



Smarter Living

Moving Forward to a Sustainable Energy Future
with the 2000 Watt Society



sia



The 2000 Watt Society: Working to Secure the Fair and Sustainable Use of the World's Resources

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While the world's finite resources are being depleted at an alarming rate and greenhouse gases continue to spur global warming, the use of fossil fuels in the developed countries of the world remains highly inefficient. Indeed, the amount of energy that is allowed to dissipate senselessly is greater than the amount that actually powers our modern world. Moreover, the close link between high energy consumption and economic prosperity has led to tremendous disparities among the various countries and regions of the world. In Switzerland, the average person consumes energy at a continuous rate of 6500 watts and accounts for around 9 tons of CO₂ emissions a year.

The 2000 Watt Society is the vision of a society in which the world's raw materials are used in a sustainable and fair manner. The prerequisites for achieving these goals include dramatic increases in energy efficiency and in the use of renewable energies. Novatlantis, the sustainability program established by the Swiss Federal Institute of Technology, aims to establish local, national and international networks as a means of promoting the 2000 Watt Path, which is essentially a roadmap outlining the steps that need to be taken to reduce our energy needs by a factor of 3 to 4.

Furthermore, we should reduce our use of fossil fuels to the point where per capita CO₂ emissions can be maintained at around one ton per year. These goals, which are to be reached by 2150, correspond to the recommendations made by the Intergovernmental Panel on Climate Change (IPCC) for limiting the extent of global warming to +2 °C.

Studies conducted by researchers at the Swiss Federal Institute of Technology demonstrate the technological feasibility of the 2000 Watt Path. Indeed, daily life in Western Europe could actually be powered by less than one-third of the energy consumed today. To achieve this, we need to alter our consumer and user behavior and increase the efficiency of our infrastructure. In addition to Switzerland's three largest cities, many smaller municipalities have already become actively involved in a range of public-private partnerships which test practicable models and technologies for the 2000 Watt Society. Such showcase projects are to help establish the 2000 Watt Path in all areas of life and to send a signal that the journey to a sustainable society has begun in earnest. The know-how that has been acquired by Novatlantis as the pioneer of the 2000 Watt Society is in demand throughout Europe, North America and Asia.

"Energy Efficiency – An Opportunity for Switzerland"

"The forecasts released by the International Energy Agency (IEA) are clear. By the middle of the century, global consumption of primary energy will increase by more than 50%. Developing and newly industrialized countries will account for more than 90% of this increase, with China alone generating one third of the increase. The lion's share of the energy consumed (more than 80%) will continue to be supplied by coal, petroleum and natural gas. While the share of renewable energies in the energy mix will more than double, this will scarcely meet one-fifth of the world's energy needs.

Do these global developments really concern us? After all, Switzerland has enjoyed the advantages of a clean and secure supply of energy for decades. The answer is clear. Climate change is not something that stops at national borders. We, too, are affected by the increasing depletion of the world's resources, including energy and other raw materials. We, too, are exposed to the increasing costs. We, too, are directly affected by the supply shortages that arise in the wake of military conflicts, economic crises and environmental catastrophes. We therefore have every interest in using our extensive know-how in the areas of energy supply and ecology and in participating in the creation of global solutions.

"New ways of thinking and new forms of cooperation are required."

Working to actively shape the future by developing new technologies and sustainable models of energy use is better than attempting to fight the causes. Indeed, the vision of the 2000 Watt Society offers a promising approach. We should reduce our use of natural resources, using energy more sparingly and more efficiently. While this may seem to be a marvelously straightforward approach at first glance, it will require tremendous efforts to implement. This becomes clear when one considers the forecast issued by the World Business Council for Sustainable Development, according to which we will need 2.3 times the resources available on our planet in the year 2050 if the rate of global energy and resource consumption continues to rise as it has so far. These are reserves that we simply do not have. The energy system of the future will therefore need new structures. We must continue to pursue technological solutions. New ways of thinking and new forms of cooperation are required. This is the only way we will be able to achieve low-impact economic development and a sustainable society.



Doris Leuthard, Member of the Swiss Federal Council

Our country can play a crucial role in achieving these goals. As a center of innovation, Switzerland is notable for its outstanding research landscape and technology companies with highly specialized products, employees and services. We have an opportunity to play a leading role in the area of energy efficiency, power storage and smart-grid technology. Swiss contributions to energy conservation and clean energy consumption are not only an opportunity for our economy, they can help to reduce global energy consumption in the coming decades and eliminate our dependence on fossil fuels. And that is something that really concerns all of us!"

"At the Swiss Federal Institute of Technology (ETH), research is the wellspring of the future."



Dr. Fritz Schiesser,
President of the
ETH Council

"For more than three decades, our ecological footprint has exceeded the regenerative capacity of our planet. CO₂ emissions have increased faster than predicted, and global temperatures may begin to rise more rapidly than forecast in the 2007 IPCC Report. Other forecasts indicate that worldwide energy consumption may double in the next twenty years. Without considerable

technological progress, around 80 % of this demand will have to be met with fossil fuels.

This represents a challenge to our society. Part of the ETH Domain's mission is to develop novel approaches to such challenges and to provide support for these approaches in a scientific capacity until they have reached the status of viable solutions. With its two universities – ETH Zurich and EPF Lausanne – and four research institutes – the Paul Scherrer Institute (PSI), the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), the Swiss Federal Laboratories for Materials Science and Technology (Empa) and the Swiss Federal Institute of Aquatic Science and Technology (Eawag) – the ETH Domain is committed to addressing the issues that are critical to our energy future. The ETH Domain develops and optimizes its proposals taking into account the overall system and takes a balanced approach to achieving the goals of energy security, environmental protection and economic sustainability.

The ETH Domain has established a broad-based research network that has enabled its researchers to productively share their ideas with one another and with the public. The prominence that is given to the ETH Domain

"Our core mission is to establish and maintain an environment in which researchers are free to participate in open scientific discourse. Given the role that scientific inquiry can play in shaping a brighter future – and given the ETH Domain's reliance on public funding – it is incumbent on us to accomplish this mission."

in this brochure should therefore not be construed as an endorsement of any particular solution, but as a commitment to all avenues of inquiry that promise to help us to secure a safe and sustainable supply of energy.

Our core mission is to establish and maintain an environment in which researchers are free to participate in open scientific discourse. Given the role that scientific inquiry can play in shaping a brighter future – and given the ETH Domain's reliance on public funding – it is incumbent on us to accomplish this mission. It gives me great pleasure to see outstanding research in the field of energy science make its way to the general public in the form of inspiring ideas and viable applications."

"Innovative entrepreneurs are needed if we are to find sustainable building solutions."

"Building construction and operation account for nearly half of Switzerland's energy needs. Changes in the area of new construction and building renovation would therefore seem to present a great opportunity to reduce our total energy consumption. The architectural solutions for the 2000 Watt Society are already available. Appropriate incentives have been introduced to spur renewal, bringing us closer to securing a sustainable supply of energy.

The goal is to construct affordable buildings that offer both comfort and the highest degree of energy efficiency. Buildings with highly insulated envelopes and controlled ventilation systems help to improve the economic feasibility of renewable energies.

Hans Ruedi Schweizer,
Managing Director at
Ernst Schweizer AG,
Metal Construction



It's a small step from your own home to a small power plant: surplus energy houses produce more solar energy than they need for heating, hot water and electricity. Modern buildings distinguish themselves in terms of their energy-efficient designs, their active and passive use of solar energy, and their comfort and ambient air quality.

"Responsible companies do all they can to conserve resources and minimize the environmental impact of their products. This commitment extends from the extraction of raw materials to production, installation, use, and recycling."

The contribution that can be made by the building sector includes the development of innovative products, ranging from high-quality facade systems to user-friendly systems for producing solar energy. Responsible companies do all they can to conserve resources and minimize the environmental impact of their products. This commitment extends from the extraction of the raw materials to production, installation, use, recycling and disposal. As an essential part of any sound and environmentally responsible business policy, the development of energy-efficient products is also a key to economic success. Indeed, innovative entrepreneurs have demonstrated in recent years how a commitment to sustainable building practices can have a positive effect on sales and employment.

We all stand to benefit from an informed and broad-based discussion of sustainable building concepts, the increasing use of solar energy and new solutions for sustainable buildings."

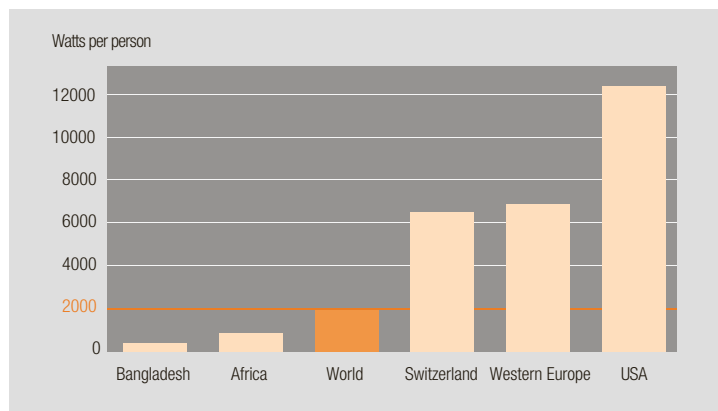
2000 Watt Society – Working Towards the Fair and Sustainable Use of Resources

Our vision of the future use of the world's natural resources is motivated by the belief that all regions of the world should enjoy equal opportunities for economic development and a high standard of living, i.e. these should not be reserved for a select group of industrialized countries. Energy consumption and its benefits – activities, services and goods – should therefore be adjusted to a sustainable degree and distributed fairly. The current global rate of energy consumption per capita is 2000 watts, which corresponds to the continuous output of twenty 100-watt light bulbs or an annual 17 500 kilowatt hours or 1750 liters of petroleum per capita. The regional differences in consumption, however, are astounding, with many people in Africa

and Asia consuming only a small fraction of what North Americans and Western Europeans consume. While consumption in China and India is currently somewhere in between, it is rising rapidly.

Current use of the world's finite fossil fuel resources in the industrialized countries of the world is inefficient. Up to two thirds of the energy contained in primary forms of energy is lost in the process of converting these to more readily useable forms of energy. Transportation and lighting offer typical examples of low energy efficiency. In both of these cases, only a small percentage of the immediate source of energy (gasoline or electricity) is transformed into effective propulsion (automobile) or luminosity (light bulb). Most of the potential energy is lost in the form of waste heat, which is left to merely dissipate. In contrast, the 2000 Watt Path offers a fair and sustainable model of "smarter" living (→ Lifestyle Models, page 12). Here, it is essential to bear in mind that the standard of living that is typical of industrialized countries can be made accessible to all of the world's inhabitants at the same time as we significantly reduce carbon emissions and our overall energy needs (→ 2000 Watt Path, page 8).

On a per capita basis, the world's inhabitants use 2000 watts of energy a year. Behind this figure are tremendous regional disparities. While those living in developing countries in Asia and Africa consume only a few hundred watts a year, the figure for Switzerland is 6500 watts, and that for the USA is up to 20 times more. (Source: PSI)



Dr. Thomas Stocker, Professor for Climate and Environmental Physics, University of Bern, Co-Chair of the IPCC's Working Group 1

"Our analyses show that the rate of global warming over the last 50 years is unusual when compared to other periods in the last 1300 years. The associated degree of climate change can be expected to greatly exceed that of previous change. But ultimately, we are the ones who will determine the extent of climate change."

Petroleum and other fossil fuels have been the motor of industrial development for more than 150 years. Eighty percent of the energy that is available to Western societies comes from fossil fuels. High CO₂ emissions have come to be a chief indicator of a country's economic and social prosperity. At an annual per capita rate of around nine tons, greenhouse gas emissions are correspondingly high in Europe and, at more than 20 tons, exorbitant in North America. In contrast, per capita emissions in developing regions of the world amount to a few hundred kilograms.

According to the International Energy Agency (IEA), our energy needs and CO₂ emissions continue to rise. The anticipated consequences include an accelerated greenhouse effect, involving rising sea levels, more frequent natural catastrophes, restricted land utilization, and species extinction. According to the Intergovernmental Panel on Climate Change IPCC (→ Glossary, page 33), an increase of 2 °C in the average surface temperature of the earth would be tolerable. However, we would have to reduce CO₂ emissions by between 50 % and 85 % by 2050, compared to the reference year of 1990. To this extent, the reduction goals set by the IPCC conform to those of the 2000 Watt Path.

Increasing energy consumption and CO₂ emissions intensify climate change and its consequences for people and nature.



Reducing Energy Consumption and CO₂ Emissions to Enhance Our Quality of Life

If Switzerland would like to become a 2000 Watt Society, it will have to aim to reduce the current per capita rate of energy consumption – 6500 watts – to 3500 watts in the span of two generations, i.e. by the year 2050. At the same time, annual per capita CO₂ emissions will have to drop from around nine tons to around two tons. The final sustainable goal is then to be reached by the year 2150, at which time the country's total per capita rate of energy use will have been lowered to 2000 watts. For Switzerland, this would mean returning to the same level of

energy consumption that applied in 1960, i.e. when the country had just entered a sustained period of solid economic growth. However, only one quarter of the country's total energy needs are to be met by fossil fuels, so that an annual per capita low-impact mass of one ton of CO₂ emissions can be maintained. It follows that making progress on the 2000 Watt Path will depend on our ability to produce energy more intelligently and to use it more efficiently – in industrial production, providing public infrastructure and in our daily lives (→ Energy Production, Mobility, Construction, page 14 ff.).

In their "White Book on the 2000 Watt Society", researchers at the Swiss Federal Institute of Technology published data demonstrating the feasibility of dramatically increasing energy efficiency. In the case of passenger vehicles and buildings, the researchers outline the feasibility of reducing our energy needs by 50 % to 90 %. Housing (room heating, hot water, and lighting) and mobility account for the lion's share of total energy consumption in Switzerland today. Buildings account for 40 % to 50 % of total energy consumption, while mobility accounts for nearly

Chart right: Switzerland on the 2000 Watt Path. The use of fossil fuels is to be reduced by 50 % by 2050 and total energy consumption by a factor of three or more by 2150.

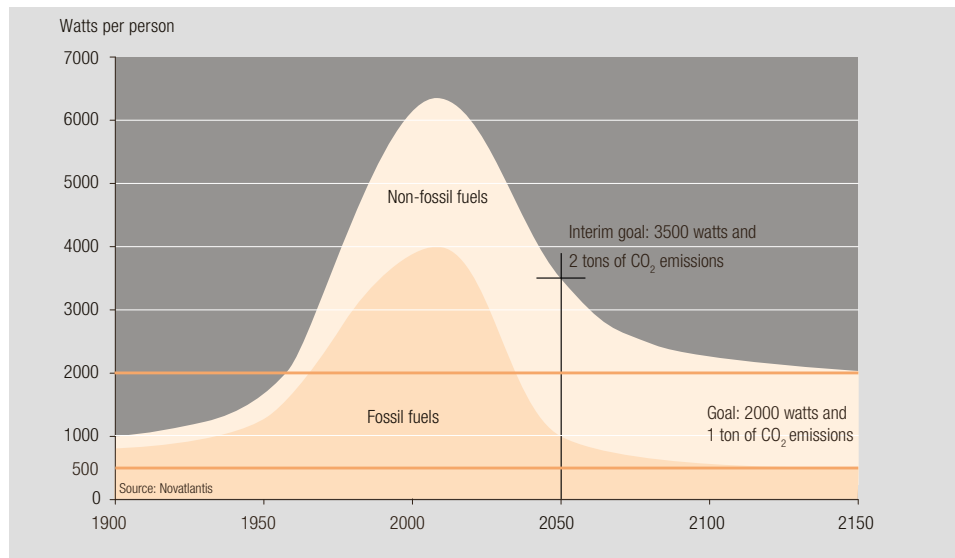


Table right: Energy use by sector in Switzerland (Source: BFE)

Energy Use in Switzerland by Sector (Year 2006)	
Buildings	47%
■ Heating	35%
■ Hot water	6%
■ Lighting	3%
■ Appliances, equipment	3%
Services, industry	24%
■ IT, communications	2%
■ Process heat	13%
■ Machines	9%
Mobility	29%
Total: 242 million GWh (100%)	

30 %. Given the right political and economic framework and the deployment of the best of the available technologies, the authors of the White Book indicate that it would be altogether feasible to increase energy efficiency in these important areas by a factor of five. Moreover, the use of available technologies would allow us to provide two thirds more energy services – i.e. for heating and lighting buildings, for motors and computers – while consuming only a third of the energy.

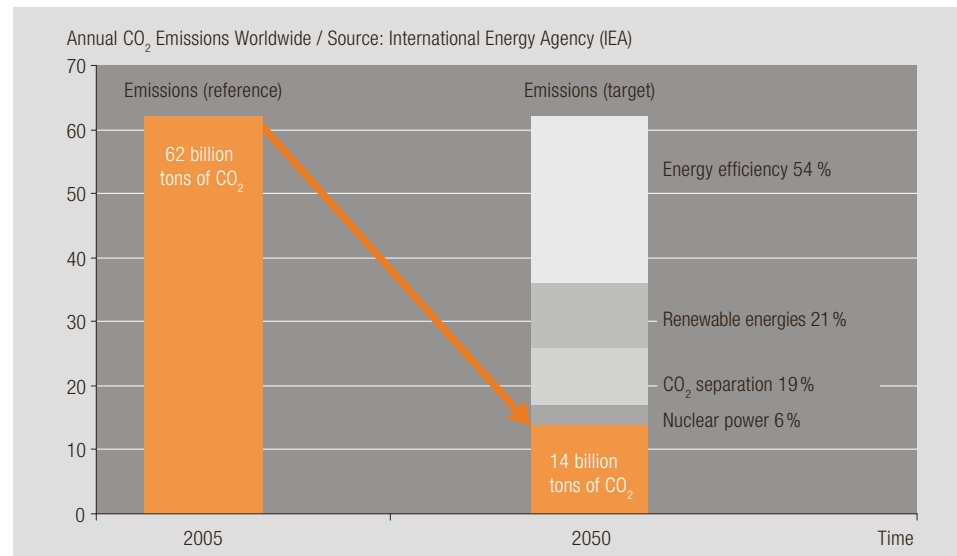
The International Energy Agency (IEA) has published its own efficiency scenarios for reducing global greenhouse gas emissions by 2050. According to the IEA's "Blue Map", annual CO₂ emissions are to be reduced from their current level of 62 billion tons to 14 billion tons. In orienting itself on the target value of two tons of CO₂ emissions per capita per year – as per the recommendations contained in the IPCC Report (→ Disparities in Energy Use, page 7) – the IEA's strategy essentially confirms the goals of the 2000 Watt Path. The IEA would like to reach this

goal in advance with the help of increases in energy efficiency. Achieving this goal will require a transfer of know-how in order to benefit research and development which aligns innovative key technologies to the needs of a sustainable society. Furthermore, such know-how can be shared on test sites in the field, where representatives from the fields of research, business, politics and society come together to test the broad-based applicability of such technologies (→ Pilot and Partner Regions, page 20 ff.).

IEA Efficiency Scenario

The "Blue Map" scenario published by the International Energy Agency (IEA) shows how annual CO₂ emissions can be reduced from 62 billion tons to 14 billion tons. The IEA scenario was presented for the first time in the World Energy Outlook 2008. The efficiency scenario offers a quantitative outline of an approach that is comparable to that of the 2000 Watt Path. The measures that are to contribute to the reduction of greenhouse gases are largely the same:

- Greater efficiency in the use of products and the generation of power = **reduction of 54 %**;
- Alternative fuels and renewable energies = **reduction of 21 %**;
- CO₂ capture and storage (CSS) = **reduction of 19 %**;
- Nuclear power = **reduction of 6 %**.



Energy Efficiency in Everyday Life – Lifestyle Models and Ecological Options

Switzerland is currently a 6500-watt society, with the average Swiss citizen accounting for around nine tons of CO₂ emissions a year. These figures assume individual consumption behavior for an average two-person household living in a modern city apartment with a floor area of more than 100 m². Within and around the home, the household members follow the most important tips for saving energy and use energy-efficient appliances. To get to work, they choose to make do with a shared automobile, in which they cover nearly 10 000 kilometers a year. They also make regular use of a bicycle and public transportation. While they usually use the train when traveling to other European countries, they also fly once a year to America or the South Seas.

Whether they are directly aware of it or not, these average citizens use services for housing, work and mobility that involve high amounts of energy and lead to considerable CO₂ emissions. How can these habits be changed? What does the 2000 Watt Society call for when it comes to lifestyles, products and technologies? The good news is that we have the means of adapting our lifestyles to meet the requirements of the 2000 Watt Path. As can be demonstrated with the use of an





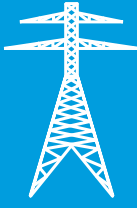
energy calculator (→ Glossary, page 32), we can reduce our personal energy needs by around 50% to 3500 watts. However, in addition to making the appropriate changes in our consumption behavior, we also need a range of products that can be manufactured and made available in an energy-efficient manner.

The lifestyle we choose and our day-to-day behavior play an important role in determining our energy footprint, and there are considerable individual choices we can make. Some measurable ways of reducing our use of resources include: living in a moderately sized home or apartment with less than 50 m² of space per person, which is preferably located in a low-energy building (e.g. Minergie standard); shortening the distances we travel to work and to vacation destinations; making greater use of public transportation; and adjusting our consumer behavior. Buying power also influences our personal energy footprint. In some cases an overly active "ecological" consumption may involve greater use of energy than modest but ecologically wasteful consumption.

The energy calculator: Our consumer behavior and choice of products play an important role in determining our personal energy footprint.



Lowering Our Personal Energy Demand from 6500 Watts to 2000 Watts

				
Housing	Mobility	Food	Consumption	Infrastructure
<p>2000 Watt Path: aims to reduce demand from 1800 watts to 500 watts</p> <p>Current state: Three-quarters of all existing residential and office buildings are more than 30 years old and do not offer a sufficient degree of energy efficiency (20-liter houses). Currently at around 50 m² per person, the living area in new homes is on the rise.</p> <p>Options for action: Well-insulated low or zero-energy buildings (Minergie-P, Minergie P-Eco) reduce heating needs to the equivalent of 2 liters of heating oil per m². Moderate house size and energy-efficient appliances are important.</p>	<p>2000 Watt Path: aims to reduce demand from 1700 watts to 450 watts</p> <p>Current state: long commuting distances, heavy shopping and recreation-related traffic, and faraway holiday destinations are typical of our current standard of mobility. Air travel uses around twice as much energy per kilometer as car travel and five times as much as train travel.</p> <p>Options for action: the use of a bicycle or public transportation for short and medium distances; little air travel; the use of an energy-efficient vehicle; and limiting driving to less than 9000 kilometers a year.</p>	<p>2000 Watt Path: aims to reduce demand from 750 watts to 250 watts</p> <p>Current state: A lot of energy is packed into the food we eat. Farm production also requires large amounts of fertilizers, silage and water. Meat production is especially energy-intensive: the production of 1 kg of beef requires 10 times more energy than the production of 1 kg of pasta.</p> <p>Options for action: Place an emphasis on products which are fresh, local, organic, and in season. Consume little meat.</p>	<p>2000 Watt Path: aims to reduce demand from 750 watts to 250 watts</p> <p>Current state: Products with short service lives (clothes, furniture, etc.), non-basic services and events (concerts, hotel stays, etc.) are popular items that involve large amounts of embodied energy. We should bear in mind that a large part of our leisure and consumption infrastructure, which often requires considerable time to put in place, is used only temporarily.</p> <p>Options for action: an efficient consumer behavior is also called for when it comes to clothing, accessories, health, culture and hotel stays.</p>	<p>2000 Watt Path: aims to reduce demand from 1500 watts to 550 watts</p> <p>Current state: public infrastructure includes airports, train stations, streets, water and power supply, hospitals, schools and security systems.</p> <p>Options for action: Individuals are less able to influence the energy efficiency of public infrastructure. Public agencies must play a leading role when it comes to the installation of infrastructure that is compatible with 2000-watt goals.</p>

2000 watts as a personal lifestyle model: Using energy in a fair and sustainable manner in different areas of our lives

2000 watts

Housing
Mobility
Food
Consumption
Infrastructure

Improving Our Energy Footprint: Housing, Mobility, Food, Consumption

The notion that we can reduce our energy footprint is not utopian: if we are to realize the vision of a 2000 Watt Society, we will soon have to exploit the potential for greater efficiency in our day-to-day lives. Here we outline how a family of four can limit its per capita rate of energy consumption to 3500 watts (→ Energy Calculator, page 32). This amount corresponds to the interim goal (the year 2050) set by the 2000 Watt Society.

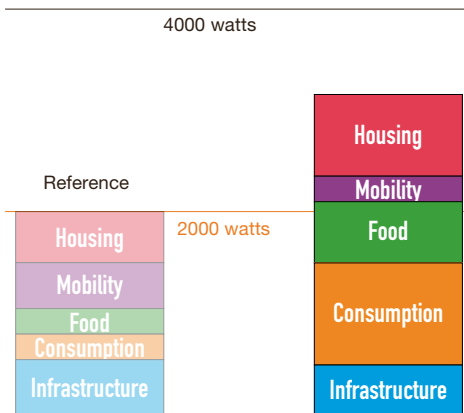
■ **Housing.** Our family lives in a duplex home measuring 172 m² on the outskirts of a medium-sized city. Although the home is nearly 10 years old, it was originally built to accommodate the active and passive use of solar energy, including solar collectors and

photovoltaic cells. A heat pump has been installed to meet most of the family's room heating needs.

■ **Mobility.** Short distances are the key, indeed reducing individual mobility generally. Both parents use a bicycle or public transportation to get to work. The children walk or ride their bicycles to school. The family's summer and winter vacations are spent in Switzerland at locations offering family-friendly accommodation and a view of a lake or mountains.

■ **Food.** The family makes a point of buying organic foods from local or regional production as well as products that are in season. They limit their meat consumption to one or two meals a week.

■ **Consumer products.** The family's budget for these items is moderate. Articles of clothing and shoes are therefore worn for as long as possible. Furniture and other household items are only replaced when they are broken or cease to function as they should. Electronic devices are only purchased if they are durable and energy-efficient.



What is the impact of your ski vacation in the mountains or your vacation in the South Seas on your well-being? While answers to

this question will be subjective, it is possible to arrive at an accurate assessment of the energy use associated with your vacation (→ Energy Calculator, page 32). We will now sketch the lifestyle of a fictional single person whose rate of consumption is 9000 watts, demonstrating that there are virtually no limits to the amount of energy we can use.

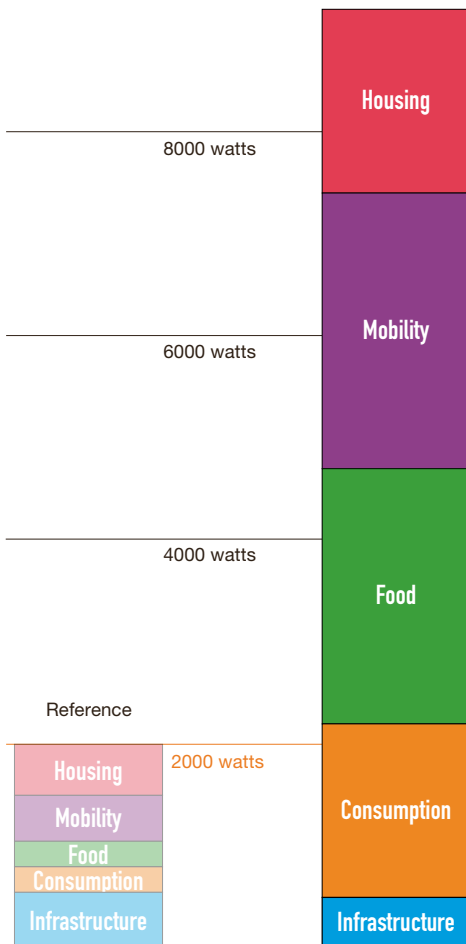
■ **Housing.** Mr. X lives in an attic apartment in the center of the city. The building was built to meet the Minergie standard. Although these circumstances are in

themselves favorable, Mr. X's personal energy balance is undermined by the size of the apartment (75 m²).

■ **Mobility.** Mr. X uses the streetcar or the bus to get to work. While his compact car remains parked on the street in a space reserved for residents during the week, he uses it on the weekend for trips in and around the city, driving around 4500 kilometers a year. However, large amounts of energy are consumed for regular vacation-related plane trips – once a year to Mexico and multiple trips each year to other cities in Europe.

■ **Food.** For Mr. X, price, quality and regional production all play an equal role. However, ready-to-eat products and frequent restaurant visits tend to increase his personal energy demand, taking into account the energy required to provide the entire infrastructure.

■ **Consumer products.** Mr. X's consumer habits lead to a high rate of energy consumption. Social and recreational activities go hand in hand with shopping for clothes and accessories. Mr. X's environmental awareness is of a pragmatic nature. Measures aimed at saving energy are implemented only when they don't run counter to his personal comfort.



The Solution: Consistent Use of Renewable Sources of Energy for Electricity Generation

Solar energy, geothermal heat, hydro-power, wind and biomass represent an important reservoir for the 2000 Watt Path. A clear consensus has been reached about the need to develop renewable sources of energy and to increase the share of renewable energies in the overall energy mix. Calls for action can be heard at many levels of society, politicians have begun to establish the necessary framework and many investors have turned their attention to large and small energy production and extraction systems. The use of

"In the long term, renewable energies will suffice to meet 100 percent of our heating needs if demand decreases by two thirds. Concrete measures must be implemented to ensure the success of this transition as well as the success of Swiss companies on future energy technology markets."

renewable sources of energy has begun and new, optimized technologies have reached a promising stage of development (→ ETH Domain, page 28 ff.). This means we will be able to replace fossil fuels and finite energy sources to a large extent. Indeed,

it is only to a limited extent that such a substitution remains a technical problem.

Economic and political hurdles will have to be cleared if we are to meet our heating and power needs with domestic and



use of these technologies in existing buildings depends on increasing the low rates of heating system renewal.

The production and use of electricity

will play a more major role in the 2000 Watt Society. In contrast to a reduction in our overall energy needs, our demand for electricity will increase in the short and medium term, as – for instance – the requirements in buildings rise (e.g. as the use of heat pumps spreads)

and more electric cars are introduced in the private transportation sector (→ Mobility, page 15). A reduction in

Dr. Kathy Riklin, Member of the Swiss National Council and President of the Advisory Body on Climate Change (OcCC)

renewable sources of energy. The "roadmap" published by the Swiss Academy of Engineering Sciences (SATW) outlines how this can be done and how the potential of renewable sources of energy can be exploited to the full. Consider, for instance, the new approaches being taken to heating demands in Switzerland (→ Sustainable Construction, page 16): According to the SATW roadmap, one in every two buildings can be outfitted with heat pumps, wood stoves and solar collectors in order to meet the demand for heating and hot water. However, the increased

our demand for electricity will only be feasible in the long term and it will not keep pace with the reduction in our demand for primary energy. The scenarios for the sustainable supply of electricity are of special interest to power companies. For instance, the power company of the city of Zurich (→ Partner Region, page 22) plans to meet nearly 100% of demand using electricity generated from renewable sources. The main contribution is to be made in the form of hydropower, with photovoltaic installations accounting for 10%.

On the Way to a Sustainable Future: on Foot, by Bicycle, Using Public Transportation or The One-Liter Car

The sustainable mobility plan envisages in the long term the use of the appropriate means of transport depending on the distance traveled. Slower means of transport are especially suitable for short distances. Public transportation is suitable for medium distances. Airplanes powered by fossil fuels remain the means of transport for long, transcontinental distances. In the short term, it is essential to reduce CO₂ emissions associated with cars. At 6.9 liters of gasoline per 100 kilometers (2009) – a rate corresponding to 170 grams

of CO₂ emissions per kilometer – the average fuel efficiency of new cars is still too high.

The percentage of electric cars in city traffic can be expected to increase. Light vehicles with efficient motors are in demand in the entire model segment. Low carbon fuels such as natural gas and biogas can make an additional contribution to the reduction of greenhouse gases when used to power larger private and commercial vehicles. Scientists at the Swiss Laboratories for Materials Science and Technology (Empa) and at the Swiss Institute of Technology (ETH) are currently developing prototypes with especially energy-efficient and clean natural gas and biogas engines that can be deployed in hybrid vehicles (→ ETH Domain, page 28 ff.). Engineers at the Paul Scherrer Institute (PSI) are also at

work on the development of low-emissions vehicles that are powered by hydrogen fuel cells. Other researchers and engineers are working together to test the general viability of new mobility technologies and concepts in an everyday context. The "Experience Space Mobility" project creates a setting for new mobility experiences in the "Basel Pilot Region" (→ page 20) in which pilot and demonstration projects can be carried out and the general public informed about alternative forms of mobility.

Low-emissions vehicles are tested in the Basel Pilot Region: Testing a catalytic converter carrier developed by Empa for use in natural gas vehicles.



Christian Bach, Head of the Combustion Engine Unit at Empa

"Cost-effective and comparatively clean-running vehicles can be produced using natural gas and biogas motors. These fuels also represent an important technological and socio-economic bridge to the development of hydrogen-powered vehicles."



Key Assessment Criteria: Location, Embodied Energy and the Planning Process

Minergie-P-Eco buildings consume less – by a factor of three – than buildings constructed according to conventional standards (Swiss Ornithological Institute in Sempach, LU-001-P-Eco).

"The Minergie-P standard is a pioneering, high-performance product. It places higher demands on all those involved in the building process. Effective communication is essential for the successful application of the standard, which already has the status of a pathbreaker and a motor of innovation."

The building of the future is already being built today. While the average building today consumes the equivalent of more than ten liters of heating oil per square meter, single-family homes, apartment buildings and office buildings designed according to the Minergie-P standard consume only two liters per square meter, or five times less. We can increase energy efficiency by positioning buildings for the passive use of solar energy, outfitting them with suitable insulation and equipping them to

make active use of renewable energies. Energy conservation and low CO₂ emissions are factors that are considered at the very beginning of the planning stage. After all, it is during the planning stage that 80 % of a given building's ultimate energy needs are determined. Only 20% of overall demand is determined by the behavior of the building's occupants.

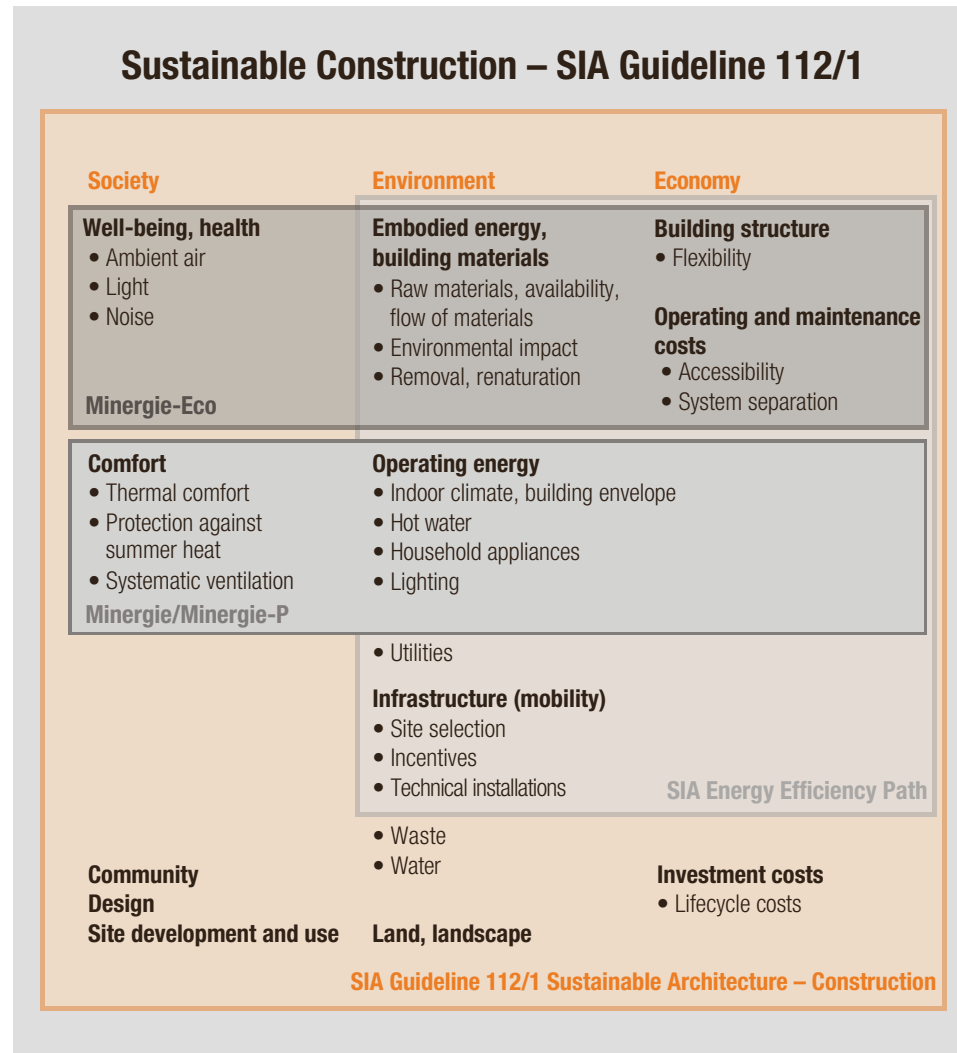
Construction methods that are compatible with a 2000-watt agenda are planned in accordance with the comprehensive specifications established by the Association of Swiss Engineers and Architects (SIA). Buildings are often required to meet the Minergie-P-Eco Standard and the assessment of their overall sustainability will include factors such as embodied energy and access-related traffic as well as energy efficiency. This is because the location of a building and the purposes for which it is to be used are just as relevant to the energy equation as the building's heating demands and insulation standard. The mobility variable, which is determined by the use of a building or complex of buildings (e.g. housing, office space), is also one of the important criteria used to evaluate whether a building is compatible with a 2000-watt agenda.

Prof. Armin Binz, Director of the Energy and Architecture Institute (FHNW) and the Minergie Architecture Agency



The SIA Guideline 112/1 is available as a comprehensive catalogue of criteria for sustainable construction. The guideline is relevant for investors and developers because the sustainable buildings will offer advantages that improve their investment value. These advantages include a high degree of energy efficiency and of user comfort, low operating costs and low long-term costs. However, creating 2000-watt buildings depends also on interdisciplinary development processes. The smooth interaction of investors, architects, specialist planners and planning authorities is an important success factor in the development of sustainable construction methods.

In order to lower the energy that is consumed in our buildings, it is essential that we do far more to increase the energy efficiency of existing buildings. Given that most of our buildings were built before 1970, the need for renovation is considerable. Technical innovations of the sort that are being developed by researchers in the ETH Domain (→ page 28 ff.) are needed. Moreover, it will also be necessary to introduce greater incentives for property owners. Progress in this area is being made by certified Swiss Energy Cities and the Novatlantis Partner Regions (→ page 20 ff.).



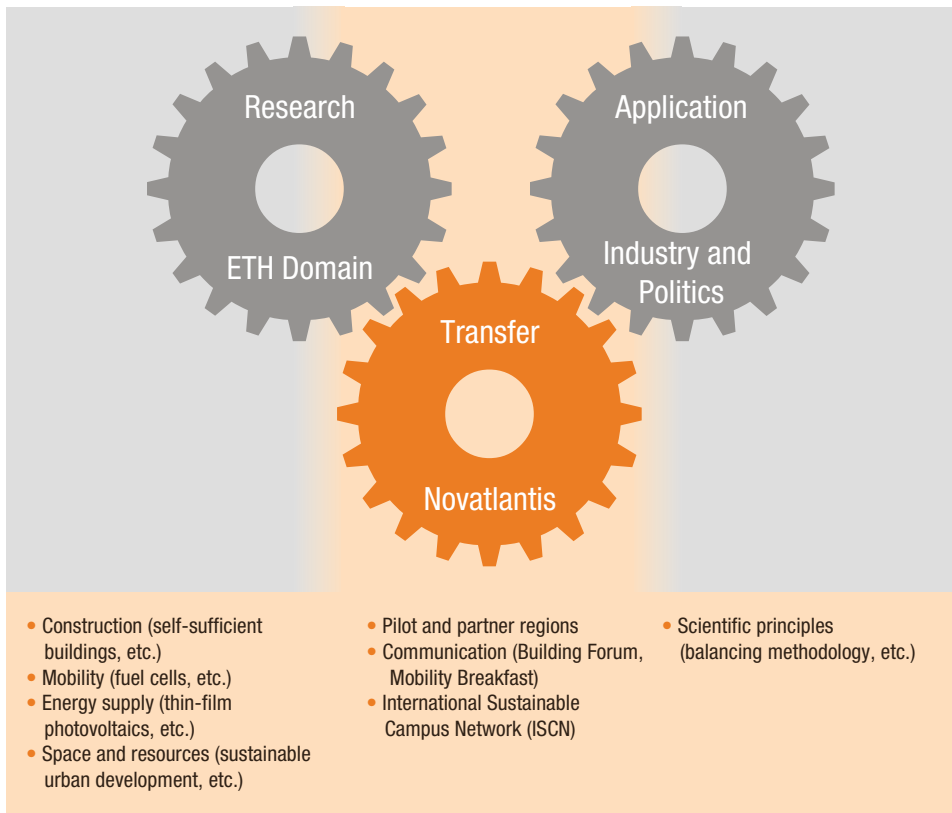
A comprehensive list of criteria for sustainable construction (as per SIA guideline 112/1).

Novatlantis Seeks Partners – Private Enterprise and the Public Sector Seek Showcase Projects

Progress on the path to sustainability and the 2000 Watt Society will require communication and a continuous exchange of information between members of the research community and their counterparts responsible for developing, approving and marketing

new products. As the sustainability initiative established by the ETH Domain, Novatlantis seeks to create a network between scientists, public administrators and industry representatives, align research efforts to the needs of society and create partnerships with cities

and communities that are committed to making progress towards the 2000 Watt Society. Close cooperation among the various stakeholders improves our ability to evaluate the feasibility and suitability of innovative technologies. The successful implementation of such technologies depends both on a sound scientific basis and effective communication. Novatlantis uses case studies, feasibility tests and information events (e.g. the Building Forum and the Mobility Breakfast) as a means of making selected specialist groups aware of showcase projects and the prospects of the sustainable 2000 Watt Society (→ Pilot and Partner Regions, page 20 ff.). This is because the success of new technologies and concepts is essentially dependent on their cost-effectiveness and their acceptance by various decision makers.



The Novatlantis partner regions are initiating numerous pilot and demonstration projects that will also play a role in the transfer of knowledge to the general public. Such pathbreaking projects are to provide a beacon of the 2000 Watt Society at a regional and a national level. For instance, a tool for sustainable urban development (NaQu) is being tested in the four regions of Basel, Geneva, Neuchâtel and Zurich with the aim of

"While many of the technologies that are required for energy sustainability are either already available or forthcoming, they often face delays when it comes to real market penetration. Novatlantis and the 2000 Watt Society are committed to facilitating this process in the interest of achieving significant reductions in CO₂ emissions and greater energy efficiency."

facilitating comprehensive urban development and renewal (→ Glossary, page 33). Further research and implementation projects have been initiated to address the issues of construction, mobility, energy supply, land development and resources. Novatlantis takes a push-pull ap-

proach to organizing specific projects and coordinating the efforts of researchers and those interested in applying the results of research:

■ **Push projects** enable knowledge and technologies developed at the various institutions in the ETH Domain to be transferred to the world of practical applications. Contacts to key persons in the public sector, in political circles, at NGOs and in private enterprise can facilitate the process. Current topics include the future supply of energy and the concept of a smart grid. In addition to this, representatives from industry, politics, and research have engaged in a "mobility dialogue" about future mobility concepts and technologies.

■ **Pull projects** promote research that directly corresponds to the needs of society and the public sector. Novatlantis seeks to unify the unlimited possibilities of research conducted in the ETH Domain with our need for specific solutions and broad applicability. This is well exemplified by the efforts in the individual pilot and partner regions and in the "Experience Space Mobility" project to encourage representatives from industry, society and science to enter a continuous dialogue concerning long-term and sustainable mobility policies.

Innovation and implementation platforms

for sustainable development are in demand not only locally and nationally, but also globally. This is why Novatlantis also plays a representative role at an international level to encourage the implementation of methods and technologies for sustainable development. Comprised of 120 leading universities from around the world, the International Sustainable Campus Network (ISCN) was founded for precisely this reason. ISCN conferences and working groups aim to provide a sound basis for decisions concerning the structural development of member campuses, promote communication among researchers and encourage the inclusion of the subject of sustainability in college curricula



Roland Stulz,
Executive Director of
Novatlantis

(→ ETH Domain, page 28). The first four annual ISCN conferences took place in Switzerland and China. At the ISCN meeting in 2009, the Lausanne-based École Polytechnique Fédérale even won the Construction Award.

Test Site for Realizing the Sustainable Development Vision

The canton of Basel City placed the 2000 Watt Society on its political agenda when it became a pilot region in 2001. The city's current goal is to reduce energy consumption to one-third of the Swiss average and to continuously expand the share of renewable energies in the city's overall energy mix. The canton's parliament proved that it is not just paying lip service to the notion of sustainability when it renewed its four-year investment credit of CHF 1.8 million in 2009 for the second time. The Basel pilot region is a test site for research in

Dr. Guy Morin,
President of the
Cantonal Government
of Basel City



the area of sustainable development and provides an opportunity for knowledge and experience to be exchanged with the ETH Domain and other universities. Furthermore, special tours are organized to give residents an opportunity to experience the vision of sustainable development.

Basel has also initiated various showcase projects in the area of sustainable construction. These include the customer center – a Minergie-P office building – of the local power

"The 2000 Watt Society is more than an energy conservation program; it is a metaphor that stands for sustainable development, a long-term process that requires stamina and innovation. That is why we are working together with our local universities and industry."

company (IWB). Also built according to the Minergie-P standard, the apartment building "Cosy Place" in the city's Bruderholz district is similarly a first of its kind in Basel. The aim of such pilot and demonstration projects is to demonstrate the marketability of new technologies and forms of construction. The canton has also sponsored a building renovation contest. In a canton in which 95 % of the buildings were built before 1985, and are correspondingly poorly insulated, this is an important instrument (→ Sustainable Construction, pages 16 and 17). The first-place award went to the planners of a Minergie-P renovation of a 60-year-old apartment building. Although originally organized as a one-time event, the renovation contest is to be held for a second time.

The Basel Office for Environment and Energy initiated a three-year program in 2008 to encourage property owners to renovate their buildings with an eye to enhanced energy efficiency. Those owners who carry out a complete renovation of their property are offered significant subsidies and free renovation consulting services. More than 900 property owners registered for the program and around 420 buildings are being completely renovated. The program has since been made a part of the canton's general energy subsidies program.

Efficient, low emissions car motors are tested in the context of the "Experience Space Mobility" project. The focus here is on environmentally friendly fuels and propulsion technologies (e.g. natural gas, biogas, and hydrogen). The following specific projects were initiated:

- Begun in 2009, the "hy.muve" project (→ ETH Domain, page 28) involves the testing of a street cleaner that is powered by hydrogen fuel cells.
- In the context of its "near Zero Emission Vehicle" project, Empa is developing catalytic

converters for natural gas motors (→ page 15). These converters are continuously tested in the vehicle fleets of various enterprises in the Basel region.

- Electro-mobility is soon to become a regular feature of the test site. In cooperation with Mobility Solutions, the postal service's fleet operator, the canton of Basel City plans to make a fleet of new electric cars available to the canton's administrative offices and to various private enterprises as a means of testing innovative technology.

The development and demonstration area "Space and Resources" was defined in 2009 in order to give greater attention to sustainable urban development in the canton of Basel City and to focus on the issue of a more efficient use of energy and resources. One example is the district center known as Gundeldinger Feld, which was built on the former factory grounds of the Sulzer Machines Company. The existing factory buildings were converted for sustainable use with a minimal investment volume.

World premiere in Basel: Testing of a street cleaner powered by hydrogen fuel cells.

Pilot Region Development

- 2001: Pilot region launched under the direction of the Office for Environment and Energy (AUE), canton of Basel City
- 2002: "Experience Space Mobility" project launched together with the Basel power company (IWB). Continual expansion of project sponsorship through the addition of industry partners, the canton of Basel Country and the Swiss Federal Office of Energy (SFOE)
- 2004: Pilot and demonstration projects set up relating to urban development and new construction technologies
- 2005: Integration into the political agenda, with a focus on the areas of architecture and mobility
- 2006: Building Forum and project contests for sustainable urban development

Current Projects

- Experience Space Mobility with the support of private and public fleet operators
- "hy.muve" feasibility testing of a street cleaner; "hy-light" passenger vehicle
- Renovation contest for apartment buildings (winner: Minergie-P renovation in Güterstrasse)
- Pilot and demonstration buildings (e.g. Pro Volta, IWB Customer Center, Sevogel District)
- Sustainable urban development "NaQu" at the Gundeldinger Feld and Dreispitz locations
- Novatlantis Building Forum for investors, developers and architects
- Mobility Breakfast
- Case studies
- Energy certification program for buildings



Citizens and Politicians Join Forces in Support of the 2000 Watt Society



The Zurich city council moved to place the initiative "Sustainable City of Zurich – on the Way to the 2000 Watt Society" on its main agenda for the 2006 – 2010 legislative period, thereby underscoring its intention to begin the work of implementing suitable environmental, energy and climate policies. As a complement to this resolve at the level of city government, the citizens of Zurich have also demonstrated their concern to secure an intact environment for future generations. In a referendum held in the fall of 2008, the citizens of Zurich voted in favor of writing the objective of the 2000 Watt Society into the city's constitution by over 75%. According to the provisions that have now been entered into the municipal code, per capita energy consumption is to be reduced by a factor of three and CO₂ emissions by a factor of four to six by the year 2050.

The city has since established the Minergie standard as the minimum standard – both for new buildings and renovations. In the case of architectural competitions that are organized in connection with cooperative development projects, the more ambitious Minergie-P-Eco standard typically applies.

The Trotte showcase nursing home: Zurich has adopted the Minergie-P-Eco standard to ensure compatibility with the 2000-watt agenda.

Partner Region Development

- 2005: Novatlantis establishes contact with the Building Authority of the city of Zurich
- November 2005: Joint workshop "Sustainable Development as a Goal of the Building Authority: Implementation via Partnership?"
- 2006: City council agenda focus: "Sustainable City of Zurich – on the Way to the 2000 Watt Society"
- 2006 to 2010: Action plans and measures in the areas of energy supply, energy efficiency, construction, mobility, environment, and cooperation
- 2008: Referendum to include the goals of the 2000 Watt Society in the municipal code is accepted
- Implementation plan drafted

Current Projects

- Showcase projects including the Triemli city hospital, the Trotte nursing home, the Sihlbogen housing development, and the Science City Campus
- Energy coaching for property owners
- Sustainable urban development project "NaQu" in Werdwies, the Bulling district and on the Hunzik site
- Consultation platform for small and medium-sized companies (Green Compass)
- Sensitization campaign: mobility behavior of the users of sports facilities
- Personal energy calculator and online energy game
- Spatial planning for an energy supply compatible with the 2000-watt agenda
- Energy exhibition on the 2000 Watt Society in the ewz (local power supply company) Customer Center
- Information and sensitization campaigns

A number of showcase projects are underway: the new Triemli city hospital and the Trotte nursing home are among the first projects in Switzerland that fulfill the comprehensive sustainability requirements of the 2000 Watt Society (→ Sustainable Construction, pages 16 and 17). The city of Zurich is also taking an active approach to making the experience and knowledge gained from the realization of such showcase projects available to architects, city planners, relevant specialists, and political authorities of other cities and cantons. Further implementation measures relating to the 2000 Watt Path in the area of real estate development include publicly funded consulting programs for homeowners and an energy-coaching program that is available free of charge to prospective homeowners and planners. The focus of the city's urban renewal campaign is directed equally to housing projects and commercial buildings.

"Cities provide the best conditions for reaching the goals of the 2000 Watt Society. Short distances and comparatively dense urban development with large common greenways allow us to lead a good life while consuming less energy and using less land. Zurich is determined to seize the opportunity of realizing the vision."

The establishment of an environmentally sustainable power supply for the city of Zurich is also a major step along the 2000 Watt Path. This supply is to be secured without the use of nuclear power and is to be provided essentially by renewable sources of

energy such as water, solar, geothermal heat, wind, and biomass (→ Energy Production, page 14). City administration facilities are already supplied exclusively with certified green power. Moreover, pilot and demonstration power plants are in the planning. In particular, the city of Zurich's power com-

pany is planning to use geothermal sources to meet the heating needs of individual buildings and districts. Test drilling has already been initiated to determine the feasibility.

The city's public transportation network and infrastructure for "slow traffic" are to be continuously developed. Planning and feasibility studies are being carried out in prepara-



Corine Mauch,
President of the City
Government of Zurich

ration for the implementation of a traffic plan that is compatible with the 2000-watt agenda. The city is also intensifying its measures to inform and sensitize the public to the issue of sustainable mobility. A guideline for the mobility specifications that development projects are to meet for 2000-watt compatibility has been drafted for investors. Furthermore, a calculation model is available to help evaluate the mobility factors associated with development projects.

An Association and Many Active Members – A Successful Start for Western Switzerland

In 2006, the canton of Geneva asked Novatlantis to define the measures that could be implemented at a local level to help achieve the goals of the 2000 Watt Society. No provision was to be made for the use of nuclear energy. At the beginning of 2008 a comprehensive energy concept (known as the Conception Générale de l'Energie) could already be unanimously ratified by the canton of Geneva's Grand Council. Having drafted a cantonal Energy Guidance Plan, which specifies implementation activities, timetables and necessary instruments, and having initiated various showcase projects, the canton of Geneva has taken a significant step closer to the 2000 Watt Path. Planning and development measures as well as a revision of the cantonal energy law – which may require building owners to renovate their buildings – mark the beginning of the canton's efforts to lower its energy needs. As a measure designed to begin changing the nature of the region's energy supply, Geneva's cantonal power company SIG (Services Industriels de Genève) has launched a program to help stabilize the region's power needs.

Founded in 2007, the association "Genève à 2000 watts" has been working in its capacity as a politically independent and non-profit

organization to promote the vision of the 2000 Watt Society in the canton of Geneva. Together with Novatlantis, the association has established a regional platform to facilitate the exchange of ideas among various groups of stakeholders. The association has set the following goals for itself:

- to realize the 2000 Watt Society in the Geneva region by reducing overall energy demand and introducing innovative technologies
- to develop and apply a feasible sustainability plan for mobility, construction, energy production and the public infrastructure
- to establish a network among scientists, cantonal administrators, industry representatives, and ordinary citizens.



Yves Leuzinger,
Director of hepia,
Technical College of
Western Switzerland

Partner Region Development

- 2006: Novatlantis contacts the relevant energy officials of the canton of Geneva, the University of Applied Sciences (Western Switzerland), EPF Lausanne, University of Geneva and SIG
- Novatlantis drafts an energy strategy for the local 2000 Watt Society
- 2007: The association "Genève à 2000 watts" is founded with representatives from private and public enterprises as well as the university
- 2008: 1st Building Forum in the French-speaking part of Switzerland
- 2010: The association establishes an implementation program over several years

Current Projects

- Referendum to revise the cantonal energy law, including an obligation to renovate inadequate buildings
- ChequeBatimentEnergie: building program sponsored by the canton of Geneva
- Promotion of solar power by the cantonal power company (SIG)
- Power stabilization program (Eco 21)
- Genève Lac Nations: supply network for air-conditioning with lake water

"The 2000 Watt Society offers the canton of Geneva many opportunities. These include the double challenge of developing renewable energies and achieving energy self-sufficiency. Opportunities abound as well for the canton's local economy, especially in the clean-tech sector."

Initiative "Eco 21" is the name of the campaign initiated by the cantonal power company SIG to help the region prepare for the 2000 Watt Path. In particular, the campaign seeks to encourage private enterprises and municipalities to voluntarily commit themselves to optimizing their energy and power demands. Various interested parties have responded, including the operators of shopping centers, transport companies and educational institutions, and declared their readiness, for instance, to construct energy-efficient buildings and make exclusive use of energy-saving lamps. The public Eco 21 program aims to bring about a reduction in power needs: by 2013 annual power consumption in the region of Geneva is to be reduced by 150 million kWh.

Home to many international organizations, Geneva is now helping to create the 2000 Watt Society.



A Commitment to Sustainability Made by More than 600 Municipalities

The European Energy Award (EEA) stands for effective local energy policy. More than 240 Energy Cities and 430 members of the Energy City Association representing more than four million residents have reduced their fuel needs at an annual rate of 34 million liters and their CO₂ emissions at an annual rate

of around 87 000 tons since 1999. The total annual savings of 80 million kilowatt hours of electricity correspond to the annual power needs of a medium-sized city. This has turned the European Energy Award into a trademark for successful and results-oriented local energy policy. In the context of the program, cit-

ies and other local municipalities are certified by the Energy City Association, which is itself supported by the federal "SwissEnergy for Local Communities" program. One central aspect of the certification initiative is that it is not compulsory. The participating cities and other municipalities agree to commit themselves to the sustainability process.

The "Building Standard 2011" is one example of the commitment the energy cities make as they seek to fulfill their self-imposed obligations. Launched by the cities of Lucerne, Schaffhausen, St. Gallen, Winterthur, and Zurich, the popularity of this program for public buildings has spread. A growing number of cities and other municipalities have decided to embark upon the



Becoming an Energy City

- Submission of a letter of intention by the relevant officials of the city or municipality
- Induction as a member of the Energy City Association
- Drafting of a current state analysis
- Obtaining Energy City certification upon implementation of at least 50 % of 90 measures
- Obtaining the European Energy Award Gold upon implementation of at least 75 % of 90 measures
- Annual success checks and audits every four years

The sense of common purpose that develops in the energy cities (photo: Rapperswil-Jona) as citizens become aware of the need to become more energy-efficient is impressive.

path to the 2000 Watt Society by enforcing a phased introduction of innovative building standards. In the initial phase, all new buildings are required to meet the criteria of the Minergie-Eco standard. Later, the Minergie-P-Eco standard is to apply. Heating demand is to be reduced to around 50 % of the legal limit and at least 40 % of this demand is to be supplied in the form of renewable energies. The building standard adopted by the energy cities also requires an approximately 30 % reduction in power consumption. To help reach this target, additional requirements outlined in the Minergie module are to apply to lighting and the use of highly efficient household appliances and office equipment. Moreover, all of the building materials are to meet the strictest of safety and sustainability criteria (→ Sustainable Construction, page 16).

The energy city of St. Gallen has embarked upon the 2000 Watt Path. The 2050 energy concept is based on the requirements of the 2000 Watt Society. The city's current annual energy needs of 1000 gigawatt hours for heating and hot water are to be reduced by around 50 % by the year 2050. This will require the optimal renovation of existing buildings. The city of St. Gallen is also aiming to introduce major changes in the area of



energy production (→ page 14). By using heat pumps and, if geologically possible, tapping deep geothermal sources, geothermal energy is to be used to cover a major portion of the city's heating needs. Erstfeld, an energy city in the canton of Uri, also has ambitious plans. The city's power company has already become one of Switzerland's largest producers of green power. In the future, the power company's customers are to be supplied entirely with electricity generated from local sources of renewable energy. At the same time, the city also aims to reduce its power consumption, for instance by replacing old electric

heating systems with new energy-efficient systems. The city's local power company has also launched a long-term program to promote the installation of solar systems (solar collectors for hot water and photovoltaics for electricity) on every suitable roof.

The city district of

Malley, a suburb of Lausanne, has used a largely abandoned piece of property as an opportunity to consider the 2000 Watt Society. The municipality now plans to develop the property – approximately 200 acres of former railroad yards and industrial site –

into a new sustainable residential district for 17 000 residents. The district is to include a link to the regional train network, and the Minergie-P-Eco standard is to apply to all new buildings and Minergie to all building renovations. Furthermore, the district's energy needs are to be reduced by around 50 %, despite the fact that the number of people and jobs in the district is expected to double.

"Day in and day out, EEA cities make an exemplary contribution to climate protection. They have begun the journey to the 2000 Watt Society. Although we have a long way to go, the fact that we have begun the journey is encouraging. I am convinced that we will soon have an opportunity to celebrate the first 2000-watt cities."

Kurt Egger, Director of the SwissEnergy for Local Communities Program

A Sustainable Energy Future – the Contribution Made by the Research Community

Researchers in the ETH Domain are busy researching every link in the energy chain. They have developed technologies that are ecologically, economically and socially sustainable. These researchers pursue various efficiency, substitution and self-sufficiency strategies. Some of the main aims of research include:

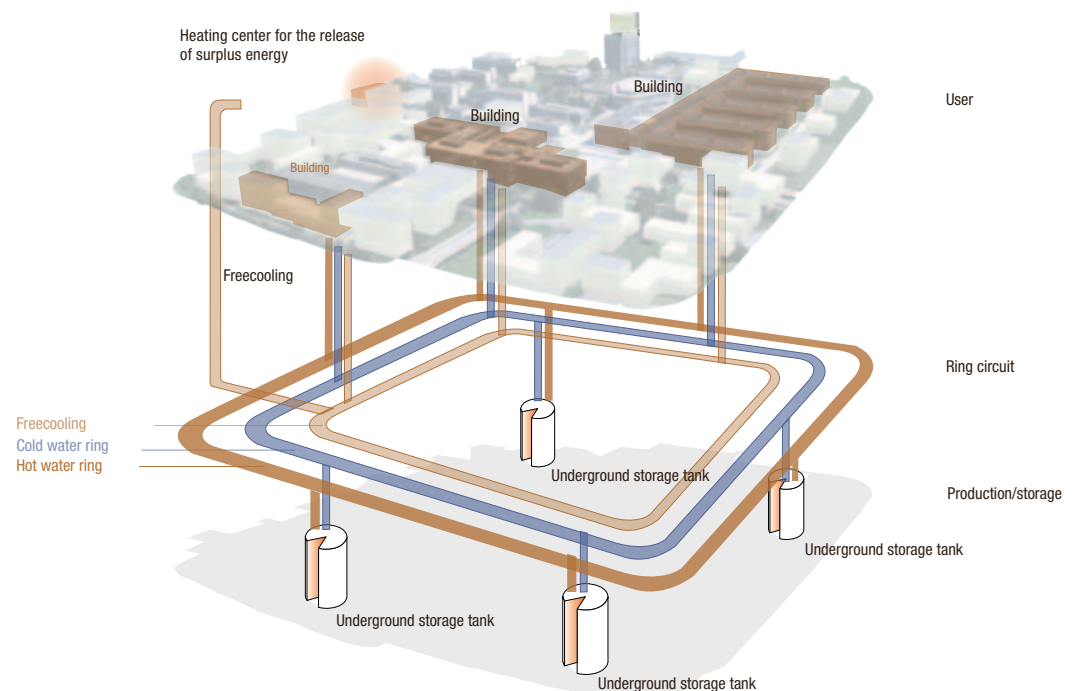
- Improving the efficiency of our energy use
- Replacing fossil fuels with CO₂-neutral or low-CO₂ fuels
- Optimizing the supply of and demand for energy services

Contributions to a sustainable energy future have been made by researchers in all of the various fields of inquiry at the Swiss Institutes of Technology in Zurich and Lausanne, as well as at the four federal research institutes the Paul Scherrer Institute (PSI), the Swiss Institute for Forest, Snow and Landscape Research (WSL), the Swiss Federal Laboratories for Materials Science and Tech-

nology (Empa) and the Swiss Institute of Aquatic Science and Technology (Eawag). The approximately 600 professors, 17 000 research fellows, and 20 000 students and doctoral candidates at these institutions produce top quality work that helps to secure a safe supply of energy, economic prosperity and environmental protection.

Science City Sustainable Energy Concept

The goals of the 2000 Watt Society provide a guideline for a sustainable supply of energy to Science City, the ETH campus in Hönggerberg. According to the plan, campus CO₂ emissions are to be reduced by at least 50 % by the year 2020. The technology involved centers on a dynamic system of underground storage tanks (diagram right): waste heat and environmental sources are used to supply low-order energy that is then converted to heating or cooling energy using highly efficient heat pumps and cooling machines. Two geothermal-probe fields with over 200 geothermal probes have been created. These are to be linked to the system's energy ring and made operational by 2011. Additional campus-based geothermal-probe fields are already in the planning.



The Energy Science Center (ESC) at the Swiss Institute of Technology in Zurich and the Energy Center (CEN) at the Swiss Institute of Technology in Lausanne are responsible for ensuring that the research carried out at these institutions in the area of energy sciences has a multidisciplinary component. Both of these organizations function as competence centers assigned to facilitate

Competence Center Energy and Mobility (CCEM)

Transport

- Low-carbon fuels (e.g. methane from biomass, CO₂-neutral production of hydrogen)
- Clean engine systems (e.g. fuel cells, zero-emission motors)

Electricity

- Electricity from renewable energies (e.g. competitive photovoltaic systems using thin-film cells, geothermal energy, hydropower)
- Safe power networks and a reduction of energy transmission losses

Buildings

- Innovative technologies for new buildings
- Plans for renovating old buildings with a focus on increasing energy efficiency
- Tool for decision-making in renovation projects

the flow of knowledge from the research community to other sectors of society. Current projects at the ESC in Zurich include:

- The one-ton CO₂ strategy, a dynamic road-map to help Switzerland achieve a sustainable energy system by the year 2050. This instrument offers a basis for making informed decisions and working out promising political strategies
- Passenger vehicle electrification: the development of plug-in hybrid engines that can be charged using low-CO₂ electricity (→ Mobility, page 15) and the creation of a comprehensive mobility system that will help us to achieve massive reductions in CO₂ emissions.

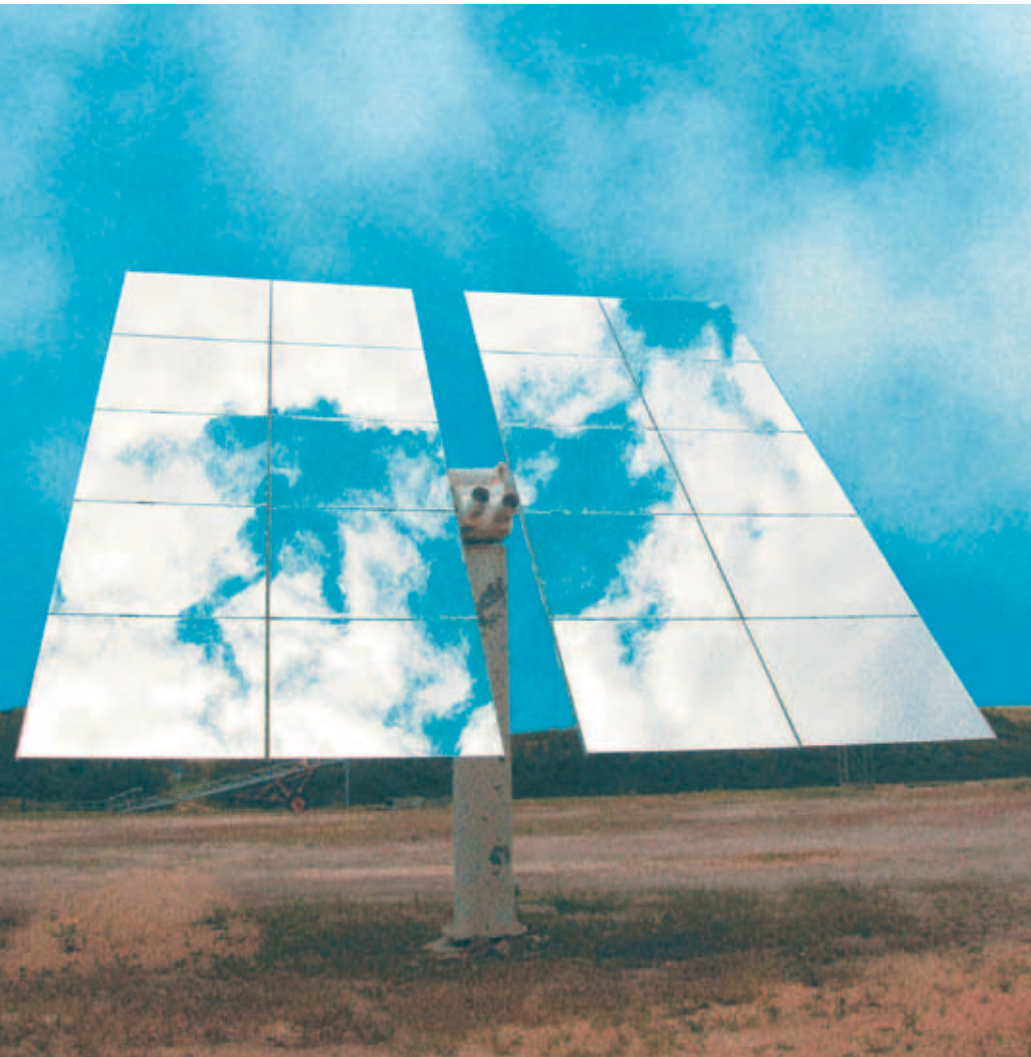
Current projects at the CEN in Lausanne include:

- The MEU project (Management of Urban Energy Systems): establishment of a consortium known as Plus-E for the planning of urban energy systems. The purpose of this consortium is to bring together the members of the research community, the public sector, private enterprise and planning offices in the search for effective solutions
- Round table for sustainably produced bio-fuels: an international initiative involving the participation of producers, enterprises, NGOs, governments and scientists

■ PECHouse initiative: establishment of a competence center for the production of hydrogen by means of direct photoelectrolysis.

The Competence Center Energy and Mobility (CCEM) works to promote multidisciplinary research in the ETH Domain. Under the direction of the Paul Scherrer Institute (PSI), the CCEM coordinates and finances research projects that are proposed by researchers in the ETH Domain or at the University of Applied Sciences Northwest Switzerland or the Lucerne University of Applied Sciences and Arts. The CCEM also solicits the involvement of industry in such research projects. The Competence Center Environment and Sustainability (CCES) focuses on research conducted throughout the ETH Domain relating to climate and environmental changes, sustainable land use, nutrition, health and natural hazards. Such research includes the development of models and technologies for application in the area of climate protection.

Research and Development in the Interest of Sustainable Concepts and Technologies



The Paul Scherrer Institute (PSI) is a multi-disciplinary, internationally renowned research center for natural sciences and engineering and is active in the areas of solid state physics, materials science, particle physics, biosciences, energy science and environmental research. In the area of energy science, for instance, researchers at the PSI are developing new fuel cells and non-polluting engine systems for passenger vehicles. Specific projects include:

- **Propulsion systems for fuel-cell hybrid vehicles:** market success will depend on lower production costs and engine durability. The PSI contributes to the production of electrolyte membranes, develops stack formation innovations and provides concepts for system simplification. The implementation of the new technology is being carried out in a joint venture with Belenos Clean Power
- **Methane from wood:** development of procedures for converting waste wood, scrap wood and used wood via thermal gasification into biofuels of the second generation.

Heliostats concentrate sunlight. Researchers at the PSI are developing ways of storing solar energy.

The Swiss Laboratories for Materials Science and Technology (Empa) is an interdisciplinary research and service institution for materials science and technological development. Through its involvement in the following projects, Empa is making an important contribution to the 2000 Watt Society:

- **Energy efficiency in buildings:** together with national and international partners (CCEM and IEA), Empa is developing ideas for energy-focused building renovation and energy self-sufficient buildings. One example of Empa's work in this area is the development of cost-effective, prefab renovation modules
- **Energy transformation and storage:** research into thermoelectricity is being conducted to develop efficient ways of transforming sunlight, geothermal heat and waste motor heat into electricity. Research is also being conducted in the area of thin-film photovoltaics and organic photovoltaics
- **Hy.muve:** hydrogen-powered vehicles are being developed in the projects known as hy.muve ("hydrogen-driven municipal vehicle") and hy-light (passenger vehicles)
- **near Zero Emission Vehicle project (nZEV):** here the aim is to discover ways of eliminating polluting emissions in natural gas engines.

The Swiss Institute for Forest, Snow and Landscape Research (WSL) conducts research in the area of land and resource management, with a special focus on land use and habitat protection. Taking a sustainable approach to our limited expanses of land is just as essential as taking a sustainable approach to the use of our natural resources. Drawing upon studies conducted in various areas of the social sciences, researchers at the WSL are investigating sustainable approaches to delineating and drawing resources from terrestrial ecosystems. Current research projects at the WSL include:

- Land resources, land use, biodiversity and conservation biology
- Forest ecosystems, natural hazards, warning and prevention
- Environmental and resource economics, regional economics and development

The Swiss Institute of Aquatic Science and Technology (Eawag) is the aquatic sciences institute in the ETH Domain. One of Eawag's special strengths has been its long-standing commitment to education, training, consulting and otherwise transferring knowledge to other sectors of society. The combination of natural sciences, engineering and social sciences permits Eawag to con-

duct comprehensive investigations of water and waterways, ranging from relatively intact aquatic ecosystems to technically sophisticated wastewater management systems. The goals of this interdisciplinary aquatic research include reducing our demand for potable water and relieving our overburdened wastewater treatment plants. The idea for the minimal-energy building "Forum Chriesbach", which makes an active supply of energy for heat and hot water almost superfluous, was developed at the Eawag. Some of the most important energy-related research projects include:

- **Aquamín House:** with the use of novel technology, wastewater is purified inside the building and then allowed to leach in the ground or is channeled to a body of flowing water.
- **NoMix technology:** urine is gathered separately in urine diversion toilets or waterless urinals. The main benefit of this technology is that it unburdens wastewater treatment plants.
- **Green power:** a catalogue of criteria has been drafted for the certification of truly sustainable hydropower plants.

Eawag in Dübendorf: The "Forum Chriesbach" uses three times less energy than buildings constructed according to conventional standards. (Foreground: installation of toilets by artist Ping Qiu of the "Artist-in-Lab" project).



Glossary

- **2000 watts:** the continuous rate of energy produced by 20 100-watt light bulbs. An output of 2000 watts amounts to 17 500 kilowatt hours (kWh) or 1750 liters of petroleum used over the course of a year. At the turn of the century, this value was equal to the global average of energy consumed per capita for all energy services.
- **2000 Watt Path:** medium to long-term reduction process to realize the 2000 Watt Society. The projected arrival dates with regard to total energy consumption and the use of fossil fuels are 2050 and 2150. The SIA Energy Efficiency Path offers a means of calculating the reduction goals that apply to a single building for 2000-watt compatibility.
- **Balancing method:** The city of Zurich, the Swiss Energy Agency and Novatlantis have joined forces in drafting a guideline for calculating a given individual's primary energy needs (in watts) and CO₂ emissions (in tons). The calculation involves primary energy factors, CO₂ equivalency factors and a definition of regional target values (in watts per person and CO₂ equivalency per person).
- **CO₂ emissions:** the 2000 Watt Society calculates greenhouse gas emissions in terms of primary energy in CO₂ equivalents, which include the remaining substances that are climate-relevant and produced by human activities (methane, nitrogen compounds, etc.).
- **Competence Center of the 2000 Watt Society:** the Competence Center of the 2000 Watt Society is funded by the Swiss Federal Office of Energy (SFOE) and supported by Novatlantis. The aim of the Competence Center is to encourage an active approach to the issue of sustainability in municipalities, enterprises, schools, and other organizations. In performing its work, the Competence Center has access to a network of certified 2000-watt consultants who provide resources and expertise to help meet the requirements of the 2000 Watt Society.
- **Efficiency:** measure of primary energy consumption in relation to an activity or a unit of utility. In order to increase energy efficiency, it is essential to minimize all energy conversion losses and incidental energy losses (e.g. transport) that may occur in the process of using primary energies to provide energy services.
- **Embodied energy:** the amount of energy that is required for the production, transport, storage, sale, maintenance and disposal of a product, including all its component parts.
- **Energy calculator:** the ECOPrivate energy calculator calculates energy needs in the area of personal consumption. For instance, **housing** variables include home size, source of energy for heat and hot water, and household appliances. **Mobility** variables include means of transport, distance and air travel. **Food** variables include eating habits (meat, restaurant visits). **Consumer** products variables include clothes, electronic devices and general infrastructure. Energy balance data are supplied by the "ecoinvent" competence center in the ETH Domain.
- **Energy services:** goods and services whose provision or production require energy including, for instance, heated houses, IT, telecommunications, mobility, manufactured products, vacations, energy supply, etc.

→ **Final energy:** final energy is the form of energy that is directly available to users in private households, industry or transportation, i.e. commercially available energy sources, for instance heating oil, natural gas, electricity, gasoline, diesel, wood pellets and district heat.

→ **IPCC:** the Intergovernmental Panel on Climate Change. Founded by the United Nations in 1988, the IPCC is charged with evaluating the risks of global warming and establishing strategies for avoiding these risks.

→ **Lifestyle model:** represents a compilation of the activities and consumer behavior displayed by individuals in their daily lives. Lifestyle models are usually determined by the economic circumstances and indirectly by the rates of energy consumption that prevail in a given country. In contrast, quality of life is defined subjectively.

→ **One-ton CO₂ strategy:** a sustainable, per capita climate balance, as specified by the 2000 Watt Society. According to the IPCC, limiting annual per capita CO₂ emission to this amount would allow us to limit the extent of global warming to a tolerable +2 °C.

→ **Primary energy:** the 2000 Watt Society specifies that when calculating our primary energy needs, we should also consider the energy consumed at upstream stages of the process, including the energy used to extract, convert and distribute the fuels in question.

→ **Self-sufficiency:** an indicator of the responsible and sustainable use of energy and other resources. Individuals replace energy-intensive services with energy-efficient services and optimize their consumer behavior. Examples include video conferences instead of air travel and reducing the amount of living space required per person.

→ **Showcase projects:** in a series of showcase projects, Novatlantis pilot and partner regions are testing the real-life feasibility of concepts and technologies that are compatible with the aims of the 2000 Watt Society. Examples include the expansion of Zurich's Triemli hospital, the Trotte nursing home in Zurich and sustainable urban development in the Erlenmatt district of Basel.

→ **Substitution:** global warming can be counteracted in the context of meeting our energy needs by substituting low-CO₂ fuels

(solar power, geothermal heat, wind, biomass, etc.) for high-CO₂ fuels (petroleum, natural gas, coal). This represents a de-carbonization of our energy supply.

→ **Sustainable urban development**

(NaQu): Commissioned by the Swiss Energy and Development Agencies, Novatlantis and SwissEnergy for Local Communities are creating a tool that will enable its users to evaluate the sustainability of urban development projects. Tests have been carried out in four pilot districts, including Dreispitz in Basel, Carré Vert in Geneva, Ecoparc in Neuchâtel and Bulling in Zurich.

→ **Useful energy:** the form of energy that is actually used by consumers, including the heat from a radiator, the light from a lamp, the propulsion of a vehicle or the process energy in the manufacturing of goods. Energy-efficient services and technologies are capable of converting a large portion of final energy into useful energy.

Further Information

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2000 Watt Society

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"Indeed, the vision of the 2000 Watt Society offers a promising approach. New ways of thinking and new forms of cooperation are required."

Doris Leuthard, Member of the Swiss Federal Council

"Responsible companies do all they can to conserve resources and minimize the environmental impact of their products. This commitment extends from the extraction of raw materials to production, installation, use and recycling."

Hans Ruedi Schweizer
Managing Director
Ernst Schweizer AG, Metal Construction

"Our core mission is to secure an environment in which researchers are encouraged to participate in open scientific discourse. Given the role that scientific inquiry can play in shaping a brighter future – and given the ETH Domain's reliance on public funding – it is incumbent on us to accomplish this mission."

Dr. Fritz Schiesser,
President of the ETH Council

"While many of the technologies that are required for energy sustainability are either already available or forthcoming, they often face delays when it comes to real market penetration. Novatantis and the 2000 Watt Society are committed to facilitating this process in the interest of achieving significant reductions in CO₂ emissions and greater energy efficiency."

Roland Stulz,
Executive Director of Novatantis

