EC Grant Agreement n°609788

CHEETAH

Cost-reduction through material optimisation and Higher EnErgy outpuT of solAr pHotovoltaic modules - joining Europe's Research and Development efforts in support of its PV industry

Deliverable

D5.6 - Mid-term public event for disseminating the cheetah results – Report on transfer of knowledge activities to industry and the PV community (minutes)

WP5 – Acceleration of innovations' implementation

Section 1 – Document Status

Document information

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Document validation

Name	Organisation	Date	Visa
Ioannis Thomas Theologitis – WP5 leader	SolarPower Europe	23/12/2015	OK
Jan Kroon - Coordinator	ECN	15/12/2015	OK

Document history

Version	Date	Modifications	Name
1	23/12/2015	First draft	Ioannis Thomas Theologitis
2	15/12/2015	Review	Jan Kroon
3	25/01/2016	Input from partners included	Ioannis Thomas Theologitis
Final	25/01/2016	Final Validation	Jan Kroon

Section 2 – Table of content

Section 3 – Acknowledgements

On behalf of the project consortium the organizers of the Cheetah mid-term event would like to extend sincerest thanks and appreciation to those who registered, participated and contributed with their inputs or questions to the event. Your interest and active involvement was rather beneficial for the realization of a successful event but moreover for the successful continuation of the Cheetah project.

Special thanks to the project coordinator, the expert speakers, the moderators and the expert panelists on behalf of the industry whose involvement was key for the event.

Last but not least, this work wouldn't have been realized at this level of quality without the support of the Funding Authority, the European Commission and the guidance of the Project Officer.

The event took place during the 31st European PV Solar Energy Conference and Exhibition (EU PVSEC) in Hamburg 16th September 2015.

Section 4 – Introduction

This report includes the main highlights (minutes) from the mid-term public event of Cheetah project that was organized on September 16th 2015 in Hamburg, Germany during the 31st European PV Solar Energy Conference and Exhibition (EU PVSEC). The event was titled as: ***"Europe's Research and Development efforts in support of its PV industry"***.

The objective of the event was twofold:

- Disseminate the project results - up to that date - to the public, present the tasks of the project, focusing more on the research activities and expose the future plans and actions towards the main objectives of Cheetah project.
- Discuss the progress of the project with experts outside the consortium from the research community but also from the industry community. The purpose was to run an unofficial public consultation and receive feedback and guidance from external research partners that possibly conduct similar analysis and from the industry community which will include the cost and business parameter (reality check) in our activities.

The target group of the event was mainly researchers and academics working on the solar PV field as well as the industry in an attempt to sustain the links between research and industry community strong.

The event was organized in three main sessions as those are presented in section 8 of this report. Session 1 focused on more global aspects of Cheetah project and its objectives, session 2 dived into more details on the different research activities of the project while session 3 addressed the challenges, the business feasibility and the possible exploitation of Cheetah innovations in due time.

This report mainly summarizes the key highlights of the event focusing more on table discussions of session 3 (reported here in Section 6).

The participation reached around 75 to 80 experts (including the consortium partners) with most of them being researchers and academics.

All presentations – part of the event's proceedings - can be found here.

The agenda of the meeting, the list of participants as well as a small collection of representative pictures fromt event are attached at the end of this report. *The list of participants is not exhaustive*.

Section 5 – Event minutes

- The workshop started on time at 13:15 following up half an hour of registration process
- The workshop started with some welcoming and logistical notes from organizers and then the Project Coordinator (PC) and moderator of the first session were invited to welcome the participants and kick off the event. The agenda of the day was quickly presented.
- The event continued with a short presentation from the Project Officer (PO) on behalf of the European Commission who provided some context regarding integrated research programs, the SET-Plan, EERA and then how Cheetah fits within all these initiatives. Objectives and challenges were summarized *(Ref: CHEETAH – Integrated research programme in the field of photovoltaics)*.
- The PC continued with a more detailed presentation on the project and its activities. Information about the funding, the duration, the consortium, the work structure, the objectives as well as the main innovations to be brought by the project were also presented. More information can be acquired by the relevant presentation *(Ref: Cost-reduction through material optimization and Higher EnErgy outouT of solAr pHotovoltaic modules).*

  A special reference was made on the project website where one can track all abovementioned information but also the Cheetah Knowledge Exchange Area Portal (KEAP) which is an excellent platform to collect and share available expertise, information about infrastructure or any information around solar photovoltaic research (e.g. technical documents, courses, webinars etc.)
- Session 1 was finalized with a presentation from SolarPower Europe on the potential for further solar PV cost reduction and the impact that research activities have on it. The presentation was based on an ongoing work that will continue during the first part of 2016 and the more theoretical part was presented. The Learning curve concept and some Levelised Cost of Electricity (LCOE) results were presented. The methodology to assess main Cheetah innovation in terms of their cost impact was also discussed. However, the assessment is an ongoing task.

  This stream of work supports one of the main objectives of the Cheetah project which is developing new concepts which will also reduce the cost of the final product or/and accelerate the implementation and adoption by the industry – which is directly linked with cost and business matters.
- Session 2 followed directly after SolarPower Europe's presentation. Session 2 was only dedicated to the research activities of the project. The respective leaders presented the activities of their work package focusing on the objectives, current results and upcoming challenges. All the presentations can be found here under the title: *Session II: CHEETAH Research Activities – Significant efforts on all technologies.* The presentations are clustered as below:

- Highlights on the silicon based technologies – From **ultrathin wafers** to **module development** - Pierre-Jean Ribeyron, CEA INES • Paul Sommeling, ECN
- Advanced techniques in **Thin Film** and **Organic PV** - Martina Schmid, Helmholtz – Berlin • Suren Gevorgyan, DTU

Before the end of Session 2 and the coffee break, the organizer explained the "discussion tables" concept with the participants.

- Session 3 started on time after the coffee break. The table discussions included 3 thematic tables on c-Si, Thin Film and Organic technologies respectively. More details about Section 3 are reported in the next section.

- Following some good exchanges during the table discussions, the event continued with the plenary discussion panel. The moderator allowed first for a quick presentation of the highlights from each thematic table – by the moderator of each table - which was also used to feed in the discussion with the industry representatives.

  The main title of the discussion was: *"Reality check – How can our industry benefit from Cheetah innovations".* The panelist represented the industry working on equipment manufacturing and materials. Their replies were generally for research efforts with lower TRL and not immediately commercially applicable – what Cheetah project represents.

  Main outcomes from the panel discussion:

  - The very competitive environment doesn't facilitate the "blind" adoption of new technologies and innovations unless those can prove that there is a strong impact of cost reduction by keeping the efficiency and quality at high levels. The cost for incorporating new innovations should be considered too (e.g. change in processes, equipment, material etc.)

  - The industry though remains available to participate to promising research activities besides the fact that some players run their own research programs sometimes in partnership with external institutions. However, the innovations should be carefully explored (its economic impact) and that takes time and money.

  - In this challenging time, short term applicable solutions are important – maybe more important than longer term suggestions.

  - There are different and multiple research activities from different programs and authorities. What is important for Europe at this stage is to consolidate the efforts and focus on areas where added value can be created – where it can be competitive. Collaborative research can support that.

  - Innovation and quality have always been Europe's value propositions.

- Research innovations and relevant technology developments should be linked with specific applications – therefore it is important to keep the dialogue between the industry and the research community open, especially with big strategic player.

- The event ended on time with some closing remarks, thanking the participants and experts who contributed and inviting everyone for a short networking drink where the relevant discussion continued.

Section 6 – Discussion Points

The first part of Session 3 was organised to hold 3 separate table discussions split in 3 different thematic: one focusing on c-Si, one on Thin Film (TF) and one on Organic PV (OPV) technologies. The objective was to stimulate discussions among different experts – not necessarily experts on these particular technologies – and share views on challenges, barriers, solutions with a view to further development and exploitation.

Therefore, a set of questions was prepared in advance with the support of Cheetah experts (work package leaders) to facilitate the discussions. The set of questions that is presented below was created only as an **example** and consisted of some specific per technology questions but also some generic and cross cutting questions relevant for all different technologies. Due to time constraints and specific moderator's and participants' interest/focus on its discussion table, it was not possible to address all questions with the same level of detail. However, the discussion flow was sufficient under the circumstances.

1. Example set of questions that was shared with the experts

For the c-Si table

- What do people see as important technology innovations that should be pushed forward in order to realize further cost reduction and consequently increase the competitiveness?
- Are very thin silicon foils still the way to go? (now that several start-up companies go for thick epi-wafers)
- What are the most important barriers that prevent industry to switch to new advanced potentially lower cost concepts like HIT, Back Contact (MWT, IBC)?
- Is handling of 50um thick foils in an industrial line feasible?
- What are the main drivers today for the industry that has a short term focus and how should the R&D sector follow?

For the Thin Film table

- How could thin films PV technology stand out and compete with c-Si? Consider technologies, potential in Europe and applications
- How can we obtain maximum efficiency (by which combination of concepts)? Are we aiming at maximum efficiency or rather at maximum energy yield?
- How to realize thermal management for high efficiency thin-film concepts?

- What do people see as important technology innovations that should be pushed forward in order to realize further cost reduction and consequently increase the competitiveness?
- What are the main drivers today for the industry that has a short term focus and how should the R&D sector follow.

For the OPV table

- Where the investments should be focused on for OPVs? Materials, testing equipment, manufacturing equipment, systems installations, demonstrations?
- How to boost the relation between industry and researchers in OPV field – how to collaborate for Horizon2020?
- What do people see as important technology innovations that should be pushed forward in order to realize further cost reduction and consequently increase the competitiveness?
- What are the main drivers today for the industry that has a short term focus and how should the R&D sector follow?

2. Main highlights by the experts

Feedback from the c-Si table

- Where the investment should be focused on for c-Si?
    - Screen-printed c-Si has advanced very far, much further than people expected. So if improvements are possible by incremental changes that are easy to implement without large investments one should do that.
    - Efficiency is a critical parameter
    - To really lower the costs of Si we have to consider other types of Si (for example foils)
    - The point of view of a factory owner is totally different from the view of an investor setting up a new production line

- What are the barriers?
    - Big investments needed
    - High risk
    - Big producers are at 5 GW/yr, a scale so large that it is very hard to be ever competitive. Even for better products this is a deterrent factor - very difficult to introduce new things apart from innovations on the incremental improvement level.

Feedback from the Thin Film table

- What are the Barriers/Requirements?
    - CdTe has lowest costs and good efficiency levels, but the availability of Te might be problematic or critical especially if recycling processes and rates don't increase or become even more efficient. On the other hand Cd is considered a hazardous material (Restriction of Hazardous Substances Directive 2002/95/EC) and this might be considered restrictive too in the future, although PV panels are not included under the abovementioned directive.
    - LCOE becomes more important => BOS important => high efficiency, high productivity in certain climates, long lifetime, and/or markets with €/m² or aesthetics like special BIPV
    - Economies of scale are an issue (high investment barrier in thin film technology equipment), large fraction of module price determined by equipment cost.
    - No lobby for thin film, many companies develop different technology (absorber and process) – however, it was mentioned that a white paper on CIGS was recently prepared.

- What are the advantages?
    - Modules: Flexible substrates, lightweight, arbitrary shape possible
    - Processing: Roll to roll production might reduce cost, fully automated processes with few sample handling steps.
    - Low CO2-footprint, lowest energy payback time
    - No wafers => no hidden cracks in the modules that cause fast failure
    - Thin film technology is the most flexible and the most sustainable.

Feedback from the OPV table

- Where the investment should be focused on for OPV?
    - There are two issues that need to be addressed: no market and no market-ready products. Competition with x-Si PV for power applications currently makes no sense due to the lower performance of OPV. One should first develop products for niche markets that cannot be served by x-Si, based on unique properties of OPV (such as tunable absorption or mechanical flexibility).
    - In due time, OPV may be a candidate for power applications if the performance of OPV devices has improved substantially. To this end, new materials are required with better absorption properties. Investments should be focused on materials development (functional polymers, perovskites etc.).

- How to boost the relation between industry and researchers in OPV field –how to collaborate for Horizon2020.
    - Collaboration of researchers with material manufacturers/suppliers has to be further stimulated and enhanced in order to develop new materials with better performance than the current OPV materials.
    - To develop the OPV industry emphasis should be given to OPV demonstrators, building on the unique properties of OPV, for e.g. BIPV, automotive, digital additive manufacturing and portable Internet of Things applications.
- What do people see as important technology innovations that should be pushed forward in order to realize further cost reduction and consequently increase the competitiveness?
    - Look at unique properties of OPV for applications that cannot be readily served by other PV technologies, e.g. mechanical flexibility, roll-to-roll fabrication, tunable optical properties, semitransparency (for BIPV applications), very short energy payback time, lightweight, low cost for OPV installations, low environmental footprint.
- What are the main drivers today for industry that have short term focus and how should the R&D sector follow?
    - Restoring profit margins, and having differentiating technology. R&D sector should develop devices for applications based on unique properties of OPV, see above.

Section 7 – Agenda of the event

CHEETAH

Europe's Research and Development efforts in support of its PV industry

Cost-reduction through material optimisation and higher Energy output of solar photovoltaic modules

Hamburg, Germany, 16th September 2015 (13:00 – 16:45)
CCH - Congress Centre Hamburg (EU PVSEC 2015) – Hall 7 on the first floor

Event organised by: SolarPower Europe

Supported by: EU PVSEC 2015

13:00-13:15	**Registration & Welcome coffee**	
Session I: CHEETAH – Strategically supporting the PV industry		
	Moderator: Jan Kroon, ECN and Project Coordinator	
13:15-13:30	Welcome notes from the European Commission	*Maria Getsiou, European Commission and Project Officer (tbc)*
13:30-14:00	The CHEETAH project – Halfway through our goals	*Jan Kroon, ECN and Project Coordinator*
14:00-14:15	Towards further solar PV cost reduction – Impact of research innovations	*Ioannis Thomas Theologitis, SolarPower Europe*
Session II: CHEETAH Research Activities – Significant efforts on all technologies		
	Moderator: Kris Van Nieuwenhuysen, imec	
14:15-14:40	Highlights on the silicon based technologies – From ultrathin wafers to module development	*Pierre-Jean Ribeyron, CEA INES • Paul Sommeling, ECN*
14:40-15:00	Advanced techniques in Thin Film and Organic PV	*Martina Schmid, Helmholtz – Berlin • Suren Gevorgyan, DTU*
15:00-15:15	**Coffee break**	
Session III: Assessing the CHEETAH innovations – What is the way ahead?		
15:15-16:00	Discussion tables split 3 main thematics (c-Si, TF, OPV) – discuss challenges, ways forward and relevance to the European PV industry	*Experts will discuss on a predefined set of questions and topics that are relevant with CHEETAH – A moderator per table is assigned*
16:00–16:30	Plenary Panel Discussion ***Topic:** Reality check - how can our industry benefit from CHEETAH innovations?* ***Moderator:** Nigel Taylor, European Commission JRC*	***Panellists:** Jan-Marc Luchies, R&D Director, Tempress • Ian Bennett, Senior System Specialist PV Solar, DSM*
16:30	Closing remarks	*Jan Kroon, ECN and Project Coordinator*
16:45	**Networking drink**	

The project has received funding by the Seventh Framework Programme for Research and Technological development of the European Union (FP7/2007-2013) under grant agreement n° 609788

CHEETAH

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CHEETAH project

Cost-reduction through material optimisation and Higher EnErgy outpuT of solAr pHotovoltaic modules - joining Europe's Research and Development efforts in support of its PV industry

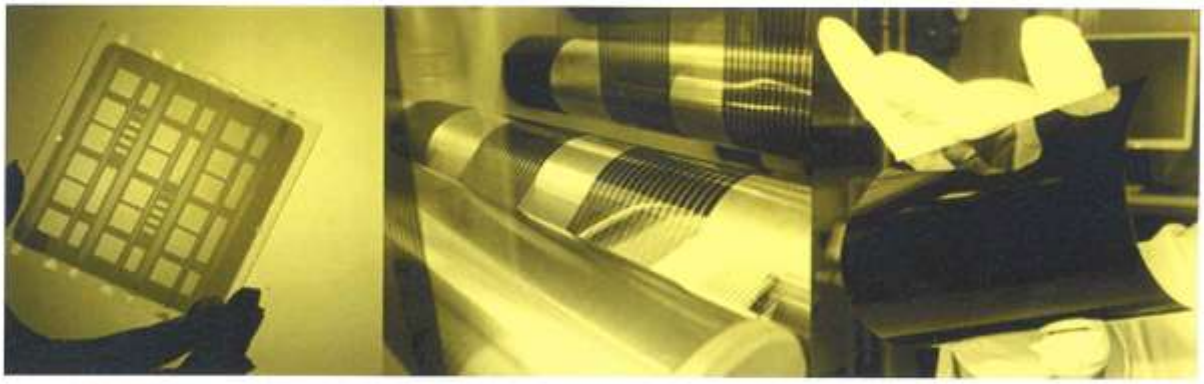
CHEETAH is a combined collaborative project (CP) and coordination and support action (CSA) funded under the European Commission's 7th Framework Programme. CHEETAH's aims to solve specific R&D issues in the EERA-PV Joint Program and to overcome fragmentation of European PV R&D in Europe and intensify the collaboration between R&D providers and industry to accelerate the industrialization of innovations.

With 16 nationalities represented in the consortium, CHEETAH's ambition is to develop technology and foster innovative manufacturing capabilities and photovoltaic products so that Europe can develop its technological and industrial capacity in all parts of the value chain.

CHEETAH's objectives for the first 4 years of the program 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, exchange and training researchers inside and outside Europe, efficient use of infrastructures, promoting best practices and standards
- Accelerating the implementation of innovative technologies in the PV industry, by a strong involvement of EPIA and EIT-KIC InnoEnergy in this program

For more information:
www.cheetah-project.eu



The project has received funding by the Seventh Framework Programme for Research and Technological development of the European Union (FP7/2007-2013) under grant agreement n° 609788

Section 8 – Attendance list

Winfried Hoffmann ASE

Simon Boddaert CSTB

Europe's Research and Development efforts in support of its PV industry

16th September 2015, 13:00 - 16:45

Room 7 CCH Congress Centre Hamburg

Rasit Turan METU - GUNAM

Takashi Ohigashi RTS Corp.

CHEETAH

Attendance list

First Name	Last Name	Company	Attendance
Sofia	Arancon	WIP	PRESENT
Ya Brigitte	Assoa	CEA INES	
Andreas	Beinert	Fraunhofer Institute for Solar Energy Systems ISE	
Michail	Beliatis	DTU	
Stephanie	Betz	WIP Renewable Energies	
Matteo	Biancardo	Plougmann & Vingtoft	
Julio	Carabe	CIEMAT	
Julien	Couderc	IPVF - EDF R&D	
Klaus	Eberhardt	M+W Group	
Gabriele	Eder	OFI	
Adel	El Gammal	Becquerel Institute	
Ahmed	Ennaoui	QEERI	
Sermet	Eray	Hacettepe University	
Aynur	Eray	Hacettepe University	
Suren	Gevorgyan	Technical University of Denmark	
Josef	Haase	centrotherm photovoltaics AG	
Jukka	Hast	VTT Technical Research Centre of Finland	
Reiner	Klenk	Helmholtz-Zentrum Berlin	
Lejo Joseph	Koduvelikulathu	ISC Konstanz	
Keiichi	Komoto	Mizuho Information & Research Institute	
Tuomas	Korvenkangas	Luvata	
Johannes	Kroon	ECN Solar Energy	
Iver	Lauermann	HZB	
Inaki	Legarda Ereno	Mondragon Assembly S. Coop.	
Xianzhong	Lin	Helmholtz-Zentrum Berlin	
Barrovecchio	Luc	ENGIE	
Martha Ch.	Lux-STeiner	Helmholtz-Zentrum Berlin (HZB)	
Maider	Machado	Tecnalia	
David	Maguire	BNRG Renewables	
Katharina	Mangold	greateyes GmbH	
Antonio	Marti	Universidad Politecnica de Madrid	
Espen	Olsen	NMBU	
Riccardo	Po	Eni spa	
Subramanyam	Ratakonda	Ratakonda Energy Systems UG	
Markus	Rees	Eppstein Technologies GmbH	

Wilhard Wiesmann ZSW

Carlos del Cañizo Instituto Energía Solar - UPM

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Europe's Research and Development efforts in support of its PV industry
16th September 2015, 13:00 – 16:45
Room 7 CCH Congress Centre Hamburg

CHEETAH
Attendance list

Franz	Baumgartner	ZHAW baut@zhaw.ch
LARS	PODLOWSKI	FIRST SOLAR
Roberto	Rivas	Sika Services AG
Francesco	Roca	ENEA Energy Tchnologies Departement
Eduardo	Roman	TECNALIA
Ingrid	Romijn	ECN
Rune	Søndenå	Institute for Energy Technology
Andrea	Scaccabarozzi	University of Milano Bicocca
Martina	Schmid	Helmholtz-Zentrum Berlin
Joao	Serra	University of Lisbon
Emilien	Simonot	KIC InnoEnergy
Paul	Sommeling	ECN
Wim	Soppe	ECN - Solliance
Wolfgang	Storm	Wacker Chemie AG
Nigel	Taylor	European Commission JRC
Marko	Topic	University of Ljubljana
Stathis	Tselepis	CRES
~~Kris~~	~~Van Nieuwenhuysen~~	~~imec, v.z.w.~~
Jan	Vandesande	janCONSULT
Eero	Vartiainen	Fortum
Sjoerd	Veenstra	ECN - Solliance
Alessandro	Virtuani	SUPSI
Alberto	Visentin	European Patent Office
Karsten	Wambach	Wambach-Consulting
Ingrid	Weiss	WIP-Renewable Energies
Florian	Wessendorf	VDMA Photovoltaic Equipment
Wolfram	Witte	ZSW
Paul	Wyers	ECN
Nicolas	Wyrsch	EPFL
Maria	Getsioni	EC
Myrto	Papoutsi	SolarPower Europe
Ioannis-Thomas	Thedoridis	SolarPower Europe
Pierre-Jean	Ribeyron	CEA INES
Jan-Marc	Luches	Tempress
Franco	Traverso	Meyer Burger
Ian	Bennett	DSM
JÜRGEN	HÜPKES	JÜLICH FORSCHUNGSZENTRUM
Kris	Van Nieuwenhuysen	IMEC
Armin	ABERLE	SERIS
Philippe	MALBRANCHE	CEA - INES
IVAN	GORDON	IMEC

Section 9 – Pictures