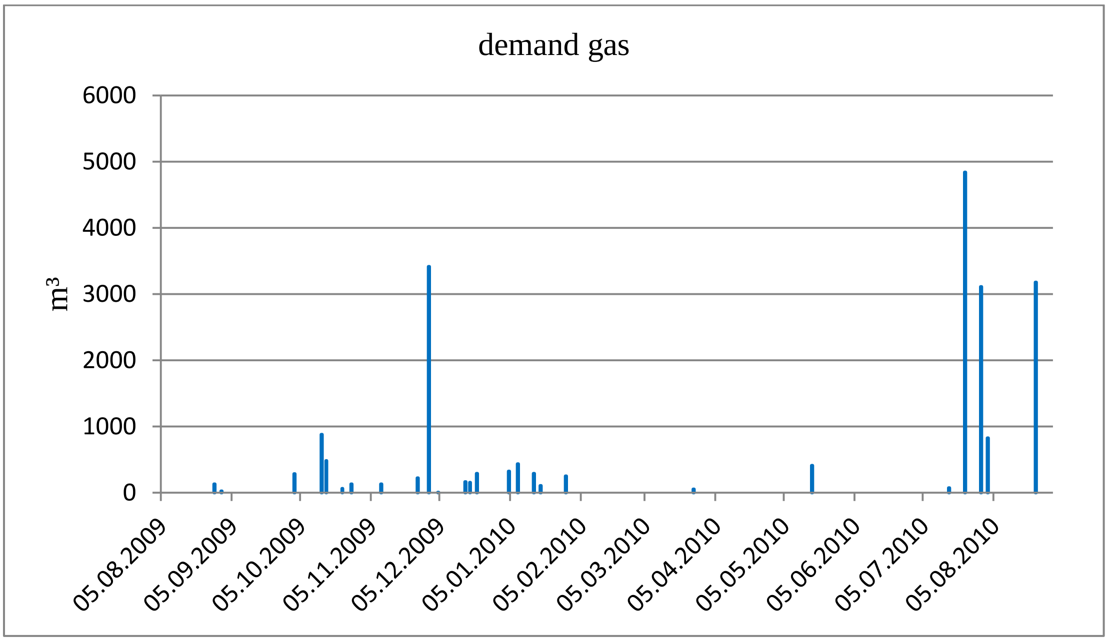


Figure 26: Demand gas (m^3)

The goal of the construction of an additional solar thermal plant is to reduce gas consumption as well as the use of biomass.
To which extent this is useful is covered in the next part.

4.7 Expected future demand

It is to be assumed that, in case of a full upgrade, the annual demand amounts to approximately 9.000 MWh. In the process, the heat demand during summer will mainly be covered by drying sewage sludge, around 1.000 MWh are to be expected during summer season.

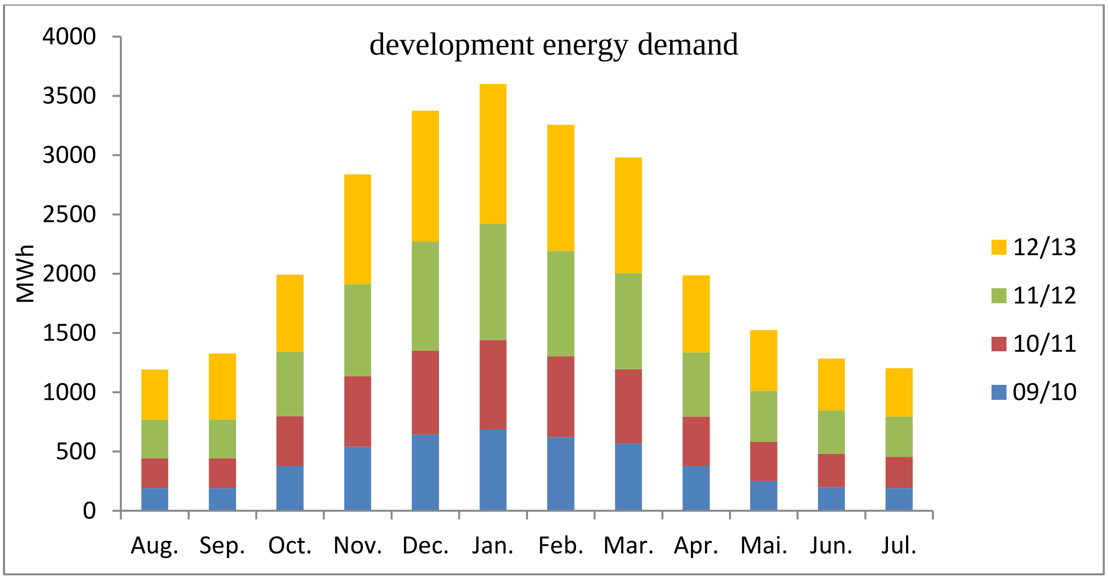


Figure 27: Expected development energy demand (MWh)

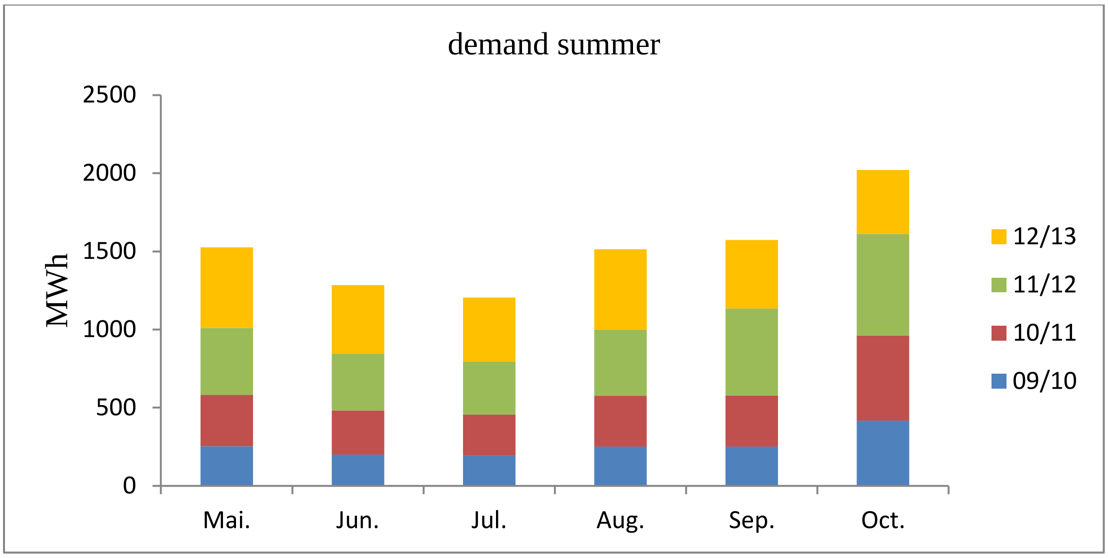


Figure 28: Demand summer (MWh)

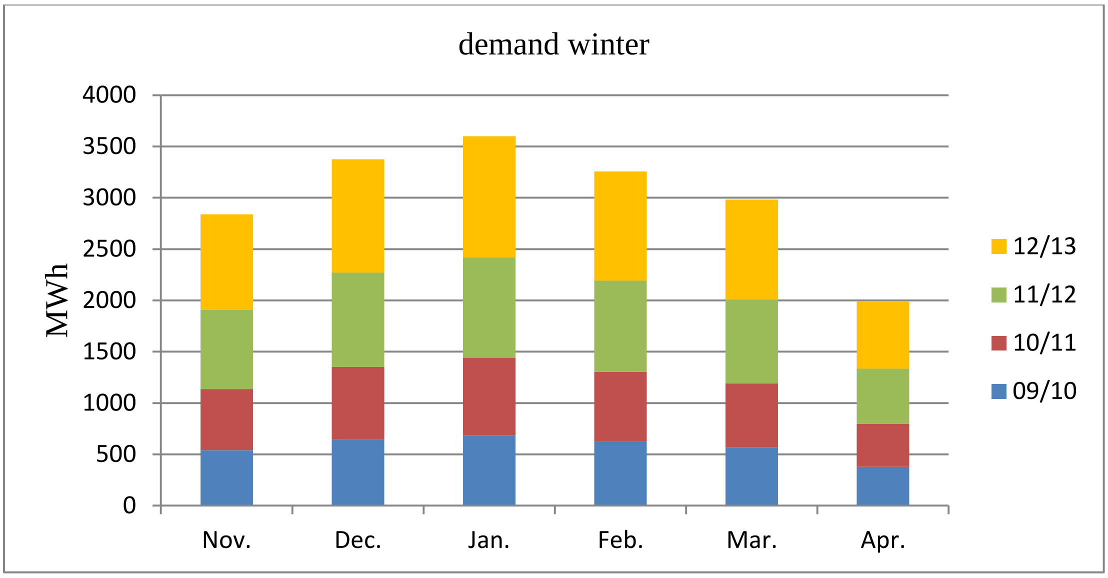


Figure 29: Demand winter (MWh)

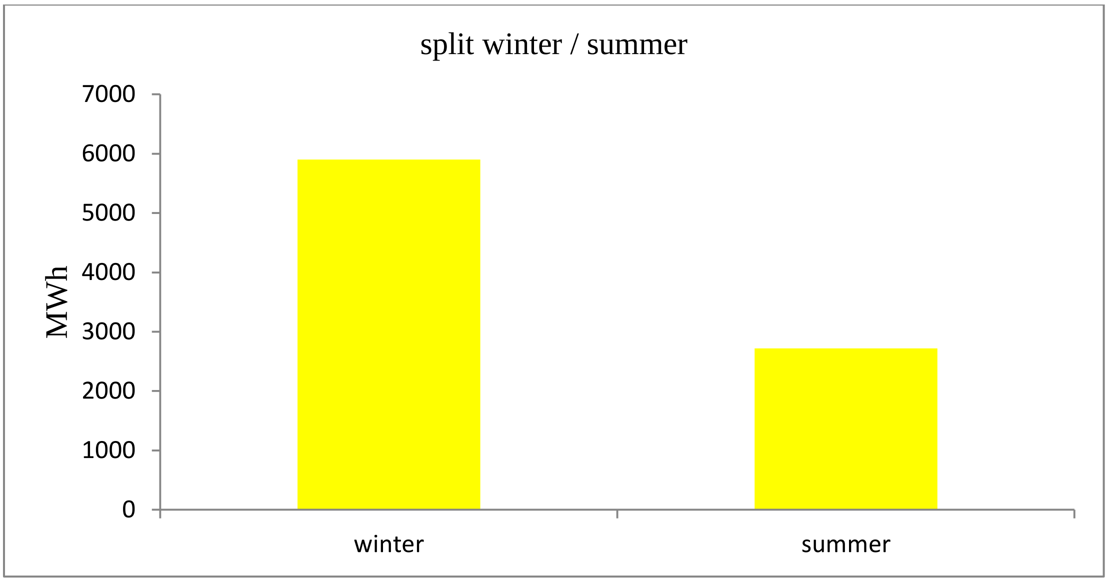


Figure 30: Split summer, winter demand

The tables above show the future demand. The irregularities of this development are caused by the time difference of the grid's expansion phases, the connecting of new buildings and the changing demand in the drying of sewage sludge.

In case of a full upgrade, the heat demand for the summer season, May to October, will amount to a total of 2.700 MWh. In the heating season, i.e. the winter months, the heat demand will be around 5.900 MWh, whereas the development of heating demand will be as shown in table 9.

5 Promoting of solar heating

5.1 Solar radiation

The combination of a biomass district heating plant with the planned solar thermal plant, the natural conditions of solar radiation in general and that of the concerned location in particular, have to be taken into consideration.

The significant influences of the specifically gained solar energy depend on:

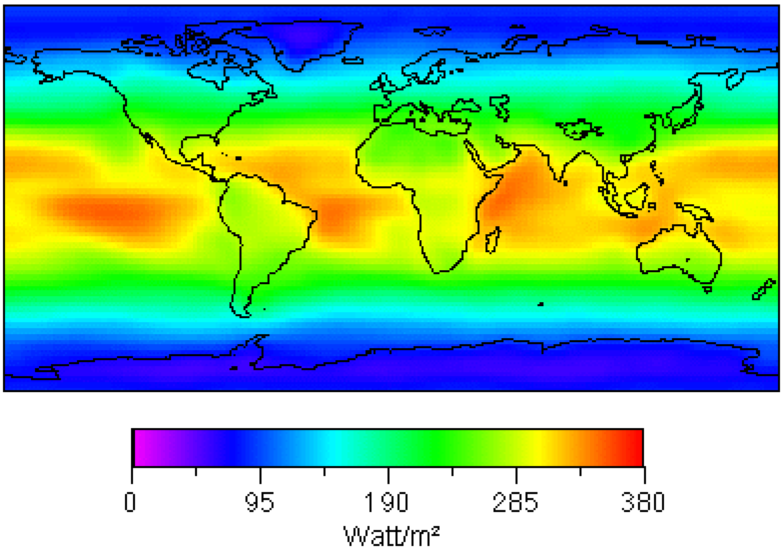
- Geographic location concerned
- Topographical situation
- Average sun hours/a
- Cloud coverage
- Frequency of fog
- Technology applied for solar collectors
- Plant efficiency
- Mounting

Since the sunlight travels through the atmosphere, its intensity is diminished by various constituents of the atmosphere when it eventually reaches the ground. These constituents are gases, liquid and solid particles, and clouds (condensed water). Out of these factors, the clouds attenuate the solar intensity the most.

Non-reflected or scattered radiation that reaches the surface directly is called beam or direct radiation. The scattered radiation that reaches the ground is diffuse radiation and the rather small part of radiation, reflected from the ground onto a tilted receiver is called reflected radiation. Global solar radiation is the sum of these three components of radiation.

How much of the incident global radiation can be used for energy conversion through a receiver is influenced by the angle used for the installation of the modules, e.g. solar thermal collectors. Obviously, solar radiation reaches its maximum when received by a surface perpendicular to the sunbeams. During the course of the year, the optimal angle changes, due to the inclination of the Earth's axis.

Figure 31 shows the total solar radiation of the whole planet.



Figur 31: Earth's solar radiation (Paeger)

In Austria, the average energy content of solar radiation is 1.100 kWh/m² per year, whereas 1.400 kWh/m² are possible in higher altitudes, due to a lower frequency of fog.

In the case of the Trumau project, the solar radiation levels in Vienna (1.068 kWh/m² per year) will be taken as a point of reference Trumau is situated 30 km from Vienna.

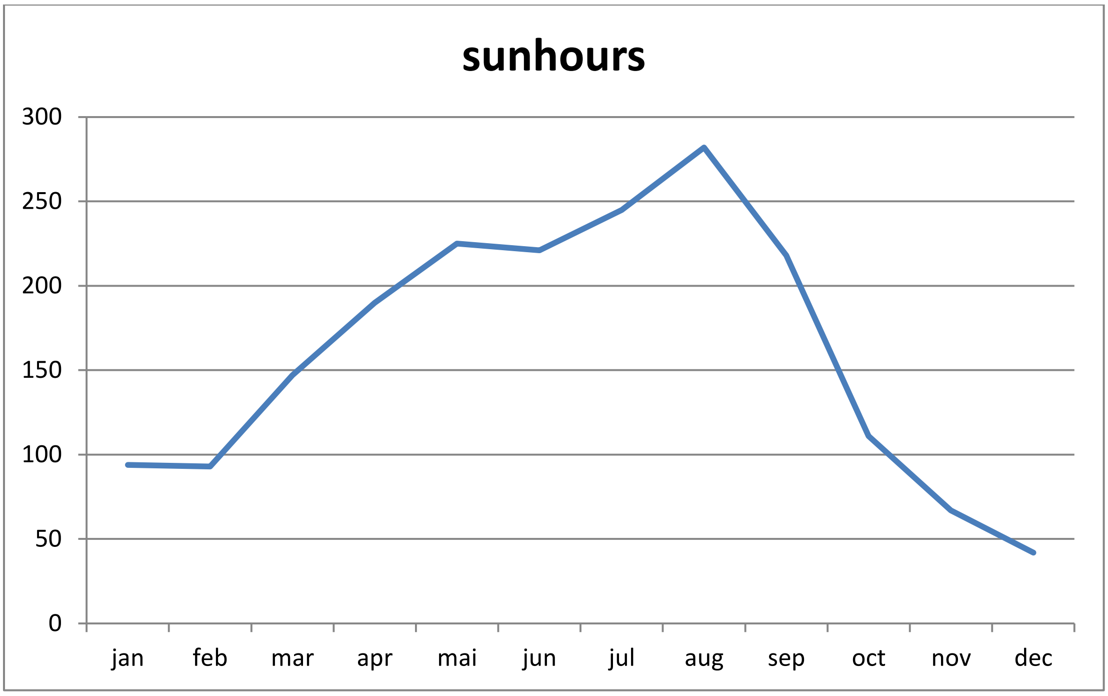


Figure 32: Sunhours Vienna (http://www.pelka.co.at/statistik.html, 2005)

5.2 Choice of technology

It is the solar collectors' task to transform solar energy into heat, which can be used for different purposes.

Bacsically, one can distinguish between:

- Flat-plate collectors
- evacuated tube collectors

In this case, solar heat is used for the heating of water and for the heat input of an existing local heating grid based on biomass.

The flow temperature is between 80° C and 95° C, the return temperature is between 55° C and 70° C.

Due to the operational parameter and by taking into account the investment costs, it is assumed that the use of flat-plate collectors is technically and economically useful.

The range of the efficiency flat-plate collectors is relatively high. Different models of different origins are available. In order to correspond to the highest quality standards and to ensure warranty, an Austrian product is being chosen.

Naturally, it is also possible to choose a product of different origin, should it possess the appropriate quality criteria but in this case it was not done, particularly due to the topic of warranty.

The collector chosen for this application is called „oekoTech HAT 14.3“. OekoTech recommends this type of collector for efficient operating in the temperature range between 60° C and 95° C. For lower temperatures, the GV and GS models are recommended.

5.2.1 Collector efficiency

The efficiency curve of a solar thermal collector is determined by the level of global solar radiation, and the difference between the ambient temperature and the medium’s temperature inside the collector. Naturally, there are also differences due to the individual technical specifications of the chosen collector. The basic formula for the collector's efficiency is:[1]

$$\eta = \eta_0 - a_1.(t_m-t_a)/G - a_2.(t_m-t_a)^2/G$$

η_0 .... maximum efficiency (conversion factor)

t_m .... mean temperature of the collector's medium, °C

t_a .... ambient temperature outside of the collector, °C

G .... global solar radiation, W/m²

a_1 …… linear heat loss coefficient of the collector, (W/m²)/K

a_2 …… quadratic heat loss coefficient of the collector, $(W/m^2)/K^2$

[1] Weiss (2009), p. 33

The collector’s efficiency while converting solar radiation into heat depends on its individual conversion factor, which is defined as the maximum efficiency, when the ambient temperature is the same as the heat fluid’s temperature, and it also takes into account the specific heat loss coefficients of the collector type. Apart from those technical criteria related to the construction of the collector, the efficiency is influenced by two external factors, namely by the difference between the average temperature of the collector’s heat fluid and the ambient temperature outside, as well as by the actual level of the solar irradiance.

Figure 33 shows the difference in efficiency of collector HT and collector GS based on the range of temperature

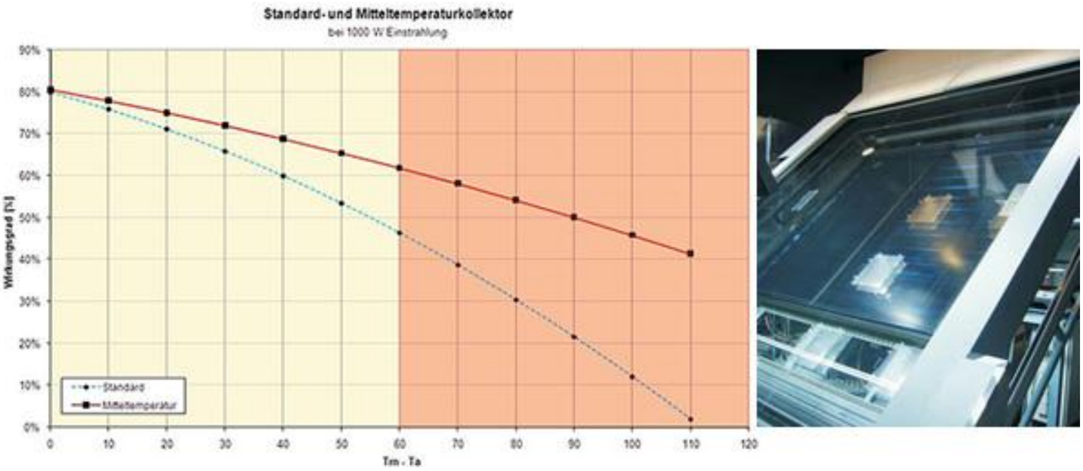


Figure 33: Comparison of the efficiency of standard and HT collectors (oekoTech, 2010)

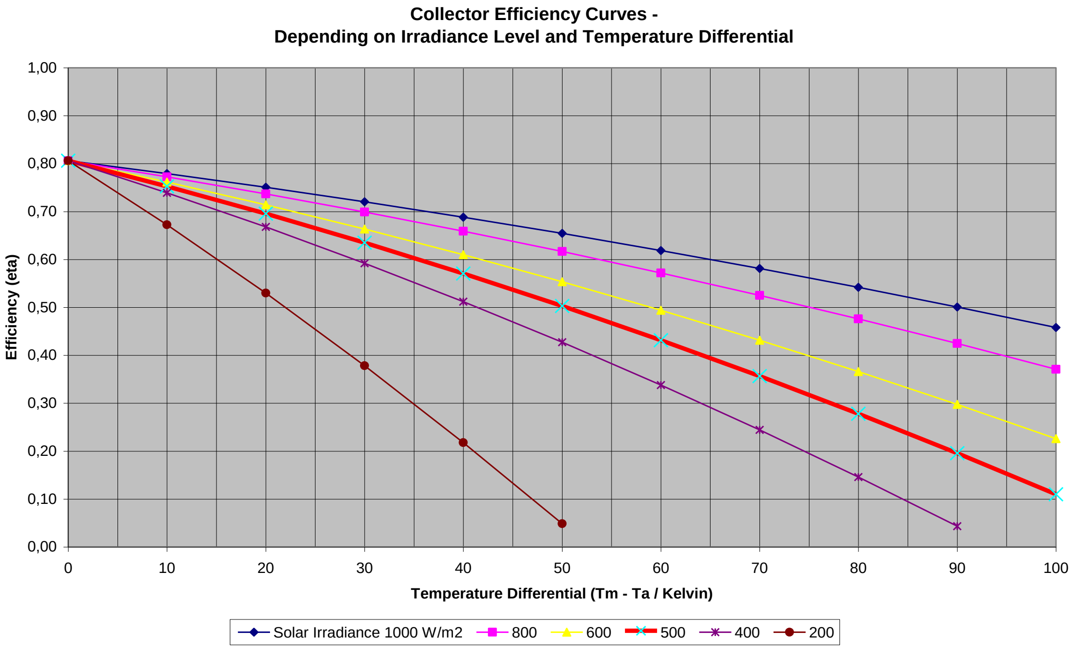


Figure 34: Collector efficiency curves (oekoTech HT 14.3)

In the case of a district heating application, the temperature of the collector's medium stays rather high, e.g. in comparison to the use in private homes, because of the relatively high return flow temperatures of 55° C(summer) to 65° C (winter). Due to the specific situation that the water, heated by the solar collectors, can be brought back into the return flow (see chapter 5), we estimate that the average temperature of the collector's medium will only be 5 degrees higher than the return flow's temperature. Certainly, this assumption must be verified in real operation. Especially on very clear and warm summer days there could be constellations that can not move all the heat fast enough from the collector to the grid flow, because the recommended flow rate for the collector chosen is a maximum of 80 litres per hour.[2]

The monthly average ambient temperature fluctuates between -2.5 and 15° C. On a daily basis, the fluctuations are naturally even higher. So, the difference of the temperature of the collector's fluid vary between approximately 30° C on the warmest summer days and 80° C on the coldest days in winter.

[2] arsenal (2008), p.5

Looking at the graphs in the figure above, it can be concluded that the maximum efficiency is reached during summer time with efficiency values of 60% to 70% at clear-sky days. In winter, the temperature differences rise significantly, and the efficiency drops to just around 50 % on days with relatively high levels of solar irradiance. However, if the solar irradiance is down to only 200 to 300 W/m² on bad weather days, the efficiency will drop significantly, and subsequently there will be no energy output. Even during summer time, the energy output of the collector might drop significant, e.g. if the ambient temperature were below 20°C and the solar irradiance were only 200 W/m².

Summarizing the efficiency analysis, it can be said that there is only little potential for solar thermal heat production from November until January. This also means that the energy output during the remaining months can be increased by finding a new optimum of the collectors' inclination angle.

5.3 Solar output

Deriving the percentage of solar heat that can be gained in combination with the biomass heating plant at Seefeld requires a realistic estimation of the solar thermal energy output's potential. As discussed above, the energy output fluctuates during the year, due to different weather conditions that influence the collector's efficiency. In short, this means that the main preconditions for a high amount of solar thermal energy output from the collector are:

- The solar radiation levels are high, i.e. when the skies are clear and the sun is at high altitude.
- The efficiency of the collector is the better, the lower the difference in temperature between the heat fluid inside and the ambient outside.
- The energy output of the collector can be maximized by using the optimal inclination angle.

Obviously, the optimum for the solar thermal energy production cannot be found easily. In order to get accurate figures over the whole year, it is necessary to sum up the power contributions for all the units of time, each of them depending on the actual conditions of solar irradiance and temperature differential. The inclination angle of the collectors is fixed at 41 degrees for this purpose. The calculation formula for the collector's power at a certain point in time is:[3]

$P_i = G_i.\eta_i.A$

P_i …… Power at a certain time, W

G_i …… Solar irradiance (at a fixed inclination angle of the collector), W/m²

η_i .... Actual efficiency of the collector at that point of time (chapter 4.3.2)

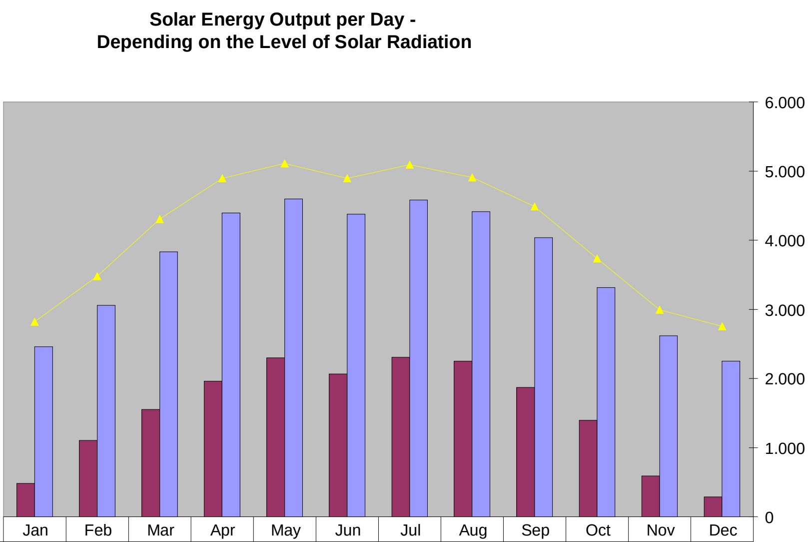
A ……. Aperture area of the collector (times number of collectors), m²

i …….. Point in time

As a consequence of the scattered values and according to the various energy efficiencies it would be necessary to calculate the collector's energy output for rather short units of time and to integrate it over the time of the year. Due to the fact that not only the temperature but also the solar irradiance frequently changes during daytime and during the year, the best and easiest thing to do, would be to use an adequate software tool in order to sum up the various pieces of energy output precisely.

In a simplified model, based on a total gross area of app. 600m² (as below mentioned in chapter 5.4) the average solar energy output per month can be computed on a daily basis of average solar radiation and ambient temperature values, for which the data base from the JRC is used[4]. The result of this calculation is shown below.

[3] ESTIF (2007), p. 1 et seqq.
[4] JRC (2009), http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Global Radiation	483	1.104	1.552	1.960	2.299	2.064	2.307	2.253	1.870	1.396	591	287
Clear-sky Radiation	2.459	3.058	3.832	4.394	4.597	4.377	4.580	4.412	4.036	3.314	2.617	2.252
Maximum Clear-sky + 15°C	2.819	3.478	4.306	4.895	5.110	4.895	5.092	4.908	4.489	3.736	2.994	2.754

Figure 35: Solar energy output per day

On the basis of the average global solar radiation, the collector's energy output ranges between almost zero in December and nearly 2200 kWh per day in summer. However, also in February, March and October, the results are still quite acceptable. On clear-sky days, obviously, the energy output reaches much higher levels, i.e. more than 4.500 kWh per day in summer and still about half of it in those months with low intensities of solar irradiance.

On very warm and clear-sky summer days, the energy output is higher because of the decreased temperature difference between the ambient and the collector's medium. Assuming the best case in this situation with ambient temperatures of about 15 degrees more than the daily long-term average (i.e. days with 30° C in July and August), the difference to the liquid inside the collector decreases by the same amount of 15 degrees. In this situation, the collector reaches its maximum efficiency (as shown in the efficiency curves above in chapter 5.2.1), e.g. on the line for an irradiance of 800 W/m², the efficiency factor is 0.7 for a temperature differential of only 30° C on such hot days. With this optimal constellation, the energy output per day is almost 20% above the average amounts, reaching maximum values of about 4.800 kWh per day.

Depending on the time of the day, the energy output is variable and reaches its maximum at noon. The following chart shows the average daily profile of the solar energy produced per square meter (aperture area) on a clear-sky day during the month of August, when the maximum output levels are reached:

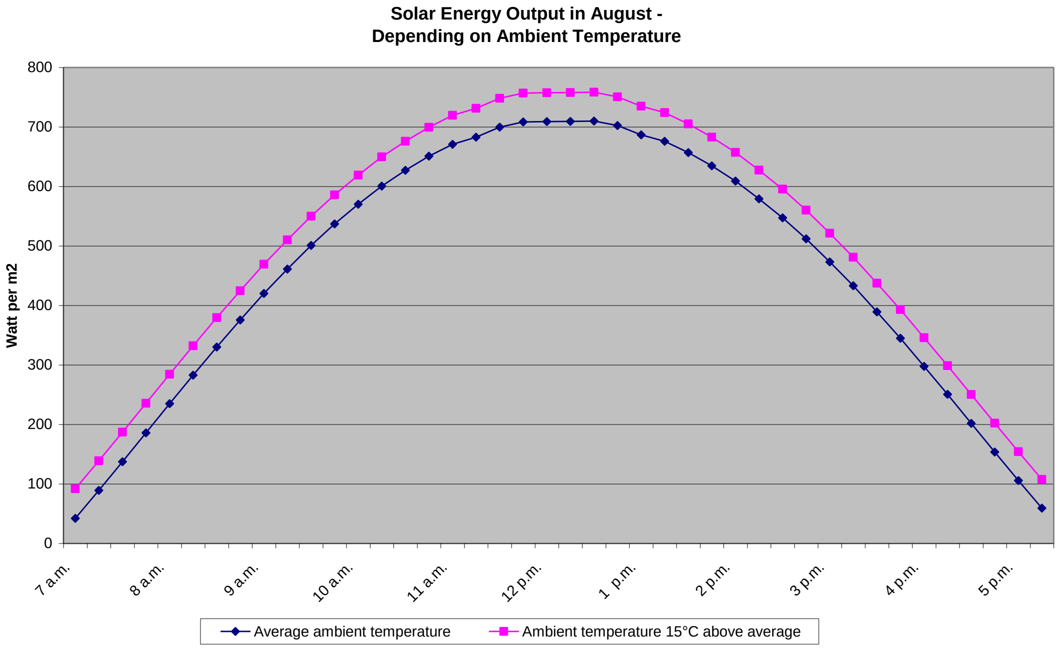


Figure 36: solar energy output during a clear-sky day in August:

The total solar energy output per square meter of the gross collector area can be determined by multiplying the daily energy contributions for each month with the respective numbers of days (last column shows the total energy output per period, all other columns are daily averages).

Table 2 shows the monthly solar energy output with a collector angle of 41° in Trumau.

Table 2: Solar output Trumau (JRC, 2009)

Fixed system: inclination=41°, orientation=0°				
Month	***E_d***	***E_m***	***H_d***	***H_m***
Jan	Jän.33	41.3	Jän.57	48.6
Feb	02.Feb	56.5	Feb.44	68.3
Mar	Feb.81	87.0	Mär.52	109
Apr	Mär.49	105	Apr.56	137
May	Mär.77	117	05.Jun	157
Jun	Mär.82	114	Mai.19	156
Jul	04.Mai	126	Mai.55	172
Aug	Mär.74	116	05.Sep	158
Sep	Mär.26	97.7	Apr.29	129
Oct	Feb.49	77.3	Mär.17	98.2
Nov	Jän.41	42.4	Jän.72	51.6
Dec	0.96	29.Sep	Jän.14	35.4
Yearly average	**Feb.77**	**84.1**	**Mär.61**	**110**
Total for year		**1010**		**1320**

H_m: Average sum of global irradiation per square meter, received by the modules of the given system (kWh/m²)

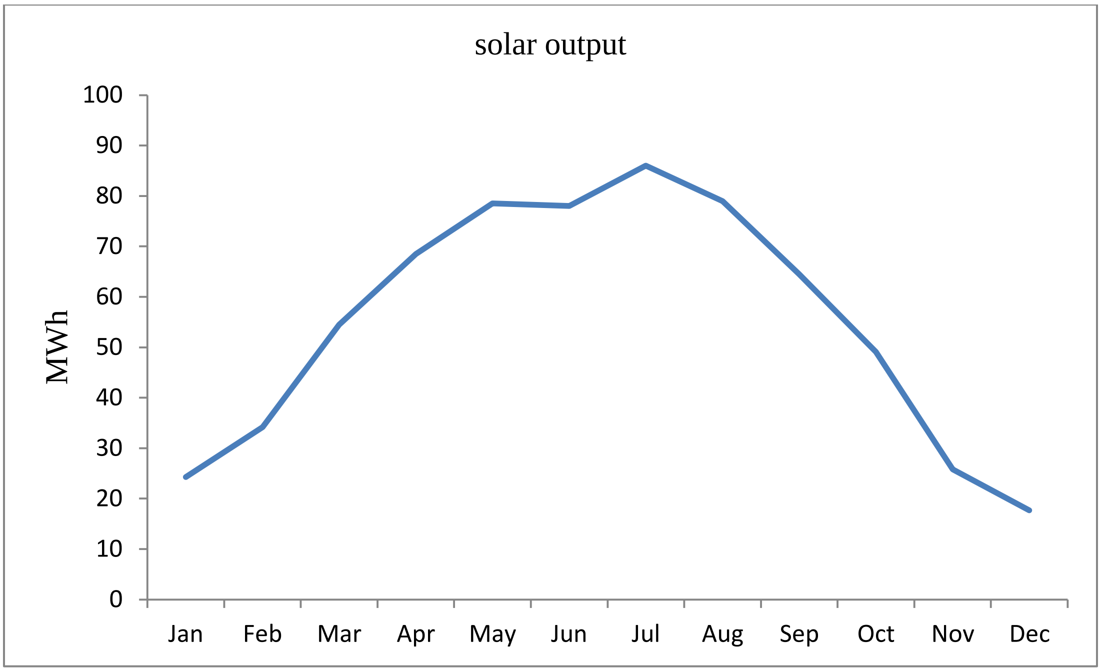


Figure 37: Solar output Trumau (JRC, 2009)

If the available solar energy is reduced by a level of efficiency of 65%, based on the level of efficiency mentioned under 5.2.1, the result will be the amount of energy that can be used, which can be seen in figure 38.

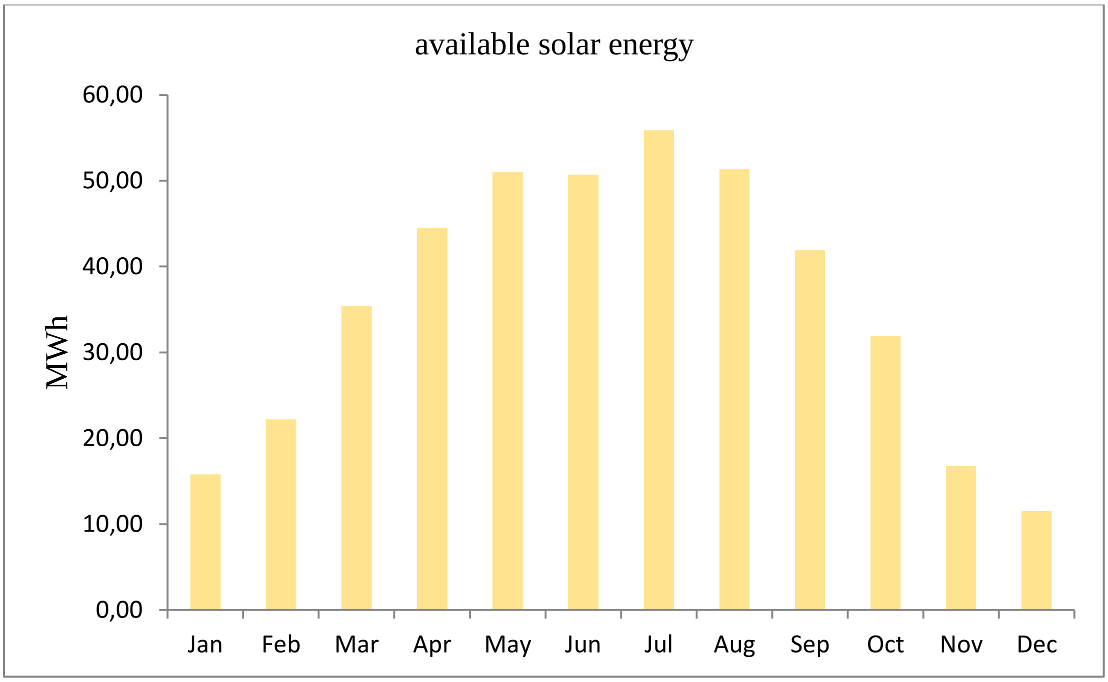


Figure 38: Available solar energy Trumau

In figure 39, Trumau's energy demand, in its final form, under the given conditions can be seen.

4.8% of the total energy demand per year can be covered by solar energy.

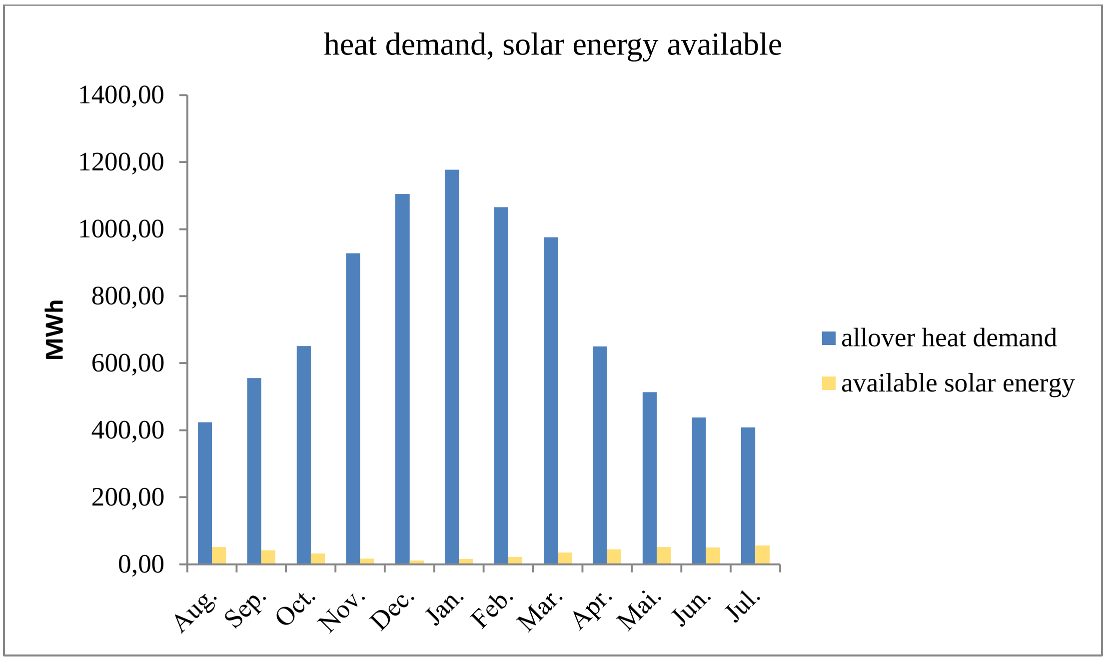


Figure 39: Comparison of the all over heat demand and the available solar energy

During summer season, from May to October, nearly 10% of the heat demand can be covered by solar energy.

Figure 40 shows the specific „summer situation“.

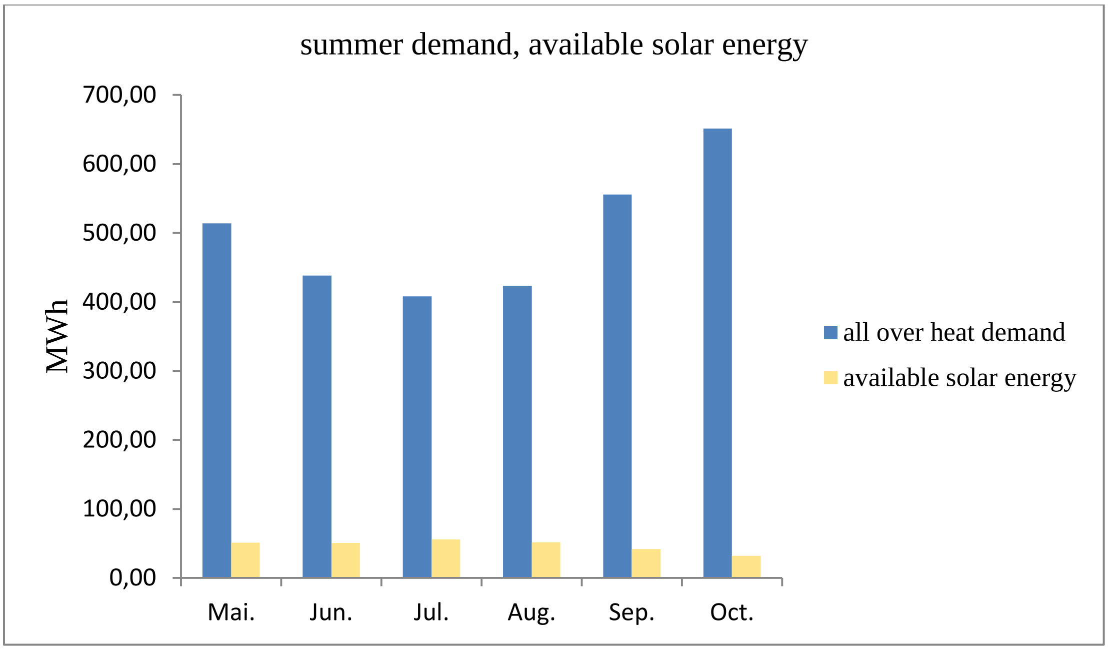


Figure 40: Comparison of summer demand and available solar energy

Under the conditions shown above, approximately 430 MWh of the total energy demand can be covered by solar energy.

On the basis of the biomass in use, with an energy content of approximately 730 kWh/srm, (ÖNORM M 7132 1998) and a boiler efficiency of approximately 83%, the solar energy in use can replace 710 srm/a.

The economic evaluation will be dealt with under chapter 6.

5.4 Space requirement

The space available for the possible installation of solar thermal collectors is 1000m². In order to calculate the number of collectors that can be installed on this plot, it is assumed that the distance between two rows of collectors should normally be around two times its height. The width of the collector is 233 cm and its length is 613 cm, so the calculated height is 403 cm for an inclination angle of 41 degrees. Therefore, the distance between the collector rows should roughly be 8 meters. In this respect, it is possible to put some 46 collectors on a land area of 1000m². In practise, this number will probably be slightly lower due to the plot's shape.

The optimal angle of the collector for collecting a maximum of solar radiation is 41 degrees. Further on in this paper, the inclination angle will be reduced to 35 degrees to maximize the energy output during the time of the year, when the sun's altitude is higher. By lowering the inclination angle, the distance between the collector rows is reduced a little as well, but it is still large enough to avoid shadow effects. So, for the further calculations and considerations, we will stick to the number of 46 collectors, each with a gross collector area of 14.3 m² and an aperture area of 13.1 m². The total gross area of the 46 collectors is 658 m² and the aperture area amounts to 602 m².

6 Economics

6.1 Investment costs

The investment costs are estimated to app. € 240.000,- including the following assumptions:

- 46 Collectors
- Installed capacity 460kW$_{th}$
- Buffer storage with 120 m^3
- Technical integration
- System costs

The above shown costs, are based on the specific investment of app. € 370,- / m^2 collector surface.
That corresponds in this case to € 520,- / kW installed capacity.
(S.O.L.I.D. Söll 11/2010)

6.2 Subsidies

The all over subsidy can be assumed with 30% of the total investment.

It might be possible to get further subsidies from local feed systems. For the NPV calculation the expectation is to get 30% subsidy of the investment. So the finical demand is nearly € 170.000,- .

6.3 Economic calculations

The cost benefit analysis is based on NPV calculation. So the validity of the investment under economic conditions will be shown.

430 MWh of the total heat demand can be covered by solar thermal power.

As in 5.3 shown, the gained solar thermal heat can substitute 710 srm/a.

The app. price for wood chips is assumed with € 22,- /srm.

So the whole substituted costs are € 15.620,-/a.

Table 3: Parameter for Net Present Value (NPV) calculation

Net Present Value Parameters		
Invest per KW solar power	520	Euro/KW
installed capacity	460	KW
Investment in solar thermal project	167.440	Euro
Subsidies	30%	of investment
Index rate for wood chip costs	2%	
Maintenance costs as % of investment	2%	
Maintenance costs first year	2.512	Euro
Index rate for maintenance costs	2%	
Interest rate	4,00%	
Efficiency of biomass boiler	83%	
Wood chip price for fuel input	22	Eur/SRM
Energy content of wood chips	730	KWh/SRM
Solar energy yield per year	430.000	KWh
Amount of wood chips substituted	710	SRM
Tax rate	25%	
Depreciation period	20	years
Net Present Value	**19.124**	**Euro**

Based on the defined underlying conditions and considered for period of twenty years, the NPV will be € 19.124,-.
In this case, the investment can be recommended.
Further on, the expected development for the future situation will be shown.

The main parameter for a higher positive NPV are the investment costs, wood price and interest rate. (Interest rate not changed.)
In table 4 a scenario is shown, were the NPV will get more positive.

Table 4: Parameter for a higher positive NPV calculation

Net Present Value Parameters		
Invest per KW solar power	440	Euro/KW
installed capacity	460	KW
Investment in solar thermal project	141.680	Euro
Subsidies	30%	of investment
Index rate for wood chip costs	2%	
Maintenance costs as % of investment	2%	
Maintenance costs first year	2.125	Euro
Index rate for maintenance costs	2%	
Interest rate	4,00%	
Efficiency of biomass boiler	83%	
Wood chip price for fuel input	23	Eur/SRM
Energy content of wood chips	730	KWh/SRM
Solar energy yield per year	430.000	KWh
Amount of wood chips substituted	710	SRM
Tax rate	25%	
Depreciation period	20	years
Net Present Value	**53.736**	**Euro**

The above shown NPV is based on 15% reduction of investment costs and a higher wood chip price to € 23,-/srm.

The environmental benefit has not been evaluated. Using solar thermal power guarantees an emission free heat production.

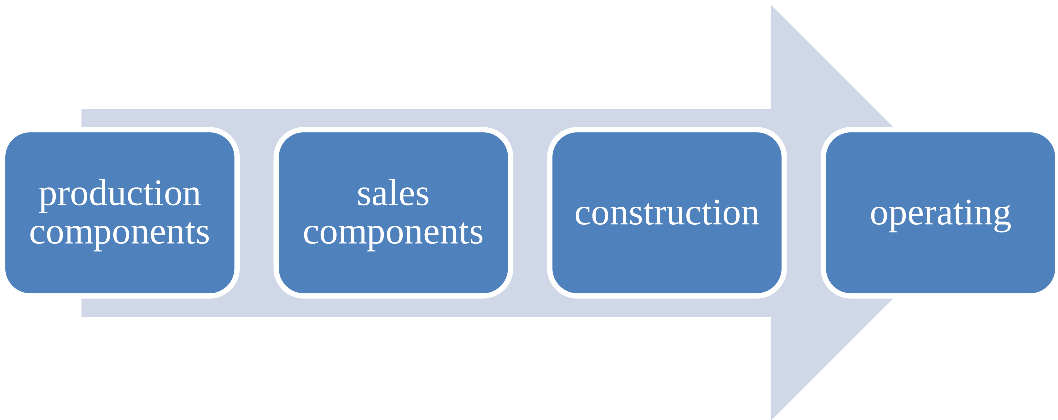
Combustion of biomass generate also CO_2 emissions, but in an all in all consideration in relatively CO_2 neutral way.

For a community there is rather a marketing related benefit. Because the community will show their environmental consciousness by displaying a solar thermal installation.

7 Preconditions for the promoting of solar heat

7.1 Process value analysis

The value chain is defined as follows:



The use of technological potential for innovation and the introduction of industrial mass production in all product ranges will at least lead to the halving of solar heat prime costs until the year 2030. The potential for innovation and cost reduction is described as follows.

Today, production costs for standard flat-plate collectors are about 140€/kWth (100€/m²). Due to an annual cost degression of 3%, the costs can be reduced to 70€/kWth (50€/m², price level 2005) until 2030, which would only be half as much as before. This potential for cost reduction requires the exhaustion of innovative potential by further developing existing collector concepts and by creating new ones in combination with expanding industrial mass production. (Weiss, 2009)

It is to be assumed that the main part of value creation is generated through the production of components and the following selling of those plant components..

The necessary grants for the placement of these new environmentally friendly technologies contribute to a high price policy of plant components.

A general cost reduction and a shift of value creation in the direction of plant construction and operation will promote the additional construction of solar thermal plants and the development of further potential.
The need for grants can be reduced, which ensures the long-term establishment of solar technology.
Only in case of cost parity with or without similar grants for traditional fossil fuel technologies, a sustainable and extensive replacement of fossil fuels can be assumed.

7.2 Development of energy costs

The cost development of fossil fuels had a major influence on the sustainable and long-term application of solar energy.
Supply and demand will not be the only factors that influence the price development.
A great deal will be contributed to price development, especially concerning the scarcity of existing resources, by speculation in raw materials (oil, gas).

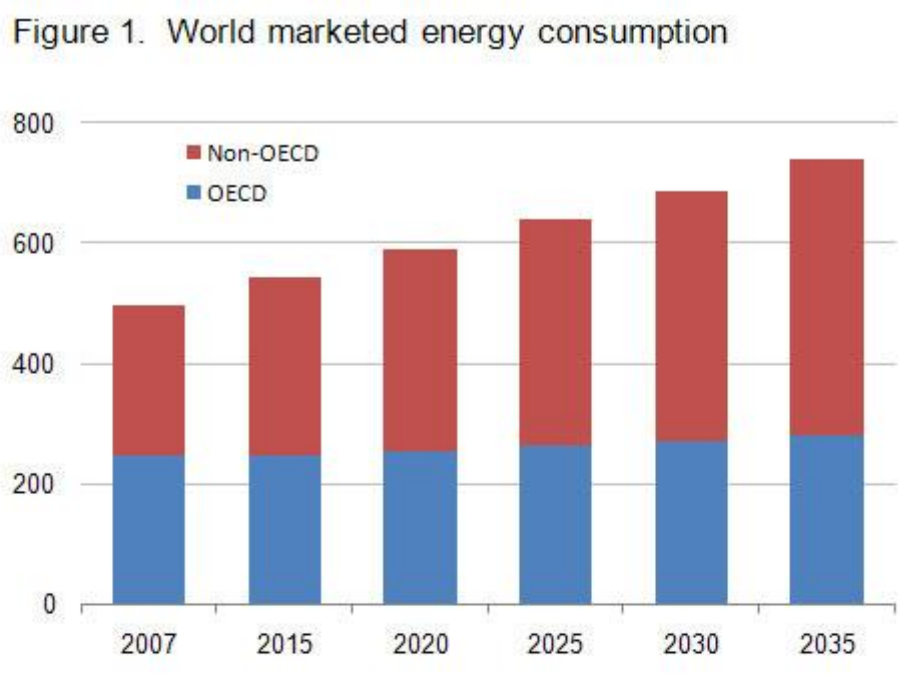


Figure 41: World marketed energy consumption (eia, 2010)

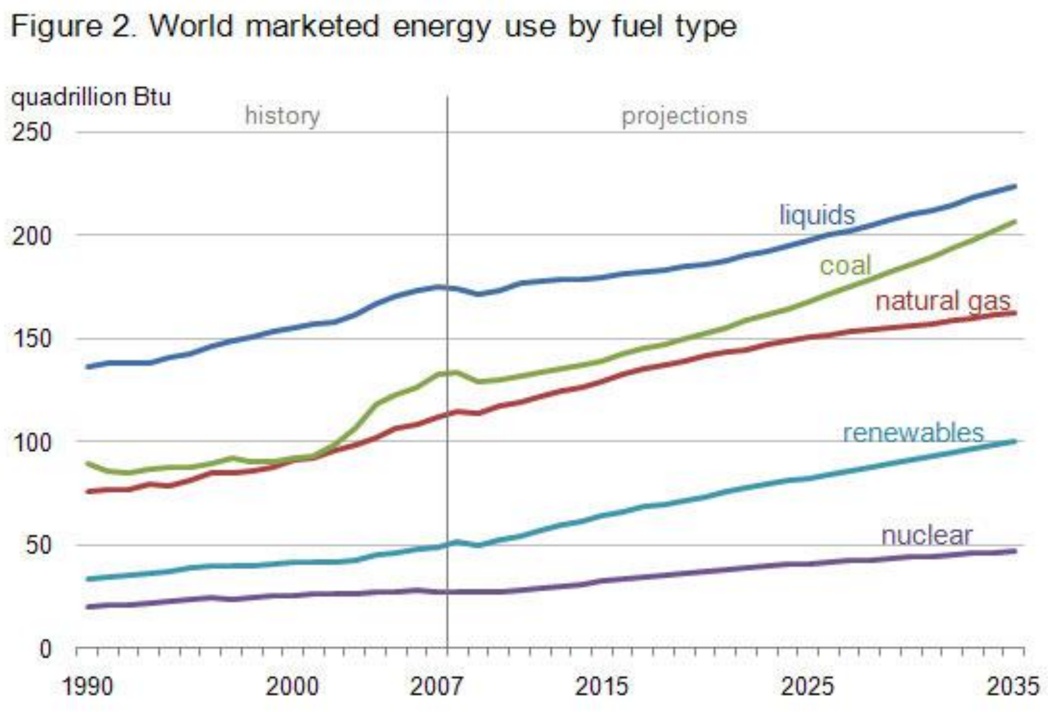


Figure 42: Development world market energy use by fuel type (eia, 2010)

The development of demand shown above, substantiates the expectations of increasing to strongly increasing energy prices.

The following graphics confirm the price developments, especially those of oil. The development of gas prices is directly related to the oil prices and those will therefore progress in the same way, only somewhat later.

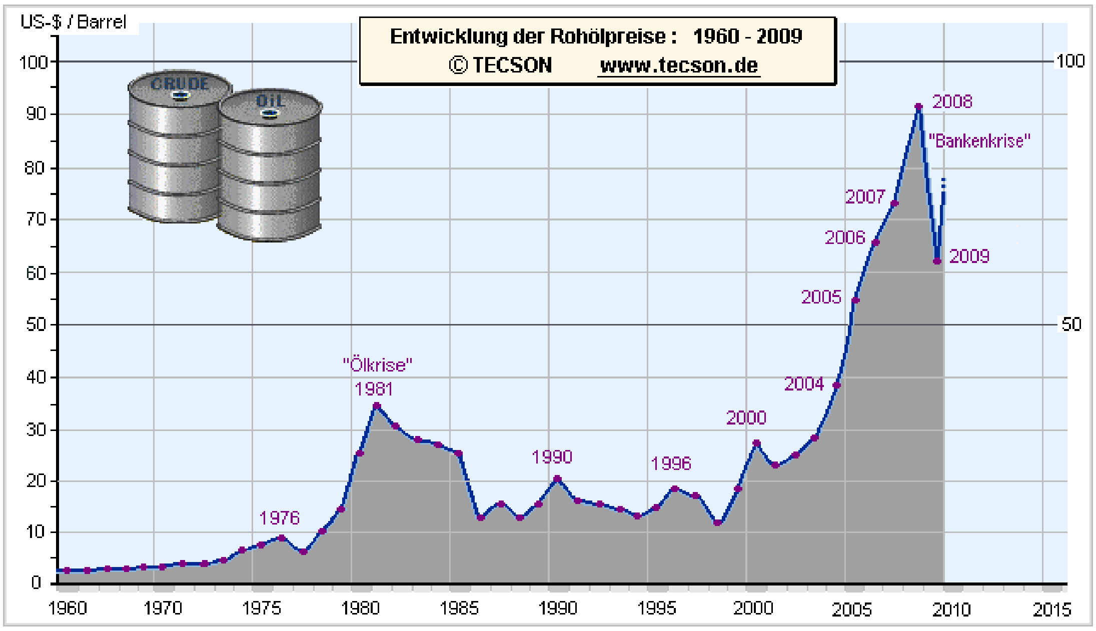


Figure 43: Development of crude oil prices (tecson, 2010)

In figure 43, the price trend of crude oil from 1960 onwards is shown.
A striking feature is the extreme increase in prices since the end of the 1990’s.

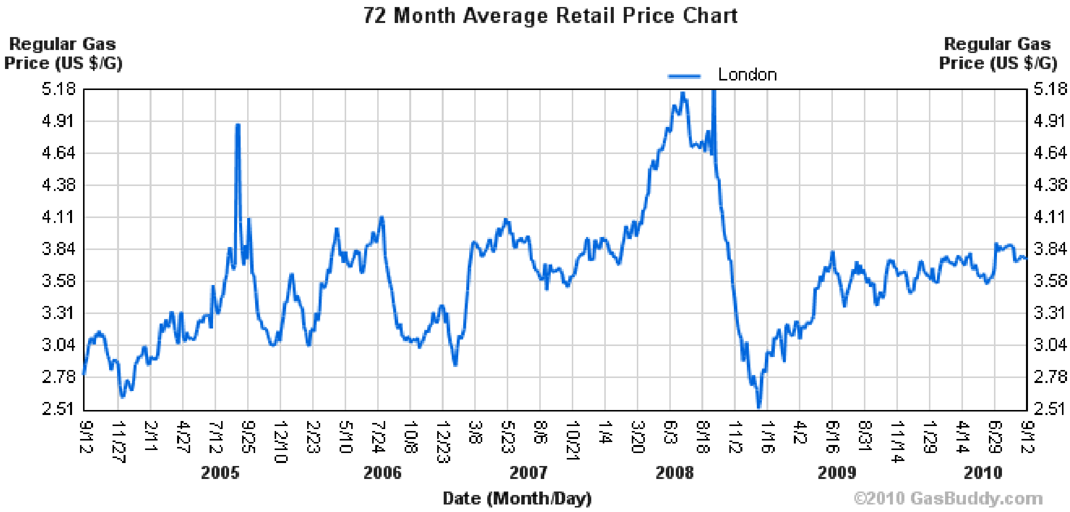


Figure 44: Development gas price - London (gasbuddy, 2010)

The increasing prices of primary energy carriers will influence the cost developments of hot water preparation and heating systems.

The cost developments of hot water preparation and heating systems of recent years already show these trends.

Apart from short-term counter-developments due to the economic crisis, heating costs, especially those of gas and oil, have been increasing steadily.

Figure 45: Development heating costs (BFE, 2010)

Practise has shown that a change in behaviour is especially brought about by cost pressure.
The cost development shown above will further promote the application of renewable energies, especially that of solar energy.

The following will show how legal regulations can further promote the use of solar energy.

7.3 Legal regulations

First of all, it has to be said that the variety of funding systems provides a good basis for the use of solar energy. Especially the linking of subsidised housing with the application of solar collectors supports the further development of solar thermal energy.

An extensive access to existing and future possibilities for using solar thermal plants seems to be essential. Support mechanisms and legal regulations have to be specifically adapted to each operational area.

At the same time, solar thermal energy must remain competitive compared to fossil fuels.

In respect to funding, the inspection of the functioning of existing plants is a main criterion for the efficient use of solar energy.
Experience has shown that many existing solar plants are being neglected during operation, after they have been constructed.
As a result, the plants only provide a small share of the possible energy yield after only a short time. There are practically no official examinations of plants, e.g. of biomass heating plants.

Regular enacted controls would ensure many years of efficient use of the facilities. This would also make it easier for users to recognize the long-term benefits, especially the economic ones.

The creation of the much-discussed tax on CO_2 emissions is also an important factor for the general increase of the application of renewable energies.

8 Summary

Especially due to an increase in demand, we are faced with the challenge to efficiently secure the global energy supply in an environmentally friendly way.

At the same time, energy should remain affordable and not block economic growth. Instead, it should possibly stimulate it further and it should also improve people's standards of living.

The efficient use of free primary energy carriers, e.g. of solar energy, is obviously a viable alternative in this respect.

Energy efficiency should be considered as a matter of priority and it must go hand in hand with the development of renewable energies.
The efficient use, production and distribution of energy reduce demand and are an important precondition in order to increase the share of alternative energies in the overall energy mix.

Geographic production structures are also essential.
Local energy production will bring local value creation and it will support local communal developments with all their positive effects, e.g. the creating of jobs in the region.

This requires the use of local renewable energies, e.g. biomass or solar energy, which are available in unlimited quantities, depending on the respective local potential.

In this respect, short-term economical success does not necessarily have to be the focal point.
As can be seen in the above-mentioned example of Trumau, short-term financial success is not always ensured. From a long-term perspective and considering the price and cost development of fossil fuels, the long-term economical results can be regarded as rather positive.

The increased use of renewable energies leads to a decreasing dependency on fossil fuels. Dependency on suppliers of oil and gas or on countries with the according deposits will be reduced and the own country's national economy as well as those of the EU will be reinforced.

Therefore, political schemes that once again support the use of nuclear energy and therefore diminish the creative as well as the financial resources for the further development of alternative energies seem all the more disconcerting.

An environmentally conscious and an economically viable mixture of energies with a local focus seem to be a reasonable model for a sustainable energy supply.

It is to be hoped that the powerful energy supply companies as well as politics will seize opportunities, recognize all the possibilities for further development and implement them. In this respect, the major focus should be put on the seizing of new chances for the people as well as the environment and not on the "threats" posed by existing systems.

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10 Glossary

DHP	District Heating Plant
KPC	Kommunalkredit Public Consulting
MW	Megawatt
MWh	Megawatt hours
kW	Kilowatt
kWh	Kilowatt hours
W	Watt
lfm	Meter
srm	Stére (loose cubic metre)
NPV	Net present value