Floating PV vs land based PV: A yield comparison

Minne de Jong
Maarten Dörenkämper
Kostas Sinapis
Wiep Folkerts

Partner in solar energy solutions

Sunday 8-11-'17

Why floating solar?

- Enormous potential
- People live near water
- Land scarcity
- On hydro-reservoirs: combination with storage
- Other potential benefits:
  - Reduction in evaporation
  - Less algae
  - …

credit: energyfive.net

credit: olive-abacus.com

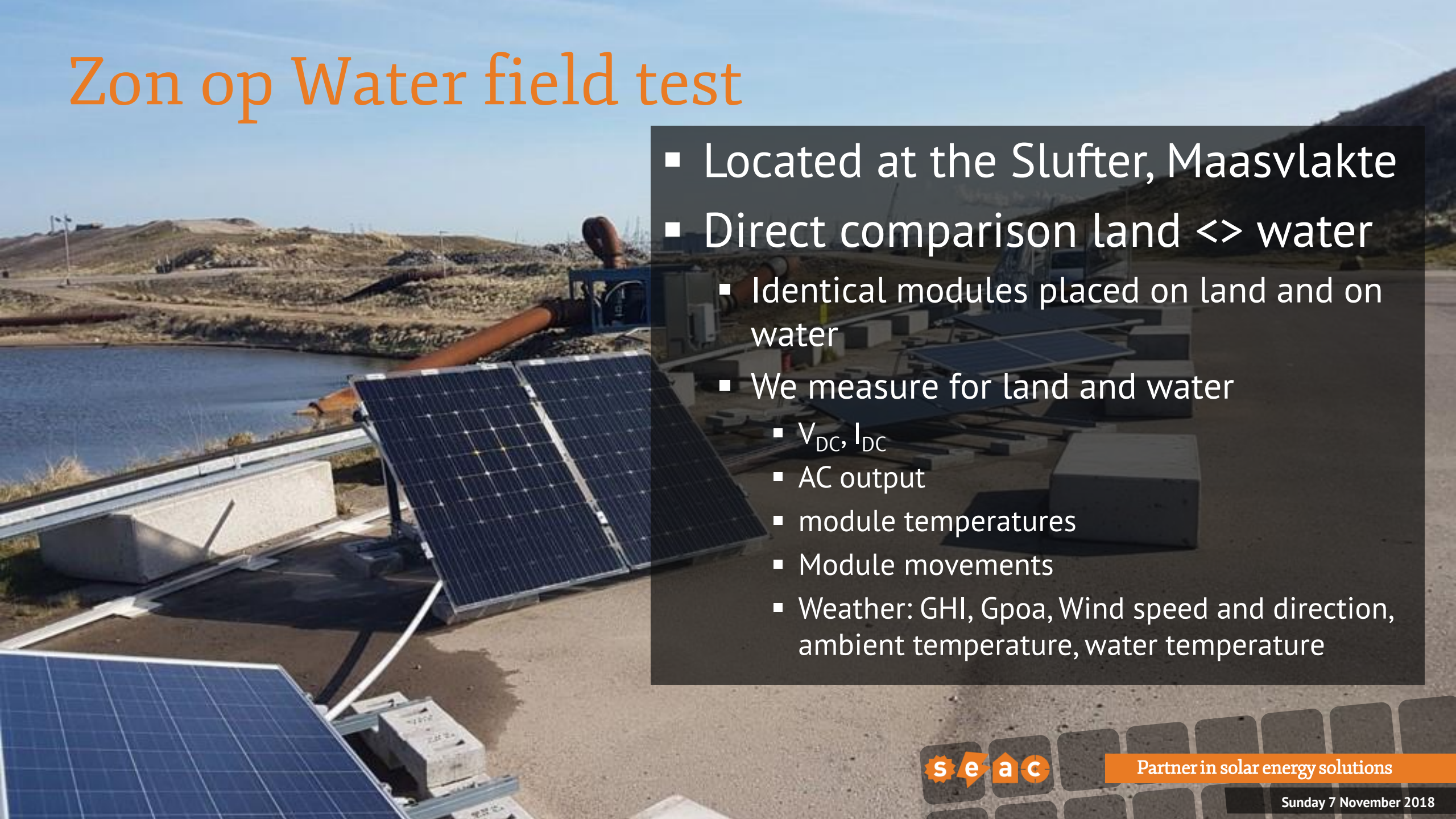
Zon op Water field test

seac

Partner in solar energy solutions

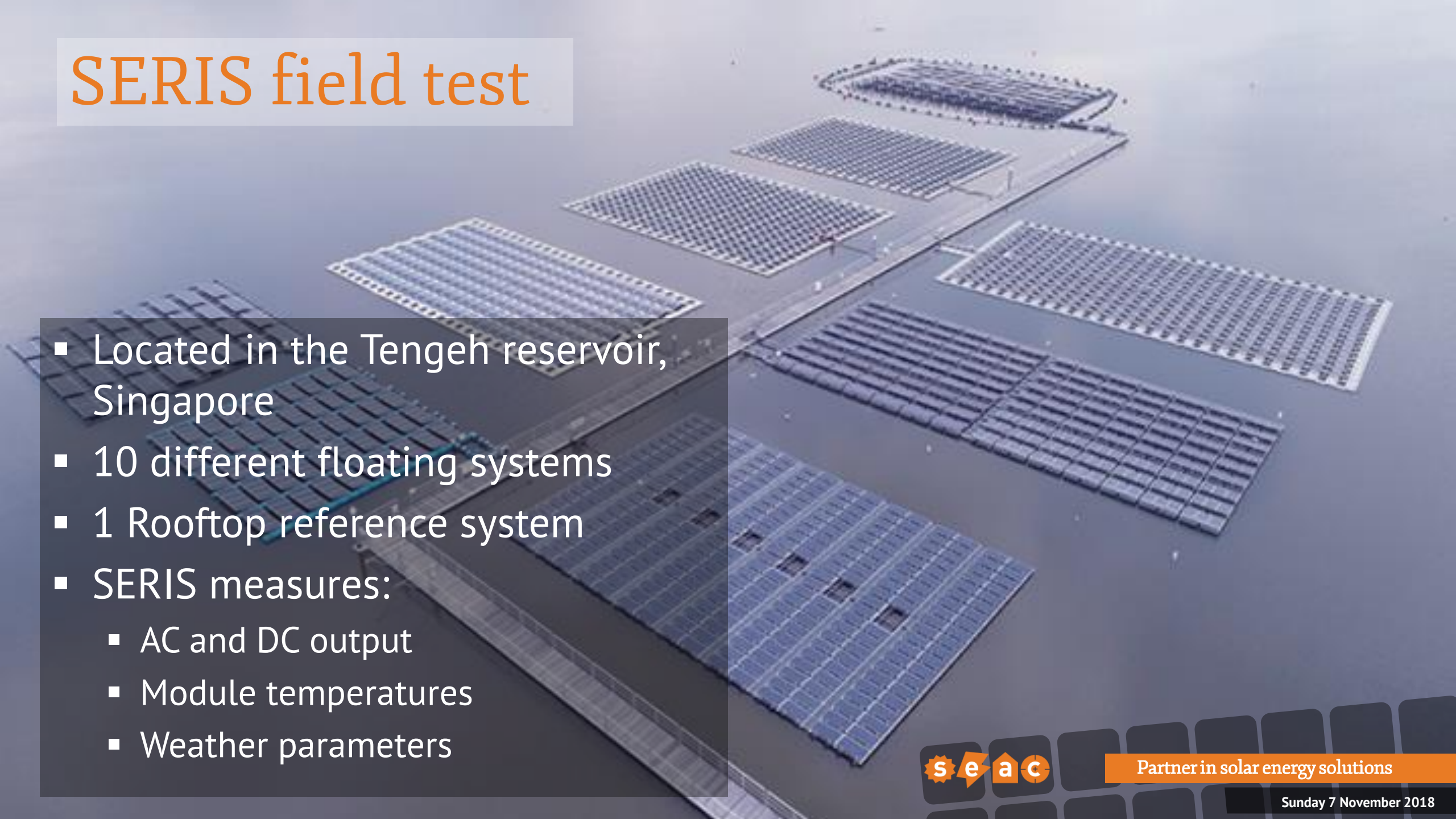
Sunday 7 November 2018

Zon op Water field test



- Located at the Slufter, Maasvlakte
- Direct comparison land <> water
  - Identical modules placed on land and on water
  - We measure for land and water
    - V_{DC}, I_{DC}
    - AC output
    - module temperatures
    - Module movements
    - Weather: GHI, Gpoa, Wind speed and direction, ambient temperature, water temperature

SERIS field test



- Located in the Tengeh reservoir, Singapore
- 10 different floating systems
- 1 Rooftop reference system
- SERIS measures:
  - AC and DC output
  - Module temperatures
  - Weather parameters

Water vs Land

What's the difference?

- Temperature
- Irradiation
- Mechanical movements
- Soiling

Temperature

Floating structure design

Small footprint on water

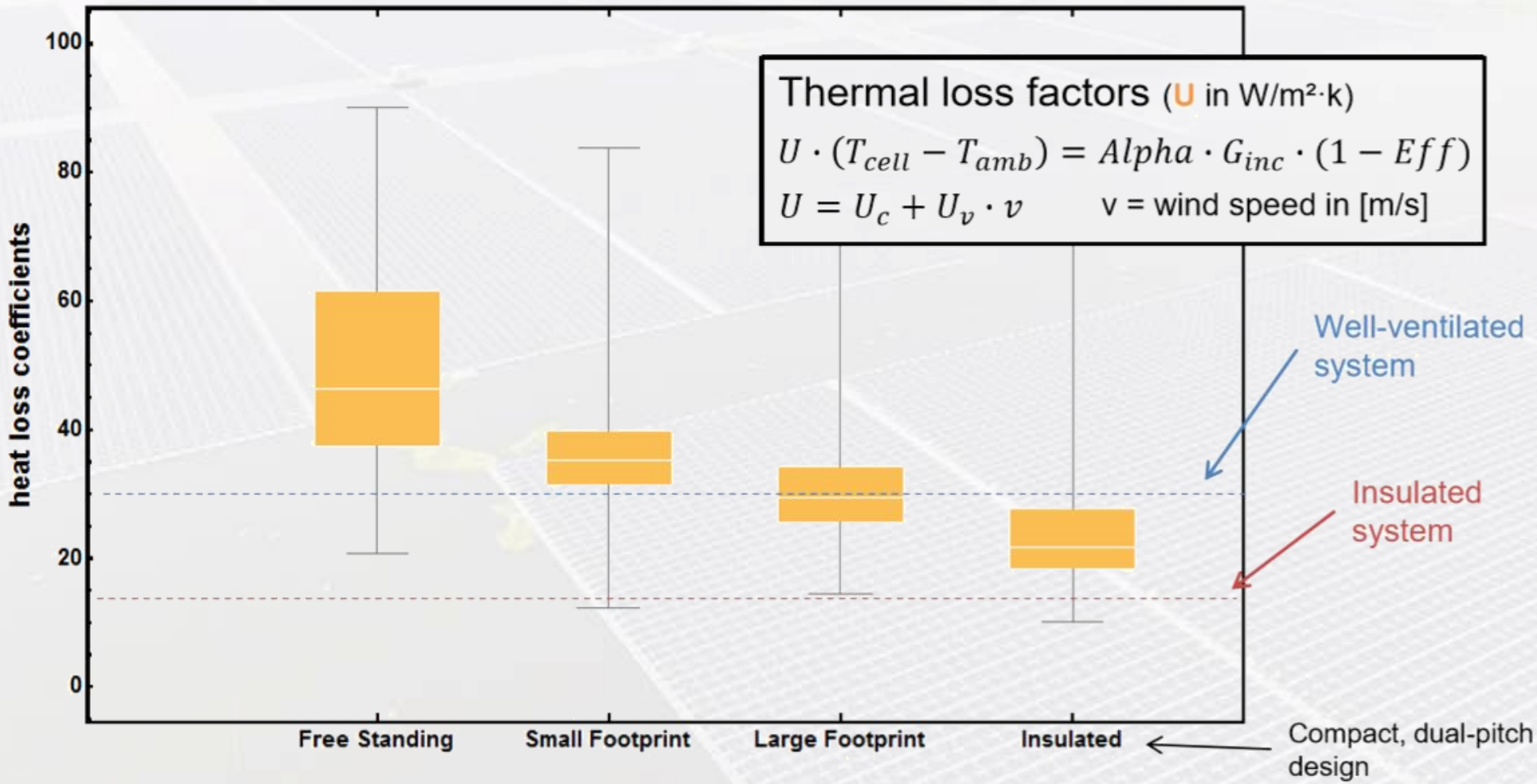
Solaris Synergy

Large footprint on water

Texel4Trading

Temperature

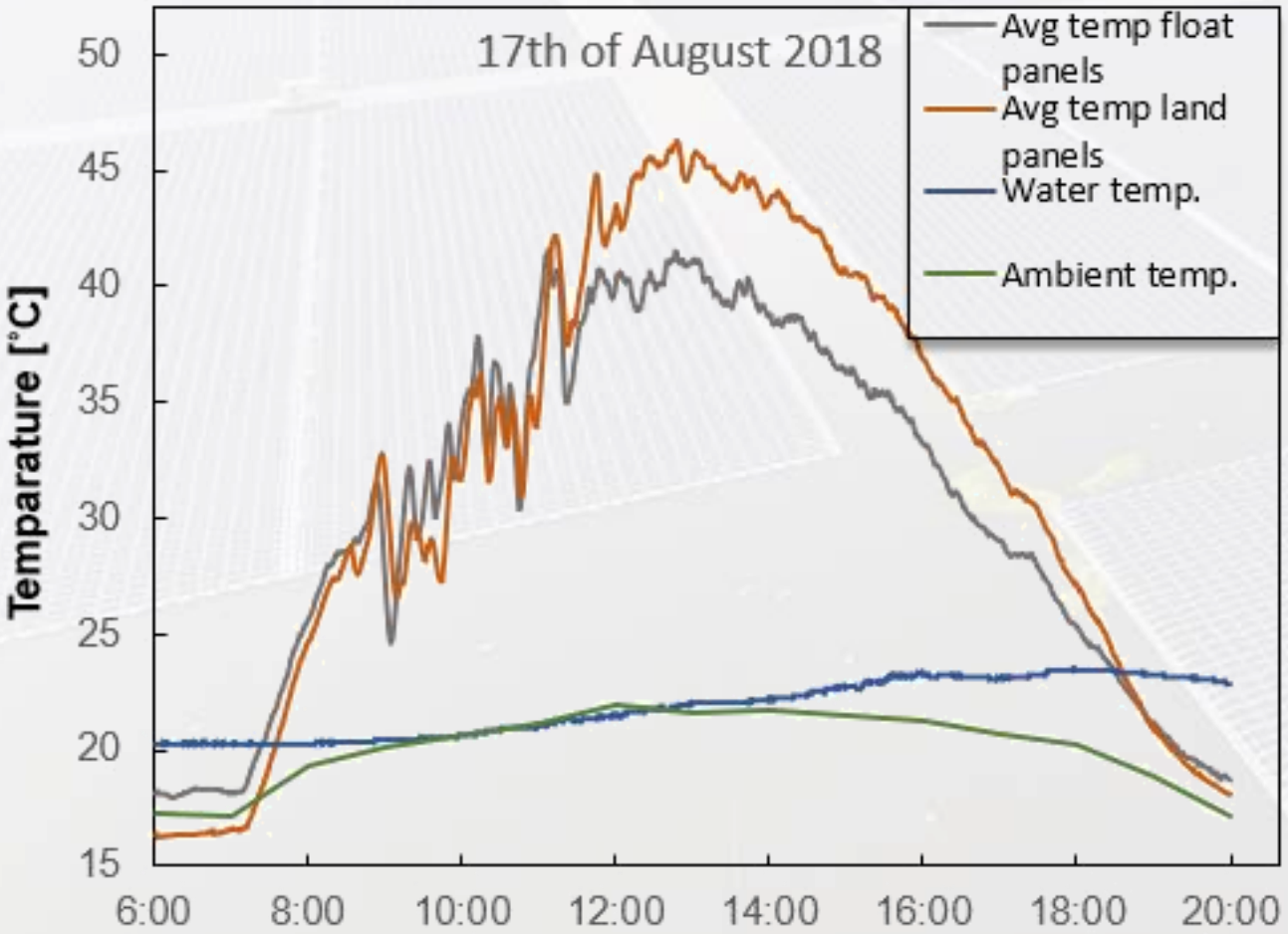
Cooling effect



Source: T. Reindl, SERIS

Temperature

Slufter observations

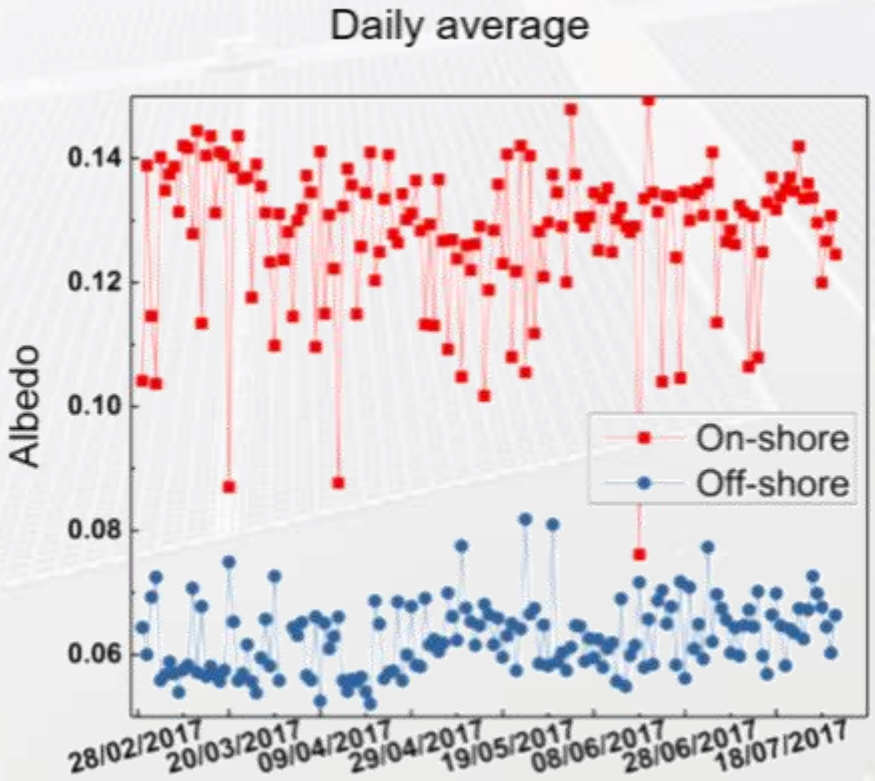


- Cooling observed
  - between -2°C and 6°C
- Complex system
  - System design
  - Ambient temperature
  - Water temperature
  - Wind speed
  - Wind direction
  - Temperature spread
- Modelling needed (and in progress)

Irradiation

Albedo

- Daily average albedo on water is small -> 5-8%

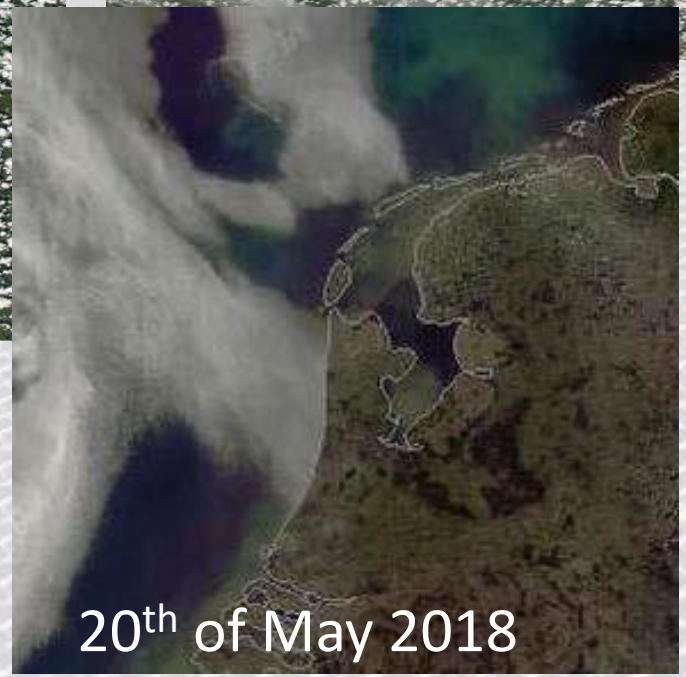


Source: T. Reindl, SERIS

Tengeh reservoir, Singapore

Irradiation
Land vs Sea

- Water temperature Noordzee and IJsselmeer relative cold
- More convective cloud formation above land
- Mist above sea, which dissolves above land

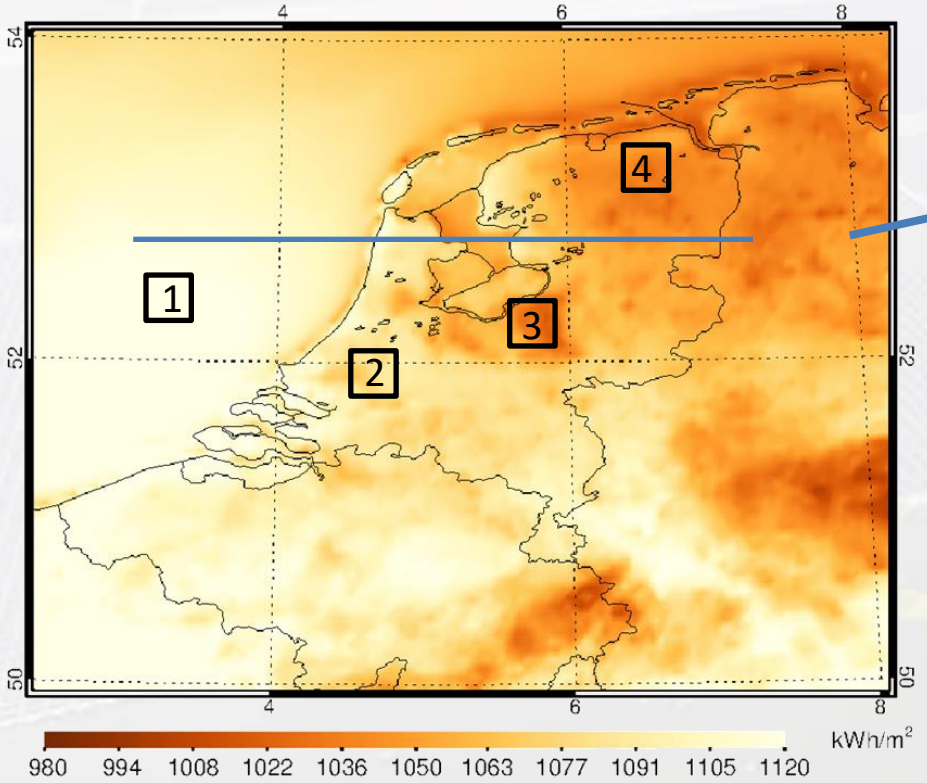


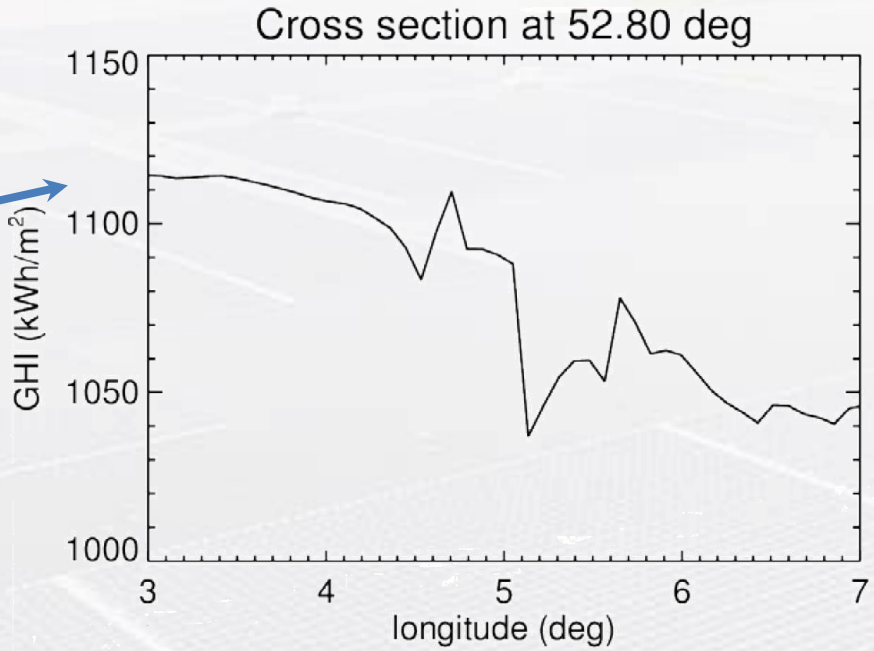
Source: J.F. Meirink, KNMI, Zonopwater.nl

Irradiation

Land vs Water

Source: J.F. Meirink, KNMI, zonopwater.nl



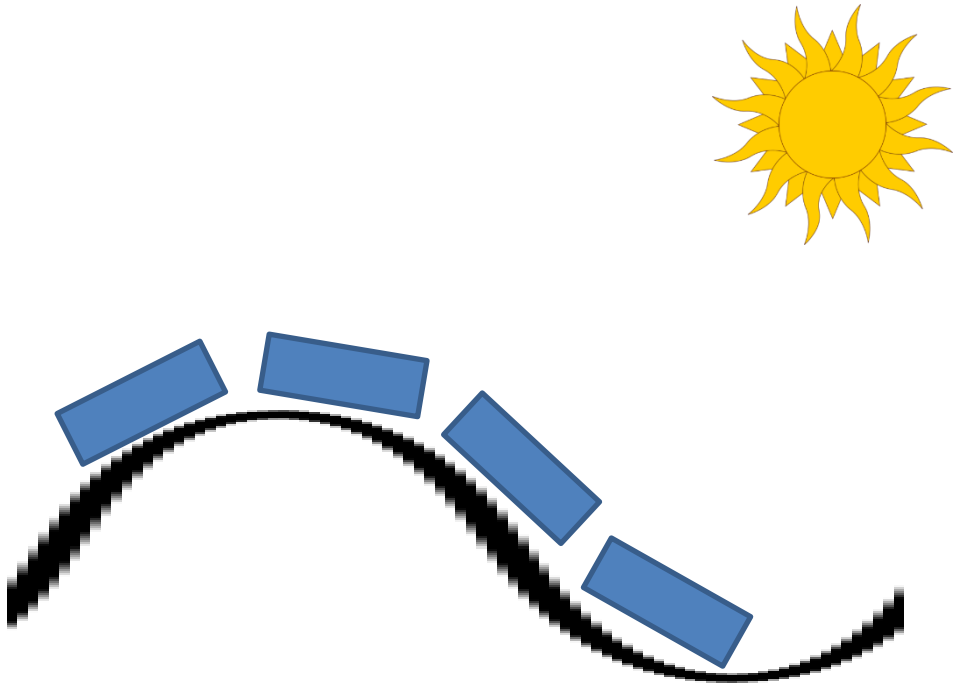


Annual irradiation values (kWh/m²):
1. Noordzee: 1127
2. Zuid-Holland: 1085 (-4%)
3. Veluwe: 1040 (-8%)
4. Groningen: 1042 (-8%)

- Measurement artefacts for satellite data in shallow water:
  IJsselmeer, coastline, Wadden
- Noordzee 4-8% higher annual irradiation

Mechanical movement

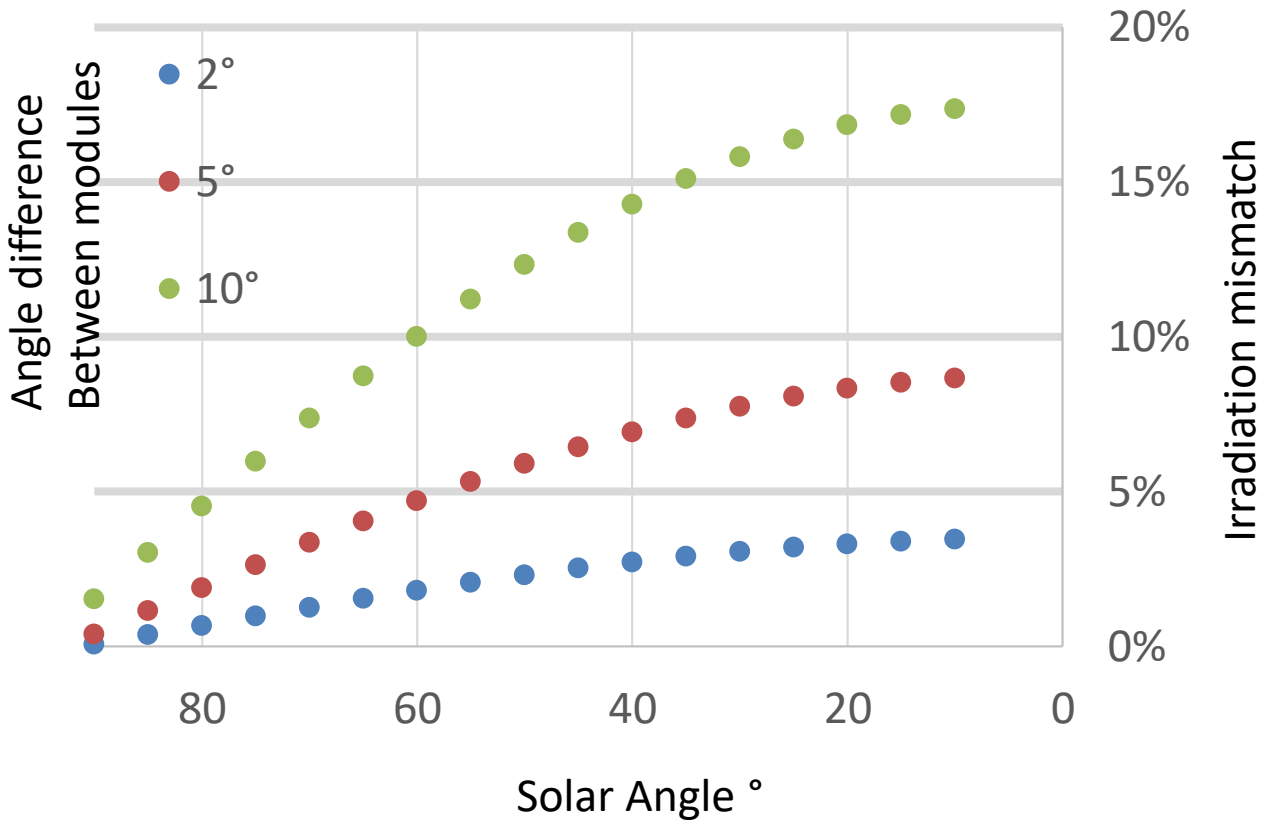
Module misalignment



- Movement -> orientation change

Back of envelope:

- Mismatch depends on
  - Sun angle
  - Wobble intensity



Mechanical movement

Module misalignment

- Modelling:
  - Full year modelling needed!
  - Module movement
    - Wind (KNMI measurements)
    - Waves (Marin measurements)
  - Weather correlations (?)
    - Sunny weather <> low winds
  - Strings vs MLPM
    - Speed of PPT-tracking?

Soiling

- Bird droppings
  - Birds seem to like floating platforms
  - Soiling level is site-dependent, but can be severe
  - Custom cleaning routine and bird repelling measures

Slufter

QE II, UK

Conclusions

- Yield differences are caused by
  - Temperature
    - Moderate temperature reduction observed
  - Irradiation
    - No gain from water albedo, possible gain from weather patterns
  - Mechanical movements
    - Weather and design dependent
  - Soiling
    - Site specific
- More measurements and modelling is needed for better understanding

Thank you for your attention

Contact:

dejong@seac.cc
www.seac.cc
www.zonopwater.nl

Partner in solar energy solutions