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Instituto de Energía Solar

EUA Energy Clustering Event

Renewable integration and energy storage

The Solar Energy Institute experience

Prof. Carlos del Cañizo
Director Instituto de Energía Solar
Nancy, March 2018



The Instituto de Energía Solar

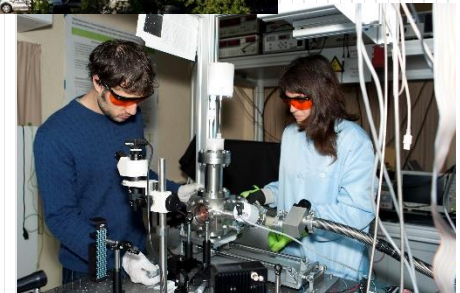
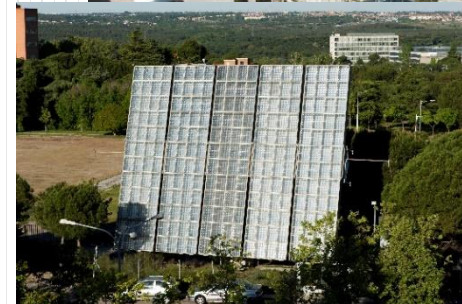


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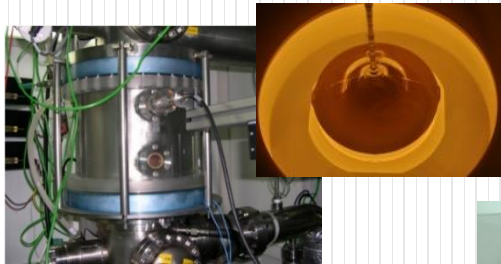
Mission: Contribute to the development of Photovoltaic Solar Energy through R&D

3 research lines following a *vertically-integrated* approach (“from the material to the system”):

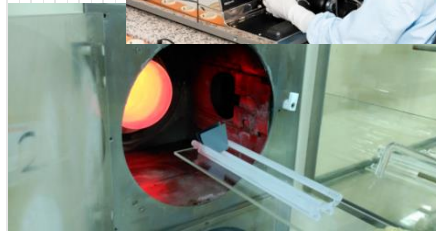
- **Improvement of conventional technologies**
 - Silicon Technology
 - Photovoltaic Modules and Systems
- **Concentration Photovoltaics**
 - Multijunction solar cells
 - Concentrator Instruments and Systems
- **New concepts for solar cells and applications**
 - Limits in photovoltaic conversion
 - Intermediate band solar cells
 - Thermophotovoltaic solar cells in novel applications



Instituto de Energía Solar facilities

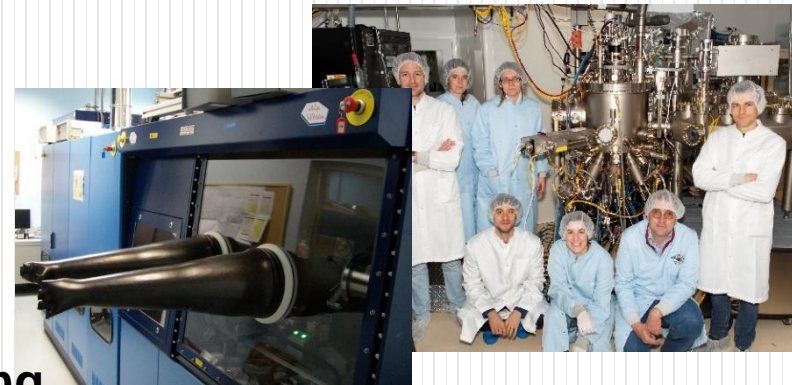


Silicon production



Solar cell manufacturing

MBE y MOVPE epitaxial reactors



Characterization of PV materials and devices



Concentration PV test benches



Building integration PV



Quality of PV systems

IES indicators



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~80 people (20 professors, 10 postdoc, 35 PhD students, 15 support)

✓ **Some indicators of the last five years:**

- Participation in 30 competitive national and regional R&D projects
- Coordination of 4 European projects and participation in 8 more
- Participation in 30 private contracts with industry
- Publication of more than 250 scientific papers, 4 books, 15 book chapters, 20 patents
- Promotion of spin-offs (Solar Added Value, webPV, QPV, SILSTORE)
- 20 PhD thesis defended
- Promotion of a master on Photovoltaic Solar Energy

PhD programme



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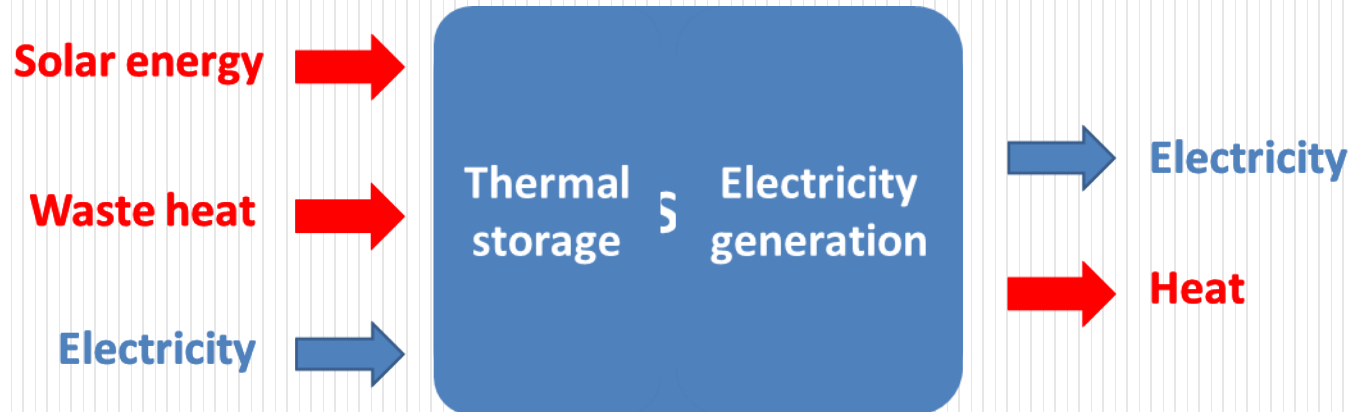


- ✓ **Running, under different administrative frameworks, for more than 40 years**
- ✓ **More than 130 PhD thesis defended**
- ✓ **Variety of topics, from materials to systems. For example:**
 - Research on intermediate band solar cells and development of capacitive techniques for their characterization
 - Artificial recurrent neural networks for the distributed control of electrical grids with photovoltaic electricity
 - Uncertainty reduction in the estimation of PV plants performance

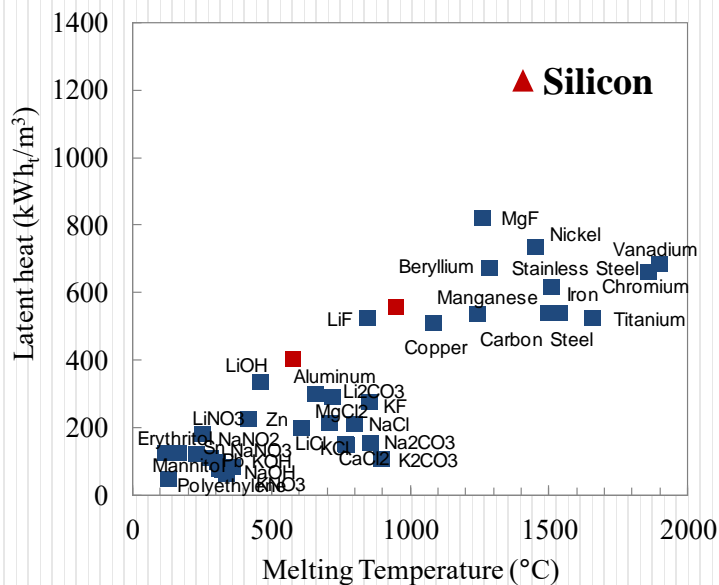
Example of a research topic



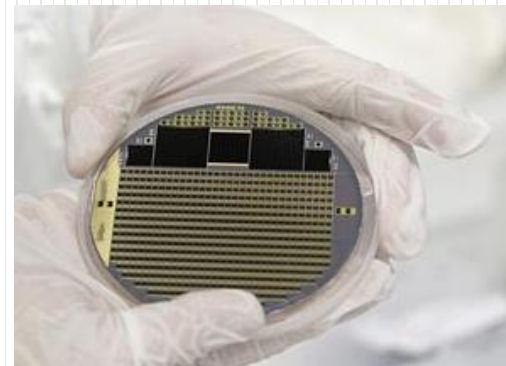
SILSTORE: Ultra high temperature thermal energy storage



Silicon as a Phase Change Material



Thermophotovoltaics for a contactless heat-to-electricity conversion

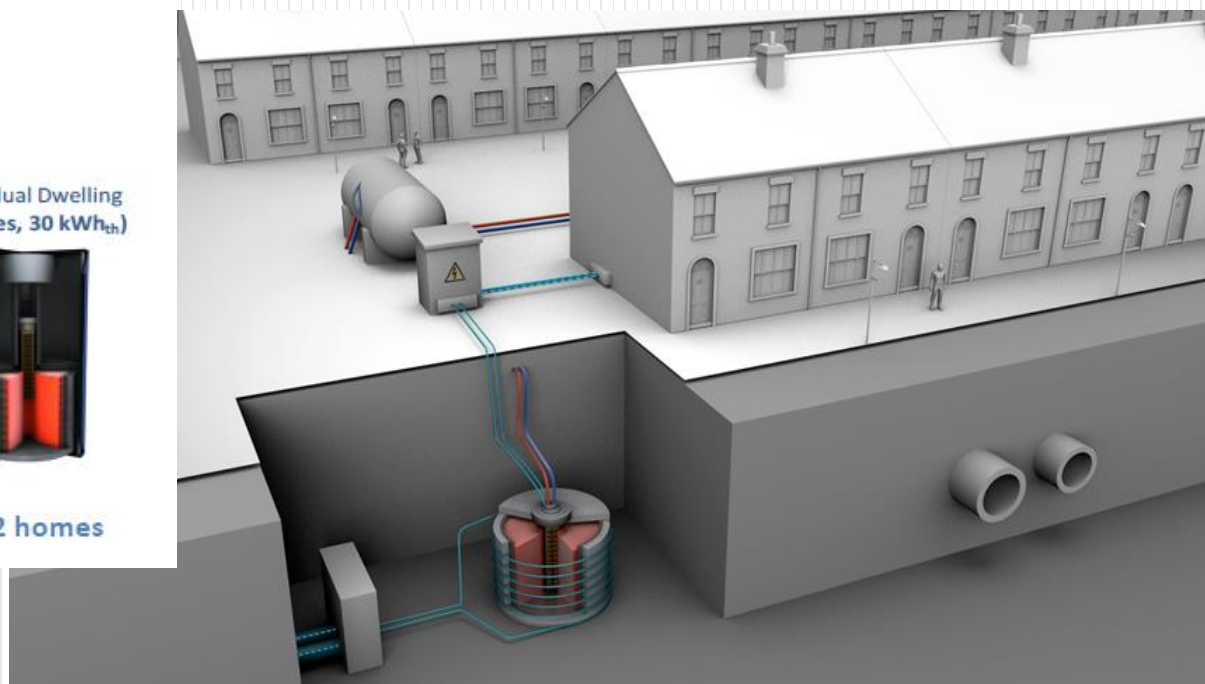


Example of a research topic



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SILSTORE: Ultra high temperature thermal energy storage



Under development in the H2020 FET-OPEN project

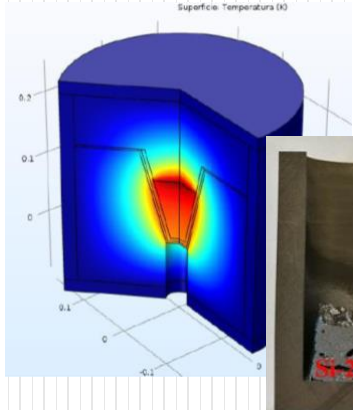


<http://www.amadeus-project.eu/>

Example of a research topic

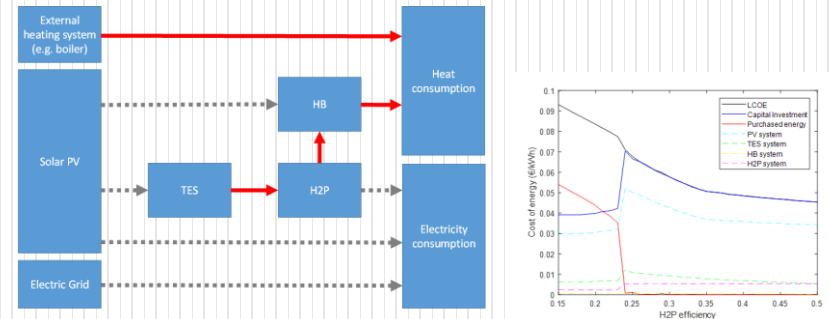


Topics addressed by the research team (which translate in PhD thesis topics):

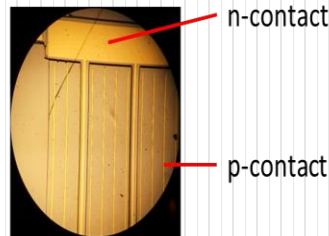
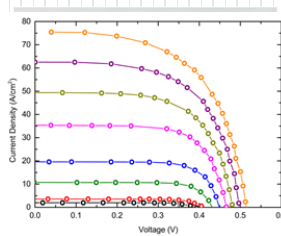
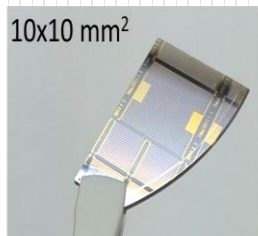


- Prototype design and construction (refractory materials, thermal analysis...)

- Cost analysis in a real environment



- Development of high efficiency thermophotovoltaic solar cells on Ge and GaSb



- System integration and smart control

➡ **Several disciplines coming together: need of global vision, socioeconomic perspective... and team work!**

Methodology in the PhD programme

- ➡ The key aspect continues to be the interaction with the thesis advisor, and the interaction with peers and other professors
- ➡ Some cross curricular subjects (handling bibliography, technology transfer...) offered by the University
- ➡ The participation in conferences, the student exchanges in foreign institutions, the collaboration with industry... is incorporated in the culture of the PhD programme
- ➡ nano-MOOCs: A recent e-learning initiative for PhD students and researchers with videos and exercises: addressing specific research topics in short open courses (10-20 h workload)

“Learning PV at Speed”

CHEETAH

Speed”

Part of the European Project Cheetah

Course syllabus

Production of solar cells & modules with equivalent circuits

Production

Basics of equivalent circuits

Solar cells

Interconnection & modules

CHEETAH

Speed”

Part of the European Project Cheetah

Antonio Martí, 2017

Master on Photovoltaic Solar Energy



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Máster en Energía Solar Fotovoltaica

10th Edition • Curso 2017-2018



CAMPUS
DE EXCELENCIA
INTERNACIONAL



FOCUS ON:

- Vertical integration
- Hands-on

Master Programme



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1 year degree (60 ECTS)

FIRST SEMESTER

COMPULSORY SUBJECTS	ECTS
Energy & society	5
Fundamentals of solar cells	4
Engineering of PV systems	4
Characterization of solar cells (Lab)	4
	17
ELECTIVE SUBJECTS	ECTS
Electrical engineering of PV systems	4
Solar cell technology (Lab)	5
Physics of photovoltaic materials	4
Optical Engineering	4
Seminars: current issues on energy	4
	23

SECOND SEMESTER

COMPULSORY SUBJECTS	ECTS
PV modules & installations (Lab)	4
Final Project	15
	19
ELECTIVE SUBJECTS	ECTS
Grid-connected systems	4
New generation of solar cells	3
Building Integration PV	3
Concentration PV-systems (Lab)	4
Cell & System Simulation (Lab)	4
Seminars: cross-cutting issues	4
Electrical engineering for PV (Lab)	4
PV Materials Computational Lab	4
	30

Cross-cutting topics in the master



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Energy and Society: knowledge of energy in a broad sense

- Concept of energy, environmental impact, world energy system, energy technologies, overview of renewables (other than PV)
- Final project freely elected by the student that should tackle energy issues with the broad perspective that the course provides

Seminars

- Experts in different fields related to energy give a conference, after which there is group work around the topics that have been addressed

Extra-curricular training

- Support by the university on “Starting a technological company”

Master Final Project

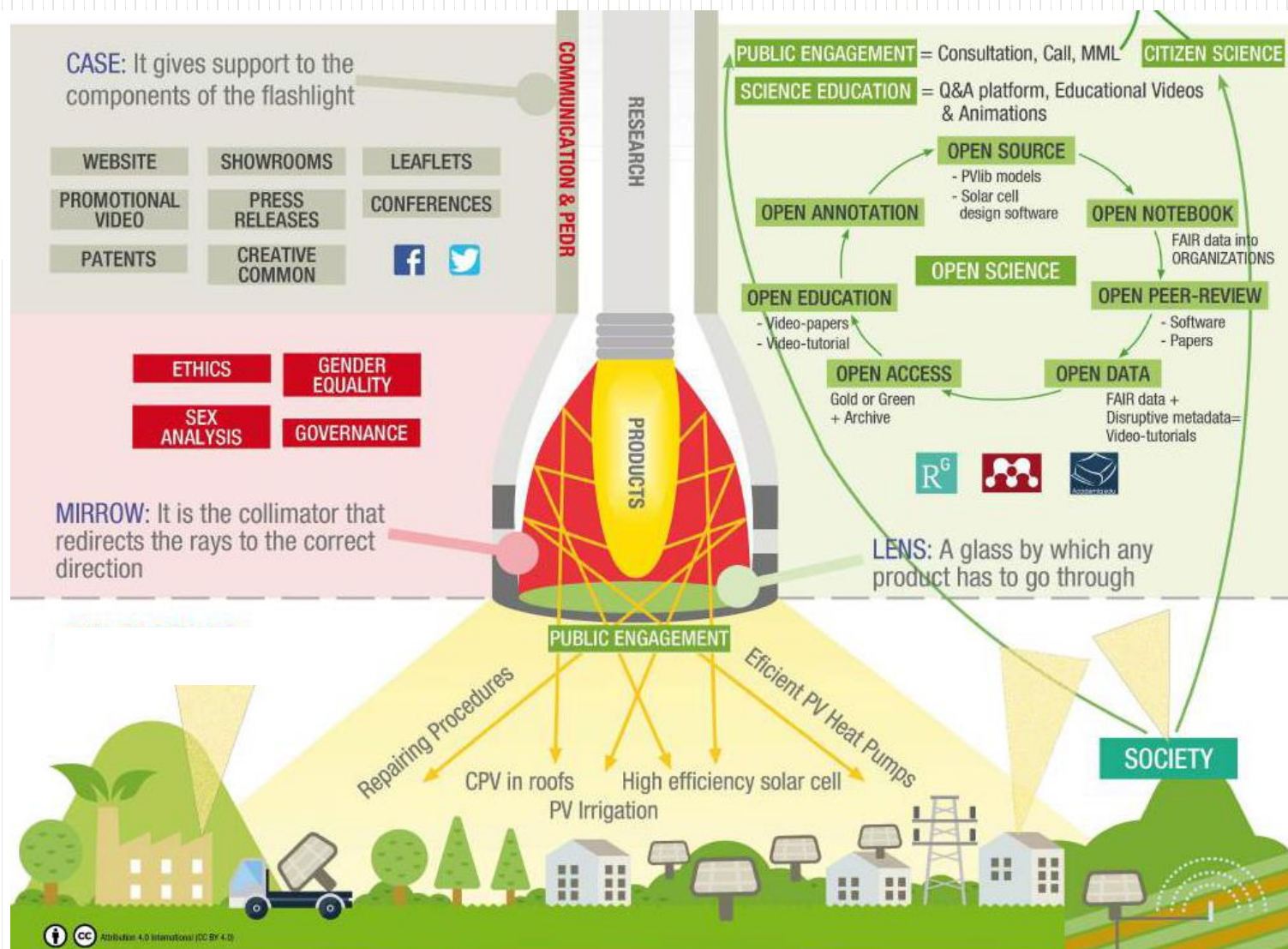
- Always including an innovative aspect
- Strong interaction with an advisor

Putting Open Science into action



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H2020 SWAFS Project



Some ideas for an Open PV Science



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☞ **PV plant performance**

- Collaboration between industry, academy and society to understand in-field degradation and test repairing procedures

☞ **PV for irrigation**

- Which should be the research priority: Integration of batteries or use of salty water? Discussion with government and irrigators' community

☞ **PV heat pumps and PV micro-concentrators for Zero-Energy Buildings**

- Dynamic contrast of research results with stakeholders for product acceptance

☞ **Research in new solar cell materials and architectures**

- OPEN database enabling the research community to find materials with suitable properties for new tandem solar cell structures

Learnings – to trigger discussion



- ☞ Tension between specialization and global vision: adopt both, but there is not a universal solution**
- ☞ Need of context. Need of purpose. In dialogue with the relevant stakeholders**
- ☞ Flexibility... to throw down discipline barriers**
- ☞ Incorporate new methodologies... without forgetting the relevance of the apprentice-master relationship**
- ☞ Challenge: to avoid that the administrative environment work against innovation and flexibility!**



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Developing PV

since 1979

www.ies.upm.es