# Smarter living

## Generating a new understanding for natural resources as the key to sustainable development – the 2000-watt society

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## Editorial

# If only Pharaoh had known…

Federal Councillor Moritz Leuenberger
*Head of the Federal Department of Environment, Transport, Energy and Communications (DETEC)*

"We are all familiar with Pharaoh's dream about the seven lean and seven fatted calves. And we also know the measures taken by Pharaoh as a result of Joseph's interpretation of his dream: he ordered corn to be stored for the seven lean years, and thus saved his country from famine. This was a precautionary measure by the state to safeguard the future of the nation.

Present-day Switzerland is also taking measures to safeguard the country's future. We are endeavouring to maintain a balance between income and expenditure. We are planning social insurance over a medium to long-term horizon, not on a short-term basis. We are taking account of the needs of future generations by investing in infrastructure such as railways and roads. And we also have an obligation to protect the environment and make sure that there will be sufficient energy resources in the future. This is in accordance with the objective of sustainable development that is laid down in the Federal Constitution.

The concept of sustainable energy supply is to be translated into practice on the basis of the vision of a 2000-watt society – a goal towards which the Federal Council will be working over the next couple of decades. The idea here is that the level of energy consumption per person is not to exceed 2000 watts, which is equivalent to half to one-third of the level in Switzerland today. This vision is by no means unrealistic: the most efficient new appliances, motor vehicles and buildings only require a fraction of the energy consumed by other technologies. And renewable forms of energy also have the potential to contribute enormously towards meeting our future energy needs.

I would like to express my thanks to those who are working towards the goal of a 2000-watt society. As a result of these efforts, no one will have to be afraid of seven lean years following the seven good ones."

# Contents



## Abstract

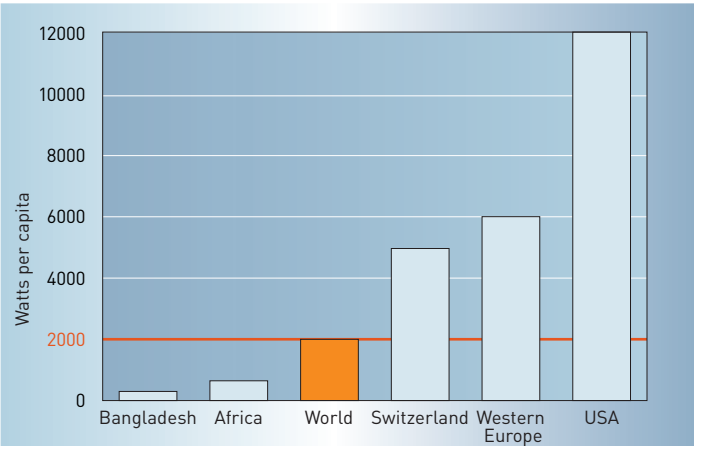
# Smarter living for a better future


**World-wide average annual energy consumption** per capita is 17500 kilowatt hours. This is equivalent to a continuous consumption of 2000 watts. The figure for Switzerland is two-and-a-half times higher (i.e. 5000 watts per capita), while in western Europe it is close to 6000 watts per capita. By contrast, in some Asian and African countries, consumption is a mere fraction of the global average. The vision of a 2000-watt society allows us to make comparisons between industrialised and developing nations, and thus paves the way for everyone to enjoy a high standard of living.

**The global reservoir of fossil fuels,** – especially oil – is depleting at an increasingly rapid pace, and before long we will have to rely on reserves that are much more difficult to exploit. The exhaustion of these supplies will inevitably give rise to actual or perceived shortages, and these in turn will lead to economic crises and even armed conflicts. There is no doubt that we are living at the expense of future generations, and this also applies to the problem of $CO_2$ emissions. Over the past 125 years, the concentration of carbon dioxide in the atmosphere has increased by 35 percent, so there is clearly an urgent need for action.

**Researchers** at the Swiss Federal Institutes of Technology and other institutions have confirmed that the vision of a 2000-watt society is feasible. They have been closely examining the largely unexploited efficiency and substitution potentials that exist in Switzerland, paying special attention to the average renewal cycle for vehicles and appliances, and have come to the conclusion that a period of between 50 and 100 years will be required for this vision to become reality.

**However,** this will call for rigorous modifications of buildings and installations, vehicles and equipment, as well as a new understanding for energy services. If we are unable to make materials more efficient, increase the level of energy efficiency and use resources selectively, then the envisioned 2000-watt society will remain a mere declaration of intent.


The average energy requirement per capita world-wide is 2000 watts, but this fluctuates enormously from country to country. In developing nations it is often just a few hundred watts, while in other countries it may be up to 20 times higher!

## Need for action

# We're playing in the second half

**The question** as to when the global reservoir of fossil fuels will be depleted is of course a highly valid one, but it is not decisive. Whether oil exploration reaches its production peak in ten, twenty or thirty years, thus triggering a genuine shortage and accompanying increases in energy prices, is only of secondary importance.

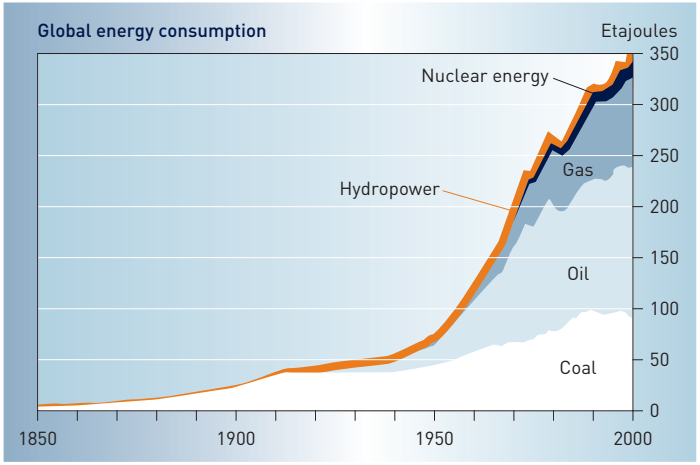
**There are two vital factors here.** Firstly, we already know that the days of exploitation of conventional fluid light oil are numbered, and although there are still considerable reserves of oil sand, oil shale and deep-sea oil, their exploitation is complex and thus costly. And secondly, the slightest signs of a shortage – whether real or anticipated – give rise to political tensions and often trigger armed conflicts, as we have seen often enough in recent times.

**Since 1880, the concentration of $CO_2$** in the earth's atmosphere has risen by 35 percent. And in the view of the Intergovernmental Panel on Climate Change (IPCC), this trend is likely to increase in pace during the next decade or so. The warning by the IPCC is very clear: the intensifying greenhouse effect will severely alter the global climate, and the consequences of this are expected to cost around 5000 billion US dollars per annum in just a few decades time.

**A large proportion** (probably around two-thirds) of the enormous quantity of primary energy is lost as the result of conversion processes, and is therefore of no direct benefit to us. The provision of end energy is associated with very high losses, and additional vast quantities are wasted through the use of buildings, appliances and motor vehicles, mainly because of often extremely low levels of energy efficiency. As a consequence, the amount of end energy that actually reaches consumers is merely a fraction of the original quantity.

> "A large proportion of primary energy (around two-thirds) is lost as the result of conversion processes and is therefore of no direct benefit to us."

**Given the explosive nature of the development in energy consumption, we clearly cannot speak of «normal» growth. Over the past 50 years, global consumption has increased more than fourfold. (Chart excluding renewable energies and waste)**




**We are living at the expense of future generations.** In view of the enormous waste of resources in the world today, it will no longer be possible to ensure a just distribution among future generations, and this also applies to the use of land and water. In Switzerland, every second almost a square metre of cultivable land is developed for residential or industrial purposes.

**Water** has already become scarce in many parts of the world. In North Africa and the Middle East, for example, there has not been enough water for decades, while reserves have been practically depleted in India and the same will apply to China within the next ten years. The consequences are often drastic: severe shortages of drinking water, the spread of disease due to insufficient personal hygiene, failed harvests due to a lack of irrigation, and restricted production of foodstuffs.

**The careful use** of resources will become the major challenge of the 21st century. The shortage of available energy – whether genuine or staged – will inevitably lead to higher prices, and this in turn will fundamentally alter the general economic situation and give rise to social crises. But a 2000-watt society would at least reduce these negative impacts, if not prevent them altogether.

## MORE THAN DOUBLED IN 50 YEARS

For every litre of petrol that flows through a car's engine in just a few minutes today, 25 tonnes of biomass would have had to be produced in the days before the discovery of the combustion engine. Today, petrol (like other oil products) is mostly burnt – well below its true value. And each year, global consumption increases by around 2 percent. According to the World Energy Council, energy demand will increase by 30 to 50 percent up to 2020, and this means it will almost double by 2050. Approximately 80 percent of the energy consumed throughout the world comes from fossil sources: oil, gas and coal.

## The vision

# 2000 watts – that's all we really need!

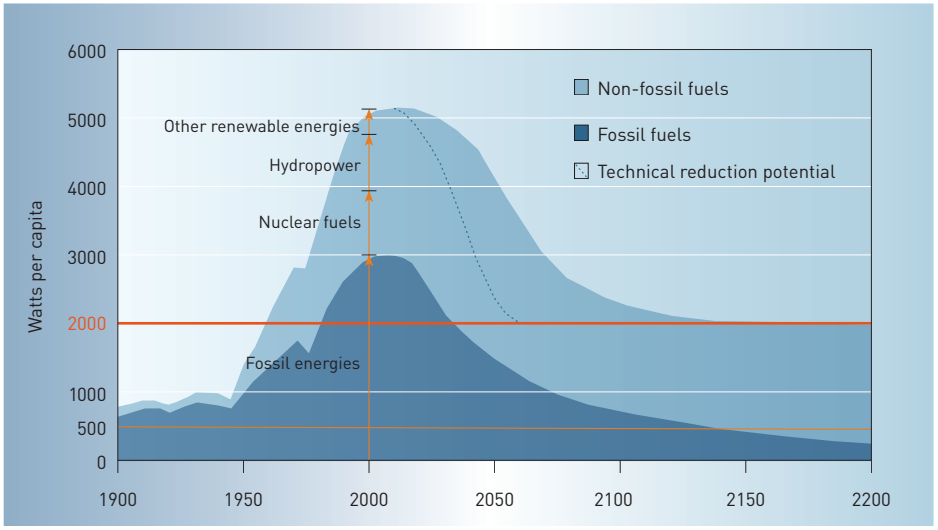
**Switzerland was once a 2000-watt society,** namely back in 1960. But today, only four decades later, we each consume 5000 watts for our daily life and work, leisure-time activities and travel. This is equivalent to an annual per capita consumption of 44000 kilowatt hours, or approximately 4400 litres of heating oil. For a 2000-watt society, this figure would need to be two-and-a-half times lower, namely 17500 kilowatt hours per annum.

**2000 watts** is the average level world-wide, but the discrepancies are currently enormous. The figure for the USA is 12000 watts, whereas in some developing countries the level is around twenty times lower, or just a few hundred watts. West Europeans require an average of 6000 watts, while the figure for Switzerland is 5000 (cf. graph on page 3).

**Approximately 60 percent** (or 3000 watts) of Switzerland's energy consumption is attributable to fossil fuels, i.e. primarily oil and gas products. Around 1000 watts each are attributable to nuclear energy and renewable energy (at present, almost entirely in the form of hydropower). None of these figures include energy contained in imported goods.

> "Switzerland was once a 2000-watt society back in 1960, and the aim is to make it one again as quickly as possible."

**The vision of a 2000-watt society** calls for the continual reduction of energy consumption to 2000 watts within the shortest possible time. It should be possible to cut the proportion of fossil fuels by half by 2050, i.e. from 3000 to 1500 watts per capita. There are some valid reasons for this broad timeframe. A rigorous modification of infrastructure will be essential, as will a smarter way of life, otherwise the vision of a 2000-watt society will simply be an illusion.




The level of primary energy consumption (excluding embodied energy) in Switzerland today is 5000 watts per capita. This graph depicts a potential development towards a 2000-watt society.

**A limit of 1 tonne of $CO_2$ per capita** is the long-term target that also applies to Switzerland. This means that our consumption of fossil fuels needs to fall to around 500 watts. If it should fall at the rate called for in the 2000-watt vision, it would be possible to achieve the ambitious $CO_2$ objective during the second half of this century or at latest by the first half of the next century.

**Only one-third** of primary energy actually reaches end users as utilisable energy, but the aim for the future is to greatly increase this proportion, primarily through the more efficient use of energy and materials.

**The ultimate target** for reducing the use of fossil fuels is 500 watts. The current level is 3000 watts, and the aim is to reduce this by half by 2050. This goal calls for a reduction rate of ten percentage points per decade.

**In the envisioned 2000-watt society,** the quality of life will not suffer at all. On the contrary, aspects such as safety and health, comfort and the development of the individual will in fact improve, and income is expected to rise by around 60 percent over the next fifty years. However, ambitious goals call for decisive action in a variety of areas, e.g. improving materials and increasing the level of energy efficiency; substituting fossil fuels with renewable forms of energy and reducing the $CO_2$ intensity of other utilised fossil fuels; adopting a smarter way of life and rethinking current business practices, including increasing the level of professionalism in the areas of planning and investment and the operation of buildings and installations.


Sustainable urban development does not mean a lower quality of life. On the contrary: better materials and a higher degree of energy efficiency, the substitution of fossil fuels with renewable forms of energy, and modifying business practices and increasing the level of professionalism of processes will all contribute towards a better urban environment. The new buildings housing the EAWAG research centre and the Swiss Federal Laboratories for Materials Testing and Research (EMPA) in Dübendorf are a prime example of how strictly structural measures can reduce heating requirements to such an extent that heat that in any case forms inside a building is sufficient to maintain a comfortable temperature. This passive method of producing heating and hot water only requires around 10 percent of the energy consumption of an average office building.

## Scientific background
# Feasibility assured

**Is a 2000-watt society actually feasible?** According to scientists and researchers at the Swiss Federal Institutes of Technology and other involved organisations, the answer to this question is yes – and they also have the figures to back up their findings. Their research has been carried out on the basis of a tried and tested, globally recognised method: they quantified the largely untapped efficiency potentials relating to materials and energy use, and combined these effects with the statistical renewal cycles of buildings, vehicles and installations in Switzerland.

**Residential buildings** can be taken as a good example for demonstrating the scientific methods and effects. The energy required for operating the average residential dwelling today is around 1400 watts per person (excluding grey energy), whereas a house built in line with the «Minergie-P» standard – which may be compared with the «passive house» standard in use in Germany – only requires between 350 and 550 watts per person (or 3000 to 4800 kilowatt hours per annum). This corresponds to a technological reduction potential of factor 3 to 4 for a «Minergie-P» house.

**The very slow renewal cycle** for the overall building volume in Switzerland means that it will be a long time before any changes will begin to take effect. The annual proportion of new buildings is currently only 1 percent of the overall volume, and the rate relating to renovation and upgrading is even lower. This means that a broad use of highly promising technologies (e.g. as per the «Minergie-P» standard) would be required without delay in order to lastingly reduce the energy consumption of the overall housing volume. The renewal cycles for vehicles and installations are shorter, but in most cases the service life is measured in decades rather than in years. Switzerland's infrastructure may therefore be described as sluggish. Adaptation is costly and would take between 50 and 100 years, and the same applies to investments and durable consumer goods.

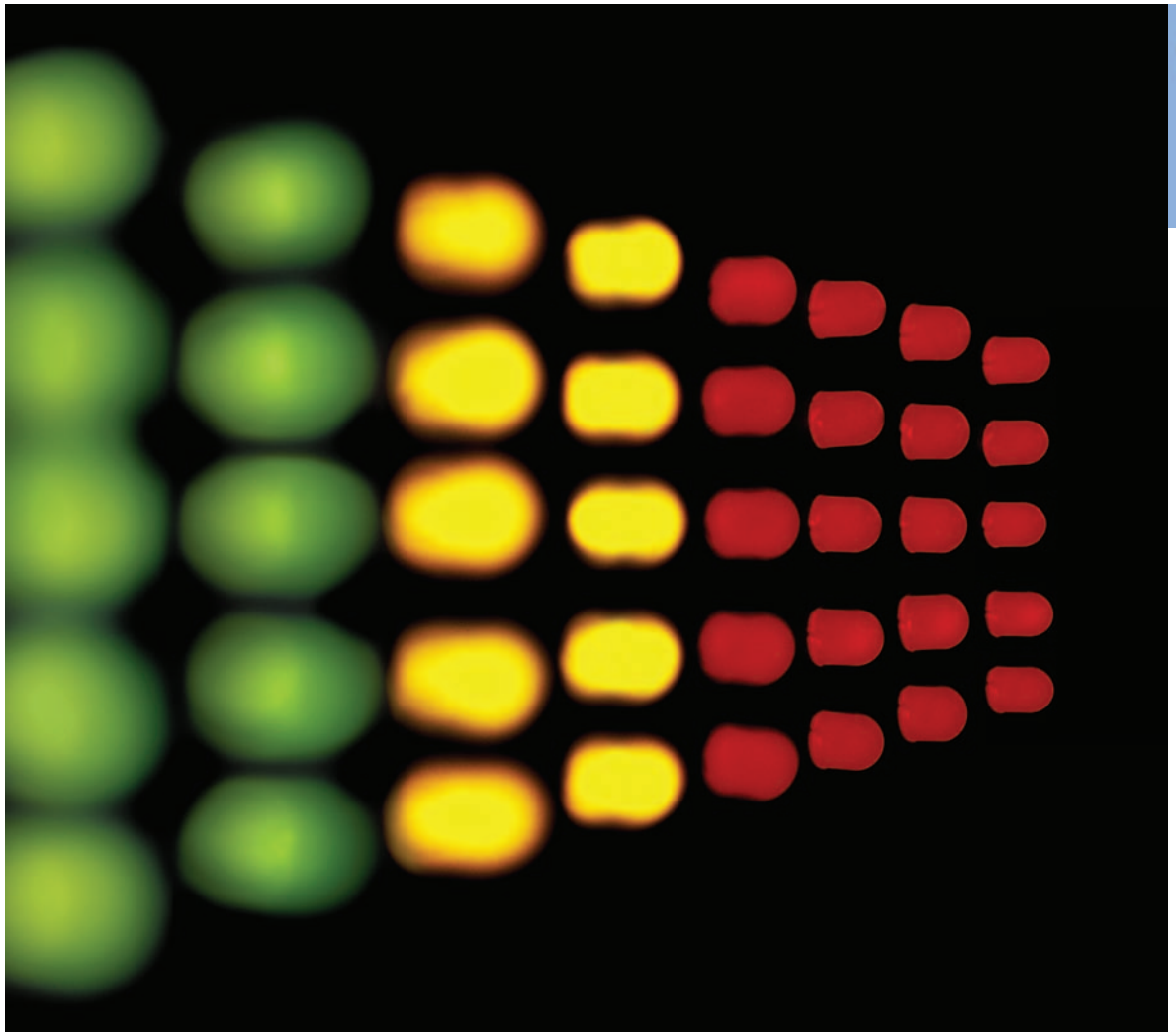
> «Technology alone cannot suffice – the way towards a 2000-watt society will also have to be paved by social (and thus political) as well as economic measures.»

**Researchers** have also identified enormous potential for increasing energy and material efficiency in other areas, especially in the mobility sector. A standard Volkswagen Polo that has been optimised to use gas instead of petrol emits 30 percent less $CO_2$ than the same model running on petrol, and at the same time it complies with the most stringent exhaust limits. However, this is not a suitable vehicle for the future 2000-watt society! The genuine potentials are still many times greater, especially with respect to weight and drive technology, but also in the area of aerodynamics. By 2050, vehicles that have been fully optimised in all respects will only require a quarter of the fuel the average motor vehicle needs today. And the choice of means of transport also has a tremendous impact: trams, buses and trains, combined with light vehicles of all types, form a full range of mobility options.

### «SUSTAINABILITY IS NOT JUST A BUZZWORD.»

If we really want to achieve sustainability, we need a clear vision with precise and comprehensible criteria. With the vision of a 2000-watt society, the Federal Institutes of Technology are able to offer this kind of reliable perspective. We want to demonstrate to researchers and decision-makers that sustainability is not just a buzzword, but rather is something we can truly achieve and experience – initially in pilot regions, and later on throughout the whole of society.

**Prof. Alexander J. B. Zehnder**
**President of the ETH Board**



The increase in efficiency in the area of light production is a prime example of rapid technological development. In 1879, the Edison light bulb produced a luminous flux of 3 lumens per watt, compared with 100 lumens per watt produced by fluorescent lamps and LED elements (see large photo).

## Substitution, efficiency, selection

# The key to sustainability


En route with a two-litre car: HY-LIGHT was jointly developed by tyre manufacturer Michelin and the Paul Scherrer Institute. This light motor vehicle is equipped with a fuel cell, super capacitors, a new type of electric drive, and a chassis management system. The fuel cell produces exhaust-free electricity from hydrogen and oxygen that drives the two traction engines.

**The key to a sustainable future** is to substitute materials and types of energy and use them more efficiently, while adopting a smarter lifestyle. This calls for a broad range of solutions – political, economic, social and scientific.

**In Switzerland alone,** 600000 tonnes of plastics are brought onto the market each year, which is equivalent to 94 kilograms per person. The figure for the EU is 57 million tonnes, while the global total is around 150 million tonnes. In Switzerland, 20 percent is used in the construction sector, 40 percent in the packaging industry and the remainder is used for semi-finished products for appliances, vehicles and other products. 1.5 kilograms of oil are required for each kilogram of plastic, and this means that a total of 200 million tonnes of this precious resource are required to produce the global supply of plastics.

**Some of these energy-intensive materials** can be substituted with bio-plastics, which are fully degradable and thus do not pollute the environment after their disposal. By fermenting vegetable starch or processing sugars obtained from maize or potatoes, polymers can be produced that can then be refined and formed in conventional plastics processing machines. A variety of processes – some of which are new, while others have been tested for many years – can lead to savings in fossil-based energy of between 20 and 80 percent.

**The future's for the lightweights!** This applies to vehicles and building materials, clothing and packaging. Everything needs to be lighter and recyclable, just like bottles have become today: over the past 40 years they have lost around 45 percent in weight, and when glass bottles layered with polyethylene – which are currently undergoing development – come onto the market, they will be another 30 percent lighter.

"The key to a sustainable future is to substitute materials and types of energy and use them more efficiently, while adopting a smarter lifestyle."

**Researchers have high hopes** for fuel cells charged with hydrogen, but if these are to be compatible with a 2000-watt society the hydrogen will have to be produced from renewable energy sources, i.e. hydropower, wind energy, biomass and solar energy. Although it is not renewable, nuclear energy – which is practically neutral in terms of $CO_2$ emissions – could also make a contribution here.

**These systems and fuels** are only available on the market to a limited extent, so there is a great need for research and development. Furthermore, the general economic conditions will also need to be adapted. But despite the various obstacles, sustainable fuel cell technologies should be more widely available in the not too distant future.

**More than 90 percent** of the energy used for heating, ventilation and hot water production in 2050 will be required for existing buildings, while only 10 percent will be required for new buildings in the coming fifty years. It is therefore clear that the focus has to be on improving the substance of existing buildings.

**This is precisely the aim** of a competition organised by the Swiss Federal Office of Energy concerning the renovation of apartment blocks on the basis of the «Minergie-P» standard. The award-winning building, an apartment house in Zurich-Höngg, demonstrates the effectiveness of the implemented measures: with the «Minergie-P» standard it is possible to save 120 kilowatt hours of primary energy per square metre of heated residential space compared with a conventional renovation. This means that the energy consumption for an apartment with a living area of 110 square metres is around 13000 kilowatt hours, or 1500 watts, so «Minergie-P» buildings can be regarded as milestones along the route to a 2000-watt society!

## DOMESTIC AND RENEWABLE

Forests represent a source of heat – but also of fuel for mobility purposes. Timber can be used for producing a methane-based gas for fuelling motor vehicles that is comparable to natural gas. The ongoing Novatlantis «Ecogas» project aims to optimise the entire supply chain – from wood gasification and distribution via the gas network, through to use in low-emission motor vehicles.

## Pilot Region Basel

# Testing the new technologies in an urban environment

**The vision of a 2000-watt society** for securing sustainable development is based on a fundamental criterion, namely that all spheres of life have to be included. For this reason, a suburb or – even better – a major urban centre is the ideal practical laboratory. In an urban environment it is possible to combine town planning measures with building requirements, alternative mobility concepts and unconventional financing models. The fact that renewable forms of energy play a central role here is self-evident in view of the declared target of 2000 watts.

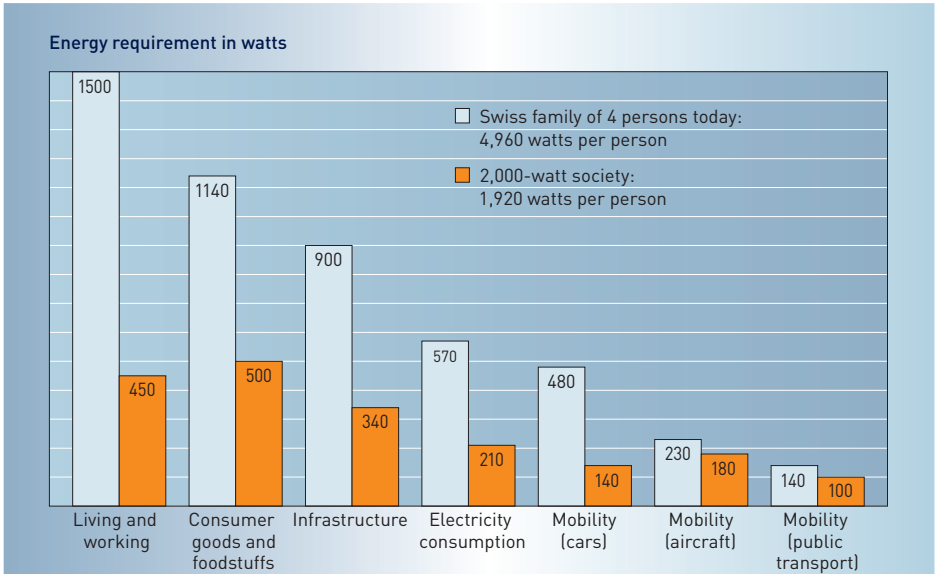
**«Pilot Region Basel»** is a public/private partnership between industry, science and the authorities. In addition to researchers from the Federal Institutes of Technology, the technical university of the Basel region and the University of Basel, it incorporates the civil engineering departments of the two Basel cantons, as well as countless private investors. Novatlantis and the technical university of the Basel region function as the co-ordination centre for the project.

> “As a public/private partnership between industry, research and the authorities, «Pilot Region Basel» functions as a kind of extensive laboratory for sustainable development with numerous innovative vehicles and construction technologies.”

**Sustainable urban development** is the objective of numerous projects in the Basel region. These include inner-city zones, as well as individual buildings, that are being remodelled to function as examples for a future 2000-watt society.

**In a practical laboratory for sustainable development,** the transfer of know-how is taking place in close co-ordination with the various focus groups in which the local population is represented. Both partners benefit from these exchanges, since for implementation purposes, researchers have to rely on practical experience in an urban environment. Areas undergoing development in the Basel region – e.g. Pro Volta, Erlenmatt, Novartis Campus, Dreispitz and Gundeldinger Feld – provide the perfect environment for utilising these interactions.

**Innovative vehicle and building technologies** provide a basis for pilot and demonstration projects. They offer an opportunity to test new technologies, and they yield concrete evidence with respect to their functionality. Finally, the Novatlantis Building Forum pas-




Comparison of the energy requirements of a family of 4 persons today versus the envisioned 2000-watt society.

Steinenvorstadt in Basel: on the right, the planned customer service centre of Industrielle Werke Basel, a «Minergie-P» building that incorporates new solutions for exploiting potentials relating to production and recycling of materials, including from the point of view of grey energy.

ses on findings and know-how to investors, planners and public authorities, as well as to managers of real estate portfolios.

**In the area of mobility,** residents and companies can familiarise themselves with new vehicles and transport concepts, and fleet and taxi operators are encouraged to make use of them. Acceptance and preferences, as well as objections and resistance, become apparent through dialogue and practical testing. An increasing number of cleaner and more efficient vehicles are now to be found on our roads, including gas-fuelled cars using the «clean engine vehicle technology» developed by the Swiss Federal Laboratories for Materials Testing and Research (Empa). Biogas is also making a significant contribution. The concept of the HY-LIGHT, a vehicle that is already being used by Michelin and the Paul Scherrer Institute to demonstrate the potential of hydrogen-based fuel cell technology, fits perfectly into this environment (cf. page 10).

## «WE ALL HAVE TO WORK TOGETHER IF WE ARE TO TURN THE VISION OF A 2000-WATT SOCIETY INTO REALITY!»

The envisioned 2000-watt society is more than just a drastic reduction of energy consumption. It entails a vision of a society based on sustainability – a society that can only survive over the long term if everyone (the general population, trade and industry, researchers and developers, as well as politicians) joins forces in defining and implementing the necessary strategies. We are currently gathering valuable findings for this ambitious process within the scope of «Pilot Region Basel».

**Barbara Schneider**
**Minister and Chief executive of departement of public works of the Canton of Basel-Stadt**

## Novatlantis – in search of sustainability

# Network for sustainable development

**Novatlantis is a programme** that was initiated jointly by the Swiss Federal Council of Education and Federal Institute of Technology research centres such as the Paul Scherrer Institute, the Swiss Federal Laboratories for Materials Testing and Research (Empa), EAWAG and WSL – for the purpose of applying findings obtained from research activities to sustainable urban development. With the aid of path-finding projects, Novatlantis and its partners – investors, planners, industrial and commercial companies – aim to show how the vision of a 2000-watt society can be turned into reality on a step-by-step basis. The various players – research centres, the Federal Institutes of Technology in Zurich and Lausanne, universities and engineering colleges – join forces in defining projects aimed at turning the findings obtained from research into practical benefits for society as a whole.

**This «network for sustainable development»** is constantly expanding and gaining in density. Novatlantis connects local players in the «Pilot Region Basel» programme with the CCRS (Center for Corporate Responsibility and Sustainability) at the University of Zurich and the TSF (Sustainability Forum Zurich). «ETH Sustainability» and the Alliance for Global Sustainability at the Federal Institute of Technology, Zurich, work together with leading universities throughout the world. And with a variety of planned competence centres – e.g., the joint CSM (Center for Sustainable Mobility) within the Paul Scherrer Institute, the Federal Institutes of Technology in Zurich and Lausanne, the Empa, and the Northwestern Switzerland University of Applied Sciences – there will be a number of high-level research centres in existence that are committed to the goal of sustainability.

**Both the Swiss Federal Office of Energy (SFOE) and the Association of Swiss Architects and Engineers (SIA)** are committed to the 2000-watt society as a long-term objective. Thanks to the support of the SFOE and the Federal Office of Area Planning, a variety of pilot and demonstration buildings and environment-friendlier vehicles are being developed. As the country's biggest trade association in the development and planning sector, the SIA provides its members with information and education, and issues standards and recommendations, including in the area of sustainable construction.

**The «SIA efficiency path for energy»** and SIA recommendation 112/1, «Sustainable construction», are two of many planning and decision-making aids that specialists can use to build in a more cost-conscious, ecological and user-friendly manner – very much in keeping with the criteria for a 2000-watt society. There is certainly no lack of suitable instruments for realising this vision.

**The SwissEnergy programme** wants to achieve the objectives of the $CO_2$ Act through voluntary measures. This represents a contribution towards the Kyoto Protocol and a step in the direction of a 2000-watt society. Novatlantis is putting up signposts to point the way, while SwissEnergy is promoting the widespread application of more energy-efficient technologies and environment-friendly behaviour.

### «LINKING RESEARCH AND PRACTICAL IMPLEMENTATION.»

A lot of the technologies that will be required for the envisioned 2000-watt society are already available or are currently in the trial stage. Pilot and demonstration projects are a means of showing investors what has been achieved in practical terms. Supporting this process is one of the main functions of Novatlantis – the other is to initiate trans-disciplinary research and development projects together with scientists at the Federal Institutes of Technology and associated organisations, with the aim of generating relevant results for the envisioned 2000-watt society through project design.

**Roland Stulz**
**Architect, Managing Director of Novatlantis**

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The average energy requirement per capita world-wide is 2000 watts. In Switzerland, the corresponding figure is two-and-a-half times higher, namely 5000 watts. Switzerland was once a 2000-watt society back in 1960, and the aim is to make it one again as quickly as possible while maintaining the present-day quality of life. This will call for a broad range of solutions in the areas of politics and the economy, as well as in society and scientific research.

“In view of the tasks that lie ahead, the question of costs is a pressing one. High costs are inevitably going to arise, either in response to climate change or in the form of investments to secure a sustainable future.”

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