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# Response to SET-Plan consultation:
# Initiative for Global Leadership in Photovoltaic Solar Energy

## Introduction

This "Input Paper" is a response of the European Platform of Universities in Energy Research & Education (EUA-EPUE) to the invitation of the European Commission to contribute to the consultative process on the European Strategic Energy Technology Plan (SET Plan).

EUA-EPUE responds to the consultation from the perspective of the universities' role in society. Universities constitute a significant part of the research capacity in Europe. At the same time, they educate the highly skilled work force of our societies. It therefore seems important to mobilise the capacity of Europe's universities to contribute to successful implementation of the SET Plan.

In this light, EUA-EPUE wants to emphasise that the long-term goal of technological leadership should not only focus on high-TRL, close-to-market technologies. It also requires **sustainable support for next generation technologies made available through fundamental research, including "use-inspired basic research"**.[1] Similarly, the goal demands the **development of a highly skilled workforce** capable to sustain innovation and technological leadership in the long run. The availability of highly skilled professionals is bound to be a limiting factor for how well Europe can position itself in the global energy market.

According to the OECD, "Countries should step up their investment in long-term R&D to develop frontier technologies that will reshape industry, healthcare and communications and provide urgently needed solutions to global challenges like climate change."[2] Both the IEA and the IPCC also state a clear need for a paradigm shift in renewable energy, which also calls for supporting research that has a longer time horizon to the market, but is use-oriented towards renewable energy.

The UNI-SET project's survey of activities at universities show that many universities, in particular the technology universities engage with industry and research institutes in applied research for technology development. Integration of education with innovation oriented applied research is a very effective way of disseminating new research knowledge, and converting it into industrial innovation. Experience shows that disruptive innovations often come from young innovators, we see that the world's innovation hotspots are fuelled by talented students. It seems that Europe is not as effective as the US in exploiting the innovation potential of young graduates.

We consider therefore that setting up the SET Plan projects with ensured integration of innovative research with education, including industrial partners, will provide a high pay-off towards achieving the energy system transition that is the objective of the SET plan.

In the SET-Plan process, universities have contributed to the SET-Plan Education & Training and the SET-Plan Integrated Roadmap initiatives. EUA-EPUE is now taking forward this commitment with the UNI-SET project, an FP7 Coordination & Support Action aiming to mobilise the university sector in the SET-Plan process and the Energy Union (http://www.uni-set.eu/).

[1] A term coined by Donald Stokes in "Pasteur's Quadrant – Basic Science and Technological Innovation", Brookings Institution Press, 1997

[2] See OECD "Governments must step up R&D in frontier technology", press release available at http://www.oecd.org/newsroom/governments-must-step-up-rd-in-frontier-technology.htm, full report "OECD Science, Technology and Industry Scoreboard 2015" is available at http://www.oecd.org/science/oecd-science-technology-and-industry-scoreboard-20725345.htm (links accessed 16/11/2015).



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**RESPONSE**

**Proposed targets in photovoltaic (PV) solar energy**

**For the main expected outcome: To make specific recommendations on the priorities/targets proposed in the issues paper(s)**

- Do you agree with the targets set in the issue paper?
- Do you think that the level of ambition is correct?
- Are there any standing issue(s) in the way to reaching the proposed targets/priorities?

It may be useful to understand the broader context in which these targets/priorities need to be achieved. If possible, we suggest that the following is addressed as well:

- *What are your specific recommendations on prioritising R&I activities on these issues (and building where appropriate on relevant existing initiatives)?*
- *Who are the best placed actors to implement the targets/priorities (Industry, EU, Member States, regions, groups of countries/organisations/etc.)?*

- The Issues Paper No.2 provides a good synopsis of the current situation with respect to solar PV technology in Europe. It is widely recognised that PV has the potential to make a substantial contribution to terrestrial energy generation. According to the 2015 Solar Power Europe Report[3] solar PV global installed capacity will exceed 0.5 TW in five years. In the longer term solar PV has the potential make the largest contribution of all renewable energy technologies. The main barriers to achieving this are a combination of **technical, societal, political and economic**. It is believed that the **societal, political and economic barriers require as much attention as the technical challenges**.

- The Issues Paper quotes Solar Power Europe as estimating that PV has the potential to meet 8% of EU electricity demand in 2020 and 15% in 2030. Given the right conditions, such as in the context of nZEB refurbishment, the potential of solar PV is much higher than this.[4] The history of PV in Germany provides a valuable case study demonstrating that effective financial and economic interventions can expedite PV technology in achieving a significant contribution to meeting electricity demand.

- The Solar Power Europe report notes that 2014 was another "record year" for solar PV with an additional 40 GW being added to global capacity. This is being led by China (10.6 GW), Japan (9.7 GW) and USA (6.5 GW). The total for Europe was 7 GW with the UK leading in Europe at 2.4 GW. This provides good evidence that solar PV can make an effective contribution in climates with lower solar insolation. The report further notes that for the first time renewables in Europe contributed more than nuclear power.

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[3] Solar Power Europe report "Global Market Outlook for Solar Power 2015 - 2019". Available from http://www.solarpowereurope.org/index.php?eID=tx_nawsecuredl&u=0&g=0&t=1446718380&hash=62eb82cfd971e3d4f85447265c18324a0cbcd4a3&file=fileadmin/user_upload/secure/Global_Market_Outlook_2015_-2019_lr_v23.pdf (link accessed 04/11/15)

[4] Fraunhofer ISE report "Aktuelle Fakten zur Photovoltaik in Deutschland". Available from https://www.ise.fraunhofer.de/de/veroeffentlichungen/veroeffentlichungen-pdf-dateien/studien-und-konzeptpapiere/aktuelle-fakten-zur-photovoltaik-in-deutschland.pdf (link accessed 12/11/15)

- Other factors of note are that Solar PV is contributing more than 7% of electricity demand in 3 countries in Europe: Italy, Germany and Greece.
- The Solar Power Europe Report also sets out a number of scenarios looking at the solar generation cost in Europe compared to other technologies. In the most optimistic scenario, using 3% WACC (Weighted Average Cost of Capital), large scale solar is predicted to be cheaper than offshore wind, gas and nuclear for much of Europe. It is further predicted to be cheaper than coal and onshore wind for areas of high solar irradiation in southern Europe.
- This provides a convincing demonstration of the technical capabilities of solar PV confirming that a significant programme of leadership in Europe on Solar PV can establish Europe as a leader in this field. The United States Department of Energy established the SunShot Initiative[5] in 2011 as a national collaborative effort to make solar energy cost-competitive with other forms of electricity by the end of the decade, as a response to the falling position of US manufacturing in the solar PV market place from 43% in 1995 to 7% in 2010.
- The competition is well established in China, as described in the Issues Paper No. 2. China dominates the world silicon PV manufacturing industry, benefitting from support from the Chinese government. In the past Europe has had solar manufacturers but these have either been driven out of the market in the face of fierce competition or have been taken over.
- As also noted in the Issues Paper No. 2, an area where Europe is well established is in the solar PV value chain including equipment and inverter manufacturing. European universities also have considerable expertise in the development of smart-grid approaches to electricity generation which will be required to see full integration of large capacity renewable energy sources.
- There has been a rapid advent of in the research on and the development of new materials and mechanisms (e.g. dye sensitised cells, organics, kesterites, perovskites) over the last 25 years. Some of these new materials have rapidly come to challenge even the efficiency of crystalline silicon. Although these materials have significant potential, there are challenges associated with long-term stability which requires further research. Against this background, the proposed targets, if viewed over the longer time frame to 2030, could be more ambitious. Research should be supported into emerging and new materials, mechanisms and technologies capable of producing a new generation of solar cells, with dramatically higher efficiencies and / or substantially lower costs, with a horizon for delivery of 2030 and beyond. **A long-term vision for global leadership in photovoltaics requires support and concrete goals for next generation materials and technologies in photovoltaics.**
- Europe has a number of world-leading research laboratories and facilities dedicated to researching a broad range of solar PV materials including thin-film and next generation materials. Many of these laboratories are in universities and it is essential that this world-leading research expertise is harnessed to bring a thorough understanding of the fundamental properties of new materials to inform the design and development of the next generation of PV devices. University laboratories are the only organisations that currently have the expertise to effectively tackle the major scientific and technical barriers that the next generation of PV devices will need to overcome to be successful. If Europe is to achieve these ambitious targets thought must be given to developing stronger research collaborations to draw on the full range of expertise in European universities. Supporting research that addresses the political and economic barrier should also be supported.

[5] See http://energy.gov/eere/sunshot/sunshot-initiative for details (link accessed 04/11/15)

**Proposed targets in photovoltaic (PV) solar energy**

1. Re-build EU technological leadership in the sector by pursuing high-performance PV technologies and their integration in the EU energy system. Achieve major advances in efficiency and lifetime of established technologies (c-Si and CIGS thin film) and new concepts;
    - **Increase PV module efficiency by at least 20% by 2020** compared to 2015 levels, **and by at least 35% by 2030**;
    - Increase **module lifetime** to a guaranteed power output time (at 80% of initial power) **longer than 35 years, by 2020**;
    - Increase large scale manufacturing concepts and capabilities by **demonstrating PV production capabilities of at least 20 m2 per minute by 2020.**

- As PV technology continues to develop a number of alternative PV materials will become positioned to enter the market. Proposed target No. 1 sets out an effective strategy to challenge to dominance of silicon-based PV modules manufactured in China. As new, higher performance, lower cost PV technologies approach market readiness the research expertise across Europe in Europe's universities will be well positioned to develop a new generation of PV technologies, for example based on thin-film PV using sustainable lower cost elements, enabling PV technologies with lower energy payback times.

- The efficiency, lifetime and production targets represent a challenge at this stage. However these should be reviewed periodically as the growth of the PV industry is so rapid. In the last decade solar PV capacity has increased by almost 100 times[1]. Efficiency targets should be set for system as well as module outputs.

- If Europe is to develop its own PV manufacturing capability again it is essential that urgent action is taken. Given the scale of the challenge the response must be a coordinated EU response. It is unlikely that any single state will have the resources or political environment to develop a successful challenge to the dominance of China in global PV module manufacturing.

**Proposed targets in photovoltaic (PV) solar energy**

2. Reduce the cost of key technologies
    - **Reduce turn-key system costs by at least 25% by 2020** as compared to 2015;
    - **Reduce turn-key system costs by at least 50% by 2030** with the introduction of novel potentially very-high-efficiency PV technologies manufactured at large scale.

- Proposed target No. 2 sets out cost reductions which are ambitious but which are also suggested by considering the rapid cost reductions seen over the last decade. An examination of historic trends suggests that the 50% reduction proposed by 2030 could be exceeded, particularly as new PV technologies come on stream.

**Proposed targets in photovoltaic (PV) solar energy**

3. Make "(near) Zero Energy Buildings" possible thanks to Building-Integrated PV (BIPV)
    - **Develop BIPV modules**, which include thermal insulation and water protection, to replace entirely roofs or facades **at costs below 100 €/m2 and a module efficiency of** *[we solicit*
    - *proposals]* **by 2020, and 75 €/m2 and a module efficiency of** *[we solicit proposals]* **by 2030**

- Proposed target No. 3 covers building-integrated PV. A holistic approach to integrating PV into (e.g. nZEB) buildings, material and glazing as implied by this target, will enable lower costs to be achieved. The proposal invites targets for BIPV module efficiencies by 2020 and 2030 and greater market penetration. This is one area where fundamental science can help inform the setting of the targets. The fundamental limit of a single absorber layer solar cell with an ideal bandgap, close to the maximum of the solar spectrum, is calculated to have an efficiency of 32%[6]. It is likely that the dominant PV technology for terrestrial power generation will have a single absorber layer reducing device complexity and cost. Allowing for recombination losses in solar cells would suggest that module efficiencies of 25% could be achieved by 2030.

**Proposed targets in photovoltaic (PV) solar energy**

4. Achieve major advances in installation
    - **Develop PV modules designed for fully automated installation** for both ground-mounted arrays and building renovation, **by 2020**.

- Proposed target No. 4 aims to achieve PV modules designed for automated installation in new arrays and retro-fitting of buildings by 2020. New mechanised techniques for installing modular PV framing need to be developed that integrate all system components and provide a ready-to use electrical output. The process can be reinforced by negotiating and agreeing standard protocols for PV module design among manufacturers, if necessary this aim can be supported through appropriate EU legislation.

[6] This limit is known as the Shockley–Queisser limit. It uses a detailed balance limit approach to demonstrate that the maximum theoretical efficiency of a solar cell using a p-n junction to collect power from the cell is 32%. It was first calculated by William Shockley and Hans Queisser at Shockley Semiconductor in 1961. See Shockley, W. and H.J. Queisser, *Detailed Balance Limit of Efficiency of p-n Junction Solar Cells.* Journal of Applied Physics, 1961. **32**(3): p. 510-519 DOI: http://dx.doi.org/10.1063/1.1736034

**If possible, to identify possible gaps/barriers & areas of cooperation on the priorities/targets proposed in the issues paper(s).**

- *Identify possible barriers (when not done already in the Integrated Roadmap) related to regulation, cooperation issues, standardisation / industrialisation / manufacturing, socioeconomics, etc.*
- *Identify possible gaps or duplication of efforts in the R&I priorities (based on the Integrated Roadmap);*
- *Identify priorities where there is scope for and benefit in more coordination and/or cooperation across EU, Member States, regions, Research Institutions and/or industry.*
- *Identify best practices of past or present coordination and/or cooperation that can be used as an example or as a starting point.*

- The solar PV industry operates in an increasingly complex environment where, as noted above, a wide range of non-technical factors have a substantial influence on the development, production and deployment of solar PV. For solar PV to achieve its full potential it will be essential that those working in the solar industry have a full understanding of the complex political, societal and economic factors that constrain solar PV. Universities will play an increasingly important role in developing individuals with the correct set of skills to address these problems. Europe's universities have the potential to provide significant support in this area through the design and development of novel approaches to the training of early-career research through multidisciplinary approaches.

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