MSc Program Renewable Energy in Central and Eastern Europe

The Potentials of Renewable Energy Sources in South Tyrol – Assessment of their Realizable Potential up to 2050

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

supervised by
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24.09.2010, Bozen

Affidavit

I, **Sabine Schwarz**, hereby declare

1. that I am the sole author of the present Master Thesis "The Potentials of Renewable Energy Sources in South Tyrol – Assessment of their realizable Potential up to 2050", 250 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.

Bozen, _______________ ___________________________

Date Signature

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Abstract

The work gives an overview about the current situation of renewable energy sources in South Tyrol, the northern province of Italy. In the main part the potentials of renewable energy sources until 2050 are analysed in order to evaluate the possibility of reaching “Energy Autarky” including transportation.

The methodology used is a literature and information research about the current data of renewable energy sources in South Tyrol.

The evaluation of the potentials for renewable, local energy production in the future was conducted by the use of literature, information research in the internet, personal interviews with responsible people in the field of renewable energy, with local energy experts and by own analysis, elaborations and calculations. The obtained information is presented in the main part.

The most important conclusion from the potential analysis is that in South Tyrol a 100% renewable “Energy Autarky” is not possible until 2050. The ratio between local energy consumption and local renewable energy production (ESS) will rise until 2015 from 64% to 69%, until 2020 to 91% and until 2050 to 96%. The calculation includes electricity, heat and mobility sector as well as energy efficiency and energy savings in residential buildings and private households.

The results obtained provide a comprehensive input for future policy formulation and implementation.

Executive Summary

Due to its favourable site conditions, its autonomous power and peculiarities of the economic structure, South Tyrol has good preconditions to become a leader in the energy and climate policy. The autonomous power and a certain predictability of the public budget facilitate the decisions for an expansion of renewable energy sources. The high sensitivity of the region regarding climate change (water availability, permafrost, natural hazards, depending on climatic conditions in the agriculture and tourism, scarce settlement area) require a particularly efficient and consciuos use of energy sources and to substitute continuously fossil fuels in daily live.

The three pillars of an energy model that can lead South Tyrol towards energy autarky by 2050 are intelligent use of energy, improving energy efficiency and developing renewable energy sources. According to the new local Climate Strategy 2050, the share of renewable energy of the total energy consumption in South Tyrol amounted to 59% in 2007 (without transport), up to 2020 it will amount to 75% and up to 2050 the aim will be to reach almost energy autarky in South Tyrol (over 90% of the energy consumption covered by renewable energy sources excluded transport and included energy saving measures).

In order to achieve those ambitious goals, numerous innovations and coordinated actions are needed in various sectors. Programs such as support schemes, training and information initiatives as well as an appropriate legal framework are necessary.

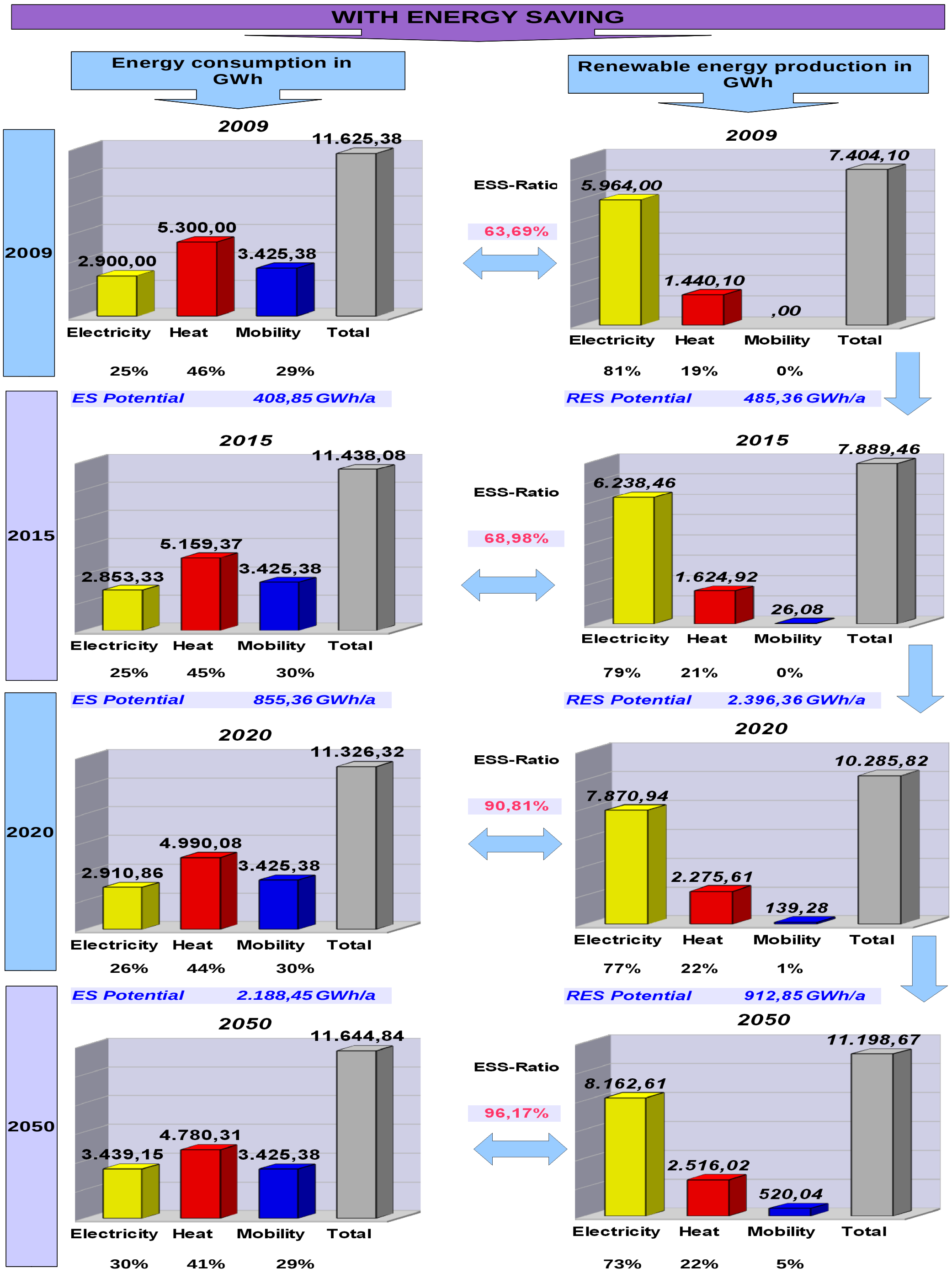
In this Master's Thesis, the realizable potentials of the renewable energy sources in South Tyrol were analysed including energy efficiency and saving measures in residential buildings and private households.

The investigation about realizable potentials of the alternative sources hydro power, biomass, biogas, photovoltaic, solar thermal, wind and geothermal and energy efficiency and energy saving measures in residential buildings and private households led to the following results as shown in the figure below:

- The ratio between local energy consumption and local renewable energy production (ESS) was 64% in 2009 (transportation included);
- Until 2015 the ESS ratio is expected to rise from 64% to 69%, until 2020 to 91% and until 2050 to 96%.

The long-term potential up to 2050 is elaborated in detail for photovoltaic, solar thermal, energy efficiency and energy saving in residential buildings and private households and for the electro-mobility sector.

Figure A: Potentials of renewable energy sources in the period of 2009-2050 (with energy saving measures) – Overview



ESS – Ratio between local energy consumption and local renewable energy production
ES – Energy saving
Source: Own elaboration

Electricity

The following renewable energy sources have the greatest potential in the electricity sector (2,199 GWh_e/year in total):

- Hydro power with a potential of 1,414 GWh_e/year;
- Photovoltaic energy production with a potential of 438 GWh_e/year;
- Wind power with a potential of 131 GWh_e/year;
- Followed by vegetable oil, biogas and geothermal energy with 74 GWh_e/year, 72 GWh_e/year and 70 GWh_e/year.

Three aspects should be taken into consideration:

1. The realization of hydro power and wind power plants is costly in terms of time in a technical and administrative point of view. A positive outcome of the Environmental Impact Assessment (EIA), in which it is necessary to examine every concerned environmental aspect and to get construction permits are preconditions for the realization of such projects.
2. Due to the actual promotion schemes it is economically feasible to invest in photovoltaic facilities, but without that financial support the profitability of photovoltaic projects is reached only after 8-12 years.
3. A vegetable oil CHP (combined heat and power) plant must deal with the following aspects: Firstly, it has to fulfil sustainability criteria such as for transport, cultivation and utilization of heat and secondly, the profitability of such plants highly depends on the price of raw materials (vegetable oil) and feed-in-tariffs. In the medium and long term it is difficult to foresee such parameters.

Furthermore, in this thesis two storage methods are explained in more detail: the electromechanical storage by pumped storage hydro power systems and the electrochemical storage by hydrogen. With those storage possibilities, the region can achieve an overall advantage and better exploit its water potential and geological situation. South Tyrol is able to autonomously produce the electricity required over the year, but for peak loads the country depends on electricity imports. Both storage technologies could be useful to produce and store energy for peak loads from renewable energy sources. In the Climate Strategy 2050 is foreseen to investigate and develop such concepts until 2015.

Heat

The following renewable energy sources have the greatest potential in the heat sector (1,076 GWh_{th}/year in total):

- Geothermal energy with a potential of 520 GWh_{th}/year (use of heat pumps, use of the tunnel water of the Brenner Base Tunnel and seven deep geothermal plants);
- Solar thermal energy with a potential of 361 GWh_{th}/year;
- Followed by biomass (small installations of wood chips, pellets and wood logs), vegetable oil and biogas with a potential of 97 GWh_{th}/year, 80 GWh_{th}/year and 18 GWh_{th}/year.

Also in the heat sector two aspects should be considered:

1. The realization of geothermal plants is, from a technical and administrative point of view, costly in terms of time. A positive outcome of the Environmental Impact Assessment (EIA) and construction permits are necessary for the realization of such projects. The construction permits and the EIA for the seven deep geothermal plants are available but the industry is doubtful about the successful realization of this project. The probability to achieve the estimated heat and electricity production by the seven deep geothermal plants is unfortunately low, nevertheless this potential is included in the study.

2. The potential of biomass is exhausted to some extent. The existing 66 biomass district heating plants use only one third (402,000 lcm – loose cubic metre) of their biomass supply from local forests, two thirds (804,000 lcm) of the wood chips were imported in 2009. The additional amount that can be harvested with respect to a sustainable management is about 718,798 lcm wood chips, which is not enough to cover the whole demand by local wood chips for the 66 biomass district heating plants in operation in 2009.

Mobility

In the mobility sector, the main possibilities to switch from fossil to renewable sources are the use of hydrogen as alternative fuel and the switch to electric cars. The construction of a *hydrogen production* plant in Bozen and the distribution and use of hydrogen, initially for the public transportation and later on for private cars, is already in construction. Up to 2015, the production of hydrogen in the amount of 5.5 GWh/year is estimated.

For *electric-mobility* it is assumed that:

- 2% of the registered cars in South Tyrol will be converted into electric cars until 2015, which are driven by electricity produced from the renewable energy sources with a total amount of 20.58 GWh/year;
- 13% up to 2020 with a total amount of 133.78 GWh/year;
- 50% up to 2050 with a total amount of 514.54 GWh/year.

Energy efficiency and saving

The main potentials analysed for energy efficiency and energy saving in residential buildings and private households can be summarized as follows:

1. The net saving possibilities in the heat sector (energy efficiency and saving measures in the residential building sector):
    - Up to 2015: 140.63 GWh/year;
    - Up to 2020: 169.29 GWh/year;

- Up to 2050: 209.77 GWh/year.

2. The saving potentials in the electricity sector (energy saving measures in private households e.g. exchange of lamps, substitution of old electric devices and avoidance of standby losses and street lighting):

- Up to 2015: 81 Gwh/year
- Up to 2020: 81 GWh/year and 9 GWh/year for street lighting
- Up to 2050: 0 GWh/year

In order to ensure a sustainable development, it is also important to consider the impact on agriculture, nature protection and natural resources, when increasing the use of renewable sources.

List of Content

List of Tables

List of Figures

List of Abbreviations

C – Celsius

CH – ClimateHouse

BMDH – Biomass District Heating Plant

€ – Euro

EIA – Environmental Impact Assessment

ES – Energy saving

ESS – Ratio between local energy consumption and renewable energy production

EU – European Union

GDP – Gross domestic product

GLS – General lighting service

HDR – Hot dry rock

KWh – Kilowatt hour (one thousand watt hours)

MWh – Megawatt hour (one million watt hours)

GWh – Gigawatt hour (one billion watt hours)

KW – Kilowatt (one thousand watt)

MW – Megawatt (one million watt)

GW – Gigawatt (one billion watt)

KW_e – Kilowatt electric

MW_e – Megawatt electric

GW_e – Gigawett electric

KW_{th} – Kilowatt thermal

MW_{th} – Megawatt thermal

GW_{th} – Gigawatt thermal

KWh_e– Kilowatt hours electric

MWh_e – Megawatt hours electric

GWh_e – Gigawett hours electric

KWh_{th} – Kilowatt hours thermal

MWh_{th} – Megawatt hours thermal

GWh_{th} – Gigawatt hours thermal

l – Litre

lcm – Loose cubic metre

m – Metre

m^2 – Square metre

m^3 – Cubic metre

Mtoe – Million tons of oil equivalents

ORC – Organ Rankine Cycle

Prad a. Stj. – Prad am Stilfserjoch

PSPP – Pumped-Storage Power Plant

PV – Photovoltaic

s – Second

scm – Solid cubic metre

V.A.T. – Value added tax

W – Watt

1 Introduction

South Tyrol is an attractive region with very favourable natural conditions: rivers, forests, many sunny days and fertile soils. The more it is important that these resources are used in the sense of a sustainable energy supply, which guarantees the preservation of an intact ecosystem for the next generations.

Nowadays it stays in a better position with respect to the use of renewable energy sources compared to the national level. The difference between the small region and the state is, that it takes advantage of the existing opportunities such as hydro power, biomass and solar, while Italy lag behind in particular in the field of solar thermal and biomass.

The work gives information about the population development, the energy consumption, the energy prices, the legislation about the promotion schemes and the actual situation of the use of renewable energy sources and the application of energy saving measures. In parallel, similar regions such as Bavaria and Tyrol will be described.

The main part is focused on the analysis of the still exploitable potential of renewable energy sources and the efficiency and saving possibilities in residential buildings and private households with their drivers and barriers. The results will be summarized at the end in order to obtain an outlook for the future.

1.1 Motivation

South Tyrol takes part in a suitable overall political situation in the European Union and the Arge Alp, Association of Alpine countries, founded on 12 October 1972 in Tyrol, to solve problems in the cultural, social, economic and environmental field in good neighbourly way. The aim is to increase the awareness of shared responsibility for the alpine habitat, to promote contacts between the citizens, to strengthen the position of the countries, regions, provinces and cantons, and to work together with other institutions to contribute to the cooperation within Europe. The Arge Alp consits of 10 regions in Germany, Austria, Italy and Switzerland.

The regional political environment is very favourable and the natural conditions and resources are ideal in South Tyrol. The share of renewable energies is increasing, but the energy demand is growing as well. Another important aspect not to forget is the high innovation potential in the energy-efficient building sector (e.g. ClimateHouse). Italy is still a country with many exploitable possibilities in the field of renewable energy and the northern province can function as bridgehead.[1]

The diverse benefits of renewable energies give the motivation to conduct this analysis which are:

- Renewable / growing again;
- Locally available;
- Local / regional value added;
- Security of supply;
- Independence;
- Crisis-proof;
- Stable prices;
- Short transportation routes;
- Economically for the consumer and the producer;
- New jobs;
- Neutral emission;
- Sustainable for the environment and the climate;
- Ability to interlink.

1.2 Objective

The main aim of this study is to give an overview about the actual situation of the renewable energy sources in South Tyrol and to analyse the potentials regarding those energy sources. The effort will be concentrated mainly on hydro power, biomass, biogas, solar (photovoltaic and solar thermal), wind, geothermal and

1 Presentation of Dr. Michl Laimer on 27.11.2009, http://www.biomasseverband-ooe.at/cms/upload/aktuelles_09/generalversammlung/Vortrag_Michl_Laimer.pdf, download 03.06.2010

energy efficiency and energy saving in residential buildings and private households. An important investigation about the drivers and barriers is also included.

The study evaluates the possibility to reach the "Energy autarky" (traffic included). The results obtained can be used for policy formulation and implementation.

1.3 Citation of Main Literature

The main literature used is the following:

General statistical sources:

- ISTAT – National Institute of Statistic (Italy);
- ASTAT – Regional Institute of Statistic (South Tyrol);
- EUROSTAT – European Institute of Statistic;
- EEA – European Environment Agency.

Sources for legislation, regulatory and data about renewable energy:

- Ministero dello Sviluppo economico (Ministry of Economic Development);
- Autonome Provinz Bozen (Autonomous Province of Bozen):
  - Abteilung für Wasser und Energie (Department of Water and Energy);
  - Amt für Stromversorgung (Office of Electricity supply);
  - Amt für Energieeinsparung (Office of Energy Saving);
  - Bezirksamt für Landwirtschaft Bruneck (District Office of Agriculture Bruneck);
  - Abteilung für Landwirtschaft (Department of Agriculture);
  - Abteilung für Forstwirtschaft (Department of Forestry);
  - Amt für Handel und Dienstleistungen (Office of Commerce and Service);
  - Hydrografisches Amt (Meterological Office).

Other sources:

- KlimaHaus Agentur (ClimateHouse Agency), Bozen;
- EURAC European Academy of Bozen/Bozen: Institute for Renewable Energy;
- TIS innovation park, Bozen;
- Biomass Association in South Tyrol;

- Energy forum South Tyrol;
- Terna – Rete elettrica nazionale (National electricity distribution company);
- AEEG – Autorità per l'energia elettrica e il gas (Authority for electricity and gas);
- GSE – Gestore servizi elettrici (promotion of the development of renewable energy sources in Italy);
- ENEA – Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (Italian National Agency for New Technologies, Energy and Sustainable Economic Development);
- GME – Gestore dei mercati energetici (management of the Electricity Market);
- Hydro power generation companies SEL AG (shareholders: the Autonomous Province of Bozen with 93.88% and SELFIN GmbH with 6.12%), Hydros, Enel, Seledison
- and much sources were used.

1.4 Structure of Work

The first chapter provides a description of the current situation of the renewable energy sources in South Tyrol, which are classified into electricity, heat, mobility and gives current information about energy efficiency and energy saving about energy efficiency and energy saving in residential buildings and private households. At the beginning of the first chapter general information about the location, the area, the days of sun, the mean temperature, the mean velocity of the wind and the development of the population are given, followed by a summary of the energy production and energy demand for electricity, heat and fuels.

In the second chapter the potentials of renewable energy sources will be analysed. First of all the local conditions (e.g. mountains, forest, agriculture, water, solar, etc.) will be described and the most important facts about renewable energy of similar regions like Bavaria and Tyrol which can be compared with South Tyrol, will be presented. Also information about the energy and raw material prices, the investment costs of the facilities and plants, the supporting schemes and the local Energy Program will be given in the initial part.

In the main part of the second chapter the potentials of the renewable energy sources in South Tyrol, divided into electricity, heat and mobility, will be analysed. Also a detailed investigation about the potentials of energy efficiency and energy saving in residential buildings and private households will be given at the end, through which the “Energy Autarky” is possible at all. All the results obtained will be summarized at the end of this chapter.

In the last chapter the most important conclusions of the potential analysis about renewable local energy production and energy efficiency and energy saving in residential buildings and private households will be presented and an outlook for the future will be given indicating the main drivers and barriers for the development of the renewable energy sources in South Tyrol.

2 Methodology

This work consists of a literature and information research about the current data of renewable energy sources in South Tyrol. Various sources were used to describe the current situation of renewable energy sources on local level, as indicated in the previous chapter. The evaluation of the potentials for renewable local energy production and the energy efficiency and energy saving in residential buildings and private households was conducted by the use of literature, information research again, personal interviews with responsible people in the renewable energy field and with local energy experts and by own analysis and calculations. The obtained information were then elaborated and presented in the main part.

3 Current Situation

In this chapter the current situation of the renewable energy in South Tyrol is explained. A distinction is made between the three categories electricity, heat and mobility. In each section the most important facts are described. At the beginning general information about the location, the area, the days of sun, the mean temperature, the mean velocity of the wind and the development of the population are given, followed by a summary of the current situation about the renewable sources in the electricity, heat and mobility sector and the energy efficiency and energy saving in residential buildings and private households.

3.1 General Data of Italy

Italy must promote the use of renewable energy according to the international standards (Kyoto Protocol) and the European directives (Climate package 20-20-20). It offers - similar to other countries - attractive funding instruments such as green certificates, feed-in tariffs and tax abatements in order to meet the EU targets by 2020 which are:

- To reduce the greenhouse gases by 20% compared to the level of 1990;
- To increase the share of renewable energy in energy consumption;
- To reduce energy consumption by 20% of projected 2020 levels by improving energy efficiency;
- To replace 10% of the fossil fuels by biofuels.

The National Action Plan in Italy for renewable energy sources[2] contains the targets listed below up to 2020 to cover certain shares of final energy consumption by renewable energy sources which are:

- A total share of 17% on final energy consumption;
- A share of 10.14% in the transport sector;
- A share of 26.39% for electricity;
- A share of 17.09% for heating and cooling and
- taking into account the effects of energy efficiency and energy saving measures on the final energy consumption with an expected amount of 133 Mtoe until 2020.

ISTAT, the National Institute of Statistics, published an overview about the Italian energy system in 2009 with references to the last decades.[3] The analysis is based on the data received from the Ministry of Economic Development, ENEA and Terna.

ISTAT states Italy to be still far from those goals. In 2009 the fossil fuels had a predominant share accounting for 41% of the gross domestic consumption followed

2 Ministry of Economic Development: National Action Plan for renewable energy sources in Italy, 30th June 2010

3 ISTAT, Rapporto annuale sulla situazione del Paese nel 2009, p. 221 ff., Roma, 2010

by natural gas (35.5%), renewables (10.7%) and solid fuels (7.4%). In comparison to the previous year the availability of energy from renewable sources increased by 1.8 percentage points, from natural gas it decreased by 0.9 percentage points and from solid fuels it decreased by 1.3 percentage points. The share of fossil fuels did not change.

The process of substitution between the energy sources is more evident compared to 2000, particularly among fossil oil products where the use decreased significantly (-8.5 percentage points), +while the share of renewables increased by 3.8 percentage points and of natural gas by 4.1 percentage points. There is a stable share of solid fuels and electricity.

The total production of electricity by traditional thermal generation decreased from 81.2% in 2004 to 76.4% in 2009 and the renewable energy sources increased from 18.8% 2004 to 23.6% in 2009 (the European target is set at 25.0% in 2010).

According to the report about the renewable energy sources 2010 of ENEA[4] some renewable sources have achieved very encouraging developments last year, thanks to high financial incentives. The new installed capacity of photovoltaic was 711 MWp in 2009 and was considerably higher in comparison to the previous year (458 MWp), exceeding 1 GWp in total.

Italy stays on the third position in Europe in terms of new installed capacity (1,113 MW) and accumulated capacity (4,850 MW) of wind power in 2009.

Referring to other renewable sources, there are still considerable delays. In particular solar thermal and biomass lag behind in which Italy is still far from exploiting the available potential.

3.2 General Data of South Tyrol

South Tyrol is situated in the North of Italy. The official name is Autonomous Province of Bozen with the main capital Bozen. It has a continental climate and the mean annual temperature depends on the altitude of the localities, for example it lies between 12.2° C in Bozen (260 m above sea level) and 5.5°C in Toblach (1,250

4 ENEA, Le Fonti Rinnovabili 2010, p. 191, Roma, 2010

m above sea level). In the table below some general figures are indicated about the number of inhabitants, the area, the days of sun per year, the annual mean temperature and the mean velocity of the wind.

Table 3 - 1: *Number of inhabitants, the area, the GNP, the unemployment rate, the days of sun per year, the annual mean temperature and the mean velocity of the wind in South Tyrol*

Number of inhabitants	503,434 (31.12.2009)[5]
Area	7400 km², 48% forest
Gross National Product (GNP)	12.8 billion Euro
Unemployment	2.6%
Days of sun per year	300 - 315
Annual mean temperature	2°C
Mean velocity of the wind	1-2 m/s in the valleys and 5-7 m/s on the mountains

5 ASTAT info n°15, Bevölkerungsentwicklung 4. Trimeste r 2009, Bozen, 29.03.2010

Fig 3 - 1: Location of South Tyrol in Italy

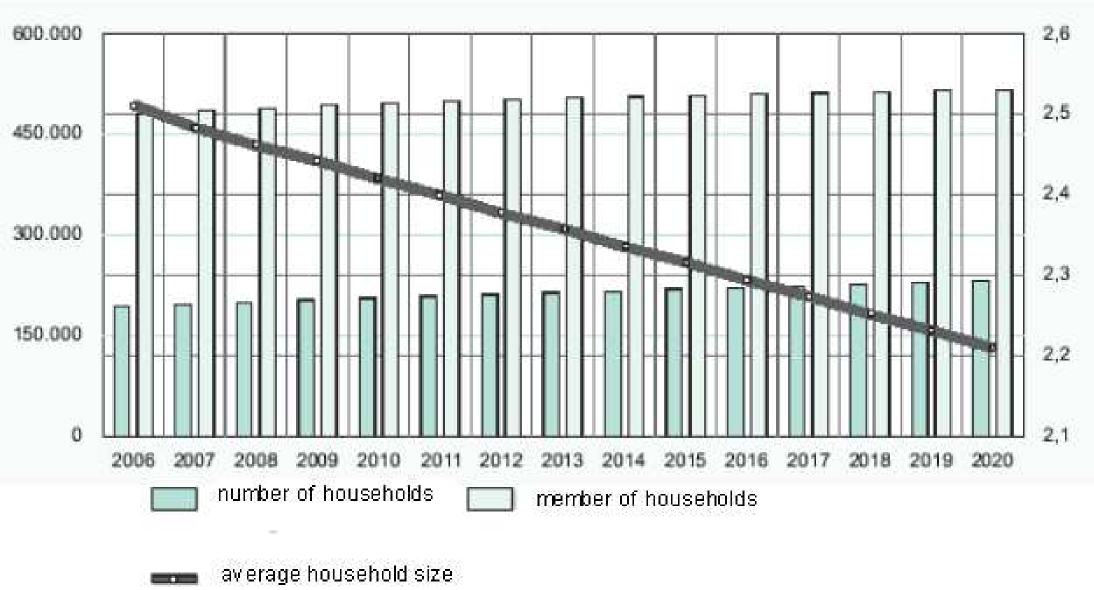
Energy consumption and greenhouse gas emissions are closely linked to demographic changes. The development of the resident population, its structure and distribution, the number of dwellings and households influences the energy needs of a region.

The following demographic forecasts are based on the analysis of the Regional Institute of Statistics, ASTAT, in Bozen.[6]

In 2007 a total of 493,910 inhabitants lived in South Tyrol. For the year 2020 ASTAT anticipates a total of 521,960 inhabitants, which live in 231,559 households (Fig 3 - 2). This leads to a growth of 5.68% for the population and 17.68% for the households. The number of residents per household was 2.51 in 2007 and will be 2.26 in 2020. In South Tyrol the number of households increased more than the population in recent years. Thus, the average number of members of a household declined slightly (Fig 3 - 2). The trend towards smaller household sizes - based on the number of persons - will continue and it is likely that energy consumption will increase more than in the past, if energy saving measures will not be adopted.

6 ASTAT Schriftenreihe n. 136, Bevölkerungsprognose: Haushalte und Wohnungsbestand in Südtirol – 2006-2020, Bozen, 2008

Fig 3 - 2: Number of households, member of household and average household size – 2006-2020



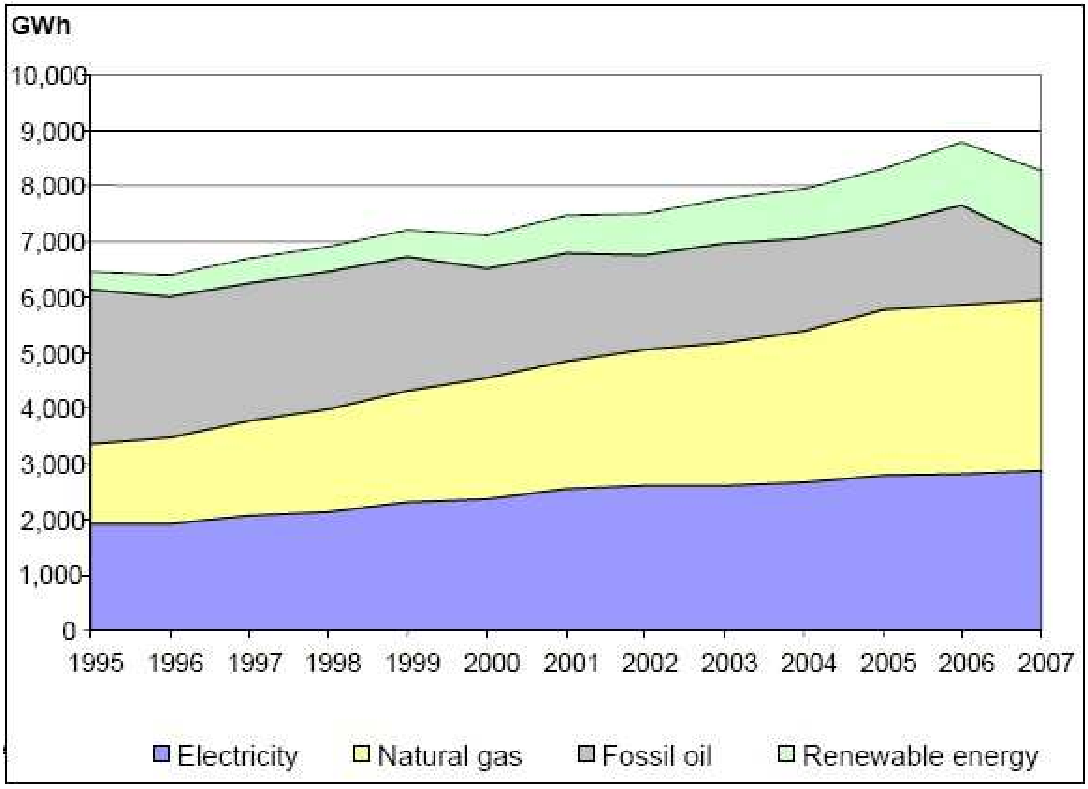
Source: ASTAT Schriftenreihe n. 136, Bevölkerungsprognose: Haushalte und Wohnungsbestand in Südtirol – 2006-2020, p. 14, Bozen, 2008

3.3 Summary of the Current Situation

In this section, all relevant data about the current situation of the renewable energy sources are summarized, which serves as input for the assessment of the future potential. A look at the development in the last years shows, that the energy consumption (electricity, natural gas, oil and renewable energy sources) has increased by 2.1% on average annually (Fig 3 - 3). Since 1995 the consumption increased from 6,446 GWh to 8,268 GWh in 2007 without traffic.[7]

7 Climate Strategy, Energy South Tyrol 2050, p. 45, draft version 01.08.2010

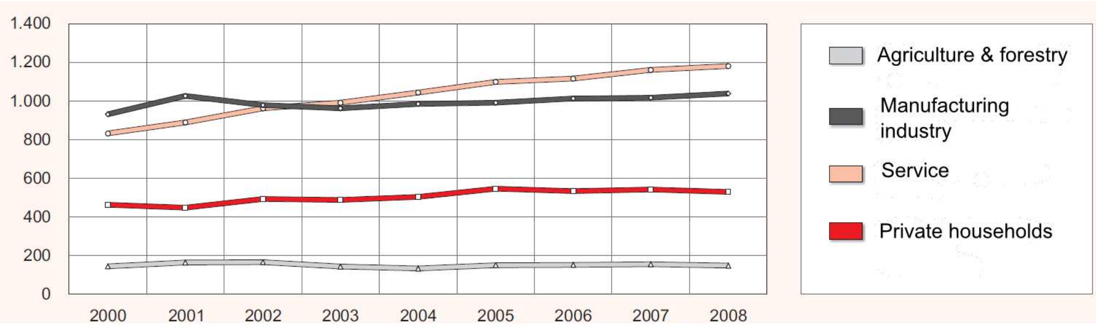
Fig 3 - 3: Energy consumption in South Tyrol (without traffic) per year – 1995-2007



Source: Climate Strategy, Energy South Tyrol 2050, p. 45, draft version 01.08.2010

The electricity consumption in the service sector grew by 42.0% in 2008 with respect to 2000 (Fig 3 - 4). The tertiary sector overtook the manufacturing industry in 2003 which increased by only 11.6%. The second largest growth rate had the sector of the private households with 14.3%. The agriculture and forestry sector spent the lowest amount for electricity, which was 148 GWh in 2008 and had the lowest growth rate of 2.5% in the eight-year period.

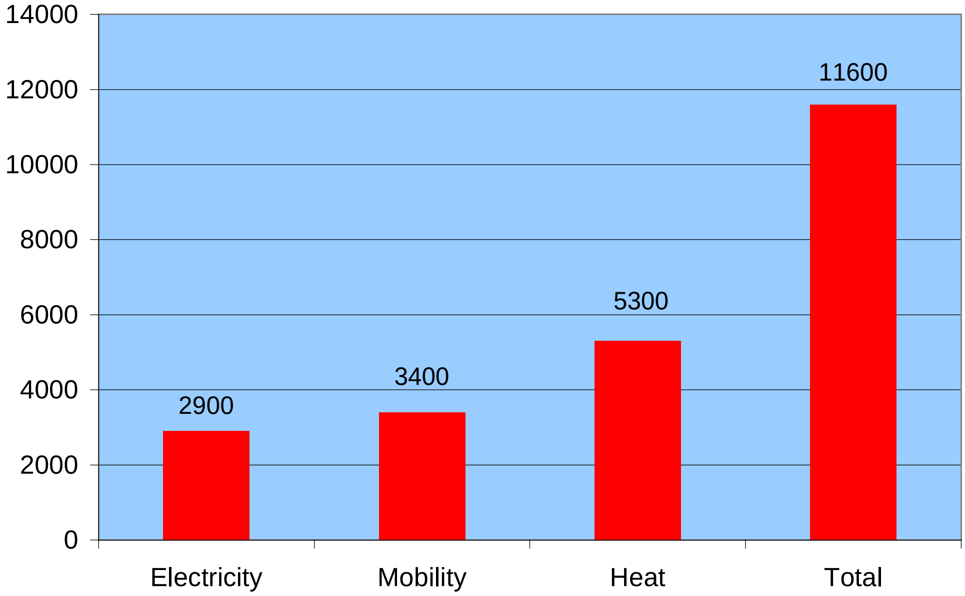
Fig 3 - 4: Electricity consumption by sector in GWh – 2000-2008



Source: ASTAT info n. 45, Verbrauch von elektrischer Energie 2008, Bozen, August 2009

According to ASTAT[8] the annual electricity consumption amounts to about 2,900 GWh, the consumption for heat about 5,300 GWh and for fuel about 3,400 GWh.

Fig 3 - 5: Energy consumption by electricity, heat and mobility in GWh – 2009



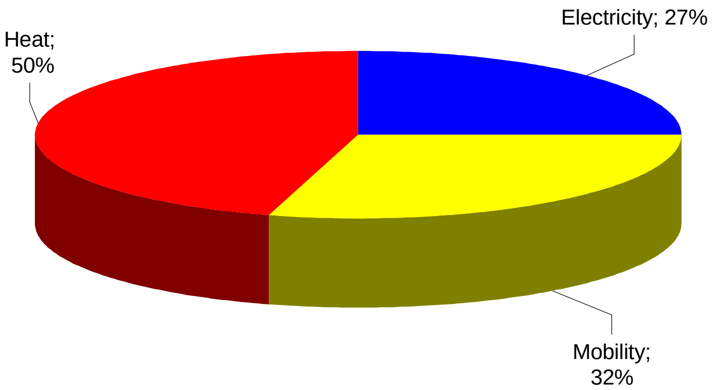
NB: Values rounded.

Source: ASTAT, Amt für Energieeinsparung, Climate Strategy 2050

8 ASTAT info n. 45, Verbrauch elektrischer Energie 2008, Bozen, August 2009 and ASTAT info n. 57, Fossiler Energieeinsatz 2005-2008, Bozen, October 2009

50% of the energy is used for heat, 27% for electricity and 32% for fuel as shown in the next figure.

Fig 3 - 6: Energy consumption by electricity, heat and mobility in %



Source: ASTAT, Climate Strategy 2050

Approximately 97.2% of the electricity production is generated by hydro power (Table 3 - 2). Only a very small part is due to vegetable oil (0.9%), biomass (0.7%), biogas (0.6%), photovoltaic (0.6%) and wind power (0.1%). The heat is mainly produced by biomass (90.1%), followed by solar thermal (8.3%), vegetable oil (4.3%), biogas (1.2%) and geothermal (0.4%).

Table 3 - 2: Heat and electricity production by renewable energy sources – 2009

Renewable energy sources	Electricity production in GWh	%	Heat production in GWh	%	Total energy production	%
Hydro power *	5,794.4	97.2	0.0	0.0	5,794.4	78.3
Biomass **a)***	39.7	0.7	1,243.0	90.1	1,282.7	17.3
Solar thermal **	0.0	0.0	114.4	8.3	114.4	1.5
Biogas ****b)	33.8	0.6	16.6	1.2	50.4	0.7
Photovoltaic*****c)	37.1	0.6	0.0	0.0	37.1	0.5
Wind power **	4.0	0.1	0.0	0.0	4.0	0.1
Geothermal **d)	0.0	0.0	6.1	0.4	6.1	0.1
Vegetable oil******	55.0	0.9	60.0	4.3	115.0	1.6
Total	**5,964.0**	**100.0**	**1,440.1**	**100.0**	**7,404.1**	**100.0**

a) Heat production from biomass district heating plants (693 GWh_{th}) and small wood chips, pellets and wood logs installations (220,000 tons of wood multiplied with an average caloric value of 4,2 kWh/kg and an average efficiency grade of 60% gives a heat production of about 550 GWh_{th}; value rounded).

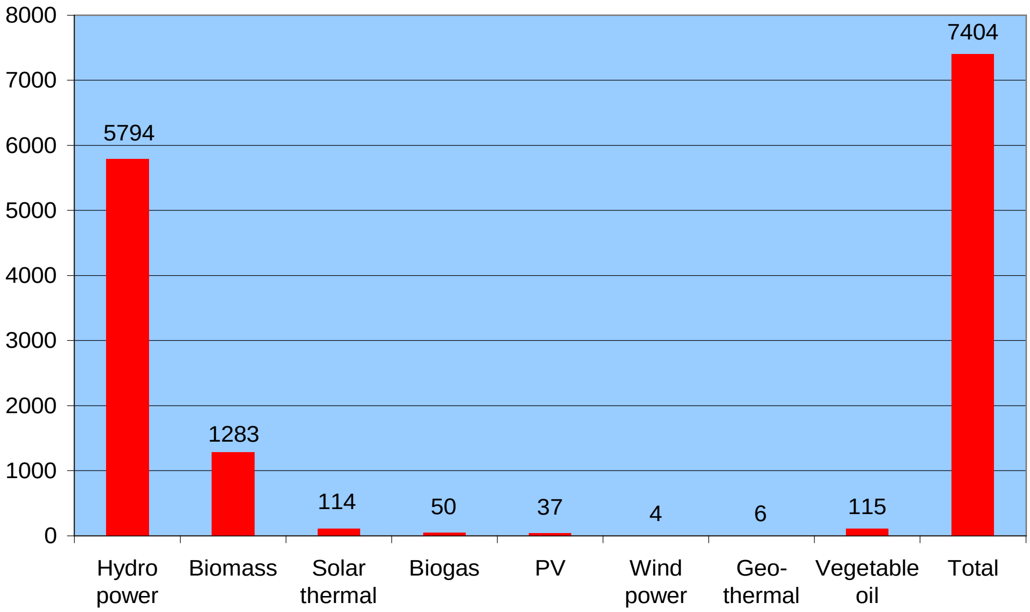
b) Electricity and heat production from slurry and solid biomass and electricity production from waste water treatment plants.

c) Specific grade of efficiency kWh/kWp in South Tyrol = 936.4 kWh_e (Source: GSE "Il fotovoltaico 2008").

d) Heat production estimated by installed capacity of 5,112 KW multiplied with 1200 hours yearly.

Source:
* Amt für Stromversorgung
** Amt für Energieeinsparung
*** TIS innovation park (small wood chips, pellets and wood logs installations)
**** Bezirksamt für Landwirtschaft Bruneck
***** GSE
****** Climate Strategy 2050

Fig 3 - 7: Heat and electricity production by renewable energy sources in GWh – 2009



NB: Values rounded.

Source: Amt für Stromversorgung, Amt für Energieeinsparung, Bezirksamt für Landwirtschaft Bruneck, TIS innovation park and GSE

If the mobility sector, which uses fuel, is excluded, 90% of the total energy consumption in South Tyrol is covered by the production of renewable energy sources. Including the transport sector, the coverage rate falls to 64%. In the heat sector 27% of the heat energy consumption is covered by the alternative sources whereas in the electricity sector 206% of the power consumption is covered by them. It should be noted that the electricity produced is twice as much as the consumption. Hence, around the half of the generated electricity is consumed locally and the remaining energy is exported. There is no renewable energy produced for fuels.

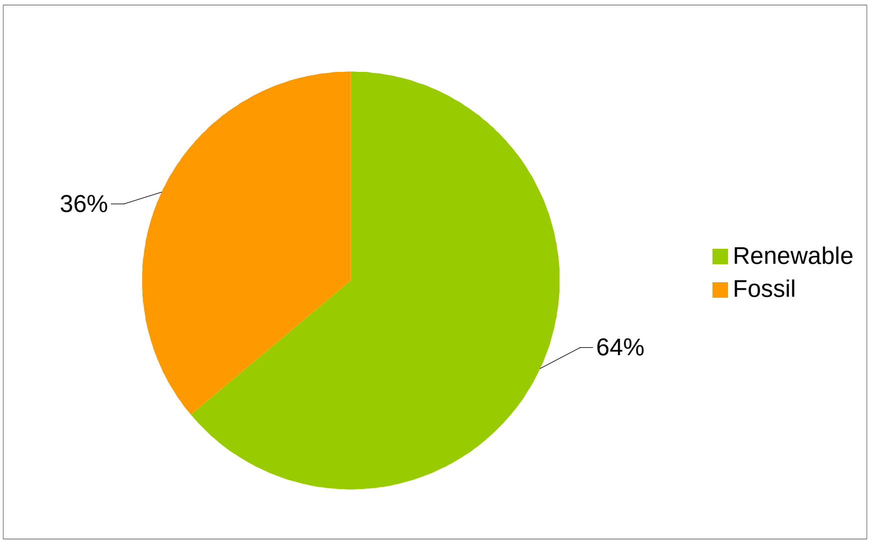
Table 3 - 3: Energy consumption covered by renewable energy production – 2009

	Energy consumption in GWh	**Renewable energy production in GWh**	**Energy consumption covered by renewable energy production in %**
Electricity	2,900	5,964.0	206
Heat	5,300	1,440.1	27
Mobility	3,400	0.0	0
Total	**11,600**	**7,404.1**	**64**

NB: The electricity produced is twice as much than the consumption. Hence, around the half of the generated electricity is consumed locally and the rest is exported. Values rounded.

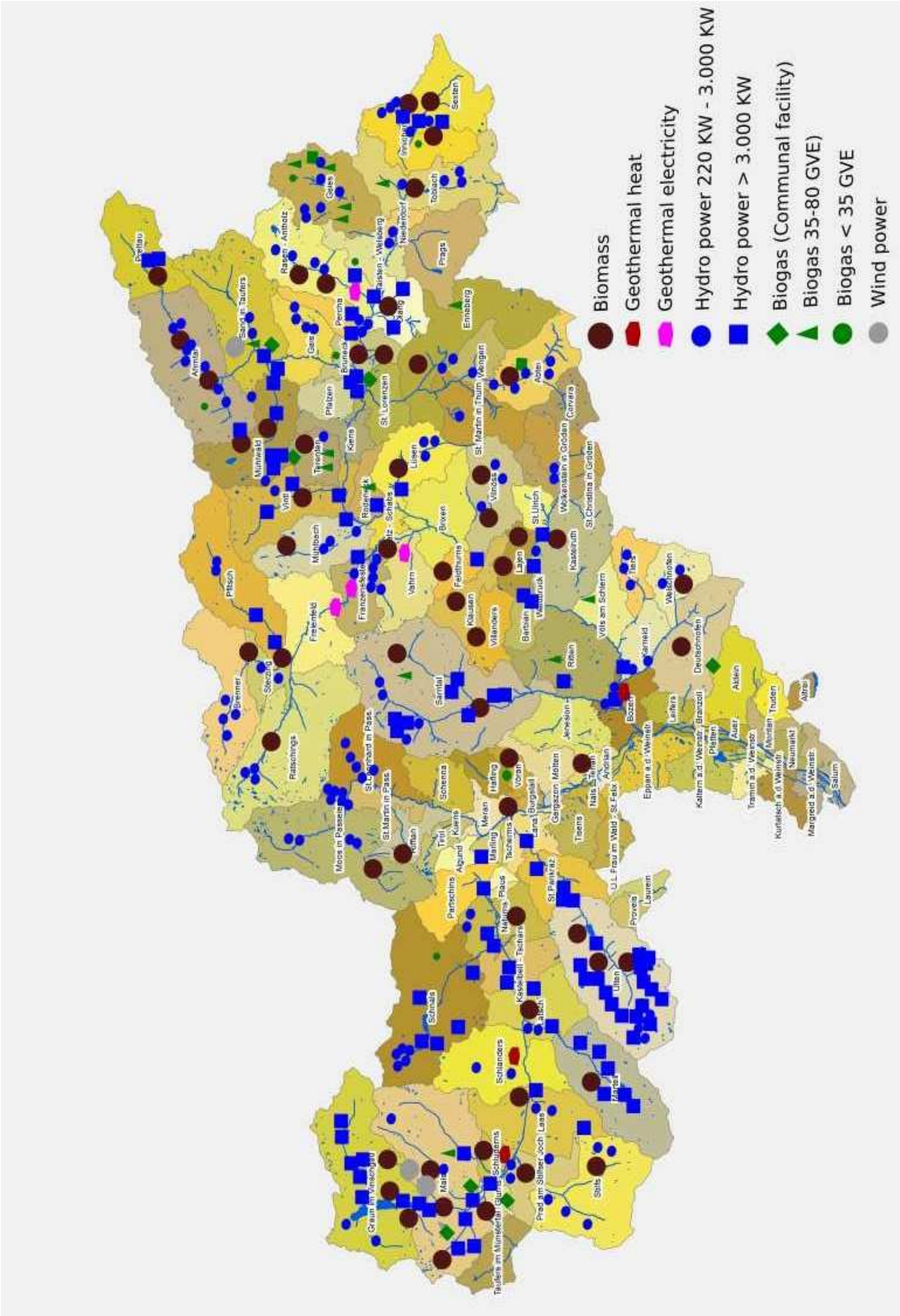
Source: ASTAT, Amt für Energieeinsparung, Amt für Stromversorgung, Bezirksamt für Landwirtschaft Bruneck, TIS innovation park, Climate Strategy 2050 and GSE

Fig 3 - 8: Total energy consumption covered by renewable and fossil energy (mobility included) – 2009



Source: Own elaboration

Fig 3 - 9: Locations of the main renewable energy sources in South Tyrol



Source: Own elaboration

The medium- and large-sized hydro power plants are located along the main rivers Etsch, Eisack, Rienz, Passer, Talfer and other important streams. In the figure the 784 small hydro power plants (<200 KW) are omitted due to reasons of space.

The biomass district heating plants are distributed more ore less equally (except the southern part of the region).

Two of the larger wind power plants are situated at the Malser Haide, close to the Reschenpass. The third one stands in Sand in Taufers.

On the map are indicated 30 biogas plants. The largest biogas plant got into operation in St. Lorenzen last year. It is one of the seven communal facilities in South Tyrol and is aligned for a total capacity of 2600 livestock units. The seven communal facilities produces 86% of the electricity and 59% of the heat. Three are collocated on the west side (Prad, Schluderns, Schlinig), three on the east side (Sand in Taufers, St. Lorenzen, Terenten) and one on the south side (Aldein) of South Tyrol.

Furthermore, the map contains the location of the planned construction of three geothermal district heating plants and four geothermal electricity-generating power plants.

3.4 Electricity

For the following chapters 3.4.1 and 3.4.2 the statistical data of 2008 according to the ASTAT publication info n. 49, August 2009, were used. The data of 2009 were published by ASTAT (info 45, August 2010) at the end of this study. The data between 2008 and 2009 were compared and did not change substantially: The electricity consumption of 2,900 GWh in 2008 is also valid in 2009. The data indicated in the next Table 3 - 4, which describe the generation of electricity by renewable energy sources among others, were not considered, but in order to describe the current situation of renewable energy production, the data were collected from various sources.

3.4.1 Production of Electricity

South Tyrol has no significant stocks of fossil fuels, but it has abundant water, which is an environmentally friendly resource highly significant for the electricity production.

The production of electricity by hydro power plants is dominant. A total of 930 hydro power plants with a nominal power of 870 MW fed electricity into the public distribution grid in 2009. In comparison to hydro the produced amount of electricity by solar and wind are very low.

0.7% of the total electrical energy generated in South Tyrol is needed to keep the electricity production plants going. The remaining net production is distributed to the consumers via the power grid. In 2008, the net electricity production was 5,558 GWh according to the statistical data of ASTAT, which is 1.8% of the total electricity production in Italy and it is almost due to the hydro power (98.8%). While the generation of electricity by hydro power is dominant in South Tyrol, in Italy it is the combined heat and power with 83.2% on the total production, followed by hydro power with only 15.2%.

In the field of combined heat and power, the electricity is produced mainly by biomass or gas, while in the rest of Italy primarily natural gas and coal are used. The amount of electricity generated from solar and wind energy is in Italy and in South Tyrol very low.

Table 3 - 4: Generation of electricity by energy source in Italy and South Tyrol – 2008

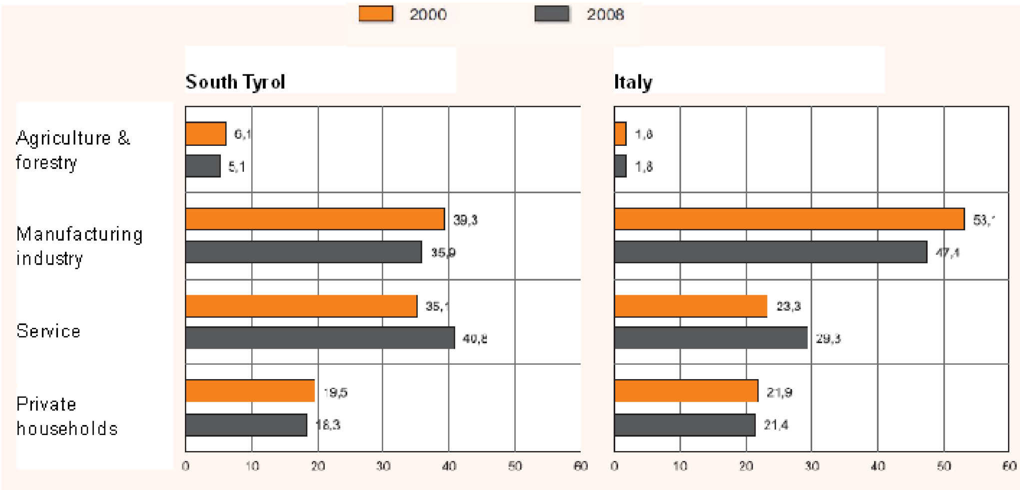
	Italy		**South Tyrol**		
	Current value in GWh	Value in %	Current value in GWh	Value in %	% on national value
Own consumption	12,065.10	3.8	37.00	0.7	0.3
Net production	307,064.50	96.2	5,558.10	99.3	1.8
Gross production	**319,129.60**	**100.0**	**5,595.10**	**100.0**	**1.8**
Hydro power	46,672.60	1.6	5,488.60	98.8	11.8
Photovoltaic and wind	5,045.30	15.2	19.30	0.3	0.4
CHP	255,346.70	83.2	50.10	0.9	0.0
Total	**307,064.60**	**100.0**	**5,558.00**	**100.0**	**1.8**

Source: ASTAT info n. 49, Produktion elektrischer Energie 2008, Bozen, August 2009

3.4.2 Consumption of Electricity

As shown in the figure below, in 2008 over 40% of the total amount of electricity was consumed by the service sector, 35.9% by the manufacturing sector, around 18% by private households and 5.1% by agriculture.

Fig 3 - 10: Consumption of electricity in Italy and South Tyrol by sector in % – 2000 and 2008

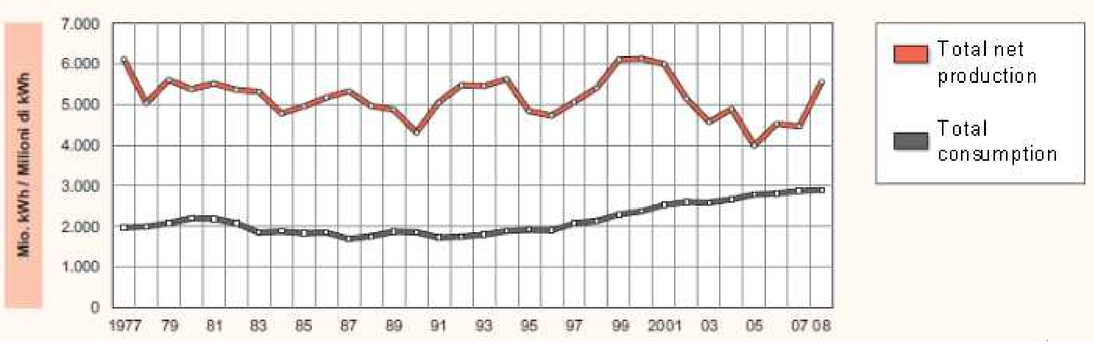


Source: ASTAT info n. 45, Verbrauch elektrischer Energie 2008, Bozen, August 2009

The consumption of electricity has increased from 2000 to 2008 in South Tyrol much more than in the rest of the national territory - while the growth on regional level was 22.2%, the corresponding growth rate on national level was 14.2%.

The ratios of the sectors on total consumption show differences: while the service sector on regional level has a dominant position, at the national level it is not yet the case: The manufacturing industry with nearly half of the total electricity consumption is leading, followed by the service sector (29.3%) and the consumption of private households (21.4%).

Fig 3 - 11: Net production and consumption of electricity in South Tyrol – 1977-2008



Source: ASTAT info n. 49, Produktion elektrischer Energie 2008, Bozen, August 2009

3.4.3 Hydro Power

The electricity is generated by hydro power, which is a part of the natural hydrologic cycle composed of the evaporation, precipitation and run-of of water. The part of the rainfall which flows into the rivers can be used for energy production. The energy of the water flow (kinetic energy) drives generators with the aid of a turbine wheel and the generators produce electricity. Hydro power plants can achieve a high electrical efficiency of over 90%. The quantity of electricity generated depends mainly on the quantity of flowing water and the height difference. In South Tyrol run-off river hydro power plants are used as well as storage hydro power plants. Different turbines such as Kaplan turbines, Francis turbines, Pelton turbines and cross-flow turbines are used depending on the volumetric flow rate of the water and the height from which the water falls.

In total 930 hydro plants are counted in South Tyrol, among them 784 are small (<220 KW), 116 are medium- (220-3000 KW) and 30 are large-sized (>3000 KW). The small plants generate 3%, the medium-sized 11% and the big-sized 86% of the electricity. The installed nominal power amounts to 870 MW. In 2009 the electricity generated by hydro power was 5,800 GWh. This figure can change every year. It depends upon the amount of precipitation during a year.

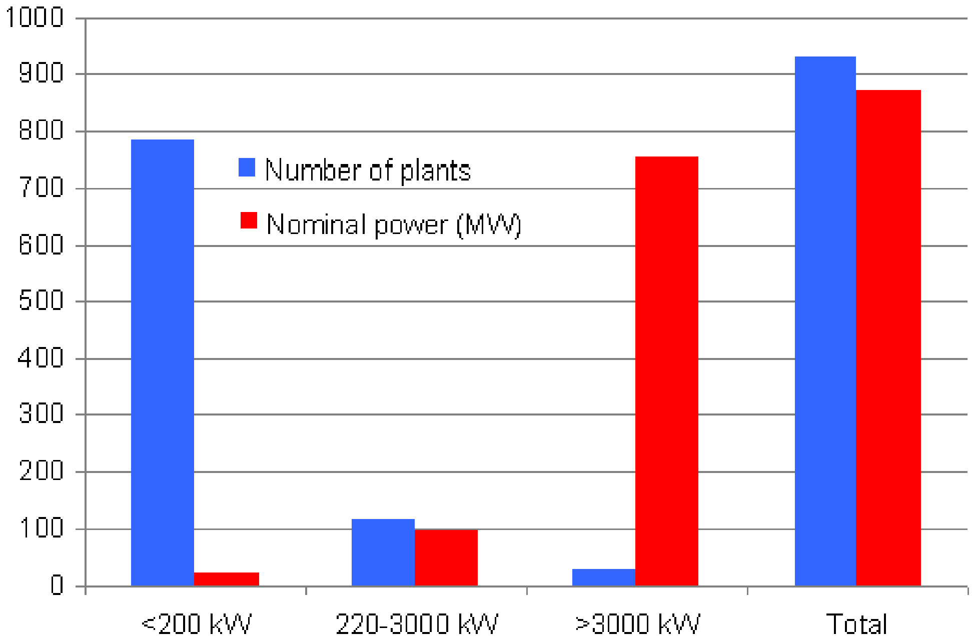
As said before, almost the half of the electricity produced by the hydro power plants is consumed locally and the remaining electricity is exported. The electrical efficiency of hydro power plants lies between 80-90%.

Table 3 - 5: Number and nominal power of hydro power plants in South Tyrol

Power range	<200 KW	220-3000 KW	>3000 KW	Total
Number of plants	784	116	30	930
Nominal power (MW)	23.03	95.88	752.4	871.31
	2.64%	11.00%	86.35%	100%

Source: Amt für Stromversorgung: Die Wasserkraftwerke in Südtirol, 29.05.2009

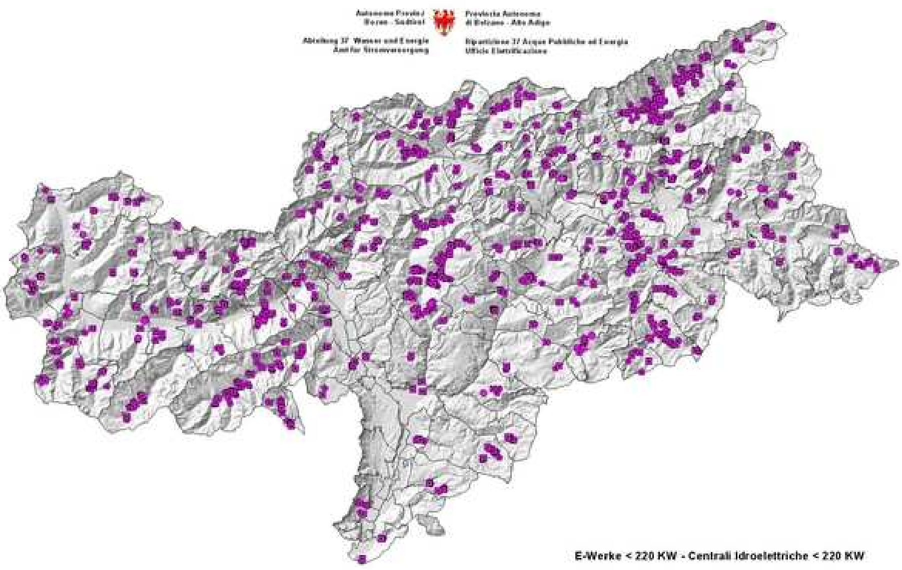
Fig 3 - 12: Number and nominal power of hydro power plants in South Tyrol



Source: Amt für Stromversorgung: Die Wasserkraftwerke in Südtirol, 29.05.2009

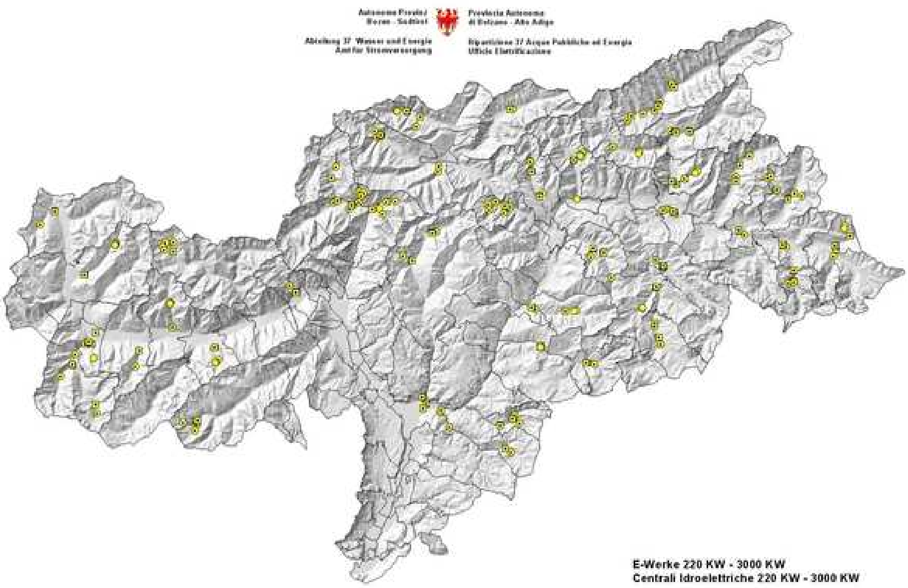
It has to be stated, that 19 hydro power plants are larger than 10 MW with a nominal power of 684 MW (79% of the total nominal power installed), which are not included in the statistics of the renewable energy sources according to the definition of the European Union and the European Small Hydropower Association (ESHA). In this study all hydro power plants are considered.

Fig 3 - 13: Locations of hydro power plants with a nominal power of <220 KW



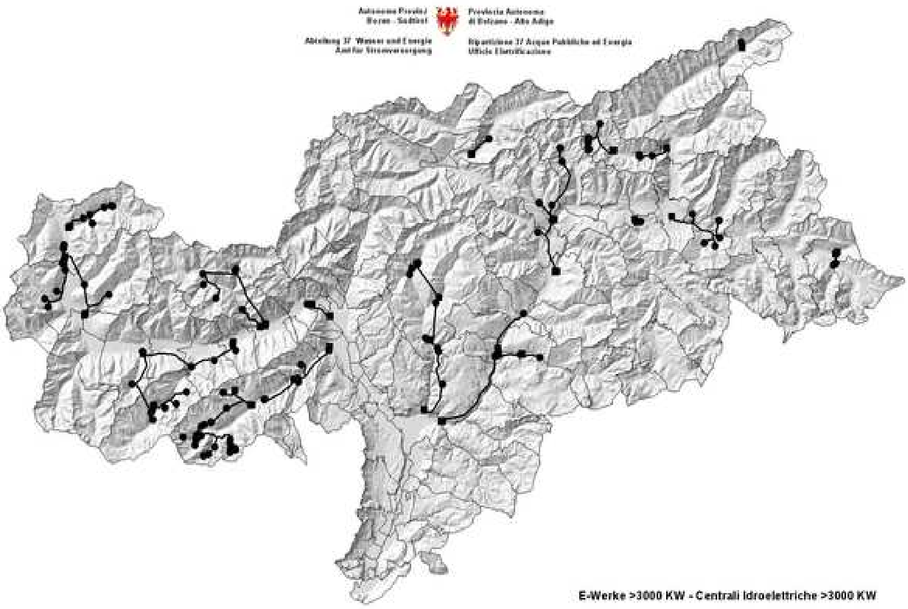
Source: Abteilung Wasser und Energie, http://www.provinz.bz.it/wasser-energie/energie/wasserkraftwerke.asp, download 03.06.2010

Fig 3 - 14: Locations of hydro power plants with a nominal power of 220-3000 KW



Source: Abteilung Wasser und Energie, http://www.provinz.bz.it/wasser-energie/energie/wasserkraftwerke.asp, download 03.06.2010

Fig 3 - 15: Locations of hydro power plants with a nominal power of >3000 KW



Source: Abteilung Wasser und Energie, http://www.provinz.bz.it/wasser-energie/energie/wasserkraftwerke.asp, download 03.06.2010

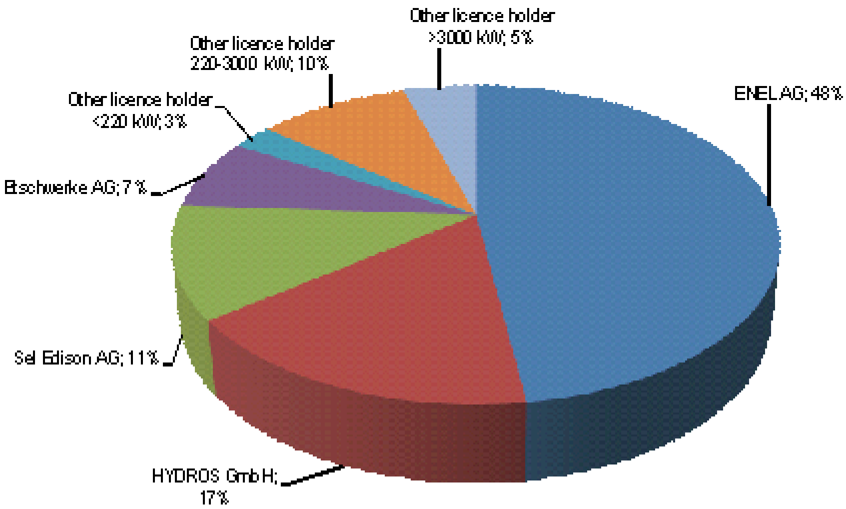
Table 3 - 6: Overview about the existing hydro power plants in the hands of the licence holders in South Tyrol

	Volume of water [l/s]	**Nominal power [KW]**	**Nominal production [GWh]**
ENEL AG	178,429.25	416,422.91	2,682.48
HYDROS GmbH	111,425.50	146,315.16	1,007.00
Sel Edison AG	27,217.00	99,536.00	633.00
Etschwerke AG	29,788.00	62,132.61	468.00
Stadtwerke Bruneck	39,951.70	7,637.28	53.10
Enerpass AG	5,250.00	13,305.15	101.60
Tauferer Elektrowerk AG	2,074.00	8,841.95	62.40
E-Werk Moos Kons. mbH	1,458.00	6,769.84	47.50
Ahr Energie GmbH	2,116.08	3,685.54	31.40
Other licence holder 220-3000 KW	106,663.53	84,160.32	547.29

Other licence holder <220 KW	76,168.05	22,531.30	160.61
Total	**580,541.11**	**871,338.06**	**5,794.38**

Source: Amt für Stromversorgung: Die Wasserkraftwerke in Südtirol, 29.05.2009

Fig 3 - 16: The percentage of the nominal power in the hands of the licence holders



Source: Amt für Stromversorgung: Die Wasserkraftwerke in Südtirol, 29.05.2009

ENEL AG runs half of the hydro power plants in South Tyrol, followed by HYDROS GmbH (17%) and Sel Edison AG (11%). ENEL AG is run by national investors, whereas in the case of HYDROS and Sel Edison AG the regional government is participating as a shareholder. On 23.10.2008 an agreement[9] was signed with ENEL in which the distribution grid is transferred to the regional energy company SEL and a new joint company between SEL and the national company ENEL was set up, which is running the ENEL hydro power plants in South Tyrol. At this joint company the regional energy company SEL holds a share of 60% and ENEL a share of 40%. The acquisition of the distribution grid by the regional energy company SEL is important to ensure the supply of rural areas, which would risk to become a victim of

9 Communication of the Regional Press Office of 23.10.2008, http://wai.provinz.bz.it/lpa/news/detail_d.asp?artc_id=262135, download 03.06.2010

the liberalization process, and it offers the possibility that electricity prices can be reduced for the population.

3.4.4 Photovoltaic

All life on earth is supported by the sun, which produces an amazing amount of energy. Only a very small percentage of this energy strikes the earth but that is still enough to provide all our needs. A nearly constant 1360 watts per square meter (the solar constant) of solar radiant power reaches the earth.

Photovoltaic (PV) uses the sunlight, which is an unlimited, environmentally friendly and free energy source, to generate electric power by using solar cells. Electricity and heat can be produced from sunlight. In addition, it is possible to use the solar energy for solar cooling which is becoming more and more important.

The heart of each solar cell is a semi-conductor, in most cases silicon. The sunlight is converted into direct current, which is used directly to operate electrical equipment or is stored in batteries. Direct current can also be converted into alternating current and can fed into the public grid. At the end of 2009, photovoltaic systems with an output of 37.5 MWp electrical power were installed in South Tyrol.

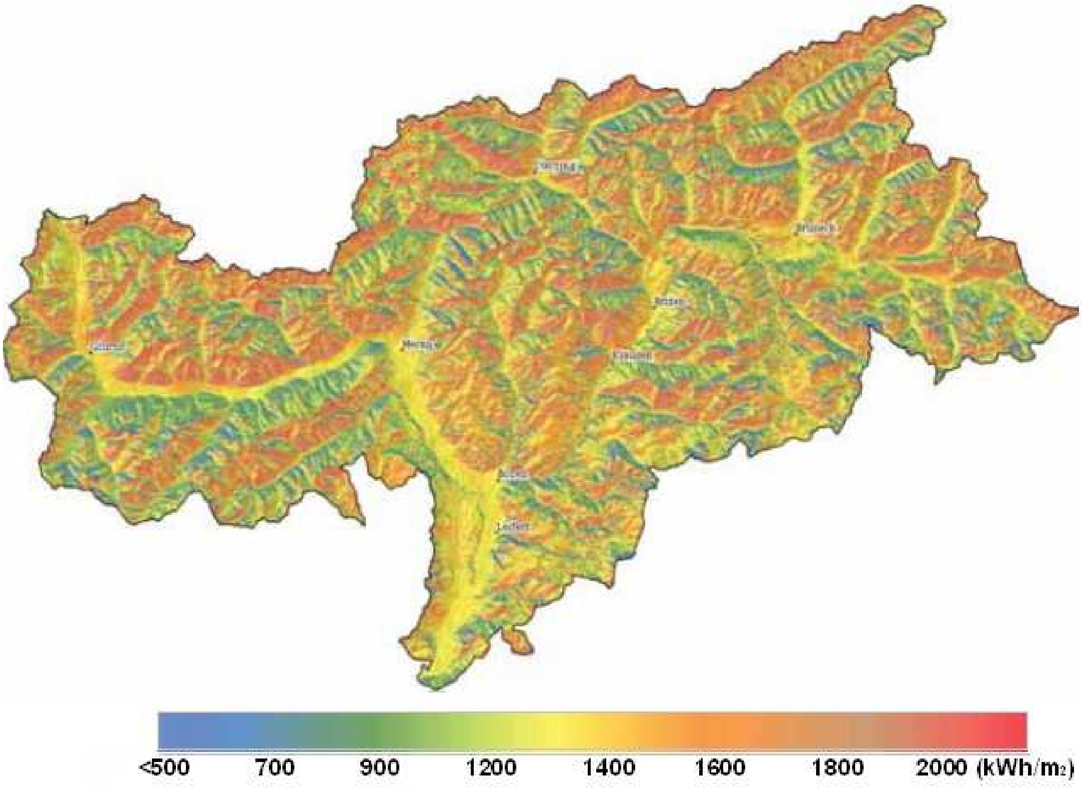
From 2004 to 2009 the total capacity of photovoltaic increased from 0.6 to 37.5 MWp, which implies an increase of 6,150%. It corresponds to 4.4% of total installed capacity of PV in Italy. Almost 1,400 installations exist in South Tyrol.[10] Dividing the capacity with the number of the current population in South Tyrol, it gives 74.5 kWp / 1000 inhabitants. The electricity production per year is approximately 37.1 MWh, calculated with the specific grade of efficiency which is 936.4 kWh/kWp for the region Trentino-Alto Adige which includes the provinces Trento and South Tyrol).[11]

The solar radiation varies between 1,100 and 1,900 kWh/m² depending on the location in South Tyrol. The most influencing factors are the number of sunny days and hours, the orientation and inclination, the shading degree and the applied technology. In the centre and south of Italy the solar radiation is still higher.

10 GSE (Gestore servizi elettrici), http://atlasole.gsel.it/viewer.htm, download 03.06.2010

11 GSE, Il fotovoltaico 2008, p. 19, 2008

Fig 3 - 17: Annual solar insolation map of South Tyrol



Source: TIS innovation park, HydroloGIS

The largest photovoltaic plant in South Tyrol with 916.6 kWp is located on the roof of the Fruit Cooperative Algund with 6656 m² modules, which covers the entire electricity demand of the company. 70% of the electricity generated is used for the own consumption for the compressors of refrigerators and ventilation system of the large apple storage depots. The remaining 30% is fed into the grid. The payback time for the investment of 4 million Euro is expected to be ten years.

Fig 3 - 18: The largest photovoltaic plant in Algund

Source: Radius, p. 71, February 2009

3.4.5 Wind Power

Electricity is generated by the kinetic energy of the wind via the rotary movement of the turbine's rotor blades which drives a generator inside the nacelle. The yield depends upon the design of the rotor blades as well as the wind speed. If the wind speed doubles the output of the turbine can increase eight times as much.[12]

Three bigger wind power plants (1.2 MW, 1.5 MW and 300 KW) stand in South Tyrol. Two of them are situated at the Malser Haide. The first protoype LTW62 of the MW class was built in 2003 and two years later was built the second prototype of the MW-class called LTW77, which has a rotor diameter of 77 m. Both facilities are used for demonstration purposes. The third one stands in Sand in Taufers (about 15 km to the north of Bruneck) and has a nominal power of 300 KW and a rotor diameter of 30 m. The total production of electricity by wind power is about 4 GWh_e/year.

In addition to these facilities a number of small not grid-connected systems are in operation in the alpine region for the supply of electricity for refuges or farms.[13]

12 Agentur für erneuerbare Energie, http://www.unendlich-viel-energie.de/en/wind/on-land-onshore.html, download 03.06.2010

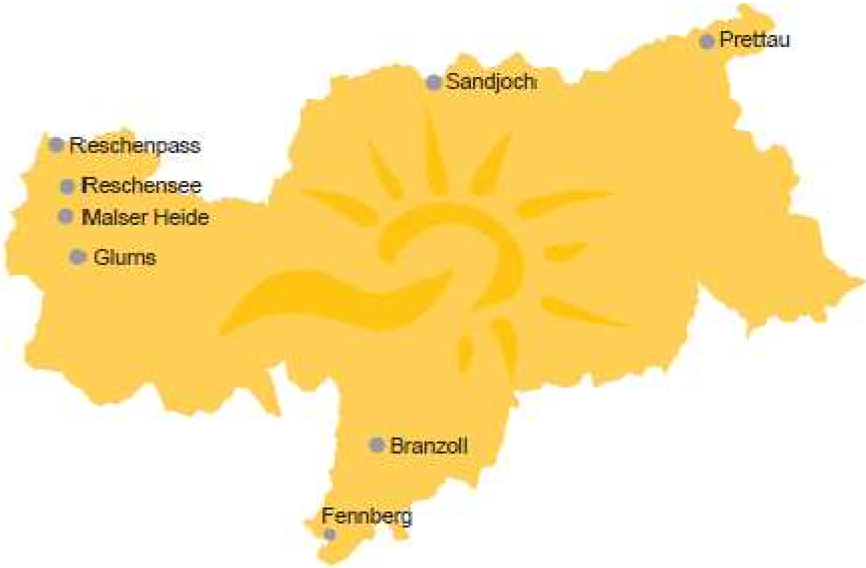
13 Executive summary report n. 3-1, Alpine Windharvest, Interreg IIIB “Alpine Space Program”, p. 15, 2005

Fig 3 - 19: The wind power plant at the Malser Haide

Source: Schulsprengel Graun, http://www.obervinschgau.org/energie/energie31.htm, download 03.06.2010

The Office of Energy Savings (Amt für Energieeinsparung) started with the wind measurements in various locations in South Tyrol several years ago. It has chosen suitable sites in cooperation with relevant public entities in order to achieve an acceptance in the population and to avoid any speculation about the project. The monitoring stations were lent to the interested municipalities for a year. The Office of Energy Savings got the data daily and calculated the average wind speed and the wind direction during a year. Also the air temperature and solar radiation were recorded. The obtained data allow further studies about the use of wind power.

Fig 3 - 20: Locations of the wind measurements in South Tyrol – 2004



Source: Amt für Energieeinsparung, Windmessungen in Südtirol, 2004, http://www.provinz.bz.it/wasser-energie/service/publikationen.asp?redas=yes&wasserenergie_action=300&wasserenergie_image_id=56208,download 03.06.2010

Table 3 - 7: Results of the wind measurements in South Tyrol – 2004

Location	**Municipality**	**Sea level (m)**	**Average yearly wind speed**
Reschenpass	Graun	1,490	4.3
Reschensee	Graun	1,500	4.2
Malser Haide	Mals	1,460	4.9
Glurns	Glurns	925	3.5
Branzoll	Branzoll	225	1.7
Fennberg	Margreid	1,145	3.5
Sandjoch	Brenner	2,150	7.0
Prettau	Prettau	1,910	4.0

Source: Amt für Energieeinsparung

3.4.6 Biomass

For general information about the heat production by biomass is referred to the chapter 3.5.1. Out of the 66 biomass district heating plants, 9 have produced electricity of 39.7 MWh_e in 2009 using the ORC technology with a total installed electric capacity of 7 MW_e.

3.4.7 Biogas

Biogas is generated by the fermentation of organic substances. The term fermentation refers to the degradation of biogenic material by microorganisms in the absence of oxygen under anaerobic conditions. Several groups of bacteria transform biogenic material in biogas which consists of about two thirds of methane, and about one third of carbon dioxide and residual gases.

Biogas can be used directly for heating purposes or through combined heat and power stations (CHP) for the combined production of electricity and heat. This co-generation is particularly efficient. Electricity is transported to the consumer via power grids and heat via local heating networks.

In the meanwhile it is possible to use fuel cells in relation with the combustion of biogas, sewage gas, landfill gas, which deliver the highest electric efficiency of 55% at the moment. Other alternative possible uses of biogas is to feed it into the gas grid after an appropriate treatment or to use it as fuel for engines of vehicles. These possibilities do not find yet application in South Tyrol.

Agricultural biogas plants use as base material slurry and/or solid manure. A cow with 500 kg produces a biogas yield of maximum 1.5 m^3 per day. In energy terms, this equates to around one litre heating oil. To increase the gas yield, coferments such as raw materials or waste from the food industry are often used. Biogas plants are also often built for energy production by using regrowing raw materials so-called energy crops (for example grass, maize silage, fooder beet, etc.). Another possibility to produce energy out of biogas is the treatment of industrial waste water or the stabilization of waste water sludge in digesters.

The production of biogas from agricultural and organic waste has gained more importance over the last years in South Tyrol. The biogas is produced decentrally in agricultural biogas plants. Imports of biomass do not play any role.

It is important to select well-oriented sites which bring agricultural producers and consumers together. Due to the so-called anaerobic digestion the disposal problem is solved in an ecological way. The biogas production from anaerobic digestion of manure or organic waste products is an expandable sector in South Tyrol, which is pointed out in chapter 5.

The current contribution of the biogas energy production is relatively low. 30 biogas plants are currently in operation. 12,472,500 m³ biogas per year can be gained out of the slurry and solid biomass of about 9,980 livestock units, which supplies electricity of 23.2 GWh_e/year and heat of 16.6 GWh_{th}/year, but the heat which is really used amounts to 7.6 GWh_{th}/year. 6 plants are feeding directly into the district heating network. 24 biogas plants produce electricity with an electrical capacity of 4.3 MW_e.

The largest biogas plant got into operation in St. Lorenzen in 2009. It is one of the seven communal facilities in South Tyrol and is aligned for a total capacity of 2,600 livestock units. The seven communal facilities produces 86% of the electricity and 59% of the heat.

Fig 3 - 21: The largest biogas plant in St. Lorenzen

Source: TIS innovation park

In addition to the seven larger plants mainly smaller plants exist with a capacity of about 20-100 livestock units. Especially the fermentation of manure is of interest to rural areas and farms, because by the fermentation thermal and electrical energy can be obtained. The remaining manure is of high quality and has less malodorous and can be used as a high quality fertilizer. As other advantageous aspects biogas production strengthens regional added value, uses closed material cycles, creates synergies and offers farmers an additional pillar to diversify their economic activities.[14]

Landfill gas come from the decomposition of waste. The eight largest landfills in the country produce in total about 3 million m³ of gas per year (lean gas is not taken into account), which experience hardly energetic valorisation until now. The energy of at least about 12 GWh remains unused. Even if the potential is low compared to other energy sources, it is still necessary to examine better the opportunities available in each individual case.[15]

In the digesters of the waste water treatment plants the sewage sludge is fermented and therefore gases are released. Those gases are used to generate electricity to an extent of about 10.6 GWh_e.[16]

The use of biogas is supported particularly by the promotion of the Regional Government and the national support scheme of the so-called "Green Certificates".

3.4.8 Geothermal

In Mittewald, Franzensfeste, Rasen-Antholz and Vahrn the construction of four electricity-generating power plants by a private company is planned. In those locations a particularly advantageous layer in the rock through geological investigations was found. In the depth lies a geologically young about 15 km long granite island, which releases relatively high temperatures. The locations are also very suitable for the deep geothermal use from a technical and practical point of view. More detailed information are given in the chapter 3.5.4.

14 Bezirksamt für Landwirtschaft Bruneck

15 Climate Strategy, Energy South Tyrol 2050, p. 39, draft version 01.08.2010

16 TIS innovation park, data about the waste water treatment plants obtained on 19.07.2010

3.4.9 Vegetable Oil

In the municipalities Franzensfeste (estimated fuel use of 18,000 t/year, electricity production of 74 GWh_e and heat production of 80 GWh_{th}) and Natz-Schabs (estimated fuel use of 13,410 t/year, electricity production of 55 GWh_e and heat production of 60 GWh_{th}) has been built vegetable oil CHP plants based on vegetable oil-fired engines. The plant in Natz-Schabs is in operation and the plant in Franzensfeste is expected to get into operation soon.

3.4.10 Fossil

According to the Office of Energy Saving (Amt für Energieeinsparung) the electricity produced from fossil fuels produced in biomass district heating plants is about 27.7 GWh_e.

3.5 Heat

The main renewable energy source in the heating sector in South Tyrol is biomass. It is mainly used for heating purposes, especially as a replacement or supplement to fossil fuels. The energetic use of biomass is based primarily on the resource of wood and its derivatives by burning it as firewood, wood chips or wood pellets. 48% of the land area in South Tyrol is covered with forest.

Table 3 - 8: Total heat production by renewable energy sources in South Tyrol – 2009

Renewable energy sources	GWh	%
Biomass *	693.0	48.1
Firewood **	550.0	38.2
Solar thermal	114.4	8.3
Biogas	16.6	7.9
Geothermal ***	6.1	0.4
Vegetable oil	60.0	4.2
Total	**1,440.1**	**100.0**

* Biomass district heating plants
** Small wood chips, pellets and wood logs installations
*** Heat production estimated due to installed capacity of 5,112 KW in 2009 multiplied with 1200 hours yearly

Source: Amt für Energieeinsparung, Bezirksamt für Landwirtschaft Bruneck, TIS innovation park, Climate Strategy 2050

The following table shows the amount of timber and firewood in scm (solid cubic metre) deforested from 2004 to 2008, which increased until 2006 and decreased in the years 2007 and 2008.

Table 3 - 9: Logging by type of use – 2004-2008

	2004	2005	2006	2007	2008
Timber	331,364	333,580	417,803	412,104	311,882
Firewood	163,360	171,140	199,292	180,274	163,990
Total	**494,724**	**504,720**	**617,095**	**592,378**	**475,872**

Original source: Abteilung Forstwirtschaft (Department of Forestry), published in ASTAT, Statistisches Jahrbuch 2009, p. 356, Bozen, 2009

3.5.1 Biomass

In Biomass the solar energy is stored in the form of energy wood or residual materials (straw, bio waste and slurry). As biomass is available and flexibly usable, it plays an important role in energy supply on the basis of renewable energy. It provides an additional pillar for the agriculture - the farmers become “energy producers”. The decentralised use of biomass can strengthen regional added value, close material life cycles and utilise local synergies.

Electricity, heat as well as fuels can be produced from solid, liquid and gaseous biomass. In view of rising prices for fossil energy sources, much undeveloped potential is available from forest and waste wood for heat generation.

The generation of heat is usually done with the help of a combined heat and power plant, an incinerator or a district heating plant. District heating means the transport of thermal energy from the central production plant to the consumer via a district heating grid. In most cases district heating is used for the supply with hot water as well as for heating, but it can also be used for industrial processes or for cooling. The consumer avoids the administrative work such as the planning, installation and operation of its own plant. The emissions of polluting substances via a district heating plant can be reduced in comparison to many small private heating plants.

Water is a very suitable medium for the transport of thermal energy, which can be used in liquid or gaseous state. In a closed circuit the cooled heating water or condensed steam flows back to the district heating plant. It should be noted that heat losses are unavoidable over long distances even in case of a very good insulation of the pipeline. Long distances of the district heating grid lead to higher investment costs. Hence, a densely built-up district heating grid is appropriate (settlement structures).

Almost 13% of the total heat consumption are covered by the renewable energy production of 66 biomass district heating plants (BMDH) with a thermal capacity of 236 MW_{th} and a renewable heat production of 693 MWh_{th} in 2009 (the total heat production was 728 MWh_{th}). 90% of BMDH are organized in form of cooperatives.

The total number of heat connections is 11,820 and the district heating grid amounts to 715 km. The production and the sale of heat and electricity are shown in the next table.

Table 3 - 10: *Production and sale of heat and electricity by biomass district heating plants – 2009*

	Production in GWh	**Sale in GWh**
Heat	693.0	552.1
Electricity	39.7	30.2
Total	**732.7**	**582.3**

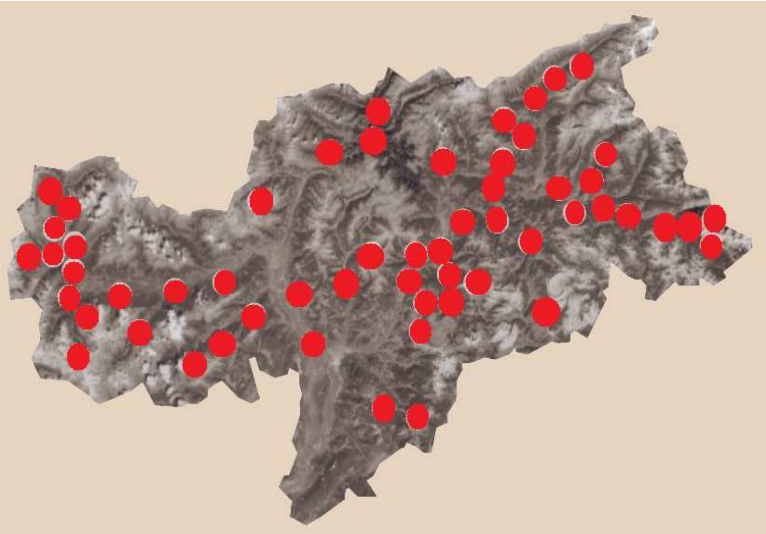
Source: Amt für Energieeinsparung

In 2009 1.2 million m³ scm of biomass were combusted in the 66 BMDH with an ash volume of around 3,000 tons. 52% came from domestic production (sawmills and wood industry), 10% were wood chips delivered directly from the local farmers and 37% were imported from abroad. It has to be added, that the wood chips produced domestically do not come only from local forests. Hence, the amount of imported biomass is much more higher.[17] Only a third of the wood chips combusted in the South Tyrolean biomass district heating plants comes from local forests according to the press release of the Regional Government on 02.07.2010.[18]

17 Amt für Energieeinsparung

18 Presseamt, http://www.provinz.bz.it/lpa/service/news.asp?redas=yes&archiv_action=4&archiv_article_id=332858, download 03.06.2010

Fig 3 - 22: Locations of district biomass heating plants in South Tyrol



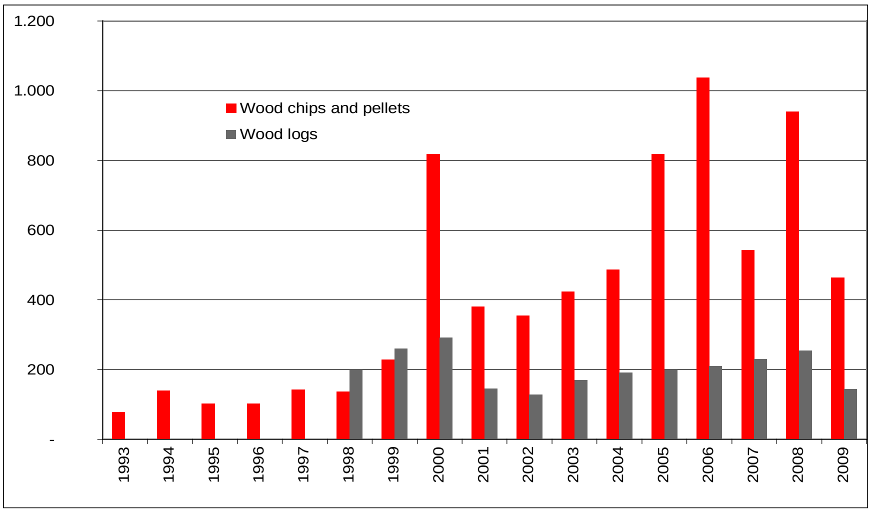
Source: Amt für Energieeinsparung

Fig 3 - 23: The Biomass District Heating Plant in Toblach

Source: Biomassefernheizwerke in Südtirol, p. 23, September 2008

The development of the new small installations of wood chips, pellets and wood logs from 1993 to 2009 is shown in the next figure. In specific the number of the submitted applications to the Office of Energy Saving per year is presented, where a small percentage probably has not been realized, but this is negligible. Around 9,600 small wood chips, pellets and wood log installations were installed and subsidized until 2009.

Fig 3 - 24: New small installations of wood chips, pellets and wood logs – 1993-2009



Source: Amt für Energieeinsparung, own elaboration

In the study "Survey and monitoring of biomass heating systems in the province of Bozen (October 2009)", elaborated by TIS innovation park, were counted in total about 90,000 small biomass facilities in South Tyrol with a heat production of about 550 GWh_{th}/year.[19]

3.5.2 Solar Thermal

The radiation of the sun is converted into thermal energy by means of solar collectors. In South Tyrol thermal heat is usually used for hot water provision and for combined provision of hot water and heating. Solar thermal systems are also used to heat swimming pools.

19 TIS innovation park, Erhebung und Monitoring von holzbetriebenen Heizanlagen in der Provinz Bozen, October 2009; own elaboration (220,000 tons of wood multiplied with an average caloric value of 4,2 kWh/kg and an average efficiency grade of 60% gives a heat production of about 550 GWh_{th}; value rounded)

Solar collectors absorb solar radiation, convert it into heat and pass the heat to a heat transfer medium. This is pumped through a pipe system to a storage device; there the heat is transferred to the domestic hot water with the help of a heat exchanger and, now cooled, the heat transfer medium flows back to the collectors. The controller keeps the pump in operation as long as usable heat is available in the collectors. In the winter, for example, a boiler based on natural gas provides the missing heat.

A collector area of 4 to 5 m² is sufficient to provide around 60% of the hot water in a detached house. Solar collectors with an area of 8 to 15 m² can even supply approximately 25% of the total requirements for heating and hot water.

The solar radiation varies between 1,100 and 1,900 kWh per year per m² depending on the location in South Tyrol. The most influencing factors are the number of sunny days and hours, the orientation and inclination, the shading degree and the applied technology. In the centre and south of Italy the solar radiation is still higher.

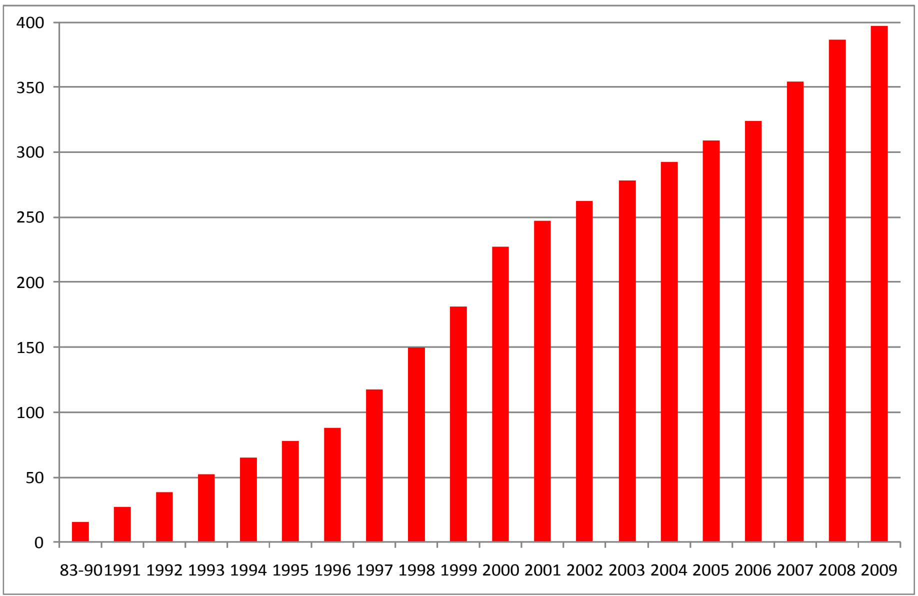
In 2009 the total number of solar thermal plants accounts for 18,120 and the solar collector area covers around 198,600 m² in South Tyrol. 114.4 GWh_{th} were produced by solar thermal in 2009.[20] Dividing the solar collector area with the number of the current population in South Tyrol, it gives 394 m² / 1000 inhabitants. The goal of the European Union for 2010 is just reached (264 m² / 1000 inhabitants). 2% of the total heat consumption is covered by solar thermal.

In one in six cases solar collectors are self-built. In the last 17 years there have been built over 32,000 m² do it yourself collectors.[21] Despite the considerable achievements in the annual installations there is still a great potential in South Tyrol. Many suitable roofs in the private and public sector are not used for solar thermal production yet. Even in the winter the solar thermal plant operates with a high level of coverage and on sunny days it heats the water sufficiently. In cloudy days a sufficiently large boiler can provide hot water supply until exhaustion of the reserves, then the auxiliary heating has to be turned on.

20 Amt für Energieeinsparung

21 Energy forum of Bozen, Folder 02/2010

Fig 3 - 25: The development of solar collector area in m² per 1000 inhabitants – 1983-2009

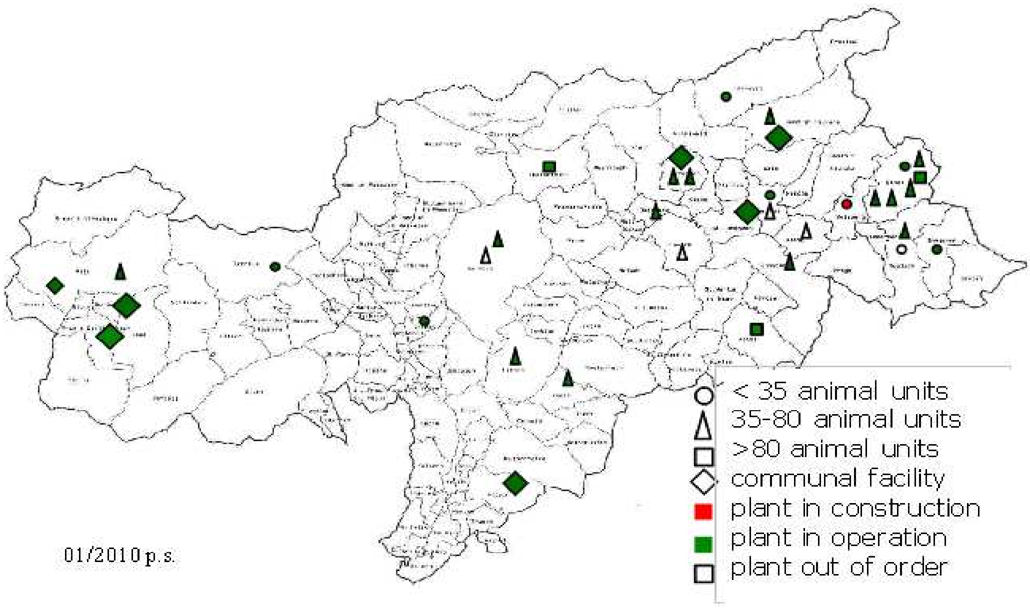


Source: Amt für Energieeinsparung

3.5.3 Biogas

The introductory part is given in chapter 3.4.7. 27 of the biogas plants in South Tyrol produce heat. The thermal capacity amounts to 7.5 MW_{th}. In total 16.6 MWh_{th} heat is produced but from it only 7.6 MWh_{th} is really used. 8 plants use the biogas for the production of hot water and space heating purposes and 6 plants are connected to a district heating net.

Fig 3 - 26: Locations of biogas plants in South Tyrol



Source: Bezirksamt für Landwirtschaft Bruneck

3.5.4 Geothermal

Geothermal energy is a long lasting source of energy. When drilling down from the earth's surface to deeper layers, the temperature for the first 100 m remains almost stable at approximately 10°C. After that the tempe rature increases by an average of 3° C per every 100 m depth. The heat extracted at t his depth is called geothermal heat which can be used for energy production purposes by means of different methods.

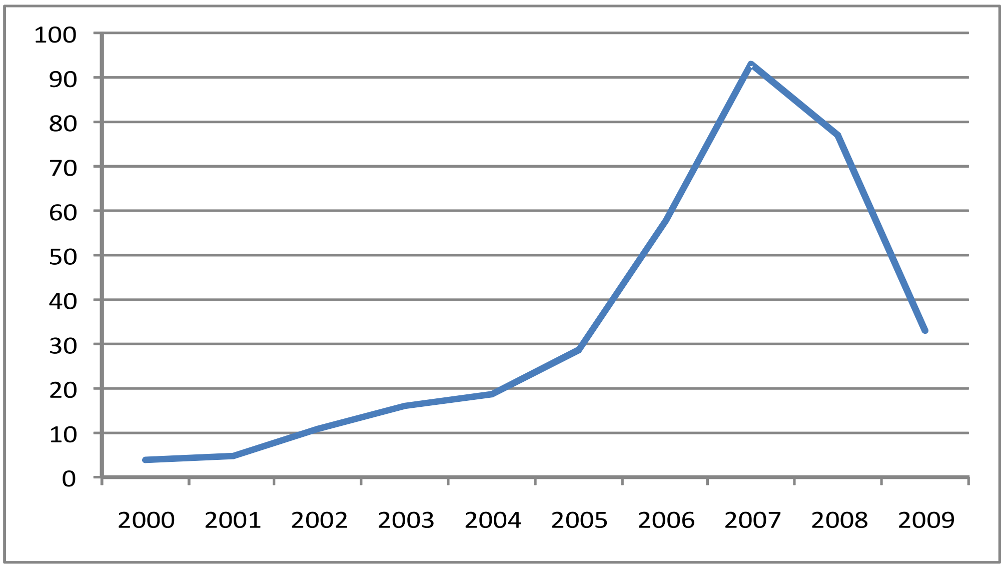
There are three main possibilities to harvest geothermal heat: near-surface geothermal systems (down to a depth of 400 m), geothermal systems harvesting warm underground water (down to a depth of 4,500 m) and systems, which also extract heat from deep rock layers for power generation with drilling currently down to a depth of 5,000 m.

The geothermal market in South Tyrol played a rather modest role until now. However, especially in the sector of heat or cold supply in buildings a strong growth in the coming years is expected.

3.5.4.1 Near-Surface Geothermal

The utilization of geothermal energy in South Tyrol is limited to the use of near-surface geothermal energy by using heat pumps for heating, cooling and warm water of residential and industrial buildings.

Fig 3 - 27: Number of heat pumps installed in South Tyrol – 2000-2009



Source: Amt für Energieeinsparung

In total a number of 318 heat pumps were installed in 2009 with a total thermal capacity of 5,112 KW and a thermal production of 6.1 GWh_{th}[22].

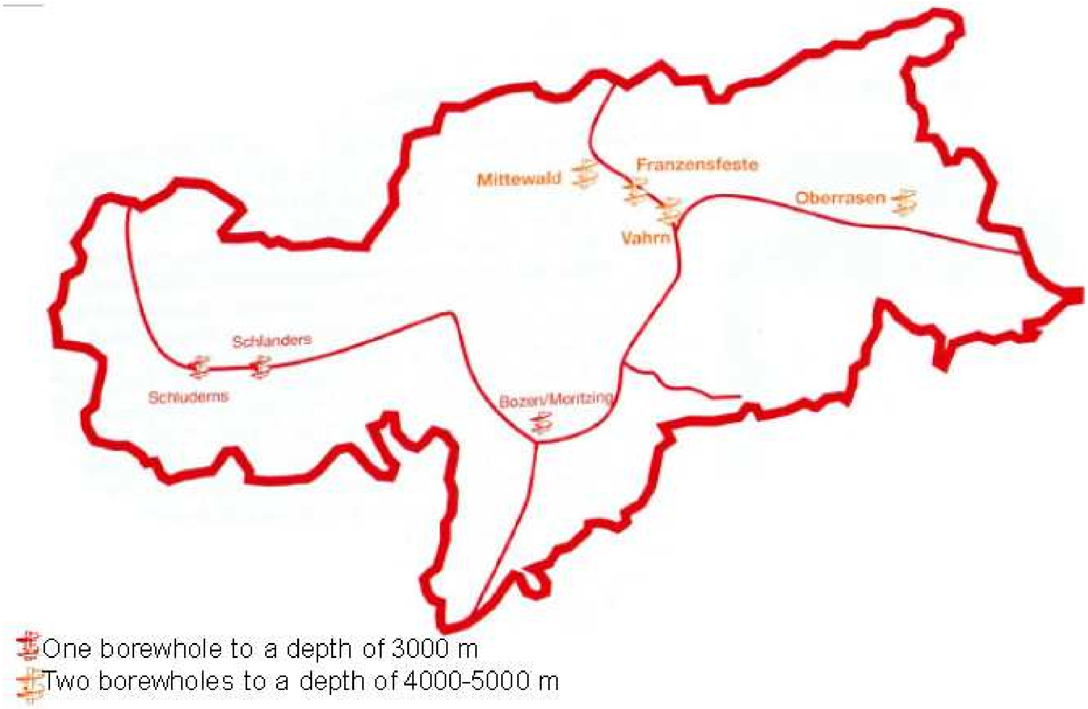
3.5.4.2 Deep Geothermal

The use of deep geothermal energy is not yet in place in the country. But seven geothermal installations for heat and power generation will be built in the next years. There is planned the construction of three geothermal district heating plants and four electricity-generating power plants. In autumn 2010 the start of the construction of one deep geothermal electricity-generating plant in the eastern part of South Tyrol, close to Bruneck, is foreseen. The first one is a demonstration plant and the

22 Heat production estimated due to installed capacity of 5,112 KW in 2009 multiplied with 1200 hours yearly.

realisation of the next plants depends upon how successful the drilling and production phase of heat and electricity will be.

Fig 3 - 28: The foreseen locations of the deep geothermal plants in South Tyrol



Source: FF – Das Südtiroler Wochenmagazin, n. 20, 2010

In contrast to the hydro geothermal energy, which transforms the hot vapour in electricity, the so-called hot dry rock process uses the heat of the rocks in deep layers. The first step is the drilling of an in- and outgoing whole in the earth in a depth of 2000-5000 m. The fissures in the rock are then extended artificially to create a horizontal connection. Water is injected under high pressure in a borehole, heated up in the hot rock and comes to the surface again through the second hole with a temperature of 50-90°C. The hot water is transformed in electricity by means of a turbine. With the current technology, only 13% of the heat can be converted into electricity. The remaining heat is fed into a district heating net. While the HDR technique is used in Mittewald, Franzensfeste, Rasen-Antholz and Vahrn, the prerequisites for an efficient electricity production are not given in Schlanders, Schluderns and Bozen. Therefore, in these areas only one borehole will be dug and the extracted heat will be forwarded directly to the district heating net.

3.5.5 Vegetable oil

This section is explained in the previous chapter 3.4.9.

3.5.6 Fossil

The consumption of fossil oil has declined in the years 1993 to 2007 of nearly 300 million litres to 81.7 million litres. Although it is not to be expected that this trend will continue to the same extent in the next years, fossil oil products as energy sources in the building sector will play a minor role in mid-to-long term. The new building techniques and the trend towards energy saving and passive houses with solar thermal systems will reduce the demand for fossil fuels for heating purposes.

Natural gas is currently the most important energy source in South Tyrol in the building sector: In 2007 natural gas had a share of 36% on final energy consumption.

Table 3 - 11: *Heat energy consumption by fossil energy sources in South Tyrol – 2007*

Fossil energy sources	Consumption	Lower heating value*	Density	Heat in MJ	Heat in kWh
Liquid gas	13,859,707 kg	108,55 MJ/m³	2.02 kg/m³	745,142,827	206,984,118
Natural gas	280,292,658 m³	34,56 MJ/m³		9,754,532,342	2,709,592,317
Light fuel oil	1,314,256 kg	42,63 MJ/kg		56,026,733	15,562,981
Heavy fuel oil	5,892,447 kg	40,7 MJ/kg		239,822,593	66,617,387
Gas oil	81,746,590 l	40,7 MJ/kg	0.95 kg/l	3,327,806,213	924,190,615
Kerosene	146,880 kg	42,37 MJ/kg		6,244,040	1,728,900
			Total	**14,689,420,063**	**4,080,394,462**

* Data from database GEMIS 4.5

Source: Climate Strategy, Energy South Tyrol 2050, p. 48, draft version 01.08.2010

In 2007 nearly 66% of the fossil energy consumption for heating purposes was natural gas, followed by gas oil (23%) and the residual part (11%) of liquid gas, light and heavy fuel oil and Kerosene.

In the last years a clear shift towards natural gas took place. Since 2002 the company Selgas AG procures, distributes and supplies the natural gas in the eastern part of South Tyrol. After the merger with the gas company Energas Südgas AG in 2005, the Selgas AG expanded its service area significantly.

Currently four natural gas distribution companies exist in South Tyrol. The Selgas AG serves by far the most customers; in 2006 more than 28,000 customers in 52 communities were provided with 105 million m^3 of natural gas. Then there are the energy-environmental companies SEAB AG, the Etschwerke AG, Stadtwerke Brixen AG, which supply the cities of Bozen, Meran and Brixen with natural gas.[23]

23 Götel D., Meyer M. Regionale Energieautarkie einer Region – Das Beispiel von Südtirol, p. 30, 2008

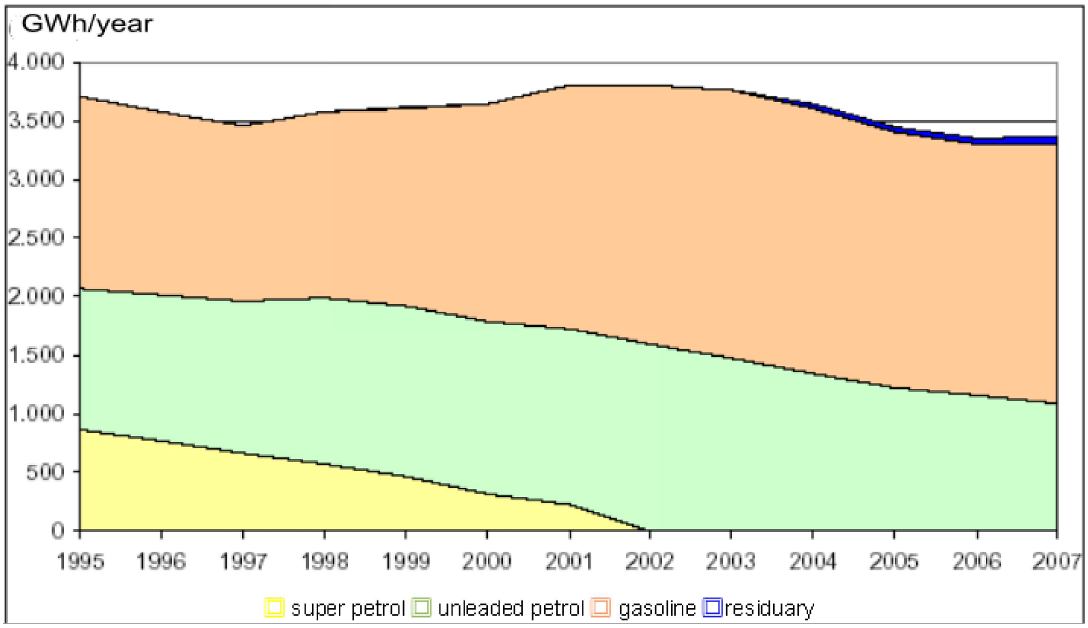
3.6 Mobility

The fuel for mobility sector comes almost from 100% of fossil energy sources such as petrol, diesel, gas and liquid gas. There is no production of bioenergy as fuel for transportation in South Tyrol. The share of renewable energy sources in this sector is only about 1% on the national level, consisting mainly of biodiesel. Thus, it is necessary to catch up in this sector, because the European Union, has set the target of 10% for biofuels in 2020.

3.6.1 Fossil

In South Tyrol the amount of fossil fuel used for transportation on the road has decreased slightly since 1995 (figure below).

Fig 3 - 29: Energy demand in the mobility sector – 1995-2007



Source: Amt für Handel und Dienstleistungen

The data presented in the next table take into account the sales volume of fuel at the service stations along the countrywide road network including the freeway. Also the quantities distributed through in-house tank stations and the aviation fuel were taken into account. The data was collected by the Office of Commerce and Service (Amt für Handel und Dienstleistungen).

Table 3 - 12: Fossil fuel consumption in South Tyrol – 2000-2008 (included fossil fuel tanked along the freeway in l)

Year	Petrol*	Diesel	Liquid gas (GPL)	Natural gas (Methane)	GECAM**	Jet A1	Aviopetrol
2000	202,755,574	181,112,987	3,380,896	/	/	347,208	96,548
2001	194,895,258	200,280,974	3,047,386	/	/	448,489	93,136
2002	178,993,525	209,010,278	3,400,222	/	/	519,808	80,451
2003	165,583,291	214,279,992	2,631,884	/	/	424,631	n.d.
2004	149,678,211	213,148,965	2,421,963	406,827	2,098,095	405,416	n.d.
2005	137,032,685	208,120,646	2,741,413	1,529,334	1,487,579	602,472	106,508
2006	129,620,904	218,594,042	4,139,139	847,463	1,206,216	676,859	n.d.
2007	123,158,733	232,577,098	5,472,500	3,526,222	n.d.	698,189	121,868
2008	116,913,529	233,525,309	6,642,591	4,547,736	11,406	675,368	94,363

* After 2002 only unleaded petrol.
** Also called white diesel oil, distributed only through in-house tank stations.

Source: Amt für Handel und Dienstleistungen

The fuel consumption by the transport sector slightly decreased from 1995 to 2007 (Fig 3 - 29). However, it is important to note that the data provided about the fuel consumption in South Tyrol is only a rough estimation of the energy consumed on the roads of South Tyrol. As a border region South Tyrol is strongly influenced by the price gap to neighbouring countries in terms of fuel consumption. Moreover, it is likely that a significant proportion of the fuel is tanked outside, but consumed at least in part in South Tyrol. This fact is not reflected in the data of the Table 3 - 12. Also the South Tyrolean tank tourism to neighbouring countries is not included in the analysis carried out. The fuel quantities tanked at the gas stations in the country and driven elsewhere, were fully included in the calculations.

The recent developments in the tourism sector have to be considered: While the number of arrivals since 1995 of 4.09 increased to 5.39 million in 2008, the average amount of stays was 6.4 days in 1995 and 5.1 in 2008 according to ASTAT 2009. Many of the guests travelled to South Tyrol by car. Due to the shorter length of the stay, however, the likelihood increases that visitors often do not need further fuel stop. A decrease in fuel consumption and energy demand for mobility may be surprising at first, but the impression remains that the traffic would increase continuously. Indeed, the counting stations counted an increase of traffic during the last years. Only in 2008 various counting stations registered a slight decline (table 3-12). This is likely a result of the year of galloping fuel prices and the looming financial crisis. Whether it is a real turnaround, can not be verified today.

Table 3 - 13: *The average daily traffic at selected counting stations since 2002*

Counting stations		**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
S.S.40	Reschenpass	5,029	5,263	5,228	5,157	5,177	5,048	4,860
S.S.38	Töll	15,215	15,359	15,196	15,103	15,074	15,719	15,744
S.S.238	Marling	16,799	16,521	17,332	17,591	17,326	17,689	17,347
S.S.88	Pankraz	366	381	361	380	413	464	393
S.S.38	Vilpian	26,184	26,947	27,785	28,147	28,834	29,913	29,092
S.S.165	Schwefelbad	8,237	8,049	8,085	7,859	7,869	7,693	7,397
S.S.12	Steinmannwald	21,734	20,998	20,529	---	22,730	22,903	18,765
S.S.12	Auer North	11,075	11,054	10,905	10,861	10,822	10,823	10,505
S.S.508	Sarnthein	4,354	4,477	4,541	4,615	4,642	4,700	4,598
S.S.12	Mauls	4,993	4,820	4,709	4,654	4,740	4,690	4,415
S.S.12	Brenner	5,221	5,183	5,163	5,026	5,020	5,288	5,117
S.S.244	Montal	4,906	5,043	5,137	5,114	6,060	6,735	6,819
S.S.49	Bruneck East	14,182	15,251	15,100	15,410	15,761	16,427	15,893

Source: ASTAT Schriftenreihe n. 146, Mobilität und Verkehr in Südtirol, p. 126, Bozen, 2009 and ASTAT, Statistisches Jahrbuch 2009, p. 556, Bozen, 2009

3.6.2 Hydrogen

The hydrogen-production plant is under construction next to the freeway, exit Bozen South, which produces and distributes hydrogen for cars and buses at the filling stations along the freeway A22 from Brenner to Modena. A detailed description is given in chapter 5.3.8.2.

3.6.3 Electric Vehicle

Innsbruck and Bozen are working together to promote the increase of electric vehicles on the roads. In May 2010 the Economic Assessor of North Tyrol, the

Environment and the Mobility Assessor of South Tyrol have decided to cooperate together in the electro-mobility in order to achieve market leadership and significant value creation. The switch from fossil to electric vehicles with electricity from hydro, solar, biomass and wind can be made more rapidly in North and South Tyrol then elsewhere, thanks to the highly innovative, renewable energy sector and the wealth of natural resources. The first concrete cooperation will be the "Lighthouse project of electric vehicles", prepared by the working group of the electro-mobility of the cluster of the Tyrolean Future Foundation and submitted to the Climate and Energy fund. The companies Elektro Drive Tirol, Tiroler Wasserkraft and SEL AG are involved in this project.[24] On 1st September 2010 the "Lighthouse project of electric vehicles" was presented in Bozen. The topics of the research project are the range, the charging options and the costs of electric-mobility.[25]

Another important project about electric-mobility to mention is that the first ski resort in the world, Reinswald, provides a service station for electric cars at the lift station since 5th December 2009.[26] Skiers and visitors can park their hybrid or electric vehicle next to the lift station in the first place and connect them to the new electric fuel pumps.

Reinswald, the ski resort, is able to cover the total electricity demand by itself. The Energy Cooperative Reinswald/Durnholz produces enough electricity by hydro and solar power to cover the total electricity demand of the ski area. The electric fuel pumps are operated by the photovoltaic system on the roof of the lift station.

The environmentally-friendly service station project is an initiative of the Energy Cooperative Reinswald/Durnholz in cooperation with the Reinswalder Lift GmbH and the car manufacturer Fisker[27] from the United States.

24 Solar-driver online, http://solar-driver.dasreiseprojekt.de/hauptbericht.php?ok=46&uk=100&uuk=78&uuuk=0&id=3376, download 03.06.2010

25 Presseamt, http://www.provinz.bz.it/lpa/service/news.asp?redas=yes&archiv_action=4&archiv_article_id=336674, download 02.09.2010

26 Reisenews onlilne, http://www.reisenews-online.de/2009/12/18/erstes-skigebiet-mit-e-zapfsaulen-fur-elektro-bzw-hybridautos/, download 03.06.2010

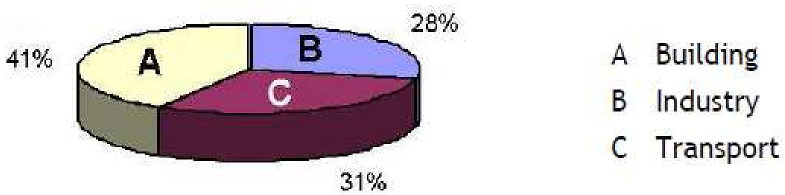
27 Fisker Automotive, www.fiskerautomotive.com

This innovative offer is an indication of the increasing importance of a sustainable management of resources, especially in a tourist region like South Tyrol.

3.7 Energy Efficiency and Energy Saving

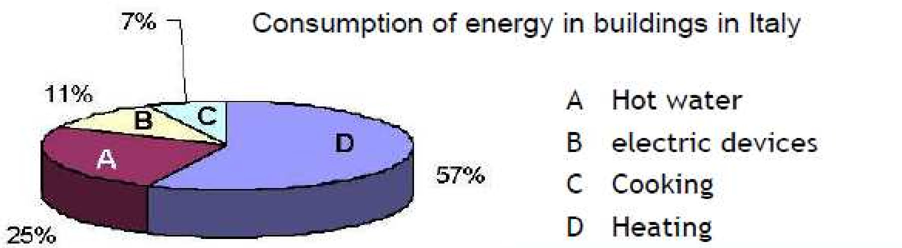
Energy saving or energy efficient building reduces the heat demand, thus, saves valuable resources and prevents pollution and emissions. The achievable potential of savings is enormous: 41% of the total energy consumption (Fig 3 - 30, Fig 3 - 31, Fig 3 - 32) is due to buildings and of this about 57% is used for space heating, 25% for hot water production, 11% for electric devices and 7% for cooking. Compared to the existing buildings, the energy for space heating can be reduced to one tenth for new buildings. The energy demand can also be drastically reduced by renovation of existing buildings. It is important to take into consideration energy-saving measures in new buildings and renovations immediately; afterwards energy-saving measures can only be realized with higher financial costs.

Fig 3 - 30: Energy consumption by sectors in Italy



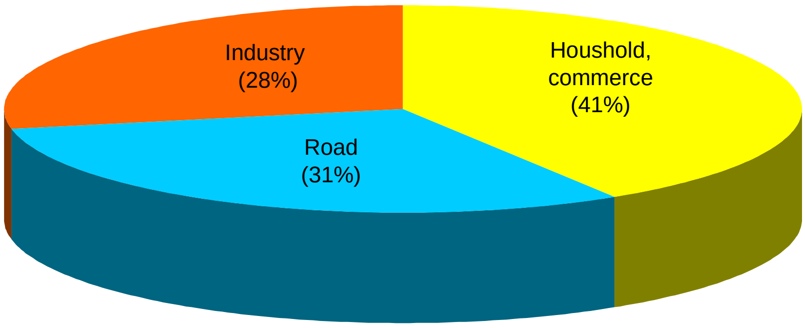
Source: Castagna M., EURAC, "Casanova Bozen: High comfort, low energy", 28/05/2009

Fig 3 - 31: Energy consumption in buildings in Italy



Source: Castagna M., EURAC, "Casanova Bozen: High comfort, low energy", 28/05/2009

Fig 3 - 32: Final energy consumption in the European Union – 2005



Source: EEA, Eurostat

3.7.1 ClimateHouse Certification

ClimateHouse/KlimaHaus/CasaClima, the certification system of old and new buildings, was introduced in 2001 and was a voluntary measure first. It focuses on new and old houses to be renovated considering energy-saving aspects.

The certification programme consists of controlled calculations and examinations on site (thermography, air tightness pressure tests, etc.) conducted by the ClimateHouse Agency. Since it was introduced, more and more municipalities made the system compulsory, until 2004, when it became mandatory in South Tyrol by the Regional Law n. 34, December 2004.

ClimateHouse classifies buildings according to their annual space heating requirement in standard Gold: <10 kWh/m²/year, standard A: <30 kWh/m²/year, standard B: <50 kWh/m²/year; all of them are considered to be low energy buildings. The ClimateHouse Gold standard corresponds to a passive house, but the calculation code is less detailed, so that it does not correspond exactly to the requirements for a passive house. The option of CasaClima+ was introduced in order to underline not only energetic aspects, but also sustainable development.

This applies to buildings where ecological aspects, such as ecological construction materials and renewable energy sources for heating, are used.

Since the introduction of the Regional Law n. 34 in December 2004 residential and office buildings (except those in industrial areas) that apply for the building permission, may not exceed the building standard C with the space heating requirement of 70 kWh/m²/year referred to the climate of Bozen (about 7 litres of heating oil per square meter per year). To get the habitability confirmation, the corresponding values have to be attested.

The most important principles of a ClimateHouse are:

- A compact construction,
- a careful execution,
- a high thermal insulation of the building envelope,
- a high thermal insulation of the windows,
- an air-tight execution,
- the avoidance of thermal bridges,
- the use of solar energy and
- optimized construction methods.

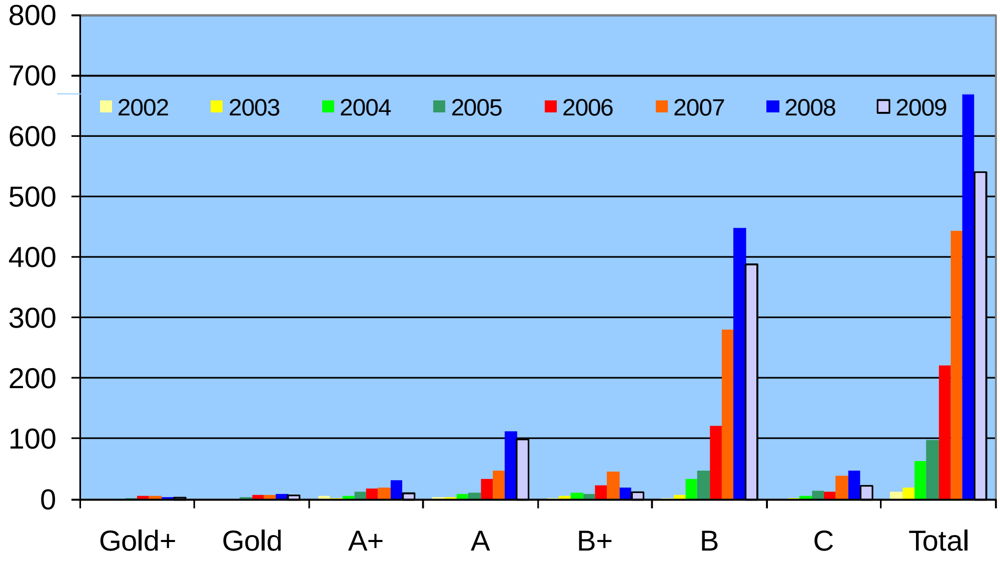
Table 3 - 14: *The ClimateHouse standards according to the annual space heating requirement*

ClimateHouse standards	**Space heating requirement**
Gold, Gold Plus	<10 kWh/m²/year
A, A Plus	<30 kWh/m²/year
B, B Plus	<50 kwh/m²/year
C	<70 kWh/m²/year
D	<90 kWh/m²/year
E	<120 kWh/m²/year
F	<160 kWh/m²/year
G	>160 kWh/m²/year

* The space heating requirement is referred to the climate of Bozen.

Source: ClimateHouse Agency

Fig 3 - 33: The development of the building certifications – 2002-2009



Source: ClimateHouse Agency, data from 31.12.2009

Until the end of 2009 approximately 2,070 low-energy-houses were constructed and the most buildings got the certification standard B.

ClimateHouse certification of buildings is based on:

- The energy efficiency of the building envelope (annual heating demand),
- the overall energy efficiency (building envelope and building service engineering with regard to the CO2 emissions) and
- the sustainability (ClimateHouse Plus and ClimateHouse Nature).

Buildings of the categories Gold, A and B receive an energy certification and a label, a visible sign for the low energy consumption of the building. The label ClimateHouse/KlimaHaus/CasaClima can be seen as a mix of incentives and regulatory elements as well as an information and communication tool, as a whole package of various components including the energy pass, consulting and advanced training for builders to encourage energy-efficient construction. The ClimateHouse is nowadays a kind of status symbol with which people associate a positive image.

Table 3 - 15: The number of building certification by the ClimateHouse standards – 2002-2009

Class	2002	2003	2004	2005	2006	2007	2008	2009	Total
Gold+	0	0	0	1	6	5	4	3	**19**
Gold	0	0	0	4	7	7	9	7	**34**
A+	6	2	6	12	18	19	31	10	**104**
A	4	3	9	11	33	48	112	99	**319**
B+	2	6	10	9	23	46	19	11	**126**
B	1	8	33	47	121	281	449	388	**1,328**
C	0	1	5	15	13	38	47	22	**141**
Total	**13**	**20**	**63**	**99**	**221**	**444**	**671**	**540**	**2,071**

Source: ClimateHouse Agency, data from 31.12.2009

3.7.2 Renovation of Old Buildings

With the rising of fuel prices, the thermal quality of the building (so the energy consumption) is getting more and more important. In the most cases the age is crucial for the quality and the condition of the building.

The possibilities for renovation of old buildings are:

- Thermal insulation of the roof;
- Thermal insulation of the exterior wall;
- Thermal insulation of the basement;
- Replacement of windows;
- Replacement of the heating system.

About 86% of the residential buildings in South Tyrol were built before 1990. Some of the renovations measures were realized such as thermal insulation of individual components, replacement of windows and doors, etc. Due to these measures, the heating costs were reduced, the quality of living improved and defects (such as mold infestation, which occurs mostly due to inadequate insulation) removed. Nevertheless, in the majority of the buildings nothing changed in the thermal terms. Most of such renovations take place only in the case of a change of the ownership or a damage of the building.

When a complete renovation of the building is planned, it is the ideal time to perform energy improvements. In order to state the profitability of the renovation, it is necessary to analyse the actual situation of the building. What are the current heating costs? How pleasant it is in the own home in winter and summer time? Once clarified these questions, it must be decided which energy improvement comes first, for example, if the outer wall is plastered new, so it is preferable to do also the thermal insulation.

The costs must be considered in relation to future energy savings. It should be also taken into account that due to the renovation of a building the comfort is usually improved.

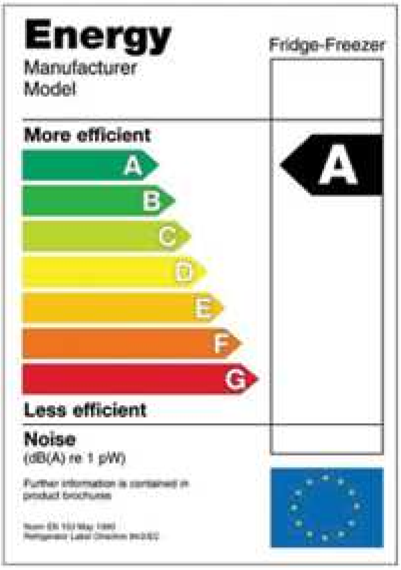
3.7.3 Energy Saving in Households

3.7.3.1 Energy Label

Light bulbs, cars and most electrical appliances (e.g. refrigerators, stoves, washing machines) carry the European Energy Label. The energy levels A to G give the consumer the opportunity to compare the energy efficiency of appliances. A stands for the most energy efficient and G for the least energy efficient appliance.[28]

28 Europe's Energy Portal, http://www.energy.eu/index.php, download 03.06.2010

Fig 3 - 34: *EU Energy label ranging from A to G*



Source: Europe's Energy Portal, http://www.energy.eu/index.php, download 03.06.2010

Apart from the clear colour-coded classification there is also other information on the energy label. For example, the energy label for light bulbs often shows its 'lumen', an indication of perceived power of light, and 'Watt', the consumption of joules of energy per second. Recently, also the qualification A+ and A++ were introduced for refrigerated appliances.

The EU energy label is used for light bulbs, refrigerators, freezers, washing machines, dishwashers, cars, etc.

The label shows the classification of the light bulb's electrical consumption relative to a standard (GLS or incandescent) light bulb that produces the same brightness (lumen).

Class A & B	Energy savers fall into these categories. They are the most efficient type of light bulb and use up to 80% less energy than standard GLS light bulbs.
Class D	Mains voltage halogen bulbs usually fall into this category.
Class E & F	Standard incandescent light bulbs are the least efficient alternatives.

A	B	C	D	E	F	G
20-50%	50-75%	75-90%	90-100%	100-110%	110-125%	>125%

Refrigerators and freezers

The number is calculated according to the consumption and the compartments volume of the appliance. This is an index, it is not calculated in kWh.

A++	A+	A	B	C	D	E	F	G
<30	<42	<55	<75	<90	<100	<110	<125	>125

Washing machines

For washing machines the energy efficiency scale is calculated using a cotton cycle at 60℃ (140℉) with a maximum declared load. This load is typically 6 kg. The energy efficiency index is in kWh per kilogramme of washing.

A	B	C	D	E	F	G
<0.19	<0.23	<0.27	<0.31	<0.35	<0.39	>0.39

Dishwashers

The energy efficiency is calculated according to the number of place settings. For the most common size of appliance, the 12 place setting machine the following classes apply. The unit is expressed in kWh per 12 place settings.

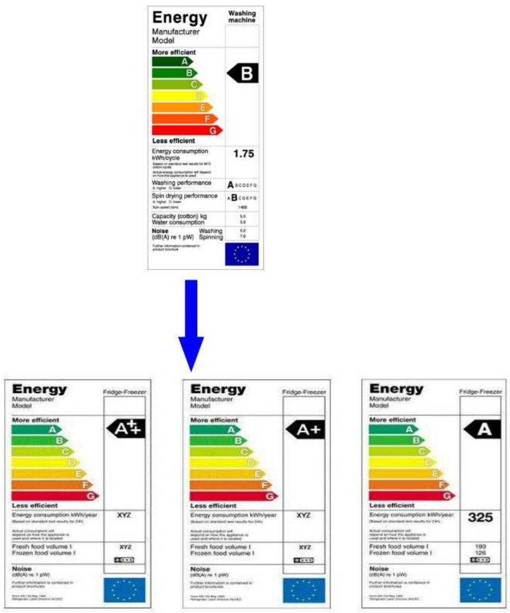
A	B	C	D	E	F	G
<1.06	<1.25	<1.45	<1.65	<1.85	<2.05	>2.05

Cars

For cars it is not the electrical efficiency that is indicated, but its carbon dioxide emissions in grammes per kilometre travelled.

A	B	C	D	E	F	G
<100	<120	<140	<160	<200	<250	>250

Fig 3 - 35: EU Energy label A++, A+, A and B



Source: Europe's Energy Portal, http://www.energy.eu/index.php, download 03.06.2010

3.7.3.2 Energy Saving Lamps

The state of the art of the techniques in the lighting sector has developed rapidly. In the kitchen, living room, hall or office – due to the use of energy efficient lamps the cost of electrical energy can be reduced. Energy saving lamps are by far the cheaper option compared to the incandescent bulb. Incandescent bulbs are cheaper to buy compared to some energy-saving lamps, but if the life span and the electricity consumption are considered, the energy saving lamps are a better alternative. When using an 11 watt energy saving lamp (10,000 hours durable) and a 60 watt saving incandescent bulb with the same brightness over the lifetime of the lamps, about 80 Euro can be gained while less electricity is consumed. Counting together all the lighting sources in a house, it is possible to calculate the additional costs of electricity.

The following table shows a comparison between the performance in watt of the energy saving lamp and the incandescent lamp. The lamps have an equally bright light.

Table 3 - 16: *Comparison of the performance in watt between incandescent and energy saving lamp*

Incandescent lamp [Watt]	**Energy saving lamp [Watt]**
15	3 - 5
25	5 - 7
40	7 - 9
60	11 - 16
75	15 - 20
100	20 - 23
120	23 - 26

Source: Wikipedia, http://www.elweb.info/dokuwiki/doku.php?id=verbrauch, download 03.06.2010

4 Potentials / Challenges

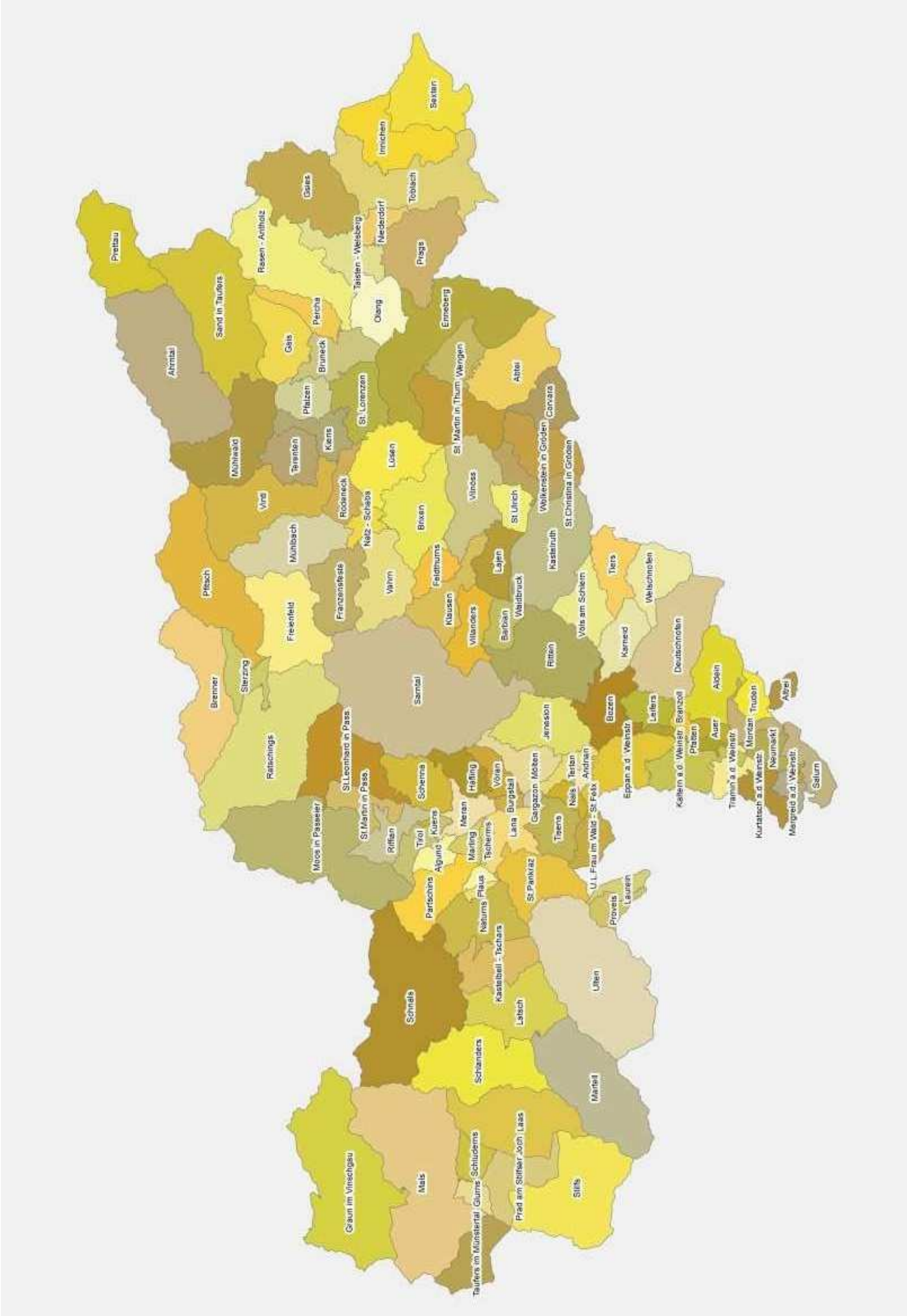
South Tyrol is an advantageous region with very favourable natural conditions: rivers, forests, many sunny days and fertile soils. The more it is important that these resources are used in the sense of a sustainable energy supply, which guarantees the preservation of an intact ecosystem for the next generations.

This chapter describes the natural conditions of South Tyrol and two similar areas such as Bavaria and Tyrol (North and East Tyrol). Furthermore the work gives an overview about the national and regional laws which regulate the promotion schemes of renewable energy sources. Finally some information about the electricity price, the fuel price of heating oil, liquid gas (in tank), natural gas, pellets, wood chips, wood log mixed and district heating and the investment costs for the purchase of different heating systems will be presented.

4.1 Local Conditions

South Tyrol is situated in the North of Italy. The official name is Autonomous Province of Bozen with the main capital Bozen. It is divided into 116 communities as shown in the figure below.

Fig 4 - 36: Map with the 116 communities of the Autonomous Province of Bozen



Source: Own elaboration

It has a continental climate and the mean annual temperature depends on the altitude of the localities, for example it lies between 12.2° C in Bozen (260 m above sea level) and 5.5° C in Toblach (1,250 m above sea level). 48% of the total area are forest, 44% agricultural area and 8% not productive area.

The solar radiation varies between 1,100 and 1,900 kWh/m² depending on the location in South Tyrol. The most influencing factors are the number of sunny days and hours, the orientation and inclination, the shading degree and the applied technology. In the centre and south of Italy the solar radiation is still higher.

The wind conditions are not really favourable for a mountainous region like South Tyrol. The Office for Energy Savings (Amt für Energieeinsparung) started with the wind measurements in various locations in South Tyrol several years ago. It has chosen a few suitable sites in cooperation with relevant public entities in order to achieve an acceptance in the population and to avoid any speculation about the project. Most of them are situated in the western and northern border to Austria. The sites are shown on the map in chapter 3.4.5.

What is really dominant in the energy production by renewable energy in this region, is hydro power. The mountainous landscape of South Tyrol is ideal for the use of hydro power. Currently there are 930 hydro power plants in operation with a total installed nominal power of 870 MW_e. With approximately 5,800 GWh_e per year, more electricity is produced than consumed. Nearly the half can be exported.

48% of the land area in South Tyrol is covered with forest with a substantial amount of wood, which is a very common energy source for the heat production. Currently 23% of the total heat consumption is covered by the heat production of the biomass district heating plants and the small firewood installations.

4.1.1 Mountain Area

South Tyrol is entirely located in the Alps. The province's landscape is dominated by mountains. The highest mountain is the Ortler (3,905 m) in the western part of the region. The conditions for the production of electricity by hydro power are very favourable. The hight is one of the parameters which influences the electricity production. Another influencing parameter is the volume flow of the water, which again depends on the amount of precipitation: It lies between 20 and 120 l/m² per month on average[29]. The glaciers melting water in the spring and summer time has also an impact on the power generation.

4.1.2 Agriculture

The agriculture in South Tyrol is characterized by a homogeneous territorial distribution. It is one of the characteristic sectors of the local economy and counts for 5.5% of the GDP in South Tyrol. The main crops are apples and grapes, which are concentrated on the bottom of the valleys. On higher levels of the valleys farms with forest and agricultural land for livestock are situated. On the farms it is particularly common “farm holidays” as second income pillar.

At local level there are 26,600 agricultural and forestry companies with a total area of about 610,000 ha, while 48% is covered by forests, 44% by agricultural area and the remaining part (8%) is a not productive area.

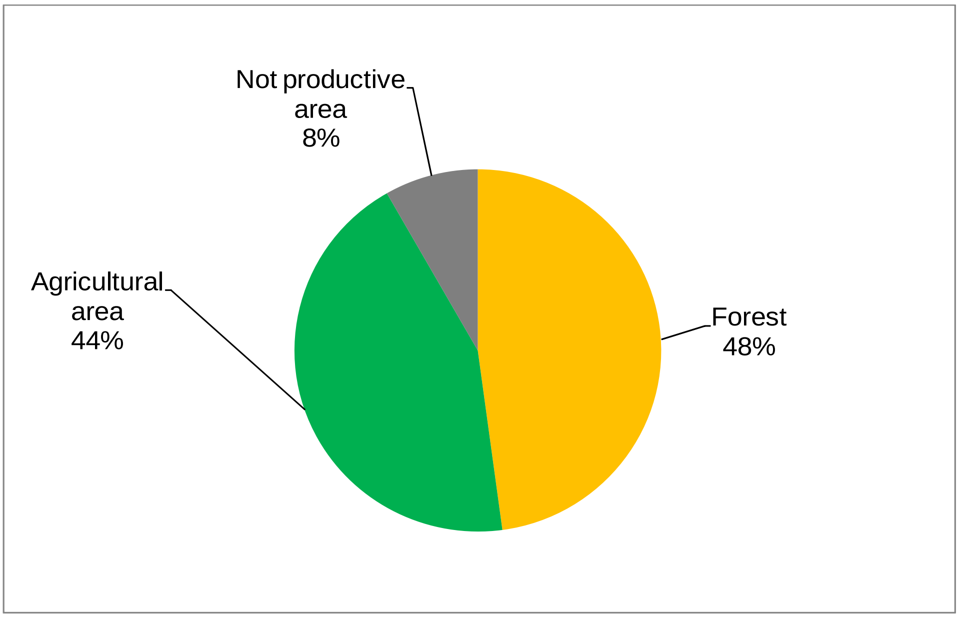
Table 4 - 17: *Forest, agricultural and unproductive land*

	Area (ha)	%
Forest	292,000	48
Agricultural land in use	267,400	44
Not productive area	50,500	8
Total	**609,900**	**100**

Source: Census of Agriculture 2000

29 Hydrografisches Amt, Bozen, 2010

Fig 4 - 37: Percentage of the forest, agricultural and not productive area



Source: ASTAT, Statistisches Jahrbuch 2009, Chapter 13 - Agriculture and Forestry, p. 341, Bozen, 2009

The forest can be divided into high forest (97%) and coppice (Niederwald). Farms in South Tyrol operate mainly with their own family members.[30]

30 ASTAT, Statistisches Jahrbuch 2009, Chapter 13 - Agriculture and Forestry, Bozen, 2009

4.2 Similar Regions

4.2.1 Bavaria

The share of renewable energies on primary energy consumption is with 8% above the national average (6%). Also in the regenerative power generation Bavaria is leading (share of 20% in Bavaria and 13% in Germany).

Table 4 - 18: Share of renewable energy sources on primary energy consumption in Bavaria – 2004

	Consumption [PJ]	**Percentage [%]**
Total primary energy consumption	2014.4	100.0
Primary energy consumption of renewable energy sources	156.2	7.8
Thereof		
Biomass	105.0	5.2
Hydro power	45.0	2.2
Other (Solar thermal, heat pumps, wind power, photovoltaic, deep geothermal)	6.2	0.4

Source: Report of the Bavarian Ministry of Economy about the Renewable Energies, http://www.stmwivt.bayern.de/fileadmin/Web-Dateien/Dokumente/energie-und-rohstoffe/erneuerbare-energien/Erneuerbare_Energien_Bayern.pdf, download 17.06.2010

4.2.1.1 Overview about the Renewable Energy Sources in Bavaria

The bio fuels have a particular focus. In the primary energy balance with a share of about 5.2% the bio energy sources are before Bavarian hydro power (2.2%). The use of biomass in the fuel sector has developed particularly dynamic recently. Nationwide the proportion of bio fuels in 2006 was about 6.3%, exceeding the 2010 target of 5.75%. Bavaria has also a leading position in the hydro power sector. More than a half of the electricity produced by hydro power in Germany comes from Bavarian hydro power stations. About 4,300 hydro power stations are in operation, contributing to about 20% of Bavaria's electricity supply. Approximately 4,000 of these are small plants. Such plants with a capacity of up to 1 MW are usually operated by private people. Depending on the water supply hydro power contributes approximately 15-18% to the electricity generation and 2% to the primary energy coverage (in comparison to the nationwide value of 4% to the electricity generation and less than 1% to the primary energy coverage). Studies have shown that the hydro power in Bavaria can be increased by about 10%.

Bavaria has about 1,900 hours of sunshine per year and is one of the sunniest countries in Germany. It is a pioneer in the solar energy use: About half of the total generated electricity in Germany comes from Bavarian photovoltaic systems. In Bavaria, the production of solar power currently contributes about 1% to the total power generation (in comparison to the nationwide value of approximately 0.3%).

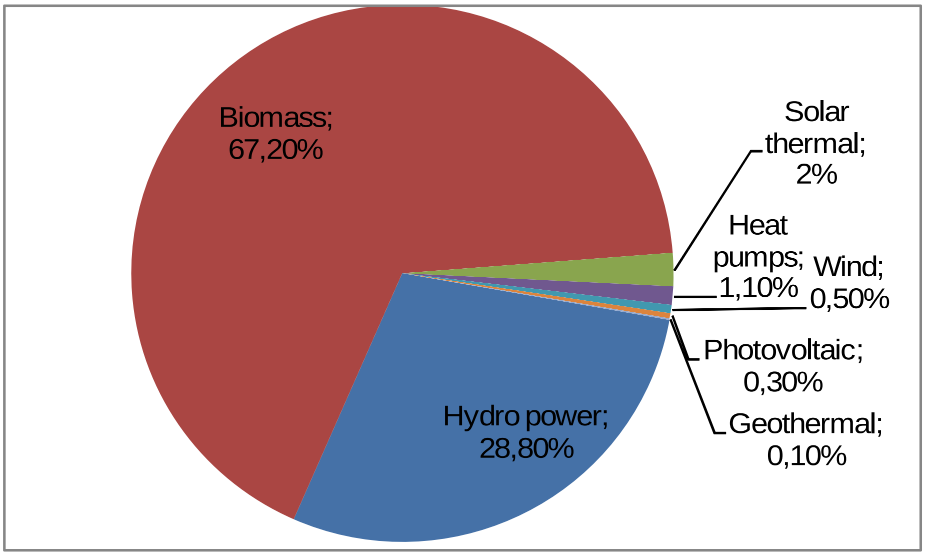
Also in the thermal energy with solar panels and heat pumps Bavaria is on the top with 3 million m^2 solar collectors (in comparison to the nationwide value of 9 million m^2). 100,000 of the total 300,000 heat pumps in Germany are installed in Bavaria. For the final energy consumption of heat and the primary energy consumption these facilities count so far only for a few tenths percentage.

In Germany, the best areas for wind are to the German North coast. Bavaria has only a relatively limited potential of wind power. Nevertheless, there are some suitable sites. The geological conditions in Bavaria offer relatively favourable conditions for the use of the hot water in depth. To exploit this energy source, usually two holes are needed with a depth of up to 4,000 m for the removal and return of the hot water. Relevant plants in Bavaria are located in Erding, Straubing, Munich-Riem, Pullach, Simbach, Unterhaching and Unterschleissheim.

The aim of the Bavarian government, as stated in the Bavarian Climate Program 2020 of November 2007, is to double the share of renewable energy sources in the primary energy consumption from the current 8% to 16% until 2020. [31]

31 Report of the Bavarian Ministry of Economy about the Renewable Energies, http://www.stmwivt.bayern.de/fileadmin/Web-Dateien/Dokumente/energie-und-rohstoffe/erneuerbare-energien/Erneuerbare_Energien_Bayern.pdf, download 17.06.2010

Fig 4 - 38: The allocation of the renewable energy sources in Bavaria – 2004



Source: Report of the Bavarian Ministry of Economy about the Renewable Energies http://www.stmwivt.bayern.de/fileadmin/Web-Dateien/Dokumente/energie-und-rohstoffe/erneuerbare-energien/Erneuerbare_Energien_Bayern.pdf, download 17.06.2010

4.2.1.2 Potential of Wood Energy in Bavaria

The forest area in Bavaria of 25,000 km^2 amounts to almost a quarter of the total forest area in Germany. The National Forest Inventory provides reliable data on forest conditions and forest development in Bavaria in the last 15 years. 54% of the forest are distributed among 700,000 private owners. 37% of the total forest area are small areas under 20 ha. The Second National Forest Inventory point out a positive development of the natural resources forest and timber in Bavaria.

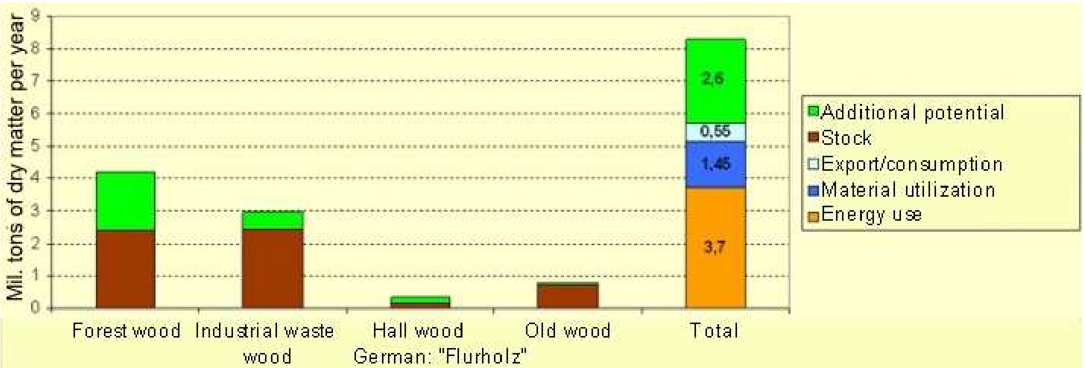
On 01.01.2002 the total stock was 978.8 million m^3 scm (solid cubic metre) wood, where about three quarters are conifer (750 million m^3). Compared with the other “Länder”, Bavaria has by far the greatest stock of wood in Germany. In comparison to Austria and Switzerland, it has the highest stock with 403 m^3/ha.

According to the results of the Second National Forest Inventory not the entire Bavaria's wood growth was used in the recent years. Taking into account the conservation of nature, the sustainable exploitation of the wood growth and the technical feasibility, additional quantities of wood could be obtained. Low-grade assortments such as branches, small timber, industrial wood are interesting as fuel price.

At the same time the sawmill settlements and the cut-in of round-wood will increase. Even the hallway and driftwood (Flur- und Schwemmholz) could double on a lower level.

Thus, the additional energy potential amounts to about 2.6 million tons of dry matter (in German *absolute Trockenmasse* abbreviated *atro)* of wood (base year 2003/04), of which the largest part takes the forest energy wood. In this quantity is also included wood which will be used from the paper, pulp and wood industry, so that a portion will flow into those areas.

Fig 4 - 39: Potential of wood energy in Bavaria



Source: LWF Wissen Nr. 53 - Energieholzmarkt Bayern, September 2006, own elaboration

Not included are the short term rotation crops. Currently their share is still very low, but with rising energy prices, it will get more and more economically interesting. Poplar wood has a yield of 8-12 tons of dry matter per hectare per year. Potential areas are agricultural areas which are temporarily closed down or are managed with other energy crops (e.g. rapeseed or maize). The agricultural set-aside area (excluding set-aside land with energy crops) amounted to 103,000 ha in 2007 in Bavaria according to the Bavarian Agricultural Report 2008. If one part of this land will be planted with short term rotation crops, the use of wood energy will increase, e.g. by 40% of the set-aside area the output will be 0.4 million tons of dry matter.

In 2003 about 3.7 million tons of dry matter (in German a*bsolute Trockenmasse)* of wood were used for energy production in Bavaria. This corresponds to an energy content of 1.6 million tons of fuel oil (the consumption of fuel oil in Bavaria in 2003 was 6 million tons).[32]

4.2.2 Tyrol

Tyrol is a region located in the western part of Austria, which borders to South Tyrol (Italy). It consists of two parts called North Tyrol and East Tyrol. According to the Land Use Register from January 2010, 36.3% of the total area is forest (463,395.6 ha).

The Tyrolean Energy Strategy 2020 is based on two pillars: increase of the energy efficiency in all sectors and the expansion of the domestic renewable energy production in terms of sustainable development.

Fig 4 - 40: Map of North, East and South Tyrol

Source: Wikipedia, http://upload.wikimedia.org/wikipedia/commons/thumb/f/fc/Tirol_1918.png/300px-Tirol_1918.png, download 23.07.2010

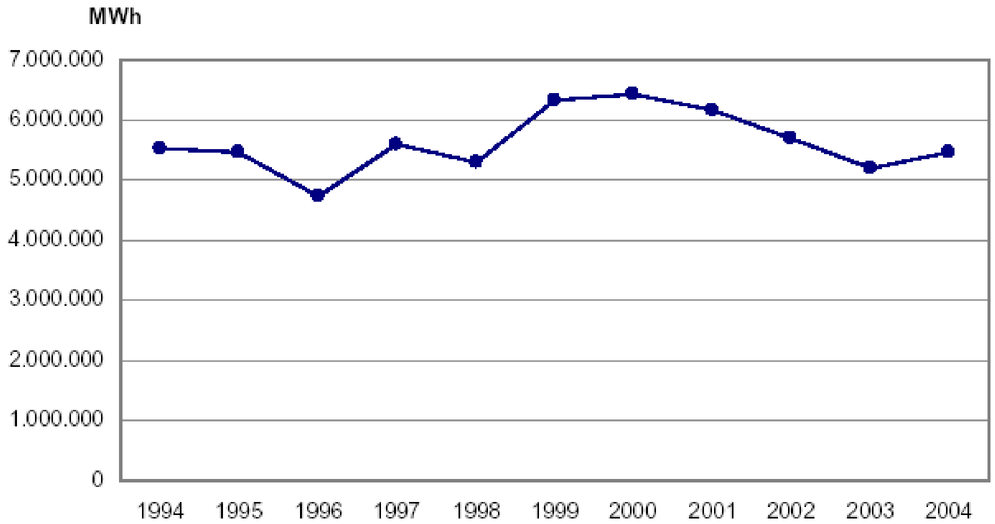
32 LWF Wissen Nr. 49, Bayerische Landesanstalt für Wald- und Forstwirtschaft, The Second National Forest Inventory 2002 - results for Bavaria, June 2005

4.2.2.1 Overview about the Renewable Energy Sources in North and East Tyrol

Compared to other countries, North and East Tyrol have already achieved a share of about 40% of renewable energy sources related to final end energy consumption (excluding traffic). The share is about 30% including traffic. The residual 70% are covered with fossil energy sources. A substantial contribution comes from hydro power, followed by biomass. The use of solar energy and heat pumps plays a minor role. In the area of waste management there exist biogas plants and facilities of the valorization of residual waste. Due to the topographic location, the use of wind power in North and East Tyrol is reduced to a few locations. The energy sources biomass/wood, solar and geothermal energy currently cover about 8% of the final energy consumption. The share of electricity is about 22%. Since the year 2000, the demand for the renewable energy biomass/wood and solar energy increased a lot.[33]

The amount of the electricity generated by the existing hydro power plants in Tyrol is approx. 5,900 GWh_e per year (+/- 10% depending on the precipitations) similar to South Tyrol.

Fig 4 - 41: Hydro power generation in North and East Tyrol – 1994-2004



Source: Statistik Austria, Energiebilanzen Tirol

33 Amt der Tiroler Landesregierung, Abteilung Wasser-, Forst- und Energierecht, Tiroler Energiestrategie 2020 – Grundlage für die Tiroler Energiepolitik, Innsbruck, 2004

Table 4 - 19: Number, nominal power and power generation of hydro power plants in North and East Tyrol

Power range	>10 MW	<10 MW	Total
Number of plants	22	116	**30**
Nominal power (MW)	2,698	238	**2,936**
Power generation without pumped hydro storage plants (GWh)	4,651	1,258	**5,909**

Source: Amt der Tiroler Landesregierung, Abteilung Wasserwirtschaft (August 2006)

The technical and economic potential of hydro power can be estimated with about 5,000 GWh_e per year. The Regional Government approved the construction of four new hydro power plants with a electricity generation of 1,100 GWh_e per year. In addition, other hydroelectric projects (Grenzkraftwerk-Inn, Innkraftwerk-Telfs) with an electricity generation of 500 GWh per year are planned.[34]

Since the Green Electricity Act from 2001, a total electric capacity of 27 MW_e was installed in 10 biomass co-generation plants. Those power plants are fed mainly with saw residuals (bark, chippings, wood chips).

Table 4 - 20: Number, power capacity and the amount of electricity fed in by biomass co-generation plants in North Tyrol

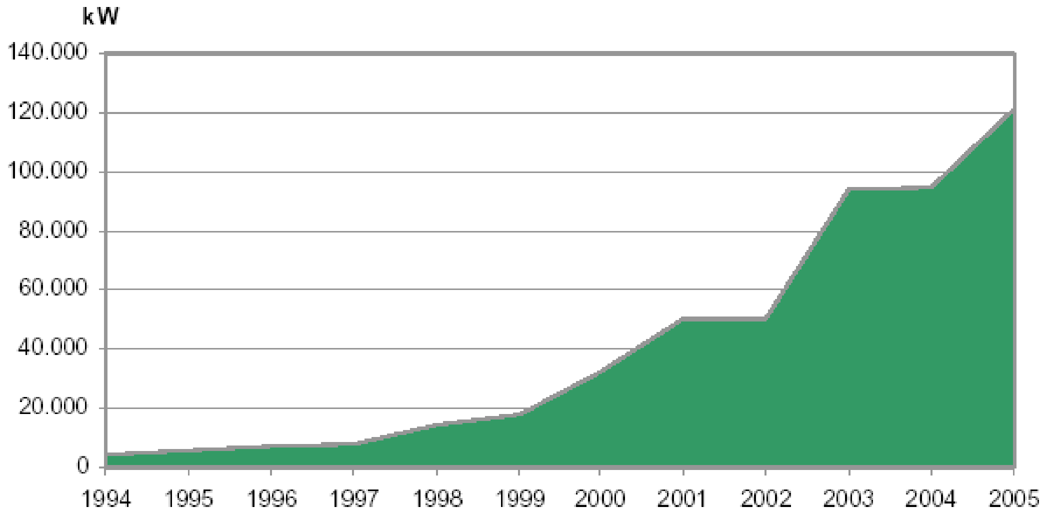
Number of plants	Power capacity (MW)	Electricity fed in (GWh)
10	27.28	181.38

Source: Energie-Control GmbH, Öko-BGV, January 2006

A significant increase was registered in the field of district heating based on saw residuals and forest wood chips. In 2004, approximately 250,000 lcm (loose cubic metre) biomass were used. With the start-up of co-generation plants, in 2007 already more than 1 million lcm saw residuals (bark, chippings, wood chips) were used.

34 Amt der Tiroler Landesregierung, Abteilung Wasser-, Forst- und Energierecht, Tiroler Energiestrategie 2020 – Grundlage für die Tiroler Energiepolitik, Innsbruck, 2004, p. 24

Fig 4 - 42: Installed heat capacity of the biomass district heating plants in North and East Tyrol – 1994-2005



Source: Energie Tirol

Around 270,000 m² of solar collector for hot water and heating were built until 2006. In the period 1994-2006, the collector area could be ten-fold increased. The annual growth of 10,000 to 15,000 m² summed up to 88,000 m² in 2006. In statistics private and commercial installations as well as facilities for swimming pool heating are considered.

In 2005 about 4% electricity (198.7 GWh_e) came from "eco power facilities" (without small hydro power plants). Most of it is produced by biomass combined heat and power plants, a smaller proportion is produced from biogas, landfill and sewage gas. Photovoltaic systems play a minor role. Since the end of 2005 were built an additional 40 photovoltaic plants with about 0.2 MWp in North and East Tyrol.

Table 4 - 21: Number, power capacity and the amount of electricity produced by biogas, landfill and sewage gas plants and fed into the grid in North and East Tyrol

	Number of plants	**Power capacity (MW)**	**Electricity fed in (GWh)**
Biogas	18	2.77	3.44
Landfill and sewage gas	13	5.11	7.56

Source: Energie-Control GmbH, Öko-BGV, January 2006

The use of near-surface geothermal energy (up to max. 200 m depth) in Tyrol, after very low growth rates until 2005, it increased significantly since then.

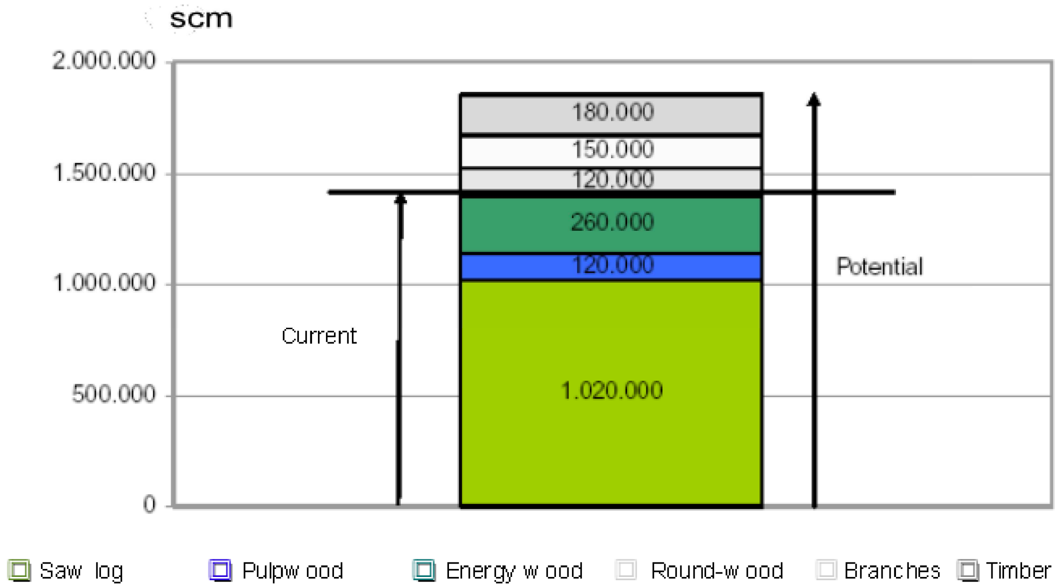
The energy model Tyrol 2000-2020 estimates an usable energy potential of 400 GWh out of around 160,000 tons of residual waste with an average calorific value of 11 MJ/kg.[35]

4.2.2.2 Potential of Wood Energy in Tyrol

The following graph shows that from the annual exploitable potential of 1.7 million m^3 scm (solid cubic metre) of round-wood and 150,000 m^3 scm of branches a high percentage is already used. In the years 2004 – 2006 on average 1.4 million m^3 scm of round-wood per year have been harvested. According to the wood potential study of the Office of the Tyrolean Government - Forest Group, the estimated additional sustainable usable volume amounts to 120,000 and 150,000 m^3 scm of round logs and branches, thus a total sum of 270,000 m^3 scm. In order to get this additional amount of energy wood, a strong promotion of thinning is necessary.

35 „Untergruppe Energie“ des Tiroler Raumordnungsbeirates, Energieleitbild Tirol 2000–2020, Innsbruck, p. 29, 2003

Fig 4 - 43: Wood potential of Tyrol



Source: Amt der Tiroler Landesregierung, Abteilung Wasser-, Forst- und Energierecht, Tiroler Energiestrategie 2020 – Grundlage für die Tiroler Energiepolitik, p. 26, Innsbruck, 2004

4.3 Promotion Schemes

In this chapter the most important laws on national and regional level are cited which regulate the promotion of renewable energy sources and the energy efficiency and saving measures in buildings.

4.3.1 National Legislation

National legislation about the promotion of renewable energy sources:

- Legislative Decree 29th march 2010, No. 56: Changes and additions to Decree 30th May 2008, No. 115, regarding the implementation of the European regulation 2006/32/EC on efficiency of the final use of energy and energy services and the abrogation of the European Directive 93/76/EEC.

- Ministry of Agriculture, Food and Forestry: Ministerial Decree 2nd March 2010: Implementation of the Law of 27th December 2006, No. 296 about the traceability of biomass for electricity production.

- Law 23rd July 2009, No. 99: Regulations for the development and internationalization of enterprises, as well in the field of energy.
- Law 27th February 2009, No. 13: Conversion into law with amendments of the Decree Law 30th December 2008, No. 208, on special measures concerning water resources and environmental protection.
- Legislative Decree 30th May 2008, No. 115: Implementation of Directive 2006/32/EC on efficiency of the final use of energy and energy services and abrogation of the European Directive 93/76/EEC.
- Ministry of Economic Development: Ministerial Decree 18th December 2008: Promotion of electricity production from renewable sources according to the Law 24th December 2007, No. 244, article 2, paragraph 150.
- Law 24th December 2007, No. 244: Regulations for the formation of the annual and perennial budget of the state - Finance Act 2008.

  The Finance Act 2008 (Law 24th December 2007, No. 244) and the implementing provision (Ministerial Decree 18th December 2008) distinguish between small (up to a power capacity of 1 MW or 0.2 MW for wind power) and medium and large-sized renewable energy plants. In both cases, the IAFR ("Impianti alimentati da fonti rinnovabili" – renewable energy plants) qualification is necessary assigned by GSE.

  - Investment in medium and large-sized plants (above 1 MW power capacity) are supported by the system of Green Certificates ("Certificati verdi").
  - When investing in small facilities, the operator can choose between Green Certificates and the comprehensive tariff ("Tariffa omnicomprensiva").

  Both funds are managed by GSE and both are given for a period of 15 years from start-up of the plant, whereas the amount of the refunding is set by the Ministry of Economy every three years.

Table 4 - 22: Comprehensive tariff for renewable energy sources – 2010

Energy sources	Euro cent/kWh
Wind power (<200 KW)	30
Geothermal energy	20
Wave and ocean energy	34
Hydro power	22
Biomass and biogas	28
Bioliquid fuels (biodiesel, bioethanol, vegetable oils)	28*
Gas from landfill gas and waste water treatment and bioliquid fuels (biodiesel, bioethanol, vegetable oils)	18

* Ministry of Agriculture, Food and Forestry: Circular 31 March 2010, prot. ex Saco 5520. Explanatory circular of the traceability of pure vegetable oils to produce electricity in order to receive the comprehensive tariff (tariffa omnicomprensiva) of 0.28 Euros per kWh as foreseen by law 99/2009.

Legislative source: Finance Act 2008 (Law 24th December 2007, No. 244, and Ministerial Decree 18th December 2008)

Source in internet: GSE, http://www.gse.it/attivita/Incentivazioni%20Fonti%20Rinnovabili/Servizi/Pagine/Tariffaonnicomprensiva.aspx, download 23.06.2010

The Green Certificates, a national support mechanism for renewable energy sources, introduced in Italy on January 1st 2002 by the Legislative Decree No. 79 of 1999 (so called “Bersani”), are traded on the stock exchange by GSE.

Producers and importers of non renewable energy are obliged by law to purchase at the stock exchange, operated by GSE, the Green Certificates that are needed to reach a share of 2% on renewable energy of the total production. At the request of the producers of energy from renewable sources, the Green Certificates are issued by GSE. In case the producer of renewable energy is not be able to sell them on the market, the GSE is obliged to purchase them at a price equal to the average market price.

The price is calculated as follows:

Price per MWh: 180 Euro minus the annual average selling price according AEEG (Autorià per l'energia elettrica ed il gas). For 2009, the price was 88.66 Euro/MWh. The payment of the value of the Green Certificates is guaranteed for

15 years. The amount of energy is adjusted by a specific coefficient. A ratio of 1.8 for biomass and 0.9 for geothermal means for example, that for the same quantity of kWh produced, the double amount is subsidized for biomass than for geothermal.

Table 4 - 23: Coefficient of the Green Certificates – 2010

Energy source	**Coefficient**
Wind power (> 200 MW)	1
Wind power offshore	1.5*
Geothermal	0.9
Wave and ocean energy	1.8
Hydro power	1
Biodegradable waste and biomass	1.3*
Biomass and biogas produced by agriculture, livestock breeding and forestry from short chain supply (“filiera corta”)	1.8**
Gas from landfill gas and waste water treatment	0.8

* The Law 23rd July 2009, No. 99 raised the coefficient of wind energy offshore in paragraph 1-bis and biodegradable waste and biomass in paragraph 6, respectively from 1.10 to 1.50 and from 1.10 to 1.30.

** The Ministerial Decree of the Ministry of Agriculture, Food and Forestry 2nd March 2010 determines the modalities for the farmers to ensure traceability of the short chain supply (“filiera corta”) in order to achieve a coefficient of 1.80.

Source: GSE, http://www.gse.it/attivita/Incentivazioni%20Fonti%20Rinnovabili/Servizi/Pagine/RilascioCertificativerdi.aspx?Idp=1&Anno=&SortField=Created&SortDir=DESC, download 23.06.2010

- Law 27th December 2006, No. 296: Regulations for the formation of the annual and perennial budget of the state - Finance Act 2007.

- Legislative Decree 29th December 2003 No. 387: Implementation of the European Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market. It regulates the burden sharing between the regions in order to achieve the national goal for 2020. The European Directive 2009/28/CE foresees for Italy to achieve a share of 17% on final energy consumption covered by renewable energy sources until 2020.

- Ministry of Economic Development: Ministerial Decree 19th February 2007: Criteria and procedures for promoting the production of electricity by photovoltaic conversion of solar energy - Implementation of article 7 of Legislative Decree 387/2003:

  Feed-in tariffs for photovoltaic: Solar energy is promoted by the feed-in tariffs through a specific, very attractive system, the so-called "Conto Energia".

Table 4 - 24: Feed-in tariffs for the installation of photovoltaic plants – 2010

	Type of installation		
Power capacity [KW]	Not integrated [Euro]	Partially integrated [Euro]	Integrated [Euro]
1-3	0.384	0.422	0.470
3-20	0.364	0.404	0.442
>20	0.346	0.384	0.422

Source: GSE

Energy exchange ("scambio sul posto"):

a) *Deduction of electricity consumed by itself.* The energy exchange is handled by the GSE since 01.01.2009 and can be chosen for photovoltaic plants with a capacity up to 200 kWp. If the operator at the time of energy production (solar radiation) consumes the electricity by itself, the electricity consumed does not appear on any bill. Hence, the advantage is that the costs of electricity consumed can be saved. The amount of savings depends upon the costs of electricity and the amount of electricity consumed directly.

b) *Energy sale with own consumption (Sale of the surplus produced).* Alternatively, the operator of a plant with 1 kWp can choose the so-called energy sale with own consumption. This is useful if the photovoltaic system is oversized (the electricity produced is much higher than the self-consumed electricity). If the operator at the time of energy production (solar radiation) consumes the electricity by itself, the electricity consumed does not appear on any bill. If the operator does not use the electricity, it will be completely fed into the power grid. In this case, the operator receives in addition to the feed-in tariff an additional fixed minimum price to the total amount of electricity fed in, which lies currently between 0.0722 to 0.0985 €/kWh (given by AEEG - “Autorità per l'energia ed il gas”). The operator must be in the possession of a tax position and must declare the profit of selling electricity in the next tax declaration.

- Legislative Decree 16th March 1999, No. 79: Implementation of European Directive 96/92/EC on common rules for the internal electricity market.

Energy efficiency and saving in buildings:

- Ministry of Economic Development: Ministerial Decree 26th June 2009: National guidelines for energy certification of buildings.
- Ministry of Economy and Finance: Ministerial Decree 7th April 2008 implemented by the Finance Act 2008 ("Decree buildings”): Regulations relating to cost deductions for energy efficiency measures of existing buildings, according to article 1, paragraph 349, of the national law 27th December 2006, No. 296.
- Legislative Decree 29th December 2006, No. 311: Corrective and supplementary regulations to the Legislative Decree 19th August 2005, No. 192 implementing the European Directive 2002/91/EC on the Energy Performance of Buildings.
- Legislative Decree 19th August 2005, No. 192: Implementation of European regulation 2002/91/EC on energy efficiency in buildings.

4.3.2 Regional Legislation

Regional legislation about the promotion of renewable energy sources:

- Regional Law 7th July 2010, No. 9: Regulations in the field of energy saving and renewable energy sources.

- Regional Law 22nd January 2010, No. 2: Regulations about agriculture, civic uses, public use of water, energy, urban planning and environmental protection.
- Decree of the Regional Government 1st March 2010, No. 359 - Annex A for private persons, farmers and public entities and Annex B for companies: New criteria for granting incentives for energy efficiency and use of renewable energy from 1st March 2010:

  The Regional Law No. 4 from 19.02.1993, substituted with the Regional Law No. 9 from 09.07.2010 in the meanwhile, foresees a regional financial support for the use of renewable energy sources. On 1st March 2010 the new criteria for the energy promotion were approved by the Regional Government, which are considered as a part of the climate package with the objective to promote the intelligent energy use, the increase of energy efficiency and the development of renewable energy sources.

  The Regional Government promotes energy efficiency measures, the use of renewable energy sources, innovative initiatives, transfer of knowledge and the distribution of planning tools in this area with a maximum contribution of 30%. For the installation of photovoltaic systems and wind power plants the grant can be increased to 80%, if the electricity demand is completely covered by the photovoltaic plant (only applicable for private persons, farmers and public entities). For the installation of photovoltaic systems financed by EU programs, a maximum contribution of 20% is granted.

  The following grants are given for the following measures (according to the Decree of the Regional Government 1st March 2010, No. 359, art. 3 of the annex A and B):

  a) Thermal insulation of roofs, upper floors and inaccessible terraces of existing buildings.
  b) Thermal insulation of exterior walls, the lowest floors, ceilings, arcades and terraces of existing buildings.

c) Replacement of windows and doors of buildings under monumental protection, whereas the demolition of the building is not permitted for reasons of monument protection.

d) Installation of solar thermal systems for hot water and / or swimming pool heating.

e) Installation of solar thermal systems for heating and / or cooling.

f) Installation of automatic-fired heating systems.

g) Installation of wood gasification boilers solid biomass.

h) Installation of geothermal heat pumps.

i) Heat recovery systems for cooling products.

j) Installation of photovoltaic systems and wind power plants to generate electricity. The grants are awarded only if there is not granted a national funding and the connection to the power grid is not feasible without an adequate technical and financial support. From this regulation photovoltaic systems, funded by EU programs, are excluded.

k) Realization of feasibility studies or energy-related investigations for the purpose of energy-saving and / or the use of renewable energy sources.

The eligible costs for each measure are listed in annex A for individual persons and in annex B for companies.

The national and the regional law do not allow the accumulation of subsidies. The citizen must choose between the national or regional funding scheme.

- Decree of the Regional Governor 28th September 2007, No. 52: Facilities for the energy production from renewable sources.

Energy efficiency and saving in buildings:

- Decree of the Regional Government 27th July 2009, No. 1969: Energy certificate for apartments.

- Decree of the Regional Governor 29th September 2004, No. 34: Implementing the regional urban planning law in the field of energy saving in buildings.

4.4 Energy Prices

In this section the local energy prices will be illustrated. The Consumer Advice Centre in Bozen has conducted a survey about the fuel price of heating oil, liquid gas (in tank), natural gas, pellets, wood chips, wood log mixed and district heating at the beginning of March 2010. For the price survey an average annual consumption of 15,000 kWh of a building with a ClimateHouse standard C (<70 kWh/m²/year) was considered. For buildings with much higher or lower annual consumption, prices can vary a lot due to the higher or lower fuel quantity needed.

In order to compare the different fuels, the price per unit has to be divided by the energy content of each fuel. The obtained result in kilowatt per hour (kWh) can then be compared with each other.

The fuel prices range from 0.141 Euro/kWh for liquid gas (tank) to 0.025 Euro/kWh for wood chips, which is at the moment the most economic combustible for the consumer within this circumstances as explained before.

It is important to add that not only the kilowatt per hour price is crucial for a budget-friendly heating, but also the investment costs and the efficiency of each boiler, and not least the user behaviour of the consumers.

Table 4 - 25: Comparison of fuel prices

Fuels	**Price in Euro per unit**	**Energy content in kWh**	**Price in Euro per kWh**
Liquid gas (tank)	1.802 €/kg	12.8	0.141
Heating oil	1.080 €/l	10	0.108
District heating (yearly fixed tax included)	0.088 €/kWh	1.0	0.088
Natural gas	0.68 €/m³	9.8	0.069
Pellets	0.2296 €/kg	4.8	0.048
Wood log mixed	0.133 €/kg	4.3	0.031
Wood chips	0.139 €/kg	5.5	0.025

NB: Price survey conducted by the Consumer Advice Centre in Bozen at the beginning of March 2010

Source: Consumer Advice Centre in Bozen, price comparison of fuels, http://www.verbraucherzentrale.it/17v116d28079.html, download 23.07.2010

The electricity price for a household with a 3 KW connection and a primary residence which consumes 2,700 kWh per year amounts to 15.76 cent€/kWh according the price information on 28.06.2010 from the Consumer Advice Centre in Bozen.[36]

The average price of the wood chips was 15.14 €/loose cubic metre in 2009, which will rise at least between 16.50 and 17.00 €/loose cubic metre in 2010.[37]

4.5 Investment Costs

In this section the total costs for the purchase of different heating systems will be illustrated. The Consumer Advice Centre in Bozen has conducted a survey about the most cost saving ways to heat the house and apartment in October 2009. The investment, the fuel and maintenance costs were taken into account.

The investment includes the costs for the acquisition of the boiler, the oil tank, natural gas connection, heat transfer stations, the biomass silos and so forth. The regional subsidy of 30% for new installations was deducted from the costs.

36 http://www.verbraucherzentrale.it/download/12v58315d58981.rtf, download 09.08.2010

37 Price information received from the Biomass District Heating Plant in Toblach-Innichen on 01.06.2010

For the fuel costs the current price for a period of 20 years was considered. The future development was not taken into account

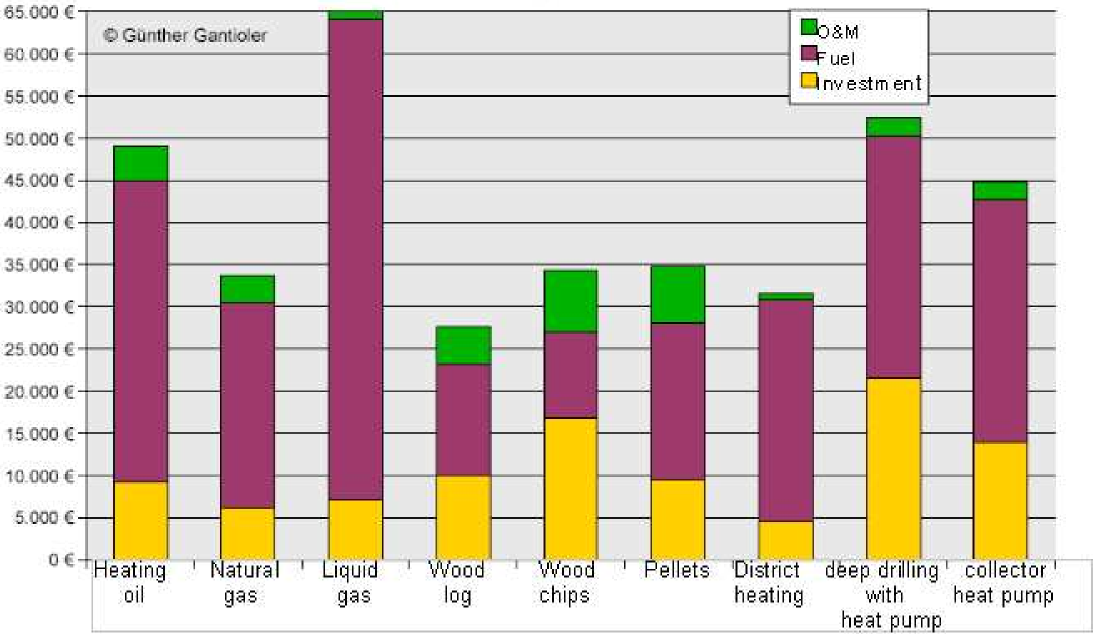
The maintenance costs include the costs for the chimney sweep, electricity and service. All prices were calculated with a V.A.T. of 4%.

As basis for the cost study about the different heating systems a building with a capacity of 15 KW and an average annual consumption of 15,000 kWh was used which corresponds to a building with a ClimateHouse standard C (<70 kWh/m²/year).

The figure below shows that the fossil heating systems are in total more expensive than the renewable heating systems, except natural gas, which is in comparison to wood chips and pellets slightly cheaper. Natural gas competes with district heating in some locations; it depends upon the district heating price which the biomass district heating plants offer the consumers.

The price difference between the most expensive system, the liquid gas system, and the most economic, the fire wood boiler, is about 80%. The comparison of a fuel oil heating system with a pellet installation shows, that the pellet installation is in total about 30% cheaper.

Fig 4 - 44: Cost comparison of various heating systems



Survey: October 2009

Source: Consumer Advice Centre in Bozen, http://www.verbraucherzentrale.it/17v116d22584.html, download 23.07.2010

Table 4 - 26: Price comparison of various heating systems

Heating system	**Price comparison**
Heating oil	100%
Natural gas	69%
Liquid gas	139%
Wood log	56%
Wood chips	70%
Pellets	71%
District heating	65%
Deep drilling with heat pump	107%
Collector heat pump	91%

Survey: October 2009

Source: Consumer Advice Centre in Bozen, http://www.verbraucherzentrale.it/17v116d22584.html, download 23.07.2010

5 Potential of Renewable Energy

At the EU Summit from 08.03.2007 to 09.03.2007 in Brussels were set the core objectives for European energy supply for the year 2020 which are:

- Reducing the greenhouse gases to 20% up to 2020 compared to the 1990 levels.
- Increasing the share of renewable energies on total energy to 20% up to 2020.
- Increasing the energy efficiency to 20% up to 2020.
- Increasing the share of biofuels to 10% on total fuel consumption up to 2020.

These targets are global targets for the entire European Union. Each member state has to convert those targets in national targets.

The potentials of hydro power, biomass, biogas, solar (photovoltaic and solar thermal), wind, geothermal and energy efficiency and energy savings in residential buildings and private households will be presented in this chapter.

5.1 Local Energy Program

According to the new local Climate Strategy 2050 the current renewable energy share on energy consumption in South Tyrol is 59% (without transport), up to 2020 it should be 75% and up to 2050 the aim is to reach almost the energy autarky in South Tyrol (over 90% of the energy consumption covered by renewable energy sources excluded transport and included energy saving measures).[38]

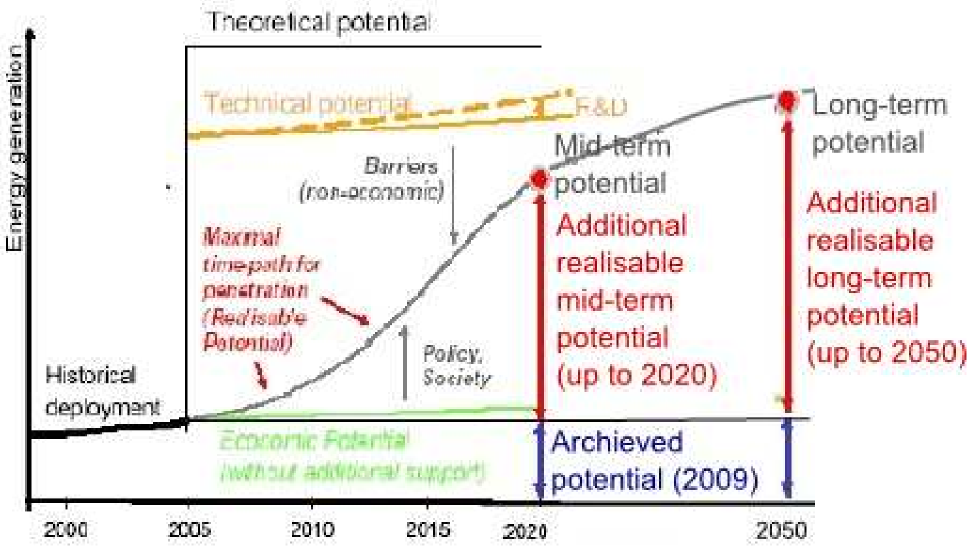
It should be noted, that the above data do not take into account the overproduction of hydro power (more electricity produced than consumed), whereas in chapter 3.3, in Table 3 - 3, the coverage rate of energy consumption by renewable energy sources considers the total yearly production of hydro power.

5.2 Definition of Potential

The potential can be differentiated in a theoretical, economic, technical and realizable potential. In the study the focus is on the analysis of the realizable mid- and long-term potential of renewable energy sources taking into account social, environmental and legal considerations.

38 Climate Strategy, Energy South Tyrol 2050, p. 88, draft version 01.08.2010

Fig 5 - 45: Theoretical, economic, technical and realizable potential



Source: Haas R., University of Technology Vienna, lecture documents of the master course "Renewable Energy in Central- and Eastern Europe", 2008-2010, 2010

5.3 Electricity

5.3.1 Hydro Power

The mountainous landscape of South Tyrol is ideal for the use of hydro power. Currently there are 930 hydro power plants in operation. In 2009 approximately 5,800 GWh_e/year were generated by hydro power, which is considerably more electricity than consumed. About the half is consumed locally and the rest is exported.

5.3.1.1 Methodology to Determine Potential

The data about the potential of hydro power come from the Regional Office of Electricity Supply and from ENEA – the Italian National Agency for New Technologies, Energy and Sustainable Economic Development.

5.3.1.2 Realistic Potential

The Regional Office of Electricity Supply estimates an expansion of approximately 9% of the current hydro power capacity which means that an additional nominal capacity of 80 MW_e could be realized with an electricity production of more or less 496 GWh_e/year.

In this estimation the scenario of the connection of small hydro power plants to medium-sized hydro power plants is considered, but the greatest potential lies in the rivers Gader, Mareiter Bach, Ahr, Rienz (Kniepass/Mühlbach), Eisack (Mauls-Villnöss ladder), Passer and Rambach.

In the CO2 study for the Municipality of Bozen realized by EURAC one possible reduction scenario is the construction of three hydro power plants along the rivers in Bozen. The electricity generation accounts for approximately 118 GWh_e/year, one seventh of the total annual electricity consumption in Bozen.[39]

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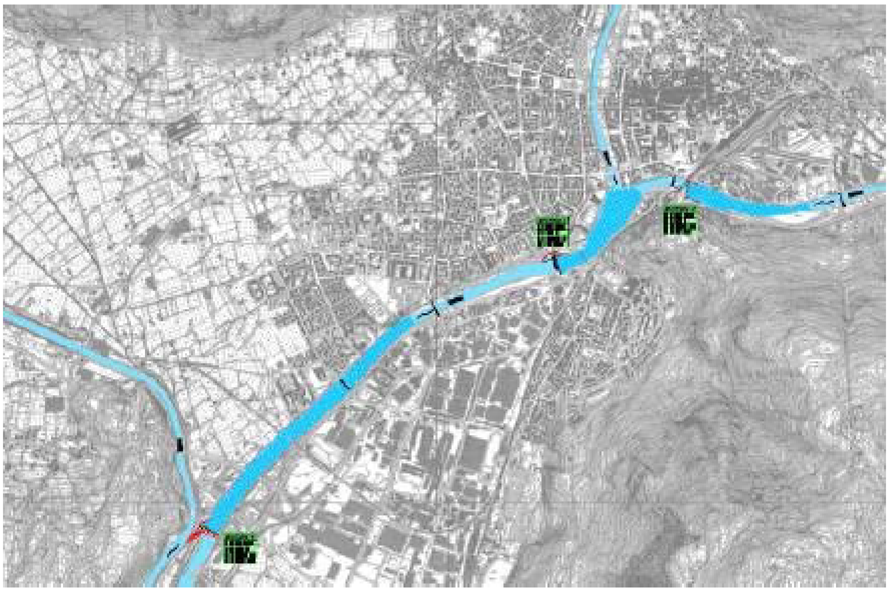
39 EURAC research, CO2 Emissionen und mögliche Reduktionsszenarien für die Stadt Bozen, p. 37, 01.02.2010

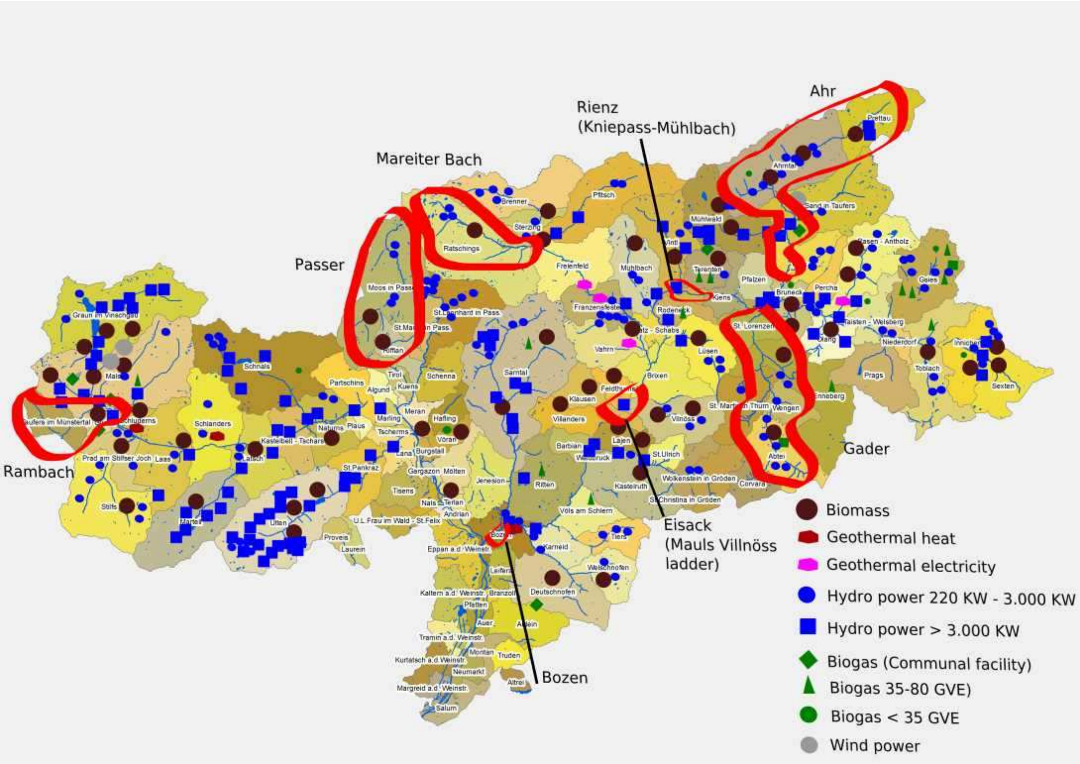
Fig 5 - 46: Possible locations of the construction of three hydro power plants in Bozen



Source: EURAC research, CO2 Emissionen und mögliche Reduktionsszenarien für die Stadt Bozen, p. 37, 01.02.2010

Furthermore the electricity generation of the already existing hydro power plants on the rivers Passer and Eisack could be raised by 400 GWh_e/year.

Fig 5 - 47: Locations of the realizable potentials of hydro power in South Tyrol



Source: Own elaboration

Table 5 - 27: Summary of the realizable potentials of hydro power until 2020

Year of realization	**Projects**	**Electricity production in GWh$_e$/year**
2015	Optimization of existing hydro power plants along Passer and Eisack *	400
2020	Construction of new hydro power plants *	496
2020	Three hydro power plants along the rivers in Bozen **	118
	Total	**1,414**

Source: * Amt für Stromversorgung, ** EURAC research

In chapter 5.3.8 the potential of pumped storage hydro power stations and hydrogen production in South Tyrol will be presented.

5.3.1.3 Drivers

In the future some hydro power plants have to be refurbished, upgraded and revitalized which allows the installation of more efficient power generation systems to produce a higher amount of electricity.

Another driving force are the Green Certificates, a national support mechanism for renewable energy sources, introduced in Italy on January 1st 2002 by the Legislative Decree No. 79 of 1999 (so called “Bersani”), which makes the investment in hydro power plants more attractive.

Producer and importers of non renewable energy are obliged by law to purchase at the stock exchange, operated by GSE, the Green Certificates that are needed to reach a share of 2% on renewable energy of the total production. At the request of the producers of energy from renewable sources, the Green Certificates are issued by GSE. In case the producer of renewable energy is not able to sell them on the market, the GSE is obliged to purchase them at a price equal to the average market price. The price of such a Green Certificate stood at 88.66 Euro/MWh in 2009.

5.3.1.4 Barriers

The EU Water Framework Directive 2000/60/EC on 23rd October 2000 establishing a framework for Community action in the field of water policy was introduced in Italy by the Legislative Decree No. 152 of 3rd April 2006. Each region has to fulfil the prescriptive limits. In South Tyrol the Water Use Plan was approved by the Regional Government with Decree No. 704 of 26th April 2010. It summarizes the major potential impacts from water use in one sector on other sectors. It illustrates the most important areas of cross-sectoral water competition. The most water-sensitive sectors are agriculture, forestry, biodiversity conservation, households, tourism, industry and energy production.

Especially during the summer time, for which climate change scenarios project much drier and warmer conditions, competition for water will probably increase. More pronounced climatic changes are expected in the Southern Alps. Thus, water conflicts could become more severe in this region.

However, further exploitation of water resources is limited. Hydro power companies are obliged by legislation to protect the landscape and water. It is mandatory to leave adequate residual flows in watercourses. The amount of residual flows was increased in the new Water Use Plan recently approved. All new water draw-offs from surface waters are constrained to release a minimum of residual water of 2 l/s per km² water catchment area. Also the hydro power plants, which renew the concession, have to apply the same amount of residual flows in watercourses. For water draw-offs with an average of over 100 l/s the preparation of a limnological study as technical support to determine the minimum residual flow is mandatory.[40]

Water catchment area (in Geman: Wassereinzugsgebiet) of 6 km² (exception: in the case of new hydro power plants, which use a considerable drop height and achieve a power capacity of more than 220 KW, the water catchment area can be less than 6 km²).[41] In the report of ENEA about Renewable Energy Sources 2010[42] a reduction of 25% of the electricity generation by hydro power is estimated in 2016 based on the figures of 2004 due to the binding amount of residual flows. The report considers that no adequate residual flows in watercourses were binding until now. In South Tyrol the situation is different. Before the approval of the Water Use Plan by the Regional Government with Decree of 26th April 2010, a certain amount of residual flows in watercourses were already defined. The Office of Electricity Supply (Amt für Stromversorgung) estimates that due to the new Water Use Plan of 2010 the electricity generation will decrease by 5% in South Tyrol.

Aspects related to the environmental impact and already main exploited watercourses limit the possibility to build new large plants. A few possibilities in the rivers Gader, Mareiter Bach, Ahr, Rienz (Kniepass/Mühlbach), Eisack (Mauls-Villnöss ladder), Passer and Rambach still exist.

Another fact is that by the Regional lLw No. 2 of 22nd January 2010, paragraph 5, article 3 of the Regional Law No. 7 of 30 September 2005 the following sentence is added: The request of building a new hydro power plant of up to 3 MW is

40 Regional Water Use Plan, part 3 - normative part, art. 38, p. 23, 2010

41 Regional Water Use Plan, part 3 - normative part, art. 16, p. 15, 2010

42 ENEA, Le Fonti Rinnovabili 2010, Roma, p. 191, 2010

inadmissible, if it is not accompanied with the title of the property availability of the affected area. This article restricts the construction of new hydro power plants of up to 3 MW in the future.

In the past banks granted loans without equity. Nowadays equity of 20% must be demonstrated. For example, the construction of large hydro power plants with a total cost of 50 million Euro, equity of 12 million Euro is necessary in order to get a loan from the bank.

GSE continues to purchase the Green Certificates in excess, but with restrictions of 30% regarding to the expenses of 2010 (01.01.2011). The amendment was introduced by the Law No. 78 of 31st May 2010 and adds to the art. 2 of the Law 24th December 2007, No. 244 (Finance Act 2008) the paragraph 149 bis which introduces this new aspect for the Green Certificates. As explained in the chapter before, the producers of renewable energy, which are not able to sell the Green Certificates on the market, the GSE is obliged to purchase them at a price equal to the average market price, but from 01.01.2011 with restrictions of 30% regarding to the expenses of 2010. Only producers below 1 MW power capacity, which get the “Tariffa omnicomprensiva” of 22 €cent/kWh, are not affected by the new regulation.

5.3.2 Photovoltaic

5.3.2.1 Methodology to Determine Potential

The study “Solar city Brixen” about the Municipality of Brixen and the CO2 study with possible reduction scenarios about the Municipality of Bozen, were conducted by EURAC, the European Academy of Bozen/Bozen - Institute for Renewable Energy. Both studies are used to describe the photovoltaic potential in the cities Brixen and Bozen.

The potential of photovoltaic panels on the roofs of public buildings will be delineated in the succeeding part.

A detailed analysis of the photovoltaic potential for the entire South-Tyrolean region is further included.

5.3.2.2 Realistic Potential

In the CO2 study were analysed possible reduction scenarios for the Municipality of Bozen. One part of this study is focused on the use of photovoltaic modules on the roofs of new buildings.

In the study were considered the construction of 10 new buildings with a total building area of 3,160 m², based on the data estimated by the communal Office of Urban Development of Bozen. The buildings consist of 5 storages with 4 flats per storage and an average living area per flat of 79 m² (ASTAT).

Two scenarios were proposed: In the first scenario were analysed to put photovoltaic panels on the entire available roof of the new buildings. In the second scenario were considered the use of solar thermal collectors, which should cover 60% of the total requirements for hot water, and for the remaining area were planned to use photovoltaic panels. The second scenario will be presented in chapter 5.4.2.

In this section the first case will be investigated. In order to calculate the amount of electricity production it was assumed that for 1 kWp of photovoltaic energy an area of 8 m² is needed which produces an amount of electricity of approximately 1 MWh_e/year. Under this conditions the total electricity production amounts to 395 MWh_e/year.

Potential of photovoltaic panels on the roofs of public buildings:

The public buildings in South Tyrol have a roof area of not less than 20,000 m², which could be used for the energy production. The Regional Government announced the willingness to investigate how it can be used.[43]

In Bozen 12 public buildings with a roof area of about 10,770 m² are suited for the installation of photovoltaic panels. The feasibility study of Bozen is not realized yet. Thus, assumed an area of 8 m² for 1 kWp and an amount of 936.4 kWh/kWp/year electricity produced (specific grade of efficiency for the region Trentino-Alto Adige)[44], the total electricity production will be 1,261 MWh_e/year.

A feasibility study about the installation of a photovoltaic system on the roof of public buildings in Brixen was realized in 2009. 9 public buildings with a roof area of about 2,620 m² are suited for the installation of photovoltaic panels Sanyo HIT 210/230 which show the best results. Those panels use hybrid technology that combines the cell technologies of crystalline silicon wafers and ultra thin amorphous silicon layers, resulting in a higher module conversion efficiency. Apart from the higher efficiency, the amorphous layers help to increase the daily performance (i.e. energy collection over the day) as they are less prone to effects of shadow and clouds. Through a better temperature coefficient (lower temperature coefficient compared to mono-crystalline panels) these modules provide better results especially at high temperatures.

43 Presseamt, http://www.provinz.bz.it/lpa/service/news.asp?redas=yes&archiv_action=4&archiv_article_id=317114, download 03.08.2010

44 GSE, Il fotovoltaico 2008, p. 19, 2008

Table 5 - 28: Results of the technical analysis about three different photovoltaic technologies – Overview

Overview about the results of the survey				
Technology of the modules	**Installed power capacity [kWp]**	**Electricity production [kWh/year]**	**Average efficiency [kWh/year per kWp]**	**CO2-savings [kg]**
Mono-crystalline	383.04	379,589	991	174,611
HIT (hybrid intrinsic thin layer)	436.04	449,421	1,031	206,734
Amorphous (thin layer) and CdTe	199.03	209,713	1,054	96,468

Source: Feasibility study about the installation of a photovoltaic system on the roof of public buildings in Brixen, p. 11, May 2009

Under consideration of the best case (HIT - Hybrid intrinsic thin layer) the value of electricity produced amounts to 449 MWh_e/year with an efficiency of 1,031 kWh per kWp and year.

For the detailed analysis of the photovoltaic potential for the whole South-Tyrolean region were used as parameters all municipalities of South Tyrol (116), their number of inhabitants (31.12.2009)[45] and all buildings (2001)[46], as shown in the table below. The municipalities were assigned to the settlement categories by the number of inhabitants and from this it was possible to calculate the average photovoltaic potential in kWp according to the study of Lödl M. (2010).[47]

It was calculated a potential of 0.972 GWp which corresponds to an annual electricity production of about 972 GWh_e. Over 83% of the production comes from the rural municipalities and the villages, because especially the agricultural enterprises with their roofs cover a large area.

45 ASTAT info n. 15, Bevölkerungsentwicklung 4. Trimester 2009, Bozen, 29.03.2010

46 ASTAT, 14. Allgemeine Volkszählung 2001, Band 2, Gebäude und Wohungen, Bozen, 2005

47 Lödl M., Abschätzung des Photovoltaik-Potentials in Deutschland, Graz, 2010 http://www.hsa.ei.tum.de/Publikationen/2010/2010_Loedl_Kerber_Wi_Graz.pdf, download 27.08.2010

Table 5 - 29: Distribution of the photovoltaic potential by categories of settlement

Categories of settlement	Average photovoltaic potential per house connection in kWp
Rural	25.8
Village	13.9
Suburb	5.7

Source: Lödl M., Abschätzung des Photovoltaik-Potentials in Deutschland, Graz, 2010, http://www.hsa.ei.tum.de/Publikationen/2010/2010_Loedl_Kerber_Wi_Graz.pdf, download 27.08.2010

Table 5 - 30: Distribution of the categories of settlement by number of inhabitants

Categories of settlement	Number of inhabitants
Rural municipality	Up to 2,000
Village	Up to 5,000
Small town	Up to 20,000
Medium-sized and large town	Over 20,000

Source: Lödl M., Abschätzung des Photovoltaik-Potentials in Deutschland, Graz, 2010, http://www.hsa.ei.tum.de/Publikationen/2010/2010_Loedl_Kerber_Wi_Graz.pdf, download 27.08.2010

Table 5 - 31: The photovoltaic potential in South Tyrol

	Rural municipality	Village	Small town	Medium-sized and large town	Total
Numbers	48	49	16	3	116
Number of inhabitants	58.447	153.607	130.060	161.320	503.434
Number of buildings	13.691	31.039	21.593	11.319	77.642
Average PV potential in kWp	353.228	431.442	123.080	64.518	972.268
Average PV potential in GWp	0,353228	0,431442	0,123080	0,064518	0,972268
Average PV potential per building in kWp	25,8	13,9	5,7	5,7	12,5
Yearly electricity produced in kWh	353.227.800	431.442.100	123.080.100	64.518.300	972.268.300
Yearly electricity Produced in GWh	353,23	431,44	123,08	64,52	972,27
Investment costs in Euro	1.787.332.668	2.183.097.026	622.785.306	326.462.598	4.919.677.598
Total area in m²	2.825.822	3.451.537	984.641	516.146	7.778.146
Distribution of the production in %	36,33%	44,37%	12,66%	6,64%	100,00%
Distribution of the number of inhabitants in %	11,61%	30,51%	25,83%	32,04%	100,00%
Distribution of the number of buildings in %	17,63%	39,98%	27,81%	14,58%	100,00%
Distribution of the municipalities in %	41,38%	42,24%	13,79%	2,59%	100,00%
Average area per building in m²	206	111	46	46	100
Average area per person in m²	48	22	8	3	15
Average amount of electricity produced per person/year in kWh	6.044	2.809	946	400	1.931
Average amount of electricity produced per building/year in kWh	25.800	13.900	5.700	5.700	12.522
Area in km²	2,83	3,45	0,98	0,52	7,78

Source: Own elaboration

A further photovoltaic potential have the buildings of the fruit cooperatives with huge roof areas. Currently, approximately 3.82% of this potential is covered, so it can be anticipated still an enormous growth potential over the period 2015 to 2020 and to 2050. The total theoretical photovoltaic potential is about 7.78 km². Each inhabitant would produce on average about 1,931 kWh_e electricity per year. The total costs would amount to 5 billion Euro, which correspond approximately to the current annual public budget of South Tyrol.

Table 5 - 32: Theoretical photovoltaic potential by agricultural enterprises

Number of agricultural enterprises	kWp	kWh/year	GWh/year	Roof area in m²	Investment costs in Euro
25,297	652,662.6	652,662,600	652,66	5,221,300.8	3,302,472,756

Source: Own elaboration

Assumptions:

- Total kWp = 25.8 kWp (per building) multiplied by the number of enterprises
- Total kWh = kWp multiplied by 1,000
- Roof area: kWp multiplied by 8 m²
- Investment costs: 5,060 Euro/kWp (10% V.A.T. included)[48]

The agricultural enterprises could cover approximately 67.13% of the technical photovoltaic potential.

Table 5 - 33: Total theoretical, technical and realizable photovoltaic potential in South Tyrol – 2015-2050

Photovoltaic potential	Theoretical potential	Technical potential	Status quo 2009	Realized technical potential in %	2015	2020	2050
Total	972	972	37	3,8%	86	183	475

Source: Own elaboration

48 Südtiroler Bauernbund, http://www.sbb.it/photovoltaik/ , download 27.08.2010

For the following periods are assumed following scenarios:

- 2015: Growth potential: 5% of the technical potential
- 2020: Growth potential: 10% of the technical potential
- 2050: Growth potential: 30% of the technical potential
- Total growth: 45% of the technical potential = Economic potential

Up to 2050 almost 49% of the photovoltaic potential can be covered.

5.3.2.3 Drivers

The Regional Government announced the willingness to investigate how the roof area of the public buildings could be used for the production of energy. In Bozen and Brixen photovoltaic systems on the roofs are already planned to install. Within 2018 on all flat roofs of public buildings (state and local entities, schools, hospitals, etc.) photovoltaic systems should be installed, if the site is suitable for the construction. For new buildings photovoltaic systems and solar panels in the public sector are mandatory, under the constraint, that no reasonable alternatives exist.[49]

For single houses photovoltaic is a good alternative to become energy self-sufficient.

The municipality Bozen foresees in the latest revision of the building regulations, approved by the Council Decision No. 9/8926 of 1st February 2007, that the use of photovoltaic panels or solar collectors for the production of domestic hot water for new buildings is mandatory.[50] It defines the following conditions for the construction of new private and public buildings and the renovation of buildings by at least 50% of the volume or floor space:

- The construction of the building according to the ClimateHouse standard B as a minimum standard (<= 50 kWh/m²/year).

49 Climate Strategy, Energy South Tyrol 2050, p. 106, draft version 01.08.2010

50 Municipality Bozen, http://www.gemeinde.bozen.it/urb_context02.jsp?ID_LINK=540&page=5&area=75, download 03.08.2010

- The use of solar energy by photovoltaic panels or solar collectors to cover at least 25% of the total heat energy consumption and at least 50% for the production of domestic hot water.

This year started the project “How much potential energy is on the own house roof?” and will be finished in the year 2013. The questions about the suitability of the roof for a photovoltaic installation and the electricity production of such a plant will be answered in the future in a few seconds - it is enough to enter the address and click once. This project was launched by the EURAC Institute for Renewable Energy and the Applied Remote Sensing and is focused preliminary on the area of Brixen, but in the future the service should be extended to other areas in South Tyrol. It will be made available to the citizens.

As basis serve satellite data provided by the own receiving station on the Rittner Horn and a high-resolution elevation model of the Province of Bozen. The high resolution of the elevation model shows impressive details such as trees or roofs. From the satellite data can be calculated how cloudiness and turbidity reduce the solar radiation and the photovoltaic potential can be estimated. EURAC evaluates the technological side of photovoltaic in the laboratory and on site. The aim is to develop a geographic model that illustrates the potential energy of a given area. The model takes several parameters into account: the geographical position, the thermal radiation, the shading areas such as mountains, hills, slopes or buildings, the cloudiness over the year and the solar radiation minus the heat rejection to the atmosphere.

5.3.2.4 Barriers

The barriers for photovoltaic are aesthetic questions or questions of costs compared to energy saving measures like thermal renewing of buildings.

According to the energy expert P. Erlacher one kWh of electricity produced with photovoltaic costs 40-50 €cents and in order to save one kWh through insulation of the building costs 4-5 €cents. Thus, the earnings for the households could be much higher by applying energy saving measures than the production of electricity.

Therefore the information and assistance of the citizen on energy efficiency should be increased. Nevertheless, the photovoltaic technology will continue to growth also in the next years and the production price of modules on average diminishes of 5% per year, which leads to a decrease of the electricity price. It can be assumed that the price curve of solar power production in the sunny Sicily will cross that of the "normal power" in about two years. In South Tyrol this might be the case in four to six years when photovoltaic power costs equal to conventional electricity without any financial support.[51]

According to the Decree of the Governor No. 52 of September 28th 2007, it is not allowed to install more then 50 m² photovoltaic on green areas for aesthetic and landscape reasons.

Most municipal building regulations foresee only an announcement before the start of construction up to a certain size. Constructions above a certain defined size must apply for a concession. Especially for the photovoltaic installations in historic centres on buildings which are under special protection/conservation, the municipality can determine in its building regulations if the installation of photovoltaic systems is allowed or not. Therefore it is useful to get in contact with the municipality before the start of the construction.

51 WIKU, newspaper article „Solare Auseinandersetzungen", 28.04.2010

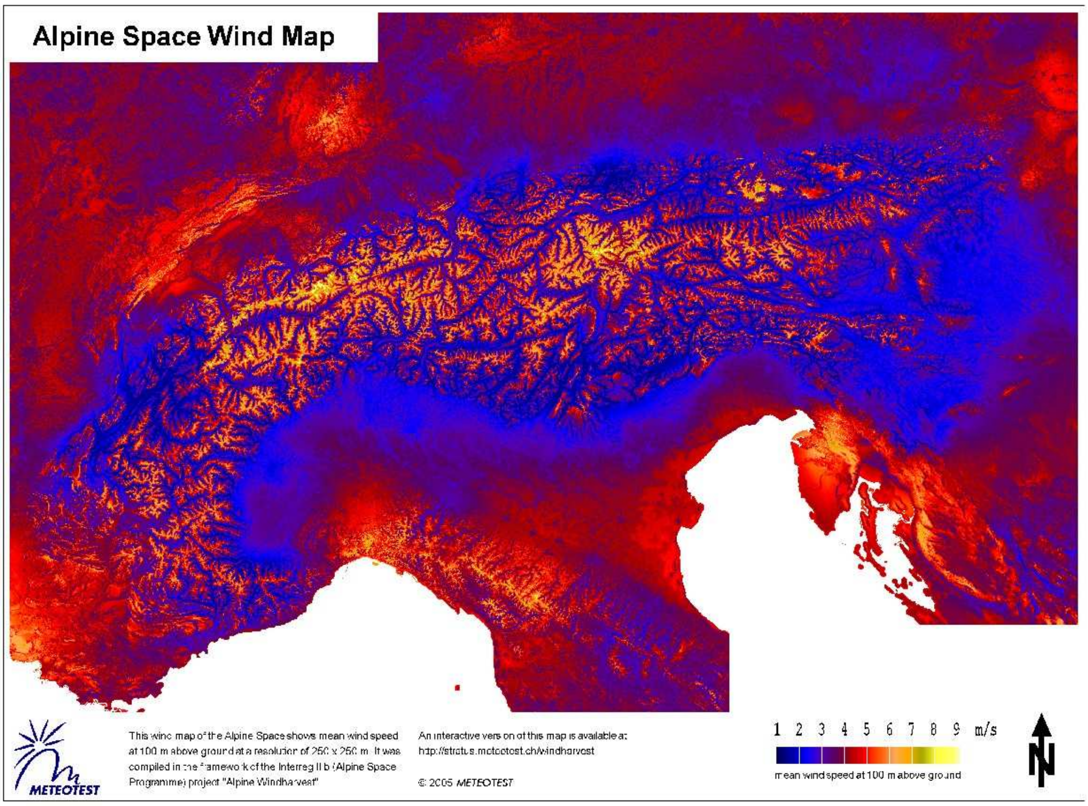
5.3.3 Wind Power

Harvesting wind power is an old renewable form of producing electricity without major impacts on natural resources. This energy which is directly gathered by wind turbines or wind mills is in general solar power. Wind power is expressed as the difference of warming up the landmass and the sea in spatial and temporal organization, and hence the rotation of the earth itself. This energy is convincingly a sustainable form of producing electric power apart from the production of the wind turbine itself. In the potential analysis are presented two wind park projects which are in discussion to be realized. The pros and cons are then briefly explained.

5.3.3.1 Methodology to Determine Potential

The renewable energy source wind power plays a margin role in South Tyrol. In the recent past two wind projects are in discussion to be realized. The wind potential will be described on the basis of these two planned projects. The chosen sites are one of the best in South Tyrol in terms of wind speeds. The places coincide with the defined suitable places obtained from the wind measurements conducted by the Office of Energy Savings and the EU Intereg III b project “Alpine Windharvest”. The following alpine space wind map was compiled in the framework of Intereg III b project ”Alpine Windharvest”.

Fig 5 - 48: Alpine space wind map

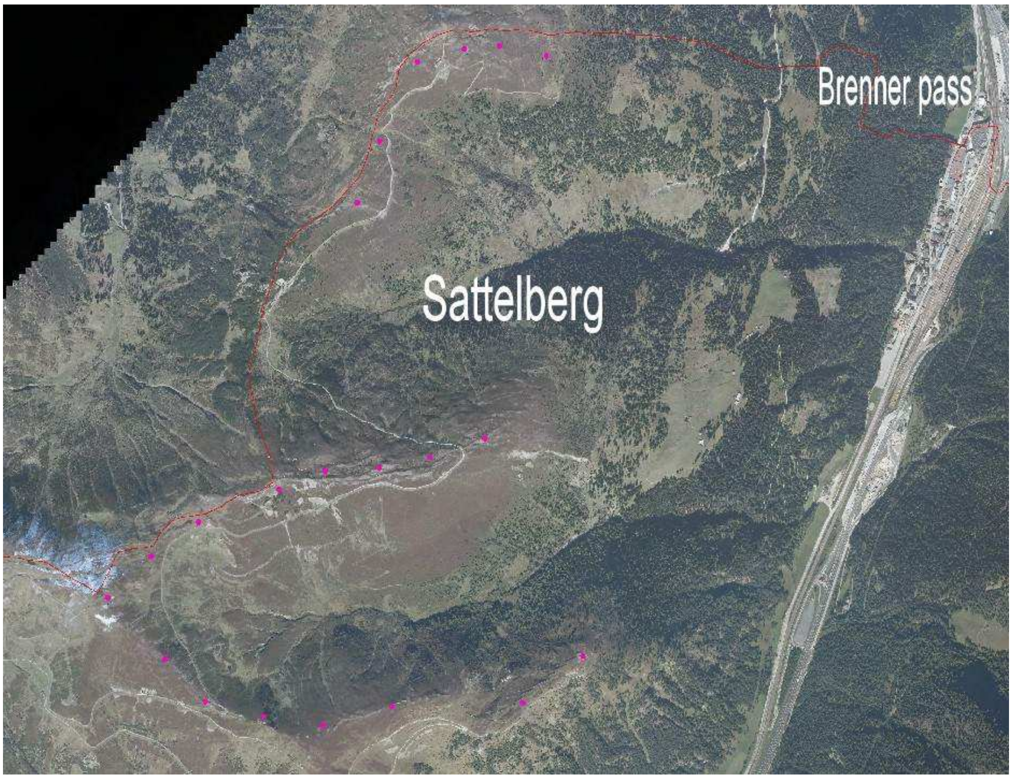


Source: Alpine Windharvest, http://stratus.meteotest.ch/windharvest/, download 06.08.2010

5.3.3.2 Realistic Potential

The first wind park project is based on the wind measurements of Sattelberg near to the Brenner pass. The selection of the places is based on the results obtained from the research project “Alpine Windharvest”, an EU Intereg III b project conducted from 2002 to 2005. The places of the wind mills are shown in the figure below. There are planned to install 22 wind power plants (hub hight of 60 m and rotor diameter of 70 m) with a total power capacity of 44 MW_e (2 MW per wind mill) in a hight of 2000-2200 m above the sea level. The yearly average wind speed measured is about 7.8 m/s. In total an electricity generation of about 111_e GWh/year can be estimated.

Fig 5 - 49: Location of the planned wind mills in Sattelberg



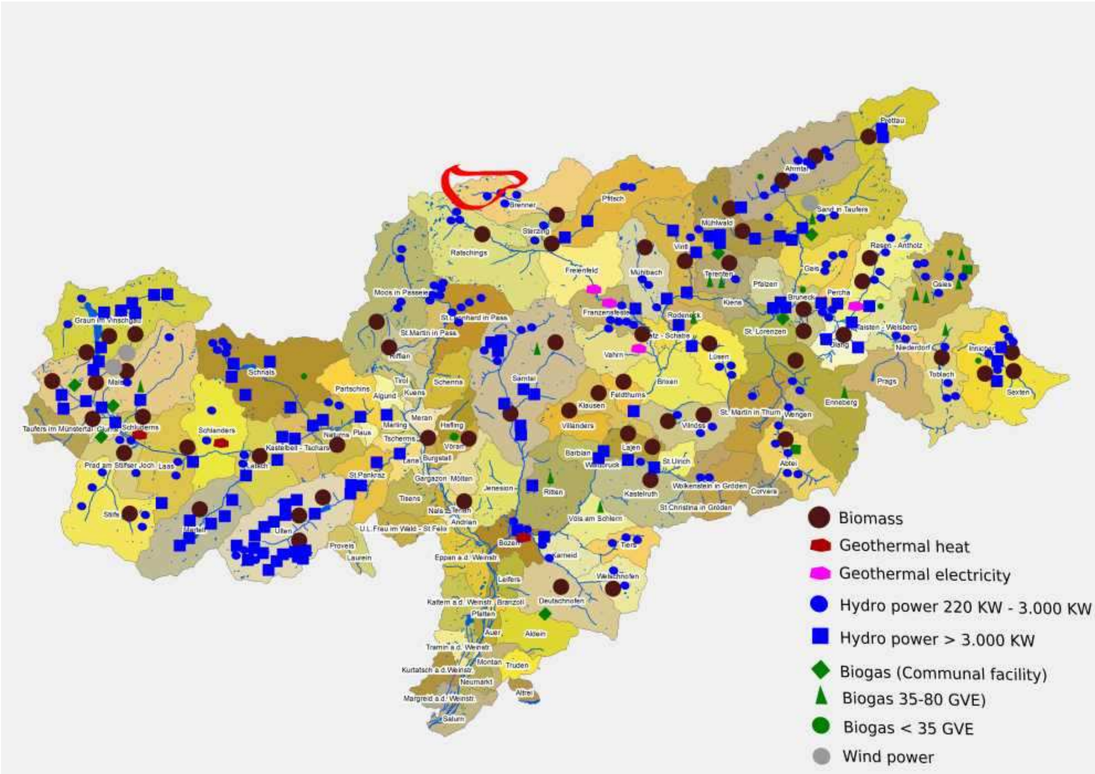
Source: Own elaboration

The wind power plants of the second project are planned to be built in the same area, in Sandjoch and Portjoch. The places of the wind mills are shown in the figure below and are one of the sites with the highest wind speeds in South Tyrol. The yearly average wind speed measured is about 7.8 m/s. There are planned to install 4 wind power plants with a power capacity of 1.7 MW (hub hight of 62 m) and 5 smaller wind power plants with 250 KW (hub hight of 51 m) with a total capacity of 8.05 MW_e in a hight of 2,140-2,360 m above the sea level. In total an electricity generation of about 20 GWh_e/year can be assumed.

Fig 5 - 50: Location of the planned wind mills in Sandjoch/Portjoch

Source: Own elaboration

Fig 5 - 51: Location of the planned wind mills in the North of South Tyrol



Source: Own elaboration

It will be assumed that the two wind projects in Sattelberg and Sandjoch/Portjoch with a total electricity production of 131 GWh_e/year will be realized until 2020.

5.3.3.3 Drivers

The local producer company of wind turbines is interested in installing, testing and selling wind turbines in South Tyrol and is a promoter of the wind park projects.

Another driver is the project "Brenner Green Corridor" (Munich–Brenner–Modena)[52], a new initiative developed by the Brenner Corridor Platform aiming to promote and develop the so-called Green Corridor concept: along the long distance freight corridor are planned concrete measures which are taken to reduce the

52 Source: Huber W., "Green Corridor Brenner", Presentation on 3rd December 2009, http://ec.europa.eu/transport/sustainable/events/doc/2009_12_09_walter-huber.pdf. download 06.08.2010

environmental impact from transport activities. It is an innovative project of great importance in particular for the exchange of know-how and cross-border cooperation with the neighbouring regions. A number of projects are under development, in particular on geothermic tunnel energy, energy transport and hydrogen fuel stations along the corridor. The concept foresees hydrogen refill stations every 100 km along the highway Munich–Brenner–Modena among other activities. The first production and distribution station for hydrogen will be activated 2011 in Bozen. For the second production station of hydrogen by electrolysis it is planned to use the wind power from Brenner and for the third station photovoltaic energy provision in Rovereto should be used, both of them going into activation at the end of 2012.

5.3.3.4 Barriers

The natural conditions in an alpine region are less favourable for the wind energy production (mountains, frost in the winter, no constant and substantial wind speed conditions etc.). Many uncertain parameters exit. For example for the wind project in Sandjoch/Portjoch a total uncertainty of 25.5% of the energy production will be assumed.

Wind power plants are a risk in ecological sensitive areas like the alpine ecosystem. Loss or damage to habitats is caused by turbine bases, substations, access roads and transmission line corridors. Especially in an alpine region, an ecological sensitive area like South Tyrol, the conflicts with the habitat, fauna and flora should be taken into consideration. It is also important to measure the extent to which a change in land cover will be visible to an observer (landscape).

In April 2004, as part of the EU project Alpine Wind Harvest (2002-2005), night bird migration observations at several locations in South Tyrol were carried out. There are two main passage routes:

- Axis Etschtal-Bozen-Brenner (South-North axis)
- Axis Bruneck-Ahrntal (South-North-East axis)

In the autumn more migrating birds were observed than in the springtime. The migration density in autumn is generally higher, because the migratory birds leave the breeding sites with the young birds. In the springtime fewer birds return to their breeding sites, as many of them do not survive the return from the winter quarters.

The results from the “Alpine Wind Harvest” project were integrated with current observation results in the project area:

On 26th August 2007 at the Sattelberg, Brenner (2021 m above sea level) most of the migratory birds fly at an altitude of 210-2300 m above the Brenner area, a lower percentage at an altitude of 2300-2500 m and even fewer in a hight of 2000-2100 m.

On 3rd October 2009 in Obernberg, Gereit (1439 m above sea level) most of the migratory birds fly at an altitude of 1900-2100 m above the Brenner area, a lower percentage at an altitude of 1700-1900 m and even fewer in a hight of 2100-2300 m. Only a small part of the observed migratory birds fly at an altitude of 1500-1700 m.

Comparing the height of Sattelberg (2113 m), Steinjoch (2185 m), Kreuzjoch (2242 and Portjoch (2109 m) with the determined fly altitudes, so it can be concluded that the main migration route runs in the area below the mountain ridge and that a more distributed number of migratory birds runs just above the mountain ridge and only a smaller number in a greater altitude.

In order to find the right sites for the rotors, the results of those studies have to be taken into account.

Other issues to consider are that the electricity production by wind power plants at high altitudes is lower than at the sea level (about 20% according to the internet calculation tool on the basis of the wind turbine Repower MM92 2000 KW).[53] The maintenance should be provided throughout the year and the access roads have to be kept clear: In a mountain area, such as in the described areas above, it is more costly than in lowlands.

53 Suisse Eole, http://www.wind-data.ch/index.php, download 06.08.2010

5.3.4 Biomass

This section is explained in chapter 5.4.1.

5.3.5 Biogas

5.3.5.1 Methodology to Determine Potential

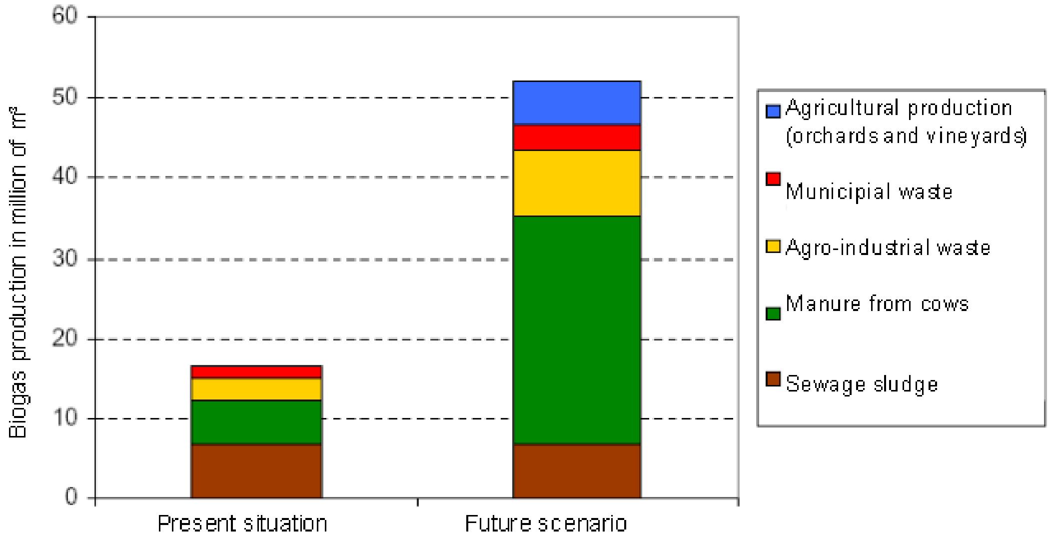
The data about the potential of biogas in part come from the Department of Agriculture and were elaborated by TIS innovation park, Bozen. Also an estimation about the biogas potential by the energy expert Georg Wunderer (Chairman of the Electricity Cooperative in Prad), who runs the biogas plant in Prad, will be presented.

5.3.5.2 Realistic Potential

Recently a study about biogas was conducted by the TIS innovation park, commissioned by the Department of Agriculture of the Autonomous Province of Bozen. The objective of the study was to quantify the potential of the biomass available from agricultural production, manure, agro-cultural waste and municipal solid waste. The estimation of the biomass produced from arable land in South Tyrol was conducted by the Office of Agricultural Mechanization based on the data from the agriculture and forestry computer system (LAFIS – Land- und forstwirtschaftliches Informationssystem). 13% of the total area in South Tyrol is agricultural area (950,000 ha). Of that area 59% are occupied by meadows, 25% by orchards and vineyards, 9% by permanent pasture and about 3% is used for the cultivation of fodder plants, while the rest of the area is non productive.

As shown in the figure below, it is estimated a total biogas potential of anaerobic digestion of about 35 million m³ of biogas, equivalent to more than double the production of 2008. In particular, the agricultural sector of livestock breeding (manure from cows) can provide the greatest contribution (65% of biogas is still producible) with a biomass potential equal to 8 times which is produced currently in anaerobic digestion. The second contribution comes from the agro-industrial and the agricultural production. Each of them can provide about 15% of the biogas potential, which is still exploitable.[54]

Fig 5 - 52: Present situation and future scenario of biogas production



Source: TIS, Project Conclusion Report, Mapping of the anaerobic digestion in South Tyrol, p. 93, 2010

Table 5 - 34: Present situation and future scenario of biogas production

	Agricultural production	Manure from cows	Agro-industrial waste	Municipal waste	Total
Exploitable biomass [t/year]	59,767	927,057	57,150	15,559	**1,059,533**
Biogas production [m³/year]	5,379,000	23,176,422	5,260,749	1,769,231	**35,585,402**
Biogas production [kWh/year]	29,046,600	125,152,677	28,408,046	9,553,849	**192,161,172**
Installable power capacity [KW]	1,643	7,080	1,607	540	**10,871**
Gross electricity production [kWh/a]	10,456,776	45,054,964	10,226,896	3,439,386	**69,178,022**
Net electricity production [kWh/a]	9,411,098	40,549,467	9,204,207	3,095,447	**62,260,220**
Gross heat production [kWh/a]	11,618,640	50,061,071	11,363,218	3,821,540	**76,864,469**
Useful heat production [kWh/a]	2,323,728	10,012,214	2,272,644	764,308	**15,372,894**

Source: TIS innovation park, Project Conclusion Report, Mapping of the anaerobic digestion in South Tyrol, p. 92, 2010

54 TIS, Project Conclusion Report, Mapping of the anaerobic digestion in South Tyrol, p. 96, 2010

According to the results obtained by the study an additional power capacity of about 10.9 MW_e can be installed with a net electricity production of about 62.3 GWh_e/year and a useful heat production of 15.4 GWh_{th}/year. It will be assumed that the half of the additional potential of heat and electricity production can be realized up to 2015 and the other half up to 2020.

Georg Wunderer, energy expert of South Tyrol, estimated that the exploitable amount of biogas production by manure amounts to 327 GWh.[55] He assumed the use of co-ferments and 60% use of 130,000 livestock units. The basis for the estimation were the data achieved from the biogas plant in Prad a. Stj. (biogas production from manure) run by the agricultural cooperative with 50 farmers.

As explained in chapter 3.4.7, the eight largest landfills in the country produce in total about 3 million m^3 of gas per year (lean gas is not taken into account), which experience hardly energetic valorisation until now. The energy at least about 12 GWh remains unused (for simplicity the production of 9.7 GWh_e of electricity and 2.3 GWh_{th} heat are assumed in the potential analysis). Even if the potential is low compared to other energy sources, it is still necessary to examine better the opportunities available in each individual case.

In 2008 the utilization of green cuts in Prad a. Stj. for a dry fermentation were analysed under the instructions of Prof. W. Graf, University of Vienna. The climatic changes have led to the situation that in the Upper Vinschgau apples can be grown. A few decades ago this was still unthinkable. Apples bring far more profit than keeping of animals. This is one of the main reasons that the grass lands are getting fewer and fewer in the Upper Vinschgau. But between the apple trees are collocated small grass strips (about 2.5-3.2 m wide). The grass potential of the grass strips was investigated and it was calculated that a dry matter yield of about 6 t/ha per year could be generated.

In the groupwork Wunderer M., Krappinger A. and Schwarz S. “Feasibility study of an existing biogas plant by the introduction of a new raw material (green cuts) available in the local region” the total gross energy from grass input in the existing

55 Wunderer G., http://www.gemnova.net/613/uploads/4_wunderer.pdf, download 03.06.2010

biogas plant in Prad a. Stj. was analysed, which can be achieved per year. The main result was that the current production of gross energy could be increased by 68%, if full capacity is utilized. The total net heat production can be increased from 1,922,327 kWh to 3,223,698 kWh and the electricity production from 823,855 to 1,381,585 kWh/year, grass silage from grass land and grass silage form apple orchards in mixture to the current input of substrates.

5.3.5.3 Drivers

The dry fermentation with green cuts is under investigation. The results obtained are promising and it could present a new opportunity for the local farmers. The combination of the fermentation process and the optimizing the management of the meadow a gas yield increase of 20% or more can be expected.[56] It is necessary to study this potential to make the biogas production more attractive and to give the farmers a chance to improve their long term earning possibilities. Further research in the field of the optimal grass composition, in combination with the optimization of the cutting dates and fertilizer management of the composition for this grass, offers opportunities for significant increases of the biogas yield and the resulting substantial increase in the biogas output.

5.3.5.4 Barriers

A biogas plant has to deal with the following obstacles:

- Risks during the operation:
  - Failures due to lack of "Know How"
  - Damage of the plant
  - Market fluctuations
  - External influences on the system
- Ecological risks due to the biogas production: Beside the high yields, the management of the green area, the cutting management and the use of fertilizer play an important role.

56 Müller N., ff. Bioenergie aus Gras, Pisa- Wien, p. 169, 2009

- Possible social risks switching to energy production by biogas which are unpleasant smells, noise pollution from transport, groundwater deterioration and risk of explosion. It is very important to organize information sessions for the population and to consider those problems during the planning process of the plant.

Especially in the case of the use of the small grass strips between the apple trees for the biogas production three management problems should be solved first of all:[57]

a) To remove the leaves in autumn;

b) To remove the apple branches;

c) To convince the farmers about the advantages.

According to information from K. Stocker who is involved in this process, those questions should be solved in the near term and the implementation of the biogas production from grass out of the apple plantations after adaptation of the existing biogas plant in Prad a. Stj. can start.

5.3.6 Geothermal

This section is explained in chapter 5.4.4.

5.3.7 Vegetable oil

5.3.7.1 Methodology to Determine Potential

The evaluation of the potential of vegetable oil CHP plants is based on the data of one plant in Franzensfeste, which is expected to go into operation soon.

5.3.7.2 Realistic Potential

Other forms of biomass such as vegetable oils find increasing entrance in South Tyroleans energy production. In the municipality Natz-Schabs the vegetable oil CHP plant went into operation recently (fuel use of about 13410 t/year, electricity production of 55 GWh_e, heat production of 60 GWh_{th}), whereas in the municipality

57 Telephone information from Stocker K., 12.08.2010

Franzensfeste (fuel use of 18000 t/year, electricity production of 74 GWh_e, heat production of 80 GWh_{th}) the vegetable oil CHP plant will go into operation within this year. These facilities are producing primarily electricity.[58]

The construction of a few smaller vegetable oil CHP plants is planned, but the realization of those projects depends upon the development of the influencing parameters, which are the volatile raw material price and the financial support. The planned smaller vegetable oil CHP plants will not be considered in this study.

5.3.7.3 Drivers

The construction of vegetable oil CHP plant is attractive as long as the national financial support of 28 €cent/kWh according to the Finance Act 2008 will be provided. It must be guaranteed that the vegetable oil comes from an integrated administration and control system foreseen by the EU Regulation No. 73/2009 of 19th January 2009.

The intensive use of agricultural land for growing energy crops (oilseed rape, miscanthus, sudan grass, beets, potatoes, corn) to produce energy is not an issue yet. This can change rapidly in the medium term by the increase of oil and natural gas prices, by changing the promotion criteria and by the difficult situation in the mountain farming.

5.3.7.4 Barriers

This form of biomass is very controversial as many transports for the supply of fuels are needed and often the vegetable oils are not produced in a sustainable way. In any case the construction of such plants has to be rejected, if the sustainability criteria – transport, cultivation, utilization of heat – are not fulfilled for the production and use of vegetable oils.

58 Climate Strategy, Energy South Tyrol 2050, p. 34, draft version 01.08.2010

5.3.8 Energy Storage Possibilities

There are several possible energy storage methods. Those can roughly be divided into the following classification:

- Electrochemical: battery, hydrogen;
- Electrostatic: classical capacitors;
- Electrodynamic: coils, superconducting magnetic storage (SMES);
- Electromechanical: pressure storage, pump storage and flywheel storage systems.

In grid-connected system power energy storage systems are used for the following applications:

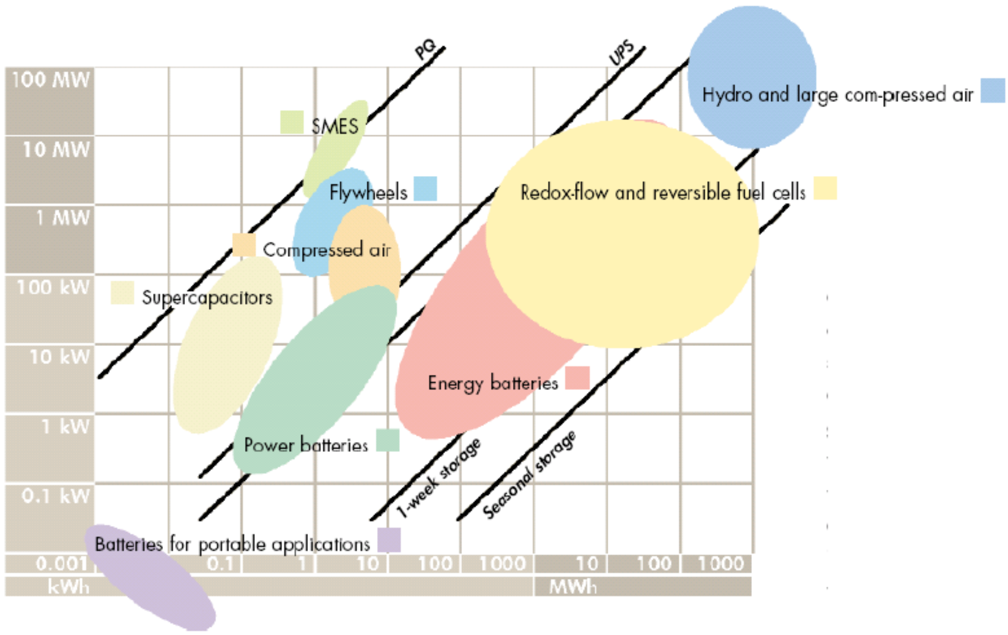
- Maintaining the power quality;
- Provision of regulating and reserve power for the grid operation;
- Support of the primary control in networks (power-frequency control);
- Provision of minutes reserve in other words provision of peak demand for electricity in a short time (<1 minute);
- Load management;
- Balance between low and high consumption (load-levelling, peak-shaving);
- Production Management;
- Virtual power plants as a combination of renewable power plants, which feed into a grid and store electricity;
- Non-interruptible power supplies (UPS);
- Emergency power supply.

In this work the two storage methods of the electromechanical storage by pumped storage hydro power systems and the electrochemical by hydrogen storage are explained more in detail, because the region can explore its water potential and its geological situation better and thus it could achieve an overall advantage with this storage possibilities.

In general, it is important to mention that all the storage possibilities especially for renewable energy (water, wind and solar energy) should be used. Here South Tyrol has its greatest benefits, since there is currently produced more electricity from renewable energy sources at certain times as it is needed and so the electricity is sold on national or international level at low prices. It could be targeted to use this power in order to store it and to release it then in more economical and also in more meaningful times.

In the figure below the application range of different storage technologies are listed.

Fig 5 - 53: Application range of the storage possibilities (electricity)



Source: Forum Netzintegration Erneuerbare Energien, http://www.forum-netzintegration.de/uploads/media/Rohrig_IWES_030310.pdf, download 02.08.2010

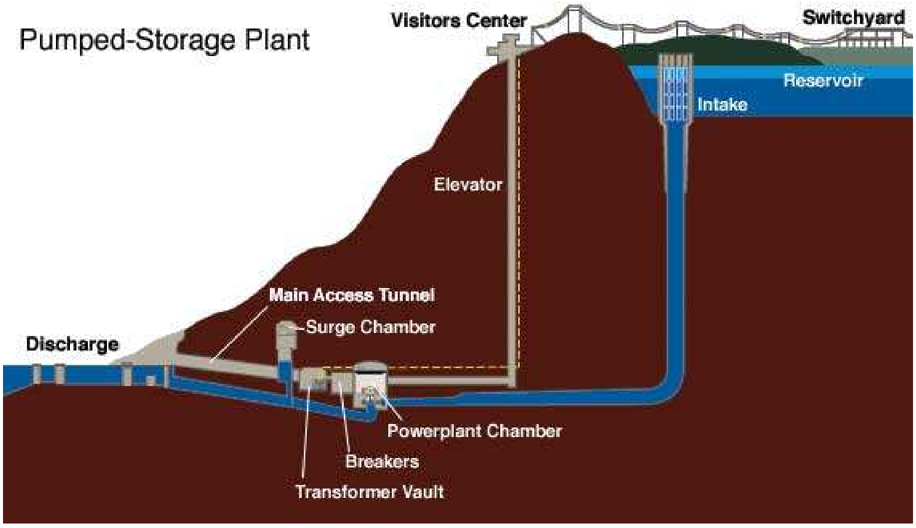
In the next chapters two possible energy storage systems are presented, which could be used in South Tyrol. Those are pumped hydro storage power plants (PSPP) and hydrogen.

5.3.8.1 Pumped Storage Plant

Pumped storage hydro power is a kind of hydro power generation used by some power plants for load balancing. The energy is stored in the form of water pumped from a lower to a higher reservoir. The pumps are run by low-cost electric power in periods such us night or weekend. The stored water is released through turbines during period of high demand. The pumped hydro storage system needs more energy than it produces. Nevertheless, it increases its revenue by selling more electricity during periods of peak demand, when electricity prices are highest. Pumped storage is nowadays the largest possibility of electrical energy storage. It is also possible to use wind turbines or solar power to drive water pumps directly. This provides a more efficient process and can smooth out the variability of energy captured from the wind or sun.[59]

In the figure below a pumped storage plant is displayed.

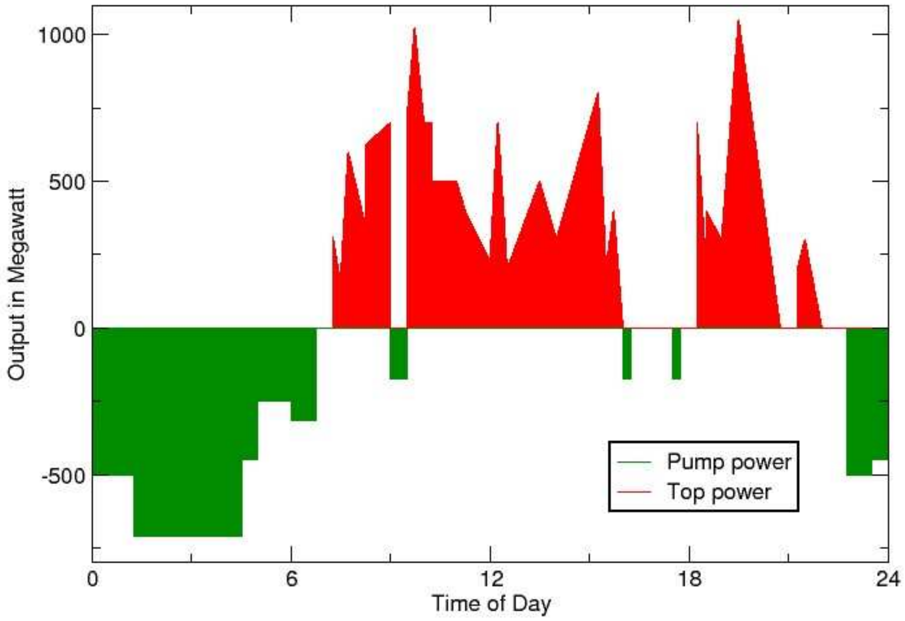
Fig 5 - 54: Diagram of a pumped-storage plant



Source: Wikipedia, http://en.wikipedia.org/wiki/Pumped-storage_hydroelectricity, download 02.08.2010

59 Wikipedia, http://en.wikipedia.org/wiki/Pumped-storage_hydroelectricity, download 02.08.2010

Fig 5 - 55: Power distribution over a day of a pumped-storage plant



NB: Green stays for the power consumed in pumping and red stays for the power generated.

Source: Wikipedia, http://en.wikipedia.org/wiki/Pumped-storage_hydroelectricity, download 02.08.2010

Table 5 - 35: Costs and information about pumped storage power system

	Pumped storage power system
Weekly storage today	3-11 ct/kWh
Weekly storage in 2020	3-11 ct/kWh
Hourly storage today	3-6 ct/kWh
Hourly storage in 2020	3-6 ct/kWh
Investment costs	600-3,000 €/KW
Efficiency	75-80%
Storage capacity	0.7 kWh/m^3

Source: Fraunhofer IWES, 03.03.3010[60]

60 Rohrig K. Welche zentralen Speicherarten sind möglich und wie teuer sind sie? http://www.forum-netzintegration.de/uploads/media/Rohrig_IWES_030310.pdf, download 02.08.2010
Fraunhofer IWES, 03.03.2010, download 02.08.2010

Of course, for each pumped storage power system more energy is needed than produced. Energy is needed to pump the water to a higher reservoir. Nevertheless it has currently the highest efficiency factor for the storage of electricity. The level of efficiency is at least 75-80%, whereas the relatively small output losses for the transport of the electricity in both directions are not considered.

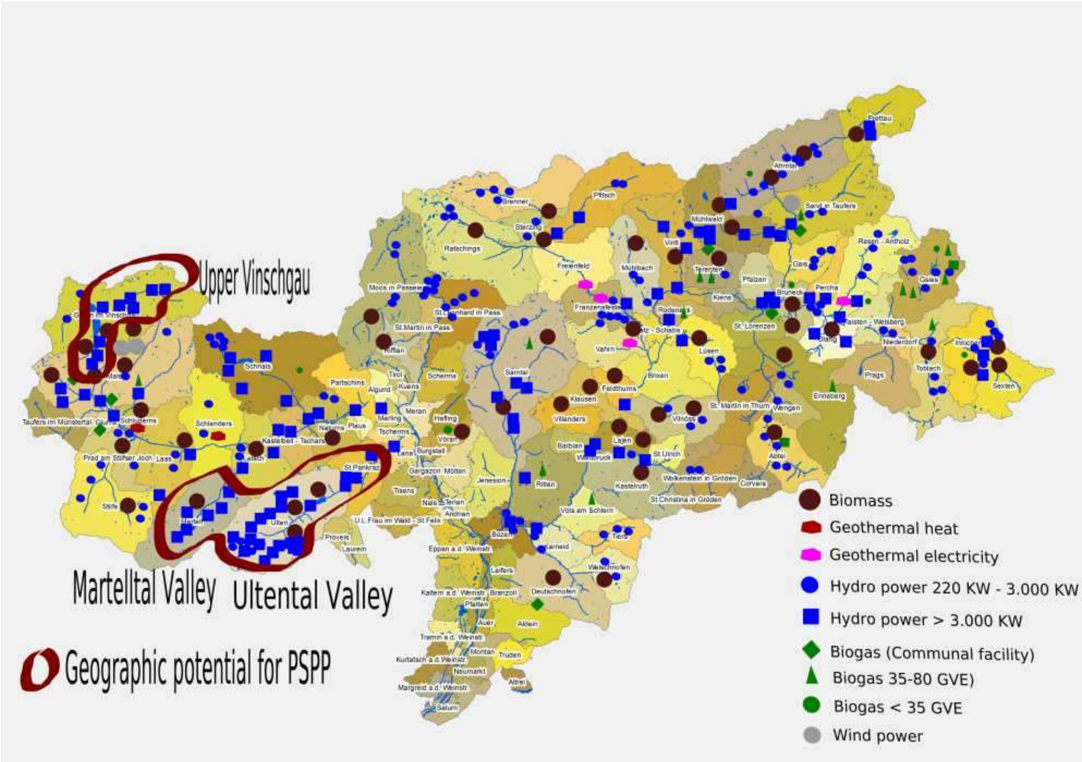
Due to the geological conditions (mountain areas) and by the existing hydro power plants with reservoirs at different heights, South Tyrol has very good preconditions for the construction of hydro power pumped storage systems.

Possible potentials for South Tyrol could be to use already existing hydro power plants with artificial lakes and rebuild/expand them, so that they can be used as pumped storage systems. The hydro power plants could improve their efficiency, and it would be avoided to interfere with the sensitive nature.

Furthermore, there are other technically feasible projects, where underground caverns could be used for storage. This unfortunately requires a greater intervention, and also the environment is stressed enormously by extraction of rocks from the mountain for the construction of the caverns.

Possible areas, where already available hydro power plants with different slopes of the lakes could be used for pumped storage hydro power systems, are the Martell Valley and Ulten Valley and also the Upper Vinschgau Valley, as shown in the figure below. Of course, a technical feasibility study and an accurate information of the population are necessary, so that such opportunities could be used and developed.

Fig 5 - 56: Possible locations of pumped storage hydro power systems in South Tyrol



Source: Own elaboration

Two possible locations for pumped storage hydro power plants have been discussed recently. The first location in the municipality Ritten was rejected by the population, and for the second location the public discussion has just started in July 2010. Both projects are briefly presented in this master thesis.

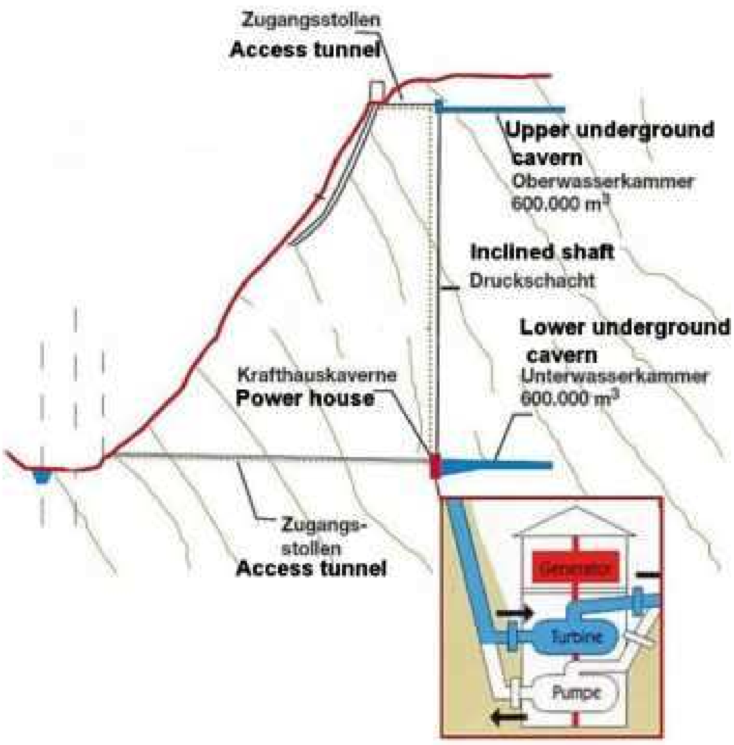
5.3.8.1.1 Pumped Storage Hydro Power Plant in Leifers

Since about July 2010, there are concrete plans to build an underground pumped storage plant in Leifers. There were found best topographic conditions for the construction of such a plant on the basis of thorough analysis by the operating company. Great drop heights and at the same time steep mountain flanks are given. It is planned to build the pumped hydro power station with two underground lakes, which are connected with a gallery inside the mountain on the North of Leifers. Even geologically this location offers favourable conditions and a low interference with the urbanized areas. The planned power capacity amounts to 300 MW_e.

The plant consists of:

- An upper underground cavern;
- The inclined shaft (in German: Kraftabstieg);
- A power house with the mechanical equipment (turbine, etc.);
- A lower underground cavern;
- A tunnel to the upper and lower underground cavern;
- A tunnel for the transmission of the generated power.

Fig 5 - 57: Diagram of the pumped storage hydro power plant in Leifers



Source: South Tyrol Energy, http://www.southtyrol-energy.com, download 02.08.2010

Facts & Figures:

- Approximately four years of construction;

- Only two visible tunnel portals outside of populated areas;
- Inside of the town minimal construction traffic during the construction period;
- No danger for the population;
- No visible changes in the environment;
- Almost all the works are deep in the mountain, so the exposure to dust, noise and vibrations can be excluded;
- Pumped storage hydro power plants have a very long life span (are in use in European countries for many decades).

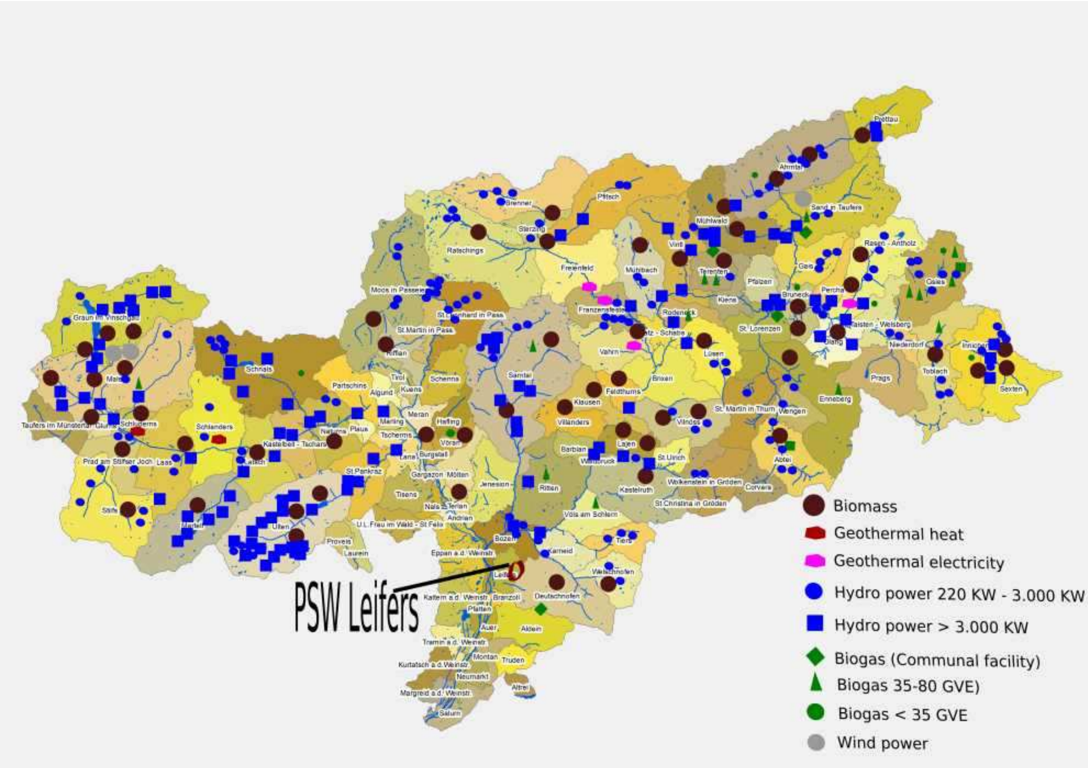
The EU foresees for Italy to increase the share of renewable energy from the current 5.2% to 17% until 2020, equivalent to a tripling of which the country is still far away. Without such plants the appropriate expansion of electricity generation from wind and solar power is not possible. The project will be realized to the end of 2015, as listed in the following table.

Table 5 - 36: Schedule of the realization of the pumped storage hydro power plant in Leifers

Deposit of enquiry for Environmental Impact assessment (EIA)	01.07.2010
EIA procedure (3 months)	01.10.2010
Approval by the Regional Government	01.11.2010
Building permission and agreement with the municipality	01.11.2010
Detailed planning and realization of the project	Winter 2010/2011
Start of construction	01.06.2011
Start-up	End of 2015

Source: South Tyrol Energy, http://www.southtyrol-energy.com, download 02.08.2010

Fig 5 - 58: Location of the pumped storage hydro power plant in Leifers

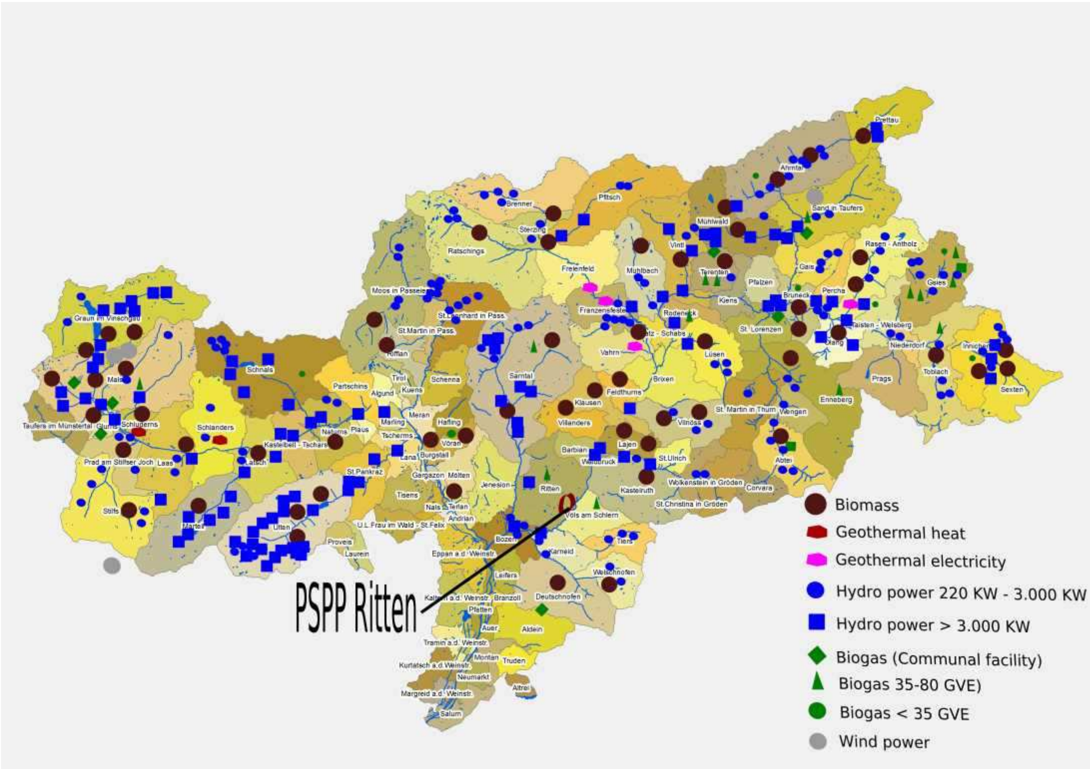


Source: Own elaboration

5.3.8.1.2 Pumped Storage Hydro Power Plant in Ritten

The plan of a pumped storage power plant in the municipalities of Bozen and Ritten were presented in Summer 2008. The Council of Environmental Impact Assessment approved the project on 23rd June 2008. On 1st September 2008 also the Regional Government approved it. The Austrian energy provider KELAG and the wind operator AG wanted to invest approximately 250 million €. The electricity should have mainly come from wind turbines. The storage of electricity from hydro power or nuclear energy was excluded. The construction period of the plant was estimated to be five years. The location of the plant is shown in the chart below.

Fig 5 - 59: Location of the pumped storage power plant in Ritten



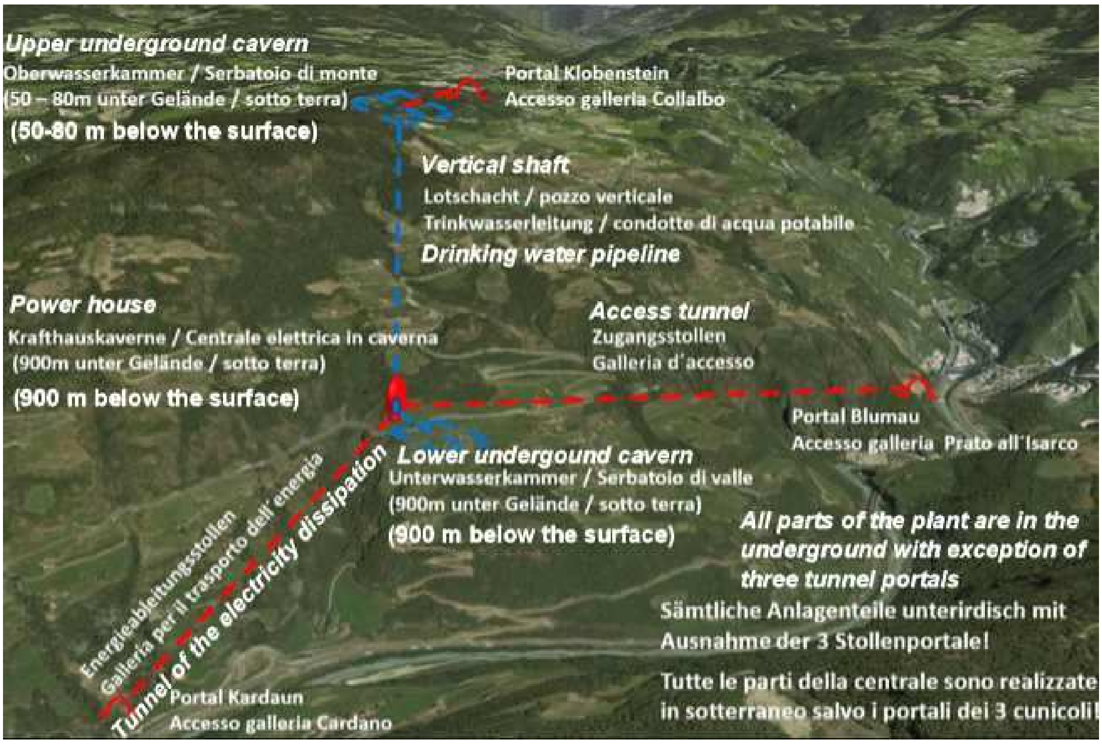
Source: Own elaboration

The technical pre-feasibility study and the project planning by the company Kelag came up with the suitable location in Ritten/Bozen. There is guaranteed a sufficient height for the water and the geological stability of the rock. Moreover, in the vicinity there exists already necessary infrastructure for the transport of electricity. The power capacity of the PSPP amounts to 250 MW_e, which corresponds to a power generation of 600 GWh_e per year.

All facilities of the pumped storage power plant are underground constructions. The cavern of the powerhouse as well as the lower reservoir are built 900 m deep. The upper underground reservoir is planned to build 50 to 80 m deep under the surface near the industrial area in Klobenstein. The upper underground reservoir and the power house are connected by a pressure shaft. The individual facilities of the power plant are connected via an access tunnel at Collalbo and an access tunnel in Blumau. Another tunnel connects the power house with the transformer station in

Kardaun, the connection point to the already existing high voltage grid. From the pumped storage power plant are visible from outside only the three portals of the access tunnel.[61]

Fig 5 - 60: Diagram of the pumped storage power plant in Ritten



Source: KELAG, http://landwirte.kelag.at/content/page_6811.jsp, download 02.08.2010

In the beginning of September 2009 the promoters have withdrawn the project due to the strong resistance movements of citizens groups, the municipality Ritten would not have given a positive building permission at that time.

5.3.8.2 Hydrogen

Hydrogen is not an energy resource, except in the hypothetical context of commercial nuclear fusion power plants using deuterium or tritium, a technology presently far from development. The Sun's energy comes from nuclear fusion of hydrogen, but this process is difficult to achieve controllably on Earth. Elemental hydrogen from solar, biological, or electrical sources require more energy to produce

61 KELAG, http://landwirte.kelag.at/content/page_6811.jsp, download 02.08.2010

it than is obtained by burning it, so in these cases hydrogen functions as an energy carrier, like a battery. Hydrogen may be obtained from fossil sources (such as methane), but these sources are unsustainable.[62]

Some general information about hydrogen and its storage costs are shown in the following table.

Table 5 - 37: Information about hydrogen and its storage costs

	Hydrogen*
Weekly storage today	23 ct/kWh
Weekly storage in 2020	8 ct/kWh
Hourly storage today	24 ct/kWh
Hourly storage in 2020	11 ct/kWh
Investment costs	2000-6000 €/KW**
Efficiency	25-40%***
Storage capacity	163 kWh/m^3

* Conversion in electricity by combined gas and steam turbine generating plant (GuD-Prozesse)
** Costs of fuel cells
*** 40% by combined gas and steam turbine generating plant (GuD) and presumably 25 – 30% with fuel cells

Source: Fraunhofer IWES, 03.03.3010[63]

5.3.8.2.1 Methodology to Determine Potential

The data about the potential of hydrogen production in South Tyrol come from the Institute for Innovative Technologies in Bozen.

5.3.8.2.2 Realistic Potential

In South Tyrol following condition is favourable for the implementation of a hydrogen infrastructure: the abundant availability of renewable energy from hydro power. Moreover, most of the approximately 800 existing hydro power plants of various sizes are designed as a direct derivation without storage. This means that the

62 Wikipedia, http://en.wikipedia.org/wiki/Hydrogen, download 02.08.2010

63 Rohrig K. Welche zentralen Speicherarten sind möglich und wie teuer sind sie?http://www.forum-netzintegration.de/uploads/media/Rohrig_IWES_030310.pdf, Fraunhofer IWES, 03.03.2010, download 02.08.2010

electricity generation can not take place only at the times of highest demand, but when the water is available.[64]

For the development of hydrogen as an energy source for South Tyrol the Institute for Innovative Technologies ("The Hydrogen platform"[65]) has elaborated a concept in 2009. It investigates the technological options and challenges for South Tyrol, which have their origin from the abundant existing hydro power. Other possible source of secondary importance could be in the long term the biomass.

A plant, which produces and distributes hydrogen for cars and buses at the filling stations along the freeway A22 from Brenner to Modena, is under construction in Bozen.

Location:

The hydrogen-production plant is built next to the freeway, exit Bozen South. It is an ideal position, which facilitates the entrance for all types of vehicles and is reachable from any direction and also from the freeway.

Production capacity of the plant:

The plant can produce a total amount of 240 Nm^3/h hydrogen under determined temperature and air pressure conditions, which gives an annual production of around 2,000,000 Nm^3. It can be stored an amount of two daily productions, also approximately about 8,000-11,000 Nm^3. The storage building can be reached by trucks and the filled bottles can be charged and brought to the customers. Similarly, hydrogen can also be filled in gas transport trucks directly.

The hydrogen is distributed by a hydrogen pressure line directly to a public multi-energy filling station. This station provides hydrogen for hydrogen cars and mixed gas (methane-hydrogen). The nearby bus parking place of SASA will be connected with a hydrogen refuelling line for buses with a methane gas mixture (hydrogen-methane).

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64 H2 Südtirol, http://www.h2-suedtirol.com/index.php?id=50, download 02.08.2010

65 Huber, W., Wasserstoff Technologie Südtirol, Institut für Innovative Technologien, 2009

Applications in hydrogen-powered cars:

The average H_2-consumption of fuel cell cars: 12-16 Nm^3/100 km (about 1.0 to 1.3 kg H_2/100 km). The hydrogen production plant can supply up to 1,000 fuel cell cars for an average daily driven distance of about 40 km.

Application in hydrogen buses:

Average H_2-consumption of fuel cell buses: 120-150 Nm^3/100 km (10-13 kg H_2 /100 km) The hydrogen production plant can supply up to 25 fuel-cell buses for an average daily driven distance of about 180 km.

Reduction of greenhouse gases:

The hydrogen production plant can replace annually about 650,000 litres of petrol or 550,000 litres of diesel. Thus, per year up to 1.6 million kg of climate-damaging CO2 can be saved.[66]

The following table provides an overview about the steps and milestones in the next ten years.

Table 5 - 38: Time, activities, milestones for hydrogen production in South Tyrol

Year	**Activities/milestones**
2009	Concept development, formation of the hydrogen platform.
2010	Start-up phase: First buses, first facilities, first research projects.
2011-12	Filling stations along the freeway A22, first cars, research projects about storage and applications.
2013-14	Along the whole freeway Monaco-Modena (650 km) the hydrogen distribution is completed for cars, trucks, snow groomer, etc.
2015-17	The public fleet is successively converted to hydrogen; the amount of private cars run by hydrogen is increasing.
2018 ff.	Production and gas station network away from the highway will be completed. Complete solutions will be developed and installed. Local maintenance is established, private cars has achieved a consistent number.

Source: Roadmap of Renewable Energy, p. 22-23, 2010

66 H2 Südtirol, http://www.h2-suedtirol.com/index.php?id=96, download 03.06.2010

The hydrogen-production plant is located next to the freeway, exit Bozen South, as shown in the figure below. It is an ideal position, which facilitates the entrance for all types of vehicles and is reachable from any direction and also from the freeway.

Fig 5 - 61: Hydrogen production site with facilities in Bozen

Source: Huber W., "Green Corridor Brenner", Presentation on 3rd December 2009, http://ec.europa.eu/transport/sustainable/events/doc/2009_12_09_walter-huber.pdf. download 06.08.2010

5.3.8.2.3 Drivers

The local politics encourages the hydrogen production. South Tyrol has an overproduction of hydro power, which can be used for the production of hydrogen. An advantage is that hydrogen-powered-fuel-cell vehicles have zero emissions.

5.3.8.2.4 Barriers

The production of hydrogen is very energy intensive. Hydrogen is gaseous and can be stored in a small space with very high effort, because it is very volatile. Strict product, technology or process safety measures must be taken into account.

The construction of the infrastructure and the development of the hydrogen-powered-fuel-cell vehicles market are necessary for the distribution and sale of hydrogen.

5.4 Heat

5.4.1 Biomass

The main renewable energy source in the heating sector in South Tyrol is biomass. It is mainly used for heating purposes, especially as a replacement or supplement to fossil fuels. The energetic use of biomass is based primarily on the resource of wood and its derivatives by burning it as firewood, wood chips or wood pellets.

5.4.1.1 Methodology to Determine Potential

The data about the potential of biomass come from the Regional Public Company for Forestry and Domain Management and the Climate Strategy 2050.

5.4.1.2 Realistic Potential

The energetic use of biomass is based primarily on the resource of wood and its derivatives by burning it as firewood, wood chips or wood pellets. 48% of the land area in South Tyrol is covered with forest. The total stock of wood counts 60.2 million scm (solid cubic metre). The yearly growth amounts to 952,681 scm, whereof 80% can be used in a sustainable way according to the Climate Strategy 2050 (762,145 scm). On average 474,626 scm are used per year, which is the half of the yearly growth amount. The following table shows the forest area, the total stock and the yearly growth and logging. The additional amount, which can be harvested, is about 287,519 scm with respect to a sustainable management (762,145 minus 474,626 gives 287,519 scm).

The potential of biomass in some extent is exhausted. The 66 biomass district heating plants used only one third (402,000 lcm - loose cubic metre) of the biomass from local forests in 2009, and two thirds (804,000 lcm) of the wood chips were imported. Hypothetically, out of the whole additional amount of 287,519 scm with respect to a sustainable management, can be produced 718,798 lcm wood chips (1 lcm wood chips corresponds to 0.4 scm)[67], which is not enough to cover the whole demand for the 66 biomass district heating plants by local wood chips.

67 Wikipedia, http://de.wikipedia.org/wiki/Raummeter, download 03.06.2010

Table 5 - 39: South Tyrol's forest area, total stock, yearly growth and logging

Forest area	292,819 ha
Total stock	60,231,078 scm
Yearly growth	952,681 scm
Yearly logging	542,748 scm
Average yearly use	474,626 scm
Total stock/ha	206 scm/ha
Yearly growth/ha	3.25 scm/ha
Yearly logging/ha	1.85 scm/ha
Average yearly use/ha	1.62 scm/ha

Source: Abteilung Forstwirtschaft (Department of Forestry), Regional Forest Inventory from 2003

The following table shows the amount of timber and firewood in scm deforested from 2004 to 2008, which increased until 2006 and decreased in the years 2007 and 2008.

Table 5 - 40: Logging by type of use – 2004-2008

	2004	**2005**	**2006**	**2007**	**2008**
Timber	331,364	333,580	417,803	412,104	311,882
Firewood	163,360	171,140	199,292	180,274	163,990
Total	**494,724**	**504,720**	**617,095**	**592,378**	**475,872**

Original source: Abteilung Forstwirtschaft (Department of Forestry), published in ASTAT, Statistisches Jahrbuch 2009, p. 356, Bozen, 2009

As described in chapter 3.5.1, in Fig 3 - 24, in total 9,600 small installations of wood chips, pellets and wood logs were installed in 2009. The same yearly average increase from 2005 to 2009 was assumed for the next years up to 2020. An installation of 4,500 new wood chips, pellets and wood logs installations can be expected until 2015 and the same number of 4,500 until 2020, which corresponds to a total heat production of about 48.6 GWh_{th} in 2015 and 2020 (Assumption: Average heat capacity of 6 KW_{th} per facility and average operating hours of 1,800 per year).

The sustainable use of the biomass in South Tyrol is determined by typical factors of a mountain region the different functions of a forest eco-system such as:

- A habitat for animal and plant species;
- A protection area against natural hazards;
- A drinking water protection area;
- A recreational area;
- Landscape-aesthetic elements have to be considered.

Characteristics of the forest in South Tyrol:

- 70% privately owned forest;
- 52% private individual companies;
- Average forest area per company: 5-10 ha;
- 50% of the companies: smaller than 5 ha;
- 21,258 forest owners.

In order to get more biomass out of the forest following requisites are necessary:

- Higher prices.
- Better organization through:
  - Taking wood in heating plant;
  - Forest Management;
  - Full machine utilization;
  - Continuity;
  - Long-term supply contracts;

Right now far less wood is used, as it would be possible for a sustainable forest management. A major challenge is the competitiveness of timber harvesting in a mountain area. In order to become economical feasible in this case, adequate funding is needed.

5.4.1.3 Drivers

66 biomass heating plants in South Tyrol with a total of 116 communities is a respectable number. A certain potential is still to be found in outlying areas, which are not covered with a biomass heating plant. For low energy buildings in a residential complex it could be a good alternative to have a common pellets or wood chip installation. The efficiency is much better, than each of them would have its own heating system.

5.4.1.4 Barriers

The average price of the wood chips was 15.14 €/loose cubic metre in 2009, which will rise at least between 16.50 and 17.00 €/loose cubic metre in 2010. In South Tyrol there are 66 biomass heating plants, which require a significant amount of raw material. The huge demand caused a sharp increase in the commodity prices from 2009 to 2010, which signifies that the price advantage over other fuels (natural gas, heating oil) will decrease, so that the attractiveness of biomass district heating plants would be gone. Moreover, in the rest of Italy the biomass use is increasing (primarily used for power generation), thus more biomass will be requested.[68]

Another barrier is the competition with natural gas. SELGas and some municipalities have stipulated a contract: municipalities receive 5% from the volume of sales, when they renounce to build a biomass district heating plant. Other barriers to overcome are the following disadvantages of biomass recovery from the forest:

- Altitude with longer winters;
- Steepness of the forests connected with high costs;
- Missing of infrastructure;
- Contaminated forests (pasture, collecting leaf litter for animals);
- Lack of organizations (use, market);
- Size of the forests and fragmentation and small parcels;
- Tourism / landscape protection.

68 Information received per e-mail from the Biomass District Heating Plant in Toblach-Innichen on 01.06.2010

5.4.2 Solar Thermal

5.4.2.1 Methodology to Determine Potential

The solar thermal potential will be described on the basis of the CO2 study with possible reduction scenarios for the Municipality of Bozen realized by EURAC. One part of this study is focused on the use of solar thermal collectors on the roofs of new buildings.

A detailed analysis of the solar thermal potential for the entire South-Tyrolean region is further included.

5.4.2.2 Realistic Potential

In the study were considered the new construction of 10 buildings with a total building area of 3,160 m², based on the data estimated by the communal Office of Urban Development of Bozen. The buildings consist of 5 storages with 4 flats per storage and an average living area per flat of 79 m² (ASTAT).

Two scenarios were proposed: In the first scenario it was analysed to put photovoltaic panels on the entire available roof of the new buildings. In the second scenario the use of solar thermal collectors was considered, which should cover 60% of the total requirements for hot water and for the remaining area was planned to use photovoltaic panels.

In this section the second case will be investigated. It was assumed for the latitude of Bozen, that the solar thermal heating system produces 400 kWh/m²/year. For the production of 60% of the total requirements for hot water with solar thermal, 416 m² are required. The residual area of 2,744 m² is used for the photovoltaic panels. The amount of electricity produced by photovoltaic was calculated by the assumption, that for 1 KWp of photovoltaic an area of 8 m² is needed, which produces electricity of approximately 1 MWh_e/year. Under the described conditions the amount of heat produced amounts to 161 MWh_{th}/year and the electricity to 343 MWh_e/year.

60% of the total requirements for hot water and 70% of the total electric energy needs can be covered, based on the following reference data:

The average electricity consumption in Italy according to EURECO – Politecnico di Milano, is about 31 kWh/m²/year. The consumption for hot water heating purposes amounts to 17 kWh/m²/year according to UNI/TS 11300-2 for an average area of 80 m².

In the photovoltaic potential analysis in chapter 5.3.2, in Table 5 - 31, the usable area in m² was estimated according to the study of Lödl M. (2010)[69]. This study mentioned the model of Quaschning V. (2000)[70], where 66% of the area is reserved for photovoltaic and 34% for solar thermal. Due these considerations the reserved area in m² for solar thermal was calculated in South Tyrol. Using the total usable area for solar thermal, the heat production was estimated under the assumption of 400 kWh/m²/year.

With solar thermal with a smaller roof area (34% solar collectors, 66% photovoltaic panels) can be produced more energy compared to photovoltaic (1,603 GWh_{th} <-> 972 GWh_{e})and the total investment costs would be even lower. Thus, solar thermal should be promoted much more, as it can be produced more energy with fewer resources. The amount of 1,603 GWh_{th} is only a theoretical potential of solar thermal, because currently do not exist structures for the distribution of heat over long distances. A realistic approach means to reduce the theoretical potential to 50%, which corresponds rather to the technical potential.

69 Lödl M., Abschätzung des Photovoltaik-Potentials in Deutschland, Graz, 2010 http://www.hsa.ei.tum.de/Publikationen/2010/2010_Loedl_Kerber_Wi_Graz.pdf, download 27.08.2010

70 Quaschning, Volker: Systemtechnik einer klimaverträglichen Elektrizitätsversorgung in Deutschland für das 21. Jahrhundert, VDI-Verlag GmbH, Düsseldorf, 2000

Table 5 - 41: The solar thermal potential in South Tyrol

	Rural municipality	Village	Small town	Medium-sized and large town	Total
Area in m² *	1.455.727	1.778.064	507.239	265.894	4.006.924
Heat production in kWh/year **	582.290.676	711.225.765	202.895.680	106.357.440	1.602.769.561
Heat production in GWh/year **	582	711	203	106	1.603
Average area per building in m²	106	57	23	23	52
Average area per person in m²	25	12	4	2	8
Average amount of energy produced per person/year in kWh	9.963	4.630	1.560	659	3.184
Average amount of electricity produced per building/year in kWh	42.531	22.914	9.396	9.396	20.643
Investment costs ***	1.455.726.691	1.778.064.412	507.239.200	265.893.600	4.006.923.903
Distribution by production in %	36,33%	44,37%	12,66%	6,64%	100,00%
Area used in km²	1,46	1,78	0,51	0,27	4,01

* Assumption: A percentage of 34% of the roof area for the use of solar thermal was taken into account according to the study of Quaschning V. (2000).
** Assumption: Heat production of 400 kWh/m²/year.
*** Assumption: Investment costs of 1,000 Euro per m² [71]

Source: Own elaboration

80% of the heat energy will be produced by the peripheral municipalities. In this model was assumed, that 34% of the roofs will be covered with solar collectors and

71 Top-Ranking-Internet-Beratung, http://www.top-ranking-internet-beratung.de/wordpress/?p=92, download 23.08.2010

66% with photovoltaic panels (since both of them are in competition with each other).[72]

Currently, approximately 14.28% of the technical potential of solar thermal is already covered.

Table 5 - 42: Solar thermal and photovoltaic potential in South Tyrol

Total solar energy	Theoretical potential	Technical potential	Status quo 2009	Realized technical potential in %	2015	2020	2050
Solar thermal	1603	801	114	14,28%	154,47	234,61	475,02
Photovoltaic	972	972	37	3,82%	85,71	182,94	474,62
Total	**2575**	**1774**	**152**	**8,54%**	**240,18**	**417,55**	**949,64**

Source: Own elaboration

For the reference years are assumed following scenarios:

- 2015: Growth potential: 5% of the technical potential
- 2020: Growth potential: 10% of the technical potential
- 2050: Growth potential: 30% of the technical potential
- Total growth: 45% of the technical potential = Economic potential

Until 2050 almost 60% of the technical potential of solar thermal and 49% of photovoltaic can be covered.

5.4.2.3 Drivers

A hundred of companies are specialized in the renewable market in South Tyrol, and they are offering the planning and implementation of a solar thermal system. Searching in the internet for “solar collector” companies a number of 44 is showing up on the Portal of Environment and 27 companies are registered in the Chamber of Commerce in Bozen. There can be estimated many more, which are engaged in the planning and installation of solar thermal systems, especially companies, which are specialized in the sanitary sector are offering the mentioned service.

72 Quaschning, Volker: Systemtechnik einer klimaverträglichen Elektrizitätsversorgung in Deutschland für das 21. Jahrhundert, VDI-Verlag GmbH, Düsseldorf, 2000

In the new Climate Strategy 2050[73] the introduction of the following measure is foreseen: Consideration of energy principles in the arrangement and orientation of objects in the development planning: The municipalities have to optimize the use of solar energy in their land-use plans as good as possible throughout the choice of the building area, the distances and the orientations of the buildings in order to achieve a lower energy demand.

Further the municipality Bozen foresees in the latest revision of the building regulations, approved by the Council Decision No. 9/8926 of 1st February 2007, that the use of photovoltaic panels or solar collectors for the production of domestic hot water for new buildings is mandatory.[74] It defines the following conditions for the construction of new private and public buildings and as well for the renovation of buildings of at least 50% of the volume or floor space:

- The construction of the building according to the class B as a minimum standard (<= 50 kWh/m²/year).
- The use of solar energy by photovoltaic panels or solar collectors to cover at least 25% of the total heat energy consumption and at least 50% for the production of domestic hot water.

According to the cost-effectiveness analysis the use of solar collectors for hot water and heating purposes is one of the most efficient and most economic measure for the user. In Fig 7 - 78 the costs of one kWh produced by different energy sources are compared, and the costs for solar collectors with 0.05 Euro for one kWh are the lowest (except the costs for thermal insulation). Dividing the costs (fuel costs, maintenance and investment costs) for a private user over an average life span of 25 years of the facility by the annual demand of useful heat it gives the costs for one kWh.

73 Climate Strategy, Energy South Tyrol 2050, p. 110, draft version 01.08.2010

74 Municipality Bozen, http://www.gemeinde.bozen.it/urb_context02.jsp?ID_LINK=540&page=5&area=75, download 03.08.2010

5.4.2.4 Barriers

Most municipal building regulations require only an announcement before the start of construction up to a certain size. Constructions above a certain defined size must apply for a concession. Especially for the installations in historic centres for buildings which are under special protection/conservation, the municipality can determine in its building regulations for which installation a concession is necessary. Therefore it is useful to get in contact with the Municipal Building Authority before the construction.

5.4.3 Biogas

This section is explained in chapter 5.3.5.

5.4.4 Geothermal

5.4.4.1 Methodology to Determine Potential

The geothermal potential will be described in terms of the development of the heat pumps until 2020. Further two different projects of the geothermal use will be described.

One project is presented in part in chapter 3.5.4, where seven geothermal plants for heat and power generation are planned to be built in the next years, three geothermal district heating plants and four geothermal electricity-generating power plants.

Another project is linked to the construction of the Brenner Base Tunnel, a 55-kilometre long railway tunnel from Innsbruck (North Tyrol) to Franzensfeste (South Tyrol) through the base of the Brenner massif. The construction phase of the tunnel lies between 2010 and 2020.

5.4.4.2 Realistic Potential

As described in chapter 3.5.4, in total 318 heat pumps were installed in 2009. The same yearly average increase from 2005 to 2009 was assumed for the next years until 2020. An installation of 319 new heat pumps can be expected until 2015 and the same amount (319) up to 2020, which corresponds to a total heat production of about 6.15 GWh_{th}/year in 2015 and in 2020.[75]

The construction of the following geothermal plants is planned:

- Three geothermal district heating plants in 3000 m depth: The expected heat capacity is about 1-6 MW and the heat production about 8.76-52.56 GWh_{th} per year and plant.
- Four geothermal electricity-generating power plants in 5000 m depth: The expected electric capacity is about 2 MW_e and the electricity production about 17.52 GWh_e per year and the expected heat capacity about 4.5 MW_{th} and the heat production about 39.42 GWh_{th} per year and plant.

Another project is linked to the construction of the Brenner Base Tunnel (BBT), where about 785 litres of water per second with a temperature of 22-26° C are forecasted in the southern entrance. The usable heat of the tunnel water depends upon the amount and temperature of the surface water (in this case, temperature and volume of the river Eisack), in which the cooled water of the tunnel will be released. The tunnel water is allowed to change the temperature of the river only by + / - 1°C.

The amount and temperature of the water of the river varies greatly during the year (summer - winter). One can assume that the water tunnel can/must be cooled to about 10 to 20°C. Consequently, at 785 litres per second a heat capacity between 32 and 64 MW_{th} and a heat production of about 280.3 and 560.6 GWh_{th} per year can be expected.

There are several ways of utilizing the heat: Construction of a district heating net in the municipalities Aicha and Franzensfeste or use the heat directly for agricultural use in greenhouses and for fish farming. Probably the most sensible use of the heat will be due to the enormous heat potential the connection to the district heating net

75 Heat production estimated due to the total installed capacity of 10,256 KW (638 heat pumps) multiplied with 1200 hours yearly.

of the municipalities Brixen/Vahrn to bring the heat at the heat level of the net using a heat pump.

Table 5 - 43: Summary of the realizable potentials of geothermal energy until 2020

Year of realization	Projects	Heat production in GWh_{th}/year	Electricity production in GWh_e/year
2015	Installation of heat pumps	6.15	/
	Total in 2015	**6.15**	**/**
2020	Installation of heat pumps	6.15	/
2020	Use of the heat of the Brenner Base Tunnel (BBT) water *	280.3	/
2020	Construction of three geothermal district heating plants in 3000 m depth **	70.1	/
2020	Construction of four geothermal electricity-generating power plants in 5000 m depth	157.7	70.1
	Total in 2020	**514.25**	**70.1**

* Assumption: The heat capacity of 32 MW_{th} was considered.

** Assumption: 1 plant produces the maximum amount of 52.56 GWh_{th}/year and the other 2 plants produce the minimum amount of 8.76 GWh_{th}/year.

Source: Own elaboration

5.4.4.3 Drivers

The heat and electricity production by geothermal energy has the following advantages:

- The energy production takes place by 24 hours per day and 365 days per year;
- Geothermal energy is the only renewable energy source who can deliver reliable base load without additional energy storage;
- Absolute independence on the weather conditions;
- Zero emissions in the production process of heat and electricity;
- The construction requires only small interferences in the environment;

- The current geothermal power plants have minimal negative aesthetic impact on the landscape;
- The closed water cycle creates the precondition for the production of hot water and electricity for decades;
- Another positive aspect is, that the geothermal energy compared to the fossil or nuclear energy has a very limited local production cycle. Moreover, no complex pre-treatment or conversion processes are necessary, as it is for the production of the fossil and nuclear energy sources;
- Geothermal energy is a guarantee for the continuity of energy supplies (supply of heat and fed electricity into the power grid).

5.4.4.4 Barriers

Barriers of near surface geothermal:

The investment costs of the heat pumps are relatively high, also the price of the electricity used by the heat pump. Probably due to the still high investment costs and the relatively high operation costs (electricity) the boom subsided in the last two years as shown in Fig 3 - 27.

Barriers of deep geothermal:

According to experiences in Switzerland so-called "Micro-tremors" from geothermal energy can not be excluded such as happened during the exploration phase (drilling to a depth of 5000 m at the Kleinhüningen site) of the pilot plant “Deep Heat Mining” by the company Geo Power Basel.[76] Also water contaminations can occur during drilling at great depths. In Southern Germany in the city of Staufen buildings became deep fissures due to geothermal drillings.[77]

Other technical difficulties can occur during the drilling phase, when the success of the creation of a heat exchanger in the underground can not be foreseen.

76 Geopower Basel, http://www.geopower-basel.ch/de/pilotprojektbasel/standort.php, download 30.08.2010

77 Spiegel Online, http://www.spiegel.de/wissenschaft/natur/0,1518,589944,00.html, download 30.08.2010

5.4.5 Vegetable Oil

This section is explained in chapter 5.3.7.

5.5 Mobility

In this chapter the potential of electric mobility and the mobility with hydrogen will be described. The potential for the electric vehicle lies more in the sector of private small cars, whereas hydrogen is used probably more for the public transportation (autobus) in the next 10 years.

5.5.1 Electric Vehicle

In this area South Tyrol has a huge potential. Of course, much of it depends on the general trend worldwide. If the raw materials such as fossil oil or liquid gas should become scarcer in the near future, the price would rise and the introduction of electric cars would accelerate in the coming years.

5.5.1.1 Methodology to Determine Potential

The potential analysis of electric vehicles is based on own elaborations and calculations. For the estimation of the future increase of electric vehicles until 2020 more careful assumptions were taken into account, than the studies of McKinsey and Boston Consulting Group have assumed.

5.5.1.2 Realistic Potential

Since South Tyrol has a surplus of electricity, this could relatively easily used for the mobility sector. The efficiency of electric motors lies between 85% and 95%.[78] In comparison the diesel engine has only an efficiency of 45% and the benzine engine an efficiency of 35%. Currently the electric car consumes on average between 15-30 kWh/100 km[79] (rural and urban traffic). Thus, in the calculation a value of 22 kWh/100 km is used. If a daily average distance of 50 km will be assumed, then the yearly driven distance is 18,250 km, which leads to a consumption of about 4,015 kWh per year. According to the McKinsey study[80] the share of electric cars could

78 Wikipedia, http://de.wikipedia.org/wiki/Elektroauto , download 13.08.2010

79 LEIFI, http://www.leifiphysik.de/web_ph10/umwelt-technik/05elektroauto/elektroauto.htm, download 13.08.2010

80 Glocalist Daily News, http://www.glocalist.com/news/kategorie/wirtschaft/titel/studie-schon-2015-16-marktanteil-fuer-elektroautos/ , download 13.08.2010

amount to 16% in 2015 and already 26% in 2020 according the study of the Boston Consulting Group.[81]

The following assumptions were taken into account for South Tyrol:

- A change of 2% of the conventional cars into electric cars will be estimated until 2015, 13% until 2020 and 50% until 2050.
- Current annual consumption of an electric car: 4,015 kWh/year (18,250 km/year multiplied by 22 kWh/100 km)

Table 5 - 44: Registered cars by standards in South Tyrol – 2008

Car standard	Benzine	Petrol or Liquid Gas	Petrol or Methane	Diesel	Other	Data unknown	**Total**
EURO 0	18450	510	47	2022	11	3	**21.043**
EURO 1	16849	579	23	2627	0	2	**20.080**
EURO 2	48534	1146	90	21473	0	0	**71.243**
EURO 3	19881	563	122	39592	2	4	**60.164**
EURO 4	46317	1870	592	34942	2	2	**83.725**
Data unknown	46	0	0	0	2	4	**52**
Total	**150077**	**4668**	**874**	**100656**	**17**	**15**	**256.307**

Source: ACI [82]

Registered cars in South Tyrol (year 2008)[83]: 256,307

Converting private conventional cars into electric cars, the consumption will be about 1.029 GWh/year, which could easily be covered by the overproduction of electricity in South Tyrol.

$EMAX_{\text{electricity consumption of electrical vehicle [GWh/year]}} = N_{\text{number of all vehicles}} * D_{\text{average driving distance per year by car [km]}} * C_{\text{consumption in 1 km [kWh]}} / 1{,}000{,}000$

EMAX = 256,307 * 18,250 *0,22/1000000 = 1,029 GWh (maximum value)

81 Pressemitteilungen online, http://www.pressemitteilungen-online.de/index.php/26-prozent-der-neuwagen-koennten-2020-elektro-oder-hybridantrieb-haben/ , download 13.08.2010

82 ACI, http://www.aci.it/sezione-istituzionale/studi-e-ricerche/dati-e-statistiche.html, download 13.08.2010

83 ACI, http://www.aci.it/sezione-istituzionale/studi-e-ricerche/dati-e-statistiche/autoritratto-2008.html , download 13.08.2010

Table 5 - 45: Number of all registered vehicles in South Tyrol – 2008

Registered vehicles in 2008	South Tyrol
Autobus	935
Trucks	30.793
Special trucks	4.705
Cars	256.307
Small motobikes/cars	1.061
Motobikes	38.301
Special motobikes	483
Long trucks	3.738
Semi long trucks	6.023
Tractors	1.654
TOTAL	**344.000**

Source: ACI [84]

Table 5 - 46: Consumption and fuel costs in South Tyrol – 2007

	Benzine	Diesel	Liquid Gas	Methane	Total
Consumption	121.324.907	225.863.382	5.472.500	847.463	**353.508.252**
Cost in Euro	1,4010	1,2520	0,6990	0,8630	**/**
Percentage	34,32%	63,89%	1,55%	0,24%	**100,00%**
Total cost in Euro	**169.976.195**	**282.780.954**	**3.825.278**	**731.361**	**457.313.787**

Source: Office of Commerce and Service and own elaboration

$E_{\text{electricity consumption of electrical vehicle [GWh/year]}} = N_{\text{number of vehicles [year]}} * D_{\text{average driving distance per year by car [km]}} * C_{\text{consumption in 1 km [kWh]}} / 1{,}000{,}000$

Table 5 - 47: Scenario of electric cars in South Tyrol – 2010-2050

	Percentage	Number of electric cars	Consumption in GWh
2010	0	0	0,00
2015	2,00%	5.126	20,58
2020	13,00%	33.320	133,78
2050	50,00%	128.154	514,54

Source: Own elaboration

84 ACI, http://www.aci.it/sezione-istituzionale/studi-e-ricerche/dati-e-statistiche.html, download 13.08.2010

5.5.1.3 Drivers

The support of the government is significant for the switch from a conventional to an electric car. The goal of the National Electric Mobility Platform in Germany for example, which Chancellor Angela Merkel launched this year, is to have one million cars on German roads driving with electricity in 2020. The Platform is headed by Henning Kagermann from the National Academy of Sciences acatech. In seven working groups, representatives from industry, science, politics and civil society will discuss problems from the battery storage technology to the standardization.[85]

5.5.1.4 Barriers

Here are indicated the barriers which electric cars have to overcome:[86]

- Unreasonable expectations: It is difficult to say if people want to buy an electric car. People woud not buy an electric car as long, as they would not sacrifice any of the benefits of the conventional cars they are used to, and they would not pay a much higher price for an electric than for a conventional car.
- Range anxiety: Most Electric cars will travel 100-200 km, and it is unclear if people will accept that.
- Unfamiliarity: Customers have to be invited to try the cars out at “driving centers” and local businesses should keep test cars on hand.
- Availability: At the moment only a few electric cars will be available nationwide.
- Fear: The fear about electric shock (either when charging or when the car is in an accident) is one hurdle to get over.
- Costs: Uncertainty for the charging installation costs at home and the sale price of the car.
- Government support: State incentives are needed to reduce costs for consumers.

85 Bild.de, http://www.bild.de/BILD/politik/2010/05/03/elektro-auto-gipfel/2020-sollen-1-million-autos-mit-strom-fahren.html, download 13.08.2010

86 CBS Business network, http://www.bnet.com/blog/electric-cars/seven-barriers-to-the-electric-car/1491, download 13.08.2010

5.5.2 Hydrogen

A plant, which produces and distributes hydrogen for cars and buses at the filling stations along the freeway A22 from Brenner to Modena, is under construction in Bozen. The hydrogen production plant can replace annually about 650,000 litres of benzine or 550,000 litres of diesel.[87]

The total energy production of the plant amounts to 5.5 GWh/year (550,000 litres of diesel multiplied with 9.9 kWh/l/diesel).

The efficiency grade of the production of hydrogen is 40%. In order to produce 5.5 GWh/year hydrogen, 13.75 GWh_e of electricity (5.5 GWh *1/0.4) are needed.

The drivers and barriers of hydrogen are analysed in chapter 5.3.8.2.

87 H2 Südtirol, http://www.h2-suedtirol.com/index.php?id=96, download 03.06.2010

5.6 Energy Efficiency and Energy Saving

The electricity consumption is rising 3.5% per year in South Tyrol and has reached a value of around 2,900 GWh in 2009. Currently, we have an overproduction of electricity about twice as much (exactly 5,896.4 GWh_e). If no energy saving measures would take place and the average growth rate remains the same like in the last years, in the year 2030 the energy consumption would reach the current electricity production (2009).

On the contrary, the situation in the heat sector is different: South Tyrol needs to invest much more in energy saving measures in the coming years to increase the share of renewable energy and to replace fossil fuels more and more.

In the medium and long-term the goal should be to switch from the overproduction of electricity to the direction of heat and transport.

The energy saving topic is therefore a crucial and important issue. In this way it is possible to use the renewable energy efficiently and to decide for a possible change to this energy form. In the next sections the various energy saving possibilities in the heat and electricity sector will be presented.

5.6.1 ClimateHouse – Residential Buildings

5.6.1.1 Methodology to Determine Potential

At the beginning of the investigation of the energy saving potentials all relevant data in the residential building sector were collected. The following sources were used:

– ASTAT:
  The following data for the study were collected:
  - Number of households and increase or growth potential of the number of housholds in the future;
  - Construction period of the residential buildings (distribution on a percentage basis).
  - Net living area per year:

  - Amplification of residential buildings in m²;
  - Renovation of residential buildings in m².
- Population.

– ClimateHouse Agency:

The following data for the study were collected:

- Number of the certifications until the end of December 2009;
- Data about the heat energy demand per each ClimateHouse standard.

– Various factors such as:

- Subsidies (financial grants and also with cubature bonus);
- Guidelines;
- Laws;
- Information of the citizen.

– Own calculations and elaborations:

- Calculation of the increase of the net living area in the periods 2004-2050;
- Division of the residential buildings based on the certifications of the ClimateHouse Agency and the construction period of the buildings;
- Calculation model for the heat energy consumption and the energy saving of new residential buildings between 2004-2050;
- Calculation of the growth potential for each ClimateHouse standard for the period 2010-2050. In this calculation the average new and renovated building stock in the last 15 years (from 1995 to 2009) was considered, which was extrapolated to the possible new stock, so that realistic estimations could be made.

Some preliminary observations about the analysis and its accuracy:

- With the investigation of the energy efficiency for residential buildings the primary goal is to demonstrate, which potentials/opportunities in this sector exist and hence, what resources could be free. Of course, the estimates for the different ClimateHouse standards are not 100% scientifically consolidated, because a more detailed analysis of the building structure in South Tyrol has to be conducted. As basis the data of the construction periods and the ClimateHouse certifications were used and from those data the percentage distribution of the building standards was generated. Hopefully more detailed analysis / data / studies will be conducted in this area in the future, so that more accurate figures / saving potentials can be provided and more accurate statements for the future can be made (also from political point of view).

Uncertainty values are the following:

- The ClimateHouse values refer to the capital of the province, Bozen (260 m above sea level). Thus, the values of heat energy demand for residential buildings above a higher sea level can be up to 50% higher. In the future there are needed better values for the entire region provided by the ClimateHouse Agency in order to have a more accurate data available for the potential analysis. The average climate values in South Tyrol and the number of buildings could be used as parameters.
- The thermal energy demand (which corresponds to the thermal energy consumption) was determined under the assumption, that the heating systems of the buildings of ClimateHouse standard C, B, A and Gold have an efficiency of 85% and the other buildings "only" 70%. Those data are naturally only approximated values.

Overall, it is estimated that the results of the energy efficiency potential for residential buildings can differ by max. 20%, but in general the values are rather underestimated, since all data are calculated according to the climate values of Bozen.

In this analysis were taking into account the following scenarios:

1. Scenario: Amplification of the net living area (increase of the net living area).

2. Scenario: Net living area of the year 2010 for all periods, which means to take constant the net living area and to apply the new measures of ClimateHouse standards.

3. Scenario: Allocation formula of the year 1990 for all periods, which allows to see what occurs when taking into account the composition of the building stock in 1990.

4. Scenario: Allocation formula of the year 2010 for all periods, which allows to see what occurs when taking into account the composition of the building stock in 2010.

5. Scenario: Maximum potential, which means to build the entire net living area according to the best quality standard, ClimateHouse standard Gold.

5.6.1.2 Realistic Potential

From 1st June 2010 (Decree of the Regional Government No. 2299 of 30.06.2008) the new residential buildings must follow the requirement of 5 litres of oil, which corresponds to the standard B. For a building with standard A a cubature bonus of 5%, standard B Plus a bonus of 10% and standard A Plus even a bonus of 15% is granted. But that's not all: From 2015 the standard A will be mandatory for all new residential buildings and from 2020 even the standard A Plus.

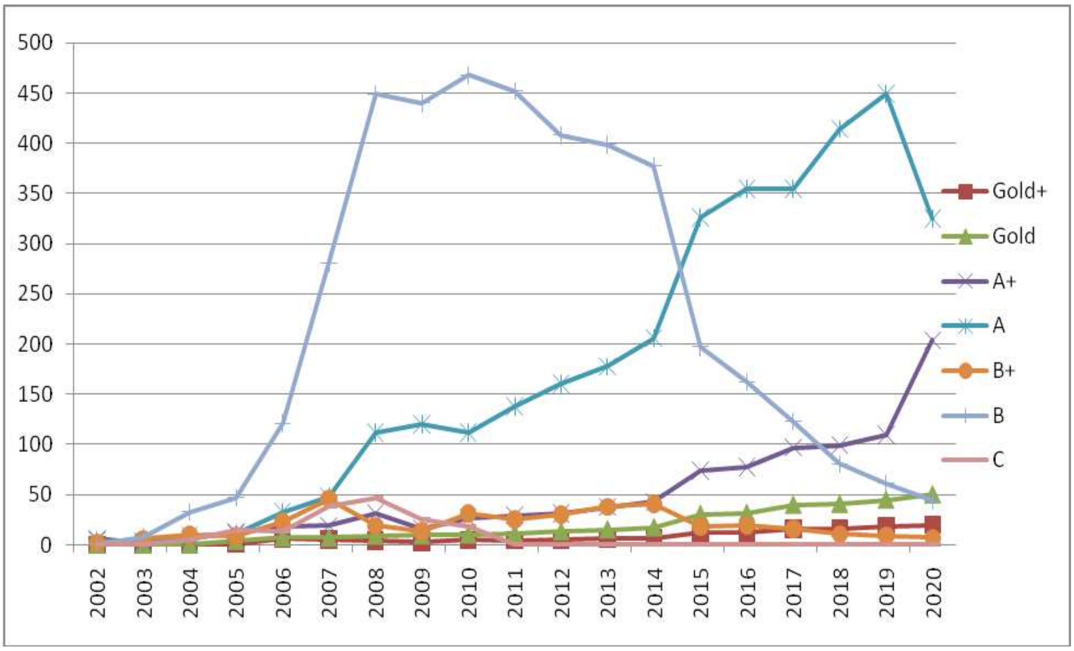
For old residential buildings the situation is different: The standard C is sufficient for the houses, which were built before 2005. If an existing building will be demolished and rebuilt, the cubature bonus can only be obtained, if the ClimateHouse standard A is reached.[88]

The following scenario for new residential buildings in the next ten years in South Tyrol is based on the promotion criteria of the Regional Government described above and the historical statistical data of new residential buildings. An equal number of 650 new residential buildings annually certified and the basic parameters of the promotion scheme from the Regional Government will be taken into account.

88 Presseamt,http://www.provinz.bz.it/lpa/service/news.asp?redas=yes&archiv_action=4&archiv_article_id=317114, download 03.06.2010

Unfortunately, a precise statement about the quality of the new residential buildings is not possible, because only certified new residential buildings appear in the statistics. Not all ClimateHouse new buildings with the standard C are included in the statistic, since these houses do not need any specific certification. Only renovations of old buildings, which apply for a national or regional subsidy, have to renovate to ClimateHouse standard C or B (to receive the cubature bonus) and therefore they must be certified, however others are not obliged.

Fig 5 - 62: Scenario of the certified residential buildings – 2010-2020



Source: Own elaboration

In the figure above the various policy decisions / promotion activities for the next ten years are included. In the capital city of Bolzano the minimum ClimateHouse standard B was introduced in the early 2007. In the rest of the region it was introduced on 01.06.2010. From 2015 the standard A for new residential buildings will be mandatory and therefore more application for Climate House A will take place instead of B, whereas the renovations of buildings can be realized to standard B. From 2020 even the ClimateHouse standard A+ will be mandatory.

Table 5 - 48: Scenario of the total number of new residential buildings and their percentage in periods of 5 years – 2010-2020

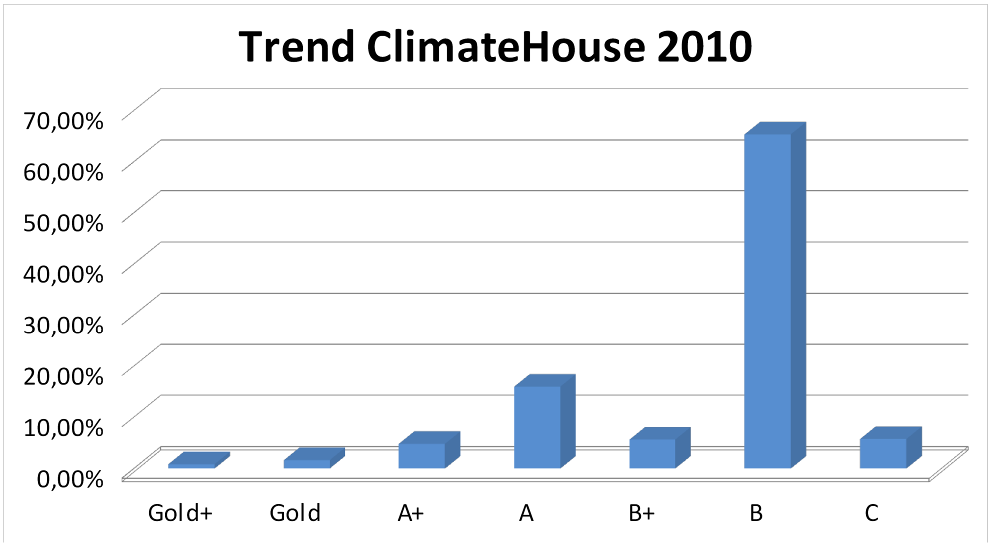
Climate House Standard	Trend 2010	Trend 2015	Trend 2020	Trend 2010	Trend 2015	Trend 2020
Gold+	24	60	147	1%	1%	2%
Gold	43	120	299	2%	2%	3%
A+	128	314	820	5%	5%	9%
A	453	1,332	3,044	16%	23%	35%
B+	156	300	359	6%	5%	4%
B	1,775	3,499	3,947	66%	60%	45%
C	159	198	204	6%	3%	2%
Total	**2,708**	**5,822**	**8,815**	**100%**	**100%**	**100%**

Source: Own elaboration

In the table above the estimated data of the next ten years are listed, whereas the number of new residential buildings is summed up (the same applies to the percentages).

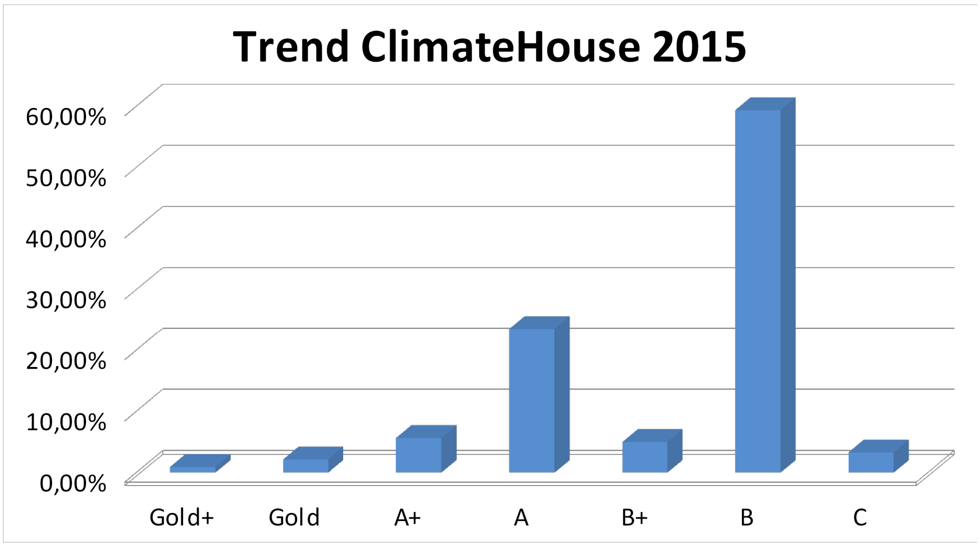
The following three figures depict the estimated pecentage development of the ClimateHouse standards in the periods 2010, 2015 and 2020.

Fig 5 - 63: Percentage development of the ClimateHouse standards in 2010



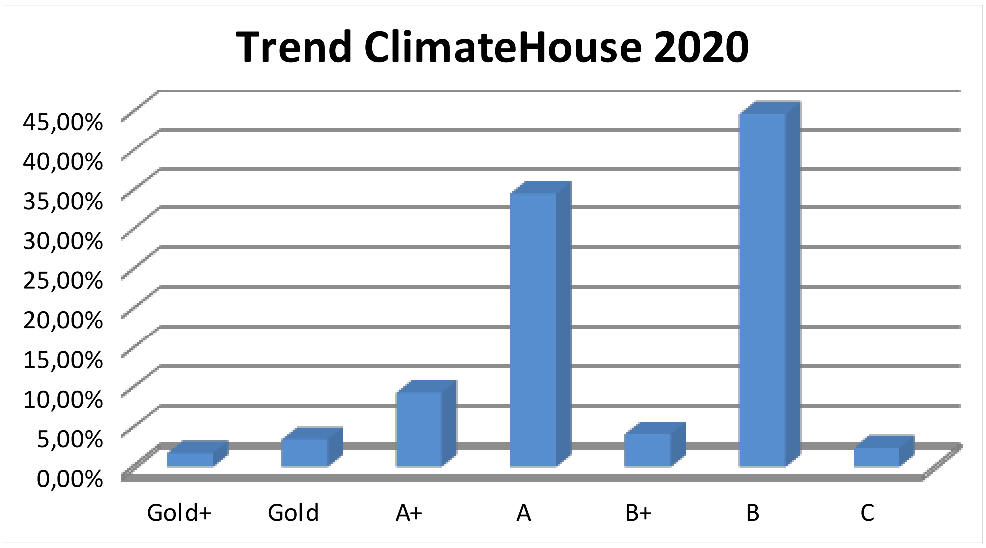
Source: Own elaboration

Fig 5 - 64: Percentage development of the ClimateHouse standards in 2015



Source: Own elaboration

Fig 5 - 65: Percentage development of the ClimateHouse standards in 2020



Source: Own elaboration

In general the trend goes more and more towards improved quality of building standards in the future and thus towards improved energy values for each building. In the following table the heat energy demand, the heat energy consumption and the theoretical saving potentials in percentage of the different building standards are described.

Table 5 - 49: Values of the heat demand and the heat energy consumption of the different ClimateHouse standards

Building stock	Heat energy demand (heating) in kWh/m²/year)	Efficiency of the heating system	Heat energy consumption (heating) in kWh/m²/year)
CH F	160	70,00%	229
CH E	120	70,00%	171
CH D	90	70,00%	129
CH C	70	85,00%	82
CH B	50	85,00%	59
CH A	30	85,00%	35

Source: Own elaboration

Heat energy consumption (heating) in (kWh/m²/year) = Heat demand (heating) (kWh/m²/year) / efficiency of the heating system

Old stock: Heat energy consumption of about 200 kWh/m²/year (average of ClimateHouse standard F and ClimateHouse standard E)

Table 5 - 50: Values of the heat energy consumption and the heat energy saving of the different ClimateHouse standards and their saving potentials

Building stock	Heat energy consumption (heating) in kWh/m²/year)	Heat energy saving (heating) in kWh/m²/year)	Energy Saving potential to the higher building standard	Energy saving potential towards old stock in percentage
Old stock (CH F and CH E)	200	0	0,00%	0,00%
CH D	129	71	35,50%	35,50%
CH C	82	47	36,43%	59,00%
CH B	59	23	28,05%	70,50%
CH A	35	24	40,68%	82,50%

Source: Own elaboration

Table 5 - 51: Reference data for the ClimateHouse calculation model

Years	Number of households	Net living area in m²	Growth potential of net living area	Number of inhabitants
1980		*10.569.218*		
1990	146.495	*13.057.132*	23,54%	432.989
2001	173.433	**15.504.497**	18,74%	463.209
2004	185.067	*16.246.338*	4,78%	477.067
2010	205.976	*17.745.013*	9,22%	508.846
2015	218.824	*18.916.983*	6,60%	519.101
2020	231.559	*20.088.954*	6,20%	527.654
2050*	231.559	*27.120.776*	35,00%	527.654

* Data base of 2009
** 3rd column,4 wow 2001 (15,504,497 m²): Source ASTAT; other values in italic of the 3rd column: Own trend calculation (the average value of the last fifteen years growth was added).

Source: ASTAT

- Increase of the net living area of new residential buildings from:
  - 2004 to 2010: 1,498,675 m²
  - 2004 to 2015: 2,670,645 m²
  - 2004 to 2020: 3,842,616 m²

- Increase of the number of households from:
  - 2004 to 2010: 20,909
  - 2004 to 2015: 33,757
  - 2004 to 2020: 46,492

Table 5 - 52: Estimation of the net living area of residential buildings – 1980-2010

Years	Net living area in m²	Growth potential of net living area	Growth potential of net living area from 1980	Growth potential of net living area from 1990	Growth potential of net living area from 2010
1980	*10.569.218*				
1990	*13.057.132*	23,54%	23,54%		
2001	**15.504.497**	18,74%	46,69%	18,74%	
2004	*16.246.338*	4,78%	53,71%	24,43%	
2010	*17.745.013*	9,22%	67,89%	35,90%	
2015	*18.916.983*	6,60%	78,98%	44,88%	6,60%
2020	*20.088.954*	6,20%	90,07%	53,85%	13,21%
2050	*27.120.776*	35,00%	156,60%	107,71%	52,84%

** 3rd column, 4th row 2001 (15,504,497 m²): Source: ASTAT; other values in italic of the 3rd column: own trend calculation (the average value of the last fifteen years growth was added).

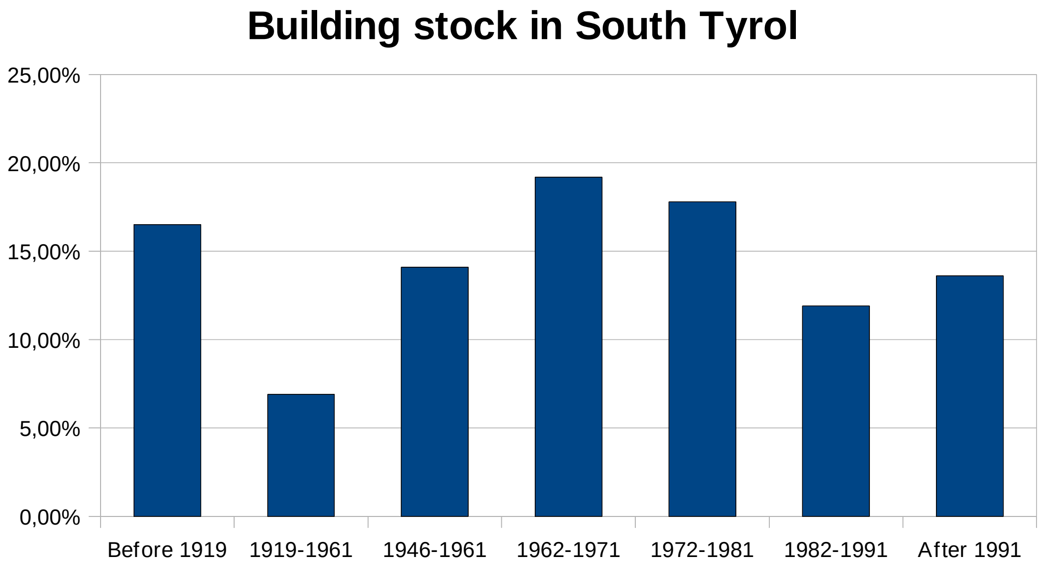
Source: ASTAT

Table 5 - 53: Temporal distribution of the building stock in South Tyrol

Building stock	Before 1919	1919-1961	1946-1961	1962-1971	1972-1981	1982-1991	After 1991
South Tyrol	**16,50%**	**6,90%**	**14,10%**	**19,20%**	**17,80%**	**11,90%**	**13,60%**

Source: ASTAT

Fig 5 - 66: Building stock in South Tyrol



Source: ASTAT, own elaboration

Accordingly, 56.7% of the residential buildings are dated before 1972 and 74.5% before 1982. 86.40% of the residential buildings were built until 1991. Since energy consumption data are not available for each building, the data of the building-specific energy consumption were estimated by the construction year the net living area and the average consumption of the building from a particular construction period.

In general the building stock in South Tyrol is partially obsolete and consequently it has insufficient insulation values.

5.6.1.2.1 Trend Analysis of Energy Saving Potentials of new Residential Buildings after 2004

The objective of this evaluation was to determine the potential reduction of energy consumption for the construction of new residential buildings.

As shown in the above graphs and table, most of the new residential buildings were built in the recent years between 2004-2010 (the last six years) covering a net living area of 1,498,675 m². The Table 5 - 48 is used for the distribution of the different ClimateHouse standards:

- Standard C: 5.87%
- Standard B and B+: 71.33%
- Standard A and A+: 20.33%
- Standard Gold and Gold+: 2.47%

In the year 2015 a net living area of 2,670,645 m² (2004-2015) and the percentage of the different building standards from Table 5 - 50 were taken into account. The same applies for the period 2004-2020, for which a net living area of 3,842,616 m² was calculated.

The following formula was used:

$E_{\text{heat energy consumption in period x [GWh]}} = E_{\text{heat energy consumption per building standard [GWh]}} * P_{\text{percentage of building standard (Table 5 - 48)}} * W_{\text{net living area of the residential buildings [m}^2\text{] in period x}}$

Table 5 - 54: Estimation of the heat energy consumption of the new residential buildings – 2004-2020

Building stock	Heat energy consumption (heating) in kWh/m²/year)	Heat energy consumption between 2004-2010 in GWh	Heat energy consumption between 2004-2015 in GWh	Heat energy consumption between 2004-2020 in GWh
Old stock	200	0	0	0
CH C	82	7,21	7,44	7,34
CH B	59	63,07	102,82	110,58
CH A	35	10,66	26,41	58,96
CH Gold	12	0,44	0,99	2,33
		81,39	**137,67**	**179,21**

Source: Own elaboration

The total heat energy consumption for all new residential buildings between 2004-2010 is about 81.39 GWh, between 2004-2015 137.67 GWh and between 2004-2020 179.21 GWh. Thus, on average approximately 13.56 GWh of thermal energy per year will be consumed between 2004-2010, these are only 12.52 GWh between 2004-2015 and 11.20 GWh between 2004-2020.

Despite the increase of the new built net living area, the heat energy consumption will decrease due to the application of quality-improved ClimateHouse standards.

Shortening the period, the annual heat energy consumption will amount to 11.26 GWh between 2010-2015 and 8.31 GWh between 2015-2020 only. Hence, due to the improved quality of the buildings the average annual amount of thermal energy consumed will be reduced from the period 2004-2010 to the period 2004-2020 by over 38.75%.

Table 5 - 55: Comparison of the heat energy consumption and the saving effects of the different ClimateHouse standards in terms of the total new building stock – 2004-2010

Building stock	Theoretical heat energy consumption per ClimateHouse standard in the period 2004-2010 (GWh)	Saving/additional consumption in comparison to the calculated value in the table 5-54 in the period 2004-2010 (GWh)
Old stock	299,74	218,35
CH C	122,89	41,50
CH B	88,42	7,03
CH A	52,45	-28,93
CH Gold	17,98	-63,40

NB: The heat energy consumption of the total new building stock between 2004-2020 for each building standard is included in the calculation.

Source: Own elaboration

Table 5 - 56: Comparison of the heat energy consumption and the saving effects of the different ClimateHouse standards in terms of the total new building stock – 2004-2015

Building stock	Theoretical heat energy consumption per ClimateHouse standard in the period 2004-2015 (GWh)	Saving/additional consumption in comparison to the calculated value in the table 5-54 in the period 2004-2015 (GWh)
Old stock	534,13	396,46
CH C	218,99	81,33
CH B	157,57	19,90
CH A	93,47	-44,19
CH Gold	32,05	-105,62

NB: The heat energy consumption of the total new building stock between 2004-2020 for each building standard is included in the calculation.

Source: Own elaboration

Table 5 - 57: *Comparison of the heat energy consumption and the savings effect of the different ClimateHouse standards in terms of the total new building stock – 2004-2020*

Building stock	Theoretical heat energy consumption per ClimateHouse standard in the time period 2004-2020 (GWh)	Saving/additional consumption in comparison to the calculated value in the table 5-54 in the period 2004-2020 (GWh)
Old stock	768,52	589,32
CH C	315,09	135,89
CH B	226,71	47,51
CH A	134,49	-44,71
CH Gold	46,11	-133,09

NB: The heat energy consumption of the total new building stock between 2004-2020 for each building standard is included in the calculation.

Source: Own elaboration

If we compare the estimated thermal energy consumption (Table 5 - 57) with the consumption of each building standard, we see that the trend is going closer to the consumption of a ClimateHouse Standard A until 2020.

If no ClimateHouse standard will be prescribed by the Regional Government and people even continue to build buildings according to the old building stock, so an additional heat energy consumption of 589.32 GWh between 2004-2020 will arise; for the ClimateHouse standard C still an additional amount of 135.89 GWh will be consumed, which is 75.83% higher as the predicted consumption in the period 2004-2020.

In the following table the heat energy consumption for the different ClimateHouse standards in the relevant period is listed. It shows the possible savings in the periods 2004-2010, 2004-2015 and 2004-2020, if in spite of an ClimateHouse C a better building standard will be chosen.

Table 5 - 58: *Comparison of the saving potentials for new residential buildings towards ClimateHouse standard C*

Building stock	ClimateHouse Standard C	ClimateHouse Standard B	ClimateHouse Standard A	ClimateHouse Standard Gold
Heat energy consumption 2004-2010 in GWh	122,89	88,42	52,45	17,98
Saving towards CH C 2004-2010 in GWh	**-**	**34,47**	**70,44**	**104,91**
Heat energy consumption 2004-2015 in GWh	218,99	157,57	93,47	32,05
Saving towards CH C 2004-2015 in GWh	**-**	**61,42**	**125,52**	**186,95**
Heat energy consumption 2004-2020 in GWh	315,09	226,71	134,49	46,11
Saving towards CH C 2004-2020 in GWh	**-**	**88,38**	**180,60**	**268,98**

Source: Own elaboration

The energy saving potential goes so far, that with the ClimateHouse standard Gold 268.98 GWh less of thermal energy would be consumed than with ClimateHouse standard C in the period of 2004-2020.

5.6.1.2.2 Trend Analysis of Energy Saving Potentials of all Residential Buildings

Formula for the calculation of the total heat energy consumption per building standard:

$E_{\text{total heat energy consumption in period 2010 [GWh]}} = E_{\text{heat energy consumption per building standard [GWh]}} * W_{\text{net living area of residential buildings [m²] in period 2010}}$

Formula for the calculation of the heat energy saving potential per building standard towards old building stock:

$Es_{\text{heat energy saving 2010 [GWh]}} = E_{\text{heat energy consumption OLD building stock [GWh]}} - E_{\text{heat energy consumption per building standard [GWh]}}$

Formula for the calculation of the maximum energy saving potential towards old building stock:

$Es_{\text{heat energy maximum saving 2010 [GWh]}} = E_{\text{heat energy consumption OLD building stock [GWh]}} - E_{\text{heat energy consumption ClimtateHouse Standard Gold [GWh]}}$

Table 5 - 59: *Heat energy consumption by ClimateHouse standards – Maximum energy saving potential in 2010*

Maximum saving potential				
Building stock	**Heat energy consumption (heating) in kWh/m²/year)**	**Heat energy saving (heating/hot water) in kWh/m²/year)**	**Total heat energy consumption per net living area in GWh**	**Total energy saving potentials towards Old stock in GWh**
Old stock (CH F and CH E)	200	0	3.549	0
CH D	129	71	2.289	1.260
CH C	82	47	1.455	2.094
CH B	59	23	1.047	2.502
CH A	35	24	621	2.928
CH Gold	12	23	213	3.336

Source: Own elaboration

Formula for the calculation of the heat energy consumption in the year 1990:

$E_{\text{heat energy consumption in 1990 [GWh]}} = \sum_{i=1}^{n} E_{i\ \text{heat energy consumption per building standard [GWh]}} * P_{\text{percentage of building standard (Table 5 - 60)}} * W_{\text{net living area of the residential buildings [m²] in period 1990}}$

$E_{\text{heat energy consumption in 1990 [GWh] Net living area 2010}} = \sum_{i=1}^{n} E_{i\ \text{heat energy consumption per building standard [GWh]}} * P_{\text{percentage of building standard (Table 5 - 60)}} * W_{\text{net living area of the residential buildings [m²] in period 2010}}$

n = number of building standards

i = heat energy consumption per building standard [GWh]

Table 5 - 60: Heat energy consumption in 1990 by ClimateHouse standards and building stock in 1990

1990				With the net living area of 2010	
Building stock	**Estimated building standards in %**	**Calculated net living area for each building standard in m²**	**Annual heat energy consumption in GWh**	**Calculated net living area for each building standard in m²**	**Annual heat energy consumption in GWh**
Old stock (CH F and CH E)	74,50%	9.727.563	1.945,51	*13.220.035*	*2.644,01*
CH D	18,70%	2.441.684	314,98	*3.318.317*	*428,06*
CH C	6,80%	887.885	72,81	*1.206.661*	*98,95*
CH B	0,00%	-	-	-	-
CH A	0,00%	-	-	-	-
CH Gold	0,00%	-	-	-	-
	100%	**13.057.131,73**	**2.333,30**	***17.745.013,07***	***3.171,02***

Source: Own elaboration

The following assumptions were made: All residential buildings constructed until 1971 (Table 5 - 66) and 50% of the residential buildings constructed between 1972-1981 (Table 5 - 66) belong to the old building stock with 200 kWh/m² energy consumption for space heating per year. The other 50% of the residential buildings between 1972-1981 (Table 5 - 66) were built mostly applying ClimateHouse standards D. Residential buildings between 1982-1991 (Table 5 - 66) belong to the ClimateHouse standard C and only from 1992 residential buildings were constructed also with the standards B, A and at the end Gold. It can be assumed that approximately 80% of the residential buildings from this construction period can be assigned to standard B and the remaining buildings to Gold and A. The situation of good quality buildings is overestimated in the scenario, because it might occur that between 1992-2010 the insulation quality of some buildings was inferior and not all buildings between 1972-1981 got standard C. But for the calculation model the overestimated data seem to be a satisfactory value.

The following calculations are based on the increase of the last 15 years and their annual average: Between 1995-2009 an average annual net living area of 234,394 m² of new residential buildings (included amplifications), which corresponds to approximately 2,813 flats, and 254,131 m² of renovated residential buildings (recovery of old building stock), which corresponds to about 1,332 flats, were added. In total, an annual increase of approximately 488,525 m² of net living area (4,145 flats) was achieved.

Formula for the calculation of the heat energy consumption in the year 2010:

$$E_{\text{heat energy consumption in 2010 [GWh]}} = \sum_{i=1}^{n} E_i \text{ heat energy consumption per building standard [GWh]} * P_{\text{percentage of building standard (Table 5 - 61)}} * W_{\text{net living area of the residential buildings [m²] in period 2010}}$$

n = number of building standards

i = heat energy consumption per building standard [GWh]

Table 5 - 61: Heat energy consumption in 2010 by ClimateHouse standards and building stock in 2010

2010			
Building stock	**Estimated building standards in %**	**Calculated net living area for each building standard in m²**	**Annual heat energy consumption in GWh**
Old stock (CH F and CH E)	65,60%	11.640.729	2.328,15
CH D	8,90%	1.579.306	203,73
CH C	11,90%	2.111.657	173,16
CH B	10,88%	1.930.657	113,91
CH A	2,45%	434.398	15,20
CH Gold	0,27%	48.266	0,58
	100%	**17.745.013**	**2.834,72**

Source: Own elaboration

Formula for the calculation of the heat energy consumption in the year 2015:

$$E_{\text{heat energy consumption in 2015 [GWh]}} = \sum_{i=1}^{n} E_i \text{ heat energy consumption per building standard [GWh]} * (P_{\text{percentage of the composition of the building stock in 2010 (Table 5 - 61)}} + P_{\text{percentage of the composition of the building stock in 2010 (Table 5 - 61)}} * G_{\text{growth potential 2015 (Table 5 - 62)}}) * W_{\text{net living area of the residential buildings [m²] in period 2015}}$$

n = number of building standards

i = heat energy consumption per building standard [GWh]

Growth potential:

ClimateHouse C: 30%, ClimateHouse B: 79,96%, ClimateHouse A: 29.90%, ClimateHouse Gold: 10.29%

Table 5 - 62: Heat energy consumption in 2015 by ClimateHouse standards and building stock in 2015

2015				
Building stock	**Growth potential**	**Building standards (growth potential included) in %**	**Calculated net living area for each building standard in m²**	**Annual heat energy consumption in GWh**
Old stock (CH F and CH E)	-17,68%	54,00%	10.215.171,04	2.043,03
CH D	-21,35%	7,00%	1.324.188,84	170,82
CH C	30,00%	15,47%	2.926.457,33	239,97
CH B	79,96%	19,58%	3.703.945,35	218,53
CH A	29,90%	3,18%	601.560,07	21,05
CH Gold	10,29%	0,30%	56.750,95	0,68
		100%	**18.828.073,58**	**2.694,09**

Source: Own elaboration

Formula for the calculation of the heat energy consumption in the year 2020:

$$E_{\text{heat energy consumption in 2020 [GWh]}} = \sum_{i=1}^{n} E_{i\ \text{heat energy consumption per building standard [GWh]}} * (P_{\text{percentage of the composition of the building stock in 2015 (Table 5 - 62)}} + P_{\text{percentage of the composition of the building stock in 2015 (Table 5 - 62)}} * G_{\text{growth potential 2020(Table 5 - 63)}}) * W_{\text{net living area of the residential buildings [m²] in period 2020}}$$

n = number of building standards

i = heat energy consumption per building standard [GWh]

Growth potential:

ClimateHouse C: 16.35%, ClimateHouse B: 24.92%, ClimateHouse A: 167.30%, ClimateHouse Gold: 80%

Table 5 - 63: Heat energy consumption in 2020 by ClimateHouse standards and building stock in 2020

2020				
Building stock	**Growth potential**	**Building standards (growth potential included) in %**	**Calculated net living area for each building standard in m²**	**Annual heat energy consumption in GWh**
Old stock (CH F and CH E)	-19,44%	43,50%	8.738.694,87	1.747,74
CH D	-28,57%	5,00%	1.004.447,69	129,57
CH C	16,35%	18,00%	3.616.011,67	296,51
CH B	24,92%	24,46%	4.913.758,08	289,91
CH A	167,30%	8,50%	1.707.561,07	59,76
CH Gold	80,00%	0,54%	108.480,35	1,30
		100,00%	**20.088.953,73**	**2.524,80**

Source: Own elaboration

Formula for the calculation of the heat energy consumption in the year 2050:

$$E_{\text{heat energy consumption in 2050 [GWh]}} = \sum_{i=1}^{n} E_{i\ \text{heat energy consumption per building standard [GWh]}} * P_{\text{estimated percentage of the composition of the building stock in 2050(Table 5 - 64)}} * W_{\text{net living area of the residential buildings [m²] in period 2050}}$$

n = number of building standards

i = heat energy consumption per building standard [GWh]

Estimation of the percentage of the building stock in 2050:

Old building stock: 20%, D: 1%, ClimateHouse C: 20%, ClimateHouse B: 35%, ClimateHouse A: 18%, ClimateHouse Gold: 6 %

Table 5 - 64: Theoretical heat energy consumption in 2050 by ClimateHouse standards and building stock in 2050

2050			
Building stock	**Estimated building standards**	**Calculated net living area for each building standard in m²**	**Annual heat energy consumption in GWh**
Old stock (CH F and CH E)	20%	5.424.155,15	1.084,83
CH D	1%	271.207,76	34,99
CH C	20%	5.424.155,15	444,78
CH B	35%	9.492.271,51	560,04
CH A	18%	4.881.739,63	170,86
CH Gold	6%	1.627.246,54	19,53
	100%	**27.120.775,73**	**2.315,03**

Source: Own elaboration

Table 5 - 65: Annual heat energy consumption by ClimateHouse standards – Summary

Building stock	Annual heat energy consumption in 1990 in GWh	Annual heat energy consumption in 2001 in GWh	Annual heat energy consumption in 2010 in GWh	Annual heat energy consumption in 2015 in GWh	Annual heat energy consumption in 2020 in GWh	Annual heat energy consumption in 2050 in GWh	Annual heat energy consumption in 2010 – theoretical maximum in GWh
Old stock (CH F and CH E)	1.945,51	2.263,66	2.328,15	2.043,03	1.747,74	1.084,83	3.549,00
CH D	314,98	380,02	203,73	170,82	129,57	34,99	2.289,11
CH C	72,81	101,71	173,16	239,97	296,51	444,78	1.455,09
CH B	-	-	113,91	218,53	289,91	560,04	1.046,96
CH A	-	-	15,20	21,05	59,76	170,86	621,08
CH Gold	-	-	0,58	0,68	1,30	19,53	**212,94**
	2.333,30	**2.745,38**	**2.834,72**	**2.694,09**	**2.524,80**	**2.315,03**	

Source: Own elaboration

Table 5 - 66: Heat energy consumption and saving potentials – Summary

Year	Heat energy consumption in GWh	Saving potentials in GWh	Saving potentials in %	Saving potential towards 1990 in %	Saving potential towards 2001 in %
1990	2.333,30	-			
2001	2.745,38	-412,08	-17,66%	-17,66%	
2010	2.834,72	-89,34	-3,25%	-21,49%	-3,25%
2015	2.694,09	140,63	4,96%	-15,46%	1,87%
2020	2.524,80	169,29	6,28%	-8,21%	8,03%
2050	2.315,03	209,77	8,31%	0,78%	15,68%
Maximum potential	212,94	2.102,09	90,80%	90,87%	92,24%

Source: Own elaboration

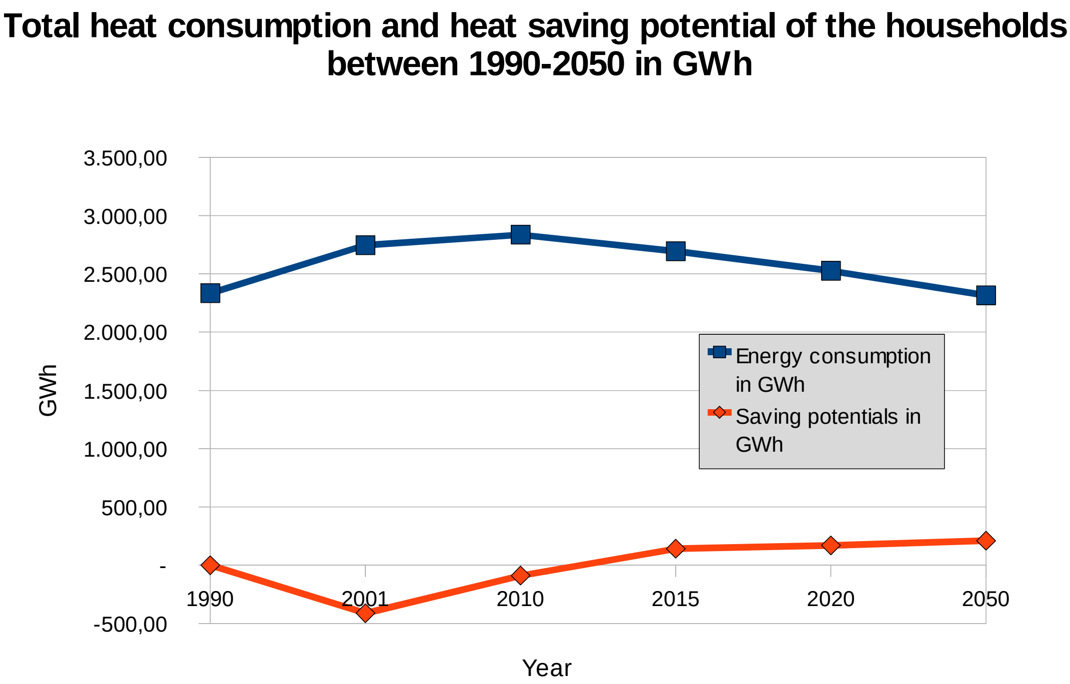
In the table above the heat energy consumption and the energy saving potentials for all residential buildings in South Tyrol in different years are listed.

From 1990 to 2010 there is no energy saving (-21,49%), because in this period there were added almost 36% of the building volume and so the total energy consumption increased despite the improved construction quality. On the other hand if we would not use improved construction quality measures, the energy consumption would increase by the same value as the building volume: 36% instead of 21.49%. In 2020 we will have almost the same (-8,21%) total energy consumption as in 1990, whereas 54% of the net living area from 1990 to 2020 will be added.

Thus, the heat energy consumption between 2001-2010 increased by over 3.25%, and will decrease in the period of 2010-2015 by further 4.96% and in the next period by another 6,28%, because in that period it will be invested more in the ClimateHouse building standard A. Furthermore it is still possible to reduce the heat energy consumption of the households to 2,315.03 GWh in the long-term until 2050, resulting in further savings of almost 8.31% compared to 2020, even if the net living area will increase by approximately 35%.

A further saving possibility from a technical point of view is difficult to reach, because of the technical barriers, which impede to bring the old building stock to a quality-improved building standard (for example buildings under monument protection).

Fig 5 - 67: Total heat energy consumption and heat saving potential of the private households between 1990-2050 and the maximum potential (increase of the net living area included)



Source: Own elaboration

Table 5 - 67: Heat energy consumption by ClimateHouse standards – Summary (increase of the net living area included)

Year	Energy consumption in GWh
1990	2.333,30
2001	2.745,38
2010	2.834,72
2015	2.694,09
2020	2.524,80
2050	2.315,03
Maximum potential	212,94

Source: Own elaboration

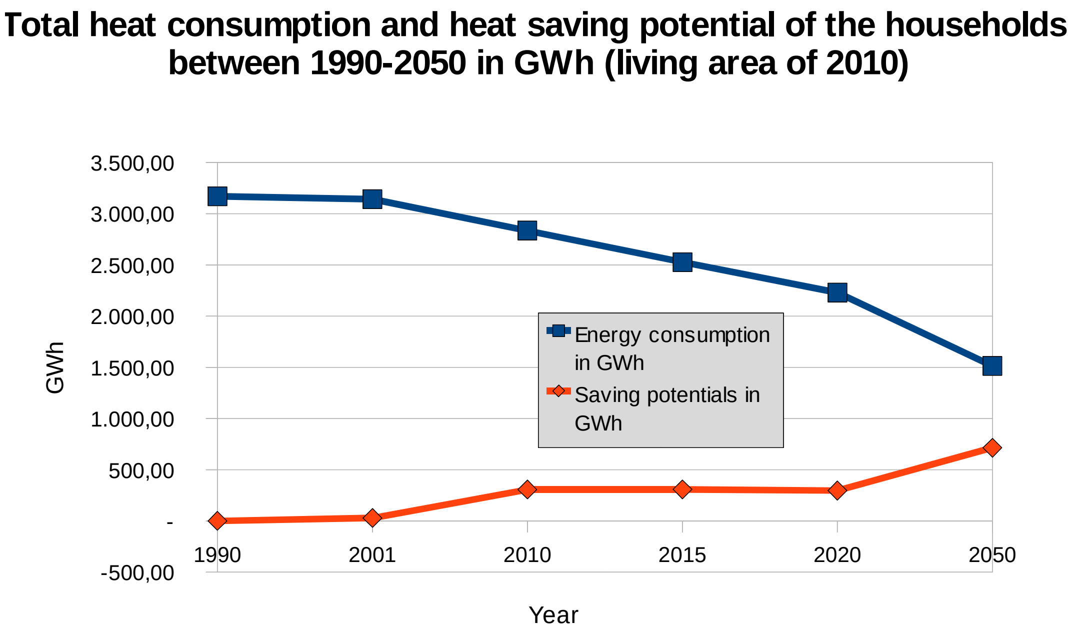
In the figure above the development of the energy saving and energy consumption from 1990 to 2050 and the maximum potential are shown. Important to mention is that all calculations are based on the following assumptions:

Increase of the net living area between:

- 1990-2001: 18.74%
- 1990-2004: 24.43%
- 1990-2010: 35.90%
- 1990-2015: 44.88%
- 1990-2020: 53.85%
- 1990-2050: 107.71%

Between 2001-2020 thermal energy savings by over 8,03% is possible, although in this calculation an increase (29.57%) of net living area was included. Would the same net living area of 2001 considered in the calculation for 2020, then heat energy savings would even amount to almost nearly 30%. The maximum energy savings in South Tyrol would be 212.94 GWh with the building cubature of 2010. This value would be reached, if all the residential buildings would correspond to the ClimateHouse standard Gold.

Fig 5 - 68: Total heat energy consumption and heat saving potential of the private households between 1990-2050 and the maximum potential (net living area of 2010)



Source: Own elaboration

Table 5 - 68: Heat energy consumption by ClimateHouse standards – Summary (net living area of 2010)

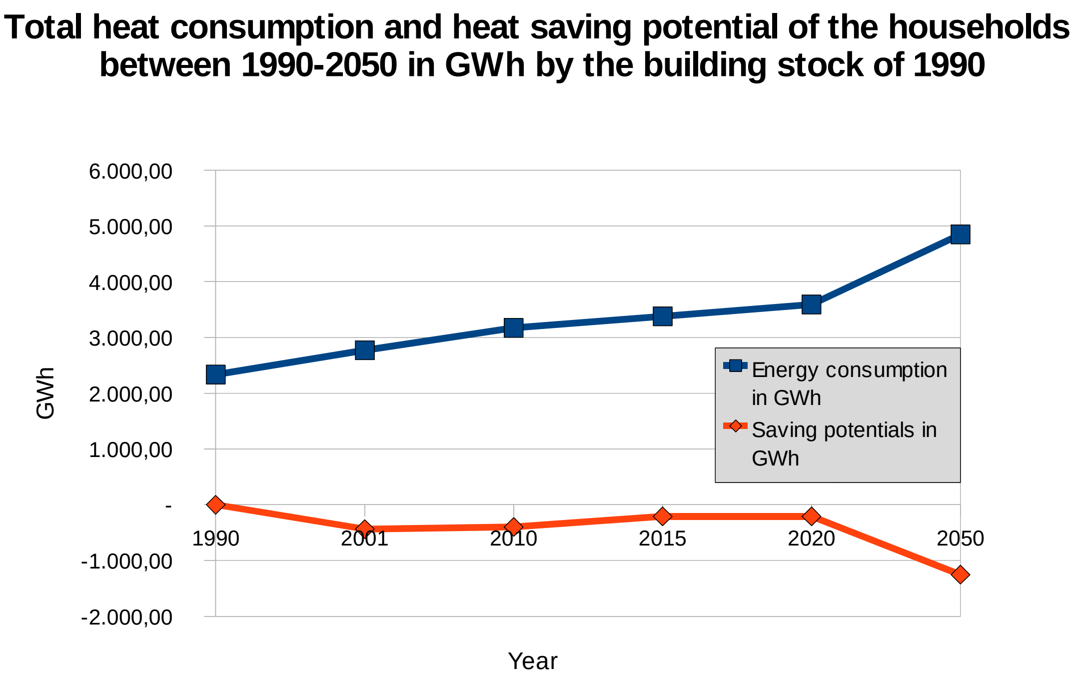
Year	Heat energy consumption in GWh
1990	3.171,02
2001	3.142,11
2010	2.834,72
2015	2.527,18
2020	2.230,21
2050	1.514,71
Maximum potential	212,94

Source: Own elaboration

In the figure above the development of the energy saving and energy consumption from 1990 to 2050 and the maximum potential are shown with a constant net living area of 2010 (17,745,013 m²) for all years.

Here one can see which great energy saving potentials exist. If taking into account a constant net living area (2010), it is possible to see, how much of the heat energy consumption can be saved. Thus, between 2001-2020 almost 30% less heat will be consumed and until 2050 the heat energy consumption can be lowered by over 50%, under the condition that no new living area will be created, but only the old living area will be renovated to the new status.

Fig 5 - 69: Total heat energy consumption of the private households between 1990-2050 by the building stock of 1990



Source: Own elaboration

Table 5 - 69: Heat energy consumption by the building stock of 1990 – Summary

Year	Heat energy consumption in GWh
1990	2.120,11
2001	2.493,18
2010	2.834,72
2015	3.021,94
2020	3.209,16
2050	4.332,48
Maximum potential	212,94

Source: Own elaboration

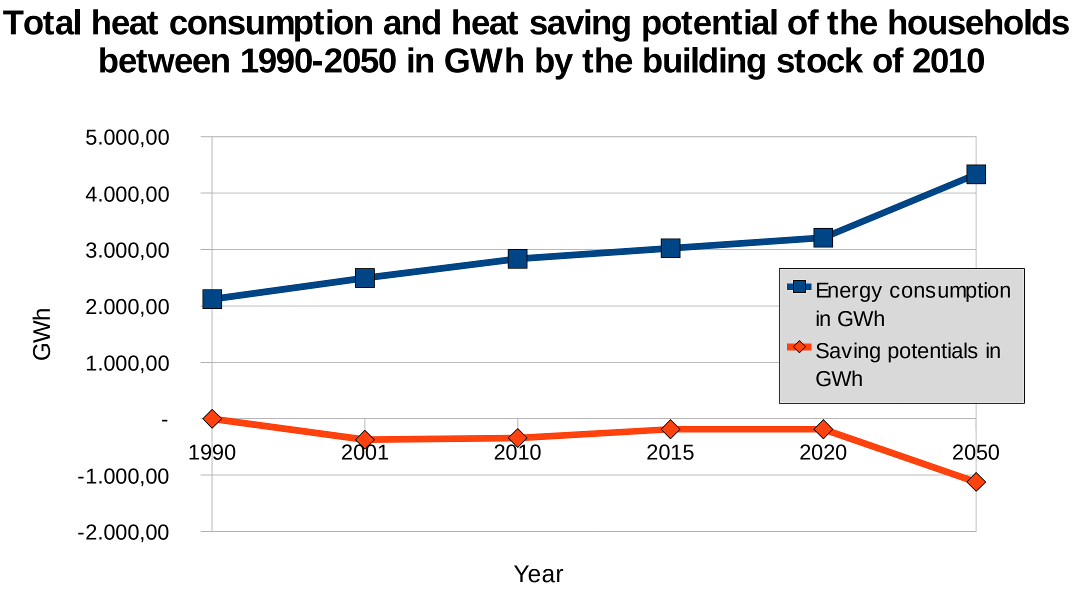
In the figure above the development of the energy saving and energy consumption from 1990 to 2050 is shown with the assumption that new flats are built according to the building stock 1990 and also old flats are renovated according to the building stock of 1990.

The following division of the building stock 1990 is assumed:

- Old stock (ClimateHouse Standard F and E): 74.5%
- ClimateHouse Standard D: 18.70%
- ClimateHouse Standard C: 6.80%

In case new flats would be built in the same way as in 1990, the heat energy consumption would rise more than double until 2050.

Fig 5 - 70: Total heat energy consumption of the private households between 1990-2050 by the distribution of building stock of 2010



Source: Own elaboration

Table 5 - 70: Heat energy consumption by the building stock of 2010 – Summary

Year	Heat energy consumption in GWh
1990	2.120,11
2001	2.493,18
2010	2.834,72
2015	3.021,94
2020	3.209,16
2050	4.332,48
Maximum potential	212,94

Source: Own elaboration

In the figure above the development of the energy saving and energy consumption from 1990 to 2050 by the building stock of 2010 for the old and new flats is shown.

The following division of the building stock 2010 is assumed:

- Old Stock (ClimateHouse Standard F and E): 65.60%
- ClimateHouse Standard D: 8.90%
- ClimateHouse Standard C: 11.90%
- ClimateHouse Standard B: 10.88%
- ClimateHouse Standard A: 2.45%
- ClimateHouse Standard Gold: 0.27%

If we continue to build according to the same standard at the present days (2010), the heat energy consumption will increase in the next 10 years by about 13% and until 2050 by over 43%. Therefore it is more important to establish improved ClimateHouse standards and to apply them consistently.

Table 5 - 71: Energy saving possibilities in the heat sector by residential buildings – Summary

Year	Heat energy consumption (heating) in kWh/m²/year)	Heat energy consumption (heating) in kWh/m²/year) by building stock 2010	Saving possibilities in the heat sector
2010	2.834,72	2.834,72	-
2015	2.694,09	3.021,94	327,85
2020	2.524,80	3.209,16	684,36
2050	2.315,03	4.332,48	2.017,45

Source: Own elaboration

Saving possibilities $_{period}$= Heat energy consumption potentials $_{period}$ – heat energy consumption by building stock 2010 $_{period}$

5.6.1.3 Drivers

The following drivers are:

- Political measures to promote the construction of low energy buildings.
- Less heat energy consumption and thus lower costs in the medium-long term.

- Improved indoor environmental quality and higher well being.
- More information of the citizen.

According to the cost-effectiveness analysis the installation of thermal insulation is the most efficient and most economic measure for the user. In Fig 7 - 78 the costs of one kWh produced by different energy sources are compared, and the costs for thermal insulation with 0.03 Euro for one kWh are the lowest. Dividing the costs (fuel costs, maintenance and investment costs) for a private user over an average life span of 25 years of the facility by the annual demand of useful heat it gives the costs for one kWh.

5.6.1.4 Barriers

The following barriers are:

- Short-term higher costs.
- Protection of historic buildings.
- Some houses heat with fire wood which is almost available for free.
- Inadequate information of the citizen.

Another barrier are the multifamily buildings, where it is difficult to find a consens among all the occupants for the application of energy saving measures (insulation fo the buildings etc.) or the installation of renewable energy production facilities (solar thermal, etc.). The reasons are mainly the costs.

Therefore it is important to offer financial models, which cover completely the investment costs at the beginning. One possibility to mention is the so called contracting model.

The most important key features of a contracting model are:

- The comprehensive planning and the implementation of measures by the contractor, operation and maintenance of the facilities by the contractor during the contract period;

- The financing of the measures by a third party (usually the contractor, but also mixed forms of financing such as for example construction grants by the customer);
- The contractual guarantee of energy and cost savings as well as any other guarantees (standards of comfort, level of investment);
- The contractor as general contractor with the overall responsibility for planning, implementation, financing and success responsibility.

5.6.2 Private Households

5.6.2.1 Energy Saving Tips

Energy saving tips in a household are the following[89]:

Electricity:

- When buying a electric appliance pay attention to electricity consumption (A class);
- Correct ventilation in well-insulated house;
- With a warm water connection on the washing machine, energy can be saved;
- Washing with high spin;
- Cooking with natural gas instead of electricity;
- With long-cooking dishes using the pressure cooker;
- Switching off stand by mode;

Heat:

- Good insulation of the building;
- Use of an efficient circulation pump;
- Installation of modern protective windows;
- Hot water preparation with power is unfavourable;
- The temperature of the hot water storage should be specifically regulated;
- Showers, instead of a bath;

89 http://www.ews-schoenau.de/fileadmin/content/documents/Mitwissen/Energiesparen/Stromsparbroschuere.pdf, download 13.08.2010

- Use of solar collectors;
- Illumination of spaces with energy saving lamps.

Two energy saving possibilities are elaborated in the next chapter with the presentation of the results.

5.6.2.2 Energy Saving Lamps

205,976 households in South Tyrol (2010)[90]

Assumptions:

- Incandescent lamps per household: 10 (in reality the number is probably higher)
- Average burning time: 2 hours per day

The garden lighting is included.

	Numbers	**Incandescent lamps (Watt)**	**Energy saving lamps (Watt)**
30%	3	100	24
70%	7	60	11

Consumption per year:

$$E_{\text{heat energy consumption light in 2010 [kWh]}} = \sum_{i=1}^{n} E_{i\ \text{heat energy consumption per different light [Watt]}} / 1000 * h_{\text{daily lighting time of the lamp}} * 365$$

n = 10

i = heat energy consumption per different light [Watt]

Incandescent lamp	**Energy saving lamp**
525.6 Watt	108.77 Watt
526 kWh	109 kWh

Reduction of the electricity consumption with energy saving lamps per household:

417 kWh

90 ASTAT Schriftenreihe n. 136, Bevölkerungsprognose: Haushalte und Wohnungsbestand in Südtirol – 2006-2020, p. 14, Bozen, 2008

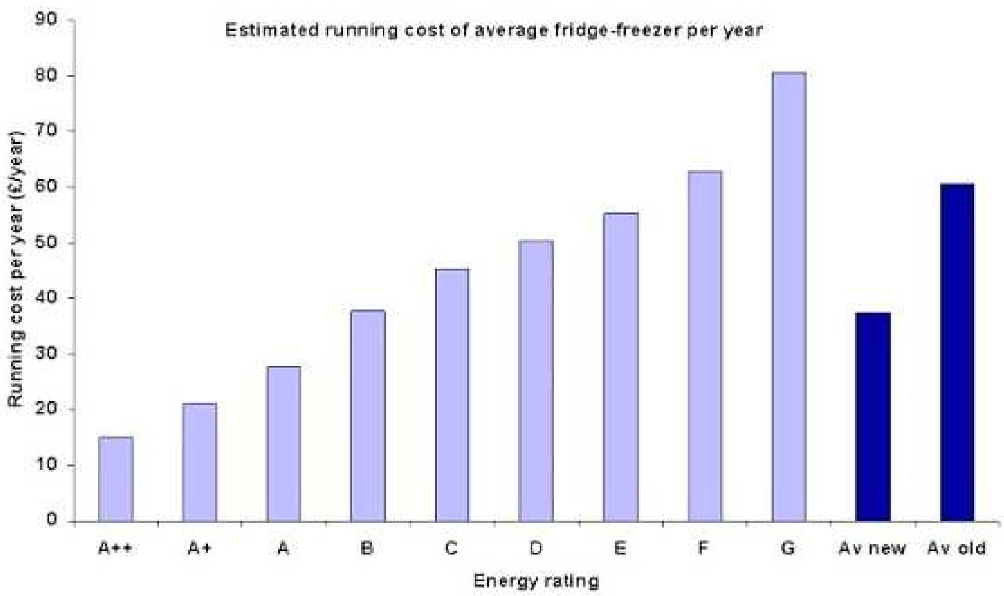
Maximum possible reduction of electricity of all households in South Tyrol:

85,856,976 kWh (86 GWh)

5.6.2.3 Substitution/Replacement of Electric Devices

Old refrigerators are consuming a lot of electricity. A high-efficiency refrigerator of the highest energy efficiency rating A + + can save 400 to 500 kWh per year (up to 100 Euro) compared to an average old equipment.[91]

Fig 5 - 71: Estimated running cost of average fridge-freezer per year



Source: http://www.swea.co.uk/ProE_coldRetail.shtml, download 13.08.2010

The table below shows the relative efficiency of the different energy rating bands, based on a D rated appliance using 100%:[92]

91 Nationaler Energieeffizienzplan "Strategien des Bundesumweltministeriums", Stand: 16.10.2008, http://www.bmu.de/files/pdfs/allgemein/application/pdf/energieeffizienzplan.pdf, download 13.08.2010

92 Severn Wye Energy Agency, http://www.swea.co.uk/ProE_coldRetail.shtml, download 13.08.2010

Table 5 - 72: Efficiency of the different energy rating bands

A++	Less than 30%
A+	30%-42%
A	42%-55%
B	55%-75%
C	75%-90%
D	90%-100%
E	100%-110%
F	110%-125%
G	More than 125%

Source: Severn Wye Energy Agency, http://www.swea.co.uk/ProE_coldRetail.shtml , download 13.08.2010

At which point is it worth to replace the equipment (eco-efficiency analysis)? The table below shows which device (A++, A+ or A) should be purchased instead of the old device (made up to 1990, 1995 or 2000).

Table 5 - 73: Buying a new device from an environmental point of view in the listed cases

Purchase of a new device	**Replacement of old device, made up to**
Fridges	
A++	2000
A+ and A	1995
Fridge-freezers	
A++	2000
A+	1995
A	1990

Freezers	
A++ and A+	2000
A	1995

Source: Innovative Informations- und Vermarktungsstrategien und zeitgemäße Standards: Ökoeffiziente Haushaltsgeräte, http://www.adelphi-consult.com/dialog/images/stories/5_fd_hintergrundpapier.pdf, download 13.08.2010

Conclusion:

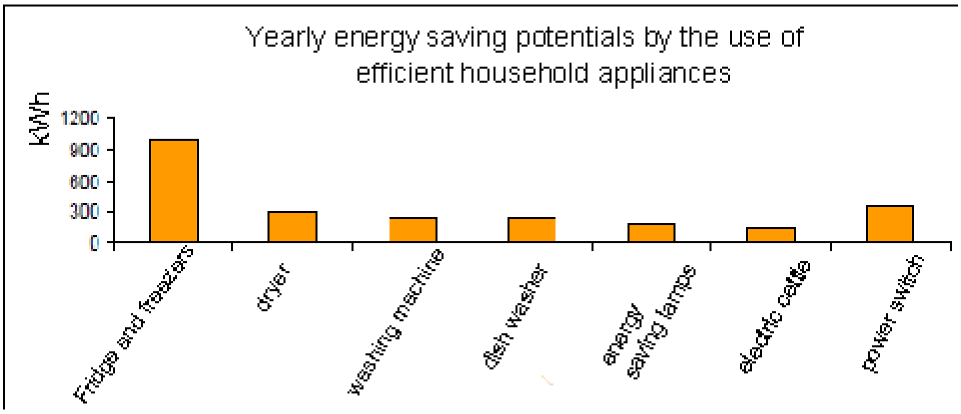
The time of exchange depends on the age of the equipment:

- Devices of the premium class exchange later.
- Devices of the base class exchange early.

In future only small efficiency improvements can be expected for many devices.

- New devices should be used until the end of life span.
- For the replacement of the old equipment only devices with the best energy efficiency and long lifetime should be chosen.

Fig 5 - 72: Yearly energy saving potentials by the use of efficient household appliances



Source: Nationaler Energieeffizienzplan "Strategien des Bundesumweltministeriums"; Calculations of BMU – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety in Germany (maximum values); Status 16.10.2008; http://www.bmu.de/files/pdfs/allgemein/application/pdf/energieeffizienzplan.pdf , download 13.08.2010

Old refrigerators are consuming a lot of electricity. A high-efficiency refrigerator of the highest energy efficiency rating A + + can save 400 to 500 kWh per year (up to 100 Euro) compared to an average old equipment.[93]

Assumptions:

- Every third household has an old refrigerator.
- The average savings for the exchange of an old refrigerator with a refrigerator with the highest energy efficiency rating A + + amounts to about 450 kWh.
- Households in South Tyrol: 205,976

Considering those assumptions, the energy saving potential per affected household and in total amounts to:

205,976/3 x 450 kWh = 30.896.400 kWh = **31 GWh total savings of all households in South Tyrol**

Saving potentials per affected household (every third): **450 kWh**

5.6.2.4 Standby Losses

An almost free of charge and directly exploitable source of savings is the avoidance of unnecessary standby losses. For example, the standby losses of appliances such as televisions or other electronic devices which are always on “stand-by”, even if they are not needed over hours (e.g. at night) or days (e.g. on holidays). Standby losses are produced also by chargers of mobile phones or other similar devices, which remain plugged-in.

Some devices or lights need a lot of electricity, if they have no switch-off with which they can be completely disconnected from the power grid. Only the standby losses in an average household cause an electricity consumption of 437 kWh per year

93 Nationaler Energieeffizienzplan “Strategien des Bundesumweltministeriums”, Stand: 16.10.2008, http://www.bmu.de/files/pdfs/allgemein/application/pdf/energieeffizienzplan.pdf, download 13.08.2010

which corresponds to about 85 Euro per year - with an increasing trend by rising energy prices.[94]

Assumption:

- Every second household has devices on “Standby”.

205,976/2 x 437 kWh = 45,005,756 kWh = **45 GWh total savings for South Tyrol**

Saving potentials per affected household (every second): **437 kWh**

5.6.2.5 Conclusions of Energy Saving Potentials in Private Households

The Federal Association of the Consumer Advice centres in Germany has elaborated an electricity consumption index (SVI)[95], which is composed as follows (without electric hot water preparation):

SVI = Person x 500 kWh + 500 kWh

This would be an ideal amount of electricity consumption of a household, but the current consumption unfortunately is much higher.

Table 5 - 74: General electricity saving potential[96]

	Investigation of the Association of the Electricity Industry (VDEW) 2006 in kWh	Electricity consumption index (SVI) in kWh	Saving potential (difference between VDEW and SVI) in kWh	Saving potential (difference between VDEW and SVI)
1 person	1,790	1,000	790	44%
2 persons	3,030	1,500	1,530	50%
3 persons	3,880	2,000	1,880	48%
4 persons	4,430	2,500	1,930	44%

Source: VDEW (in German: Verband der Elektrizitätswirtschaft), press release of the Association of the Electricity Industry, Stromverbrauch der Haushalte wächst gering, 18.09.2006

94 Nationaler Energieeffizienzplan “Strategien des Bundesumweltministeriums” Stand: 16.10.2008 http://www.bmu.de/files/pdfs/allgemein/application/pdf/energieeffizienzplan.pdf , download 13.08.2010

95 Bundesverband der Verbraucherzentralen und Verbraucherverbände, http://www.vzbv.de/mediapics/paper_stromverbrauchsindex.pdf , download 13.08.2010

96 Universität Münster, http://www.uni-muenster.de/imperia/md/content/transpose/publikationen/kr__mker_und_dehmel_2010_neu.pdf, p. 27, download 13.08.2010

If we assume that 4,770 kWh on average per household were consumed in Austria and 2,930 kWh in Italy in 2003, probably the value lies somewhere in the middle in South Tyrol. Therefore, a value of 4,000 kWh/year per household is assumed. According to an information from the SEL AG an average four-person-household consumes 3,000-4,000 kWh/year (without dryer or hot water preparation).

Table 5 - 75: Summary of total electricity saving potentials in private households in South Tyrol

	Electricity saving potential of all affected households in South Tyrol in kWh	**Electricity saving potential of all affected households in South Tyrol in GWh**	**Savings per affected household in kWh**
Exchange of lamps	85,856,976	86	417
Replacement of old devices	30,896,400	31	450
Standby losses	45,005,756	45	437
Total	**161,759,132**	**162**	**1,304**

Source: Own elaboration

Assumption of electricity consumption per household in South Tyrol:

4,000 kWh/year

Thus, the private households would consume 162 GWh less electricity in South Tyrol, which corresponds to a reduction in electricity consumption of 5.58% from 2,900 GWh in 2009 to 2,738 GWh in 2050.

Further saving potentials in the household could be complemented by a detailed investigation / replacement of other equipment such as:

- Heating optimization and heat pump replacement
- Dryer (better avoid completely)
- Washing machine (ideal with hot water connection)
- Substitution of electricity heating and hot water preparation

- Cooking: Substitution electricity by gas
- Hot water preparation: Substitution electricity by gas
- Efficient garden lighting

5.6.3 Industry, Commerce, Trade and Services

Following energy efficient possibilities in industry, commerce, trade and services are possible:[97]

- Investment subsidies for the implementation of energy efficiency technologies;
- Preparation of concepts for an overall energy use of the facilities (electricity and heat): The objective is to combine in a optimal way energy-and electricity-efficient components and individual facilities (such as electric motors, co-generation plants, cooling systems). With overall energy use concepts production, processes can be further optimized (eg, use of process heat and cooling, optimization of the total system);
- Partnership for climate protection, energy efficiency and innovation.

Further savings in industry, commerce, trade and services are:

- Electricity-saving process heating;
- Efficient process cooling production;
- Efficient production of compressed air;
- Efficient lighting system;
- Efficient ventilation-/air conditioning system;
- Reduction of standby losses;
- Efficient refrigerators for food;
- Efficient Street Lighting.

97 Nationaler Energieeffizienzplan “Strategien des Bundesumweltministeriums” Stand: 16.10.2008 http://www.bmu.de/files/pdfs/allgemein/application/pdf/energieeffizienzplan.pdf , download 13.08.2010

5.6.4 Street Lighting

The electricity consumption for street lighting of a German municipality is on average 7% of total urban electricity consumption. [98]

The percentage of street lighting on the total electricity consumption in Germany is about 0.72%. The street lighting accounts to about 30-50% of the purchased electric power and this is a significant cost factor in the tight public budgets.[99] In South Tyrol can be assumed that those values are similar. Hence, the electricity consumption for street lighting in this region can be estimated to about 20.88 GWh. A reduction of 30-60% of the electricity needed for street lighting could be possible.[100] In total **9 GWh** could be saved in South Tyrol (assumed a reduction of 45%), and at the same time an improvement of light pollution could be reached.

98 Deutsche Energie-Agentur, http://www.energieeffizienz-im-service.de/energieeffiziente-beleuchtung/energieeffiziente-strassenbeleuchtung.html , download 13.08.2010

99 Diplomarbeit: "Engergieeinsparung an der Straßenbeleuchtung in Kassel durch elektronische Leistungsabsenkung" von Harald Wetekam, http://www.upress.uni-kassel.de/online/frei/978-3-89958-254-3.volltext.frei.pdf, download 13.08.2010

100 Diplomarbeit: "Engergieeinsparung an der Straßenbeleuchtung in Kassel durch elektronische Leistungsabsenkung" von Harald Wetekam, http://www.upress.uni-kassel.de/online/frei/978-3-89958-254-3.volltext.frei.pdf, download 13.08.2010

6 Summary of the Results of the Potential Analysis

In this chapter the results of the potential analysis of the renewable energy sources are summarized with and without energy saving measures.

The potentials of renewable energy sources in the electricity, heat and mobility sector can be summarized as follows:

6.1 Electricity sector

Table 6 - 76: Summary of realizable potentials in the electricity sector in GWh by renewable energy sources in South Tyrol – 2009-2050

Electricity production by renewable energy source	2009	2015	2020	2050	Total
Hydro power	5,794.40	/	1,414.00	/	**7,208.40**
Biomass	39.70	/	/	/	**39.70**
Biogas	33.80	40.85	31.15	/	**105.80**
Photovoltaic	37.10	48.61	97.23	291.67	**474.61**
Wind power	4.00	111.00	20.00	/	**135.00**
Vegetable oil	55.00	74.00	/	/	**129.00**
Geothermal	/	/	70.10		**70.10**
Total	**5,964.00**	**274.46**	**1,632.48**	**291.67**	**8,162.61**

Source: Own elaboration

6.2 Heat sector

Table 6 - 77: Summary of realizable potentials in the heat sector in GWh by renewable energy sources in South Tyrol – 2009-2050

Heat production by renewable energy source	2009	2015	2020	2050	Total
Biomass	1,243.00	48.60	48.60	/	**1,340.20**
Solar thermal	114.40	40.07	80.14	240.41	**475.02**
Biogas	16.60	10.00	7.70	/	**34.30**
Geothermal	6.10	6.15	514.25	/	**526.50**
Vegetable oil	60.00	80.00	/	/	**140.00**
Total	**1,440.1**	**184.82**	**650.69**	**240.41**	**2,516.02**

Source: Own elaboration

6.3 Mobility sector

Table 6 - 78: Summary of realizable potentials in the mobility sector in GWh by renewable energy sources in South Tyrol – 2009-2050

Fuel production by renewable energy source	2009	2015	2020	2050	Total 2009-2050
Electricity	0.00	20.58	113.20	380.76	**514.54**
Hydrogen	0.00	5.50	0.00	0.00	**5.50**
Total	**0.00**	**26.08**	**113.20**	**380.76**	**520.04**

Source: Own elaboration

6.4 Energy efficiency and saving potentials in residential buildings and private households

The potentials of energy efficiency and saving measures in residential buildings can be summarized as follows:

Table 6 - 79: Summary of the energy efficiency and saving potential in residential buildings in GWh in South Tyrol – 2009-2050

	2009	2015	2020	2050
Heat energy consumption TOTAL without energy saving	5.300,00	5.487,22	5.674,44	6.797,76
Heat energy consumption of residential buildings without energy saving*	2.834,72	3.021,94	3.209,16	4.332,48
Difference between heat energy consumption in residential buildings and heat energy consumption of residential buildings of the previous period	-	-187,22	-187,22	-1.123,32
Heat energy consumption of residential buildings with energy saving	2.834,72	2.694,09	2.524,80	2.315,03
Difference between heat energy consumption of the residential buildings and heat energy consumption of residential buildings of the previous period	-	140,63	169,29	209,77
Heat energy consumption TOTAL with energy saving	5.300,00	5.159,37	4.990,08	4.780,31
Increase of energy saving potential added up	-	327,85	684,36	2.017,45
Increase of energy saving potential per period	-	327,85	356,51	1.333,09

* Considered the division of the building stock of 2010 and an annual increase of the net living area of 1.5%.

NB: In orange: Energy saving potentials are not taken into account.
In yellow: Energy saving potentials are taken into account.

Source: Own elaboration

Table 6 - 80: Summary of the energy saving potential in private households in GWh in South Tyrol – 2009-2050

	2009	2015	2020	2050	Total
Electricity saving in private households	**0.00**	**81.00**	**81.00**	**0.00**	**162.00**

Source: Own elaboration

The results for energy efficiency and energy saving in residential buildings (Table 6 - 79) and energy saving in private households (Table 6 - 80) are considered in the Table 6 - 87 in order to make detailed predictions about the development of the saving potentials.

Table 6 - 81: Summary of the energy saving potential in street lighting in GWh in South Tyrol – 2020

	2020
Street lighting	**9**

Source: Own elaboration

For the calculation of the values in Table 6 - 79 the following assumptions are taken into account:

Heat energy consumption of residential buildings without energy saving:

Those values come from the calculation of the heat energy consumption, where the building stock is constant (basis of 2010) and an annual increase of the net living area of about 1.5% is considered.

Heat energy consumption of residential buildings with energy saving:

Also those values come from the calculation of the heat energy consumption, where the building stock is variable (renovation of existing buildings and new buildings are considered). More and more improved building standards are taken into account. A detailed analysis can be found in chapter 5.6.1.

6.5 Results of the Potential Analysis Without Energy Saving Measures

In this section the results of the potential analysis of the renewable energy sources are summarized without the energy saving measures.

Table 6 - 82: Status quo 2009 (without energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	2.900,00	5.964,00	205,66%
Heat	5.300,00	1.440,10	27,17%
Mobility	3.425,38	,00	0,00%
Total	**11.625,38**	**7.404,10**	**63,69%**

Source: Own elaboration

Table 6 - 83: General potential 2015 (without energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	2.934,33	6.238,46	212,60%
Heat	5.487,22	1.624,92	29,61%
Mobility	3.425,38	26,08	0,76%
Total	**11.846,93**	**7.889,46**	**66,59%**

Source: Own elaboration

Table 6 - 84: General potential 2020 (without energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	3.081,86	7.870,94	255,40%
Heat	5.674,44	2.275,61	40,10%
Mobility	3.425,38	139,28	4,07%
Total	**12.181,68**	**10.285,82**	**84,44%**

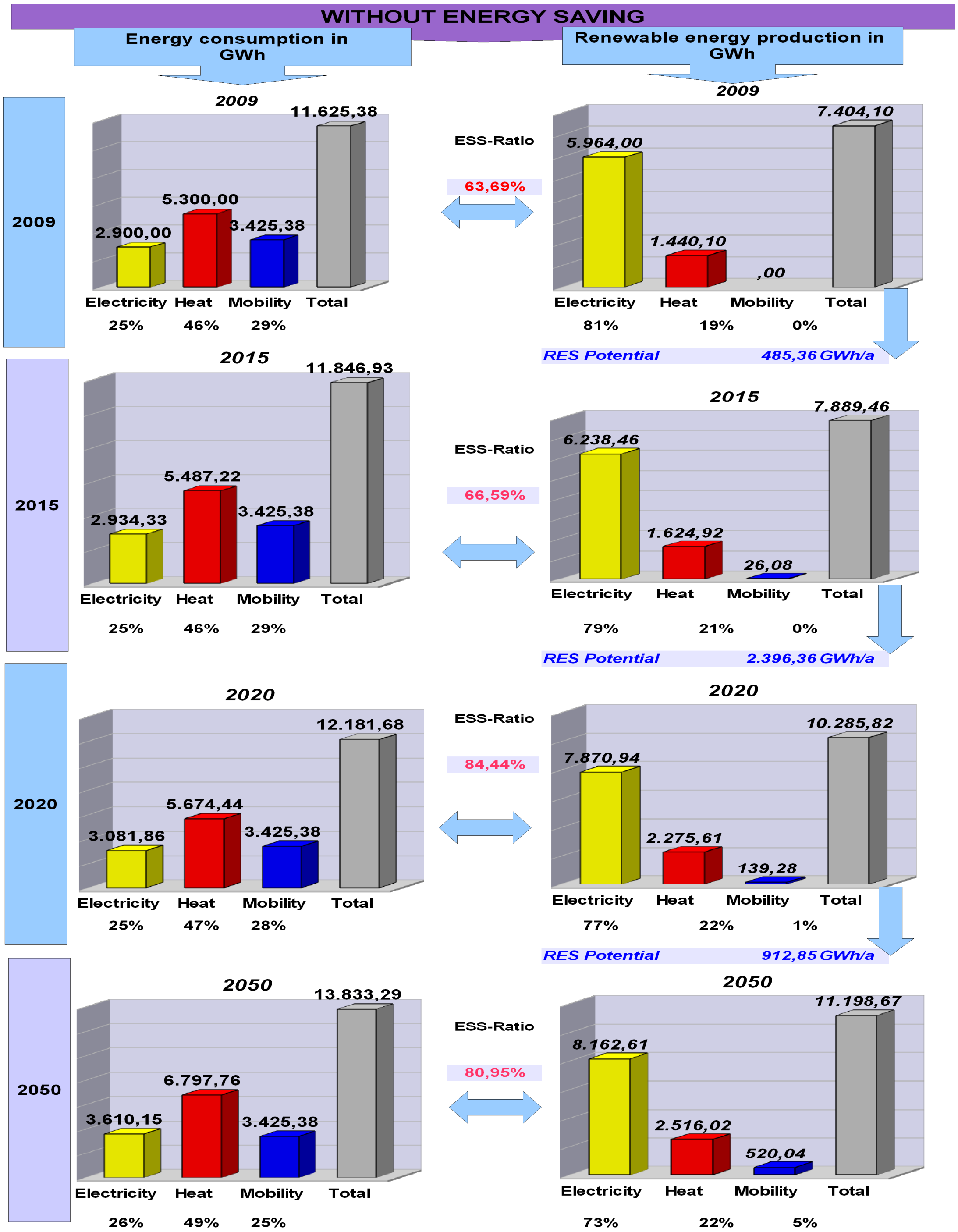
Source: Own elaboration

Table 6 - 85: General potential 2050 (without energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	3.610,15	8.162,61	226,10%
Heat	6.797,76	2.516,02	37,01%
Mobility	3.425,38	520,04	15,18%
Total	**13.833,29**	**11.198,67**	**80,95%**

Source: Own elaboration

Fig 6 - 73: General potential 2009-2050 (without energy saving)



Source: Own elaboration

Table 6 - 86: General potential 2009-2050 (without energy saving) – Overview

	Renewable energy production in GWh											Energy consumption in GWh											
	2009	%	2015	%	Growth % 2009-2015	2020	%	Growth % 2009-2020	2050	%	Growth % 2009-2050	2009	% of production	%	2015	% of production	%	2020	% of production	%	2050	% of production	%
Electricity	**5.964,00**	**100,00%**	**6.238,46**	**100,00%**	**4,60%**	**7.870,94**	**100,00%**	**31,97%**	**8.162,61**	**100,00%**	**36,86%**	**2.900,00**	**205,66%**		**2.934,33**	**212,60%**		**3.081,86**	**255,40%**		**3.610,15**	**80,33%**	
Hydro power	5.794,40	97,16%	5.794,40	92,88%	0,00%	7.208,40	91,58%	24,40%	7.208,40	88,31%	24,40%		199,81%			197,47%			233,90%			0,00%	
Biomass	39,70	0,67%	39,70	0,64%	0,00%	39,70	0,50%	0,00%	39,70	0,49%	0,00%		1,37%			1,35%			1,29%			0,00%	
Solar thermal													0,00%			0,00%			0,00%			0,00%	
Biogas	33,80	0,57%	74,65	1,20%	120,86%	105,80	1,34%	213,02%	105,80	1,30%	213,02%		1,17%			2,54%			3,43%			0,00%	
Photovoltaic	37,10	0,62%	85,71	1,37%	131,03%	182,94	2,32%	393,09%	474,61	5,81%	1179,28%		1,28%			2,92%			5,94%			0,00%	
Wind power	4,00	0,07%	115,00	1,84%	2775,00%	135,00	1,72%	3275,00%	135,00	1,65%	3275,00%		0,14%			3,92%			4,38%			0,00%	
Geothermal						70,10	0,89%		70,10	0,86%			0,00%			0,00%			2,27%			0,00%	
Vegetable oil	55,00	0,92%	129,00	2,07%	134,55%	129,00	1,64%	134,55%	129,00	1,58%	134,55%		1,90%			4,40%			4,19%			0,00%	
Heat	**1.440,10**	**100,00%**	**1.624,92**	**100,00%**	**333,33%**	**2.275,61**	**100,00%**	**8884,00%**	**2.516,02**	**100,00%**	**9094,16%**	**5.300,00**	**27,17%**		**5.487,22**	**29,61%**		**5.674,44**	**40,10%**		**6.797,76**	**37,01%**	
Hydro power													0,00%			0,00%			0,00%			0,00%	
Biomass	1.243,00	86,31%	1.291,60	79,49%	3,91%	1.340,20	58,89%	7,82%	1.340,20	53,27%	7,82%		23,45%			23,54%			23,62%			19,72%	
Solar thermal	114,40	7,94%	154,47	9,51%	35,03%	234,61	10,31%	105,08%	475,02	18,88%	315,23%		2,16%			2,82%			4,13%			6,99%	
Biogas	16,60	1,15%	26,60	1,64%	60,24%	34,30	1,51%	106,63%	34,30	1,36%	106,63%		0,31%			0,48%			0,60%			0,50%	
Photovoltaic													0,00%			0,00%			0,00%			0,00%	
Wind power													0,00%			0,00%			0,00%			0,00%	
Geothermal	6,10	0,42%	12,25	0,75%	100,82%	526,50	23,14%	8531,15%	526,50	20,93%	8531,15%		0,12%			0,22%			9,28%			7,75%	
Vegetable oil	60,00	4,17%	140,00	8,62%	133,33%	140,00	6,15%	133,33%	140,00	5,56%	133,33%		1,13%			2,55%			2,47%			2,06%	
Mobility	**,00**	**0,00%**	**26,08**	**100,00%**	**0,00%**	**139,28**	**1,77%**	**0,00%**	**520,04**	**6,37%**	**0,00%**	**3.425,38**	**0,00%**	**100,00%**	**3.425,38**	**0,76%**	**100,00%**	**3.425,38**	**4,07%**	**100,00%**	**3.425,38**	**15,18%**	**100,00%**
Petrol												1.040,43	0,00%	30,37%	1.030,14	0,00%	30,07%	968,04	0,00%	28,26%	777,66	0,00%	22,70%
Diesel												2.288,55	0,00%	66,81%	2.272,76	0,00%	66,35%	2.221,66	0,00%	64,86%	2.031,28	0,00%	59,30%
Liquid gas (GPL)												43,64	0,00%	1,27%	43,64	0,00%	1,27%	43,64	0,00%	1,27%	43,64	0,00%	1,27%
Natural Gas (Methane)												45,34	0,00%	1,32%	45,34	0,00%	1,32%	45,34	0,00%	1,32%	45,34	0,00%	1,32%
Others												7,42	0,00%	0,22%	7,42	0,00%	0,22%	7,42	0,00%	0,22%	7,42	0,00%	0,22%
Electricity			20,58	78,91%		133,78	1,70%		514,54	6,30%		,00	0,00%	0,00%	20,58	0,60%	0,60%	133,78	3,91%	3,91%	514,54	15,02%	15,02%
Hydrogen			5,50	21,09%		5,50	0,07%		5,50	0,07%		,00	0,00%	0,00%	5,50	0,16%	0,16%	5,50	0,16%	0,16%	5,50	0,16%	0,16%
Total	**7.404,10**	**21,74%**	**7.889,46**	**26,56%**	**6,56%**	**10.285,82**	**29,92%**	**30,37%**	**11.198,67**	**35,63%**	**8,87%**	**11.625,38**	**63,69%**		**11.846,93**	**66,59%**		**12.181,68**	**84,44%**		**13.833,29**	**84,04%**	
Hydro power	5.794,40	78,26%	5.794,40	73,44%	0,00%	7.208,40	70,08%	24,40%	7.208,40	64,37%	24,40%		49,84%			48,91%			59,17%			0,00%	
Biomass	1.282,70	17,32%	1.331,30	16,87%	3,79%	1.379,90	13,42%	3,65%	1.379,90	12,32%	7,58%		11,03%			11,24%			11,33%			0,00%	
Solar thermal	114,40	1,55%	154,47	1,96%	35,03%	234,61	2,28%	51,88%	475,02	4,24%	315,23%		0,98%			1,30%			1,93%			0,00%	
Biogas	50,40	0,68%	101,25	1,28%	100,89%	140,10	1,36%	38,37%	140,10	1,25%	177,98%		0,43%			0,85%			1,15%			0,00%	
Photovoltaic	37,10	0,50%	85,71	1,09%	131,03%	182,94	1,78%	113,43%	474,61	4,24%	1179,28%		0,32%			0,72%			1,50%			0,00%	
Wind power	4,00	0,05%	115,00	1,46%	2775,00%	135,00	1,31%	17,39%	135,00	1,21%	3275,00%		0,03%			0,97%			1,11%			0,00%	
Geothermal	6,10	0,08%	12,25	0,16%	100,82%	596,60	5,80%	4770,20%	596,60	5,33%	9680,33%		0,05%			0,10%			4,90%			0,00%	
M-Electricity	,00	0,00%	20,58	0,26%		133,78	1,30%	550,05%	514,54	4,59%			0,00%			0,17%			1,10%			0,00%	
M-Hydrogen	,00	0,00%	5,50	0,07%		5,50	0,05%	0,00%	5,50	0,05%			0,00%			0,05%			0,05%			0,00%	
Vegetable oil	115,00	1,55%	269,00	3,41%	133,91%	269,00	2,62%	0,00%	269,00	2,40%	133,91%		0,99%			2,27%			2,21%			0,00%	

Source: Own elaboration

6.5.1 Explanations of the table without energy saving

All the values for the "Renewable energy production in GWh" were added in the relevant columns in the "Summary of the results of the potential analysis" (chapter 6). The values from Table 6 - 76 (electricity sector) and Table 6 - 77 (heat sector) were transferred to the sheet "Renewable energy production in GWh".

For the calculation of the values in the Table 6 - 78 (mobility sector) the following calculation model was used:

- In the worksheet "Renewable energy production in GWh" under the category "Mobility" the values of "Electricity" and "Hydrogen" for the respective years were taken over.
- Since the electricity and hydrogen for the mobility sector come from the electricity sector, the production costs (additional consumption) in the table sheet "Energy consumption in GWh" under the category "Electricity" were added according to the following calculation model:

  $\text{Electricity consumption}_{\text{period}} = \text{Electricity consumption}_{\text{previous period (2009, 2015 or 2020)}} + \text{Electricity Mobility}_{\text{period}} + \text{Hydrogen Mobility}_{\text{period}} * 1/0{,}4$ (average efficiency for hydrogen production by the use of electricity)

The heat energy consumption was calculated in the following way (see Table 6 - 79):

$\text{Heat energy consumption}_{\text{period}} = \text{Heat energy consumption}_{\text{previous period (2009, 2015 or 2020)}} + \text{Heat energy consumption}_{\text{period of residential buildings}} - \text{Heat energy consumption}_{\text{previous period (2009, 2015 or 2020) of residential buildings}}$

In the table without energy saving (Table 6 - 86) the heat energy consumption of the residential buildings with the building stock 2010 was considered in the calculation. So the following statements can be made: How much will increase the heat energy consumption with the same building activities of the last 15 years, when no improvements regarding to the energy efficiency in the building stock (level of 2010) will occur? The heat energy consumption will rise from 5,300 GWh in 2009 to 6,798 GWh in 2050 (over 28%).

6.6 Results of the Potential Analysis With Energy Saving Measures

In this section the results of the potential analysis of the renewable energy sources are summarized with the energy saving measures.

Table 6 - 87: Energy saving potentials 2009-2050 – Summary

Up to	Energy saving potentials	GWh
2009	**Energy saving (electricity and heat)**	**0,00**
2015	***Total***	***408,85***
	Electricity	**81,00**
	Standby losses	22,50
	Replacement of old devices	15,50
	Exchange of lamps	43,00
	Heat	**327,85**
	Residential buildings	327,85
2020	***Total***	***846,36***
	Electricity	**171,00**
	Standby losses	45,00
	Replacement of old devices	31,00
	Exchange of lamps	86,00
	Street lighting	9,00
	Heat	**684,36**
	Residential buildings	684,36
2050	***Total***	***2.179,45***
	Electricity	**171,00**
	Heat	**2.017,45**
	Residential buildings	2.017,45

NB: The energy saving potential in residential buildings is added up (Table 6 - 79).

Source: Own elaboration

6.6.1 Explanations of the table with energy saving

In general, the same statements as indicated in chapter 6.5.1 are valid with the following supplements:

The energy saving values explained in Table 6 - 87 indicate which amount of energy savings is possible in the respective period (year). Those values are added up. The difference of the energy consumption without savings and with savings is calculated. Thus, in the year 2050 the maximum amount of energy saving with 2,179.45 GWh will be reached. The saving values are taken into account in the energy balance (Table 6 - 96) in the following way (explanations see chapter 6.5.1) with the following corrections of the energy saving values:

– 2009: The energy values are constant (nothing will be added).
– 2015: The difference of the heat energy consumption without savings and with savings is calculated.

The heat energy consumption will decrease from 5,300 GWh in 2009 to 4,780 GWh in 2050 (almost 10%), although in the whole period was assumed that over 50% more net living area (residential buildings) will be built.

RÈSUMÈ:

In total approximately 40,000 GWh of heat energy consumption could be saved in residential buildings between 2009 and 2050, which corresponds to an amount of 4.32 billion Euro of fuel costs according to the price of heating oil (1.08 Euro/l) and the corresponding energy content (10 kWh/l) in Table 4 - 25.

Table 6 - 88: Status quo 2009 (with energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption by covered renewable energy production in %
Electricity	2.900,00	5.964,00	205,66%
Heat	5.300,00	1.440,10	27,17%
Mobility	3.425,38	,00	0,00%
Total	**11.625,38**	**7.404,10**	**63,69%**

Source: Own elaboration

Table 6 - 89: General potential 2015 (with energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	2.853,33	6.238,46	218,64%
Heat	5.159,37	1.624,92	31,49%
Mobility	3.425,38	26,08	0,76%
Total	**11.438,08**	**7.889,46**	**68,98%**

Source: Own elaboration

Table 6 - 90: General potential 2020 (with energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	2.910,86	7.870,94	270,40%
Heat	4.990,08	2.275,61	45,60%
Mobility	3.425,38	139,28	4,07%
Total	**11.326,32**	**10.285,82**	**90,81%**

Source: Own elaboration

Table 6 - 91: General potential 2050 (with energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	3.439,15	8.162,61	237,34%
Heat	4.780,31	2.516,02	52,63%
Mobility	3.425,38	520,04	15,18%
Total	**11.644,84**	**11.198,67**	**96,17%**

Source: Own elaboration

Table 6 - 92: Status quo 2009 (with energy saving and without mobility)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	2.900,00	5.964,00	205,66%
Heat	5.300,00	1.440,10	27,17%
Total	**8.200,00**	**7.404,10**	**90,29%**

Source: Own elaboration

Table 6 - 93: General potential 2015 (with energy saving and without mobility)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	2.853,33	6.238,46	218,64%
Heat	5.159,37	1.624,92	31,49%
Total	**8.012,70**	**7.863,38**	**98,14%**

Source: Own elaboration

Table 6 - 94: General potential 2020 (with energy saving and without mobility)

	Energy consumption in GWh	**Renewable energy production in GWh**	**Energy consumption covered by renewable energy production in %**
Electricity	2.910,86	7.870,94	270,40%
Heat	4.990,08	2.275,61	45,60%
Total	**7.900,94**	**10.146,54**	**128,42%**

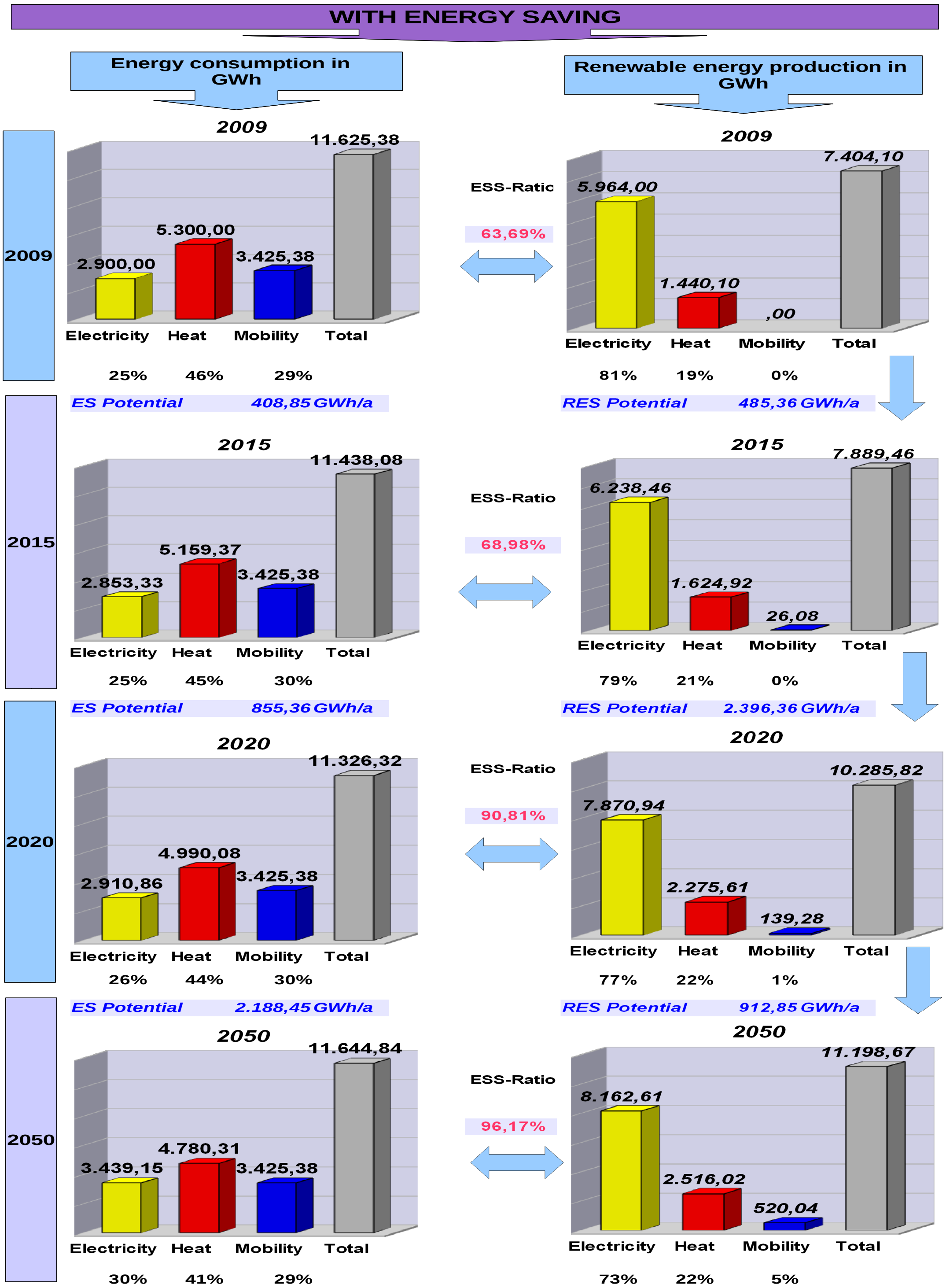
Source: Own elaboration

Table 6 - 95: General potential 2050 (with energy saving and without mobility)

	Energy consumption in GWh	**Renewable energy production in GWh**	**Energy consumption covered by renewable energy production in %**
Electricity	3.439,15	8.162,61	237,34%
Heat	4.780,31	2.516,02	52,63%
Total	**8.219,46**	**10.678,63**	**129,92%**

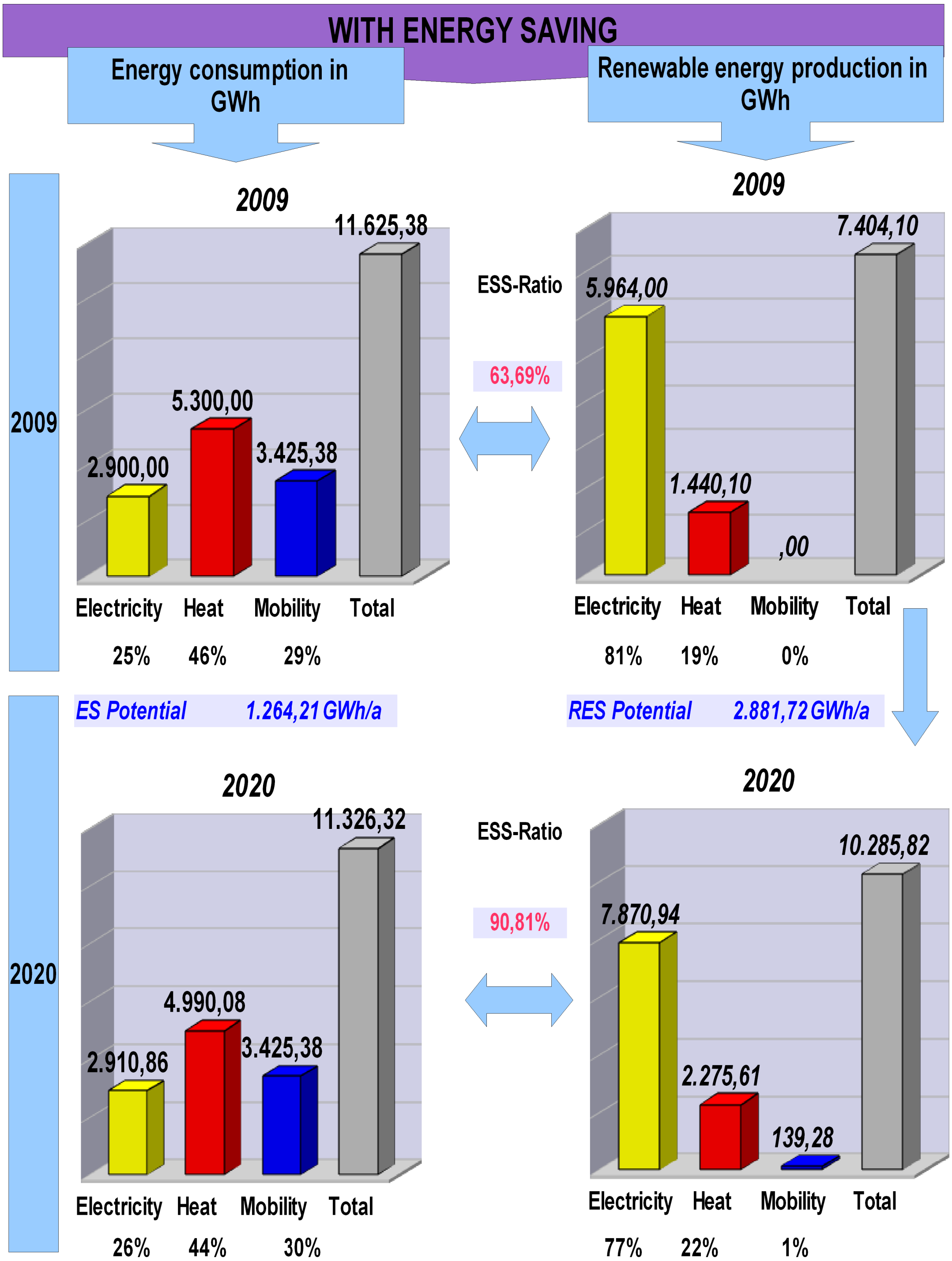
Source: Own elaboration

Fig 6 - 74: General potential 2009-2050 (with energy saving)



Source: Own elaboration

Fig 6 - 75: General potential 2009-2020 (with energy saving)



Source: Own elaboration

Table 6 - 96: General potential 2009-2050 (with energy saving) – Overview

	Renewable energy production in GWh										
	2009	%	2015	%	Growth % 2009-2015	2020	%	Growth % 2009-2020	2050	%	Growth % 2009-2050
Electricity	**5.964,00**	**100,00%**	**6.238,46**	**100,00%**	**4,60%**	**7.870,94**	**100,00%**	**31,97%**	**8.162,61**	**100,00%**	**36,86%**
Hydro power	5.794,40	97,16%	5.794,40	92,88%	0,00%	7.208,40	91,58%	24,40%	7.208,40	88,31%	24,40%
Biomass	39,70	0,67%	39,70	0,64%	0,00%	39,70	0,50%	0,00%	39,70	0,49%	0,00%
Solar thermal	,00	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%
Biogas	33,80	0,57%	74,65	1,20%	120,86%	105,80	1,34%	213,02%	105,80	1,30%	213,02%
Photovoltaic	37,10	0,62%	85,71	1,37%	131,03%	182,94	2,32%	393,09%	474,61	5,81%	1.179,28%
Wind power	4,00	0,07%	115,00	1,84%	2.775,00%	135,00	1,72%	3.275,00%	135,00	1,65%	3.275,00%
Geothermal	,00	0,00%	,00	0,00%	0,00%	70,10	0,89%	0,00%	70,10	0,86%	0,00%
Vegetable oil	55,00	0,92%	129,00	2,07%	134,55%	129,00	1,64%	134,55%	129,00	1,58%	134,55%
Heat	**1.440,10**	**100,00%**	**1.624,92**	**100,00%**	**333,33%**	**2.275,61**	**100,00%**	**8.884,00%**	**2.516,02**	**100,00%**	**9.094,16%**
Hydro power											
Biomass	1.243,00	86,31%	1.291,60	79,49%	3,91%	1.340,20	58,89%	7,82%	1.340,20	53,27%	7,82%
Solar thermal	114,40	7,94%	154,47	9,51%	35,03%	234,61	10,31%	105,08%	475,02	18,88%	315,23%
Biogas	16,60	1,15%	26,60	1,64%	60,24%	34,30	1,51%	106,63%	34,30	1,36%	106,63%
Photovoltaic	,00	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%
Wind power	,00	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%
Geothermal	6,10	0,42%	12,25	0,75%	100,82%	526,50	23,14%	8.531,15%	526,50	20,93%	8.531,15%
Vegetable oil	60,00	4,17%	140,00	8,62%	133,33%	140,00	6,15%	133,33%	140,00	5,56%	133,33%
Mobility	**,00**	**0,00%**	**26,08**	**100,00%**	**0,00%**	**139,28**	**1,77%**	**0,00%**	**520,04**	**6,37%**	**0,00%**
Petrol	,00	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%
Diesel	,00	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%
Liquid gas (GPL)	,00	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%
Natural Gas (Methane)	,00	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%
Others	,00	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%	,00	0,00%	0,00%
Electricity	,00	0,00%	20,58	78,91%	0,00%	133,78	1,70%	0,00%	514,54	6,30%	0,00%
Hydrogen	,00	0,00%	5,50	21,09%	0,00%	5,50	0,07%	0,00%	5,50	0,07%	0,00%
Total	**7.404,10**	**21,74%**	**7.889,46**	**26,56%**	**6,56%**	**10.285,82**	**29,92%**	**30,37%**	**,00**	**0,00%**	**-100,00%**
Hydro power	5.794,40	78,26%	5.794,40	73,44%	0,00%	7.208,40	70,08%	24,40%	7.208,40	35,63%	24,40%
Biomass	1.282,70	17,32%	1.331,30	16,87%	3,79%	1.379,90	13,42%	7,58%	1.379,90	64,37%	7,58%
Solar thermal	114,40	1,55%	154,47	1,96%	35,03%	234,61	2,28%	105,08%	475,02	12,32%	315,23%
Biogas	50,40	0,68%	101,25	1,28%	100,89%	140,10	1,36%	177,98%	140,10	4,24%	177,98%
Photovoltaic	37,10	0,50%	85,71	1,09%	131,03%	182,94	1,78%	393,09%	474,61	1,25%	1179,28%
Wind power	4,00	0,05%	115,00	1,46%	2775,00%	135,00	1,31%	3275,00%	135,00	4,24%	3275,00%
Geothermal	6,10	0,08%	12,25	0,16%	100,82%	596,60	5,80%	9680,33%	596,60	1,21%	9680,33%
M-Electricity	,00	0,00%	20,58	0,26%		133,78	1,30%		514,54	5,33%	
M-Hydrogen	,00	0,00%	5,50	0,07%		5,50	0,05%		5,50	4,59%	
Vegetable oil	115,00	1,55%	269,00	3,41%	133,91%	269,00	2,62%	133,91%	269,00	0,05%	133,91%

	Energy consumption in GWh											
	2009	% of production	%	2015	% of production	%	2020	% of production	%	2050	% of production	%
Electricity	**2.900,00**	**205,66%**		**2.853,33**	**218,64%**		**2.910,86**	**270,40%**		**3.439,15**	**237,34%**	
Hydro power		199,81%			203,08%			247,64%			209,60%	
Biomass		1,37%			1,39%			1,36%			1,15%	
Solar thermal		0,00%			0,00%			0,00%			0,00%	
Biogas		1,17%			2,62%			3,63%			3,08%	
Photovoltaic		1,28%			3,00%			6,28%			13,80%	
Wind power		0,14%			4,03%			4,64%			3,93%	
Geothermal		0,00%			0,00%			2,41%			2,04%	
Vegetable oil		1,90%			4,52%			4,43%			3,75%	
Heat	**5.300,00**	**27,17%**		**5.159,37**	**31,49%**		**4990,08**	**45,60%**		**4780,31**	**52,63%**	
Hydro power		0,00%			0,00%			0,00%			0,00%	
Biomass		23,45%			25,03%			26,86%			28,04%	
Solar thermal		2,16%			2,99%			4,70%			9,94%	
Biogas		0,31%			0,52%			0,69%			0,72%	
Photovoltaic		0,00%			0,00%			0,00%			0,00%	
Wind power		0,00%			0,00%			0,00%			0,00%	
Geothermal		0,12%			0,24%			10,55%			11,01%	
Vegetable oil		1,13%			2,71%			2,81%			2,93%	
Mobility	**3.425,38**	**0,00%**	**100,00%**	**3.425,38**	**0,76%**	**100,00%**	**3.425,38**	**4,07%**	**100,00%**	**3.425,38**	**15,18%**	**100,00%**
Petrol	1.040,43	0,00%	30,37%	1.030,14	0,00%	30,07%	968,04	0,00%	28,26%	777,66	0,00%	22,70%
Diesel	2.288,55	0,00%	66,81%	2.272,76	0,00%	66,35%	2.221,66	0,00%	64,86%	2.031,28	0,00%	59,30%
Liquid gas (GPL)	43,64	0,00%	1,27%	43,64	0,00%	1,27%	43,64	0,00%	1,27%	43,64	0,00%	1,27%
Natural Gas (Methane)	45,34	0,00%	1,32%	45,34	0,00%	1,32%	45,34	0,00%	1,32%	45,34	0,00%	1,32%
Others	7,42	0,00%	0,22%	7,42	0,00%	0,22%	7,42	0,00%	0,22%	7,42	0,00%	0,22%
Electricity	,00	0,00%	0,00%	20,58	0,60%	0,60%	133,78	3,91%	3,91%	514,54	15,02%	15,02%
Hydrogen	,00	0,00%	0,00%	5,50	0,16%	0,16%	5,50	0,16%	0,16%	5,50	0,16%	0,16%
Total	**11.625,38**	**63,69%**		**11.438,08**	**68,98%**		**11.326,32**	**90,81%**		**11.644,84**	**0,00%**	
Hydro power		49,84%			50,66%			63,64%			61,90%	
Biomass		11,03%			11,64%			12,18%			11,85%	
Solar thermal		0,98%			1,35%			2,07%			4,08%	
Biogas		0,43%			0,89%			1,24%			1,20%	
Photovoltaic		0,32%			0,75%			1,62%			4,08%	
Wind power		0,03%			1,01%			1,19%			1,16%	
Geothermal		0,05%			0,11%			5,27%			5,12%	
M-Electricity		0,00%			0,18%			1,18%			4,42%	
M-Hydrogen		0,00%			0,05%			0,05%			0,05%	
Vegetable oil		0,99%			2,35%			2,37%			2,31%	

Source: Own elaboration

Additional interesting note: Scenario with an annual increase of electricity consumption (2.1%)

In the following two tables the current annual increase of 2.1% (3.3 Summary of the Current Situation) taken into account for the next years until 2050. Thereby the energy consumption will increase by the double until 2050. The ratio between local energy consumption and renewable energy production would remain the same in 2050 as in 2009 (Table 6 - 97: 2009: 63.69%, 2050: 63.15%). Considering the energy saving in residential buildings and private households the coverage rate would increase by around 8 percentage points from 63.69% in 2009 to 72.05% in 2050 (Table 6 - 98). From the results of this investigation it can be drawn the conclusion that is very important to decrease the energy consumption. This can be achieved by various measures such as information and sensitization of the population, creating more awareness about energy consumption, investment in improved electrical appliances and improvement of the various support schemes to minimize the electricity consumption.

Table 6 - 97: General potential 2050 (with an annual increase of electricity consumption by 2.1% and without energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	7.509,28	8.162,61	108,70%
Heat	6.797,76	2.516,02	37,01%
Mobility	3.425,38	520,04	15,18%
Total	**17.732,42**	**11.198,67**	**63,15%**

Source: Own elaboration

Table 6 - 98: General potential 2050 (with an annual increase of electricity consumption by 2.1% and with energy saving)

	Energy consumption in GWh	Renewable energy production in GWh	Energy consumption covered by renewable energy production in %
Electricity	7.338,28	8.162,61	111,23%
Heat	4.780,31	2.516,02	52,63%
Mobility	3.425,38	520,04	15,18%
Total	**15.543,97**	**11.198,67**	**72,05%**

Source: Own elaboration

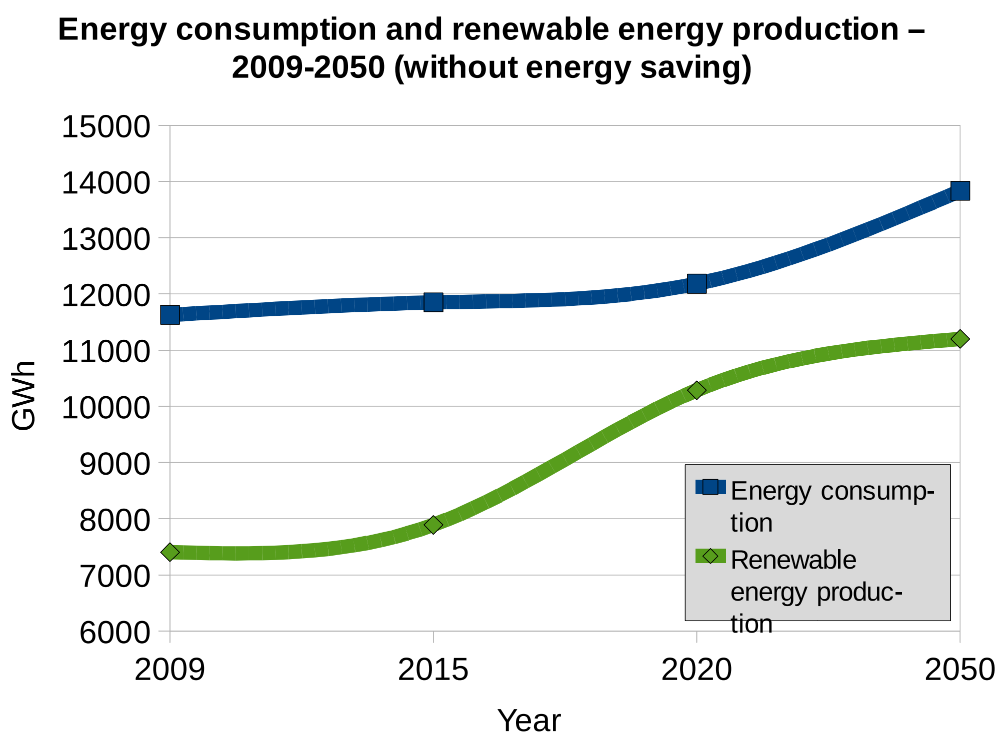
7 Conclusions and Outlook

In summary, it can be said that South Tyrol is on a good path towards the use of renewable energy. From the analysis of the current situation and the potential of renewable energy sources the following picture can be drawn:

If no energy efficiency measures are taken into account, the curve of energy consumption and renewable energy production is expected to diverge after 2020 (as shown in Fig 7 - 76).

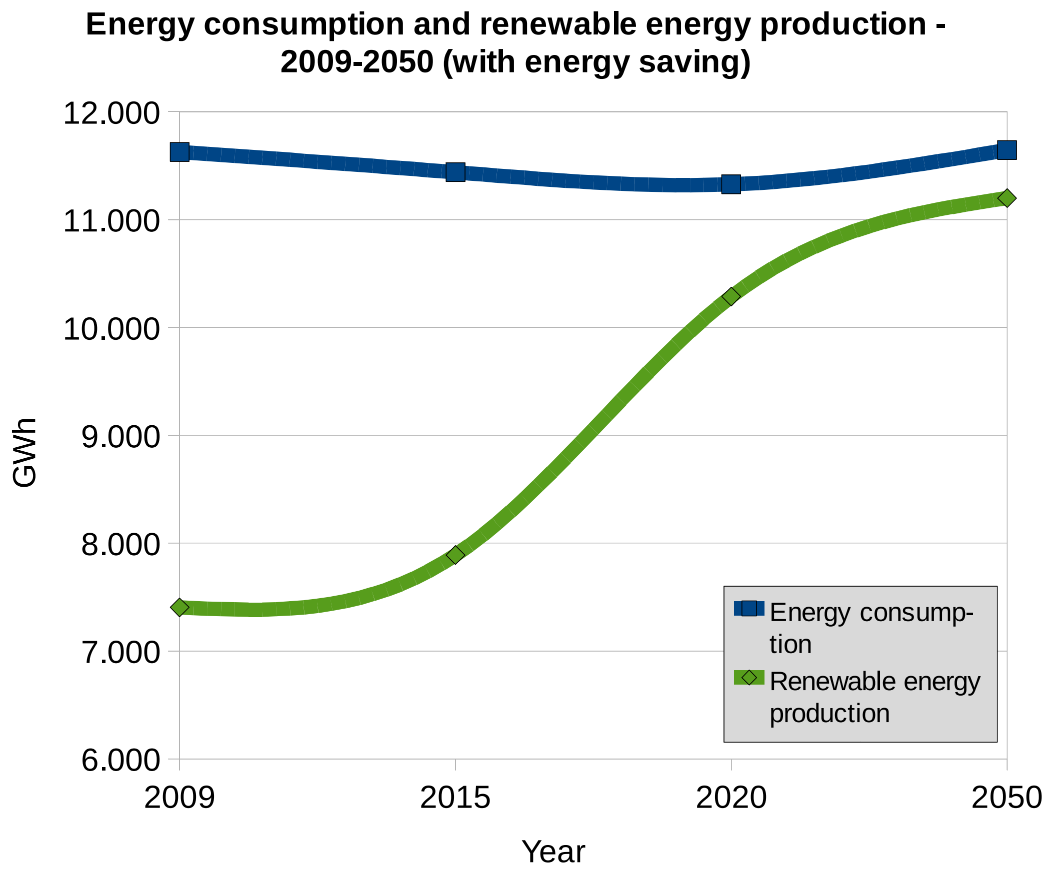
In case of implementation of efficiency and energy saving measures, the curve of energy consumption and energy production is expected to converge up to 2050 (as shown in Fig 7 - 77).

Fig 7 - 76: Energy consumption and renewable energy production – 2009-2050 (without energy saving)



Source: Own elaboration

Fig 7 - 77: Energy consumption and renewable energy production – 2009-2050 (with energy saving)



Source: Own elaboration

The renewable energy production increases in Fig 7 - 76 and Fig 7 - 77 to the same extent, but in Fig 7 - 76 (without energy saving) the energy production hardly covers the energy consumption up to 2050, because the energy consumption is expected to increase too much (80.95% of the local energy consumption is covered by the local renewable energy production in 2050).

In the Fig 7 - 77 the two curves come closer due to energy saving measures in the private households (heat and electricity). Up to 2050 the energy production is expected to meet the consumption (96.17% of the local energy consumption is covered by the local renewable energy production in 2050).

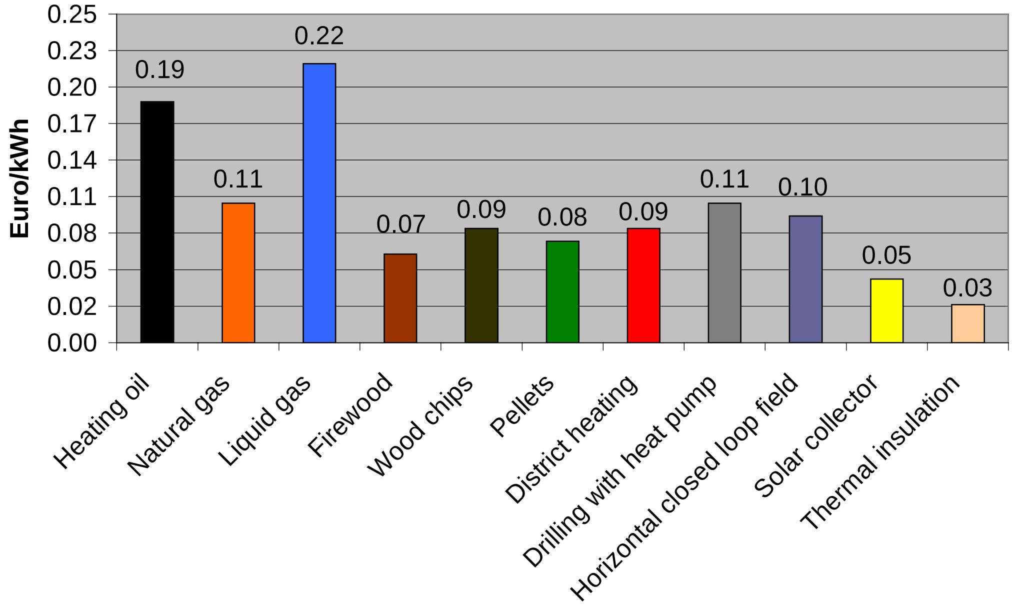
In the field of energy efficiency and energy saving possibilities the study primarily focused on private households. It is necessary to investigate the industrial and services sector more closely in order to obtain a more comprehensive result. Thus, considering the potentials of the use of renewable energy sources and the energy efficiency and energy saving measures for all the sectors, energy autarky might be realizable in South Tyrol up to 2050.

In this analysis the following assumption was considered: The consumption of electricity will be stay constant until 2050. But if the electricity consumption will increase by 2.1% per year, then the ratio between local energy consumption and renewable energy production would increase only from 63.69% in 2009 to 72.05% in 2050 (Table 6 - 98).

Referring to the use of renewable energy sources and the installation of thermal insulation the cost-effectiveness analysis shows the following results: Solar collector and thermal insulation are the most efficient and most economic measures for the private user. Hence, their implementation should be promoted strongly.

Dividing the costs (fuel costs, maintenance and investment costs) for a private user over an average life span of 25 years of the facility by the annual demand of useful heat it gives the costs for one kWh.

Fig 7 - 78: Comparison of the costs of one kWh of energy produced



NB: Fuel costs, maintenance and investment costs and an average life span of 25 years of the facility are considered.

Source: Climate Strategy, Energy South Tyrol 2050, p. 55 draft version 01.08.2010

The greatest opportunities lie in the promotion of a balanced policy for the use of renewable energy sources.

Furthermore the public sector sets a good example as described in the chapter 5.3.2 about photovoltaic.

Various concrete projects on local level are planned in the future in South Tyrol in order to stimulate the investments for energy efficiency and saving as well as for renewable energy production.

It is planned that the Autonomous Province of Bolzano sets up an Energy Agency combining research and knowledge in the field of energy efficiency, renewable energy technologies and intelligent energy planning in order to achieve the objectives of the Climate Strategy up to 2050. The Energy Agency will co-operate with the existing research and innovation centres, it will prepare the appropriate legal and administrative policy framework with the organizations and companies and will establish strategic partnerships with centres of excellence across national and regional borders.[101] It includes the ClimateHouse initiative, the contact platform in the fields of system, process and material research, the monitoring on the implementation of the energy strategy, emission certificates and CO2 balances and a centre for energy audits.[102]

It should be mentioned, that no centrally administered data base exists for renewable energy sources in South Tyrol. It required a lot of time to collect all the data necessary for the elaboration of this study, not to speak of the many different contact points (public offices, agencies, research centres, organizations, associations, municipalities, private experts, etc.). In this sense the Energy Agency can be defined as information centre about renewable energy sources as well as about other energy sources.

Other concrete examples for future projects are the "Lighthouse project of electric vehicles" (chapter 3.6.3), the construction of the hydrogen production plant (chapter 5.3.8.2.2) and the “Green Corridor” (chapter 5.3.3.3).

A first concrete cooperation between Bozen (South Tyrol) and Innsbruck (North Tyrol) is the "Lighthouse project of electric vehicles", prepared by the working group for the electromobility of the cluster of the Tyrolean Future Foundation and submitted to the Climate and Energy fund. The companies Elektro Drive Tirol, Tiroler Wasserkraft and SEL AG are involved in this project.[103]

Another important project to mention is the hydrogen production plant which is under construction in Bozen and can replace about 650,000 litres of petrol or 550,000 litres of diesel annually.[104] The Table 5 - 38 gives an overview about steps and milestones in the next ten years.

101 Climate Strategy, Energy South Tyrol 2050, p. 90, draft version 01.08.2010

102 Climate Strategy, Energy South Tyrol 2050, p. 111, draft version 01.08.2010

103 http://solar-driver.dasreiseprojekt.de/hauptbericht.php?ok=46&uk=100&uuk=78&uuuk=0&id=3376, download 03.06.2010

104 http://www.h2-suedtirol.com/index.php?id=96, download 03.06.2010

The barriers and difficulties are to find the right balance between the production of renewable energy and the compliance with environmental criteria.

For example, as explained in chapter 5.3.1.4 further exploitation of water resources is limited due to the EU Water Framework Directive 2000/60/EC. It is mandatory to leave adequate residual flows in watercourses.

The sensitive fauna and flora and the beautiful landscape represent an ecological barrier for the use of wind power in the Alpine valleys, which must be overcome (chapter 5.3.3.4).

Similarly, the success of the deep geothermal projects (in 3000-5000 m depth) for the production of heat and electricity is a very difficult and uncertain undertaking. It represents a great potential, but many obstacles are associated with the geological nature of the subsurface, possible triggering of earthquakes, etc. (chapter 5.4.4.4).

Renewable energy projects are manifold and the use of renewable energy sources is promoted on a broad level in South Tyrol, in order to benefit from diverse advantages of renewable energy as described in chapter 1.1.

It is a paramount that the already chosen right way for more renewable energy, energy efficiency, and energy savings in the public and private sector will be pursued and accelerated, but also and especially in the services and manufacturing industry sector, so that the total energy demand can be covered by renewable energy sources in South Tyrol in the future.

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