MSc Program

Renewable Energy in Central & Eastern Europe

Energy Concept of Kötschach-Mauthen

Potential of Technical and Economic Use of Renewable Energy for an Energy-self-sufficient Community in the Alps

A Master Thesis submitted for the degree of

"Master of Science"

supervised by

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Krumpendorf, 9.2.2008

Affidavit

I, **Christoph Markus Aste**, hereby declare

that I am the sole author of the present Master Thesis, " Energy Concept of Kötschach-Mauthen”

1. 76 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 Thesis as an examination paper in any form in Austria or abroad.

Krumpendorf, ________________ ______________________________

Date Signature

Acknowledgement

First of all I want to thank for the patience of my family doing a post graduate while having 3 kids and a job. I also want to say thank you to all teachers, especially to Univ. Prof. DI Dr. Dr. h.c. H. Drobir giving lessons to a group of sometimes stressed and absent students. For giving me the possibility for studying while working in the Development Agency of Carinthia I express my thanks to Mag. Sabrina Schütz-Oberländer and to Peter Schark. The best motivator for doing this work were Wilfried Klauss, the renewable energy pioneer, and the community of Kötschach-Mauthen chaired by the major Mr. Hartlieb and his secretary Jürgen Themessel – thank you all. Last but not leased DI Dr. Gerfried Jungmeier please accept my grateful thanks for guiding me through this diploma thesis.

Contents

Abstract

The core objective of this work is to find out whether a community in the Alps is able to fulfill all there energy requirement out of their own local resources in the 21st century. In order to demonstrate the possibilities for an independent energy supply shown in the community Kötschach-Mauthen, we need to know its energy demand, as well as the distribution of the demand within the individual sectors. For the estimation of the energy demand predominantly data of Statistik Austria were used in addition to analysis of the district heating system and the local electricity grid. As a result the energy demand of Kötschach-Mauthen with 102 GWh/a is in contrast to the current local renewable energy production of 75.6 GWh/a. Therefore from the existing renewable energy plants in the community, 343 % of the electricity demand, 55 % of the heat demand and 0 % of the fuel demand are met by renewable energy carriers. The total gradient of energy self sufficiency of the community can be calculated with 74.2%. The most important conclusion of the evaluation of future additional potentials for renewable local based energy production with 39.8 GWh/a and for energy saving actions with 13 GWh/a is that a self-sufficient energy supply of the community of Kötschach-Mauthen is until 2020, in principle, to high degree up to 100% possible. 3 different feasibility studies show examples for possible measures in the electricity and heat production and for mobility services with the production of 7.6 GWh/a, raising the degree of energy self sufficiency from 74% to 82 % in the community.

Summary

In Carinthia around 42% of the gross energy consumption is produced with RES. However, 58% is imported through fossil fuels. Due to its topography Carinthia has no fossil energy resources but is rich in biomass, hydro power and has good possibilities for the use of solar energy. The core objective of this work is to find out whether a community in the Alps is able to fulfill all there energy requirement out of their own resources in the 21st century. The motivation for this question is the fact that up to the 19th century a lot of villages in the Alps were not connected to electricity grids and were the more or less left on their own devises. Through development of the valleys the dependency on energy import raises to an extend that with raising energy prices purchasing power is locally lost and global climatic problems occur through the use of fossil energy. The core question is whether the described process is reversible and whether a small village in the Alps can prove energy self sufficiency, reached by producing close to the amount of energy that is consumed in the community of Kötschach-Mauthen.

In order to demonstrate the possibilities for an independent energy supply shown in the community Kötschach-Mauthen, we need to know its energy demand, as well as the distribution of the demand within the individual sectors. Since it was not possible to obtain specific data regarding the energy demand of all business enterprises and of agriculture of the region, the energy demand had to be derived from key figures of existing statistical data, as well as from literature on energy statistics. For the estimation of the energy demand predominantly data of Statistik Austria were used, especially the results of the census 2001 (census of population, buildings, places of work) in addition to analysis of the district heating system and the local electricity grid. A major issue for independent energy supply is the availability of the area required for the supply of resources. Since soil is a restricted and non-'increasable' reproductive resource, the areas available for energy production have to be calculated by using land-use data, like the national forest inventory or data available by the regional GIS-system.

As a result the final energy demand of Kötschach-Mauthen with 102 GWh/a for heat, electricity and mobility is in contrast to the current local renewable energy production of 75.6 GWh/a (Fig.A). Therefore from the existing renewable energy plants in the community, 343 % of the electricity demand, 55 % of the heat demand and 0 % of the fuel demand are met by renewable energy carriers. The power production in the community is the strongest sector of renewable energy even for export, whereas the fuel production sector is today near to zero and needs a long term perspective. Due the technical developments of the past years the highest potential to fulfil energy self sufficiency in the near future is within the heat sector. The total gradient of energy self sufficiency of the community, as a ratio between

local final energy demand and final energy production based on local resources (ESS-ratio) can be calculated with 74.2%.

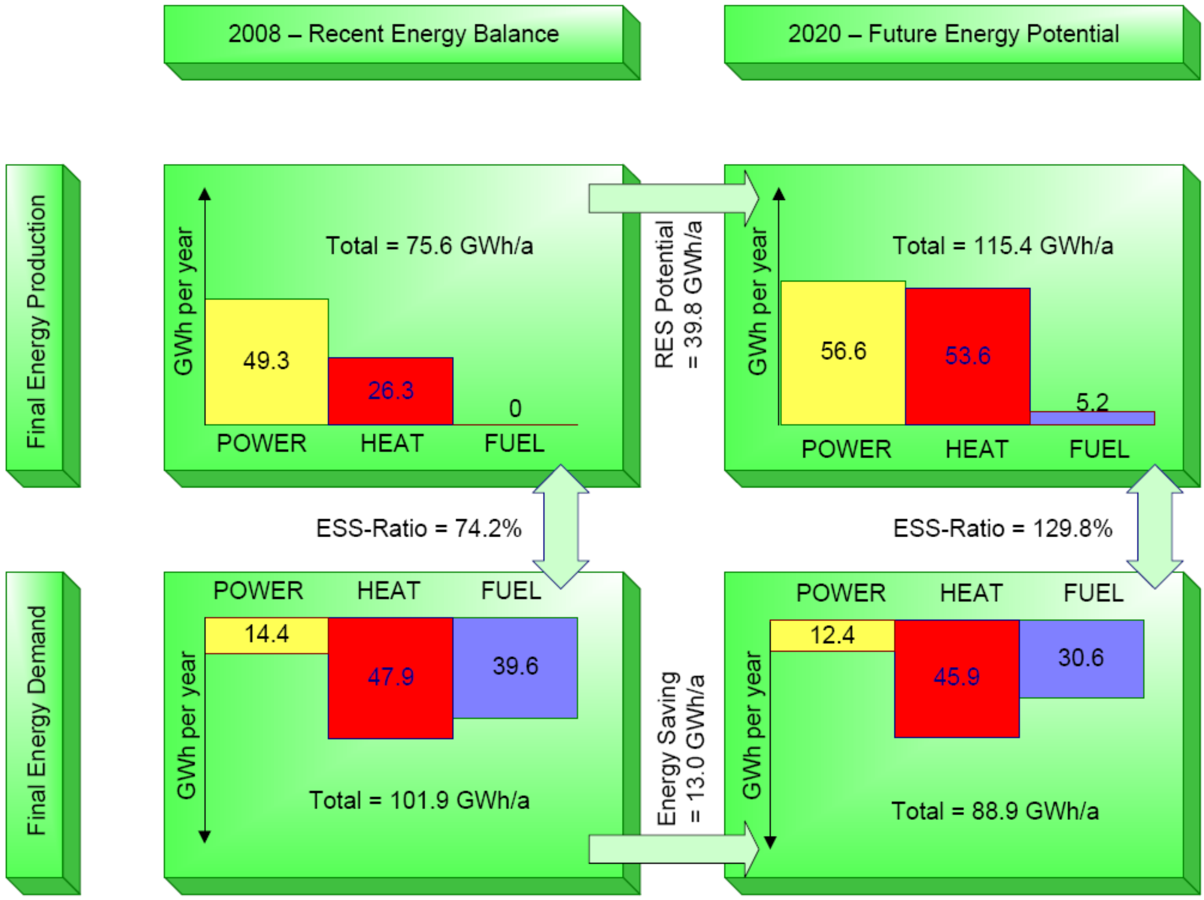

Figure A: Final energy demand and renewable energy production 2008 and potentials for the future energy production based on local resources and for energy efficiency actions until 2020

The most important conclusion of the evaluation of future additional potentials for renewable local based energy production with 39.8 GWh/a and for energy saving actions with 13 GWh/a is that a self-sufficient energy supply of the community of Kötschach-Mauthen is until 2020 up to 129.8%, ESS-ratio 115.4 GWh/a renewable final energy production to 88.9 GWh/a local final energy demand, possible.

The results of the project represent an important basis for the further project phases towards the *"Energy-self-sufficient community Kötschach-Mauthen"*. In the next step specific planning for the given lighthouse projects for industrial heat production, additional wind power production and for solar mobility as examples for possible actions for the production of 7.6 GWh/a, raising the degree of energy self sufficiency from 74% to 82 %, are necessary for the achievement of energy-self-sufficiency. The consequences for further development of the Energy Program until 2020 are personal and structural capacity building within the platform "energie:autarkes Kötschach-Mauthen" and to involve the population step by step to the proposed energy efficiency actions.

1 Initial Situation and Methodology

1.1 Introduction

The core objective of this work is to find out whether a community in the Alps is able to fulfill all there energy requirement out of their own resources in the 21st century. The motivation for this question is the fact that up to the 19th century a lot of villages in the Alps were not connected to electricity grids and were the more or less left on their own devises. Through development of the valleys the dependency on energy import raises to an extend that with raising energy prices purchasing power is locally lost and global climatic problems occur through the use of fossil energy. The core question is whether the described process is reversible and whether a small village in the Alps can prove energy self sufficiency, reached by producing close to the amount of energy that is consumed in the community of Kötschach-Mauthen. Energy independence is highly concerned with oil consumption, being the most important imported energy source for purposes of heat, transportation and electricity. Most of the world today relies on sources of oil that are often from politically unstable lands. Such resources are finite and decreasing, despite an increase in demand worldwide.

1.2 Best Practise for Energy Self Sufficiency in Literature

1.2.1 Energy Self Sufficiency in the Alps

1.2.1.1 The Schiestlhaus

The Austrian Tourist Club opened in 2005 the first high-alpine passive building, named the Schiestlhaus at mountain range Hochschwab at 2,153 m a.s.l. The Schiestlhaus was built as part of the "building of tomorrow" program, an initiative by the Austrian Federal Ministry of Transport, Innovation and Technology. It is based on an overall ecological concept that integrates aspects such as timber construction in zero-energy house standards, energy self-sufficiency using solar cells to provide hot water and photo-voltaic modules for electricity generation, biological waste water treatment, and rainwater utilization.[1] Architectural and overall building concepts are based on the principles of solar building construction. The building site on Mount Hochschwab permitted a clear southward orientation

[1] http://www.hausderzukunft.at/results.html/id2765 , 2008

of the building and thus the active utilization of solar irradiation, which is particularly favorable at this altitude. Technically, the concept follows passive house standards, and is adapted to meet the meteorological and geological requirements prevailing in alpine regions. Given average solar irradiation, more than 60% of the annual electrical energy requirement can be covered by the 7.5 kWp photovoltaic system. The remaining power requirement is provided by a rape oil operated block type power plant, which also serves as backup for power and heat supply. Heat supply and storage is effected by means of three buffer storage tanks with a total capacity of 2,000 liter which are fed, for 80%, by the 46 m^2 facade integrated thermal collectors. In the kitchen, an additional wood fired range with heat exchanger is installed, which serves for cooking and for charging the buffer storage tank.[2]

1.2.1.2 The e5 Community of Mäder

The European Energy Award® is a quality management system for steering and controlling communal energy policy in order to review systematically all energy-related activities. By this, the activities concerning climate protection in a municipality are collected, benchmarked, calculated, planned and controlled, so that the potentials for sustainable climate protection can be identified and used. This process is controlled by an energy team and supported by an accredited advisor. As an appreciation for the improvement of climate protection the cities and municipalities get certified and awarded with the European Energy Award® (the e). If a certain standard concerning implemented and finalized measures is reached, the community receives the European Energy Award®Gold. The European Leader is the community of Mäder (with the maximum of eeeee) with 84 % of the all measures reached.[3] The e5 – program for energy-efficient communities is responsible for coaching, certification and awarding of communal energy policy. The contributing communities need a prioritized program and a process instead of single projects and a network for exchange of experience and know-how. A systematic evaluation of the own activities and a benchmarking system to compare with others is given by the program. The outstanding highlights reached by this community concerning the e5-catalogue of measures (fig. 1-1) show in the category communal buildings&facilities an overall reduction of CO_2 emissions of -10% from 2000 to 2004. Mäder is serving in the category internal organization as a pilot community for ecological procuring since 2001. In the category spatial planning this e5 community agreed on an energy concept for all public buildings and the mayor serves as a trained energy consultant within the building proceedings. The community increases the amount of renewable energy

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[2] http://www.etn.wsr.ac.at/nw_pdf/fofo/fofo2_05_en.pdf, 1.2.2008

[3] http://www.european-energy-award.org/News.156.0.html, 3.1.2008

up to 25 % of total final energy consumption in the part supply&disposal and within the mobility section they implemented step by step a concept with bicycle paths, mobility management and renewing the car park of the community with bicycles and public traffic tickets. In the category communication&cooperation the community of Mäder started qualified technical and organizational support to a foreign aid project dealing with energy supply in India referring to the audit of the energy institute of Vorarlberg 2005.[4]

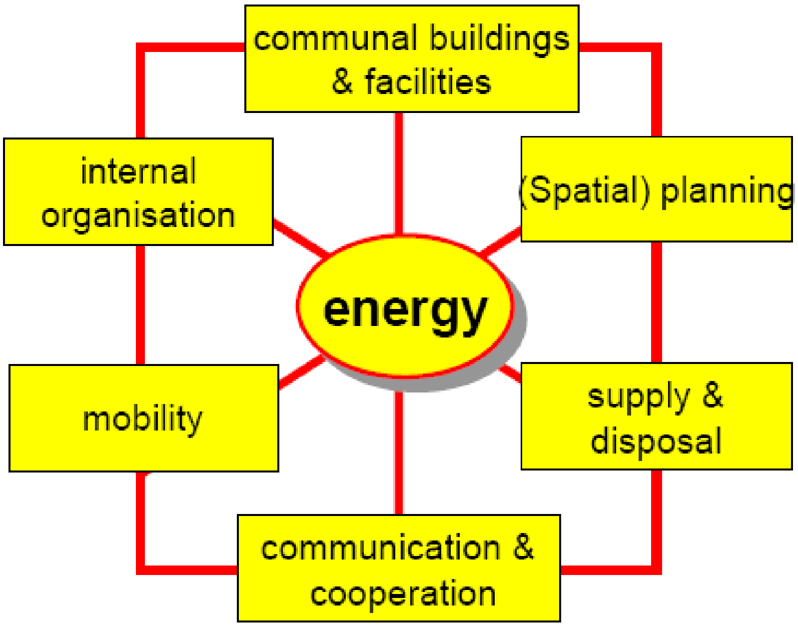

fig. 1-1: The structure of the e5-catalogue of measures (source:www.energieinstitut.at, 3.1.2008)

1.2.2 Energy Self Sufficiency in Austria – the Community of Güssing

In 1990, experts developed a model, which provided for a complete abandonment of fossil energy. The objective was to supply, in a first step, the town of Güssing and subsequently the whole district with regionally available renewable energy sources thus providing the region with new forms of added value. The model comprises the aspects heat generation, fuels, and electric power. First steps toward implementation consisted in targeted energy saving measures in Güssing. As a result of the energetic optimization of all buildings in the town center, expenditure on energy was reduced by almost 50 %. Then, the realization of numerous demonstrations energy plants in the town and the region helped to promote the implementation of the model step by step. Examples include the successful installation of a bio-diesel plant using rape oil, the realization of two small-scale biomass district heating systems for

[4] Energieinstitut Vorarlberg 2005. Audit – Bericht zur e5 und eea®-Zertifizierung der Gemeinde Mäder November 2005, www.energieinstitut.at

some parts of Güssing, and, finally, a district heating system based on wood fuel supplying the town of Güssing (fig. 1-2). Energy self-sufficiency was finally realized in 2001 when the biomass CHP plant Güssing was installed; it relies on a newly developed biomass-steam gasification technology. At present, Güssing produces more energy (heat, fuels, and electric power) from renewable resources than is consumed in the town on an annual basis. This benefited the region an added value of Euro 13 million per year. In recent years, Güssing has been awarded honors as the "environmentally most friendly town" and "most innovative municipality" in Austria. [5] Work within the "Energy Systems of Tomorrow" subprogram aims to further disseminate this successful model. The objective consists in the further development of the strategies and technologies tried out in the town of Güssing and in applying them in the whole district. By 2010, this area should also have attained self-sufficient energy supply and, thus, numerous concomitant positive effects for the economy in the region.

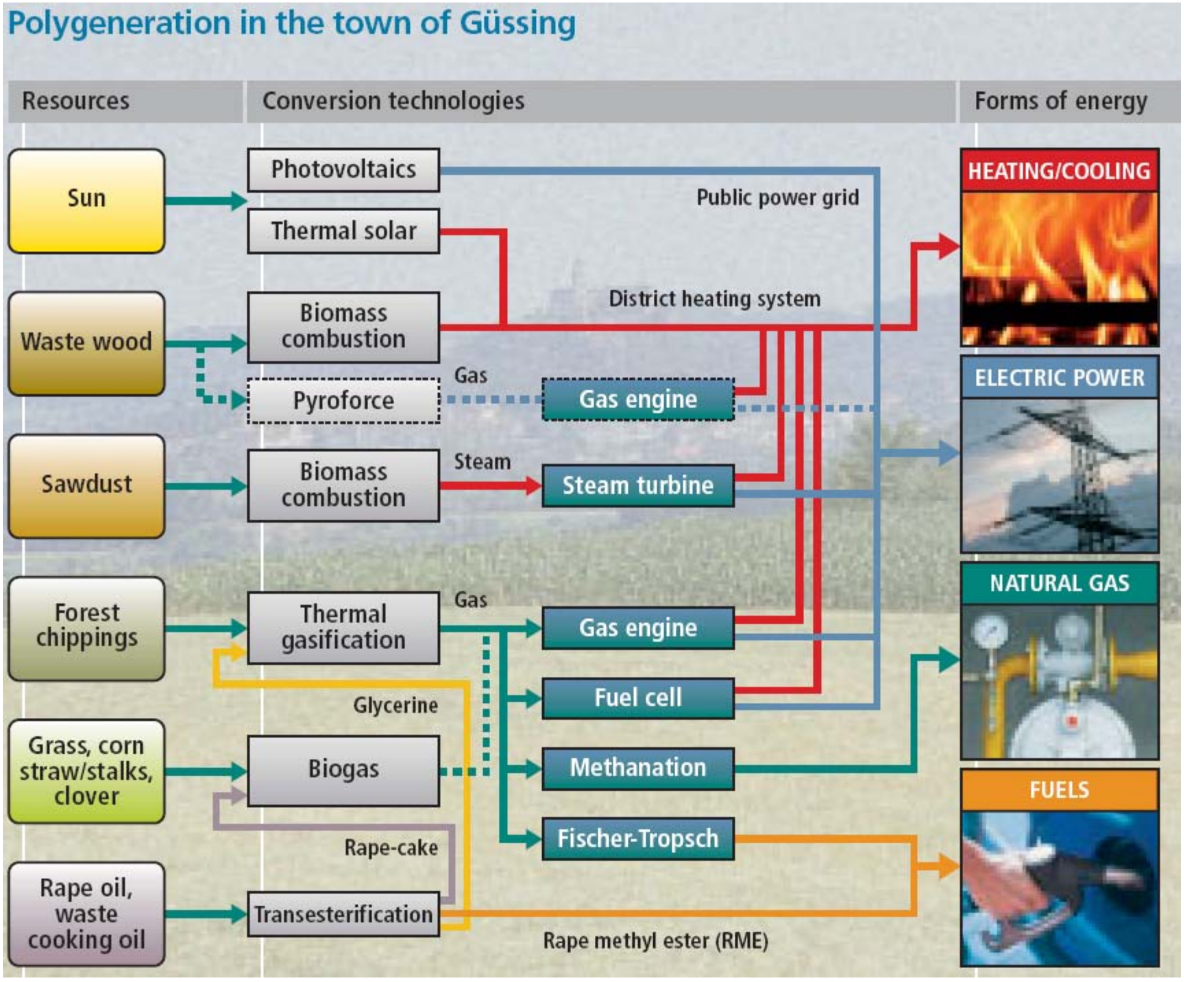

fig. 1-2: Implementation strategy for polygeneration from 2007 to 2013 in Güssing (source:www.eee-info.net, 3.1.2008)

[5] http://www.eee-info.net/Download/20070430_Forschungsforum_GuessingEEE.pdf, 3.1.2008

1.2.3 Energy Self Sufficiency in Europe – the Island of Samsø

The island is 100% self-sufficient with wind-generated electricity. About 70% of island heating needs are met with renewable energy, and the transportation energy consumption is 100% compensated by the electricity production from the offshore wind turbines, calculated as a virtual exchange of the energy content of this offshore electricity production, fed to the national grid, and the demand for transportation fuel. A number of people are working to establish a cooperatively run farm-based biogas plant to extract biogas from the major pig farms' slurry. This biogas will be used to produce electricity and the excess heat will be used for heating purposes. The remaining 30% of the island households will be approached in information campaigns to promote new neighbourhood heating systems and individual solutions like solar collectors, photovoltaic panel or household windmills . Heat pump systems are now attractive solutions because the island generates a surplus of electricity. The transport sector can in part be supplied with canola oil for diesel vehicles and the island's gasoline cars can use bioethanol or can be converted to hydrogen and electricity. The foundation work for the ten offshore wind turbines started in 2002 and the offshore wind park was the biggest project in the renewable energy implementation plan. These wind turbines were erected to compensate for the CO_2 emissions from the transport sector and to match the energy consumption in this sector.[6]

1.3 Objectives for an Energy Concept of Kötschach-Mauthen

To follow the goals of the contract with the promoters of "Plattform energie:autarkes Kötschach-Mauthen" from the 2nd of March 2006 with 2015 the community intends to replace oil heating all over Kötschach-Mauthen with renewable sources of energy. Further to this the community intends to serve as a model *for energy-self-sufficient* communities in the Alps by having constant long term research and development projects; by establishing eco energy tourisms and by developing 'adventures' in renewable energy.

The existing use of the available local renewable energy resources based on hydro power, biomass as well as wind and solar energy, should also be an example for other communities which intend to make use of their renewable resources. Kötschach-Mauthen declared themselves as climate-alliance community (program line "Klimabündnisgemeinde"). For that reason the community decided to intensify the development of renewable energy projects. The goal in the future is to use fossil energy for thermal

[6] http://www.energiakademiet.dk/front_uk.asp?id=55, 2008

heat in exceptional cases only. This strategy will contribute on the one hand to the reduction of greenhouse gases and on the other hand, to the authentic philosophy of unaffected air in context with the high quality tourism. The alternative and sustainable energy supply of Kötschach-Mauthen can access small hydro power, wind power, biomass as well as biogas and solar heat and power as renewable energy resources for further optimization.

1.4 Methodology

1.4.1 General Overview

In order to achieve the aims mentioned above, at the beginning of the project, basic data was collected. Based on that data an analysis of the current energy demand of the community Kötschach-Mauthen, taking into account the energy carriers used at present, was carried out and the current state of renewable energy carriers used in existing local heating systems were surveyed.

The results of these investigations, technical possibilities and scenarios for the energy supply of the community Kötschach-Mauthen were then considered and elaborated upon. Based on that, the saving potential of fossil energy was calculated. In order to ensure an efficient biomass and energy supply, alternatives for logistics in the community were considered. In terms of the planned implementation of the project, legal basic conditions, required management structures, and costs were also investigated as part of an implementation strategy.

The most important target groups regarding a later implementation of the *„Energy-self sufficient community Kötschach-Mauthen"* are the people living in Kötschach-Mauthen. In recognition of this fact collaboration with the community already took place in the course of the surveys, and people were constantly informed about the project's progress and invited to informative meetings under the name of "energie:autarke plattform Kötschach-Mauthen" chaired by the major Mr. Hartlieb or his secretary Mr. Themessel. With regard to the sustainable implementation of the concept other target groups were also involved in the preparation of the concept at an early stage. Intensive discussions took place not only with the community, therefore, but also with (potential) operators and constructors.

1.4.2 Literature and Information Search

In order to take previous actions in case of energy self sufficient communities in the Alps into consideration and to take care that this work is based on lessons learned already two major resources for literature were screened:

In a first step the national programs for renewable energy like "haus der zukunft", „energiesysteme der zukunft", „e2050", „klima:aktiv" were evaluated on their relevance to this work. Besides presentations on various workshops of information the homepages of the Ministries of Agriculture, of Labour and Economy and Innovation and Technology were the main source.

To a high extend the energy demand calculations were based on data of Statistic Austria. In addition recent data for traffic on district level are available from the Austrian Automobile Association ÖAMTC and some useful inputs were also found on the web of the Austrian e-control. Besides the magazine "energy" and the homepage from the Austrian Energy Agency was a useful source for state of the art in renewables. Especially for analysing the local renewable resource potential the geographical information system KAGIS of the regional government of Carinthia gives a lot very detailed information of forest coverage, land use activities and solar radiation.

In a second step the European Program Intelligent Energy Europe with more than 350 projects available on www.ec.europa.eu/energy/intelligent/projects/index_en.htm was screened for useful information. In addition the intelligent energy news review with a lot of project abstracts was a great help in literature search.

On the local level know written documents about energy demand were available. But due to the fact that the energy supply is to large extend locally owned and that nearly each energy supply owner is member of the platform "energie:autark Kötschach-Mauthen" is was possible to get the important information by interviewing local energy experts. Wilfried Klauss and his company Alpe Adria Energie Wasserkraft GmbH running the local electricity grid supported this study not only with anonym data of electricity consumption for 354 households and commercial consumer from the time period 1.1.2006 to 31.12.2006 but also with all electricity production data in 2007. Jakob Lederer, managing director of the local district heating system, enabled the anonym collection of heat consumption data for every single consumer in the district heating grid of Kötschach and in Mauthen. In addition a number of local experts and local micro grid heat providers, big commercial energy consumers and the Tourism Association were integrated in collection and interpretation of data.

The systematical borders for the collection of energy consumption data are excluding the following:

- Transit traffic and traffic caused by incoming commuters and tourists
- Energy demand of the transalpine oil-pipeline TAL for e.g. pumps
- Nutrition for the human population as the major source for energy

The calculation for technical and economical feasibility studies were carried out with the software

Retscreen[7] Version 3.2 Clear Energy Project Analysis Software provided by the Minister of Natural Resources of Canada.

1.4.3 Before Start

Before starting the energy concept several projects were done by the author as an energy network manager of the Carinthian development agency for the community of Kötschach-Mauthen and the Alpe Adria Energie GmbH (AAE) on the following topics:

- Founding of the platform energie:autark Kötschach-Mauthen and serving as vice secretary
- Biogas upgrading project in collaboration with the Austrian Bioenergy Centre[8]
- Biogas planning based on EN standards in collaboration with TÜV Thüringen[9]
- Biogas digestate as fertiliser in combination with bottom ash of the biomass combustion in collaboration with the University of Agricultural Science Vienna[10]
- Quality management for the district heating system in collaboration with QM-Heizwerke[11]
- Potentials for a thermal renovation of the town hall in collaboration with Arsenal research GmbH[12]
- Biomass action plan for Carinthia together with the chamber of agriculture[13]
- Biomass supply chain for Carinthia with the University of Agricultural Science Vienna[14]

To a high amount assumption in this work are based on these expertises, references are given on the concerned positions in the text.

1.4.4 Method of Approach

In order to proceed to obtain the core objective of this work whether a community in the Alps is able to fulfill all there energy requirement out of their own resources in the 21st century the following questions have to be asked:

- How high is the actual energy demand divided in the sections heat consumptions, electricity

[7] www.retscreen.net

[8] Roschitz 2006

[9] Aste et al. 2006

[10] Wenzel and Zivkovic 2006

[11] www.qm-heizwerke.at

[12] Gosztonyi 2007

[13] Kuneth 2007

[14] Aste et al.2006

consumption and fuel consumption separated in private and commercial use?

- How much energy can actually be supplied by local and district heat, electricity and fuel production based on renewable resources?
- How high is the actual degree of energy self sufficiency in Kötschach-Mauthen?
- How high is the degree of energy self sufficiency of the most experienced communities in central Europe in comparison to Kötschach-Mauthen?
- What are the lessons learned out of this comparison of energy balances and where are potentials for energy savings?
- Which renewable resource can be used to what extend for further development for replacing fossil fuel?
- What actions for energy savings and for renewable energy productions are necessary for obtaining energy self sufficiency?
- What outstanding projects have to be implemented in order to set up new standards?
- Are these projects technical and economical feasible?
- What sort of conclusions can be drawn for further implementation to fulfil energy self sufficiency in Kötschach-Mauthen?

Koch et al. 2006[15] show for the district of Güssing a model for the calculation of energy self sufficiency. As this model gives the recent state of the art this work is based on their model for the calculation of the energy demand. The primary energy extracted from nature is based in Kötschach-Mauthen on resources from wind, water, solar and biomass. The final energy is the energy delivered to the consumers for heat, electricity and transportation, whereas the useful energy is the energy converted by final appliances like light from bulbs or heat from the central heating system. In this work the calculations are done with final energy equivalents in order to compare the right units in the local energy flow.

[15] Koch R., Brunner C., Hacker J., Urschik A., Sabara D., Hotwanger M., Hofbauer H., Rauscher W., and E. Fercher 2006. Energieautarker Bezirk Güssing. Energiesysteme der Zukunft 82/2006. Ministry for Transport, Innovation and Technology, Vienna. 177p.

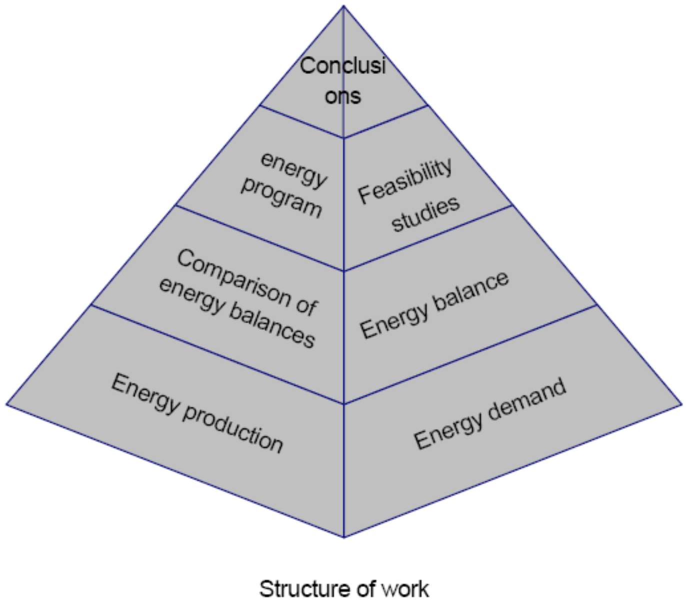

fig. 1-3: The structure of work for the method of approach

To demonstrate the possibilities for an independent energy supply of a community, we need to know its energy demand, as well as the distribution of this demand within the individual sectors. Since it was not possible to obtain specific data regarding the energy demand of all business enterprises and of the agriculture of the community, the energy demand had to be derived from key figures of existing statistical data, as well as from literature on energy statistics. Then the derived energy demand was allocated to the individual sectors and to the community. For the estimation of the energy demand predominantly data of Statistik Austria were used, especially the results of the census 2001 (census of population, buildings, places of work), of the analysis of useful energy 1998, the main data of energy balances, as well as the energy report 2003 of the Austrian Federal Government. In addition to the data of Statistik Austria, enquiries based on recommendations of the project experts and local energy suppliers were carried out in households and business enterprises. A major issue for independent energy supply is the availability of the area required for the supply of resources. Since soil is a restricted and non-'increasable' reproductive resource, the areas available for energy production have to be calculated by using land-use data, like the national forest inventory or data available by the regional GIS-system. Thus, the areas necessary for nutrition, settlement, traffic and other private, economic as well as public use have to be subtracted from the area of a community. Based on the balances of the area it was determined on the level of the community, whether and to what extent the coverage of the energy demand is possible. Using the calculation on the community level, on the one hand, focused on the distribution of demand, and on the other hand, site potential can be evaluated more effectively. By use of these data and results, future prospects of a sustainable energy-self-sufficiency of the community Kötschach-Mauthen can be made.

1.5 Community of Kötschach-Mauthen

Bordering Italy the community of Kötschach-Mauthen is located 705 metres above sea level, surrounded by limestone Alps of Carnica region with the highest Peak Hohe Warte (2780 m) as shown in figure 1-4. The community covers an area of 154.48 km² and has a population density of 23 inhabitants per km².[16]

The residential population in Kötschach-Mauthen were counted 2001 with 3613 inhabitants by Statistik Austria. The households in the community come up to a total number of 1364 with an average size of 2.6 persons. The population trend in the community is rather stable since 1951 and shows only a small reduction of 100 main domiciles in the period of from 1991 to 2001.

In 205 places of work 1650 employees find employment in the community, mainly in production of goods, construction works, trade, tourism and health service. In Kötschach-Mauthen 44 buildings are managed for tourism including hotels and bed&breakfast. 263 farms cultivate 14,416 ha land including 9,025 ha forests.

In total 1,259 buildings are in the community, in average since 1993 7.7 residential building are constructed per year. This results only in a slow renewing, 0.6% of all buildings per year of the rather old building structure, in average older than 80 years. 75% of the buildings are single or double family houses. The average size of homes is 4.7 rooms.

In the community of Kötschach-Mauthen there are 31 different villages, 8 of them have more than 50 inhabitants, as the villages of Kötschach, Mauthen, St.Jakob im Lesachtal, Strajach, Würmlach, Mannsdorf, Laas and Weidenburg. The village of Kötschach is on the sunny side of the valley, whereas the village of Mauthen is on the shady side.

[16] Source: www.statistk.at 2007

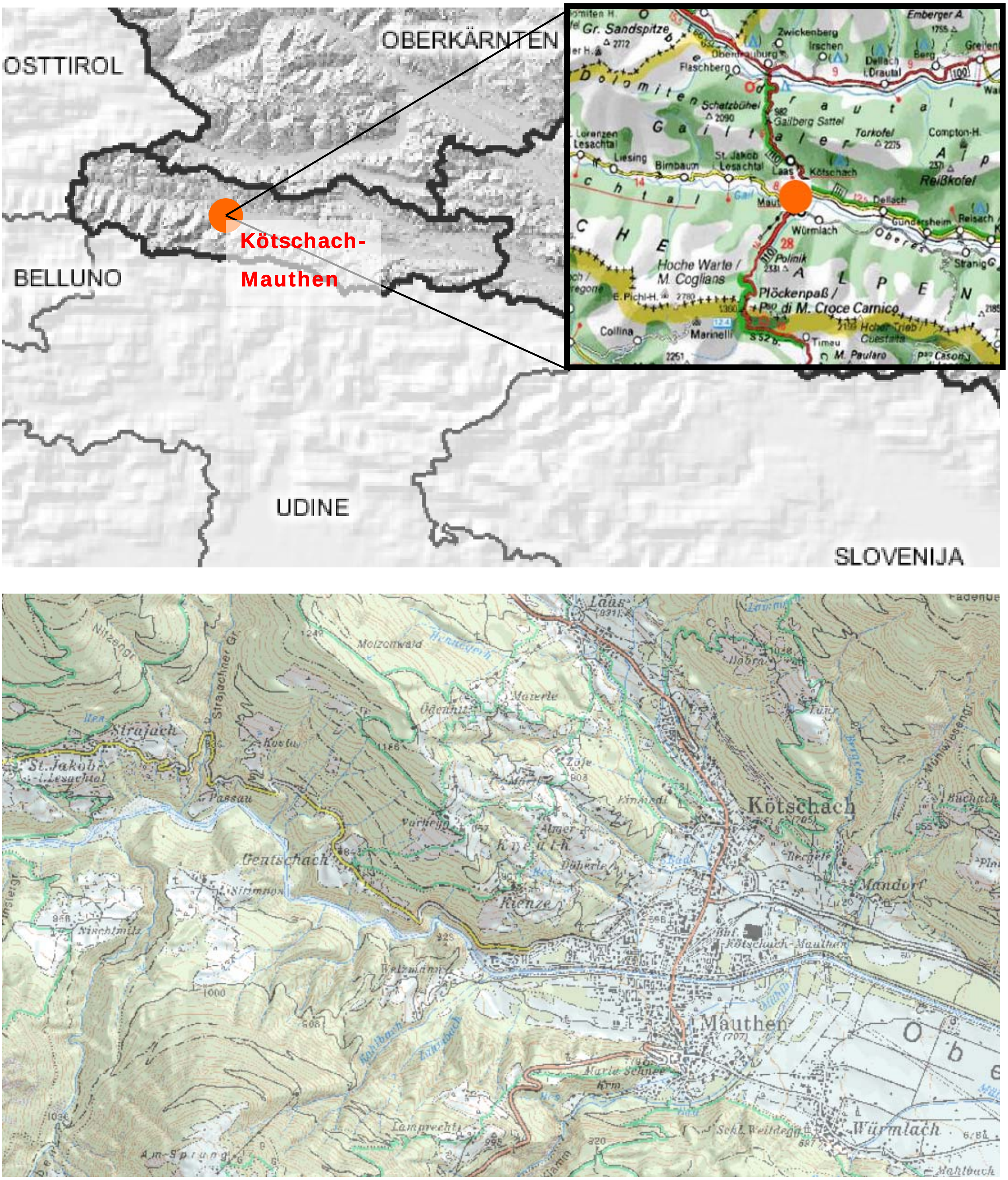

fig. 1-4: Location of the community of Kötschach-Mauthen (Source: http://gis.ktn.gv.at/atlas)

2 Energy Production and Demand in Kötschach-Mauthen

2.1 Energy Production in Kötschach-Mauthen

2.1.1 Small Hydro Power

In the community of Kötschach-Mauthen there are 21 small hydro power plants (fig. 2-1) producing together 40.5 GWh up to 43 GWh per year. The first SHP plant was built in 1886 being the 5th in the Austrian empire and 1st in Carinthia by Anton Klauss. Additionally to this early plant construction the local electricity grid of Kötschach was connected and is still in local ownership. In addition to the SHP plants 3 artificial lakes with a total capacity of 150.000 m³ are serving as mountain reservoirs and recreational areas. The gross head of these lakes to the turbine comes up to 520 m.[17]

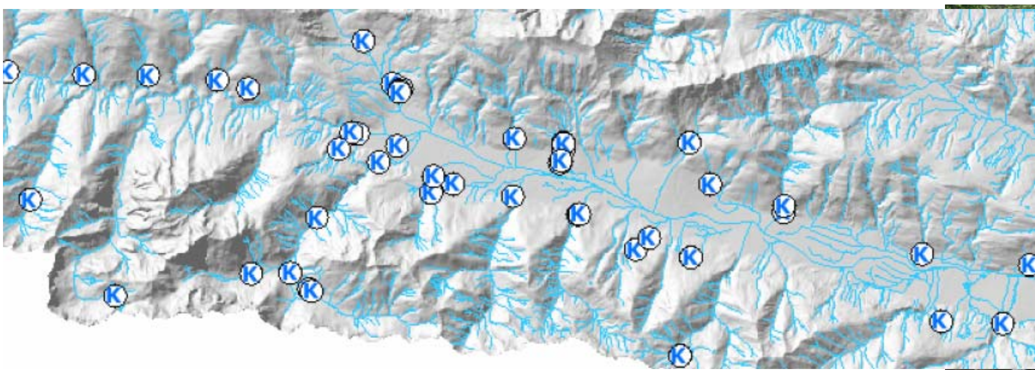

fig. 2-1: Existing small hydro power plants in Kötschach-Mauthen and the surrounding communities in Carinthia, Source:www.kagis.ktn.gv.at; 24.7.2007

2.1.2 Wind power

On Plöckenpass in addition to the hydro power plants together with 5600 kW one wind turbine (1360 m a.s.l) with 500 kW is annually producing 0,6 GWh. with 1000 hours a year in operation (Enercon E40 - 50m high and a diameter of 44 m) since 1997. Wind, biogas and hydro power are integrated within the private grid and have their own command control. Within this system wind power can be

[17] Klauss Wilfried, 2006. Die Wiege der Kleinwasserkraft, Magazine Kraftwerk 14 – Dez.2006 p. 8 -11, Austrian Association of Small Hydro Power

stored passively or actively in 3 artificial lakes by reducing hydro power or by pumping water back to the lakes (Valentinsee, Grünsee, Cellonsee).

2.1.3 Solar Heat and Power

On the solar site of the renewable energy there is the five year old solar power station for electro cars and a number of solar thermal collectors. It is worth mentioning that there are 2 plants, first the demonstration installation of the local camp site with 105 m² solar collectors and second the heat production of the regional hospital of Laas with 350 m² solar collectors producing 500 MWh thermal heat and saving 35.000 l of oil per year.

2.1.4 Biomass

2.1.4.1 Biogas

One biodiesel and 2 biogas engines with a total installed capacity of 1300 kW and with a total annual electricity production of 6 to 10 GWh, are running for the local power base load within the privately owned power grid of the village of Kötschach. 75% of the waste heat of the biogas engines is used within the district heating system of Kötschach. In summertime the biogas engine is covering the district heat production alone, whereas in wintertime the heat of the engine is used in addition to biomass combustion. The input for the biogas plant is 10,000 t/a of grass and maize (70 % whole plant, 30% corn) produced mainly in the Gailtal valley and additionally 1500 t/a of local manure. On a daily base the input is 15 t of maize silage, 8.5 t of corn, 3t of grass and 10 m³ manure. The fermentation process runs at a temperature of 38 to 41°C and with a duration time of 21 days.

2.1.4.2 Biodiesel

For the additional support of the district heating system of Kötschach a CHP plant based on Biodiesel is installed with 516 kW electrical power and 580 kW thermal power producing 4 GWh/a electricity and 4,5 GWh/a heat. The biodiesel, a fatty methyl ester, is produced in Arnoldstein in the valley of Gailtal based on regional renewable resources but not in the community of Kötschach-Mauthen.

2.1.4.3 Wood Chips

With regional biomass resources 2 district heating systems (MW level) and 2 local heating systems (kW level) are producing a total annual heat output of 7,750 MWh. For example in Kötschach a 1.5 MW biomass combustion based on a consumption of 10,000 m³/a of wood chips is generating, besides the biogas engine, the major load for the annual heat production in the district heating system of Kötschach with 4 GWh/a.

2.1.5 Summary of the Electricity Production

The total annual renewable energy production in the community of Kötschach-Mauthen is calculated with 51.1 GWh/a (fig. 2-2) reduced by losses of 1.8 GWh/a resulting in a final energy production of 49.3 GWh/a electricity. The main part is produced by power plants of the company of Alpe Adria Energie AG (AAE).

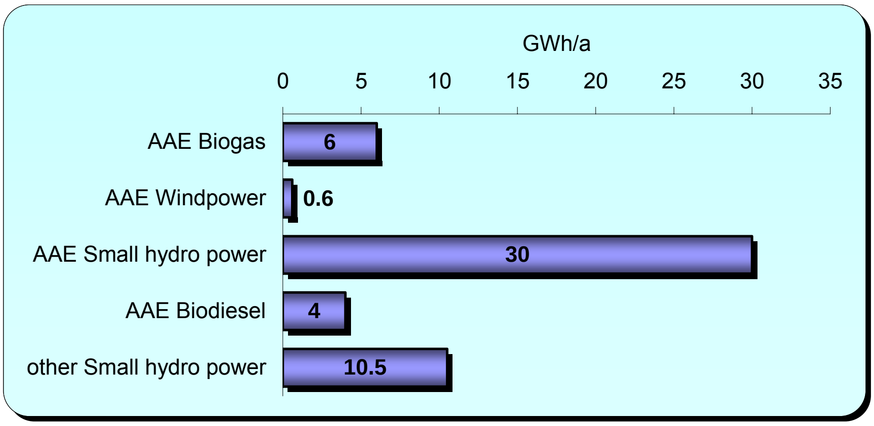

fig. 2-2: Annual energy production based on renewable resources in Kötschach-Mauthen (Source: AAE 12.7. 2007)

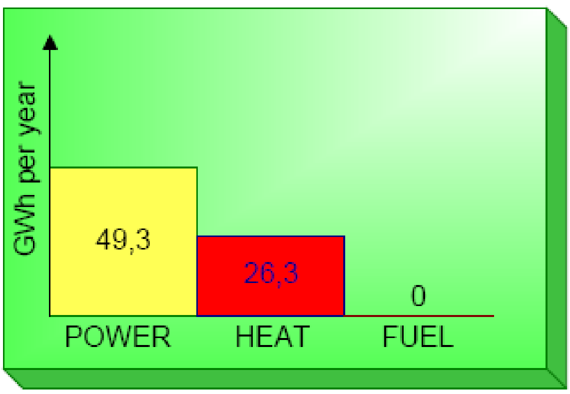

fig. 2-3: Annual final energy production based on renewable resources in Kötschach-Mauthen

2.2 Energy Demand in Kötschach-Mauthen

2.2.1 Electricity Consumption of an Average Consumer

In the privately owned electricity grid of the village of Kötschach with 431 customers the local demand comes up to an annual consumption of 5578 MWh. In 2006 an average household is consuming without any electric heating 3196 kWh/a but with electric heating 6361 kWh/a. Households have an average electricity consumption of 4558 kWh/a whereas enterprises come up to 13148 kWh/a (fig. 2-4). 55% of the households have neither electrical heating nor electrical hot water preparation (fig. 2-5). In total the electricity consumption of the households for the whole community Kötschach-Mauthen is in the 1364 households 6217 MWh/a.

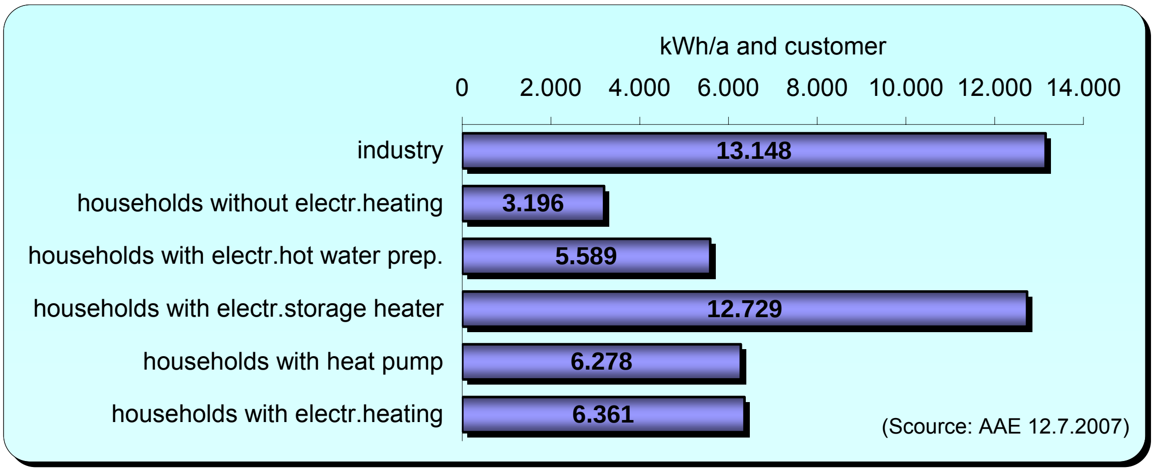

fig. 2-4: Average electricity consumption of households and enterprises in the electricity grid in Kötschach (Source: AAE)

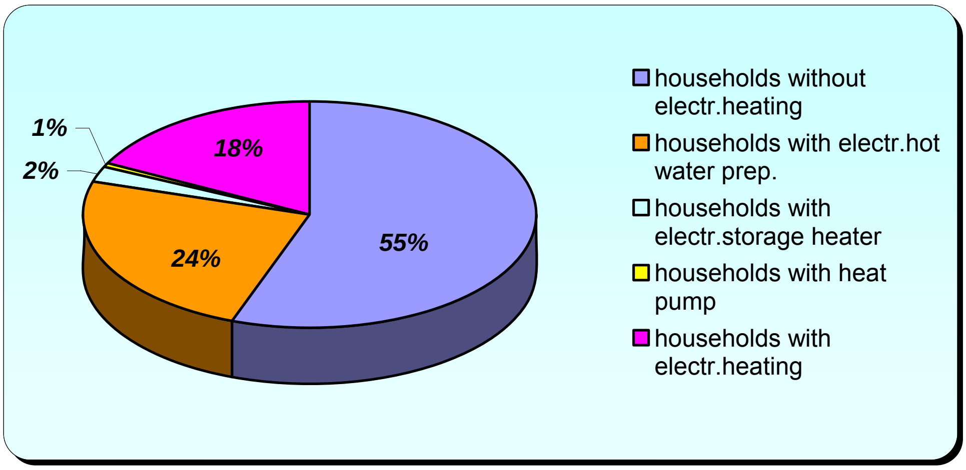

fig. 2-5: Distribution of electricity consumption in households of Kötschach (Source: AAE)

2.2.2 Private and Commercial Heat Consumption

The district heating system of the village of Mauthen has 31 private and 13 commercial whereas Kötschach has 73 private and 28 commercial customers. In the district heating grids of the villages of Kötschach and of Mauthen with in total 145 customers, the local demand comes up to an annual consumption of 6,2 GWh (fig. 2-7) or of 3000 m³ solid wood. Households have an average heat consumption of 14.825 kWh/a whereas commercial use reaches up to 113.724 kWh/a (fig. 2-6). The difference between the average private biomass heat consumption is based on the different solar radiation in winter between the two villages.

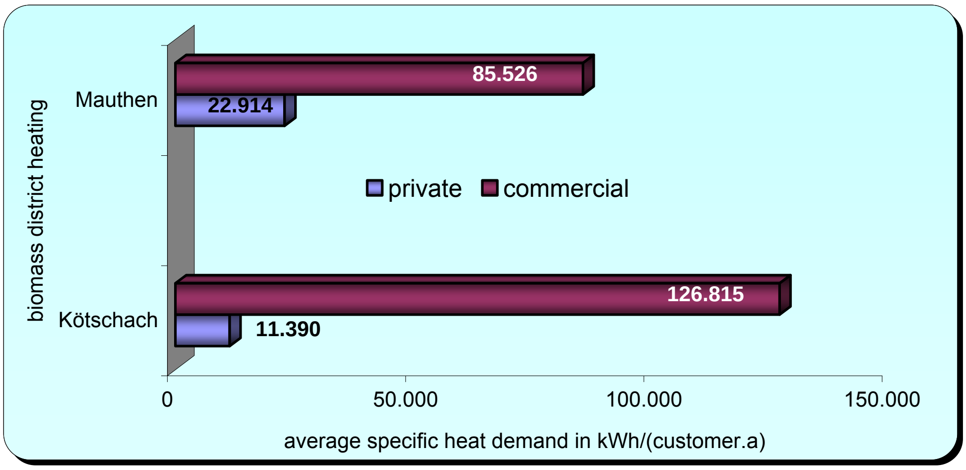

fig. 2-6: Average annual private and commercial heat consumption in the private owned district heating systems of Kötschach and Mauthen (Source: AAE and Lederer 2007)

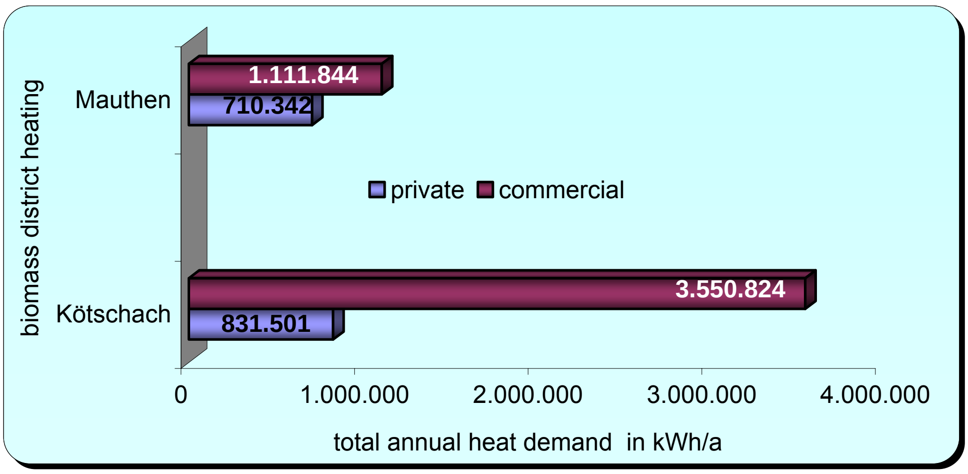

fig. 2-7: Total annual private and commercial heat consumption in the private owned district heating systems of Kötschach and Mauthen (Source: AAE and Lederer 2007)

In the community 44.5% of the 1259 buildings have a heating system based on renewable energy resources. Still 55.5% of the buildings are using fossil, mainly oil, or electricity for heating purpose (fig. 2-

8). In average 7.7 new houses are constructed per year according to Statistik Austria.

The average flat size is around 94 m² and the yearly average heat demand including hot water preparation is 157.7 kWh/m² per household.

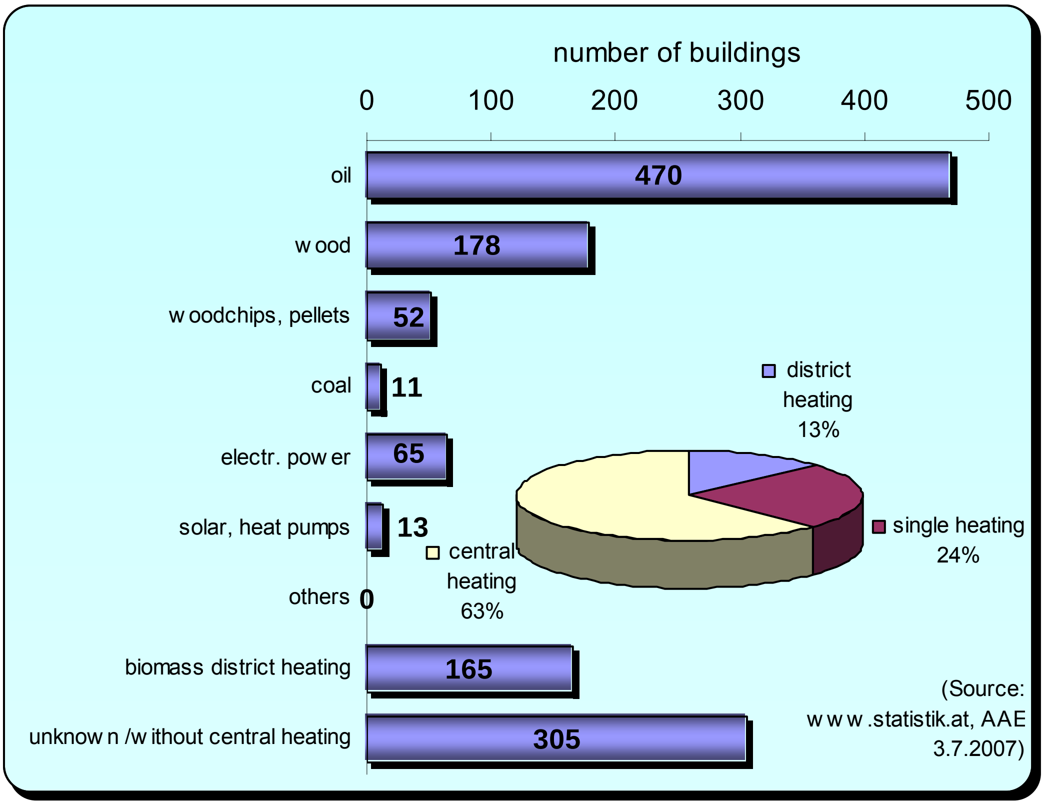

fig. 2-8: Distribution of energy carriers for heating systems of the buildings in the community of Kötschach-Mauthen (Source: www.statistk.at, modified by AAE 3.7. 2007)

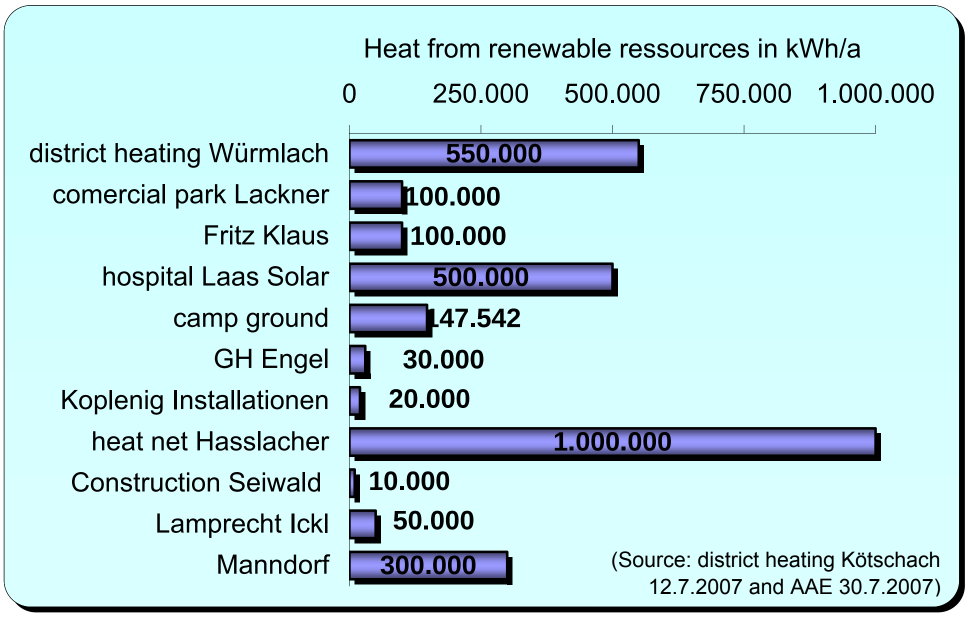

fig. 2-9: Small local heating systems based on renewable ressources in Kötschach-Mauthen (Source: AAE and Lederer 12.7. 2007)

In the villages of St.Jakob, Strajach, Laas and Weidenburg are more than 20 households within a compact settling structure and they are still without district heating systems. In spite of this a number of small renewable heating systems with in total 2.8 GWh/a are already installed within the community (fig. 2-9).

2.2.3 Private Transportation Fuel Consumption

Corresponding to analyses of Statistik Austria in 2004/05 83% of the households in rural areas have one car, additionally 26% of all rural households have 2 cars[18]. These cars have an average annual consumption of 15.070 km per car in the district of Hermagor[19]. That means we have statistically 1.487 cars in Kötschach-Mauthen with a total annual consumption of 22.405.473 km/a or 17.924 MWh/a. The average annual fuel consumption per household comes up to 13,1 MWh/a.

441 commuters for profession are living in the community, 299 of them are commuting daily. The whole commuter traffic is causing a consumption of 7,4 million km a year, resulting in a use of 5,9 GWh/a. The main 5 destinations for commuting are Hermagor, Villach, Klagenfurt, Spittal and Lienz (fig. 2-10).

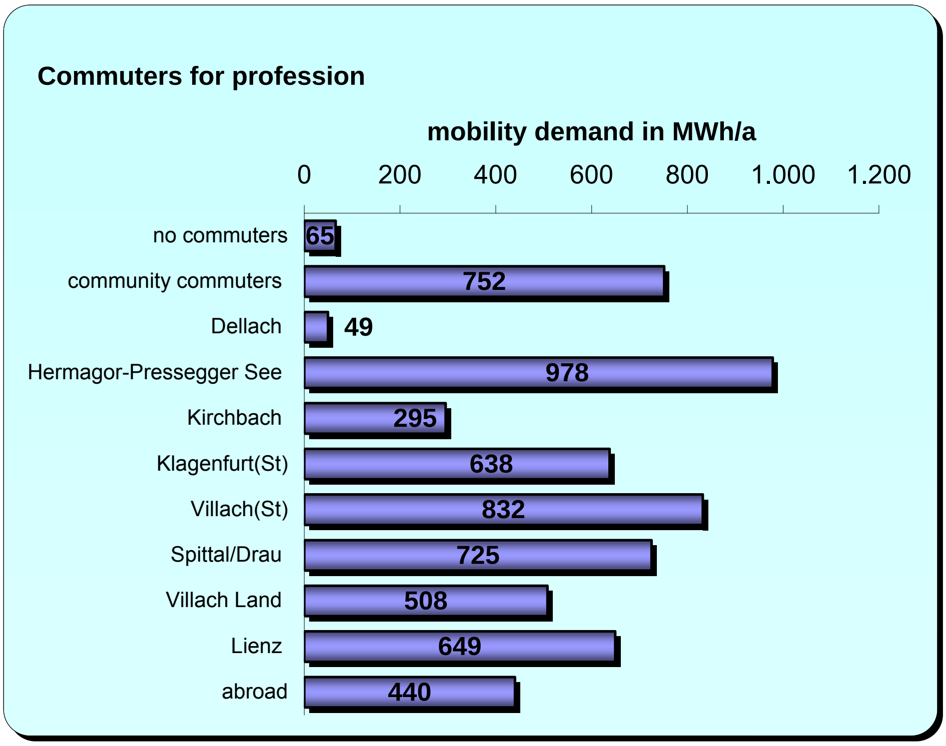

fig. 2-10: Mobility demand from commuters for profession of the community Kötschach-Mauthen (Source: www.statistik.at 2007)

[18] Source : http://www.statistik.at/web_de/presse/pressemitteilungen_vorjahr/3/009414?year=2006&month=3

[19] Source: www.oeamtc.at 25.7. 2007

2.2.4 Energy Consumption of Households

Summing up the results of the energy consumption of households in the community of Kötschach-Mauthen by analysing statistical and real data we can calculate the total and the average annual demand shown in fig. 2-11 and 2-12:

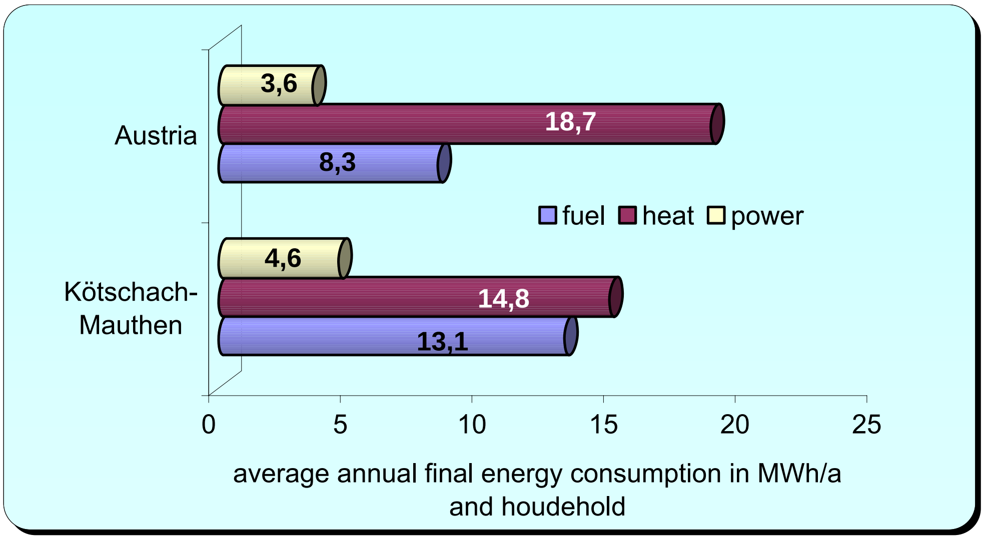

fig. 2-11: Average annual energy consumption of households in Kötschach-Mauthen in comparison to Austria (Source: www,statistik.at 2007)

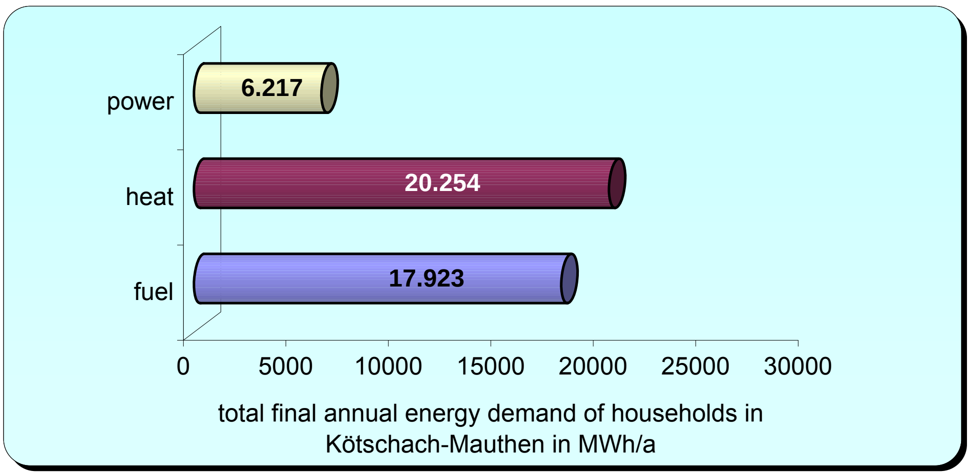

fig. 2-12: Total annual energy demand of households in Kötschach-Mauthen

2.2.5 Commercial Energy Consumption

In the community of Kötschach-Mauthen 1650 employees follow a profession in 205 places of work, additionally we have 88 people working in agriculture and forestry at 263 farms with an average size of

55,23 ha[20] (fig. 2-13).

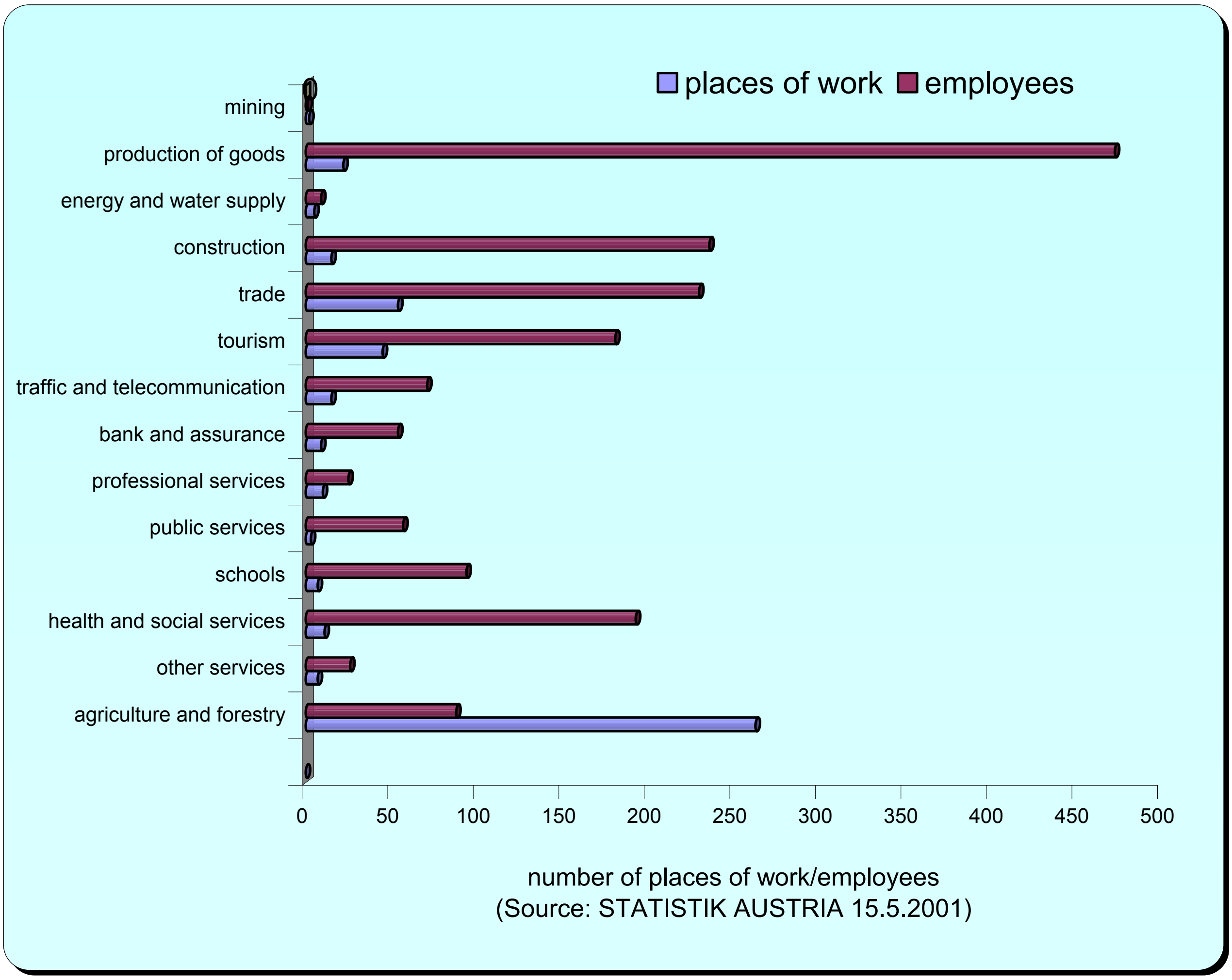

fig. 2-13: Number of places of work and employees within the economic branches in the community of Kötschach-Mauthen (Source: www,statistik.at 2007, analysis from 15.5.2001)

Corresponding to Statistik Austria the average energy input per employee subtly differentiated between branches of industry in Austria describes as follow:

[20] Source: www.statistik.at 25.7.2007

Table 2-1: Average annual final energy demand per employee in Austria (Source: www,statistik.at 2007):

	MWh per employee and year			
branch	**fuel**	**heat**	**power**	**total**
agriculture and forestry	32,92	11,82	7,01	**51,75**
mining	142,92	139,29	86,51	**368,72**
production of goods	21,37	44,62	24,80	**90,79**
energy and water supply	51,90	17,90	42,93	**112,73**
construction	12,71	3,06	1,54	**17,31**
trade	3,81	2,12	3,51	**9,44**
tourism	0,74	7,25	8,23	**16,22**
traffic and telecommunication	34,75	7,25	18,07	**60,07**
bank and assurance	1,21	1,79	3,25	**6,25**
professional services	1,00	0,79	1,02	**2,81**
public services	8,00	25,92	19,42	**53,34**
schools	8,64	313,07	138,86	**460,57**
health and social services	0,23	12,29	11,24	**23,76**
other services	8,00	25,92	19,42	**53,34**
average	**23,44**	**43,79**	**27,56**	**94,79**

By multiplying the number of employees (fig. 2-13) with the average energy demand per employee (table 2-1) we can calculate the statistical annual final energy consumption of the branches of industry in Kötschach-Mauthen Table 2-2).

Table 2-2: Total annual final energy demand per economic branch in Kötschach-Mauthen (Source: www,statistik.at 2007)

	MWh per year			
branch	**fuel**	**heat**	**power**	**total**
agriculture and forestry	2.897	1.040	617	**4.554**
mining	143	139	87	**369**
production of goods	10.108	21.105	11.730	**42.944**
energy and water supply	467	161	386	**1.015**
construction	3.000	722	363	**4.085**
trade	876	488	807	**2.171**
tourism	134	1.312	1.490	**2.936**
traffic and telecommunication	2.467	515	1.283	**4.265**
bank and assurance	65	97	176	**338**
professional services	25	20	26	**70**
public services	456	1.477	1.107	**3.040**
schools	812	29.429	13.053	**43.294**
health and social services	44	2.372	2.169	**4.586**
other services	208	674	505	**1.387**
total	**21.703**	**59.551**	**33.799**	**115.052**

In practice this result is heavily influenced by two big energy consumers (schools and the company ECO). That is why in this analysis, based on the data of the local power and heating grid owners, we take the average of the local real data and add to the energy demand of the mentioned big consumers, the average energy consumption multiplied by the number of places of work.

In Kötschach-Mauthen enterprises including schools have an average electricity consumption of 13.148

kWh/a and an average heat consumption of 113.724 kWh/a. In addition the company ECO has an annual energy demand for electricity of 2.8 GWh/a and for heat of 3.3 GWh/a.

In total we can calculate, therefore, an annual energy demand of all enterprises in Kötschach-Mauthen of 21.7 GWh/a for transportation fuel, of 27.7 GWh/a for heat and 8.2 GWh/a for electricity (fig. 2-14).

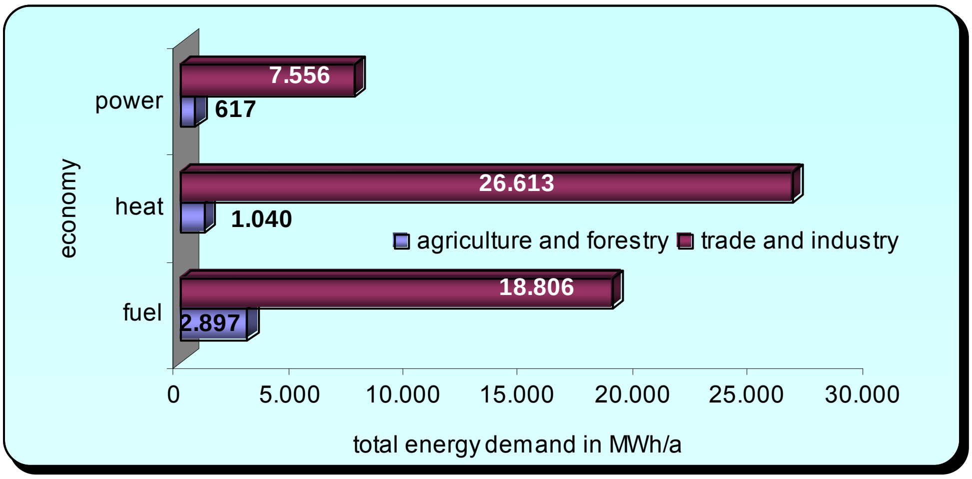

fig. 2-14: Total annual final energy demand from agriculture and forestry, trade and industry in Kötschach-Mauthen

2.2.6 Total Energy Consumption

Summing up the results of the analysis of final energy consumption in the community of Kötschach-Mauthen, the electricity consumption is 14.4 GWh/a, the heat consumption 47.9 GWh/a and the transportation fuel consumption 39.6 GWh/a (fig. 2-15)

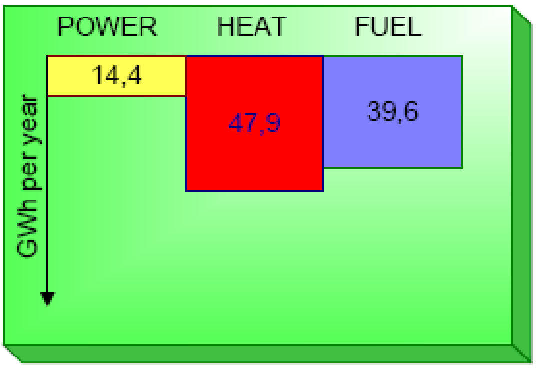

fig. 2-15: Total annual final energy demand in the community of Kötschach-Mauthen

2.3 Energy Balance in Kötschach-Mauthen

2.3.1 Actual Energy Balance 2007

The actual energy balance of the community of Kötschach-Mauthen is shown in table 2-3:

Table 2-3 Actual energy balance in Kötschach-Mauthen 2007

demand of final energy MWh/a	*fuel*	*heat*	*power*	*total*
private	17.923	20.254	6.217	44.394
commercial	21.703	27.654	8.173	57.530
total	39.626	47.907	14.390	101.923

production of endenergy MWh	*fuel*	*heat*	*power*	*total*
renewable	0	26.328	49.312	75.639
non renewable	0	21.579	0	21.579
total MWh	0	47.907	49.312	97.219

balance of endenergy MWh	*fuel*	*heat*	*power*	*total*
surplus of renewables			34.921	34.921
needs for renewables	39.626	21.579		61.205

As a result we can see that the energy demand of Kötschach-Mauthen with 102 GWh/a is in contrast to the local renewable energy production of 76 GWh/a. Therefore from the existing plants in the community, 343 % of the electricity demand, 55 % of the heat demand and 0 % of the fuel demand are already met by renewable energy carriers. The power production in the community is the strongest sector of renewable energy with export of electricity to 5000 electricity costumers in Austria[21], whereas the transport fuel production sector is today not existing and needs a long term perspective based on mobility by means of biogas and/or electricity. Due the technical developments of the past years the highest realistic potential to fulfil energy self sufficiency in the near future is within the heat sector. The total gradient of energy self sufficiency of the community can be calculated with 74.2%.

2.3.2 Comparison of Energy Balances of other Energy Self Sufficient Communities

The comparison of energy balances of other energy self sufficient communities provides us with a way to evaluate the results of the actual energy balance in Kötschach-Mauthen. The Austrian communities of Mäder in Vorarlberg and Güssing in Burgenland are from a size and structural perspective,

[21] www.aae.at

comparable and have a similar goal of energy self sufficiency as Kötschach-Mauthen (table 2-4).

Table 2-4: Comparison of the structure of energy self sufficient communities Source: Horak et al.2007[22]:

Community	Unit	Güssing	Mäder	Kötschach-Mauthen
Households 2001	number	1.455	1.057	1.364
Inhabitants 2005	number	3.811	3.320	3.613
Employees 2001	number	2.603	1.022	1.738

The number of households, inhabitants and employees in the 3 communities are similar. Güssing is famous for the European centre for renewable energy whereas Mäder is the first Austrian community with 5 e in the European program e5.

Table 2-5: Comparison of the annual heat consumption of energy self sufficient communities in Austria (Source: Horak et al.2007)

Community	Unit	Güssing	Mäder	Kötschach-Mauthen
Total heat demand	MWh/a	67.955	44.841	47.907
Renewable heat production	MWh/a	65.237	11.210	26.328
Spec. heat demand	MWh/(inhab./a)	17,8	13,5	13,3
Heat self sufficiency	%	96	25	55

The leading position of Güssing in heat self sufficieny is due to the supply of heat for the new settled industry by the well constructed heat grid in the municipality (table 2-5).

Table 2-6: Comparison of the annual electricity consumption of energy self sufficient communities in Austria (Source: Horak et al.2007)

Community	Unit	Güssing	Mäder	Kötschach-Mauthen
Total electricity demand	MWh/a	33.639	18.635	14.390
Renewable electricity production	MWh/a	31.957	2.050	49.312
Spec. electricity demand	MWh/(inhab./a)	8,8	5,6	4,0

[22] Source : Horak D., M. Laaber, A.Müller, C. Neururer, S. Reinstadler, A. Schwarzbauer, J. Stadelmann and L. Strahlhofer 2007, Energieautarke Gemeinden – Bewertung des Erreichens dreier österreichischen Gemeinden, Sustainable Europe Research Institute No.13, April 2007 41 p.

Electricity self sufficiency	%	95	11	343

Kötschach-Mauthen has due to the small hydro power plants a position for electricity export to the regional grid (table 2-6). In Güssing 32 GWh/a are produced by biomass CHP plants.

Table 2-7: Comparison of the annual fuel consumption of energy self sufficient communities in Austria (Source: Horak et al.2007)

Community	Unit	Güssing	Mäder	Kötschach-Mauthen
Total fuel demand	MWh/a	40.732	17.280	39.626
Transportation fuel production	MWh/a	105.903	0	0
Spec. fuel demand	MWh/(inhab./a)	10,7	5,2	10,9
Fuel self sufficiency	%	260	0	0

Fuel self sufficiency in Güssing was achieved through a biodiesel plant with an annual production of 105.000 MWh/a of fatty acid methyl ester. It is remarkable that the specific fuel consumption in Mäder was at least half of the other communities, as a result of their sophisticated local mobility concept (table 2-7).

The conclusion out of this comparison is that the specific heat consumption in Kötschach-Mauthen is comparable good, whereas the heat self sufficiency is average compared to the communities of Güssing and Mäder. Kötschach-Mauthen has actually no transportation fuel production possibilities and has an average specific fuel consumption but is in a position for electricity export. The highest potential to fulfil energy self sufficiency in the near future is in the heat sector. In the mobility sector Kötschach-Mauthen, in comparison to the community of Mäder, has to reduce the specific consumption at least by half of the actual amount and has to shift fuel demand to electrical driven solutions due to the surplus of electrical power. In order to fulfil all demands the power production should be further developed.

3 Energy Program 2020

3.1 General Assumptions

In the following section the energy program will concentrate on the technical and economical feasibility for the implementation of renewable energy projects based on available resources in the community of Kötschach-Mauthen. The targets of the energy concept of Kötschach-Mauthen should be reached until 2020 with following technologies:

- Increase energy efficiency for decreasing of overall energy demand
  - a) Increase energy conversion efficiency
  - b) By energy saving action e.g. insulation
- Shift of heat production from fossil to renewable energies
- Production of power by use of solar, wind and hydro resources
- Reduction of fuel consumption by defining action to reduce mobility consumption

The implementation of this program (production and supply and use of electricity, room and process heating, cooling and transportation fuels) will be supported and promoted by the involvement of the inhabitants, the regional energy companies, the community administration, the stakeholder in the tourism sector and the local companies as well as the members of the „Plattform energie:autark Kötschach-Mauthen". 3 lighthouse projects for the implantation of the Energy Program 2020 of Kötschach-Mauthen are described in detail in chapter 4.

3.2 Energy Efficiency

3.2.1 Energy Efficiency Actions

Based on actions for energy efficiency defined by the Federal Ministry of Trade, Industry and Labour 2007 the local Energy Program 2020 starts with definition for energy efficiency actions separated to heat, electricity and fuel consumption (table 3-1). The purpose of energy efficiency measures is to reduce the final energy consumption of an energy service. It is also intended, however, that energy efficiency measures do not reduce the level of provision rendered by the energy service. In order to implement energy efficiency measures, various instruments can be used which influence technical or organisational factors and usage behaviour in the conversion or in the usage of useful energy.

Table 3-1: Definition for energy efficiency actions for the Energy Program of Kötschach-Mauthen until 2020

Heat - Consumption	Power - Consumption	Mobility - Consumption
Promoting of more densified residential construction, and "solar-oriented building" in building law	promoting of energy-efficient household appliances (A+/A++)	Campaign to raise awareness of climate-friendly mobility;
Section of ecological building materials	For internal lighting, use of energyefficient lamps with "A" and "B" energy efficiency classifications	renewing of car park of the community with gasdriven engines
Improvement of the thermal insulation standard in accordance with the state of the art	Use of energy-efficient technologies in the installation of new exterior lighting systems	use of railway esp. for transport of goods
Active climate protection ("klima:aktiv") standard for 50% of new buildings	Combining of support for decorative lighting (Christmas lighting) with energy efficiency criteria	Adaptation of path and road planning, development of infrastructure, and links to public transport (facility to take cycles onto public transport)
Ongoing optimisation of residential building subsidy for energy-saving and environmentally friendly heating installations	monitoring of energy consumption in the public sector	Creation of local cycle path concepts, and extension of local cycle path networks
Implementation of a thermal insulation offensive for local communities	promotion of local best practise for energy efficiency	bicyle path grid for local mobility including railway station
criterias for a minimum energy efficiency of heating systems	Introduction of a local energy-efficiency award	Formation of driving cooperatives (car pooling for commuters)
Further development of the district heating network in districts with a high heat density	education actions for energy efficiency and energy consultance events	express bus connections for commuters
Replacement of old standalone solid-fuel heaters and old oil and gas heating systems with modern, energy-efficienct renewable driven heating systems	Establishing of an energy savings / energy efficiency focus in schools and kindergartens, and in other childrens' and youth eduction forums	Mobility management center for schools, tourism, commuters, in enterprises
Mandatory replacement of old boilers (> 30 years) in accordance with building regulations / Ordinance on Firing Installations	Near-instant measurement of electric power consumption with data interpretation and savings recommendations for the end user	Integration of shopping and leisure centres into residential areas to facilitate access by public transport, and by pedestrians and cyclists
Period inspections by qualified, independent experts in respect of the efficiency of the heating system as a whole	Promotion of innovative billing systems	Revision of spatial planning to take account of energy-related criteria
Promoted use of solar thermal systems in multi-storey residential buildings, public and private services sector	Promotion of online energy recording systems and energy accounting for users	Procurement of fuel-efficient vehicles for public services
Promotion for utilisation of industrial waste heat	energy monitoring in tourism	Procurement of natural-gas vehicles for public services
For providers of heating, free access to existing district heating networks	Support for establishment of an internet platform for purchasing of energy-efficient appliances	Establishment of a biogas-gas filling stations
energy-related optimisation of wastewater treatment plant	Information measures such as competition: "environmentally friendly, energy-saving office"	Information activities relating to fuel economy, in conjunction with providers (e.g. driving schools)
subsidies for RES heating systems	Appointment of personnel with responsibility for energy use in offices	Information and use of alternative, energy-efficient vehicles
energy contracting modell for not grid connected buildings	Energy advice for tourism enterprises and office buildings	Solar Powered Go Mobil initiative
Identification and utilisation of existing waste heat potentials	Creation and expansion of a local energy consultation service	Further electrification of the non-electrified rail network
pilot project for the use of waste heat of wastewater through heat pumps	Information, consultation and training of local authority employees	new modern smart solar powered railway project for attracting eco-tourism

3.2.2 Potential for Energy Efficiency Actions

According to the Federal Ministry of Trade, Industry and Labour 2007 the overall national indicative energy savings target shall reduce of 9 % of the annual average amount of consumption be measured after nine years. In average the demand on energy in a household follows this distribution[23]:

- Thermal energy: Heating= 86%, Hot water preparation=14%
- Electrical energy: Lightning= 30%, Household appliances= 70%

The energy saving with thermal renewing e.g. with insulation or window changing for houses older than 1980 without previous renewing measures should be 25% of the heat demand of 14,8 MWh/a. Until 2020 only 92 new houses will be built in order to raise the recent building standards. There have been 615 households already renewing parts until 2007. From the remaining 749 households 549 have been constructed before 1980 and have a potential for energy saving of 2.030 MWh per year until 2020 (table 3-2). The energy demand for hot water preparation of annually 0.92 MWh per person should be covered to a high extend by thermal solar collectors. Koch et al 2006 described the energy demand of standby function with annually 385 kWh per household, which could be saved only by change of behaviour. In addition the lightning with energy efficient lamps can reduce the energy demand of lightning by 80% compared to normally used lamps. The total potential for energy saving is 1.1 MWh per year and household.[24] Referring to chapter 2.2.3 the whole traffic for commuters causes 5.9 GWh of fuel energy per year nearly to 100% for fossil fuel. In changing this behaviour in favour for public transport e.g. express shuttles from and to Kötschach-Mauthen will have the biggest potential for energy saving. In addition as shown in chapter 2.3.2 a mobility concept can reduce the overall energy consumption for mobility at least by half.

Table 3-2: The potential for energy saving in 1364 households in Kötschach-Mauthen until 2020

Energy saving actions [MWh per year] until 2020	**Heat**	**Power**	**Mobility**
Thermal renewing of buildings	- 2.030		
Stand by function for appliances		- 525	
Lightning with energy efficient lamps		- 1.506	
Public transport of commuters			- 5.900
Change of mobility behaviour			- 3.100
TOTAL	**- 2.030**	**- 2.030**	**- 9.000**

[23] Koch et al., 2006

[24] http://www.klimaaktiv.at/article/archive/18262/

3.3 Potential for Renewable Energy Production

The resources that are already used (maize, manure, biological waste, garbage etc. for the biogas plant, wood chips for biomass district heating and individual heating plants) are coming out of the region Kötschach-Mauthen. For the model „Multifunktionales Energiezentrum Kötschach-Mauthen" renewable resources will be available in addition.

Using these renewable resources the model „Multifunktionales Energiezentrum Kötschach-Mauthen" will provide efficient and sustainable energy services: room heating (after insulating public buildings like the town hall), process heating for companies, energy for cooling buildings and freezing of products (at meat markets or super markets), transportation service (upgraded biogas as fuel) and electricity (for motors and household equipment).

An analysis of the potential for renewable energy production was carried out and the renewable resources of the region were surveyed. Those surveys and investigations were carried out on the level of the community of Kötschach-Mauthen. Based on that, technical possibilities and scenarios for the energy supply of the community of Kötschach-Mauthen were developed.

3.3.1 Potential of Small Hydro Power

3.3.1.1 Definition and characteristics

There are no sharply defined criteria, for how to define SHP. Mostly it is defined with the parameter capacity. It differs from state to state but both, in Austria and in the EU the capacity is limited with 10 MW[25]. Further on SHP can be specified with the characteristics of decentralised production as follows:

- normally locally owned and sometimes local/regional consumption
- plants with lower environmental impacts as Large hydro power (LHP)
- Well accepted in the public for existing plants.
- Local/Regional identification with electrical power production and consumption.
- Creation of awareness for energy questions.
- Limited consumption of land and low impact on natural scenery

[25] BGBL Nr. I Nr. 149/2002, §5, lit16

- In some cases positive contributions to environmental conditions in the surrounding areas.
- Multiple-shift usage with potable water supply or waste water disposal (in mountainous regions), power production in combination with flood control projects

3.3.1.2 Electricity production from SHP in Austria

In 2005 66.359 GWh from hydro and thermal power were produced in Austria. In 2006 round 2.200 SHP plants were operating in Austria. They produced around 4.300 GWh electricity[26]with an installed capacity of 1.100 MW. Compared with the Austrian electricity production from hydro power (SHP and LHP without pump storage) SHP has a rate 9%. Compared with the whole electricity production in Austria the SHP has a share of 6%.

3.3.1.3 Potential of SHP

Potential for SHP in Austria

Based on an estimated share of 40% of probability that realisable potential indeed will be erected (cp. Pelikan in Haas et al (2001), Haas et al[27] estimated a whole realisable potential for SHP is 2.120 MW or 10.500 GWh per year[28]. These authors calculated with 5.000 full load hours. Having a look to the statistics 2002 to 2005 there is an installed capacity of 1.000 MW (as an average of 2002-2005) and a yearly production of about 4.000 GWh. This means that achieved full load hours are at 4.000 h. Considering the existing power capacity we can calculate an additional realisable potential for SHP of 1.100 MW or an electricity production of 4.500 GWh/year (realistic point of view) to 5.500 GWh/year (optimistic point of view) in Austria (cp. Haas et al (2001). Haas et al (2001) and Pelikan (ibid.) came to the result that 75% of the additional realisable potential can be figured out as capable production. A mighty influence to the potential of SHP came in with the European water framework direction, which was enforced in Austria by an amendment of the "Wasserrechtsgesetz" in 2003. Essentially it says that until 2015 all water regimes have to be in "good quality". One of the targets is an improvement of aquatic biosphere and a sustainable protection of surface water runoffs. It is focused on a better residual flow donation (especially at minimum stream flow) and on the erection of fish by pass systems. Stigler et al[29] announced a loss of production of 10 to 32% (in monetary value about 16-49 Mill €) by ensuring a residual flow at diversion plants. Another estimation from VEÖ (Verband der Elektrizitätswerke

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[26] Source: www.e-control.at

[27] Haas et al (2001): S. 70

[28] Calculated with 5.000 full load hours

[29] Stigler, H., Huber, C. Wulz, C., Todem, C. (2005)

Österreichs) gives a loss of production of 15% for whole hydro power sector due to adjustments to the European water framework direction[30].

Concerning a continuous stream flow Stigler estimates costs for construction of fish by-pass systems of 90 Billion €. These mandatory expenses increase the production costs and reduce the economical profitability of SHP. Therefore it is appropriate to rate the capable potential with 70% (or even less) of realisable potential: The additional capable potential is about 750 MW and 3.100 GWh. For a comparison: this amounts to about 5 % of electricity demand in Austria or is the increasing demand for three years.

Refurbishing (upgrading) and Revitalisation

There is a potential for refurbishing and modernising of existing plants of round 800 GWh/year[31]. In former times SHP plants were often used for private supply. Changing the focus to an optimum production with upgrading (better efficiency in the turbine and generator section, improvements of head and tail water section and, in general, improving structure of the plant) an increased output on the existing site can be reached. A revitalisation could be interesting because of an existing infrastructure like weirs, canals, penstocks and other buildings. Pelikan[32] estimates 1.000 sites in Austria have the potential for revitalisation.

Costs of producing electric power

SHP has to be engineered very accurately (location finding and optimising, technical layout, getting several permissions…) with the same precision as larger hydro power plants (LHP). Due to the smaller capacity output, a SHP Plant has higher specific initial costs per kWh than larger plants. Further the specific costs for environmental work (e.g. fish by-passes) are much higher than for LHP. Complex environmental protection restrictions and requirements, long permission proceeding add to the challenges of this system. Ensuring a residual flow in line with European water framework conditions leads to an over proportional loss of discharge and decreases economic profitability. Uncertain prognosis of consequences of European water directive and permission proceedings, lead in addition to resistance of the public to new plants in untouched river/surface water systems, and to a stop in investments in SHP.

The most cost intensive parameter is the construction of buildings (storage pools, water catchment

[30] Kraftwerk, Magazine of Assoziation „Kleinwasserkraft Österreich“ Edition 7 04/05, p. 4

[31] Haas et al (2001)

[32] Pelikan, B. (1997)

buildings, penstocks and/or canals, power house). These costs are about 50% of whole investing costs. In case of storage power plants even more (increasing up to 70%). Second cost parameter is the mechanical engineering: about 20 - 30% for turbine, control systems, valves and nozzles, speed increaser, emergency stops and so on. Third portion of cost is the electromechanical equipment: generator, transformer and grid connection. They are about 10-15%. Additional costs are for planning and design, permissions, taxes and fees, purchase of site, environmental protection (fish by pass system) and other. They are about 15 to 20%[33].

The spread of investment costs in SHP is very wide. Haas et al (2001) announced costs between 2.400 €/kW and 6.500 €/kW. Projected with the "Baukostenindex"[34] up to 2007 we can calculate with initial costs of 3.000 to 8.000 €/kW. The tightened water protection directives and the strong increasing prices of construction materials in the last few years lead probably to a higher count. Lechner[35] announces the costs for refurbishing and upgrading between 2.300 €/kW and 4.500 €/kW (projected up to 2007 by the author).E-control estimates costs for operating and maintenance at around 1% per year. This is a very low percentage, other authors indicates with 2, up to 2,5% per year.

Haas et al[36] calculated with a data basis from "Verband der Kleinwasserkraftwerke" total costs for power production. They analysed 56 constructions between 40 kW and 8,5 MW. For the time basis 2001 they found out, that the average production costs are 8,8 €cent/kWh[37] with the calculation parameters 4.638 full load hours, interest rate 7% and life cycle of 30 years. Madlehner (2001) in Pelikan[38], in contrast, calculated in a field survey of 55 sites for Federal ministry of Economy and Labour production costs of 7,15 €-cents/kWh.

SHP Potential in Kötschach-Mauthen

Due to the intense construction of SHP in the community of Kötschach-Mauthen there is nearly no realisable potential to further develop SHPs, besides some upgrading measures until 2020 with additional 3% of electricity production – at least 1,215 GWh annually. There is one major exception. Because of river straightening measurements of the river Gail in the centre of Kötschach-Mauthen there is the possibility to construct a SHP in an already heavily influenced site. The assumption for the power production according to Alpe Adria Energie GmbH is 0,8 GWh per year.

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[33] www.e-control.at

[34] www.linz.at/zahlen/090_Indexservice/040_BaukostenIndizes

[35] Lechner et al (2001) in Haas et al (2001), S. 101

[36] Haas et al (2001) , S. 100

[37] Haas et al (2001) S. 99/100

[38] http://www.kleinwasserkraft.at/mitteilungen.htm

3.3.2 Potential for Wind Energy

3.3.2.1 Local Wind Situation

The circulation pattern above the Gail and Lesach valley is characterised by valley and slope wind systems. During the daytime, air rises up the slope as it gets warmer than the air above the valley centre, and as a result air is drawn into the valley. At night the wind circulation is reversed, resulting in a downward flow of air on the slopes and out of the valley. According to investigations of the Federal Environmental Agency[39] from 1997 to 1998 by sodar measurements, wind velocity profiles observed above Gail Valley increased with altitude during daytime (at 50 m high: 4,5m/s and at 200 m: 6 m/s in the afternoon), whereas above the narrow Lesach valley such increase were observed only above 100 m (at 200 m high: 8 m/s in the afternoon). Calms (wind velocity < 0,5 m/s) were observed 1.7 times more frequently during winter than summer and much more frequently., 72% at the valley bottom in contrast to higher altitudes with 14%. The effect of the south or north facing wind system passing through a 130 m narrow gorge is to create air jets occurring in the narrow mouth of Lesach valley with 4 to 7 m/s at 100 m high and on Plöckenpass, with 6 m/s in 70 m high.
This wind system is caused by the meteorological divide of different temperatures between the Mediterranean influenced climate zone of the But valley and the alpine zone of the Gail valley.

3.3.2.2 Statistical Description of Wind Speeds:

If wind speed is measured throughout a year, it is to notice that in most areas strong gale force winds are rare, while moderate and fresh winds are quite common. This particular site has a mean wind speed of 7 metres per second, and the shape of the curve is determined by a so called shape parameter of 2. This distribution is known as a Rayleigh distribution. Figure 3-1 shows a probability density distribution. Half of the blue area is to the left of the vertical black line, showing wind speeds of less than 6.6 metres per second. The 6.6 m/s is called the median of the distribution. The mean wind speed is actually the average of the wind speed observations. In this graph the distribution of wind speeds is not symmetrical. Sometimes there are very high wind speeds, but they are very rare. Wind speeds of 5.5 metres per second, on the other hand, are the most common ones. 5.5 metres is called the modal value of the distribution.

[39] Spangl W., 2000, Immissions- und Windmessungen im Raum Kötschach-Mauthen, BE-158, Umweltbundesamt, Wien.

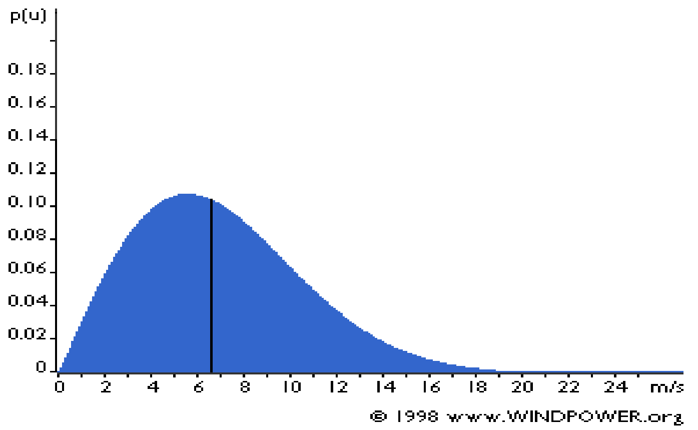


fig. 3-1: Wind speed distribution (Danish Wind Industry Association (www.windpower.org)

3.3.2.3 Mountain Winds

Mountain regions display many interesting weather patterns. One example is valley wind which originates on south-facing slopes, which may be the case for the Gail Valley. When slopes and neighbouring air are heated the density of the air decreases, and the air ascends towards the top following the surface of the slope. At night the wind direction is reversed, and turns into a downwards wind. If the valley floor is sloped, the air may then move down or up the valley, as a canyon wind (fig. 3-2).

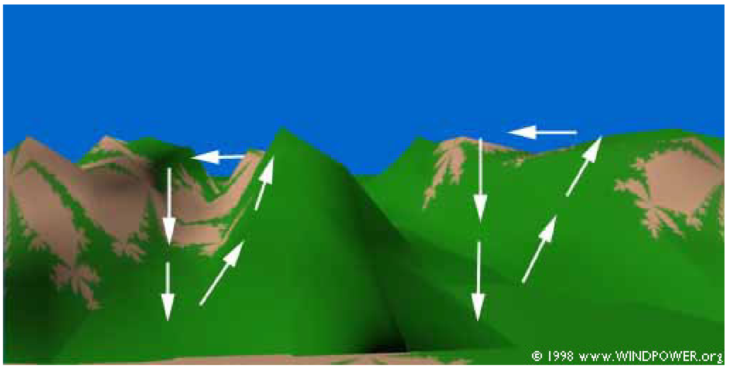


fig. 3-2: mountain wind dynamic / Danish Wind Industry Association (www.windpower.org)

3.3.2.4 Potential of Wind Energy in Kötchach-Mauthen

Due to the mountain wind situation there are only a few possibilities to produce electricity with wind turbines, one in the narrow mouth of Lesach valley with 4 to 7 m/s at 100 m high and one on Plöckenpass, with 6 m/s in 70 m high.

3.3.3 Solar Potential for Energy Production

The average global solar radiation in Kötschach-Mauthen ranges from 1.100 to 1.400 kWh/m^2 per year Fig.3-3 and 3-4).

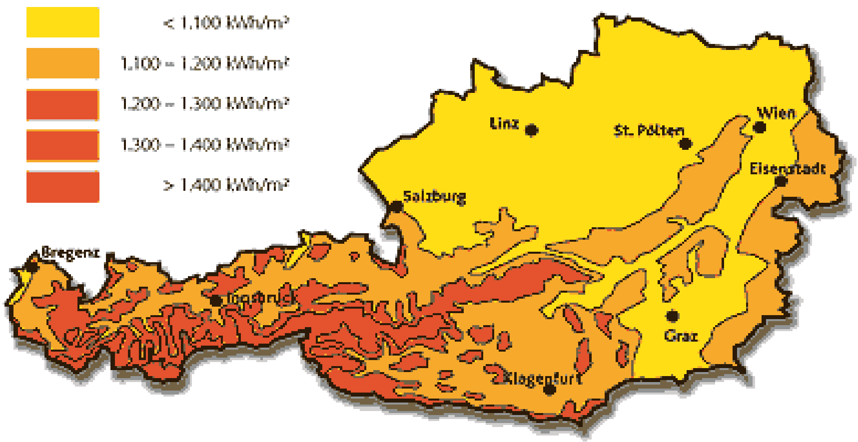


fig. 3-3: Solar radiation in Austria Source: www.austrosolar.com

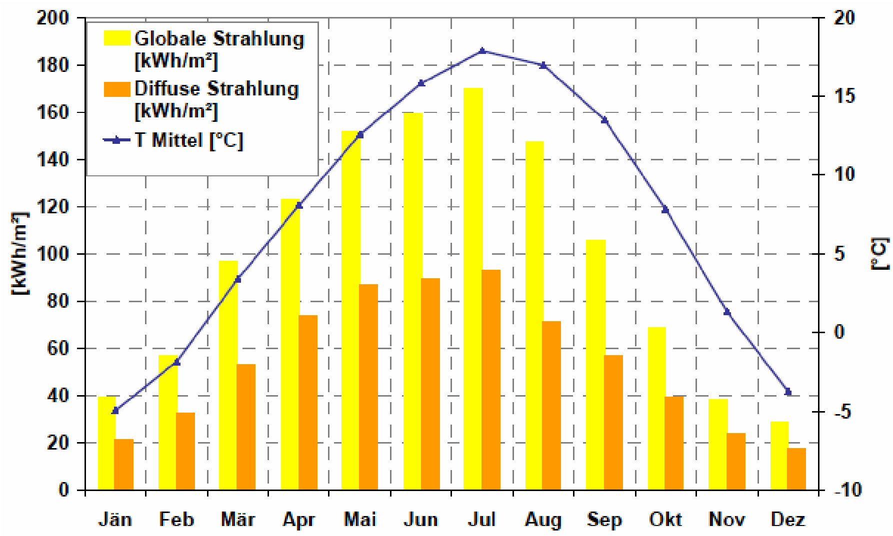


fig. 3-4: Monthly global and diffuse solar radiation in Kötschach-Mauthen, Source: Gosztonyi 2006

Looking at a map[40] (fig.3-5) showing the solar hours per day in December we can presume that on the north facing side of the village of Mauthen there is only a little direct radiation during wintertime, making it the least effective place to positing solar panels. By contrast, the best places to install solar energy production units are in the centre of Kötschach-Mauthen (at the town hall and at the production side of

[40] Source:www.kagis.ktn.gv.at

the company eco) and in the village Laas.

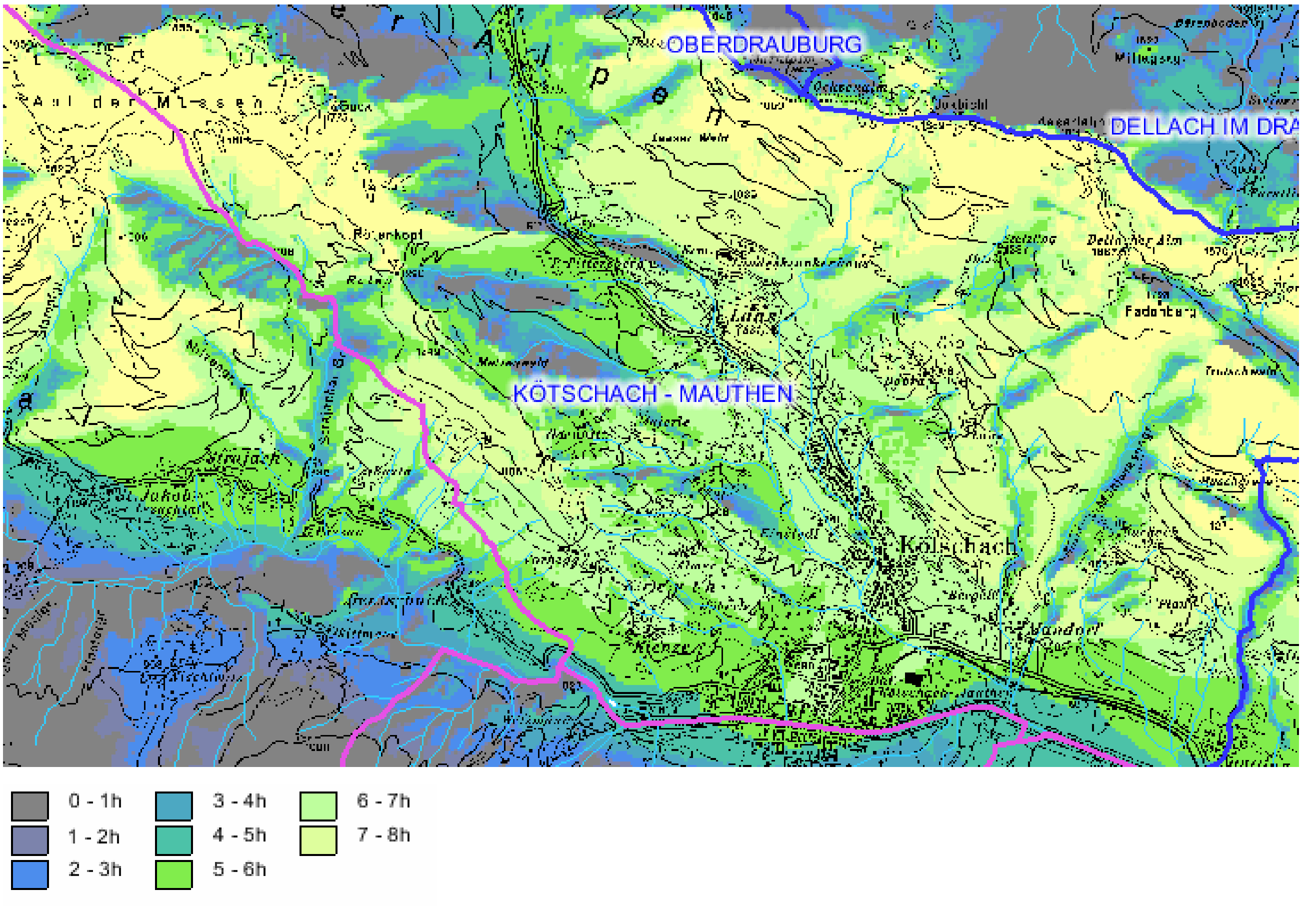


fig. 3-5: Solar radiation in December in hours per day in Kötschach-Mauthen, Source:www.kagis.ktn.gv.at; 24.7.2007

In principle there are two established approaches for direct utilisation of the sun as an energy source: solar thermal and photovoltaic. The first is mainly used for warm water preparation, the second for generation of electricity.

3.3.3.1 Thermal Heating and Warm Water Preparation

- Technology

The efficiency of flat collectors ranges from 55 to 60% with 800 W/m² solar radiation and a temperature gradient from collector to air of 40° K (summer) and in winter from 30 to 40% with 600 W/m² and a gradient of 60° K. Generally, solar systems for warm water preparation are planned with an average solar coverage of 20 to 40% and with 5 to 20 % for heating support systems. This means that solar coverage for warm water preparation must be 40 to 80 % on sunny days. That is why the solar system efficiency throughout the year is around 25 to 40% for warm water preparation and with combined heating support 10 to 30%. The solar yield of flat collectors for warm water preparation at 50°C is 350 to 450 kWh per m² installed collector area, and 200 to 350 kWh per m² for heating support (Peritsch 2006).

- Economics

The investment costs for the planning and construction of warm water preparation are between 300 and 600 €/m² flat collectors and between 700 and 1000 €/m² for vacuum collectors. The investment costs for warm water preparation and parallel heating support are between 400 and 800 €/m² for flat collectors and between 800 and 1200 €/m² for vacuum collectors.

The thermal energy price for solar systems offered by energy contractors is currently 0.06 to 0.12 €-Cent/kWh. Under present economic conditions the return on investment is between 7 and 14 years.

The annual average cost for maintenance is around 1 to 2 % of the investment costs. The life span of thermal solar systems can normally be expected to be between 20 and 30 years.

- Potential in the community of Kötschach-Mauthen

Referring to the given solar radiation in the community it would be feasible to install thermal solar collectors in the villages Kötschach, Kreuth, Laas and Mandorf. To calculate the potential for solar collectors for hot water preparation the 754 concerned households can due to the recent annual hot water demand of in average 13% of the total heat demand produce 1116.5 MWh annually. This potential has to be reduced by the annual hot water demand of district heat connected households in Kötschach with 108 MWh. The potential for solar hot water production in the areas with high solar radiation is 1008 MWh per year. This assumption for solar hot water potential does not include the possibilities for solar hot water production for tourism and does not include the few already installed solar panels in households. The potential of solar heating is due to the rather old buildings low and not predictable but this potential has do be realized with new buildings in the community.

3.3.3.2 Photovoltaic

- Technology

PV-systems have a long tradition, most of the projects use polycrystalline wafers. The electrical efficiency for polycrystalline wafers is ~12 to 15%, for monocrystalline wafers it is 15 to 18 % (Peritsch 2006). In the long run, integrated manufacturing of thin wafers (100 µm or less) and subsequent cell and laminate production is probably the most effective route.

- Economics

70 % of the entire investment cost are the costs for the module, the rest relates to battery, inverter and to the construction. In 2004 the investment costs were around 5 500 € per kW(peak) installed capacity. Overall, the present value of PV projects is determined by the feed in tariffs. Maintenance costs for proved components are very low. The life span of PV modules can reach up to 50 years, whereas for inverter, battery and cables it is significantly shorter, depending on dust, humidity, temperature gradients

and on solar radiation. Figure 3-6 shows the future costs of photovoltaic systems:

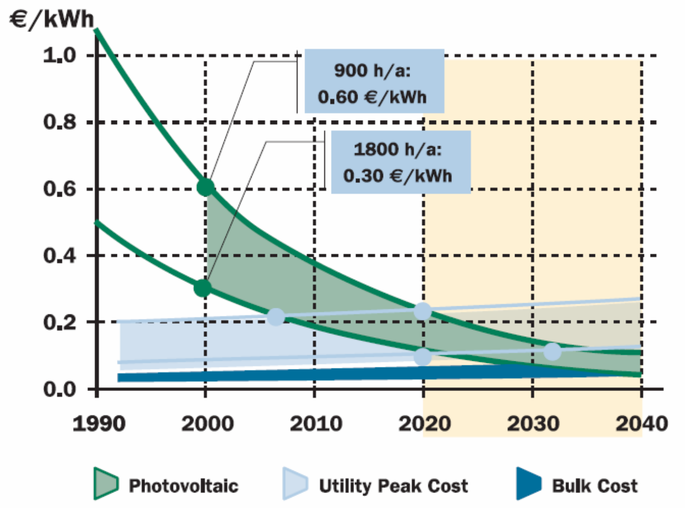
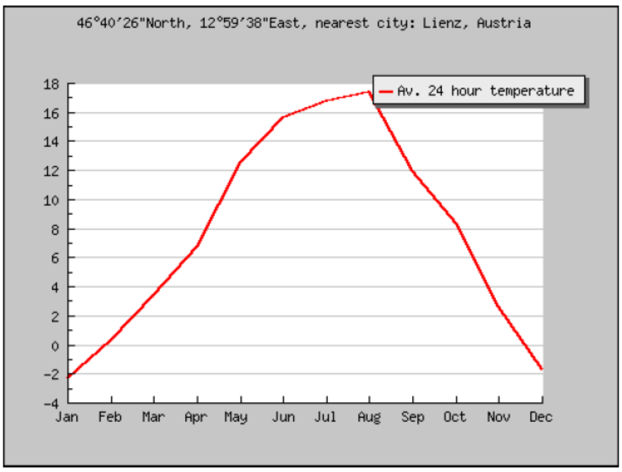


fig. 3-6: Capacities, recent and future costs of photovoltaic systems (source: German Aerospace Center in www.schott.com/solar)

- Potential in the community of Kötschach-Mauthen

Referring to the given solar radiation in the community (fig. 3-7) it would be feasible to install PV modules in the villages Kötschach, Kreuth, Laas and Mandorf. Theoretically the 754 concerned households in these villages can due to the recent subsidy guideline with a maximum of 10 kW(peak) PV systems per household produce 7540 kW(peak) nominal power and in total 7 GWh per year. The generation profile of PV during daytime basically corresponds to the electricity demand. If we consider 20% of the potential PV system installation as realisable until 2020, the energy concept should calculate with a potential of 1.4 GWh until 2020.



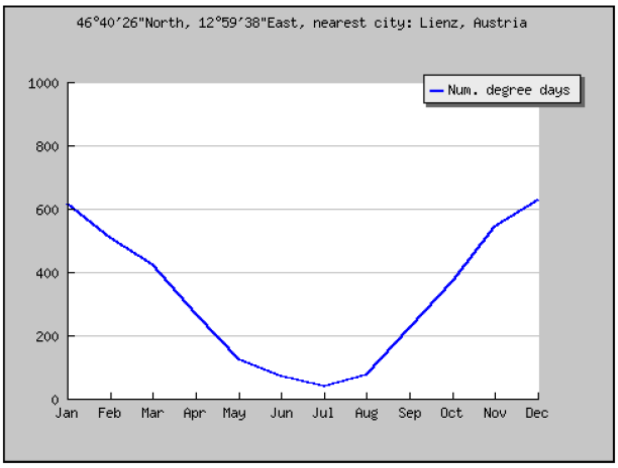


fig. 3-7: 24 hour average of temperature (°C) and number of heating degree-days of Kötschach-Mauthen Source: Photovoltaic Geographical Information System http://re.jrc.ec.europa.eu/pvgis/apps3/PVcalc.php 2.10.2007

3.3.4 Potential of Biomass

A study by the Carinthian Development Agency in 2005 Kanzian and Kindermann discovered that, an additional biomass potential with regard to the actual use of timber for the Carinthian wood based industry, forest ecology and biomass logistic of 0.66 TWh per year, which could actually be supported by the regional forest (fig.3-8).

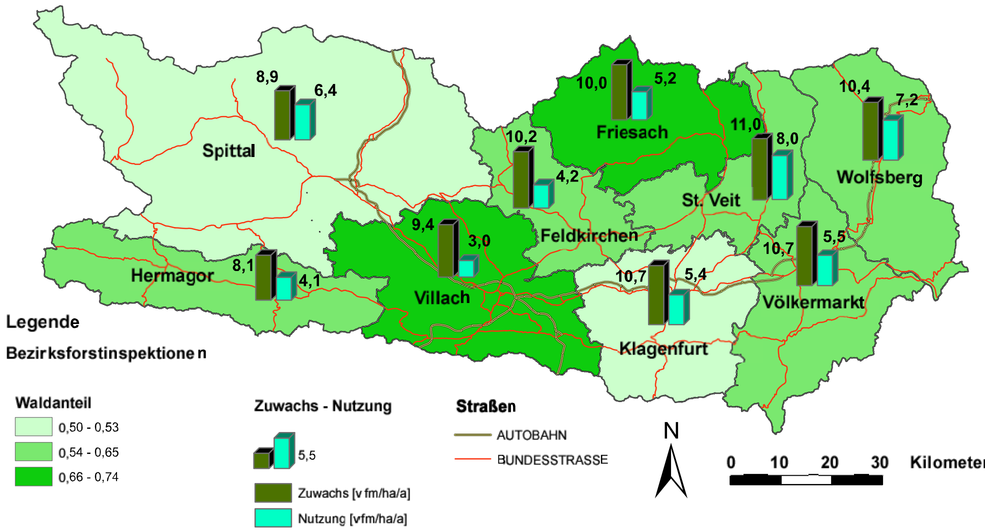


fig. 3-8: Share of forests, annual increment and annual cut in Carinthia (source: Kanzian and Kindermann 2005).

The additional potential of 320.000 m³ wood for biomass in Carinthia is equivalent to 60 Million litres of fuel oil. A typical family house dated 1980, needs around 2000 litres of fuel oil per year. With the estimated biomass potential additional 30.000 houses could be heated. This number could be increased ten-fold by constructing low energy houses.

According to a study of the Arbeitsplattform Wald&Holz in Kärnten 2007 there are 87.000 ha of forests in the district of Hermagor. In the period of 2000 to 2002 the average cut per hectare was at 1.19 m³/ha.a industrial wood and 0.65 m³/ha.a energy wood. Looking forward to 2020 the forest experts in Carinthia calculated that for Hermagor an additional annual allowable cut of industrial wood and energy wood of 13.500 m³ or 0.155 m³/ha would be possible. Summing up, the annual potential for the regional biomass supply would be 1.85 m³ per hectare forest and year. In the community of Kötschach-Mauthen there are ca. 9.000 ha forests (tab.3-3) with 60% of them being forest with protection function (fig. 3-9).

Table 3-3: Forest area and forest coverage in the villages of the community of Kötschach-Mauthen (Source: land register 2007 given by the District Forest Office of Hermagor)

Village	Forest area	Forest coverage
Mauthen	2115,95 ha	49,5%
Kötschach	2772,93 ha	71,8%
Strajach	2153,91 ha	62,5%
Würmlach	1982,15 ha	51,3%
Total	**9024,94 ha**	**58,4%**

Overall an annual usable biomass potential for energy use of 16.650 m³/a or 36.6 GWh/a from forests and 20.000 m³ loss volume of industrial wood chips with an energy content of 16 GWh/a has an annual primary energy amount of 52.6 GWh/a.

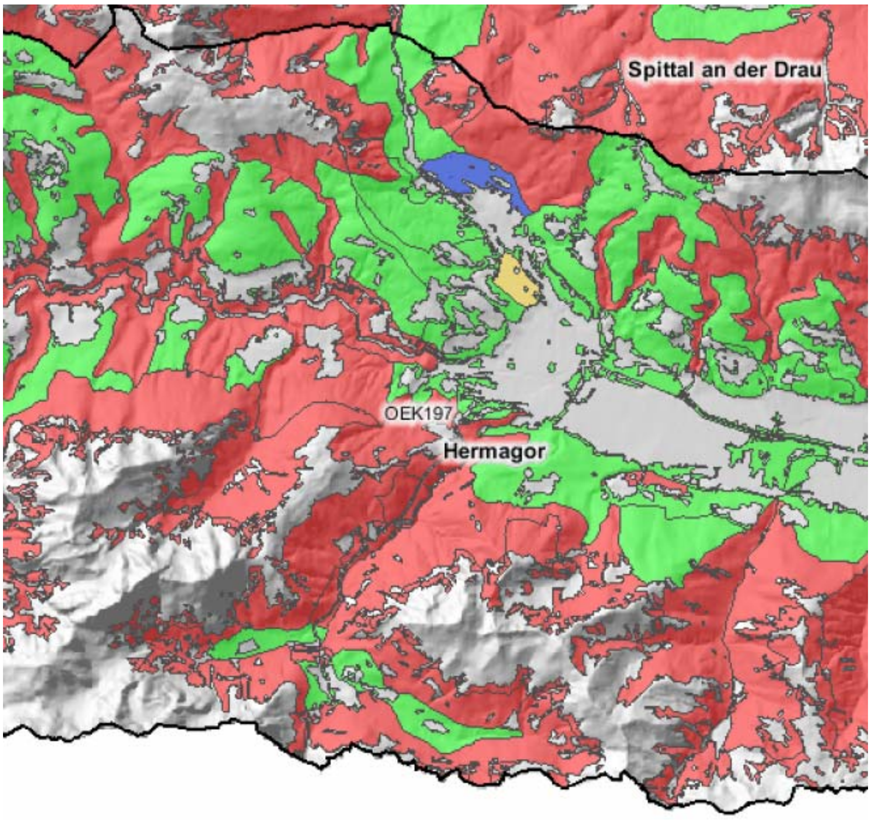


fig. 3-9: Forest area in Kötschach-Mauthen (green= forests in yield, red= forests with protection function, yellow= forests for recreational areas, blue= forests for water protection) Source: www.kagis.ktn.gv.at; 24.7.2007

According to the given scenario of harvesting forest as usual, the remaining annual forest yield for energy production is estimated at 20 hectares per year. To reach energy-self-sufficiency for heat in 2020 no further forest area of the community would need to be available for production of energy carriers for any future additional demand. If we take into account that only 65% of the allowable cut is used nowadays it can be assumed that there is an additional biomass potential for further heat demand based on the local forests. From the biomass potential of 52 GWh/a out of the forest an amount if 26 GWh/a is already used for heat energy. In addition to this, by changing to 100% heating energy from biomass resources with additional 26 GWh per year, CO_2 emissions in the region would be decreased by 6788 tons of CO_2 per year.

Presently only up to 5 % of the community, as shown in figure 3-10, is used as agricultural crop land (~750 ha), an additional 15% is permanent grassland (~2.000 ha); 250 ha of agricultural land is nowadays for energy production[41]. Due to the raising prices for crops nearly no additional agricultural crop land is available for the production of energy carriers.

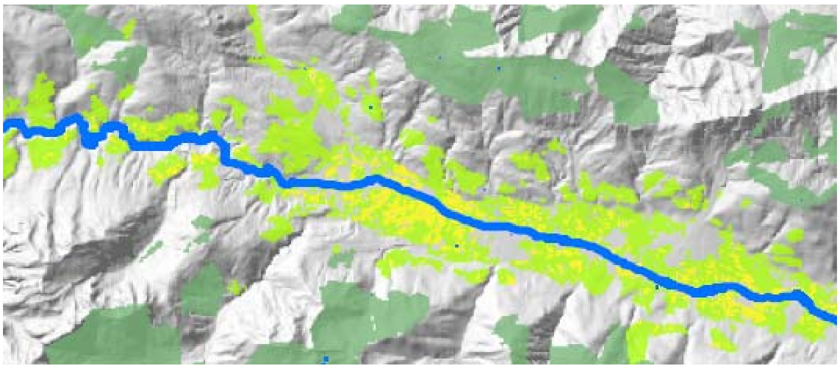


fig. 3-10: Agricultural land use in Kötschach-Mauthen (yellow=cpro Land, light green=grass land, dark green=alpine meadows) Source:www.kagis.ktn.gv.at; 24.7.2007

In order to meet the electricity demand of the community of Kötschach-Mauthen, a biogas plant could supply the basic load. In total they would need to have the capacity to deliver 1 MW. The use of biogas plants to cover the basic load is obvious, due to the electrical efficiencies it offers, and the simplicity of the procedure. Power production via biogas plants also has the potential to cover the thermal energy demand of the summer load of district heating systems. Thermal gasification in small plants, by means of the wood gasifer-procedure, provides an alternative to biological gasification. An appropriate pilot plant is presently being implemented in Kötschach-Mauthen. Missing power peak loads could easily be covered by small hydro power plants.

Regarding logistics, mobilization of biomass use, supply security, market circumstances and decentralized energy supply we have to find the best conversion technologies for 9.000 ha forest and 2.750 ha agricultural area for energy use. Herdin (2005)[42] shows the highly developed efficiency of biogas use with around 90 MWh/ha and year, whereas the annual yield in forests is only 20 MWh/ha and year. Therefore the theoretical biomass potential in Kötschach-Mauthen is around 247.5 GWh/year.

[41] www.kagis.ktn.gv.at

[42] Herdin 2005

3.4 Scenario for an Energy Balance 2020

Referring to the previous chapters the additional potentials of resources to satisfy the final energy demand of the community including efficiency of conversion to final energy can be summarized with an overall amount of nearly 40 GWh/a of renewable energy per year. Additionally 13 GWh/a can be saved with energy efficiency actions in the community Kötschach-Mauthen until 2020 (table 3-4).

Table 3-4: Annual additional potentials of resource for Kötschach-Mauthen until 2020

Final energy [MWh/a]	Heat production	Power production	Fuel production
Hydro	0	1.975	0
Wind	0	3.958	0
Solar	1.008	1.400	5
Biomass	26.272	0	5.260
Energy saving	2.030	2.030	9.000
TOTAL	**29.310**	**9.363**	**14.265**

Scenarios of a future energy balances of the community of Kötschach-Mauthen until 2020 were discussed within the "platform energie:autarkes Kötschach-Mauthen". The favourite one shows table 3-5 with the assumptions of a constant population with intensified renewable energy:

Table 3-5 Scenario of a future energy balance for Kötschach-Mauthen in 2020

demand of final energy MWh/a	***fuel***	***heat***	***power***	***total***
private	8.961	18.228	6.963	34.153
commercial	17.362	24.888	9.154	51.404
total	26.324	43.116	16.117	85.557

production of endenergy MWh	***fuel***	***heat***	***power***	***total***
renewable	5.265	43.116	54.412	102.793
non renewable	0	0	0	0
total	5.265	43.116	54.412	102.793

balance of endenergy MWh	***fuel***	***heat***	***power***	***total***
surplus of renewables		0	38.295	38.295
needs for renewables	21.059	0		21.059

To reach the goals written in the scenario above, a defined energy program for measures within the community has to be realized. This energy program for 2020 gives the following quantitative targets:

- 50% reduction of the annual fuel consumption in households until 2020
- 20% reduction of the annual commercial fuel consumption until 2020

- Production of at least 5.000 MWh/a renewable fuels (e.g. with biomethane or solar)
- 2% reduction of final energy per year of the heat consumption
- 100 % of the heat energy by use of renewable resources
- Production of additional 5.000 MWh/a renewable power until 2020

The implementation of the concept, besides energy saving and energy-self sufficiency, the community's independence from energy imports as a result, would add considerable value for the region by the extension of local infrastructure. As a result the acceptance of the project is expected to be high and local self-confidence to be strengthened. The publicity of the region as an alpine energy centre will also be increased, which will lead to new possibilities for tourism, culture and sports in the region, as well as new possibilities for local companies, institutes training- and research establishments for co-operations at home and abroad. This in turn will have positive repercussions for the region. Overall sustainable impulses for the development of the region and the development of the model role for other communities in the Alps are expected.

4 Feasibility Studies for Energy Production

4.1 Electric Energy with additional Wind Turbines at Plöckenpass

The proposed concept for the new wind energy project has to build two turbines with 800 kW each (Wind turbine model: Enercon 48). The rotor diameter is 48 m; the hub height 76 m, the swept area covers 1810 m². The wind power density at hub height is therefore 396 W/m². The energy production of the 2 turbines is estimated with 2306 MWh per year and turbine. The coefficient for losses is taken with 0.876 and the specific yield is calculated with 1116 kWh/m². The final energy of 4 GWh will be delivered through this project to the local electricity grid.

4.1.1 Choice of Site

The proposed location for the implementation of the wind turbine is at Plöckenpass in the vicinity of the existing wind turbine (fig. 4-1).

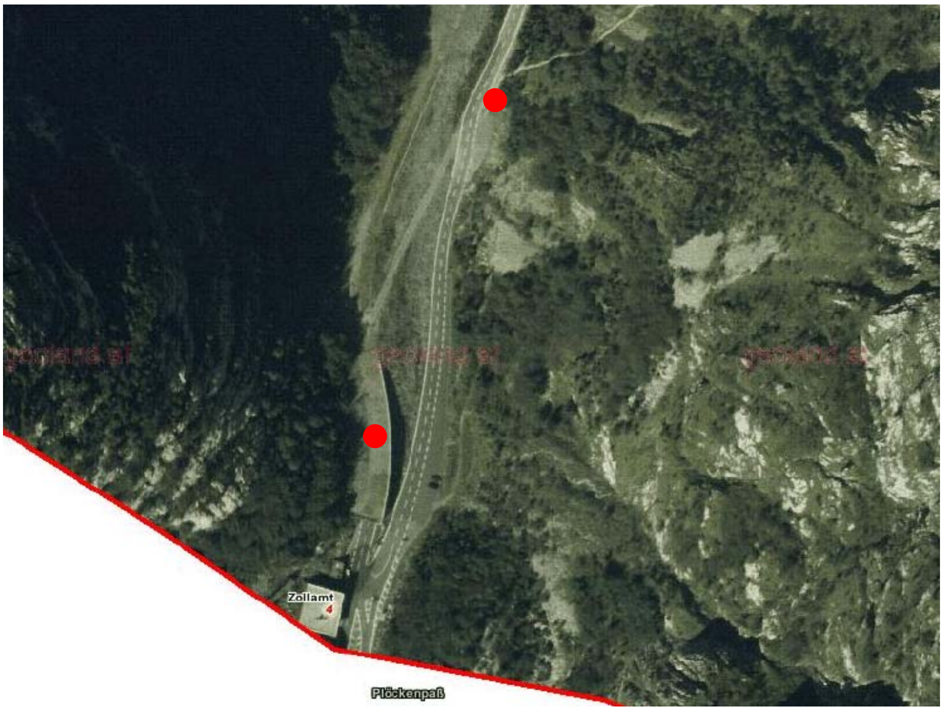


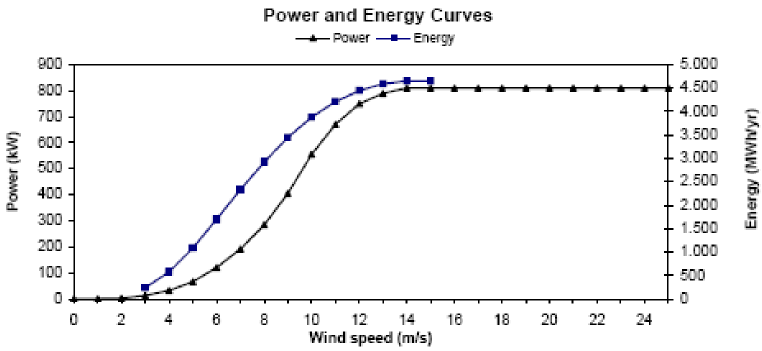
fig. 4-1: Location of the proposed wind turbines at Plöckenpass, Source:www.geoland.at; 24.7.2007

4.1.2 Wind conditions

According to the survey by the existing wind turbine the mean wind speed is 6 m/s at hub height 70 m. Based on this survey power and energy curves on this site are developed shown in table 4-1:

Table 4-1: Wind Turbine Protection Data of the Windpark at Plöckenpass (Source: www.retscreen.net)

Wind speed (m/s)	Power curve data (kW)	Energy curve data (MWh/yr)
0	0,0	-
1	0,0	-
2	2,0	-
3	12,0	234,1
4	32,0	575,2
5	66,0	1.084,7
6	120,0	1.697,2
7	191,0	2.330,1
8	284,0	2.924,2
9	405,0	3.446,4
10	555,0	3.878,6
11	671,0	4.212,6
12	750,0	4.448,1
13	790,0	4.591,9
14	810,0	4.655,7
15	810,0	4.653,2
16	810,0	-
17	810,0	-
18	810,0	-
19	810,0	-
20	810,0	-
21	810,0	-
22	810,0	-
23	810,0	-
24	810,0	-
25	810,0	-



4.1.3 Accessibility and Grid Connection Possibilities

The proposed location can be accessed on public road with distance of 21 km from Kötschach-Mauthen bordering Italy. The project is located in a narrow gorge on Plöckenpass with no special endangered fauna and flora because the wind mill stands directly on a gallery of the public road. Because of the gallery there is no problem with ice fall in wintertime. Due to the existing wind turbine on the top of Plöckenpass a 20 kV cable can be connected via a 20 kV/400 volt transformer directly to the wind mills.

4.1.4 Economic Feasibility Study

The following calculation evaluates the investment of wind turbines by analysing net present value, annuity and discounted pay back period and the cumulative discounted cash flow (table 4-2). The calculation for the economical feasibility studies is done with the software Retscreen[43] Version 3.2 Clear Energy Project Analysis Software provided by the Minister of Natural Resources of Canada.

Table 4-2: Energy balance, financial parameters, project costs and financial feasibility of the Windpark at Plöckenpass (Source: www.retscreen.net), note: $ = €

Annual Energy Balance					
Project name		AAE			
Project location		Plöckenpass			
Renewable energy delivered	MWh	4.039	Net GHG reduction	t_{CO2}/yr	1.892
Excess RE available	MWh	-			
Firm RE capacity	kW	1.600			
Grid type		Central-grid	Net GHG emission reduction - 25 yrs	t_{CO2}	47.302

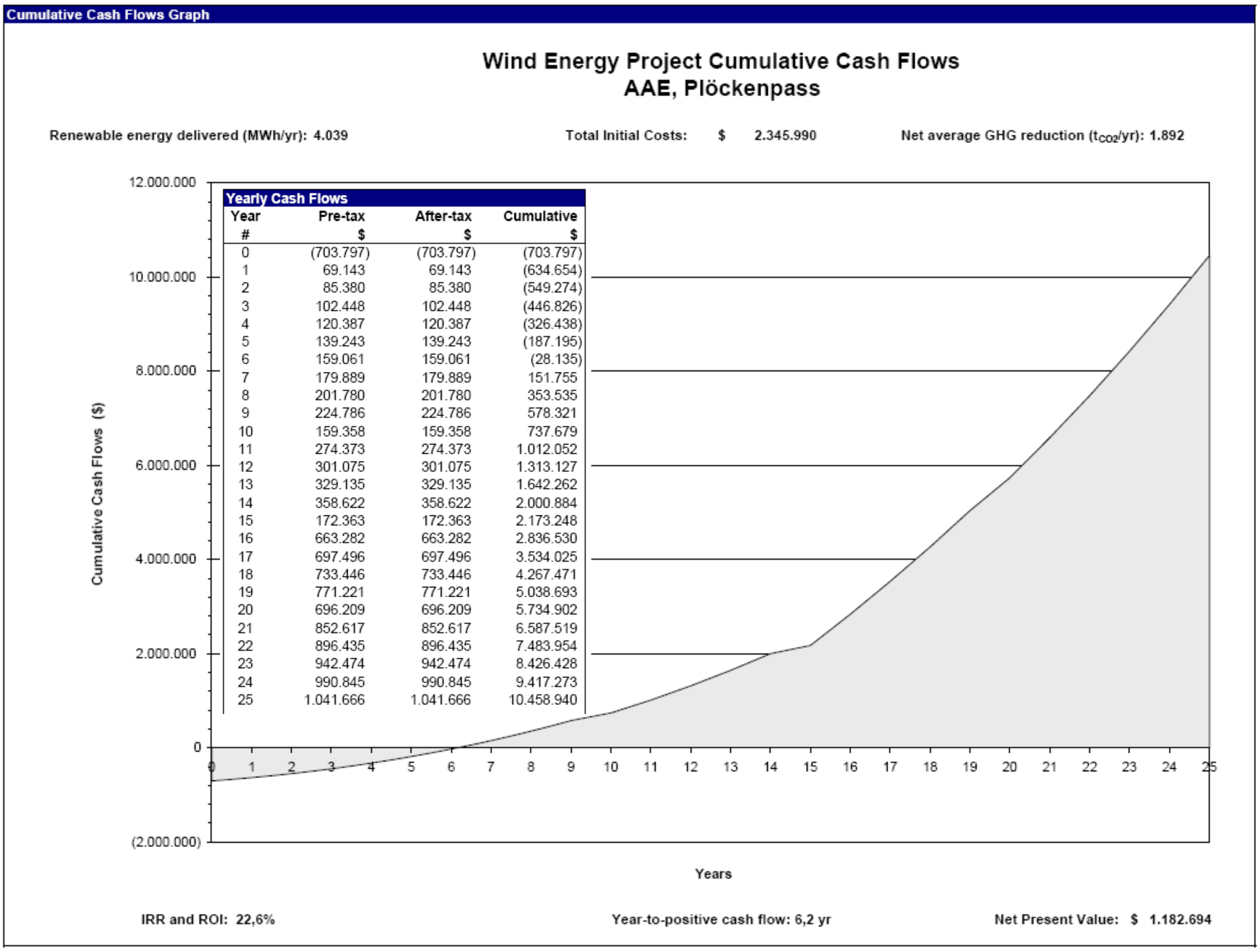
Financial Parameters					
Avoided cost of energy	$/kWh	0,0800	Debt ratio	%	70,0%
RE production credit	$/kWh	-	Debt interest rate	%	12,0%
			Debt term	yr	15
GHG emission reduction credit	$/$t_{CO2}$	-	Income tax analysis?	yes/no	No
Avoided cost of capacity	$/kW-yr	-			
Energy cost escalation rate	%	5,0%			
Inflation	%	2,5%			
Discount rate	%	12,0%			
Project life	yr	25			

Project Costs and Savings						
Initial Costs				**Annual Costs and Debt**		
Feasibility study	1,1%	$	25.200	O&M	$	28.281
Development	3,4%	$	80.000			
Engineering	0,0%	$	-	Debt payments - 15 yrs	$	241.114
Energy equipment	73,1%	$	1.714.000	**Annual Costs and Debt - Total**	**$**	**269.395**
Balance of plant	14,9%	$	350.000			
Miscellaneous	7,5%	$	176.790	**Annual Savings or Income**		
Initial Costs - Total	100,0%	**$**	**2.345.990**	Energy savings/income	$	323.090
				Capacity savings/income	$	-
Incentives/Grants		$	-			
				Annual Savings - Total	**$**	**323.090**
Periodic Costs (Credits)						
Drive train		$	70.000	Schedule yr # 10,20		
Blades		$	150.000	Schedule yr # 15		
		$	-			
End of project life - Credit		$	-			

[43] www.retscreen.net

Financial Feasibility					
			Calculate energy production cost?	yes/no	No
Pre-tax IRR and ROI	%	22,6%			
After-tax IRR and ROI	%	22,6%	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	8,0			
Year-to-positive cash flow	yr	6,2	Project equity	$	703.797
Net Present Value - NPV	$	1.182.694	Project debt	$	1.642.193
Annual Life Cycle Savings	$	150.793	Debt payments	$/yr	241.114
Benefit-Cost (B-C) ratio	-	2,68	Debt service coverage	-	1,29

Cumulative Cash Flows Graph



Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(703.797)	(703.797)	(703.797)
1	69.143	69.143	(634.654)
2	85.380	85.380	(549.274)
3	102.448	102.448	(446.826)
4	120.387	120.387	(326.438)
5	139.243	139.243	(187.195)
6	159.061	159.061	(28.135)
7	179.889	179.889	151.755
8	201.780	201.780	353.535
9	224.786	224.786	578.321
10	159.358	159.358	737.679
11	274.373	274.373	1.012.052
12	301.075	301.075	1.313.127
13	329.135	329.135	1.642.262
14	358.622	358.622	2.000.884
15	172.363	172.363	2.173.248
16	663.282	663.282	2.836.530
17	697.496	697.496	3.534.025
18	733.446	733.446	4.267.471
19	771.221	771.221	5.038.693
20	696.209	696.209	5.734.902
21	852.617	852.617	6.587.519
22	896.435	896.435	7.483.954
23	942.474	942.474	8.426.428
24	990.845	990.845	9.417.273
25	1.041.666	1.041.666	10.458.940

The conclusion of this analysis is that this project is economical feasible. It is shown that an additional electricity amount of 4 GWh/a can be produced at Plöckenpass by 2 of wind turbines. The total initial costs are 2.350.000 €, the year to positive cash flow is 6.2 years and the net present value is 1.182.700 €. The green house gas reduction with 1892 tco_2/year is rather low because the base line was taken with 50 % hydro power and 50 % oil.

4.2 Process Heat from Biogas

4.2.1 Aim of Producing Process Heat with Biogas

The company ECO, a producer of heat exchanger and the main employer in the region, is using heating oil to produce 1.1 GWh/a for heating the industrial site at the temperature level of 90°C, 1.7 GWh/a for heat of reaction for degreasing with 170°C and 2.2 GWh/a for powder coating at 220°C (fig. 4-2). This means that ECO is the main single heat energy consumer in the community of Kötschach-Mauthen. To produce heat in a renewable way this project investigates whether the heat demand of 5 GWh/a, as annual final energy from heating oil, can be replaced by local produced biogas.

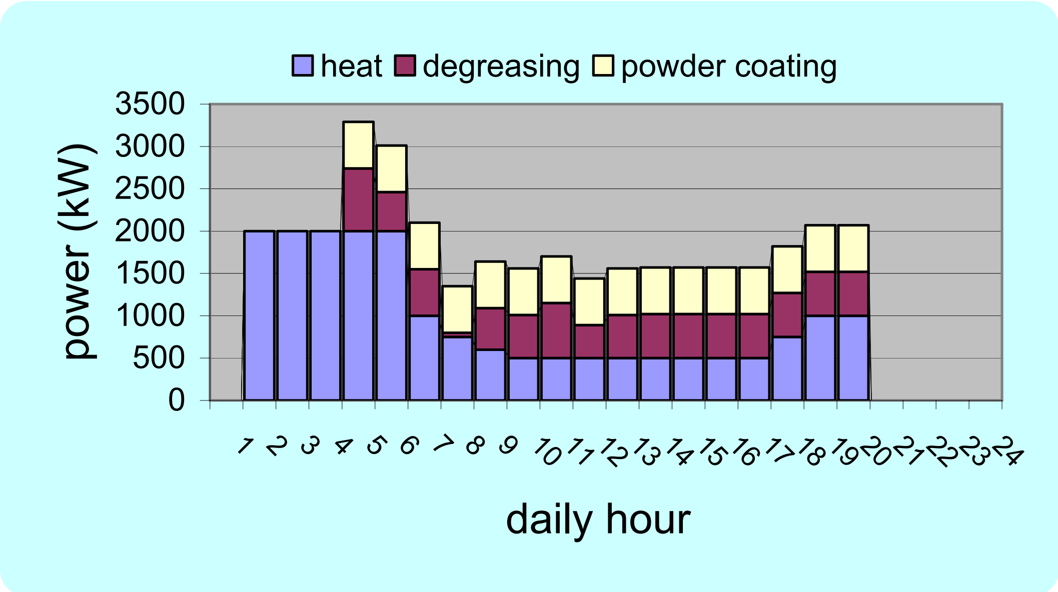


fig. 4-2: Energy need of the company ECO on an average day in the end of September 2003

4.2.2 System of Biogas Use in Kötschach-Mauthen

Biogas is produced by the anaerobic digestion of manure and energy crops mainly from the community and district. Animal slurries are collected from the pre-storage tanks of several farms in special vacuum container and transported to the biogas plant, where they are mixed with organic crops, homogenised and pumped in the digester tank. The digestion process takes place at mesophilic temperatures. The digested slurry -now called digestate- is pumped from the digesters to the gas proof storage tanks, where the remaining gas production is recovered and joins the gas produced in the digesters. The produced biogas is used for combined heat and power generation, in future for industrial heat production and for biomethane for mobility.

After liquid and fibre separation the digestate is transported at the storage tanks of the farmers, placed out in the fields and applied on the crops as an integrated part of the fertilisation plan of each farm, replacing mineral fertilisers in combination with bottom ash of the district biomass combustion. The excess of digestate is sold to the crop farms in the neighbourhood. This way, a redistribution of the excess of nutrients takes places in the area (fig. 4-3). [44]

The biogas produced in the biogas plant Würmlach is used at a rate of 180 m³/hour in a 250 kW CHP gas engine for producing electricity and heat for fermentation. The remaining gas is transported via a 2 km biogas pipeline to Kötschach. There, 380 m³/hour are used in a 500 kW CHP gas engine to produce electricity and heat for the district heating grid. In the near future 50 m³/hours will be used in a biogas filling station for the vehicle fleet of the community and the biogas plant owners. In addition 100 to 250 m³/hours or 627 000 m³/year of biogas should be used for heat production in the company ECO replacing the existing oil burner (fig.4-4).

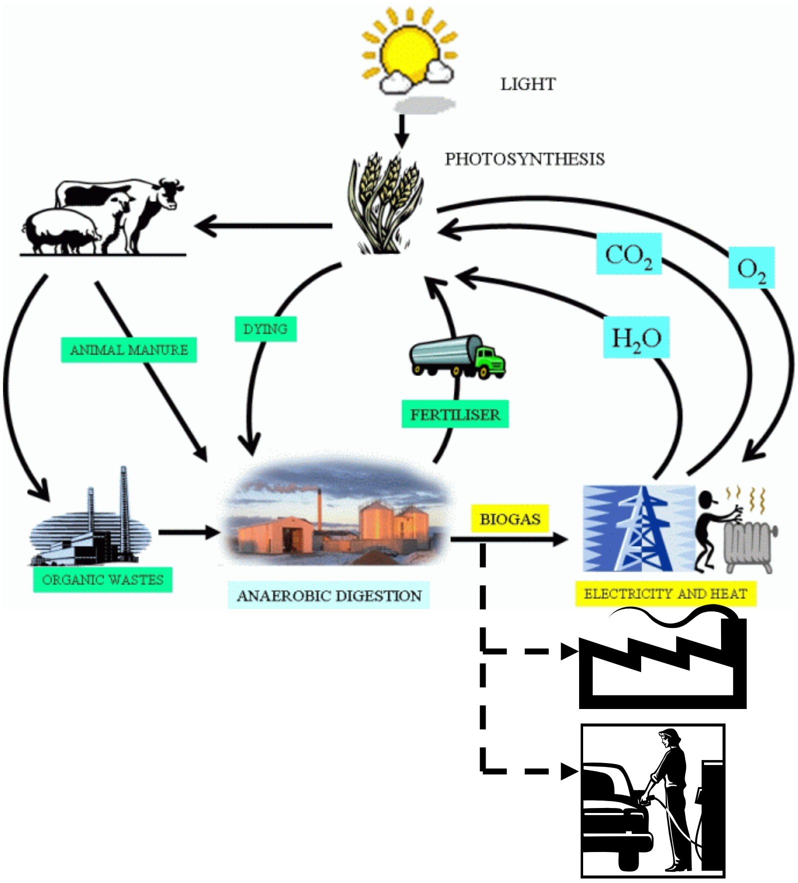


fig. 4-3: the system of biogas polygeneration in the community of Kötschach-Mauthen (Source: http://websrv4.sdu.dk/bio/probiogas.htm)

[44] Source: http://websrv4.sdu.dk/bio/probiogas.htm

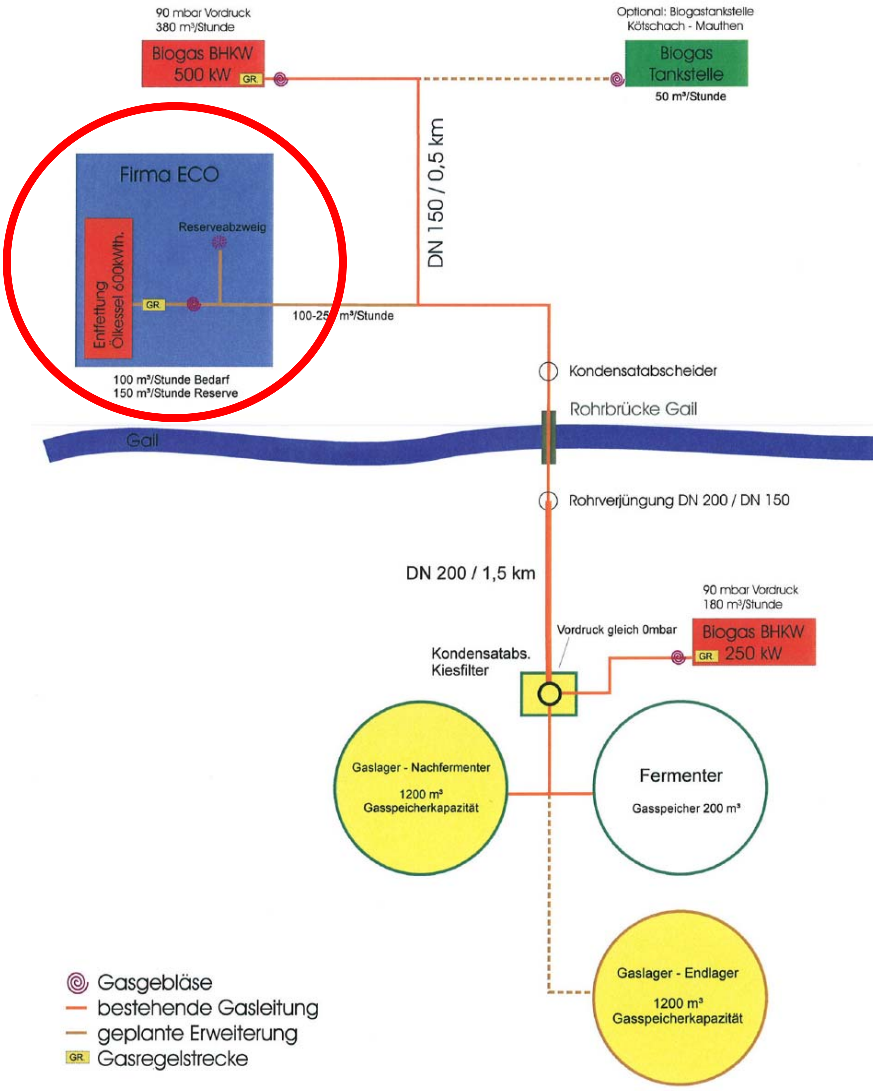


fig. 4-4: current and future use of biogas in Kötschach (Roschitz 2006)[45]

The additional input for co-fermentation should come in future from the collection of the organic waste of the community in order to force the independency of sources from outside.

4.2.3 Quality of Biogas in Kötschach

The biogas pipeline was measured in 2 places in Kötschach to test the biogas quality in 2006 by the Austrian Bioenergy Centre (Roschitz 2006). The measurement point 1 was at the point that the gravel

[45],Roschitz C. 2006. Probenahme Beprobung & Beurteilung von Gaskomponenten; Austrian Bioenergy Center GmbH im Auftrag der Entwicklungsagentur Kärnten

filter at the biogas plant in Würmlach was installed, and the second in front of the 500 kW CHP gas engine in Kötschach, 2 km away. At these points the parameters of the produced and transported biogas, for example the content of CH_4, CO_2, N_2, ethane, ethylene, O_2, C_3, ammonia, mercaptans and siloxans, were observed. (All siloxanes were less than <35[µg/Nm³dr] and mercaptanes <7 [µg/Nm³dr] could not be measured due to the low content.) While biogas transport the content of water and ammoniac is decreasing by condensation. (table 4-3)

Table 4-3: biogas benchmarks and content at 2 different measurements in Würmlach and in Kötschach

measurement		*Würmlach*		*Kötschach*	
CH_4	[%Vol.]	57,4		55,97	
CO2	[%Vol.]	42,31		43,32	
N2	[%Vol.]	0,04		0,063	
O2	[%Vol.]	2,83		3,06	
Ethylen	[%Vol.]	0,002		0,002	
H_2O	[gH_2O/Nm³tr]	25		8	
		min	max	min	max
NH_3	[mgNH_3/Nm³dr]	59	69	1	2
H_2S	[mgH_2S/Nm³dr]	78	127	148	152

biogas quality parameters		
Energy content (dry)	[kJ/Nm³,dr]	20.561,1
Energy content (wet)	[kJ/Nm³,w]	20.137,6
Wo (Wobbe-Index),u, w,40 °C	[kJ w/Nm³ w]	19.680,4
Air ratio, real biogas	[Nm³ air/Nm³ gas_dr]	5,354

By comparison to natural gas, biogas has a higher content of CO_2 and H_2S. Therefore the biogas burner in the company ECO will most probably have comparable higher flue gas content of NO_x and of SO_2. The use of biogas within the given parameters at the measurement point 2 is possible for the use of gas burners in the industrial site of the company ECO, however the following issues should be considered:

- Condensation of the water content in the biogas while transport and usage
- Corrosion in the biogas pipelines resulting in a higher O_2 content in the biogas
- Possible higher NO_x und SO_x emissions

In order to fulfil the targets of replacing heating oil at ECO we have to monitor the NH_3 and H_2S content of biogas in order to reduce it in future.

4.2.4 Economic Feasibility Study

The heating value of the biogas is around 5.6 kWh per m³. Gas engines with more than 140 kW power can reach an electrical efficiency of 37.5% up to 43 %. [46] This value produces 2.2 kWh electricity and 2 kWh thermal energy. If we presume that we get 0.15 €/kWh for electricity and 0.025 €/kWh for waste heat, 1 m³ of biogas produces with a CHP gas engine has a value of 0.38 €/m³.

When producing heat for industrial processes the value of 1 kWh is equivalent to more or less the price of oil, plus an additional 12 % of other related costs (capital costs, annual costs) and has the efficiency factor of an (old) oil burner with .85 resulting in a heat price of 0.073 €/kWh. The thermal efficiency of a modern gas burner is at least 90%. So we can calculate the comparable price for biogas with 0.37 €/m³ depending on the oil price. Due to the lower initial cost of a gas burner and 300 m gas pipeline compared to a CHP gas engine, and the easier maintenance work, the production of 3.5 GWh/a industrial needed heat seems to become an alternative solution especially if polygeneration possibilities for biogas use are existing.

The conclusion of this analysis is that this project is economical feasible (table 4-4). It is shown that an additional heat amount of 3.5 GWh/a can be produced with biogas for industrial use. The total initial costs are 530000 € for additional digester, biogas burner and biogas pipeline, the year to positive cash flow is 6.2 years and the net present value is 558 000 €. The green house gas reduction with 1235 tco_2/year is quite high because the base line was taken with 100 % oil.

[46] Herdin Günther 2005, Ertragsbetrachtungen bei der Verstromung von Biomasse Symposium Polygeneration 2005, 15. – 16. Dezember 2005, Güssing

Table 4-4: financial parameters, project costs and financial feasibility of the project biogas for industrial heat

CAPITAL BUDGETING - NET PRESENT VALUE

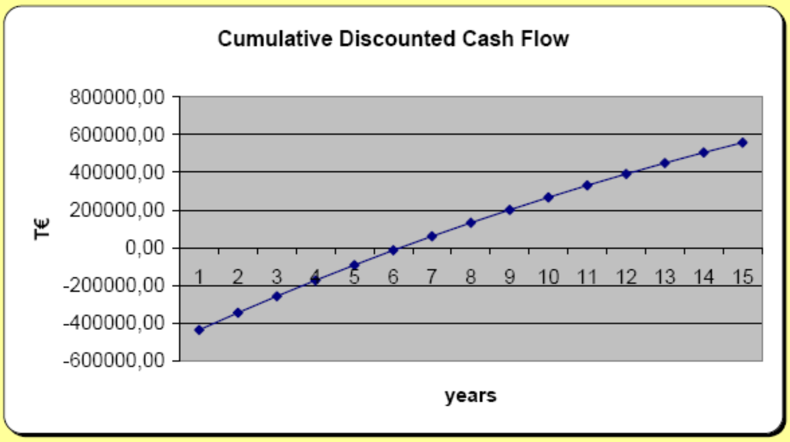
Datas

interest rate	5,5	%	production	3500	MWh/a	investment	530000	€
inflation	1,75	%		70	€/MWh			
corporate tax	25	%	costs	125400	€/a			

[T€]

year	*revenue*	*operating costs*	*deprecia-tion*	*R-C-D*	*corporate tax*	*NOCF net operating cash flow*	*PV present value*	*CDCF cumulative discounted cash flow*	*PVIFA interest factor of annuity*
1	245000,0	125400	35333,3	84266,7	21066,7	98533,3	95030,96	-434969,04	0,96
2	246715,0	127594,50	35333,3	83787,2	20946,8	98173,7	91318,57	-343650,46	0,93
3	248442,0	129827,40	35333,3	83281,3	20820,3	97794,3	87732,27	-255918,20	0,90
4	250181,1	132099,38	35333,3	82748,4	20687,1	97394,6	84268,02	-171650,18	0,87
5	251932,4	134411,12	35333,3	82187,9	20547,0	96974,3	80921,94	-90728,23	0,83
6	253695,9	136763,32	35333,3	81599,2	20399,8	96532,8	77690,25	-13037,99	0,80
7	255471,8	139156,68	35333,3	80981,8	20245,4	96069,7	74569,27	61531,29	0,78
8	257260,1	141591,92	35333,3	80334,8	20083,7	95584,4	71555,48	133086,77	0,75
9	259060,9	144069,78	35333,3	79657,8	19914,4	95076,7	68645,42	201732,19	0,72
10	260874,3	146591,00	35333,3	78950,0	19737,5	94545,8	65835,77	267567,96	0,70
11	262700,4	149156,34	35333,3	78210,8	19552,7	93991,4	63123,30	330691,25	0,67
12	264539,3	151766,58	35333,3	77439,4	19359,9	93412,9	60504,88	391196,13	0,65
13	266391,1	154422,49	35333,3	76635,3	19158,8	92809,8	57977,47	449173,60	0,62
14	268255,8	157124,88	35333,3	75797,6	18949,4	92181,6	55538,16	504711,76	0,60
15	270133,6	159874,57	35333,3	74925,7	18731,4	91527,6	53184,08	557895,84	0,58
						1430602,9	1087895,8		11,37

Graph



Results

NII	530000	T€ net initial investment		
DPP	6,2	discounted payback period		
kreal	4	% real interest		
NPV	557896	€ Net present value	> 0 GO	< 0 STOP
ANN	49081	€ Annuity	> 0 GO	< 0 STOP

4.3 Mobility from Photovoltaics at the Town Hall

4.3.1 General Assumptions

The total south oriented facade of the town hall (Location: 46°40'26" North, 12°59'38" East, Elevation: 771 m a.s.l.) has a size of 353 m². 25% of this area has windows which mean there are 265 m² facing south and which could be used for PV modules. Shadowing effects should be avoided especially by leaving the central part of the town hall for PV use. In addition PV modules can be installed on the roofs or as shadow structures. The town hall PV system converts direct current into alternating current and has a connection to the local low voltage power grid. Due to the planned general thermal renovation of the building[47] the costs for the sub construction of the facade integrated modules are within the redevelopment project. The duration of solar radiation is highest at the town hall within the village Kötschach-Mauthen in June this is 13,5 hours per day, in March and September 10,5 hours per day and even in December 6,5 hours per day (fig. 4-4). Only at the North West edge of the building of the company ECO is a similar solar radiation situation usable for PV Systems.

In order to serve as a pilot project for renewable mobility the platform “energie:autarkes Kötschach-Mauthen” wants to install PV modules for solar electricity filling station for its electro vehicles.

[47] Gosztonyi 2006

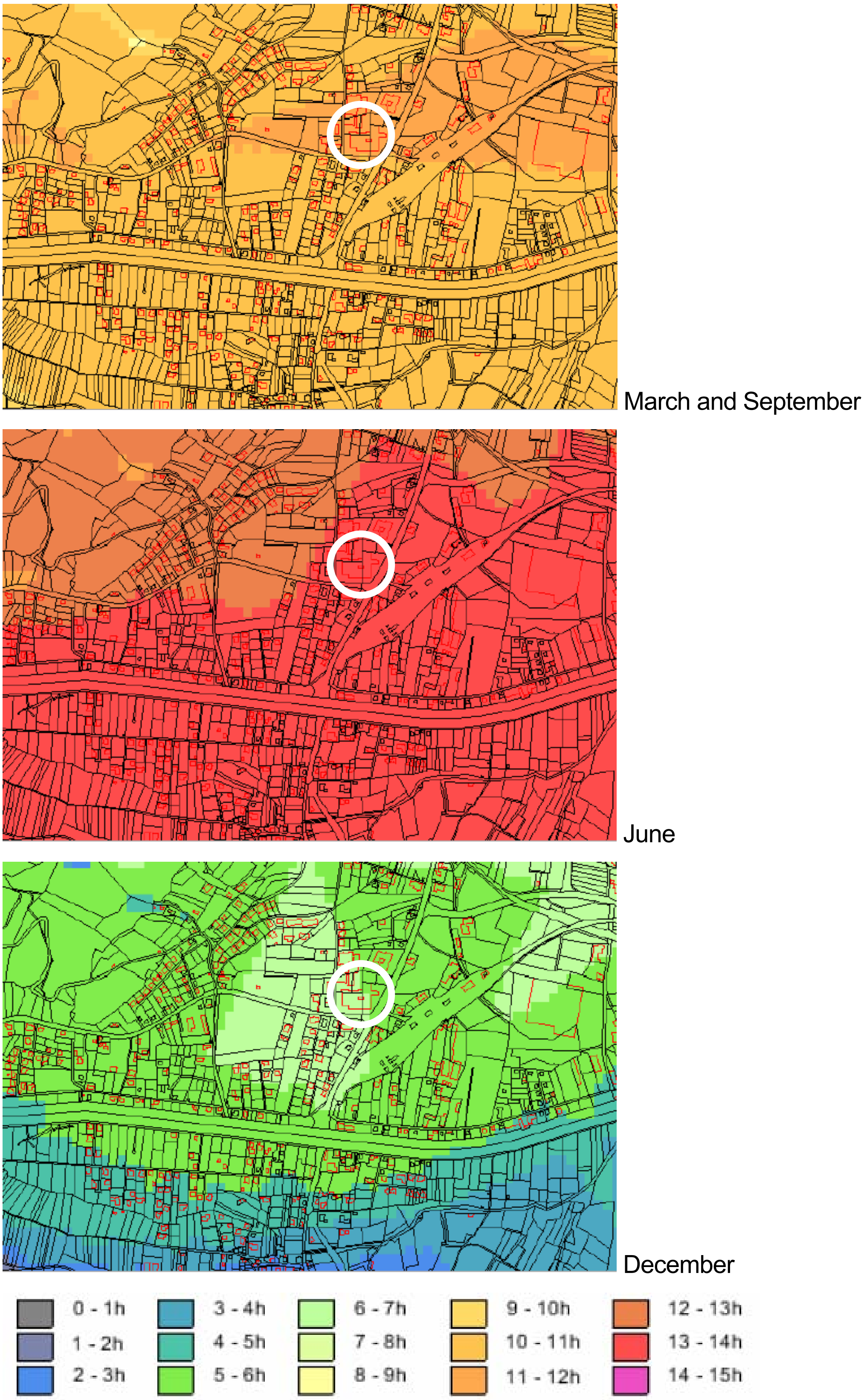


fig. 4-5: Solar radiation in hours per day in the centre of Kötschach-Mauthen, Source:www.kagis.ktn.gv.at; 24.7.2007

4.3.2 Poly Crystalline Solar modules

Solar modules with a nominal power of 175 Wp with the following specifications are used in this project. These modules have 54 poly crystalline cells, 156mm x 156mm with Tyco-Contact. The maximum voltage is 700 V DC and the power tolerance +/- 4,5%.[48] The Nominal PV module efficiency is 13,1%. The estimate annual energy production is based on a specific yield of 123 kWh/m² and year.

4.3.3 Performance of Grid-connected PV

According to PVGIS[49] the estimated amount of solar electricity generation one can expect each month from a 265 m² PV system at the town hall of Kötschach-Mauthen, with a nominal power of the PV system of 35 kWp (poly crystalline silicon) are as follows. The inclination of modules was chosen with 0.0° at the façade and with an optimal inclination angle of 37 degrees at the roof and an azimuth with 0.0° (fig.4-5). Using local ambient temperature data, the estimated losses are 5.6% due to temperature and 4,1% due to angular reflectance effects. In addition one can calculate other losses e.g. of cables, inverter etc. with 14.0%. Overall the combined PV system losses are 23.7%.

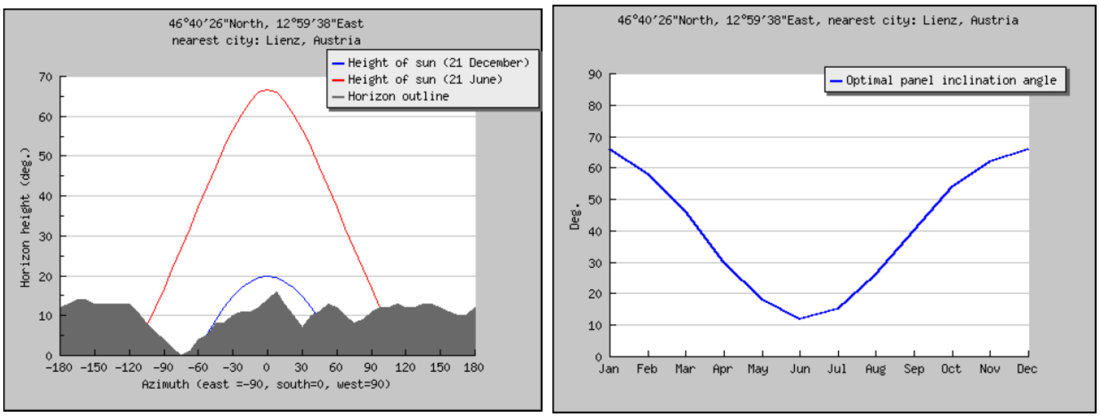


fig. 4-6: Outline of horizon with sun path for winter and summer solstice and the optimal panel inclination angle of a PV system at the town hall of Kötschach-Mauthen Source: Photovoltaic Geographical Information System http://re.jrc.ec.europa.eu/pvgis/apps3/PVcalc.php 2.10.2007

48 www.kioto-pv.com; 2.10.2007

49 PVGIS (c) European Communities, 2001-2007

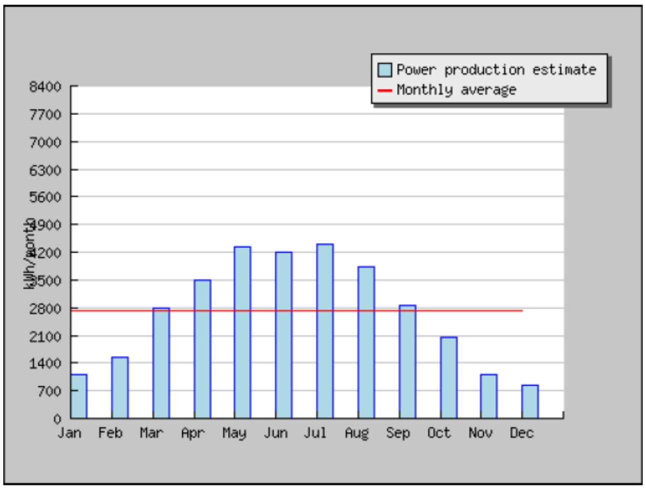


fig. 4-7: Monthly energy output from fixed-angle PV system at the town hall of Kötschach-Mauthen Source: Photovoltaic Geographical Information System http://re.jrc.ec.europa.eu/pvgis/apps3/PVcalc.php 2.10.2007

The yearly average electricity production comes up to 2720 kWh per month, 89,3 kWh per day (fig.4-6). With a PV system with 35 kWp nominal power we can produce in total 32.640 kWh per year (table 4-5). The generation profile of PV during daytime basically corresponds to the daily electricity demand curve of the town hall and local mobility needs.

Table 4-5: Average electricity production of a 35 kWp PV system and global irradiation at the town hall of Kötschach-Mauthen (Source: Photovoltaic Geographical Information System http://re.jrc.ec.europa.eu/pvgis/apps3/PVcalc.php 2.10.2007)

	Fixed system: inclination=0 deg., orientation=0 deg.			
Month	**Ed**	**Em**	**Gd**	**Gm**
Jan	35.90	1110	1.32	41.0
Feb	55.70	1560	1.99	55.8
Mar	90.30	2800	3.23	100
Apr	116.00	3490	4.18	125
May	140.00	4340	5.15	160
Jun	140.00	4200	5.21	156
Jul	142.00	4410	5.31	165
Aug	124.00	3840	4.64	144
Sep	95.30	2860	3.49	105
Oct	65.60	2030	2.40	74.5
Nov	37.40	1120	1.38	41.4
Dec	27.30	848	1.02	31.6
Year	89.30	2720	3.28	99.9

Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)
Gd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)
Gm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

4.3.4 Subsidies for PV Systems

The Ökostromgesetz 2002 with the amendment 2006 promotes also the target of installations of PV systems in 2006 and 2007. A feed-in tariff system with guaranteed tariffs was established. The tariffs in 2007 were stepped with the amount of power and are valid for PV panels proofed at the standard IEC 61215 and a maximum load of 10 kWp:

in Cent/kWh	Contract 2007
up to 5 kWp	46 Cent/kWh
between 5 -10 kWp	40 Cent/kWh

4.3.5 Economic Feasibility Study

The following calculation evaluates the investment of PV panels by analysing net present value, annuity and discounted pay back period and the cumulative discounted cash flow (table 4-6). The calculation for the economical feasibility studies is done with the software Retscreen[50] Version 3.2 Clear Energy Project Analysis Software provided by the Minister of Natural Resources of Canada.

Table 4-6: Energy balance, financial parameters, project costs and financial feasibility of the PV - park at the town hall (Source: www.retscreen.net)

Annual Energy Balance					
Project name		Commercial Building			
Project location		Kötschach-Mauthen,Austria	Nominal PV array power	kWp	35,00
Renewable energy delivered	MWh	32,641	Net GHG reduction	t_{CO2}/yr	31,18
Excess RE available	MWh	0,666			
Firm RE capacity	kW		Net GHG emission reduction - 20 yrs	t_{CO2}	623,61
Application type		On-grid			

Financial Parameters					
Avoided cost of energy	€/kWh	0,400	Debt ratio	%	60,0%
RE production credit	€/kWh	0,400	Debt interest rate	%	8,5%
RE production credit duration	yr	25	Debt term	yr	20
RE credit escalation rate	%	0,0%			
GHG emission reduction credit	€/t_{CO2}	-	Income tax analysis?	yes/no	No
Avoided cost of excess energy	€/kWh	-			
Energy cost escalation rate	%	3,0%			
Inflation	%	2,5%			
Discount rate	%	5,5%			
Project life	yr	20			

50 www.retscreen.net

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**			
Feasibility study	2,0%	€	5.000	O&M		€	2.380
Development	6,1%	€	15.000	Fuel		€	-
Engineering	6,1%	€	15.000	Debt payments - 20 yrs		€	15.476
Energy equipment	64,5%	€	157.500	**Annual Costs and Debt - Total**		**€**	**17.856**
Balance of equipment	16,2%	€	39.585				
Miscellaneous	4,9%	€	12.014	**Annual Savings or Income**			
Initial Costs - Total	100,0%	**€**	**244.099**	Energy savings/income		€	13.056
Incentives/Grants		€	-	RE production credit income - 25 yr		€	13.056
				Annual Savings - Total		**€**	**26.113**
Periodic Costs (Credits)							
Inverter Repair/Replacement		€	50.000	Schedule yr # 12			
		€	-				
		€	-				
End of project life -		€	-				

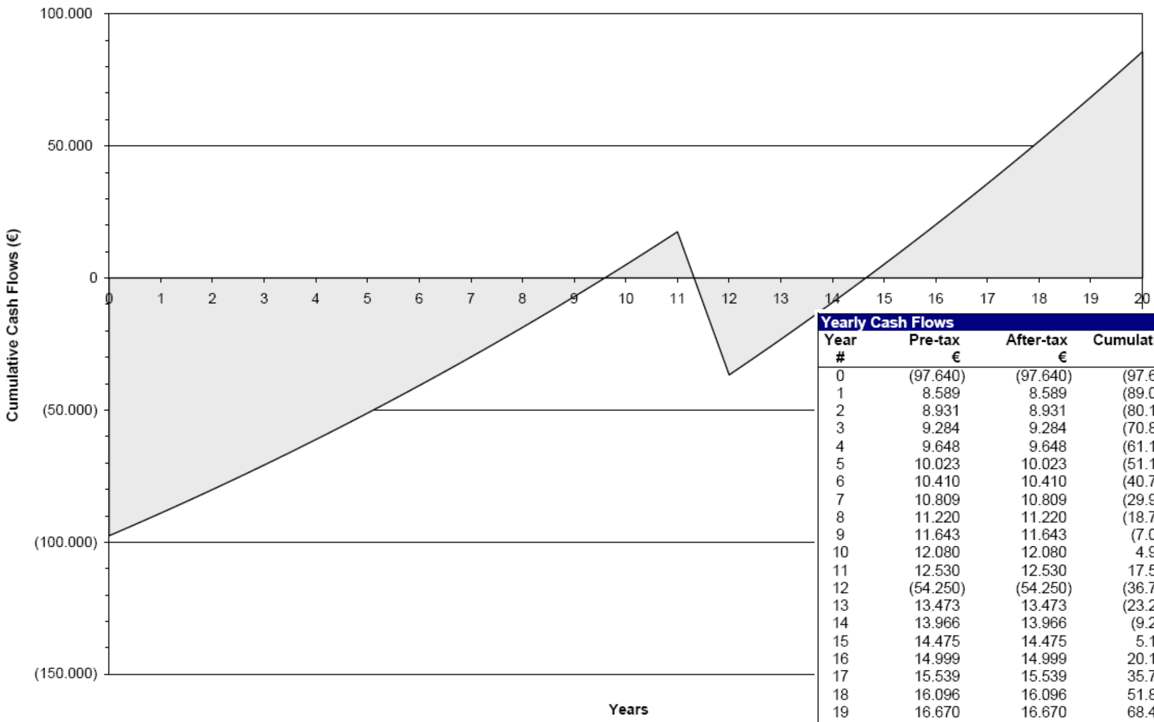
Financial Feasibility

			Calculate energy production cost?	yes/no	No
Pre-tax IRR and ROI	%	6,3%			
After-tax IRR and ROI	%	6,3%	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	10,3			
Year-to-positive cash flow	yr	9,6	Project equity	€	97.640
Net Present Value - NPV	€	7.367	Project debt	€	146.459
Annual Life Cycle Savings	€	617	Debt payments	€/yr	15.476
Benefit-Cost (B-C) ratio	-	1,08	Debt service coverage	-	1,55

Cumulative Cash Flows Graph

Photovoltaic Project Cumulative Cash Flows
Commercial Building, Kötschach-Mauthen,Austria

Renewable energy delivered (MWh/yr): 32,641 — Total Initial Costs: € 244.099 — Net average GHG reduction (t_{CO2}/yr): 31,18



Yearly Cash Flows

Year #	Pre-tax €	After-tax €	Cumulative €
0	(97.640)	(97.640)	(97.640)
1	8.589	8.589	(89.051)
2	8.931	8.931	(80.120)
3	9.284	9.284	(70.836)
4	9.648	9.648	(61.188)
5	10.023	10.023	(51.165)
6	10.410	10.410	(40.755)
7	10.809	10.809	(29.946)
8	11.220	11.220	(18.726)
9	11.643	11.643	(7.083)
10	12.080	12.080	4.997
11	12.530	12.530	17.527
12	(54.250)	(54.250)	(36.723)
13	13.473	13.473	(23.250)
14	13.966	13.966	(9.283)
15	14.475	14.475	5.191
16	14.999	14.999	20.190
17	15.539	15.539	35.728
18	16.096	16.096	51.824
19	16.670	16.670	68.494
20	17.261	17.261	85.755

IRR and ROI: 6,3% — Year-to-positive cash flow: 9,6 yr — Net Present Value: € 7.367

The conclusion of this economic feasibility study is that this project is economical feasible. It is shown that an additional electricity amount of 32.6 MWh/a can be produced at the Town Hall by means of solar energy. The total initial costs come to 244.099 €, the year to positive cash flow is 9.6 years and the net present value is 7.367 €. Due to replacement of fossil based mobility consumption by PV driven electro cars the green house gas reduction is 31.18 tco_2/year with a base line 100 % gasoline.

4.3.6 Solar Powered Mobility

The solar power supply is feasible for so-called "LEMs" (light electric mobil) with low power requirements. LEMs require typically less than 10 kWh per 100 km. Some models are available in the market, and the energy can be supplied by the so-called "solar-net". The solar-net consists of solar power stations feeding the energy into the grid and charging stations for recharging the vehicles batteries. This idea or model is the basis for the "Park & Charge®" system of public charging stations for electric vehicles, which at present exists in Switzerland, Germany, Austria, France and Italy[51]. The Park & Charge®-system consists of simple power outlets 230V 16 A and all necessary fuses and protection circuits in a metal box with key. The initial costs for 3 outlets in a station are 1.188 €. The definition of the solar vehicle at present is a vehicle, which has at home, or elsewhere, a solar power source (or similar sustainable source from wind or water power etc.) which delivers the required amount of energy to recharge the batteries. The energy is fed into the grid system and can be taken out elsewhere from the system.

According to the "Pflichtenheft für die Konstruktion von Solar- und Elektroautos"[52] the energy consumption should be less than 10 kWh per 100 km, based on a vehicle carrying two persons of 75 kg each with an average speed of 50 km/h on flat roads. The maximum speed should be 100 km/h, the range also 100 km at 50 km/h speed and with 50 % load. The energy requirements are so low that they can be supplied by PV panels. The PV system at the Town hall will produce 32.640 kWh annually, which should be sufficient for 130.000 to 300.000 km. With Li-Ion or Li-Poly batteries the capacity of a battery used by a solar car (e.g. Peugeot 106 electric) should be at least 50 kWh or more than 350 km range. The "DLR - Deutsches Zentrum für Luft und Raumfahrt" investigated several drive systems using renewable sources of energy, like hydrogen from various sources, methanol, and the conventional electric vehicle with batteries. The primary energy requirements were the lowest for the electric car with batteries using around 25 kWh only per 100 km, in comparison to hydrogen supplied cars using 52 to

[51] R. Reichel R. Why Solar Powered Mobility?, Bundesverband Solarmobil e.V. (German Solar Car Federation) www.solarmobil.org 22.12.2007

[52] Pflichtenheft für die Konstruktion von Solar- und Elektroautos, September 1990, Hessisches Ministerium für Wirtschaft und Technik, Wiesbaden, ISBN 3-89205-084-8

116 kWh per 100 km[53].and an average gasoline driven car with 80 kWh per 100 km. One solar mobile can save 8.25 MWh/a due to lower primary energy requirement and is based on renewable local produced energy carriers.

5 Conclusion

As a result the final energy demand of Kötschach-Mauthen with 102 GWh/a for heat, electricity and mobility is in contrast to the current local renewable energy production of 75.6 GWh/a (fig. 5-1). Therefore from the existing renewable energy plants in the community, 343 % of the electricity demand, 55 % of the heat demand and 0 % of the fuel demand are met by renewable energy carriers. The power production in the community is the strongest sector of renewable energy even for export, whereas the fuel production sector is today near to zero and needs a long term perspective. Due the technical developments of the past years the highest potential to fulfil energy self sufficiency in the near future is within the heat sector. The total gradient of energy self sufficiency of the community, as a ratio between local final energy demand and final energy production based on local resources (ESS-ratio) can be calculated with 74.2%.

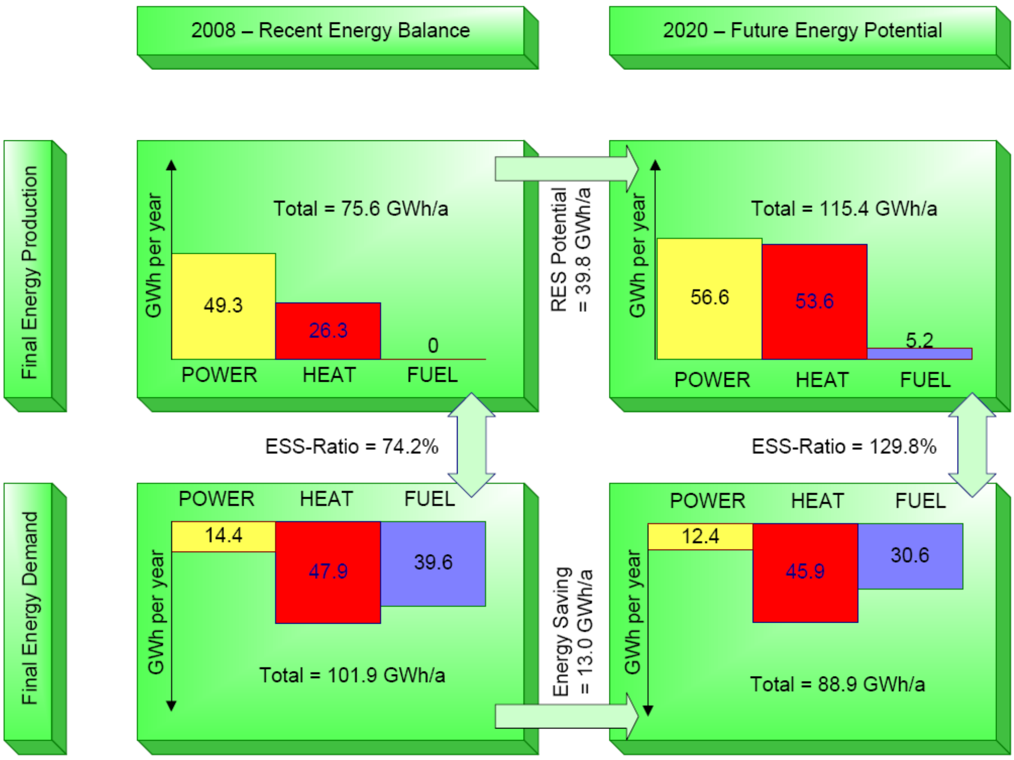


fig. 5-1: Final energy demand and renewable energy production 2008 and potentials for the future energy production based on local resources and for energy efficiency actions until 2020

[53] Carpetis C. Globale Umweltvorteile bei Nutzung von Elektroantrieben mit Brennstoffzellen und/oder Batterien im Vergleich zu Antrieben mit Verbrennungsmotor, DLR, Deutsches Zentrum für Luft- und Raumfahrt, STB-Bericht Nr. 22, April 2000

The most important conclusion of the evaluation of future additional potentials for renewable local based energy production with 39.8 GWh/a and for energy saving actions with 13 GWh/a is that a self-sufficient energy supply of the community of Kötschach-Mauthen is until 2020 up to 129.8%, ESS-ratio 115.4 GWh/a renewable final energy production to 88.9 GWh/a local final energy demand, possible.

The conclusion out of this comparison is that the specific heat consumption in Kötschach-Mauthen is comparable good, whereas the heat self sufficiency is average compared to the communities of Güssing and Mäder. Kötschach-Mauthen has actually no transportation fuel production possibilities and has an average specific fuel consumption but is in a position for electricity export. The highest potential to fulfil energy self sufficiency in the near future is in the heat sector. In the mobility sector Kötschach-Mauthen, in comparison to the community of Mäder, has to reduce the specific consumption at least by half of the actual amount and has to shift fuel demand to electrical driven solutions due to the surplus of electrical power. In order to fulfil all demands the power production should be further developed.

It is however, also important to note that the energy-self-sufficiency can only be reached provided with sustainable handling and use of resources and that technologies to support the process are carefully considered. Due to the intense construction of small hydro power in the past in the community of Kötschach-Mauthen there is beside one major exception and some upgrading measures nearly no realisable potential to further develop of hydro power projects. The wind situation allows construction of further wind turbines in the narrow mouth of Lesach valley and on Plöckenpass. To reach energy-self-sufficiency for heat in 2020 the actual forest area of the community is sufficient for production of energy carriers for the heat local demand. Referring to the solar hours per day in December the best places to install solar energy production units are in the centre of Kötschach-Mauthen (at the town hall and at the production side of the company eco) and in the village Laas.

The information resulting from the energy program until 2020 can furthermore be an important catalyst for decision makers. Overall this project is especially important in highlighting these results, given that the appropriate basic conditions crucial to implement the "Energy-self-sufficient Kötschach-Mauthen" actually exist. Already during the project local people, as well as local and regional politicians took on this subject. So the project *"Energy-selfsufficient community Kötschach-Mauthen" has* already initiated discussions and impulses in Carinthia. The idea of an *energy-self-sufficient community* is also emanating to other communities and is now under discussion for the whole region of Carinthia.

In a next step specific planning for feasible "energy lighthouse projects" for industrial heat production, additional wind power production and for solar mobility as examples for possible actions for the production of 7.6 GWh/a, raising the degree of energy self sufficiency from 74% to 82 %, are described for the achievement of energy-self-sufficiency.

The consequences for further development of the Energy Program until 2020 are personal and structural capacity building within the platform “energie:autarkes Kötschach-Mauthen” like the Samsø Energy Academy or the European Centre for Renewable Energy in Güssing and to involve the population step by step to the proposed energy efficiency actions by:

- Workshops in schools and renewable energy exhibition in the town hall
- Public participation in the investment of the PV-solar power plant
- Adventure around the wind turbine park and the planned small hydro power along the river Gail
- Solar mobility with electro cars for tourism and local traffic
- Renovation and reinstallation of the public small hydro power trail Hydro-Solar
- Information for hotels about solar hot water preparation and solar heating
- Installation of local heating systems in the villages St.Jakob, Strajach, Laas and Weidenburg
- Local energy guide for inhabitants and tourists
- Intensifying biomass harvest in local forests through excursions for transfer of know-how
- Mobility concept for the community and mobility office for commuters
- Renewable energy days for all building owners
- Networking with other communities concerning energy self sufficiency even using e5-platform

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7 Annexes

7.1 List of Figures

7.2 List of Tables