# Input paper - consolidated response to European Commission's Issues Paper "Photovoltaics"

**Preface**

The European Photovoltaic Technology Platform (EU PVTP) welcomes and supports the positive tone and the high levels of ambition set in the Issues Paper and agrees with the main elements of strategy targets and priorities. Therefore the revisions proposed in this response are to be considered as finetuning of, and providing context to an already high quality starting document.

Context for our proposed revised targets is given in the annexes at the back of the paper. In addition to the consolidated views to the targets, specific additional responses by partners involved in the consolidation process can be found in annexes.

EU PVTP looks forward to working with the SET Plan Steering Group on translating these targets into European and Member State R, D & I actions.

The PV sector has gone through decades of growth and development and is now ready to serve as one of the major building blocks of a sustainable energy system. Clearly, the sector has been hit hard in the past five years, but its potential remains unaffected and Europe's position in science, technology, advanced manufacturing and large-scale use is still strong. We see research, development and innovation as key enablers for successful continuation of the EU being at the forefront of this global sector and hence, to be able to seize the great economic opportunities associated with its growth in European and global markets.

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On behalf of the European Photovoltaic Technology Platform

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**Background and approach**

Upon invitation by the EC on Oct 15, 2015 to take position on the proposed targets/priorities in the Issues Paper No. 2 "Initiative for Global Leadership in Photovoltaics (PV) Solar Energy" being in accordance with the guidelines set out in document entitled "the SET Plan actions – Implementation process and expected outcomes", and in particular its Stage 1 (Agreement on targets/ priorities) we provide an input paper as consolidated views to the proposed targets.

EU PVTP prepared the first draft of this input and was responsible for the final stages of its editing. Along the way it invited comments from EERA (Joint Programme on PV, 'EERA-PV'), ECTP (European Construction Technology Platform), ETP Smart Grids and EPUE (European Platform of Universities Engaged in Energy Research), with the first three of these providing input. ETP Smart Grids will reciprocate by inviting EU PVTP to comment on its Input Paper when it is its turn to prepare one. This year EU PVTP has sought to reinforce its partnership with ECTP and ETP Smart Grids, as its interests overlap with these sectors. An MoU between these three parties is due to be signed.

EU PVTP considers the EC's Issues Paper to be a thoughtful document that demonstrates good understanding of the challenges facing PV, and the potential rewards if they can be met.

EU PVTP has limited itself to commenting on the targets proposed in the Issues Paper, which to quote the paper are:

**Target 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;

**Target 2**
Reduce the cost of key technologies

**Target 3**
Make "(near) Zero Energy Buildings" possible thanks to Building-Integrated PV (BIPV)

**Target 4**
Achieve major advances in installation

Target 1

## Advances in efficiency and lifetime

| EC original target | EU PVTP proposed revised target |
|---|---|
| **Efficiency** | |
| **Increase PV module efficiency by at least 20% by 2020** compared to 2015 levels, **and by at least 35% by 2030** | **Increase the average European PV module efficiency by at least 15% by 2020** compared to today (2015), and develop or make available technologies to **achieve an increase of at least 35% by 2030** compared to today (2015) |
| **Lifetime** | |
| Increase **module lifetime** to a guaranteed power output time (at 80% of initial power) **longer than 35 years, by 2020**; | Increase **module lifetime** (defined as >80% of initial power) to **30 years by 2020 and 35 years by 2025**. |
| **Manufacturing** | |
| Increase large scale manufacturing concepts and capabilities by **demonstrating PV production capabilities of at least 20 $m^2$ per minute by 2020.** | Make available GW-scale manufacturing technologies that reach productivity and cost targets consistent with the capital cost targets for PV systems (Target 2). |

Annex: Advances in efficiency and lifetime

## Sustainability

| EC original target | EU PVTP revised target |
| --- | --- |
| **[none]** | • Minimisation of negative environmental impact, e.g. expressed as energy-payback time, GHG-payback time based on the Environmental Footprint of the PV technology, substitution and handling of hazardous substances along the whole production chain.<br>• Increase the recyclability of module components, such as for example glass, aluminum and silver, through recycling-friendly design and improved recycling processes to achieve a high-value recycling rate of 85 % by mass at component-level of all collected end-of-life PV panels by 2030. |

Annex: Sustainability

# Grid integration

| EC original target | EU PVTP revised target |
|---|---|
| **[none]** | **[no measurable target]** |

Annex: Grid integration

## Target 2

## Cost reduction

| EC original target | EU PVTP revised target |
|---|---|
| **Capital costs** | |
| • **Reduce turn-key system costs by at least 25% by 2020** as compared to 2015;<br>• **Reduce turn-key system costs by at least 50% by 2030 compared to 2015** with the introduction of novel potentially very-high-efficiency PV technologies manufactured at large scale. | • **Reduce turn-key system costs from 1 EUR/$W_p$ today (2015) for a 1-MW plant by at least 20% by 2020;**<br>• **Reduce turn-key system costs from 1 EUR/$W_p$ today (2015) for a 1-MW plant by at least 45% by 2030;** |
| **Levelised cost of electricity (LCOE)** | |
| [no target] | Bring down PV's LCOE by **20 % by 2020** and **40% by 2030** compared to today's most competitive LCOEs achieved with European technology in all market segments (residential, commercial, industrial, utility-scale). |

Annex: Cost reduction

## Target 3

## BIPV

| EC original target | EU PVTP revised target |
|---|---|
| **Develop BIPV modules**, which include thermal insulation and water protection, to replace entirely roofs or facades **at costs below 100 €/m$^2$ and a module efficiency of** [we solicit proposals] **by 2020, and 75 €/m$^2$ and a module efficiency of** [we solicit proposals] **by 2030**. | **[replaced by table below]** |

*Introduction*

'Nearly Zero Energy Buildings' (NZEBs) and later 'Plus Energy Buildings' will become the norm in Europe. The opportunity for BIPV to contribute to a revolution in the way that buildings are designed cannot be missed. Cross-sectoral collaboration is the way to bring new multifunctional building elements to market and to increase BIPV-favourable building design. This collaboration is today sorely lacking. With a better exchange between architects, developers, builders and the PV industry, the PV industry can deliver the flexible production procedures that will bring down the additional cost of BIPV compared to non-BIPV components (see table below). ECTP has identified a particular need for collaboration in façade components.

| | | ***BIPV's main applications*** | | |
|---|---|---|---|---|
| | | ***Roof integration*** | ***Façade-integration*** | |
| | | | *semi-transparent* | *opaque* |
| *Additional cost*[1] *(€ / sq. m)* | today (2015) | 80-120 (roof-integrated modules)<br><br>130-200 (tiles, membranes) | 150-350 | 130-250 |
| | 2020 | 50% reduction on today | | |
| | 2030 | 75% reduction on today | | |
| *Renovation rate* | today (2015) | The renovation rates in EU ranges from 0.2 %/year (Latvia, residential) to 3.6 %/year (The Netherlands, residential). The EU-27 average rate is according to Lechtenböhmer (2009) 1.0 %.[2] | | |
| | 2020 | To achieve the 2050 goal of a 100% renovated building stock, the renovation rate must increase to 3.3 %/year in 2020 across the EU. Achieve a 1 GW / a BIPV market in Europe. | | |

Annex: BIPV

[1] Additional cost means the cost of producing an element with a PV capability added to it (e.g. PV tile) or the cost of producing a module tailored to a particular site. This should be enabled by the development of software and hardware tools to translate rapidly the architectural design into tailor-made modules. The tools include production lines with increased flexibility (e.g. on module dimension, colour) as compared to traditional PV-module lines. The latter should be enabled by intensive use of robotics and software-adaptable production tools.

[2] BPIE 2011, Europe's buildings under the microscope

## Target 4

## Achieve major advances in installation

| EC original target | EU PVTP revised target |
|---|---|
| **Develop PV modules designed for fully automated installation** for both ground-mounted arrays and building renovation, **by 2020**. | **[deleted]** |

Annex: Achieve major advances in installation

# Annexes

## Advances in efficiency and lifetime

*EU PVTP comments:*

Methods do not yet exist to predict the performance of modules 35 years into the future, but they might have been developed by 2025. One thing that can be said for sure is that under the same climate chamber test, a module produced in 2020 should show less degradation than one produced today. Module lifetime and reliability is a topic that is growing in importance and is of increasing concern. Since 2008 production and the number of suppliers exploded and the average reliability of a module bought in a particular year has declined. In consequence a global task force on PV quality assurance has recently been set up to monitor and mitigate this trend.

European-made modules must meet very high standards. The necessity of meeting them is a source of competitive advantage for Europe's manufacturers.

The lifetime of the other components that make up a PV system is relevant, too. A performance ratio target corrected for the prevailing ambient temperature would put the focus on the quality of system's configuration, which would be a good thing, however EU PVTP has not had enough time to formulate such a target.

Data is needed from PV systems in operation on their failure- and degradation rates. The EC and MS/AC should facilitate access to this data and support work to measure degradation, linking field results to accelerated aging tests.

*EERA-PV comments:*

New generation technologies such as organic and hybrid PVs can enable beyond 20 $m^2$ per minute production via roll-to-roll manufacturing. However to achieve the targeted LCOE these technologies must demonstrate >10 % module efficiency and >10 years lifetime by 2020 (estimated by accelerated tests).

## Sustainability

*EU PVTP comments:*

The WEEE Directive already requires 85% by mass of an electronic object, once it has reached the end of its life, to be recycled. This target goes beyond the requirements of today's legislation by specifying that the material extracted in the recycling process should be 'high value' (glass, for example, today often is not. It finds its way into low-value construction components). Also, it refers to this recycling target being met at the component level, meaning that even difficult-to-recuperate raw materials must be recuperated at 85%. The WEEE Directive already requires the depollution of potentially toxic compounds from PV products (e.g. lead-, cadmium-compounds).

In accordance with its goal of minimising environmental impact, EU PVTP recommends that research continues to be funded into finding alternatives to potentially toxic compounds and substances which are found in today's and emerging PV technologies.

EU PVTP recognises that regulation drives improvement of the environmental footprint of PV. Already now, for example, higher recycling rates than 85% could be achieved for c-Si and thin film modules but achieving them it is not profitable under current laws and standards.

## Grid integration

*ETP Smart Grids' comments:*
As already identified in the Integrated Roadmap it is important to

- Respond to overall efficiency of the PV systems at competitive prices
- Facilitate PV systems with integration technologies that offer seamless operation with the requirements of the grid for voltage and frequency control and fault ride through capabilities capable of enhancing distributed control and quality of supply at connection point.

It is clear that further development work is required to deliver the above with end-products that will strengthen the current strong position of the European industry by providing solutions that respond to the following minimum requirements:

- Advanced inverters with storage connectivity and added control facilities capable of offering optimal local demand control for optimising the utilisation of local PV generation, local storage, local electric vehicle smart charging and the requirements of the local grid.
- Seamless connectivity capable of offering interoperability of communication equipment providing broadband connectivity to the local inverter controller for facilitating system observability and control by providing critical information on local activity (level of generation, consumption, storage, status of EV etc) and responding to system needs through system parameters and / or external (automated or initiated by the local DSO) control signals.
- A new family of components that constitute the power electronics infrastructure that can offer improved performance, longer useful life at lower cost.

*EERA-PV comments on ETP Smart Grids:*
We should insist on a "plug and play" approach with standardised interfaces in order to decrease operating costs.

## Cost reduction

*EU PVTP comments:*

It is instructive to look at cost reduction through two lenses, one being the cost of a PV system (capital cost), the other being the cost of electricity from the system (LCOE).

**Capital cost**

Our capital cost targets are made in relation to a 1-MW system and to a 2015 baseline of 1 EUR / $W_p$. This scale of system is chosen to minimise the share of 'soft costs' in the capital cost target. Soft costs relate to permitting and administration. They vary from place to place and are not addressable by R&D. Capital costs are easy to track and measure.

**LCOE**

LCOE relates the improvement in capital costs per $W_p$ to the improvement to the cost of electricity from the system. LCOE takes account of many other factors, foremost among them cost of capital (which, in Europe at least is in danger of being pushed up because of anxieties over the stability of PV's regulatory framework), opex (which represents a growing share of LCOE), irradiation and performance ratio, module lifetime. Also affecting LCOE are grid fees and curtailment, which all over the world is becoming a bigger issue (averaging, in China, around 50%). Political, regulatory and research effort should be brought to bear on these LCOE determinants.

The effect of technical enhancements related to yield rather than efficiency may also be revealed in LCOE but not in capital costs, for example module bifaciality, or the use or (or not) of trackers, concentration or reflection.

The 20-40% reduction we think may be targeted for 2020 and 2030 respectively assumes a 4% WACC and is derived from the following table where the range represents the irradiation in Malaga (lower value) and Stockholm, the units are $€_{2015}$/MWh.

| LCOE €$_{2015}$/MWh | **Current** | **2020** | **2030** |
|---|---|---|---|
| Residential 5 $kW_p$ | 90-155 | 70-125 | 55-95 |
| Commercial 50 $kW_p$ | 65-110 | 50-90 | 40-65 |
| Utility-scale 1 $MW_p$ | 50-85 | 40-70 | 30-50 |
| Utility-scale 50 $MW_p$ | 40-70 | 30-55 | 25-40 |

The targets for 'Capital cost' and 'LCOE' concord and are consistent with the results published in this EUPVTP report in July 2015.

Cost reduction could be by "novel potentially very-high-efficiency PV technologies manufactured at large scale" or by "modules designed for fully automated ground-mounted installation". We feel that it is difficult to find economies of scale in manufacturing in single plants bigger than typically 1 GW. Going further, to ultra-high capacity, supply chain integration may be taken to a new level. Rather, innovation (not necessarily focused on efficiency: could be in material use or manufacturability) or plant design and -management choices (greater automation, lower labour costs (overall, not per hour worked)) will drive cost-reduction in future.

*EERA-PV comments:*

Cost targets are acceptable only if in parallel customers can get reliable information about quality, reliability and expected lifetime. Therefore, the development of advanced failure analysis methods and meaningful (or representative) accelerated ageing test procedures at component and system levels is critical. The operating conditions of these tests may differ according to the final application (i.e. ground-mounted or BIPV applications).

## BIPV

*EU PVTP comments:*

**General**

The driver for the adoption of BIPV is legislation mandating nearly-zero energy buildings (NZEBs), rather than the end-users' expected return on investment. The values in the table assume aggressive pursuit of energy efficiency, which will be visible in a higher building renovation rate by 2020. BIPV will be one of the technologies used to meet these energy efficiency goals.

Consideration should be given to RoI. This is not easy to achieve in practice because it depends on many other factors than additional cost: system yield and the value per kWh, as well as financial parameters. However the exercise is important as part of an effort to teach architects and construction companies that BIPV creates a revenue stream.

Emerging PV technologies should by 2020 meet the same targets as other technologies (such as functional glass) for façade integration.

**Lifetime**

The electricity-generating functionality is subordinate to the structural or aesthetic property offered by the element. Lifetime of modules in BIPV installations should either be comparable to that of the other building components, or should be economical to replace.

Lifetime should greatly exceed warranty period.

**BIPV's technical challenges**

Fully integrated (BIPV) and partly integrated (BAPV) installations have generally at least two main disadvantages, compared to field installations, which are likely to reduce the lifetime of the modules (i.e. induce accelerated aging): i) higher operating temperatures and ii) shading (problematic for c-Si modules).

Aging (and power losses) from shading can be mitigated using smart electronics (i.e. power optimisers and micro-inverters). Achieving big reductions in operating temperature is very challenging and should require active cooling, possibly with water, or building designs that achieve better dissipation of heat. The construction sector could help with the latter.

## Standards

The group welcomes the imminent adoption (11 Dec 2015) of prEN 50583 "Photovoltaics in buildings" which will be a reference for good practice for both BIPV modules and systems.

Existing qualification standards for PV modules (e.g. IEC 61215 and 61646), however, still need to be adapted to take into account accelerated aging. As mentioned in the annex on Advances in efficiency and lifetime, we urge the relevant international bodies and working groups to accelerate the development and adoption of innovative test procedures aiming at ensuring increased confidence in the performance and life-time of PV modules including BIPV.

## Achieve major advances in installation

*EU PVTP comments:*

We see what the Commission is trying to do: aware that installation costs are a growing share of installation costs, it proposes an R&D-intensive route to contain the costs. However, the concept as formulated is too unclear for the group to comment on.

*EERA-PV comments:*

This approach should be supported as the diversification of applications (ground-mounted, roofs, façades, roads and lanes) represents a wide source of innovations (mechanics, coatings, wiring, etc.) beyond the conventional “module efficiency”.