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POWER & INDUSTRIAL CO.

UTILITY SCALE PV: LEVERAGING SPANISH EXPERIENCE IN THE US MARKET

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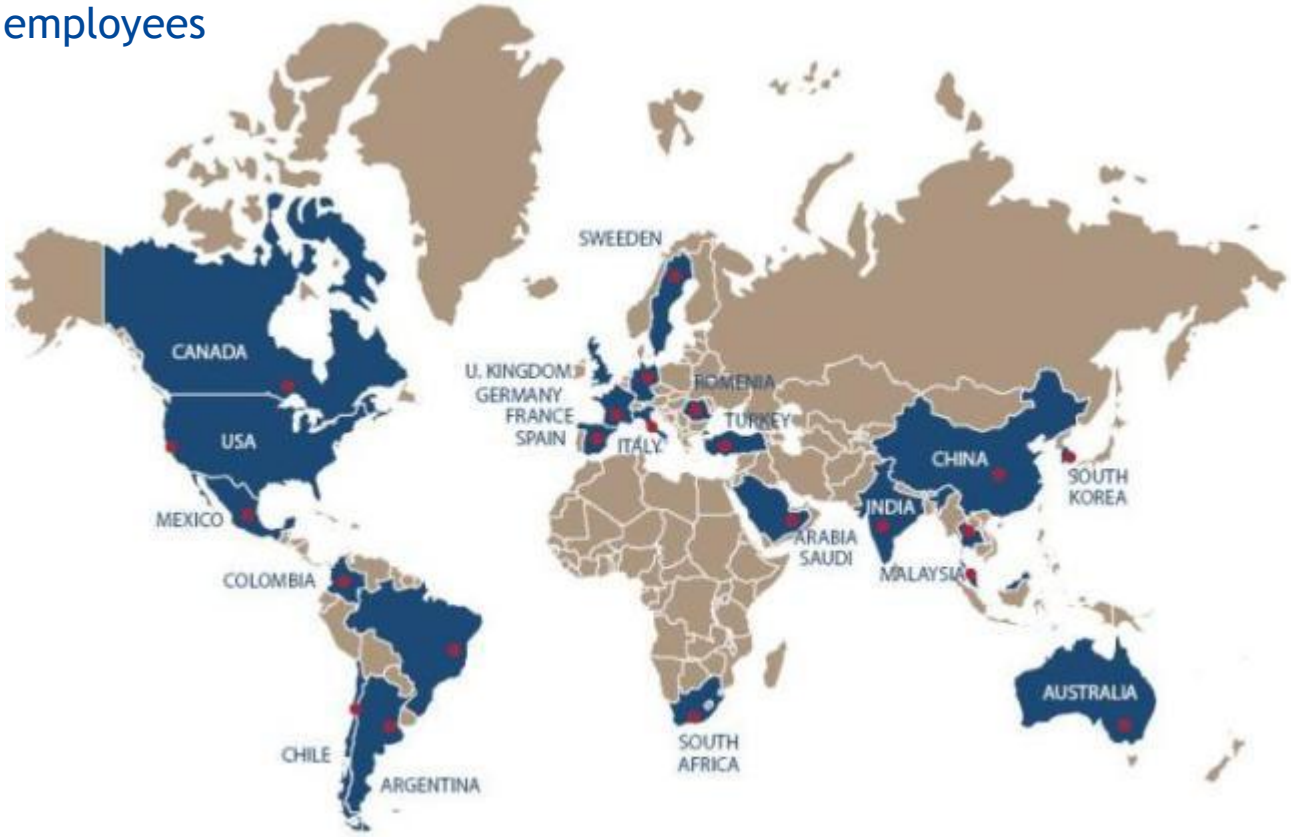
June 29, 2010

ARIES
POWER & INDUSTRIAL CO.

ARIES WORLDWIDE

- Global renewable energy engineering and project development company since 1987
- References in 20+ countries
- 160+ employees

- 15 MW PV In operation
- 150 MW CSP in construction
- Offices in Madrid, San Francisco, and Shanghai



ARIES SPANISH PV PROJECTS IN OPERATION

PROJECT INFORMATION

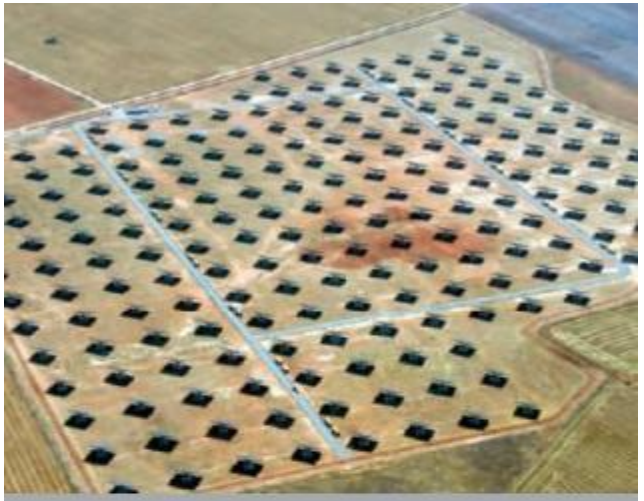
Project name	ARSOL-1	ARSOL-Toledo
Location	Damiel, Spain	Toledo, Spain
Site	40 ha / 99 acres	80 ha / 198 acres
Electrical connection	To 15 kV line	To 66 kV line
Operation date	February, 2008	July, 2008

SOLAR FIELD

Type of structure	2-axis tracking 25 kWp/tracker	2-axis tracking 12.5 kWp/tracker
Solar panels	Suntech STP 175S-24/AC	Suntech STP 270S-24/VB
Number of solar panels	33,150	43,200
Inverters	Siemens 100 kW	Siemens 100 kW

CAPACITY & PERFORMANCE

Nominal capacity	5 MW	10 MW
PV power installed	5.80 MWp	11.66 MWp
Plant performance	Contractual PR 72%; current PR during operation 80%	Contractual PR 73%; current PR during operation 80%
Gross annual energy	11.70 GWh/year	22.95 GWh/year



1. DESIGN & CONSTRUCTION

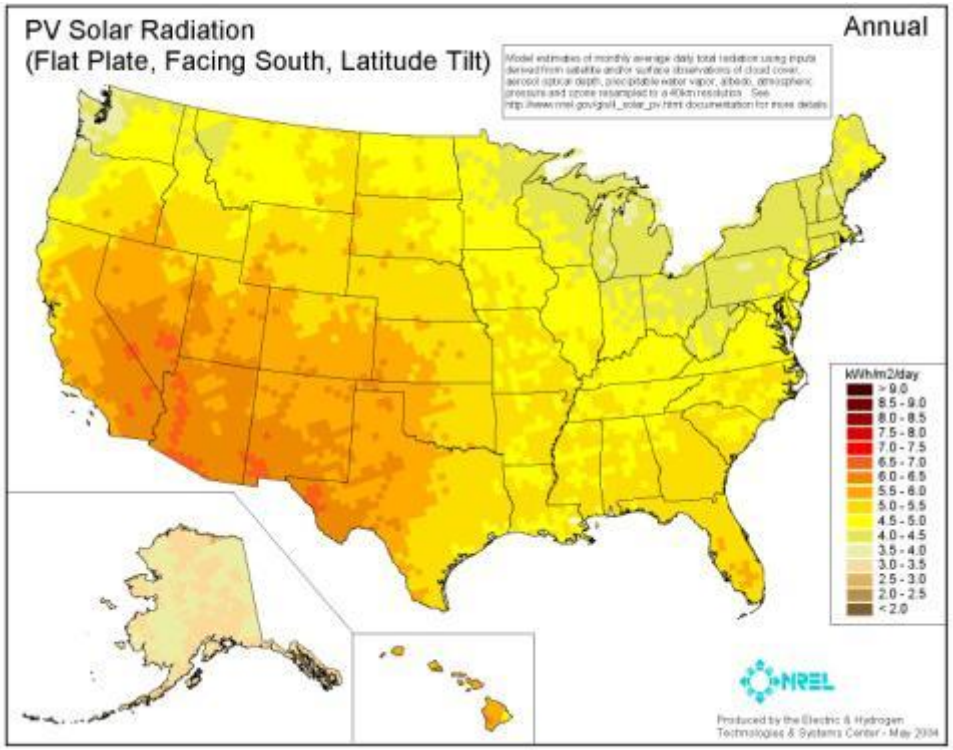
2. OPERATION AND MAINTENANCE

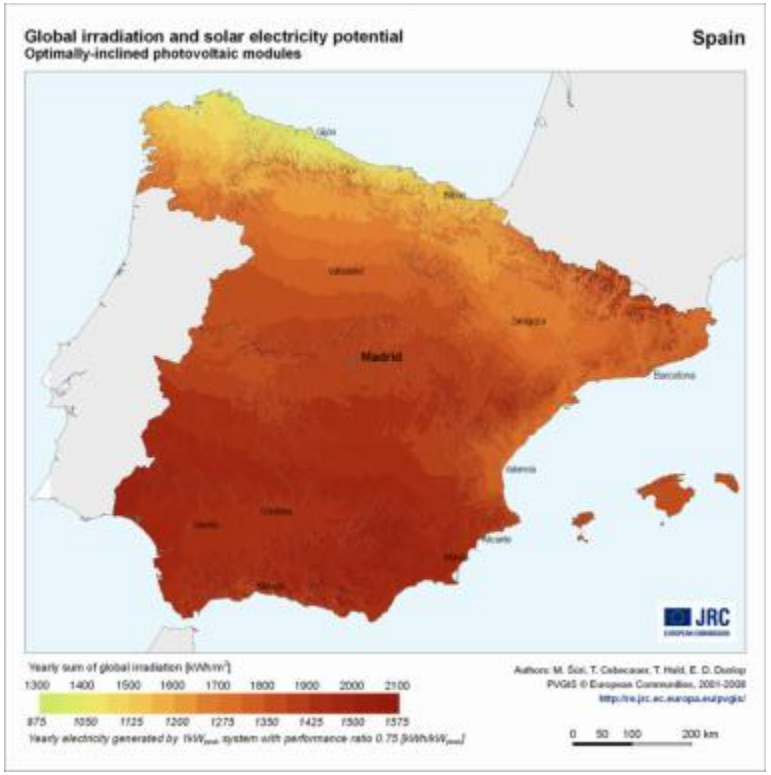
1. DESIGN & CONSTRUCTION

- 1.1. Site selection
- 1.2. Equipment selection
- 1.3. Engineering design
- 1.4. Site preparation
- 1.5. Commissioning

1.1 SITE SELECTION

Solar resource





… SW US has solar resource about 20% > Spain

1.1 SITE SELECTION

Wind conditions

1.1 SITE SELECTION

Soil Conditions

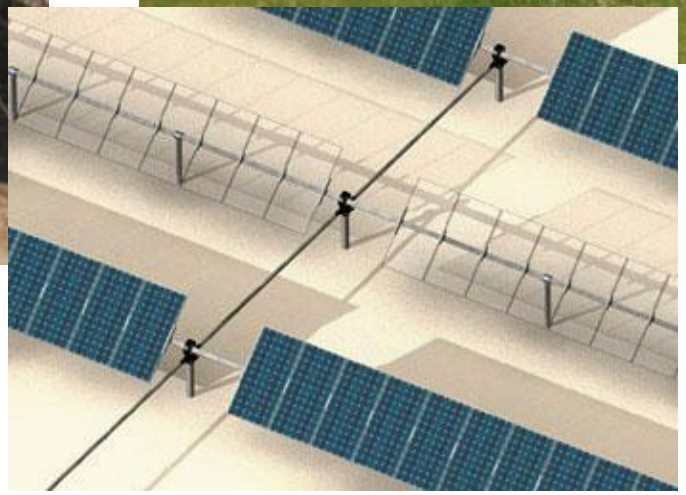
1.2. EQUIPMENT SELECTION

Fixed vs tracking structure

	Area needed	Production	Plant Availability	Energy Consumption per 1MW	1 MW Construction time
Fixed Structure	6.3 acre/MW	Base production	99,5 %	0.5 MWh/year	2 weeks
1 axis tracking	10 acre/MW	19 % increase	97 %	5.1 MWh/year	4 weeks
2 axis tracking	19 acre/MW	34 % increase	96 %	38.9 MWh/year	6 weeks

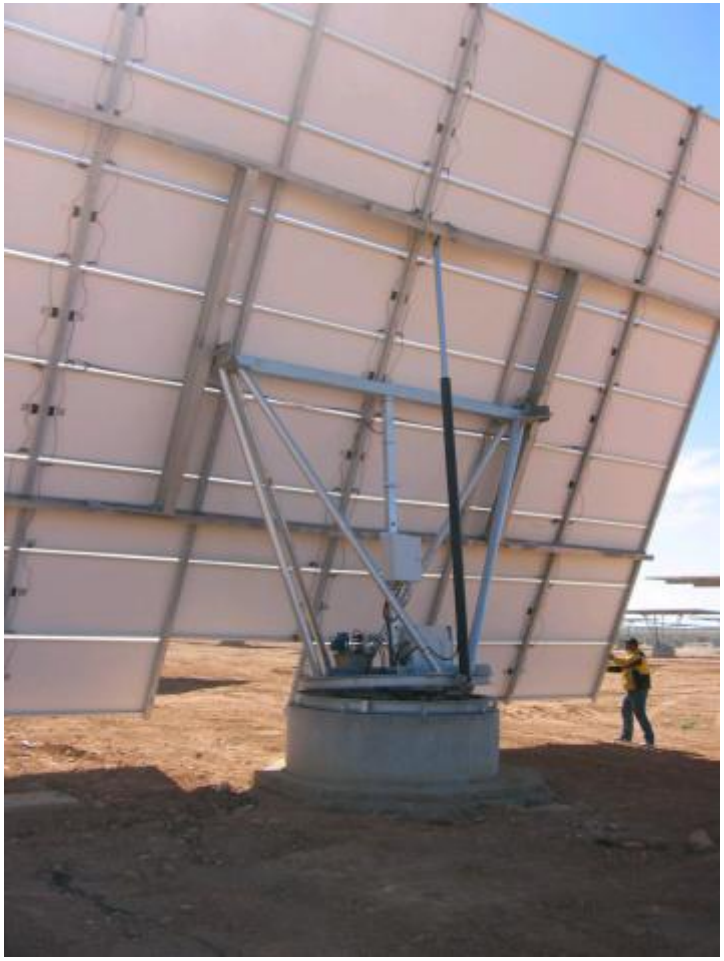
1.2. EQUIPMENT SELECTION

Fixed vs tracking structure

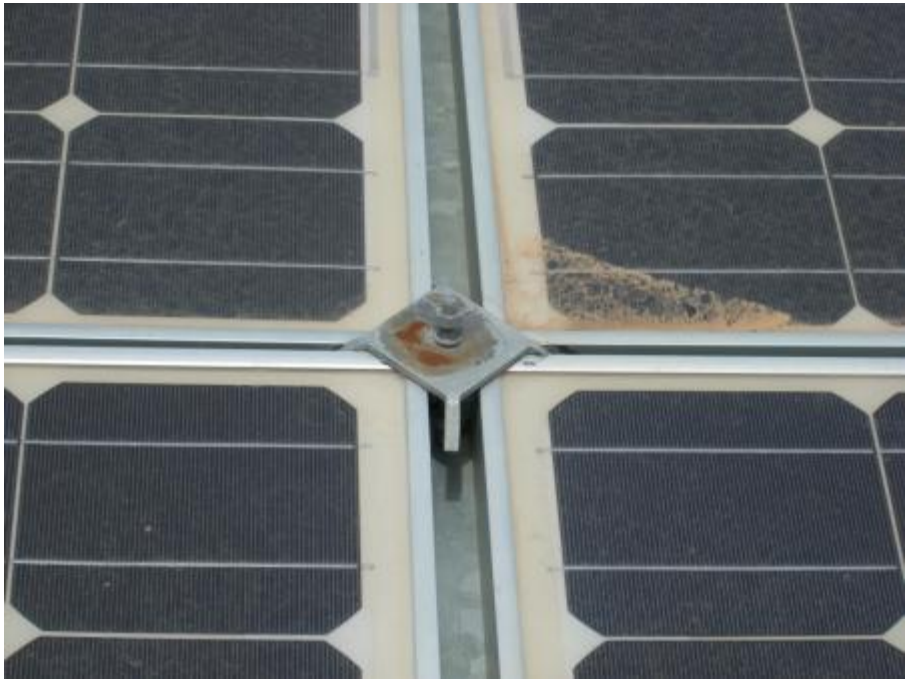


Array Technologies
Duratrac 1-axis tracker

1.2. EQUIPMENT SELECTION



1.2. EQUIPMENT SELECTION



Redesign during operation

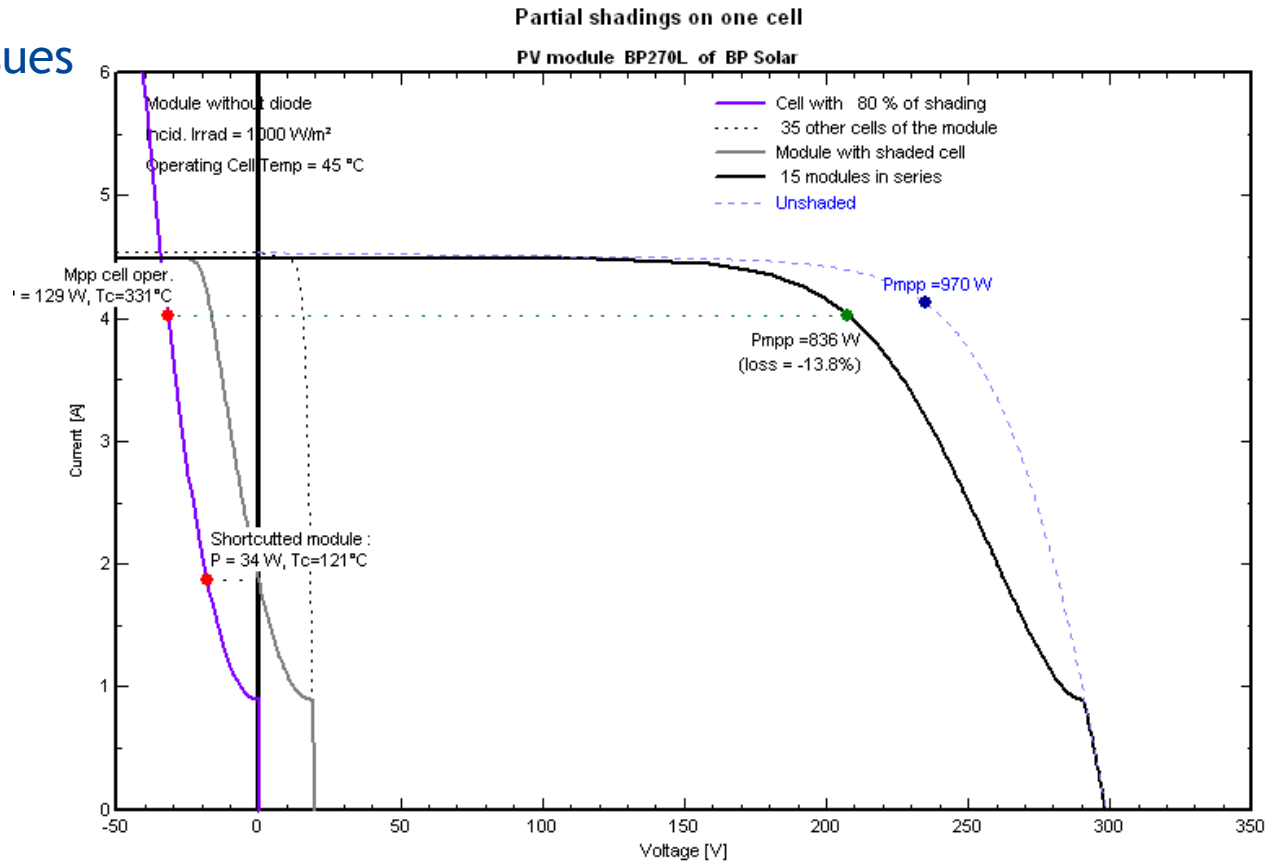
1.2. EQUIPMENT SELECTION

Redesign during operation

1.2. EQUIPMENT SELECTION

1.3. ENGINEERING DESIGN

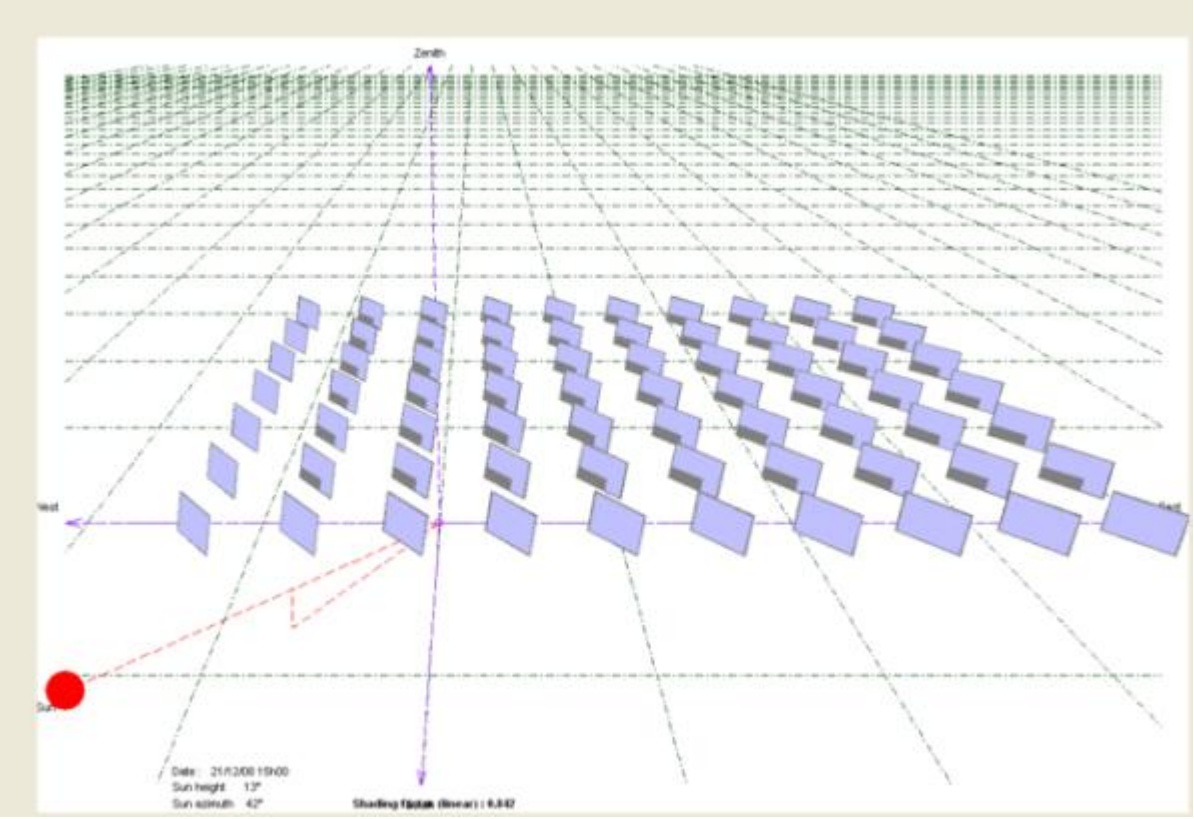
Shading issues



Effect of shadows on PV modules

1.3. ENGINEERING DESIGN

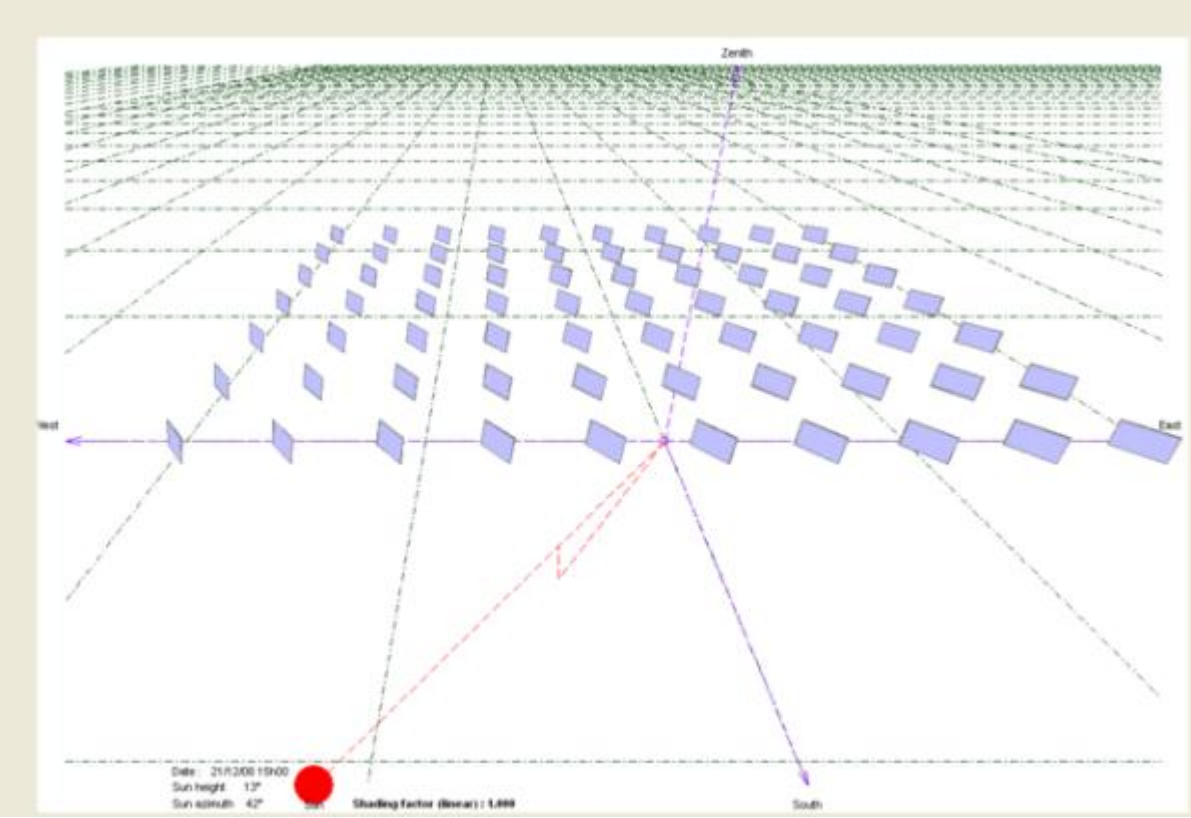
Shading issues



Two axis tracker plant with 16% shading losses

1.3. ENGINEERING DESIGN

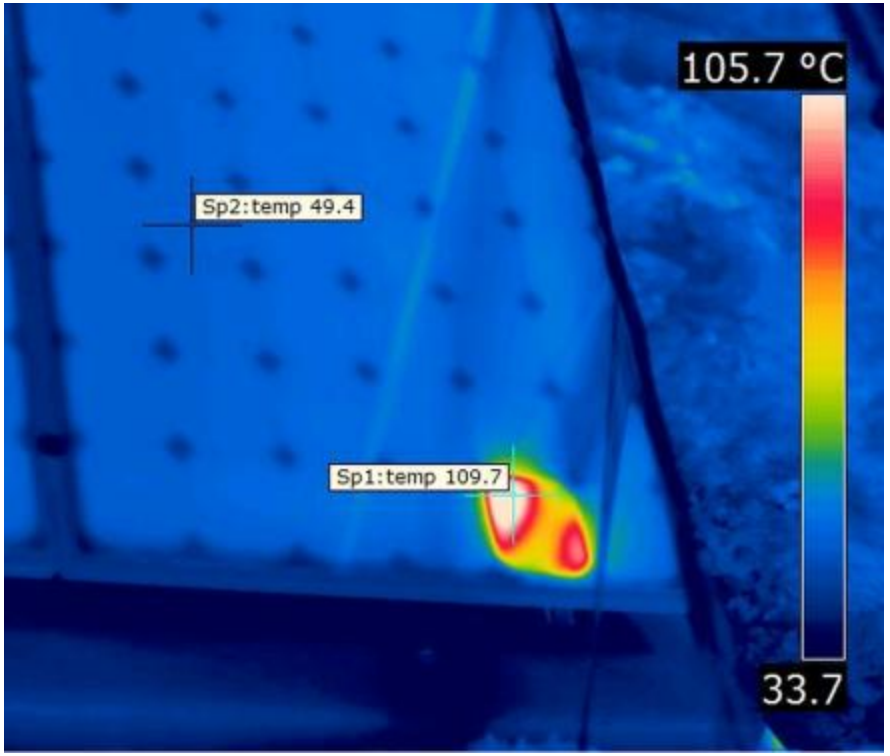
Shading issues



Two axis tracker plant without shading

1.3. ENGINEERING DESIGN

Shading issues



1.3. ENGINEERING DESIGN

Shading issues

1.3. ENGINEERING DESIGN

Foundation: Screw vs. Vibration Embedment vs. Ballasts

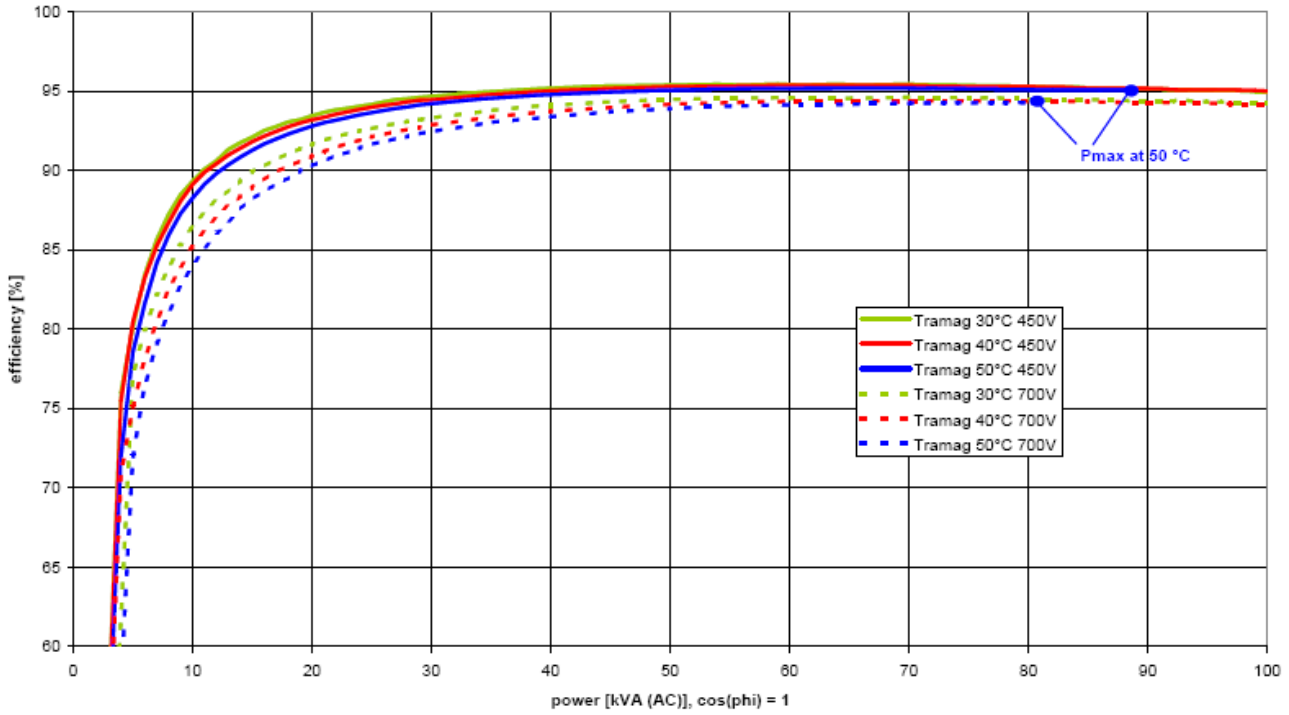
SunPower T20 Tracker at Nellis Airforce Base

1.3. ENGINEERING DESIGN

Inverters

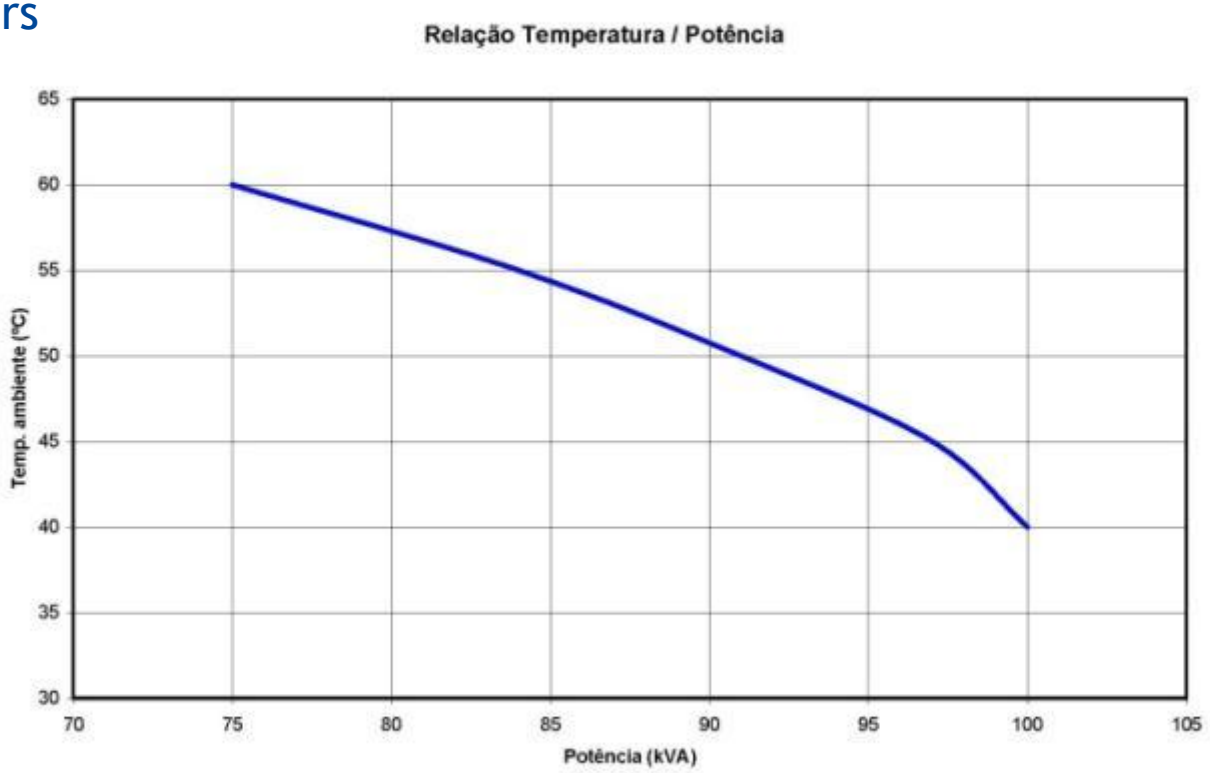
SIEMENS

SINVERT solar 100
Graph Efficiency / Power



1.3. ENGINEERING DESIGN

Transformers



Power output/temperature relation for a Siemens 100 kVA Transformer

1.3. ENGINEERING DESIGN

Cooling systems

1.4. SITE PREPARATION

Expensive earth movement and civil works …

1.4. SITE PREPARATION

… or just trenchs and foundations

1.5. COMMISSIONING

- Key elements to check before the acceptance tests:
  - Cable trace
  - Inverter measurements
  - Tracking systems (mechanical and I&C)
  - Electrical protections
  - Control system
  - Grounding

1.5. COMMISSIONING

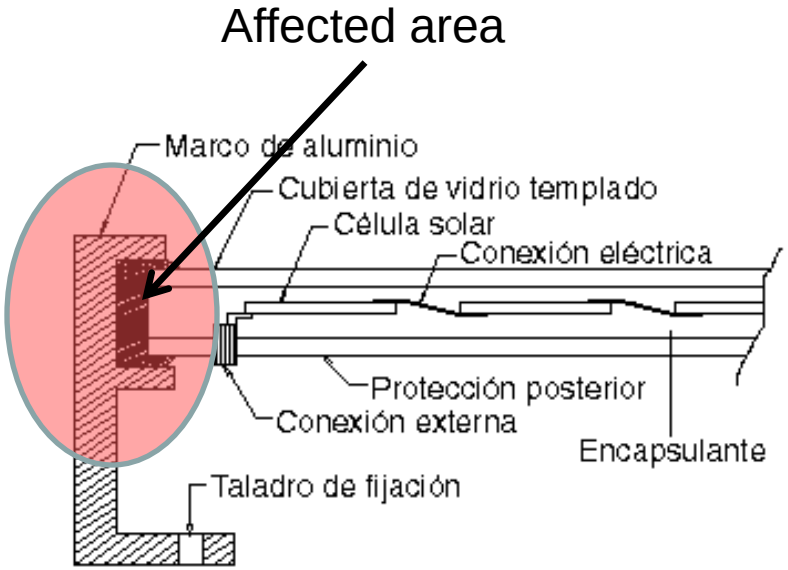
Commisioning without connection to the Grid requires a source of power for the inverters and a load for the energy produced

2. OPERATION AND MAINTENANCE

- 2.1. Panel Cleaning
- 2.2. Operation
- 2.3. Performance of the Plant
- 2.4. Thermal inspections
- 2.5. PV Control and Monitoring System
- 2.6. O&M Costs

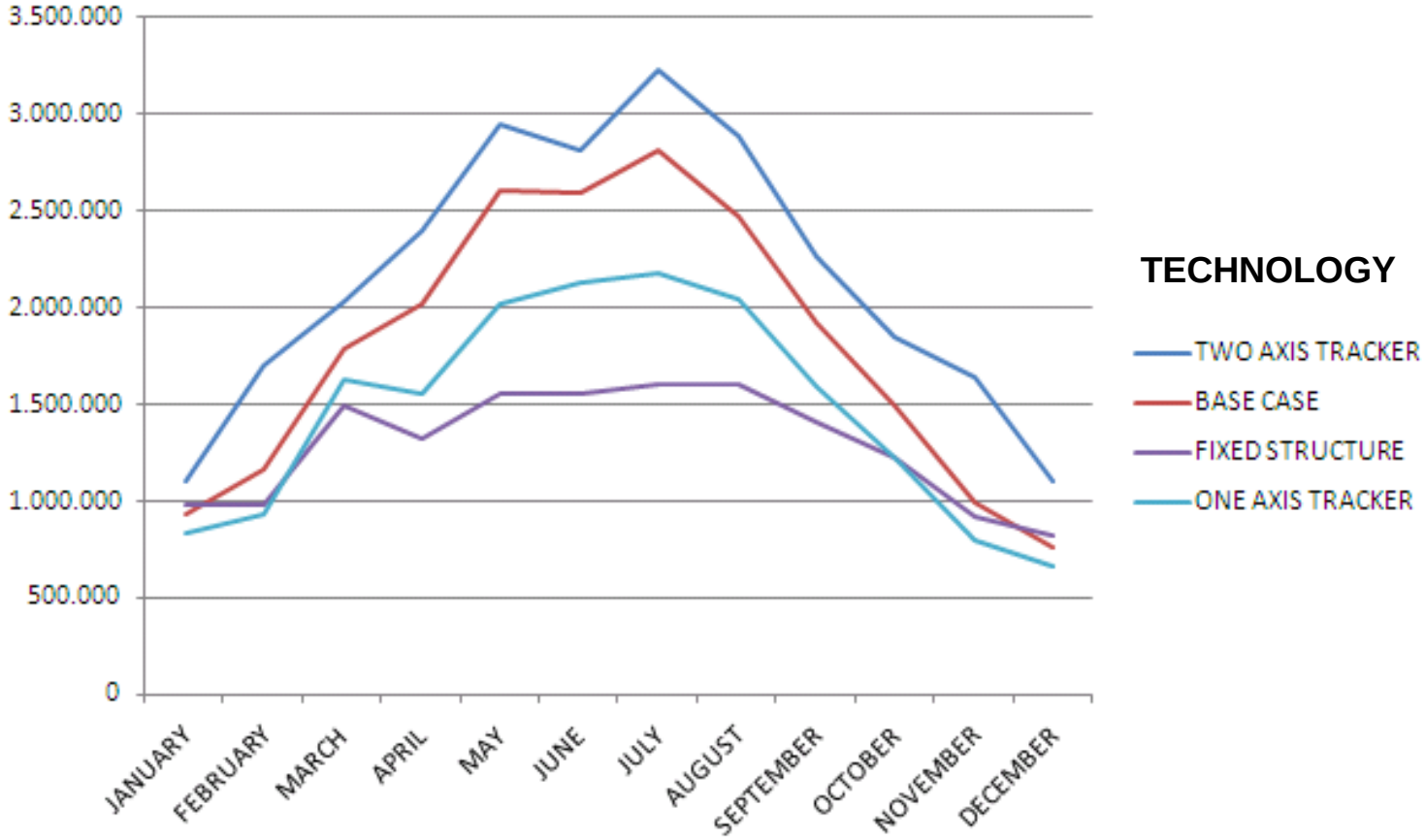
2.1. PANEL CLEANING

- Panels that are not periodically cleaned can have 5-8% power loss
- Use of groundwater may cause mineral deposits on the panels
- Use of deionized water may damage panel frame
- Effect of cleaning on power production is not as important as often stated
- Panel cleaning schedule is very site and technology specific



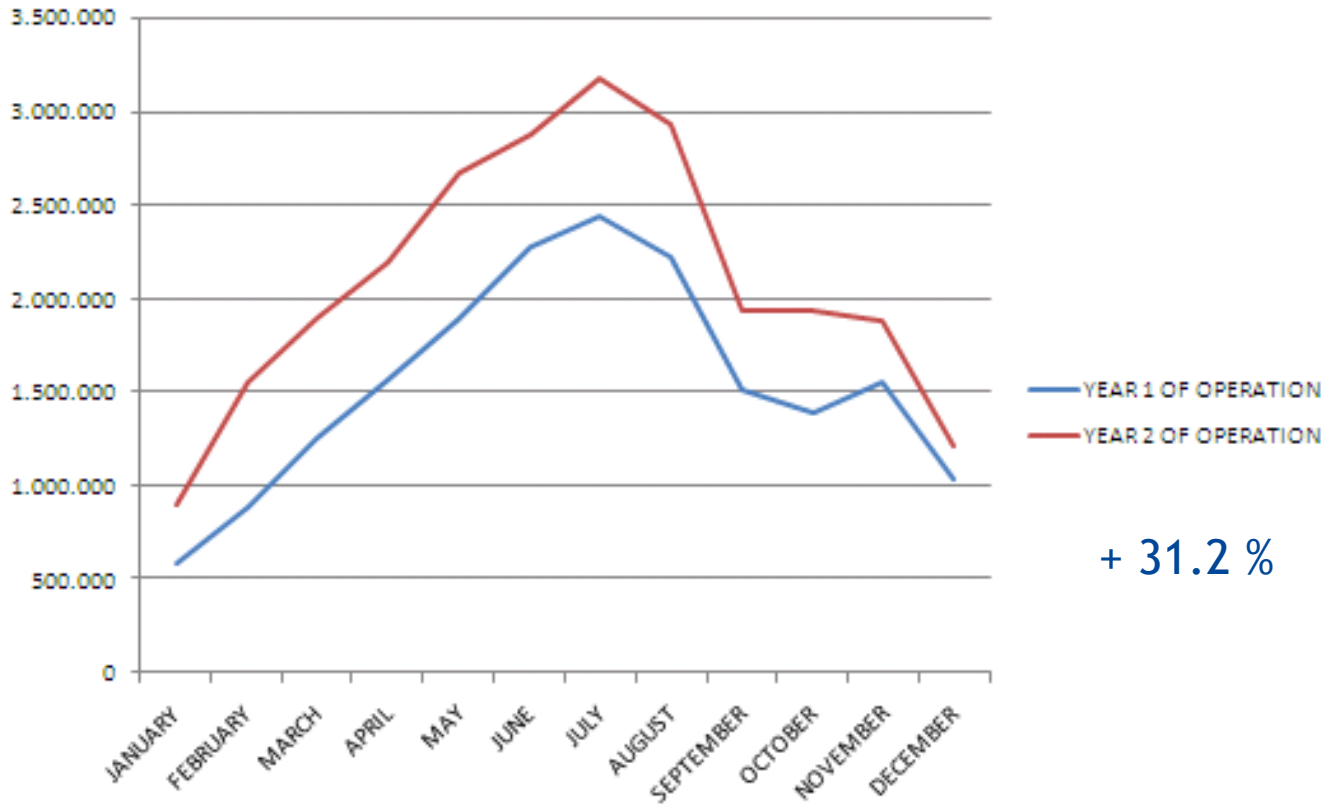
2.2. OPERATION

Real production data of different technologies of PV Plants in Spain



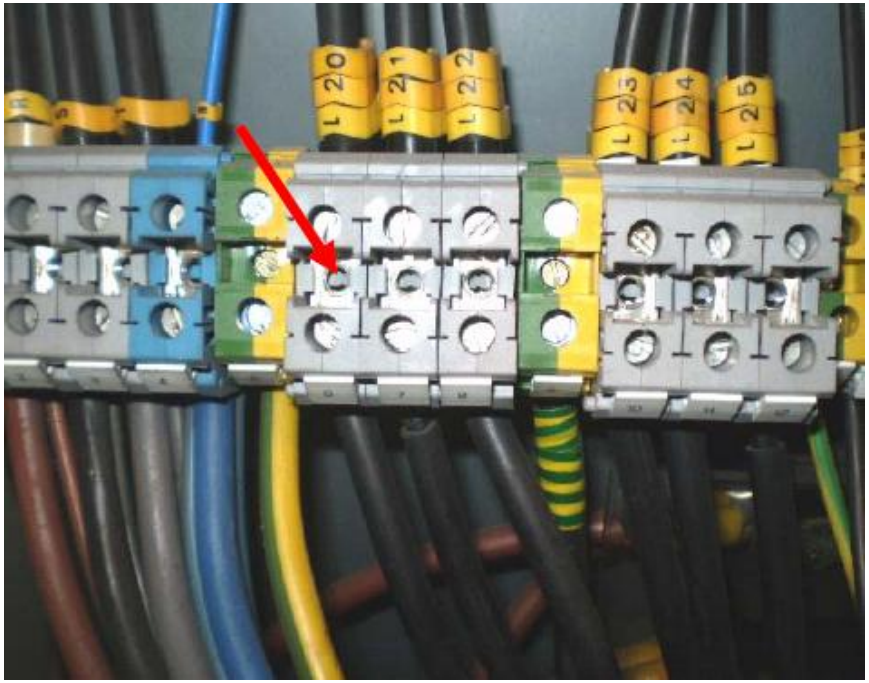
2.3. PERFORMANCE OF THE PLANT

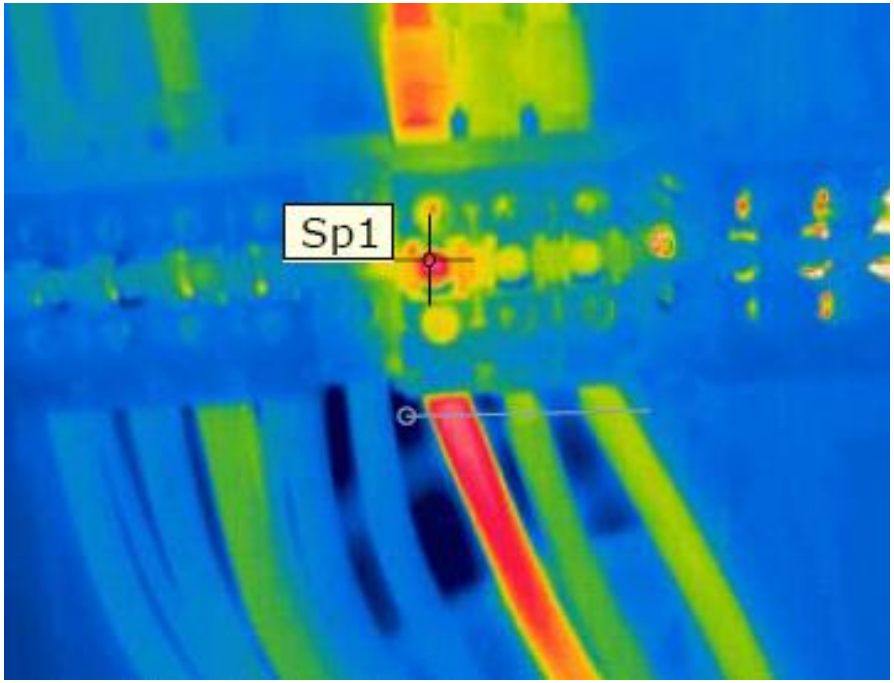
Production increase after 1 year of operation (2 axis trackers 10MW PV Plant)



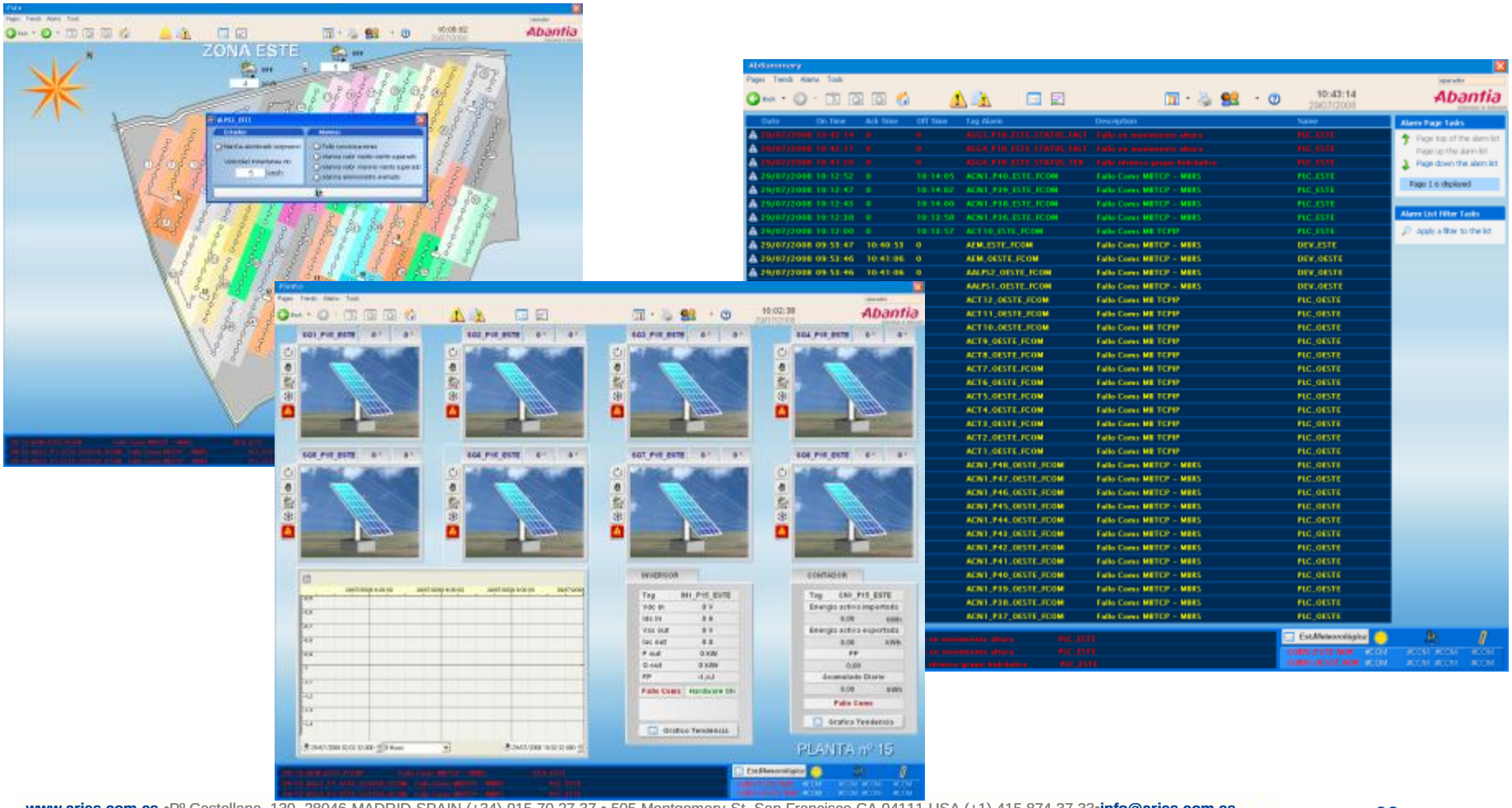
+ 31.2 %

2.4. THERMAL INSPECTION





2.5. PV CONTROL AND MONITORING SYSTEM



2.6. O&M COSTS

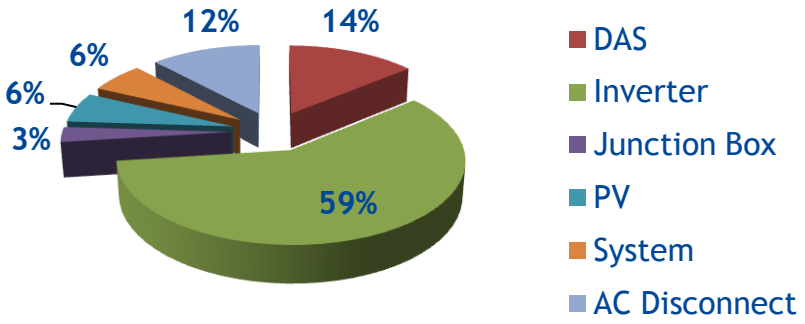
Case Study: Tucscon Electric Power (TEP) 3.51 MWp Springerville, AZ PV Plant

- Installed between 2001-2004
- 26 x 135 kWp systems, fixed structure, Schott modules and Xantrex inverters
- EPC cost $5.40/Wp ($3.33/Wp panels!)

Maintenance Cost ($/Wp/yr)

Year	Scheduled	Unsched.	Total
2002	$ 0.004	$ 0.001	$ 0.005
2003	$ 0.004	$ 0.012	$ 0.016
2004	$ 0.003	$ 0.002	$ 0.005
2005	$ 0.003	$ 0.001	$ 0.004
2006	$ 0.002	$ 0.002	$ 0.004

UNSCHEDULED MAINTENANCE COSTS BY CATEGORY



Moore, L. M.; Post, H. N. *Fiver Years of Operating Experience at a Large, Utility-scale Photovoltaic Generating Plant*. Prog. Photovolt: Res. Appl. 2008; 16:249–259. Full text article can be found online at: http://www.greentops.co.il/Portals/0/Article%20about%20Schott.pdf

LEARN FROM SPANISH MARKET EXPERIENCE?

	SPAIN	USA
Market driver	Real Decreto 661/2007	State RPS
Incentives	FiT	ITC, MACRS, State incentives
Utility scale electricity price	0.44€/kWh for 25 years; new projects 0.31€/kWh	PPAs in range of $0.12 - $0.22/kWh
Guarantees	2 year EPC Performance Guarantee + equipment warranties	Performance Guarantee? EPC Workmanship + equipment warranties
Grid-tied PV capacity addition in 2008	2500 MW+	292 MW
Grid-tied PV capacity addition in 2009	Approx. 40 MW	441 MW
Future	**Retroactive FiT cuts *or* 400 MW/year market?**	**Nationwide RPS? FiT?**

THANKS FOR YOUR ATTENTION

Arsol 1 (5MW) ARIES PV Plant

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