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30 April 2020

5 PM - 6 PM | CEST, Berlin
8 AM - 9 AM | PDT, Los Angeles
10 AM - 11 AM | CDT, México City
11 AM - 12 PM | EDT, New York

Marian Willuhn

Editor | pv magazine

pv magazine webinars

Albedo enhancing materials - Striving for highest cost-efficiency of bifacial tracker arrays

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UL

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Soltec

CONSIDERATIONS FOR BIFACIAL BANKABILITY

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30 April 2020

100+

Country locations of UL renewable energy customers

55+

Years of combined experience in the renewable energy industry

Independent / Owner's Engineer on

450+

wind & solar projects*

*since 2012

ADVISED

90%

of the wind and solar industry's top **PROJECT DEVELOPERS** and **PLANT OWNERS**

500+ UL Renewable Energy Experts

200,000+ MW

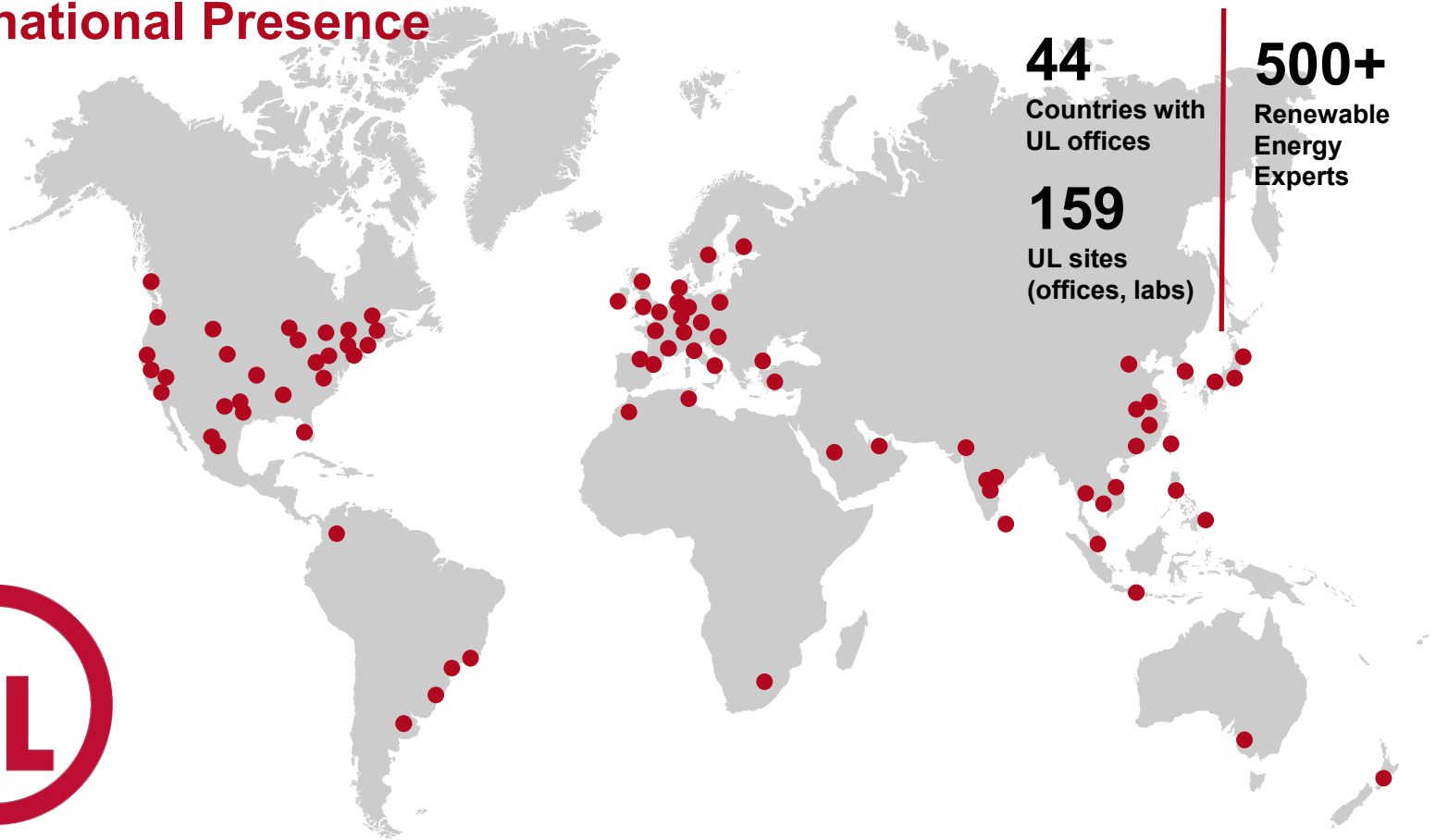
Total renewable energy megawatts (MW) assessed

FORECAST PROVIDER for

72+ GW

of installed renewable energy projects

International Presence



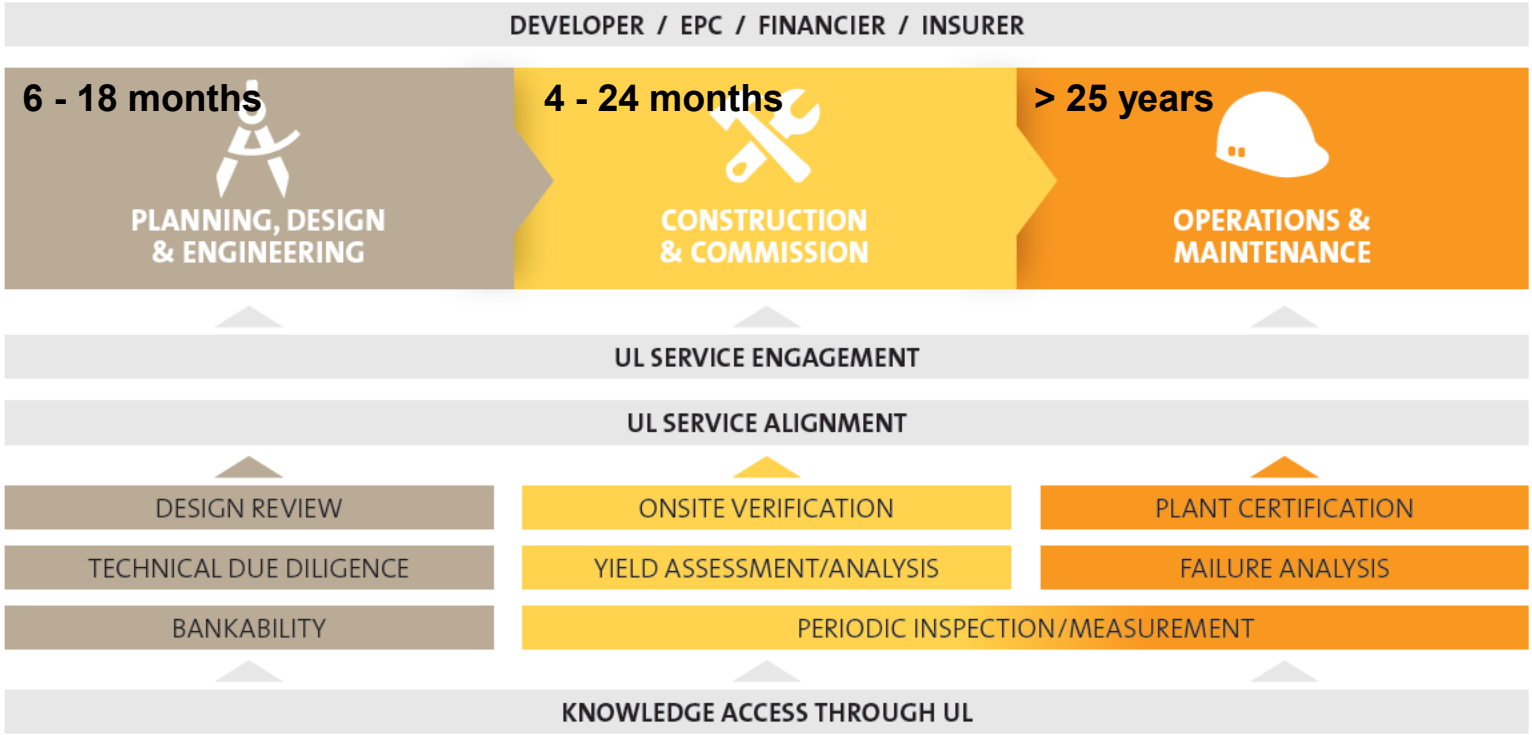
44
Countries with UL offices

159
UL sites (offices, labs)

500+
Renewable Energy Experts

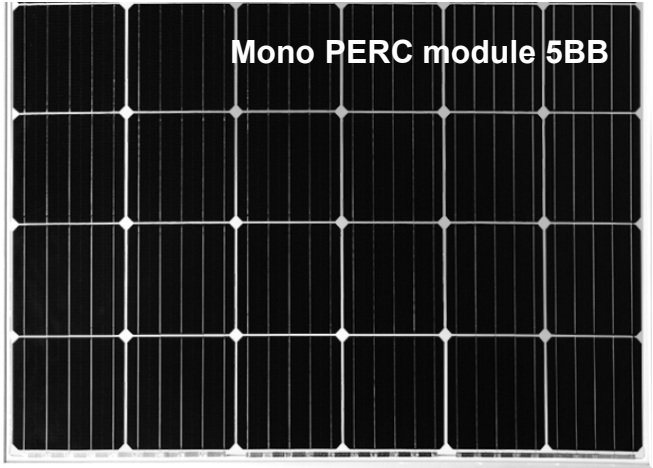

EÓLICO
SOLAR
ALMACENAMIENTO
E-MOBILITY
UL DRIVES TRUST IN RENEWABLES

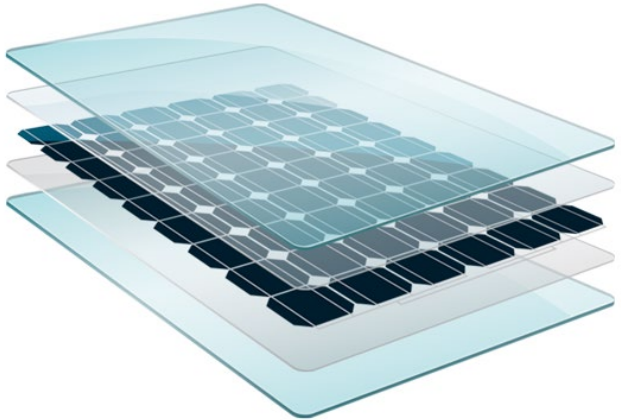
UL SERVICES IN SOLAR PV



BIFACIAL PV TECHNOLOGY

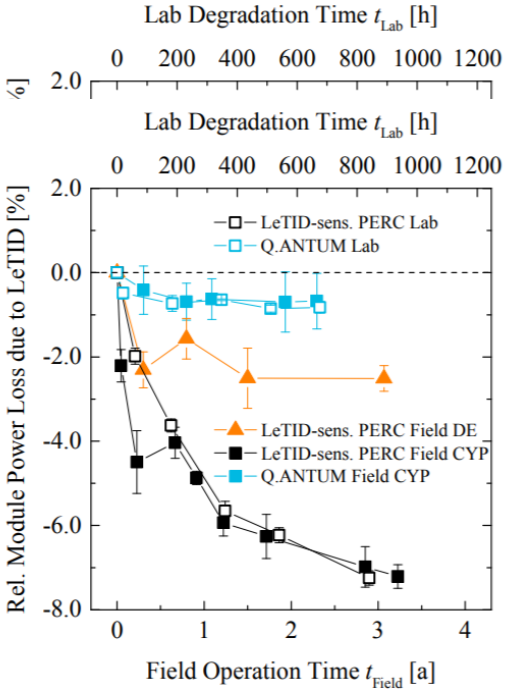
- It is expected that 60% of crystalline silicone modules will be bifacial by 2029
- Bifacial product are mostly based on mono Passivated Emitter Rear Contact (PERC) technology. PERC solar cell brings 0.5-1% higher efficiency with little more cost for additional production equipment
- Manufacturing from conventional mono to mono PERC is relatively easy and sets the base for future bifacial technology development
- The standard at the moment is to use 5-BB design or multi bus bars (MBB) reducing resistance losses.





PERC TECHNOLOGY / LETID LOSS

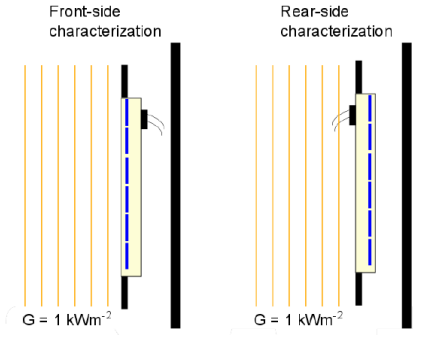
- LeTID (Light and Elevated Temperature Induced Degradation)
  - The effect is more pronounced in locations with high operating temperatures (> 50ºC)
  - The degradation observed is progressive over time and its impact is not as fast as LID (initial degradation in operating conditions). This phenomenon eventually stabilizes and efficiency may improve over time but there are not many studies in this regard.
  - There is no wide track record regarding the operation of PERC, publications suggest losses around 7% in high temperature environments and 2.5% in colder climates.



Source: Kersten, Friederike; Fertig, Fabian; Petter, Kai; Klöter, Bernhard; [illegible]hias ; Heitmann, Johannes; Mueller, [illegible]rmance loss due to LeTID. Energy Procedia."

MANUFACTURERS MUST PROVIDE TEST RESULTS TO DEMONSTRATE THAT MITIGATION TECHNIQUES IN THE MANUFACTURING PROCESS SUPPRESS OR MINIMIZE THIS EFFECT.

BIFACIAL MODULE QA TOWARDS BANKABILITY



Bifacial Power Measurements

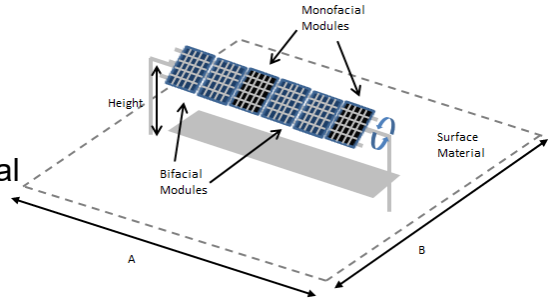
- Monofacial test conditions: standard test conditions (STC), single sided exposure at 1000 W/m^2
- New draft bifacial test conditions:

  Bifacial nameplate irradiance (BNPI)

  - Used to assess performance levels before and after stress tests (UL/IEC 61215)
  - 1000 W/m2 on the front and 135 W/m2 (or frontside irradiance of 1000 + φ*135 W/m2)

  Bifacial stress irradiance (BSI)

  - A reference condition for stress tests simulating higher rear-side contribution to total current
  - 1000 W/m2 on the front and 300 W/m2 (or frontside irradiance of 1000 + φ*300 W/m2)
  - BSI does not address all possible field scenarios, but is expected to cover typical installations that could result in high current generation over short periods.
  - Isc at BSI irradiance level proposed for use in bifacial stress tests: hot spot endurance, temperature cycling, bypass diode test (used in both 61215 and 61730)



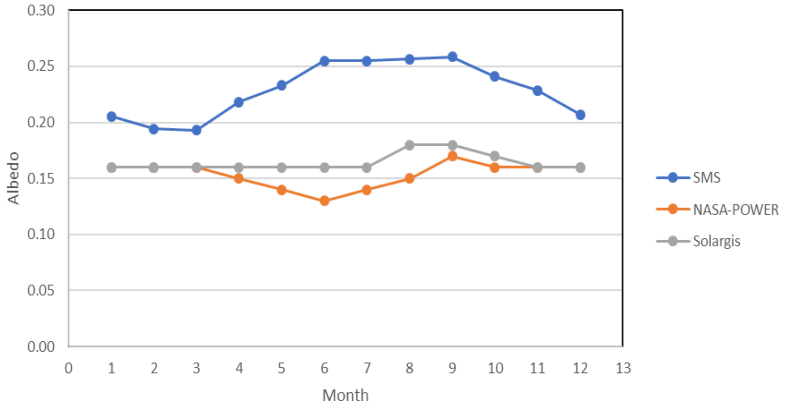
CHARACTERIZING SOLAR RESOURCE

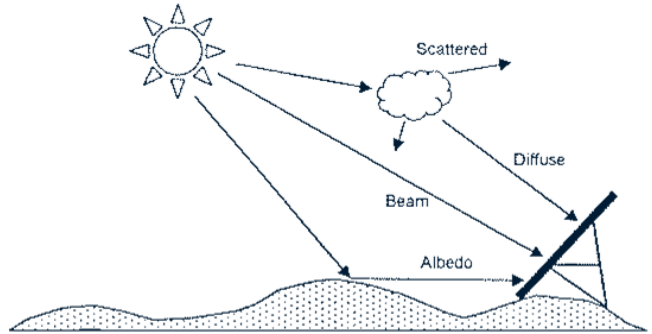
Albedo measurements are recommended for bifacial.

Modeled data sources (PSM, Meteonorm, SolarGIS, NASA-Power) have more uncertainty

Ground Conditions in the albedometer's field of vision should be prepared and maintained on a regular basis to closely match the future PV system's anticipated ground conditions.

A 3% increase in annual albedo can result in up to a 10% increase in back-side energy, corresponding to about a 1% increase in the bifacial system's overall energy



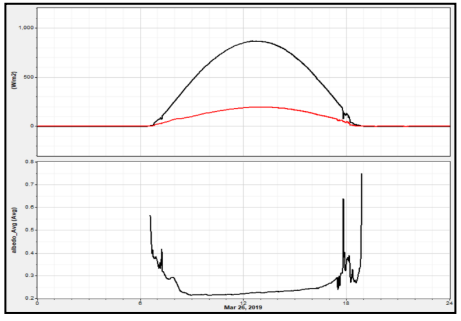


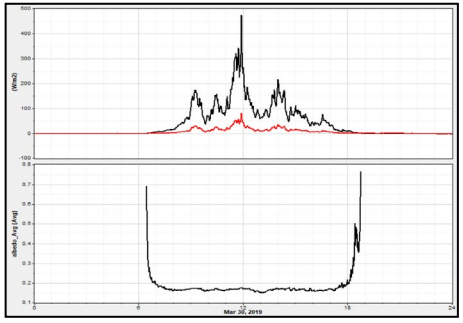
ALBEDO MEASUREMENT CONSIDERATIONS

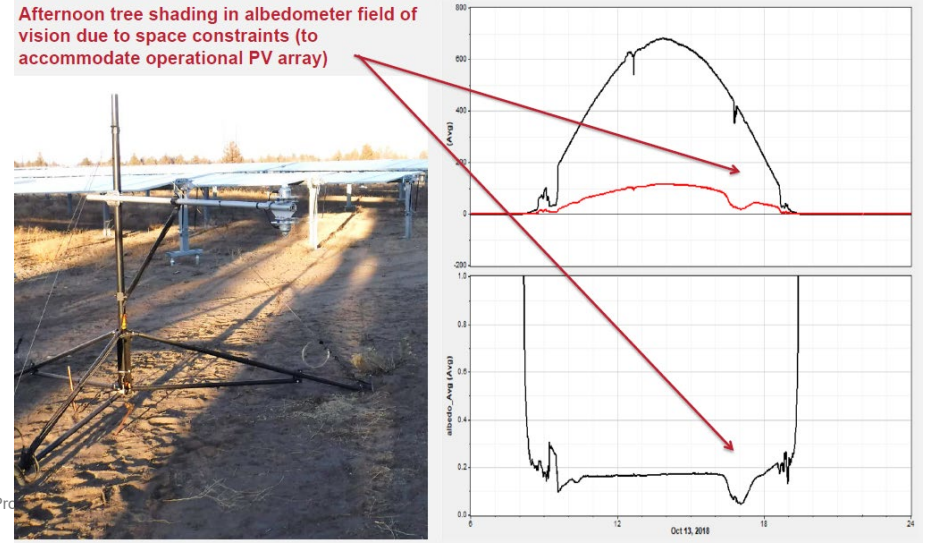
Height Above Ground.
Approximate the PV array's height. Avoid shading on upward facing instrument.

Azimuthal Orientation. 180° orientation (sunward side) to prevent shadows.

Data Validation. Filtering process is required to flag out ranges values and shading effects. Early morning and late afternoon measures might be discarded depending on the Project site due to low irradiance.







ALBEDO ANNUAL MEASUREMENTS

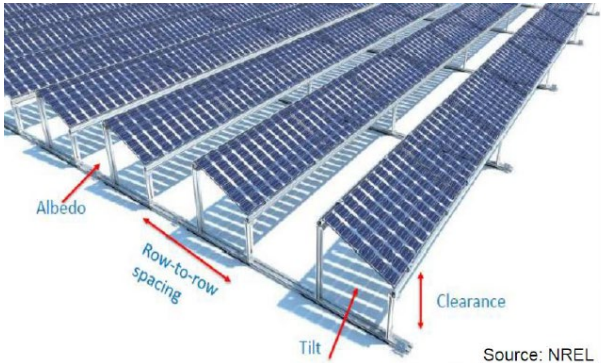
17%

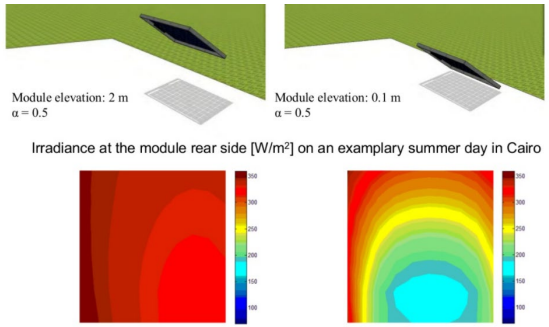
19%

23%

37%

MONOFACIAL VS BIFACIAL DESIGNS





Source: RWTH Aachen University - ISC

Parameter	Monofacial Example	Bifacial Example
DC-AC Ratio	1.15 - 1.30	1.05 – 1.15
Ground Cover Ratio	30 - 40%	28 - 35%
Structure Height	Minimal impact on energy	Influences back-side irradiance
Module-to-Module Clearance	1-2 cm is typical	May be expanded for light to pass through
Trackers	Traditional	Design minimizes back-side shading
Albedo	Low impact	Terrain coverage affect production levels of the back side
Bifacial Advantage	4-10%, realized as DC system cost reduction and/or energy gain	

BIFACIAL MODULE QA TOWARDS BANKABILITY

- Electrical design, should consider bifacial contribution. Also key for fuse rate sizing!! Minimum fuse rating would be recommended to be 1.56* I_{sc_bifi}
- Contractual performance testing: PR or Capacity Test?
- Standard PVsyst calculation provides a PR only referred to front side irradiance. Therefore, in general >85% due to back side energy contribution.
- Lack industry standard PR definition for commissioning tests considering bifaciality factor, albedo and rear side irradiance.
- IEC 61724-2 draft version provide back irradiance measurements guidelines to address bifacial performance

BIFACIAL COST COMPARISON

CAPEX

Parameter	Cost Increase (USD / Wp)
PV Modules	$0.002 - $0.01
BOP	$0.015 - $0.04
Terrain Preparation	$0.02 - $0.04
Total	$0.04 - $0.10

OPEX

Parameter	Cost Increase (USD/kWp/Year)
PV Modules Cleaning	$0.10 - $0.20
Vegetation Control	$0.125 - $0.175
Total	$0.225 - $0.375

- Vegetation control to avoid further shading losses on the rear side
- Frequent terrain maintenance to ensure a uniform albedo over the PV plant
- Back side PV module cleaning evaluation depending on the project conditions

CONCLUSIONS

The success and bankability of a solar PV Project using bifacial modules would strongly depend on

- Proper characterization of albedo at the site conditions and modelling following bets industry practices considering albedo seasonality
- Design optimization considering the right equipment for the right GCR to maximize Project generation.
- Accurate PV plant modelling through adequate characterization of albedo, bifaciality factor and calculating properly PV Project KPIs (such as PR) as they are key for performance review and contractual warranty definition.
- Independent lab testing for LeTID and bifaciality factor recommended. In addition, best practices include batch testing and witnessing module manufacturing.
- Typical bifacial advantage of 4-10%, realized as energy gain.

THANK YOU!

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