MSc Program
Renewable Energy in Central and Eastern Europe

Plan, build and run a least cost heating system for the buildings of the Jaidhof estate

A Master's Thesis submitted for the degree of

"Master of Science"

supervised by

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Jaidhof, November 2011

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Affidavit

I, **DR. GUNTARD GUTMANN**, hereby declare

1. that I am the sole author of the present Master's Thesis, "PLAN, BUILD AND RUN A LEAST COST HEATING SYSTEM FOR THE BUILDINGS OF THE JAIDHOF ESTATE", 68 pages, bound, and that I have not used any source or tool other 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.

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Signature

Abstract

A typical Austrian family estate, the Jaidhof estate owns some more than 10.000 m² non renovated historic monument protected buildings. The estate also owns agricultural land forestry and water. The owner plans to renovate all the buildings and wants to find the least cost renewable energy solution for heat and warm water production for the estate.

The idea is to investigate the own resources and to achieve a local solution based on own resources. The solution will be a combination between a 1 MW district heating unit and 3 stand alone solutions based on own produced wood chips.

The thesis invests the market possibilities of the Jaidhof estate to deliver wood as a fuel to produce heat and calculates the opportunity costs for the estate at market prices (2006) The thesis works out the business plan including financial plan and technical plan for the execution.

The thesis analyses the technical and financial problems in planning and execution and describes the steps made to improve.

The thesis results in the statement that a district heating system based on own locally produced biomass is a cost and security of supply with fuel optimal solution but the. Profitability depends very much from the hydraulic and other technical execution.

Table of content

Affidavit 2

Abstract 3

Table of content 4-5

List of Figures 6

List of tables 7

1 Task 8-9

2 Methodology 9
- 2.1 Estimation of the energy needed for heating 10
- 2.2 Estimation of the total heat energy needed 11
- 2.3 Evaluation of the fuel system 11
  - 2.3.1 Macroeconomic questions 11
  - 2.3.2 Evaluation of different fuel systems for the Jaidhof estate 12
- 2.4 Evaluation of the unit sizes 12
- 2.5 Evaluation of the development steps 13

3 The Jaidhof estate 13
- 3.1 History of the Jaidhof estate 14
- 3.2 The Jaidhof estate forestry 15
- 3.3 The buildings of the Jaidhof estate 15

4 Estimation of the total energy needed for the heating and warm water in kWh/a 17
- 4.1 First step is to estimate the square meter sizes of the buildings 17
- 4.2 As a second step the need of energy for rooms will be estimated 18
- 4.3 The next step is to set a correction factor according the heigh of the building 19
- 4.4 Step number four is the estimation of the warm water need 19
- 4.5 Result 20

5 Evaluation of a fuel system 22
- 5.1 Evaluation of different fuel systems 22
  - 5.1.1 Wood 22
  - 5.1.2 Agricultural fuels 23
  - 5.1.3 Solar thermal energy 23
  - 5.1.4 Geothermal energy 24
- 5.2 Evaluation of the own wood resources 24
  - 5.2.1 Definition and formulars 25
    - 5.2.1.1 Volume 25
    - 5.2.1.2 Moisture 26
  - 5.2.2 Opportunity price comparison 30
  - 5.2.3 Result 32
- 5.3 Decision about the fuel system 32

6 Evaluation of the unit sizes 33
- 6.1 Decision of the unit sizes 38

7 Evaluation of the enlargement szenario 39
7.1 Decision about the enlargement steps 39

8 Procedure of planning, implementation and controlling / adaption 40
8.1 Planning 40
8.1.1 Estimation of the heat needed 40
8.1.2 Decision on a heat production system fuel and unit sizes..........40
8.1.3 Business plan 41
8.1.3.1 Content of the business plan 42
8.1.3.1.1 Exekutive summary......................................42
8.1.3.1.1.1 Exekutive summary, general 43
8.1.3.1.1.2 Exekutive summary, time plan.................43
8.1.3.1.1.3 Exekutive summary, financials 43
8.1.3.1.1.4 Business desciption 43
8.1.3.1.2 Competitor analyses 44
8.1.3.1.3 Technical plan...45
8.1.3.1.3.1 Plan of the building.............................46
8.1.3.1.3.1.1 The wood storage place........47
8.1.3.1.3.1.2 The truck access area (Vorlager)..............................47
8.1.3.1.3.1.3 The wood chips storage 48
8.1.3.1.3.1.4 The technical room 49
8.1.3.1.3.1.5 Grid......................................54
8.1.3.1.4 Financial plan 56
8.1.3.1.4.1 Investment plan..................................56
8.1.3.1.4.2 Running costs 57
8.1.3.1.4.3 Financial plan, result 59
8.2 Implementation 61
8.3 Controlling and adaption 61
8.3.1 Controlling 61
8.3.1.1 System losses 61
8.3.1.2 Heat consumption per m²..62
8.3.1.3 Energy content 62
8.3.2 Adaption 63
8.3.2.1 Installation of a communication tool for the consumer side 63
8.3.2.2 Adaption of the hydraulics of the hot water storage tanks...64
8.3.2.3 Adaption of the insufficient isolation.............................65
8.4 Final evaluation 66-67
References 68

List of Figures

Figure 1 Weight, water content, moisture calorific value of wood .... page 26
Figure 2 Calorific value of wood relative to beech (fagus sylvanica) .... page 26
Figure 3 Volume (fmo) per weight (atro ton), different woods.................... page 27
Figure 4 Units of volume (srm, fmo, fm, rm) .... page 27
Figure 5 Volume wood with and without bark... page 28
Figure 6 Relation between wood with different water content .... page 28
Figure 7 Atro ton expressed in different volume units .... page 29
Figure 8 Volume and weight, different types of wood............................... page 29
Figure 9 Weight (kg) and volume (fmo) per srm....................................... page 29
Figure 10 Margin calculation dry pulp wood, 2006 .... page 30
Figure 11 Margin 1 comparison industry prices and wood chip prices....... page 30
Figure 12 Opportunity costs per kWh... page 31
Figure 13 Margin development energy wood 2009 and 2010.................... page 32
Figure 14 Specific need of wood for heat energy and potential reserves .. page 32
Figure 15 Sales estimation business plan .... page 40
Figure 16 Offer EVN calculated in EUR/kWh/a total costs .... page 44
Figure 17 Time frame of investment... page 56
Figure 18 Investment and depreciation .... page 57
Figure 19 Running costs... page 57
Figure 20 Yearly development fuel costs .... page 57
Figure 21 Earnings development .... page 58
Figure 22 Index development .... page 58
Figure 23 Financial plan, results .... page 60
Figure 24 Controlling of energy consumption... page 62

List of tables

Table 1 Buildings of the Jaidhof estate .... page 8
Table 2 Historic plan, Max von Gutmann family, buildings of the estate.. ..page 14
Table 3 Jaidhof woods .... page 15
Table 4 Historic view, chateau Jaidhof.. page 15
Table 5 Plan of the Jaidhof estate.. page 16
Table 6 “Energiekennzahlen” – energy index .... page 21
Table 7 Plan of the core buildings .... page 33
Table 8 Plan of the non-core-business buildings...................................... page 34
Table 9 Plan of the potential clients buildings .... page 34
Table 10 Single building units .... page 36
Table 11 Position of the EVN Gföhl district heating plant .... page 37
Table 12 EVN Gföhl district heating plant .... page 37
Table 13 Plan of the building .... page 46
Table 14 Wood storage place .... page 47
Table 15 Truck access area... page 48
Table 16 Wood chips storage .... page 48
Table 17 Wood chips storage, telescope arms and spiral transport .... page 49
Table 18 Wood chips storage, extra access... page 49
Table 19 Technical data Fröhling boiler 220 kW .... page 50
Table 20 Technical data Fröhling boiler 320 kW .... page 50
Table 21 Technical data Fröhling boiler 500 kW .... page 51
Table 22 Technical room with boilers... page 51
Table 23 Hot water storage tanks .... page 52
Table 24 Pump station .... page 52
Table 25 Grid in and out .... page 53
Table 26 Pressure containers .... page 53
Table 27 Electrical and steering unit .... page 54
Table 28 Grid plan .... page 55
Table 29 Construction works .... page 61
Table 30 Wood on storage place .... page 63
Table 31 Touch screen steering unit Alte Forstdirection........................... page 64
Table 32 Technical plan reconstruction of connection storage tanks .... page 65
Table 33 Insufficient isolation... page 66
Table 34 New isolation... page 66

Task and methodology

1 Task

The task is to plan, build and run a least cost heating system for the buildings of the Jaidhof estate.

The estate owns 10 buildings next to the chateau of Jaidhof (belonging to another owner), most of them historical buildings which were built for the forestry and agricultural center of the estate, the “Gutshof Jaidhof”. The majority of these buildings are monument protected. Another 3 buildings or group of buildings are farmhouses several kilometers away from Jaidhof.

The whole group of buildings has to be totally renovated, most of them do not have a modern heating system only ovens to be heated with wood. Few of the buildings have oil heating systems which are more than 20 years old. The plan is to look for an adequate use of the buildings, to find partners who would rent the building, preferable long term because the renovation of the mostly monument protected buildings is very cost intensive.



Table 1 Buildings of the Jaidhof estate

The task requires the following:

- **Find a least cost heat production system for a group of buildings with a size between 10.000 and 15.000 square meters.**

  Most of them are situated in one village together (“Gutshof Jaidhof”), few others as farm houses (“Forsthäuser”) are situated some kilometers away in a lonely environment. The majority of the buildings is monument protected and needs total renovation.

- **Find a least cost heat production system which allows flexible increase of heat production regarding the step by step renovation of the buildings.**

  As the rent partners have to be found in the future the time plan for the renovation cannot be predicted. First a renovation plan (which includes the heat production system) is needed then the plan can be offered to potential business partners. The buildings will be renovated only after the buildings are rented out with a long term contract. This means that the heat supply system has to offer the possibility of a step by step increase of the production capacities.

- **Find a least cost heat production system which includes the own local resources in an optimal way**.

  The Jaidhof estate owns 2500 hectares of wood and 200 hectares of agriculture (and 10 hectares of ponds). The wood and other resources have to be evaluated, prices compared, production costs of heat have to be calculated. The advantage of a guaranteed fuel supply has to be considered. As a result a decision regarding the optimal fuel out of own resources (wood chips) or other fuels has to be taken.

2 Methodology

The methodology for the work has to describe the procedure to reach the goal "To plan, build and run a least cost heating system for the buildings of the Jaidhof estate".

First step qualified estimation of the heat needed: It is necessary to have a qualified estimation of the heat needed. The problem is that the buildings have not been renovated since 40 years. A Plan for future use does not exist and has to be developed in the future.

A very rough estimation says that the buildings all together have substantial more than 10.000 m² all together. Some houses are bigger (over 1000 m² like the "Stallgebäude" and some are smaller (like the "Forsthaus Mottingeramt II", between 200 and 300 m²).

The procedure is to offer each house alone or a group of houses to potential business partners to find potential lessees for what use ever. In a second step a reconstruction plan has to be developed with the partner and agreed on in a contract which goes together with a rent contract. Then the reconstruction according the wishes of the future lessee can be started. The rent contract should be as long as possible.

An estimation of the reconstruction costs is Euro 2.000 and more. The intention is to keep the renovation costs in a range between Euro 1.900 and 2.200 per square meter. The reason for this relatively high amount per square meter is the monument protection. The facades need special materials and have a relive sophisticated structure. The foundations have to be stabilized, the roofs have sometimes special forms, the windows are box floor windows. A rent guaranteeing a reasonable return of the investment has to be 8 Euros per square meter and more. This is a comparable high rent per square meter. And it is much higher than average rents per square meter in the region. This rent can only be achieved when the proposed project offers highest standards in renovation together with the special subjective value of the monument protected historical building.

The potential client group for such projects are private individuals with a higher income, free lancers and small companies. The whole group of potential clients has to find advantages in the historic buildings to be able to pay the higher rents. These groups also may have different plans for renovation and use of the buildings.

Renovation can differ in intensity of renovating. For the estimation of the energy use it is a difference if a higher percentage of the rooms under the roofs will be renovated or not. The renovation of the facades does not allow a larger difference because of the monument protection. The windows will have a higher loss of energy because of the structure of the historic box floor windows. The use of isolated windows is also at least partially possible if the monument authority would allow it. This will depend very much on the use of the building. As a result it can be stated that the intensity of renovation can only be decided after an individual use and reconstruction plan is found, which means that the variety of the energy use can be rather big.

Renovation will differ according to the future use. It will result in a different demand of energy if the use is an apartment, an office or a therapy institute with a 36 degree Celsius heated pool for different therapies.

The result is that an exact calculation of the energy use of this project with more than 10.000 m² is not possible in the beginning because the exact size of the buildings, the intensity of renovation and the future use is unknown.

To reach the goals to find the least cost heat production system it is nevertheless necessary to estimate certain range of heat needed. Therefore as a first step a rough estimation of the size, a guess of the future use and a guess of the intensity of future isolation (or intensity of renovation) and a potential volatility of this number are needed.

The methodology for the qualified estimation will be the following:

2.1 Estimation of the energy needed for heating

The energy needed for heating will be estimated with kWh/m² and then be multiplied with the m² of each building. The standard estimation will be corrected by a correction factor which depends on special facts which can correct the heat needed by m². This could be special height of the rooms, special isolation (or not isolation possibility because of monument protection) special use of the building (therapy institutions may need a room temperature than offices).

heated surface (m²) * number for energy needed for heating (kWh/m²/a) * correction factor = energy needed for room heating (kWh/a)

2.2 Estimation of the total heat energy needed

The total heat energy needed has to estimate in a second step the heat energy needed for warm water. The estimation multiplies the result of the energy needed for heating with an estimated percentage to get the result of the total heat energy needed. The percentage can differ according to the differentiation of the use of the building (a therapy institution with a heated pool will consume more warm water than an apartment. An apartment will consume more energy than offices)

energy needed for room heating (kWh/a) * energy needed for warm water (%) = total heat energy needed (kWh/a)

2.3 Evaluation of the fuel system

The estimation of the total energy needed for each buildings will give us the information which total heat energy the buildings will need where. After this first step we are enabled to think about the second step to make a decision, which fuel system to use in a potential heat production unit. The following aspects will build a framework for the considerations of the least cost heat production system regarding the fuel.

2.3.1 Macroeconomic questions

Investigating the least cost heat production system does not only mean to look at today´s prices but also look at the future development of prices. A position has to be found to evaluate the development for the energy prices of different fuels for the amount of fuel which will be needed in Jaidhof for heat production. Related with the price question is the question of the supply security. This is a more and more import question. There for the own resources have to be evaluated. As there is the 2600 hectares wood production it has to be evaluated, how much energy out of wood in which price relation can be produced. If the own resources can supply enough energy for the heat production, a substantial argument will count for a wood based fuel (wood chips, eventually pellets) as a secure fuel supply is one of the most important basics for a successful renewable energy production.

These considerations can be summarized in the following questions:

A) Why do we think that renewable energy fuels are and will be cheaper than other fuels for heat production in Jaidhof?

B) How important is security of supply of fuel for the heat production in Jaidhof?

2.3.2 Evaluation of different fuel systems for the Jaidhof estate

The question to solve is to evaluate all possible fuel systems with legal, investment, running costs and different other questions to get an opinion which fuel system will be the optimal one to build the least cost heat production system in the Jaidhof estate. As mentioned above, it is not only the question about the investment and running costs but also the specific situation of the Jaidhof. Least (potential future) costs regarding supply security, considering own resources, least cost system regarding the different groups of buildings (group of buildings next to each other, some buildings kilometers away) and the enlargement steps (not all buildings will be renovated at once but they will be renovated in groups).

The result has to be a decision about a fuel system which is cost optimal for the Jaidhof buildings in investment and running costs, in optimal supply security and cost optimal for specific situation of all the buildings and also for the different enlargement steps. The answer can of course also be found in a combination of fuel systems.

2.4 Evaluation of the unit sizes

After finding a solution for the fuel system (or combination of different fuel systems) an answer has to be found which unit size (unit sizes) are the cost optimal for the different buildings. During this step a cost optimal end version has to be found. The estimation can give a range of the energy needed for heat production (kWh/a) with a certain probability. As the final energy needed for heat production per building or per group of buildings can only be calculated in an exact way after the final use of the buildings is fixed. Nevertheless the market offers standardized unit sizes for different fuel systems. The unit sizes are with some fuel systems more flexible (f.e. with solar heat production) or sometimes less flexible (f.e. wood chip combustion systems). As the Jaidhof estate has a complex of buildings and some buildings are positioned far away, it is important to consider the cost optimal dimensions of the different units.

The question to be answered is which is or are the cost optimal unit sizes of the heat production unit for the chosen fuel system per building reps. for the group of buildings.

2.5 Evaluation of the development steps

At the starting point in 2006 the development steps of the renovation at the Jaidhof estate are not quite clear. Nevertheless a scenario for the development has to be set. It has to be evaluated, which is the most probable development of the renovation of the buildings and what does it mean for the heat production system. A most probable scenario has to be created. Then the compliance of this scenario with the optimal unit sizes has to be found. The importance of the development steps and the cost optimal solution which can be found in implementing the different is very high because its result is a certain time plan for the initial investment.

The question to be answered is, which heat production unit shall be acquired when. This scenario will be the basis for the business plan. The situation will be relatively clear for the first step of the renovation phases because this will be executed when the first renovation step is already decided. The clients will be fixed and the use of the building or buildings will be fixed as well. So practically the first step of the business plan will be fix and the other steps will be possible scenarios which can come true or not.

The development after the first step will be a very important topic to be managed during the implementation phase. Any adaption of the decided scenario will have to be evaluated especially regarding lower income because of lower sales of heat or regarding higher costs.

3 The Jaidhof Estate

The Jaidhof Estate runs 2.600 hectare of forestry, 130 hectare of agriculture and 12 hectare ponds for fishing and 10.000 square meters min. in different buildings. 10 buildings are located in the village of Jaidhof next to the chateau Jaidhof. Another 3 groups of smaller buildings (“Forsthäuser”) are situated in the woods, each of them several kilometers away from the others and from Jaidhof.

3.1 History of the Jaidhof Estate

Historically the Jaidhof estate was formed by the woods around the village of Gföhl ("Gföhlerwald"). It was organized in 14 forestry's ("Waldämter"). The first time the estate was mentioned in historical documents was in the 12th century. In a document from the year 1381 Jaidhof was mentioned the first time as administrative center of the estate. It belonged directly to the feudal patron the Duke of Niederösterreich (the Babenberger family and later on the Habsburg family) and was mainly a hunting ground.

Later on it was given as a domain to different families like the Princes of Sinzendorf, the Henkel von Donnersmark and the Counts of Thurn-Valsassina.

1884 it was purchased by Baron Wilhelm von Gutmann. At that time the estate had around 10.000 hectares, mainly wood, then also agriculture, fishing waters and around 40 hectares of wineries.

The buildings where renovated in the beginning of the 19th century by Max von Ferstel, who was a well known architect in Austria He renovated the chateau, as well as other prominent buildings such as the new forest main administration building (Forstdirection). He also built buildings as stables for horses, cattle, chicken and pigs, a gardener´s house and a winery. Several buildings for workers were erected and also a riding school for children of the owner.

The chateau (which is now owned by a catholic organization) and some of the buildings are today under monument protection.

During the NS time the estate was confiscated by the regime and was a schooling center by the NS party ("Gauschulungsburg"), during Soviet occupation the Jaidhof Estate was an USIA unit. USIA was a group of companies run by Soviet troops for supply of the red army in Austria. At the End of the 1950`s the estate had to be re-purchased by Wolfgang von Gutmann. His heir Rosa von Gutmann sold 8.000 out of 10.000 hectares. In 2006 the author, a grand nephew of Wolfgang von Gutmann took the estate over as a heir of Rosa von Gutmann. The necessary renovation of the historic buildings of the Jaidhof estate was planned and partially executed.



Table 2 Historic plan, the Max von Gutmann family, buildings of the estate

3.2 The Jaidhof Estate forestry

The Jaidhof Estate forestry is situated 20 km north of Krems and 25 km south of Zwettl. The altitude is 592 m in the region Kampseen.

There are 4 units (“Reviere”) Pottaschhof and Mottingeramt near Jaidhof, Waldhof near Krems, and Groß near Hollabrunn. All together the forestry surface is 2600 hectares.

Table 3 Jaidhof woods

3.3 The buildings of the Jaidhof estate

Ten buildings are situated in the village of Jaidhof. The chateau (“Schloss Jaidhof”) is next to the buildings of the estate and belongs to a catholic organisation.

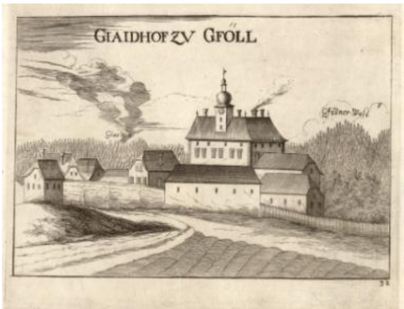


Table 4 Historic view, Chateau Jaidhof

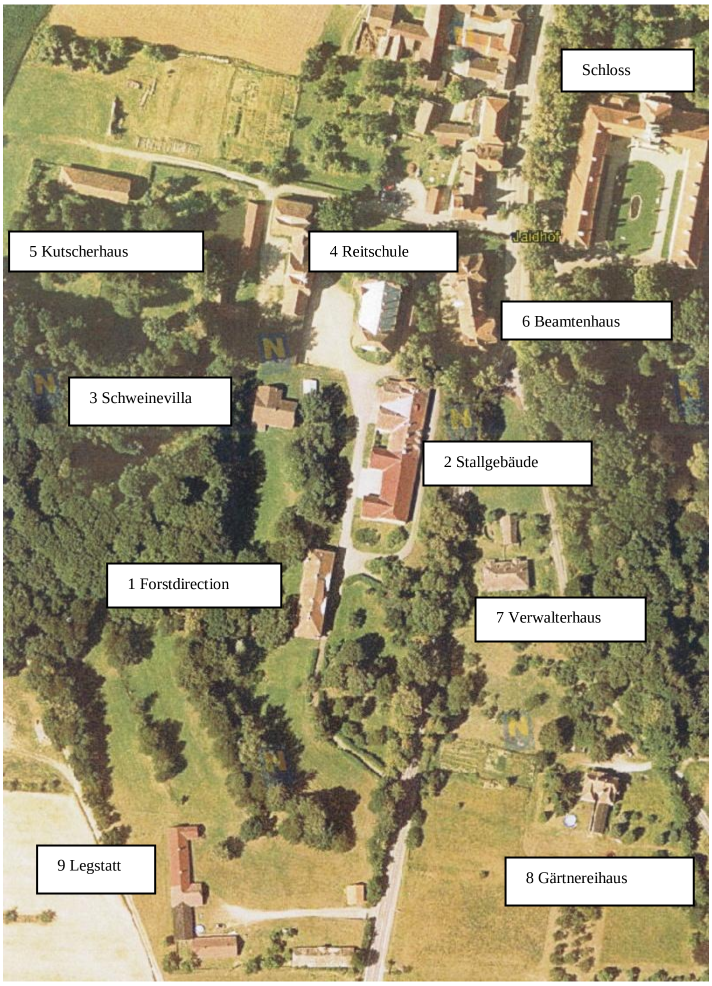


Table 5 Plan of the Jaidhof estate

The buildings in the estate are the following:

Alte Forstdirection:

The forest director`s building, offices of the estate 2 apartments

Stallgebäude:

The stables building, historically used as stables, in 2006 no use

Kutscherhaus:

The coaches building, historically used for the coaches,

horses and some apartments, in 2006 no use

Alte Reitschule:

The old riding school, historically used as a riding hall,

in 2006 no use

Neues Beamtenhaus:

The new forester´s house, historically used as apartment house,

in 2006 no use

Gärtnerei:

The gardener´s house, historically used as gardener´s house,

in 2006 rented as an apartment house

4 Estimation of the total energy needed for heating and warm water in kWh/a

The first step in the procedure is to estimate the energy need of the buildings each single and all together to have a basis for the future discussion regarding the fuel system and especially the own resources. The result of the estimation will be a total amount of the energy needed for heating and warm water (kWh/a)

4.1 First step is to estimate the square meter sizes of the buildings

In the future steps of the project the square meter sizes of the building do not only have to be estimated but have to be calculated. The calculation is a project of its own and will cost EUR 60.000.

4.2 As a second step the need of energy for rooms will be estimated

Basis for the estimation is

70 kWh/m²/a

This number results from the ÖNORM H 55, Energieausweise für Gebäude, cathegory C a newly insulated building. The value for such buildings is
100 kWh/m²/a and lower
The value for low energy houses (category B) is
50 kWh/m²/a and lower
The estimation is 70kWh/m²/a, a number which shall be reached after thermal renovation of the building. It will be used for all “normal” buildings of the Jaidhof estate (very good quality buildings 19th century and older, renovated windows, partially box floor windows, thermal renovation). The quality of the buildings is much higher than buildings from the years 1950 and younger. The buildings are the following:

Alte Forstdirection (living)
Stallgebäude (offices)
Altes Beamtenhaus (offices, living)
Kutscherhaus (offices, living)
Forsthaus Mottingeramt 1 (living)
Forsthaus Pottaschhof (living)
One building will be estimated higher , the old riding school (“Alte Reitschule”). As the building is a special high volume hall, the former riding hall with more than 7 m altitude, monument protection (like the other as well) which will make it difficult to have a thermal renovation of the ceiling the estimation is

90 kWh/m²/a

The estimation for another group of buildings will be lower. The thermal renovation of the façade is possible because there is no monument protection of the building. The buildings are the following:

Gärtnereihaus
Schweinevilla
Legstätte
Landwirtschaftsverwalterhaus

For one building reconstruction seems to be the better strategy than renovation because of the bad construction conditions of the building. It is the Forsthaus Mottingeramt 2. For this building the number for low energy houses will be used. The number is

50 kWh/m²/a

4.3 The next step is to set a correction factor according the height of the building

The historic buildings show a quite substantial differentiation in height of the rooms. The height of the rooms is between 3 and 7 meters (estimated) According the height of the rooms (and the function of the cubature) a correction factor is set.

4.4 Step number four is the estimation of the warm water need

The need for warm water is estimated as a percentage of the heat needed.
The percentage is the following:

office buildings	**+ 15% of the annual energy needed for room heating (kWh/a)**
residence buildings	**+ 20% of the annual energy needed for room heating (kWh/a)**
therapy building	**+ 35% of the annual energy needed for room heating (kWh/a)**
Other buildings	**+ 10% of the annual energy needed for room heating (kWh/a)**

(some of the buildings can be estimated with a lower energy need for warm water for different reasons, for example because the buildings are relatively large but the planned use is residence building for a small family including stables or office or therapy rooms. The need for warm water will be in this case relatively smaller compared to the square meters)

4.5 Result

The estimation of the total heat needed is
702.040 kWh/a
The estimation for the total square meters of the Jaidhof estate result in 6.080 m² total for the projects planned in the year 2006

and

5.560 m² heated surface

which means

105 kWh/m²/a for room heating (calculated from the total m²)

We estimate an energy standard which complies with category D of the valid standards[1]. This means that the used figure is at the very top figure for old, not (thermally) renovated buildings. The calculation will show that the real consumption is higher than 150 kWh/m²/a.

[1] ÖNORM H 5055 Energieausweise für Gebäude

A	HWB <= 30 kWh/(m²a)
B	HWB <= 50 kWh/(m²a)
C	HWB <= 70 kWh/(m²a)
D	HWB <= 90 kWh/(m²a)
E	HWB <= 120 kWh/(m²a)
F	HWB <= 160 kWh/(m²a)
G	HWB > 160 kWh/(m²a)

Table 6 “Energiekennzahlen” – energy index

The relevant questions will be the following:

Which percentage are energy losses of the 19th century buildings with sometimes quite massive walls, mixed (stone, brick) with some box floor windows lower than not renovated buildings with a much worse quality form the 1950 and later?
Which thermal façade, floor and roof renovation will be possible because of the monument protection of most of the buildings and how will this affect the energy need of the building for room heating and warm water?
How much will the potential future use of the buildings result in different energy consumption for room heating and warm water?
How correct is the assumption of the used and future renovated m²?
Is the estimation of the m² of the buildings correct?
Is the estimation of the intensity of the renovation good or will the future use result in more renovated m²?
How much will the end renovation result in different number of used m²?

The estimation has to evaluate a possible volatility of the estimated numbers:

The involved team (owner, management, technical advisor) decided that the volatility of the energy losses of the future renovated building shows an **upside potential from + 50 percent**. This means that the potential energy need for heating will be between 150kWh/m²/a and **105 kWH/m²/a**. The possibility for renovation will be different with every building, as most of them are monument protected only floor and roof insulation will be possible. The team did not calculate a probable volatility for that. Regarding the volatility caused by a different use the team decided that a plus minus 30 percent variety is an appropriate number. The team also decided that the volatility will be much higher if the use results in different square meter use than in different heat or warm water use. The volatility caused regarding a different square meter renovation is estimated with plus minus 40 percent. All together the team decided that the volatility to the calculated number for the mentioned buildings will be plus minus 30% with a higher probability. The probability was not estimated. The result is that with a high probability the energy need for room heating and warm water for the mentioned buildings will be

from 500.000 kWh/a to 900.000 kWh/a.

5 Evaluation of a fuel system

5.1 Evaluation of different fuel systems

The renewable energy fuels systems for heat production will be evaluated only if they are own resources. Own resources are the fuels which are at disposal at the Jaidhof estate out from own production or from the use of resources on the Jaidhof estate.

5.1.1 Wood

The estate owns 2.600 hectares of wood. The question will be to evaluate which part of the wood production can be used for heat production for adequate prices. The fuel systems to be evaluated are:

- wood chips
- wood pellets

Wood chips can be produced easily, wood pellets would have to be bought. The advantage of wood chips is that the whole fuel is available whereas would chips very likely come from other producers. The advantage of wood pellets is that the investment costs for a system would be cheaper, the storage would be easier and the systems are technically safer with fewer problems of transportation of the fuel from the storage to the combustion. Nevertheless the advantage of supply security is the valid argument for giving own production of wood chips first priority.

Pellets can be considered if there are some additional arguments for example if one of the buildings is used not regularly so that the permanent functionality of the system will be the higher valid argument. The result of these considerations is that wood chips is possible fuel system in the first priority of wood products.

5.1.2 Agricultural fuels

The estate owns 200 hectares of land.
Crop, crop wastes (straw)[2]
The land is rented out to farmers with binding contracts until the end of the year 2012. So for the Jaidhof estate this is not a considerable opportunity for a fuel system because of legal reasons.

5.1.3 Solar thermal energy

Heat production by solar thermal energy[3] can be generated by modules on the roofs of the buildings or on agricultural grounds. In the Jaidhof estate the solar thermal panes could be positioned on the roofs or on agricultural land. Both possibilities have legal obstacles.

The roofs of most of the buildings are monument protected so the use for solar thermal panels is not possible. For the agricultural land the above mentioned is valid. Moreover solar thermal heat production always produces some base load of

[2] Boyle, Godfrey: Renewable Energy, Oxford 2004, page 113 ff
[3] Boyle, Godfrey: Renewable Energy, Oxford 2004, page 18 ff

heat that means that another heat production unit will be needed anyway. Therefore contribution to heat production typically makes sense for passive house standard buildings but not for old buildings. As a result solar thermal energy production for heating and warm water production is not an opportunity for the Jaidhof estate.

5.1.4 Geothermal energy

Geothermal energy can be used for heat production on the Jaidhof estate when combining geothermal collectors with heat pumps[4]. Geothermal heat production with ground collectors also only provide a base load of heat for buildings and therefore can be considered for buildings with passive house standards to gain best efficiency. They are typically not efficient enough for historic buildings with lower energy balance.

Moreover geothermal energy requires electricity for the heat pump and the system to produce heat. Depending on the over all efficiency of the system 1 part of electricity will be used to produce 3 parts of heat. This may be an appropriate solution for buildings located in a surrounding with no other fuel to be transported but electricity, for example a building in the mountains with electricity or possibility for photovoltaic electricity production. For a situation like in the Jaidhof estate where other fuel systems are promising the author (and owner and investor) does not think that using such a high value form of electricity shall be used to produce such a relative primitive form of energy like heat.

Heat production from geothermal sources will not be considered a realistic possibility.

The result is that wood chips are the only fuel from renewable sources available on the estate which will be evaluated further.

5.2 Evaluation of the own wood resources

The Jaidhof estate owns 2.600 hectares of woods. The yearly sustainable production of wood is 10.000 m³ (“Festmeter”) of wood[5]. Main wood production is from the beech (Rotbuche, fagus sylvatica) which counts for 60% of the production,

[4] Boyle, Godfrey: Renewable Energy, Oxford 2004, page 365 ff

[5] Rieder, Anton: Operat, Gutmann`sche Forstverwaltung Jaidhof. Technischer Bericht, not published, 2010, page 132

spruce (Fichte, picea) is around 35% of the production. The rest is different wood from white beech (Weissbuche, Hainbuche, carpinus betulus) and others. The different types of wood have different calorific values. For evaluation of the own resources it is important to calculate the opportunity costs of the own wood for energy production. In other words the question is if the estate should sell the wood to the industry or use it for heat production.

Finance mathematically the **opportunity costs** have to be evaluated

Opportunity costs are costs, which define the alternative use of a narrow factor or good. Opportunity costs occur with not using the possibility of income and not hindering expenses or as a second possibility if you decide to chose one product and thus renounce the benefits of another product.

If we use the wood for selling it to the industry, we renounce the possibility of combustion and wood production. In this case we have to look at the costs for the fuel for combustion and total heat production to find out if it would have been better (meaning more profitable) using it for heat production.

The other way round if the Jaidhof estate uses the wood for heat production it has to be calculated if (and how much) it would be more profitable to sell it to the industry.

5.2.1 Definitions and formulars

5.2.1.1 Volume

Wood chip cubic meters	(Schüttraummeter), srm	1m x 1m x 1m of (cut) wood chips
Wood cubic meter	(Raummeter) rm	a pile of wood with 1m x 1m x 1m,
Cubic meter	(Festmeter) fm	m^3 of wood WITH bark (included)
Cubic meter without bark	(Festmeter ohne) fmo	m^3 of wood WITHOUT bark

To realize the difference it is important to stress the fact that

1m x 1m x 1m means the wood (the cut pieces for a pile or the wood chips) with all the air in this pile

1 m^3 is a m^3 of wood, so the tree trunk has to be recalculated. This is done by the help of certain formulas or for example in the saw mill industry by the help of calibrated measurement instruments which measure each tree trunk.

5.2.1.2 Moisture

Dry	(Anlagen trocken), atro	wood with 0% of humidity, calculated
2 years outside dry	(mind 2 Jahre getrocknet), L2	wood outside dried for minimum 2 y
Summer dry	(Sommer getrocknet), L1	wood outside dried over the summer
Fresh	(Waldfrisch), wf	fresh wood, direct after cutting, with full water content
Water content	Wassergehalt	weight (Masse) of H2O in the wood
Wood moisture	Holzfeuchtigkeit	calculatory number to reach atro weight, % of weight (Masse) H2O in atro ton (some H2O cannot be dried out of the cells!)
Calorific value	Heizwert	energy released as heat under standard condition with total combustion per weight (kWh/kg)

Figure 1 Weight, water content, moisture, calorific value of wood[6]

weight	water content	moisure (weight of moist wood in % atro)	calorific value
atro	0%	0%	-
L2	20%	15%	4 kWh/kg
L1	35%	54%	3,4 kWh/kg
wf	60%	150%	2,9 kWh/kg

Figure 2 Calorific value of wood relative to beech (fagus sylvatica)[7]

wood	% calorific value relative to weight	% calorific value relative to volume
beech (fagus sylvatica)	100%	100%
white beech (carpinus betulus)	96%	102%
sprouce (picea)	108%	70%

To compare prices it is necessary to recalculate the different units.

In the estate, like on the whole market the unit to calculate how much is harvested is **cubic meters without bark (fmo).** The wood is cut then measured (by foresters

[6] Data from: Landwirtschaftskammer NÖ: Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 11 ff

[7] Data from: Landwirtschaftskammer NÖ: Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 11 ff

according the standards) or by the buyer (paper industry, saw mills and others according to the standards) and then the volume of the bark is deducted – also according the standards. The usual trade unit for some industries (saw mills, paper industry) and per some wood products (saw logs, (wood for saw mills, Sägerundholz, the highest value product) ,pulpwood (fresh industry wood, Schleifholz, mid value product) and dry pulp wood (dry industry wood, Faserholz, lowest value product) is **per volume (fmo).**

Nevertheless some of the industries (chip board industry (Spanplattenindustrie), renewable energy industry) and for some of the products (wood for wood chips, wood residues) the unit is per ton atro which is **per weight.**

Some industries calculate per volume (fmo) or per weight (ton atro). This is sometimes the case with paper industry and in the pulp wood industry. This is also the case with some products like with wood residues (which can be the same as dry pulp wood) and wood for wood chips (before cutting it to wood chips, which can be the same like wood residues and dry pulp wood). As for calculating the opportunity costs the calorific value is important, the connections between the different units of volume and the weight have to be understood.

The connection between the weight (atro ton) and the different units of volume (as you can see above) is the following:

Figure 3 Volume (fmo) per weight (atro ton), different woods[8]

type of wood	fmo per atro ton
beech (fagus sylvatica)	1,41
spruce (picea)	2,11
white beech (carpinus betulus)	1,35

The relation between the different units of volume is important especially regarding the different wood products. Wood is harvested per fmo, all costs of harvesting (cutting and transport) is calculated per fmo (m3). If some clients cut the wood themselves, the wood is sold standing in the wood, the client pays per rm (piled wood) no costs occur. Both the wood per fmo (m3) and rm (pile of wood logs 1m) can be cut to wood chips. The relation between the different units of volume is the following

Figure 4 Units of volume (srm, fmo, fm, rm)[9]

type of wood	srm per 1 fmo	rm per 1 fmo	fmo per 1 rm	fm per 1 fmo
spruce	2,5	1,429	0,7	1,075
beech	2,5	1,429	0,7	1,075

[8] Daten aus: Landwirtschaftskammer NÖ: Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 101 ff

[9] Daten aus: Landwirtschaftskammer NÖ: Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 101 ff

Figure 5 Volume wood with and without bark[10]

fmo per 1 fm
0,9302326

The relation between the units of weight (atro ton) with different units of volume fmo and srm is important to compare prices for the different wood products and different water content. The volume does not change in a substantial way when the water content changes. This shrinking can be neglected.

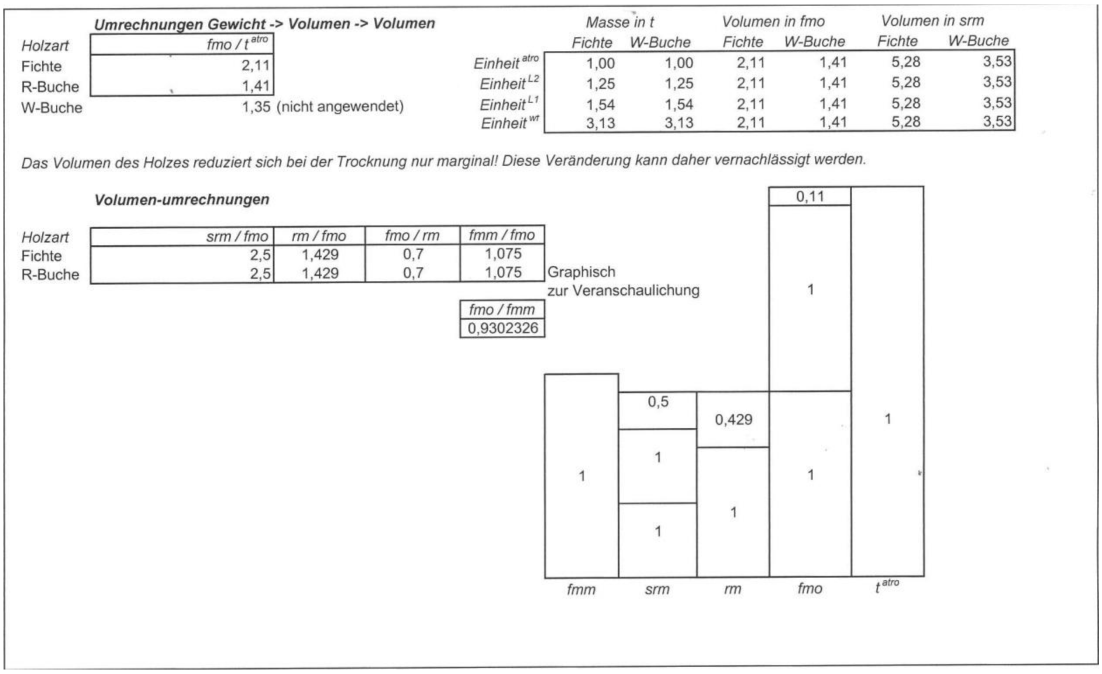
Figure 6 Relation between wood with different water content per weight (atro ton) and different units of volume, different wood types[11]

	weight in tons	weight in tons	volume (fmo)	volume (fmo)	volume (srm, chips)	volume (srm, chips)
	spruce	beech	spruce	beech	spruce	beech
atro	1,00	1,00	2,11	1,41	5,28	3,53
L2	1,25	1,25	2,11	1,41	5,28	3,53
L1	1,54	1,54	2,11	1,41	5,28	3,53
wt	3,13	3,13	2,11	1,41	5,28	3,53

Optical the following graph to see the relation between 1 atro ton of wood and the different units of volume

[10] Daten aus: Landwirtschaftskammer NÖ: Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 11 ff
[11] Daten aus: Landwirtschaftskammer NÖ:Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 101 ff

Figure 7 Atro ton expressed in different volume units[12]



Umrechnungen Gewicht -> Volumen -> Volumen

Holzart	fmo / t atro
Fichte	2,11
R-Buche	1,41
W-Buche	1,35 (nicht angewendet)

	Masse in t Fichte	Masse in t W-Buche	Volumen in fmo Fichte	Volumen in fmo W-Buche	Volumen in srm Fichte	Volumen in srm W-Buche
Einheit atro	1,00	1,00	2,11	1,41	5,28	3,53
Einheit L2	1,25	1,25	2,11	1,41	5,28	3,53
Einheit L1	1,54	1,54	2,11	1,41	5,28	3,53
Einheit wf	3,13	3,13	2,11	1,41	5,28	3,53

Das Volumen des Holzes reduziert sich bei der Trocknung nur marginal! Diese Veränderung kann daher vernachlässigt werden.

Volumen-umrechnungen

Holzart	srm / fmo	rm / fmo	fmo / rm	fmm / fmo
Fichte	2,5	1,429	0,7	1,075
R-Buche	2,5	1,429	0,7	1,075

fmo / fmm
0,9302326

As the most important volume for wood chips is srm (wood chips in 1m x 1m x 1m) it is important to see the relation to the weight of the main wood types (spruce and beech)

Figure 8 Volume and weight, different type of wood[13]

type of wood	kg (atro) per 1 srm (chips)	ton atro per 1 srm (chips)
spruce	190	0,190
beech	284	0,284

Figure 9 Weight (kg) and volume (fmo) per srm[14]

	kg spruce	kg beech	fmo spruce	fmo beech	srm spruce	srm beech
atro	190	284	0,40	0,40	1	1
L2	237	355	0,40	0,40	1	1
L1	292	437	0,40	0,40	1	1
wf	592	887	0,40	0,40	1	1

[12] Daten aus: Landwirtschaftskammer NÖ: Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 101 ff
[13] Daten aus: Landwirtschaftskammer NÖ: Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 101 ff
[14] Daten aus: Landwirtschaftskammer NÖ: Energie aus Holz, Informationsbroschüre der Landwirtschaftskammer, 9. Auflage, St. Pölten 2005, Seite 101 ff

5.2.2 Opportunity price comparison

To see the opportunity costs we calculate in a first step the margin 1 (Deckungsbeitrag 1, revenues of wood – production costs of the wood (felling and transport) of selling the dry pulp wood to the industry in the unit which is used in the industry standards (fmo) and recalculate it to the unit which is used in the renewable energy industry which is srm.

We will use the data for dry pulp wood (Faserholz) spruce and beech. In the year 2006 the Jaidhof estate sold over 5.700 fmo (m3 without bark) to the industry (paper and chipboard industry). These data are used because this product (dry pulp wood) is the product which has a comparable price to the energy wood (the saw mill products are much more expensive thus it would not make sense to use it for energy production). We looked at the prices of spruce (Fichte) and beech ((Rot-) Buche). Nevertheless the margins for breech are the more important ones because beech has a higher calorific value.

Figure 10 Margin calculation dry pulp wood, 2006

Dry pulp wood (faserholz) spruce and beech		datas from Jaidhof	Datas from Jaidhof	unit							
						spruce	**beech**	**spruce**	**beech**	**spruce**	**beech**
revenues	2006	spruce	beech			atro tons	atro tons	fmo	fmo	srm	srm
	quantity	2.669,66	3.069,25	fmo		1.265,24	2.176,77	2.669,66	3.069,25	6.674,15	7.673,13
	total revenues	80.855,86	107.770,22	EUR	=	EUR/atro ton	EUR/ato ton	EUR/fmo	EUR/fmo	EUR/srm	EUR/srm
	revenues per unit (R)	30,29	35,11	EUR per fmo	=	63,91	49,51	30,29	35,11	12,11	14,05
expenses											
	felling (Schlägerung, F)	19,44	23,65	EUR per fmo	=	41,02	33,35	19,44	23,65	7,78	9,46
	transport (Rückung, T)	6,57	6,34	EUR per fmo	=	13,86	8,94	6,57	6,34	2,63	2,54
	cutting the wood chips, (2-4 EUR/fmo, C)	3,00	3,00	EUR per srm	=	15,83	10,58	7,50	7,50	3,00	3,00
	Margin (Deckungsbeitrag 1, = R - F - T)					9,02	7,22	4,28	5,12	**1,71**	**2,05**

Now we have to look at a possible margin which the estate could have earned if the wood (dry pulp wood) would not have been sold to the industry but used for wood chips for combustion. One main question is, what would be a comparable market price for wood chips. The Vienna Stock Exchange showed a price of EUR 12,50 in December 2006[15] for wood chips spruce. So a market price of EUR 12 to 14 would be adequate for beech wood chips.

Figure 11 Margin 1 comparison industry prices and wood chips prices

	beech	beech
	EUR/srm	EUR/srm
revenues	14,50	14
felling	- 9,46	-9,46
transport	- 2,54	-2,54
		-3
margin 1	**2,50**	**-1**
differnce		**- 3,50**

[15] Wiener Warenbörse Holz: Kursblatt der Wiener Warenbörse Holz, 6.Dezember 2006

The result is, that the margin 1 (Deckungsbeitrag 1, revenues from selling wood minus wood production costs) is EUR 2,50 when selling it to the industry. In other words net income of wood business for the estate would be EUR 2,50/srm when selling it to the industry. In comparison to this the margin 1 when selling the wood cut to woodchips to a wood chip heat production unit would be EUR -1. In other words The net income of the estate would be EUR – 1 and totally the Jaidhof estate would earn 3,50 Euros less than if selling the wood to the industry.

The next step will to think about how this would affect the heat price. The calculation has to calculate how much the heat price has to generate more income to compensate the higher opportunity costs.

To have good data we use the 2010 sales data to calculate the energy density of the wood chips and the system losses. The year 2010 is the first year to have usable data in Jaidhof. The years before the construction phase and technical problems did not deliver usable data.

It has to be mentioned that the energy density of the wood chips is much lower than described in all the sources. The normal data shows an energy content from 1.000 kWh/srm to 1.200 kWh/srm. It seems that the quality of the own wood chips can be improved by technical measures. The problem seems to be the storage of the wood chips outside because there is no sufficient storage for the wood and the cut wood chips.

Figure 12 Opportunity costs per kWh

2010					
total 2010 wood chips	889,21	srm	opportunity costs	3,5	EUR/srm
combustion	537,8	MWh	opportunity costs	0,62	ct/kWh
client billed	496,16	MWh			
grid loss	41,64	MWh			
grid loss	7,74	%			
energy density	605	kWh/srm			

The result is that to cover negative margin from EUR 3,5/srm a higher heat price from 0,62 cent/kWh is necessary. If the heat price is between 6 cent/kWh and 6,5 kWh the necessary increase would be around 10%: everything under the 2006 prices and costs.

During this analysis in the year 2006 the author discovered that the production costs for wood (felling and transporting) where much too high in the Jaidhof estate and could be reduced by 30% since then. This would affect the opportunity costs for wood chips. Also the wood prices increased quite substantially. Moreover a lot of wood is used for wood chips which were not sold before because of bad quality.

Moreover the potential profits of heat production have to be taken into account. The roll over of the opportunity costs to the heat price seemed to be possible. The development from the year 2006 shows the positive development from the view of the Jaidhof estate. In the year 2008 the production of energy wood started. The use of very bad quality wood which would not be able to sell was used. To reach the necessary amount of energy wood the missing part was cut from dry pulp wood (Faserholz). The price for the use of bad quality wood seems to be a low calorific value. As mentioned before the low calorific value is not only caused by the quality of wood but also by the storage which causes a higher water content.

Figure 13 Margin development energy wood 2009 and 2010

2006e			**2009**			**2010**	
costs	15	per srm	costs	€ 13,12	per srm	costs	€ 13,02
revenues	14	per srm	revenues	€ 14,50	per srm	revenues	€ 16,23
margin	**-1**	**per srm**	**margin**	**€ 1,38**	**per srm**	**margin**	**€ 3,20**

5.2.3 Result

The total need of energy, which is between 500 MWh/ and 900 MWh/ would result in 331 fmo to 595 fmo. This wood can be delivered by the Jaidhof estate in the form of wood residues, energy wood which was not used at all until now. The potential wood supply of the Jaidhof estate is the amount of dry pulp wood (Faserholz) and energy wood is between 3.000 to 4.000 fmo which has an energy content between roughly 4 million kWh/a and 6 million kWh/a. With an increase of the quality of the wood chips an increase of estimated minimum 30% can be reached.

Figure 14 Specific need of wood for heat energy and potential reserves for energy wood 2010

	amount	unit	srm	**fmo**
potential need	500.000	kWh/a	826	**331**
potential need	900.000	kWh/a	1.488	**595**
energy density	605	kWh/srm		
potential energy	**4.537.500**	kWh/a	7.500	3.000
potential energy	**6.050.000**	kWh/a	10.000	4.000

The result is that the energy need for heat production for the Jaidhof estate can be covered by wood chips from own production. The specific quantity of wood is available and the use for energy production is also possible economically.

5.3 Decision about the fuel system

The decision was made to base the heating for the Jaidhof estate on wood chips which can be produced on the estate. The necessary amount of wood chips is only around 10% of the yearly production of a suitable wood product of the estate.

Pellets will be considered as a second possibility. The management is aware that heat production units based on pellets can be cheaper and technically easier to realize for small stand alone units. Nevertheless the supply security with own resources is given only with wood chips.

6 Evaluation of the unit sizes

After the decision to use wood chips as a priority fuel a decision about the unit sizes has to be taken. Three options will be evaluated:

District heat production unit

Single building unit

Connect the Jaidhof estate to the existing district heating in Gföhl, EVN

1) **District heat production unit**

   The first step is to evaluate which buildings can be connected to a future grid. The first group of buildings was defined as **core buildings**:

   - Alte Forstdirection (1)
   - Stallgebäude (2)
   - Schweinevilla (3)
   - Alte Reitschule (4)
   - Kutscherhaus (5)
   - Beamtenhaus (6)

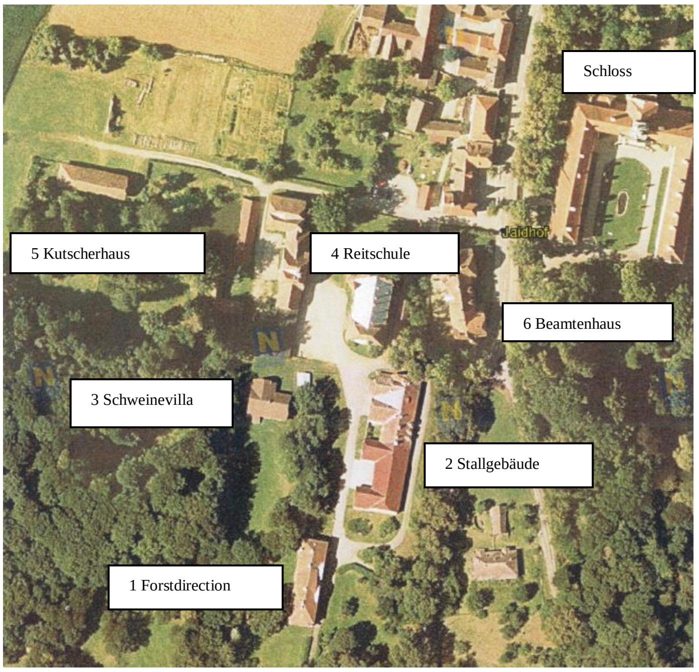


Table 7 Plan of the CORE buildings

The second group of buildings was defined as the NON CORE buildings as all of them where more than 200 m away from the core buildings

- Verwalterhaus (7)
- Gärtnereihaus (8)
- Legstätte (9)

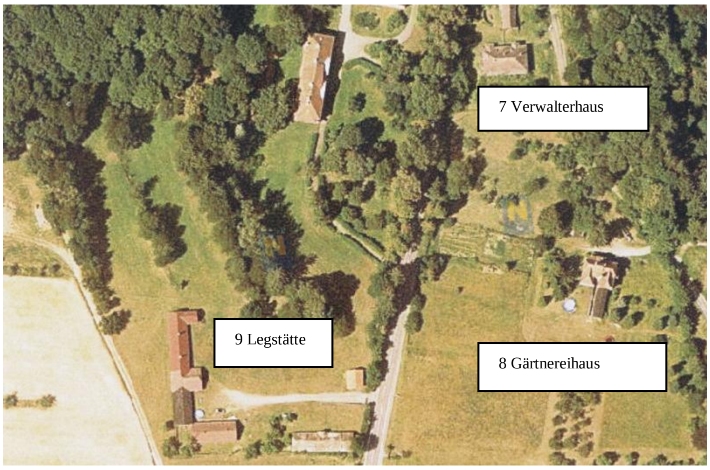


Table 8 Plan of the NON CORE buildings

The third group of buildings was defined as POTENTIAL CLIENTS buildings. These buildings are situated near to the core group buildings but belong to other owners. This potential client group has to be evaluated and addressed to learn about the possibility to connect them to a future district heating grid.

- Schloss Jaidhof
- Buildings of the Jaidhof village

Table 9 Plan of the POTENTIAL CLIENTS buildings

Very clear is the idea to connect all the core buildings together with a central heating unit.

With the non core buildings the question if a connection is possible depends on the first place if the minimum criterion of 900 kWh/a - consumption per meter of the grid can be achieved. This is a sort of knock out criterion. If this minimum number can be achieved other criteria on the economical and technical and legal side have to be evaluated. This evaluation shows another knock out criterion for the Gärtnereihaus. Because of the monument protection of the house the construction of a single unit for wood chip or for pellets heating is technically nearly impossible and economically connected with so many construction costs that it will also not make sense to follow up. In this case it will make sense to connect all non core buildings if possible.
The evaluation of the non core clients showed the following results:

- The **Jaidhof Chateau** is a potential client willing to connect to the grid. The existing wood chip heating is more than 20 years old and monument protection will not allow any new construction to build a storage and other technical equipment. The building is calculated with a 400kW connection and a consumption of 460.000 kWh/a

- The **buildings of the Jaidhof village** cannot be evaluated as potential clients. The inhabitants of the village are generally very interested in a connection to a district heating system. Only most of them have functioning systems and newly built houses often with very good energy standards. Over all the energy consumption would be far not enough to have a sufficient coverage of the length of the grid.

The evaluation shows that one single unit district heating system for the Jaidhof buildings and one external client, the Chateau Jaidhof is possible.

2) Single building unit

For the 3 Forest houses (FH Mottingeramt 1, FH Mottingeramt 2, FH Pottaschhof) a single unit is the only possible solution. Generally a wood chip storage and a technical room is possible in all of these houses. All of them have besides the residence building several old premises which can be easily adapted for wood chips.
Generally it has to be stated that for these single units a pellets system would be cheaper in investment and (present) running costs. Nevertheless the management decided to invest in wood chips unit because the supply security and the supply logistics are evaluated a higher value than the lower investment costs.
A very central question in every renewable energy project is the supply security.

With a decision for the wood chips solution for the 3 single building units the management breaks its own standard to look for the cost optimal solution for the Jaidhof buildings. The management thinks to do it with good arguments.

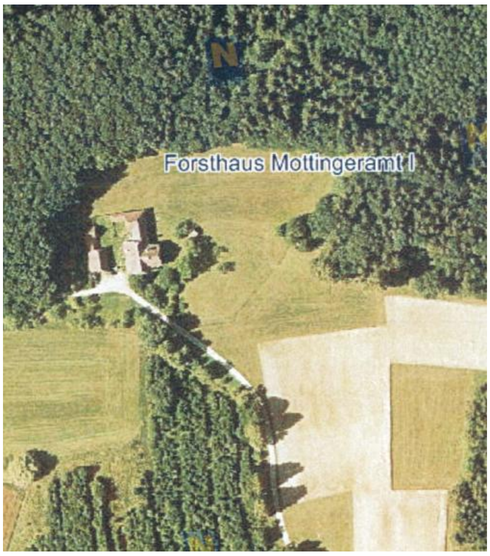


Table 10 single building units

3) **Connection of the Jaidhof village buildings (core and non core buildings) to the EVN district heating plant Gföhl**

An option to be evaluated was a possible connection to the district heating system Gföhl. The heat production unit has a 300 m distance from the last non core building (Gärtnereihaus) and 500 m distance to the core buildings.

The possibility to evaluate was to connect the Jaidhof buildings (core and non core) to the district heating grid of Gföhl.

Table 11 Position of the EVN Gföhl district heating plant

Table 12 EVN Gföhl district heating plant

A possible connection and delivery of the heat has for the management 2 preconditions:

a. Adequate heat prices

The EVN was not interested to offer adequate heat prices. The price offer was the normal single family house offer which not sufficient for a potential big client like the Jaidhof estate would be.

b. Solution for the grid

The EVN standard solution is to build the grid to the border of the land owned by private individuals. The connection from the public owned land to the house has to be paid by the client. This would be an economically very disadvantageous solution for the Jaidhof estate. The estate would have to build a grid on its own land and have no income to cover these costs because the fees go to EVN. The company was not willing to think about a better solution.

c. Guarantee to purchase wood from the estate

A solution would only make sense for the estate to connect to the EVN grid if the company gives guarantee to purchase the energy delivered as heat in the form of wood. As the company has contracts with many small farmers and was not willing to negotiate for a potential price scheme (for example connected to some representative index) a satisfying price scheme could not be found.

The result is that a connection to the existing district heating plant is not an option.

6.1 Decision about the unit sizes

The decision about the unit sizes is the following:

The Jaidhof estate will build

A) **One central district heating plant** with wood chips as a fuel and with the sizes to cover a **500 kW to 1MW** connection at the core , no core and external client buildings to cover the 960 MWh/a to 1,36 MWh/a gross (including system losses) heat production (0,5MWh/a to 0,9MWh/a from the Jaidhof estate buildings + 0,46MWh/a from the Chateau Jaidhof)

B) **3 single units** with one **40 kW** connection for the Forsthaus Mottingeramt 1, **one 10 kW** connection for the Forsthaus Mottingeramt 2 and **one 15 kW** connection for the Forsthaus Pottaschhof to cover all together **estimated 77.000 kWh/a gross (including system losses).**

The cost optimal solution would be pellets based for the single units but for supply security reasons the decision for the wood chip based units is taken.

7 Evaluation of the enlargement szenario

The first step of the enlargement is relatively easy to evaluate because only directly run buildings (without external clients as main users) are reconstructed. The second phase will depend on external clients. Nevertheless the Chateau Jaidhof is relatively probable to be connected.
So 3 Phases will be evaluated as relatively probable:

Phase 1 -Stallgebäude as the new office building
- Verwalterhaus as residence building because 50% is already rented out
- Gärtnereihaus because the therapy institute is already contracted during the planning phase
- Alte Forstdirection because this is the owners residence

Phase 2 - The Chateau Jaidhof, which is very likely to be connected as an external client during the planning phase
- Schweinevilla, a relatively small building which is run by the estate

Phase 3 - Kutscherhaus (no specific plans during the planning phase)
- Alte Reitschule (no specific plans during the planning phase)
- Beamtenhaus (no specific plans during the planning phase

7.1 Decision about the enlargement steps

The steps to build the district heating unit will be the following

The heat production unit will be built in minimum 3 steps

Phase 1 Building for 3 heat production units and 1. part of the grid

The enlargement steps will be the following:

1. Heat production unit	220kW	2008
2. Heat production unit	320kW	2010
3. Heat production unit	500kW	2011

Regarding the grid 2 steps are planned

Phase 1	430m
Phase 2	755m

The 220 kW boiler represents 21,15% of the end capacity and can serve as a base load boiler. (The specific length of the grid will be at the end only 960 m because one of the projects was not executed).

8 Procedure of planning, implementation and controlling/adaption

8.1 Planning

8.1.1 Estimation of the heat needed

After the process of estimating the whole potential energy need for heating the phase of planning requires a specific decision of the heat produced and sold.

The management had to decide a scenario which will be used for the business plan. The scenario is based on the development scenario described above. Regarding the heat sales and the development of the heat sales during the next years the following scenario is used for the business plan. (The business plan will calculate 25 years because this is the technical life time of the technical parts of the system (boiler and storage tanks, hydraulic and electric equipment), the building has of course longer technical development time):

Figure 15 Sales estimation business plan

year	heat sales		% of maximum
1	174	MWh	12%
2	354	MWh	45%
3	415	MWh	50%
4	492	MWh	64%
5	532	MWh	69%
6	571	MWh	76%
7	611	MWh	81%
8	627	MWh	83%
9	667	MWh	88%
10	683	MWh	91%
11 -25	723	MWh	96%

8.1.2 Decision on a heat production system fuel and unit sizes

The decision is to build a district heating system with combustion of own produced wood chips with 3 boilers (220 kW, 320 kW and 500 kW). The 3 Forsthäuser will be heated with own wood chip based boilers (10kW, 15kW, 40kW).

The decision for the district heating is the cost optimal solution based on own resources for the Jaidhof buildings. One external client (Chateau Jaidhof, 400MWh/a) can be acquired. This client is essential to increase the profitability of the system. Nevertheless the business plan calculates without this client because at the time of calculation of the business plan the contract was not closed yet. So as a matter of professional care the business plan was established without the external client.

8.1.3 Business plan

The business plan for the Jaidhof district heating system was set in the year 2008. The management decided to establish a company which would own and run the district heating. The company will be named **GVB - Nahwärme GmbH** and will be a 100% daughter of the GVB - Gutmann´sche Vermögensverwaltungs- und Beteiligungs- GmbH which is owned 100% by the author.

The business plans task is to plan the foundation of the company construct the building and the grid for the district heating system, purchase the wood chips from the Jaidhof estate and sell the heat to the estate, tenants of the estates buildings which are rent out to clients and to the external client Chateau Jaidhof.

So the business plan is a typical example for a plan of establishing a new business[16] From the business point of view it has to solve the following topics:

- **Plan the investments**

  As the business has to be started, the investments are a quite substantial part of the beginning phase. All investments have to be planned exactly not only with the amounts of investment but also with an exact time frame. The difficulty is like explained in the fact that the development of the estates buildings cannot be predicted. Nevertheless a scenario has to be set up and evaluated about its probability (The essentials of the scenario have been explained above).

- **Plan the permanent acquisition of the fuel (wood chips) from the Jaidhof estate**

  An essentiality of the business idea is the security of supply with the fuel. This should be important basic idea of every renewable energy project. The potential has to be evaluated and an opportunity cost calculation has to be made (see above). This means that the business plan of the GVB - Nahwärme GmbH is also based on the business of the Jaidhof estate which is, to be exact, a different business unit (and also a different legal unit). The relation between the two business partners offers some flexibility in steering costs and income and tax situations.

[16] McKinsey & Company: Planen, gründen, wachsen, Mit dem professionellen Businessplan zum Erfolg; 3. Auflage, Zürich 2002, page 7

Nevertheless the business plan calculates with market conditions as among non related business partners. The possibility of steering in the interest of the whole group (all businesses in the Gutmann Group) has on the first hand legal (often taxlegal) limits but is nevertheless there. The business plan does not take this into account and calculates everything according to given market situation.

- **Plan the sales of the heat**

  The same thin is valid for planning the heat sales. Heat sales are planned to be to the Jaidhof estate itself (Gutmann`sche Forstverwaltung Jaidhof) which on the other hand sells the wood chips to the heat producer. Moreover the sales are also to client of the estate who rent apartments, offices and buildings. And sales go to one external third party client, the Chateau Jaidhof.

  It is very clear that all these clients have to be treated equally. A differentiation can only be for business reasons. The main differentiation in heat sales is the amount of sold heat. The more heat purchased the better the price. This is based in contracts which is valid for all clients. This is controlled by a quality manager because public support is connected with this. So all the clients sales planning is based on market prices and like with external business partners.

8.1.3.1 Content of the business plan

The GVB - Nahwärme GmbH (following GVB Nahwärme) business plan has the following content[17]:

1. Executive Summary
   most important topics summarized
2. Business description
   idea for the business , description of the business
3. Competitor analysis
4. Technical plan
5. Financial plan

8.1.3.1.1 Executive summary

[17] Based on: McKinsey & Company: Planen, gründen, wachsen. Mit dem professionellen Businessplan zum Erfolg; 3. Auflage, Zürich 2002, page 49ff

8.1.3.1.1.1 Executive summary, general

GVB establishes a 100% daughter the GVB - Nahwärme GmbH (future the GVB Nahwärme). The GVB Nahwärme will build and run a district heating system to connect the CORE and NON CORE buildings (see above) and sell the heat to the external clients. The woodchips will be purchased from the estate.

8.1.3.1.1.2 Executive summary, time plan

The district heat system will be established in 3 steps:

1) Year 1:
   construction of the building
   construction of the 1 part of the grid
   installation of the first boiler with 220 kW

2) Year 2
   construction of the 2 part of the grid
   installation of the second boiler with 329kW

3) Year 3
   Installation of the third boiler with 500kW

8.1.3.1.1.3 Executive summary, financials

Total investment	EUR 520.000.
Equity	EUR 180.000
Loans	EUR 340.000 (25 years, 6% p.a.)
public support	EUR 180.000 (year 2, one time payment)
Return on equity	8% p.a.

Fuel	EUR 15,85/srm
heat production costs total (incl. 6% p.a. profit margin	EUR 0,0831 per kWh

After 25 years the investments will be written off, the building will have a rest value. **How profitable the business will be after 25 years depends on the reinvestment and the public support after 25 years.**

8.1.3.1.1.4 Business description

As described above

8.1.3.1.2 Competitor analysis

As only competitor the EVN Fernwärme Gföhl is identified. As mentioned above the offer was not able to solve some of the business topics (step by step acquisition of clients, wood purchase) and some technical topics (grid on the estates grounds). Nevertheless the financial side of the offer was analyzed and the heat production costs were calculated.

As main other costs the financing costs of the investment where calculated:

- Technical equipment
- Investment grid on the estates grounds
- Transfer stations for the grid

A main negative factor was that no public support can be achieved in this case. And the positive business margin on the estates wood sales was also not calculated because they will affect another legal entity.

The calculation results in the following

Figure 16 Offer EVN calculated in EUR/kWh/a total costs for the Jaidhof estate (calculation by Robert Juch 2008)

Investment				
Investment technical	EUR	10.000,00	Main distributor	
Investment construction	EUR	14.000,00	20m2 x EUR 700	
Investment grid	EUR	77.000,00		
Investment transfer stations	EUR	24.500,00		
Connection costs	EUR	38.750,00		
Single unit Legstätte	EUR	35.000,00		
Planning costs	EUR	8.000,00		
TOTAL	**EUR**	**207.250,00**		
Public support	EUR	-		
total investment costs/a	**EUR**	**16.630,28**	**perkWh/a**	**0,0222**
			(750.000 kWh)	
Running costs				
Maintainance	EUR	139,00		
Insurance and others	EUR	207,00		
electricity	EUR	240,00		
personal	EUR	1.484,00		
Total running costs	**EUR**	**2.070,00**	**perkWh/a**	**0,028**
EVN offer				
Basic costs EVN	EUR	8.820,00		
Heat price EVN	EUR	46.447,00	per kWh/a	0,06
general fee EVN	EUR	225		
total heat costs EVN	EUR	55492,5	per kWh/a	0,074
Total heat cost connection EVN	**EUR**		**per kWh/a**	**0,0989**

When recalculating this offer to own production, it would allow a **wood chip price of EUR 19,36/srm**!

The comparison shows that the own offer (calculation) is competitive compared to the EVN offer. The advantage for the client is certainly in the security, the security of fuel supply and the security of operation.

The **security of fuel supply** is based in the fact that the GVB Nahwärme has a secured supply of fuel with valid contracts with the estate which is not the case for the EVN unit. The EVN unit can purchase wood from farmers but it is not obligatory for them to sell the wood. The market will not make it difficult for the EVN unit to buy wood but the situation can change with narrowing of the market because of increased demand from paper and chip board industry. Compared to this the GVB Nahwärme has resources which can be considered as good as own.

The **security of operation** means that the client has an increased security that the GVB Nahwärme will run the heat supply because the companie´s owner has an increased interest in supplying the clients because they are at the same time tenants of the owner. Of course the owner of the heat supply unit is a different legal person than the owner of the buildings. Nevertheless both are controlled by the same person. In Austria during the last years some of the biomass companies got into difficult situation and also some of them went bankrupt. So this security of the GVB Nahwärme is an advantage for the client.

8.1.3.1.3. Technical plan[18]

The district heat production unit delivers heat to a central heat storage with 20.000 liters which is based in the technical room of the district heat production unit. From this storage the hot water will be pumped through the grid to the end users. The steering of the system works on demand of the end users. The end users are all connected to the net and the heat production unit.

The wood chips are delivered to the boilers automatically. The wood chips are stored in extra storages for each boiler. The ash cleaning is automatic. The ash will be collected in ash collectors with a suitable size. The boilers are equipped with automatic heat register cleaning[19]

[18] Schramek (Hrsg), Ernst Rudolf: Taschenbuch für Heizung und Klimatechnik, 73. Auflage, München 2007
[19] TB Juch: Ansuchen um Baubewilligung für den Einbau einer Hackgutfeuerungsanlage, 4.9.2008

The technical plan has 3 parts

Plan of the building

Plan of the boiler and other technical equipment

Plan of the grid

8.1.3.1.3.1 Plan of the building:

The building for the unit was placed on a hill a few meters outside the estates houses. The place is dedicated “agricultural land, green land” (“Widmung Grünland Landwirtschaft). The building is constructed in massif construction with pre-fabricated concrete elements. The technical room is constructed as an own fire sector.

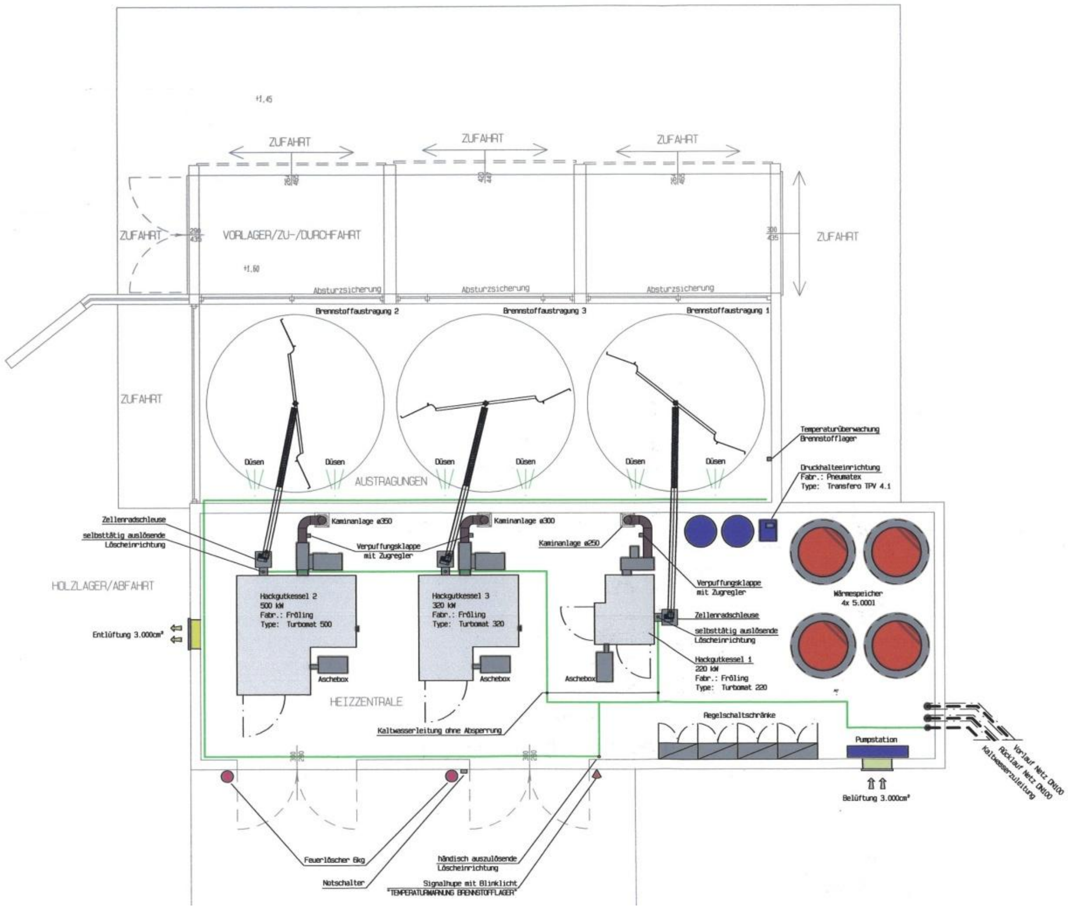


Table 13 Plan of the building

80 Meters more of the grid have been taken into account as additional costs, the advantage of the place is an easy access for the trucks and the wood chip cutter. The place the easiest place to reach from the biggest capacity street, the B37. The trucks with the wood can access the place without going through the village and can cut or do other manipulation without disturbing the population. Moreover the last building of the estate, the Legstätte can be also connected because the plant is situated next to it.

The building has 4 parts:

8.1.3.1.3.1.1 The wood storage place

The wood storage place is the place where the wood is stored outside to dry. In the future a roof for humidity protection is planned to increase the quality of the wood chips.

Table 14 Wood storage place

8.1.3.1.3.1.2 The truck access area (Vorlager)

The truck access area is the area where the trucks can deliver the wood chips or were the wood chips can be cut. The size is 52m².

Table 15 Truck access area

8.1.3.1.3.1.3 The wood chips storage

The wood chips storage has 3 parts for 3 boilers. The size is around 72 m² and it is constructed for 600 m3 of wood chips which is 26% of the annual need calculated It is equipped with 3 wood chip transport systems with telescope arms and a spiral system to transport the wood chips to the boiler. It has a temperature measurement system and a cold water fire extinguish system. An extra access at the side with access level floor of the storage would allow easy emptying of the wood chip storage (The wood storage is 1,45 m lower than the truck access area)

Table 16 Wood chips storage

Table 17 Wood chips storage, telescope arms and spiral transport

Table 18 Wood chip storage, extra access at the level of the wood chip storage

8.1.3.1.3.1.4 The technical room

The size of the technical room is 115m², the level is the same as the storage and 3 positions for boilers are prepared. The technical room is an extra fire sector. It is protected by passive means like concrete wall up to the roof, mechanical constructions to protect the spiral transport of the wood chips and active means by a water anti fire system (for the technical room and the wood chip storage)

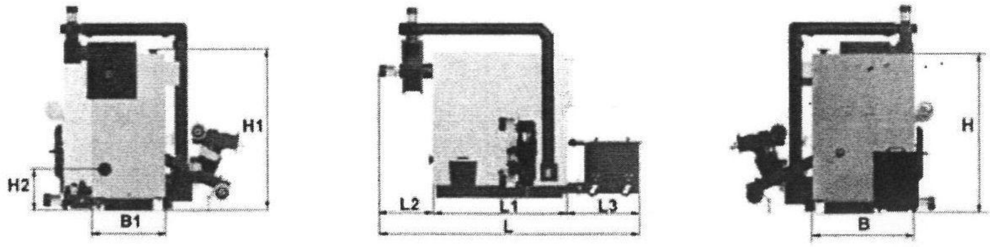
The technical room contains the following:

Boiler

The three boilers (220 kW, 320 kW, 500 kW) from Fröling

KESSEL 1:

Fabrikat: Fröling
Type: Turbomat 220

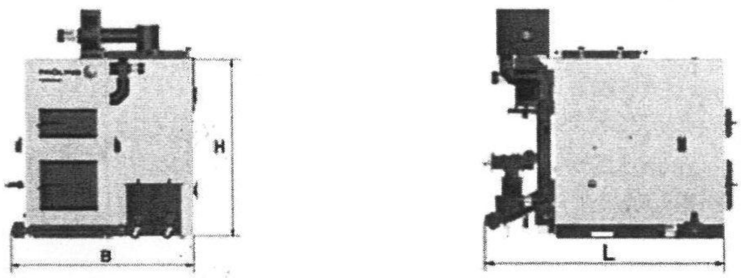


Turbomat		150	220
Nennwärmeleistung	kW	150	220
Abgasrohrdurchmesser	mm	200	250
Kesseltiefe L	mm	3240	3390
Kesselbreite B	mm	1210	1490
Kesselhöhe H	mm	1870	1870
Höhe Vorlauf/Rücklauf H1/H2	mm	1930/495	1930/495
Länge Kessel L1	mm	1710	1750
Länge Saugzuggebläse L2	mm	600	710
Breite Wärmetauscher B1	mm	870	870
Länge Aschewagen für Retortenentaschung L3	mm	930	930
Minimale Einbringhöhe/minimale Einbringbreite	mm	1950/1000	1950/1000

Table 19 Technical data Fröling boiler 220 kW

KESSEL 2:

Fabrikat: Fröling
Type: Turbomat 320



Turbomat		320	500
Nennwärmeleistung	kW	320	500
Abgasrohrdurchmesser	mm	300	350
Kessellänge inkl. Stoker L	mm	3250	3600
Kesselbreite inkl. Anbauteile B	mm	2500	2980
Kesselhöhe H	mm	2440	2605
Durchmesser Stokerschnecke	mm	150	200
Wärmetauscherfläche	m2	19,04	32,73
Kesselinhalt (Wasser)	Liter	560	750
Kesselgewicht (trocken)	kg	5070	6800
Mindestraumhöhe	mm	3000	3300

Table 20 Technical data Fröling boiler 320 kW

KESSEL 3:

Fabrikat: Fröling
Type: Turbomat 500

Turbomat		320	500
Nennwärmeleistung	kW	320	500
Abgasrohrdurchmesser	mm	300	350
Kessellänge inkl. Stoker L	mm	3250	3600
Kesselbreite inkl. Anbauteile B	mm	2500	2980
Kesselhöhe H	mm	2440	2605
Durchmesser Stokerschnecke	mm	150	200
Wärmetauscherfläche	m2	19,04	32,73
Kesselinhalt (Wasser)	Liter	560	750
Kesselgewicht (trocken)	kg	5070	6800
Mindestraumhöhe	mm	3000	3300

Table 21 Technical data Fröling boiler 500 kW

Table 22 Technical room with boilers

Hot water storage tanks

The unit has 4 hot water storage tanks with 5.000 liters each

Table 23 Hot water storage tanks

Pump station

The pumping station pumps the hot water into the system and presses the cold water back out to be heated up again

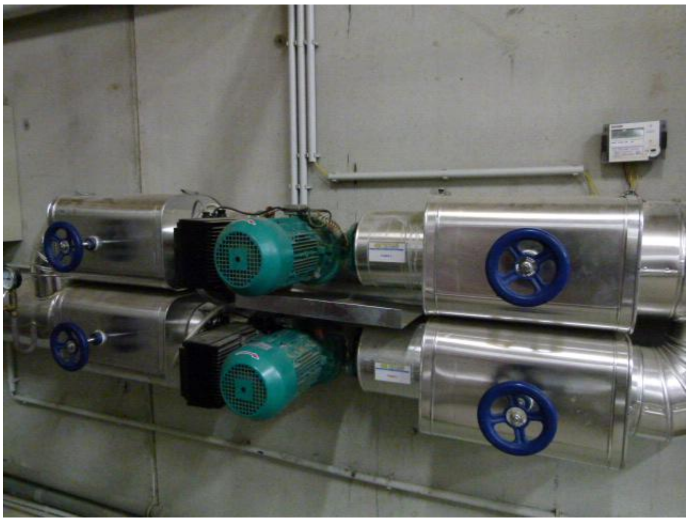


Table 24 Pump station

Grid in and out, cold water in

The hot water is pumped into the grid and after supplying the buildings comes back as cold water to be heated up again

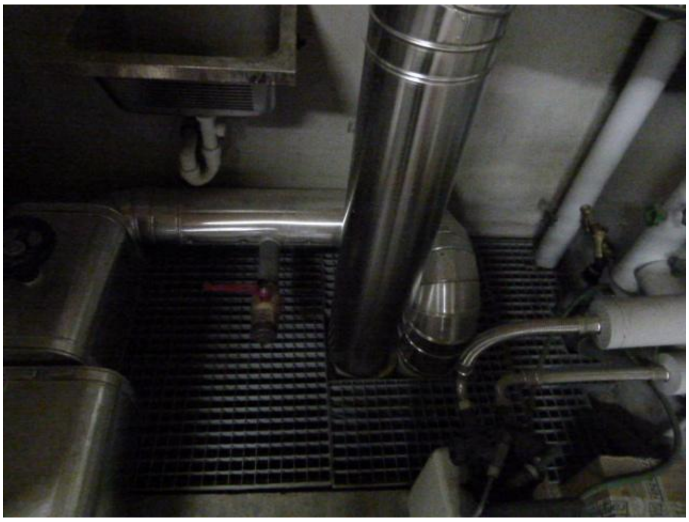


Table 25 Grid in and out, cold water in

Pressure containers

The pressure containers help the system to equalize potential pressure differences in the grid.

Table 26 Pressure containers

Electrical and steering unit

The electrical unit supplies and controls the electricity for the system. The steering unit regulates the incoming supply demands from the different end users and orders heat pumping to the system, starting and stopping the boilers.

Table 27 Electrical and steering unit

8.1.3.1.3.2 Grid

The grid connects all the buildings together and supplies them with hot water. The length of the grid is 960 m including house connections. This means 1022,93 kWh/m. The yearly usage grade (Jahresnutzungsgrad) of the grid is 83,57 %. Net losses are 193 MWh/a.

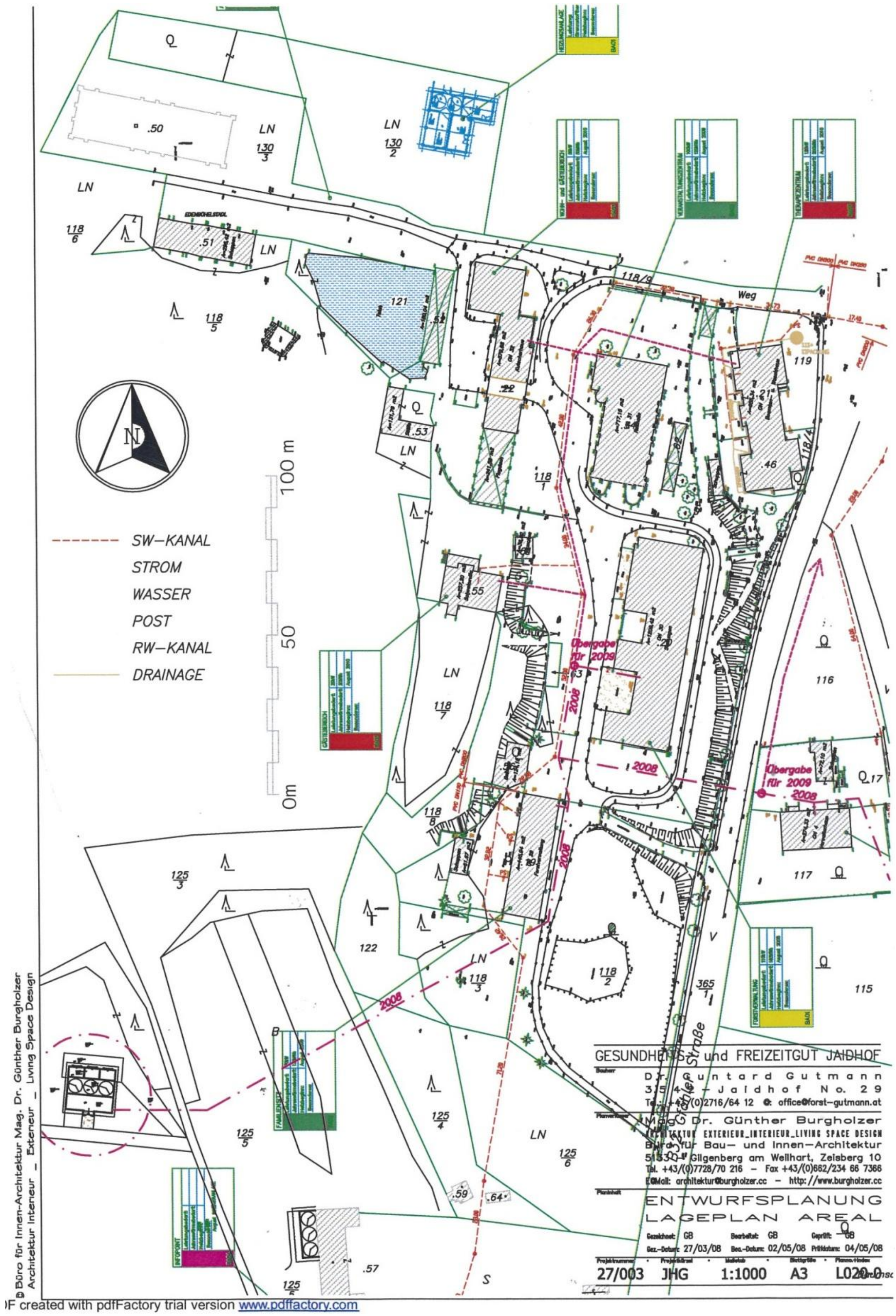


Table 28 Grid plan

8.1.3.1.4 Financial plan

8.1.3.1.4.1 Investment plan

The investment plan has to take into account the first year of construction (phase 1) without any income. The income will start with the phase 2 (year1)

Figure 17 Time frame of investment

Time plan investment		technic	construction	**total**	public support	
phase 1	construction	99.000	322.887	**421.887**		EUR
phase 2	year 1	67.000		**67.000**	122.066	EUR
phase 3	year 2	10.500		**10.500**	20.100	EUR
phase 4	year 3	3.500	13.113	**16.613**	3.230	EUR
					5.240	EUR

Ad phase 1

Technic: EUR 90.000 (boiler 220kW, one wood chip storage with transport spiral, steering)

Transfer stations EUR 10.500, (Stallgebäude, Verwalterhaus, Gärtnereihaus)

Ad phase 2

Technic: EUR 60.000 (boiler 320 kW, second wood chip storage with transport spiral, steering)

Transfer station EUR 7.000 (Alte Forstdirection, Reitschule)

Ad phase 3

Transferstation EUR 10.500 (Wohngebäude, Schweinevilla, Beamtenhaus)

Ad phase 4

Transferstation EUR 3.500 (Kutscherhaus)

The one time investments are activated in the balance sheet and are cost effective with depreciations. The depreciation is calculated with the fiscal live time of an investment which can differ. The legal entity chooses a method and the finance authorities can accept this method of depreciation or not. The years of depreciation are chosen according long time experience.

Figure 18 Investment and depreciation

Components							
		years of use	total EUR/year	year 1	year 2- 15		
investment technic	150000	15	10000	10000	10000	14207	(incl. reinvestment indexed)
investment construction	170000	50	3400	3400	3400	3400	
investment grid	106000	50	2120	2120	2120	2120	
investment transfer stations	30000	15	2000	2000	2000	2841	
investment legal real estate	5000	25	200	200	200	200	
investment planning	36000	1	36000	36000			
investment quality manager	4000						
investment other project costs	15000	1	15000	15000			
total investment	**516000**						
public support	-150300						
investment net	365700	**depreciation**	**68720**	**68720**	**17720**	**22768**	

8.1.3.1.4.2 Running costs

The running costs are planned as a certain % of the investment costs, the fuel costs are calculated with EUR 19, 36 per srm. The fuel costs are relatively high to be on a conservative side. The number of EUR 19,36 is dedicated from the total heat production costs in the case of EVN connection. These heat production costs would allow in own production a fuel price from EUR 19,36.

Figure 19 Running costs

yearly running costs	% of investment p.a.	EUR p.a.	
maintenance	0,41%	2.130	
insurance and other	0,51%	2.653	
rent of grounds	0,06%	325	
electicity costs	0,23%	1.200	
personal costs	0,93%	4.823	
fuel costs	5,61%	29.036	1.500 srm
Total	**7,75%**	**40.167**	

Essential for the 25 year business plan the yearly development of the fuel costs is important. The business plan calculates with a certain scenario.

Figure 20 Yearly development fuel costs (Klaus Trampisch/Robert Juch)

jährliche Entwicklung des laufendes Aufwandes (Brennstoffnotwendigkeit)					lt. RJ Angaben vom 16.4.08
lfd. Jahre	Wärmeabnahme	Verlust	geschätzter Brennstoffbedarf		gesamt lfd. Aufwand
1	12%	0,5%	12,0%	3.488,-	14.619,-
2	45%	4,3%	49,0%	14.235,-	25.366,-
3	50%	4,3%	54,7%	15.888,-	27.019,-
4	64%	4,3%	68,0%	19.756,-	30.887,-
5	69%	4,3%	72,9%	21.173,-	32.304,-
6	76%	4,3%	80,0%	23.233,-	34.364,-
7	81%	4,3%	84,9%	24.651,-	35.782,-
8	83%	4,3%	87,6%	25.426,-	36.557,-
9	88%	4,3%	92,4%	26.843,-	37.974,-
10	91%	4,3%	95,1%	27.618,-	38.749,-
11	96%	4,3%	100,0%	29.036,-	40.167,-
12	96%	4,3%	100,0%	29.036,-	40.167,-
13	96%	4,3%	100,0%	29.036,-	40.167,-
14	96%	4,3%	100,0%	29.036,-	40.167,-
15	96%	4,3%	100,0%	29.036,-	40.167,-
16	96%	4,3%	100,0%	29.036,-	40.167,-
17	96%	4,3%	100,0%	29.036,-	40.167,-
18	96%	4,3%	100,0%	29.036,-	40.167,-
19	96%	4,3%	100,0%	29.036,-	40.167,-
20	96%	4,3%	100,0%	29.036,-	40.167,-
21	96%	4,3%	100,0%	29.036,-	40.167,-
22	96%	4,3%	100,0%	29.036,-	40.167,-
23	96%	4,3%	100,0%	29.036,-	40.167,-
24	96%	4,3%	100,0%	29.036,-	40.167,-
25	96%	4,3%	100,000%	29.036,-	40.167,-

Also a scenario for the development of the earnings depends on the connection of the different buildings and a scenario for the consumption of the heat.

Figure21 Earnings development (table Klaus Trampisch)

Eingabewerte und Teilergebnis: Einnahmenentwicklung

Einnahmenentwicklung

Jahre	*Einnahmen* nicht indexiert	*Wärmeab-nahme p.a. in MWh nach Nutzungs-szenario*	*An-schluß-bezah-lung*	Wärme-abnahme *relativ*	*An-schluss-schritt*	*Anschlussschritte nach Bauphasen 1* neue Forstkanzlei, 4-er Haus, Tomatis 100% 13,5% 101.570kW 13.550 205MWh/a	*und Anteil der 2* Familiensitz, Ver-anstaltungshalle 95% 44,3% 331.912kW 44.250 240MWh/a	*Wärmeabnahme 3* Therapiehaus 95% 24,4% 183.092kW 24.400 200MWh/a	*4* Reitbereich inkl. Whg 95% 17,8% 133.426kW 17.800 105MWh/a	*Summe* 100,0% *750.000kW* 100.000 *750MWh/a*	Mehreinnahmen durch Differenz Gestehungskosten zu Verkaufspreis
1	€ 29.162,80	174 MWh	13.550	12%	12%	85%					€ 69,70
2	€ 75.990,80	354 MWh	44.250	45%	33%		75%				€ 145,95
3	€ 61.584,00	415 MWh	24.400	50%	6%	15%		15%			€ 176,11
4	€ 61.838,40	492 MWh	17.800	64%	13%		10%		50%		€ 214,83
5	€ 47.622,40	532 MWh		69%	5%			20%			€ 239,28
6	€ 51.184,00	571 MWh		76%	7%		10%		15%		€ 264,89
7	€ 54.768,00	611 MWh		81%	5%			20%			€ 291,95
8	€ 56.179,20	627 MWh		83%	3%				15%		€ 308,45
9	€ 59.763,20	667 MWh		88%	5%			20%			€ 337,97
10	€ 61.174,40	683 MWh		91%	3%				15%		€ 356,33
11	€ 64.758,40	723 MWh		96%	5%			20%			€ 388,53
12	€ 64.758,40	723 MWh		96%	0%						€ 400,18
13	€ 64.758,40	723 MWh		96%	0%						€ 412,19
14	€ 64.758,40	723 MWh		96%	0%						€ 424,55
15	€ 64.758,40	723 MWh		96%	0%						€ 437,29
16	€ 64.758,40	723 MWh		96%	0%						€ 450,41
17	€ 64.758,40	723 MWh		96%	0%						€ 463,92
18	€ 64.758,40	723 MWh		96%	0%						€ 477,84
19	€ 64.758,40	723 MWh		96%	0%						€ 492,17
20	€ 64.758,40	723 MWh		96%	0%						€ 506,94
21	€ 64.758,40	723 MWh		96%	0%						€ 522,15
22	€ 64.758,40	723 MWh		96%	0%						€ 537,81
23	€ 64.758,40	723 MWh		96%	0%						€ 553,95
24	€ 64.758,40	723 MWh		96%	0%						€ 570,56
25	€ 64.758,40	723 MWh		96%	0%						€ 587,68
	€ 1.530.643,20	15.967 MWh				100%	95%	95%	95%		€ 9.631,64
	€ 61.225,73	639 MWh									€ 385,27 (indexierte Berechng.)

Relevant for the development are also scenarios about the growth of the indexes over the next 25 years. For the business plan a linear development is chosen

Figure 22 Index development

Index development	**estimation**		**comparison: develompent 2000/2006**	
running costs	2,10 % p.a.		consumer price index	2,40 % p.a.
reinvestments	2,54 % p.a.		construction cost index	3,50 % p.a.
dividends	2,40 % p.a.		construction price index	2,54 % p.a.
heat price	3,00 % p.a.		working cost index (mixed)	2,10 % p.a.
accounts				
credits and loans	7,00 % p.a.			
assets	3,50 % p.a.			

8.1.3.1.4.3 Financial plan, result

The result of the financial plan has to be described with all important numbers. See the following table.

For the management the 2 important numbers are the purchase price wood chips (EUR 15,85). This is important for the Gutmann Group internal financial calculation.

The wood chip price is evaluated to be at the upper end for the GVB Nahwärme.

Generally a lower price shall be achievable at least during the first years when the project will be started.

The longer the business plan runs, the more uncertain is a prediction of the wood price. Nevertheless the chosen index adaption (2,10 % p.a.) shows a quite substantial increase of the wood chip price.

The other important number is the relative profit 8% per annum (return on equity) This is a quite ambitious number. In other words the reserves are good.

For the management a return on equity from 3 % and more is related to the interest situation of the years 2006 – 2008 is considered as moderate profitable, especially considering that the deliverer of the fuel is a related person and that the majority of the clients are related persons, which means that the risk is lower than in a totally non related market environment.

Figure 23 Financial plan, results

investment estimated	EUR	517.121	
equity	EUR	180.992	
equity % of total capital		35%	
credits and loans	EUR	336.129	
loan		25	years
interests		6%	p.a.
interests total	EUR	220.929	
public support scheme	EUR	150300	30% of investment in year 2
running costs		6,75%	of investment with full production per annum
running costs	EUR	42258	per annum
index running costs		2,10%	per annum
reinvestment	EUR	255.728	afer 15 years
reinvestment index		2,54%	per annum
aditional loan	EUR	210.000	for 10 years
dividends		6%	on equity per annum
dividends total	EUR	14.647	per annum
dividends index		2,4 %	per annum
costs			
with fuel costs	EUR	15,85	per srm
heat production costs	EUR	0,0831	per kWh
income needed to reach the target			
heat price total	EUR	0,09	per kWh
value of investment	EUR	110.255	after 25 years
capital account	EUR	957	after 25 years
dividends total	EUR	366.171	after 25 years
heat price margin	EUR	166.114	(heat price - heat production costs)
result total	EUR	643.497	after 25 years
initial equity	**EUR**	**180.992**	
total profit	EUR	462.526	(result total - inital equity) after 25 years
income tax	EUR	85.517	
total profit	EUR	337.009	after 25 years
relativ profit		208,30%	after 25 years
relativ profit		**8%**	per annum

8.2 Implementation

The start of the implementation (phase 1), the construction of the building, the first part of the grid and the connections of the first renovated buildings were as planned in time with no major organizational problems.

Table 29 Construction works

8.3 Controlling and adaption

8.3.1 Controlling

The controlling system of GVB Nahwärme contains regular and irregular information to control the finance plan. Here we concentrate on the information which affect our assumptions for the business plan and technical information like specific heat consumption of each building

8.3.1.1 System losses

During the year 2009 the controlling discovered high boiler working times. The combustion time was 8.000 h during this year. A reason could have been the construction phase. Then the controlling showed very high losses in the system. It turned out to be major hydraulic problem by miss planning. The responsible technical planning office went bankrupt. The management had to hire another

technical planning office and to invest another X EUR into the adaption of the system (see below) The company had to increase its capital by EUR
Generally it can be said that hydraulic optimization is a very important topic generally. The author has the impression, that heat systems are often not optimized sufficiently (Hydraulischer Abgleich). This would be very important. Studies prove, that hydraulic optimization can reduce the heat consumption and electric consumption of the system up to 20%[20][21]

8.3.1.2 Heat consumption per m²

For each building a certain heat consumption was assumed. The controlling of the specific heat consumption gave a better understanding about the real use. The year 2009 seems to have been an irregular year. The reason was the absence of the tenants because of the construction phase.

The total heat consumption was 496.100 kWh/a. This number is 131.000 kWh/a or 36% higher than calculated. A specific differentiation of the m² consumption can be seen. All the buildings with 19 century façade have more than 150 kWh/a/m². The only building with 115 kWh/a/m² is the Verwalterhaus which has a new facade. Nevertheless the consumption substantial is higher than the calculated energy losses.

Figure 24 Controlling of energy consumption

	Installed kW	calculated kWh/a	consumption 09	consumption 10	m2	**kWh/a/m2; 10**
Stallgebäude	110	180.000	106.150	170.000	1.116	**152**
Verwalterhaus	30	25.000	32.900	41.800	364	**115**
Gärtnereihaus	30	40.000	37.000	79.300	497	**160**
Alte Forstdirection	70	120.000		205.000	1.283	**160**
Total		**365.000**		**496.100**		
Total without Alte Forstdirection		**245.000**	**176.050**			

8.3.1.3 Energy content

The energy content of the wood chips where calculated with 650 kWh/srm. The energy content of the 2010 used wood chips was only 605 kWh/srm. Only beech was needed. The interesting fact is, that in the literature the energy content is calculated with 1.000 kWh/srm and more[22].

[20] Stannek, S; Eine richtig einregulierte Anlage spart richtig Geld, SI 12/05, 2005, page 33-34
[21] Jagnow, K; Wolff, D; Technische Optimierung und Energieeinsparung, DBU Kurzbericht, www.optimus-online.de; visited on October 13th, 2010
[22] Energie aus Holz, Landwirtschaftskammer NÖ; Informationsbroschüre der Landwirtschaftskammer, St. Pölten, 2005, page 101 ff

The reason seems to be in the quality of the wood and in the storage

Table 30 Wood on the storage place

The decision of the management is to increase the quality of the wood chips by two measures. The first measure will be to use in the future better quality wood and sell the bad quality wood to the market. As a substantial cost factor is the cutting of the wood chips, it is more profitable to cut wood with more energy content per fm. The second measure will be to build a wood storage to reduce moisture.

8.3.2 Adaption

The following parts of the system were adapted:

8.3.2.1 Installation of a communication tool for the consumer side

No steering unit was installed at the consumer´s side. The buildings where not able to call for heat: The heat was pumped to the buildings permanently. The hot water was pumped around much too fast and with a non sufficient use of the heat. A totally new steering unit had to be installed.

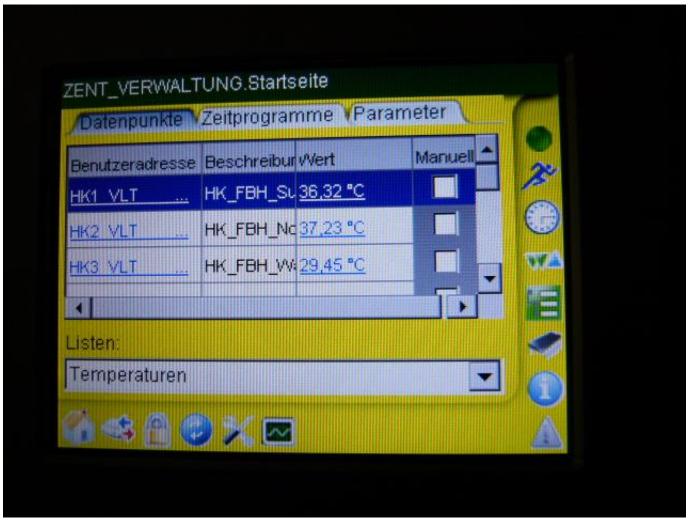


Table 31 Touch screen steering unit Alte Forstdirection

8.3.2.2 Adaption of the hydraulics of the hot water storage tanks

The hot water storage tanks were connected together in a way that the hydraulic did not fill them in a proper way. The water tanks acted as a permanent additional consumer not as a storage.

The storage tanks had to be reconnected.

The bankrupt technical office which caused the damage did not hand over any technical plans. So only the plan of the reconnection can be presented.

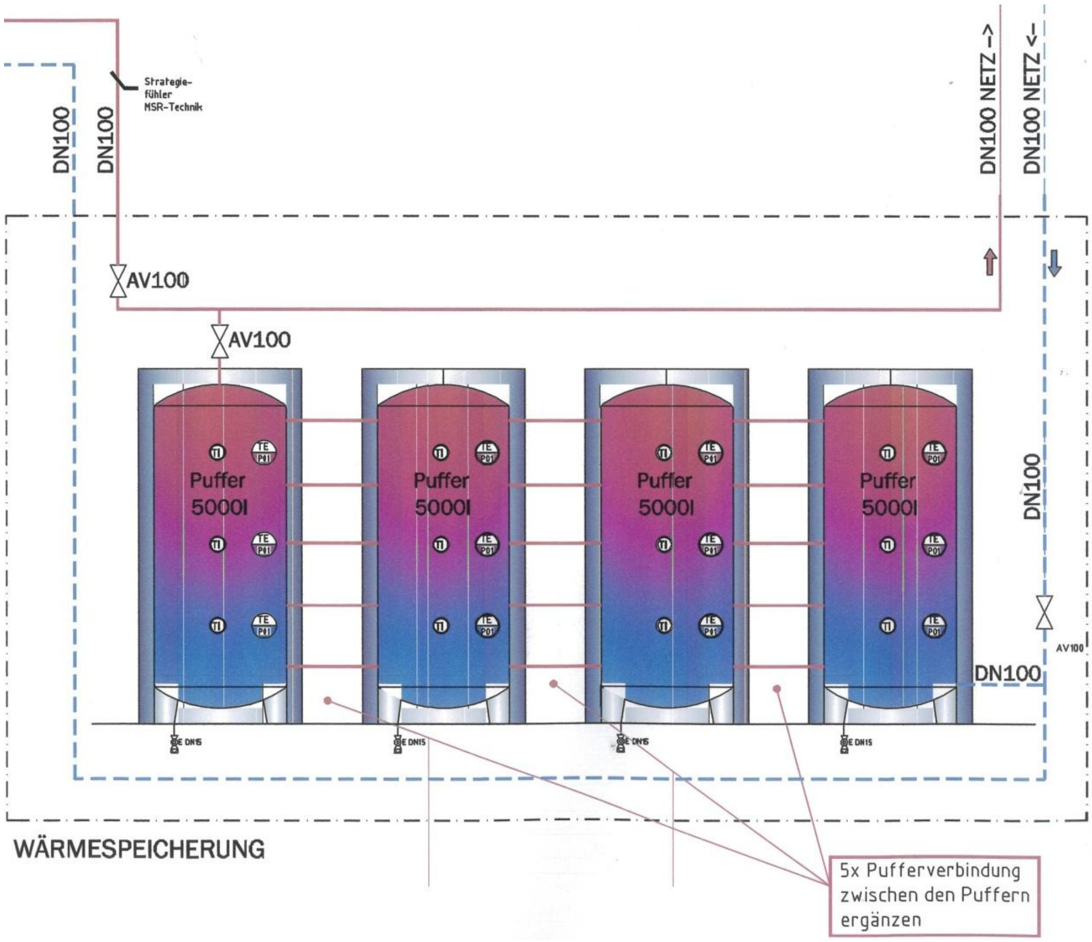


Table 32 Technical plan of the new connection to the storage tanks
(Büro Seehuber)

8.3.2.3 Adaption of the insufficient isolation

The isolation of the storage tanks, the pipes in the technical room where not existing or much too weak. The isolation had to be renewed totally.

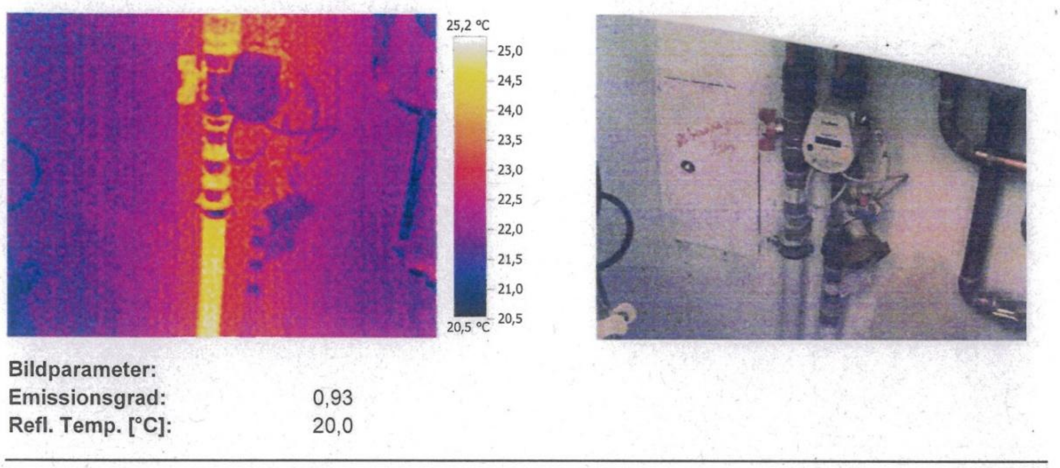


Table 33 Insufficient isolation

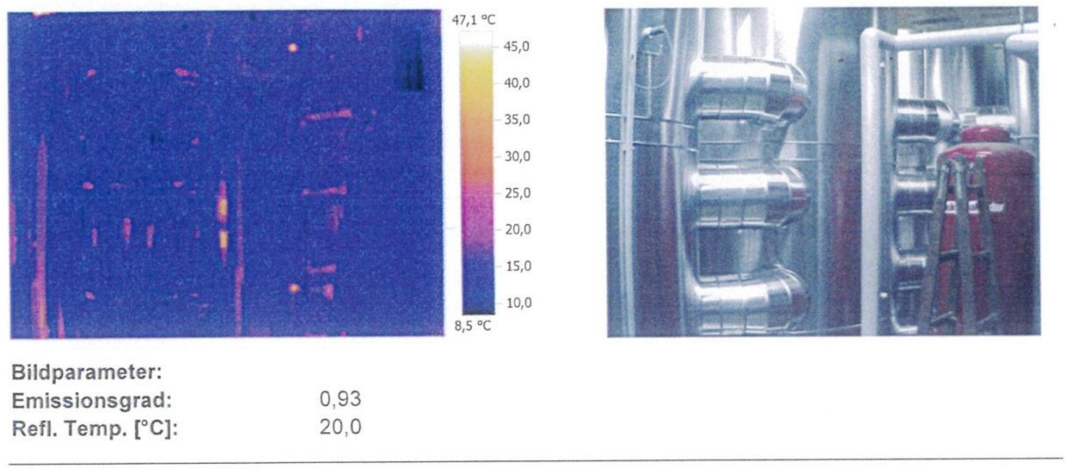


Table 34 New isolation

8.4 Conclusions - final evaluation

The districted heating solution with a wood chip fuel is the least cost renewable energy system for the Jaidhof estate. The opportunity costs show sufficient reserves in relation to negative relative price developments in the wood market. Moreover markets expect relative price increase for other fuels like oil.
The decision for the wood chip based district heating system for the buildings of the Jaidhof estate is based on a important rule of the renewable energy business. The fuel supply is secured with sufficient resources. Many biomass projects don't have a secured fuel base. The fuel is produced in a circle within 20km and the consumers are directly in the place.
Secondly it has to be mentioned that the heat production serves for buildings with a relative high heat energy consumption (more than 100kWh/a) and more square

meters than single family houses. A biomass heat production is an optimal system for large volume monument protected buildings with local fuel production.

The district heating for the Jaidhof buildings suffered from miss planning and missing technical controlling .The system suffered from substantial hydraulic problems and quality in the detail execution. The repair needed a new capital investment. The profitability will decrease and has to be recalculated.

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