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Renewable Energy Sources and Technologies in Austria

State of the Art Report 2005

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Renewable Energy Sources and Technologies in Austria

State of the Art Report 2005

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Austrian National Report 2005

For the IEA-Working Party on Renewable Energy Technologies

Klagenfurt, December 2005

On behalf of the Austrian Federal Ministry for Transport, Innovation and Technology

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Renewable Energy Sources and Technologies in Austria

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1. Renewable Sources of Energy and Technologies

Renewable Energy is energy that is derived from natural processes that are replenished constantly. In its various forms, it derives directly or indirectly from the sun, or from heat generated deep within the earth.

Included in the definition of renewable energy sources, *Renewables* is energy generated from solar, wind, biomass, geothermal, hydropower and ocean resources, and bio fuels and hydrogen derived from renewable resources. Commercial markets for Renewables are today: Hydropower, Bioenergy, Solar Heating and Cooling, Solar Thermal Power Plants, Photovoltaic, Wind Energy and Geothermal Energy; Fig. 1.

The substitution of fossil fuels with Renewables leads to significant reduction of CO_2 emissions and to a diversification of supply resources and therefore to a greater security of energy supply. Renewables support the development of a sustainable energy system as a requirement for economic sustainable development. On the political level, this fact was reflected in a continuous promotion of Renewables through Austria's energy, research and promotional policies – including subsidies.

Figure 1: Renewable Energy Sources for Energy Supply

2. Conditions for the Market Deployment of Renewables in Austria

Austria is among the top countries in Europe using Renewables; Fig. 2.1 to 2.6. Fig. 2.1 and Fig. 2.2 show the contribution of Renewables to the total primary energy supply, TPES, in OECD Member States and European countries. Renewables contributes to the total energy supply in Austria about 21.3%. The average annual percent change of Renewables to TPES was in the time period 1990 – 2004 1.3%; Fig. 2.3. Renewables share to electricity production amounts in the year 2004 to 65.0%, compared to OECD/Europe of 18.2%; Fig. 2.4 and Fig. 2.5. The share of electricity productions from "other" Renewables (excluding hydro-power) was 3.4% in 2003. The electricity production by Eco-Power Plants amounts in the year 2004 5433 GWh, from which were produced 73.38% with Small Hydropower, followed with 17.04% with Wind-energy, and 5.76% with solid biomass and renewable waste; Fig. 2.7.

Hydropower and biomass are the major renewable energy sources. Beside of these recourses, Austria is one of the pioneering countries in the thermal use of solar energy, the production of biodiesel, and the use of ambient heat. Combined with the increasing use of Renewables, the design and production of hydro-power plants, solar thermal installations, biomass boilers as well as the manufacturing of components for the use of wind energy and photovoltaic increased in the past years.

Both the extension and the use of Renewables have also created other positive effects e.g. technological innovations. The industry producing the facilities for the use of Renewables belongs to the most dynamic sectors of the Austrian economy. This guarantees regional value added and secure jobs not only today, and offers excellent chances for the future.

Tax system for the Promotion of a Sustainable Energy System

In the context of Austria's sustainability policy, the tax system was adjusted for the requirements of sustainable energy system (1996). More than 10% of this tax revenue is made available to the federal provinces for the implementation of energy-saving and environmental-protection measures, which also include measures to promote the market deployment of Renewables. On the European level, the preconditions for an "ecologisation" and harmonisation of the Member States' tax systems were created by the political consensus on the "EU Energy Tax Directive". Austria has already anticipated most of the required adjustments with its new tax on coal and the increase in diesel tax.

Green Electricity Act

In the course of the gradual liberalisation of the EU's internal energy market and the full liberalisation of the Austrian energy market, the legal conditions for the generation of electricity from Renewables have been further developed in the past years. The 2002 Green Electricity Act introduces a uniform purchase and compensation obligation for "green electricity facilities" for all of Austria. Green electricity facilities are based on solar energy, wind, biomass, biogas, landfill and sewage sludge gas as well as geothermal energy and particular types of wastes. By 2008, a share of 4% of these energy sources in the overall supply of electricity to the end consumer (final consumption) has to be gradually reached. The same support scheme is used for electricity production from small hydropower stations (<10 kW), whereby it was determined to raise their share in electricity generation to 9% by 2008. The aim of measures is to reach the target share of 78.1% of the electricity generation from Renewables of Austrian gross domestic consumption, as defined in the EU directive on the

promotion of electricity from Renewables in the internal electricity market (2001). Other changes include:

- The certificate system for small-scale hydroelectric power stations expired at the end of 2002.
- As of 1 January 2003, there was no longer a quota obligation for the network operators and no compensation payments.
- All operators of green plants have the right to a listing of the certification of origin by the network operators.
- The electricity identification system, which specifies the source of energy used for electricity generation on consumer bills, will be standardised after a transitional period up to 1 July 2004 and then all electricity suppliers must identify a standard composition on consumer bills ("standard dealer mix").

The Act guarantees payment of feed-in tariffs for thirteen years at the following rates (per kWh):

- Small hydro power, depending upon the amount of electricity fed into the grid: from € 0.0315 to € 0.0568 for existing plants, from € 0.0331 to € 0.0596 for refurbished plants, from € 0.0378 to € 0.0625 for new plants.
- PV: € 0.47 for plants > 20 kW_{peak}, € 0.60 for plants < 20 kW_{peak}.
- Wind: € 0.078 for new plants.
- Geothermal: € 0.07.
- Wood chips: € 0.102 to € 0.16.
- Waste with high bio-share: € 0.027 to € 0.128.
- Co-firing in fossil fuel plants: € 0.03 to € 0.065.
- Bio-fuels: € 0.1 for plants > 200 kW, € 0.13 for plants < 200 kW.
- Biogas: € 0.0725 to € 0.165.
- Landfill gas: € 0.03 for plants > 1 MW, € 0.06 for plants < 1 MW.

The actual situation concerning green electricity production and feed-in tariffs are documented in Fig. 2.8 to Fig. 2.10. The average feed-in tariffs by green electricity production are documented in Fig. 2.8. The green-electricity budget for 2004 was 301.924 million Euros (Fig. 2.9) and budget for 2005 is estimated with 284 million Euros (Fig. 2.10).

Bio-fuels for the Transport Sector

Within the new Austrian legislation, biodiesel is added up to 5 % to the fossil diesel since October 2005. This share is related to 440,000 tonnes biodiesel per year, from which 55,000 tonnes are produced in Austria up to now. Therefore, about 90% of biodiesel has to be imported. It is the goal of the Austrian Energy Policy to produce the full requirements for the Austrian Transport sector - with public support - in Austria latest in 2007.

Other Promotion Measures for Market Deployment of Renewables

In addition to "tax revenue" and "green electricity support", the market penetration of Renewables in Austria is supported by a large number of other promotion instruments as housing and agricultural subsidies as well as financial support for business and industry. For example, the market penetration of Renewables in housing (domestic, commercial and industry) was supported by subsidies of about 50 million Euros in 2004. Also research

promotion funds of about 10 million Euros promoted activities in the field of Renewables in 2004 – from basic scientific work to market launch.

Federal grants and incentives for renewable energy producers such as firms, associations and public entities are administered primarily by the "Kommunalkredit". These federal grants typically constitute 30% of eligible costs and are granted to entrepreneurs investing in small hydro plants, modern biomass-based heating systems which include small networks for district heating, biogas, sewage gas, geothermal systems, heat pumps, solar thermal above 10 m^2, photovoltaic and wind installations. These grants can also be combined with financial support from the local governments ("Länder") to cover 66% of costs.

Public Expenditures for Energy Research, Development and Demonstration

The public expenditures for Energy Research, Development and Demonstration (RD&D) in Austria is illustrated in Fig. 2.11 for the time period 1977 – 2004. The maximum RD&D budget was in the year 1985 with 33.548 million Euros, the minimum budget in the year 1990 with 10.000 million Euros. In 2004 the RD&D budget reached with 33.534 million Euros the second best value.

Approximately 28.5% of Austria's federal energy R&D budget in 2004 was allocated specifically to renewable sources (39.7% in 2003); Fig. 2.12a and Fig. 2.12b. The public Expenditures for Renewable Energy RD&D are documented for 2003 in Figure 2.13a and Figure 2.13b for 2004. This funding was split in 2004 to 75.4% for biomass, 8.4% for Solar Thermal, 6.1% for Solar Electric (PV), 4.4% for Wind-energy, 2.9% for Geothermal and 2.8% for Hydro-power; Fig. 2.13b.

Summarising, by constantly stepping up Renewables in Austria a domestic sales market as well as stable investment and innovation framework conditions for the further development of Renewables was created. These favourable framework conditions in Austria facilitated not only in the introduction of Renewables technologies to the market but also formed the basis for the domestic economy to develop further internationally outstanding position in the areas of Renewables technologies.

But the reasons for the positive market development for Renewables is not only the continual promotion by means of Austria's energy, research and promotional policies (including subsidies), but also the traditionally strong environmental awareness of the Austrian citizens, who have supported the idea of using Renewables right from the outset.

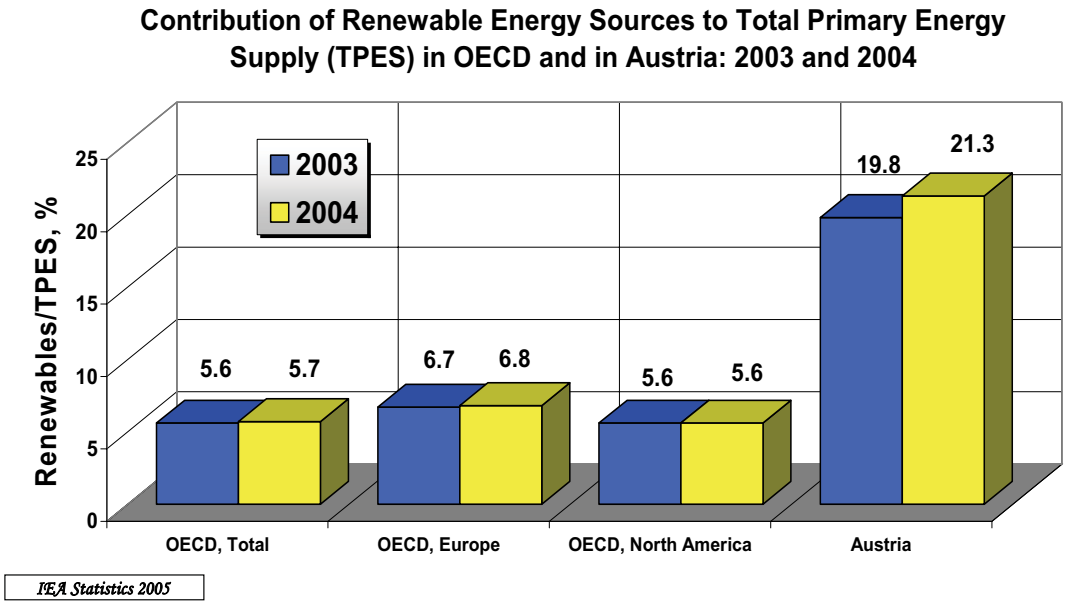


Figure 2.1: Contribution of Renewables to total primary energy supply In OECD-Member States: 2003 and 2004

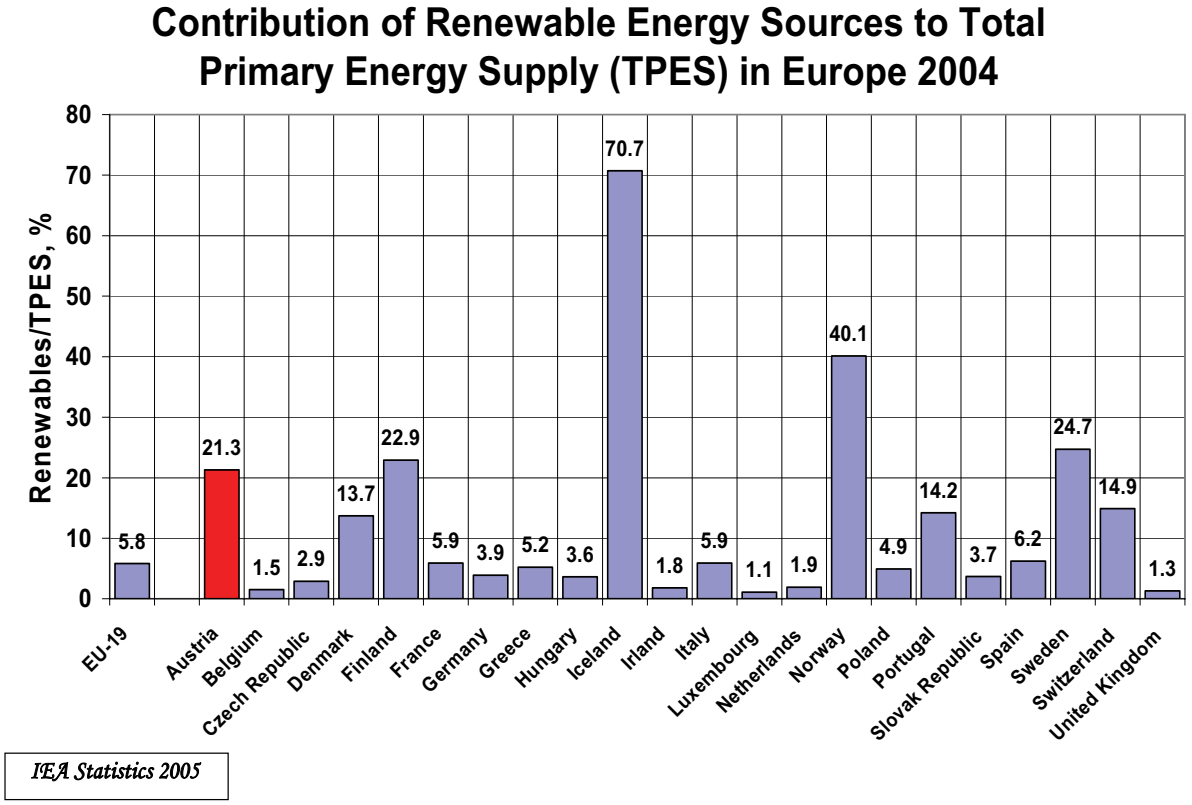


Figure 2.2: Contribution of Renewables to total primary energy supply In EU-Member States: 2004

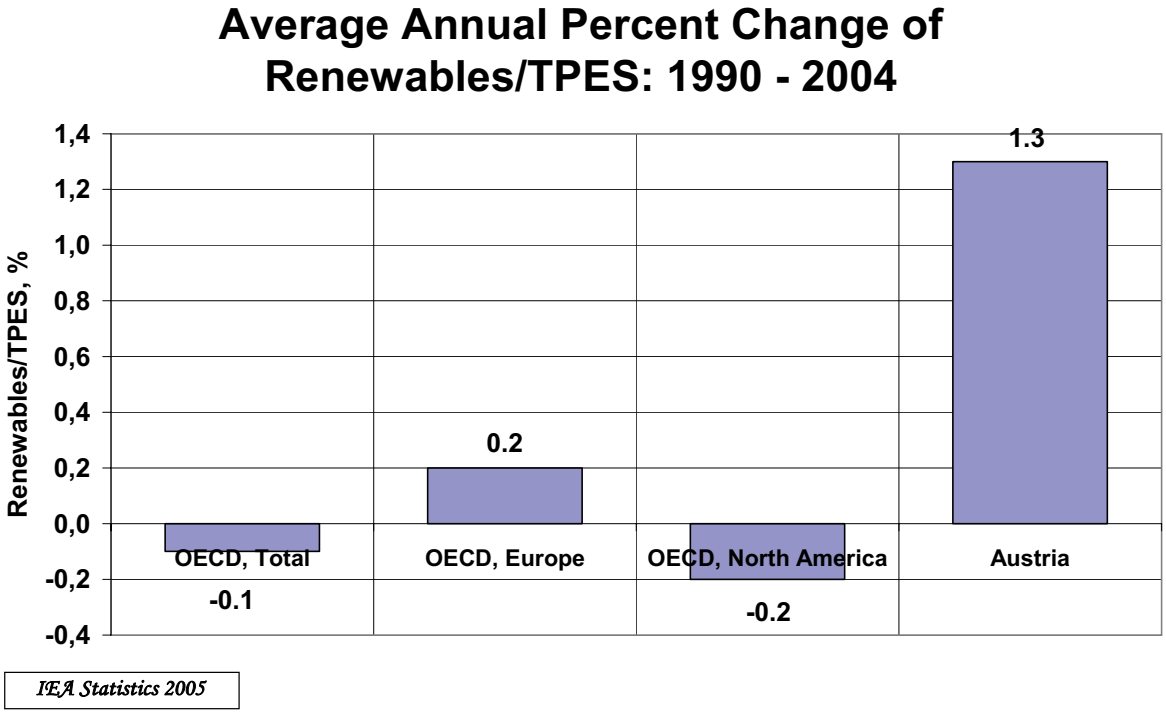


Figure 2.3: Average annual change of Renewables to total primary energy supply In OECD-Member States: 1990 - 2004

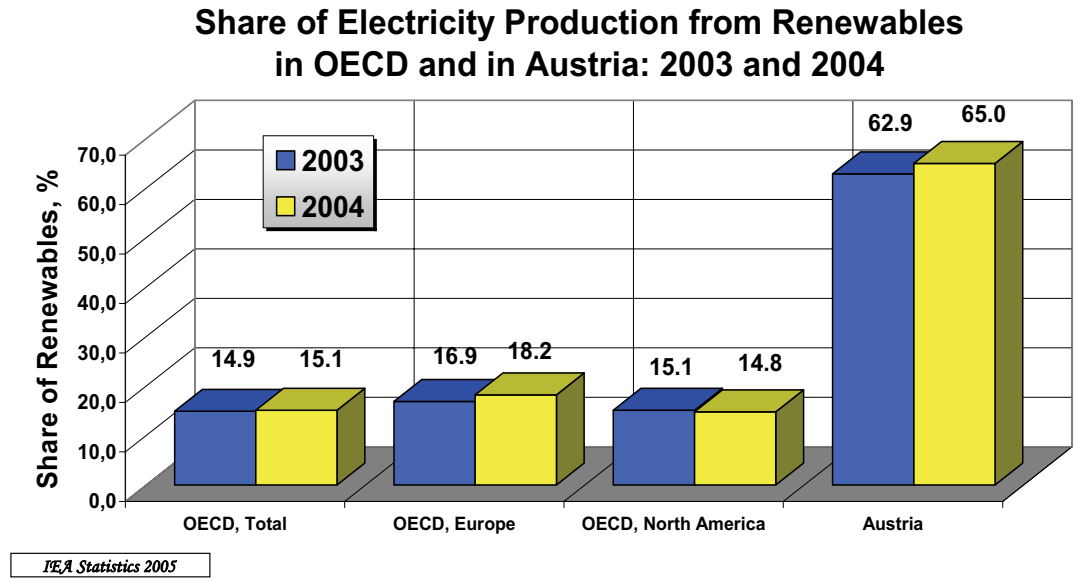


Figure 2.4: Share of electricity production from Renewables In OECD-Member States: 2003 and 2004

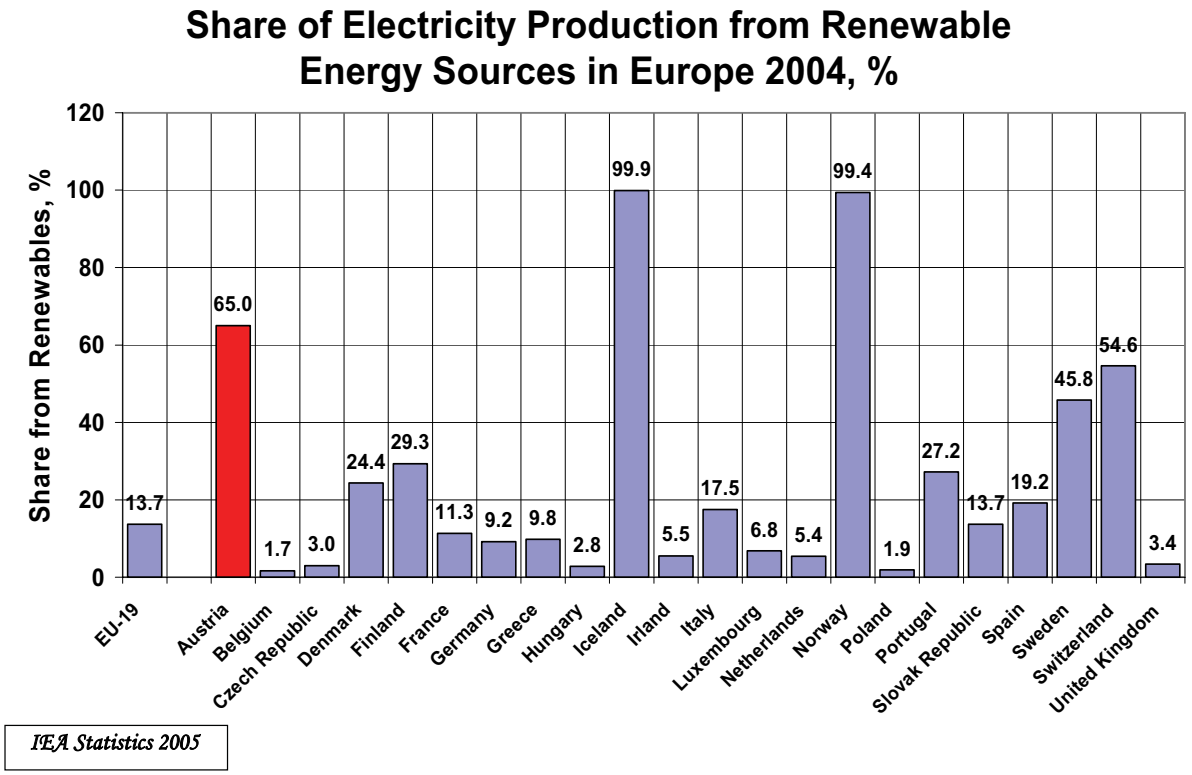


Figure 2.5: Share of electricity production from Renewables In EU-Member States: 2004

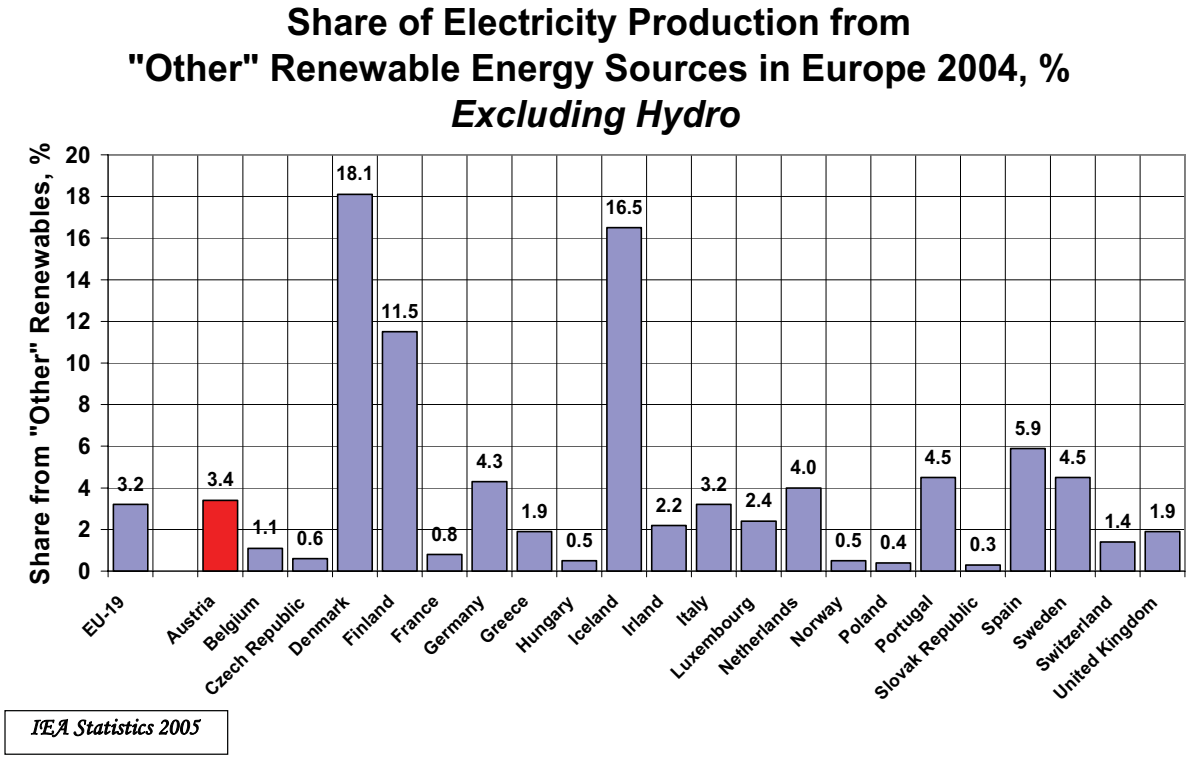


Figure 2.6: Share of electricity production from "other" Renewables In EU-Member States: 2004

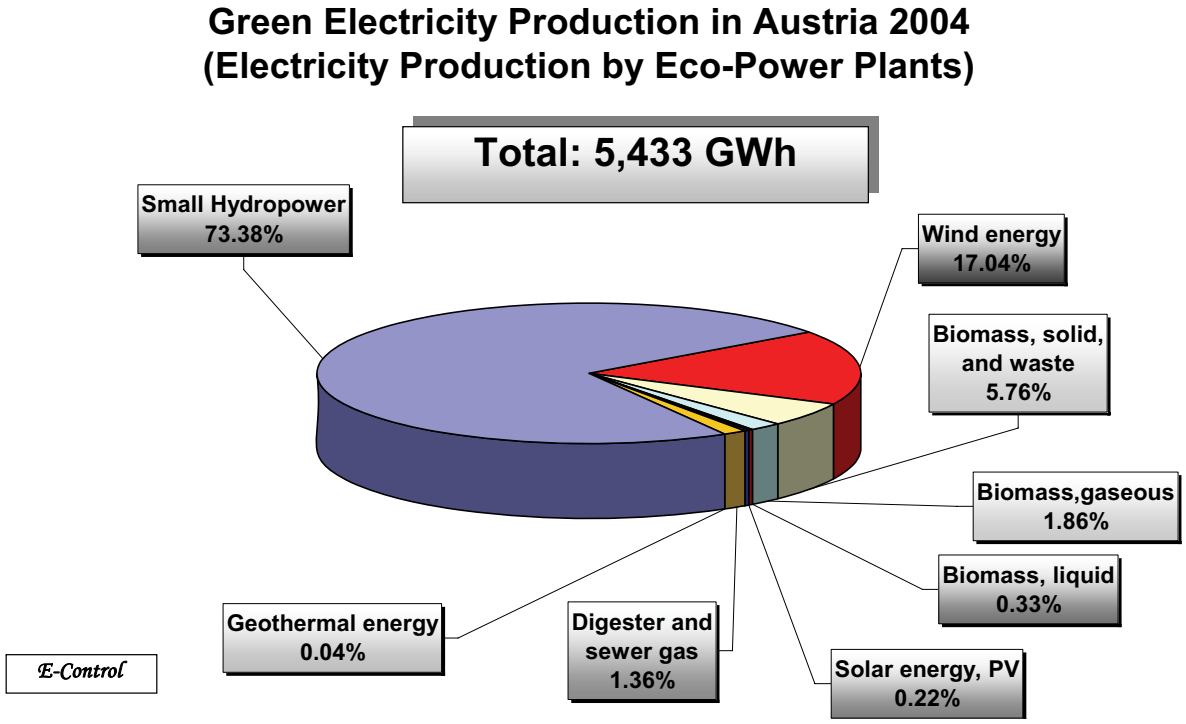


Figure 2.7: Electricity production from eco-power plants In Austria 2004 (Source: E-Control)

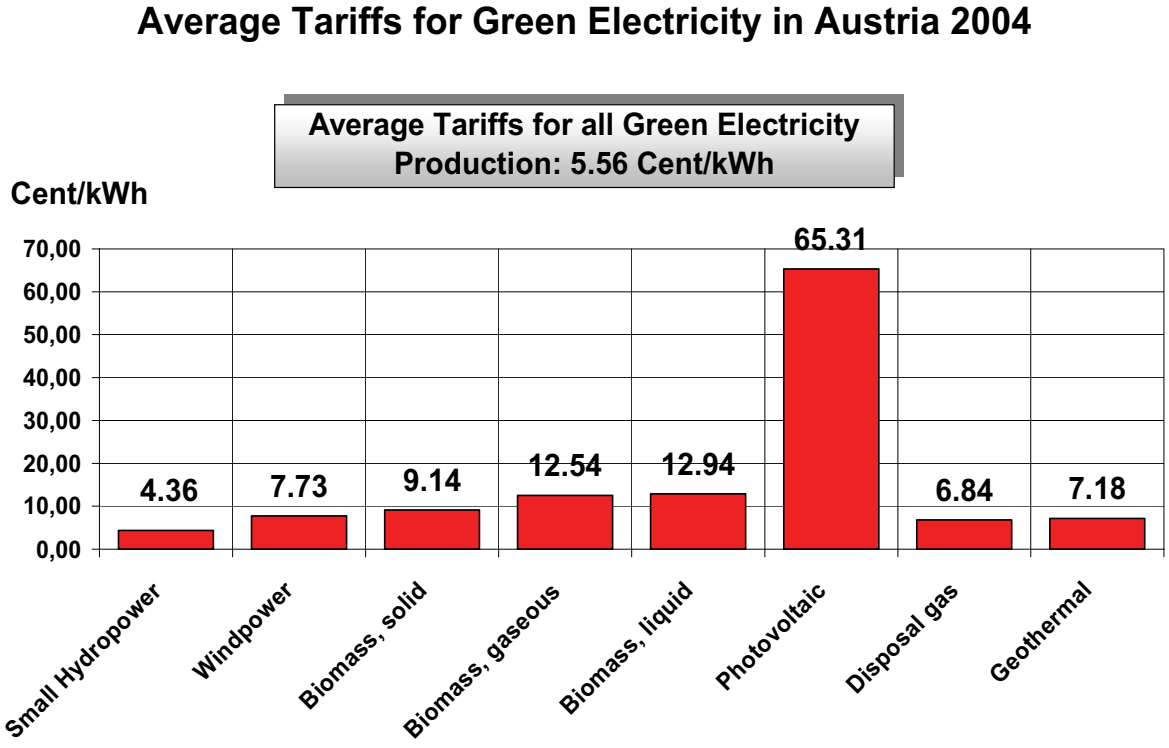


Figure 2.8: Average feed-in tariffs for green electricity production In Austria 2004 (Source: E-Control)

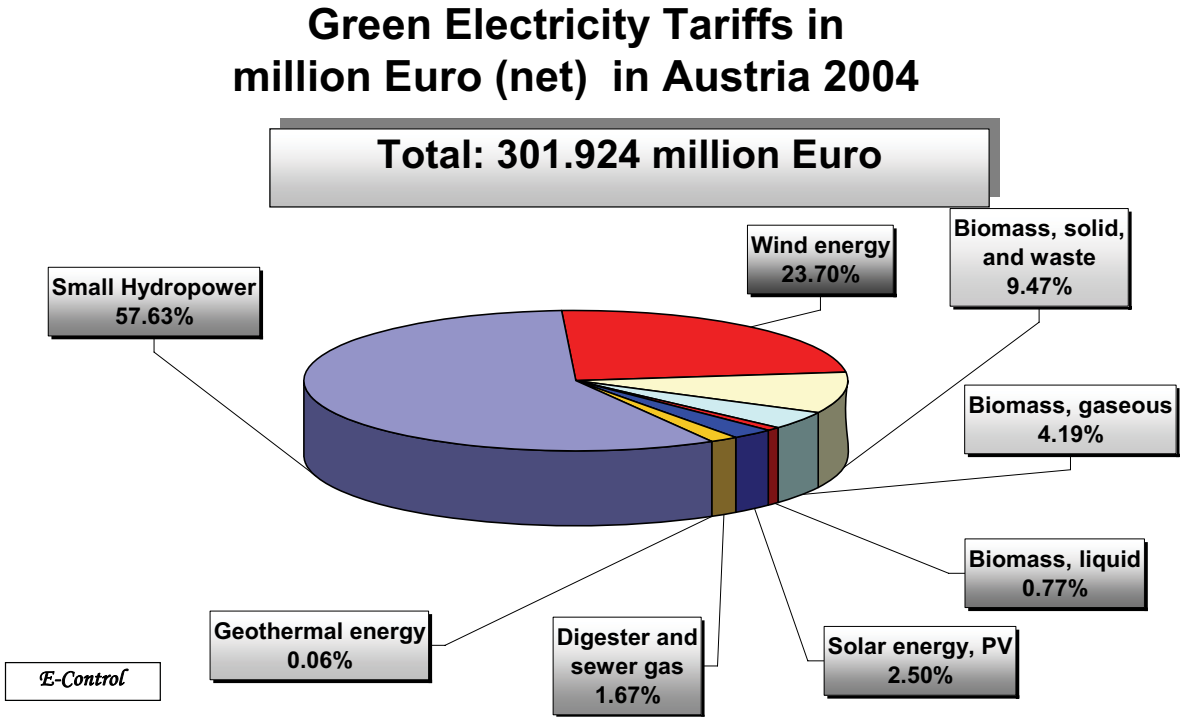


Figure 2.9: Green electricity budget In Austria 2004
(Source: E-Control)

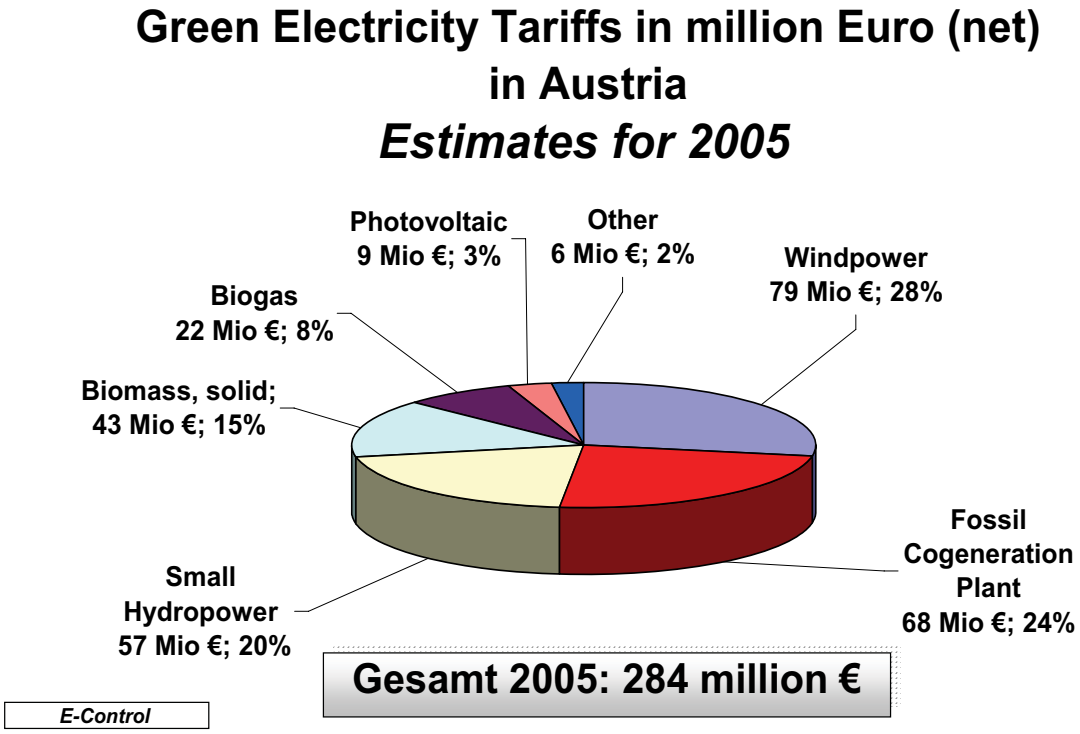


Figure 2.10: Green electricity budget In Austria: Estimates for 2005
(Source: E-Control)

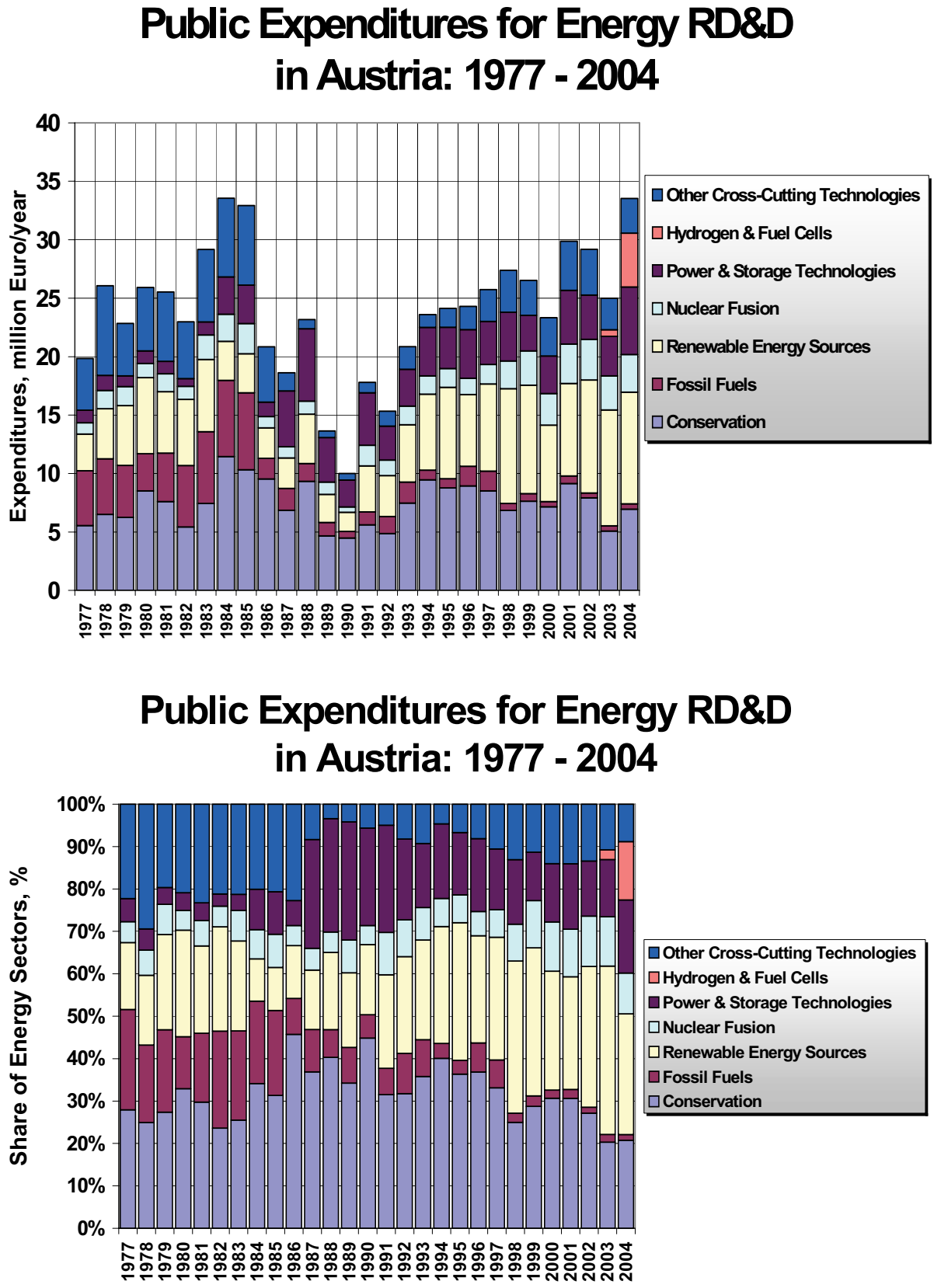


Figure 2.11: Public expenditures for Energy Research, Development and Demonstration In Austria: 1977 – 2004
(Source: BMVIT-G. Faninger, 1977 – 2002, Austrian Energy Agency, 2003 – 2004)

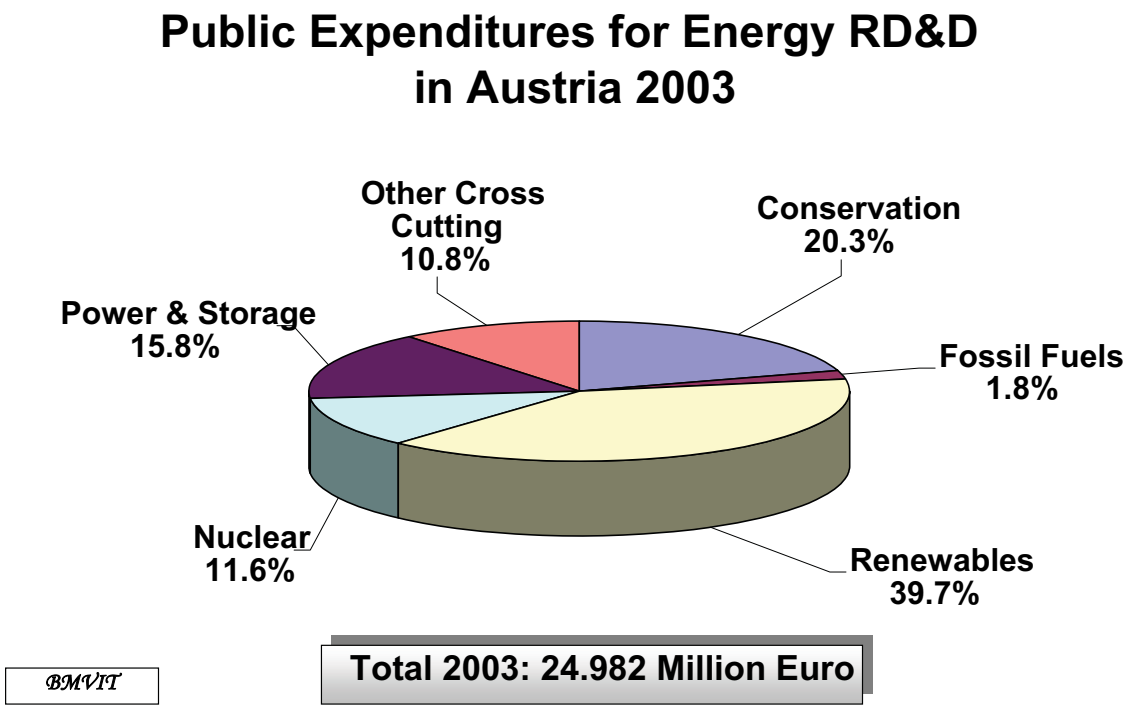


Figure 2.12a: Public expenditures for energy research, development and demonstration In Austria 2003 (Source: BMVIT/Austria Energy Agency)

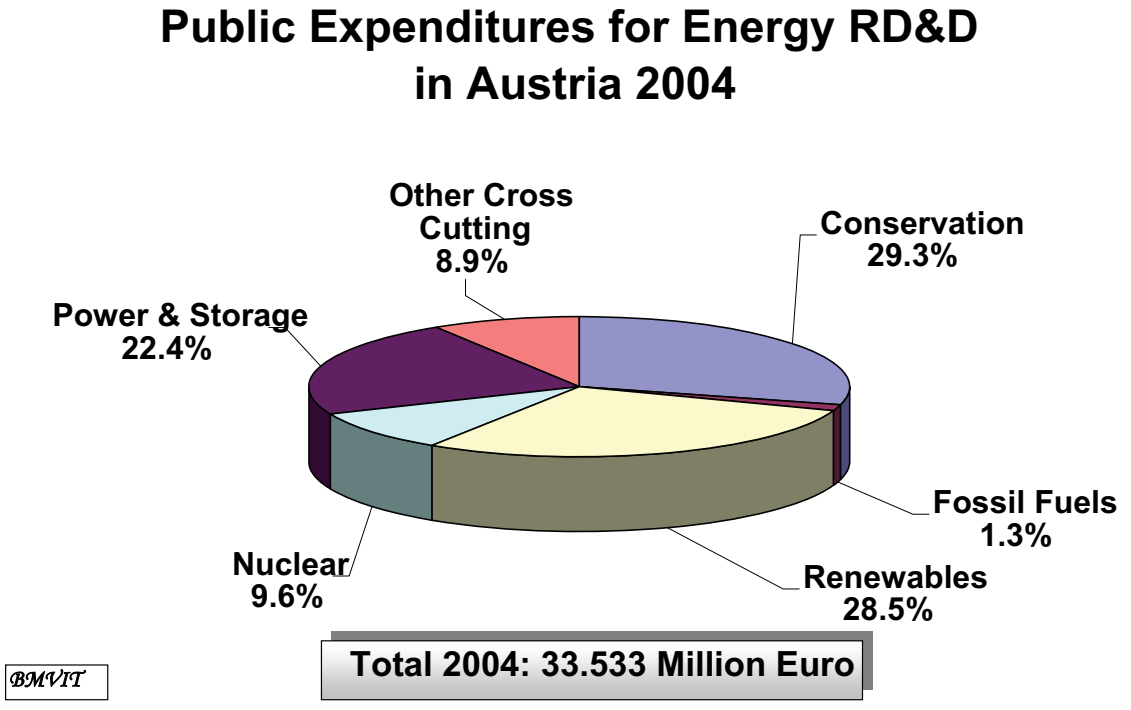


Figure 2.12b: Public expenditures for energy research, development and demonstration In Austria 2004 (Source: BMVIT/Austria Energy Agency)

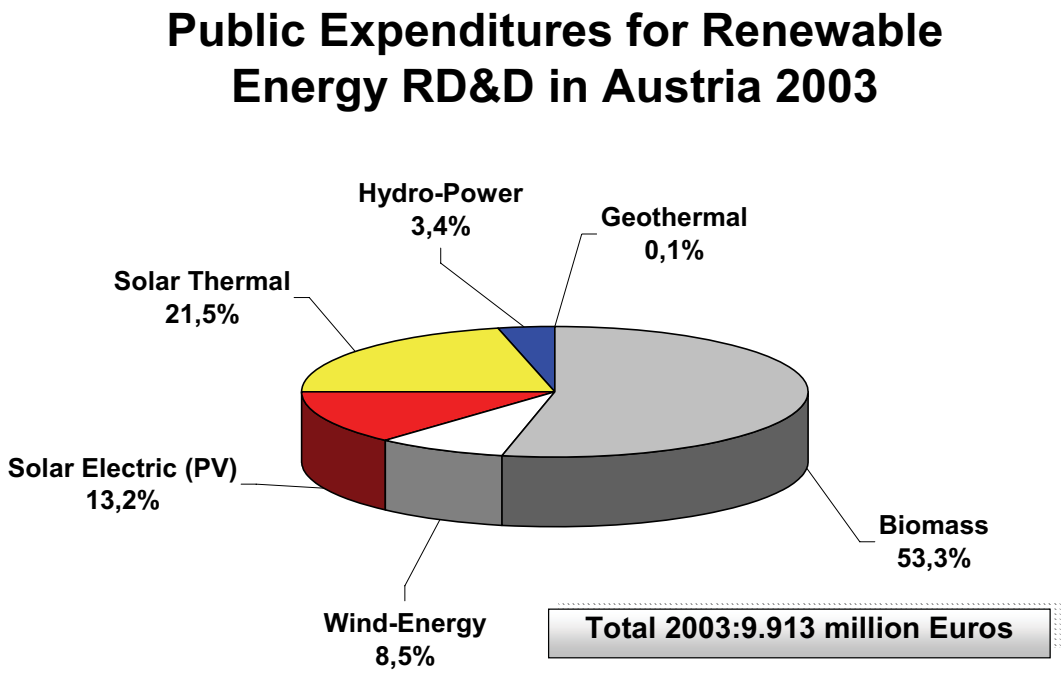


Figure 2.13a: Public expenditures for renewable energy research, development and demonstration In Austria 2003 (Source: BMVIT/Austria Energy Agency)

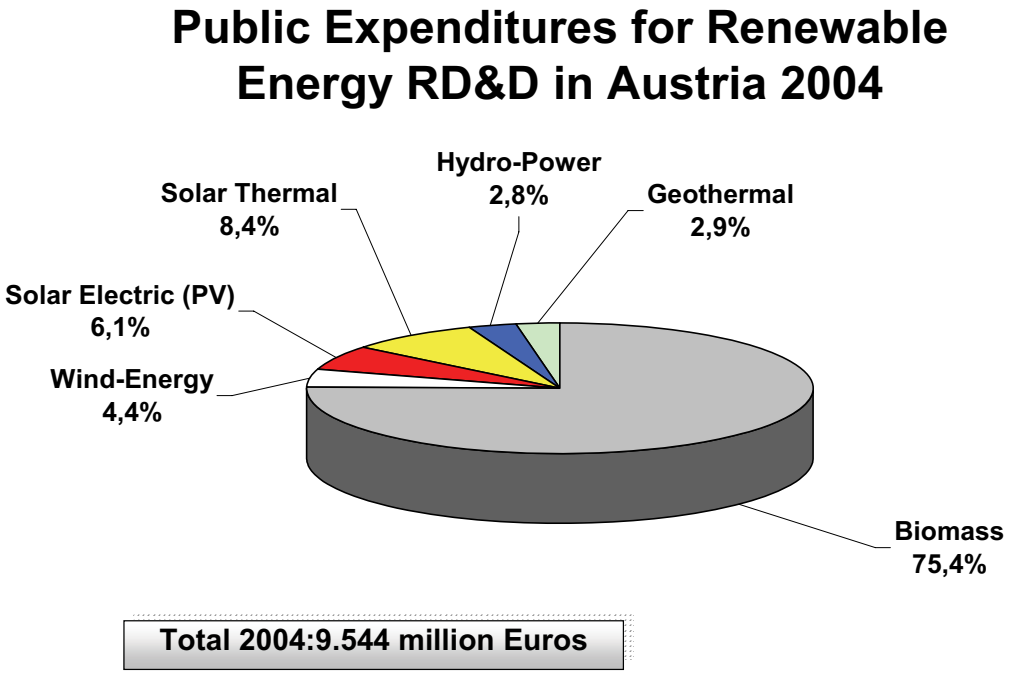


Figure 2.13b: Public expenditures for renewable energy research, development and demonstration In Austria 2004 (Source: BMVIT/Austria Energy Agency)

3. The Competence of the Austrian Industry in Renewable Energy Technologies

The promotion efforts resulted in the creation of a domestic sales market and stable investment and innovation conditions for a further development of renewable energy technologies.

The sector of industry constructing and producing the facilities for the use of renewable energy sources is one of the fastest growing sectors in Austria. Sales, value added and employments in the business sector of Renewable energy technologies are reported in /4/. The following 9 renewable energy technologies which are relevant for Austria are analyzed and documented: biomass (solid, gas and liquids), geothermal energy, small hydro power, photovoltaic, solar thermal energy, heat pumps and wind power. For these technologies the aspects of sales, value added and employment are estimated; Fig. 3.1 to Fig. 3.3. The results of the study show the importance of these technologies for Austria. In the year 2004 sales in the context of above specified technologies reach the value of 1.46 billion Euros. The corresponding value added was 1.04 billion Euros. The total number of jobs (full time equivalent) created by the production and installation of renewable energy technologies was 13600 and for this reason, these technologies have a strong impact on the national job market. In addition 19.110 jobs were created through the use of the equipment, from which belong to the employment of the biomass preparation for energy use.

The impact of renewable energy technologies on climate protection is also to point out. The reduction of CO_2-emissions caused by renewable energy technologies in Austria in the year 2004 was 11.9 million tons. Even in case of consideration of total life cycle emissions of technologies there are remaining reductions of 10.8 million tons CO_2 /4/.

A moderate scenario for the year 2012 show, that there is a high additional emission saving potential in Austria. In case of continuous political efforts for research and development and the diffusion of technologies there can be a net reduction of CO_2-emissions in 2012 of about 15 million tons. The fictitious monetary value of the savings in the year 2004 is equivalent to 216 million Euro and can be interpreted as an additional value added of renewable energy technologies. Concluding from present study results, renewable energy technologies developed to a multi dimensional and weighty factor in Austrian's political economy. Beside the economic and climate protecting effect these technologies show a lot of positive structural effects.

Respective technologies are appropriate for decentralized applications and therefore a high value for rural areas is implicated. Regionally created jobs, regional value added the reduction of necessary transport of persons and goods and the increasing security of energy service provision by decentralized units are some of the additional positive effects of renewable energy technologies. In this sense renewable energy technologies provide a major contribution to sustainable development of Austrians society. Austrians energy policy has the big chance to force this development by supporting research and development and the diffusion of these technologies.

Austrian enterprises are today technological pioneers on the worlds market, especially in the area of solar collectors and components for hydro-power plants and photovoltaic Systems (e.g. inverters). Austria also plays a pioneering role concerning the utilisation of biogas in

large facilities that use energy crops as substrate. In the field of heat pump production, Austrian companies assume a leading position concerning efficiency and quality.

Austria's excellent position on the export markets constitutes a great opportunity for Austrian companies and their employees.

The remarkable market development of renewable energy technologies in Austria has only been possible because Austrian firms have in co-operation with research centres developed cost-effective technologies, especially for solar thermal and solar electric (photovoltaic) applications (including equipment like inverters, modules for solar cells) as well as wind energy converters and advanced environmentally-friendly biomass heating systems with optimised combustion technology. Especially test results led to technical improvements in renewable energy technologies as well as the basis for a common standardisation.

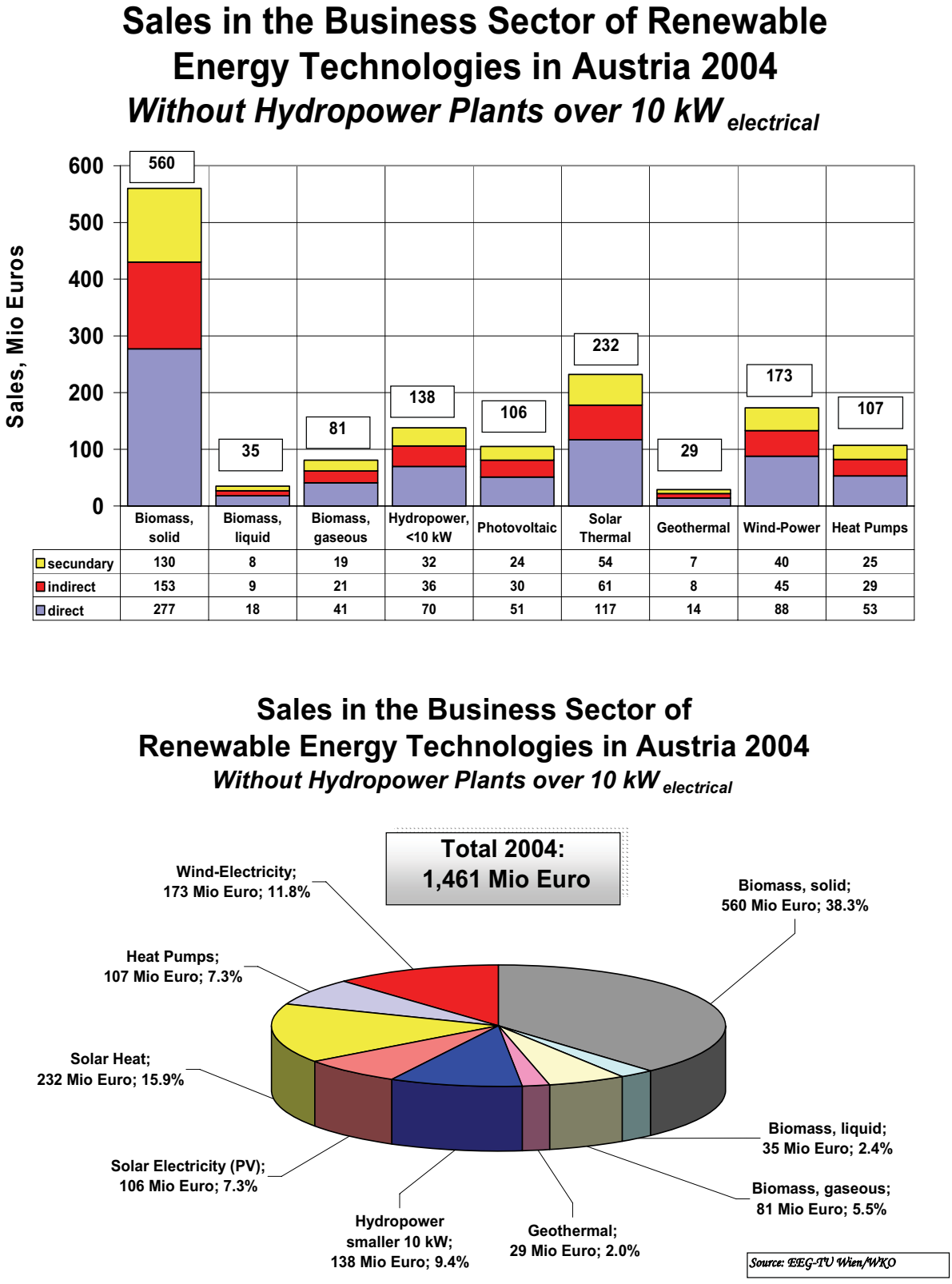
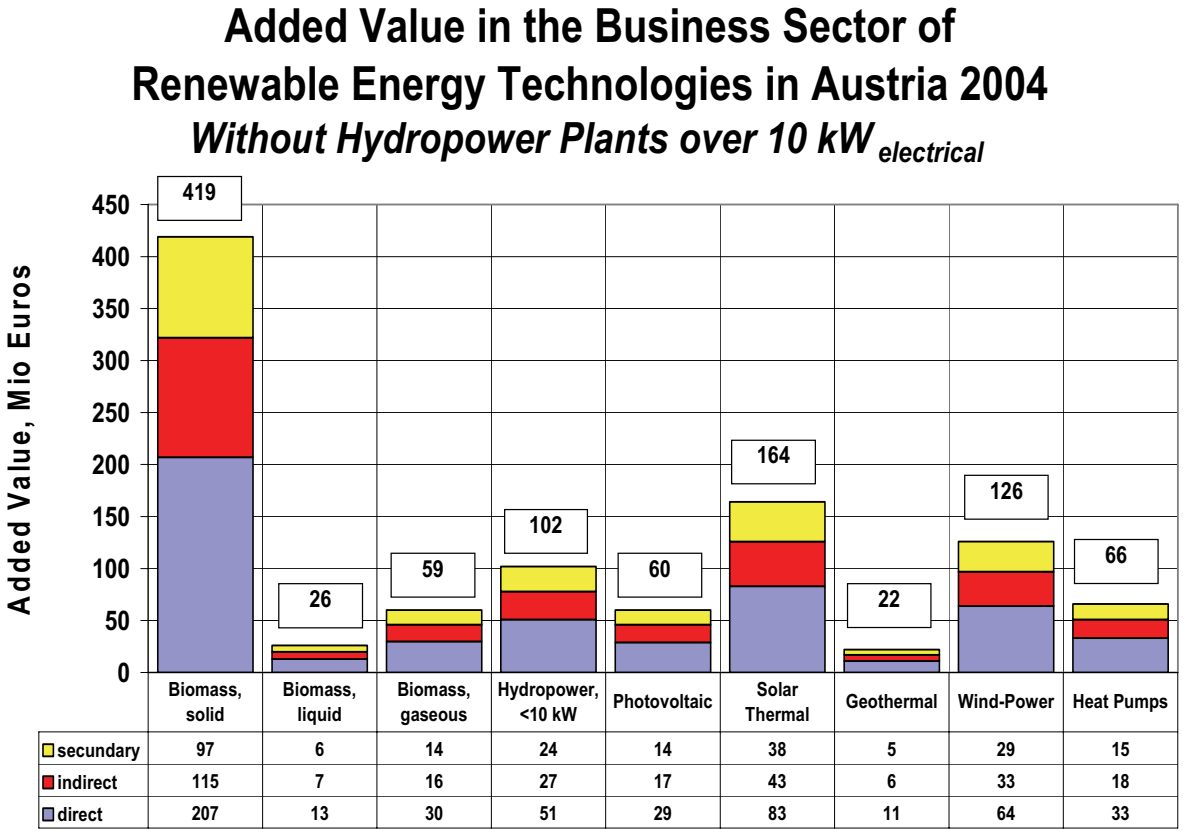


Figure 3.1: The economy of renewable energy technologies: Sales (Source: EEG-TU Vienna/WKO)



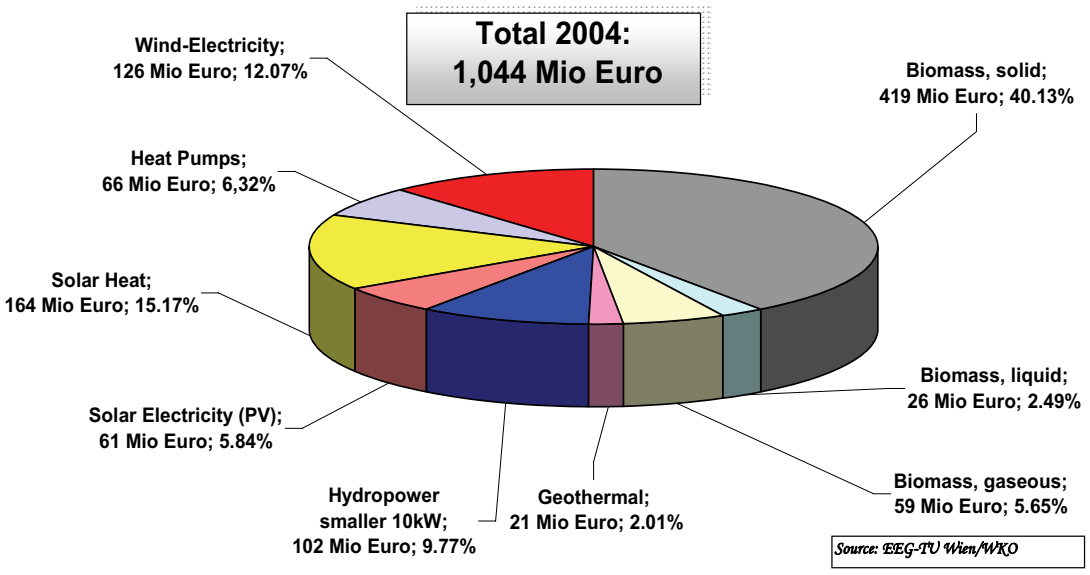
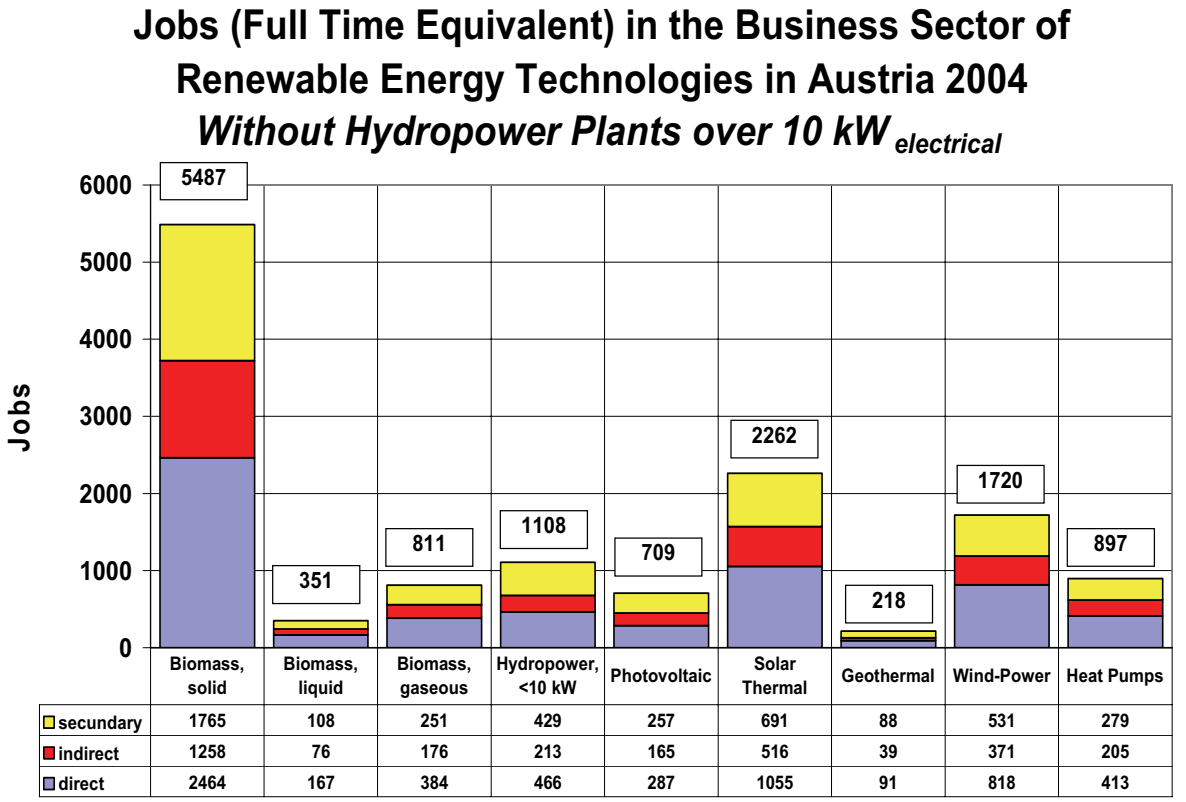
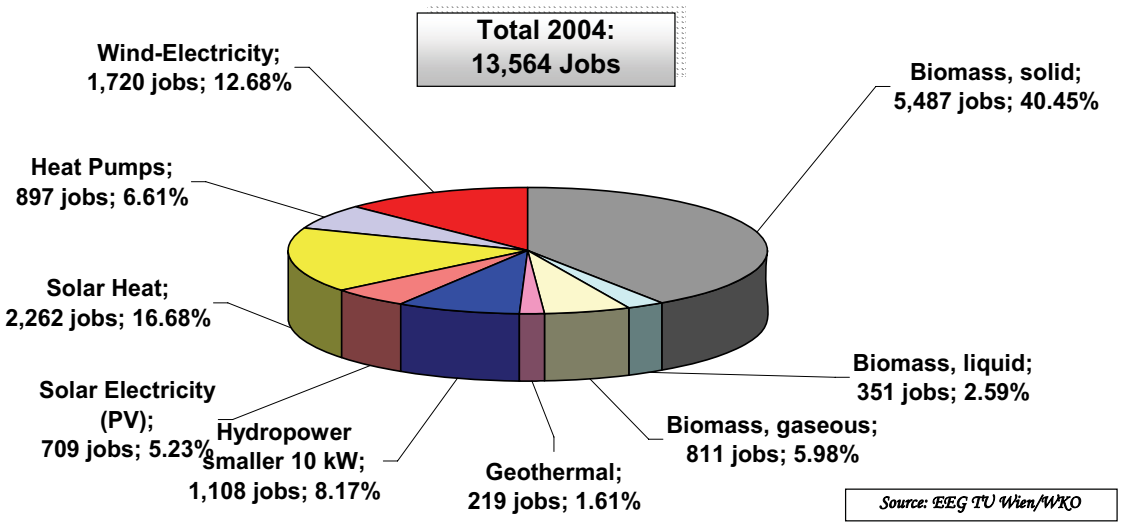


Figure 3.2: The economy of renewable energy technologies: Added value (Source: EEG-TU Vienna/WKO)





In addition 19,110 jobs were created through the use of the equipment, from which belong to the employment of the biomass preparation for energy use.

Figure 3.3: The economy of renewable energy technologies: Jobs (Source: EEG-TU Vienna/WKO)

4. The Role of Renewables in the Austrian Energy Supply

The Utilisation of Renewable Energy Sources has a long tradition in Austria - due to the nature of its landscape. Since the middle of the 1970s, the contribution of Renewables to the energy supply in Austria has been steadily increasing; Fig. 4.1 to Fig. 4.4. Fig. 4.3 illustrates the market development of renewable energy supply in Austria from 1970 to 2003. All Renewables increased during this time period. The market deployment of the "other" Renewables from 1990 to 2004 shows Figure 4.4. There are a number of renewable energy and waste sources which are considered to be economically viable or approaching economic viability: hydro-power, solar-energy, geothermal-energy, wind-energy, solid biomass (fire wood, wood/biomass waste), biogas (landfill gas, sewage sludge gas), and liquid bio-fuels, as well as industrial and municipal solid waste.

Besides hydropower, biomass and solar energy - used in the different ways - and for some places also wind energy are promising renewable energy sources for Austria. In 2003 the share of Renewables in total energy consumption (supply) amounts to an average of about 21.1%, of which 9.4% is accounted to hydro power and 10.7% to "other" Renewables (Bio-energy, Solar-thermal, Geothermal, Wind-energy, Photovoltaic); Fig. 4.5a and Fig. 4.5b. Austria is amongst the leaders when it comes to using renewable energy sources both the traditional and the "other" Renewables. About 93.8% of the contribution of "other" Renewables is shared by bioenergy, followed with 2.3% by ambient heat, 1.9% by solar thermal, 1.8% by wind-energy, 0.2% by geothermal and 0.02% by solar-electricity, PV; Fig. 4.6. The heat-/electricity output of solar-heat, solar electricity, wind-electricity and ambient heat is shown in Figure 4.7a and the installed heat/electrical load in Figure 4.7b. At the end of 2004 the heat/power output reached 12,243 TJ and the installed heat/power load was 3,282 MW.

The electricity production in Austria in the year 2004 is documented in Fig. 4.8 to Fig. 4.14. The total electricity production was in 2004 about 59,354 GWh, from which were produces 62% from hydro-power plants, 37% from thermal power plants and 1% from Renewables and non-renewable wastes; Fig. 4.8. To the electricity production in 2004 contributed 96.3% hydro-power plants, 3.1% was produced from "other" Renewables and 0.6% from non-renewable wastes; Fig. 4.9. The gross electricity production from "other" Renewables to the electricity supply in 2004 is shown in Fig. 4.10. About 1.210 GWh were produced. The electricity production from eco-power plants reached 286 GWh in 2002, 375 GWh in 2003 and 941 GWh in 2004; Fig. 4.11. The electrical capacity of electricity power plants with Renewables was in 2004 15,785 MW_{el}, Fig. 4.12. Summarizing, the electricity production in Austria in the time period is illustrated in Fig. 4.13a and b. Fig. 4.14a illustrates the gross electricity and heat production (CHP-plants) and Fig. 14b the heat production by Renewables in 2004. Gross and final consumption of "other" Renewables are documented in Fig. 4.15a and Fig. 4.15b. Production/gross energy consumption of wood/wood waste/other solid wastes and of liquid bio-fuels is shown in Fig. 4.16a and Fig. 4.16b.

The market deployment of Renewables in Austria has been quite successful. Larger contributions of renewable energy carriers in total energy consumption require more activities to reduce the energy demand within higher energy-efficiencies in all sectors of energy consumption. Especially the substitution of fossil fuels by renewable energy sources should be considered.

In terms of lessons learned, there was a certain tendency in the past to put too much emphasis on high-technology solutions in the end-user sector. Experience shows that intermediate-technology solutions which are reliable and easy to handle are of more importance, at least for

near-term applications and commercialisation. Sufficient experience and operational data exist now to ensure that renewable energy technologies are professionally designed and installed to provide optimum performance.

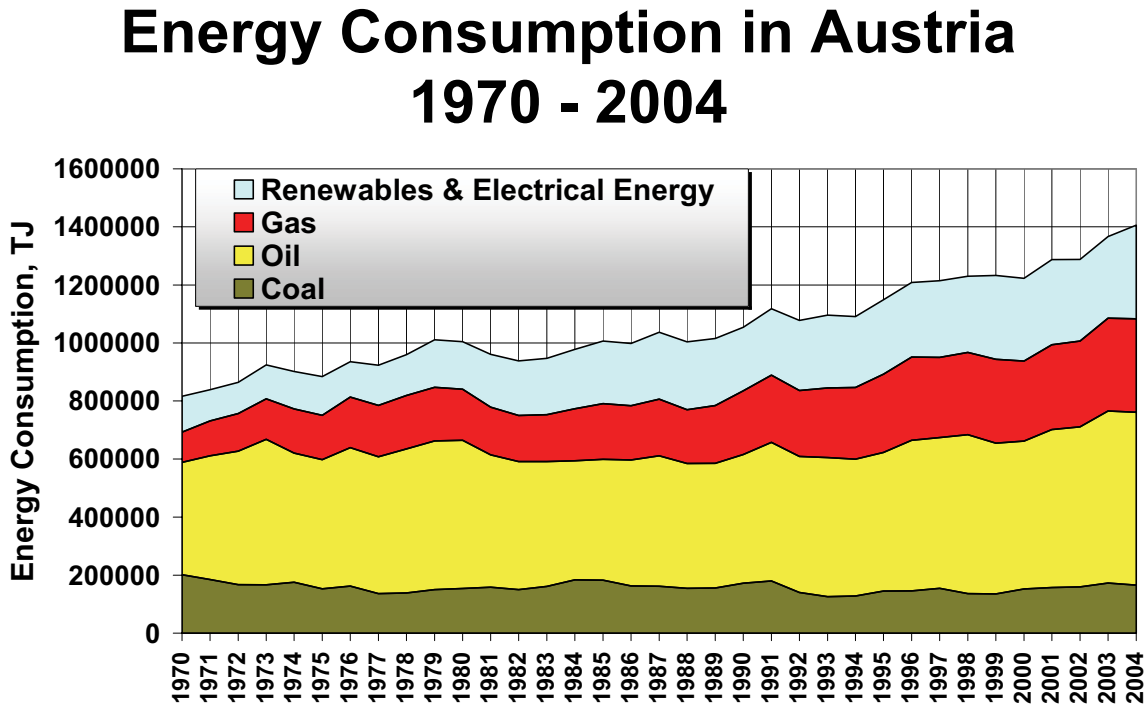


Figure 4.1: Gross energy supply In Austria: 1970 – 2004
(Source: Statistik Austria)

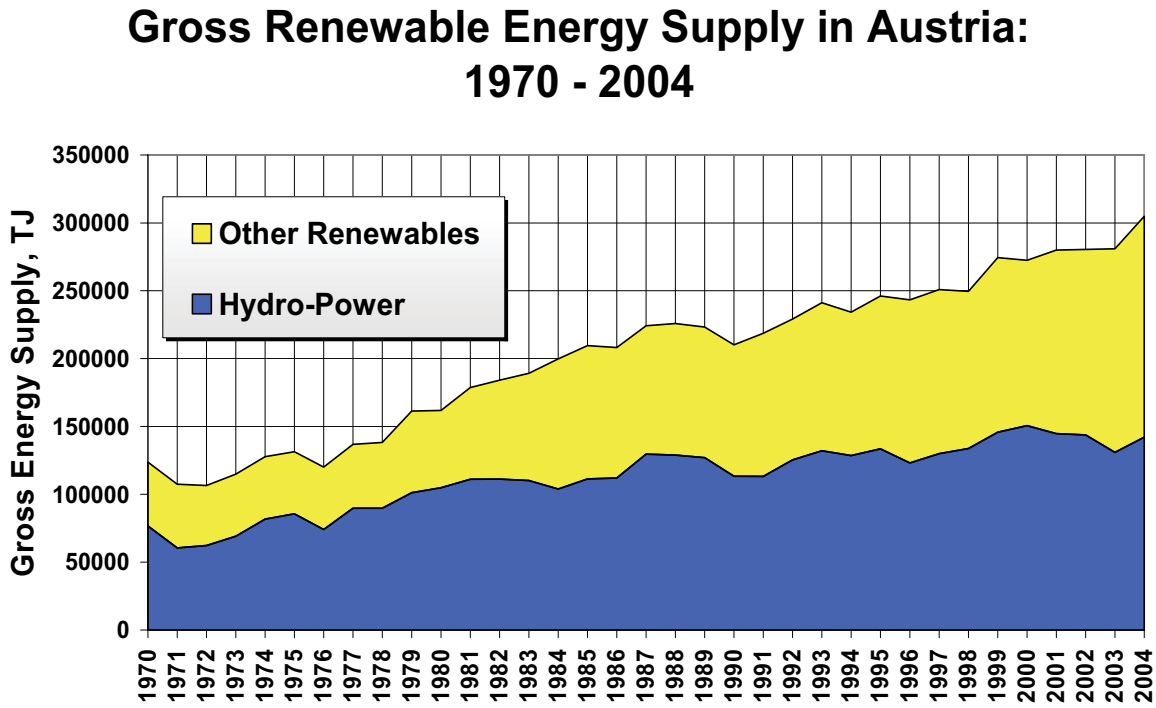


Figure 4.2: Gross hydro- and other renewable energy supply In Austria: 1970 – 2003
(Source: Statistik Austria)

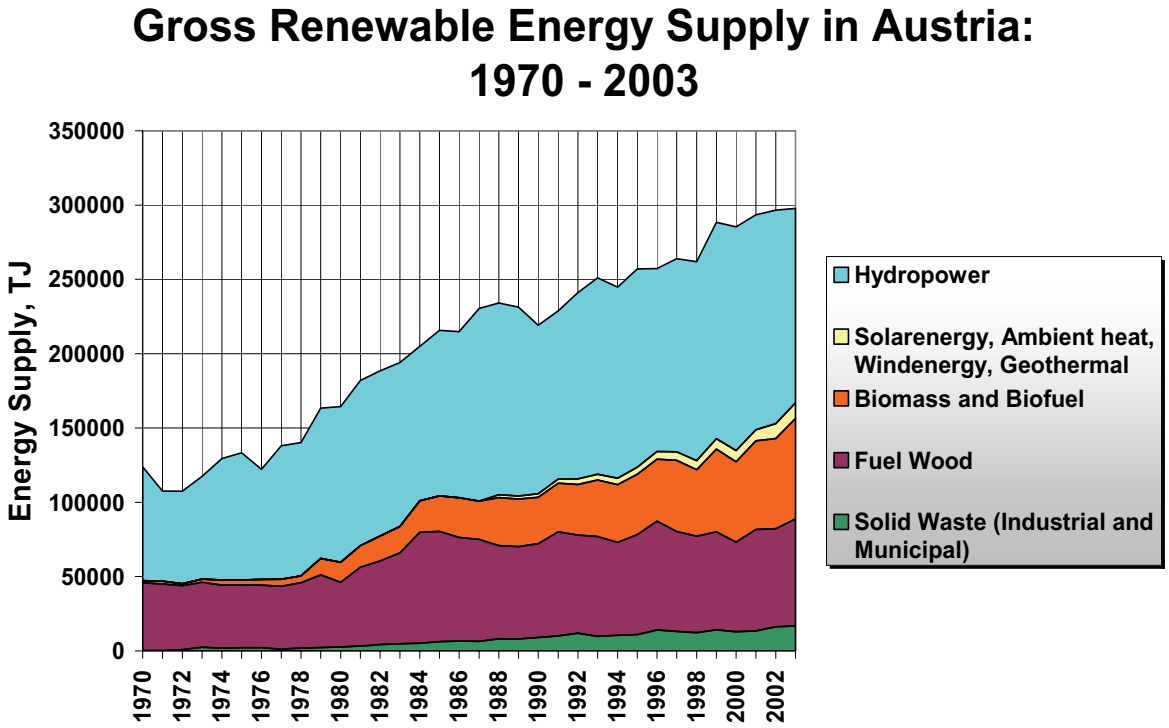


Figure 4.3: Gross Renewables energy supply In Austria: 1970 – 2003 (Source: Statistik Austria)

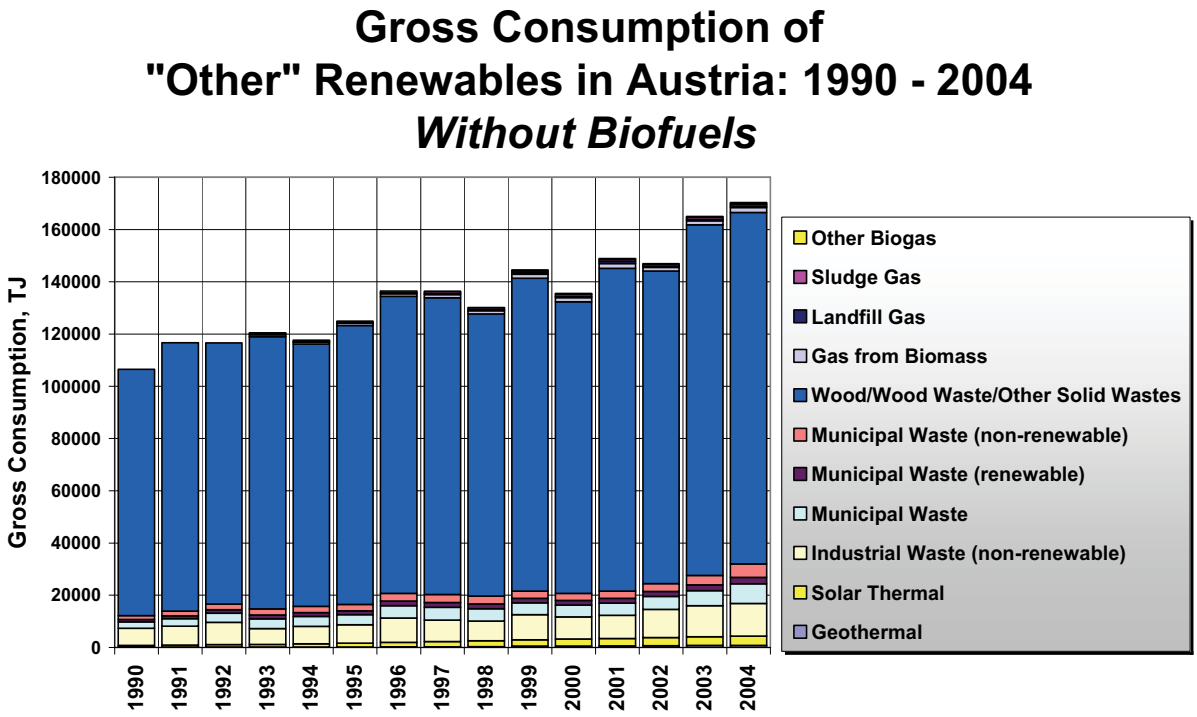


Figure 4.4: Gross "other" Renewables energy supply In Austria: 1990 – 2004 (Source: Statistik Austria)

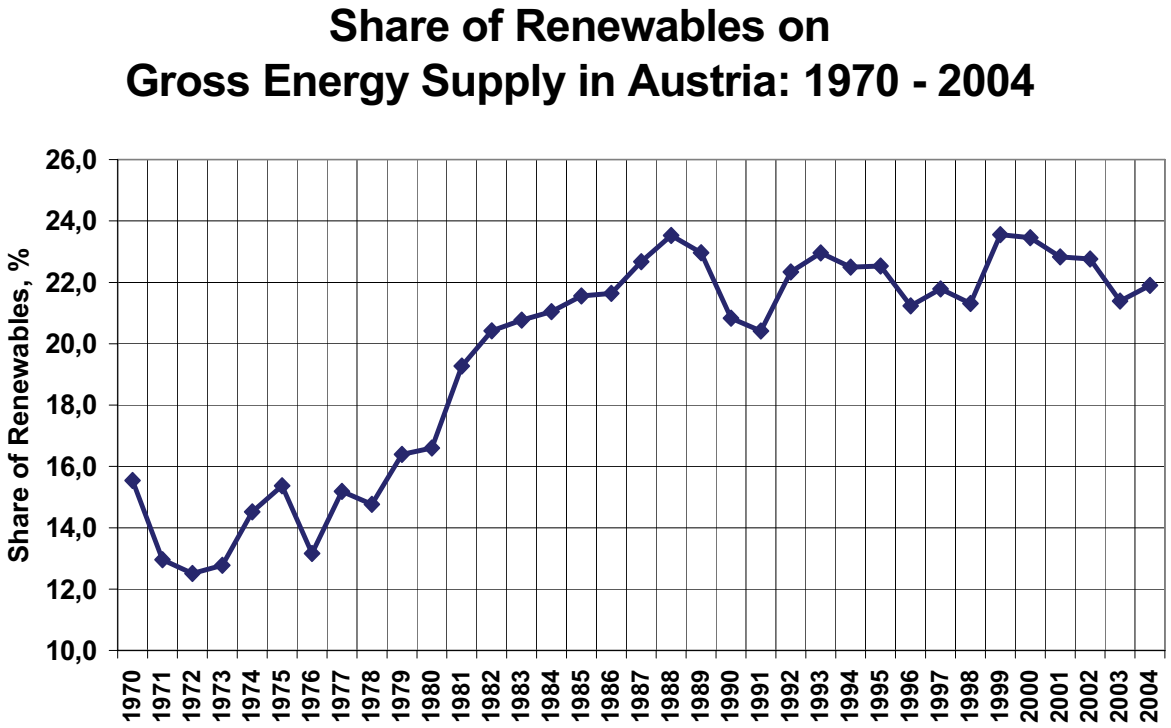


Figure 4.5a: Share of Renewables on energy supply In Austria: 1970 – 2004
(Source: Statistik Austria)

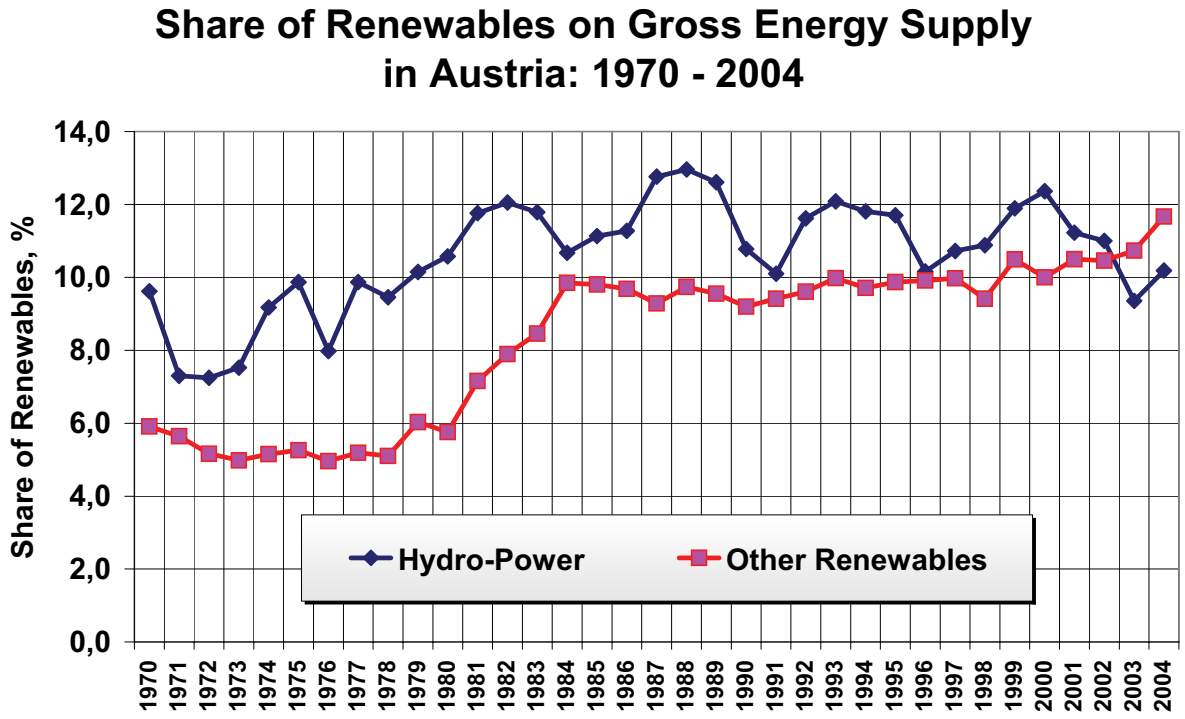


Figure 4.5b: Share of hydropower and other Renewables on energy supply In Austria: 1970 – 2004
(Source: Statistik Austria)

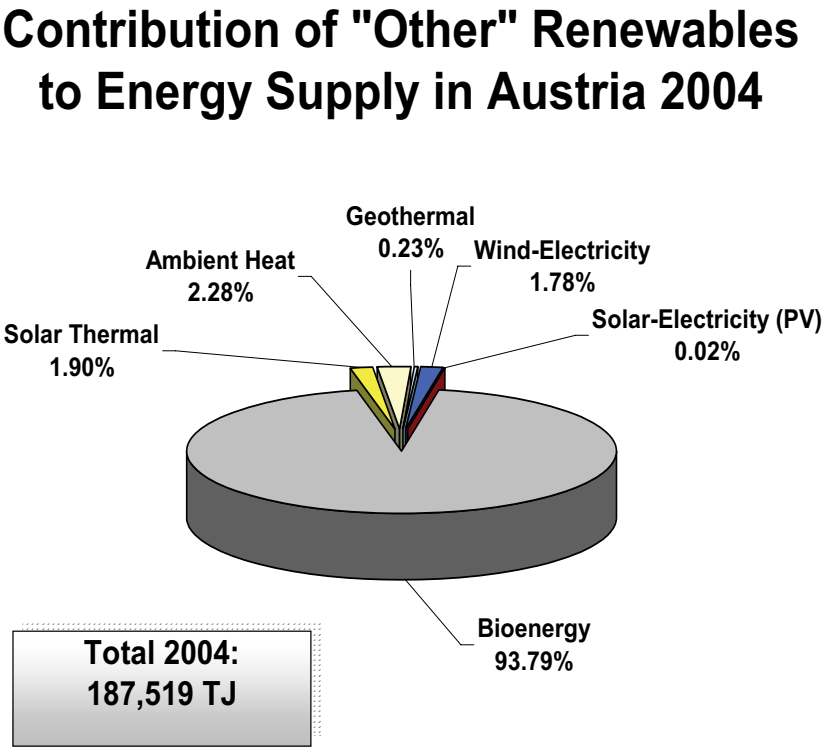


Figure 4.6: Contribution of „Other“ Renewables to energy supply In Austria 2004

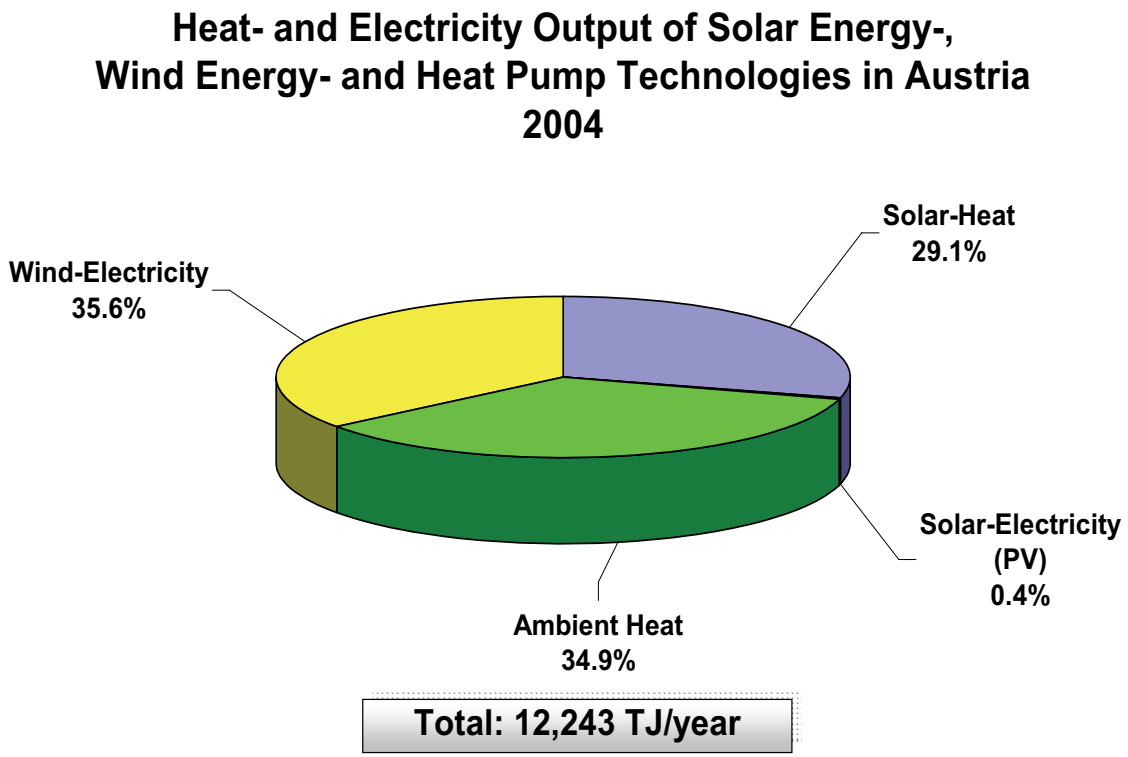


Fig. 4.7a: Heat-/electricity-output of solar energy-, wind energy, and heat pump technologies In Austria 2004

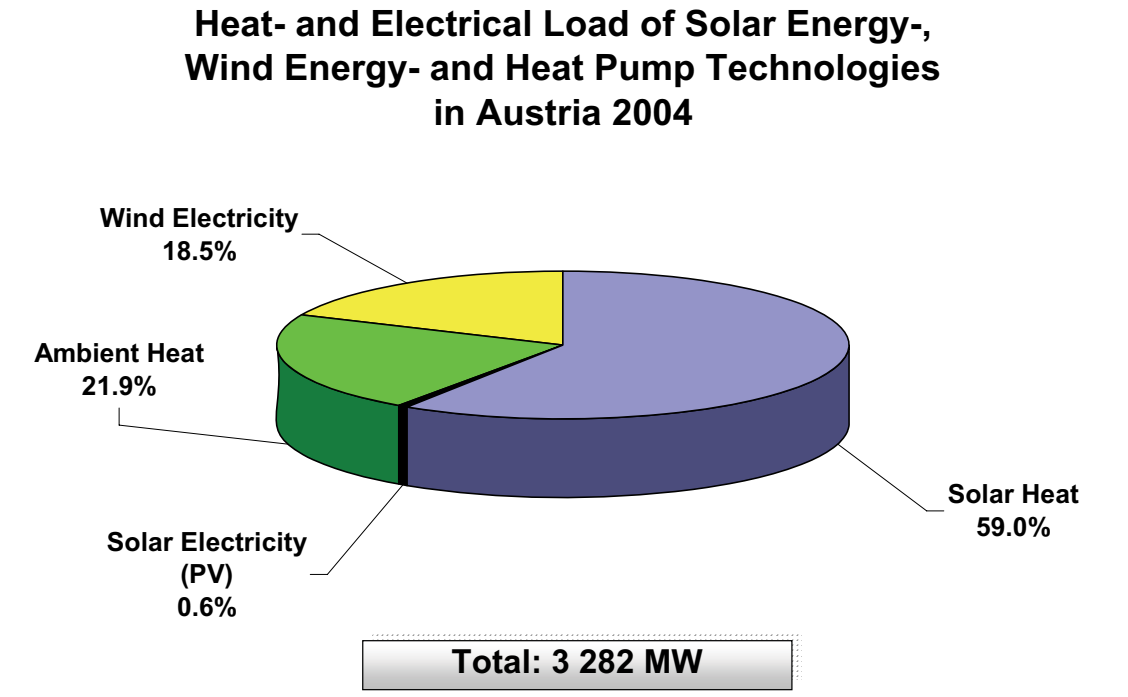


Fig. 4.7b: Heat-/electrical load of solar energy-, wind energy, and heat pump technologies In Austria 2004

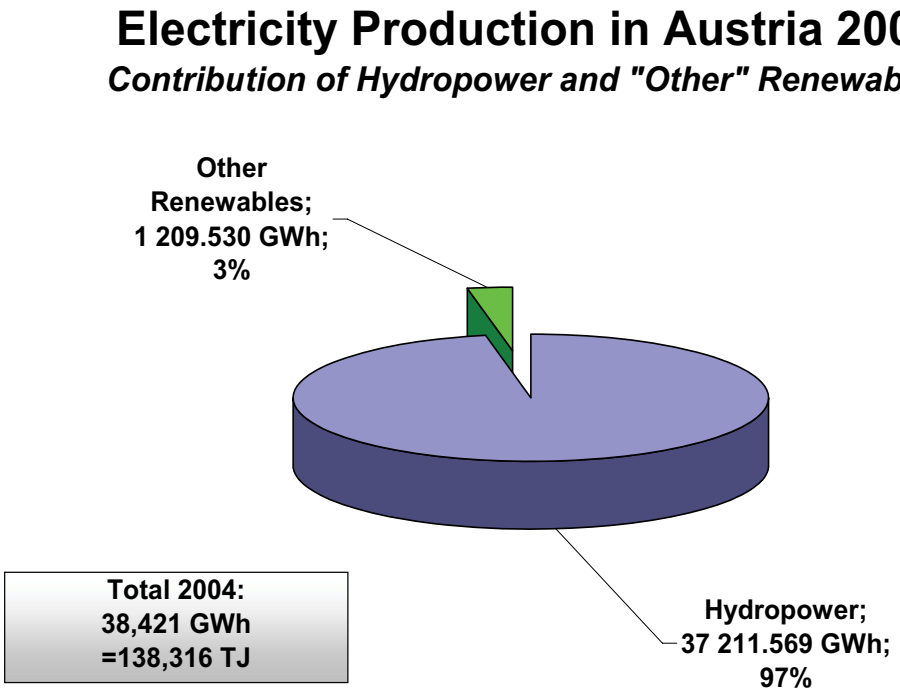


Figure 4.8: Electricity production from Hydropower and "Other" Renewables In Austria 2004

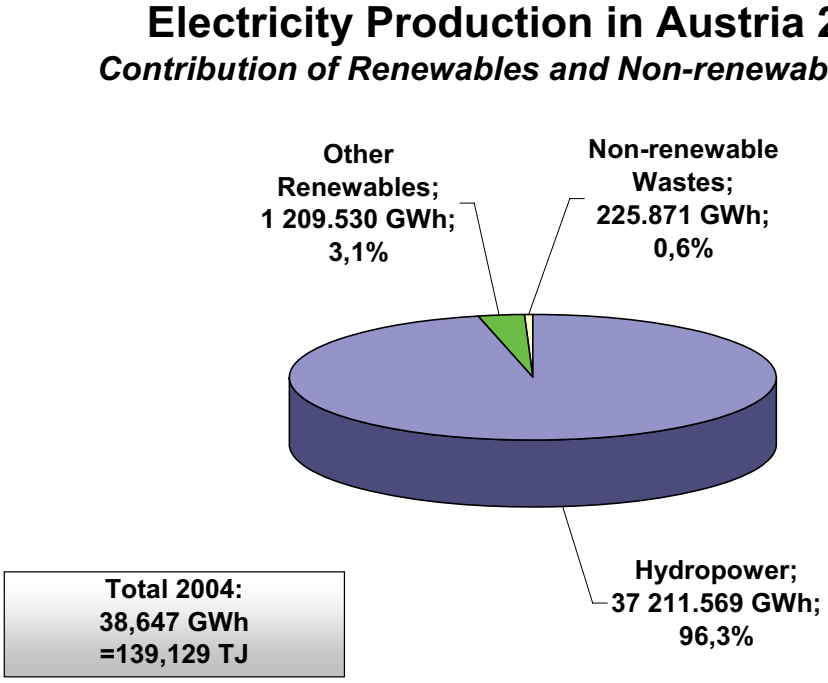


Figure 4.9: Contribution of Renewables and Non-renewable wastes on electricity production In Austria 2004

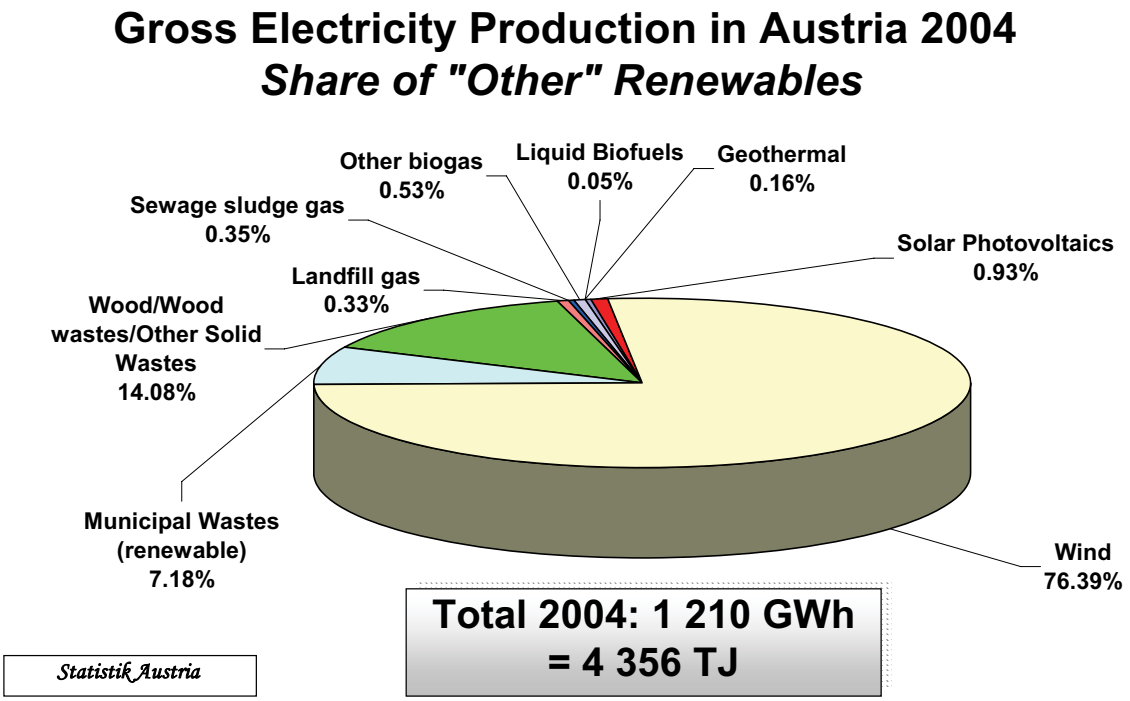


Figure 4.10: Share of „Other“ Renewables on electricity production In Austria 2004

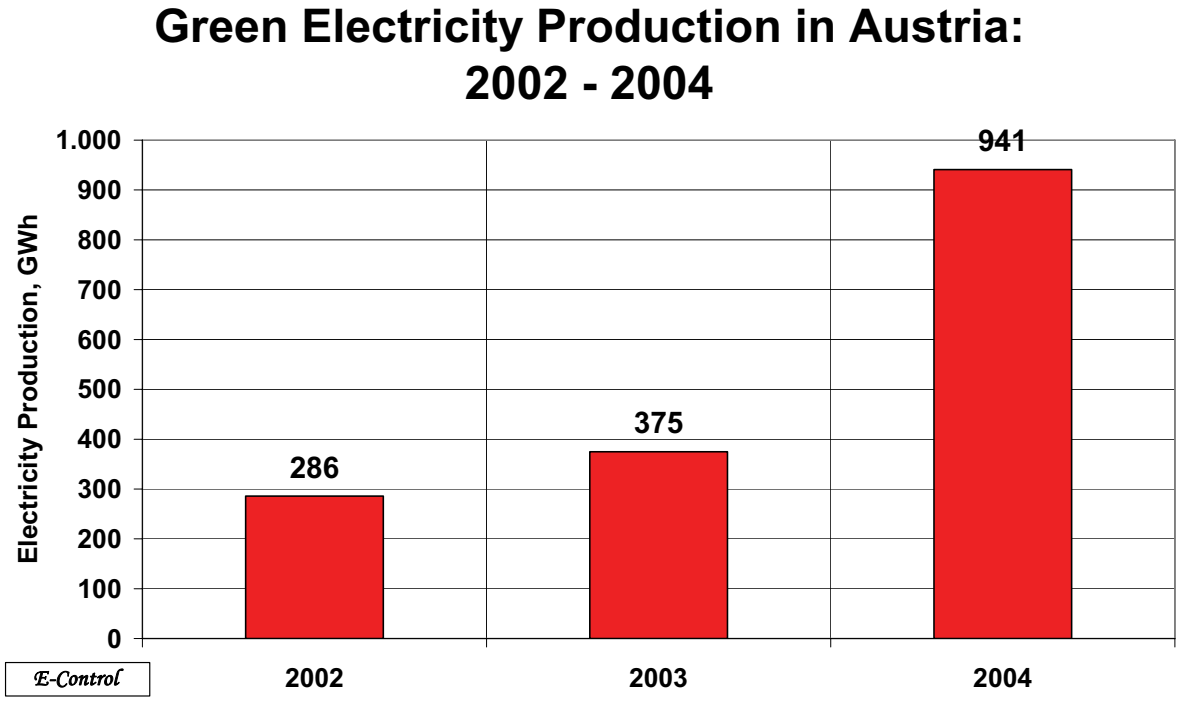


Figure 4.11: Green electricity production In Austria 2002 – 2004 (Source: E-Control)

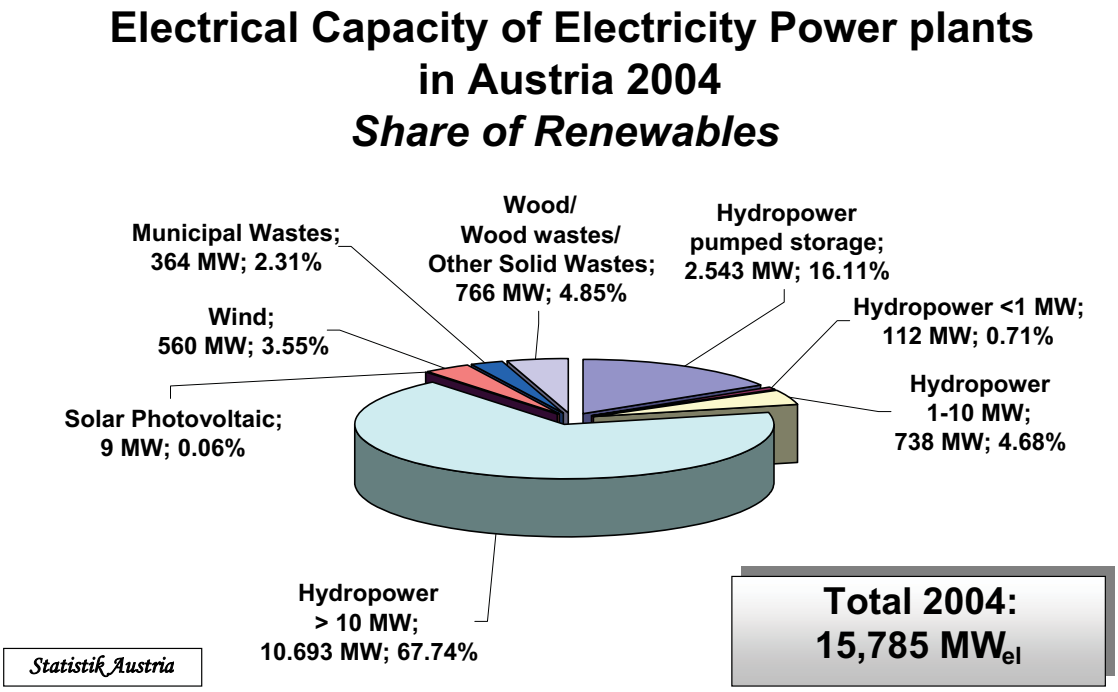


Figure 4.12: Electrical capacity of power plants in Austria 2004: Share of Renewables

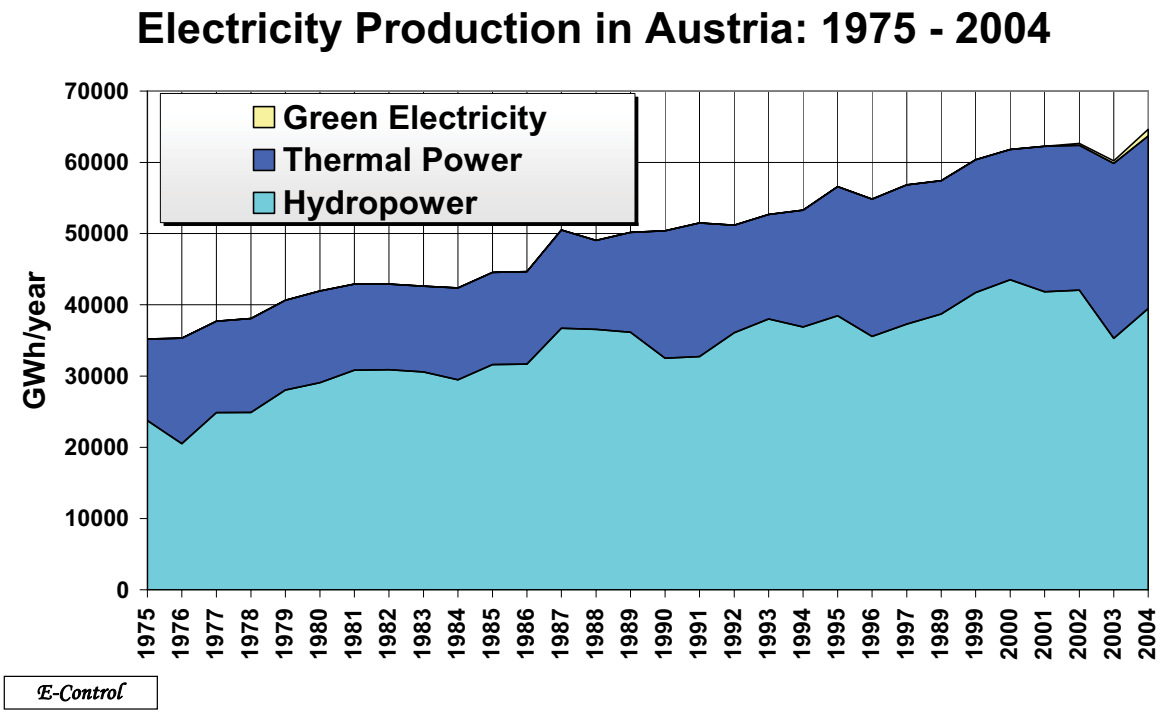


Figure 4.13a: Electricity production In Austria: 1975 – 2004
(Source: E-Control)

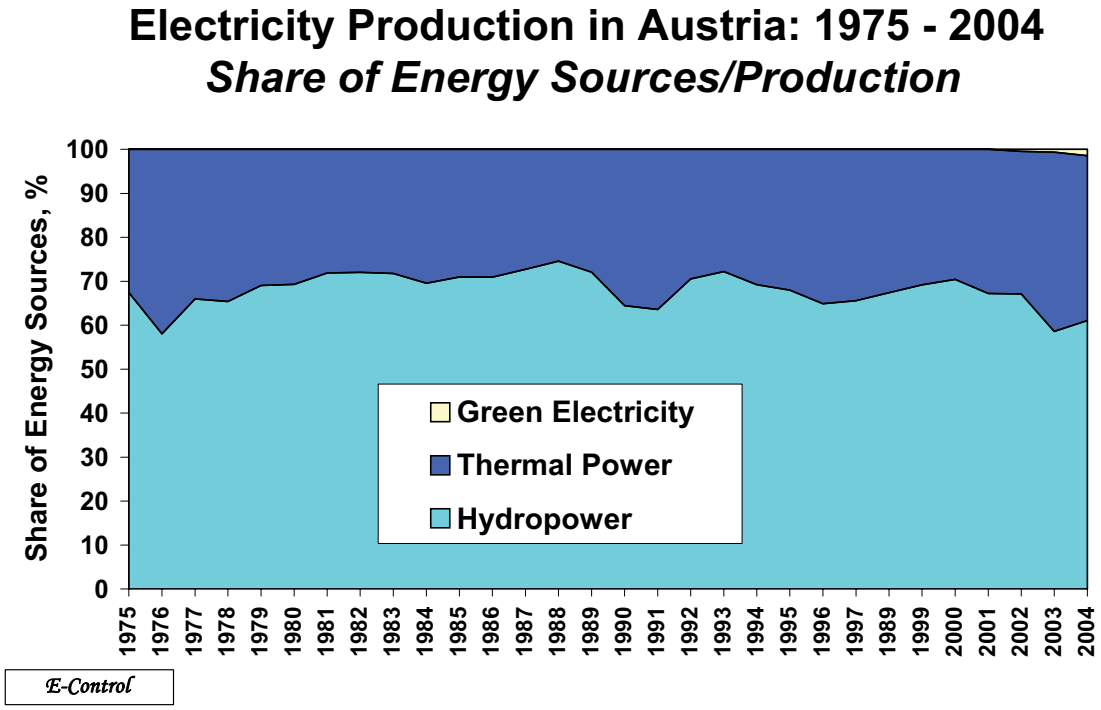


Figure 4.13b: Share of power plants on electricity production In Austria: 1975 – 2004
(Source: E-Control)

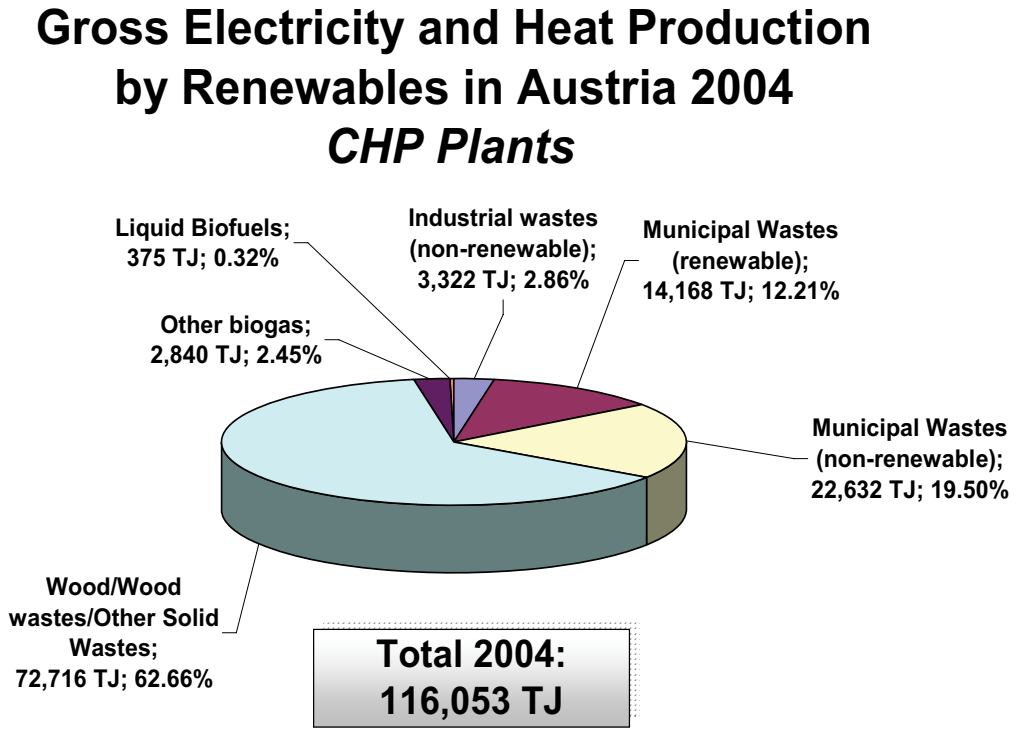


Figure 4.14a: Gross electricity and heat production by Renewables In Austria 2004 (Source: Statistik Austria)

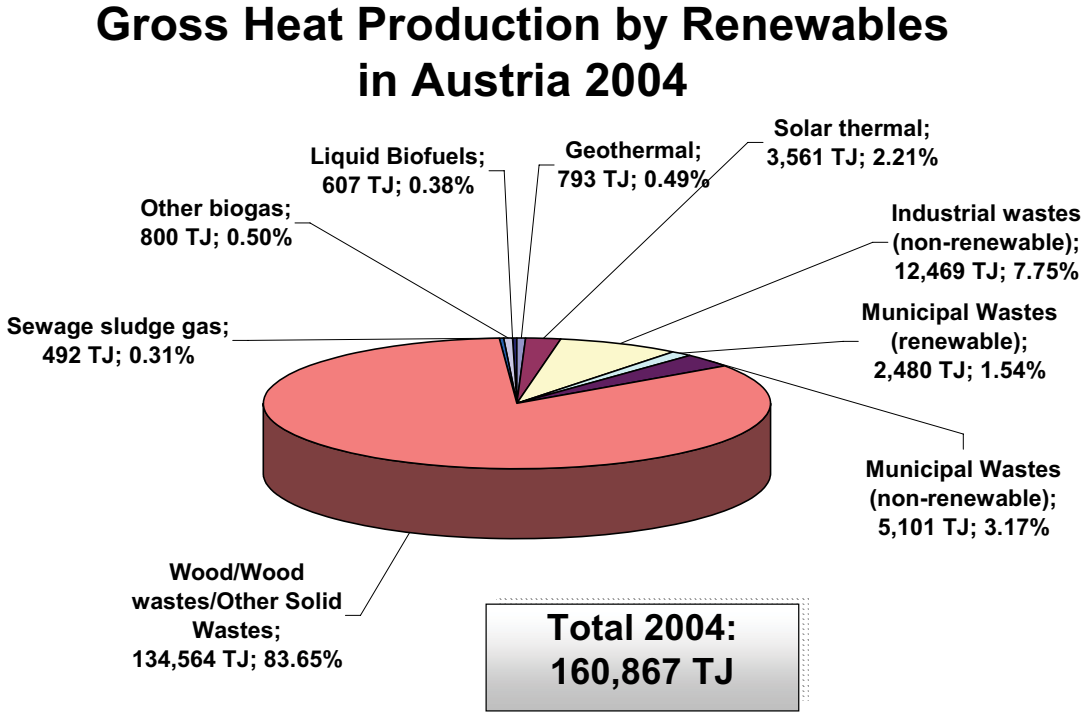


Figure 4.14b: Gross heat production by Renewables In Austria 2004 (Source: Statistik Austria)

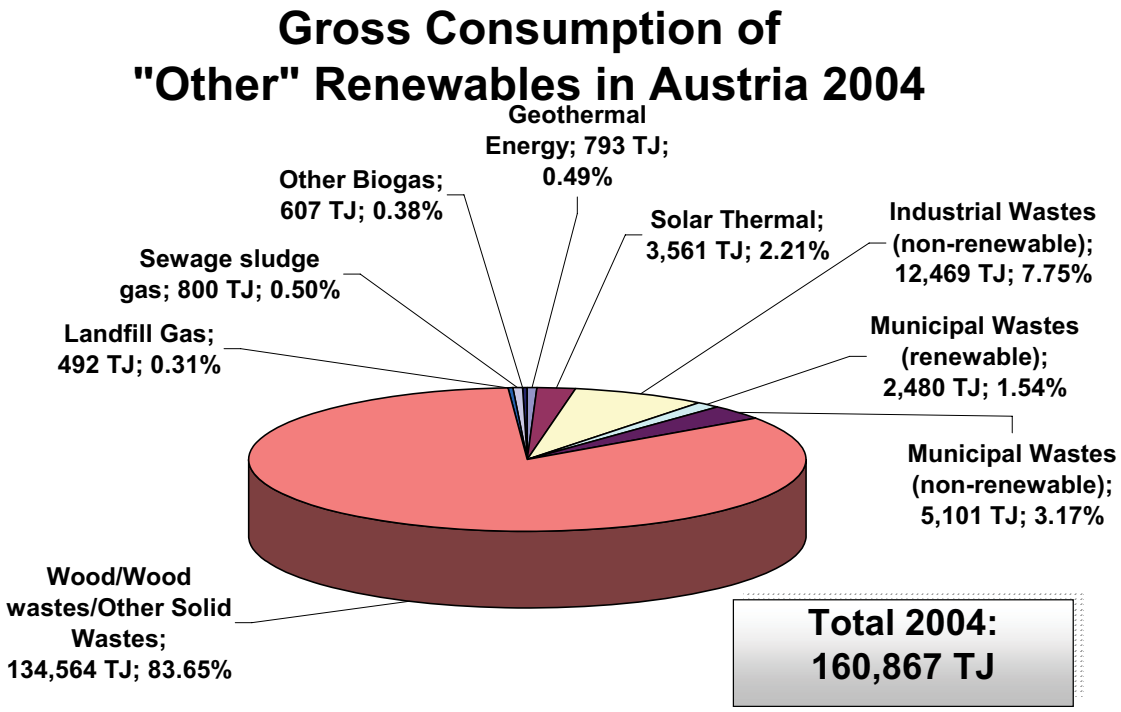


Figure 4.15a: Gross consumption of "other" Renewables In Austria 2004 (Source: Statistik Austria)

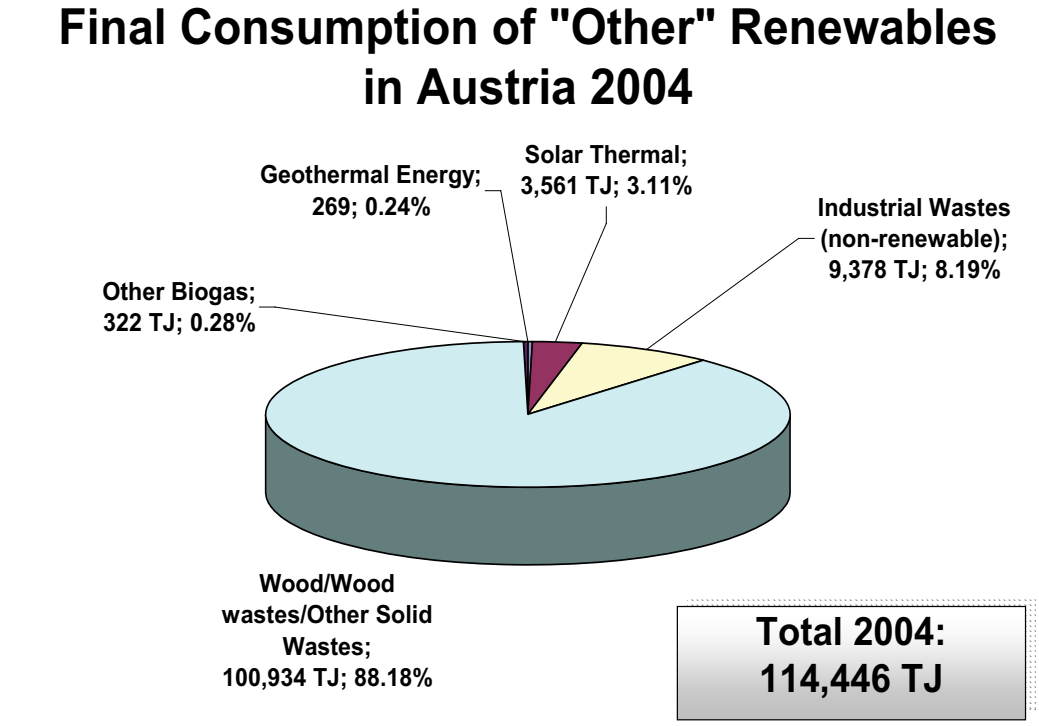


Figure 4.15b: Final consumption of "other" Renewables In Austria 2004 (Source: Statistik Austria)

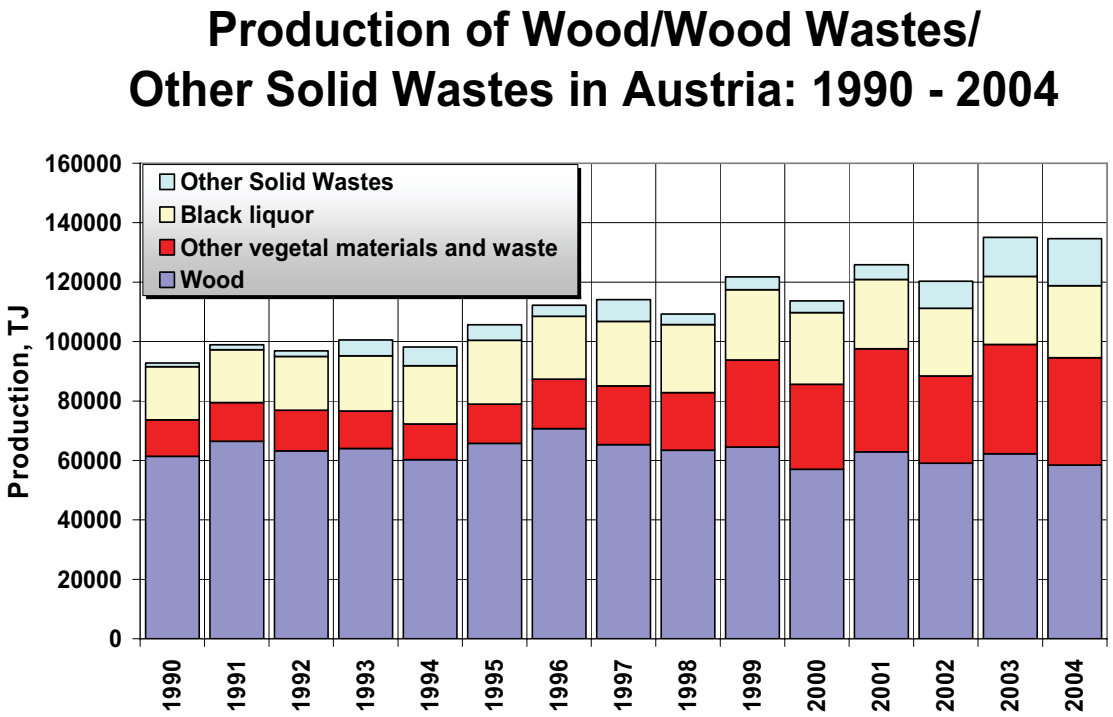


Figure 4.16a: Production of wood/wood wastes and other solid wastes In Austria: 1990 - 2004
(Source: Statistik Austria)

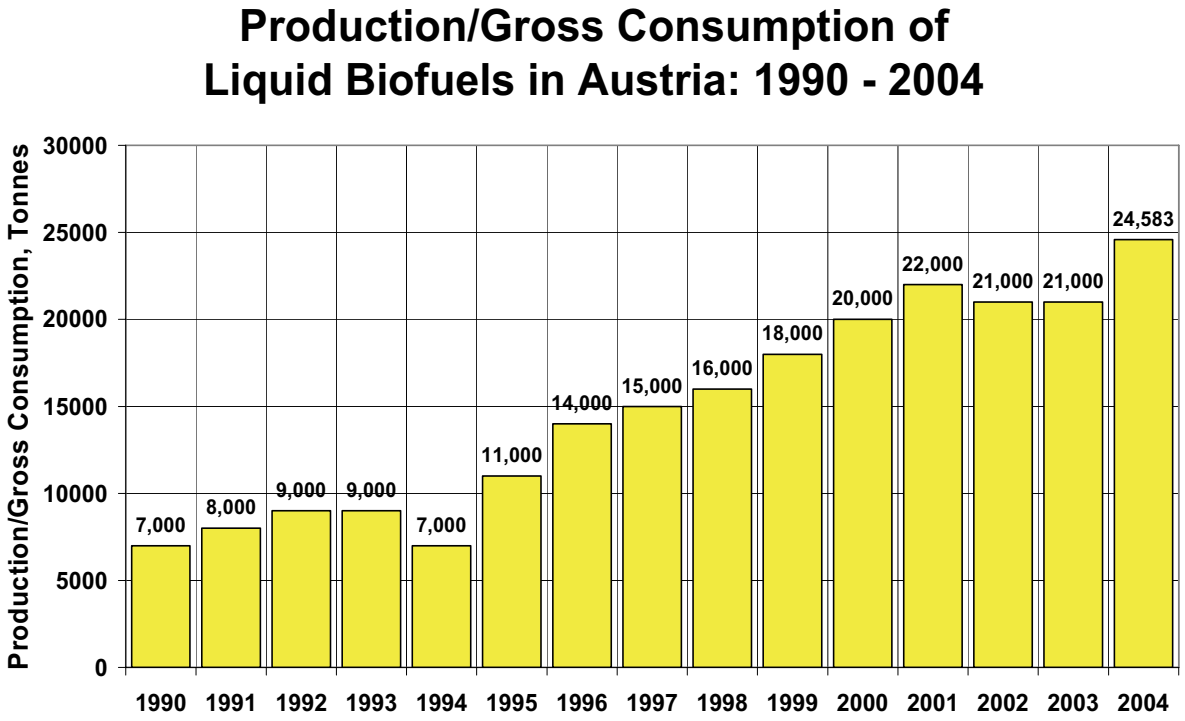


Figure 4.16b: Production of liquid bio-fuels In Austria: 1990 - 2004
(Source: Statistik Austria)

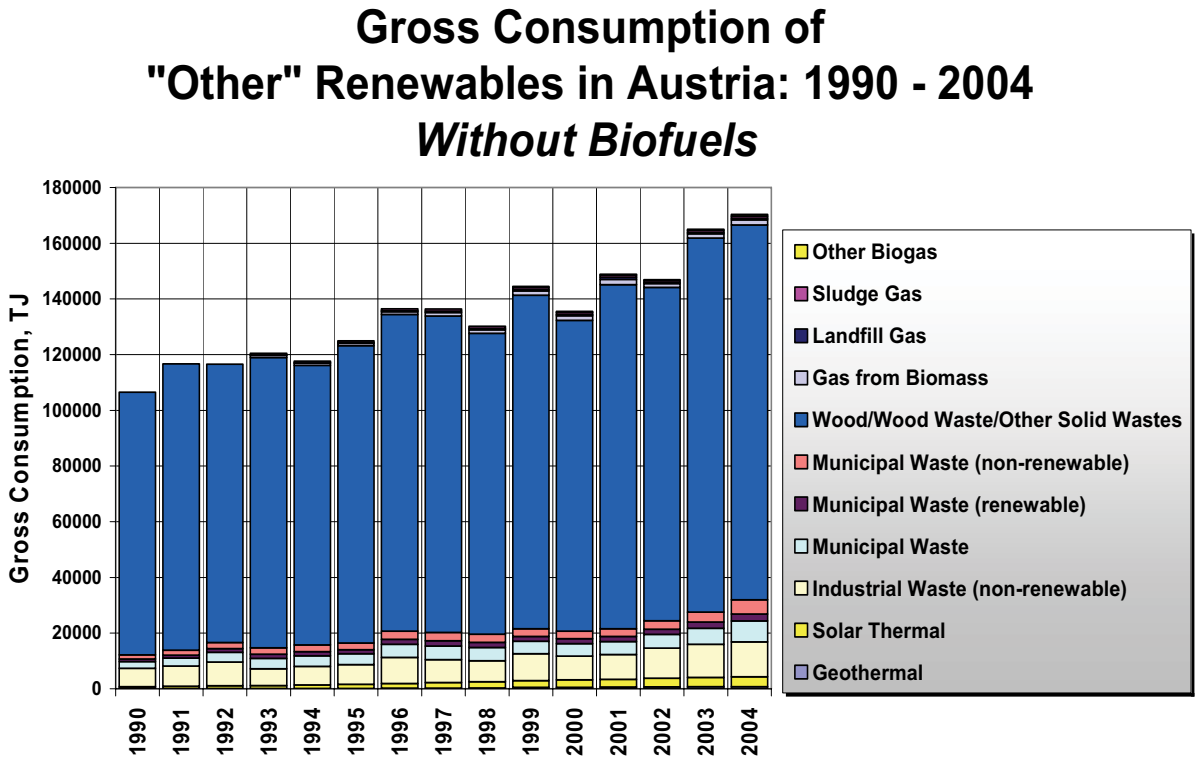


Figure 4.16c: Gross consumption of "other" Renewables In Austria: 1990 - 2004 (Source: Statistik Austria)

5. Development of Energy Supply in Austria

The development of energy consumption in Austria in the time period 1970 – 2004 is illustrated in Fig. 5.1. Gross energy / final energy consumption as well as the contribution of Renewables in energy supply increased: gross energy consumption with 75.02% (related to an average annual change rate of 2.21%), final energy consumption with 90.51% (related to an average annual change rate of 2.66%) and the contribution of Renewables in energy supply with 146.29% (related to an average annual change rate of 4.30%); Fig. 5.1 and Fig. 5.2. Also the share of Renewables in energy supply increased from 15.53% in the year 1970 to 21.86% in the year 2004 (related to gross energy consumption) and from 21.50% in 1970 to 27.79% in 2004 (related to final energy consumption).

Even if Renewables production has increased remarkable since 1970, the share of Renewables in energy supply did not growth at the same level. This means that Renewables just could keep pace with the overall increase in energy demand but more needs to be done to expand their shares in the fuel mix.

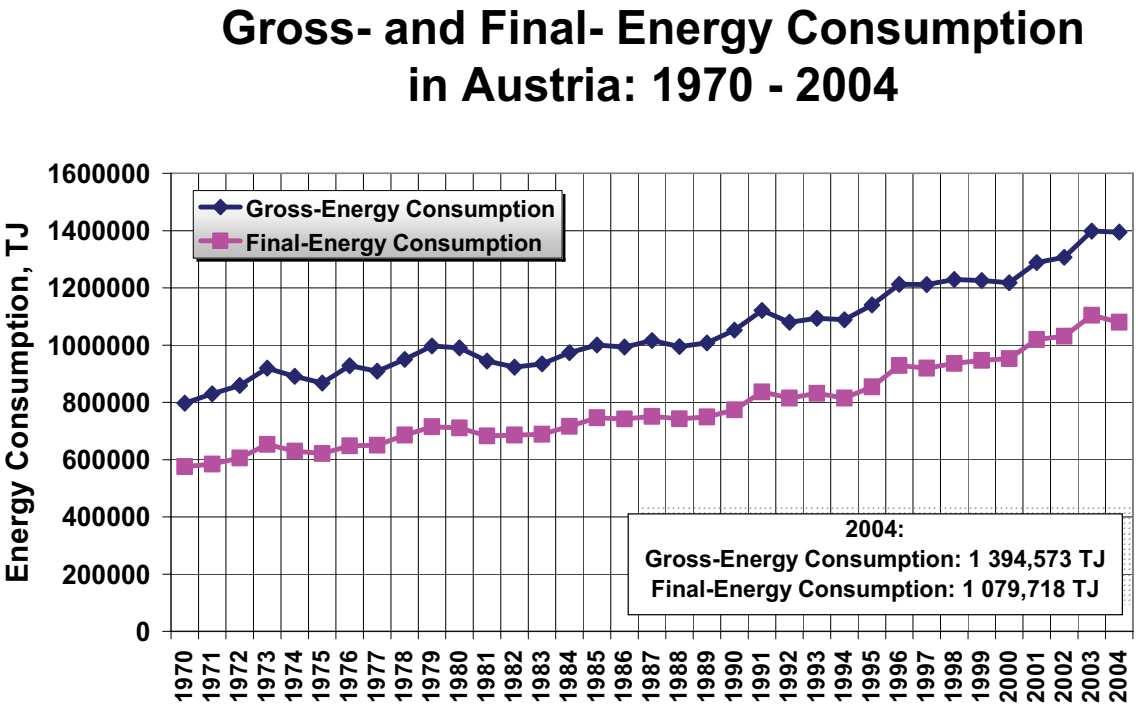
The gross-consumption of Renewables and wastes from 1990 – 2004 is shown in Fig. 5.3, and the share of Renewables and wastes in the energy consumption in the year 2004 in Fig. 5.4.

The gross energy supply related to energy sources is shown in Fig. 5.5a for 2003 and in Fig. 5.5b for 2004. Oil is dominating with about 43%, followed by gas with 23% and Renewables with about 21%. Fig. 5.6a and Fig. 5.6b illustrate the final energy supply for 2004 and 2004.

The gross energy consumption in Austria from 1970 to 2004 and related to energy sectors is shown in Fig. 5.7a and in Fig. 5.7b. Fig.5.8a and Fig. 5.8b show the share of energy consumption sectors in the year 2003 and 2004. The largest energy consumer with about 30% is the transportation sector, followed from the production and household sectors with both about 27%- 28%, the energy service sector with about 12% and the agriculture sector with about 2.4%. The market development of energy supply in the different supply sectors is illustrated in Fig. 5.9a, and in the year 2004 in Fig. 5.9b. The transportation sector is leading with 31.8%, follows by space heating, air-conditioning and hot water preparation with 29.3%.

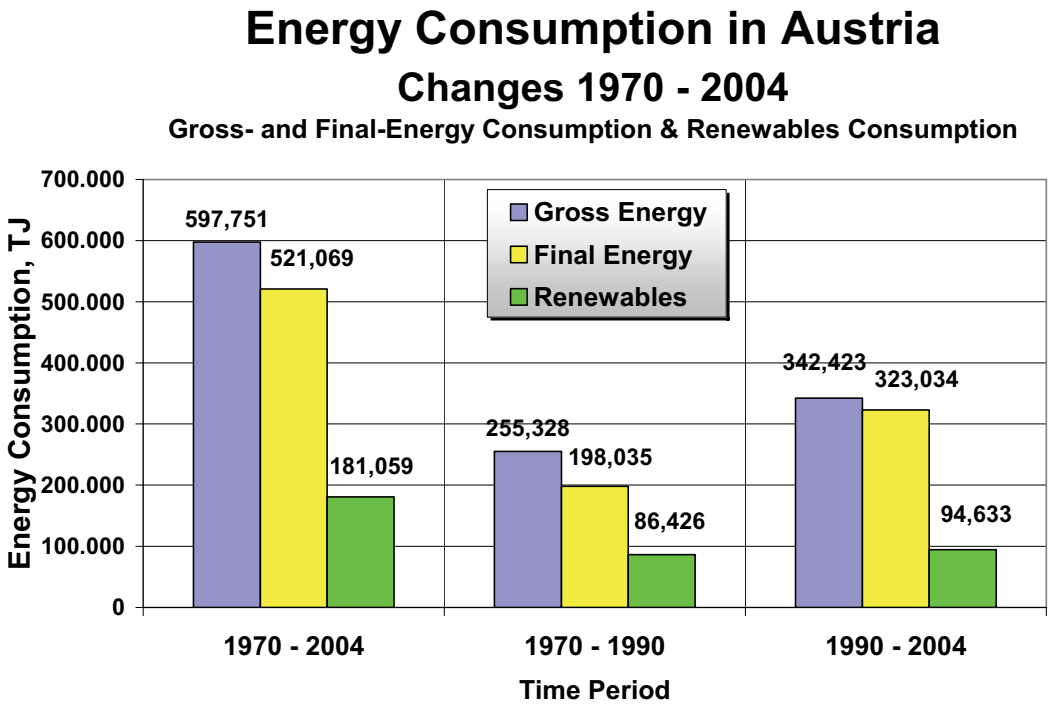
The total electricity supply was in 2003 62,916 GWh (Fig. 5.10a) and in 2004 64,776 GWh; Fig. 5.10b. The grid losses are of about 5.2% to 5.3% and the internal electricity supply of about 3.1% to 3.2%.

The market development as well as the electricity production in Austria from 1970 to 2004 is characterized in Chapter 4.



The Change of Energy Consumption in Austria 1970 - 2004			
Gross-, Final-Energy and Renewables Consumption			
Energy Consumption, TJ			
	1970	**1990**	**2004**
Gross-Energy Consumption	796822	1052150	1394573
Final-Energy Consumption	575725	773760	1079718
Renewables Consumption	123770	210196	304829
Change in Energy Consumption, TJ			
	1970 - 2004	**1970 - 1990**	**1990 - 2004**
Gross-Energy Consumption	597751	255328	342423
Final-Energy Consumption	521069	198035	323034
Renewables Consumption	181059	86426	94633
Change in Energy Consumption, TJ			
	1970 - 2004	**1970 - 1990**	**1990 - 2004**
Gross-Energy Consumption	597751	255328	342423
Final-Energy Consumption	503993	198035	305958
Renewables Consumption	181059	86426	94633
Change in Energy Consumption, %			
	1970 - 2004	**1970 - 1990**	**1990 - 2004**
Gross-Energy Consumption	75,02	32,04	32,55
Final-Energy Consumption	87,54	34,40	39,54
Renewables Consumption	146,29	69,83	45,02
Average Annual Change in Energy Consumption, %			
	1970 - 2004	**1970 - 1990**	**1990 - 2004**
Gross-Energy Consumption	2,21	1,6	2,33
Final-Energy Consumption	2,66	1,72	2,98
Renewables Consumption	4,30	3,49	3,22
Share of Renewables , %			
	1970	**1990**	**2004**
Gross-Energy Consumption	15,53	19,98	21,86
Final-Energy Consumption	21,5	19,99	28,23

Figure 5.1: Energy consumption In Austria: 1970 – 2004
(Source: Statistik Austria)



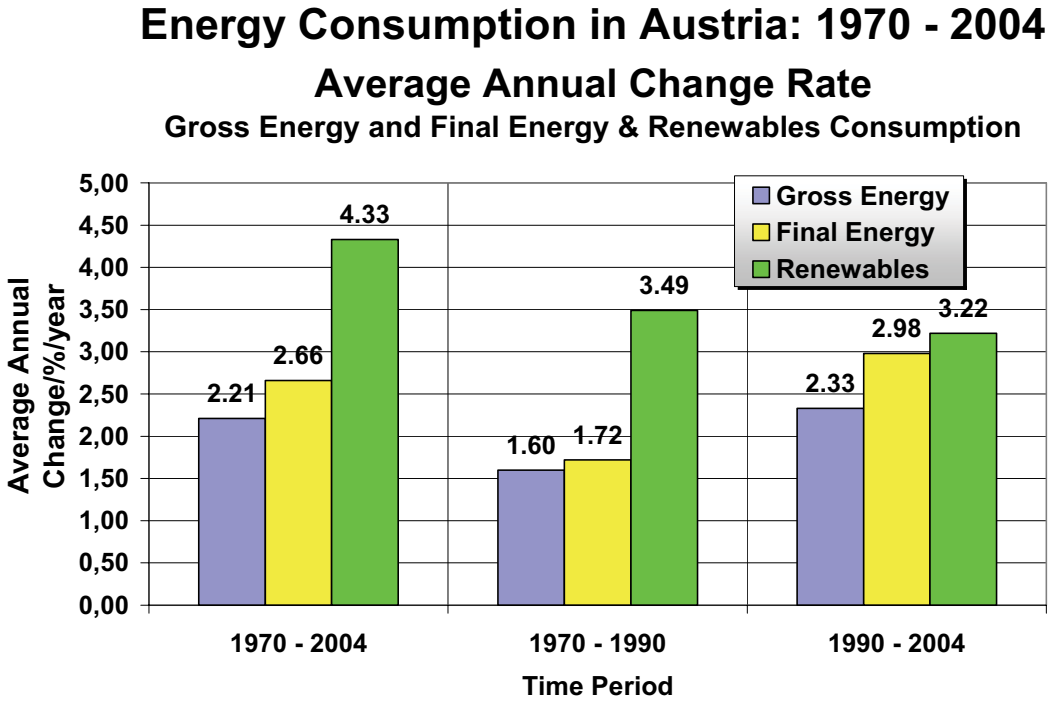


Figure 5.2: Average annual change in energy consumption In Austria: 1970 – 2004 (Source: Statistik Austria)

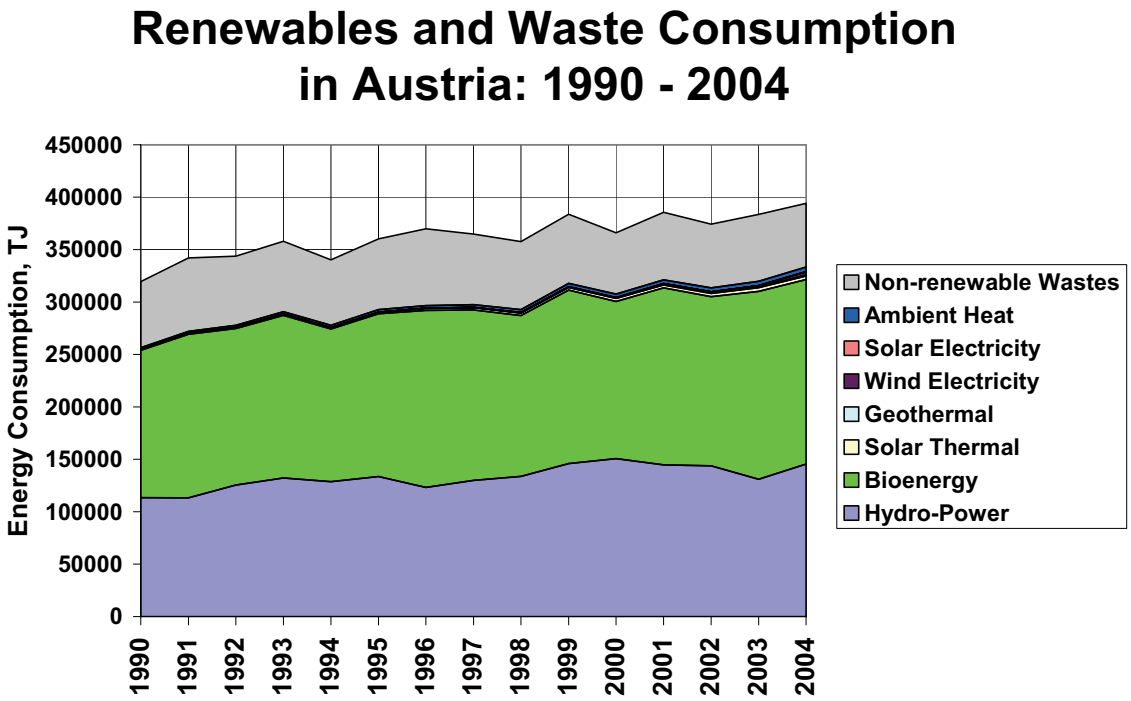


Figure 5.3: Renewables and waste consumption In Austria: 1990 – 2004 (Source: Statistik Austria)

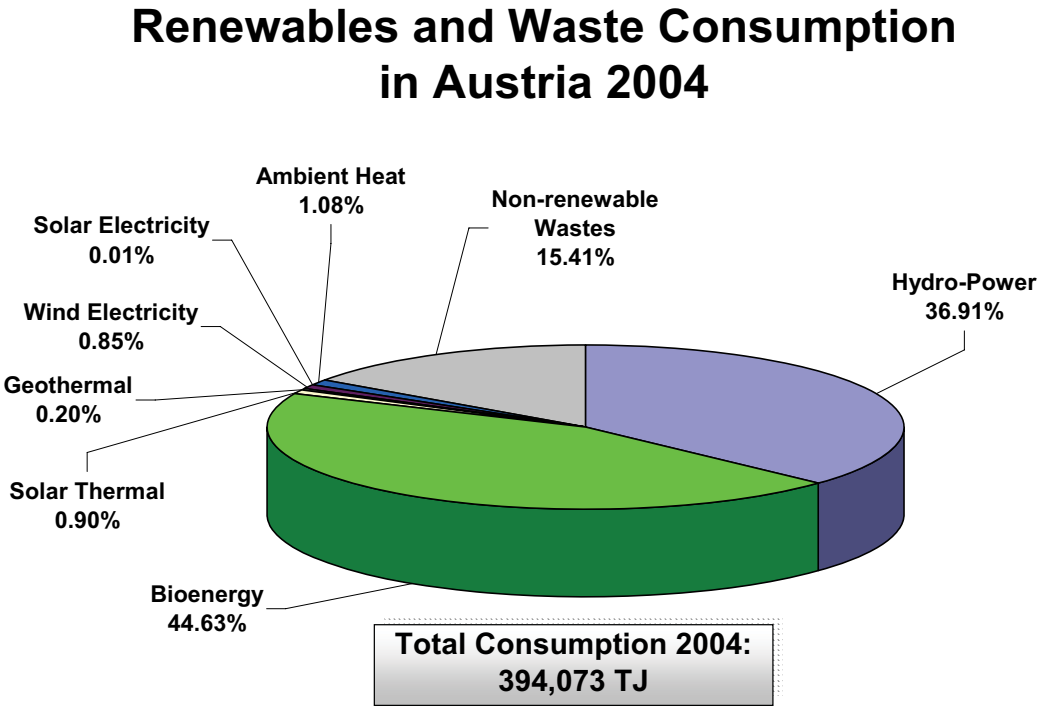


Figure 5.4: Renewables and waste consumption In Austria 2004 (Source: Statistik Austria)

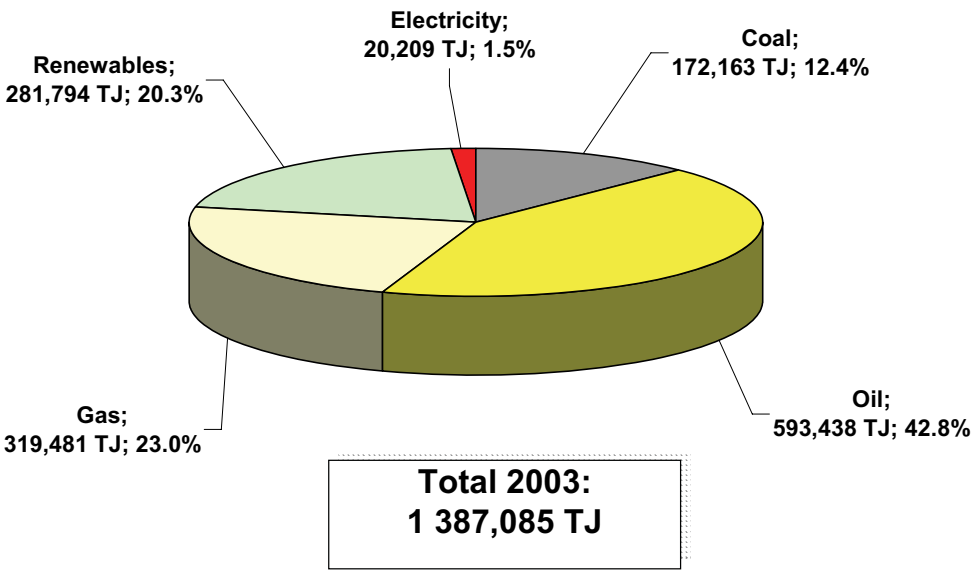


Figure 5.5a: Gross energy supply in Austria 2003
Related to energy supply sectors
(Source: Statistik Austria)

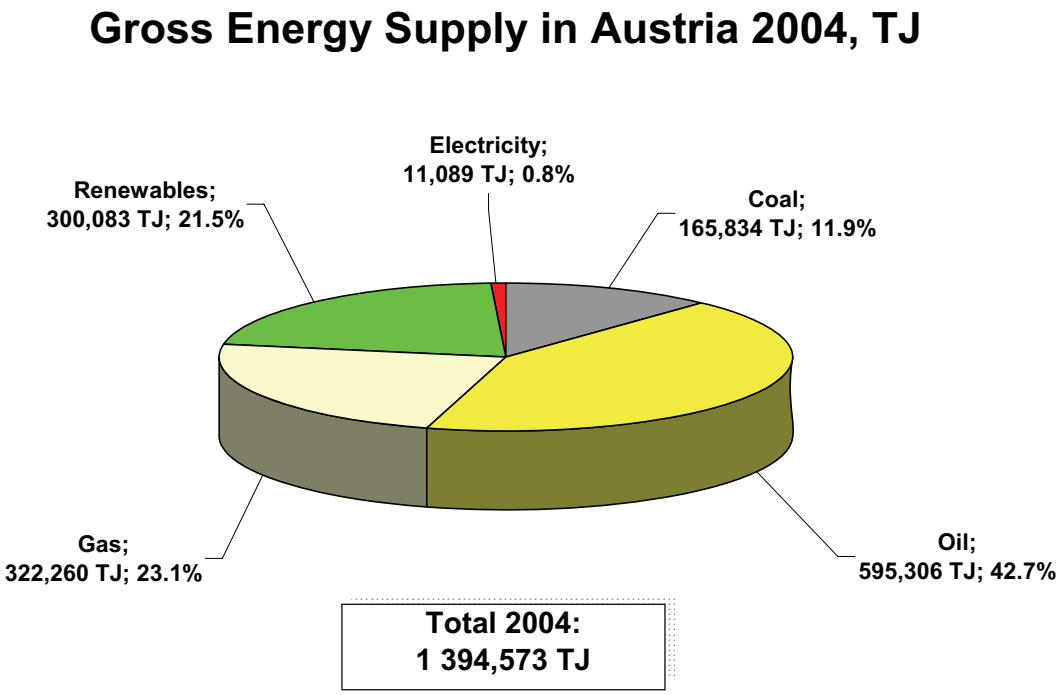


Figure 5.5b: Gross energy supply in Austria 2004
Related to energy supply sectors
(Source: Statistik Austria)

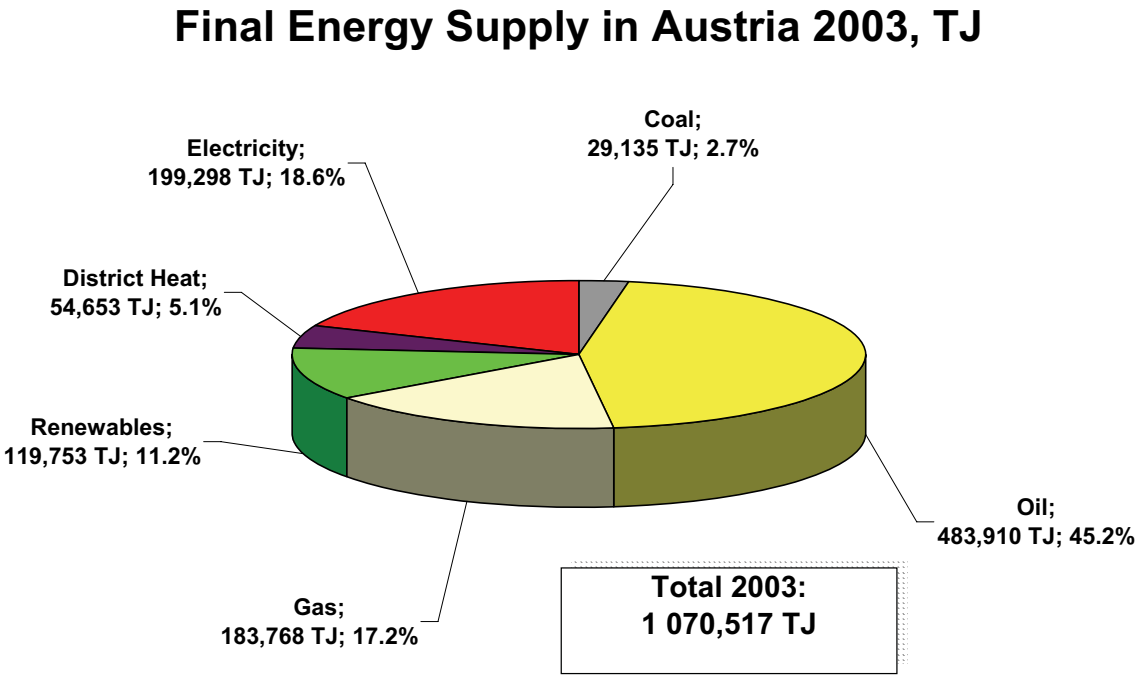


Figure 5.6a: Final energy supply in Austria 2003
Related to energy supply sectors
(Source: Statistik Austria)

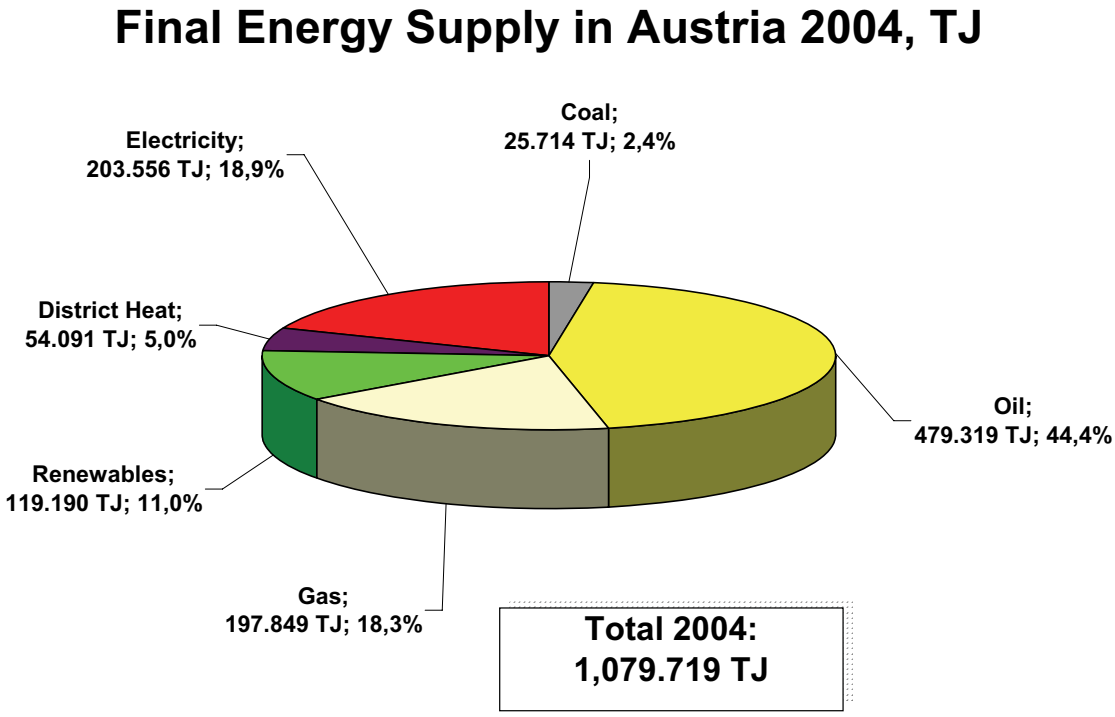


Figure 5.6b: Final energy supply in Austria 2004
Related to energy supply sectors
(Source: Statistik Austria)

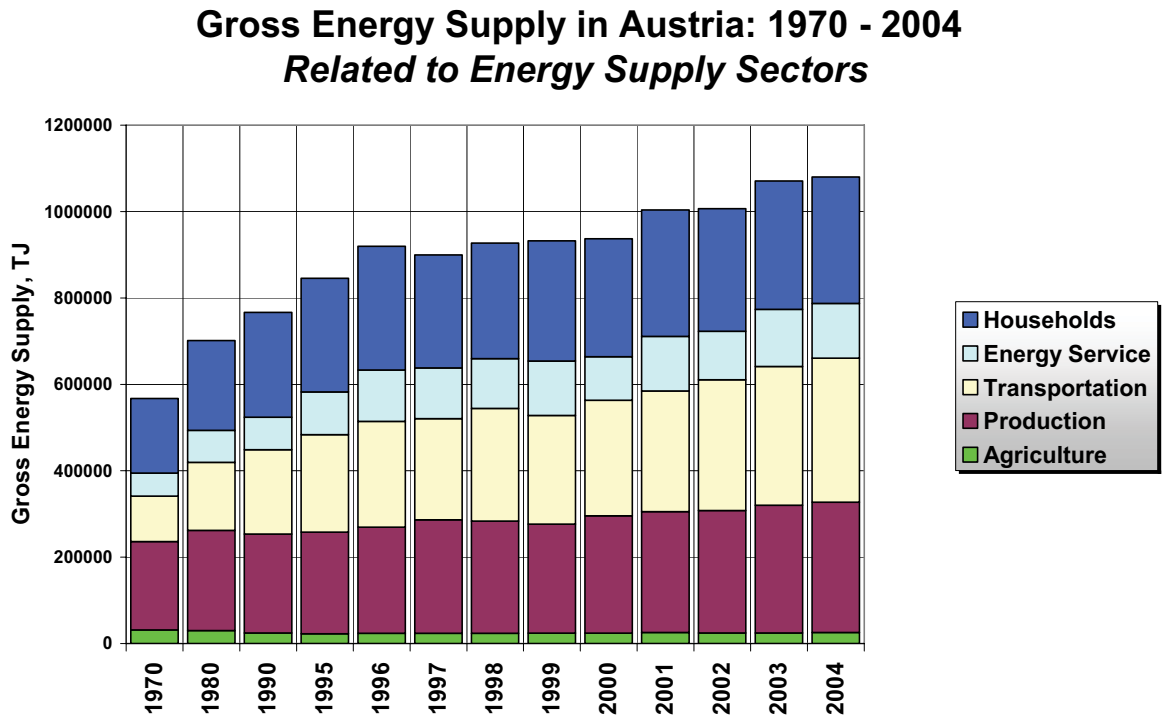


Figure 5.7a: Gross energy supply in Austria: 1970 - 2004
Related to energy supply sectors
(Source: Statistik Austria)

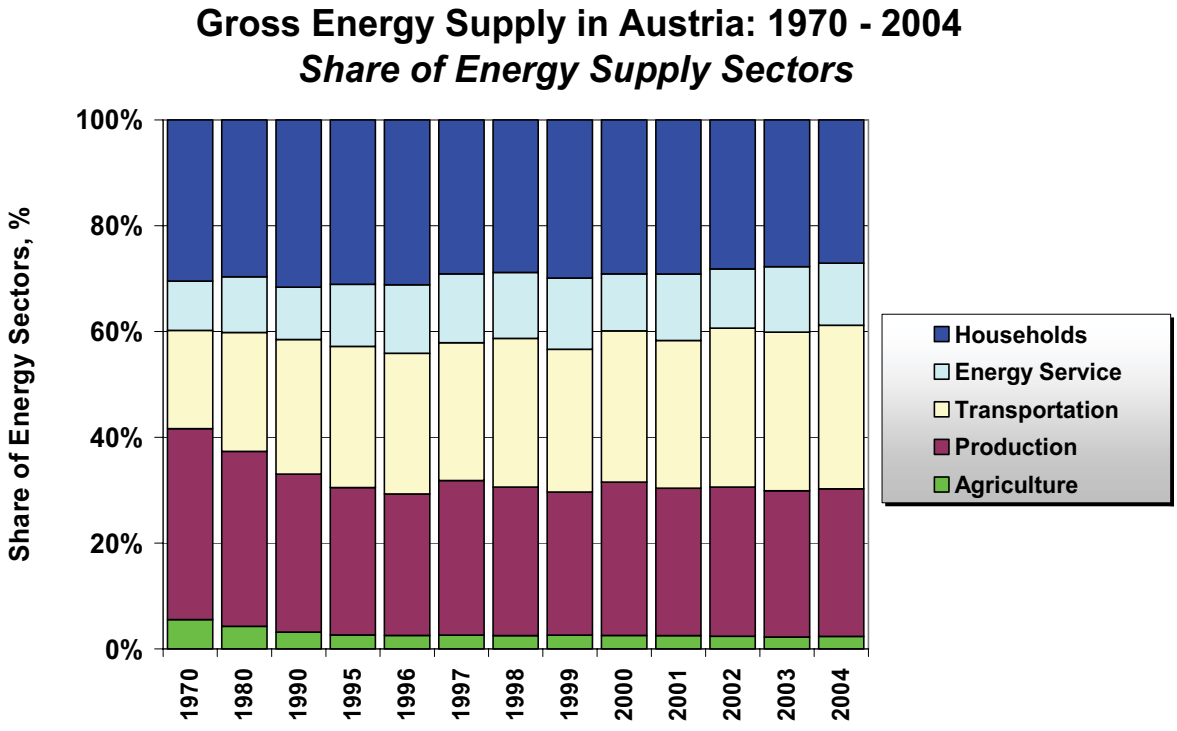


Figure 5.7b: Gross energy supply in Austria: 1970 - 2004
Share of energy supply sectors
(Source: Statistik Austria)

Gross Energy Supply in Austria 2003
Related to Energy Supply Sectors

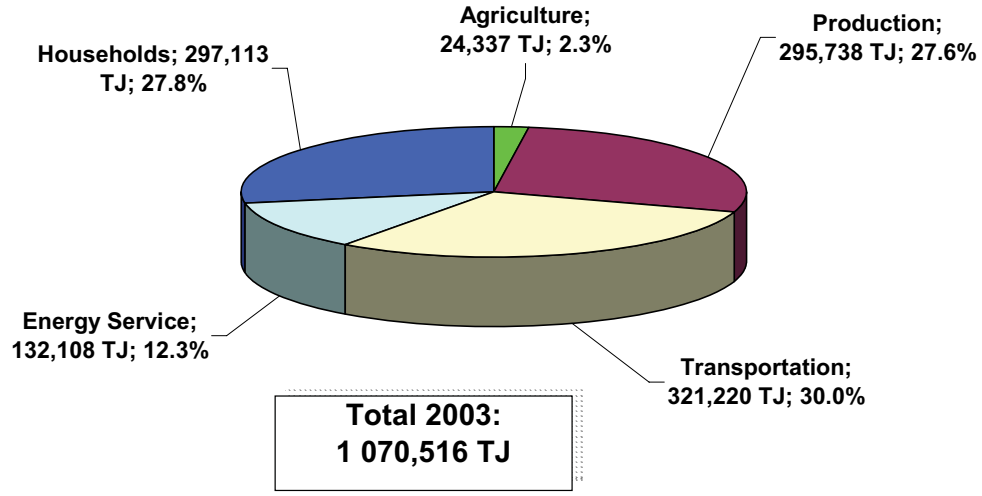


Figure 5.8a: Gross energy supply in Austria 2003
Share of energy supply sectors
(Source: Statistik Austria)

Gross Energy Supply in Austria 2004
Related to Energy Supply Sectors

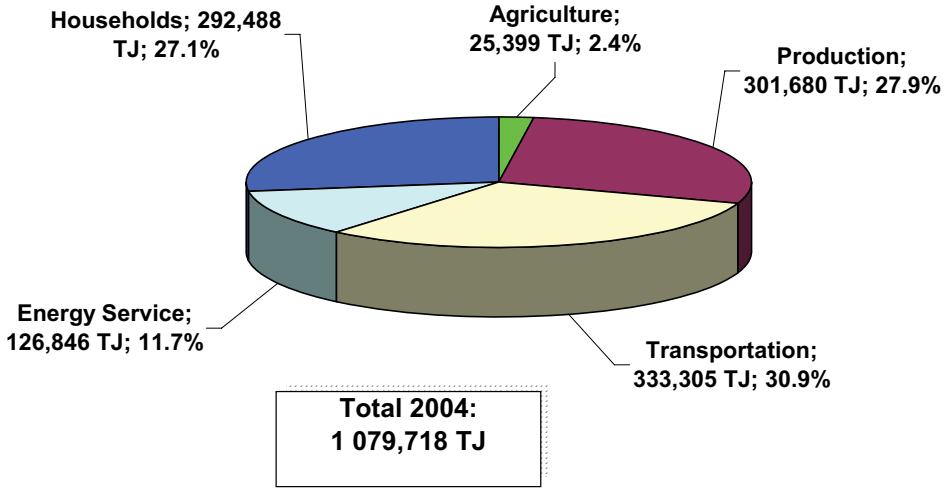


Figure 5.8b: Gross energy supply in Austria 2004
Share of energy supply sectors
(Source: Statistik Austria)

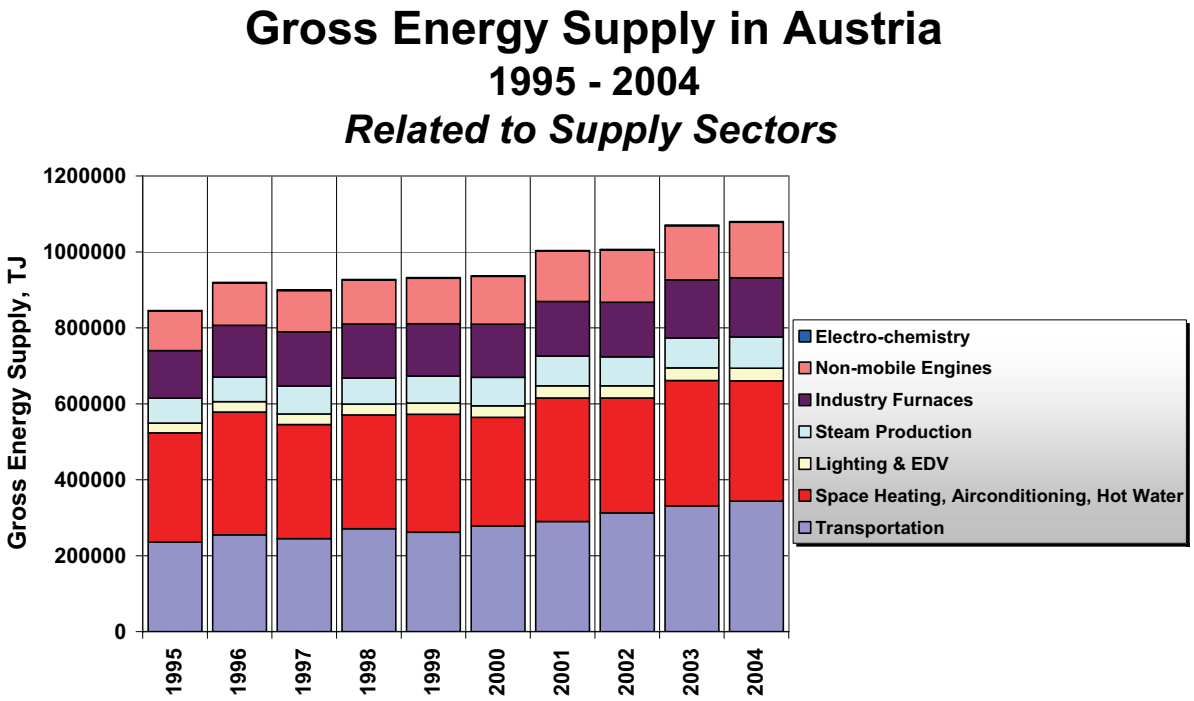


Figure 5.9a: Gross energy supply in Austria: 1994 - 2004
Related to supply sectors
(Source: Statistik Austria)

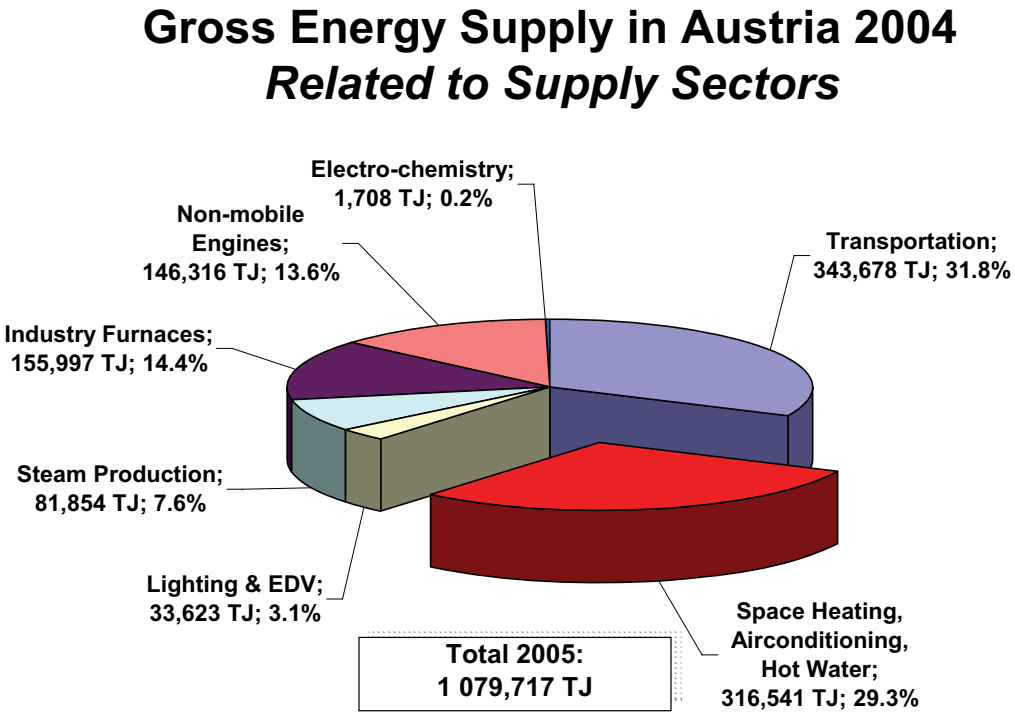


Figure 5.9b: Gross energy supply in Austria 2004
Related to supply sectors
(Source: Statistik Austria)

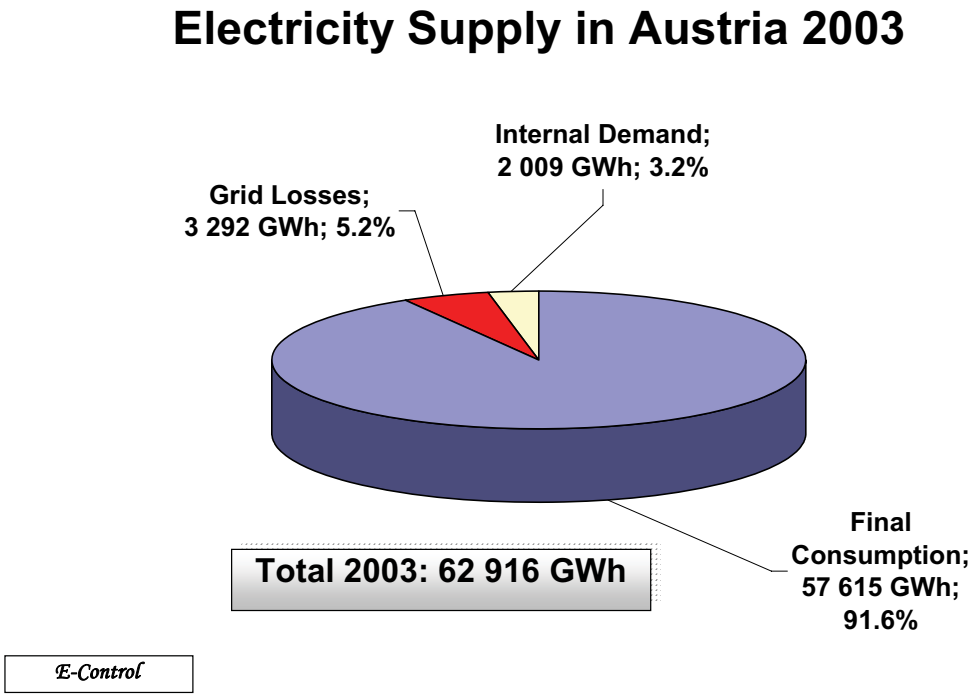


Figure 5.10a: Electricity supply In Austria 2003 (Source: E-Control)

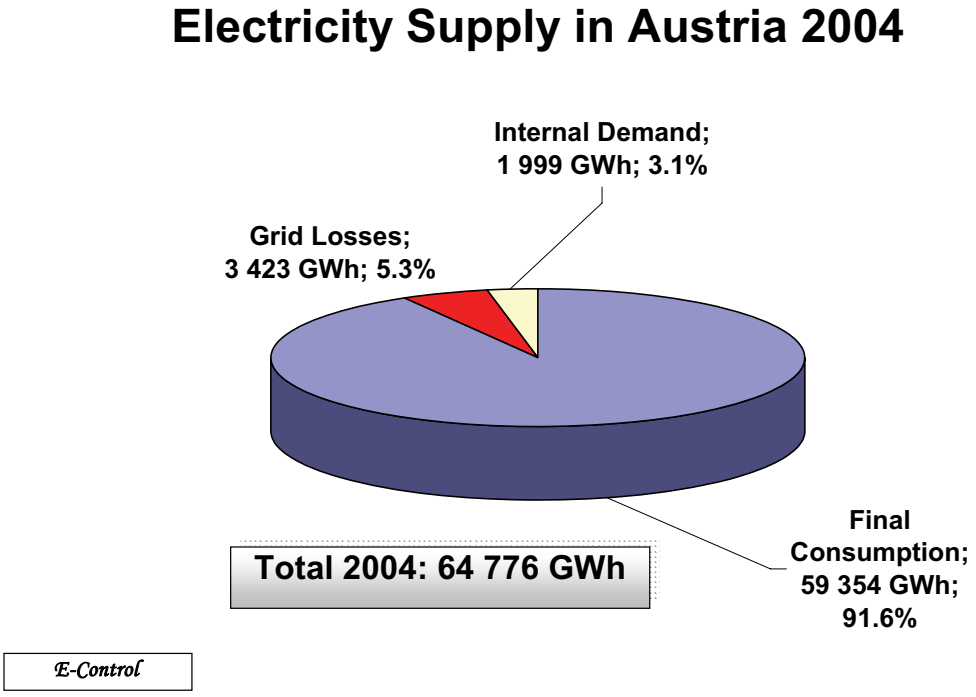


Figure 5.10b: Electricity supply In Austria 2004 (Source: E-Control)

6. Renewable Energy Sources and Technologies in Austria



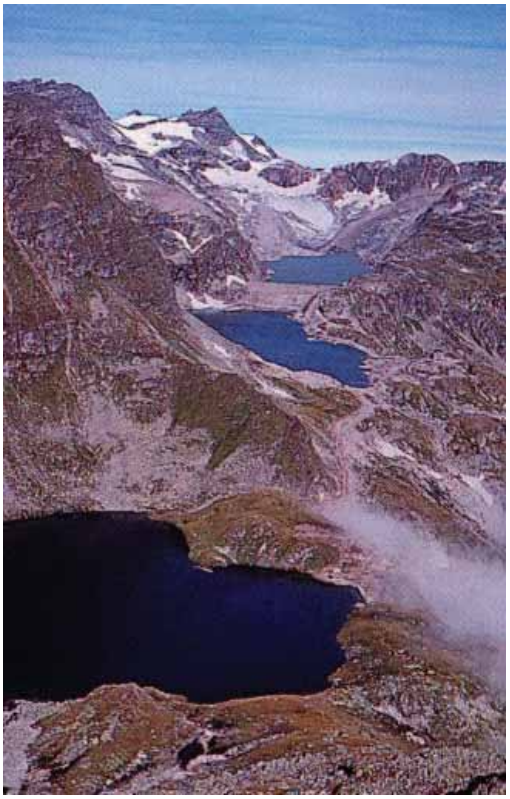



Renewable Energy Technologies in Austria

6.1. Hydropower

Hydro-Power:

Hydro refers to potential and kinetic energy of water converted into electricity in hydroelectric plants. Hydro includes also the output from pumped storage plants.



Hydropower Technologies in Austria

Hydro-power is the most commonly used of all Renewables for power generation in Austria. About 70% of the exploitable hydro-power sites have been harnessed. The exploitable potential for hydro-power in Austria is estimated to be 58% of the present average electricity generation per year. Some more "green" electricity production can be realised within rehabilitated, modernized or redeveloped small hydropower plants.

Hydro-power is also one of the most cost effective sources of Renewables, and offers significant benefits such as flood control, irrigation, potable water etc.

New technology developments in the area of hydro-power technologies have allowed the efficiency of these plants to rise, while the environmental impact of them has been significantly reduced. Small hydro-power plants can be used competitively as distributed or captive power where there is sufficient resource, or as bulk power.

The market deployment of electricity production by hydro-power plants in Austria is shown in Fig. 6.1 and Fig. 6.2, and the actual situation (end of 2004) in Fig. 6.3. The contribution of hydro-power for electricity production was at the end of 2004 37,200 GWh (135,720 TJ), from which were produced 85% from hydro-power plants ≥ 10 MW, 7% 1 – 10 MW, 1% smaller 1 M, and 7% production from pumped storage; Fig. 6.3. The installed hydropower load is shown in Fig. 6.4a for the time period 1990 – 2004 and in Fig. 6.4b in detail from 1999 – 2004. Table 1 illustrates the gross electricity production by hydropower and "other" Renewables in 2004.

More information about electricity production in Austria is provided in Chapter 4 and Chapter 5.

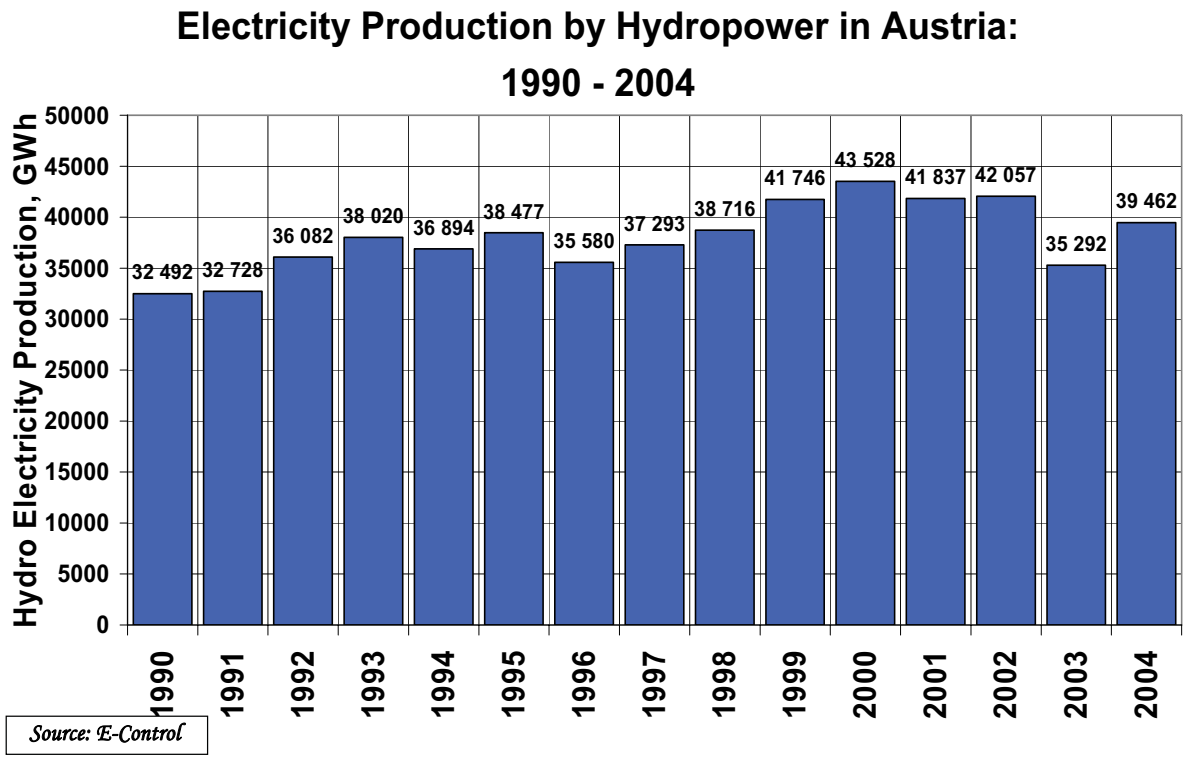


Figure 6.1: Electricity production by hydro-power plants In Austria: 1990 – 2004 (GWh) (Source: E-Control)

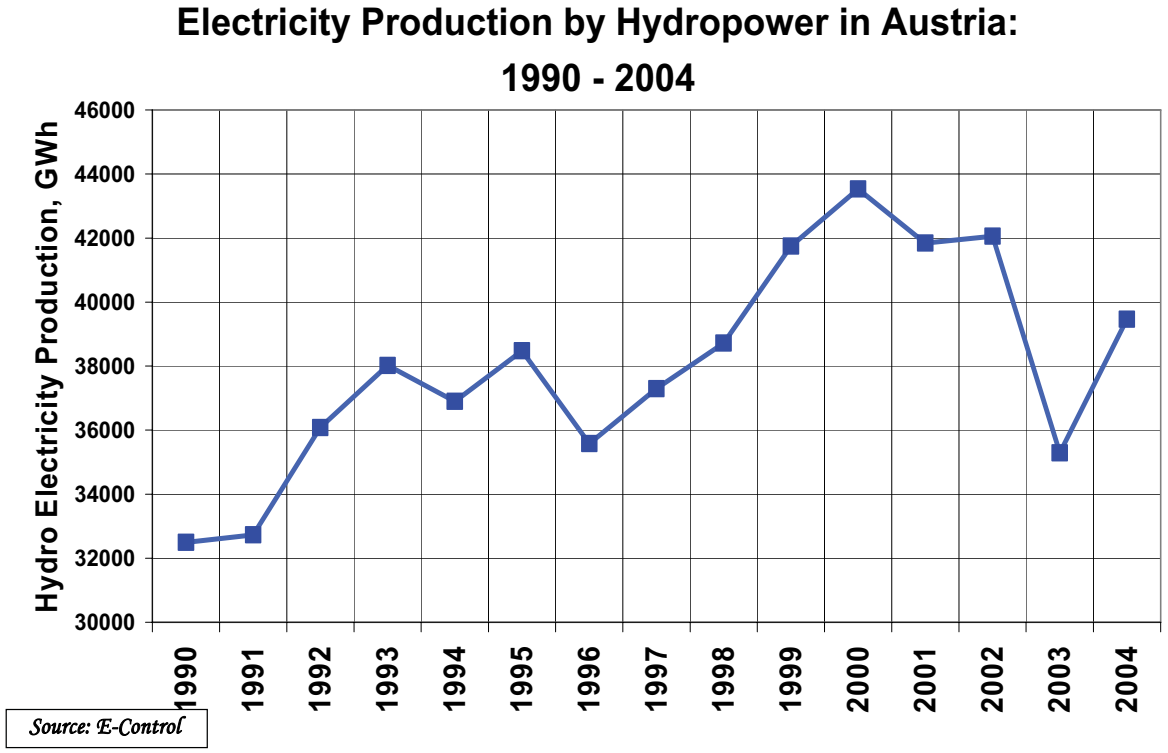


Figure 6.2: Electricity production by hydro-power plants In Austria: 1990 – 2004 (GWh) (Source: E-Control)

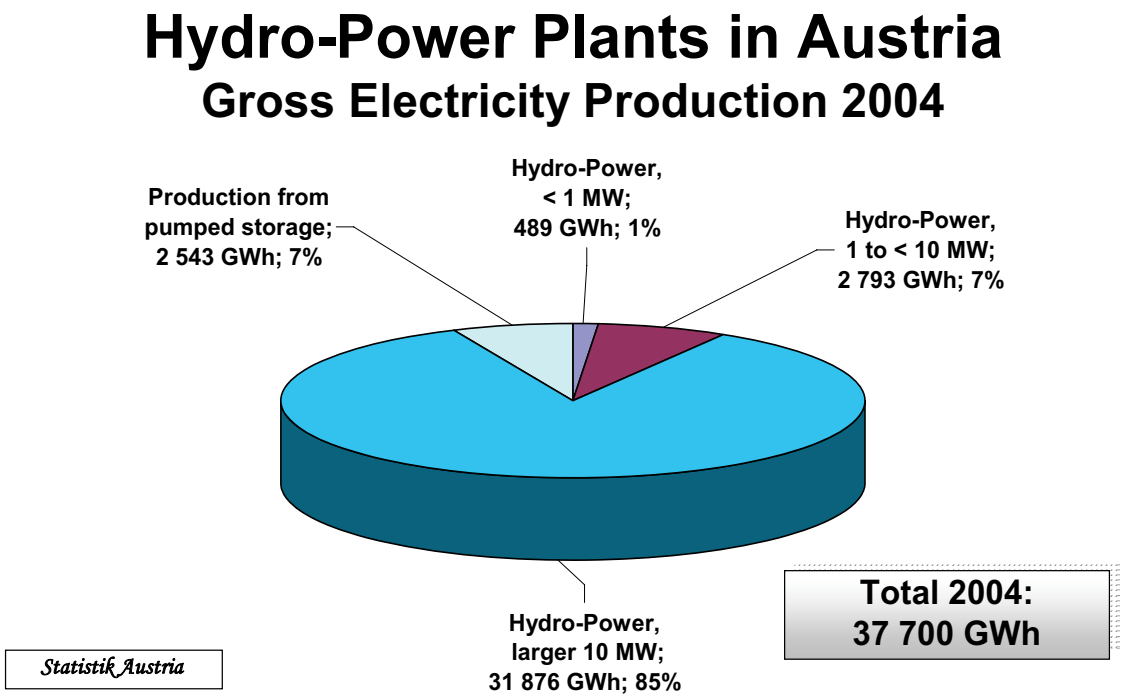


Figure 6.3: Gross electricity production from hydro-power plants In Austria 2004 (Source: Statistik Austria)

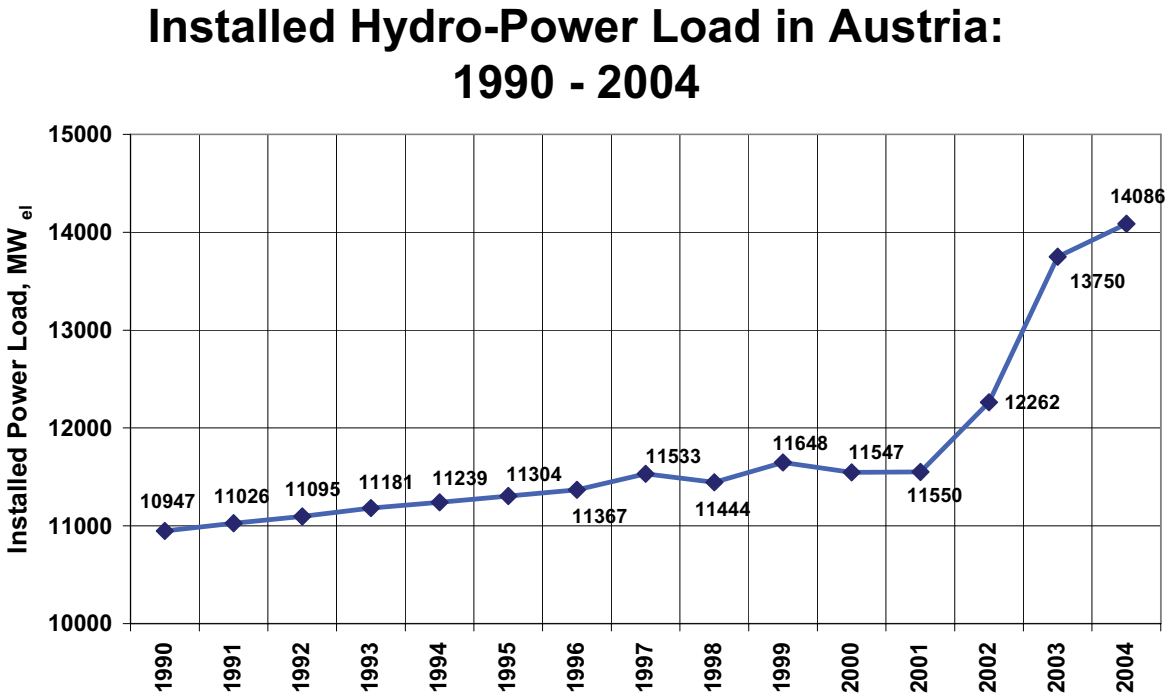


Figure 6.4a: Installed hydropower load In Austria: 1990 – 2004 (Source: Statistik Austria)

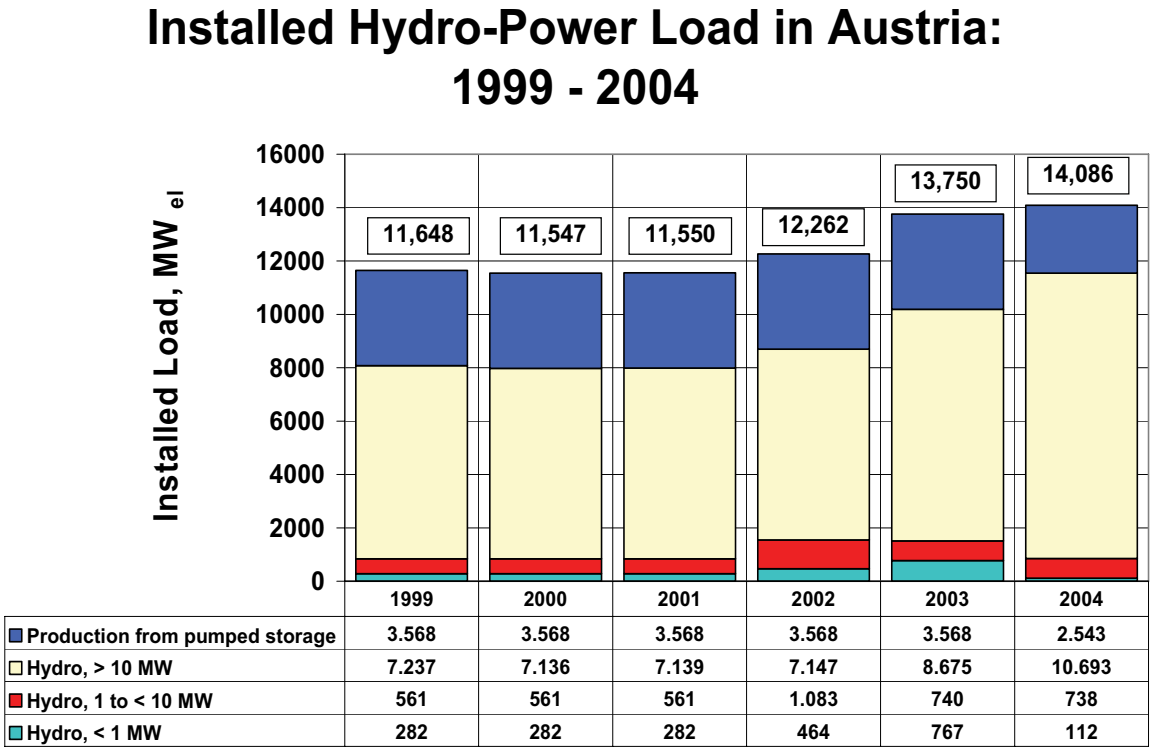


Figure 6.4b: Installed hydropower load In Austria: 1999 – 2004
(Source: Statistik Austria)

Gross Electricity Production by Renewables in Austria 2004		
Power Plant	**MWh/year**	**Share, %**
Hydropower	37.700.239	96,3322
Geothermal	1.976	0,0050
Solar Photovoltaics	11.307	0,0289
Wind	923.915	2,3608
Industrial wastes (non-renewable)	25.320	0,0647
Municipal Wastes (renewable)	86.819	0,2218
Municipal Wastes (non-renewable)	200.551	0,5125
Wood/Wood wastes/Other Solid Wastes	170.300	0,4352
Landfill gas	3.938	0,0101
Sewage sludge gas	4.248	0,0109
Other biogas	6.390	0,0163
Liquid Biofuels	637	0,0016
Total	**39.135.640**	**100**

Table 1: Gross electricity production by Renewables In Austria 2004
(Source: Statistik Austria)

6.2. Bioenergy

Bioenergy:
Bioenergy is solar energy captured by plants through photosynthesis and fixed in carbohydrate material.





Biomass Technologies in Austria

The term “bioenergy” is used for biomass energy systems that produce heat and / or electricity and “bio fuels” for liquid fuels for transportation. Bioenergy products are offered in form of firewood, bark and wood chips from the forests and as remnants of the wood processing industry. In many ways biomass can be considered as a form of stored solar energy. The energy of the sun is “captured” through the process of photosynthesis in growing plants. There is a vital difference between energy production from fossil fuels and from biomass. Burning fossil fuels releases CO_2, which has been locked up for millions of years in the ground and will require many more millions of years to return back to the ground. By contrast, burning biomass simply returns to the atmosphere the CO_2 that was absorbed as the plant grew over a relatively short period of time and there is no net release of CO_2 if the cycle of growth and *harvest is sustained*. Using biomass as a fuel means that carbon dioxide (CO_2) that was absorbed from the air while the plant was growing is released back into the air when the fuel is burned. The system is said to be “*carbon neutral*”. Providing the balance is maintained between the plant growth and biomass use, the system is sustainable and helps combat climate change. On the other hand, deforestation cannot be considered “carbon neutral”. For managing eco-systems for bioenergy production good and environmental sensible forest management is essential.

In reality bioenergy products are not strictly “carbon neutral” because energy is needed for production and transport of fire wood, barks and wood chips. But the environmentally relevant CO_2-emissions are low compared with the CO_2-emissions of fossil energy sources (e.g. about 6 to 43 g CO_2/kWh for solid biomass products compared with 247 g CO_2/kWh (gas) to 452 (lignite) g CO_2/kWh). Bio-fuels depend on hydrocarbon fuels to the degree that they are agriculturally produced, result in soil impoverishment and hence are neither really carbon-free nor limitless. The issue requires further research to prioritise among them.

There are different categories of Bioenergy-products:

- Solid Biomass: Covers organic, non-fossil material of biological origin which may be used as fuel for heat production or electricity generation. It comprises: fire wood, wood wastes, other solid wastes.
- Fire Wood, wood wastes, other solid wastes: Covers purpose-grown energy crops (poplar, willow etc.), a multitude of woody materials generated by an industrial process (wood/paper industry in particular) or provided directly by forestry and agriculture (firewood, wood chips, bark, sawdust, shavings, chips, black liquor etc.) as well as wastes such as straw, rice husks, nut shells, poultry litter, crushed grape dregs etc. Combustion is the preferred technology for these solid wastes.
- Biogas: A gas composed principally of methane and carbon dioxide produced by anaerobic digestion of biomass, comprising landfill gas, formed by the digestion of land filled wastes, sewage sludge gas, produced from the anaerobic fermentation of sewage sludge, and other biogas, such as biogas produced from the anaerobic fermentation of animal slurries and of wastes in abattoirs, breweries and other agro-food industries.
- Liquid bio-fuels: cover bio-ethanol (ethanol produced from biomass and/or biodegradable fraction of waste), biodiesel (a diesel quality liquid fuel produced from biomass or used fried oils), bio-methanol (methanol produced from biomass and/or the biodegradable fraction of waste), bio-dimethylether (a diesel quality fuel produced from biomass and/or the biodegradable fraction of waste) and bio-oil (a pyrolysis oil fuel produced from biomass).

- Renewable wastes: Cover renewable industrial waste, municipal solid waste (waste produced by households, hospitals etc.).

The market deployment of bio-energy consumption in Austria is illustrated for the time period from 1980 until 2004 in Fig. 6.2.1. In 2004 about 175,882 TJ were produced from bio-energy, from which 34.5% comes from fuel wood and also 34.5% from industrial waste, followed with 19.2% from wood waste and 9.3% from other solid biomass; Fig. 6.2.2.

6.2.1. Solid Biomass

Solid biomass is defined as any plant matter used directly as fuel or converted into other forms before combustion. Included are wood, vegetal waste (including wood waste and crops used for energy production), animal materials/wastes, sulphite lyes (also known as black liquor, this is sludge that contains the lignin digested from wood for paper making), and other solid biomass.

The market deployment of consumption of fuel wood, wood waste and other solid biomass is illustrated for the time period 1980 – 2004 in Fig. 6.2.3 to Fig. 6.2.5. Other Renewables and waste are non-specified combustible Renewables and wastes associated with one or more of the following four products: industrial waste, municipal waste, solid biomass and biogas. Energy sources are reported as non- specified when national administrations are unable to break down the data into the different products (especially in earlier years of the time series), or when data are confidential.

The renewable solid waste consumption in Austria from 1980 to 2004 is documented in Fig. 6.2.6. Renewable municipal waste consists of the biodegradable part of municipal waste products that are combusted directly to produce heat and/or power. It comprises waste produced by the residential, commercial and public services sectors that is collected by local authorities for disposal in a central location, including biodegradable hospital waste.

Renewable industrial waste consists of solid, liquid and gaseous products combusted directly, usually in specialised plants, to produce heat and/or power and that are not reported in the category solid biomass; Fig. 6.2.7.

Non-renewable municipal waste consists of the non-biodegradable part of municipal waste products that are combusted directly to produce heat and/or power. It comprises waste produced by the residential, commercial and public sectors that is collected by local authorities for disposal in a central location, including non-biodegradable hospital waste; Fig. 6.2.8.

The market deployment of biomass-heating systems was actively supported by R&D efforts to improve combustion technology for domestic heating, industrial process heat applications and district heating. Also the operating comfort of biomass boilers could be improved by features of full automatic operation and a similar comfort as oil or gas fired boilers: wood chips and pellets boilers. Since 1989 about 4138 of biomass heating systems were installed in Austria; Fig. 6.2.9a and Fig. 6.2.9b. The annual increasing rate of pellets boilers is since the last three years more than 30% per year.

6.2.2. Liquid Biomass

Liquid biomass includes fuels and bio-additives such as bio-ethanol, biodiesel, bio-methanol and bio-dimethylether.

Along with the use of forestry products for bioenergy, agricultural biomass production has also received significant attention. Most progress has been made in the field of biodiesel.

The shortage of mineral oil supply led to two major bio-fuel projects after 1979. The construction of 80,000 t/year ethanol plant and the development of the biodiesel technology were planned. Whereas the ethanol project could not be realized due to the changed economic framework, the biodiesel project has developed successfully. Biodiesel has been examined in collaboration with science, economy and administration in laboratories, pilot projects, on the test bench and in fleet tests. Initially rape seed and sunflower oil were tested as raw materials, but later on cost-efficient used frying fat was also used successfully. In recent years, a market for neat biodiesel has developed.

In 1991 the world's first industrial plant for the production of biodiesel at Mureck/Styria, was founded. One of the main advantages of biodiesel production technique applied is its high flexibility with regard to the quality of the raw materials used. Even low-cost used cooking oil as well as animal fats may be processed without the addition of expensive and unused plant fats. By-products such as glycerine and solid fertilizers that are created in the course of production are sufficiently acceptable to be sold and thus contribute to the profitability and economic efficiency of biodiesel production.

The biodiesel production in Austria is shown in Figure 6.2.10. The bio-fuel production in 2004 was about 28.000 tonnes.

6.2.3. Bio-gas

Biogas is derived principally from the anaerobic fermentation of biomass and solid wastes and is combusted to produce heat and/or power. Included in this category are landfill gas and sludge gas (sewage gas and gas from animal slurries) and other biogas.

Biogas has also received a lot of attention and the number of biogas plants is increasing both in agriculture and in waste management.

The market deployment biogas consumption is shown in Fig. 6.2.11, from landfill gas in Fig. 6.2.12 and from sewage sludge gas in Fig. 6.2.13.

6.2.4. Installed Electrical Load of Bio-energy Products

The installed electrical load of wood/wood waste and other solid wastes in Austria is illustrated for the time period 1990 – 2004 in Fig. 6.2.14 and for municipal wastes in Fig. 6.2.15.

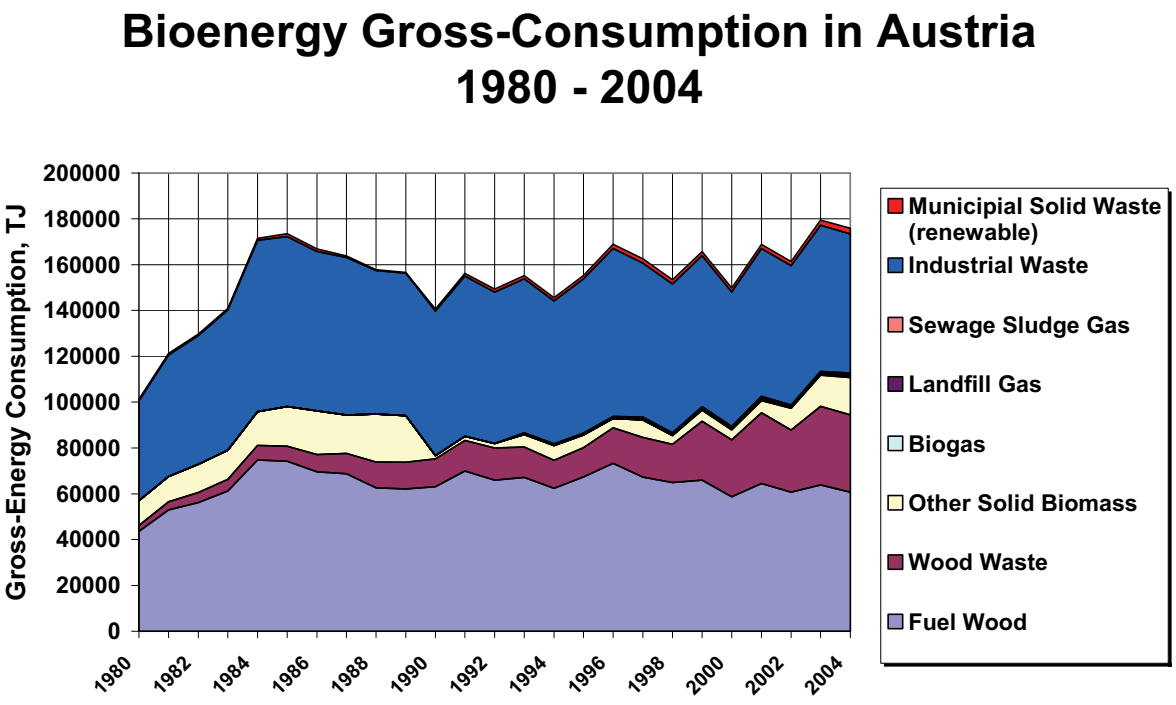


Figure 6.2.1: Bioenergy gross consumption In Austria: 1980 – 2004
(Source: Statistik Austria)

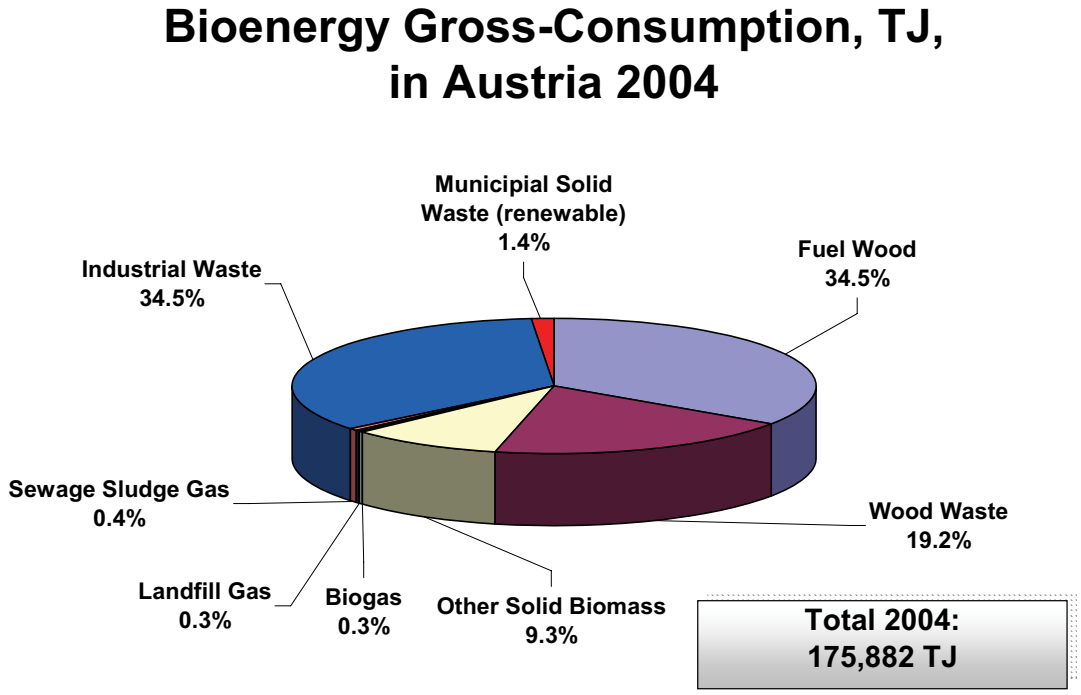


Figure 6.2.2: Bioenergy gross consumption In Austria 2004
(Source: Statistik Austria)

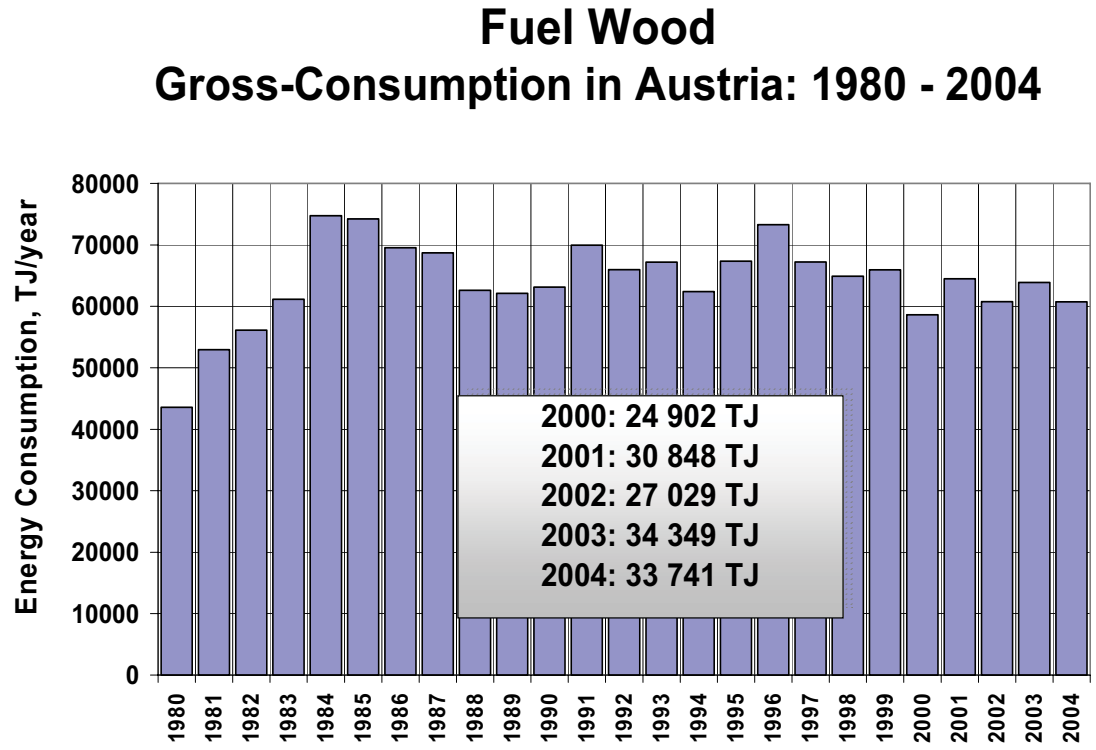


Figure 6.2.3: Fuel wood gross consumption In Austria: 1980 – 2004
(Source: Statistik Austria)

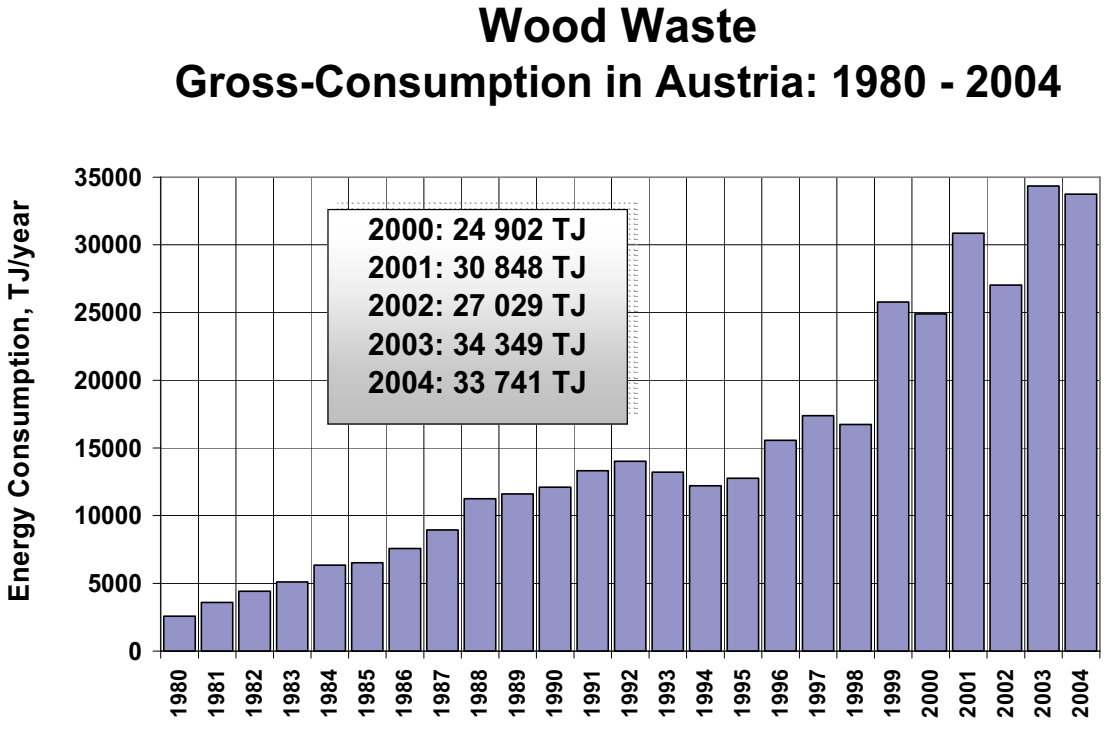


Figure 6.2.4: Wood waste gross consumption In Austria: 1980 – 2004
(Source: Statistik Austria)

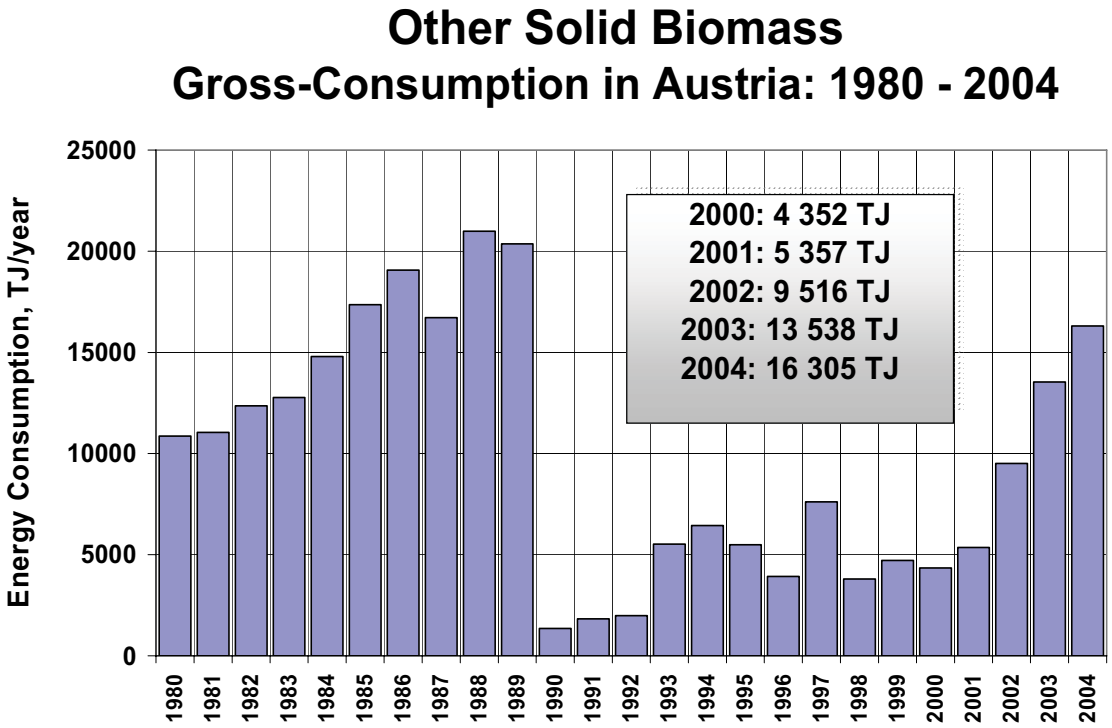


Figure 6.2.5: Other solid biomasses gross consumption In Austria: 1980 – 2004 (Source: Statistik Austria)

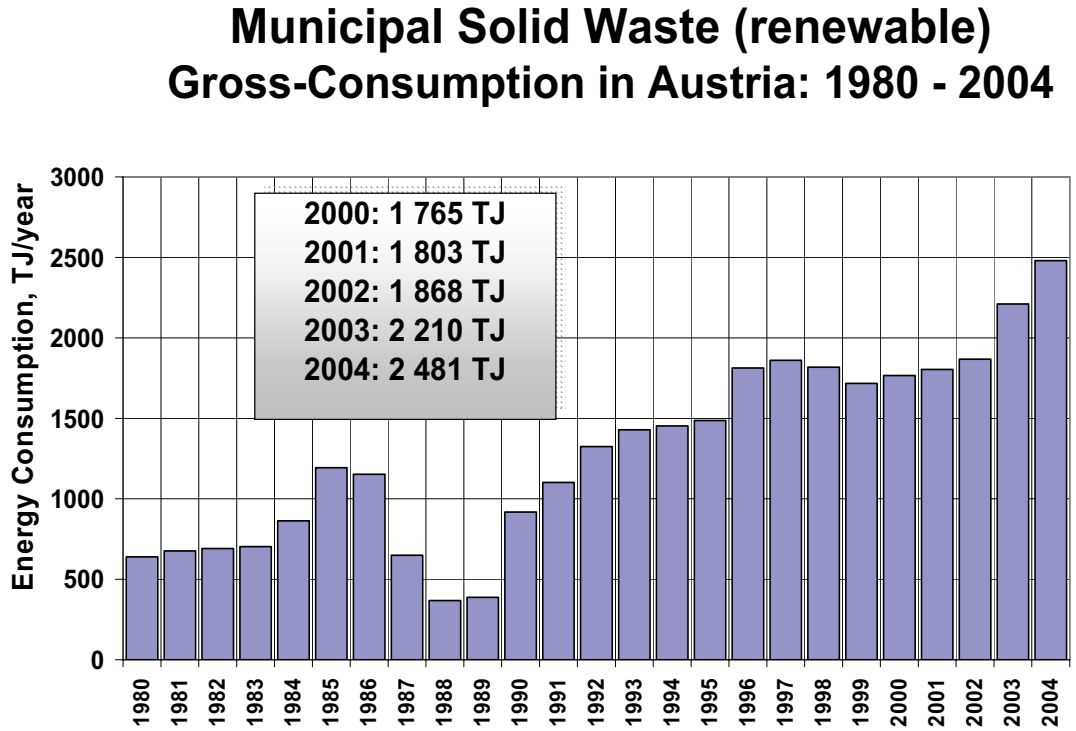


Figure 6.2.6: Renewable municipal gross consumption In Austria: 1980 – 2004 (Source: Statistik Austria)

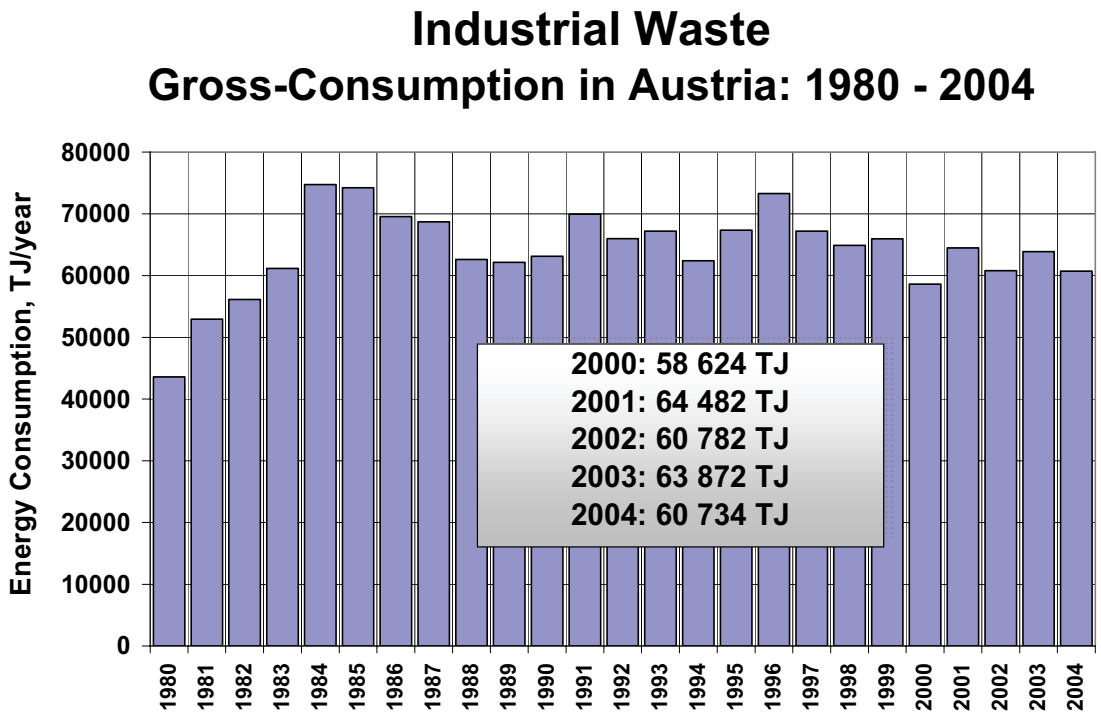


Figure 6.2.7: **Renewable industrial waste gross consumption In Austria: 1980 – 2004 (Source: Statistik Austria)**

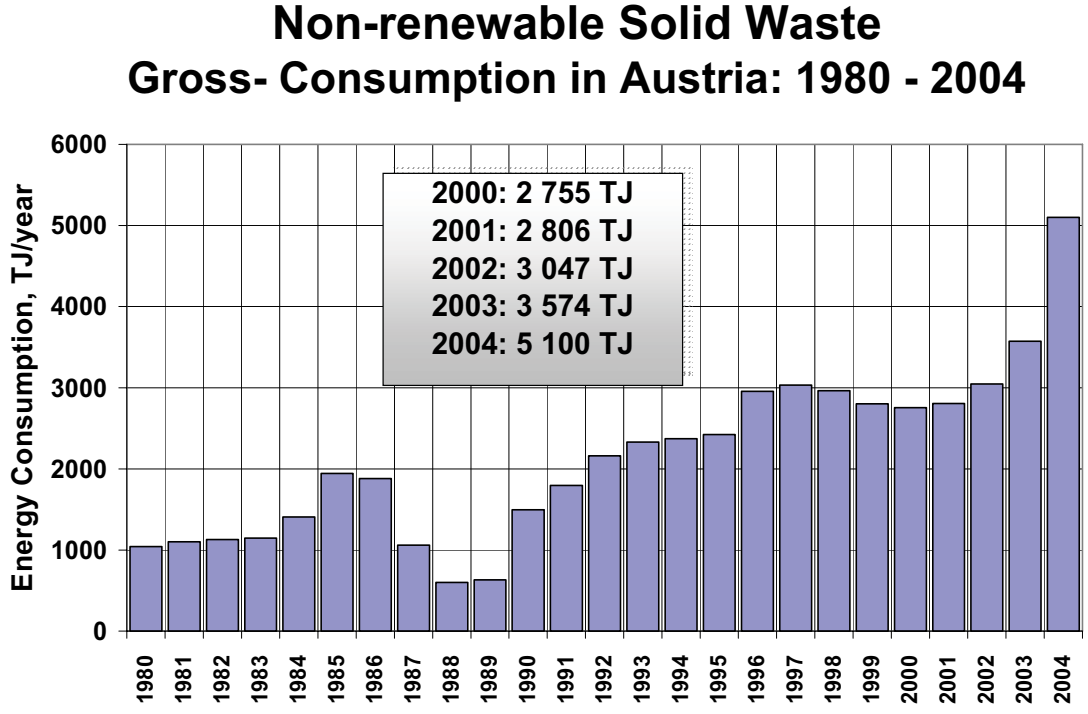


Figure 6.2.8: Non-renewable solid waste gross consumption In Austria: 1980 – 2004 (Source: Statistik Austria)

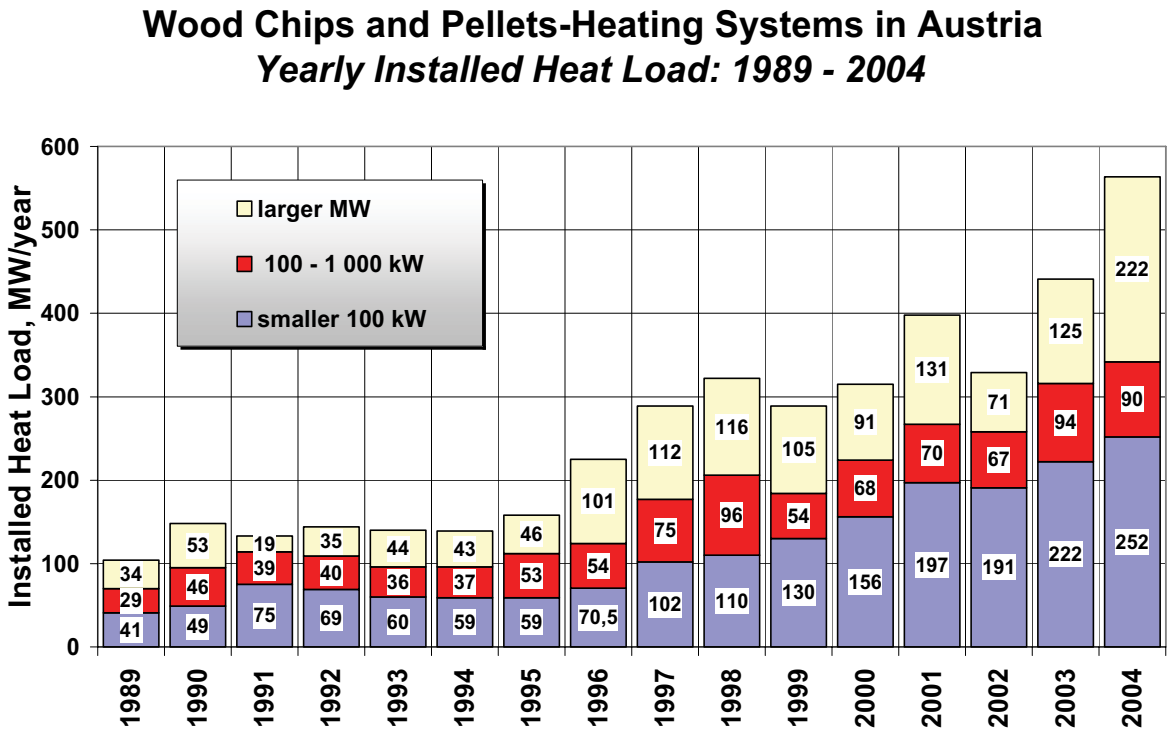


Figure: 6.2.9a: Market deployment of wood chips and pellets heating systems In Austria: 1989 – 2004 (Source: Niederösterreichische Landwirtschaftskammer)

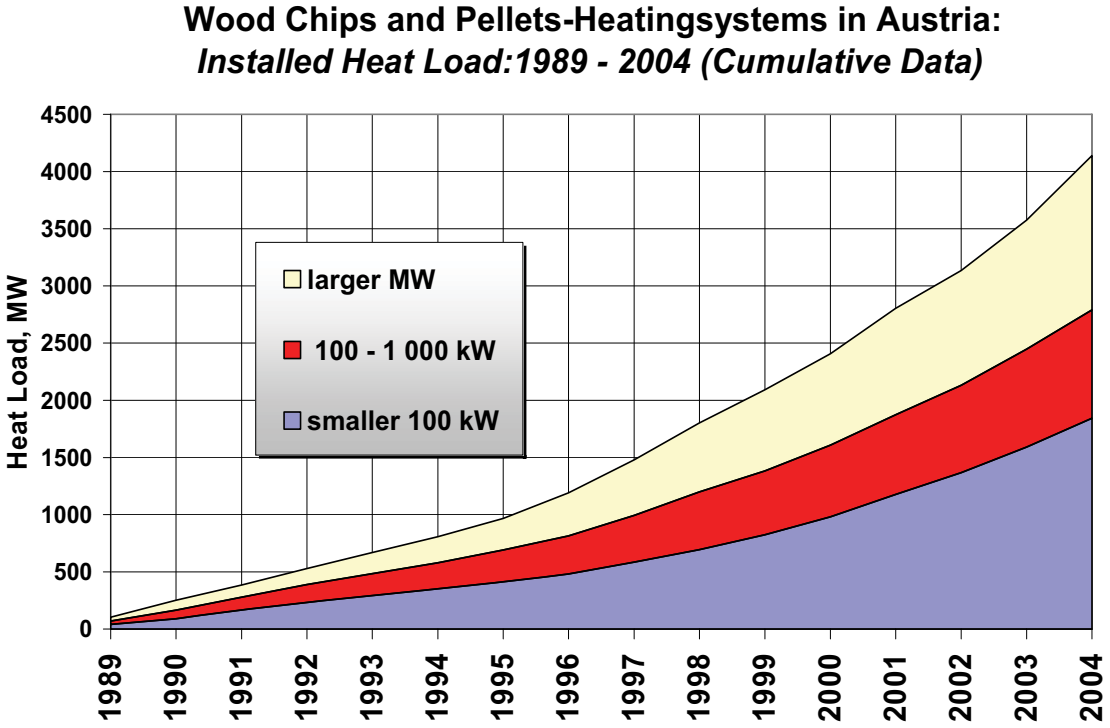


Figure: 6.2.9b: Market deployment of wood chips and pellets heating systems In Austria: 1989 – 2004 (Source: Niederösterreichische Landwirtschaftskammer)

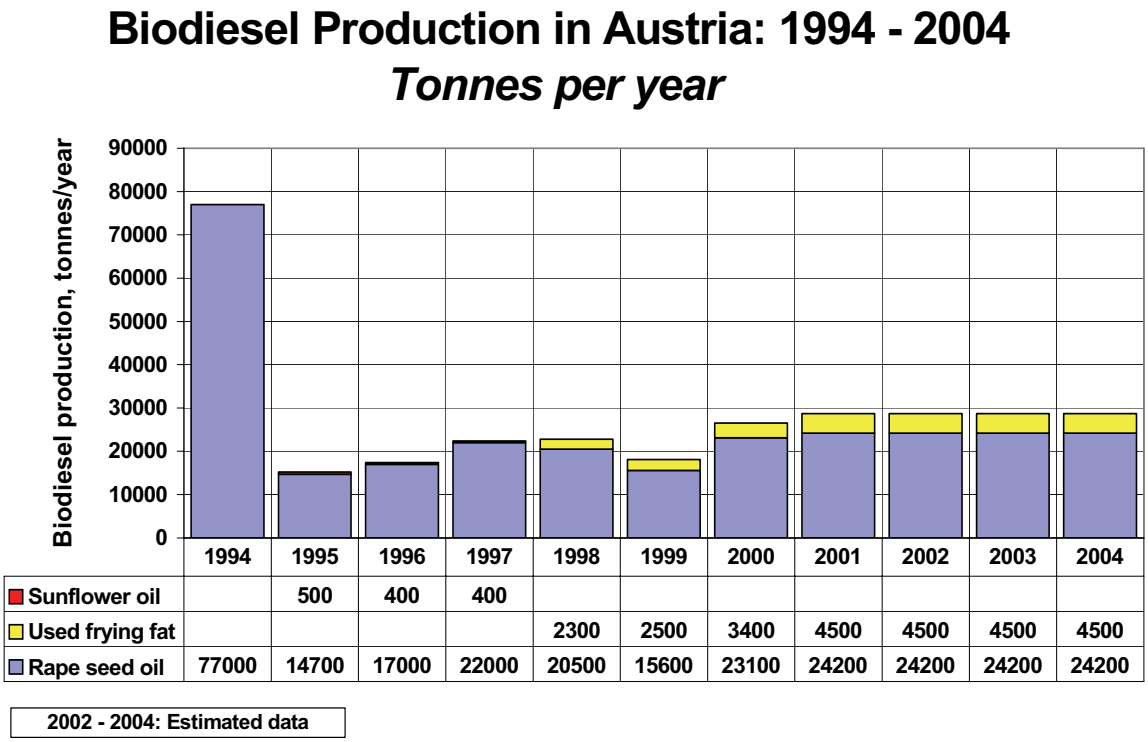


Figure 6.2.10: Biodiesel production In Austria: 1994 – 2004
(Source: BLT-Wieselburg)

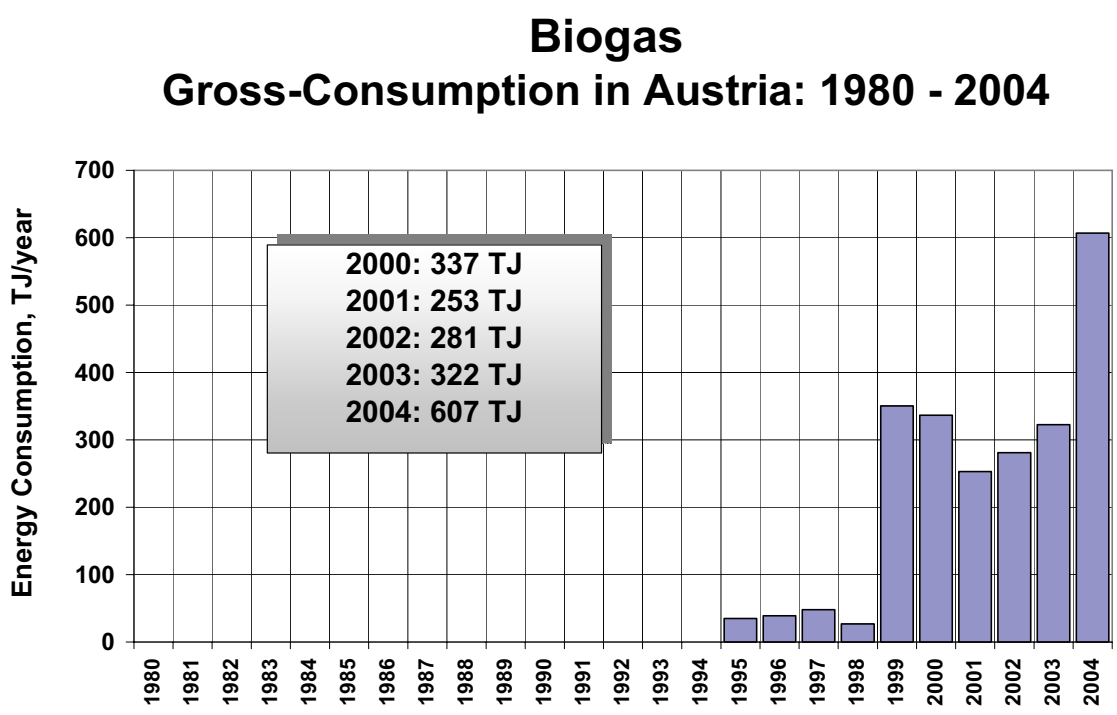


Figure 6.2.11: Biogas gross consumption In Austria: 1980 – 2004
(Source: Statistik Austria)

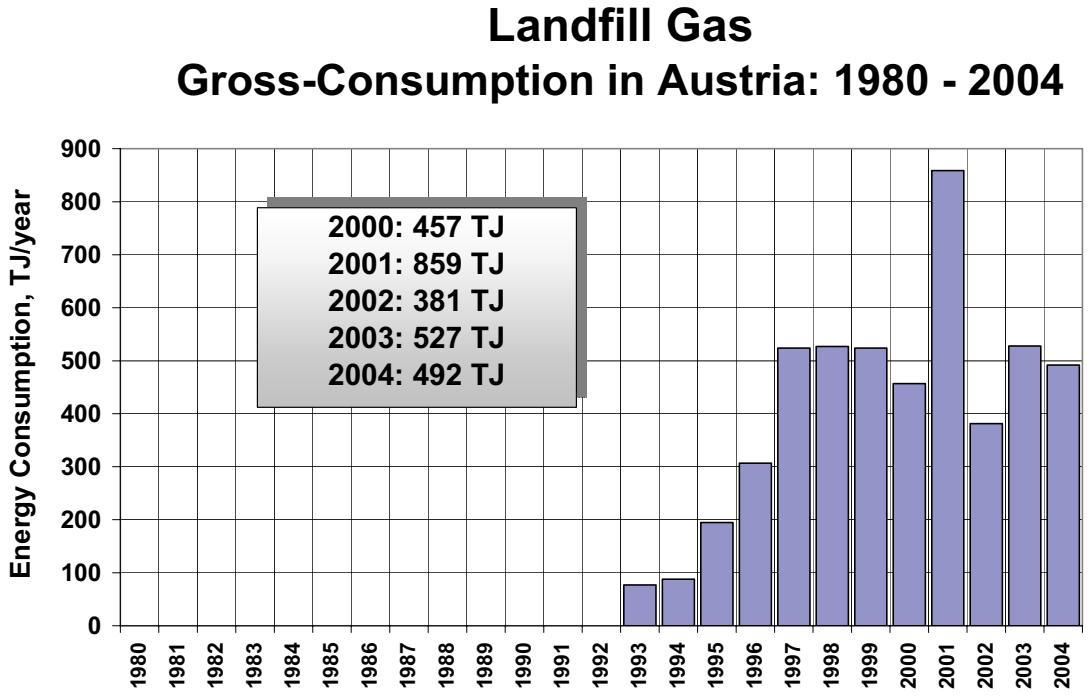


Figure 6.2.12: Landfill gas gross consumption In Austria: 1980 – 2004
(Source: Statistik Austria)

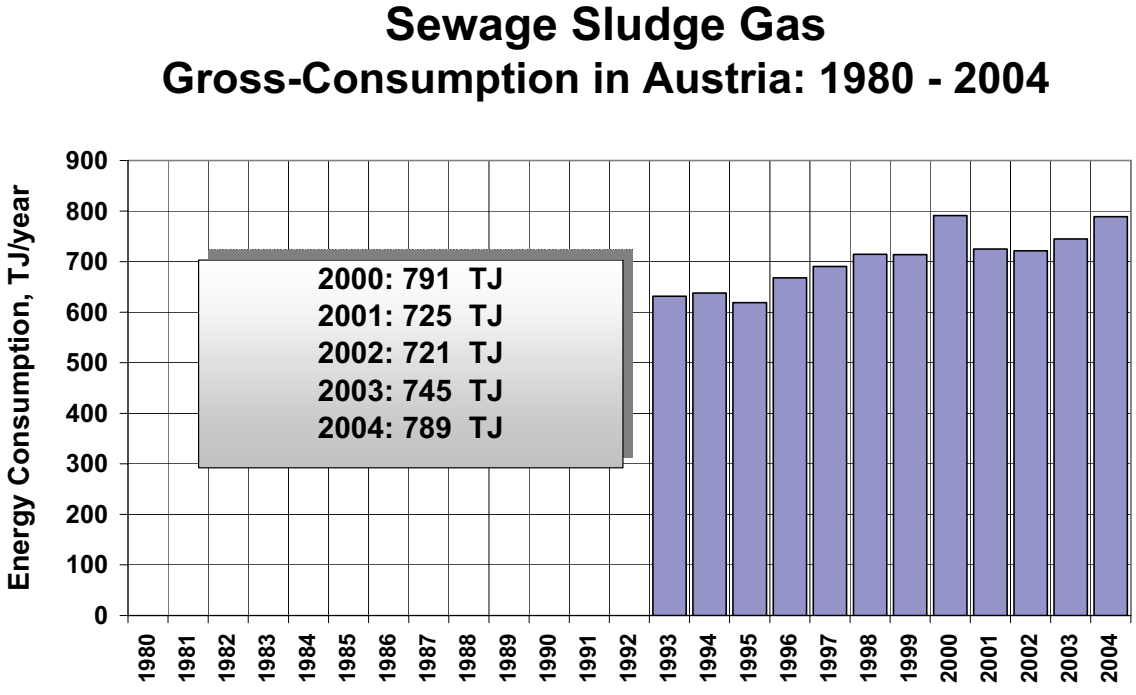


Figure 6.2.13: **Sewage sludge gas consumption In Austria: 1980 – 2004**
(Source: Statistik Austria)

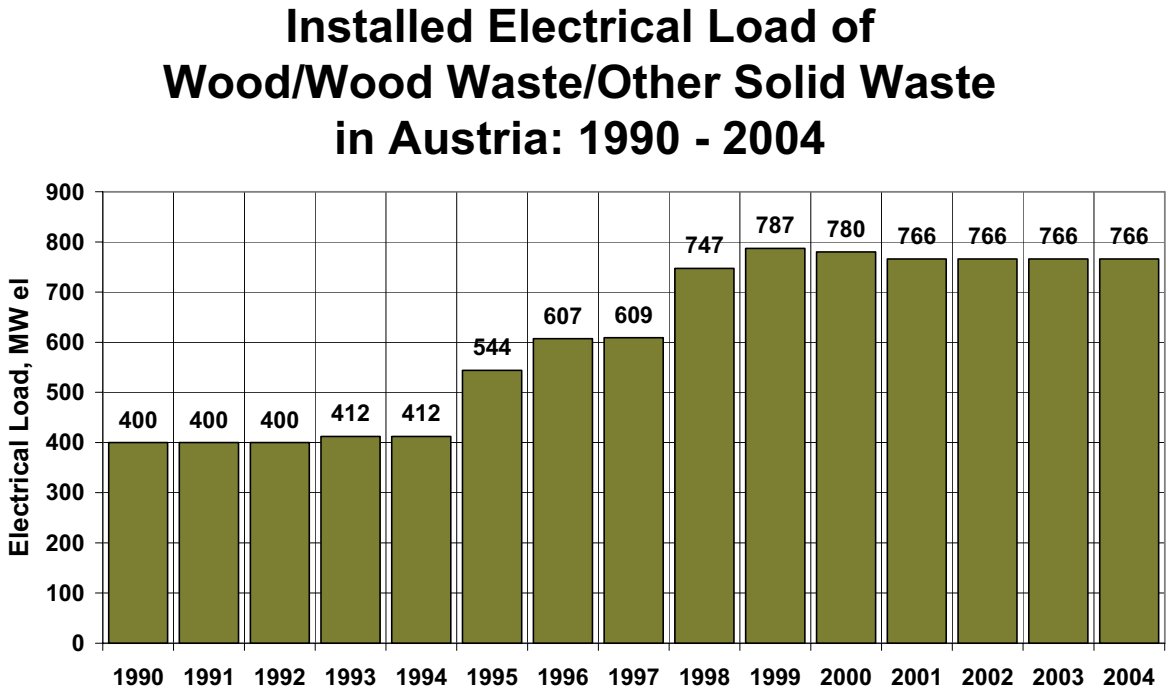


Figure 6.2.14: **Installed electrical load of wood/wood waste and other solid wastes In Austria: 1990 – 2004**
(Source: Statistik Austria)

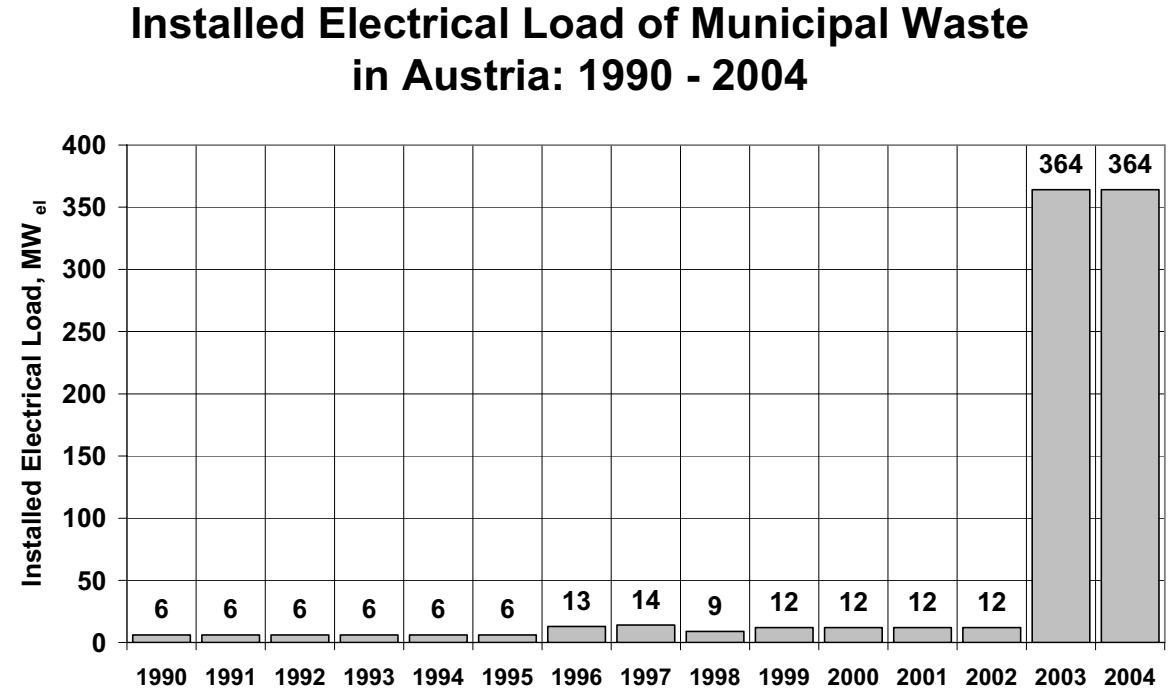


Figure 6.2.15: **Installed electrical load of municipal waste In Austria: 1990 – 2004**
(Source: Statistik Austria)

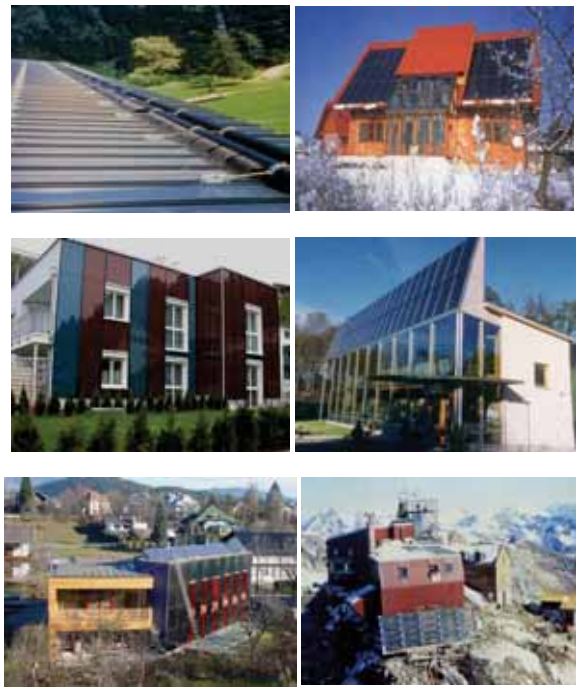
6.3. Solar Energy and Technologies

Solar Energy:

Solar energy is generated deep in the interior of the sun by nuclear fusion reactions, is carried to its surface by high-energy radiation and then to Earth and down through the atmosphere by sunlight, that is electromagnetic radiation primarily in the visible and infra-red.

Solar technologies use solar radiation to produce both heat (Solar Thermal Technologies) and electricity (Solar Electric Technologies, Photovoltaic).

Solar thermal and electric transformation inputs into heat and electricity production are estimated on the basis of 100% efficiency (based on the IEA methodology that the first energy form downstream in the production energy is considered the primary supply).



Solar Thermal Technologies in Austria

Photovoltaic Technologies in Austria

6.3.1. Solar Heat and Solar Thermal Technologies

The conversion of solar radiation in heat occurs through collectors. There are two types of collectors: *non-concentrating* and *concentrating collectors*. In case of non-concentrating collectors the global radiation (direct beam and diffuse radiation) can be fully utilized. In case of concentrating collector systems – parabolic and cylindrical collector type with point and line focussing mirrors - only the direct beam of the radiation can be used by optical installations with which the irradiation is concentrated on the absorber thus increasing the intensity of radiation on the absorber. The concentrator is equipped with a tracking device, which, in effect, ensures that it "follows the sun" continuously.

The choose of a collector-type depends from the application, e.g. the required temperature. Flat-plate collectors operates at temperatures up to 150°C, concentrating collectors at temperatures above 200°C, up to more than 1000°C for process heat and thermal electricity production.

Concentrating collector systems are preferably used in regions with more than 2500 annual sunshine hours.

Solar thermal systems for low- and medium temperature applications are mainly based on non-concentrating collectors: selective coated flat-plate collectors and evacuated tube-collectors. This type of collector allows the conversion of the global solar radiation and therefore can be used also in regions with low direct solar radiation e.g. lower sunshine hours. In Austria, flat-plate collectors are on the market. Typically applications are swimming pool heating, solar heating and cooling of buildings, drying of crops – mainly biomass products - and process heating below 200 °C.

The development of large-scale collectors with up to 15 m² absorber area has not only reduced the costs for the collectors and for the installation but also the problems arising when connecting the pipes by means of prefabricated collector modules were reduced by more than 30%.

With the rapid market development of solar thermal systems, new firms for collector production were formed and the export rates increased in the last years remarkable.

Sustainable Solar Buildings

The hot water preparation in new buildings is today standard in Austria. In the area of building renovation, solar systems for hot water preparation are attractive on the market. Especially ineffective heating systems for hot water preparation outside the heating season have been replaced by solar hot water preparation. Thus pollutant emissions through heating (wood, coal, oil boilers) could be reduced and at the same time a high comfort in hot water preparation could be reached.

The use of solar energy for space heating in buildings can be justified in the case of *low energy buildings* (new buildings) with a maximum design temperature of the heating distribution system of 40°C. Quite satisfactory technologies and approaches exist for heating systems. Combined solar heating systems increased remarkable since 2001. Today, about 20% of the installed solar thermal systems are connected to the heating system. Favourite solar combined heating systems are solar assisted biomass and ground-coupled heat pump systems.

Practical research in and demonstration of solar thermal systems in both new and renovated buildings have resulted in a number of economical and marketable solutions with solar thermal utilisation in the building sector: *Sustainable Solar Buildings*.

The market deployment of solar thermal collectors is shown in Figure 6.3.1.1 and the actual solar collector area in operation in Figurer 6.3.1.2. Figure 6.3.1.1 illustrates the positive market introduction of solar thermal systems in Austria. At the end of 2004 about 2.8 million m² collector area were in operation, from which 77.5% are glazed collectors, 1.3% vacuum-tube collectors and 21.2% unglazed plastic absorbers; Figure 6.3.1.2.

The development of useful heat output and the installed thermal load are shown in Figure 6.3.1.3 and Figure 6.3.1.4. At the end of 2004 about 3,561 TJ useful heat were contributed from solar thermal systems to the energy supply in Austria; Figure 6.3.1.3. The installed heat load of solar thermal systems in operation reached at the end of 2004 1,938 MW; Figure 6.3.1.4.

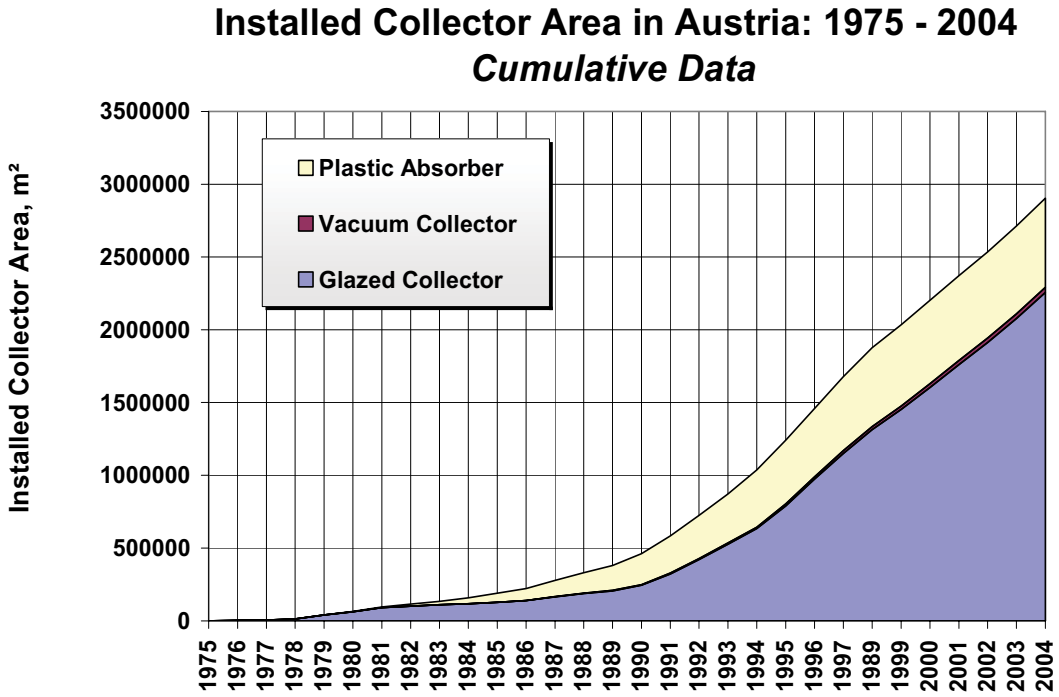


Figure 6.3.1.1: Installed collector area In Austria: 1975 – 2004 (Source: G. Faninger)

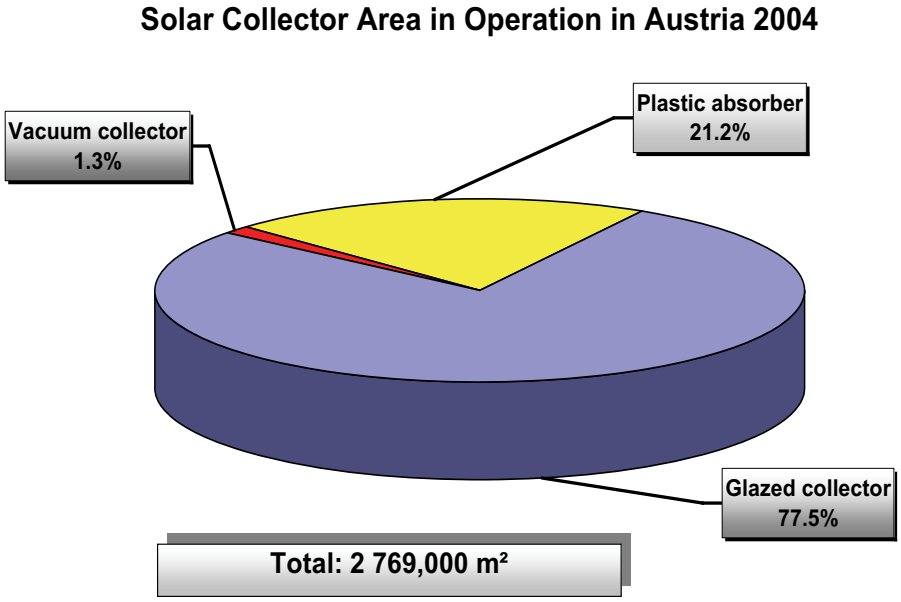


Figure 6.3.1.2: Solar collector area in operation In Austria 2004 (Source: G. Faninger)

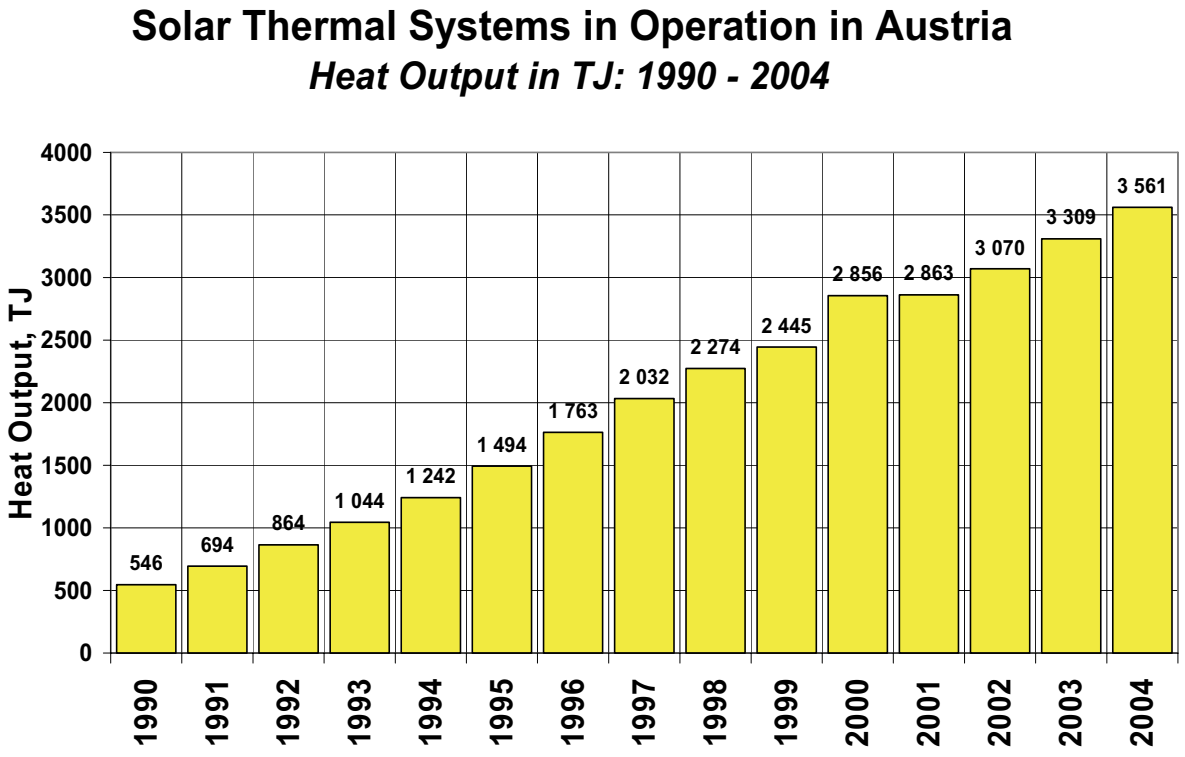


Figure 6.3.1.3: Heat output of solar thermal systems in operation In Austria: 1990 – 2004 (Source: G. Faninger)

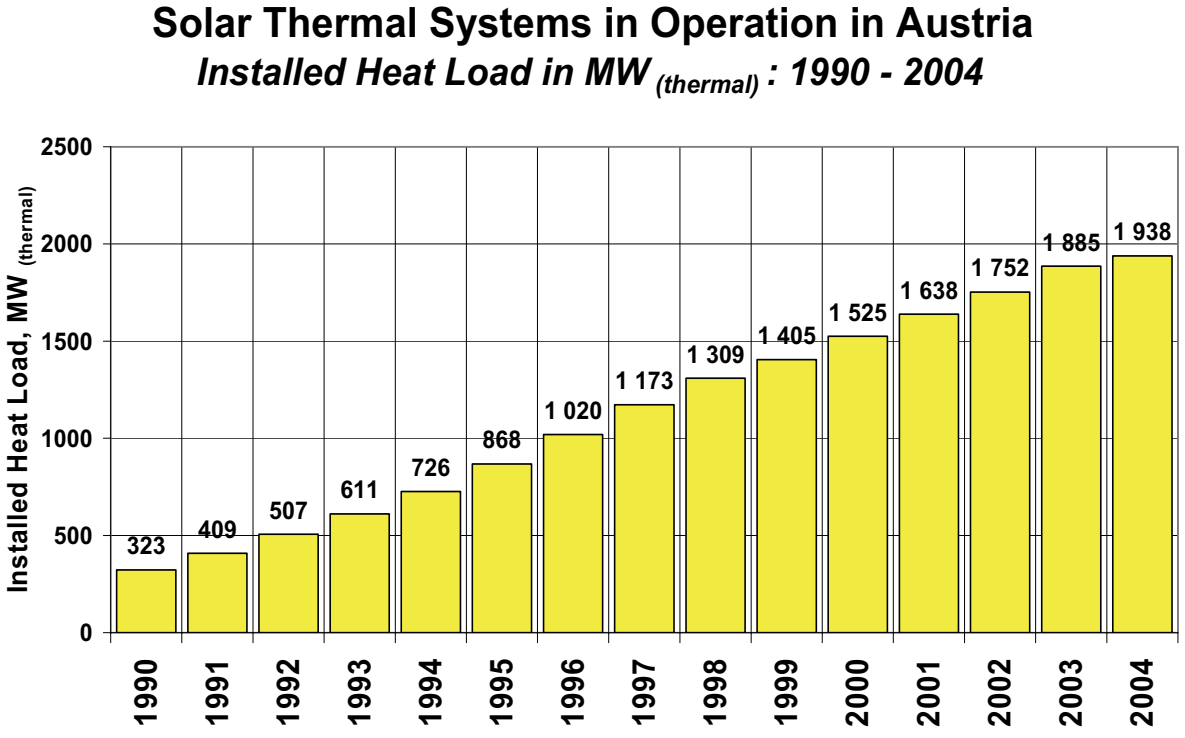


Figure 6.3.1.4: Installed heat load of solar thermal systems in operation In Austria: 1990 – 2004 (Source: G. Faninger)

6.3.2. Solar Electricity and Solar Electricity Technologies

Photovoltaic (PV) systems use semiconductor materials to convert sunlight directly into electricity. They can be used separately or in hybrid form, in combination with another generating option such as other Renewables or fossil fuels.

For *Solar Electricity Systems (Photovoltaic Systems)* there exist a number of market targets for near-term and large scale opportunities. These include PV stand-alone and grid-connected distributed generation, both in building-integrated configurations, and in utility support configurations. Several different variants of solar PV technology exist (e.g. single- and multicrystalline silicon, amorphous silicon, copper indium diselenide, cadmium telluride), and it is currently unclear which will dominate in the future. Efficiencies as well as costs of PV technologies increased in the last decade, but there is left a potential for further development, especially for cost reductions.

An increasing market share for photovoltaic applications has been observed in Austria in the last years. The future use of photovoltaic power generation systems in Austria is of special interest in connection with grid-connected systems including, for example, small rooftop installations. For the market deployment of small grid-connected photovoltaic systems, the roof or facades of buildings will be preferred to central installations.

As there has been no extension to the 15 MW cap allocated to feed-in tariff support – which reached in March 2003 – the only new initiates have been capital support grants funded by the Provinces ("Länder"). Upper Austria, with a grant level up to 65%, has had a reasonable uptake, but similar measures in Vienna and Lower Austria with lower grant levels (up to 40%) have received no applications in 2004.

The market deployment of photovoltaic systems in Austria from the very beginning up to 2004 is shown in Figure 6.3.2.1. At the end of 2004 about 19,180 $kW_{(peak)}$ were installed in Austria, from which 86% are grid-connected and 14% stand-alone systems. The electrical output is shown in Figure 6.3.2.2 for all installed PV-systems and in Figure 6.3.2.3 only for grid-connected PV-systems. The annual electricity production from PV-systems was in 2004 12.818 GWh for all PV-systems, and 11.7 GWh (42,3 TJ) only for grid-connected systems.

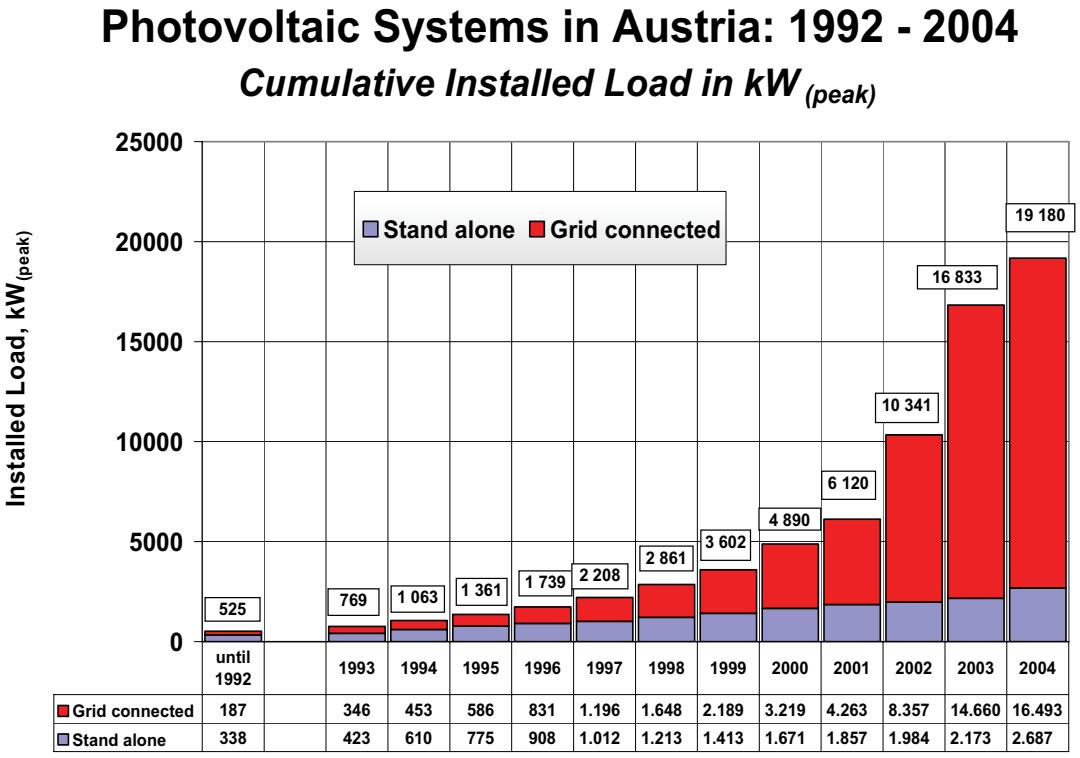


Figure 6.3.2.1: Installed electrical load of photovoltaic systems In Austria: 1992 – 2004 (Source: G. Faninger)

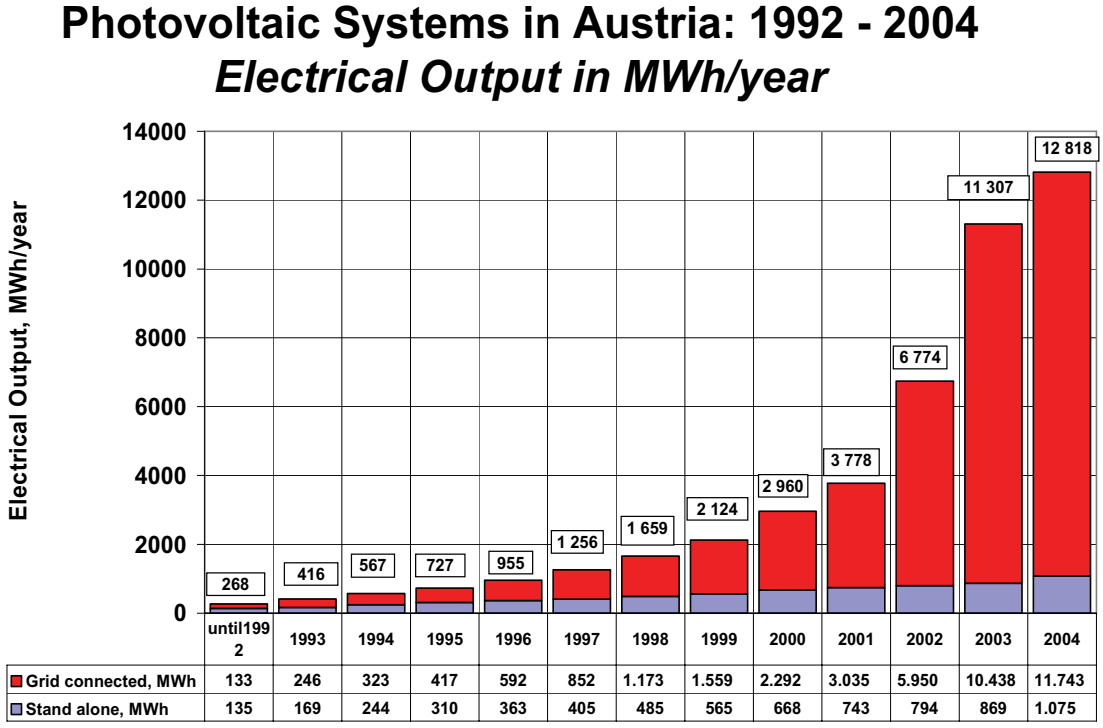


Figure 6.3.2.2: Electrical output in MWh of photovoltaic systems In Austria: 1992 – 2004 (Source: G. Faninger)

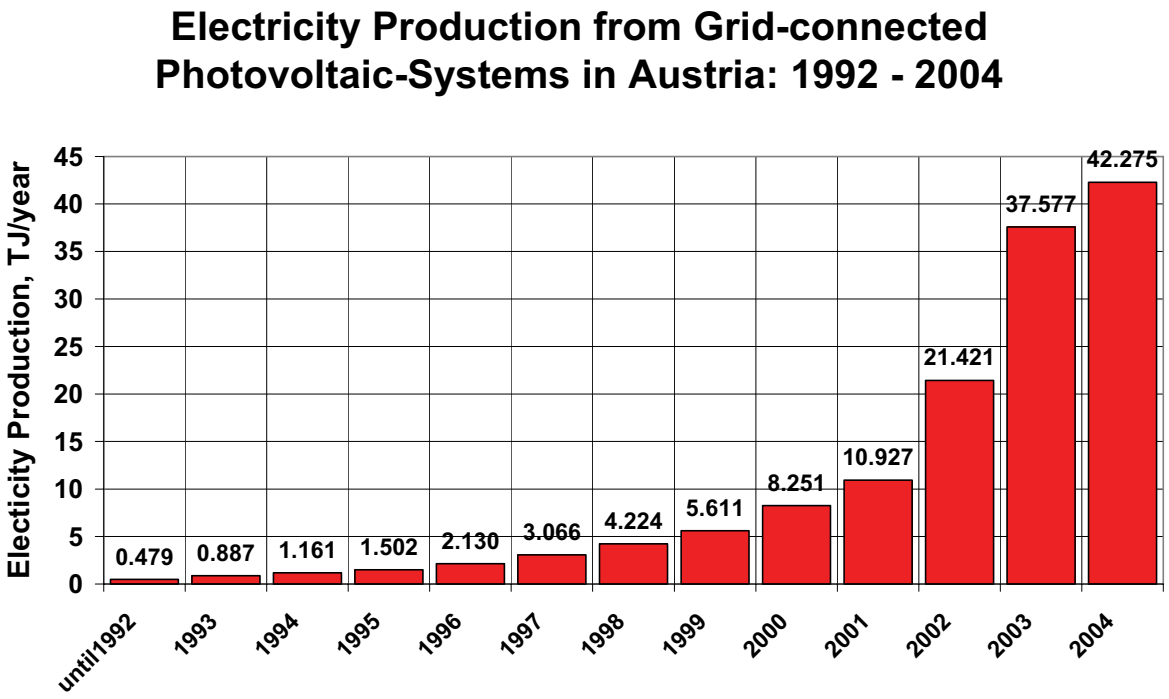


Figure 6.3.2.3: Electrical output in TJ of grid-connected photovoltaic systems In Austria: 1992 – 2004 (Source: G. Faninger)

6.4. Geothermal Energy

Geothermal Energy:

Per definition, geothermal energy is the energy in form of heat below the earth's surface, usually in the form of hot water or steam.

It is exploited at suitable sites as well as for electricity generation using dry steam or high enthalpy brine after flashing and directly as heat for district heating, agriculture etc.

Beside electric power generation, geothermal energy is today used in Austria for district heating, as well as for heating (and cooling) of individual buildings, including offices, shops, small residential houses, etc.

Promising areas for exploiting geothermal energy in Austria are only some areas in Austria: South Styrian/Burgenland and Upper Austrian where some geothermal district heating systems are situated.

The gross-consumption of geothermal energy from 1990 – 2004 is shown in Fig. 6.4.1, the final energy consumption in Fig. 6.4.2 and the geothermal output in public heat/electricity plants in Fig. 6.4.3. At the end of 2004 the gross consumption amounts to 793 TJ, the final consumption to 269 TJ and the total geothermal output in public heat/electricity plants was 524 TJ.

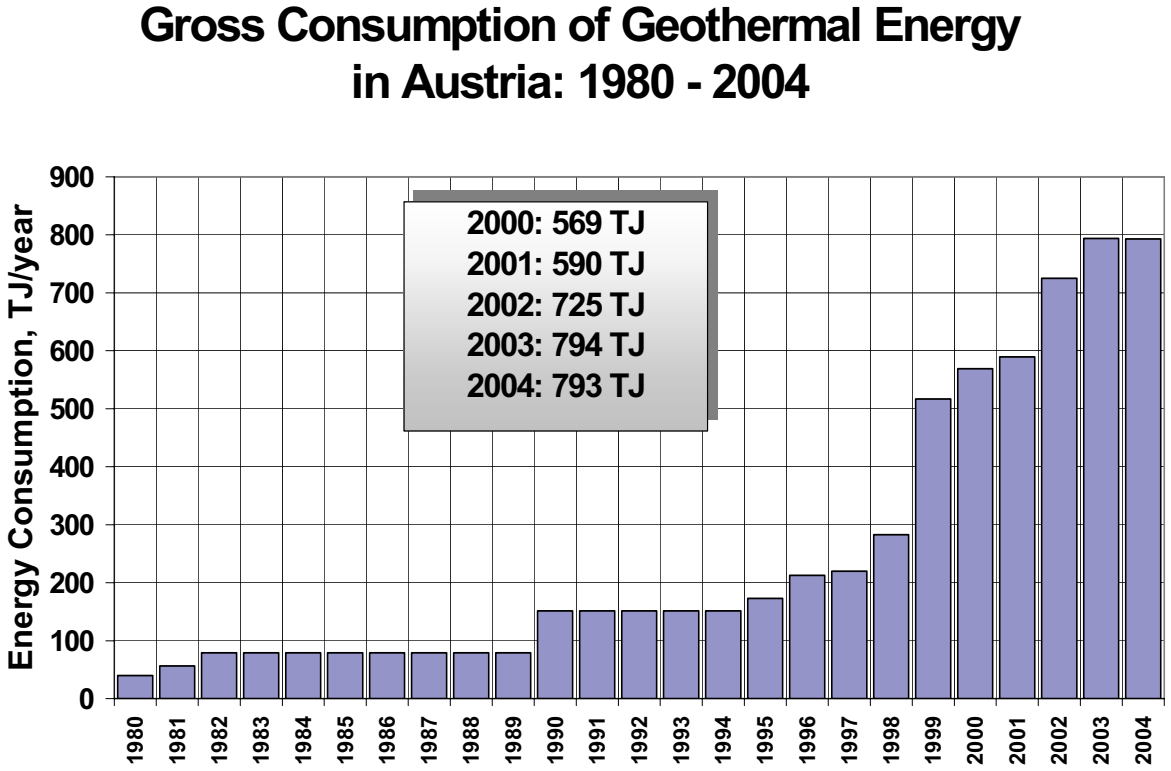


Figure 6.4.1: Gross geothermal energy consumption In Austria: 1980 – 2004 (Source: Statistik Austria)

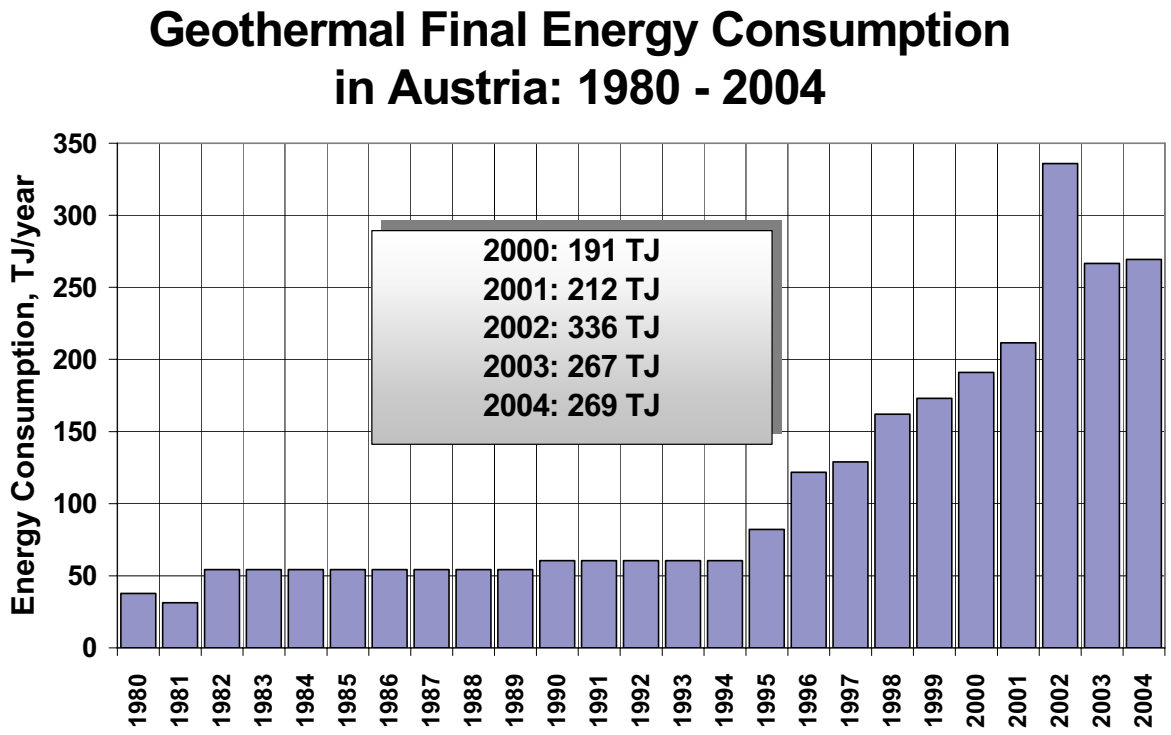


Figure 6.4.2: Geothermal final energy consumption In Austria: 1980 – 2004 (Source: Statistik Austria)

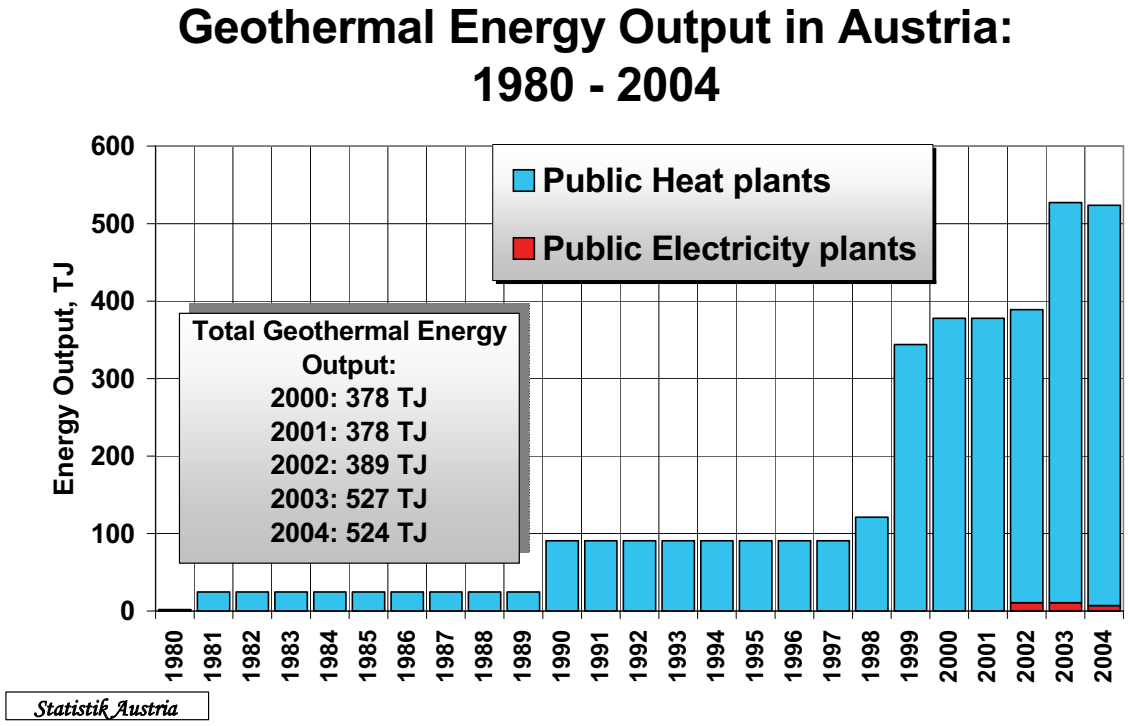


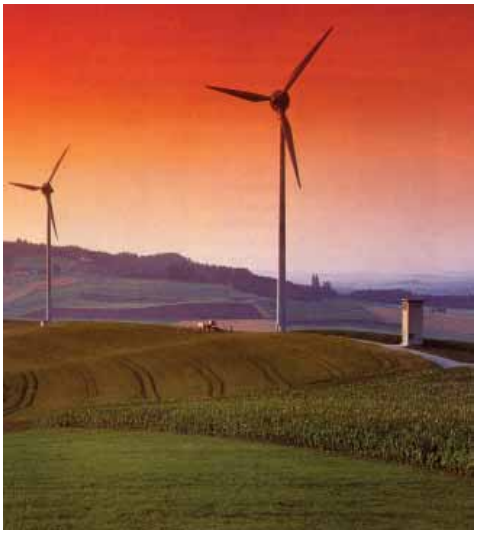
Figure 6.4.3: Geothermal energy output from public heat/electricity plants In Austria: 1980 - 2004 (Source: Statistik Austria)

6.5. Wind Energy

Wind energy:

Kinetic energy of wind exploited for electricity generation in wind turbines.

Atmospheric wind is created by sunlight, the energy of which is converted into the movement of air via convection in the atmosphere and evaporation over oceans.



Wind Energy Technologies in Austria

The market of today for *Wind Energy Technologies* is bulk grid power. This focus results from the increasing size of the machines, which has come from the drive for increased efficiency, as well as increased power output per installation.

With new technologies the market penetration of wind energy converters becomes successful in the last five years.

The market for wind-power increased since 2001 and reached 606 $MW_{(electric)}$ at the end of 2004; Figure 6.4.1. The electricity production was in 2004 926 GWh, Figure 6.4.2, related to 3,334 TJ; Figure 6.4.3.

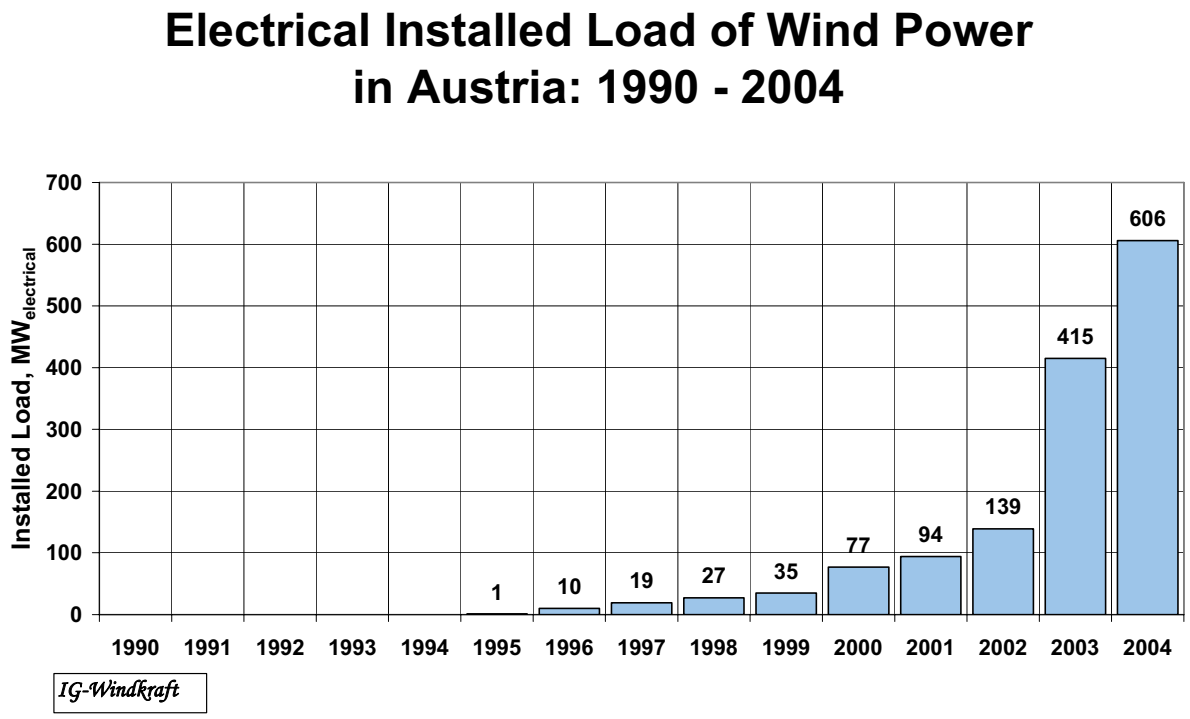


Figure 6.4.1: Installed electrical load of wind-power In Austria: 1990 – 2004 (Source: IG-Windkraft)

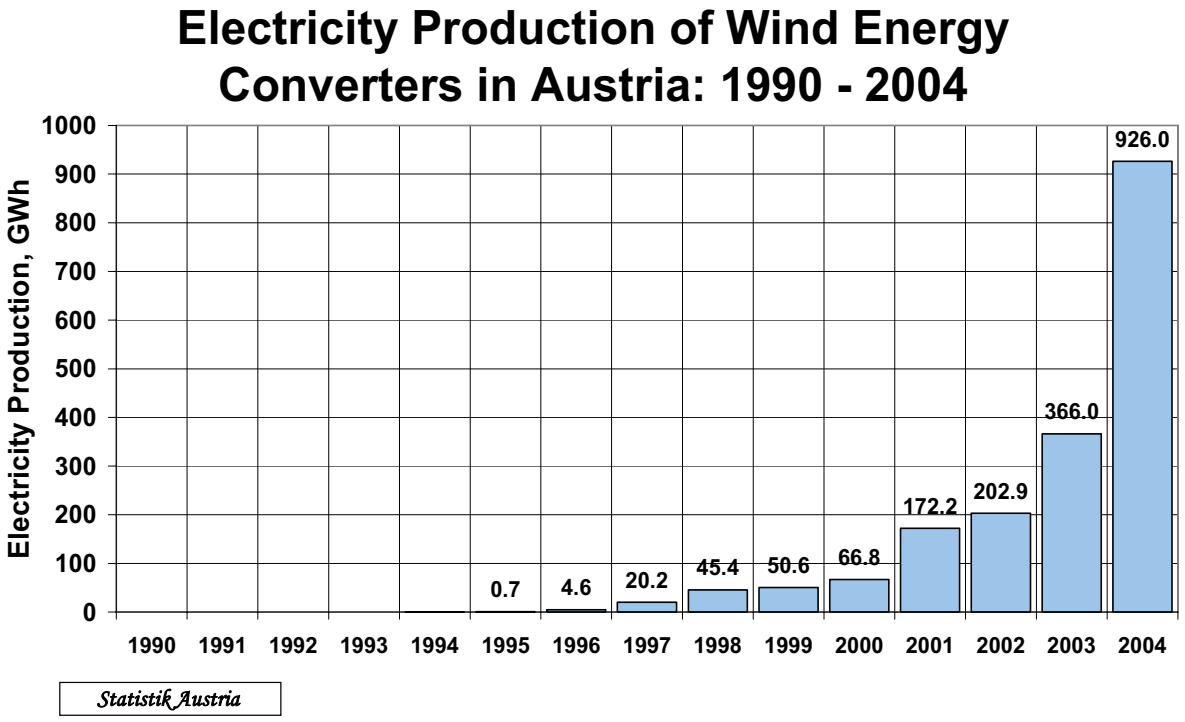


Figure 6.4.2: Electricity production from wind-power In Austria: 1990 – 2004 (GWh) (Source: E-Control/Statistik Austria)

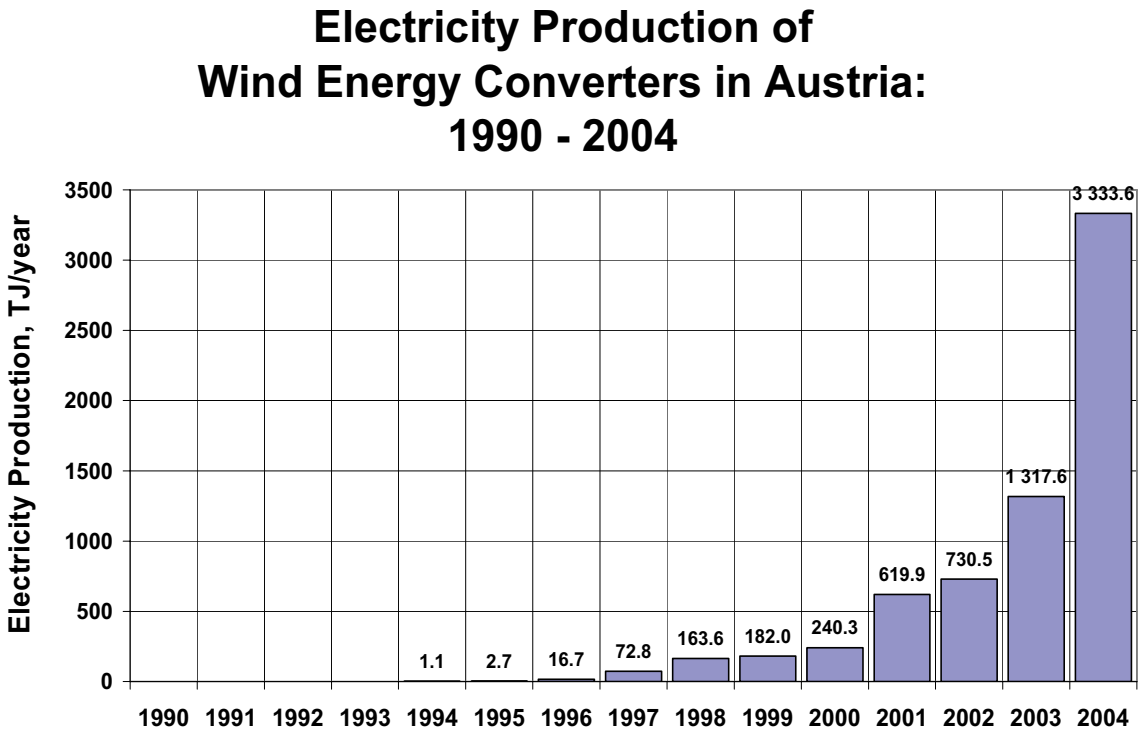


Figure 6.4.3: Electricity production from wind-power In Austria: 1990 – 2004 (TJ) (Source: E-Control/Statistik Austria)

6.6. Ambient Heat and Heat Pump Technologies

Ambient heat:

Renewable and locally available energy source from outside air, ventilation air, the ground, water (ground, lake, sea, sewage) and from waste heat for the production of useful heat

Heat pump technologies:

Heat pump technologies different types are using the ambient heat for useful heat production.

Heat PumpTechnologies in Austria

Heat pump technologies are widely used for the production of heat for space heating and/or space cooling of residential and commercial buildings, water heating, refrigeration and industrial processes. In many industrial processes, heat pumps are applied to recover process waste heat.

Heat pump technologies use different heat source types. Ambient air, ventilation air, the ground, water (ground, lake, sea, sewage) and waste heat can all be used as heat sources for residential applications. Air is often used as the heat source for the reversible heat pumps providing cooling in the summer as well as heating in the winter. In colder and moderate climates, the ground is a very suitable heat source since its temperature is relatively stable throughout the year. Ground-coupled heat pumps show increasing popularity in countries such as Austria.

The performance of heat pumps is usually described as the ***C****oefficient* ***O****f* ***P****erformance* (COP), which is the ratio of useful heat produced to the drive energy of the heat pump. The ***S****easonal* ***P****erformance* ***F****actor* (SPF) is the average COP taken over one heating season. through ground ducts.

Heat pump technologies using the ambient heat as a renewable and locally available energy source for the production of useful heat are generally environmentally attractive. The main environmental impact of this technology is that they can reduce emissions by displacing some fossil fuels through the energy production. Displacing emissions is seen as the most important environmental benefit of heat pump technologies.

The market deployment of heat pump systems in Austria is positive and characterised in Figure 6.6.1. At the end of 2004 about 154,283 heat pump systems were in operation, from which 73.2% are used for hot water preparation, 24.9% for space heating, 1.3% for swimming pools and 0.6% for air-conditioning; Figure 6.6.2.

The renewable energy source for heat pumps is ambient heat, which was utilised with 1,674 TJ in 1990 and with 4,273 TJ in 2004; Figure 6.6.3. The heat load of ambient heat, utilised by heat pump technologies was at the end of 2004 719 $MW_{(thermal)}$; Figure 6.6.4.

Ambient heat - utilised by heat pump technologies - is besides solar radiation an interesting energy source for heat production.

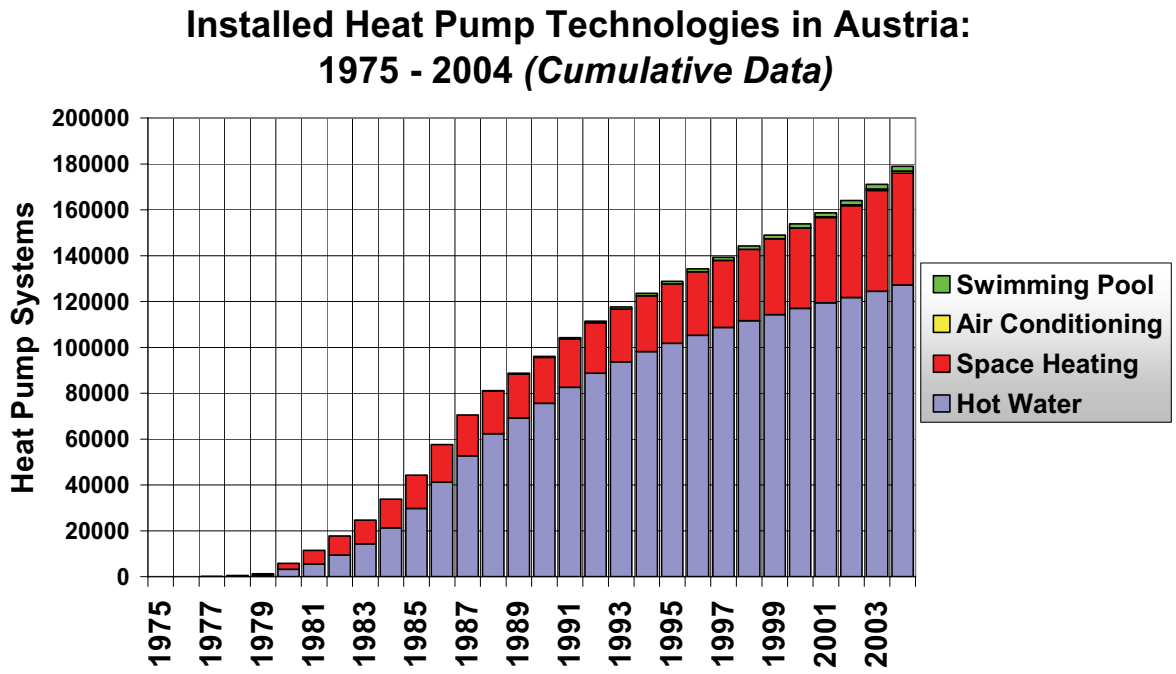


Figure 6.6.1: Installed heat pump technologies In Austria: 1975 – 2004 (Source: G. Faninger)

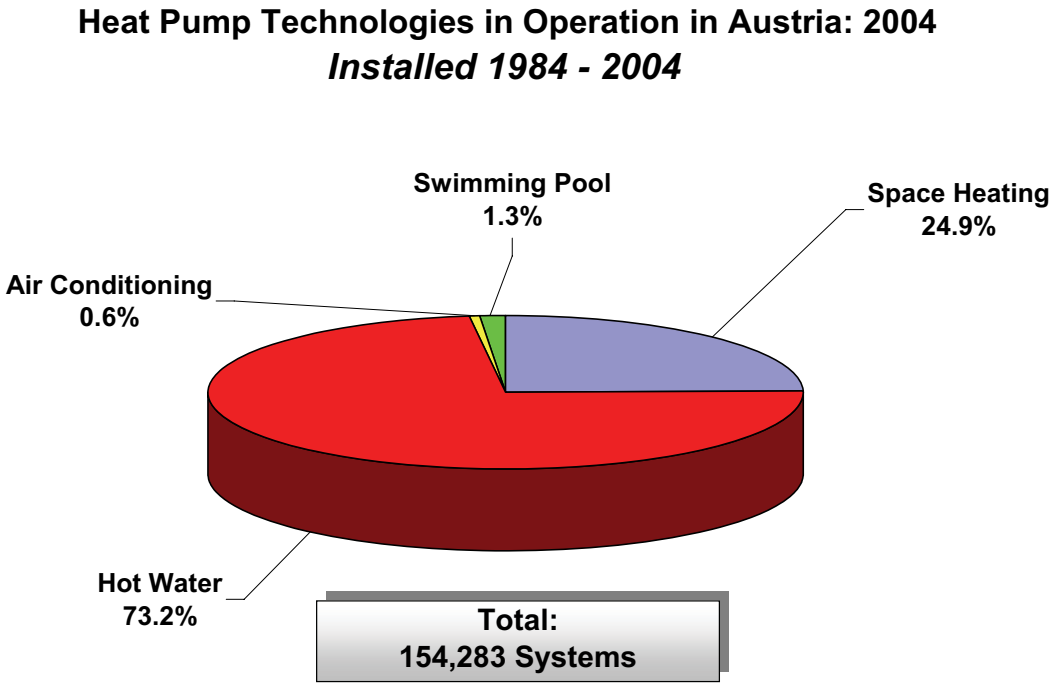


Figure 6.6.2: Installed heat pump technologies In Austria 2004 (Source: G. Faninger)

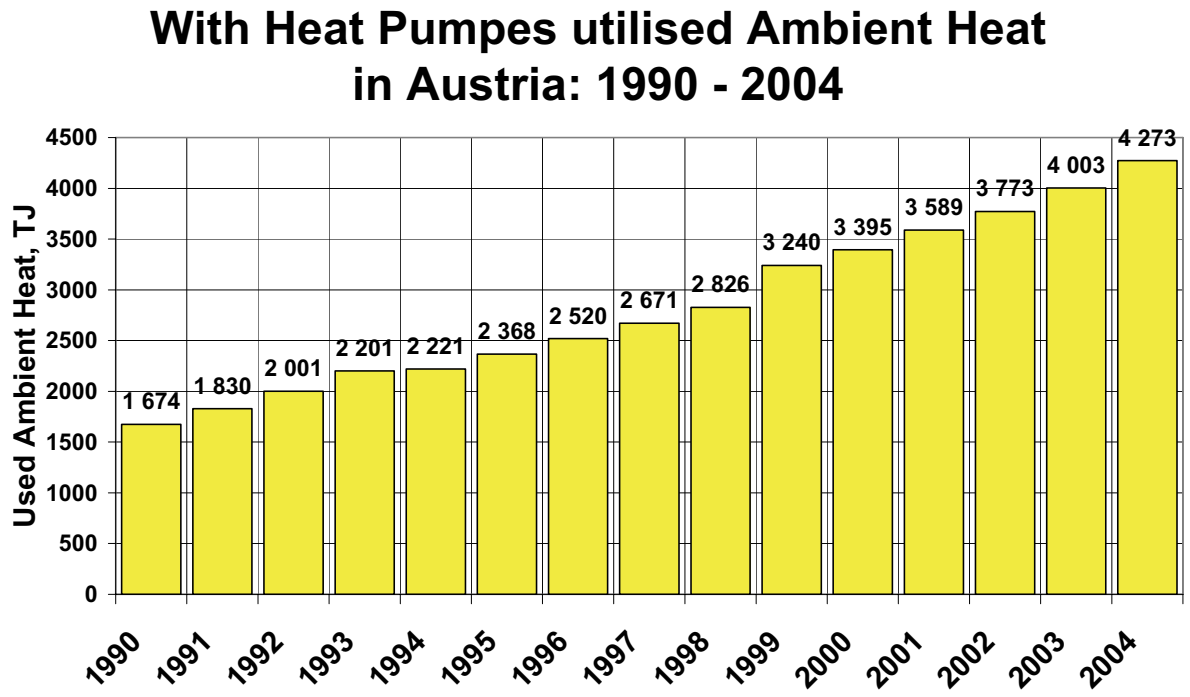


Figure 6.6.3: With heat pump technologies In Austria utilised ambient heat: 1990 – 2004 (Source: G. Faninger)

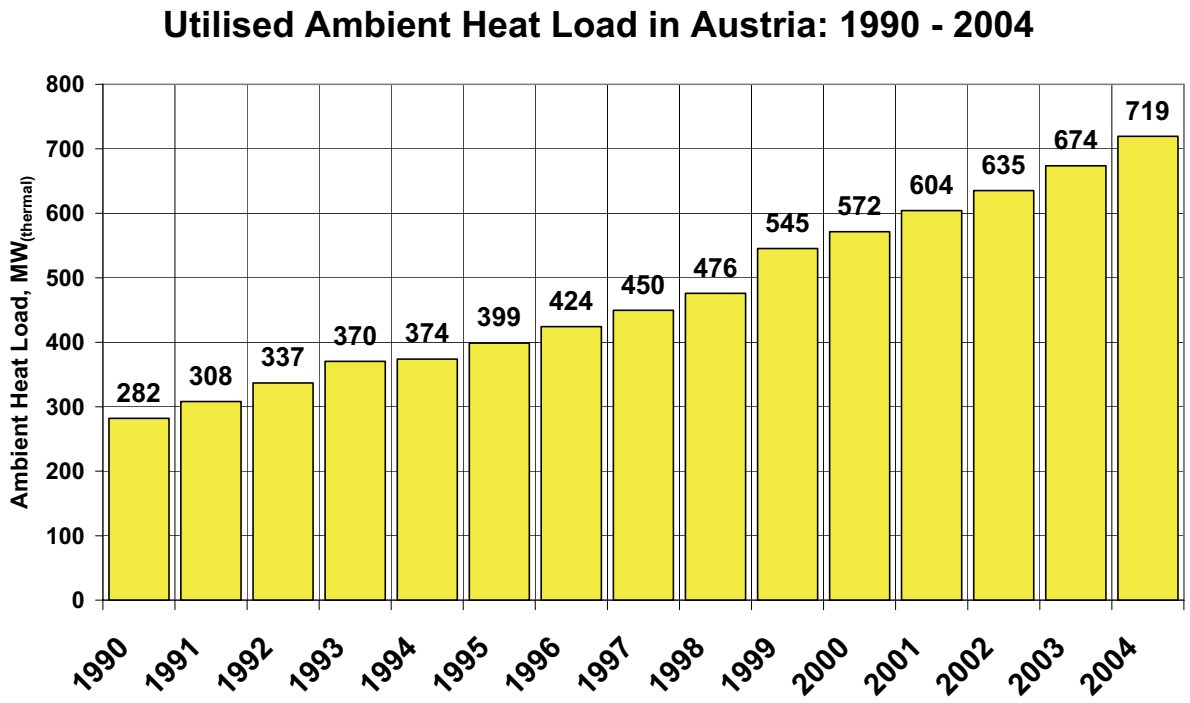


Figure 6.6.4: With heat pump technologies In Austria utilised heat load: 1990 – 2004 (Source: G. Faninger)

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ANNEX

Information on Energy Supply in Austria: 1990 – 2004

Energy Information on Solar Heat, Ambient Heat, Solar-Electricity and Wind Electricity in Austria: 1990 -2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Solar Heat															
Total Primary Energy Supply (Mtoe)	0,01305	0,01659	0,02064	0,02494	0,02966	0,03568	0,04211	0,04854	0,05430	0,05840	0,06821	0,06837	0,07334	0,07905	0,08506
Heat Output (GWh)	151,745	192,907	240,022	290,057	344,963	414,953	489,718	564,574	631,550	679,228	793,300	795,200	852,900	919,3	989,2
Heat Output (TJ)	546,282	694,465	864,079	1044,205	1241,867	1493,831	1762,985	2032,466	2273,580	2445,221	2855,880	2862,720	3070,440	3309,48	3561,12
Total Capacity (MW)	322,991	409,140	506,997	610,787	725,924	868,318	1020,008	1172,566	1308,692	1404,780	1525,447	1637,970	1752,490	1885,2239	1938,3504
Ambient Heat															
Total Primary Energy Supply (Mtoe)	0,03999	0,04370	0,04780	0,05256	0,05304	0,05656	0,06018	0,06380	0,06751	0,07739	0,08108	0,08573	0,09011	0,09561	0,10206
Ambient Heat (GWh)	465,101	508,289	555,906	611,275	616,812	657,785	699,866	741,946	785,134	900,000	943,000	997,000	1048,000	1112,000	1187,000
Ambient Heat (TJ)	1674,362	1829,839	2001,262	2200,591	2220,523	2368,027	2519,517	2671,007	2826,483	3240,000	3394,800	3589,200	3772,800	4003,200	4273,200
Ambient Heat, Total Capacity, MW	281,879	308,054	336,913	370,470	373,826	398,658	424,161	449,664	475,839	545,455	571,515	604,242	635,152	673,939	719,394
Solar Electricity															
Grid-connected															
Electrical Output (GWh)	0,000	0,000	0,133	0,246	0,323	0,417	0,592	0,852	1,173	1,559	2,292	3,035	5,950	10,438	11,743
Electrical Output (TJ)	0,000	0,000	0,479	0,887	1,161	1,502	2,130	3,066	4,224	5,611	8,251	10,927	21,421	37,577	42,275
Total Capacity (MW)	0,000	0,000	0,187	0,346	0,453	0,586	0,831	1,196	1,648	2,189	3,219	4,263	8,357	14,660	16,493
Stand-alone															
Electrical Output (GWh)	0,000	0,000	0,135	0,169	0,244	0,310	0,363	0,405	0,485	0,565	0,668	0,743	0,794	0,869	1,075
Electrical Output (TJ)	0,000	0,000	0,487	0,609	0,878	1,116	1,308	1,457	1,747	2,035	2,406	2,674	2,857	3,129	3,869
Total Capacity (MW)	0,000	0,000	0,338	0,423	0,610	0,775	0,908	1,012	1,213	1,413	1,671	1,857	1,984	2,173	2,687
Solar Electricity, Total															
Total Primary Energy Supply (Mtoe)	0,00000	0,00000	0,00002	0,00004	0,00005	0,00006	0,00008	0,00011	0,00014	0,00018	0,00025	0,00032	0,00058	0,00097	0,00110
Electrical Output (GWh)	0,000	0,000	0,268	0,416	0,567	0,727	0,955	1,256	1,659	2,124	2,960	3,778	6,744	11,307	12,818
Electrical Output (TJ)	0,000	0,000	0,965	1,496	2,040	2,618	3,438	4,523	5,971	7,646	10,657	13,601	24,278	40,706	46,144
Total Capacity (MW)	0,000	0,000	0,525	0,769	1,063	1,361	1,739	2,208	2,861	3,602	4,890	6,120	10,341	16,833	19,180
Wind Electricity															
Total Primary Energy Supply (Mtoe)	0,000	0,00000	0,00000	0,00000	0,00003	0,00006	0,00040	0,00174	0,00391	0,00435	0,00574	0,01481	0,01745	0,03148	0,07964
Electrical Output (GWh)	0,000	0,000	0,000	0,001	0,300	0,745	4,637	20,219	45,448	50,556	66,754	172,195	202,905	366,000	926,000
Electrical Output (TJ)	0,000	0,000	0,000	0,004	1,080	2,682	16,693	72,788	163,613	182,002	240,314	619,902	730,458	1.317,600	3.333,600
Total Capacity (MW)	0,000	0,000	0,000	0,001	0,320	0,780	11,800	20,310	31,570	44,020	77,207	94,000	139,000	415,000	606,170

Energy Information on Geothermal, Bioenergy and Non-renewable Waste in Austria: 1990 -2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Geothermal	151	151	151	151	151	173	212	220	283	517	569	590	725	794	793
Bioenergy															
Wood/Wood Waste/Other Solid W	94.299	102.749	99.936	104.291	100.478	106.779	113.705	113.611	108.034	119.738	111.633	123.583	119.682	134.297	134.564
Gas from Biomass	0	0	0	708	726	849	1.014	1.263	1.269	1.588	1.586	1.837	1.383	1.594	1.899
Landfill Gas	0	0	0	77	88	195	307	524	527	524	457	859	381	527	492
Sludge Gas	0	0	0	631	638	619	668	691	715	714	792	725	721	745	800
Other Biogas	0	0	0	0	0	35	39	48	27	350	337	253	281	322	607
Municipal Waste (renewable)	917	1.101	1.324	1.429	1.452	1.486	1.812	1.860	1.817	1.717	1.765	1.803	1.868	2.211	2.480
Liquif Biofuels (tonnes)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.583
Non-renewable Waste															
Industrial Waste (non-renewable)	6.576	7.180	8.525	6.015	6.704	7.005	9.246	8.227	7.503	9.598	8.454	8.908	10.826	11.853	12.469
Municipal Waste (non-renewable)	1.497	1.797	2.161	2.331	2.371	2.425	2.957	3.034	2.965	2.802	2.755	2.806	3.047	3.574	5.101

Energy Information on Hydro-Power Production in Austria: 1990-2004 (GWh)

	1990	1991	1992	1993	1994	1995	1996	1997	1989	1999	2000	2001	2002	2003	2004
Hydropower	32.492	32.728	36.082	38.020	36.894	38.477	35.580	37.293	38.716	41.746	43.528	41.837	42.057	35.292	39.462
Thermal Power	17.921	18.756	15.098	14.655	16.415	18.110	19.255	19.557	18.721	18.623	18.270	20.416	20.328	24.552	24.231
Green Electricity													286	375	941
Total	50.413	51.484	51.180	52.674	53.309	56.587	54.835	56.851	57.437	60.369	61.798	62.253	62.671	60.219	64.634

Conversions Factors for Energy

1 GWh = 3,6 TJ = 0,000086 Mtoe ($8,6*10^{-5}$)

1 TJ = 0,2778 GWh = 0,00002388 Mtoe ($2,388*10^{-5}$)