



# ATAMOSTEC

## Atacama Modules System Technology Consortium

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*April - 2019*

# ACAMA HIGH RADIATION / DESERT CONDITIONS

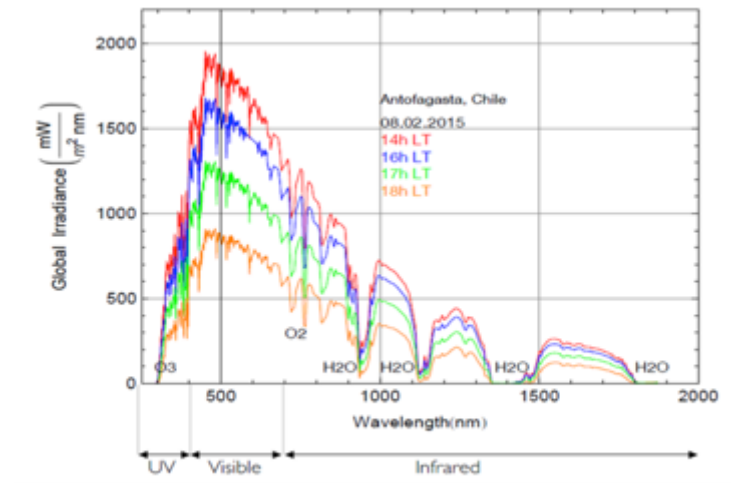
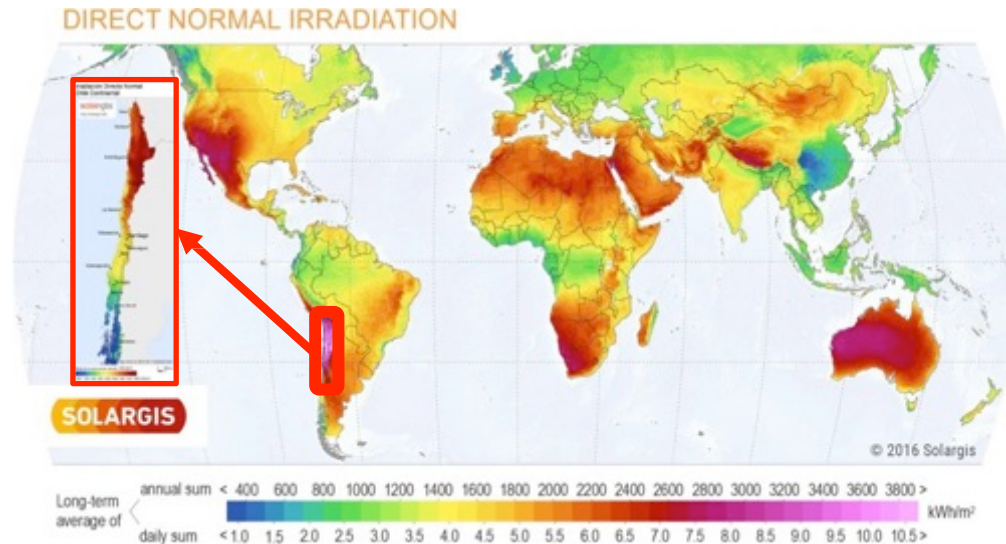
**3500 kWh/m<sup>2</sup>**

Direct Normal Radiation or DNI, is the component of solar radiation that CSP technologies use.

**2500 kWh/m<sup>2</sup>**

Global Radiation is the component of solar radiation used by photovoltaic technologies and solar flat thermal collectors.

Global radiation is 60% more intense in Chile than in Europe, which presents several challenges to the modules, BoS and O&M

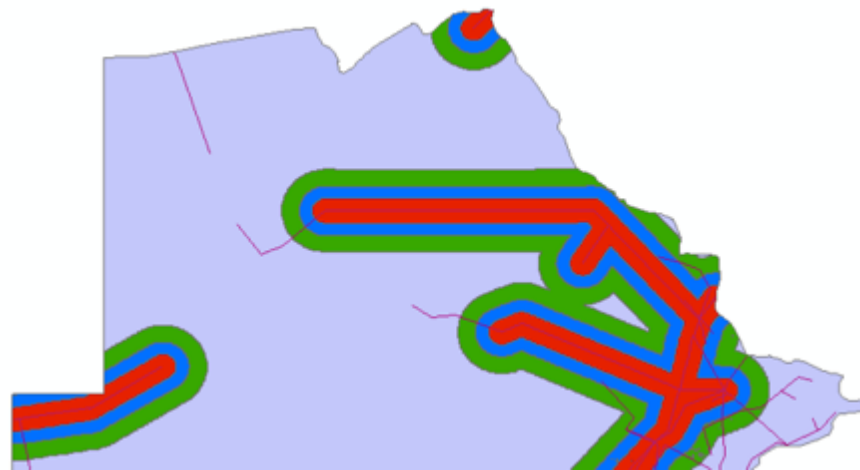


Source: Estudio Caracterización del Espectro Solar - CIFES

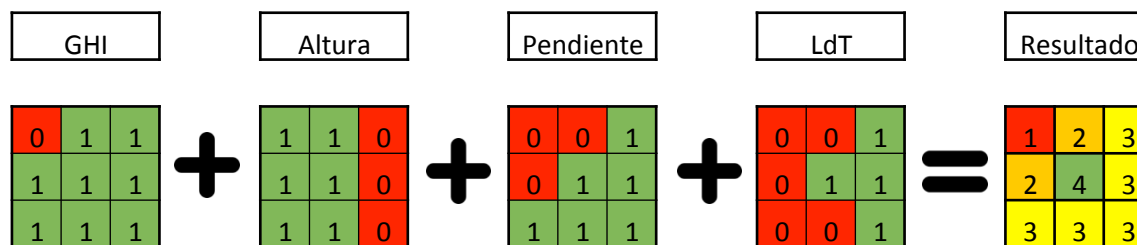
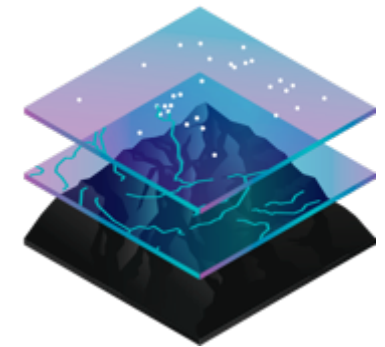
Source: 2015 CIFES Study: The Solar Spectrum in the Atacama Desert, Raúl Cordero

# Potential High Radiation Market

0 GW in photovoltaic plants for the period 2020-2030



- Buffer 15 km
- Buffer 30 km
- Buffer 50 km
- Lineas de Transmisión





# Introducing ATAMOSTEC

**Atacama Modules System Technology Consortium “ATAMOSTEC” is a Technological Consortium** that brings together industry, academia, national and international research centers, in a collaborative work of high impact for the development of photovoltaic solar energy technologies in desert areas with high radiation.

#### Goals:

- LCOE < 15 USD/MWh by 2025 with Atacama Module Systems (ATAMOS) for desert and high radiation zones
- Development and strengthening of local suppliers
- Contributing to a local sophisticated industrial manufacturing sector
- Creating human capital on R&D+Innovation
- Exporting applied innovation and R& services

#### Budget:

12 MMUSD public funding

#### Execution timeframe:

2018 - 2025

# MEMBERS



**Coexecutors**

**Stakeholders**

**Industrial Partners**

**New Partners**

The image is a composite background. The top half shows a bright blue sky with scattered white cumulus clouds. The bottom half shows a close-up, low-angle view of a solar panel array, with the blue panels and white grid lines receding into the distance. A semi-transparent dark blue horizontal band is overlaid across the middle of the image, containing the text "How do we work?". Below this band, there is a thin horizontal bar with a color gradient from orange to red.

**How do we work?**

**WPo: Coordination**

**WP1: Module Development**

**WP2: Module Performance assessment and  
labelling**

**WP3: Balance of System**

**WP4: O&M**

**WP5: Territorial Characterization**

**WP6: Demonstration of PV Systems &  
optimization**

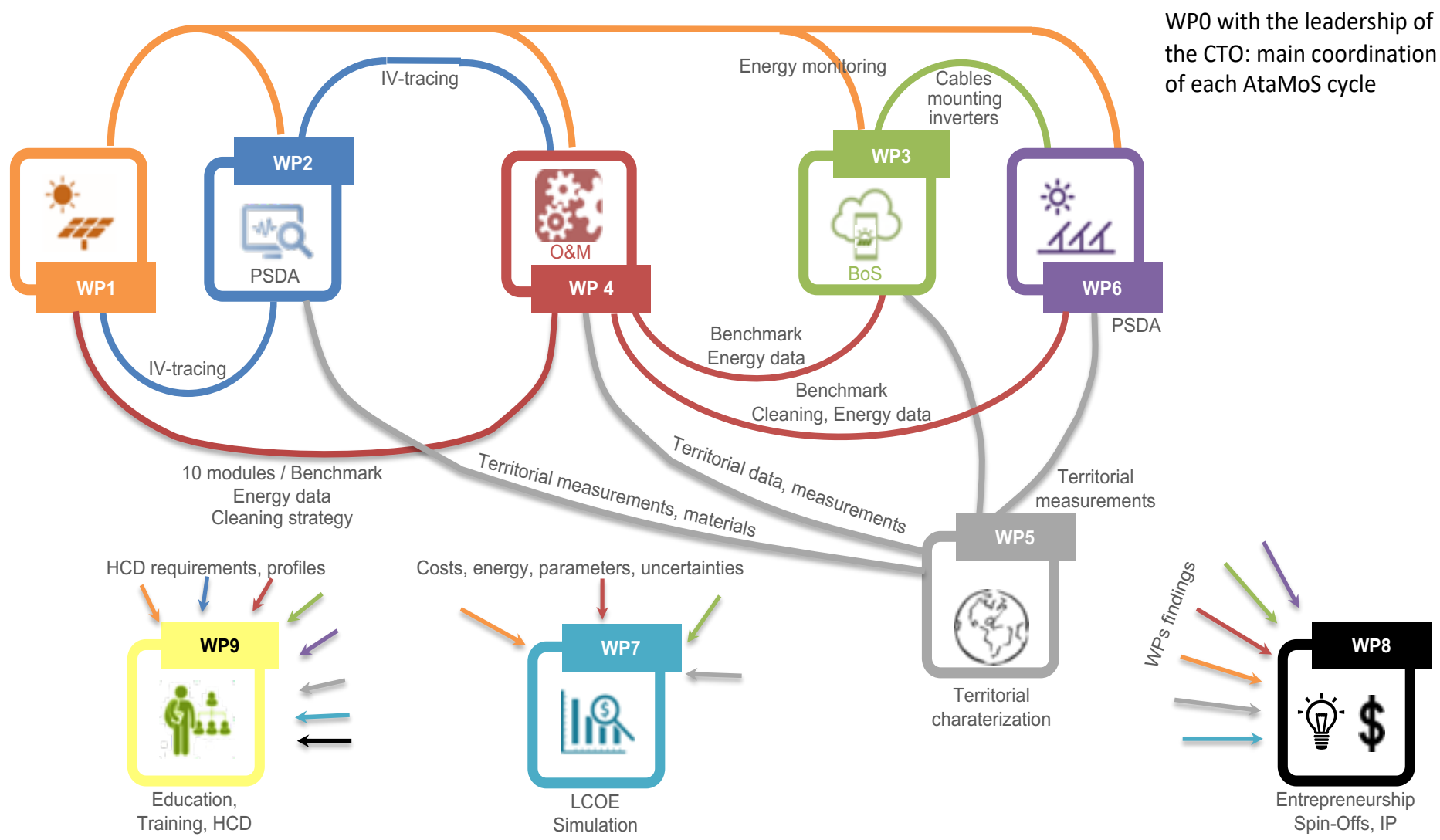
**WP8: Business models, entrepreneurship and technology transfer**

**WP9: Education, training and dissemination**

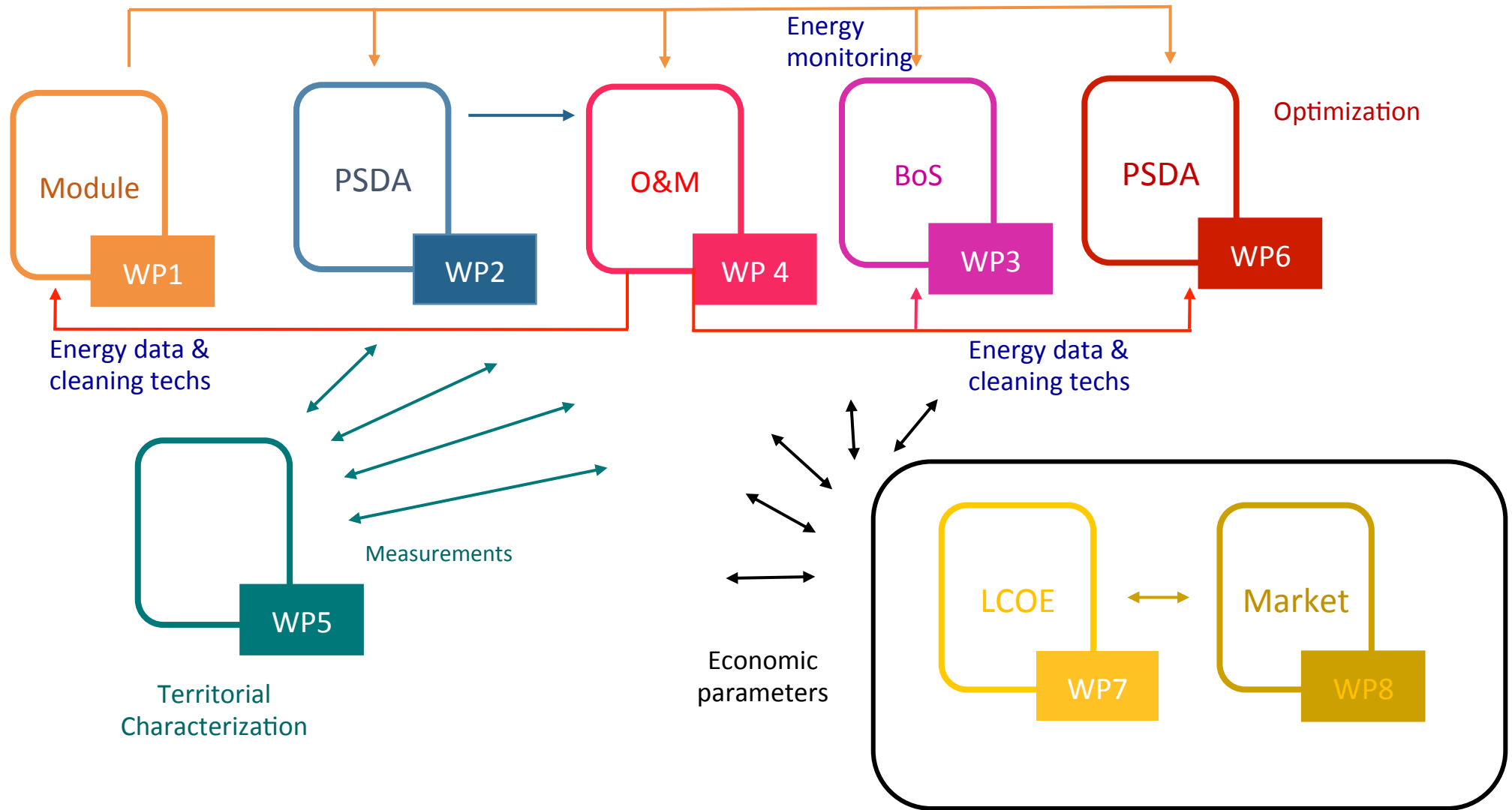
**WP7: LCOE and bankability**



# AMOS CYCLE



# AMOS CYCLE: at least 3 releases of the ATAMOSTEC module

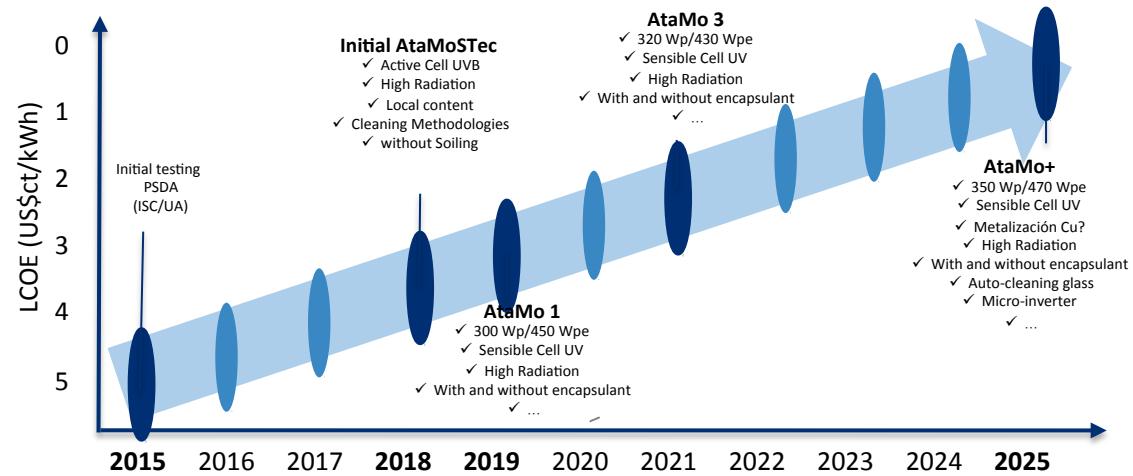


# PROJECT PORTFOLIO



1 : Module Development

2 : Module Performance assessment and labelling



**Germany South**

8 – 10 US\$/kWh Standard Module  
6 – 10 US\$/kWh Bifacial Module

**Atacama (PSDA)**

2 – 4 US\$/kWh Standard Module  
1 – 2 US\$/kWh Bifacial Module

**Atacama (PSDA)**

6 – 8 US\$/kWh Standard Module  
4 – 6 US\$/kWh Bifacial Module

## PP3: Balance of System Components

Civil Works  
Achors



Structures  
Fixed/Tracking



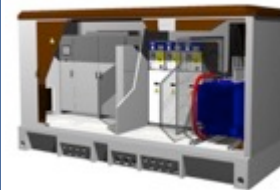
Wires and  
Connectors



Electric  
Management  
System



Inverter and  
transformers



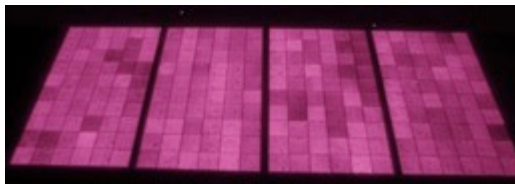
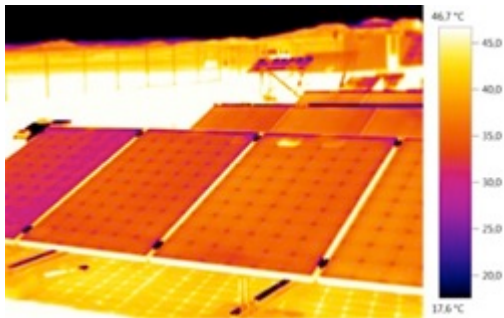
Electric  
Distributions  
System



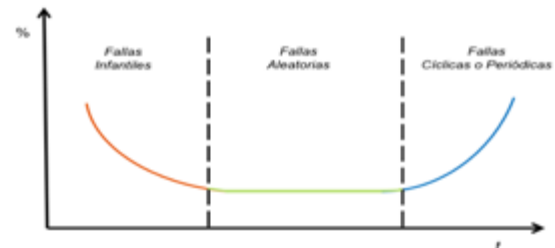
STORAGE

## 4: O & M Component Development

### Maintenance protocols (Cost Fault, RCM II)



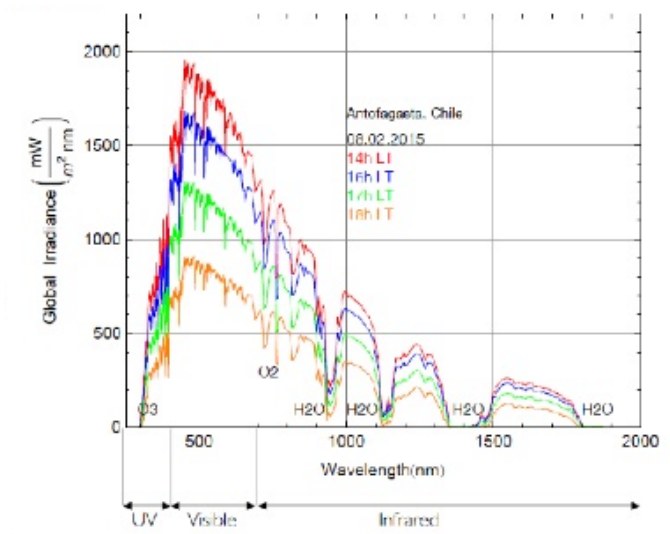
### Faults Type



ANÁLISIS DE RCM II  
Plan de Mantenimiento Centrado en Confiabilidad

| HOJA DE INFORMACIÓN RCM II                                      | ELEMENTO: LAVADOR DE GASES | Fecha  |   | Realizado por:<br>Gregorio Barrientos - Sebastian Donoso |   |
|---|----------------------------|--|---|--|---|
|   |                            | Fecha Inicial  | Fecha final   |  |   |
| FUNCIÓN   | TIPO DE FUNCIÓN            | FALLO FUNCIONAL  | MODO DE FALLA (CAUSA DE LA FALLA)   | TIPO DE MODO FALLA                                       | EFECTOS DE LAS FALLAS (QUE SUCEDE CUANDO FALLA)   |
|   |                            |  |   |  |   |
| 1 Permite lavar el rostro de una persona en caso de emergencia. | Seguridad                  | A No permite lavar el rostro de una persona en caso de emergencia. | 1 Suministro de agua potable falla  | Análisis por separado no incluido                        | Se analiza por aparte   |
|   |                            |  | 2 válvula VV10478 de entrada a la bomba neumática cerrada manualmente       | Error humano mantenimiento                               | Si durante una intervención de mantenimiento, la válvula VV10478 es cerrada manualmente, no se permitirá el paso de agua al lavador de ojos, lo será posible lavar el rostro de una persona accidentada, será necesario buscar otra fuente de agua. Puede generar consecuencias graves al operario si no se realiza un lavado inmediato.<br>Tiempo para diagnosticar y abrir la válvula VV10478 tarda 20 min. |
|   |                            |  | 3 válvula VV10478 de entrada a la bomba neumática falla en posición cerrada | Caja Negra   | Si en algún momento la válvula VV10478 falla en posición cerrada, no se permitirá el paso de agua al lavador de ojos, no será posible lavar el rostro de una persona accidentada, será necesario buscar otra fuente de agua. Puede generar consecuencias graves al operario si no se realiza un lavado inmediato.<br>Tiempo para diagnosticar y abrir la válvula VV10478 tarda 20 min.                        |
|   |                            |  | 4 Accionador de la válvula de lavador de ojos falla                         | Caja Negra   | Si en algún momento el accionador de la válvula del lavador de ojos falla y ocurre una emergencia, no será posible lavar el rostro de una persona accidentada, será necesario buscar otra fuente de agua. Puede generar consecuencias graves al operario si no se realiza un lavado inmediato.<br>Diagnosticar la falla y cambiar el accionador tarda 1 hora.   |
|   |                            |  | 5 Accionador de la válvula de lavador de ojos golpeado                      | Error humano mantenimiento                               | Si durante una intervención de mantenimiento el accionador de la válvula del lavador de ojos es golpeado y ocurre una emergencia, no será posible lavar el rostro de una persona accidentada, será necesario buscar otra fuente de agua. Puede generar consecuencias graves al operario si no se realiza un lavado inmediato.<br>Diagnosticar la falla y cambiar el accionador tarda 1 hora.                  |

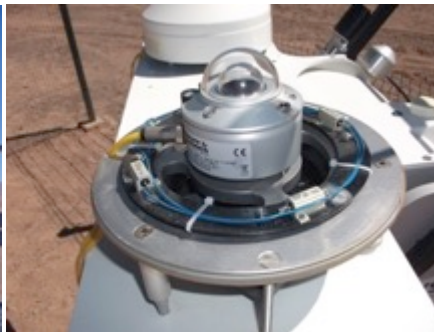
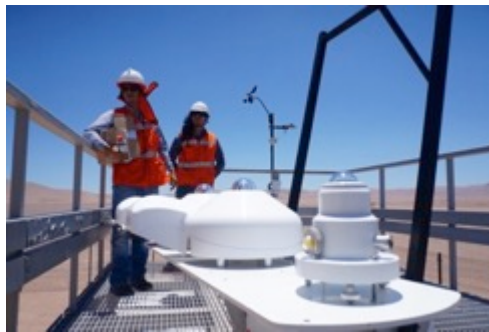
## 5: Territorial Characterization



Fuente: Estudio Caracterización del Espectro Solar - CIFES

### GIS (Geo-referenced Information System)

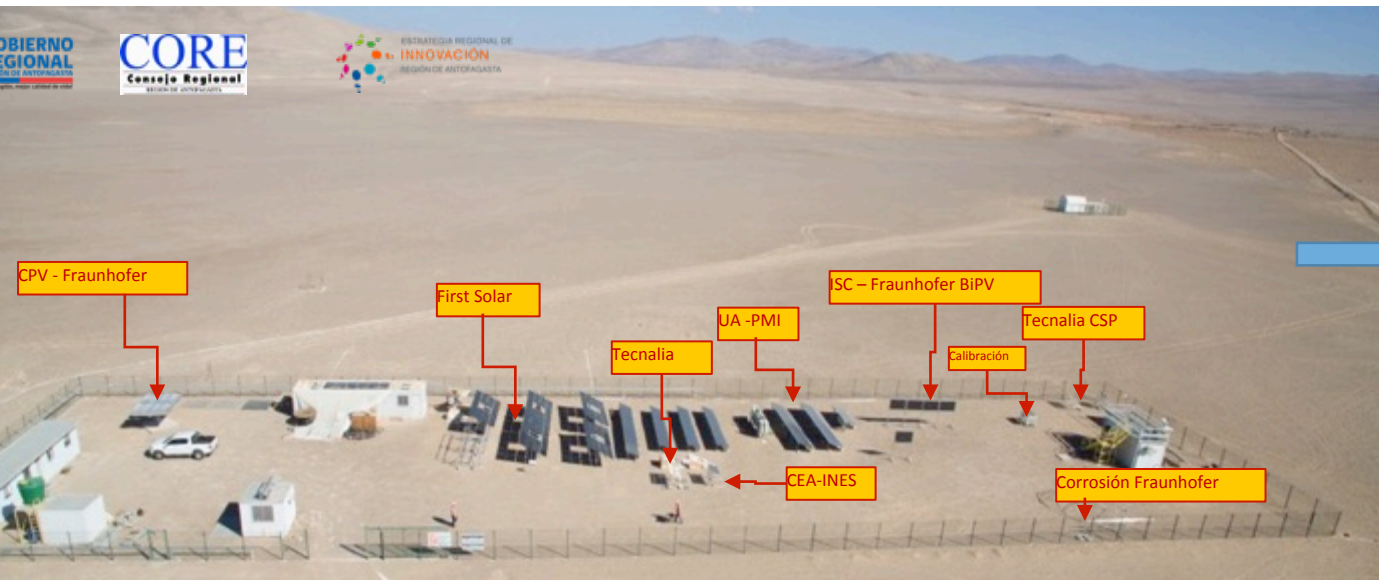
- ✓ Solar resource
- ✓ Soiling
- ✓ Weather conditions
- ✓ Electrical Systems (Grids)
- ✓ Durability (UV)



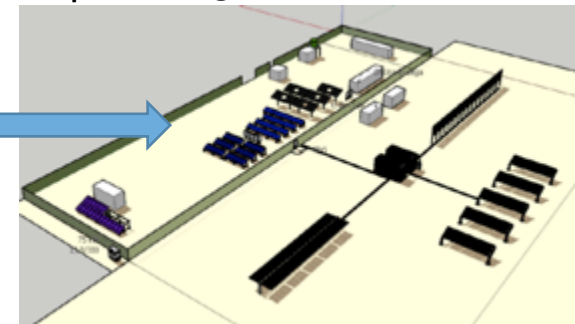
# PROJECT PORTFOLIO



## P6: Demonstration of PV Systems under desert conditions



April 2019



Pilot Test Bed

SDA+ (Plataforma Solar Desierto de Atacama)

## P6: Demonstration of PV Systems under desert conditions

| System                       | PERC | PERC+ | HET ** | PERT ** | Subtotal | Dummy | Total      |
|------------------------------|------|-------|--------|---------|----------|-------|------------|
| Fixed 20°                    | 8    | 8     | 8      | 8       | 32       | 8     | 40         |
| HSAT                         | 8    | 8     | 8      | 8       | 32       | 8     | 40         |
| Vertical                     | N/A  | 8     | 8      | 8       | 24       | 8     | 32         |
| Minimodules<br>Fixed 20°**** |      |       | 20     | 20      |          |       |            |
| <b>Total</b>                 | 16   | 24    | 24     | 24      | 88       | 24    | 112<br>*** |

Fixed system at 20 degrees with zero azimuth (that is, pointing north)

HSAT system (Single axis tracking) following the sun from east to west.

Vertical system or with 90 ° fixed angle. It has east-west orientation.

Monofacial Technology (PERC) is not mounted in vertical mode because it is not its optimal condition.



## P6: Demonstration of PV Systems under desert conditions

ca Solar Lalcktur  
illed power 1,081 MWp  
fagasta Region, Route B-475 62 km from BHPBilliton Offices  
ce used 4,18 has  
6 panels  
verters 20 kW/e

ustrial Test Bed



## P7: LCOE & Bankability

Main parameters for LCOE evaluation

AtaMoSTec



$$LCOE = \frac{I_0 + \sum_{t=1}^n \frac{(R_t + O_t + V_n + D_n)}{(1+r)^t}}{\sum_{t=1}^n \frac{H_t \times Y_i \times (1+d)^t}{(1+r)^t}}$$

Local Irradiation  
Ambient Temperature

- ➔ Electricity production
- ➔ Investment
- ➔ Exploitation costs
- ➔ Financial parameters

- CAPEX**
- Modules (€/Wp)
  - BOS
  - Support
  - Trackers
  - Cabling DC, AC
  - Inverter
  - Installation cost
  - Site preparation
  - Interconnection of modules and strings
  - Fixed costs
  - Conception
  - Commercial, marketing
  - Building permit



- OPEX**
- Variable costs
  - Manpower
  - Cleaning, monitoring
  - Site safety
  - Fixed Costs
  - Insurance
  - General costs
  - Site rent costs
  - Replacement
  - Inverter (life duration)
  - Module

**PV plant design**

- Orientation
- Fix / tracker 1-2 axes

**Module efficiency**

- Soiling, Shading issues, ALBEDO
- dégradation factors (module, components, etc)

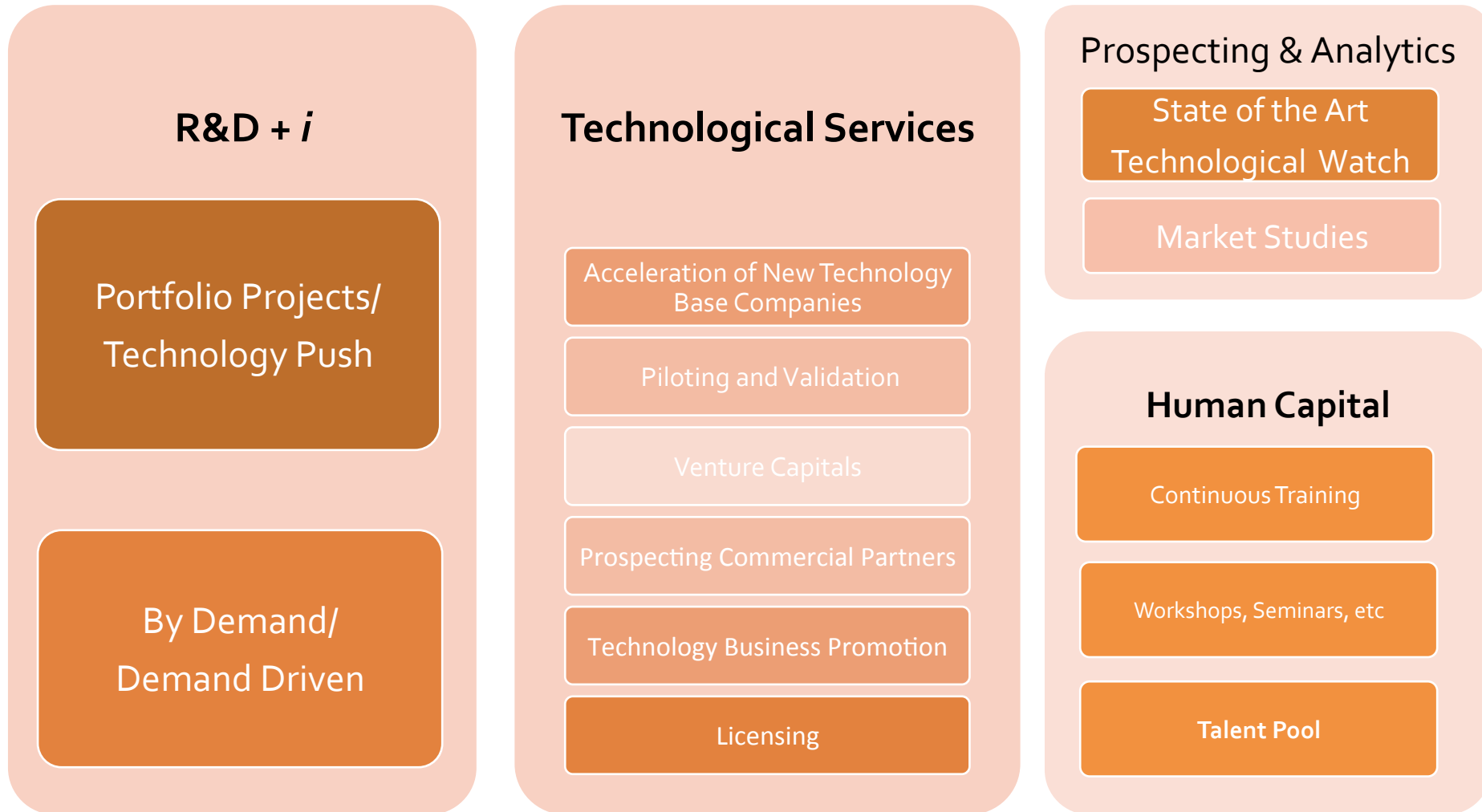
**Electrical losses**

- cabling DC, AC, network connection
- Inverter efficiency

**FINANCIAL PARAMETERS**

- Exploitation Period
- WACC : Weight Average cost of currency
- Equity ratio ( Capital/ Debt/ Interest rate)

## 8: Business models, entrepreneurship and technology transfer



**Thank You!**



**ATAMOSTEC**

TECNOLOGÍAS FOTOVOLTAICAS DE ATACAMA