A "2000-WATT SOCIETY" IN 2050: A REALISTIC VISION?

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1. The vision of a 2000-watt society

Whereas a broad consensus exists on the necessity of a strong reduction of global anthropic emission of greenhouse gases (GHGs), the prospect of reducing the average usage of energy per capita in industrialized countries is rarely considered. One exception is Switzerland, where the vision of a "2000-watt society", proposed at the end of the last century (Imboden et al. 1992; Kesselring and Winter, 1994; Jochem et al. 2002, 2004; Novatlantis 2009) and approved in 1998 by the ETH Board[1] (ETH-Rat), was adopted by the government in its "Strategy for sustainable development 2002" (Swiss Federal Council 2002) and endorsed by the most important national scientific and technological institutions.

The aim of this vision is to reduce at around 2000 watt (i.e. 2000 joule/second) per capita the mean of permanent flux of power for all energy needs; this would include, not only electricity, but all sources of primary energy corresponding in a year to 17 520 kWh or 63 GJ or 1,5 tons. of oil equivalent (toe) per capita. This would mean a reduction of the national use of primary energy from 1205 PJ in 2001 to 460 PJ in 2050, by an assumed almost constant population size of 7,1 million people (Jochem 2002). In 2000, the per capita usage of commercial primary energy in Switzerland was around 6000 watt, corresponding to 52 560 kWh or 190 GJ or 4,5 tons. of oil equivalent (toe) in a year; the national per capita emission was 6 tons. of CO_2 and 7 tons. of GHGs. Considering also the worldwide GHGs net emission in order to supply Switzerland with goods and services, the GHGs emissions of the Swiss inhabitants were esti-

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[1] The ETH Board group, the Swiss Federal Institutes of Technology in Zurich and Lausanne, and the four application-oriented research institutes – the Paul Scherrer Institute (PSI), the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), the Materials Science and Technology Research Institution (EMPA) and the Swiss Federal Institute of Aquatic Science and Technology (EAWAG).

mated to be around 10 tons. CO_2-equivalent in 2004. Worldwide, the per capita usage of primary energy in 2004 was approximately, e.g., 500 watt in Bangladesh and India, 6000 watt in Europe, 12000 watt in the USA and 16000 watt in Island.

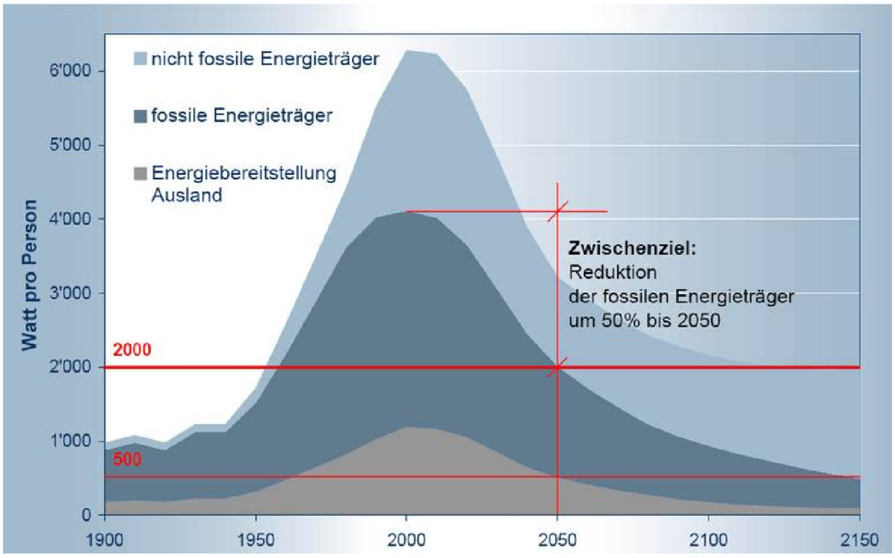

Figure 1. World usage of primary energy.

The emphasis of the vision of a 2000-watt society is on a strong rise of energy efficiency and a shift towards renewable energies. According to the Swiss government “The scenario of a «2000-watt society» serves as a conception guiding energy and climate protection policy. In the long term, this would require a reduction in greenhouse gas emissions (primarily CO_2) to the sustainable level of one tonne per capita, with per-capita energy consumption of 500 watts being derived from fossil fuels and 1500 watts from renewable sources.” (Swiss Federal Council 2002). Therefore, in the long run, the vision includes not only the reduction of the energy usage, but also the reduction of the GHGs emission as well as a dominant proportion of renewable energies, and no usage of the atomic energy.

Shall it be possible to guarantee to the inhabitants of an industrialized country in 2050 a high level of prosperity, probably higher of the present one, using the same amount of primary energy (2000 watt per capita) used in the country in the Sixties? Is the threshold of 2000 watt per person realistic whereas all nations, including industrialized countries, use more and more primary energy? Is this goal realistic, when most economists and mass-media assert that an appreciable increase in energy use is inevitable also in industrialized countries ?

The vision of a 2000-watt society implies a technological, a cultural, and a political challenge. Eco-efficient technology comes ahead in the most common advocacy of a 2000-watt society in Switzerland. The key for a reduction of two thirds of the energy usage per capita – as the vision is propagated – would be a dramatic increase in energy efficiency, i.e. a strong reduction in energy losses in the transformation chains from primary energy to final energy services. To associate a physical reduction goal to the idea of progress is a great cultural change if one considers how deeply the idea of human progress has been recently associated with an increasing per capita energy use. Furthermore, reducing energy usage in industrialized countries is a political challenge, because few are inclined to renounce to some immediate consumption in favour of both soberer lifestyles and more investment in energy efficiency. Finally, for a global energy policy, the objective of the standard of 2000 watt per capita in an industrialized country would be a political message with far-reaching consequences, especially for developing countries.

2. Proposals of an energy-sober society

In the last decades some authors suggested to consider the opportunity of a voluntary ceiling to the amount of primary energy used per capita. Wolfram Ziegler proposed a voluntary limit in the use of primary energy in central Europe under the level of 0,16 W/m^2 (Ziegler 1979; 1996); this level was based on ecological arguments and was intended to limit the anthropic pressure on biodiversity. Starting from Ziegler's arguments and data, Dürr calculated and suggested a global value of 9 TW as a voluntary limit in the use of primary energy by mankind (Dürr 1993); this level would be around one fifth of the amount of solar energy transformed by terrestrial organisms, estimated by Dürr at 40-50 TW, for a human population of 6 billions at the end of the last century, Dürr suggested consequently the vision of a "1500-watt society". Goldemberg et al. (1985; Goldemberg 2004) claimed that 1000 watt of primary energy per capita would cover "basic needs and much more". Spreng et al. (2002) suggested to steer human societies towards an "energy window", defined by a lower social limit and an upper ecological limit in the use of primary energy. In Switzerland, the idea of setting a ceiling to energy usage was formulated at the beginning of the '90s (Imboden et al. 1992; Imboden 1993). Paul Kesselring (Paul Scherrer Institute, Switzerland), and Carl-Jochen Winter (German Aerospace Research Establishment, DLR) punctually suggested a "2000-watt society" as worldwide plausible vision achievable within 50-100 years (Kesselring and Winter 1994).

3. Controversial points on a 2000-watt society

In the last years some authors considered the objective of a 2000-watt society in Switzerland to be less binding. In this century, a higher level of primary energy per capita (4000-6000 watt) was considered plausible in Switzerland and in the world[2] (Boulouchos et al., 2008), the target of 2000 watt was dropped as “a metaphor” and the focus was shifted from the energy policy to climate policy, launching the slogan of a “1-tonne-CO_2 society” (Boulouchos 2008). Leading newspapers published articles with headlines such as “Energy saving is out – The ETH abandons the “2000-watt society” in its new energy strategy” (Bergamin 2008) and “2000-watt society – A metaphor or a goal to pursue?” (NZZ 2008). In the following chapters, I will analyse some of the controversial points on the feasibility of a 2000-watt society in Switzerland.

3.1 Time horizon

The proponents of the vision of a 2000-watt society set the time horizon to 2050 (Jochem 2002, 2004; Novatlantis 2008) and stressed, that reforms had to start promptly. Other authors and policy makers considered a 2000-watt society plausible in Switzerland only in 2100 or 2150 (Koschenz and Pfeiffer 2005) or never, while others opposed the vision; one Zurich politician declared, that “the 2000-watt society would lead to a standard of living like that of the Republic of Congo”.

3.2 Environmental quality of energy: different impacts of different energy transformations

Some critics argue that a ceiling to the energy usage *per se* would be wrong. What really matters is not the quantity of energy *per se*, but the its amount and the variety of damages and risks associated with each type of energy source and related technology. According to this viewpoint, in the next decades, no overall ceiling to the individual average energy use would be reasonable. Basing on macroeconomic models, most global energy scenarios (e.g. those of IEA, OECD, IIASA) estimate that the global energy usage will in-

[2] “The global energy system can also be configured in a sustainable manner at a level of 4 – 6 kW per capita of primary energy” (Boulouchos et al. 2008).

crease – mostly through fossil fuels - by at least a factor of three up to the year 2050 (Imboden 2000). Insofar some authors consider realistic an usage of primary energy of 4000 to 6000 watt worldwide before the end of the century.

Some studies tried to compare the environmental impact of different energy technologies, especially those used to produce electricity (Hester 2003). Most studies reduced the metrics to simple parameters like monetary costs (cost-benefit analysis), or estimated mortality and morbidity risks (risk analysis). According to Stirling, who carried out a survey on 32 of these studies (Stirling 2003), methods and assumptions were quite different among them and each of these studies must be judged "seriously incomplete"; in fact they gave a very wide range of outcomes. Consequently, Stirling suggests to compare different energy technologies through an approach based on the precautionary principle[3] and proposes a framework based on it (Stirling 2009).

3.3 Climate change

On one hand, some authors say that a ceiling to energy use *per se* could make more difficult to mitigate anthropogenic climate change. In order to reduce the greenhouse effects of technological energy transformations, fossil fuels should be substituted as soon as possible with fossil-carbon-poor or -free energy sources. One strategy to do this is to force the electrification of many energy services (Boulouchos 2008), including public and private transportation, as well as heating of buildings through heat pumps (Switzerland is pioneer in this field). Electricity should be then produced without operational emission of fossil carbon, e.g. through atomic, hydro-, solar, wind, geothermic or biomass energy. An energy ceiling – it is argued - could limit the availability of fossil-carbon-free electricity, which would be necessary in large quantity to replace fossil fuels. In many cases the electrical option implies a longer and less efficient chain of energy transformations, so that, at the end, more and not less, primary energy would be needed. Insofar a trade off "more-energy-for-less-carbon" should be accepted. For this reason a rise of the usage of pri-

[3] "For its part, a '*precautionary*' approach reflects a rather different perspective, introducing a wider range of emerging issues in the general sustainability debate. At root, the precautionary approach contrasts with the more reductive 'risk-based' approach in giving equal attention to those effects that may be less readily quantifiable. It addresses issues such as the complexity, variability and potential of non-linear vulnerabilities in natural and social systems. It highlights the consequent potential for 'surprises' affecting all options. Precaution places greater emphasis on active and dynamic choices between technology and policy alternatives than to 'risk-based' approaches. It makes a point of including a wider range of social and political values, rather than those that happen to be embodied in the relatively narrow community of technical specialists." (Stirling 2003).

mary energy to 4000-6000 watt per person worldwide is taken in account (Boulouchos 2008).

On the other hand, leading advocates of a 2000-watt society consider energy saving as the most plausible and probably the only effective strategy to reduce the energy related emissions of CO_2 (Imboden 2000; Jochem 2006). According to Imboden (2000) there is an incongruence between the expected energy usage and the CO_2 scenarios for the next decades. Based on macroeconomic models, most energy scenarios (IEA, OECD, IIASA) estimate that the global usage of primary energy will increase – mostly through fossil fuels - by at least a factor of three by the year 2050. On the other hand, the IPCC claims, in its fourth assessment, that global GHG emissions should be reduced by 2050 of 50 to 85% of the level of 2000 (IPCC 2007). If these scenarios are realistic, according to Imboden (2000) the previous targets of the IPCC (IPCC 1995) can be reached only if a decarbonisation of at least factor three will be attained. Instead, the decarbonisation rate of the global energy system in the last decade of the past century was only of 0,3%. The relative affordability of fossil fuels and of their technologies compared with carbon-free technologies will determine a significantly higher rate in the next decades. If continued until 2050, this trend would give a decarbonisation of factor 1,16. This would mean that CO_2 emission of the energy system would be 2,6 times (3 / 1,16) greater than today, bringing the CO_2 concentration well above 500 ppm in 2050 (Imboden 2000).

3.4 Rebound effect

Energy efficiency does not save energy, some authors say. Starting with William Jevons (1865) several authors pointed out that technological improvements, able to reduce the usage of primary energy for a given good or service, can lead to a lower price of that good or service and to a greater demand for it, insofar offsetting part or the whole efficiency gains (Saunders 1992, Musters 1995, Herring 1999, Rubin and Tal 2007). This phenomenon has been called *rebound effect* or *energy paradox*; when more than 100 per cent of the efficiency gain is offset, this is called *Jevons paradox* or *backfire*; *Khazzoom-Brookes-Postulate* is another name for this phenomenon (Saunders 1992). There are several reasons for this contra intuitive occurrence: lower prices of an energy service mean free new purchasing power that can be used to buy more of that energy service or more of other energy demanding services; furthermore, lower prices of energy services stimulate economic growth generally leading to more energy usage.

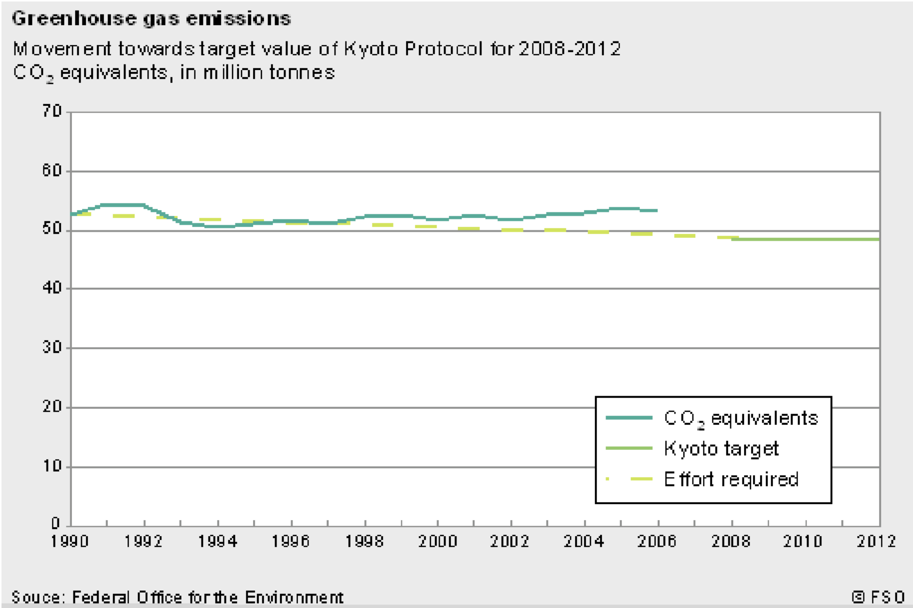

Figure 2 – Switzerland: greenhouse gas emissions (Mt of CO_2-equivalents) do not sink. Source: Federal Statistics Office.
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Based on theoretical and empirical considerations, there is controversy on the reach of the rebound effect at the micro- and macro-economic level. However, several authors agree that, in industrial countries, more energy efficiency will not lead *per se* to less energy use, unless restrictions are established by public authorities (e.g. energy taxes; cap and trade) or by self-limitation (Herring 1999, Rubin and Tal 2007). According to Flueeler et al. (2007) "increasing energy efficiency is a necessary but not sufficient means of limiting either energy use or GHGs emissions. (*omissis*) Without an adequate integral and transdisciplinary framework, energy-saving technologies can even have counter-productive (rebound) effects".

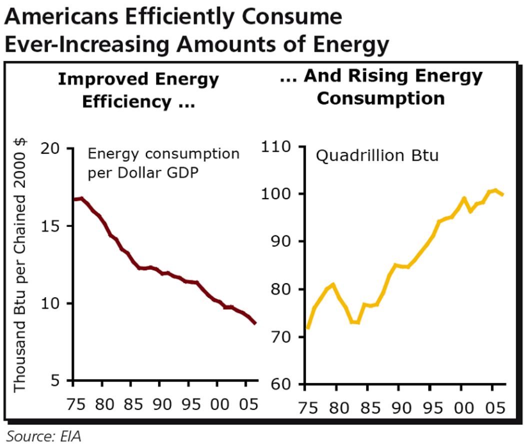

Figure 3. USA: Higher energy efficiency and higher energy usage (1975-2005). Source: Rubin and Tal 2007, http://research.cibcwm.com/ economic_public/download/snov07.pdf

3.5 Invention

As Thorstein Veblen put it, “Invention is the mother of necessity” (Wikiquote 2008). Indeed, technological invention not only meets better the existing needs but it creates new ones. When speaking of technological innovation and sustainability, the focus is generally on energy efficiency. In fact, history shows that, parallel to efficiency progress in most devices - just driven by it - technological and marketing innovation lead to growing demand for new devices (e.g. mobile phones, computers) and for more sophisticated types of old models (e.g. cars); in most cases the result is a net increase of the overall energy demand. For example, technologists can probably improve of a factor ten or hundred the efficiency of spaceships; but if this will create a market for spaceship tourism – something previously not perceived as a need – this efficiency progress would lead to use more primary energy, not less.

3.6 Marketing

Many of the people’s wishes in 2050 cannot be known. However, if one considers past evolution, in the next decades billions of people are expected to consider reasonable to claim for energy demanding devices and services, which do not exist today and some others, which nowadays are considered extravagant. Not only electronic and mechanical engineers are at work, but also “desire engineers”, i.e. millions of marketing professionals who created a science and a multitude of techniques to shape desires and transform them in needs[4]. The global cost of marketing and advertising is reckoned to be more than 1000 billion US dollars per year. Several corporations spend much more in marketing than in research and development, being aware that engineering desires is more profitable than solely engineering devices. Some technologists seem to overrate the potential of technical efficiency gains and to be not used to consider sufficiently cultural and social phenomena, which lead to overall higher usage of energy.

3.7 Social distribution of energy usage

Most surveys on energy macro-trends consider one country per capita energy usage, but not its social distribution. Delivering statistics in which energy usage per person is displayed in function of income classes would be useful to highlight the connection between income and energy usage and conceive innovative, not technology-based, energy policies. With present technologies, achieving higher energy efficiency or higher shares of renewable energy requires often higher investments; thus it could be expected that the higher the income, the more can be invested in energy efficiency and renewables. Luxury is considered legitimate for higher incomes. But, just as high-income citizens pay progressively higher taxes, they could also be asked to invest more in energy efficiency and renewable energy. A flexible energy fee could be conceived: lower prices for basic energy consumption and progressive higher prices for conspicuous energy consumption; an extra fiscal return could be devoted to finance sustainable energy technologies. Taxing consumption instead of incomes, first proposed by Thomas Hobbes three centuries ago and a recurrent theme in economics, could be applied to energy policy, with better chances, if compared to plain technological innovation, to reduce overall energy consumption. Progressive energy taxation could not only lower the energy consumption of the upper class but also moderate the emulative consumption of the much larger lower income classes.

[4] Daniel Goeudevert, former CEO of a leading German car company, put it as follows in his speech for the 150-year celebration ceremony of the VDI, the Association of German Engineers (Berlin, 16.5.2006): "Finally the focus is no longer on meeting needs or solving problems, but upon creating more and more exigent expectations, and then satisfying them profitably." (Goeudevert 2006)

3.8 Emulation

More than a century ago, Thorstein Veblen analysed the role of emulative consumption in the USA, pointing out that the endogenous needs of isolated rational economic actors are not the only drivers of economic behaviour: “With the exception of the instinct of self-preservation, – noted Veblen - the propensity for emulation is probably the strongest and most alert and persistent of the economic motives proper.” (Veblen 1899). Nowadays the analysis of Veblen is even more valid than then. Today the propensity for emulation has become stronger for three reasons. First: what Veblen called the “leisure class”, which practices “conspicuous consumption”, is now much more numerous, representing no longer few persons in thousand but perhaps one tenth or more of the population in industrial countries; insofar, the lifestyle of this class and a supposedly easy social mobility are strong stimuli for emulation. Second: much of the consumption of the leisure class is now more public and exhibited. Third: also lower income classes are exposed to an inescapable, ubiquitous and emotional propaganda for energy intensive goods and lifestyles, which often they can hardly afford. As an eminent French advertising professional said, the goal of part of advertising is “to try to convince people, that can not afford them, to buy things that they do not need”. Furthermore, the tension created between ubiquitous commercial pressure and unaffordable consumption aspiration is accompanied by extensive “buy-now-pay-later” facilities and by political propaganda (“Work more to earn more”). All this together, brings many individuals to sacrifice other aspects of their life in order to afford energy conspicuous consumption, what in fact they often succeed in doing.

Economist Robert Frank (1999a, 1999b) applied to our times an approach similar to that of Veblen and advocates a moderation of emulative consumption through a shift in the taxation system towards a progressive consumption tax. The treadmill of emulative consumption affects a good deal of the energy relevant behaviour of large parts of the population, so that addressing this phenomenon would be probably effective in order to moderate the demand of final energy services and energy intensive goods.

3.9 Efficiency, sufficiency and quality of life

In Switzerland most communication on the “2000-watt society” focuses on watts, not on society. Technological change is to the fore, not social change. For that matter, leading advocates of the 2000-watt vision are very optimistic on the potential of technology improvements: “The vision of a 2000-watt society would mean reducing the energy demand per capita in industrial nations by two thirds within five decades. If one assumes that income and consumption will continue to grow by two thirds during this period, this would mean using energy five times more efficiently.” (Jochem et al. 2004).

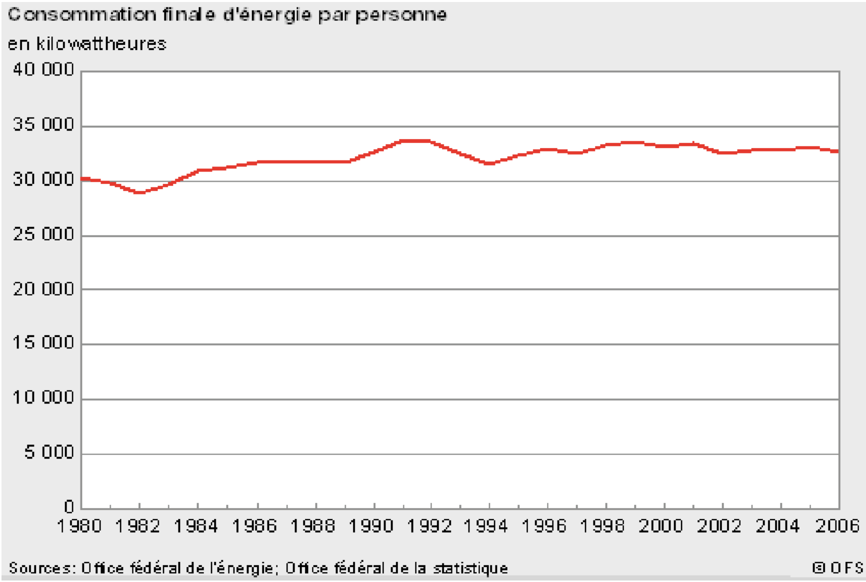

Figure 4 – Switzerland: end energy usage (kWh) pro capite does not sink. Source: Federal Statistics Office. http://www.bfs.admin.ch/bfs/ portal/ fr/index/themen/21/02/ind7.indicator. 72503.725.html

In fact, the prospect of a sizable reduction of the usage of primary energy in an industrial country is divergent from most energy scenarios, while substantial progress in this direction is not in sight in Switzerland or elsewhere. The belief that an improvement of factor five in energy efficiency is “technically feasible” (Jochem et al. 2004) is encouraging, but of little help, being the fortune of technologies entangled with cultural, social and economic systems.

“Smarter living” and “new forms of lifestyle” are indicated by the Foundation Novatlantis as instrumental, but it is officially stated: “The quality of life in the 2000-watt society does not undergo any restrictions” (Novatlantis 2008). This promise is ambiguous and perhaps maintanable/keepable/deliverable. In fact “quality of life” includes material and immaterial things. The more material things and services one person considers necessary for his own “quality of life”, the more it is likely that restrictions in the usage of material things and services – and insofar in his perceived “quality of life” - will be unavoidable, if one wants to be serious about a worldwide convergence and redistribution of energy usage. For example, if in 2050 8-9 billions people would like to travel by air as much as the top one billion consumers do now, airplanes will then have to fly with little more than one tenth of the primary energy per km they use now or a new technology with very low environmental impact will have to be found or a greater overall environmental impact shall have to be accepted.

Indeed, a 2000-watt society in industrialized countries will need no restrictions only if technical improvements in energy efficiency will allow supplying at least the present final energy services with only one third of the primary energy used today – or with just one fifth if further growth of economy and population will happen. As nobody can guarantee this in practice, a proper mix of energy-efficiency and energy-sufficiency strategies seem to be necessary. More energy-efficiency means technological improvement, which reduces primary energy usage for a non-changing final service. More energy-sufficiency means reducing the demand of final energy services. Two sorts of sufficiency reforms can be considered: satisfaction-neutral changes (i.e. avoiding wasteful consumption entailing moderate utility, e.g. turning off electricity to billboards in public spaces at night) and satisfaction-non-neutral changes (e.g. using consumer goods longer, eating less energy-intensive food, travelling less by car and by plane, using smaller and slower cars)[5].

According to the leading proponents of a 2000-watt society "If efficiency gains are chronically inadequate to effect a reduction in total or per capita energy use, or are even indirectly fuelling the increase as demand co-evolves in lockstep, a "sufficiency" revolution may be needed in addition to an efficiency revolution." (Jochem et al. 2002). Indeed, for decades efficiency gains proved to be "chronically inadequate" for reducing the overall energy use in industrialized countries. In spite of this evidence, social reforms towards sufficiency are rarely considered as options, debates on them are frowned upon, and, instead, vast resources are still invested to convince people to boost their consumptions.

[5] In this respect unusual are the considerations on energy usage, human needs and sustainability presented by Jean-Marc Jancovici, a French engineer educated at the Ecole Polytechnique and corporation consultant on technology and climate policy: "When have we "met our needs"? When we have 10 m^2 of heated dwelling per person? Or only when every earth inhabitant will have 150 m^2 of heated dwelling, plus Jacuzzi bath and private sauna? (…) Do we "need" to travel by airplane 1, 50 or zero times in our life? Do we "need" to eat 20 kg meat in a year (as in France in 1800), or 100 kg (as it was in 2000) to be happy? Do we "need" to have 1 or 10 gifts for each birthday?" (Jancovici 2003).

Avoiding to envisage a restraint of final material consumption and trying to disguise this necessity with euphemisms like "smart", "intelligent" or "new" lifestyles can accumulate not maintainable /keepable/deliverable/ too high expectations on technological change and make things worst later on.

4. Conclusions

Possible trade-offs between the goal of a strong reduction of the CO_2-emission and the goal of lowering energy use *per se* are a comprehensible concern. Nevertheless this concern is not strongly founded. On one hand, the goal of a 2000-watt society in 2050 in Switzerland encompasses the goal of 1-tonne-CO_2 society; an effective energy policy, aimed to systematically save primary energy, would favour a general energy-saving awareness, which, in turn, will help to reduce the use of fossil fuels as well. On the other hand, should no one single industrialized country be able to live in shared prosperity without much less than 6000 watt pro capita, this would be a dangerous message for the developing countries: many of them will probably feel legitimate to pursue an energy level of 6000 watt, and for several of them coal will be the cheapest and more accessible energy source (Paschotta 2008).

Furthermore, legitimate concern about climate change brings some authors to argue as if climate change were the only undesirable consequence of a too high level of energy usage; in doing so, they seem to consider possible an unrestricted expansion of energy use, if only this would be fossil-carbon-free. In fact all the known fossil-carbon-poor or -free energy sources are associated with environmental and societal costs or risks, although different for different energy sources.

More founded is the concern upon the compatibility between two goals: on one hand an unrestricted consumption of energy demanding goods and services and on the other hand a lower use of primary energy or a lower emission of greenhouse gases. Energy efficiency is surely to be pursued. But focusing on technical efficiency while neglecting to communicate the need of energy moderate lifestyles will hardly lead to an energy sober society and to lower emission of greenhouse gases.

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