HOW TO ACHIEVE A SUSTAINABLE FUTURE FOR EUROPE?

by

Robert BLINC, Dimitrij NAJDOVSKI, Sadik BEKTESHI, Skender KABASHI, Ivo ŠLAUS, and Aleksander ZIDANŠEK

Original scientific paper
UDC: 620.97:502.17
BIBLID: 0354-9836, *12* (2008), 4, 19-25
DOI: 10.2298/TSCI0804019B

According to the Lisbon declaration from 2000 the goal of European Union is to become by 2010 the most competitive and dynamic knowledge-driven economy and by 2025 a sustainable knowledge society. The EU however faces some strong challenges on the road toward these goals and is evidently lagging behind both USA and Japan. Our analysis is based on six dimensions of these challenges, including the economic challenge, the demographic challenge, the scientific challenge, the challenge of higher education, the challenge of European governance and identity/system of values, and the environmental/ecotechnological challenge. We argue that if we are to provide a sustainable secure environment and prosperity for next generations, we have to act now at least with developments in particular in the direction of clean, cheap, and renewable energy sources with an emphasis on basic, curiosity driven research which through scientific breakthroughs, is the only realistic solution to solving world's energy requirements. Such an action could for example facilitate the transition from fossil fuels to solar power in a relatively short time of about two decades, and help EU achieve its declared sustainability targets.

Key words: *sustainable development, R&D policy, solar energy*

Introduction

An assessment in 2005 showed that the average gross domestic product (GDP) per capita in the EU-15 is still 27% below that of the USA and that EU productivity is lagging [1]. In 2007, GDP per capita in EU was estimated to 32,300 USD, while US had 45,800 USD [2]. Also, US labour productivity has been growing one percent faster than that of the EU-15 between 1995 and 2005. The EU goal is to reach by 2010 gross expenditure for R&D (GERD) of 3% of its GDP, two thirds coming from private sources. In 2003 GERD in EU-15 reached 1.97%, compared with 2.6% for the USA and 3.15% for Japan. While China spent 1.3%, Italy, Spain, Greece, and Turkey spent 1.14%, 1.05%, 0.62%, and 0.64%, respectively. GERD of Poland and Slovakia even declined since 1999. The private sector in EU accounts for 54% of GERD compared with 63% in the USA. However, though Sweden achieved a high GERD of 4.27% GDP, that percentage drastically fell in 2005 when some companies outsourced – private sector contribution being 72%. The difference in investment for R&D between EU and other developed countries is even more drastic: EU invested in 2007 only 490 USD per capita per year, adjusted for purchasing power parity (PPP), while US invested 1130 USD and Japan 1090 USD [3]. Low business R&D spending in EU is reflected in low innovation: US for example filed 54 so-called triad patents (registered simultaneously in Europe, the US and Japan) per million of population in 2003, while the EU filed only 22 [1].

Knowledge can systematically improve the economic and social development in Europe. The EU is attempting to increase the percentage of people with university degrees (currently EU has 21% of working population with tertiary degree *vs*. 38% in the USA and 36% in Japan, gross enrollment being 52% in Europe, 81% in the USA, and 82% in Republic of Korea), and by establishing European Research Council and European Institute of Technology.

As EU lags behind US and Japan economically, invests less in R&D and has a less educated population, it is difficult to see, how it could reach the Lisbon Agenda target to become "the most competitive and dynamic knowledge-driven economy by 2010" and achieve a sustainable future. Here sustainable future is viewed in terms of the Brundtland Commission definition as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs". In this paper we analyze some common sense ideas, whether they can lead toward a sustainable future.

Six dimensions of sustainability challenges

We selected the six-dimensional model of analysis based on the need for a comprehensive overview of the most important challenges, which are endangering the European sustainable future.

Here the *economic challenge* is obvious: EU economy lags behind US in purchasing power parity GDP per capita, and EU invests a smaller percentage of GDP in R&D. Consequently, the economic growth in EU is slower than in the US and EU is therefore increasing the gap. Instead of becoming the most competitive and dynamic knowledge-driven economy, EU is falling further behind the US in spite of the Lisbon strategy.

The *demographic challenge* of the aging EU population is particularly difficult for the rigid pension and social security systems of most of the EU states. Aging population on one hand for example requires more investment in health care, and lack of young people on the other hand is putting stress on public finances of the welfare states.

The *scientific challenge* of EU is caused by low investments in R&D, which stimulate brain drain of the best young scientists. EU is lagging behind US both in quality of research as shown by Nobel prizes as well as in innovativeness as shown in the number of patents. In this way EU is depriving itself of a potential for a vibrant scientific community, which could solve many challenges of sustainability.

The *challenge of higher education* is reflected in the low percentage of enrolment in higher education and population with a tertiary degree as compared not only to US, but also to Japan and Republic of Korea. This deficiency further reduces the potential of EU to become a vibrant competitive and dynamic knowledge-driven economy.

The *challenge of European governance and identity/system of values* is for instance reflected in the inability of EU to resolve its internal organizational problems after the Treaty of Nice. Both the proposed European constitution and the Lisbon treaty have been rejected by voters in referendums in France, the Netherlands, and Ireland, in spite of almost unanimous support of the political elites.

The *environmental and ecotechnological challenge* in EU is represented by the lack of economically viable technologies, which could replace the fossil fuels. In 2003 EU consumed 74 EJ of energy, which is 17% of the world's total energy consumption. Share of fossil fuels in total energy production is 80%, namely 43% from oil, 24% from natural gas, and 13% from coal. From nuclear power 14% is obtained, 4% from hydroelectric, and only 2% from other renewable sources, mostly from wind with 34 GW of installed capacity in 2004 [4]. EU has a target for 2020 to increase the renewable energy to at least 20%.

In order to achieve this target in a cost effective way, EU will have to significantly improve the energy technologies. This target is also closely related to other challenges, as one needs strong economy to build renewable power plants, scientific and technological knowledge to develop better technologies, and educated workforce to change the plans in reality. Good governance and change in value systems are also important in order to reduce potentially negative impacts on this huge transition toward renewable energy, which can also be endangered by financial consequences of aging.

While all these dimensions are critically important for a successful transition toward renewable energy, such a transition would also benefit each of these dimensions:

– the EU economy would clearly benefit from leadership in energy technologies; export of knowledge could become a significant source of income and thus contribute to economic growth,
– while aging population represents a danger to public finances, it also serves as a pool of knowledge, which could significantly contribute toward the development of energy technologies, and in this way awaken the dormant resources of experience, which might otherwise not be productively exploited,
– progress in energy technologies could create more public excitement for science, and thus bring more bright young people among scientists, which would in turn create a new cycle with even more scientific achievements and technological breakthroughs,
– excitement of new technological achievements would bring more young people into education, in particular in the fields of natural sciences and technologies, and
– in addition, concrete achievements and European leadership in energy technologies would improve self esteem of Europeans and thus help in establishment of emerging value systems of European identity, which would create additional demand for good governance on public administration.

Development of new energy technologies therefore plays a central role in efforts to transform EU into a vibrant sustainable society.

Future of renewable energy technologies

Europe has already demonstrated its abilities to develop renewable energy sources. While hydroelectric energy is rather well developed, the wind energy is also getting increasingly important. Also the energy from biomass, geothermal, and solar thermal power is according the European Commission already economically viable and competitive [5]. Heat pumps [6] and agricultural residues [7] can also contribute cost effective energy in sustainable energy systems. A comprehensive review of natural energy sources [8] demonstrates that it is in principle possible to satisfy global energy needs from renewable sources, and renewable energy potential could satisfy energy needs also locally even in less developed regions such as Western Balkan [9], both under the condition that cost effective renewable energy technologies are developed. In addition to these technological developments in renewable energy, the European Commission's white paper for a community strategy established a series of measures to support the growth of renewable energy applications. Share of renewable energy of 9% is expected in 2010 with further growth above 20% by 2020.

The European Commission also expects that photovoltaics will become economically viable with increased production, which will improve the economy of scale. Therefore we decided to analyse the future of this technology in more details as an example, which might provide a technological breakthrough necessary for the transition from fossil fuels to clean renewable energy technologies.

Solar energy

Europe is not self-sufficient in energy sources and heavily depends on the import of fossil fuels. The development of nuclear energy and renewable energy resources is thus a necessity both for economic independence as well as to release the burden of CO_2 emissions on the environment.

Solar energy has the potential to meet the energy needs of the whole world. It is clean and inexhaustible. The problem is however its high price as compared to fossil fuels. In Germany, Spain, Italy, and Portugal the building of solar power plants is very intensive. The price of a solar kWh in Germany, guaranteed by the state for 20 years, is 54 cents. In Spain the price is 44 cents guaranteed for 25 years, in Italy it is between 36 to 49 cents per kWh guaranteed for 20 years and in Slovenia it was 37 cents per kWh in 2007. While these prices of electricity are justified by the price of solar panels of 3.6-5 € per watt, new solar technologies are very promising, in particular thin film photovoltaics, such as those based on printable semiconductor techniques. An example of such solar panels are the copper-indium-gallium-selenide (CIGS) as developed for example by Nanosolar. Here the price of the solar panel is expected to be about 0.6 € per watt, which is about 6-8 times lower than for classical solar panels. The production price is estimated to 0.36 $ per watt and the selling price to 0.99 $ per watt, so that solar electricity can be delivered in places with high insolation at 0.05 $ per kWh, which is competitive to the electricity from fossil fuels [10]. Even in Central Europe with about 700 hours of insolation per year and an estimated 25 year lifetime of the solar panel, electricity from such a panel can be produced cheaper than the current market price of electricity, which is about 0.1 €. While it is relatively simple to use solar panels for production of electricity and heat, wider spread of its applications in transports is not so simple due to logistical challenges. In order to deliver solar electricity to vehicles, they would either need an accumulator to store energy or fuel cells and either a reformer to produce hydrogen or a hydrogen tank. While the first two technologies are not yet economically viable, transition to hydrogen as transportation fuel would require massive investments in infrastructure. There is however an alternative solution: in Torrance, Cal., USA, a hydrogen refueling station has been built, which gets hydrogen from CIGS-based solar panels [11]. In this way hydrogen for fuel cell vehicles can be obtained locally and there is no need for an expensive infrastructure. The energy from hydrogen obtained in such a way is already cheaper than the one from oil at prices above 120 $ per barrel. Namely, one litre of oil at 0.75 $ contains about 11 kWh of energy, which can be produced from solar panels at 0.55 $ and the fuel cell is also much more efficient than oil driven internal combustion engine. The problem is however, that the price of energy is calculated from a 25-year lease of the solar panels, which brings additional dangers. The panel might not work for 25 years, and the price of other energy sources might drop significantly within these 25 years, so that investments in solar energy are associated with high risk.

However, the production price of electricity from CIGS-based solar panels is still significantly higher than the production price of oil, which varies from less than 1 $ per barrel to about 40 $ per barrel obtained by upgrading the crude bitumen to synthetic crude-oil [12]. Therefore further breakthroughs in solar technology are needed in order to make it an economically viable alternative to fossil fuels.

For a realistic yield of solar photovoltaic panels of 14% we need about 7 m^2 for a kilowatt of solar electricity. This was the highest yield achieved with CIGS-based solar panels in 2006, it increased to 19.8% in 2008, and could be further increased to 30% by using optics to concentrate the incident light [13]. If we would for example wish to replace the nuclear power plant at Krško, Slovenia, with solar energy, about 0.2% of the surface of Slovenia would have to be covered by solar panels. If we wanted to replace the complete final energy consumption in EU-27 with solar energy, one would need to cover about 2% of land area with solar panels assuming 1000 hours of annual insolation and 14% yield. Since some energy in Europe is already obtained from non-fossil fuels, with further improved yield the percentage of land area needed to replace all the fossil fuel based energy could be reduced below 1% of EU-27 land area.

Another possibility to use solar power is solar thermal power. Here the electricity is obtained from steam heated by the solar collector [14], and a similar price as in CIGS-based solar panels can be expected.

Still another possibility to use solar power is a chemical reaction similar to photosynthesis, where water could be split into oxygen and hydrogen in the presence of a catalyst using the energy from the Sun. An example of such a catalytic reaction has been presented recently by Kanan *et al*. [15], however this idea still seems to be relatively far from the economically viable technological applications.

The potential for thin film solar photovoltaics has been estimated by Prometheus Institute to grow from 1 GW in 2008 to over 9 GW by 2012 [16]. By 2012 also fast growth of solar thermal power is expected, so that more than 3 GW capacity would be installed annually. While the current production price is estimated to be between 1 and 4 $ per watt [16], it is expected to fall below 1 $ per watt already in 2009 and by 2012 to become competitive for grid electricity production. Such a fast decrease in production price will foster fast growth, so that by 2012 the thin film photovoltaics are expected to take 28% of the photovoltaics market [16]. If this estimated annual increase in production of thin film photovoltaics by over 70% annually continues, it could fulfill the major part of human energy needs in less than 20 years. As the current growth rate is mainly fueled by the difference between the market price of oil and the production price of thin film photovoltaics, the situation could change if the raw materials for thin film photovoltaics were exhausted. Fortunately, different types of thin film photovoltaics exist today, based either on CIGS, cadmium telluride, or silicon. Also, new technologies with similar characteristics are being developed, and further investment in science and technology of photovoltaics can assist in sustaining fast growth of this technology.

From this analysis it is obvious that a relatively fast transition from fossil fuels to solar power is possible even with today's technology, so that the use of fossil fuels could be reduced by an order of magnitude in less than 20 years. Further advances in technology can even increase the rapid pace of this transition. In this process Europe as the world biggest economy has a tremendous potential to play a leading role in research and development of new clean energy sources, and in particular in solar power technologies. Such an active role of European science and technology would have a beneficial effect on all the described challenges to European sustainability, and has thus the potential to put EU back on track toward the Lisbon strategy targets to become first the most competitive and dynamic knowledge-driven economy and then by 2025 also a sustainable knowledge society. A coordinated research effort similar to ITER project [17] could significantly accelerate this transition from fossil fuels to clean energy.

We must however also emphasize that breakthroughs in science can not be predicted. It is therefore always necessary to stimulate also curiosity driven research. If for example at the end of 19th century all scientists were involved in applied research only, we would have today no quantum physics and relativity, and consequently no microelectronics and modern information and communication technologies. This would significantly reduce the quality of our lives today. Therefore it is important to understand that investments in promising fields of science and technology like the thin film photovoltaics should not come at the expense of investments in the basic curiosity driven research.

Conclusions

Energy problems of the world and of Europe in particular are urgent and linked to at least some extent to all the described challenges of EU. While these problems demand fast solutions, most of the present renewable energy technologies take however about 5 to 10 years to be built and integrated into the country's energy system, even those using already proven technologies. In parallel with these endeavors, and there need be a variety of them used in almost all European countries, there should therefore also be an emphasis on basic, curiosity driven research which through scientific breakthroughs, is the only realistic solution to solving European and world's energy requirements. In this way it might be possible to overcome the challenges described in this paper, and transform the European energy consumption from fossil fuels to predominantly clean renewable energy in less than 20 years, and during this process also assist in bringing Europe back on track toward the sustainable knowledge society.

References

[1] Wanlin, A., Lisbon Scorecards VI: Will Europe's Economy Rise Again, Centre for European Reform, London, 2006
[2] ***, Central Intelligence Agency, The 2008 World Factbook, Skyhorse Publishing, 2007, see also https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html, 2008
[3] ***, OECD, Main Science and Technology Indicators 2008-1, 2008, see also http://www.oecd.org/dataoecd/49/45/24236156.pdf, 2008
[4] ***, EU Energy Data, Statistics and Analysis, Department of Energy, see also http://www.eia.doe.gov/emeu/cabs/European_Union/Energy.html, 2008
[5] ***, Energy for the Future; Renewable Sources of Energy, Directorate-General for Energy and Transport, see also: http://ec.europa.eu/energy/res/index_en.htm, 2008
[6] Blarke, M. B., Lund, H., Large-Scale Heat Pumps in Sustainable Energy Systems, System and Project Perspectives, *Thermal Science, 11* (2007), 3, pp. 143-152
[7] Zabaniotou, A. A., Skoulou, V. K., Application of Pilot Technologies for Energy Utilization of Agricultural Residues in Northern Greece, *Thermal Science, 11* (2007), 3, pp. 125-134
[8] Khan, N., Saleem, Z., Wahid, A., Review of Natural Energy Sources and Global Power Needs, *Renewable and Sustainable Energy Reviews, 12* (2008), 7, pp. 1959-1973
[9] Schneider, D. R., *et al.*, Mapping the Potential for Decentralized Energy Generation Based on RES in Western Balkans, *Thermal Science, 11* (2007), 3, pp. 7-26
[10] Sachitanand, N. N., Breakthrough in Solar Photovoltaics, The Hindu, February 3, 2005, see also: http://www,hinduonnet.com/seta/2005/02/03/stories/2005020300431600 and http://www.nanosolar.com/, 2008
[11] ***, Honda Begins Experiments with Hydrogen Home Energy Station and Improves Solar-Cell Technology for Production of Hydrogen, Press Release, Honda, October 2, 2003, see also: http://world.honda.com/news/2003/c031002.html
[12] ***, National Energy Board, Canada's Oil Sands, Opportunities and Challenges to 2015: An Update, An Energy Market Assessment, 2006, see also: http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/lsnd/pprtntsndchllngs20152006/pprtntsndchllngs20152006-eng.pdf
[13] ***, NREL Sets New CIGS Thin Film Cell Efficiency Record, see also: http://www.solarbuzz.com/news/NewsNATE50.htm, 2008
[14] Martin, J. C., Solar Tres, NREL CSP Technology Workshop, Denver, Col., USA, 2007

[15] Kanan, M. W., Nocera, D. G., In Situ Formation of an Oxygen-Evolving Catalyst in Neutral Water Containing Phosphate and Co^{2+}, *Science*, *321* (2008), 5892, pp. 1072-1075, or DOI: 10.1126/science.1162018
[16] ***, Thin-Film Solar Market to Reach 9 GW in 2012, *Semiconductor Today*, June 9, 2008, see also: http;//www.semiconductor-today.com/news_items/2008/JUNE/PROM_090608.htm, 2008
[17] ***, The ITER Project, see also: http://www.iter.org/, 2008

Authors´ affiliations:

R. Blinc
Jožef Stefan Institute
Jožef Stefan International Postgraduate School,
Ljubljana, Slovenia

D. Najdovski
X3DATA
Ljubljana, Slovenia

S. Bekteshi, S. Kabashi
Faculty of Mathematical and Natural Sciences,
University of Prishtina, Prishtina

I. Šlaus
Rudjer Bošković Institute
Zagreb, Croatia

A. Zidanšek (**corresponding author**)
Jožef Stefan Institute
Jožef Stefan International Postgraduate School
39, Jamova, 1000 Ljubljana, Slovenia
E-mail: aleksander.zidansek@ijs.si

Paper submitted: March 14, 2008
Paper revised: August 14, 2008
Paper accepted: August 22, 2008