Anti-Soiling Coatings for PV Applications

PV days conference, Halle, 25th October 2017

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Royal DSM

Contents:

- DSM innovative solution - Anti-Soiling coating (ASC)
- DSM Anti-Soiling coating technology
- Soiling test methods and results in the lab
- Validations of Anti-Soiling coating outdoor

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DSM Advanced Solar in one view

Global presence

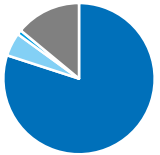
- Two production sites (Europe & China)
- Two R&D and Application Development centers (Europe, China)
- Five sales offices (Europe, China, US, India, Japan)

Products

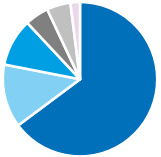
- Anti-reflective coating – global market leadership
- Backsheet – launched 1Q16
- Anti-Soiling coating – launched 2Q17
- Strong innovation pipeline

Markets by region | 2016

PV Glass Manufacturers (AR coating)



PV module Manufacturers (Backsheet)



PV system Installation (end-market)

Open innovation is key to future growth

- Partnerships and development programs with leading R&D institutes in the PV industry
- SunRISE I & II Techbridge Challenges
- Start-up competition to identify solar material innovators

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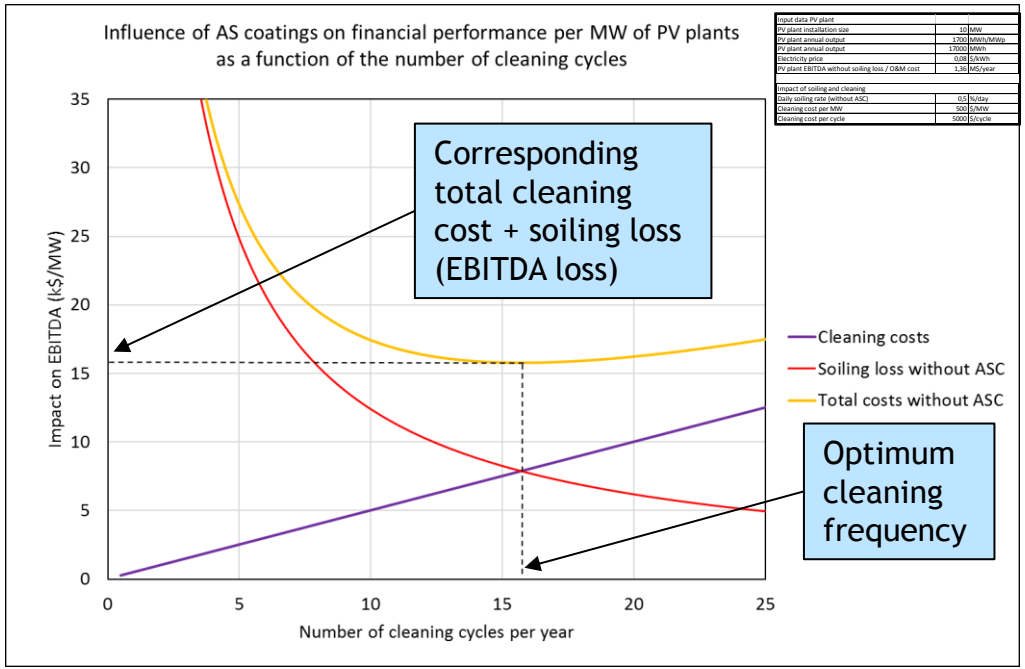
DSM innovative solution - Anti-Soiling coating (ASC)

High soiling rates in desert areas lead to output loss of PV parks and high cleaning costs, thus lowering the EBITDA/IRR, DSM developed an innovative anti-soiling coating to mitigate this issue.



DSM Anti-Soiling coating has two benefits:

- Reduction of soiling rate by preventing dust/sand from sticking to the module while using wind and gravity as the “cleaning process”.
- Reduction of cleaning costs by increasing the intervals between cleaning cycles.

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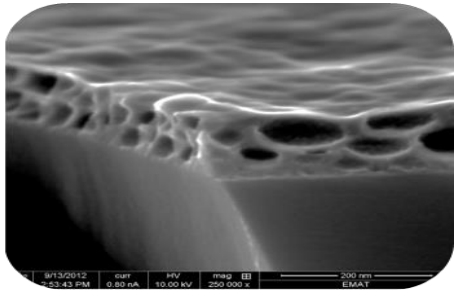
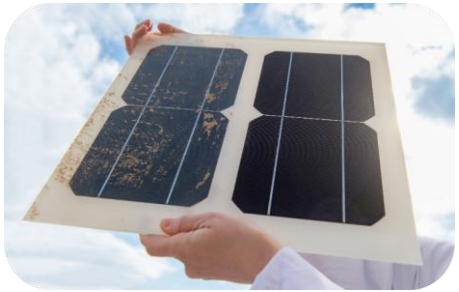
DSM Anti-Soiling coating development approach



Our ASC is based on DSM's proprietary ARC technology to secure maximum module output and coating durability

The coating is re-engineered to add AS functionality without compromising on other properties

The AS performance is validated in the lab and in >10 high-soiling locations throughout the world



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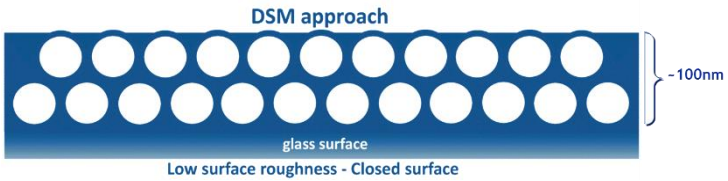
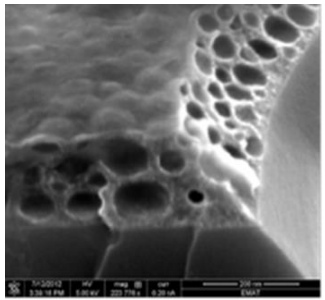
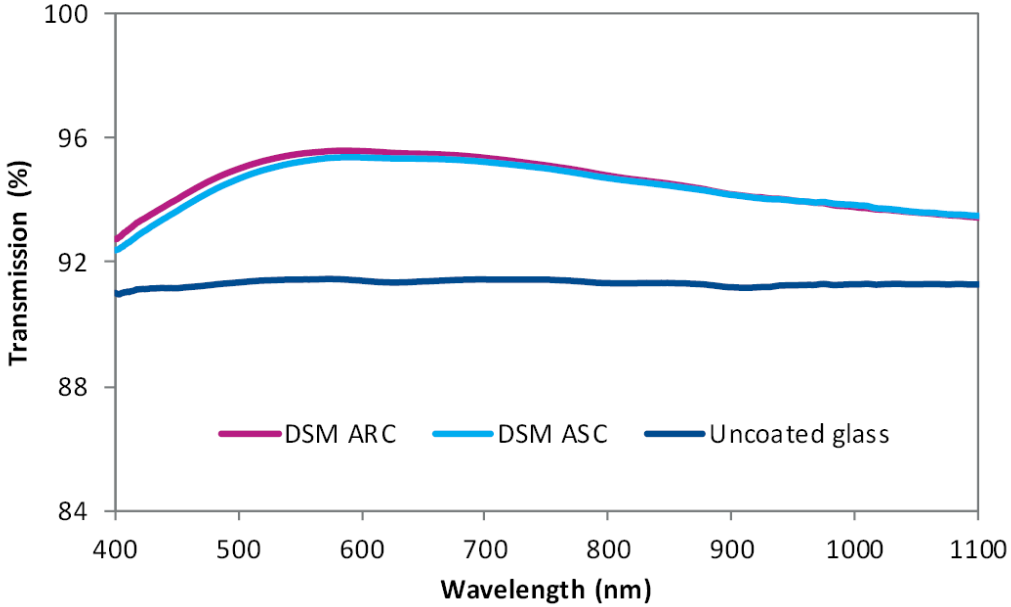
DSM Anti-Soiling coating – optical performance





Transmission gain from DSM's coatings



DSM Anti-Soiling coating is based on the proprietary DSM coating technology, the optical properties of the new ASC are similar to those of DSM's world-leading Anti-Reflective coating, thus securing the same initial module output in Wp.

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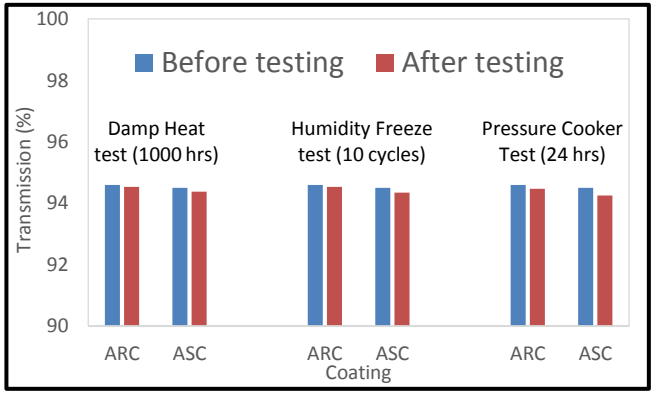
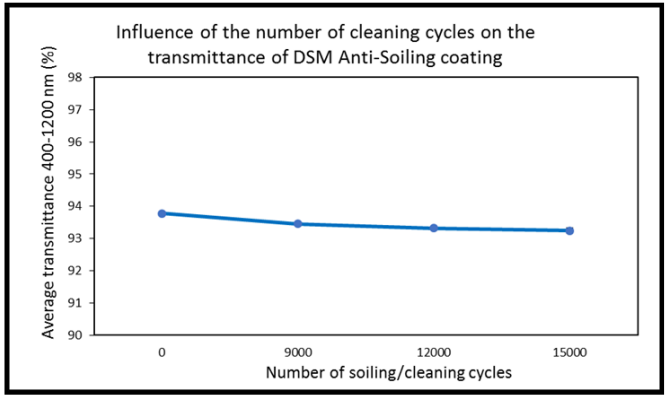
DSM Anti-Soiling coating – test performances

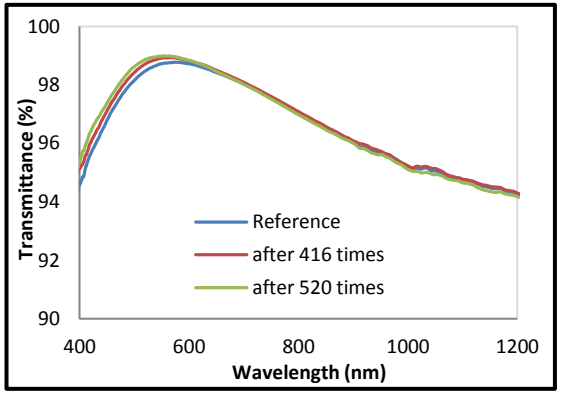
Various durability results



Cleaning test set-up in the lab



Transmittance ASC after x cleaning times



- DSM Anti-Soiling coating passes IEC standard tests and industry laboratory tests (e.g. DH, HF, PCT etc.).
- The coating is 100% inorganic which gives it an excellent UV-resistance in desert conditions.
- Accelerated cleaning tests have been executed by 2 leading vendors of robotic cleaning equipment. No significant change in optical properties nor surface damage were observed after ≥500 cleaning cycles with sand (equals biweekly cleaning for almost 25 years).

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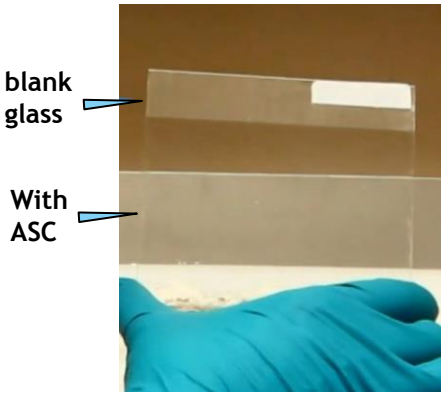
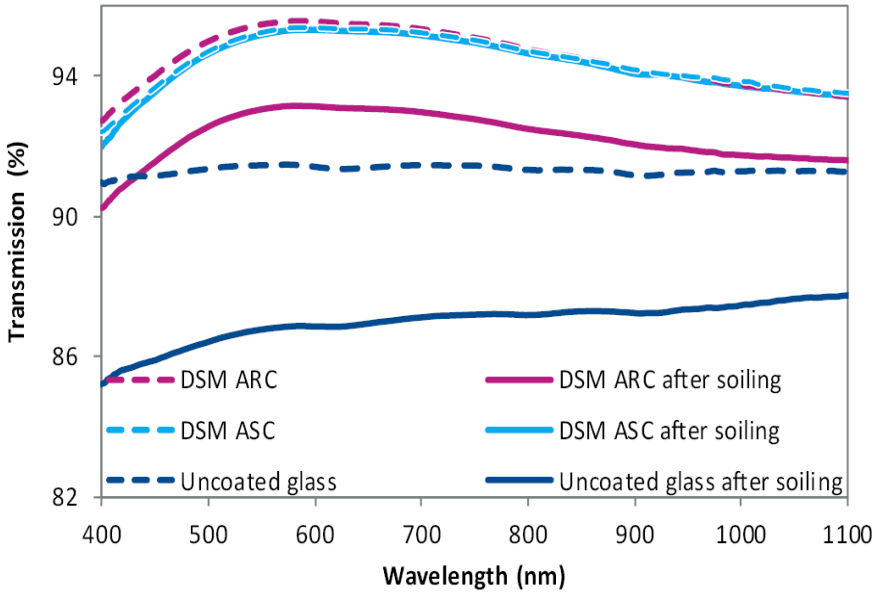
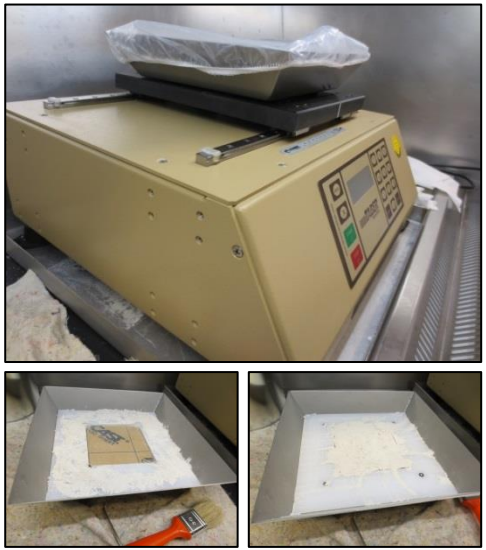
Soiling test methods – Taber oscillation test (DSM, NL)







- Taber oscillation test was originally designed to test coatings in lenses and windows (according to ASTM F735), DSM adapts such set-up for soiling test by using Arizona sand.
- The ASC shows virtually no loss in optical performance in such test, while AR-coated and uncoated glass exhibit ~2% /~4% loss.

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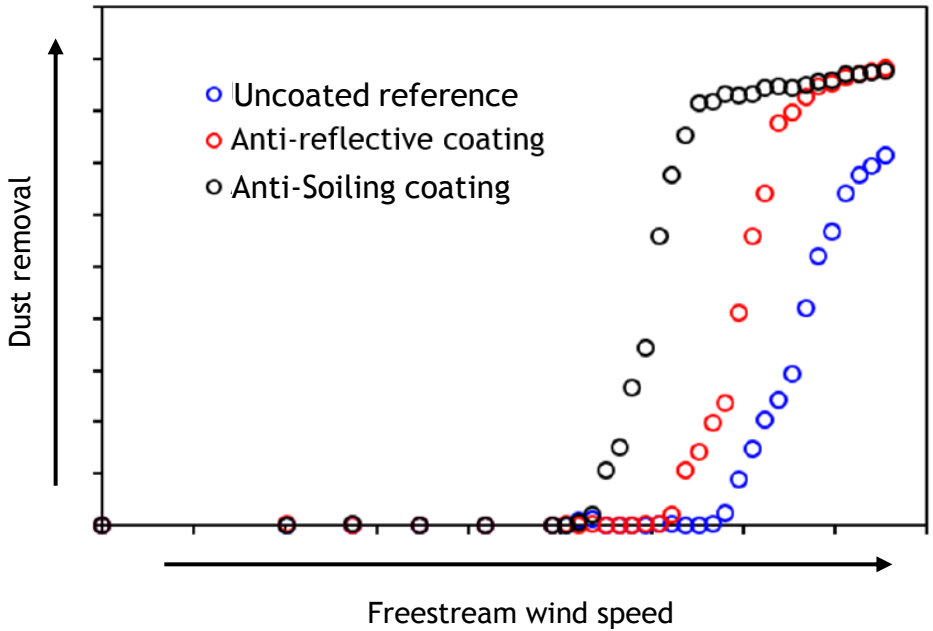
Soiling test methods – wind tunnel test (KU Leuven, BE)



- The DSM Anti-Soiling coating facilitates dust removal by wind or gravity.
- DSM internal findings are confirmed by wind-tunnel tests at KU Leuven. Dust can be removed at lower windspeeds from glass with DSM Anti-Soiling coating than from AR-coated and uncoated glass.

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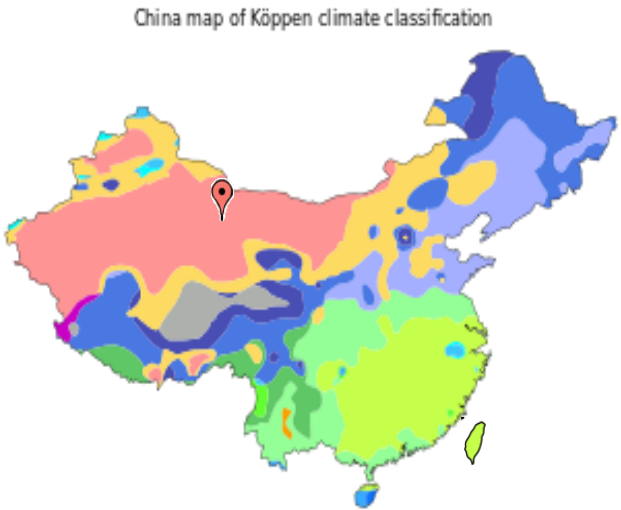
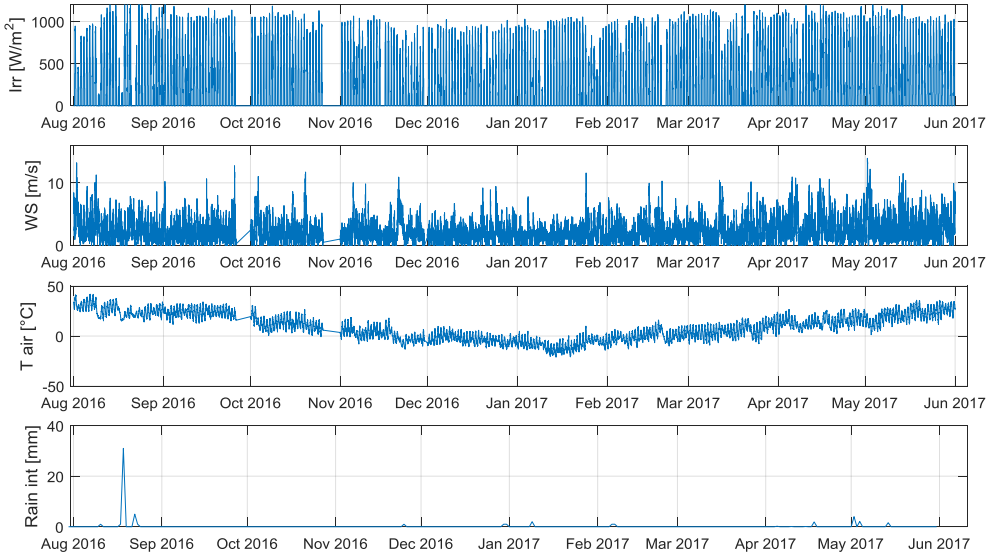
Outdoor testing - test site info





- The test site is located at Dunhuang, China (40° 14′ N, 94° 66′ E), it is characterized as BWk (arid cold desert) in Köppen climate classification.
- 3 type of modules are being tested there (blank, AR- and AS-coated modules), each type of module has 10pcs.
- The testing/monitoring is on string level and the power before invertor is recorded every minute.
- The wind speed is usually small, around 1-5 m/s. If there is a sandstorm, the maximum wind speed is around 20 m/s. Sandstorms only happen in spring.

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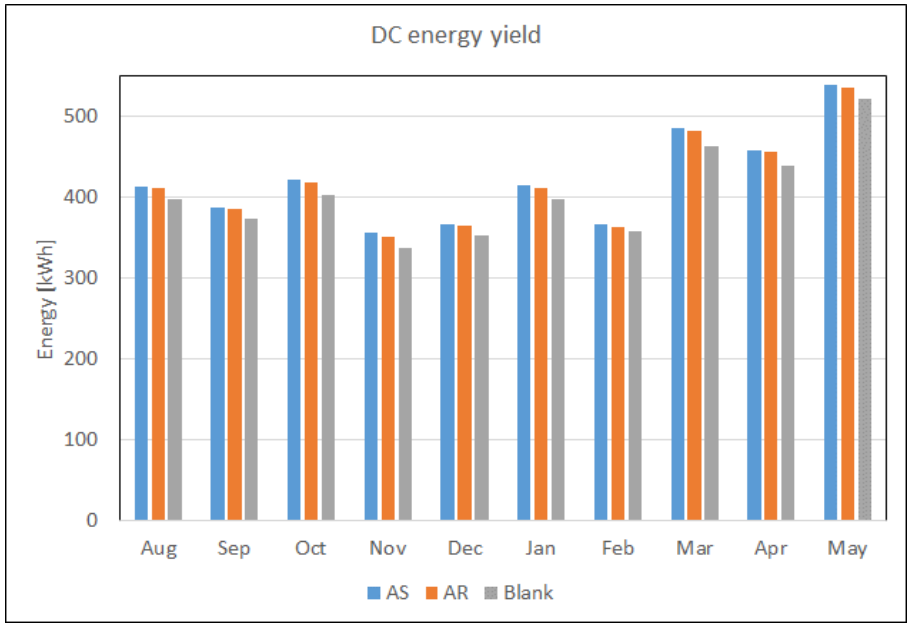
Outdoor testing – overall and specific performances



	AS	AR	Blank	AS gain	AR gain
	kWh			%	
August	412.7	411.7	398.1	3.7	3.4
September	387.3	385.0	374.0	3.6	2.9
October	422.4	419.1	402.9	4.8	4.0
November	356.4	351.1	337.5	5.6	4.0
December	367.1	364.1	352.9	4.0	3.2
January	415.2	410.8	398.1	4.3	3.2
February	367.2	363.6	357.4	2.7	1.7
March	486.1	481.7	464.1	4.8	3.8
April	458.5	456.9	440.0	4.2	3.8
May	540.1	536.4	521.7	3.5	2.8
Jun	456.2	452.9	437.3	4.3	3.6
Jul	443.5	442.5	428.3	3.6	3.3
Total	5112.6	5075.7	4912.3	4.1	3.3

- **The initial STC difference between ARC and ASC (1st generation) is around -0.4%.**
- **While the average DC energy output difference between ARC and ASC (in 10 months) is about +0.8%.**

Coating performance diff.		
	AS	AR
Transmission (400-1200nm)	2.9%	3.2%
STC difference	2.6%	3.0%

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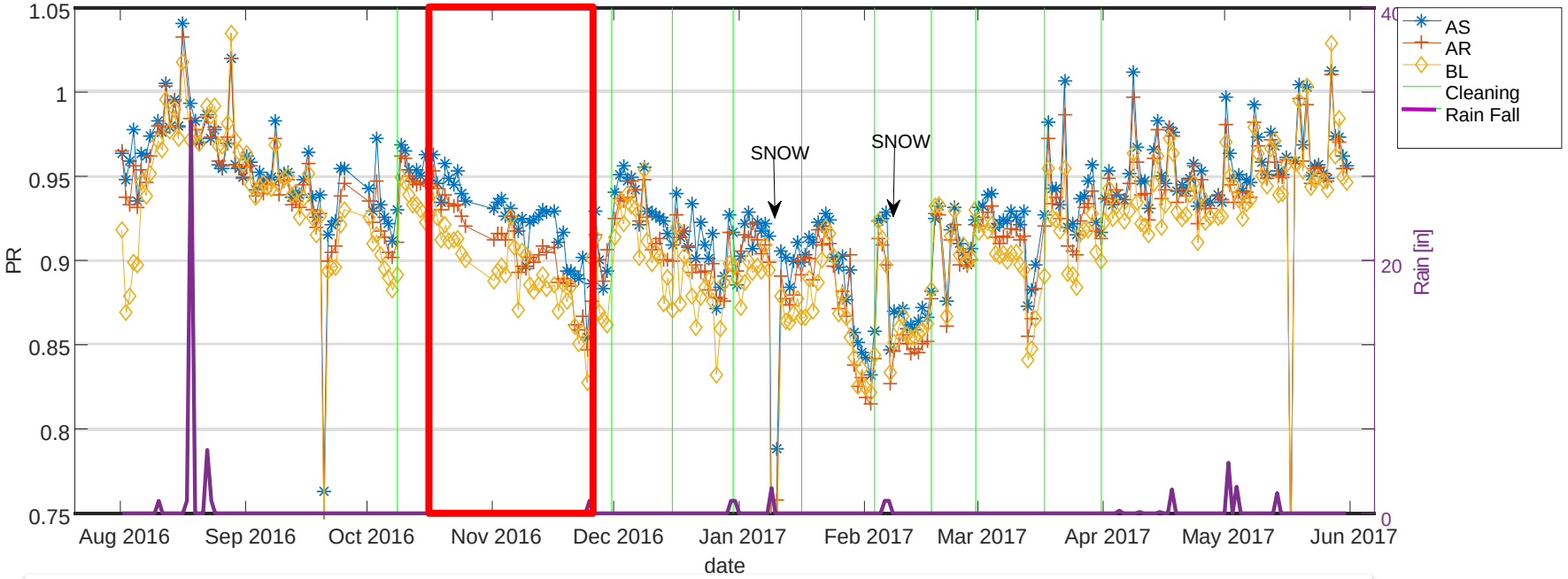
Outdoor testing – anti-soiling performances



- Both AR and AS modules show better performances than blank modules upon soiling events, different soiling rate can be extracted from the plot.
- AS modules exhibit always better anti-soiling performance than AR and blank modules.
- Soiling at location is not constant.
- Cleaning process can have a significant impact on the module performances, however, it might not fully recover the module performances (i.e. PR values < 1).

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Outdoor testing – anti-soiling performances

- An example of the soiling rate is estimated from performance ratio calculated during 3 weeks in Oct. – Nov. 2016.
- The soiling rate on AS-, AR-coated and blank modules is -0.15%/day, -0.22%/day and -0.24%/day, respectively.
- The AS-coated modules show ~32% and ~37% less soils than AR-coated and blank modules during these period of time, respectively.

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Conclusions

- DSM's new Anti-Soiling coating combines excellent anti-reflective and anti-soiling properties with a high durability.
- There is no standard lab soiling test method. The anti-soiling performance of DSM Anti-Soiling coating is proven with various test methods, both internally and externally.
- Depending on location and soiling conditions, DSM Anti-Soiling coating can significantly improve the energy output of modules outdoor due to less soiling.
- Two methods to estimate the outdoor performance with respect to (anti-) soiling have been evaluated.
- Both demonstrate the anti-soiling performance of our DSM's anti-soiling coating.

Thank you for your attention

Questions?

For more information:
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