Publishable summary – M24

1.1. Summary description of project context and objectives

Today's challenges in PV

Photovoltaics (PV) is one of the most promising renewable energy technologies for Europe. In fact, PV is now, after hydro and wind power, the third most important renewable energy source in terms of global installed capacity. PV can significantly contribute in achieving the EU's 20-20-20 climate change objectives, as well as to the longer term goal of reducing greenhouse gas emissions by 80-95%, as targeted in the European Energy Roadmap 2050.
In that purpose, the European Commission has challenged the PV industry to set new, ambitious targets for 2020 as part of the Commission's Strategic Energy Technology (SET) – Plan. For this purpose the Solar Europe Industrial Initiative (SEII) and the European Energy Research Alliance Photovoltaics Joint Research Programme (EERA-PV) were launched in 2010.

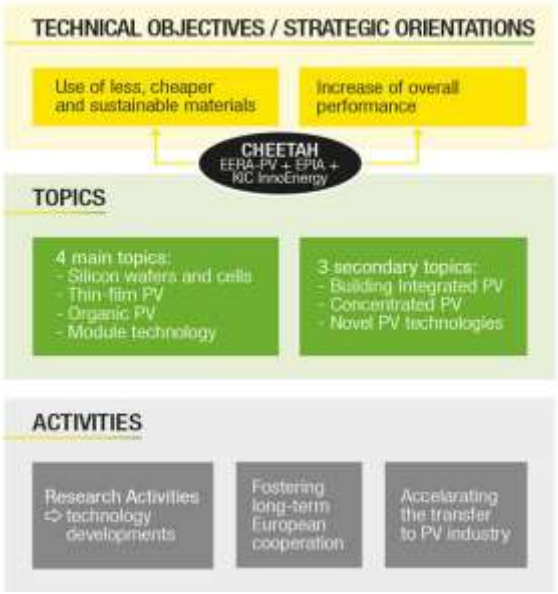
The CHEETAH project is directly linked to the EERA-PV Joint Research Program, which aims to increase the effectiveness and efficiency of PV R&D through alignment and joint programming of R&D of its member institutes, and to contribute to the R&D-needs of the Solar Europe Industry Initiative.
CHEETAH R&D will specifically support Pillar A (performance enhancement & energy cost reduction) of the SEII Implementation Plan (*http://www.eupvplatform.org/*)

Objectives

The CHEETAH objectives are threefold:
Developing new concepts and technologies for wafer-based crystalline silicon PV (modules with ultrathin cells), thin-film PV (advanced light management) and organic PV (very low-cost barriers), resulting in (strongly) reduced cost of environmentally benign/abundant/non-toxic materials and increased module performance.

Fostering long-term European cooperation in the PV R&D sector, by sharing knowledge, organizing workshops, exchanging and training researchers inside and outside Europe, providing efficient use of infrastructures, promoting best practices and standards. This is promoted through Joint Support Activities.

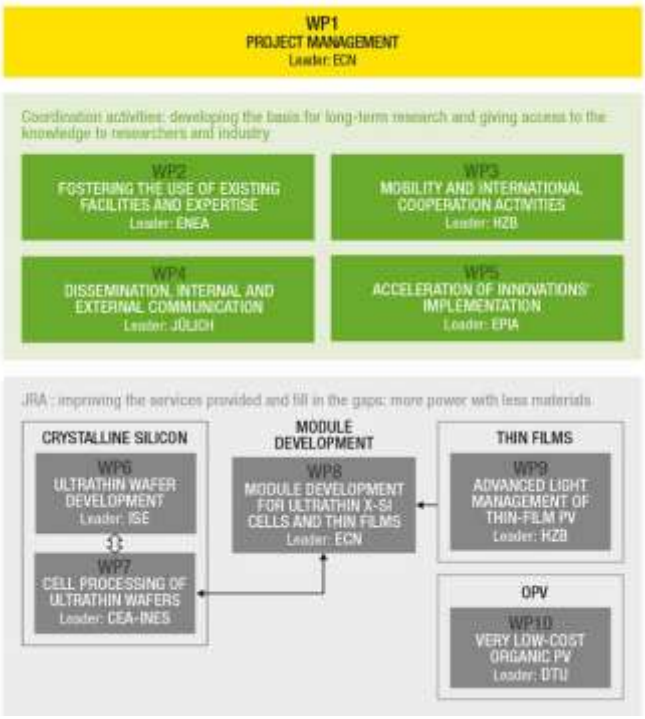
Accelerating the implementation of innovative technologies in the PV industry, by a strong involvement of EPIA and EIT-KIC InnoEnergy in this program. This is promoted through Joint Support Activities.



1.2. Description of the work performed since the beginning of the project

The Cheetah project is structured around two blocks of activities:

- **Coordination activities** (CSA): developing the basis for long-term research and giving access to the knowledge to researchers and industry (WP2, WP3, WP4, WP5)
- **Joint research activities** (JRA): improving the services provided and fill in the gaps: more power with less materials (WP6, WP7, WP8, WP9, WP10)



In the second year of the project, the following work was performed:

Coordination activities (WP2 to WP5)

- Establishment and elaboration of an open CHEETAH knowledge sharing web area called CHEETAH KEAP (http://www.cheetah-exchange.eu) containing a large database of available expertise, research infrastructure and a complete e-learning platform to offer lectures, courses and remote on-line experiments, on-line forum/fora and on-line poll to foster any internal/external technical/scientific discussions on specific themes (WP2);
- Identification of technical-scientific needs of European PV RTD Sector at project and non-project partners via extensive questionnaire/inventories (WP2);
- Identification and implementation of joined coordinative and support actions related to infrastructure use and mobility exchange (training, education) (WP3);
- Organization of research exchanges, summer schools and training workshops (WP3);
- Dissemination of project results via scientific conferences, peer reviewed and dedicated CHEETAH workshops (WP4);
- Two public reports consisting of an analysis of the cost reduction potential of the PV technology in general and a prelimnary cost assement of some selected CHEETAH innovations (WP5, WP6, WP7, WP8)
- Evaluation of shortcomings and future requirements to facilitate the commercial exploitation (e.g. guidelines for standards for new PV technologies) (WP5).
- Organization of two public dedicated CHEETAH dissemination workshop events at EUPVSEC (September 2015) and in Freiburg (January 2016) (WP4, WP5)

Joint research activities (WP6 to WP10)

- X-Si (WP6 to WP8)

Development of processes for preparing release layers, epitaxial thickening and layer release resulting in thin epitazially (EPI) grown Si wafers Development of processes to integrate thin wafers into cells and mini-modules to demonstrate technical feasibility

- For the preparation of release layers an etching process for porous silicon was developed on a large area tool with a detachment yield of 80% (WP6)
- For the epitaxial thickening and layer release the ProConCVD process have been adapted resulting in a succesfull detachment of a few 40 µm Si wafers with a size of 100 x 100 mm^2 (WP6)
- First solar cells have been succesfully produced on 35 microns epifoils (best cell: 15,3% eff) (WP6, WP7)
- First solar cells (HIT type) have been produced on thin wafers on a industrial pilot line (best cell: 20,6% eff for 97 microns) (WP7)

- First IBC solar cells have been produced on 5 cm x 5 cm area (best cell 20.56% eff for 140 microns) (WP7)
- A selection of encapsulant/back sheet combinations suitable for application in modules based on thin cells < 120 microns have been made based on accelerated lifetime tests (WP8)
- First working IBC minimodules have been manufactured with <120 micron thick IBC cells without detection of cracks (WP8)
- Thermomechanical modelling for the prediction of thermomechanical stresses
-

Execution of a benchmark Life cycle analyis study for x-Si technologies

- An indicative cost assessment was made for thin wafer based x-Si technology revealing the cost reduction potential of using thinner Si wafers (WP6, WP7, WP8)

- Thin films (WP9, WP8):

Further R&D on advanced light management solutions and modelling for mircoconcentrator CIGS cells and thin film Silicon based on Liquid Phase Crystallization of thin film Silicon

- Several advanced thin films device structure (LPC thin film Silicon and CIGS microconcentrator cells) and light management strategies (FIB nanomachning, concentrator designs) have been investigated supported by an advanced modelling and characterization platform. A 22.5 % CIGS microcontrator was achieved at 77 suns on a 0.144 mm² cell using the innovative approaches (WP9)

Development of low cost Encapsulation and interconnection designs for advanced thin film concepts

- OPV (WP10)

Establishing link between intrinsic and extrinsic stability of devices and effect of different barrier materials on device lifetime, establishing metrics for 10 photoactive materials and devices, Production of barrier layers on folis ann directly onto devices utilizating of slow rate sputtering

- Improvement in stability of unencapsulated devices was achieved via substituted hole transport layers (WP10)
- Flexible barriers based on organic/inorganic layer combinations were developed for packaging of organic solar cells (WP10)

- Lifecycle assessment model was developed for estimating the cost of organic solar cells built with various layer compositions (WP10)

1.3. The expected final results and their potential impact and use

As mentioned under the objectives, the technology developments within CHEETAH should lead to the realization of innovative and competitive PV concepts with a significant reduction in cost of materials and increase of the overall performance. These innovative developments should lead to a contribution to an accelerated implementation in the European PV industry, so that Europe can regain and build up own manufacturing capacity in all parts of the value chain in due time.

In addition, the establishment of an effective collaborative platform for the PV R&D sector via the coordinative support actions in CHEETAH will help Europe in realizing these goals.

1.4. Consortium and contact information

Coordinator

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Partners

1. ECN, Stichting energieonderzoek Centrum Nederland, Netherlands
2. CEA-INES, Commissariat à l'énergie atomique et aux énergies alternatives, France
3. Fraunhofer, Fraunhofer Gesellschaft zur Foerderung der angewandten forschung e.v, Germany
4. DTU, Danmarks Tekniske Universitet, Denmark
5. Helmholtz-Zentrum Be, Helmholtz-Zentrum Berlin fur materialien une energie GmbH, Germany
6. Jülich, Forschungszentrum Juelich GmbH, Germany
7. AIT, Austrian Institute of Technology GmbH, Austria
8. ENEA, Agencia Nazionale per le nuove technologi, l'energia e lo svilippo economico sostenibile, Italy
9. EPFL, Ecole Polythechnique Fédérale de Lausanne, Switzerland
10. IFE, Institutt for Energiteknikk, Norway
11. Forschungsverbund Be, Forschungsverbund Berlin E.V, Germany
12. IMEC, Interuniversitair Micro-electronica Centrum VZW, Belgium
13. NPL, NPL Management Limited, United Kingdom
14. SINTEF, Stiftelsen SINTEF, Norway
15. Tallinna Tehnikaulik, Estonia
16. ZSW, Zentrum for Sonnenenergie und Wasserstoff Forschung Baden Wurttembergstiftung, Germany
17. LNEG, Laboratorio Nacional de Energia e Geologia I.P, Portugal
18. TOR VERGATA, universita Degli Studi di Roma Torvergata, Italy

19. METU, Middle East Technical University, Turkey
20. TECHNALIA, Fundacion Technalia Research & Innovation, Spain
21. UPM, Universidad Politecnica de Madrid, Spain
22. CENTRO DE INVESTIGAC, Centro de Investigaciones Energeticas, Medioambbientles y Technologicas CIEMAT
23. CRES, Center for Renewable Energy Sources and Savings, Greece
24. LU, Loughborough University, United Kingdom
25. EMPA, Eidgenoessische Materialpruefungs und Forschungsanstalt, Switzerland
26. Imperial, Imperial College of Science, Technology and Medicine, United Kingdom
27. JRC, Joint Research Centre - European Commission, Belgium
28. TUBITAK, Turkiye Bilimsel ve Teknolojik Arastirma Kurumu, Turkey
29. VTT, Teknologian Tutkimuskeskus VTT, Finland
30. UPVLC, Universitat Politecnica de Valencia, Spain
31. UNIMIB, Universita' Degli Studi di Milano-Bicocca, Italy
32. EPIA, European photovoltaic Industry Association, SolarPower Europe Belgium
33. KIC SE, KIC Innoenergy SE, Netherlands
34. Alma Consulting Group SAS, France

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