SPS EUROPEAN VIEWS: ENVIRONMENT AND HEALTH

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Abstract: The paper presents two major aspects of the European approach to solar power satellites (SPS): environment and health. The commitment to durable CO_2 emission reduction requires substantial changes in our energy system. Solar power satellites are capable of generating almost entirely CO_2 emission free electricity and integrate well into a hydrogen based energy system.
Solar power satellite concepts, based on wireless power transmission via microwaves are often perceived as a potential hazard to public health. But the successful integration of wireless communication devices is expected to prepare the terrain for a responsible and serious treatment of solar power satellites and wireless power transmission, expected to become operational in a 25+ year timeframe. On the other hand, health problems caused by air pollution in metropolitan areas raise public awareness of the effects of fossil fuel based transport systems, including a strong increase of associated cost burdens on social security schemes, which SPS systems may alleviate.

INTRODUCTION

Faced with constantly growing energy demands, increasing import dependence and regional as well as global effects of our fossil fuel based society, solar power from space is considered as a potential clean and sustainable power supply option in a 2020+ timescale.
Wireless power transmission, either by laser or by microwaves is an integral key component of all SPS concepts. Basically understood since more than one hundred years and tested on laboratory scales already in the 1930's with the breakthrough work by William Brown in the 1960's, wireless power transmission has not yet found its place in daily applications (Brown [1]), and apart from efficiency limits, safety and health remain major concerns.

ENVIRONMENT AND THE ENERGY SITUATION: TIME HAS COME FOR SPS

The globally steady and strong increase of power demand allows for new sources and energy vectors to appear and gain importance without immediately threatening established energy supply branches.
Plotting the proportional supply share of 1. renewables/nuclear sources, 2. coal and 3. oil and gas as done in Fig. 1, shows that this situation occurred two times during the 20th century: Since the dawn of mankind until the beginning of the industrial revolutions in the 19th century all our energy came from renewable energy sources. The industrial revolutions were fuelled by coal burning, leading to an ever increasing share of coal until the end of the 1st world war. Since then its share decreased steadily from an all-time high of about 70% to the benefit of oil and gas, the fuel of the transport industry of the 20th century. To a lower extent, the oil crisis of the 70s had a similar effect, when the introduction of nuclear energy led to the levelling of the oil

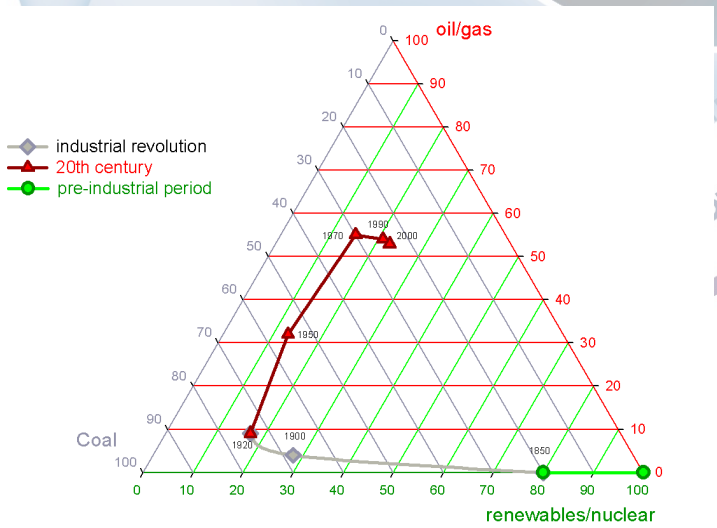

Fig. 1: Evolution of energy sources.

and gas share at about 60%. Currently a trend from oil to gas is observed (not visible in Fig. 1), in line with the successive reduction of the carbon content of fuel.[1]
Following this trend and taking into account the non-sustainability of coal, gas and oil burning, it becomes clear that our long term energy scenario can only be situated towards the lower-right corner of the proportional triangle of Fig. 1.

EUROPEAN ACTIVITIES ON IN THE FIELD OF SPS

The European Union represents about 16% of the world energy market. In 2000, it imports about half of its energy need and represent in total terms the largest energy-importing region in the world.

Europe's commitment to decrease its emission of greenhouse gases. The European Union is responsible for 14% of the worldwide man-caused CO_2 emissions. At the Kyoto Conference in 1997, it undertook to reduce its greenhouse gas emissions by 8% until 2008/2012 compared to 1990. The current trend however is a 5% increase, calling for substantial action.(EU [3]). In 2002, a European Network on SPS was created under the leadership of the European Space Agency. The network regroups all relevant European research groups from academia, industry and government agencies working on different aspects of solar power from space. A preliminary roadmap was drafted during its first meeting in August 2002 that led to the European SPS Programme Plan implemented at the Advanced Concepts Team[2], under the General Studies Programme[3] in January 2003.

European SPS Programme Plan. The Programme is structured in three distinct phases. The pursuance of the programme in phase 2 and 3 depends on the outcome of phase 1, assessing in an objective manner the general viability of SPS for power delivery to Earth and to space locations compared to other means. (Summerer [4])

Phase 1: General Viability. The first phase of the SPS Programme tries to address several issues related to the principal viability of collection and transmission of solar energy from space to Earth. In addition, the potentials of SPS to supply energy for space applications and exploration is assessed.
The results, expected early 2004, will be made widely accessible to the international community.[4].

Phase 2: System Architecture-level Trade-off. Based on the results of phase 1, a system architecture level trade-off study will be performed. The main focus of the trade-off study will be on

1. new and innovative concepts, offering substantial improvements to existing models;
2. the identification of technology areas
    a. demanding further research and development for SPS;
    b. in which European industry and research institutes already have demonstrated leadership;
    c. showing near to mid-term potential in other areas than SPS.
3. the establishment of roadmaps specific to the identified priority research areas;
4. the identification of one to three most promising concepts.

The exact content of the work depends heavily on the findings during phase 1.

Phase 3: Technology Focus and Demonstrator Selection. Promising, feasible near-term, Earth or space based demonstrator missions will be identified and two to three feasibility studies for such missions will be elaborated to a level of detail allowing the initiation of such a demonstrator mission.

EUROPEAN WPT ACTIVITIES

European research on wireless power transmission via microwaves is concentrated at the University of La Réunion. The "Grand Bassin" project[5], lead by the local university, will supply electricity to a remote, isolated mountain village. Wireless power transmission is envisaged in order to preserve the beautiful scenery of the valley by avoiding the deployment of power lines.(Pignolet [5]) In total, about 10 *kWe* would be transmitted (excluding losses) over a bit less than 1 *km* in the 2.45 *GHz* frequency. The feasibility of the project was demonstrated on laboratory scale several times.

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[1] C:H ratio: wood: ~10:1, coal: ~2:1, oil: ~1:2, gas: ~1:4
[2] Information on the ESA Advanced Concepts Team (ACT) is available at www.esa.int/gsp/ACT
[3] Information on the ESA General Studies Programme (GSP) is available at www.esa.int/gsp
[4] Presentations at the 4th International SPS Conference, SPS'04 (www.congrex.nl/04c15/) in June 2004
[5] Grand-Bassin WPT website: www.grandbassin.net

HEALTH ISSUES AND PUBLIC PERCEPTION

The relations and interactions of SPS with the environment have to be addressed, including people, the landscape, equipment, physical safety for persons and equipment, social questions connected with aesthetics, politics and economics, as well as the more general issues of climate change and sustainability of energy supply.(Pignolet [6]) The impact on public health is thus one of the major aspects of SPS development.

The realisation of any change in our energy system will also depend on public perception of advantages as disadvantages of different systems. Provided a competitive price and sufficient, controllable availability, health related and environmental arguments will play a decisive role.

On a localised scale, fossil fuel burning related metropolitan air pollution is already causing a significant impact on the general public's health, directly related to expenses by the social security schemes. Continuous growth with enhance the cost burden, increasing the public pressure for changes. The introduction of hydrogen as additional energy vector has the potential to alleviate the situation, but requires at the same time additional power sources.(Summerer [7])

On a global scale, the options for a sustainable energy systems based on currently foreseeable technical knowledge are limited to fission/fusion nuclear power plants, a combination of very large scale distributed wind, water, solar and biomass burning systems and solar power plants – in space as well as in desert areas combined with storage and long-distance transmission lines.[6] In this context, solar power from space is a viable option for the timescale 2020+. It is almost completely CO_2 emission free, requires minimal land and other resources and is practically unlimited. Environmental effects would be essentially due to frequent launches, the construction of SPS material and eventually wireless power transmission effects.

The introduction of microwave wireless power transmission would certainly require some "public education" comparable but orders of magnitude lower than the introduction of electricity one hundred years ago. The introduction of microwave ovens into our daily life and the recent rapid acceptance of all kind of wireless data transmission devices (e.g. mobile communication, wireless computer networks) are preparing the terrain.

CONCLUSIONS

European organizations are stepping up their contribution to the development of SPS technology, including WPT, with a special focus on environmental and health considerations. Solar power from space has the potential to contribute significantly to the worldwide effort to reduce global CO_2 emissions. Concerns about environmental and health impacts of WPT and SPS are studied intensively. The potential impacts of SPS and WPT are to be set in relation of environmental and health effects of alternative energy systems. Preliminary results indicate that positive effects outweigh potential negative ones.

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[6] Carbon sequestration systems are not included in this list, since they would only shift the problem but not solve it.