

# CPV-15

15<sup>th</sup> International Conference on  
Concentrator Photovoltaic Systems

March 25-27, 2019



Fes, Morocco

**PROGRAM**

[www.cpv-15.org](http://www.cpv-15.org)



# Program Overview

	Monday March 25, 2019	Tuesday March 26, 2019	Wednesday March 27, 2019	
08:00		Concentrator Cells	Optics for CPV	08:00
10:00		Coffee Break	Coffee Break	10:00
10:30		Invited Speaker	Invited Speaker	10:30
11:00		Sponsor Presentations	Panel discussion on trending CPV applications	11:00
12:00	Registration & Media Upload			12:00
12:30		Lunch	Lunch	12:30
13:00	Welcome / Introduction			
13:15				
13:30	Plenary	Applications on the Rise	Hybrid Architectures	13:30
15:15				
15:30	Coffee Break	Coffee Break	Closing Session	15:30
15:45				
16:00	Progress on CPV modules	CPV Systems & Field Experience	Technical Tour 1	16:00
17:30				
18:00	Poster Session			18:00
18:30		Bus to Dinner		18:30
19:00		Conference Dinner		19:00

## Table of Contents

Program Overview .....	2
Chairmen’s Message .....	4
Committees .....	6
Scientific Program	
Monday, March 25, 2019 .....	8
Tuesday, March 26, 2019 .....	14
Wednesday, March 27, 2019 .....	18
IEC TC82 WG7 Spring Meeting .....	22
Conference Dinner .....	24
Technical Tours .....	25
General Information .....	26

To get the latest version of the scientific program on your cell phone please scan the QR-code or enter the URL:

<https://cms.cpv-15.org/program/>



## Chairmen's Message

Since the story of CPV-x conferences started in 2002, a long way of development has been covered and there is still some to go. The PV environment is changing very fast, as is the CPV environment. Some may see uncertainty where others see great potential. However, there is one thing that is reliable in the CPV world: its strong community.

On behalf of the Chair Committee, it is our honor to welcome you to the 15th International Conference on Concentrator Photovoltaic Systems (CPV-15) in Fes.

For the first time in its history, the CPV-15 conference is being held on the African continent. Morocco is the first country hosting this event as it is one of the leaders in renewable energies in Africa, and therefore is one of the most obvious choices of location for CPV. This high DNI country became CPV industry's center of interest a few years ago. In 2016, Morocco hosted the COP22 as a testimony of its involvement in the international commitment for a better environment and has adopted a clear and non-reversible policy of development of renewable energies in Morocco (PV, wind and hydro-energy).

Two specialized agencies have been set up, IRESEN and Masen, to sustain the development and deployment of renewable energies.

The host region, Fes-Meknes, houses two public and two private universities. It is an agricultural, sunny and very touristic region. At Fes, the University Sidi Mohammed Ben Abdellah welcomes the CPV-15 conference. It is one of the huge universities in the country and decided, among the priorities and strategic researches axis, to put a pole of sustainable development and renewable energies. The Laboratory for Renewable Energies and Smart Systems, led by Prof. Ali Ahaitouf, is one of the players in this pole and he is developing some projects on CPV systems.

The city of Fes welcomes participants with the well-known Moroccan hospitality in the ancestral traditions inherited from civilizations that passed through it and lived there. Fes is one of the five imperial cities, known as the spiritual capital of the kingdom. Also at Fes, there is Al Quaraouiyine University, the oldest existing, continually operating and the first degree-awarding educational institution in the world according to UNESCO.

This is the global landscape in which the CPV-15 conference takes place. Highlights of the conference will include presentations on state-of-the-art CPV components, trackers, and installations.

Welcome to CPV-15! We wish you a successful conference and an enjoyable stay in Fes!



Mathieu Baudrit  
Scientific Chair of CPV-15  
Sono Motors, Munich



Prof. Ali Ahaitouf  
Conference Chair of CPV-15  
Faculté des Sciences et Techniques  
Université Sidi Mohammed Ben Abdellah, Fès



## Committees

### Scientific Chair

Mathieu Baudrit, Sono Motors, Germany

### Conference Chair

Ali Ahaitouf, Université Sidi Mohammed Ben  
Abdellah, Morocco

### Chair Committee

#### Chair Committee Chair:

Andreas Bett, Fraunhofer ISE, Germany

Mathieu Baudrit, Sono Motors, Germany  
Karin Hinzer, University of Ottawa, Canada  
Ignacio Antón, Universidad Politécnica de Madrid,  
Spain  
Ali Ahaitouf, Université Sidi Mohammed Ben  
Abdellah, Morocco

### Technical Program Committee

#### Program Chair:

César Domínguez, Universidad Politécnica de Madrid,  
Spain

Ali Ahaitouf, Université Sidi Mohammed Ben  
Abdellah, Morocco  
Carlos Algora, Universidad Politécnica de Madrid,  
Spain  
Ignacio Antón, Universidad Politécnica de Madrid,  
Spain  
Kenji Araki, Toyota Technological Institute, Japan  
Nicholas Ekins-Daukes, UNSW, Australia  
Simon Fafard, University of Sherbrooke, Canada  
Iván García, Universidad Politécnica de Madrid, Spain  
John Geisz, NREL, USA  
Tian Gu, MIT, USA  
Karin Hinzer, University of Ottawa, Canada  
Sarah Kurtz, UC Merced, USA  
Ignacio Luque-Heredia, BSQ Solar, Spain  
Ignacio Rey-Stolle, Universidad Politécnica de  
Madrid, Spain  
Marta Victoria, University of Aarhus, Denmark  
Maike Wiesenfarth, Fraunhofer ISE, Germany

## Publication Committee

### Chair of Publication Committee:

Myles Steiner, NREL, USA

Vincent Aimez, University of Sherbrooke, Canada

Steve Askins, Universidad Politécnica de Madrid,  
Spain

Christian Blechschmidt, Orafol Fresnel Optics,  
Germany

Sebastian Caparrós Jiménez, BSQ Solar, Spain

Romain Cariou, CEA, France

Rafael Cervantes, BSQ Solar, Spain

John Cook, University of Ottawa, Canada

Alain Dollet, PROMES, France

Eduardo F. Fernández, University of Jaen, Spain

Ryan France, NREL, USA

Rebeca Herrero, Universidad Politécnica de Madrid,  
Spain

John Lasich, RayGen, Australia

Ralf Leutz, Leopil, Germany

María Martínez, ISFOC, Spain

Kensuke Nishioka, University of Miyazaki, Japan

Maxim Shvarts, Ioffe Institute, Russia

Gerald Siefer, Fraunhofer ISE, Germany

Marc Steiner, Fraunhofer ISE, Germany

Guido Vallerotto, Universidad Politécnica de Madrid,  
Spain

Marta Victoria, Universidad Politécnica de Madrid,  
Spain

Philippe Voarino, CEA, France

## Local Organizing Committee

Ali Ahaitouf, FST de Fès, Morocco

Najia Es-Sbai, FST de Fès, Morocco

Abdallah Mechaqrane, FST de Fès, Morocco

Mohammed Jorio, FST de Fès, Morocco

Fatima Errahimi, FST de Fès, Morocco

Saad Bennani Dosse, ENSA de Fès, Morocco

Anass Mansouri, ENSA de Fès, Morocco

Lakhrissi Iounes, ENSA de Fès, Morocco

Saad Bennani Dosse, ENSA de Fès, Morocco

## Monday, March 25, 2019

**from**      **Registration & Media Upload**  
**11:00**

**13:00 -**    **Welcome / Introduction**  
**13:15**

**13:15 -**    **Session 1: Plenary**  
**15:15**

Chairs: Andreas W. Bett (Fraunhofer Institute for Solar Energy Systems ISE) and Ignacio Antón (Instituto de Energía Solar - UPM)

13:15       50% or Bust: Status of Six-Junction Concentrator Solar Cells

**John Geisz**<sup>1</sup>, Myles Steiner<sup>1</sup>, Kevin Schulte<sup>1</sup>, Ryan France<sup>1</sup>,  
Daniel Friedman<sup>1</sup>

<sup>1</sup> *National Renewable Energy Laboratory (NREL)*

13:45       Recent Progress of Multi-Junction Solar Cell Development for CPV Applications at AZUR SPACE

**Daniel Fuhrmann**<sup>1</sup>, Rosalinda van Leest<sup>1</sup>, Alexander Frey<sup>1</sup>,  
Matthias Meusel<sup>1</sup>, Gerald Siefer<sup>2</sup>, Kasimir Reichmuth<sup>2</sup>

**Presented by Werner Bensch**<sup>1</sup>

<sup>1</sup> *Azur Space Solar Power GmbH*; <sup>2</sup> *Fraunhofer ISE*

14:15       FLATCON® CPV Module Technology: New Design Development Based on the Evaluation of 10 Years of Outdoor Measurement Data

**Maike Wiesenfarth**<sup>1</sup>, Marc Steiner<sup>1</sup>, Tobias Dörsam<sup>1</sup>, Gerald Siefer<sup>1</sup>,  
Frank Dimroth<sup>1</sup>, Peter Nitz<sup>1</sup>, Andreas W. Bett<sup>1</sup>

<sup>1</sup> *Fraunhofer ISE*

14:45       Towards Industrialization of Planar Microtracking Photovoltaic Panels

**Gaël Nardin**<sup>1</sup>, Alvaro F. Aguilar<sup>1</sup>, Laetitia Anglade<sup>1</sup>, Florian Gerlich<sup>1</sup>,  
Mathieu Ackermann<sup>1</sup>, Laurent Coulot<sup>1</sup>, Delphine Petri<sup>2</sup>, Jacques Levrat<sup>2</sup>,  
Antonin Faes<sup>2</sup>, Jonathan Champlaud<sup>2</sup>, Nicolas Badel<sup>2</sup>, Julien Brossard<sup>2</sup>,  
Gabriel Christmann<sup>2</sup>, Matthieu Despeisse<sup>2</sup>

<sup>1</sup> *Insolight SA*; <sup>2</sup> *CSEM PV-center*

**15:15 -**    **Coffee Break**  
**15:45**

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---



Monday, March 25

**15:45 - Session 2: Progress on CPV Modules****17:30**

Chairs: Maxim Shvarts (Ioffe Institute) and María Martínez (ISFOC)

15:45

**Outdoor Experimental Characterization of Novel High-Efficiency High Concentrator Photovoltaic (HCPV) Modules Using Achromatic Doublet on Glass (ADG) Fresnel Lenses as Primary Optics****Guido Vallerotto**<sup>1</sup>, Maike Wiesenfarth<sup>2</sup>, Marta Victoria<sup>1</sup>, Marc Steiner<sup>2</sup>, Ignacio Antón<sup>1</sup>, Norman Jost<sup>1</sup>, Steve Askins<sup>1</sup>, Gabriel Sala<sup>1</sup><sup>1</sup> *Instituto de Energía Solar (IES-UPM)*; <sup>2</sup> *Fraunhofer ISE*

16:02

**High Performance Concentrator for Thin and Lightweight CPV Modules****Michihiko Takase**<sup>1</sup>, Nobuhiko Hayashi<sup>1</sup>, Shuteu Kanayam<sup>1</sup>, Bunji Mizuno<sup>1</sup><sup>1</sup> *Connected Solutions Company, Panasonic*

16:19

**C3PV: Mass Produced EFA Receivers for a Franchised Module Technology****Ruediger Loeckenhoff**<sup>1</sup>, Werner Bensch<sup>1</sup>, Achim Endress<sup>1</sup><sup>1</sup> *Azur Space Solar Power GmbH*

16:36

**How CPV Can Go Below \$1/W Installed****Roger Angel**<sup>1</sup>, Nicholas Didato<sup>2</sup>, Peter Strittmatter<sup>2</sup>, Ryker Eads<sup>1</sup>**Presented by Ryker Eads**<sup>1</sup><sup>1</sup> *University of Arizona*; <sup>2</sup> *REhnu Inc.*

16:53

**Update on Project ALCHEMI – A Low Cost HCPV Module for 1000 Sun Operation****Andrew Johnson***IQE plc*

17:10

**Trade-Offs and Optimizations in Trough-Lens-Cone Optics for High Efficiency at Very Low Cost****Richard Norman**<sup>1</sup>, Etienne Leveille<sup>1</sup>, William Cloutier<sup>1</sup>, Luc. G. Frechette<sup>1</sup>, Vincent Aimez<sup>1</sup><sup>1</sup> *Université de Sherbrooke*

## 17:30 - Poster Session 19:00

The poster numbers are based on topics:

- A Characterization Methods & Measurement Equipment for CPV
- B Concentrating Optics: Materials, Performances & Designs
- C High and Low Concentration Modules Performances
- D Modelling, Performance and Energy Prediction for CPV Modules & Systems
- E Novel Concepts of CPV and its Hybridization with Other Technologies
- F Solar Cells and Solar Cell Assemblies for Low and High Concentration Systems

A-1 Simple and Accurate Indoor Calibration of Component Solar Cells

**Romain Couderc**<sup>1</sup>, Philippe Voarino<sup>1</sup>

<sup>1</sup>CEA-INES

A-2 Minority Charge Carrier Lifetime Estimation for Multijunction Structures of PV Converters

**Viktor Emelyanov**<sup>1</sup>, Nikolay Kalyuzhnyy<sup>1</sup>, Svetlana Levina<sup>1</sup>, Maxim Shvarts<sup>1</sup>

**Presented by Nikolay Kalyuzhnyy**<sup>1</sup>

<sup>1</sup>Ioffe Institute

A-3 Characterization of Ultra High Power Laser Beam PV Converters

**Vladimir Khvostikov**<sup>1</sup>

**Presented by Maxim Shvarts**<sup>1</sup>

<sup>1</sup>Ioffe Institute

A-4 GaAs Subcell of Triple-Junction Solar Cells with Hybrid Quantum Objects: Temperature Photovoltaic Characteristics

**Mikhail Mintairov**<sup>1</sup>, Valery Evstropov<sup>1</sup>, Sergey Mintairov<sup>1</sup>, Maxim Shvarts<sup>1</sup>, Nikolay Kalyuzhnyy<sup>1</sup>

<sup>1</sup>Ioffe Institute

A-5 Temperature Drift of PV Parameters in High-Power Laser Converters

**Alexander Panchak**<sup>1</sup>, Mariia Nakhimovich<sup>1</sup>, Pavel Pokrovskiy<sup>1</sup>, Valeri Larionov<sup>1</sup>, Dmitriy Malevskiy<sup>1</sup>, Maxim Shvarts<sup>1</sup>

<sup>1</sup>Ioffe Institute

Monday, March 25

- A-6      **Accurate and Low Cost Sun Pointing Detector Unit for Concentrator Photovoltaic Applications**  
**Alessandro Minuto**<sup>1</sup>, Gianluca Timò<sup>1</sup>  
<sup>1</sup>*RSE*
- B-1      **Indoor Characterization of Two Secondary Optics with Fresnel Lens: Pyramid and Cone**  
**Sara El-Yahyaoui**<sup>1</sup>, Ali Ahaitouf<sup>1</sup>, Sarah El Himer<sup>2</sup>, Abdallah Mechaqrane<sup>1</sup>, Jean Paul Salvestrini<sup>3</sup>, Abdallah Ougazzaden<sup>3</sup>  
<sup>1</sup>*Université Sidi Mohammed Ben Abdellah*; <sup>2</sup>*Institut de Recherche en Energie Solaire et Energies Nouvelles*; <sup>3</sup>*Georgia Tech - CNRS UMI 2958*
- B-2      **Optimization of an Ultra-High CPV Cassegrain-Koehler Unit with 2000 × Concentration Ratio**  
**Juan Pablo Ferrer**<sup>1</sup>, Eduardo F. Fernández<sup>1</sup>, Florencia Almonacid<sup>1</sup>, Diego L. Talavera<sup>1</sup>, Pedro Pérez-Higueras<sup>1</sup>  
**Presented by Eduardo F. Fernández**<sup>1</sup>  
<sup>1</sup>*University of Jaén*
- B-3      **Spectral Selective PVT Solar Concentrator for Building Integration**  
**Daniel Chemisana**<sup>1</sup>, Alberto Riverola<sup>1</sup>, Alexandre Moreno<sup>1</sup>, Alejandro Solans<sup>1</sup>  
<sup>1</sup>*University of Lleida*
- C-1      **Optimum Design of V-Trough Solar Concentrator for Photovoltaic Applications**  
**Mohammad Alnajideen**  
*Cardiff University*
- C-2      **Fabrication and Experimental Investigation of a Direct Immersed PVT Concentrator for Building Integration**  
**Daniel Chemisana**<sup>1</sup>, Alberto Riverola<sup>1</sup>, Alejandro Solans<sup>1</sup>, Alexandre Moreno<sup>1</sup>  
<sup>1</sup>*University of Lleida*
- C-3      **High and Low Concentration Modules Performances**  
**Tajudeen Sani**  
*Federal University Dutse*
- D-1      **Aerodynamics for CPV: Investigating the Efficiency of Using Air Fairings on Solar Trackers**  
**Alexander Chekalin**<sup>1</sup>, Viacheslav Andreev<sup>1</sup>, Yuri Ascheulov<sup>1</sup>, Yuri Chumakov<sup>2</sup>  
**Presented by Vitali Kalinovskiy**<sup>1</sup>  
<sup>1</sup>*Ioffe Institute*; <sup>2</sup>*Peter the Great St. Petersburg Polytechnic University*

- D-2 Numerical Simulation of Parabolic Trough and Dish Solar Concentrator: Photovoltaic Application  
**Syham Kadri**<sup>1</sup>, Mouad Seghir<sup>1</sup>, Kenza Djermane<sup>1</sup>  
<sup>1</sup> *University of Béchar*
- D-3 Fins Integrated Phase Change Material for the Electrical Enhancement of Photovoltaic System for South West UK Climate  
**Sourav Khanna**<sup>1</sup>, K. S. Reddy<sup>2</sup>, Tapas Mallick<sup>3</sup>  
<sup>1</sup> *University of Portsmouth*; <sup>2</sup> *Indian Institute of Technology Madras*; <sup>3</sup> *University of Exeter*
- D-4 Impact of Soiling on the IV Characteristics of CPV Modules  
**Leonardo Micheli**<sup>1</sup>, Jesus Montes-Romero<sup>1</sup>, Marios Theristis<sup>2</sup>, Juan de la Casa<sup>1</sup>, George E. Georghiou<sup>2</sup>, Florencia Almonacid<sup>1</sup>, Eduardo F. Fernández<sup>1</sup>  
**Presented by Eduardo F. Fernández**<sup>1</sup>  
<sup>1</sup> *University of Jaén*; <sup>2</sup> *University of Cyprus*
- E-1 Experimental Characterisation of an Absorptive/ Reflective Crossed CPC PV/T System  
**Abdullah Alamoudi**<sup>1</sup>, Firdaus Muhammad-Sukki<sup>1</sup>, Radhakrishna Prabhu<sup>1</sup>, Nazmi Sellami<sup>1</sup>  
<sup>1</sup> *Robert Gordon University*
- E-2 GaSb Photovoltaic Cells for Laser Power Conversion  
**Vladimir Khvostikov**<sup>1</sup>, Svetlana Sorokina<sup>1</sup>, Maxim Shvarts<sup>1</sup>, Olga Khvostikova<sup>1</sup>, Natalia Potapovich<sup>1</sup>, Vladimir Khvostikov<sup>1</sup>  
**Presented by Maxim Shvarts**<sup>1</sup>  
<sup>1</sup> *Ioffe Institute*
- F-1 Nanofluid Cooling Optimization of High Concentration Photovoltaic Panels  
**Kenza Djermane**<sup>1</sup>, Syham Kadri<sup>1</sup>  
<sup>1</sup> *University of Béchar*
- F-2 Nanopyramid-based Absorber to Boost the Efficiency of InGaN Solar Cells  
**Walid El Huni**<sup>1</sup>, Yacine Halfaya<sup>1</sup>, Soufiane Karrakchou<sup>1</sup>, Taha Ayari<sup>1</sup>, Suresh Sundaram<sup>1</sup>, Simon Gautier<sup>2</sup>, Paul L. Voss<sup>1</sup>, Jean Paul Salvestrini<sup>1</sup>, Abdallah Ougazzaden<sup>1</sup>  
<sup>1</sup> *Georgia Tech - CNRS UMI 2958*; <sup>2</sup> *Institut Lafayette*

Monday, March 25

- F-3      Thermophysical Properties of a Soldered Contact of a Concentrator Solar Cell with a Heat Removing Basement  
**Vitali Kalinovsky<sup>1</sup>**, Aleksey Glazov<sup>1</sup>, Vitali Kalinovsky<sup>1</sup>, Evgeny Kontrosh<sup>1</sup>, Aleksey Nashchekin<sup>1</sup>, Kyrill Muratkov<sup>1</sup>  
<sup>1</sup> *Ioffe Institute*
- F-4      Strategies for the CVD-Preparation of Single-Domain Si(100) and Ge(100) Surfaces  
**Agnieszka Paszuk<sup>1</sup>**  
**Presented by Thomas Hannappel<sup>1</sup>**  
<sup>1</sup> *Technische Universität Ilmenau*
- F-5      Characterization and Impact of Non-Uniformity on Multi-Junction Solar Cells (MJSC) Caused by Concentrator Optics  
**Jose Manuel Saura García<sup>1</sup>**, Eduardo Fernández Fernández<sup>2</sup>, Daniel Chemisana Villegas<sup>1</sup>  
**Presented by Eduardo F. Fernández<sup>2</sup>**  
<sup>1</sup> *University of Lleida*; <sup>2</sup> *University of Jaén*
- F-6      Bifacial Low Concentrator Silicon Solar Cells with Al-Alloyed BSF and Ag-Free Multi-Wire Metallization  
**Maxim Shvarts<sup>1</sup>**, Alla Chebotareva<sup>2</sup>, Tatiana Kost<sup>2</sup>  
<sup>1</sup> *Ioffe Institute*; <sup>2</sup> *Lomonosov Moscow State University*
- F-7      Finite Element Analysis of Cooling Mechanism by Flat Heat-Sinks in Ultra-High CPV Systems  
**Alvaro Valera**  
**Presented by Eduardo F. Fernández**  
*University of Jaén*

## Tuesday, March 26, 2019

**from 07:30 Registration & Media Upload**

**08:00 - 10:00 Session 3: Concentrator Cells**

Chairs: John Geisz (NREL) and Gianluca Timò (RSE)

08:00 Self Powered Light-Induced Plating for CPV Solar Cells  
**Clément Laucher**<sup>1</sup>, Gwenaëlle Hamon<sup>1</sup>, Artur Turala<sup>1</sup>, Etienne Paradis<sup>1</sup>, Maïté Volatier<sup>1</sup>, Maxime Darnon<sup>1</sup>, Vincent Aimez<sup>1</sup>, Abdelatif Jaouad<sup>1</sup>

**Presented by Gwenaëlle Hamon**<sup>1</sup>

<sup>1</sup> *Université de Sherbrooke*

08:17 In Situ Quantification of the As/P Content in GaAsP Graded Buffers for III-V-on-Si Tandems During MOVPE

**Oliver Supplie**<sup>1</sup>, Alexander Heinisch<sup>1</sup>, Agnieszka Paszuk<sup>1</sup>, Masakazu Sugiyama<sup>2</sup>, Thomas Hannappel<sup>1</sup>

**Presented by Thomas Hannappel**<sup>1</sup>

<sup>1</sup> *Technische Universität Ilmenau*; <sup>2</sup> *University of Tokyo*

08:34 High-Efficiency Vertical-Tunnel-Junction (VTJ) Solar Cells up to 10000 Suns

**Eduardo F. Fernández**<sup>1</sup>, Natalia Seoane<sup>2</sup>, Florencia Almonacid<sup>1</sup>, Antonio J. García-Loureiro<sup>2</sup>

<sup>1</sup> *University of Jaén*; <sup>2</sup> *University of Santiago de Compostela*

08:51 IEC 62787: „Concentrator Photovoltaic (CPV) Solar Cells and Cell-On-Carrier (CoC) Assemblies – Qualification“

**Carlos Algora**<sup>1</sup>, Neftali Nuñez<sup>1</sup>, Manuel Vazquez<sup>1</sup>, Roland Schilling<sup>2</sup>, Kenji Araki<sup>3</sup>

<sup>1</sup> *Instituto de Energía Solar (IES-UPM)*; <sup>2</sup> *Azur Space Solar Power GmbH*; <sup>3</sup> *Toyota Technological Institute*

09:08 High-Voltage Low-Current Multijunction Monolithic Interconnected Microcells

**Pierre Albert**<sup>1</sup>, Abdelatif Jaouad<sup>1</sup>, Maxime Darnon<sup>1</sup>, Maïté Volatier<sup>1</sup>, Yannick Deshayes<sup>2</sup>, Christopher Valdivia<sup>3</sup>, Karin Hinzler<sup>3</sup>, Laurent Bechou<sup>2</sup>, Vincent Aimez<sup>1</sup>

<sup>1</sup> *Université de Sherbrooke*; <sup>2</sup> *Laboratoire de l’Intégration du Matériau au Système (IMS)*; <sup>3</sup> *SUNLAB*

09:25 Light Budget in Multijunction Solar Cells at Temperature Tuning

**Svetlana Levina**<sup>1</sup>, Maxim Shvarts<sup>1</sup>, Evgeniy Filimonov<sup>1</sup>, Viktor Emelyanov<sup>1</sup>

<sup>1</sup> *Ioffe Institute*

Tuesday, March 26

09:42 **Assessment of the Energy Yield Gain in High CPV Systems Using Graphene-Enhanced Multijunction Solar Cells**

**Ignacio Rey-Stolle<sup>1</sup>**, Laura Barrutia<sup>1</sup>, Iván García<sup>1</sup>, Iván Lombardero<sup>1</sup>, Carlos Algora<sup>1</sup>

<sup>1</sup>*Instituto de Energía Solar (IES-UPM)*

10:00 - **Coffee Break**  
10:30

10:30 - **Invited Speaker**

11:00 Chair: Karin Hinzer (University of Ottawa)

10:30 **Integrated Micro-Scale Concentrating Photovoltaics: a Path Towards High-Performance, Low-Cost Solar Power**  
Tian Gu, Massachusetts Institute of Technology



*Dr. Tian Gu*

Dr. Tian Gu is a Research Scientist at Materials Research Laboratory and Department of Materials Science and Engineering at MIT. His primary research interests involve integrated photonics, nano-optics and photonic materials, focusing on the areas of photovoltaics, metasurface optics, on-chip spectroscopic sensing, data communications, flexible photonics, and 2D materials integrated photonics. He is a recipient of the R&D 100 Award and the TechConnect National Innovation Award.

11:00 - **Sponsor Presentations**

12:00 Presentations from the CPV-15 Sponsors

11:00 Presentation AZUR SPACE Solar Power

11:07 Presentation BSQ Solar

11:15 Presentation IRESEN

11:22 Presentation Masen

11:37 Presentation STACE

12:00 - **Lunch Break**  
13:30

**13:30 - Session 4: Applications on the Rise**

**15:30**

Chairs: Frank Dimroth (Fraunhofer ISE) and Vincent Aimez  
(University of Sherbrooke)

13:30

A High-Concentration Photovoltaic System to Maximize  
Solar Resource Utilization in Dual Use with Agriculture

**Harry Apostoleris<sup>1</sup>, Matteo Chiesa<sup>1</sup>**

<sup>1</sup> *Khalifa University of Science and Technology*

13:47

Microconcentration for Space Applications: A 7.6X TIR  
Design

**Philippe Voarino<sup>1</sup>, Arnaud Ritou<sup>1</sup>, Caroline Seraine<sup>1</sup>, Marlène  
Roux<sup>1</sup>, Romain Couderc<sup>1</sup>**

**Presented by Romain Couderc<sup>2</sup>**

<sup>1</sup> CEA; <sup>2</sup> CEA-INES

14:04

Thermal and Resistive Loss in InGaAs Metamorphic Laser  
( $\lambda=1064$  nm) Power Converters with Over 45% Efficiency

**Nikolay Kalyuzhnyy<sup>1</sup>, Valeriy Evstropov<sup>1</sup>, Viktor Emelyanov<sup>1</sup>,  
Sergey Mintairov<sup>1</sup>, Mikhail Mintairov<sup>1</sup>, Maxim Shvarts<sup>1</sup>**

<sup>1</sup> *Ioffe Institute*

14:21

Hydrogen Generation Using CPV Technologies:  
Comparative Techno-Economic Study

**Rafika Boudries**

*CDER*

14:38

CPV System with Cylindrical Tubes and Strips of Solar  
Cells

**Sang-Moo Shin<sup>1</sup>, Yu-Bin Shin<sup>2</sup>**

<sup>1</sup> *Samsung Engineering*; <sup>2</sup> *Handong Global University*

14:55

Standardization of the CPV Technology in 2019 – Path to  
the New CPV Technologies

**Kenji Araki**

*Toyota Technological Institute*

**15:30 -**

**Coffee Break**

**16:00**

**16:00 - Session 5: CPV Systems and**

**18:00 Field Experience**

Chairs: Gabriel Sala (Instituto de Energía Solar - UPM) and  
Florencia Almonacid (University of Jaén)



Tuesday, March 26

- 16:00 CPVIndia – Energy Yield Forecasting with PVSyst  
**Marc Steiner**<sup>1</sup>, Gerald Siefer<sup>1</sup>, Alexander Wekkeli<sup>1</sup>, Soumen Sardar<sup>2</sup>, Shashank Ojha<sup>2</sup>, Jaspal Singh<sup>2</sup>, Vishal Singh<sup>2</sup>, Jatinder Singh Chandok<sup>2</sup>  
<sup>1</sup>Fraunhofer ISE; <sup>2</sup>NETRA NTPC
- 16:17 Improvement of the Spectral Sensitivity of CPV by Enhancing Luminescence Coupling and Fine-Tuning to the Bottom-Bandgap Matched to Local Atmospheric Conditions  
**Kenji Araki**<sup>1</sup>, Yasuyuki Ota<sup>2</sup>, Kan-Hua Lee<sup>1</sup>, Kensuke Nishioka<sup>2</sup>, Masafumi Yamaguchi<sup>1</sup>  
<sup>1</sup>Toyota Technological Institute; <sup>2</sup>University of Miyazaki
- 16:34 TwinFocus® New Installation Data  
**Marco Nardello**<sup>1</sup>, Sandro Centro<sup>1</sup>  
<sup>1</sup>Atemenergia srl
- 16:51 Susceptibility of CPV Optical Materials to Abrasion  
**Jaione Bengoechea**<sup>1</sup>, Eugenia Zugasti<sup>1</sup>, María Jesús Rodríguez<sup>1</sup>, Ana Rosa Lagunas<sup>1</sup>  
<sup>1</sup>National Renewable Energy Centre (CENER)
- 17:08 Towards Routine Measurement and Calculation of Spectrally Corrected DNI for CPV Systems  
**Viktar Tatsiankou**<sup>1</sup>, Henry Schriemer<sup>1</sup>, Karin Hinzer<sup>1</sup>, Richard Beal<sup>2</sup>  
<sup>1</sup>University of Ottawa; <sup>2</sup>Spectrafy
- 17:25 On-Tracker Relative Misalignments Estimation in CPV Modules Through Image Processing  
**Luis Javier San José**<sup>1</sup>, Rebeca Herrero<sup>1</sup>, Ignacio Antón<sup>1</sup>, Gabriel Sala<sup>1</sup>  
<sup>1</sup>Instituto de Energía Solar (IES-UPM)
- 17:42 Verification Tests for the Refinancing of a CPV Plant in Operation - Difficulties Associated with the Size of the CPV Modules  
**M. Martínez**<sup>1</sup>, D. Sanchez<sup>1</sup>, G. Calvo-Parra<sup>1</sup>, E. Gil<sup>1</sup>, O. de la Rubia<sup>1</sup>, J. Leloux<sup>2</sup>, C. Labeyrie<sup>3</sup>, N. Chaperon<sup>3</sup>, J. Andrade<sup>3</sup>  
<sup>1</sup>ISFOC; <sup>2</sup>Universidad Politécnica de Madrid; <sup>3</sup>Neoen
- 18:30 **Bus to Dinner**
- 19:00 - 22:00 **Conference Dinner (see page 24 for more information)**  
 The Conference Dinner is sponsored by Umicore. Thank You!

## Wednesday, March 27, 2019

**from 07:30 Registration & Media Upload**

**08:00 - 10:00 Session 6: Optics for CPV**

Chairs: Ralf Leutz (leopil - Leutz Optics and Illumination) and Marc Steiner (Fraunhofer ISE)

- 08:00 Optical Element Design for the Retrofit of the World's First Concentrator Photovoltaic (CPV) System  
**Hussam Khonkar**<sup>1</sup>, Fahad Alharbi<sup>1</sup>, Abdulaziz Alyahyah<sup>1</sup>, David C. Miller<sup>2</sup>  
<sup>1</sup>King Abdulaziz City for Science and Technology; <sup>2</sup>National Renewable Energy Laboratory (NREL)
- 08:17 High-Concentration Wide-Angle Tracking Integration with Stacked Lens Arrays  
**Håkon Jarand Dugstad Johnsen**<sup>1</sup>, Jan Torgersen<sup>1</sup>, Astrid Aksnes<sup>1</sup>  
<sup>1</sup>Norwegian University of Science and Technology
- 08:34 Optical Design for a Fly's Eye CPV System with Large, On-Axis Dish Solar Concentrator  
**Roger Angel**<sup>1</sup>, Justin Hyatt<sup>2</sup>, Ryker W. Eads<sup>1</sup>  
**Presented by Ryker Eads**<sup>1</sup>  
<sup>1</sup>University of Arizona; <sup>2</sup>Steward Observatory, University of Arizona
- 08:51 A Solar Concentrator Based on Photonic Angular Selectivity  
**Harry Apostoleris**<sup>1</sup>, Duncan Wheeler<sup>2</sup>, Yichen Shen<sup>2</sup>, Thomas Cooper<sup>3</sup>, Svetlana Boriskina<sup>2</sup>, Matteo Chiesa<sup>1</sup>, Marin Soljacic<sup>2</sup>  
<sup>1</sup>Khalifa University of Science and Technology; <sup>2</sup>Massachusetts Institute of Technology; <sup>3</sup>York University
- 09:08 Compromise Solutions for Design and Technology of Fresnel Lenses as Sunlight Concentrators  
**Maxim Shvarts**<sup>1</sup>, Viktor Emelyanov<sup>1</sup>, Mariia Nakhimovich<sup>1</sup>, Andrey Soluyanov<sup>1</sup>  
<sup>1</sup>Ioffe Institute
- 09:25 Spectral Analysis of Chromatic Aberration in Fresnel Lenses  
**Evgeniy Filimonov**<sup>1</sup>, Svetlana Levina<sup>1</sup>, Maxim Shvarts<sup>1</sup>  
**Presented by Svetlana Levina**<sup>1</sup>  
<sup>1</sup>Ioffe Institute

Wednesday, March 27

**09:42**      **Low Cost Thermoplastic-on-Glass Fresnel Lenses for CPV Applications**

**Norman Jost<sup>1</sup>**, Guido Vallerotto<sup>1</sup>, Cesar Dominguez<sup>1</sup>, Steve Askins<sup>1</sup>, Ignacio Anton<sup>1</sup>

<sup>1</sup>*Instituto de Energía Solar (IES-UPM)*

**10:00 - 10:30**      **Coffee Break**

**10:30 - 11:00**      **Invited Speaker**

Chair: Kenji Araki (Toyota Technological Institute)

**10:30**      **Pushing Energy Yield with Concentrating Photovoltaics**

Frank Dimroth, Fraunhofer ISE



***Dr. Frank Dimroth***

Dr. Frank Dimroth is heading the department „III-V Photovoltaics and Concentrator Technology“ at Fraunhofer ISE in Freiburg, Germany. The department developed multi-junction solar cells and concentrator modules with highest efficiencies over the last 25 years. Frank Dimroth was co-founder of Concentrix Solar in 2005, later SOITEC Solar, a spin-off from the department which commercialized the FLATCON concentrator module technology. He was further responsible for the development of a 4-junction concentrator solar cell with 46.1% conversion efficiency which is currently the world record for any photovoltaic device. Other research topics include space photovoltaics, III-V on Silicon, hybrid CPV modules, solar hydrogen generation and power by light technology.

**11:00 - 12:00**      **Panel Discussion on Trending CPV Applications**

Panelists:

Kenji Araki (Toyota Technological Institute)

Andreas W. Bett (Fraunhofer ISE)

Frank Dimroth (Fraunhofer ISE)

Karin Hinzer (University of Ottawa)

Ignacio Luque-Heredia (BSQ Solar)

11:00 Why and How Does Car-Roof PV Create 50 GW/Year of New Installations? Also, Why is a Static CPV Suitable to this Application?

**Kenji Araki**<sup>1</sup>, Daisuke Sato<sup>2</sup>, Taizo Matsuda<sup>3</sup>, Kan-Hua Lee<sup>1</sup>, Noboru Yamada<sup>2</sup>, Masafumi Yamaguchi<sup>1</sup>

<sup>1</sup>Toyota Technological Institute; <sup>2</sup>Nagaoka University of Technology; <sup>3</sup>Toyota Motor Corporation

11:17 Discussion

Objective of the panel: identifying the main challenges and opportunities for CPV in the near future, e.g. by showing the way to new applications and markets where CPV can add a strong value, like high-efficiency or space-constrained applications.

*During the panel discussion, we will use an interactive Q&A and polling platform called Slido. To participate, simply open a browser on any laptop, tablet or smartphone, go to [slido.com](https://www.slido.com) and enter the event code #CPV-15.*

12:00 - 13:30 **Lunch Break**

**13:30 - 15:30 Session 7: Hybrid Architectures**

Chairs: Maike Wiesenfarth (Fraunhofer ISE) and Gwenaëlle Hamon (University of Sherbrooke)

13:30 Demonstration of the Performance Static Low-Concentration Module Using Hybrid Lens Arrays

**Kan-Hua Lee**<sup>1</sup>, Kenji Araki<sup>1</sup>, Daisuke Sato<sup>2</sup>, Noboru Yamada<sup>2</sup>, Masafumi Yamaguchi<sup>1</sup>

**Presented by Kenji Araki**<sup>1</sup>

<sup>1</sup>Toyota Technological Institute; <sup>2</sup>Nagaoka University of Technology

13:47 PVSITES: An Alliance of Low-Concentration PV with a New Building-Integrated Module Design

**Paul Messaoudi**

CEA LITEN

14:04 CPV Module Based on a Hybrid Solar Cell

**Vitali Kalinovsky**<sup>1</sup>, Evgeny Kontrosh<sup>1</sup>, Alena Andreeva<sup>1</sup>, Evgeniya Ionova<sup>1</sup>, Alexandra Malevskaya<sup>1</sup>, Vyacheslav Andreev<sup>1</sup>, Valeri Zalesskiy<sup>2</sup>, Viktoriya Malutina-Bronskaya<sup>2</sup>, Alla Lemeshevskaya<sup>3</sup>, Vladimir Kuzoro<sup>4</sup>, Vladimir Khalimanovich<sup>4</sup>, Marina Zayceva<sup>5</sup>

<sup>1</sup>Ioffe Institute; <sup>2</sup>SSPA "Optics, Optoelectronics and Laser Technology"; <sup>3</sup>zSTC "Belmikrosystemy" of the JSC "Integral";

<sup>4</sup>Academician M.F. Reshetnev Information Satellite Systems; <sup>5</sup>Space Systems Research Institute

Wednesday, March 27

- 14:21      **Fluorescent Photonic Crystal Fibers Trapping Light in a Luminescent Solar Concentrator**  
**Olivier Besida**  
*CEA*
- 14:38      **Development and Investigation of Linear Fresnel Lens for Concentrator Space Solar Arrays**  
**Vitali Kalinovsky<sup>1</sup>, Evgeniya Ionova<sup>1</sup>, Alena Andreeva<sup>1</sup>, Evgeny Kontrosh<sup>1</sup>, Vyacheslav Andreev<sup>1</sup>**  
*<sup>1</sup>Ioffe Institute*
- 14:55      **Prototype Optical Modelling Procedure and Outdoor Characterization of an Embedded Topaz Crossed Compound Parabolic Concentrator for Integrated Photovoltaic Windows**  
**Katie Shanks<sup>1</sup>, Ashley Knowles<sup>2</sup>, Adam Brierly<sup>3</sup>, Hasan Baig<sup>1</sup>, Yani Sun<sup>4</sup>, Yupeng Wu<sup>4</sup>, Tapas Mallick<sup>5</sup>**  
**Presented by Hasan Baig<sup>1</sup>**  
*<sup>1</sup>University of Exeter; <sup>2</sup>Yorkshire Photonics; <sup>3</sup>Brinell Vision; <sup>4</sup>Nottingham University; <sup>5</sup>Environment and Sustainability Institute*
- 15:30 -      Closing Session**  
**16:00**
- 16:00 -      **Technical Tour University (see page 25 for more**  
19:00      **information)**

## IEC TC82 WG7 Spring Meeting, March 28 – 29, 2019

The IEC TC82 WG7 meeting will be held on March 28 – 29, just after the CPV-15 conference. It is open to engineers and scientists in CPV, tracker and car-roof PV technologies as observers. It is not a closed-door meeting.

If you would like to join the meeting and contribute to the international standardization of these technologies, please contact Dr. Kenji Araki (cpvkenjiaraki@toyota-ti.ac.jp) in advance for registration.

### Meeting venue

Just as CPV-15, the meeting takes place at the Faculté des Sciences et Techniques, Route d'Immouzzar, Fes, Morocco. The meeting room will be „La salle des réunions au décanat“ (= “the meeting room at the dean’s office”). When you enter the campus through the main gate, the décanat/ dean’s office is the first building on the right. The meeting room is upstairs, on the first floor.

### Timetable and agenda

March 28		
08:00 – 08:30	Meeting room and web connection set-up	K. Araki
08:30 – 10:00	<b>CPV module and system, WG7 scope, summary of the past meetings, and next meeting place</b> Summary of the past meetings WG7 scope (new scope is submitted to TC82) Update of the CPV module safety standard Solar simulator Active cooling system, Hybrid system	K. Araki S. Askins
10:00 – 10:15	Break	
10:15 – 12:00	<b>CPV cell and receiver</b> CPV cell/receiver/COC qualification COC+SOE or receiver qualification	C. Algora
12:00 – 13:30	Lunch break	
13:30 – 15:00	<b>Tracker IS (International standards)</b> Tracker qualification Tracker safety standards	B. Wang
15:00 – 15:15	Break	
15:15 – 18:00	<b>Tracker technical documents without pass/fail criteria</b> Tracker availability Tracker design guideline.	B. Wang K. Araki

<b>March 29</b>		
08:30 – 10:00	Car-roof PV standardization overview and summary of the past meeting, relation to the standardization body of the car industries, etc.,	K. Araki
10:00 – 10:15	Break	
10:15 – 12:00	Curved PV issue (STC)	K. Araki
12:00 – 13:30	Lunch Break	
13:30 – 15:00	Performance modeling (SOC)	K. Araki

## Conference Dinner

The Conference Dinner will take place in Palais Sheherazade in the traditional Medina of Fes. This 19th-century Arabo-Andalusian palace includes a lush garden with century-old palm trees, and a panoramic terrace offering a serene atmosphere overlooking the ancient medina.

**Date:** Tuesday, March 26

**Schedule:** 18:30 Bus transfer from the conference venue  
19:00 Conference Dinner

After the dinner, please organize your return trip to your hotel independently. Since most hotels are closer to the dinner venue than to the conference venue, there will be no bus transfer back.

**Fee:** 55 € (Pre-registration is required)

**Location:** Palais Sheherazade & Spa  
23 Arsat Bennis Douh, Medina  
30000 Fès  
Morocco  
<http://www.sheheraz.com/>

The dinner is sponsored by:

**umicore**  
Electro-Optic Materials





## Technical Tours

### Technical Tour 1: Innovation City & CPV lab of USMBA, Fez

The CPV-15 Technical Tour will take place on Wednesday, March 27, 2019, after the closing session (around 16:00). We will visit Innovation City Fez (“La Cité de l’Innovation de Fès”) and the CPV lab of the Faculty of Sciences and Technology of University Sidi Mohammed Ben Abdellah.

Innovation City Fez was set up by the University Sidi Mohammed Ben Abdellah to offer its laboratories a common platform for material characterization and qualification. Also, it is dedicated to hosting start-ups and incubating innovative projects.

Another mission is to promote the culture of entrepreneurship and to bring the university enterprises closer together by working on common interest projects.

Highlights among the equipment include:

- Infrared spectroscopy
- X-ray diffraction
- Thermal analyzer
- Raman spectroscopy
- Scanning electron microscope

At the CPV lab, we will visit the optical setup dedicated to optical elements testing. A solar simulator as well as some optical elements are available for indoor tests. Some experimental setups to bring together primary and secondary optical elements are currently under manufacturing and may be available during the conference. The aim of this tour is also to launch discussion among the local hosts and the participants about future collaboration and knowledge sharing. For late registrations, please contact the registration desk.

### Technical Tour 2: NOOR Solar Power Complex, Ouarzazate, offered by Masen

Please note that for this tour, early pre-registration was required and new registrations cannot be accepted anymore.

Masen is kindly offering you to take a free tour at NOOR (near Ouarzazate, 600 km travel distance from Fes). It will take place on Friday, March 29, from 9:30 - ca. 14:00. It will start at Masen’s visitors centre with an introduction. The tour will include a visit to:

- the NOOR I – III CSP plants
- the R&D platform (including the Masen & Sumitomo CPV platform)
- the Belvedere look-out at the visitors centre

Meeting point in Ouarzazate will be on Friday, March 29, 9:00 at the main entrance of Hotel Le Berbère Palace, Quartier Mansour Eddahbi 55, Ouarzazate, where you will be picked up by Masen. Water will be provided during the tour at NOOR. Please bring your own food.

**Important:** Please don’t forget to **bring your passport in order to get access to the site!**

Participants should organize their travel to Ouarzazate and accommodation on their own. Please note that there are no direct flights between Fez and Ouarzazate, but there are connections via Casablanca.

## General Information

### Registration

Each participant has to register in person at the registration desk to collect their name badge before attending any sessions. Please make sure to wear your badge for admission to all sessions and side events. Participants who have lost their badge should report to the registration desk.

Registration times are during conference hours, starting at 11:00 on Monday, March 25, and at 7:30 on the other two days.

### Posters

Please mount your poster before the start of the poster session. Do not remove your poster until the end of the conference. Posters are an important part of the scientific program and should be displayed the whole time.

All poster authors are welcome to submit a PDF file of their poster for presentation in the Download Area. Poster PDFs can be uploaded on-site at the Media Upload Desk.

Please remove your poster before you leave. Remaining posters will be discarded.

### Speaker Information

All presentations must be handed in at the Media Upload Desk, one hour before your session. You will not be able to display your presentation directly from your laptop computer or USB flash drive. Our technical support team will welcome you at the Media Upload Desk during all conference days, starting at 11:00 on Monday, March 25, and at 7:30 on the other two days.

Please meet your session chair(s) inside the conference room at least 10 minutes prior to the beginning of your oral session to acquaint yourself with the technical equipment.

### Certificate of Attendance

A certificate of attendance for participants will only be available on-site at the registration desk and cannot be issued after the conference.

### Conference Proceedings

The proceedings will be published open access with AIP, the American Institute of Physics ([www.aip.org](http://www.aip.org)) after the conference, covering papers with sufficient scientific quality. This collaboration will provide optimum visibility of the proceedings and ensure that the authors' publications remain traceable and citable. Final online papers will be accessible on the AIP website and contain an ISBN number for each volume as well as individual DOI numbers for each paper.

### List of Participants

Registered participants may download a list of participants on the conference website, [www.cpv-15.org](http://www.cpv-15.org). The login and password sent to you during registration will be required to gain access to the download area.

### Contact Participants

CPV-15 offers a contact opportunity for conference participants in its internal Download Area. Login with your password and contact other participants by e-mail.

All participants who want to use the contact feature can confirm their admission to send and receive e-mails to and from other conference participants in the Download Area. The first contact will occur indirectly via the conference system in the Download Area. No personal data will be handed out.

### Interactive Panel Discussion

For the panel discussion, we will use a Q&A and polling platform called Slido. To participate, simply open a browser on any laptop, tablet or smartphone, go to [slido.com](http://slido.com) and enter the event code #CPV-15. Alternatively, please scan the QR code:



### WiFi Access

WiFi access will be available free of charge. Please see signs on-site for login details.

The listed companies and institutions have supported the 15<sup>th</sup> International Conference on Concentrator Photovoltaic Systems. Through their generous contributions they have made this conference a success in fostering a great opportunity to share knowledge and push the boundaries of solar science. **We thank our Sponsors.**

Conference Host



Scientific Hosts



Premium Sponsors



Sponsors



Dinner Sponsor



Conference Organizer

