SOLAR EUROPE INDUSTRY INITIATIVE

IMPLEMENTATION PLAN 2010-2012

May 2010

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1. Introduction

The present proposal synthesises an intensive collective effort of the European PV community involving leading representatives from the Industry, from the Research community and from the European and national PV associations represented through the European Photovoltaic Industry Association (EPIA) and the EU PV Technology Platform.

This document describes the PV sector strategy and the immediate actions to be taken in the period 2010-2012 to realise the PV solar energy goals for 2020 and beyond, as described in the European Commission PV Roadmap and related documents (such as the European PV Technology Platform’s Strategic Research Agenda and its Implementation Plan), as a contribution to the overall targets of the EU.

The full implementation of the PV sector strategy is necessary in order for the European PV industry to remain competitive in a market which presents a strong and increasing competition from companies coming from countries like China, Taiwan; countries which have increased their production capacity fivefold in the five years. Meanwhile, an increasing number of emerging players like India, Korea, Singapore and Malaysia are strengthening their R&D base in PV to support the growth of their own PV industry

This state of affairs calls for a re-evaluation by those countries/regions of the world with longer-standing positions in manufacturing (e.g. Europe, the USA and Japan) of the relative importance of international competition and cooperation, and of policies on licensing intellectual property, technology transfer, and other issues arising from the rapidly changing global situation. On the one hand, the availability of low-cost, high quality PV technology, wherever it is produced, is a prerequisite for any ambitious deployment scenario. On the other hand, the European PV sector has the responsibility and the ambition to maintain a strong position on the global market and to derive economic benefit for the EU taxpayer, who has nursed PV technology through the expensive, initial stages of its development. It is interesting to note that Europe’s competitors are approaching these topics quite differently. The focus of national attention varies from pure industry policy to promote the build-up of capacity and utilisation of economics of scale in order to improve manufacturing advantages to a focus on research to develop the technology further.

As consequence on the situation, and as input for the SET-Plan and EU 2020 targets, the European industry, organised by EPIA, developed a **Vision** to establish PV as a mainstream clean, sustainable and competitive energy technology providing up to 12% of the European electricity demand by 2020, up to 20% in 2030 and 30% in 2050 (see Figure 1).

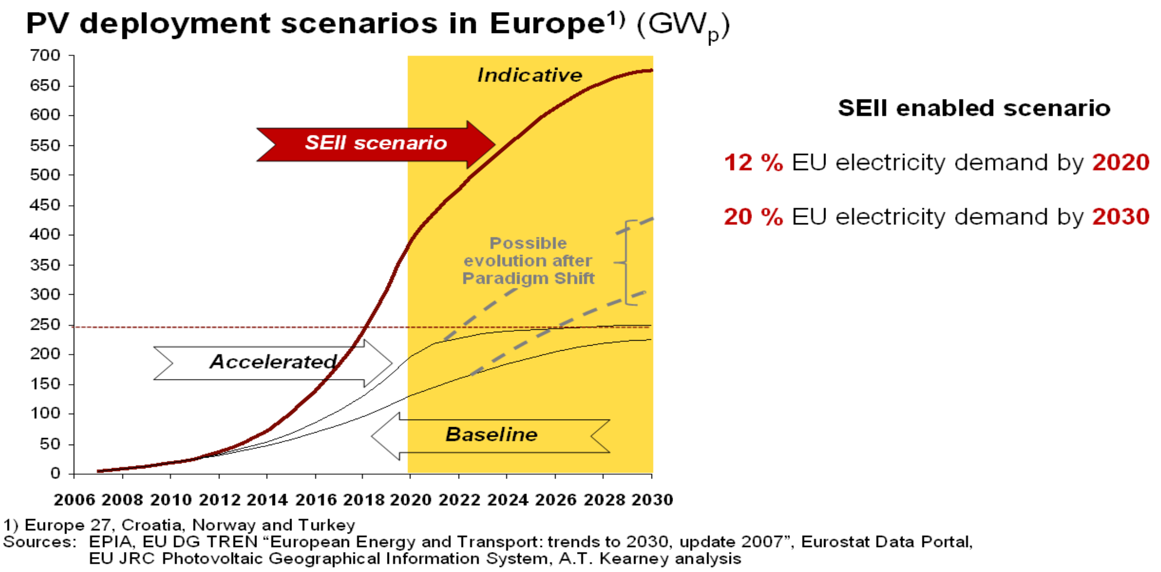

Figure 1. PV deployment scenarios in Europe

In that framework, in 2008 EPIA launched a comprehensive European project **"SET For 2020",** to establish the **industry roadmap to realise this 2020 Vision**.

The "SET For 2020" study was published in March 2009, demonstrating the benefits and implications that the 12% PV target represents for European society, including the PV industry (in terms of growth and consolidating worldwide leadership), the European utilities and regulators (integrating and managing a high-level of distributed PV generation, as well as other sources like wind power and CSP), other related stakeholders (such as the construction sector, architects, glass manufacturers, automobile industry, equipment suppliers) and, of key importance, the final consumers who will play a crucial active role in the electricity system of the future.

Realising the Vision will require that the right policy framework conditions are set by the Member States, and that continuous public support is provided to the industry in order to carry out the research, development and demonstration (RD&D) measures needed (as shown in figure 2). The **Solar Europe Industry Initiative (SEII)** describes the strategic **RD&D components of "SET For 2020", which are essential to enable rapid, large-scale deployment of PV at minimum cost and maximum benefit for society.** Besides the efforts of the PV sector, the success of other Industry Initiatives under the SET-Plan (e.g. Electricity Grid Initiative) as well as the development of other technologies (electricity storage, electrical vehicles, demand side management, etc.) are essential for the success of the SEII.

The 12% goal can only be achieved if costs are substantially reduced (through technology progress, experience and economies of volume), if grid integration issues can be solved, if PV markets can be strongly and sustainably enhanced throughout Europe. The SEII is crucial to both accelerate the cost reduction possibilities on the technology side as well as providing solutions for high penetration of PV in electricity grids.

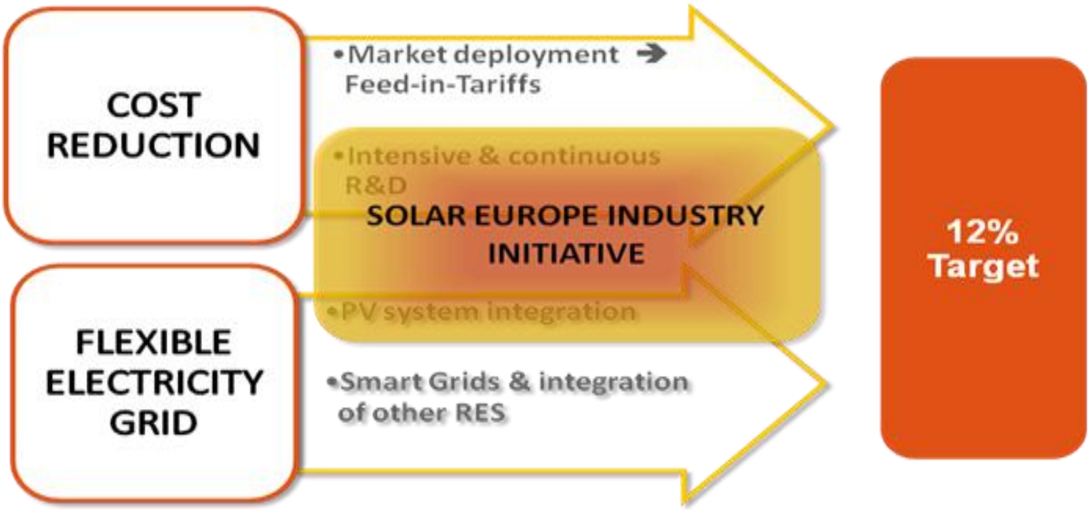

Figure 2. Scope of the Solar Europe Industry Initiative

The SEII clearly identifies the recommended actions and investment areas, their budgetary implications and the resulting expected measurable benefits for the European society.

SEII will achieve 3 strategic objectives:

1. SEII will bring PV to cost competitiveness in all market segments (residential, commercial, and industrial) by 2020 (cost reduction);
2. SEII will establish the conditions allowing high penetration of distributed PV electricity within the European electricity system (integration);
3. SEII will facilitate the implementation of large scale demonstration and deployment projects with a high added value for the European PV sector and society as a whole.

In addition to this, the SEII creates the necessary basis for development beyond 2020 and the 2020 targets, supporting the European industry to also play a leading role on the longer term.

Implementing the SEII will substantially support the European Energy Policy objectives:

- increase security of energy supply;
- substantially cut CO_2 emissions;
- increase European energy competitiveness;
- develop a robust European industry at the forefront of technical innovation, creating sustainable jobs in Europe along the value chain.

The European PV Industry is fully committed to the Solar Europe Industry Initiative, which constitutes a unique and strategic opportunity to accelerate the path to competitiveness, demonstrate the full value of centralized and distributed PV generation and fully realize the PV Industry Vision. The PV Technology Platform, as an independent representation of all PV stakeholder groups in Europe, fully and actively supports the Industry in its efforts to achieve the strategic objectives, and worked closely together with the Industry on the SEII and its Implementation Plan.

2. PV technology roadmap

2.1. State of the art and 2020 objectives

For over 30 years the PV industry has demonstrated its capability to achieve fast price reduction, as evidenced by Figure 3, which shows that the price of PV modules has been reduced by 22% for each doubling of the cumulative installed capacity. This fast decrease of manufacturing costs and selling prices is the result of extensive RD&D as well as continued support for PV market development to ensure the required experience and scale effects. The same is true on the system level (note that PV systems consist of modules and the so-called Balance of System (BoS), which comprises electronics and safety devices, cabling, mounting structures, installation, etc.). The rapid decrease of turn-key system prices has been enabled by the combination of innovation (the result of RD&D) and experience combined with economies of scale (the result of market development).

Clearly, RD&D (the topic of this SEII) by itself will not lead to large scale deployment and to reaching any volume target. The latter are dependent on important other conditions to be met, in particular in the form of market incentives until self-sustained markets are created by continued cost and price reductions. It is stressed, however, that intensified RD&D is crucial to enable PV deployment at the rate and at the rapidly decreasing price levels outlined in “SET for 2020”. In other words, the SEII enables such large scale deployment at minimum cost and maximum benefit. In fact, the societal cost benefits that may be reached by choosing an optimum combination of deployment ambition and RD&D efforts easily outweighs the cost of the latter, which is another argument to adopt this SEII.

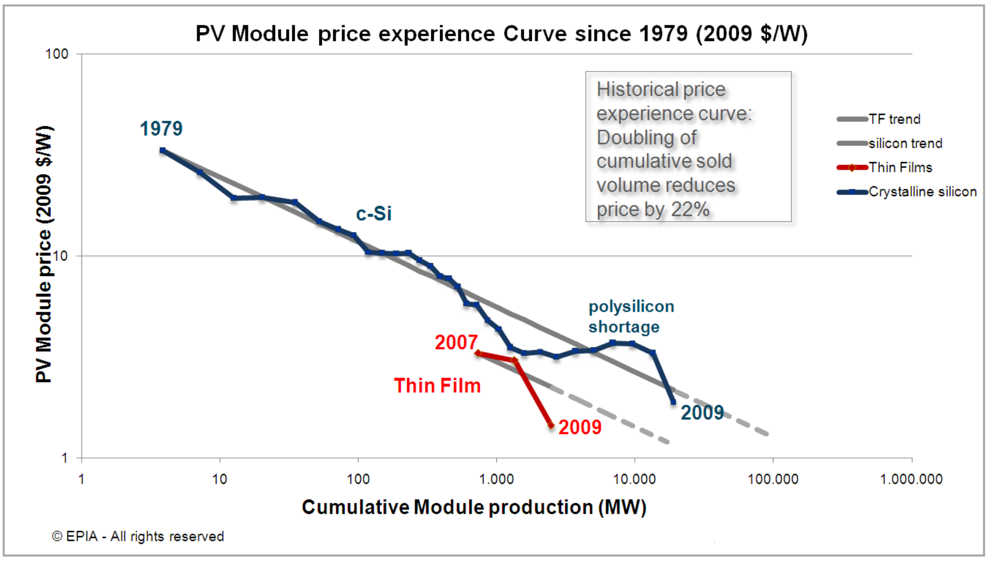

Figure 3. PV Module price experience curve.

Although costs and prices of modules and complete systems are important indicators of the evolution of the technology, the most relevant parameter and actually the one which serves to compare PV electricity with other sources of energy is the cost per kWh generated. PV systems have a very long service life (>25 years) and therefore the Levelized Cost of Electricity (LCOE) is key to understanding the real generation cost. Depending on the location, the annual output (proportional to the annual irradiation) will vary from 700-800 kWh/kWp in the Scandinavian countries to more than 1500 kWh/kWp in the South of Spain and Italy, Greece and Turkey.

Based on these outputs, and a typical system performance ratio of 80%, Figure 4 shows that current PV electricity generation cost ranges from ~0,25 €/kWh in the North of Europe to ~0,13 €/kWh in the South (based on the most competitive turn-key system price in Europe which are typically found in Germany where the market is more mature). These values will decrease significantly during the coming years with expected generation costs in the range of 0,14 – 0,07 €/kWh in almost all of Europe by 2020 (for large ground-based systems).

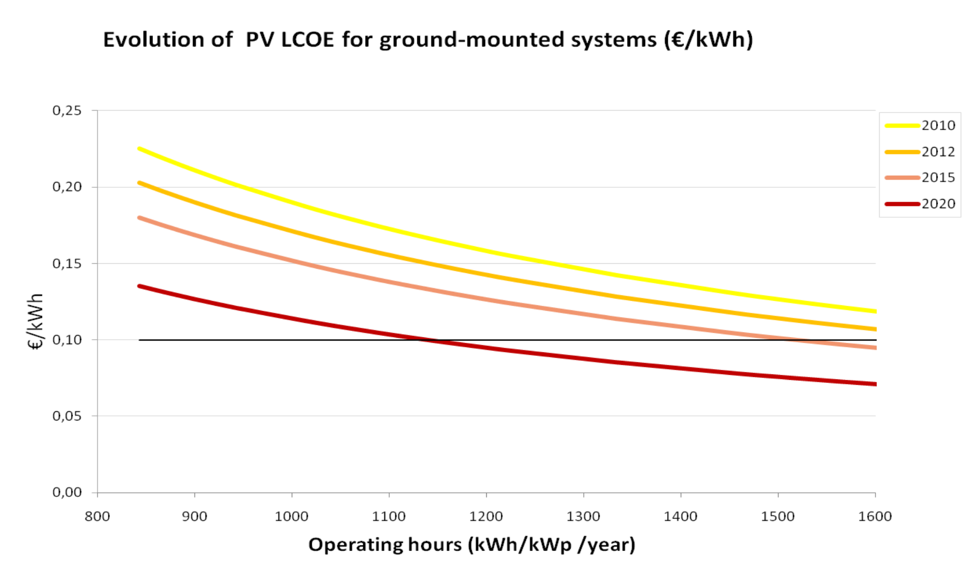

Figure 4. Levelised Cost of Energy (LCoE) evolution for large ground-mounted systems (based on the most competitive turn-key system price). Residential system prices and associated LCoE will also decrease strongly, albeit remaining higher than ground based systems.

The targeted PV technology development in the period 2010 – 2020 is summarised in Table 1 and Figure 5 (next page). The latter is taken from the EC Technology Roadmap developed in the framework of the SET-Plan, which is mostly based on documents published by EPIA and the European PV Technology Roadmap.

Table 1. PV technology state-of-the-art and major objectives/milestones for the next 10 years (numbers and ranges are indicative because of the spread in technologies, system types and policy frameworks)

PV Technology state-of-the-art and major objectives/milestones for the next 10 years		2007	2010	2015	2020
Turn-key price large systems (€/Wp)*		5	2,5-3,5	2	1,5
PV electricity generation cost in Southern EU (€/kWh)**		0,30-0,60	0,13-0,25	0,10-0,20	0,07-0,14
Typical PV module efficiency range (%)	Crystalline silicon	13-18%	15-20%	16-21%	18-23%
	Thin films	5-11%	6-12%	8-14%	10-16%
	Concentrators	20%	20-25%	25-30%	30-35%
Inverter lifetime (years)		10	15	20	>25
Module lifetime (years)		20-25	20-25	25-30	35-40
Energy pay-back time (years)		2-3	1-2	1	0.5
Cost of PV + small-scale storage (€/kWh) in Southern EU (grid-connected)=***		--	0,35	0,22	<0,15

*The price of the system does not only depends on the technology improvement but also on the maturity of the market (which imply industry infrastructure as well as administrative cost)
**LCOE varies with financing cost and location. Southern EU locations considered here range from 1500 (e.g. Toulouse) to 2000kWh/m² per year (e.g. Siracusa)
***Estimated figures based on EUROBAT roadmaps

2.2. SEII structure and priority areas

The Solar Europe Industry Initiative (SEII) is based on the idea of *"Creating an Energy Revolution through Accelerated Evolution"* and moving beyond a business-as-usual scenario.
Based on an intensive exchange of views and ideas which were worked out in close collaboration between EPIA and the European PV Technology Platform, involving stakeholders from the whole PV industry (cell & module manufacturers, BOS suppliers), the research community (universities, research centres), PV-related industries (glass, plastics/encapsulants, raw materials, metals) and, last but not least, equipment suppliers, two major initiatives have been defined:

- **SEII 1: Cost Reduction**
- **SEII 2: System integration**

Following the R&D activities in the two sub-initiatives, **demonstration projects** will be carried out to assure a large and successful implementation of the results.

The SEII also recognizes the need to undertake an important program for ***education & training*** in Europe in order to keep the leadership of the European industry and avoid a shortage of qualified PV professionals. Activities should be focused on educating scientists, engineers, installers, technicians, etc. based on the specific needs of the industry but also recognising that research and development activities provide excellent educational and training of skilled people opportunities.
The same principle applies for ***awareness & communication*** activities. The environmental, social, economical and technical benefits of PV need to be disseminated to the wider public, national and European policy-makers, utilities, architects, construction sector and other important stakeholders. These two areas, however, are beyond the scope of Industrial Initiatives and should be covered by parallel actions.

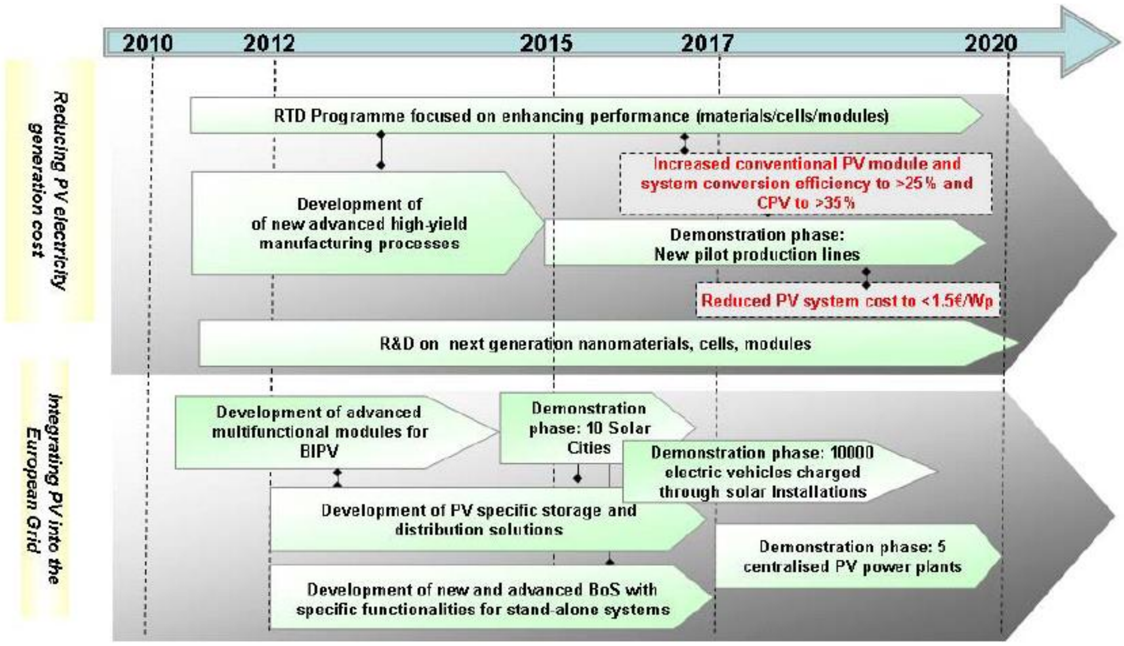

Figure 5. Overview of PV technology development in the period 2010 – 2020, taken from the EC Technology Roadmap (SEC(2009) 1295, 7 October 2009).

Figure 6 presents the structure of the SEII and indicates the major priority areas for R&D and demonstration under the 2 sub-initiatives. The interaction that will take place between the SEII and other major Industrial Initiatives is also shown. While the success of the *SEII 1 Cost reduction* depends mainly on the capacity of the PV industry to scale up and further improve performance and lifetime, the success of the *SEII 2 System integration* will be conditioned by, among others, an effective cooperation with the Electricity Grid Initiative and the Energy Efficient Buildings Initiative.

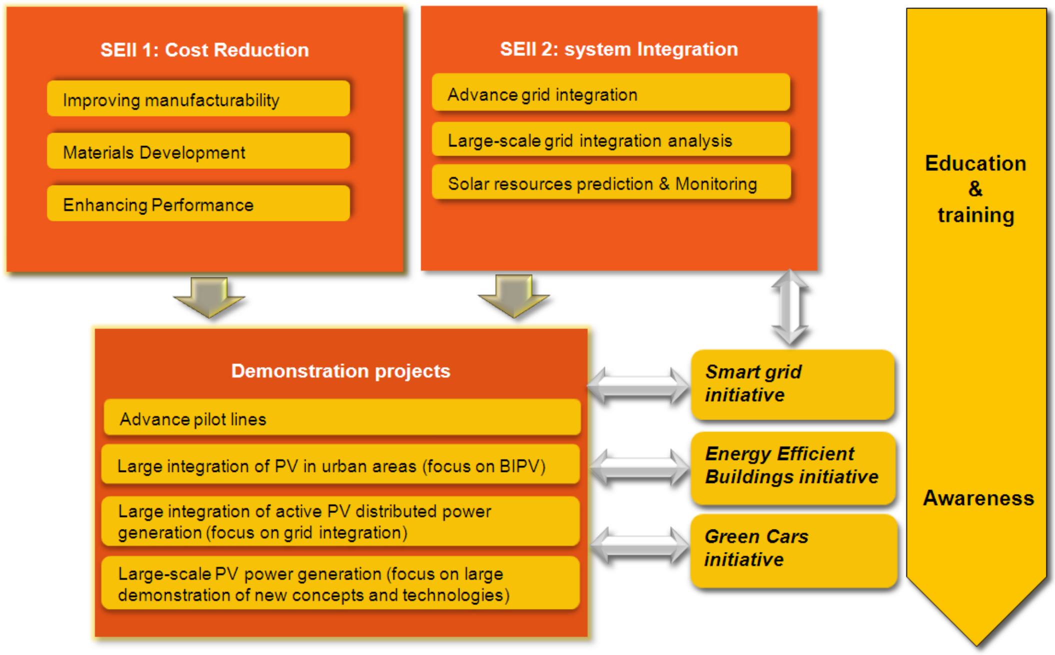

Figure 6. SEII structure: Sub-initiatives, relation to other initiatives and non-technological parallel activities.

2.2.1 SEII 1: Cost reduction

Objectives

The focus of this initiative is to reduce the generation cost of PV electricity (€/kWh) by achieving a cost reduction of the technology itself (€/Wp) and by increasing the lifetime of PV systems. An accelerated cost reduction of the PV technology will be achieved by boosting innovation and economies of scale.

It is crucial to prepare the industry for multi-gigawatt production and to accelerate the process of "from labs to commercialisation". New machinery and processes are needed to afford high-production levels and current and new materials need to be available in sufficient quantities and at low costs. In line with the recommendations of the Strategic Research Agenda of the European Photovoltaic Technology Platform, this step is to be achieved for wafer-based crystalline Si PV, thin-film technologies and concentrator PV.

Expected impact

The implementation of this initiative will lead to faster and cheaper manufacturing processes for all PV technologies with a higher grade of automation while the cell and module efficiencies will continue to increase. The use of high cost materials will decrease and substitutes for the non-earth-abundant materials currently used in the PV industry will be developed and gradually implemented. New encapsulation concepts and materials will be introduced in order to decrease cost at maintained or increased module lifetime.
With lower material usage, increased efficiency, better economies of scale and longer lifetime, the cost of electricity will be significantly reduced, making PV competitive with other energy sources.

2.2.2 SEII 2: System integration

Objectives

As distributed PV and other renewable energy technologies mature, they can provide a significant share of European electricity demand. However, as their market share grows, concerns about potential impacts on the stability and operation of the electricity grid may create barriers to their future expansion. In addition, low cost, high-quality integration of PV in buildings and other objects poses major development challenges. The goal of this initiative area is to unlock the potential for making PV a mainstream energy source, requiring special focus to be placed on system integration aspects.
In order to achieve the target of generating up to 12% of the European electricity consumption by 2020, the PV industry, together with the network operators and building sector, needs to develop economical and technical solutions which will allow a large penetration of PV at a competitive level.

Expected impact

The implementation of this initiative will bring benefits to the PV industry, utilities and regulators. On one hand, the production cost of components like inverters and batteries will decrease whereas the lifetime of those devices will increase making PV systems more economically attractive. On the other hand, grid operation will benefit from the ancillary services (frequency stability, voltage control, reactive power) that PV can bring into the system, as well as the reliability of supply when offering PV systems with energy storage solutions. Communication and control functionalities will be developed, tested and implemented facilitating the overall function of energy management systems.

2.2.3 Demonstration projects

Objectives

The results of the activities implemented under the priority areas "Cost reduction" and "System integration" will be demonstrated under real conditions. The collaboration with other key stakeholders such as utilities, car manufactures and regulators on the one hand and the building industry on the other is also essential at this level.
A variety of tests and demonstrations are required to understand the effect of a high penetration of PV systems on the grid. Especially important are the subjects of PV grid integration, PV building integration and interaction with other energy sources (such as wind power and other variable electricity production technologies).

Expected Impact

The implementation of this initiative will demonstrate the real value of PV technology and electricity, the potential to interact with other energy sources and the added value to network operators and the building sector.

3. Key Performance Indicators (KPI's)

Important explanatory note: This is work in progress and it is intended to be improved and extended by the SEII Team and SETIS in a joint activity; therefore any figure may be revised accordingly. The Final work will be concluded soon.

In order to be able evaluate the impact of the different (clusters of) projects under the SEII and benchmark the results against the development targets summarised in Table 1 and Figure 5, a set of key performance indicators and reference systems have been defined. These are structured in three categories:

3. 1. Cost reduction: paving the way to 2020

The more representative KPI's in this area are:

- Turn-key system price reduction (€/kWp)
- PV electricity generation cost reduction (€/kWh) - Note: calculation parameters to be agreed upon.
- PV module efficiency increase (%)
- Inverter lifetime increase (years)
- # of advanced pilot lines for advanced technologies
- System Performance ratio (%)
- Inverter efficiency (%)

Table 2. PV technology state-of-the-art and major objectives/milestones for the next 10 years (numbers and ranges are indicative because of the spread in technologies, system types and circumstances, etc.)

Cost reduction: paving the way to 2020		2007	2010	2015	2020
Turn-key price large systems (€/Wp)*		5	2,5-3,5	2	1,5
PV electricity generation cost in Southern EU (€/kWh)**		0,30-0,60	0,13-0,25	0,10-0,20	0,07-0,14
Typical PV module efficiency range (%)	Crystalline silicon	13-18%	15-20%	16-21%	18-23%
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	Concentrators	20%	20-25%	25-30%	30-35%
Inverter lifetime (years)		10	15	20	>25
Module lifetime (years)		20-25	20-25	25-30	35-40
Energy pay-back time (years)		2-3	1-2	1	0.5

*The price of the system does not only depends on the technology improvement but also on the maturity of the market (which imply industry infrastructure as well as administrative cost)
**LCOE varies with financing cost and location. Southern EU locations considered here range from 1500 (e.g. Toulouse) to 2000kWh/m² per year (e.g. Siracusa)

3.1.1 Reference systems for manufacturing plants

In order to measure the progress achieved in the cost reduction area, it is key to analyse the current manufacturing cost for the various commercial technologies. Thus a number of **Reference systems** are presented below (fig. 8 to fig. 10). It is very important to note that these figures are average estimations and don't intend to represent all current manufacturing cost in the market. Furthermore, the manufacturing cost depends heavily on the final module efficiency and the size of the factory; as a rough estimation we could say that for each increase of 2% in module efficiency (with a similar effort-cost), the overall cost (€ /Wp) will be reduced about 15-20%. It is similar regarding the manufacturing size. For thin film technologies (e.g. CIGS), although most producers are working with a production capacity of 20-30 MW/year, an optimal production capacity would be around 80-100MW. The evolution of manufacturing cost for Thin film technologies is presented on Fig.7.

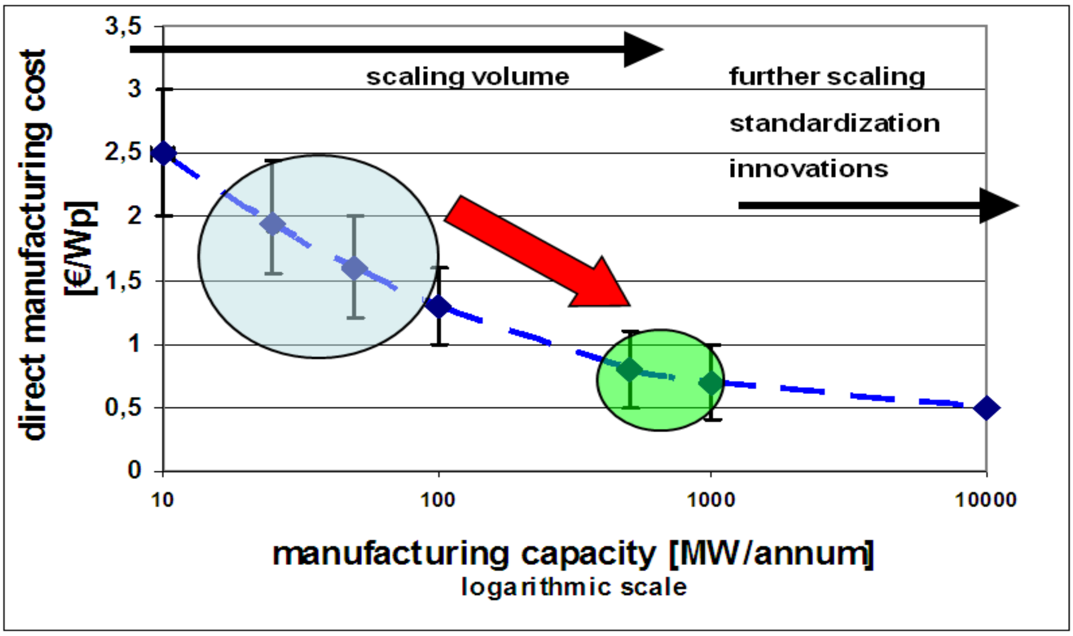


Figure 7. Cost potential for Thin Film technologies based on production volume (horizontal axis) and module efficiency (vertical arrows). Source: EU PV technology Platform.

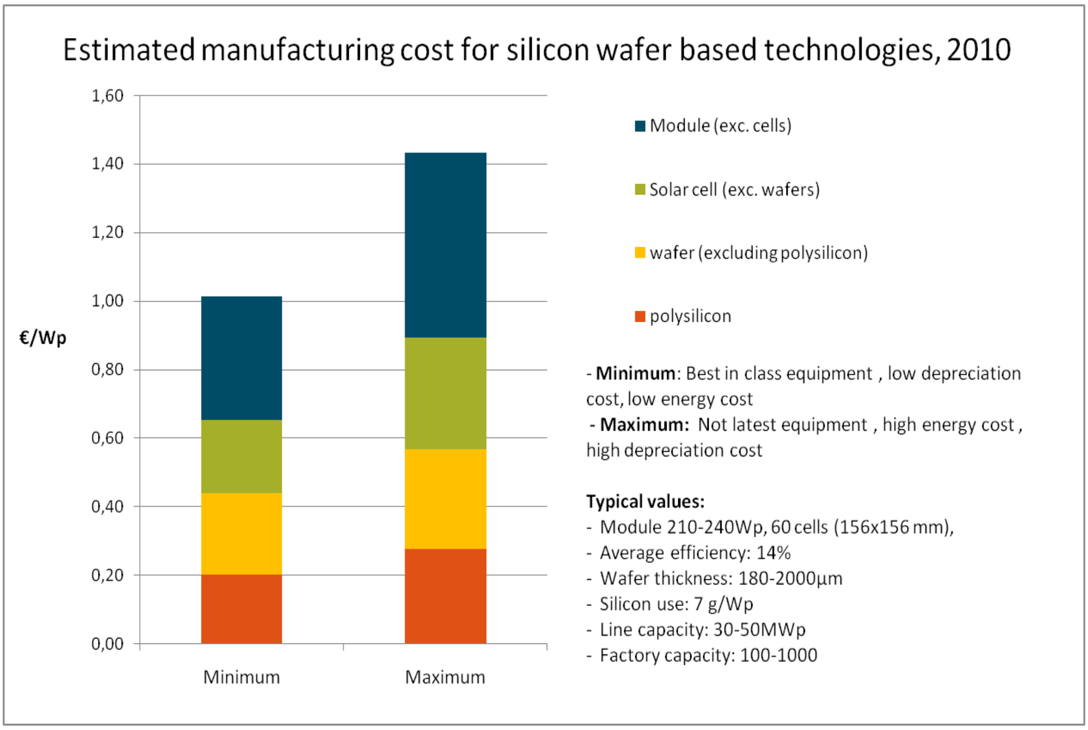


Figure 8. Reference system: C-Si Manufacturing cost for full-integrated and not integrated manufacturing plants.

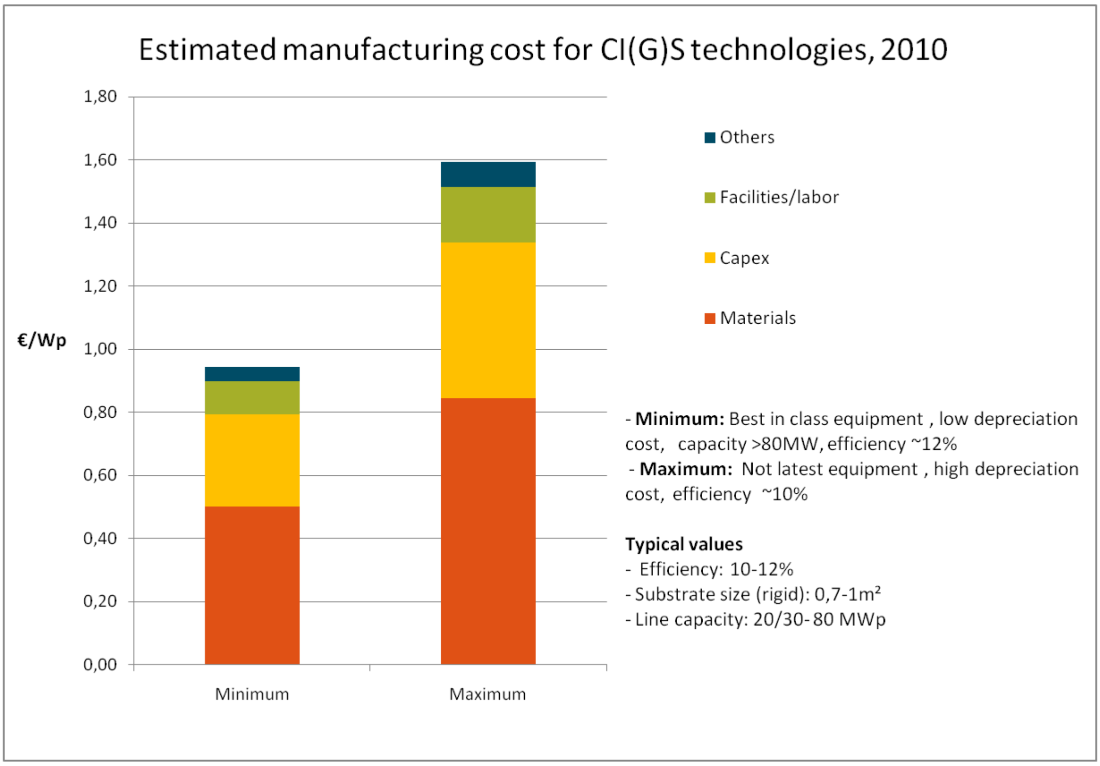


Figure 9. Reference system: Manufacturing cost for CI(G)S modules.

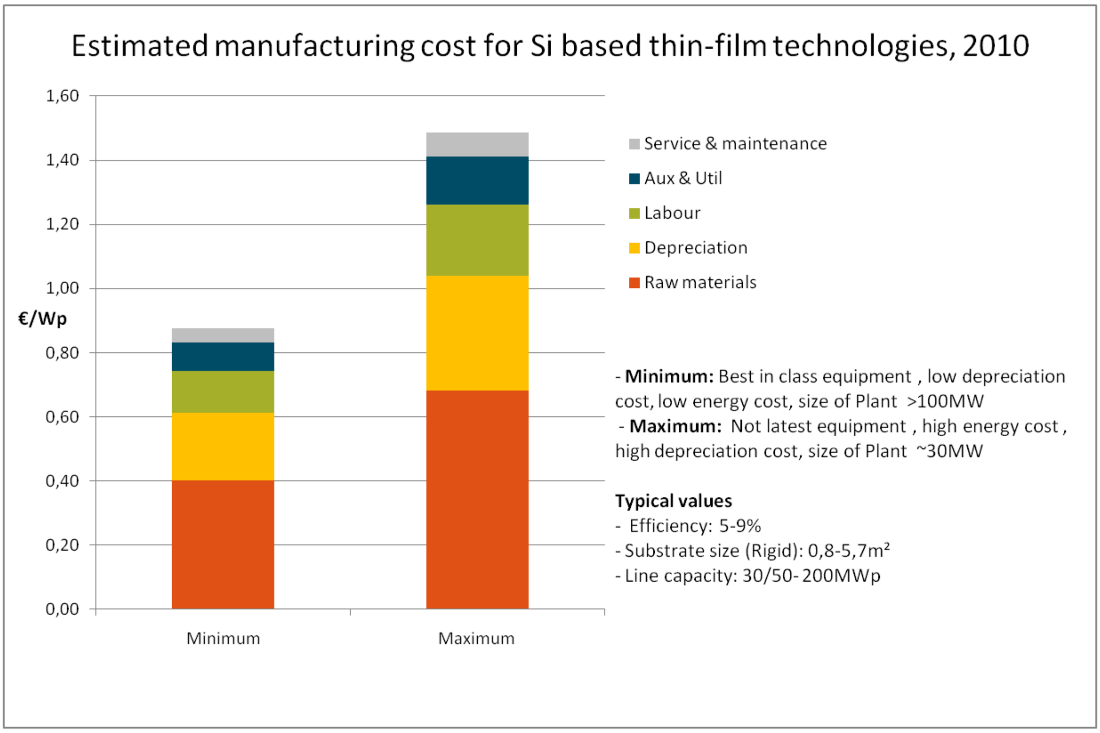


Figure 10. Reference system: Manufacturing cost for Silicon based Thin-film modules. These include single junction, tandem (a-Si/µc-Si) and triple junction.

3.1.2 Reference systems for PV power plants

As general estimation, the system price has been set in Table 2 for large system. However system price depends on size, level of integration and location/country (the latter is crucial to understand due to the fact that the price doesn't depend only on the technology and engineering but also on maturity of the market which gives a wide range of prices for administrative procedures for installation and grid connection).

Table3. Reference systems for PV power plants

System category	size	Type of installation
Residential	3-10 kWp	Roof-top/ BIPV (roof/façade)
Commercial	100 kWp	Roof-top/ BIPV (roof/façade)
Industrial	1 MWp	Roof-top
Utility scale	1-50 MWp	Ground mounted

In a later stage, the system price for the 4 system categories and the different PV module technologies will be given presenting the: modules cost, Balance of system components (BOS), engineering& installation, etc.

3. 2. System integration: paving the way to 2020

The more representative KPI's in this area could be:

For Grid integration:

- Self consumption/Grid export
- Congestion management (e.g. curtailement)
- Peak demand ratio
- Voltage quality performance, Reactive power control, e.g. for voltage control
- Power quality by reducing flickers and harmonics
- Network losses decrease
- Investment cost, Electricity Price

For Building integration

- Demonstration of high-quality, versatile integration of PV in buildings and infrastructural objects (e.g. thermal & Noise Insulation, solar shading, substitution of the building skin)
- Price of system (€/kWp) for l BIPV applications.

3. 3. Preparing for cost and penetration beyond 2020 levels

The more representative KPI’s in this area be:

- Efficiency
- Performance stability
- Cost (€/Wp)
- # of advanced pilot lines for ultra-low cost (printable) PV technologies
- # of proofs of concept for very-high efficiency novel PV technologies
- # of proofs of concept for very high levels (to be quantified) of PV penetration

Table 4. State-of-the-art and major objectives/milestones for the next 10 years regarding emerging and novel technologies (numbers and ranges are indicative because of the spread in technologies and applications)

<table>
<tr><th colspan="2">Preparing for cost and penetration beyond 2020 levels</th><th>2010</th><th>2015</th><th>2020</th></tr>
<tr><td colspan="2">Commercial module cost for emerging technologies[1] (€/Wp)</td><td>N.A.</td><td>N.A</td><td>0,5-0,8</td></tr>
<tr><td rowspan="3">Typical PV module efficiency range (%)</td><td rowspan="2">Emerging technologies[1]</td><td><7-12%
Lab-scale[3]</td><td>10-15%
Lab-scale[3]</td><td rowspan="2">>10%
Commercial[5]</td></tr>
<tr><td><5%
Pre-Commercial[4]</td><td><10%
Pre-Commercial[4]</td></tr>
<tr><td>Novel technologies[2]</td><td>N.A</td><td>N.A.</td><td>>25%</td></tr>
<tr><td colspan="2">Performance Stability (years)</td><td><5</td><td>5-15</td><td>>15</td></tr>
</table>

(1) Emerging technologies include organic photovoltaics, dye-sentisized solar cells and advanced inorganic thin film technologies
(2) Novel technologies include quantum technologies and technologies using nanoparticles.
(3) Lab-scale: Cell Area below 10cm²
(4) Pre-commercial: Sub-module area (combination of ~10 cells) below 0.1m² for consumer application
(5) Commercial: real scale module size >0.5m²

More information on the different technologies, state-of the art and target are available in the Strategic Research Agenda of the EU PV Technology Platform (www.eupvplatform.org)

4. Governance structure

Introductory remarks

- Implementation of the SEII should be based on a flexible and rolling program (able to rapidly evolve based on new situations and funding opportunities).
- Joint programming on a European or multi-country level has been found to be a very difficult and lengthy process. In order not to slow down the implementation of the SEII, the level of ambition on this point should be a realistic one and grow along with the SEII itself.
- It is essential, and the PV sector therefore expects, that dedicated public (on a short term EU, and later MS) budgets and funding instruments will be developed for projects and programs under the SEII.
- Intellectual property rights (IPR) are essential for industry development, but should be handled in a way that optimises progress of the PV industry sector as whole and thus, of the SEII.

4.1 SEII Team

An SEII Team will be defined with the following role:

- Definition of 3-year Implementation plan: *'When, What, How??'*
  - 'What' & 'When' : activities to be launched,
  - 'How': funding mechanism and budget necessary

- To be the only body to represent the SEII to Member States (through the SET-Plan High Level Steering Committee (SET-Plan HLSG)) and to European Institutions.

The SEII Team will be composed of Industry representatives (EPIA members with a seat at the EPIA managing Board), researchers (3-5 members of the EU PV Technology platform), Member States representatives, EC, and Financial institutions (e.g. EIB).

The SEII Team will be supported by the EU PV Technology Platform and by the SEII Industry Advisory Committee with the representatives of the industry (through EPIA).

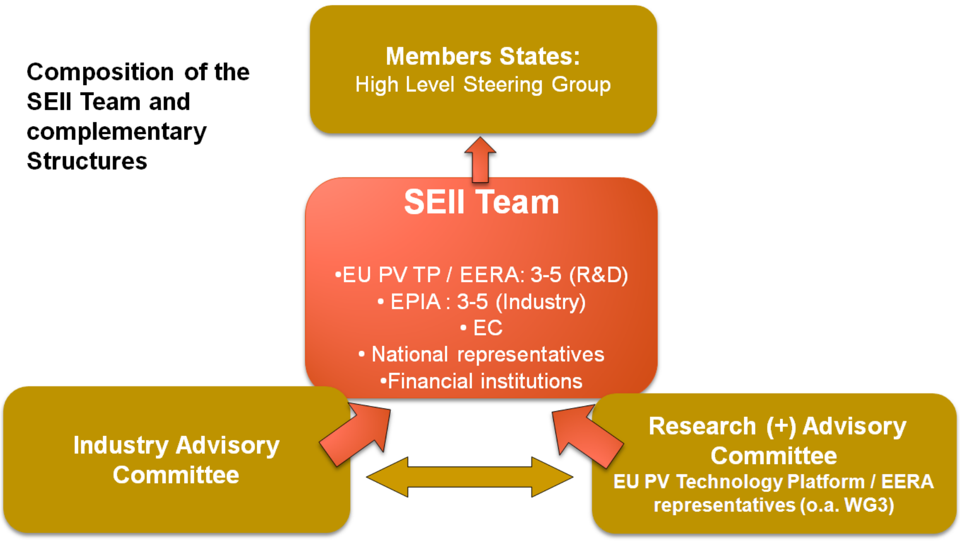


Figure 11. Composition of the SEII Governance structure

4.2 Definition of a 3-Year Implementation Plan

The SEII Advisory Team has the role of defining a *3-year Implementation Plan* which will be subject to review every second year in light of new opportunities.

In order to build up the ***SEII 3-year Implementation Plan***, the SEII Advisory Team will use as starting point the SEII Roadmap 2010-2020 which has been developed in close cooperation with EPIA, the EU PV TP and the European Commission.

The definition of the SEII 3-year Implementation Plan, as shown in Figure 8, will be carried out in continuous interaction between the SEII Team and the SET-Plan HLSC, the Sherpas group as well as with the EC. This interaction will help the SEII Team to understand the priority areas, the financial resources and the available funding mechanisms of Members States and EC.

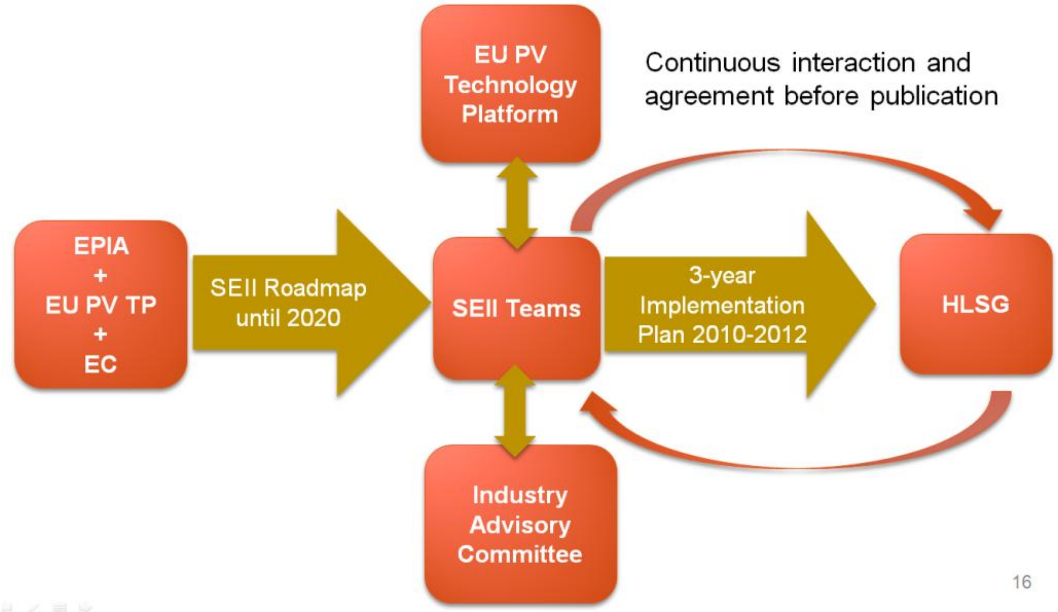


Figure 12. Process for the definition of the SEII 3-year Implementation Plan

The initiation of joint activities and the allocation of funding sources will be done with the support of the SEII Team and representatives of public funding agencies. Depending on the EU added value and the risk involved in each activity, the funding sources and mechanisms will vary accordingly. This process is represented in figure 9.

5. Three-year Implementation plan (2010-2012)

Important explanatory note: the priorities described here are projects and project clusters which have been defined *primarily in addition to* ongoing projects and programs (on EU and member state levels) and which inherently qualify for the Solar Europe Industry Initiative label. Since there is ongoing research already, the tables emphasise and quantify that research in these areas has to be *intensified substantially* in order to reach the ambitious targets for cost reduction and (enablers for) large scale deployment. Deployment as such cannot be achieved directly with this Initiative since it relies on a variety of non-technical conditions to be met (including market incentives). This Initiative aims to develop PV technology to the levels of economic and technical maturity that are required for large-scale deployment at minimum cost and maximum benefit, and with a leading role of the European PV industry sector. The overview below is *not* to be interpreted as a complete overview of all PV R&D and demonstration to be carried out in Europe in the next three years, since that is considerably broader than the priority areas defined here.

5.1 Core focus of the SEII 2010-2012: selected priority areas

Table 10. Clusters of projects under the SEII 1: Cost reduction

Cost reduction: paving the way to 2020	
Research theme	**Summary description and project clusters**
Advanced manufacturing processes for cells and modules	This cluster of projects aims at bringing a selection of key commercial technologies (in particular wafer Si, thin-film Si, CIGS and concentrator PV) further towards full maturity, i.e. very large-scale production at the required low cost. It will enable the European PV industry to compete successfully in the global market, to reach grid parity with retail prices (or beyond) in most of Europe and to supply the required hardware for multi-gigawatt-scale deployment of PV.
Performance enhancement and lifetime extension	In addition to the performance optimization and cost reduction on cell and module levels mentioned in the previous cluster, enhancement of the performance *on a system level* and enhancement of the technical lifetime of system components and systems are other ways to reduce the generation costs of solar electricity. This cluster of projects aims at increased specific energy output (kWh/Wp•yr) and enhanced lifetime. In addition, the cluster includes projects on very high efficiency approaches beyond industry capability indicated in the previous block.
Materials development & sustainability	To further improve the already favourable environmental profile of PV systems, the energy input for manufacturing and installation needs to be reduced and alternatives for some critical (non earth-abundant or hazardous) elements and materials need to be developed. Both aspects are also clearly related to cost reduction. Moreover, the implementation of the end-of-life module collection and recycling system developed by the PV CYCLE association is addressed. .

Table 11. Clusters of projects under the SEII 2: System integration

System integration: paving the way to 2020		
Enabling large-scale deployment	*Grid interface*	Large-scale deployment of PV systems (both small and large) requires new approaches towards grid integration. Rather than straightforward grid connection which is common practice for low penetration, it becomes both beneficial and necessary to consider PV electricity generation capacity as an important element in the total portfolio of users, central and decentralised generators and storage capacities, and to perform optimisation and control by energy and power management. The basic dc/ac conversion function of inverters may thus be extended substantially and they may evolve into “smart” system components. In this way they can become key components of the future smart grid. This part of the cluster of projects aims at developing and demonstrating intelligent inverters, combinations of PV with storage and strategies for high penetration.
	Building integration	Very large-scale deployment of PV will strongly benefit from (or may even partly depend upon) the availability of multifunctional PV modules for integration solutions for buildings and infrastructural objects (sound barriers and many more). This is because turn-key system costs can be reduced by advanced integration concepts, but also because public support may be fostered or strengthened by the high aesthetic quality achievable with full integration. This part of the cluster therefore aims at developing concepts and hardware for integration of PV.
Large-scale PV power plants	Technologies with a high potential but a limited track record, like concentrator PV and advanced thin-film technologies, are hampered in their application because risk assessment cannot be based on field experience. This, in turn, makes it difficult to reach the scale required for cost reduction. This circle may be broken by the development of a few very large (~20- 40MW) PV power plants aimed at demonstrating the feasibility and reliability of the respective technologies. Analyzing the impact of such large PV plants on the grid operability and stability will also support the establishment and construction of a very robust European “smart grid”.	
Solar resources, monitoring and simulation	What can we expect and what do we actually get? These are two key questions in relation to large-scale deployment of PV. Projects in this cluster aim at creating accurate & reliable, readily available, and practically useful information on all aspects of PV planning and use, for various stakeholder groups in all EU member states.	

Table 12. Clusters of projects under SEII1 Cost reduction and SEII2 system integration for beyond 2020

<table>
<tr><th colspan="2">Preparing for cost and penetration beyond 2020 levels</th></tr>
<tr><td colspan="2">Key performance indicators
2 advanced pilot lines for ultra-low cost (printable) PV technologies
2 proofs-of-concept for very-high efficiency novel PV technologies
1 proof-of-concept for very high (to be quantified) levels of PV penetration</td></tr>
<tr><td>Ultra low cost technologies</td><td>In addition to the technologies commercially available today, a range of “emerging” technologies is under development or in the pilot production phase. Prominent examples are the organic solar cells and modules (for example polymer) and CIGS technologies (for instance based on non-vacuum deposition). The general feature that these emerging technologies have in common is that they have potential for very low production costs and new applications. Although advanced versions of commercially available technologies can meet the cost targets for 2020, emerging technologies are an essential part of the R&D portfolio for the next few years because they may bring PV further down in cost on the longer term and because their development towards application maturity requires many years. This cluster comprises projects on emerging technologies which aim (ultimately) at demonstration on a pilot production level.
Research, development and pilot line demonstration of “emerging” technologies (in particular non-vacuum/printed organic and inorganic options)
Development and implementation of dedicated characterisation & testing models and methods, including the required hardware; accelerated lifetime tests</td></tr>
<tr><td>Very high efficiency approaches</td><td>In addition to the commercial and emerging technologies mentioned in previous paragraphs, a wide range of “novel” device and conversion concepts are in the laboratory phase. The common feature of these novel approaches is that they aim at efficiencies far beyond the levels foreseen for commercial and emerging technologies. Another common feature is that it is too early to make useful statements about their (future) cost. This cluster aims at exploring the limits of photovoltaic conversion: a strategic activity which is vital for the position of the PV industry sector on the longer term as well as for Europe’s global position in the PV field. The USA, Japan, Australia and other countries invest heavily in similar R&D efforts. The aim of the projects in this cluster is to demonstrate the feasibility and added value of the approaches on a device level.
Research and development of novel, PV conversion concepts aiming at very high efficiencies (various applications of quantum dots and other nanostructures, intermediate band semiconductors, hot-carrier devices, spectrum converters, and more); demonstration on proof-of-concept and/or proof-of-feasibility level
Modelling and characterisation of new concepts and innovative materials using advanced theoretical and experimental methods</td></tr>
<tr><td>Integration concepts for very high levels of PV penetration</td><td>As in the case of cell and module technologies, also the concepts and technologies for integration have to evolve and improve over time in order to comply with rapid, large-scale deployment. To prepare for very high levels of penetration of PV in the grid as well as in the built environment, this project cluster aims at developing and demonstrating new integration concepts (beyond those developed in “Grid and building integration”).
Power and energy management strategies for very high degrees of PV penetration (beyond anticipated 2020 levels), including development and testing of the required hardware, and field tests.</td></tr>
</table>

5.2 Relation with the European Energy Research Alliance (EERA)

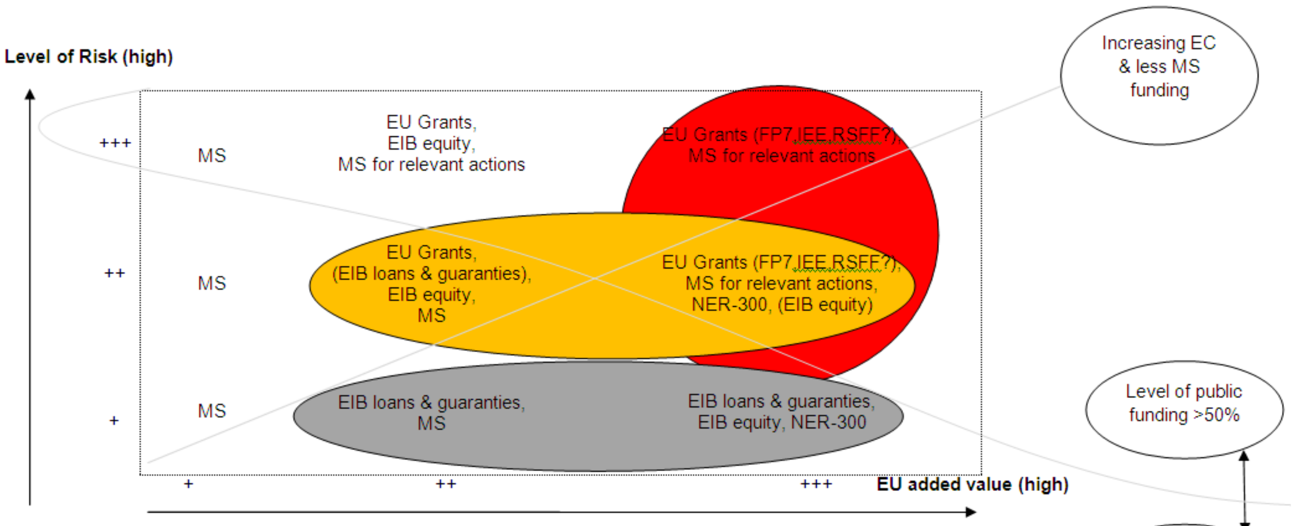
The European Energy Research Alliance (EERA) is in the final preparation phase and will soon become operational. The objective of the photovoltaics-related part, EERA-PV, is to accelerate the development of photovoltaic solar energy to an energy technology that can provide a large proportion of our electricity demand, through joint programming activities by key research institutes in Europe. Clearly the overall targets of EERA-PV and SEII coincide, as they should to form the essential drivers of the European PV development. The areas selected for initial joint programming in EERA-PV are:

- silicon materials;
- (inorganic) thin film PV;
- organic PV;
- module technology;
- education and training and use of infrastructures.

Within these broad areas EERA-PV focuses explicitly on research topics which provide *input* for the programs defined under the Solar Europe Industry Initiative. Therefore EERA strongly supports the accelerated development of PV through the SEII without duplicating research.

5.3 Financial instruments

The nature of, and instruments for funding of research, development and demonstration projects and accompanying actions should be chosen in accordance with the type of action considered. As a general principle, actions with a high EU added value warrant a high EC/MS (MS = Member States) funding ratio, while public/private funding ratios are highest for high-risk and/or long time-to-market actions. Figure 12 gives an overview of the various funding instruments and types as a function of EU added value and risk level.



State of development	Level of public funding	EC/MS share
Market uptake/innovation/private infrastructure	<30%	20/80
Manufacturing technologies , demonstration & test facilities	30-50%	40/60
Pre-competitive research	50-70%	60/40
Enabling research/policy actions	70-90%	80/20

Figure 13. Selection criteria for financing instrument based on level of risk and EU added value

The total volume of research, development and demonstration projects and accompanying actions has been organised according to their position on the S-curve, in between basic research and large-scale deployment (neither of which are part of this Industry Initiative), see Table 6.

Table 8. Distribution of the project clusters based on the state of technology development. Numeration based on Annex 1. See also Annex 1 for a detailed description of the actions within each cluster.

Enabling research / policy actions	Pre-competitive research	Manufacturing technologies/ demonstration & test facilities	Market uptake/innovation/ private infrastructure
Total public funding: level: 70%-90%	**Total public funding: level: 50%-70%**	**Total public funding level: 30%-50%**	**Total public funding level: <30%**
EC/MS shares: 80/20	**EC/MS shares : 60/40**	**EC/MS shares : 40/60**	**EC/MS shares : 20/80**
EU grants, MS for relevant actions	**EU grants, MS for relevant actions**	**EU grants, MS, Equity and loans (EIB), NER-300**	**MS, Equity and loans (EIB), NER-300**
C.2Very high efficiency approaches	A.1.4.1 Equipment and product standardisation	A.1.1Wafer silicon technologies	A.3.2.2 Implementation of PV CYCLE system
C.3 Integration concepts for very high levels of penetration	A.2.1 Flat-plate PV technologies	A.1.2 Thin-film technologies	B.2.Large scale PV power plants
	A.2.2 Concentrator PV technologies	A.1.3 Concentrator PV technologies	
	A.2.3 Balance-of-System components and systems	A.1.4.2 Low-cost framing and mounting, frameless structures	
	A.3.1 Energy and materials	B.1.1.1 Power and energy management strategies and business models	
	A.3.2.1 Design-for-recycling approaches for wafer silicon, thin-film and concentrator PV	B.1.1.3 “Solar Cities” and “Solar Islands” (first phases)	
	B.1.1.2 Power and energy prediction models	B.1.2 Building integration (except B.1.2.1 Development of new multifunctional PV-based products)	
	B.1.2.1 Development of new multifunctional PV-based products	B.2.2 Research infrastructure, test facilities	
	B.3. Solar resources and monitoring		
	C.1.Ultra low cost technologies		

5.4 Budget overview

Important explanatory Note: The following tables and figures present indicative values and do not commit the mentioned parties in any way.

The budget needed to cover the core focus of the SEII during the period 2010-2012 (selected priority areas) is presented in table 5 and figure 10 and 11 (next pages). See also the explanatory note at the beginning of Chapter 5.

Table 9. Summary table: Budget breakdown for R&D & Demonstration

R&D & Demonstration cluster	Estimated total budget for 2010-2012 (M€)	Estimated public* share (%)	EC/ MS share of public funds
Cost reduction: paving the way to 2020			
Advanced manufacturing processes for cells and modules	500	30-50%	40/60
Performance enhancement & lifetime extension	100	30%	60/40
Materials development & sustainability	50	50%	60/40
System integration: paving the way to 2020			
Enabling Large scale deployment (Grid and building integration)	130	40%	40/60
Large scale PV power plants	320	<30%	20/80
Solar resources and monitoring	25	50-70%	60/40
Preparing for cost and penetration beyond 2020 levels			
Ultra low cost technologies	50	50-70%	60/40
Very high efficiency approaches	50	70-90%	80/20
Integration concepts for very high levels of penetration	10	70-90%	80/20
TOTAL	**1235**		

* Public contribution: refers to EU grants and to debt loans (100% from industry) or aided loans (in the form of for instance soft loans or loan guarantees). The definition will be given on a project by project basis (taking into account the bankability and risk associated to the project).

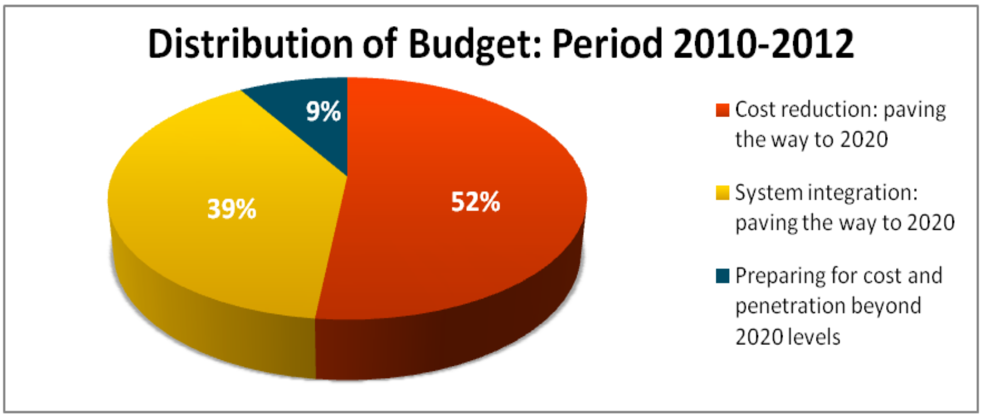


Figure 14. Distribution of budgets by categories until 2012

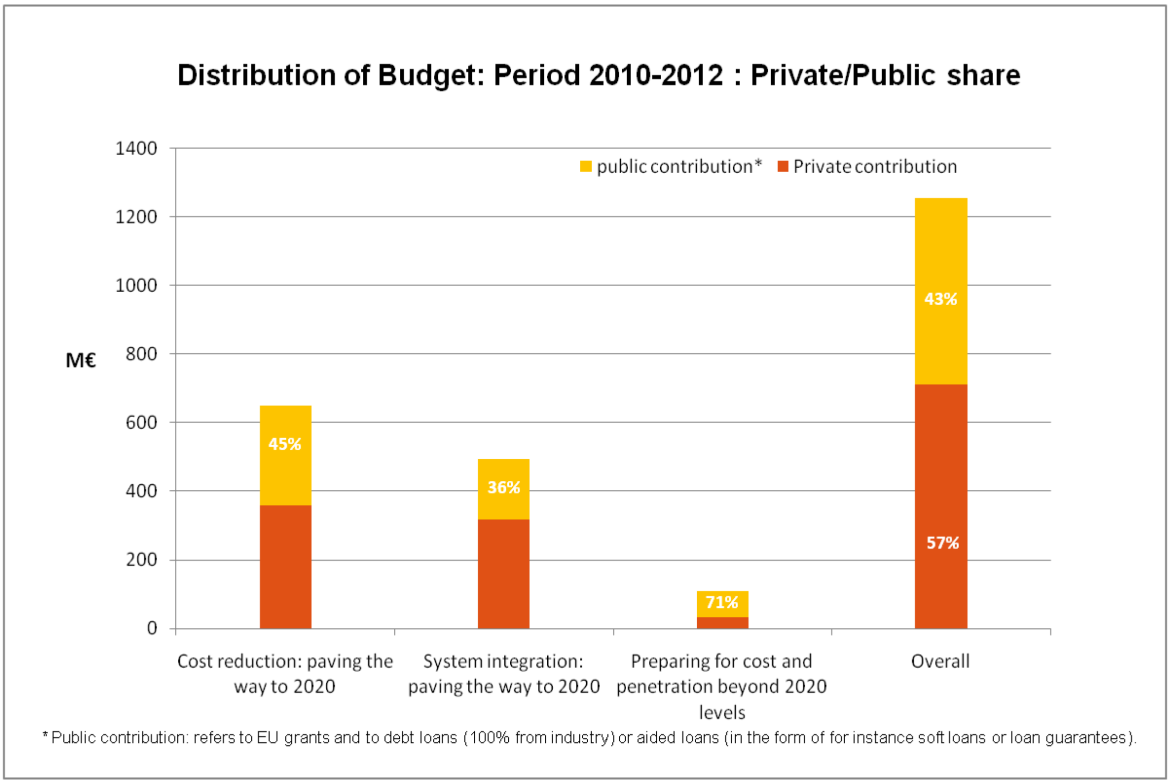


Figure 15. Private/ public share for each category projects.

Looking at the overall period (2010-2020), about 9b€ need to be invested in order to reach the SEII objectives (as communicated in the EC Technology Roadmap (SEC(2009) 1295, 7 October 2009). The distribution of the investment should follow the next trend:

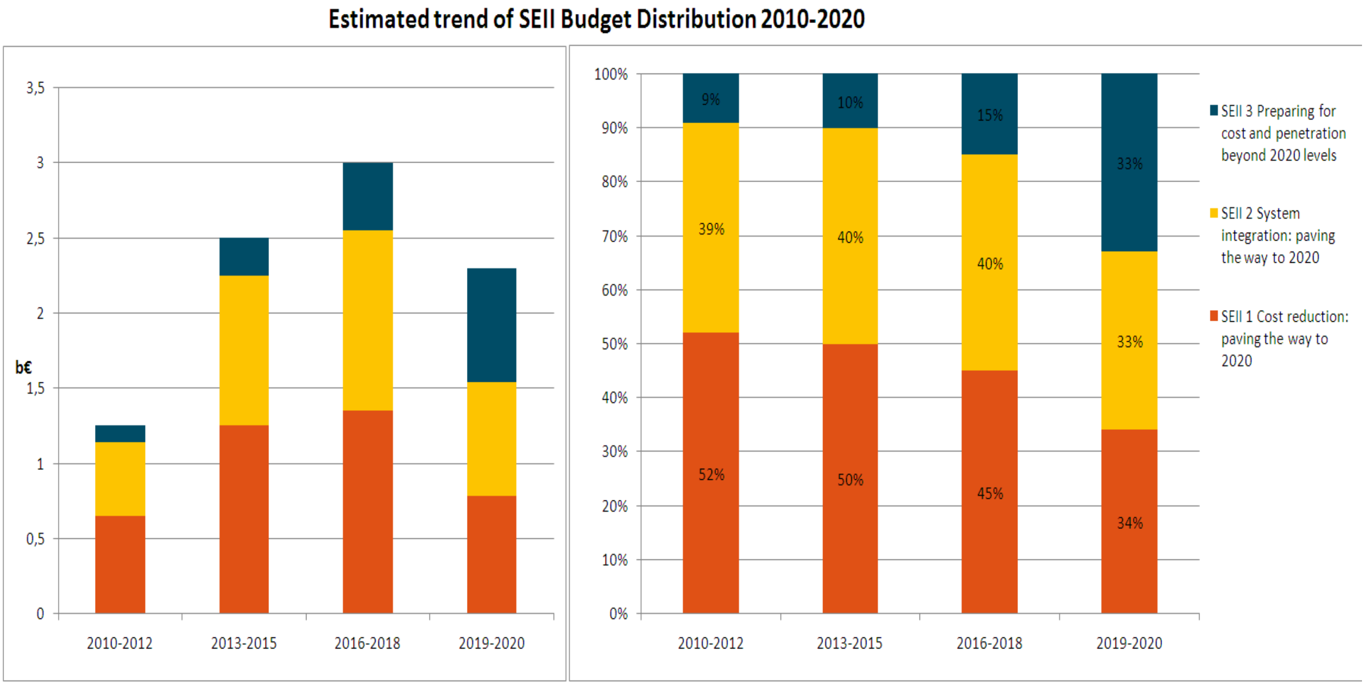


Figure 16. Distribution of budgets by categories until 2020

ANNEX 1. Detailed SEII implementation plan 2010-2012

A. Cost reduction: paving the way to 2020									
Project cluster		Estimated total budget for 2010-2012 (M€)	Estimated public contribution	EC/ MS share of public funds	Starting date (end date)	EU added Value	Level of risk	Instrument used (orientative)	Priority (1: very high, 2: high)
1.	**Advanced manufacturing processes for cells and modules**	**500**		**40/60**					
1.1	**Wafer silicon technologies**	**225**	**30-50%**	**40/60**					
1.1.1	New, low-cost & low-energy silicon feedstock technologies	50			2010	++	++	MS, loans (EIB)	1
1.1.2	Silicon crystal growth techniques for high quality and re-use of crucibles	25			2011	++	++	MS, loans (EIB)	2
1.1.3	Advanced, low/zero-loss wafering techniques for efficient materials utilisation	25			2011	+++	++	MS, Equity (EIB)	1
1.1.4	High-throughput processes for manufacturing of advanced, high-efficiency cells and modules, including integrated (wafer/)cell & module approaches and process equipment (up to 17% multicrystalline and 20% monocrystalline, on module level)	75			2010	++	++	MS, loans (EIB)	1
1.1.5	From LAB to FAB: pilot-line demonstration of (2) high-efficiency, low-cost approaches	50			2010	+++	++	FP7 (grant), Equity (EIB), MS	1
1.2.	**Thin-film technologies**	**175**	**30-50%**	**40/60**					
1.2.1	High-rate, large-area deposition processes, including process equipment and control methods (active and passive layers)	75			2010	+++	++	FP7 (grant), MS	1
1.2.2	Roll-to-roll cell & module manufacturing processes and equipment	50			2010	+++	++	FP7 (grant), MS	1

1.2.3	From LAB to FAB: pilot-line demonstration of (2) novel low-cost, high-efficiency technologies	50			2011	+++	++	FP7 (grant), Equity (EIB), MS	1
1.3	**Concentrator PV (CPV) technologies**	70	**30-50%**	**40/60**					
1.3.1	Industrial manufacturing processes for high-efficiency concentrator cells, including process equipment and control methods	25			2010	+++	++	FP7 (grant), Equity (EIB), MS	1
1.3.2	Industrial manufacturing processes for concentrator optics, including process equipment	10			2010	+++	++	FP7 (grant), Equity (EIB), MS	1
1.3.3	High-throughput, high-precision assembly technology for CPV modules	10			2010	+++	++	FP7 (grant), Equity (EIB), MS	1
1.3.4	From LAB to FAB: pilot-line demonstration of industrial manufacturing (from cell to CPV module)	25			2010	+++	++	FP7 (grant), Equity (EIB), MS	1
1.4	**Cross-cutting**	**30**	--	--					
1.4.1	Equipment and product standardisation	20	50-70%	60/40	2010	+++	++	FP7 (grants), MS	2
1.4.2	Low-cost framing and mounting, frameless structures	10	30-50%	40/60	2011	++	++	FP7 (grant), Equity (EIB), MS	2
	2. Performance enhancement & lifetime extension	**100**							
2.1	**Flat-plate PV technologies**	**40**	**50-70%**	**60/40**					
2.1.1	New low-cost, long-lifetime (typically 40 yrs) encapsulation materials and module designs	10			2011	+++	+++	FP7 (grant)	1
2.1.2	Ageing models and outdoor performance	10			2011	+++	++	FP7 (grant)	1
2.1.3	Very-high efficiency cell designs and processes (>17% multicrystalline silicon, >20% monocrystalline silicon, >12% thin-film, on module level	20			2010	+++	+++	FP7 (grant), MS	2
2.2	**Concentrator PV technologies**	**30**	**50-70%**	**60/40**					

2.2.1	Cell designs (>3 junctions), optics and thermal management for ultra-high concentration ratios (typically 2500x)	20			2012	+++	+++	FP7 (grant), MS	1
2.2.2	System designs and materials for >25 yrs lifetime	5			2010	+++	++	FP7 (grant), MS	1
2.2.3	Outdoor performance evaluation methods	5			2011	+++	++	FP7 (grant), MS	2
2.3	**Balance-of-System components and systems**	**30**	**50-70%**	**60/40**					
2.3.1	Low-cost mounting structures and electrical systems (wiring, connections, safety devices, etc.)	10			2010	+++	++	FP7 (grant), MS	1
2.3.2	Enhanced lifetime power electronics	10			2012	+++	+++	FP7 (grant), MS	1
2.3..3	Low-cost, high-accuracy tracking systems	5			2011	+++	+++	FP7 (grant), MS	2
2.3.4	Components for high-voltage (>1000 V) operation	5			2012	+++	++	FP7 (grant), MS	2
3. Materials development & sustainability		**50**							
3.1	**Energy and materials**	**30**	**50-70%**	**60/40**					
3.1.1	Exploration and development of new, low-energy processes and sustainable material alternatives	25			2011	+++	+++	FP7 (grant), LIFE+ (grant)	1
3.1.2	Life-cycle assessment of new PV technologies; implementation of improvements	5			2011	+++	++	FP7 (grant), LIFE+ (grant)	2
3.2	**End-of-life and recycling**	**20**	**--**	**--**					
3.2.1	Design-for-recycling approaches for wafer silicon, thin-film and concentrator PV	10	50-70%	60/40	2012	+++	++	Eco-innovation (CIP), LIFE+ (grant), MS	2
3.2.2	Implementation of PV CYCLE system	10	<30%	20/80	2010	+++	+	MS, loans or equity (EIB)	1

B. System integration: paving the way to 2020									
Project cluster		Estimated total budget for 2010-2012 (M€)	Estimated public contribution	EC/ MS share of public funds	Starting date (end date)	EU added Value	Level of risk	Instrument used (orientative)	Priority (1: very high, 2: high)
1. Enabling Large scale deployment		**130**							
1.1	**Grid interface**	**50**	**--**	**--**					
1.1.1	**Power and energy management strategies and business models** for high degrees of PV penetration, including development and testing of the required hardware, field tests and demonstration	25	30-50%	40/60	2010	++	++	FP7 (grants), Equity (EIB)	1
1.1.2	Power and energy prediction models including validation, for use in combination with the previously mentioned topics	10	50-70%	60/40	2011	+++	++	FP7 (grants)	2
1.1.3	The first phases of “Solar Cities” and “Solar Islands”, aimed at demonstrating the many aspects of the feasibility of large-scale use of solar energy in urban and isolated environments (see also “Building integration”)	15	30-50%	40/60	2011	+++	++	NER-300, EERP (unspent budget), Cohesion funds, EIB (JESSICA, JASPERS), CIP (ELENA), URBACT II	2
1.2	**Building integration**	**80**	**--**	**--**					
1.2.1	Development of new multifunctional PV-based products	25	50-70%	60/40	2011	+++	+++	FP7 (grants) through E2B PPP,	1
1.2.2	Research infrastructure, test facilities, and test procedures for building integrated PV (BIPV) products, in order to make innovations faster and easier	25	30-50%	40/60	2010	++	++	EU grants, MS or Equity (EIB)	1

1.2.3	Optimisation of the energy output and value in a complex environment: shadowing, demand-side management options to get the best value of the PV production (in relation to the topics listed under "grid integration")	10	30-50%	40/60	2011	++	++	FP7 (grants) through E2B PPP/CONCERTO, NER-300, EERP (unspent budget)	1
1.2.4	Further development and implementation of electrical safety requirements	5	30-50%	40/60	2010	+++	++	EU grants, MS, Equity (EIB)	1
1.2.5	The first phases of "Solar Cities" and "Solar Islands", aimed at demonstrating the many aspects of the feasibility of large-scale use of solar energy in urban and isolated environments (see also "Grid integration")	15	30-50%	40/60	2011	+++	++	NER-300, EERP (unspent budget), Cohesion funds, EIB (JESSICA, JASPERS), CIP (ELENA), URBACT II	2
2.Large scale PV power plants		**320**		**20/80**					
2.1	Realisation of large-scale CPV power plant (20MW) with tracking system	100	<30%		2011	+++	+	NER-300	1
2.2	Realisation of large-scale CIGS power plant (40MW)	120	<30%		2011	+++	+	NER-300	1
2.3	Realisation of large-scale tandem/triple junction TF silicon power plant (40MW)	120	<30%		2011	+++	+	NER-300	1
3. Solar resources and monitoring		**25**							
3.1	European "PV Monitoring centre", aimed at gathering and disseminating a variety of monitoring data and information for benchmarking, including technology, industry, market and policy aspects	15	50-70%	60/40	2010	+++	++	FP7 (grant), IEE (grant), MS	2
3.2	Development of simulation and monitoring tools (early fault detection, *Modeling and simulation of ancillary services, etc.*).	10	50-70%	60/40	2011	+++	++	FP7 (grant), IEE (grant),	1

C. Preparing for cost and penetration beyond 2020 levels									
Project cluster		Estimated total budget for 2010-2012 (M€)	Estimated public contribution	EC/ MS share of public funds	Starting date (end date)	EU added Value	Level of risk	Instrument used (orientative)	Priority (1: very high, 2: high)
1 Ultra low cost technologies		**50**	**50-70%**	**60/40**					
1.1	Advanced pilot lines (2) for ultra-low cost (printable) PV technologies	40			2011	+++	+++	FP7 (grant), MS	1
1.2	characterisation& testing, accelerated lifetime tests	10			2010	+++	++	FP7 (grant)	1
2 Very high efficiency approaches		**50**	**70-90%**	**80/20**					
2.1	proofs-of-concept (2) for very-high efficiency novel PV technologies	40			2011	+++	+++	FP7 (grant), MS	1
2.2	Modelling and characterisation	10			2012	+++	++	FP7 (grant)	1
3 Integration concepts for very high levels of penetration		**10**	**70-90%**	**80/20**					
3.1	proof-of-concept for very high levels of PV penetration	10			2012	+++	+++	FP7 (grant), MS	2