Energy Autarky for Austria in 2050

Feasibility Study

Summary

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Summary

In order to limit climate-change induced global warming to 2°C, the Council of the European Union requested (2009) all negotiating parties of the Copenhagen climate change conference to work for the 2°C target. By the year 2050 the industrialised countries would have to reduce their greenhouse gas emissions by at least 80% to 95% compared to the level of 1990. A similar recommendation was presented by the top players of the G8 at their 2009 meeting in L'Aquila. This implies the opting out of fossil energy supply. The present study investigates if and under which framework conditions Austria could achieve complete energy autarky through its own renewable energy sources by 2050.

General assumptions for the study:

- In 2050, Austria will be at 100% supplied from domestic sources of renewable energy.
- It is assumed that the present net energy import of gray energy in commodities will not further increase. At the moment Austria imports by far more energy in the form of gray energy in commodities than it exports in that same way. If this net balance with foreign countries via "energy in commodities" were taken into account, Austria's consumption of fossil energy would presently be 44% higher than the figures in the energy statistics imply. This is of relevance also for the interpretation of the term "energy autarky" and for the scenario developed in this study.
- Only agricultural surplus land is used to cover the energy demand by means of renewable energy sources. Austria's demand for agricultural land dedicated to the food and feedstock production remains the same.
- Energy exchange with the neighbouring EU countries is permitted in imports/exports on a daily/weekly basis – on annual average the import/export balance is zero.
- As regards electricity storage, it is assumed that all Austria has to do is to intermediately store its electricity overproduction in summer in its own pumped storage power stations or chemical storage systems.

The role which smart grids may play in the future to interconnect (decentralised) producers, storage systems and consumers is taken into account in the study only in so far as this is a precondition required to maintain the presently high level of supply security and ensures the compensation of fluctuations in the demand and production of electrical energy over several hours up to few days.

Potentials of renewable energy sources

The technical potentials inherent in renewable energy sources have been determined on the basis of existing studies and expert literature. The potentials have not been fully exhausted in the scenarios observed, as this was not necessary under the assumptions made.

Renewable energy sources considered

- Biomass (forestry, agriculture and green waste, sewage sludge and black liquor, residues from industry and trade, waste cooking oil and fats). Biomass can be converted into low- and high-temperature heat, electricity, biogas and synthetic gas and fuels. However, also in the future priority will be given to the recycling of biomass (as a building material and industrial raw material), a fact which is taken into account accordingly when determining the potential available for energy production.
- Hydropower and its conversion into electricity and as an electricity storage application to make up for daily and seasonal fluctuations by means of pumped storage power stations.
- Wind energy and its conversion into electricity as well as its need for storage to make up for daily and seasonal fluctuations.
- Photovoltaics and its conversion into electricity as well as its need for storage to make up for daily and seasonal fluctuations.
- Solar thermal energy and the possibility of using it for low-temperature heat in buildings and production.
- Near-surface geothermics and ambient heat and its potential use for low-temperature heat in buildings and production via heat pumps (with the corresponding demand for electricity).
- Deep geothermics and its potential use for heat and electricity generation.
- Non-biogenic waste is not taken into account, as we expect a significantly higher rate of recycling for 2050.

Technologies to convert primary into secondary energy sources considered in the study

- Cogeneration
- Facilities to generate bio-ethanol from biomass
- Facilities for gasification and biogas (methane) from biomass
- Facilities for the production of 2^{nd} generation fuels (FT diesel, bio-methane)
- Facilities for the production of fuels and methane from electricity and atmospheric CO_2 (renewable methane, long-chain hydrocarbons from electricity and CO_2)

Structures of energy demand and efficiency

The energy demand was defined in the sectors buildings and mobility via energy services (m² of floor space warmed up / cooled down, passenger kilometres and tonne kilometres). Based on a given level of comfort and mobility requirements of the population, this approach allows considering both the efficiency enhancement in buildings (reduction of the energy demand through high-quality renovation of old buildings and the construction of new passive houses) and mobility (reduction of fleet consumption) and the coverage through other technologies (public transport, non-motorised private transport) on an equal footing with the use of renewable energy sources via different technology paths. For lack of data, a different approach was chosen in the field of production. As, due to the great variety of outputs, the concept of energy services cannot be applied to the production sector, the energy demand was in the course of the study assigned to individual energy demand categories as specified in ÖNACE, the Austrian classification of the economic activities of enterprises.

Scenarios of the energy demand and their basic assumptions

The spectrum of the demand for energy services for the year 2050 has been outlined via three scenarios, of which only the constant scenario and the growth scenario were fully calculated.

- Constant scenario: In 2050, the level of the energy services of mobility and buildings and the gross value added of the industry will be the same as in 2008.
- Growth scenario: Until 2050 constant growth of the energy services of mobility and buildings and gross value added of the industry 0.8 % p.a., i.e. increase by a little less than 40 % compared to 2008.
- Efficiency improvement: Same as growth scenario, but with higher efficiency.

The end-use energy demand for the defined energy services for 2050 will thus be the result of improvements in the efficiency (= energy saving) of technologies on the one hand and of a move to less energy consuming technologies on the other hand.

In the field of private mobility the consumption of energy can be reduced for the long term by a shift in the modal split and a marked reduction in the consumption of fleets. A great part of the passenger car traffic could and would have to rely on electrical energy. The rather small quantities of fuels from renewable resources that are available in Austria can then be used for heavy commercial vehicles and machines in agriculture and the building industry, where it would be much harder to shift to electricity. In the case of passenger cars this will involve a high share of plug-in hybrid vehicles and pure electric cars. Distances driven with combustion engine vehicles would have to be covered with about 3 ltr/100 km on average, kilometres driven with electric vehicles with approximately 0.12 kWh/km. Moreover, there will be a strong move towards public transport (PT) and non-motorised private traffic (NMPT) whose share will then amount to next to 50 % in the constant scenario and over 60 % in the growth scenario. Long-distance freight transport is almost completely transferred from road to rail or ship; the consumption of fleets is reduced. Also mobile machinery and equipment, air transport and pipelines are under discussion. Regional air transport is in both scenarios almost completely transferred to rail. Taking everything into account the above-described changes will lead to a reduction of the energy demand for mobility by over 70 % in the constant scenario and by about two thirds in the growth scenario. Figure 0.1 illustrates the end-use energy demand in the field of mobility for 2008 and for the two scenarios calculated.

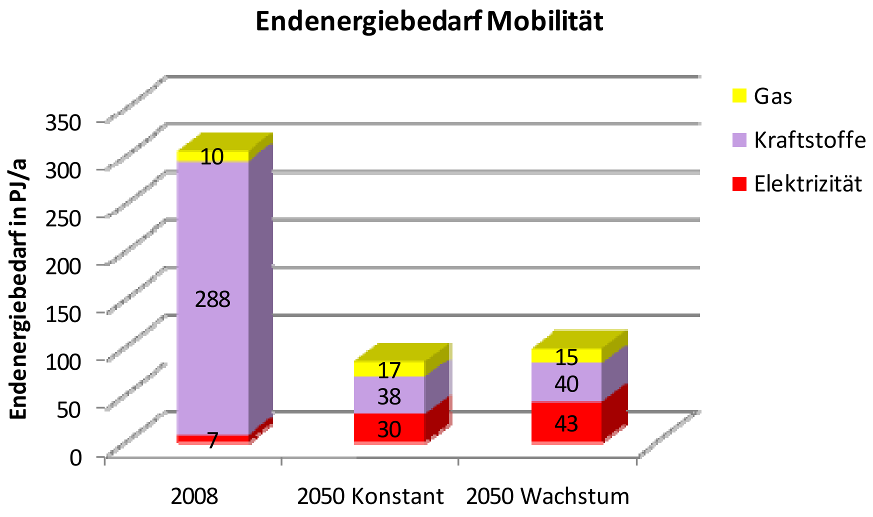

Fig. 0.1 End-use energy demand of mobility in 2008 and for the two scenarios for 2050

In the field of buildings thermal refurbishment will until 2050 lead to a reduction of the average demand for heating energy from presently approx. 144 kWh/m².a to 61 kWh/m².a in the constant scenario and 49 kWh/m².a in the growth scenario. It is assumed that, in spite of climate change, the energy demand for cooling will slightly decline due to improved building envelopes. The demand of electrical power for residential buildings and service buildings will until 2050 altogether decline by next to 20 % in the constant scenario and by 7 % in the growth scenario. As a consequence, the energy demand of buildings will decrease by 51 % in the constant scenario and by 44 % in the growth scenario. Indoor thermal comfort is in the growth scenario almost exclusively achieved by a combination of heat pumps and solar thermal energy – in this way the available biomass can be provided for mobility and the industry. Fig. 0.2 shows the end-use energy demand of buildings for 2008 and for the two scenarios calculated.

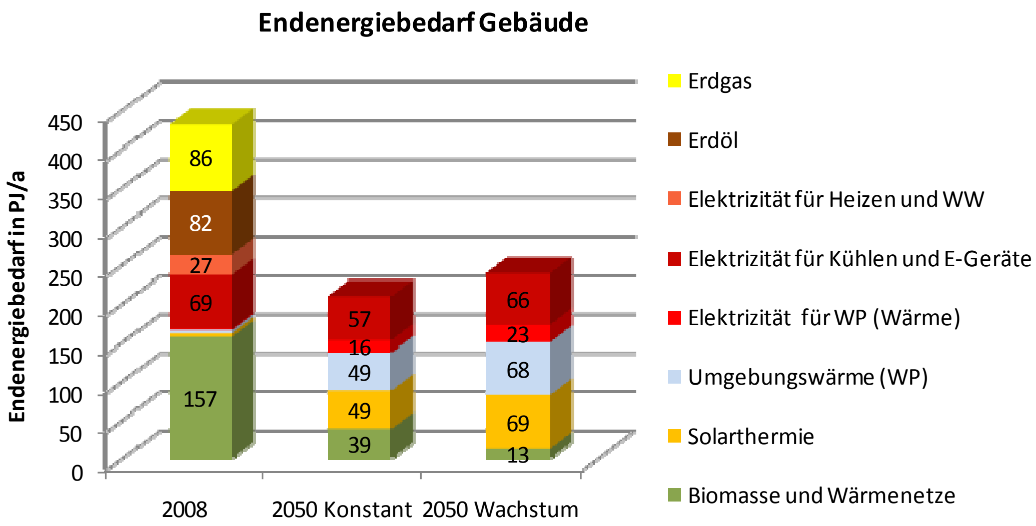

Fig. 0.2 End-use energy demand of buildings in 2008 and for the two scenarios for 2050 (HW: hot water; HP: heat pump)

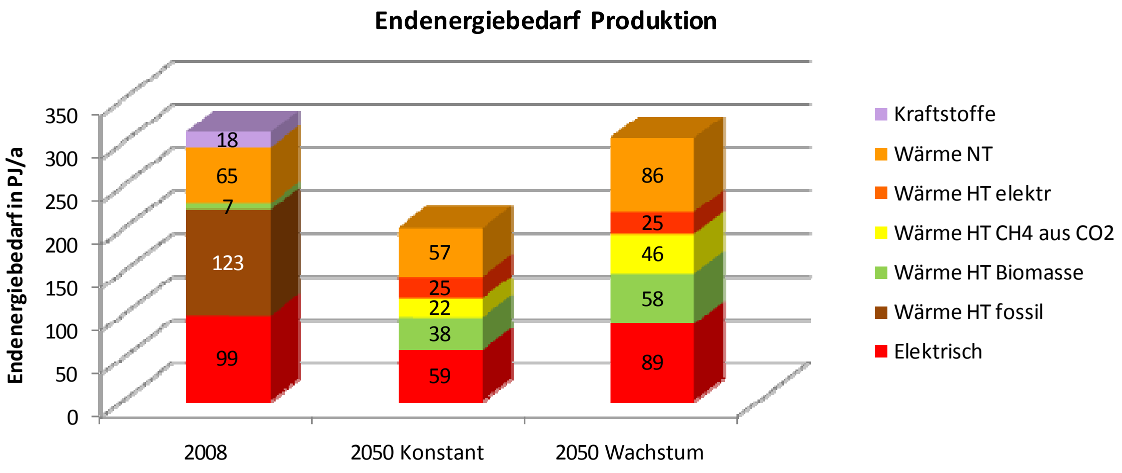

Fig. 0.3 End-use energy demand of production in 2008 and for the two scenarios for 2050 (LT: low temperature; HT: high temperature)

In analogy to the requirements of the EU's Energy Efficiency Directive an efficiency improvement of 1 % p.a. is assumed for the production sector; in the constant scenario this leads to a reduction of the energy demand by 35 %. This is due to the continuous endeavor to reduce production costs and consequently to improve the energy efficiency of processes. In the growth scenario for the production sector the energy demand will until 2050 in spite of an assumed 0.8 % annual increase in the gross value added see a decline of 2.3 % compared to 2008. Fig. 0.3 shows the end-use energy demand in the field of production for 2008 and for the two scenarios calculated.

Taking everything into account the end-use energy demand of 2050 will therefore see a 53 % reduction from approx. 1,100 PJ in 2008 to 497 PJ in the constant scenario and a 38 % reduction to 647 PJ in the growth scenario. With additional, presently not foreseeable efficiency measures it might be reduced even more.

Only if, thanks to efficiency improvements and smart energy use, the energy demand is reduced as strongly as assumed in this study can energy autarky be achieved and will it be possible for Austria to satisfy its energy demand completely with domestic renewable energy.

Energy system 2050 for the constant scenario and the growth scenario

Figure 0.4 shows the energy system for the constant scenario and figure 0.5 for the growth scenario. Biomass and hydropower cover in both scenarios considerably more than half of the energy demand.

In the constant scenario the biomass utilisation of 216 PJ in the year 2008 is extended by 13 % to 244 PJ and electricity generation from hydropower from presently 38 TWh to almost 45 TWh. Wind energy generation increases by more than five times to more than 13 TWh. Photovoltaics contributes with 16 TWh more than 500 times more to energy generation than in 2008. Also the utilisation of heat from solar energy (increase by the factor 10) and heat pumps (factor 8) increases decisively compared to the base year.

In the growth scenario the renewable energy potentials are exploited even more strongly. Biomass production increases by 36 % to 293 PJ and exploits thus 95 % of the available potential – in this context it is proceeded on the assumption that only agricultural surplus areas are used and that areas for food and feed production remain constant compared to 2008. Hydroelectric power is further developed to 177 PJ (almost 50TWh) and uses thus almost 90 % of the potential worth being developed which is said to amount to 56 TW/h. The potentials of wind energy, with more than 14TWH, and of photovoltaics, with a little bit less than 20 TW/h, are also exploited at 80 and 85 % respectively. This applies in a similar way to the utilisation of solar energy (75 PJ). Near-surface geothermics (68 PJ) is limited in its utilisation due to the electricity demand. Moreover in this scenario electricity generation from deep geothermics constitutes another renewable source of energy – which is, from the present point of view, judged to be extremely expensive – that makes with 71 PJ a considerable contribution to covering the energy demand.

Among the new transformation technologies the generation of CH_4 and longer-chain hydrocarbons and CO_2, as well as the generation of 2nd generation fuels from biomass are applied.

The necessary economic and organisational framework conditions in order to reach the further development of these technologies should be examined in further studies.

What is not entered into the flowchart is the necessary further development of pumped storage power stations in order to balance the volatility of electricity generation from photovoltaics, hydropower, and wind energy. The present pumped storage performance of about 3.8 GW would increase in the constant scenario to 7 GW and in the growth scenario to 9 GW.

Measures

The necessary framework conditions required for energy autarky call for committed, clear unequivocal political decisions and course settings. This applies, among other things, to economic instruments (e.g. energy prices), rules and regulations, infrastructural investments (in particular in the fields of mobility, power grid infrastructure, energy storage) and increased energy research efforts. In order to increase the social acceptance for the measures to be taken target-group-specific harmonised information activities as well as awareness-raising measures are to be initiated. It is to be carefully weighed against, whether increased opening-up of potentials or far-reaching efforts in the field of efficiency meet with higher acceptance.

The strong increase in efficiency due to the reduction of the fleet consumption of mobility (smaller and more efficient private cars so to speak) is a measure which results in saving costs for every private individual, but requires a change of values in the society. A shift of the long-distance goods transport from the road to the rail as well of passenger and freight transport from the aeroplane to the rail would require a strong further development of rail infrastructure.

It will be comparably easier to achieve savings in the fields of building and production. In any case the increase of the rate for high-level thermal sanitation in the building sector to the 3 % per year, already outlined by the Federal Government in the energy strategy, will be necessary. In the production sector the reduction of the energy demand is due to the permanent improvement of production processes, the development and market penetration of efficiently conceived technological solutions makes a considerable contribution in this respect. With this efficiency increase in all sectors the remaining energy demand can be covered by renewable sources of energy.

The calculations have shown that energy autarky in Austria is feasible, but that the room for manoeuvre is relatively small. This is, among other things, due to the fact that Austria has – for example compared to other EU Member States – no possibilities to use offshore wind energy and cannot apply solar thermal energy generation due to the low share of direct radiation from the sun. In the case of a further increase of the energy service level or in the case of lower efficiency increases than assumed in this study we reach the limits of the available potentials of renewable sources of energy.

Statements with respect to costs and benefits at macro-economic level are presently still premature and require further analyses.

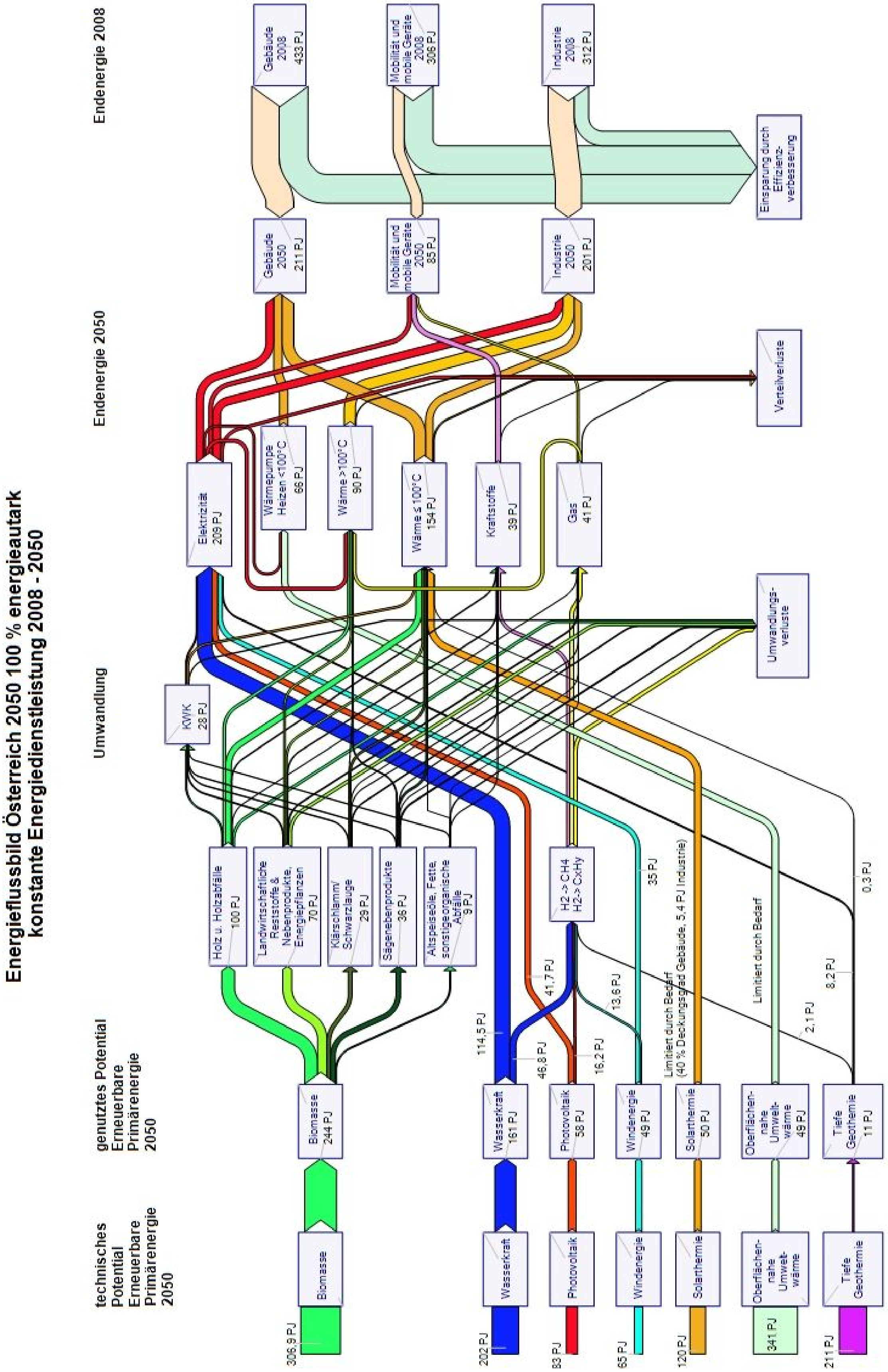

Fig. 0.4 Energy flowchart Austria 2050 with energy autarky for **constant** energy service until 2050

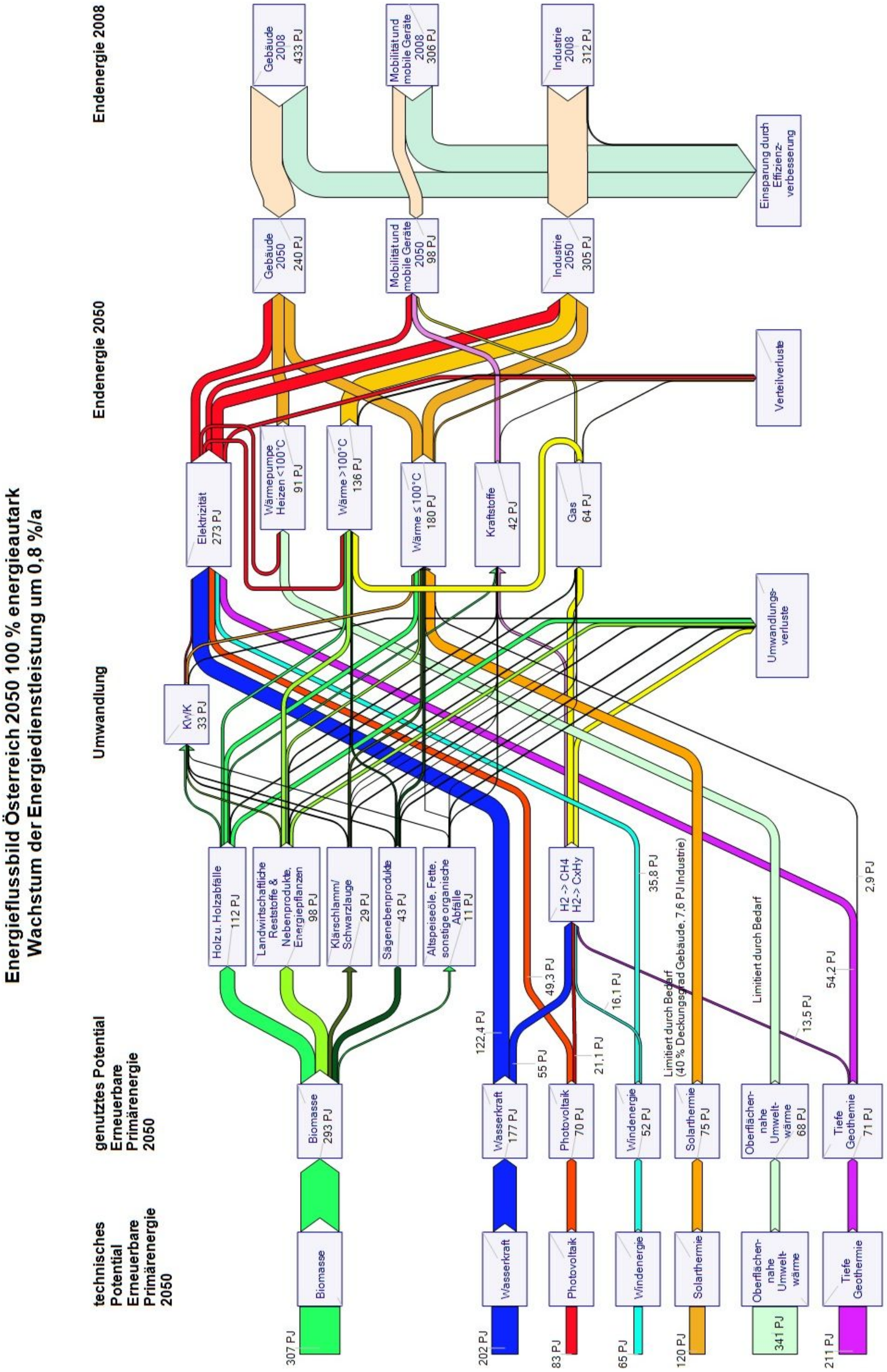

Fig. 0.5 Energy flowchart Austria 2050 with energy autarky for a **growth** of the energy service by 0.8 %/a

Das Projekt wurde abgewickelt über die

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