Future PV Roundtable
at Renewable Energy India 2018

Enablers and drivers of innovation

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Welcome & Q&A

Fezan Sayed

Head of Strategy and Sales

Americas

Heraeus

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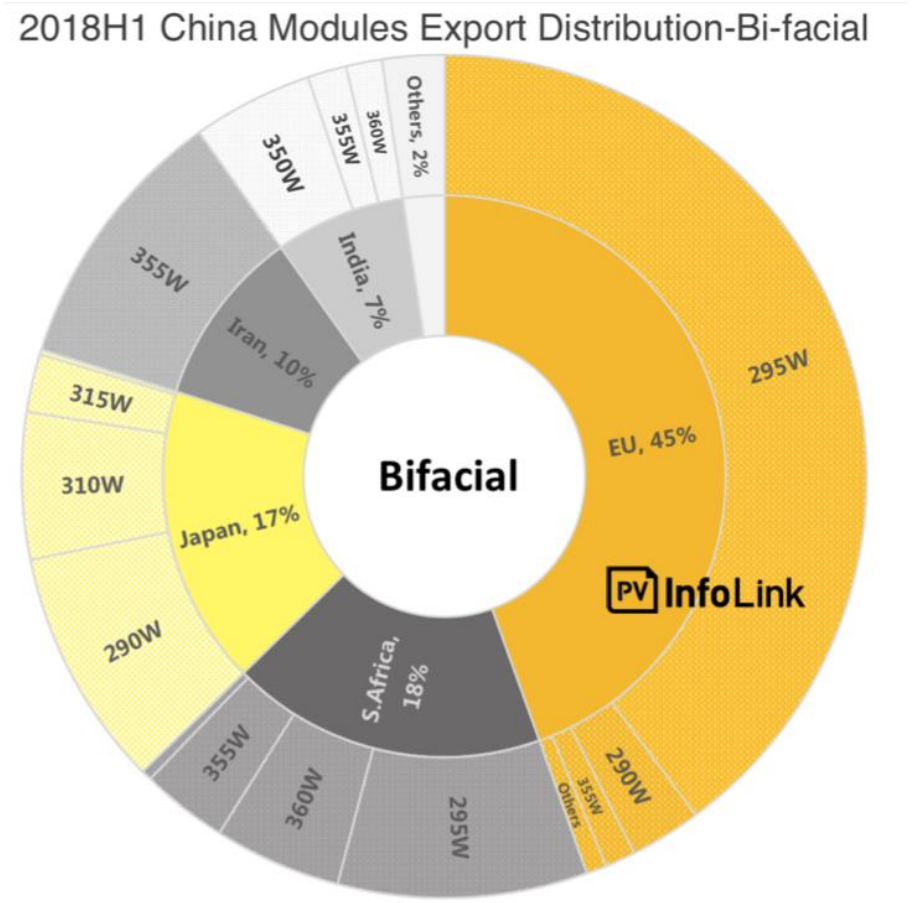
Bifacial module export 2018



Trends

- China module export data 1H18 show low level of export
- Almost all order small
- EU and Japan have been strongest export market, followed by emerging markets: India, Iran, South Africa

Major Constraint

- Lack of unified standards for rearside power generation
- This constraint most pervasive outside of China, where the Top Runner Program, which allows bifacial, brings validation and impetus

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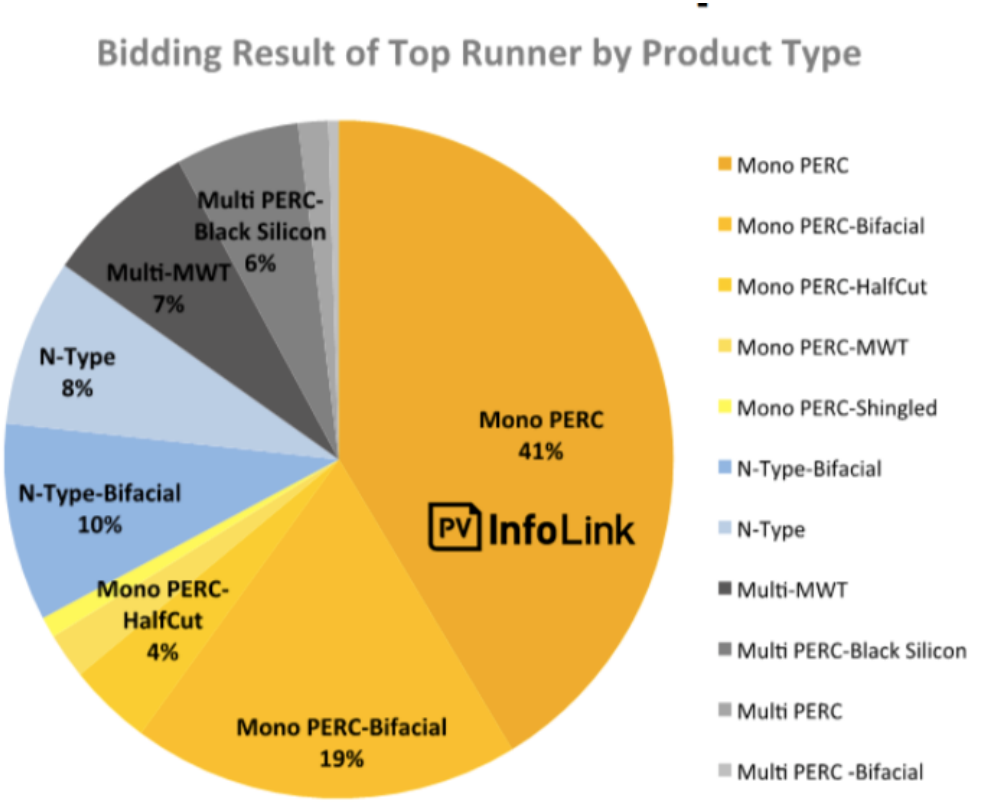
Bifacial technology trends



- In the past, bifacial modules were either HJT of N-type PERT.
- Not all N-type modules were bifacial.
- In 2017, Taiwanese producers started to promote bifacial P-type PERC cells.
- In 2018, P-type PERC cells widely promoted in China's 5 GW "General Top Runner Program"
- Bids to the "General Top Runner" mono-Si PERC: 67% of total bids. N-type also increased: to 17.5%.
- **Bifacial modules represent 30-50% of the 5 GW "General Top Runner Program – making it major source of bifacial demand in China in 2018.**

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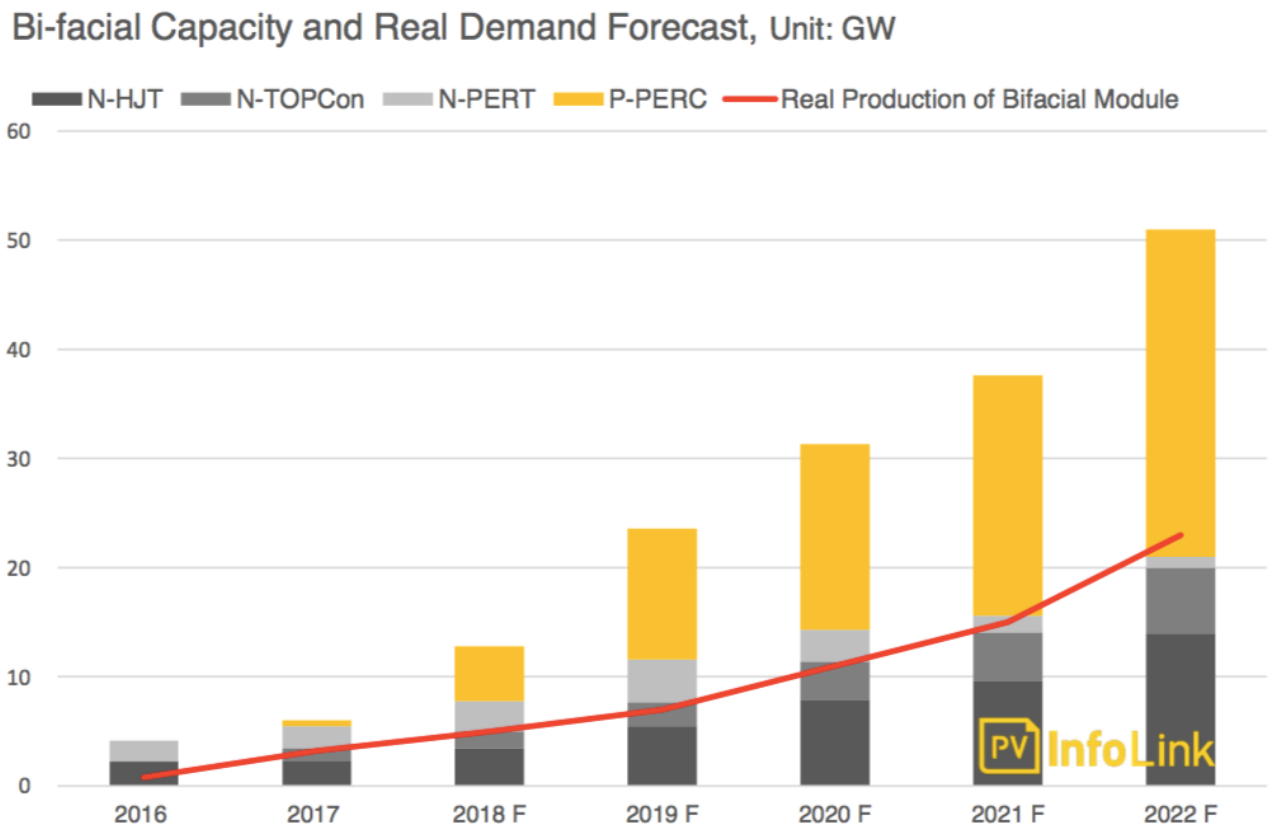
Supply-demand forecast of bifacial modules



- Almost no cost increase in cell production. Module cost increase 1-2 cents/W – double glass / framed / frameless
- Forecast development focused on bifacial P-type PERC, hence negligible cost increase.
- Bifacial is “the trend” high efficiency technology pathway. Success in “General Top Runner Program” would ensure further increase.
- Efficiency boost accepted in downstream markets.
- 2019 forecast for significant bifacial demand growth.

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Panel I

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Panel I

Harsh Govil
V.P. -Production
Adani

Rahul Kapil
VP Operations and Director
LONGi

Daniel Greger
Product Manager BU
Utility
SMA AG

Karishma Dagar
MD India
Soltec

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Fireside chat I

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Fireside chat I

Sunit Arya
Head of Sales
Heraeus

Uma Gupta
pv magazine India Editor

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Presentation I

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FUTURE PV ROUNDTABLE

Enablers and drivers of innovation in solar

Soreva Energy

Make more hay while the sun shines

GREATER NOIDA

Renewable Energy India Expo, Conference area, Seafoam Hall

SEPTEMBER 19, 2018

11 am to 1 pm

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Module Level Power Electronics(MLPE) and their future in Indian Rooftop Scenario

Subrahmanyam Pulipaka

CEO, Soreva Energy Group

Working Chairman, Africa India Youth Energy Forum

THE TECHNOLOGY

- Direct current (DC) power optimizers and micro-inverters are together categorised as module-level power electronics (MLPE)
- DC power optimizers:
  - Attached to or integrated in the junction box of a PV module
  - Designed to increase the power yield before sending an optimized DC voltage to a central inverter
  - A simple DC-DC converter that performs maximum power point tracking (MPPT) at module level.
- Microinverters:
  - Same as a central (or string) PV system inverter that converts DC into alternating current (AC), but at PV module level
  - The output of each PV module is unaffected by the other modules in the system.
  - This is in contrast to a conventional PV system in which the modules are connected in strings and then wired to a central inverter.

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WORKING

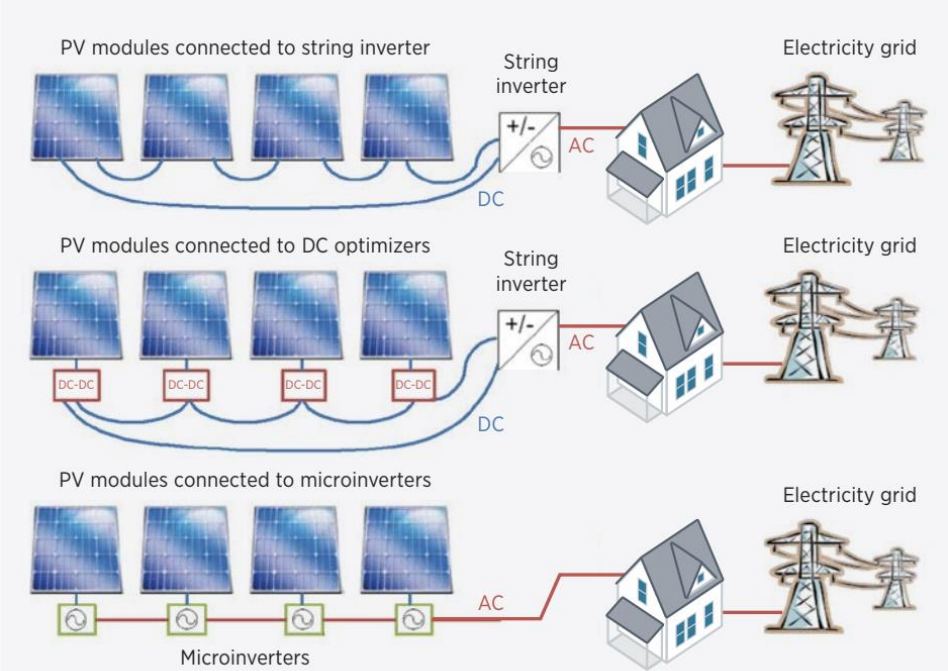

Figure 1. Schematic of conventional PV system (top); DC optimizer-equipped PV system (middle); and microinverter-equipped PV system (bottom)

➤DC power optimizers:

- ➤ Improve performance under shading or other mismatch conditions
- ➤Low-voltage safety under emergency disconnect conditions
- ➤Relaxed design constraints for the PV installer.

➤Microinverters:

- ➤ Improve overall system AC output when a PV system must be mounted on more than one roof plane or during uneven shading.
- ➤ Increase the effective overall PV system output

➤ MLPE can also allow for pro-active module-level performance monitoring and diagnostics

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Case Study - Indian Rooftop

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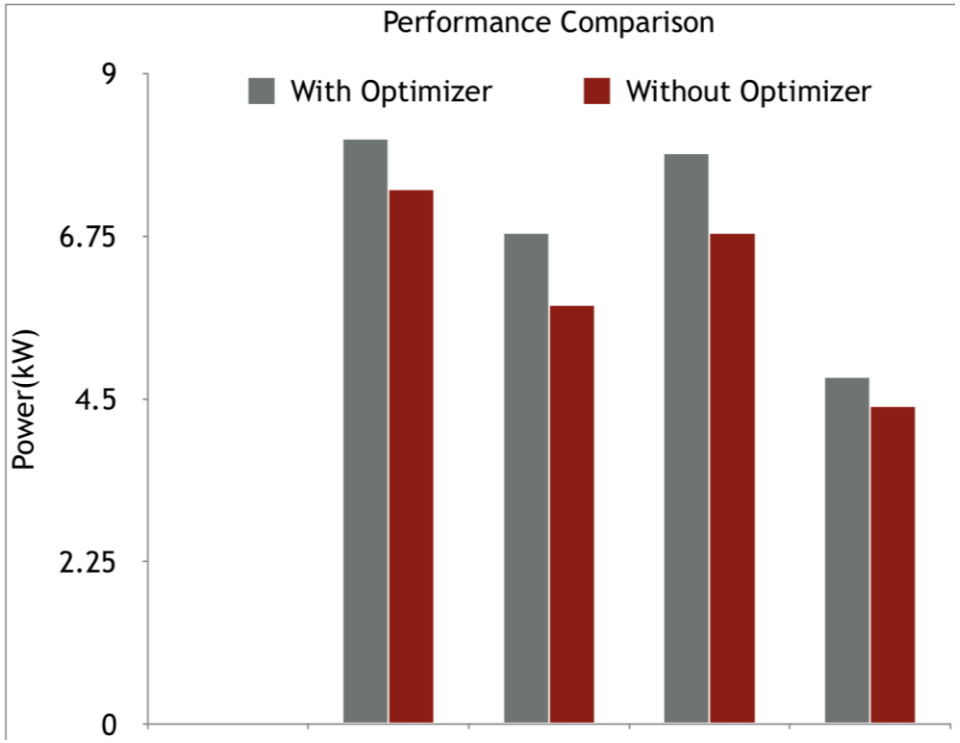

RESULTS

- Average performance increase - **12.9%**
- Cumulative peak performance increase - **6%**
- Additional Cost Variable - **15-20%**
- ROI (Increase in Efficiency vs Price per kWh) - **28 months**

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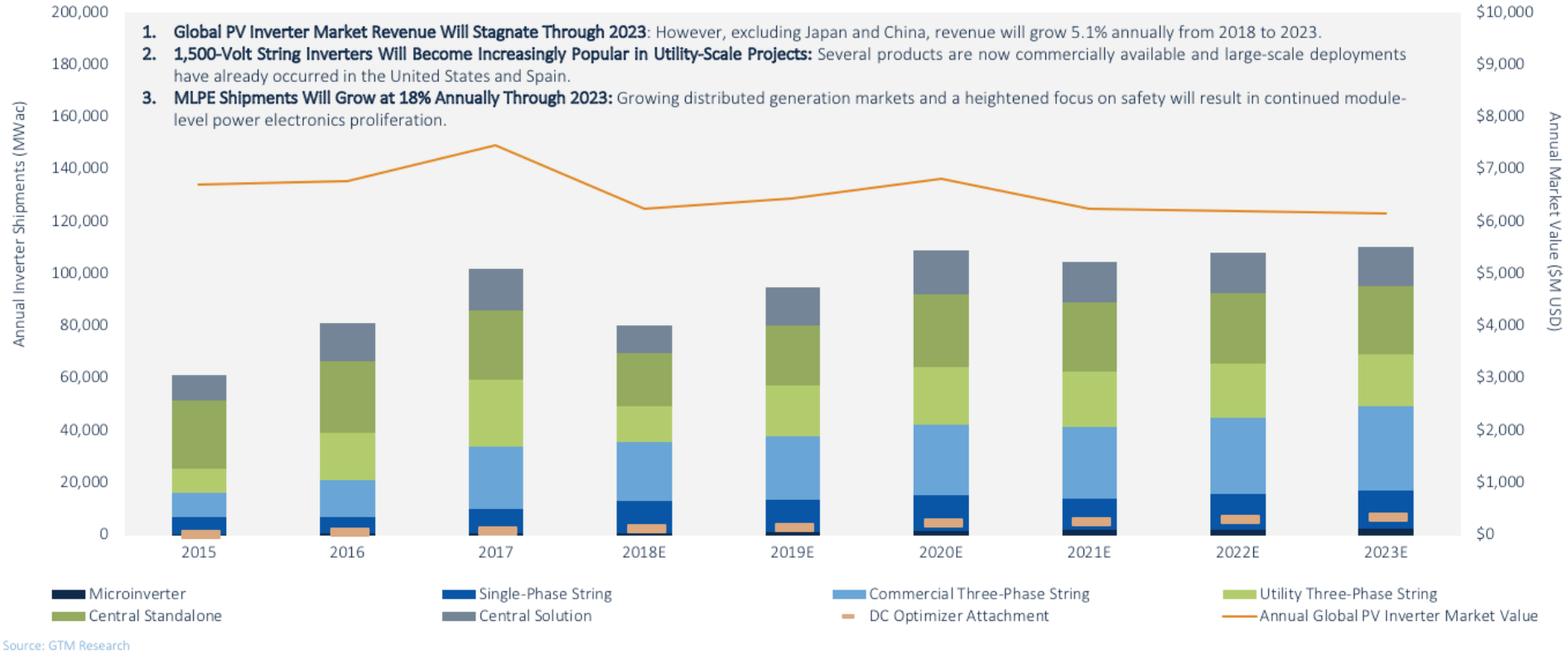
MLPE MARKET



Src: GTM Research; The Global PV Inverter and MLPE Landscape: H1 2018

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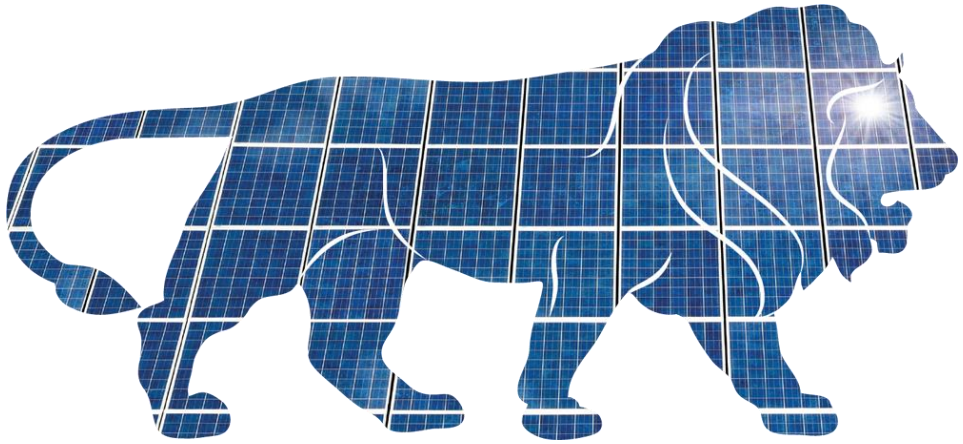

MLPE AND INDIAN MARKET

- **Opportunity**
  - Innovative/Indigenous Products to serve Indian market
  - New paradigm for module manufacturing
- **Challenges**
  - Economics of Scale
  - Skilled labour
- **Quality**
  - Streamlining of O&M
  - Better solar asset management
- **Necessity**
  - Digitisation of Solar power administration

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THANK YOU

Presentation II

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Innovation in risk-averse environments: Learnings from other industries

19 September 2018

Vivek Chaturvedi
DSM Regional Business Director IMEA

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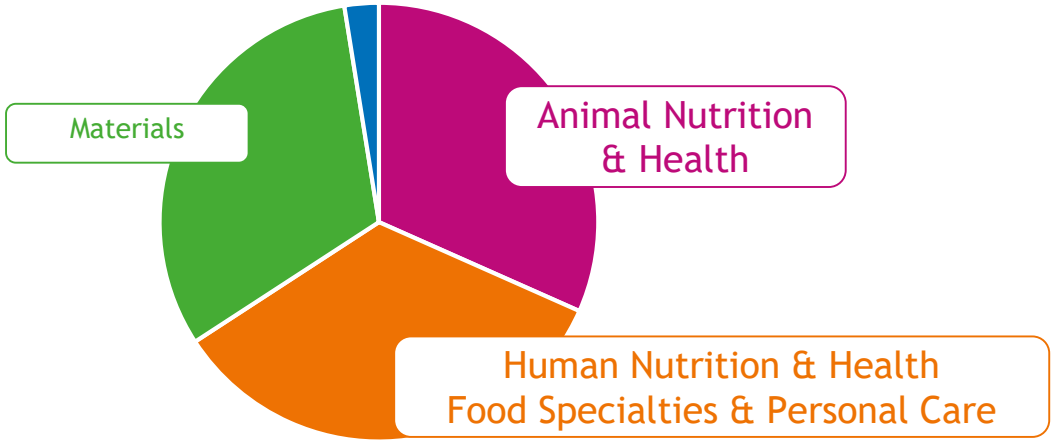
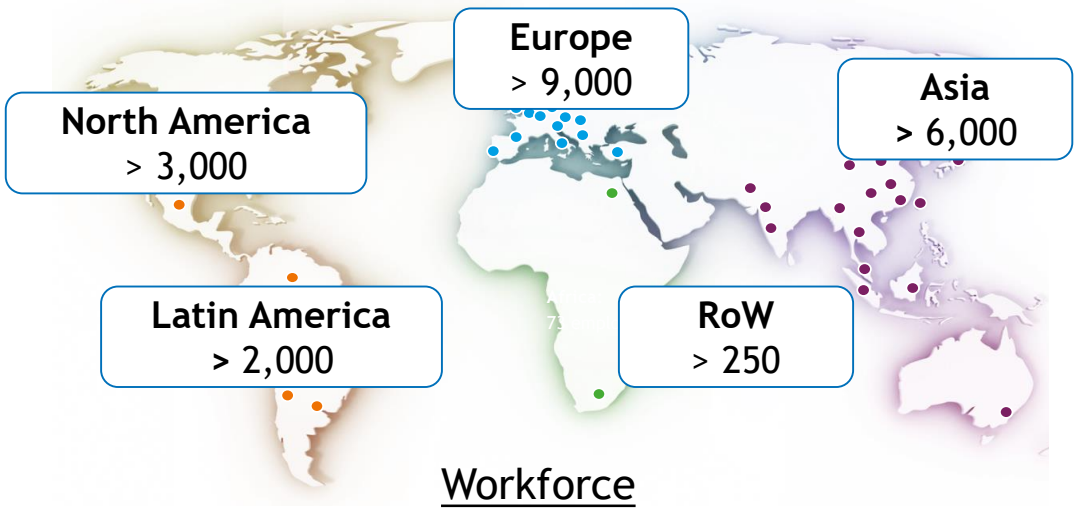
HEALTH · NUTRITION · MATERIALS

Royal DSM @ a glance: a company with a purpose (2017 numbers)

- Strategy well aligned with the Sustainable Development Goals
- Global workforce ~25,000 employees
- Sales ~€8.6bn
- EBITDA €1,445m
- Intrinsically innovative company: 21% sales from innovation
- ~ 45% sales from high-growth economies



Sales



Workforce

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DSM: a purpose led, performance driven, science-based company active in Nutrition, Health and Sustainable Living

DSM's key competences …

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Future-proof

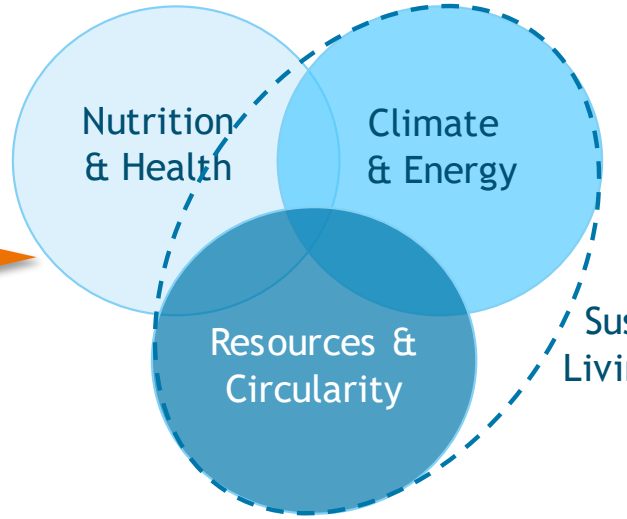
+

… addressing megatrends/SDGs …

Global Megatrends

SDGs

… provide growth opportunities in the focus-domains …



DSM Advanced Solar:
Make clean solar energy possible for all.

- Develop technologies that amplify the power generated by solar PV systems, thereby reducing the LCOE
- Establish a portfolio that will deliver market-driven growth opportunities

Same sun. More power.™

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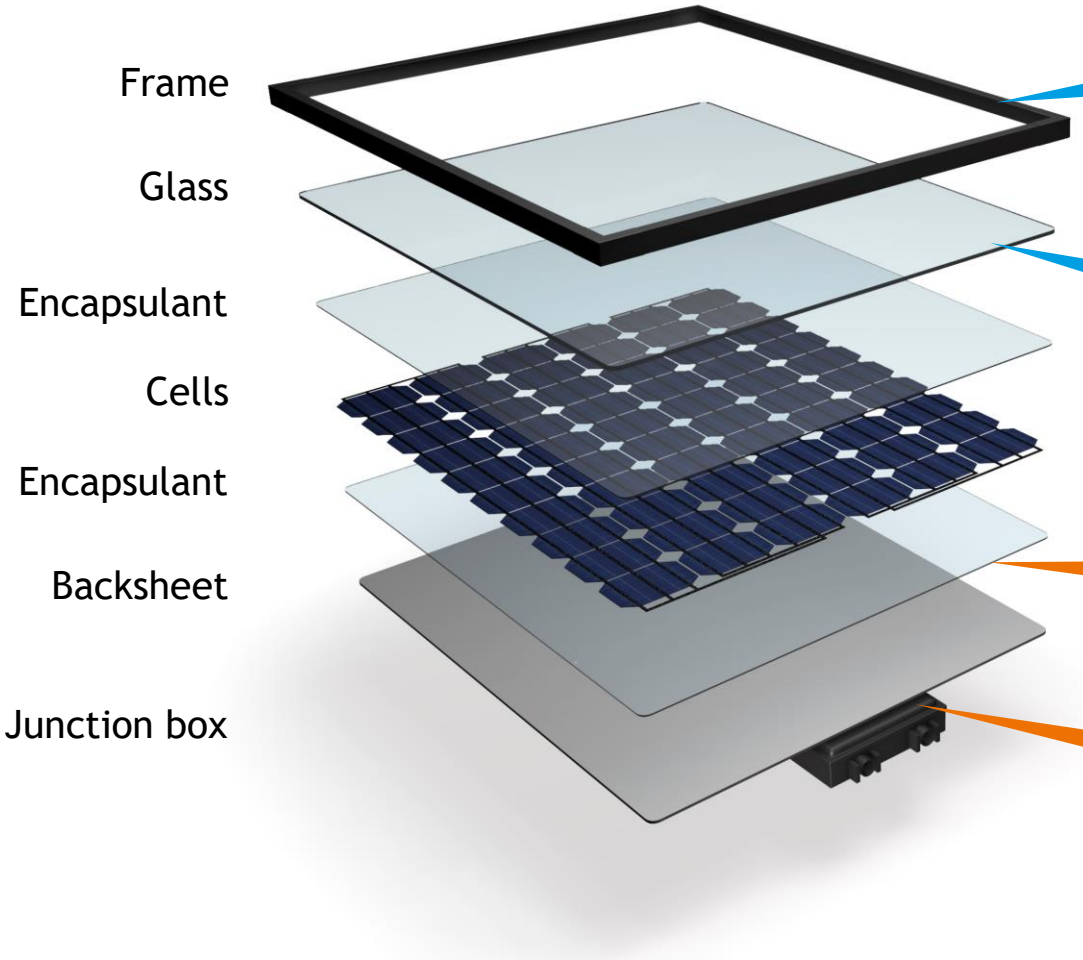
DSM innovative solutions are lowering the cost of solar power



DSM Anti-Reflective coating
Delivers a 3% higher power output consistently in flash tests

DSM Anti-Soiling coating
Increasing IRR of solar projects, by increasing power output and

DSM Endurance backsheets
Reliable solar performance in extreme environments

DSM Conductive backsheets
For back-contact high power modules

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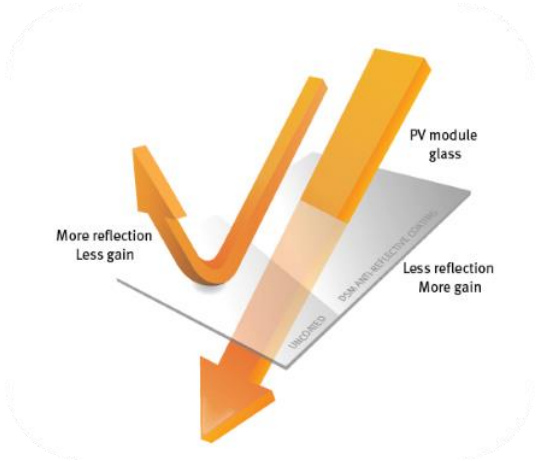
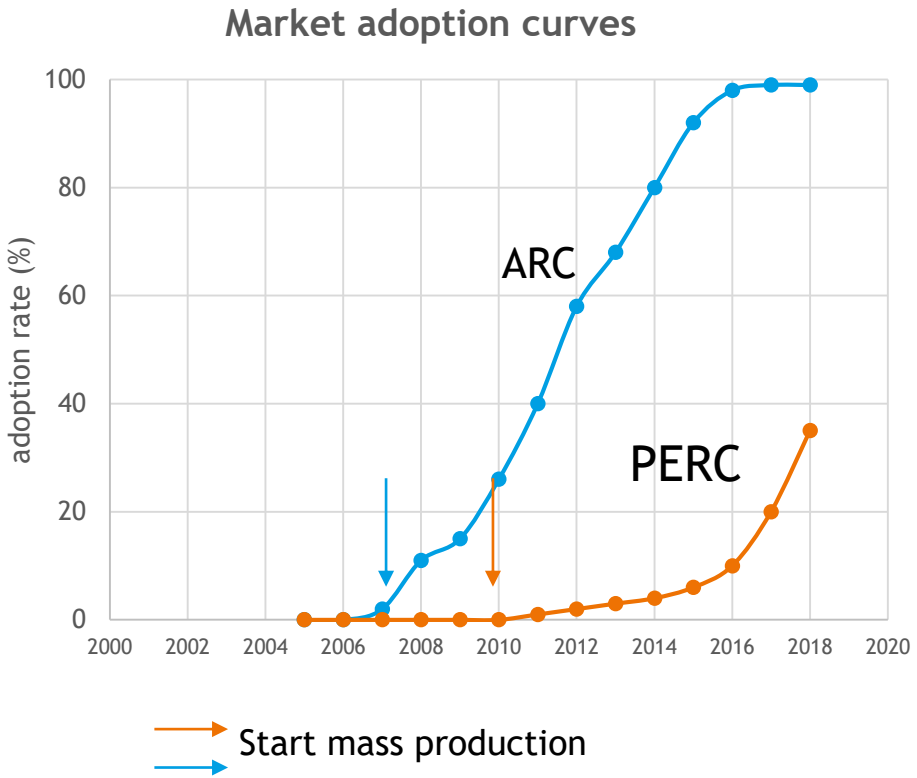
Two cases of innovation adoption after entering mass production

Anti-Reflective coating



"FAST"

3% module output gain
Drop-in solution
relative low investment
BUT less-critical component



PERC

"SLOW"

4-5% module output gain
Drop-in solution
relative low investment
BUT critical component

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Some of the adoption barriers in the PV market

INDUSTRY

To grow or to innovate
Accepted customer beliefs
Innovation track record

TECHNICAL

25 year field performance
Technology roadmap?
Disruptive solutions (no drop-in)

FINANCIAL

Upfront investment
Bankability?
Upstream cost vs. downstream value

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How to accelerate the adoption of innovations?

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Dyneema®, by DSM, the world's strongest, lightest, most versatile fiber

7 times
stronger then steel

Applications in life protection, ropes, nets, and cut resistance gloves

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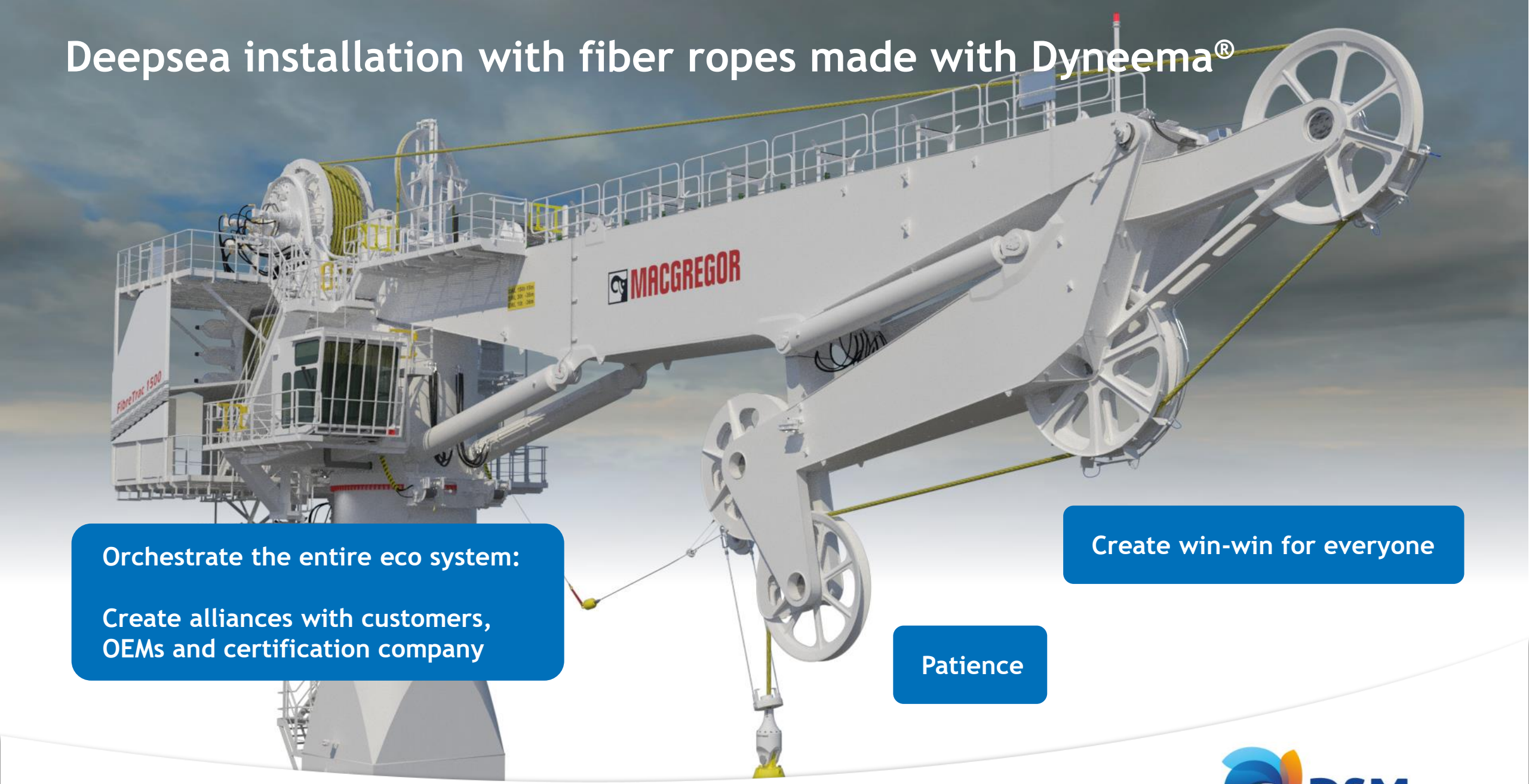
Deepsea installation with fiber ropes made with Dyneema®



Orchestrate the entire eco system:

Create alliances with customers, OEMs and certification company

Create win-win for everyone

Patience

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Synthetic link chain made with Dyneema®

Apply well-accepted design (customer belief)

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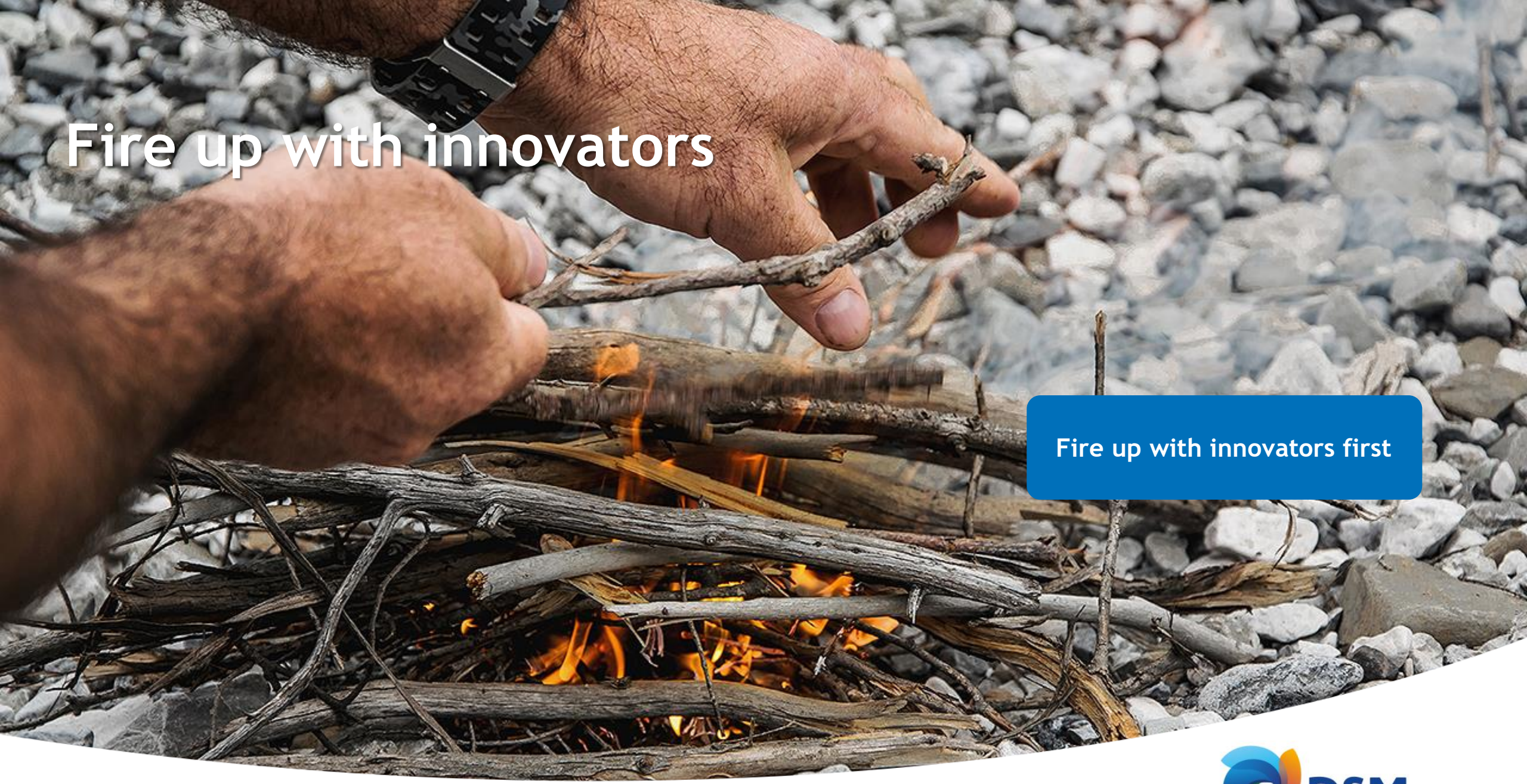
Fire up with innovators



Fire up with innovators first

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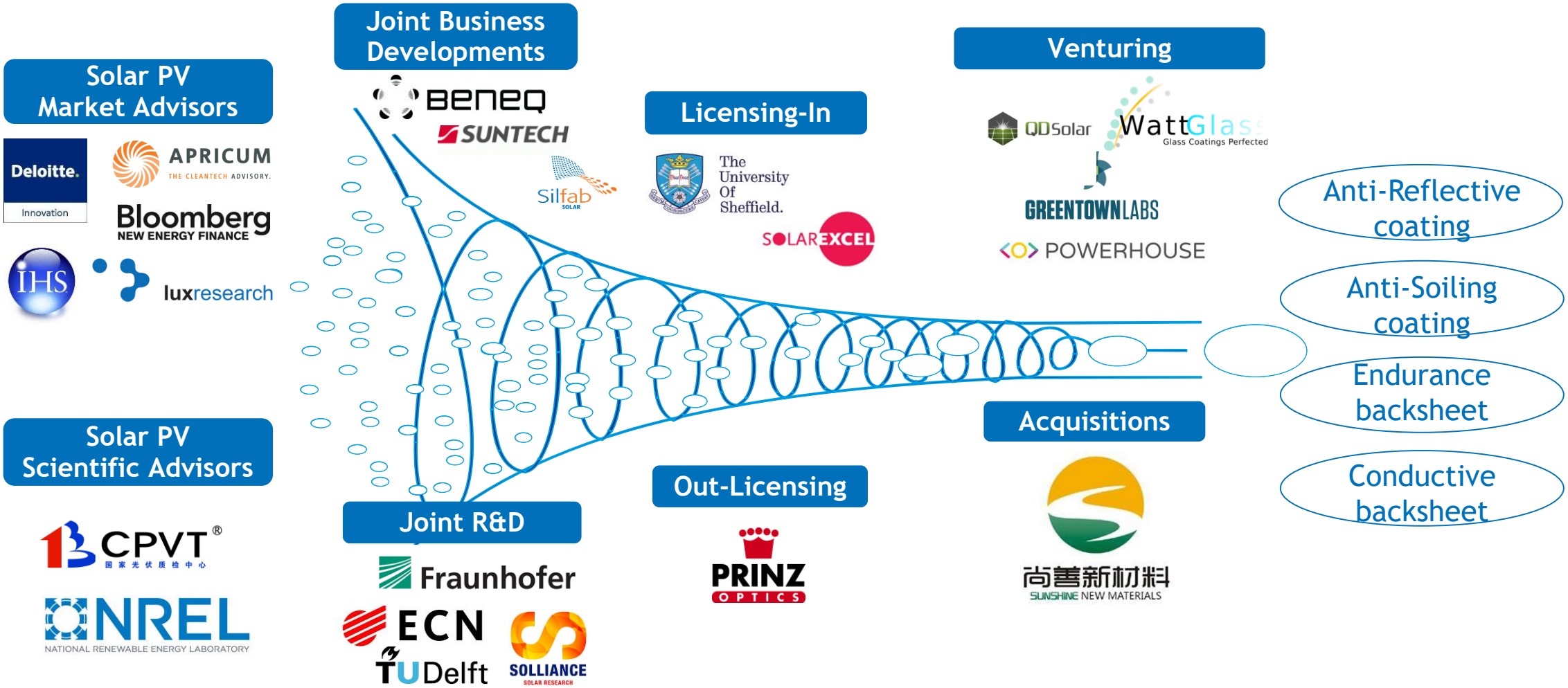
DSM Advanced Solar - Embracing Open Innovation



Illustrative, non-exhaustive overview

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The innovation race is on. Join us.

DSM Advanced Solar
email: info.samesunmorepower@dsm.com
www.dsm.com/solar

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Thank you / Questions?

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Panel II

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Panel II

Vivek Chaturvedi
India, Middle East and Africa
Regional Director Solar

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Surbhi Singhvi
Manager – Consulting
Bridge to India

Subrahmanyam Pulipaka
Founder and CEO
Soreva Energy Group

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Fireside chat II

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Fireside chat II

Christoph Artnig
Head of Renewables Marketing

Heraeus

Uma Gupta
pv magazine India Editor

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Conclusions

See you at our next Future PV Roundtable in…

- Anaheim

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