

Designing Bifacial PV Projects

PV Field Experiences



Soltec

**Making Tracks,
Building Trust**

Solar Trackers and Bifaciality

PV Field Experiences

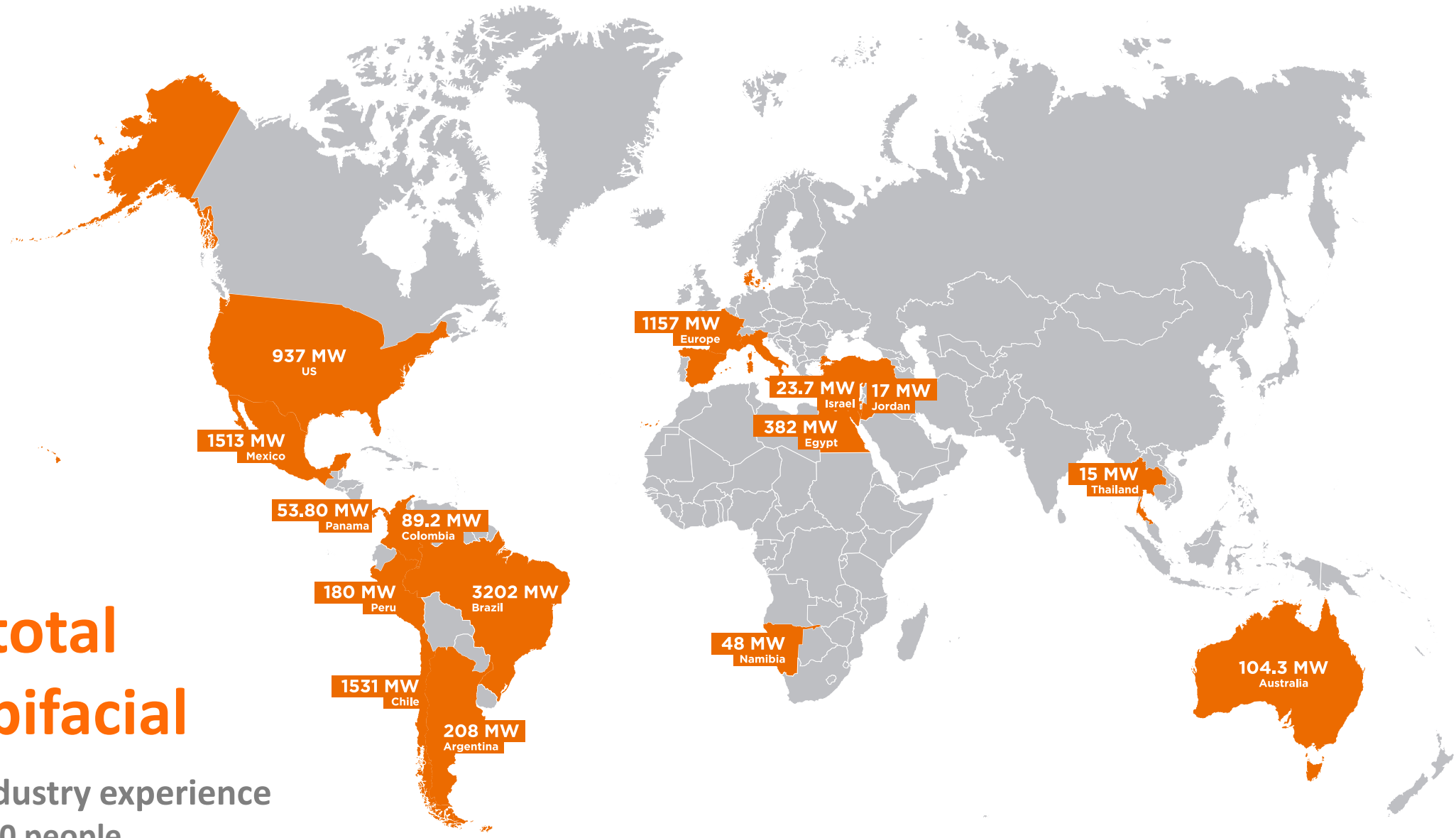
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1. Introduction and Track Record

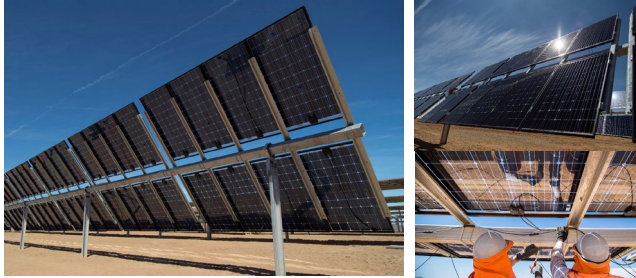
9+ GW total
3+ GW bifacial

16 years of industry experience
More than 1,500 people



2. Bifacial Experience

● 2015



'La Silla' solar plant (Chile), 2015.
Soltec produced **the first solar tracker specifically designed for bifacial modules** installed in a utility scale solar plant.

● 2017



Soltec launches SF7 Bifacial Single-Axis Tracker.

- Higher mounting height
- Shadow-free backside
- Wide-aisle reflecting surfaces

● 2018

Soltec Leads with the World's First Bifacial Tracking Evaluation Center

BiTEC (Bifacial Tracker Evaluation Center) measures bifacial performance and its effect on yield.

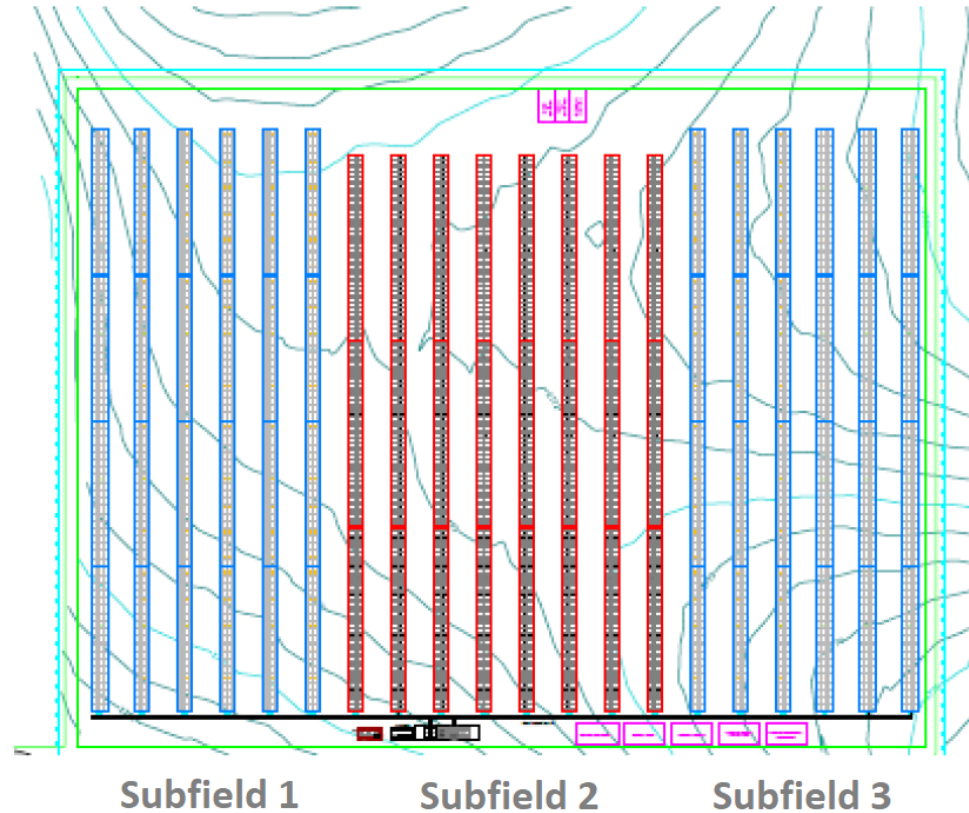
● 2019-2020

3+ GW SF7 Bifacial in projects worldwide

Sao Gonçalo I-Brazil (475 MW), Cluster MG-Brazil (118MW), Tlaxcala Mag II-Mexico (219,6 MW) among others.



3. First Plant: “La Silla” - Chile



Subfield 1: 575 kW Standard modules

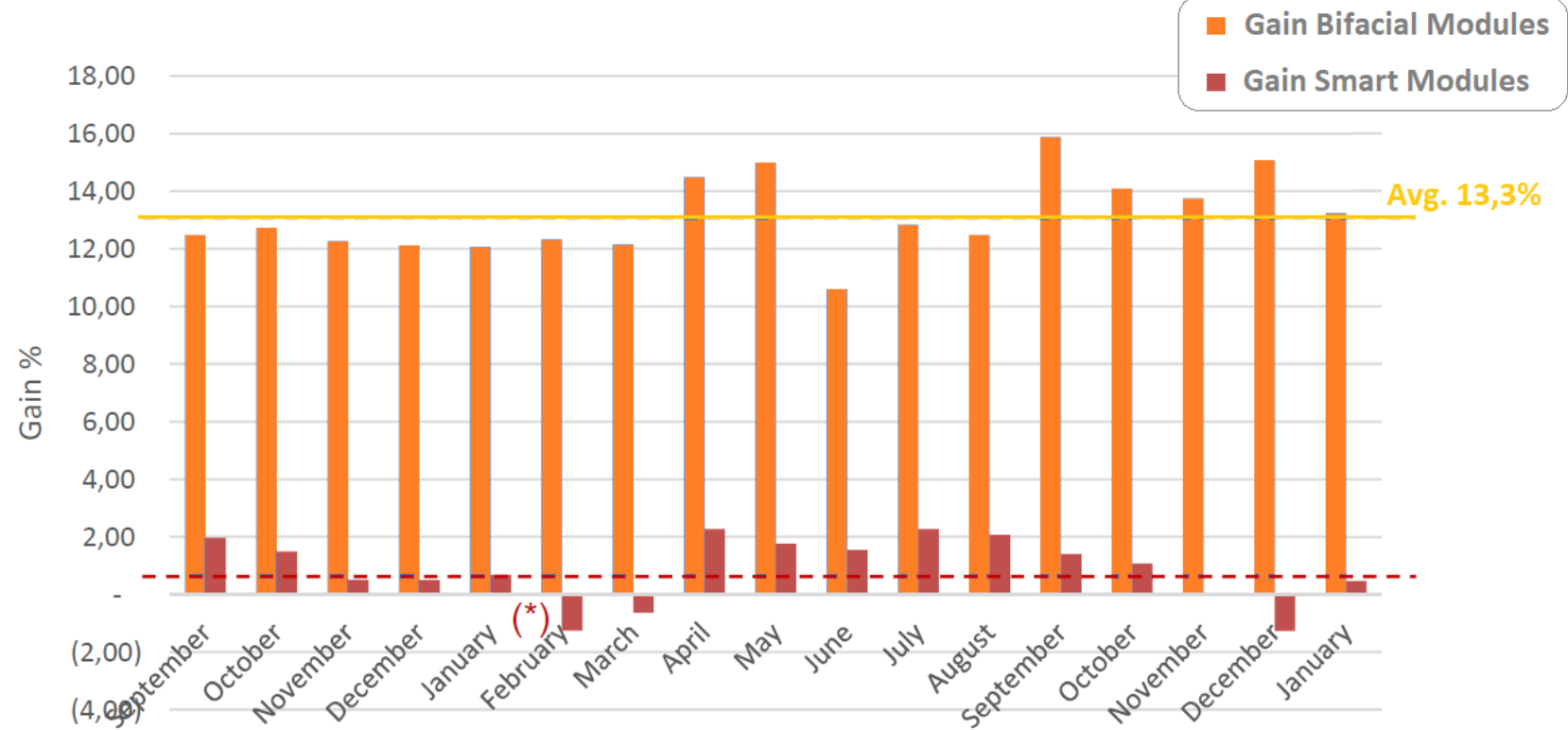
Subfield 2: 575 kW Smart modules with optimizers

Subfield 3: 575 kW Bifacial modules

GCR = 0.33



3. First Plant: “La Silla” - Chile



Bifacial Gain	12%	15%
Δ LCOE	-5.3%	-7.2%
Δ IRR	5.7%	9.1%

Source: Agnese Di Stefano, Giuseppe Leotta , Fabrizio Bizzarri,Enel Green Power SpA (2017) ‘La Silla PV plant as a utility-scale side-by-side test for innovative modules technologies’. 33rd European Photovoltaic Solar Energy Conference and Exhibition.

Comparison of the three subfields:

- Analysis of inverter data → Daily comparison and monthly average of PR data of the three subfields (IEC 61724)
- Calculation of daily and monthly average gain of the innovative technologies respect to the standard (Bifacial Gain, Smart Gain)
- (*) Some months gain is negative because tracking maintenance occurred in this subfield.

$$PR = \frac{Y_f}{Y_r} = \frac{E_{SYS}/P_{nom}}{E_{irr}/I_{ref}}$$

$E_{SYS} \equiv$ Generated energy
 $E_{irr} \equiv$ Incident Radiation
 $P_{nom} \equiv$ PV Power (STC)
 $I_{ref} \equiv$ STC Irradiance = 1kW/m²

$$Bifacial\ Gain = \frac{PR_{bifacial} - PR_{std}}{PR_{std}}$$

- $PR_{std} = 83.8\%$
- $PR_{bifacial} = 94.8\%$
- $PR_{smart} = 84.5\%$

4. Bifacial Tracker Evaluation Center



BiTEC - Livermore - California

$$\text{Bifacial Gain} = E_{\text{rear}} / E_{\text{front}}$$

$$\text{Bifacial Ratio} = G_{\text{rear}} / G_{\text{front}}$$

$$E_{\text{bifacial}} = E_{\text{monofacial}} \times (1 + \text{Bifacial Ratio} \times \text{Bifaciality})$$

Challenges:

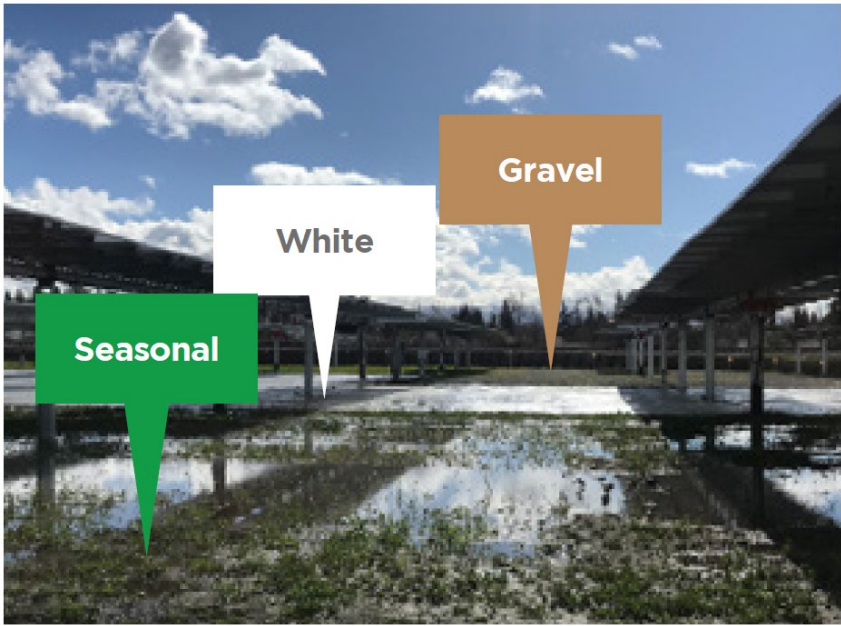
1. Acquiring long term bifacial tracking data for a setup of different scenarios
2. Recreate the conditions equivalent to large utility scale PV plants
3. Characterizing variables influencing bifacial
 - Albedo
 - GCR
 - Height
 - Shading and interferences

Determining Bifacial Gain = BG = $f(\text{Albedo}, \text{GCR}, H)$

Targets:

- Optimizing the SF7 bifacial tracker
- Developing advanced bifacial tracking algorithms
- Improving simulations parametrization

4. Bifacial Tracker Evaluation Center

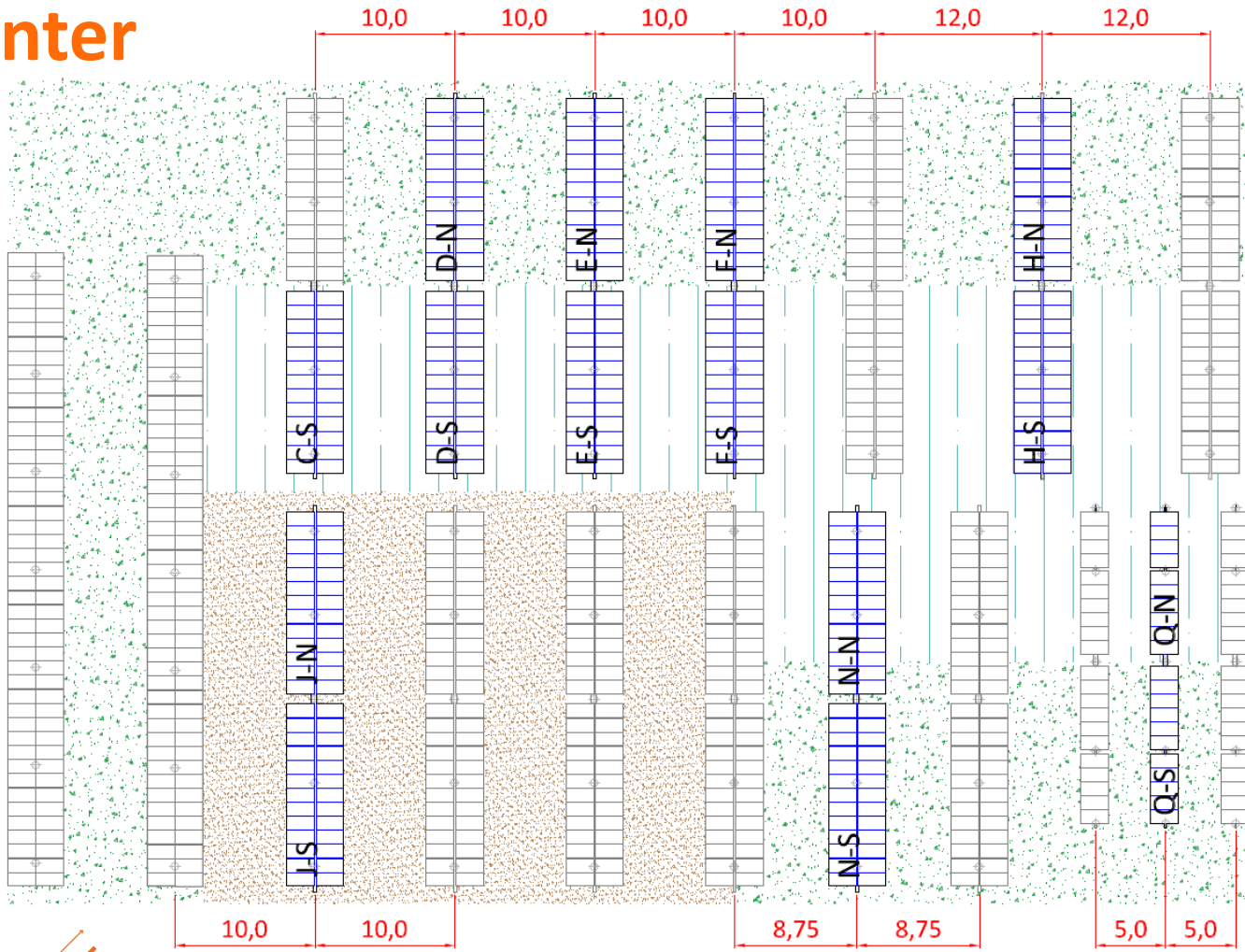
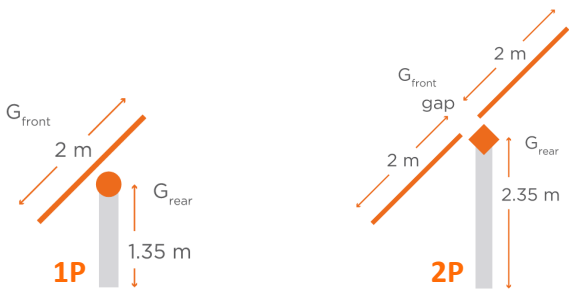


Albedo		Ground Coverage Ratio		
		0.46	0.40	0.33
White	49-65%	2P/1P		
Gravel	24-36%	2P	2P	2P
Seasonal	16-23%	2P/1P		

Test Features: --- 18 Trackers

- **Albedo:** White/Seasonal/Gravel
- **GCR:** 0.4, 0.33, 0.47
- **Height** 1P, 2P

1P → Tracker with 1 module in portrait
2P → Tracker with 2 modules in portrait



In Blue:
Modules used for measurements

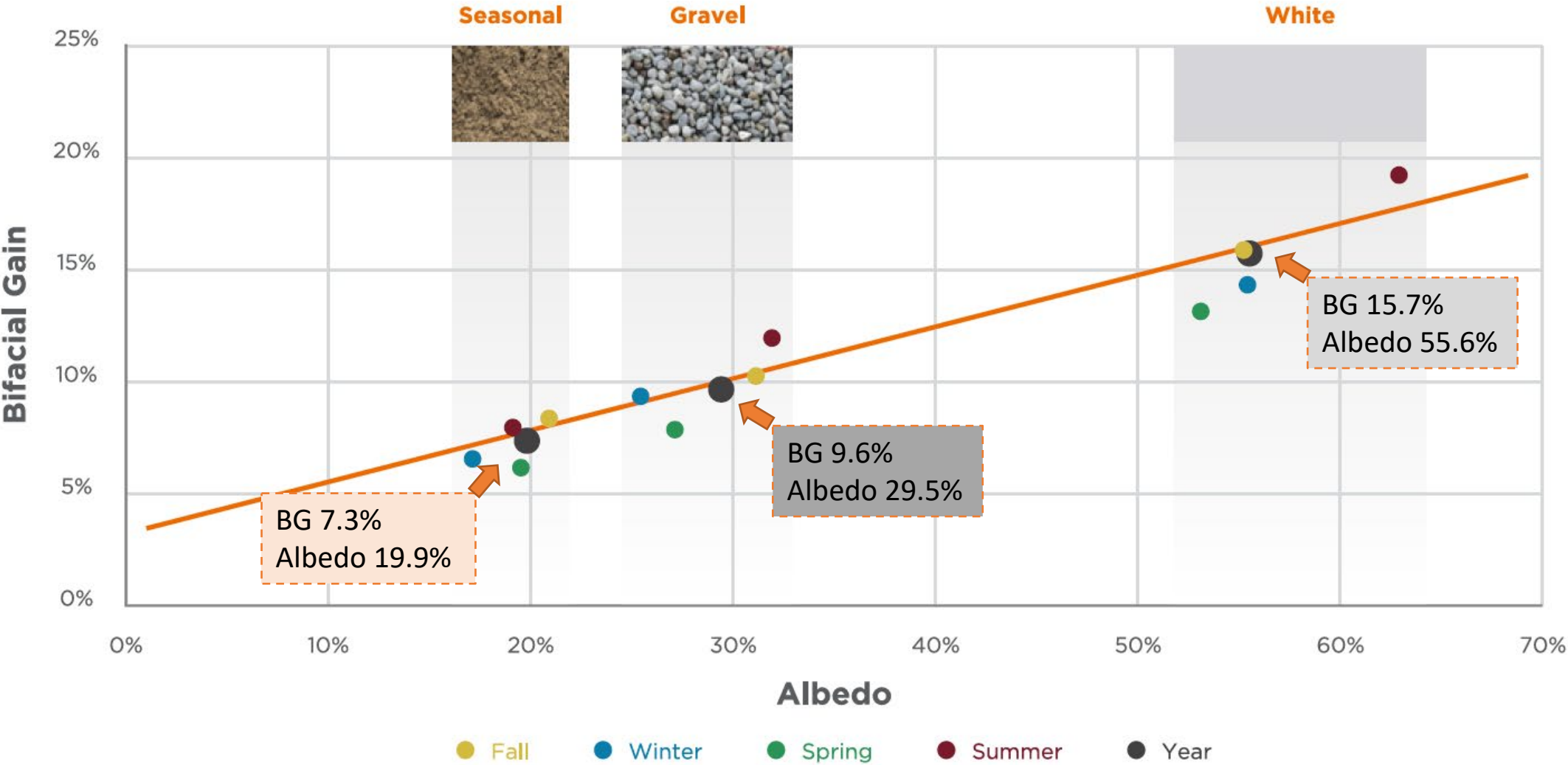
In White, Brown and Green:
White, Gravel and Seasonal albedos respectively

In Red:
Aisle Pitch in meters:

2P - 12.0, 10.0 and 8.7 meters equivalent to a GCR of 0.33, 0.40 and 0.46 respectively

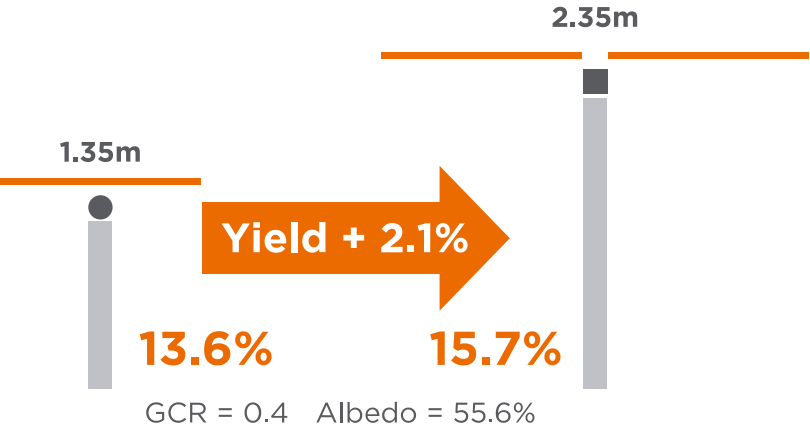
5. BiTEC – Full Year of Field Data

The Bifacial Year – Bifacial Gain Results



5. BiTEC – Full Year of Field Data

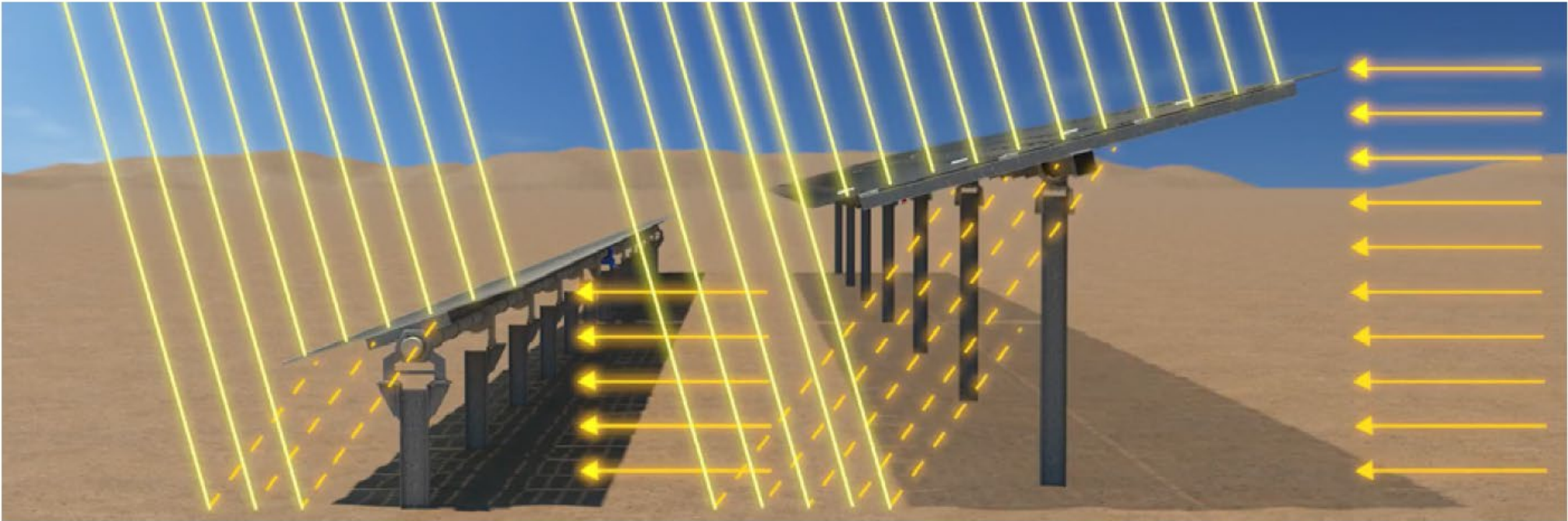
1P vs 2P



1P Standard tracker	Measured Bifacial Gain	2P SF7 Bifacial
16.8%	Fall	19.2%
12.6%	Winter	14.3%
11.2%	Spring	13.1%
13.7%	Summer	15.8%
13.6%	Year	15.8%

Test Considerations:

- Results based on energy performance at module level
- Only internal Trackers considered (avoid effect of higher diffuse on external Trackers)
- Only central modules considered (avoid effect of higher diffuse on edge modules)
- Results expected to be the average for large utility scale plants



5. BiTEC – Full Year of Field Data

1P vs 2P differences analysis

This table shows the analysis of the most relevant factors simulated in comparison with the collected data in the field for 1P and 2P Trackers.

Root cause	Factors breakdown	Differences	Tracker Type		Comments	Equivalence with PVSyst parameters
		Δ	1P	SF7 2P Bifacial		
Rear Irradiation -0.02%	View Factor	-1.00%	9.20%	8.20%	Relation between height and width of each Tracker	Tracker width – height
	Shaded area reflection	0.74%	0.09%	0.84%	Lighter shadow due to height. Raytracing simulation	
	Diffuse light	0.24%	1.51%	1.75%	Difference of height between Trackers	
Interferences/ Design +0.89%	Torque tube shading	0.56%	-0.56%	0.00%	Torque tube obstruction compared to the width of the Tracker	Shading factor
	Radiation through gap	0.17%	0.00%	0.17%	Reflection from torque tube. Raytracing simulation.	Module transparency
	Mismatch	0.16%	-0.47%	-0.31%	Effect of absolute module height to the ground. According to NREL's estimations ⁽¹⁾	Rear G mismatch
Operation +1.2%	Temperature	1.20%	-5.10%	-3.90%	Temperature field measurements	Uv & Uc
TOTAL GAIN 2P over 1P		2.07%				

(1) C.Deline, S.Ayala et al, BIFACIAL PV SYSTEM MISMATCH LOSS ESTIMATION AND PARAMETERIZATION, PVSEC2019 Marsella September 2019

6. Bifacial Plants Deployed Magdalena II – Mexico – 219.5MW

- SF7 2x42 Bifacial
- 6533 Trackers
- GCR 38.4%
- Operation started Q4 2019



6. Bifacial Plants Deployed

Sao Gonçalo I & II – Brazil – 608.67MW

- SF7 2x45 Bifacial
- 17568 Trackers
- GCR 33.85% and 27.68%
- Average albedo 25%
- Expected Operation Q2 2020



7. O&M Considerations

- Seasons affect the albedo with big variations . Examples of the same ground along the year:



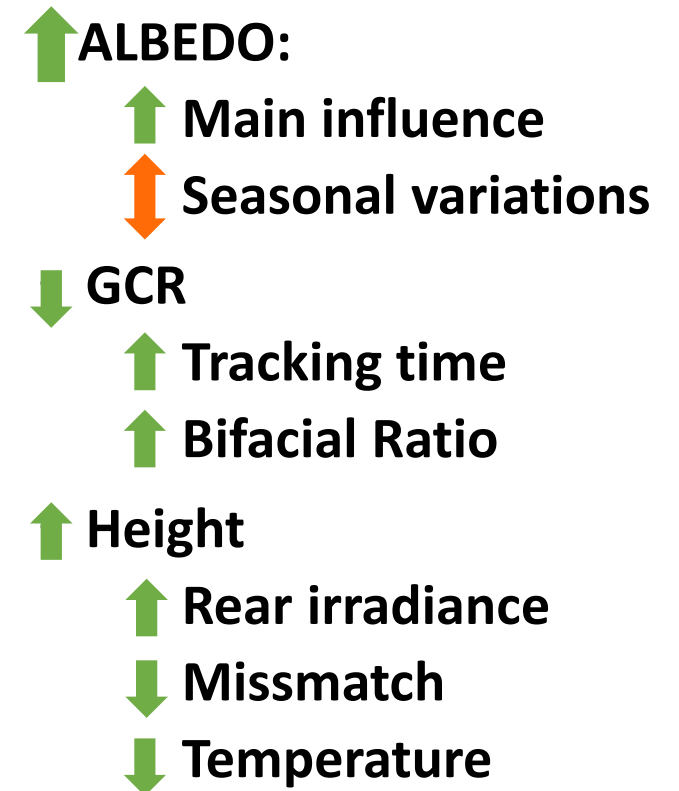
- With bigger spaces between Trackers eases the access for cleaning and trimming the grass
- Higher Trackers allow bigger machinery to reach the whole surface underneath



- Clients need a guarantee on averaged yearly albedo
- Albedo Enhance Materials (AEM) are getting attraction and being deployed at large scale already. These solutions also require maintenance during the life of the plant (cleaning, plants removal, replacement)

8. Conclusions

- 5 years since the first commercial Bifacial Tracker: La Silla Plant
- 1 FULL YEAR of BiTEC performance* data: September 2018 - August 2019
 - Bifacial Gain of 15.7% for SF7 bifacial with average albedo of about 55%
 - Bifacial Gain of 7.3% under seasonal albedo for northern California
 - Bifacial Gain for 2P SF7 Bifacial is 2.1% higher than 1P tracker
 - This difference is mainly caused by:
 - Lack of shading in the rear side of the module
 - Higher distance of the solar panels to the ground during operation
 - Lower operating temperature
- Bifacial Technology is a reality → Biggest Bifacial Plants with Soltec Trackers:
 - Magdalena II: 219.5MW
 - Sao Gonçalo I & II: 608.67 MW
- Operation and maintenance is relevant for bifacial performance
 - Possibility to increase albedos → AEM
 - Trackers' design can ease O&M tasks (2P vs 1P)
 - Possibility to guarantee a yearly average albedo → O&M costs



* Performance measured at module level

Thank you!
Any questions?

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