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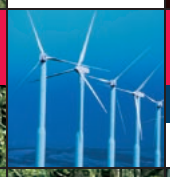

NO. 18 / APRIL 2007

ENERGIE-SPIEGEL

FACTS FOR THE ENERGY DECISIONS OF TOMORROW

The 2000 Watt Society – Standard or Guidepost?

Our energy supply is not sustainable. The energy use in developed countries is high; in developing countries it is growing rapidly. Our dependance on oil, coal and natural gas is disturbing the climate, and raising political tensions. PSI is researching the development of energy systems through the year 2050, with the goal of a more sustainable energy supply. A society that saves energy and CO_2 will show the way.

The 2000 Watt society is today often seen as a vision of a sustainable energy supply that will be environmentally acceptable and at the same time allow for at least a stable standard of living. Energy use of 2000 Watts per person (or 17,520 kWh per person per year) represents about the current global average demand. In Switzerland energy use is currently about 5000 Watts, not counting "grey" energy in imports that amounts to almost 4000 Watts. By comparison, a large part of humanity exists today on less than 1000 Watts per person.

Is 2000 Watts per person possible for Switzerland in the future, and under what conditions would it be compatible with our climate? A PSI study* shows that we must deal very carefully with the concept of the 2000 Watt society. It is not the level of 2000 Watts alone that is decisive, but rather how this power is produced.

We need more energy efficiency, energy savings and new technologies. These methods can save at most 30% of demand by 2050 in a way that is reconcilable with our society. But that we cannot reach the 2000 Watt level per person is not essential for the climate. From the perspective of climate change, the first and foremost need is to reduce CO_2 emissions as fast as possible. The long term goal is about one tonne of CO_2 per person per year, or 500 Watt per person from fossil sources. That is six times less than today, and will demand great rethinking and the use of all non-fossil energy carriers. The 2000 Watt society should serve as a long term guidepost – as an expression that unites our ambitions for affluence and a sustainable energy supply under one roof.

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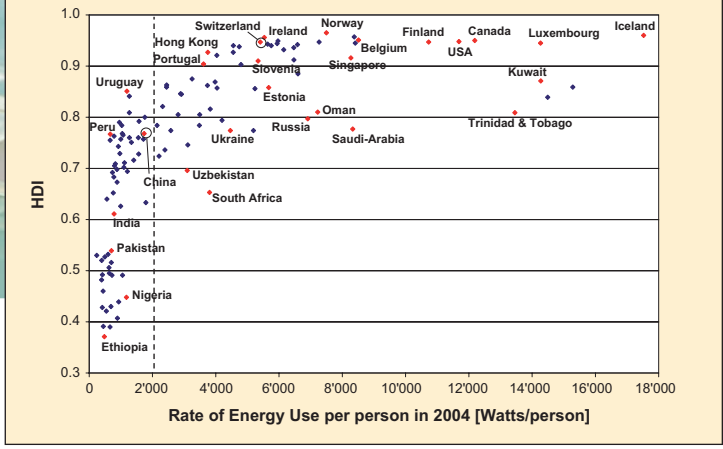
*Thorsten F. Schulz, "Intermediate steps towards the 2000-Watt society in Switzerland: An energy-economic scenario analysis," dissertation ETHZ, submitted 2007.

Energy – Key to Prosperity

Today's western standard of living depends decisively upon our energy supply: prosperity demands energy. On the reverse side of the coin are environmental problems. Especially climate change, which is becoming ever more certain. In addition, today's developing countries are attempting to quickly attain the West's level of development. Alternatives with lower energy intensities are needed.

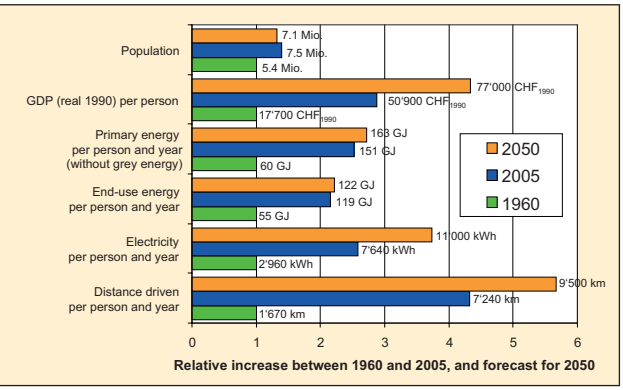
Picture: Roger Frei



Human Development Index and energy use for various countries (UNDP 2006).

Energy demand in Switzerland averaged 2000 Watts per person in 1960. Since then wealth has quadrupled, as measured by gross domestic product. The number of vehicles has also increased from 860,000 then to about 5 million today. Primary energy demand has climbed almost in parallel to the GDP. Every Swiss today uses on average almost 42,000 kWh annually, representing almost 5000 liters of gasoline, or a continuous power demand of around 4800 Watts. And that is without "grey" energy (see box), which is almost 80% of the domestic demand*. A good two thirds of this energy comes from fossil sources – oil and natural gas, mostly for heating and transportation. The consequence of this rising energy demand is ever more environmental problems. Before, smog and acid rain were the focus of the debate. Today it is particulates and climate change. And although energy demand per person has barely grown in the past few years, electricity demand has grown even more strongly than GDP.

Swiss targets for 2050: 3–4 tonnes CO_2 per person, with fossil use of 1500–2000 Watts



Growth in Switzerland from 1960 to 2005, and forecast for the base scenario in 2050 (BFE 2005) (see insert sheet).

The View Over the Borders

A sufficient energy supply is a prerequisite for a high standard of living, as shown by international comparisons. How well a country performs in the Human Development Index (HDI) depends in part upon its per capita energy use. Swiss per capita energy use is relatively low, compared to other highly developed countries like Finland, Belgium or the USA. The lower limit for a life of an acceptable level of prosperity is generally considered to be the current global average energy demand of 2000 Watts per person. But examples like Russia and Saudi Arabia also show that sufficient energy alone does not automatically mean a prosperous or highly developed society.

Problematic Developments

Even though Switzerland has traveled a successful path to development, it has become increasingly clear that we can not serve in every way as a model for current developing countries. Our energy supply, with its high dependence on fossil resources and their related CO_2 emissions, cannot serve as an ideal example for sustainable development. The fourth IPCC report published in February clearly states that high fossil energy use has strongly influenced global climate change. To keep warming of the earth's atmosphere within bearable limits, global CO_2 emissions must be decreased 50% by 2050. In view of the economic equity needed for developing countries, emissions from developed countries should be reduced by significantly more (60–80%). Direct Swiss emissions are currently at about 6 tonnes of CO_2 per person per year. In addition, significantly more than half of this amount is contained in grey imported CO_2 emissions. A long term global goal of 1 tonne of CO_2 per person per year – representing the equivalent of one flight to Turkey (Zürich–Antalya and back) – cannot be reached with our current pattern of supply. This does not mean that we must freeze in the dark. But we must strongly reduce our dependence on fossil resources and redesign our energy supply so that we can maintain at least our current standard of living with lower energy use. On the way to this distant goal, we need realistic but challenging intermediate targets for the middle of the century: 3–4 tonnes of CO_2 per person per year with 1500–2000 Watts from fossil sources (without grey emissions and energy) should be placed on our agenda.

Human Development Index (HDI)

The HDI is a country-specific measure of the level of human development on a scale of 0 to 1, which is determined annually by the UN. The calculation includes life expectation, educational standards, and the purchasing power of a country's inhabitants.

Primary energy: Energy that is contained in the original energy carriers used (e.g. natural gas, crude oil, etc.)

End-use energy: Energy available to consumers after conversion and transport losses (e.g. wood pellets, electricity, gasoline).

Energy services: The effective form of energy used by consumers (e.g. space heating, light, etc.).

Grey energy and emissions: Energy used and emissions produced in the creation of imported goods and services, which do not appear in domestic Swiss statistics.

*Personal contact with Rolf Frischknecht, ESU-services GmbH. Study still unpublished.

A higher standard of living despite less energy

We can design a more systainable energy system today: more ecological with less use of oil and at the same time more economical and socially bearable through use of the most cost efficient increases in energy efficiency and energy savings. The 2000 Watt society may not be achieved by 2050, but ambitious steps in this direction and thus towards lower CO_2 emissions should be addressed.

A pure efficiency strategy that only minimizes primary energy use will not achieve the goal. Using less energy is certainly important, but will not alone suffice to reduce CO_2 emissions. To reach a level of 2000 Watts per person (equivalent to an energy demand of 17,520 kWh per year) will require longer than to 2050. One round trip from Zurich to Los Angeles and back each year would use up half this limit. With the technological means that will be foreseeably available by the middle of this century, the best case reduction of primary energy demand would be to 3500 Watts (without grey energy).

Less CO_2 as Order of the Hour

Does it make sense to focus on the maximum reduction of energy use? This alone will not sufficiently reduce oil and natural gas use; CO_2 emissions will remain too high. We can also significantly reduce CO_2 emissions without focusing solely on energy use alone.

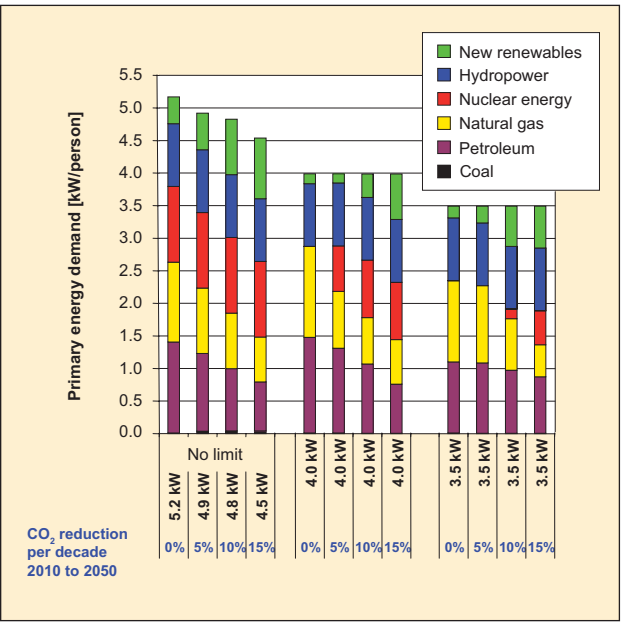
Indeed, CO_2 reduction should be the predominant goal. Setting this goal has the effect that a slight increase in primary energy use will also produce lower additional costs, Swiss air will be cleaner, and dependence on fossil energy imports will be decreased. On the basis of climate policy, Swiss CO_2 emissions should be reduced at least 50% by 2050. That means, assuming that Switzerland reaches the 2010 Kyoto target, a reduction of almost 15% per decade between 2010 and 2050. This ambitious path is technically possible only with the most extreme efforts, and will require considerable investments (see insert).

> CO_2 reduction should be the primary goal

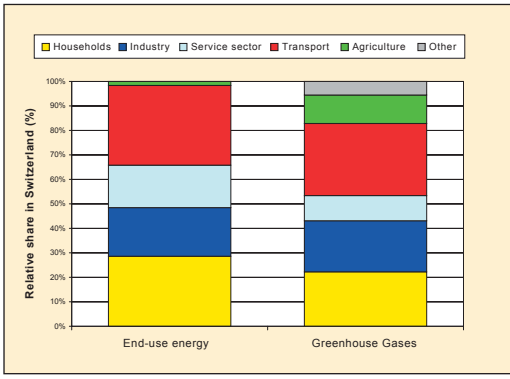
A Rocky Road

What does that mean for us concretely in the coming decades? The largest blocks of energy use and CO_2 emissions today are the construction and operation of buildings, transportation, and consumer goods from the industrial and commercial branches (figure to right). Energy savings and efficiency measures are called for in the building sector. Sharpened standards for new buildings and renovations can achieve a reduction of 60% in this sector by 2050. The reduced heat demand could then be predominantly covered through heat pumps: oil and natural gas would barely be needed. The transport sector is more difficult: if traffic increases further, energy use and CO_2 emissions can only be reduced by about a third by 2050 using technical solutions. The industrial and consumer goods sector must therefore use the most efficient processes and appliances. Lower total energy use, and above all lower CO_2 emissions, also means that electricity becomes more significant within the energy sector, and that demand will increase (see insert page).

The current study identifies possible developments, but does not say anything about what incentives we will need to throw overboard our current behaviour patterns. What is clear is that the redesign of our energy system will be difficult, and the transformation toward which we are striving will not happen by itself. It will require targeted and long term policy measures to move people in a new direction. And the earlier the necessary changes can be introduced, the simpler and the cheaper reaching these goals will be.



Primary energy demand in the year 2050: Scenarios with unlimited power; with 4 kW and 3.5 kW per person; and with prescribed CO_2 reductions per decade between 2010 and 2050 of 0%, 5%, 10% and 15%, respectively.



Share of the various economic sectors in final energy demand and in greenhouse gas emissions for Switzerland in 2004 (BAFU 2006).

"Energy efficiency and comfort are not incompatible"

Peter C. Beyeler, holds a BS in Civil Engineering from ETH, and has been on the governing council of the Canton of Aargau since July 2000, leading the Department for Building, Transport and the Environment. He was previously in the private sector, active in various engineering areas, both foreign and domestic.

Dr. Hans-Peter Fricker has been Director of WWF Switzerland since January 2004. Since his doctoral studies at the University of Zurich he has held various academic posts, was a member of the board of directors of Swiss Radio DRS, and led the Swiss Multiple Sclerosis Society.

The 2000 Watt Society is a key element of the Bundesrat's "Strategy for Sustainable Development." How do you understand this concept?

Fricker: The concept of the 2000 Watt society has two emphases: On the one side, the best technology will decrease energy use to a level that is manageable worldwide over the long term. On the other side, it is accepted that all societies will strive for the highest quality of life. A sustainable energy system, largely without fossil energy and without nuclear power, will make this possible.

Beyeler: The 2000 Watt society is a vision, but with the potential for long term transformation. First of all, a marked improvement in energy efficiency will allow demand to be strongly reduced from today's 5000 Watts, without loss of standard of living. But this is a long road.

What is the priority for you: less energy use in and of itself, or rather the reduction of CO_2 emissions?

Fricker: The reason for restructuring our energy system is the high greenhouse gas (GHG) emissions that are causing climate change. A sustainable energy supply can be more quickly realized in an economically and environmentally manageable fashion if we significantly reduce energy demand.

Beyeler: Definitely less CO_2. The consequences of "pollute now, and pay later" will be first seen in 20 years. We must replace fossil energy carriers through other forms of energy, and massively increase efficiency at the same time. Research has an important role in this, particularly the "Competence Center Energy and Mobility" led by PSI.

How should this society be motivated to a lifestyle that will save energy and CO_2?

Beyeler: Energy efficiency and comfort are not incompatible, the best example of this being the Minergie buildings. It is essential to encourage the people in their choice of energy efficient appliances, vehicles and buildings. Financial incentives in the form of startup financing can also help in this sense. I do not favor savings programs with behavioral guidelines and prohibitions.

Fricker: Policies must create clear, forward looking frameworks, so that saving energy and the use of renewable energy will pay. The populace does not itself wish to waste energy or burden the climate with CO_2 emissions. Our energy policies until now have been strongly influenced by the interests of the energy and electricity companies, i.e. towards ever more sales and not savings. New systems of incentives are needed here, e.g. revenue neutral fees and/or an ecological tax reform. Appeals and voluntary programs alone will not halt the waste.

What political measures do you hold to be necessary and appropriate to save energy and CO_2?

Beyeler: The Minenergie standard must become the norm for buildings – up to the level of the passive energy house that makes current comfort standards possible with very little energy. The Cantons are willing to pass appropriate regulations. The federal government should promote the import of energy efficient vehicles. At the Cantonal level, energy based vehicle fees are in the works. And renewable energies should be promoted to improve the CO_2 balance, especially in the building sector.

Fricker: WWF Switzerland, together with 50 other organizations, has shown in their so-called Climate Master Plan (www.wwf.ch/klimafakten), which regulations should be passed and which measures implemented, so that the investments of the state and the economy and our behaviour should move in the right direction in the future. The best technologies should succeed with a combination of market incentives and regulatory standards.

What political energy targets should the Canton of Aargau and Switzerland set for the medium term (2030 to 2050)?

Fricker: The scientific community agrees that global warming since the beginning of industrialization should not exceed 2°C. To achieve this the industrial countries, including Switzerland, will need to reduce their GHG emissions 90% by 2050. For this reason the WWF has announced along with other organizations a popular initiative, which would commit us to reduce GHG's 30% from 1990 levels by 2020. We also invite PSI to include this climate protection scenario in its energy modeling.

Beyeler: Buildings should require at most half of today's energy. We also expect clear improvements for vehicles and appliances, thanks to new standards. Said in another way: even if we cannot achieve the vision of a 2000 Watt Society by the year 2050, we must take a great step in this direction. Climbing energy prices will contribute to this, because in the end much still depends upon the pocketbook.

Impressum

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Responsible for content:
Paul Scherrer Institut
Dr. Stefan Hirschberg
5232 Villigen PSI, Switzerland
Tel. 056 310 29 56, Fax 056 310 44 11
stefan.hirschberg@psi.ch
www.psi.ch/GaBE

Editor: Christian Bauer

Subscription & Distribution:
energiespiegel@psi.ch

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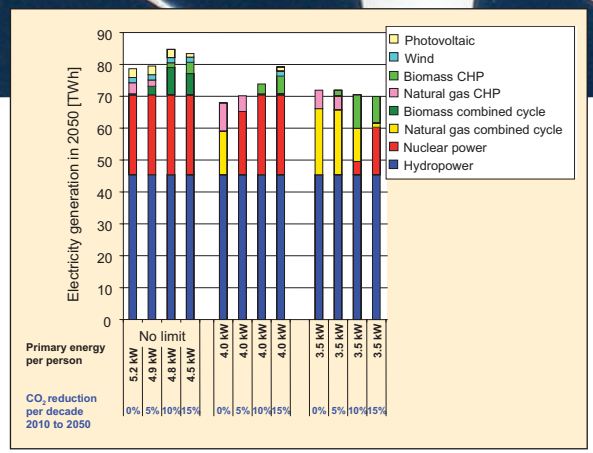
Energy Systems Analysis at PSI: The goal of energy systems analysis at the Paul Scherrer Institute in Villigen is to analyze present and future energy systems in a comprehensive and detailed way, considering in particular health, environmental and economic criteria. On the basis of Life Cycle Assessment (LCA), energy-economic models, risk analysis, pollution transport models and finally multi-criteria decision analysis, it is possible to compare different energy scenarios to create a basis for political decision-making.

GaBE works together with:
ETH Zürich; EPF Lausanne; EMPA; Massachusetts Institute of Technology (MIT); University of Tokyo; European Union (EU); International Energy Agency (IEA); Organisation für Economic Cooperaton and Development (OECD); United Nations Organization (UNO)

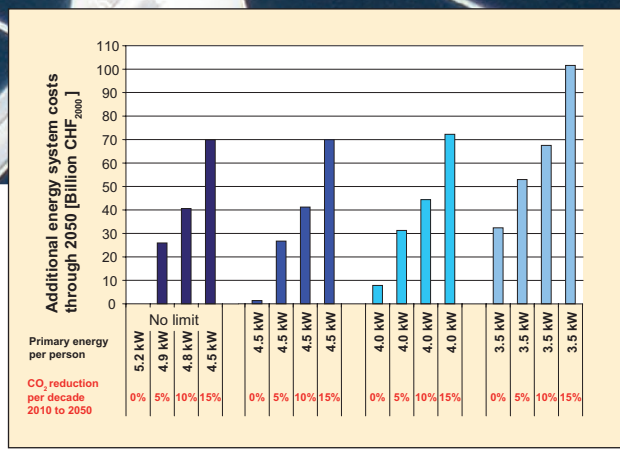
In Detail: Electricity and Costs

Electricity in the future will be more important than ever for our service economy. Electricity can efficiently replace other energy carriers, so its CO_2 free production is key to an effective reduction of CO_2 emissions. But the sustainable redesign of the current energy system will cost at least 70 billion Francs by 2050.

The prime example of the efficient substitution of electricity for fossil fuels is heat pumps. Electricity can also often replace oil or natural gas in industrial processes. If CO_2 emissions are halved in order to meet the Kyoto targets (that means close to a 15% reduction per decade from 2010), then by 2050 the electricity share of the total energy use will grow from 23% today to 35–40%. It is projected that without targeted measures for saving electricity our use will climb from 57 TWh/year today to 85 TWh/year in 2050. If we manage to reduce primary energy use by 30%, electricity demand will climb to 70 TWh/year in spite of savings. For example, the use of heat pumps contributes to higher energy efficiency, but is responsible for an increase of electricity demand of up to 8 TWh/year (see reverse side). The composition of our electricity mix will also be decisive for Swiss CO_2 emissions: effective, affordable measures against climate change will demand massive amounts of both new renewable energy and also nuclear plants, even if we fully exhaust the hydropower potential.



Electricity production in Switzerland in the year 2050; Production represents the domestic use. Significantly less CO_2 for Switzerland means that nuclear energy must also remain a significant component in the future. With strict limits only on primary energy use, nuclear energy loses share to natural gas due to nuclear's lower efficiency.



Cumulative additional costs in the energy system to 2050 in comparison to the scenario without primary energy limits and without CO_2 reduction, far left.

General Framework: The assumptions for the growth of the Swiss population, the GDP, living area, transportation growth, etc. are based on projections of federal officials. The energy system was modeled to 2050 based on these assumptions as a base case (business as usual) without primary energy or CO_2 limits. For the scenarios with lower energy demand the primary energy in each case was limited in the year 2050. The assumptions for CO_2 reductions are given in each case as the percent per decade of reduction from the baseline Kyoto target achieved in 2010. The economically optimum energy system has been calculated in each case for the assumed reduction in energy demand and CO_2 emissions, that is, the system that can meet the set limits at the least cost. Policy measures are not included in the model. The potential and costs of future energy systems are based in part on the assumptions in issues No. 14 and 15 of the Energiespiegel.

A redesign of the energy supply will cause significant costs. For a 15 percent CO_2 reduction per decade, the cumulative additional costs of the energy system by 2050 are at least 70 billion Francs, independent of the limitation of energy use. Reducing energy demand to 4000 Watts per person (without CO_2 reduction) at a cost of barely 10 billion Frances is still relatively cheap. Further reductions will be much more expensive. We would do better to invest our money in technological developments for a low CO_2 energy supply, rather than following the path of maximum energy reduction.

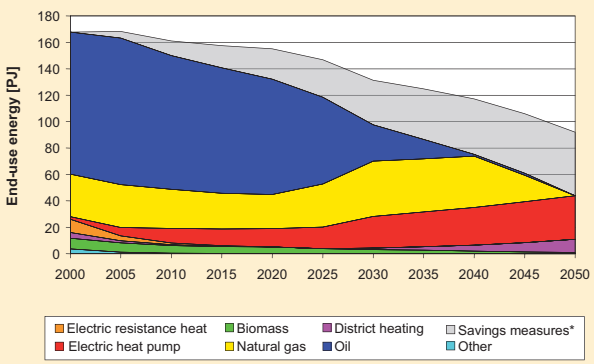
System costs: The additional costs calculated here for the energy system include total investment, and operation and fuel costs from the present to 2050. The baseline level (without additional costs) is set from the base scenario without limits on energy use and CO_2 emissions. Future costs are discounted with an interest rate of 3% per year. That means, for example, that 36 Francs invested in 2050 would be equivalent to a current investment of 10 Francs. This reflects the fact that money available to us today is of more value than money that we will have in the future. Not included are the effects on the overall economy, such as external environmental and health costs. If some measures against climate change succeed in gaining international agreement, and global warming can be limited, the avoided damage costs could partially compensate for the financial outlays for CO_2 reduction, or even exceed them. And we would also profit from better air quality.

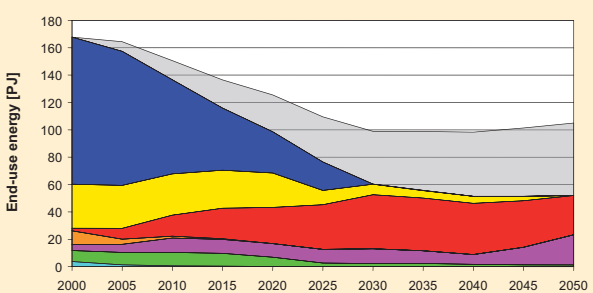
In Detail: Homes and Transportation

Our houses and our vehicle fleet must look completely different by 2050 if we want to reach the CO_2 emissions targets. Less heat demand and more heat pumps, as well as new drivetrains for cars could be the basis for this choice.

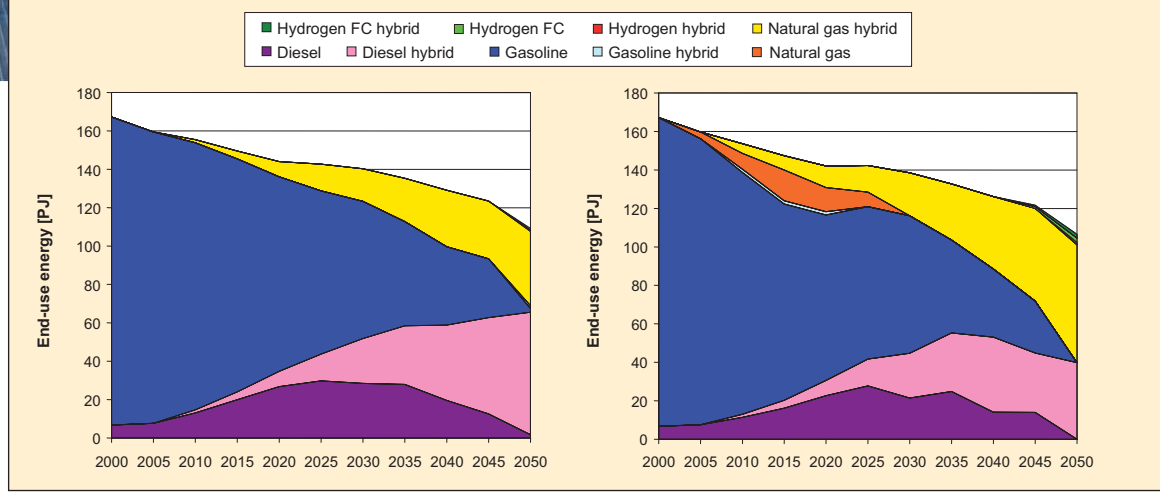
Picture: Roger Frei

Today more than 80% of space heating in private homes and apartments comes from oil and gas. These fuels can be largely avoided, even if housing space grows by around 40% as expected by 2050. The figures below show end-use energy for space heating in two possible scenarios. Energy saving construction and renovation to Minergie and MinergieP standards could reduce the heat demand to less than 40% of the current values. And if there is a massive shift to heat pumps and to district heating using biomass cogeneration or large central power plants, then we would need only a very low share of fossil fuels for heating. We could reduce the annual CO_2 emissions by 10 million tonnes (about 20% of today's total Swiss greenhouse gas emissions).





Energy used for space heating in the private housing sector by 2050 with an average total primary energy demand per person of 3500 W, no CO_2 limit (above), and –10% CO_2 per decade from 2010 (below), respectively. (*energy saving building methods)



End-use energy in the private transport sector to 2050 with a total primary energy demand of 3500 Watt, left without CO_2 limit, right –10% CO_2 per decade from 2010 (FC = fuel cells). Conservative and today very uncertain assumptions regarding costs allow hydrogen and fuel cell vehicles to first gain market share from 2045. More optimistic assumptions would lead to earlier market entry and a faster expansion.

If we continue to drive our cars more, and still want to save CO_2 in the transport sector, we must adopt more efficient drivetrains by 2050 that emit significantly less CO_2 per km. However we will still not be able to avoid fossil fuels. The figures above show the end-use energy by cars in two scenarios. Hybrid drivetrains could economically replace the gas and diesel motors that are today dominant. Gasoline has no place in the future if we are striving toward an average of 3500 Watts per person because of its relatively high consumption. Natural gas could gain acceptance next to diesel, as it is an efficient fuel and produces less CO_2. Building up the needed infrastructure would also be necessary, i.e. natural gas stations and pipelines. This would only be realistic in cooperation with the rest of Europe. With such a technology shift it would be possible to reduce energy end-use by a third and CO_2 by 5 million tonnes per year, even if it is assumed that private transport will climb 40% by 2050.