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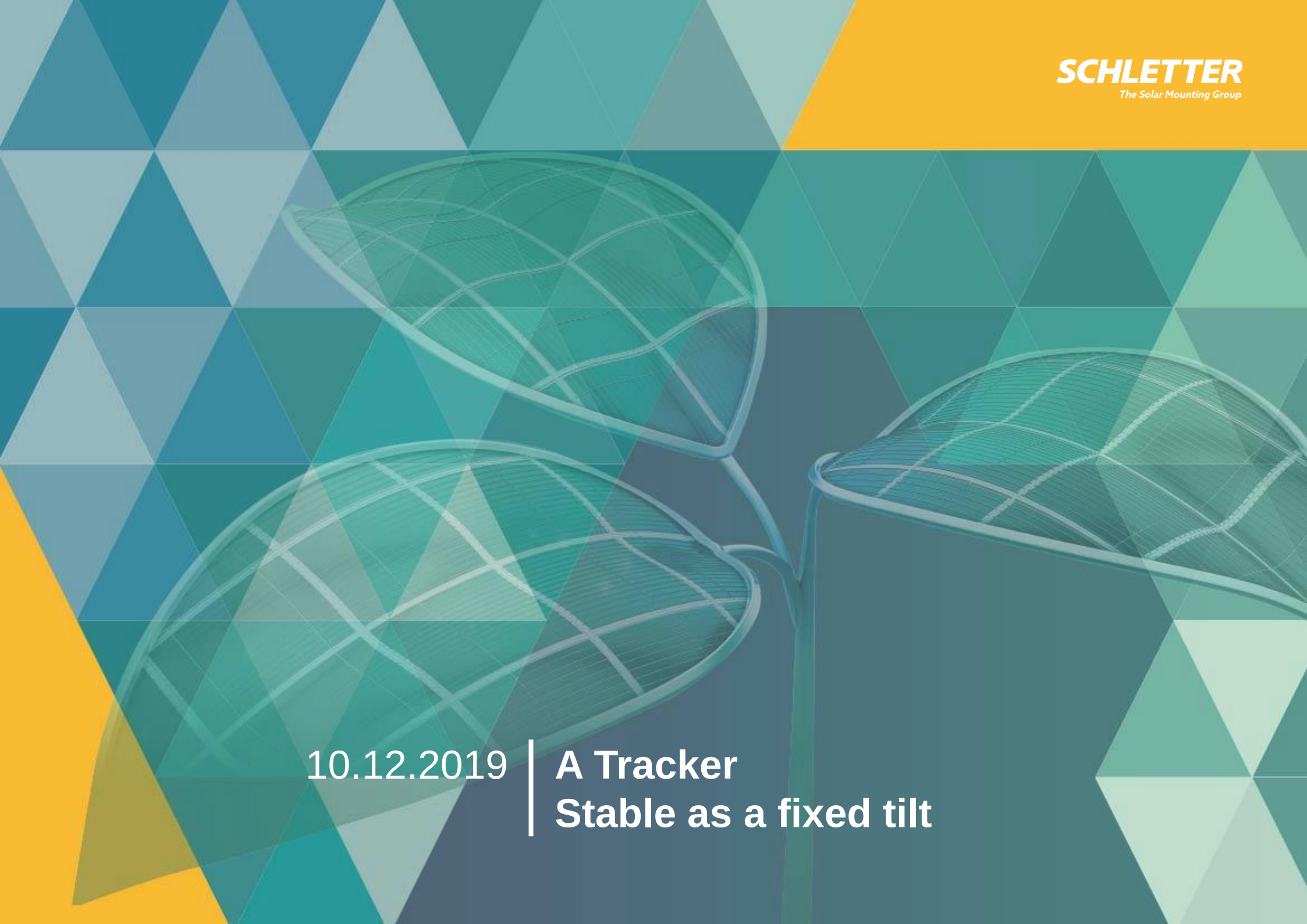
The Solar Mounting Group



10.12.2019

A Tracker
Stable as a fixed tilt

Agenda

1. Introduction
2. Technical Challenge
3. Product Development Targets
4. Technical Solutions
5. Product Features
6. Control System
7. Field Applications
8. Planning and Design
9. Summary / Discussion

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1. Introduction

Former Schletter Activities

- 2012: 12 MW in Caceres (Spain)
  (in cooperation with Clavijo)
- 2014: 55 MW in Ohad (Israel)
  (in cooperation with Clavijo)
- 2016: 6 MW in Konya (Turkey)
  (FS Track-II)
- 2016: 11 MW in Kayseri (Turkey)
  (FS Track-II)
- 2016: Some small installations

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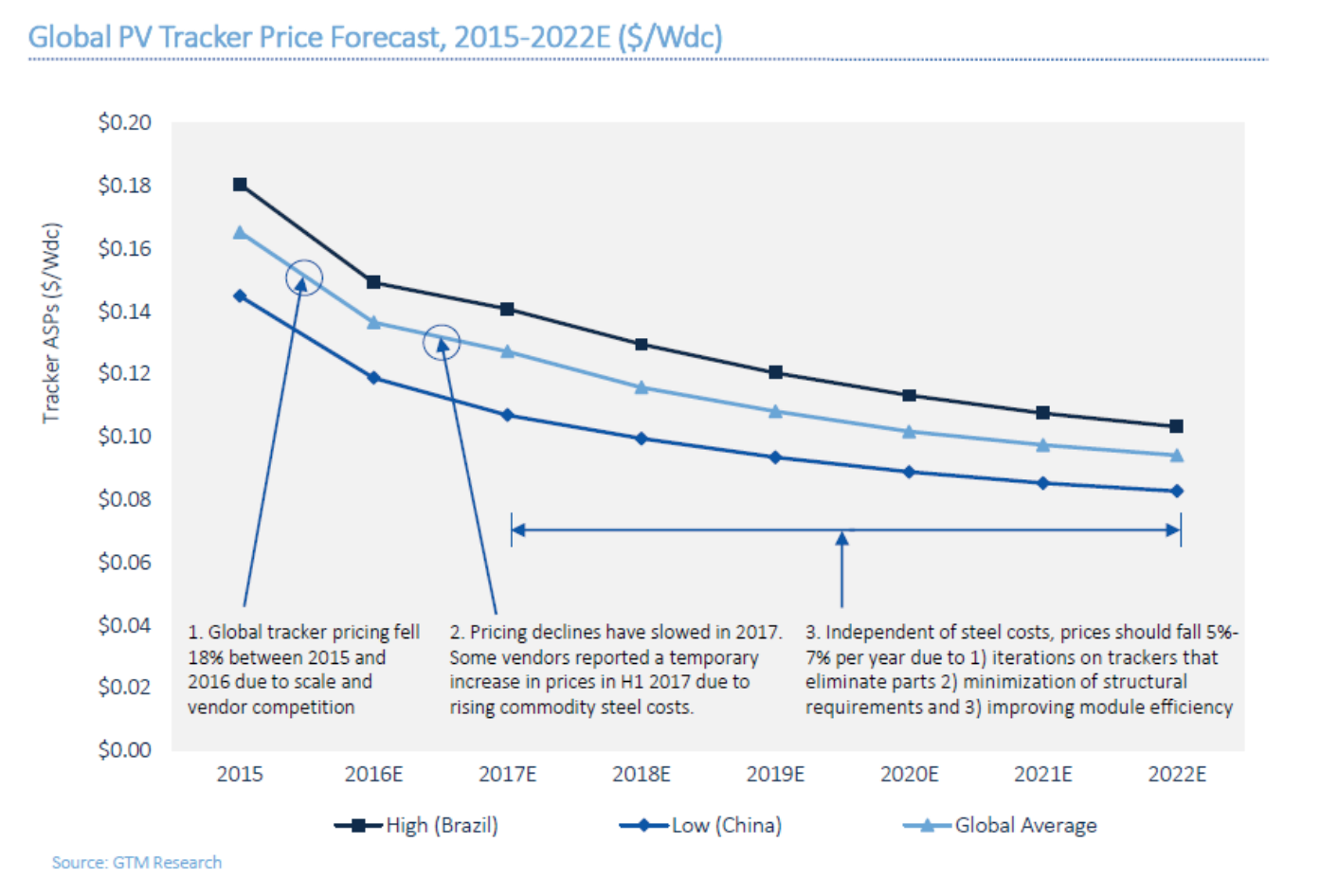
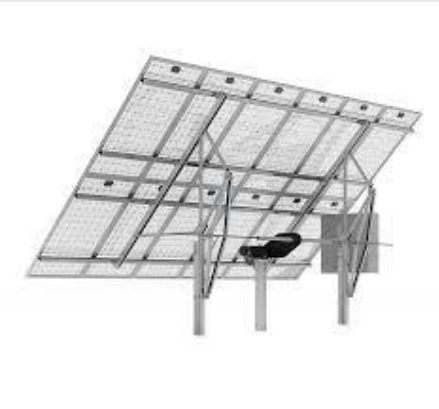
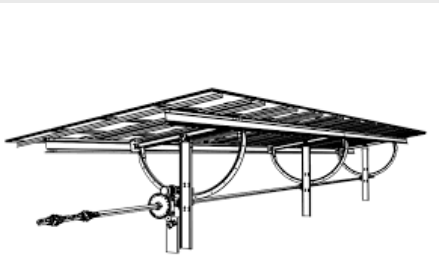
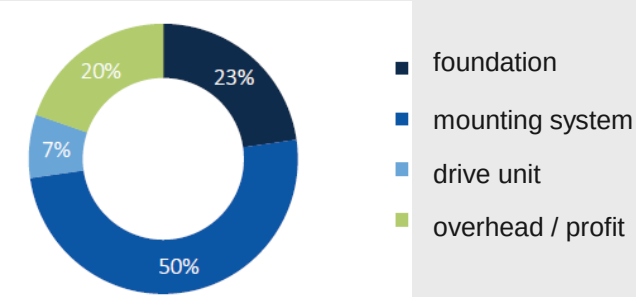
1. Introduction

Expectations for development of costs









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2. Technical Challenge

Phenomenon

wind introduced vibrations with FS Track II

fatigue failure

hydraulic damper

mass dampers

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2. Technical Challenge

Problems arising from accumulated torsional loads

- Limited torsional stiffness of rows
- Vibration-prone system
- Danger of harmonic aerodynamic stimulation (Galloping-Effect)
- Dampers are required
  - Additional costs
  - Additional maintenance
- Limitation of module area per motor at approx. 200 m²
  - Limitation in length and
  - Limitation in width of module area
- High torsional loads at actuator
  - High amount of material needed

System immanent problems have to be solved

→ Increase of costs

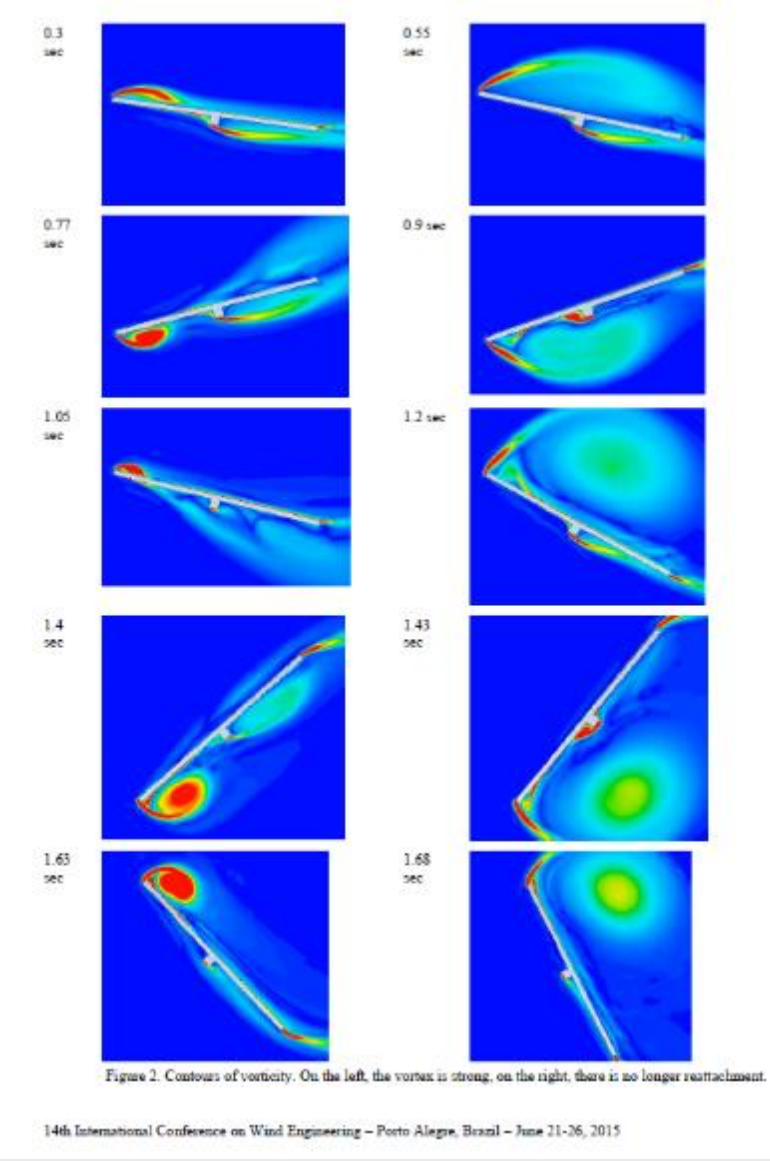

Figure 2. Contours of vorticity. On the left, the vortex is strong, on the right, there is no longer reattachment.

14th International Conference on Wind Engineering – Porto Alegre, Brazil – June 21-26, 2015

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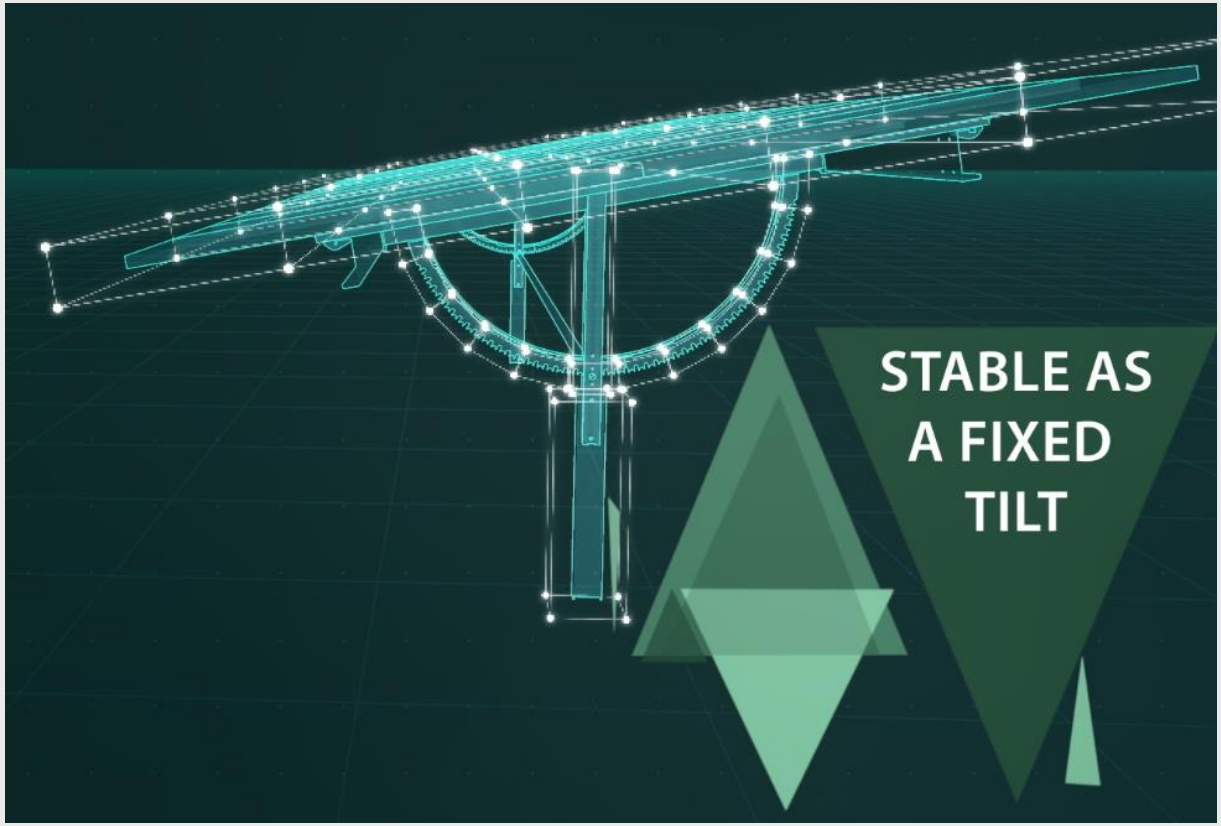
3. Product Development Targets

New System to avoid the problems

How would the perfect Tracking-System look like?

- Single row System
  - Each row can be adjusted separately
  - Easy installation
  - Free passage between rows
- Large module area per motor
  - Rack is cheaper for 2V than for 1V (see Fixed Tilt Systems)
  - GCR can be increased
- No accumulation of torsional loads
  - Loads are transmitted directly into the ground at every post
  - Galloping-Effects are excluded



→ Don’t cure the problems, avoid them!

The new Schletter-Tracking-System combines all this features in an unprecedented way

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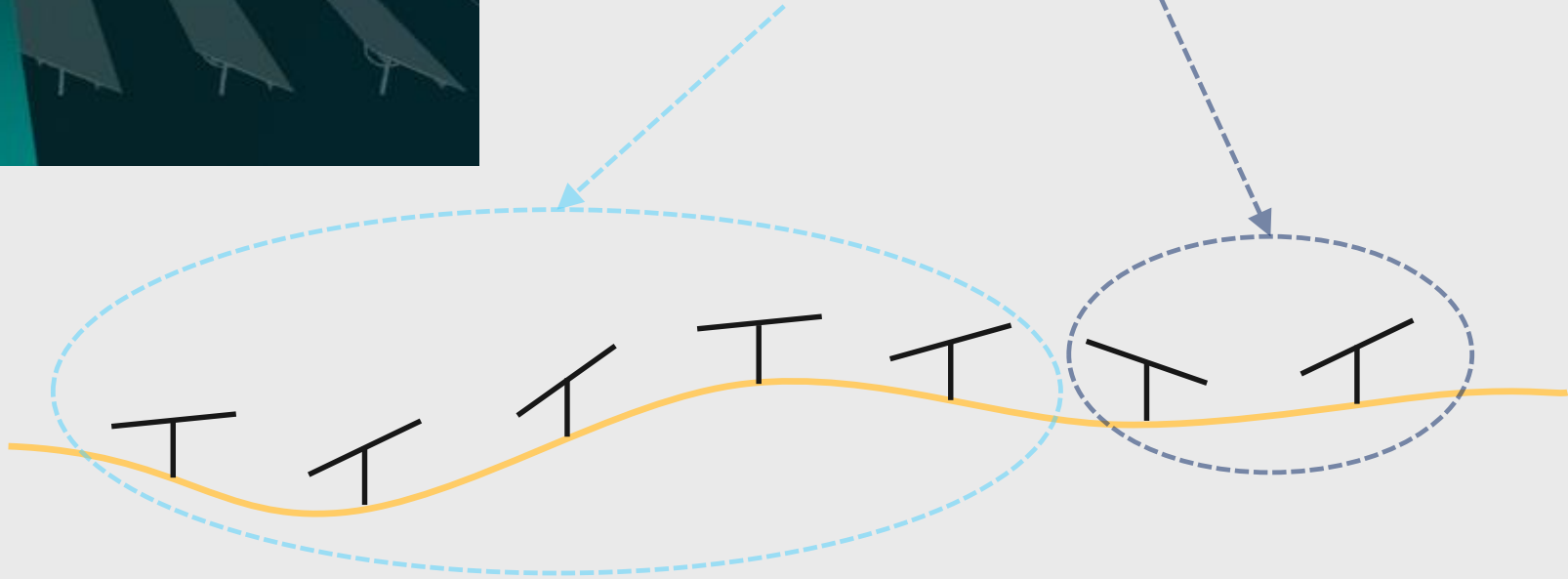
4. Technical Solutions

General approach

- Single Row System
- Easy installation in uneven terrain
- Free Servicing
- Can be installed in difficult terrain
- Higher GCR at nonrectangular properties
- Inclination of every row can be adjusted separately
  - Benefit for service and
  - Benefit for backtracking



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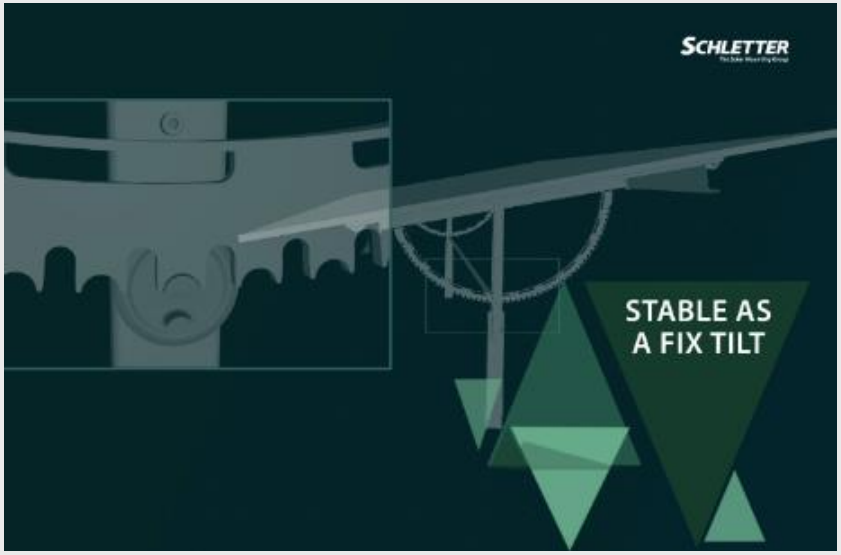
4. Technical Solution

Self Locking “Sun-Stepper-Technology”



- Self-locking mechanism at every post
- Every 3° the Tracker is in locking position
- Stable as a Fixed Tilt

- Adapting an existing principle
  - Engineered for harsh environment
  - Open system
  - No lubrication
  - Low maintenance
  - High reliability

- Testing: Laboratory test simulation 26 years
  - Fatigue
  - Wear and tear
  - Abrasion
  - Deformation
  - Lifetime

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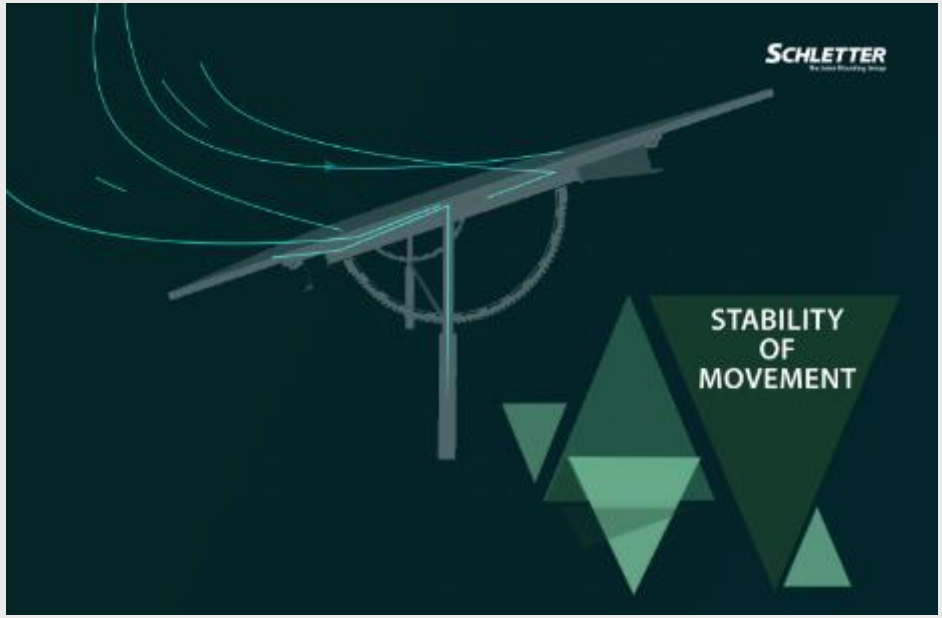
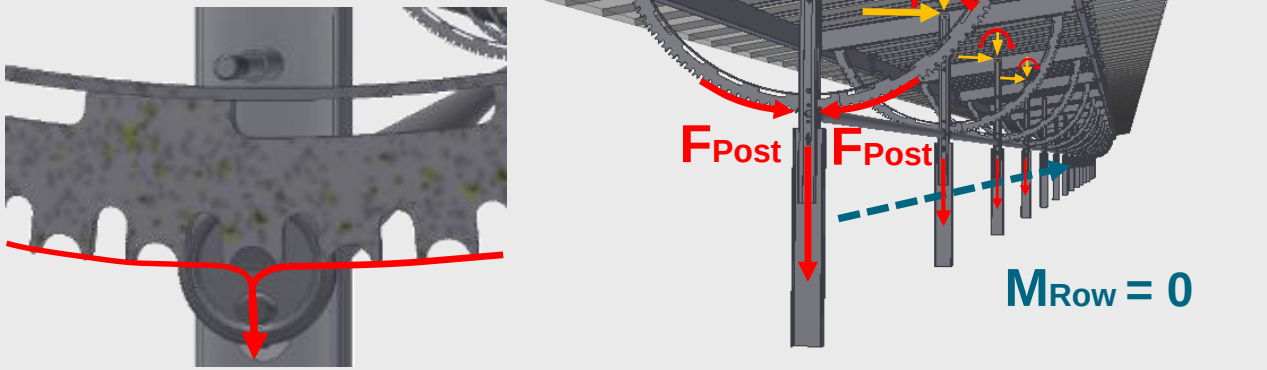
4. Technical Solution

Structural Principle



Stable as a Fixed Tilt

- All loads are transmitted directly at every post
- No torsional flexibility in the system
- No load on motor in locking position



$$\sum M_{\mathrm{Post}} = M_{\mathrm{Row}} = 0$$

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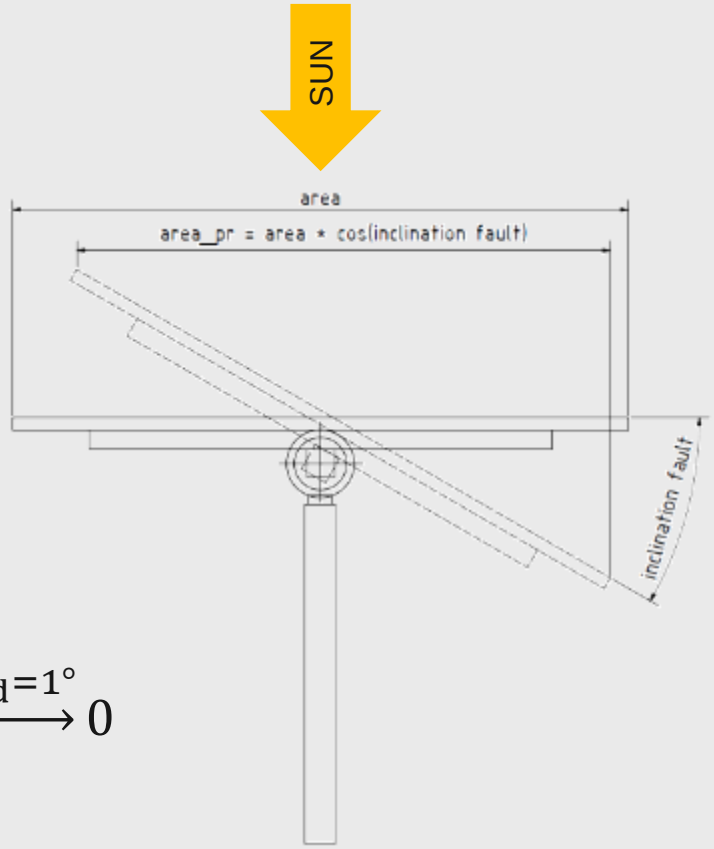
4. Technical Solution

Influence of stepping on yield

MONTH	DAY	HOUR	DIFFUS	DIRECT	TOTAL	SLOPE	ASPECT	ROTA
"1"	"0"	"7,06"	"0,00"	"0,00"	"0,00"	"0,00"	"0,00"	"0,00
"1"	"0"	"7,08"	"0,00"	"0,00"	"0,00"	"0,00"	"0,00"	"0,00
"1"	"0"	"7,10"	"0,00"	"0,00"	"0,00"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,12"	"0,00"	"0,00"	"0,00"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,14"	"0,00"	"0,00"	"0,00"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,16"	"0,00"	"0,00"	"0,00"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,18"	"0,00"	"0,00"	"0,00"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,20"	"0,00"	"0,01"	"0,01"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,22"	"0,00"	"0,04"	"0,04"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,24"	"0,00"	"0,14"	"0,14"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,26"	"0,01"	"0,38"	"0,40"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,28"	"0,04"	"0,87"	"0,90"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,30"	"0,08"	"1,69"	"1,76"	"60,00"	"90,00"	"-60,0
"1"	"0"	"7,32"	"0,15"	"2,92"	"3,07"	"60,00"	"90,00"	"-60,0

Steps of 3°

- Every 3° the Tracking System is in locking position
- No loss of earnings due to step of 3°



$$P_{\text{Loss}} \sim 1 - \cos(\alpha_{\text{ad}}) \xrightarrow{\alpha_{\text{ad}}=1^\circ} 0$$

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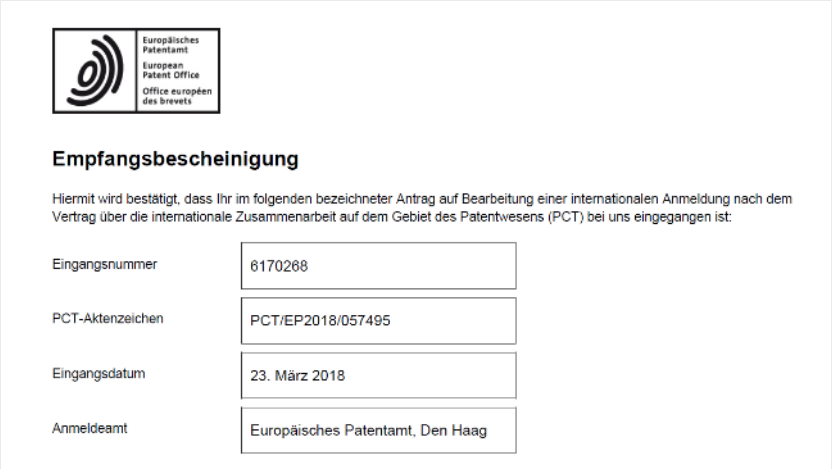
5. Product Features

- Range of movement: +/- 60°
- Stow position / Night position: 10°
- Inclination Steps: 3°
- Tracking according to astronomical calculations
- PV-Modules per Motor (up to 480 m²): up to 240
- Configuration: 2V or 4H
- Bifacial PV-Modules: in 4H and 2V-Configuratioin
- High GCR, wider module area and smaller distance for servicing
- Flooding clearance for electrical components: 1.2 m
- Piles: SRF7-Piles and W6x7 applicable
- Ground slope: up to 10° E-W and 10° N-S
- Certifications: UL / CE / Bankability Study
- Warranty: 10 years for structural components
  5 years for electrical components
- Patent



Europäisches Patentamt
European Patent Office
Office européen des brevets

Empfangsbescheinigung

Hiermit wird bestätigt, dass Ihr im folgenden bezeichneter Antrag auf Bearbeitung einer internationalen Anmeldung nach dem Vertrag über die internationale Zusammenarbeit auf dem Gebiet des Patentwesens (PCT) bei uns eingegangen ist:

Eingangsnummer	6170268
PCT-Aktenzeichen	PCT/EP2018/057495
Eingangsdatum	23. März 2018
Anmeldeamt	Europäisches Patentamt, Den Haag

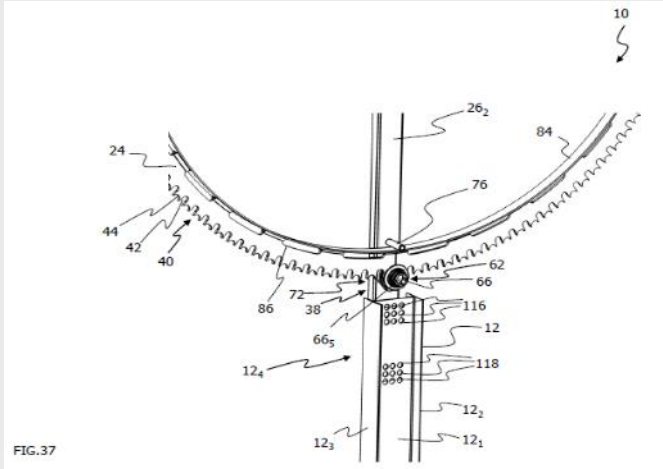


FIG.37

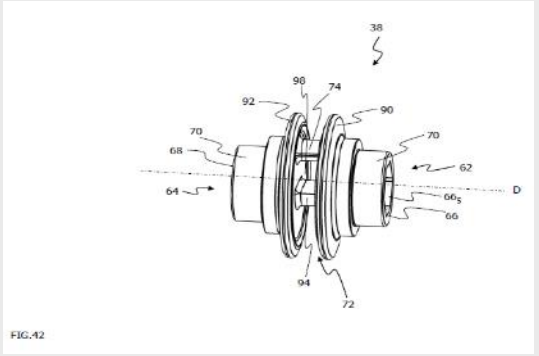


FIG.42

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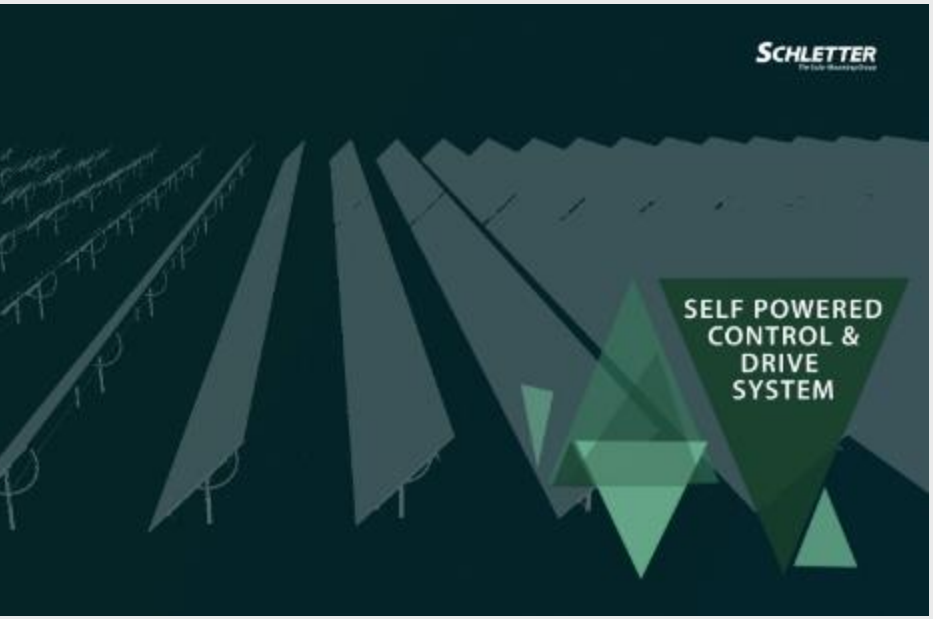
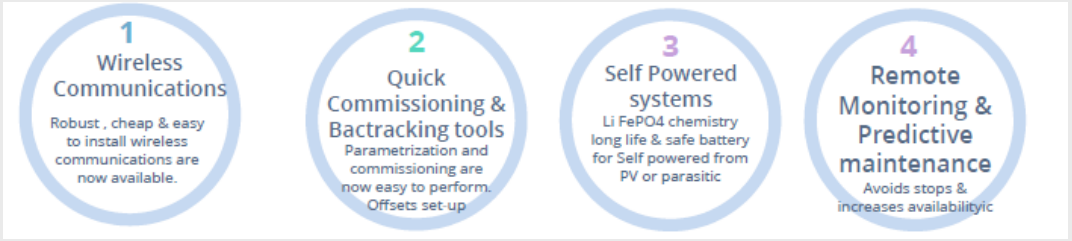
6. Control System

Self powered System



- Motor and Control powered from extra PV-Module
- No cabling between rows for motor
- No cabling between rows for control unit
- Easy installation
- Easy commissioning
- Grid Powered version available



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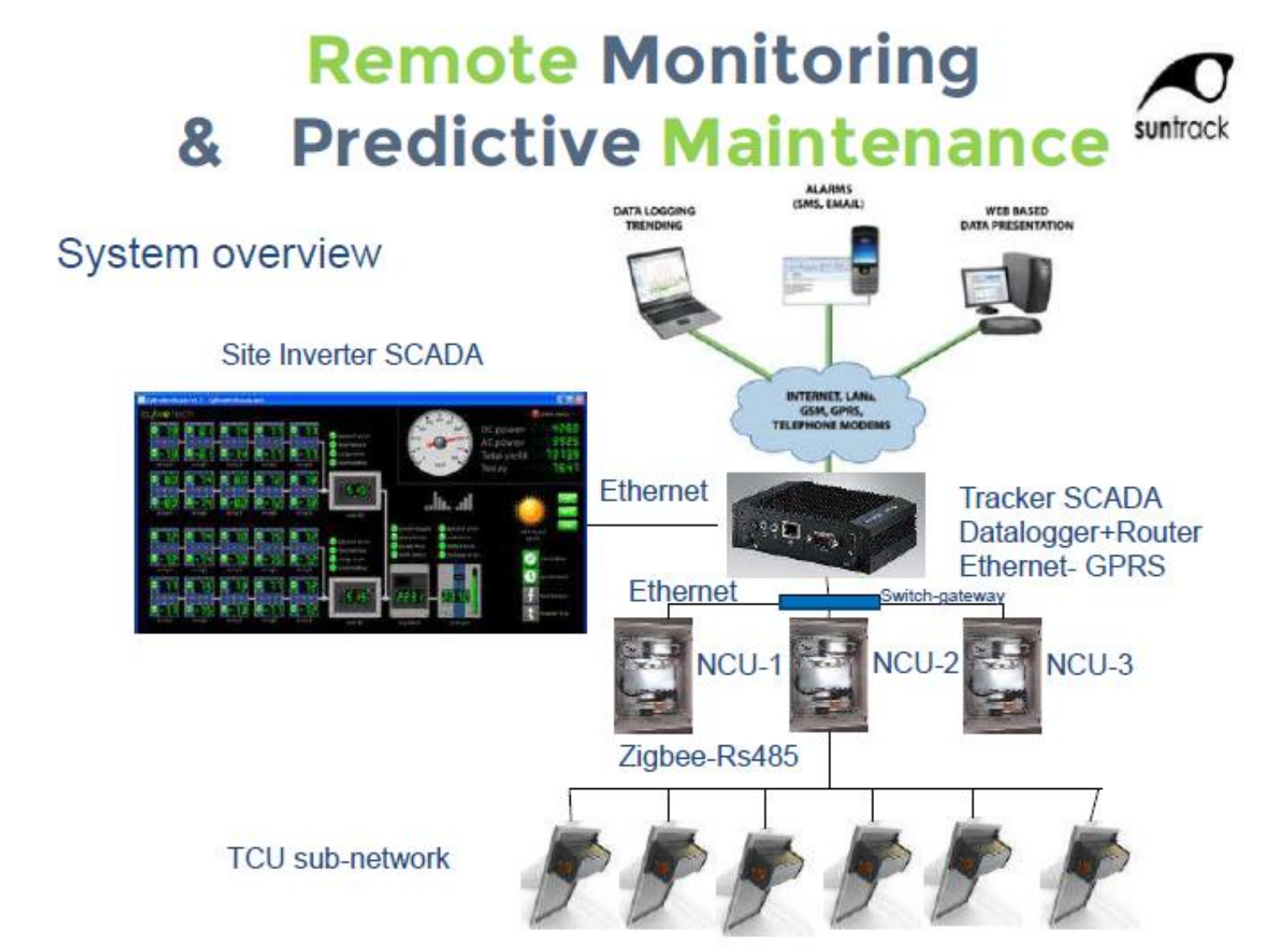
6. Control System

Remote Control



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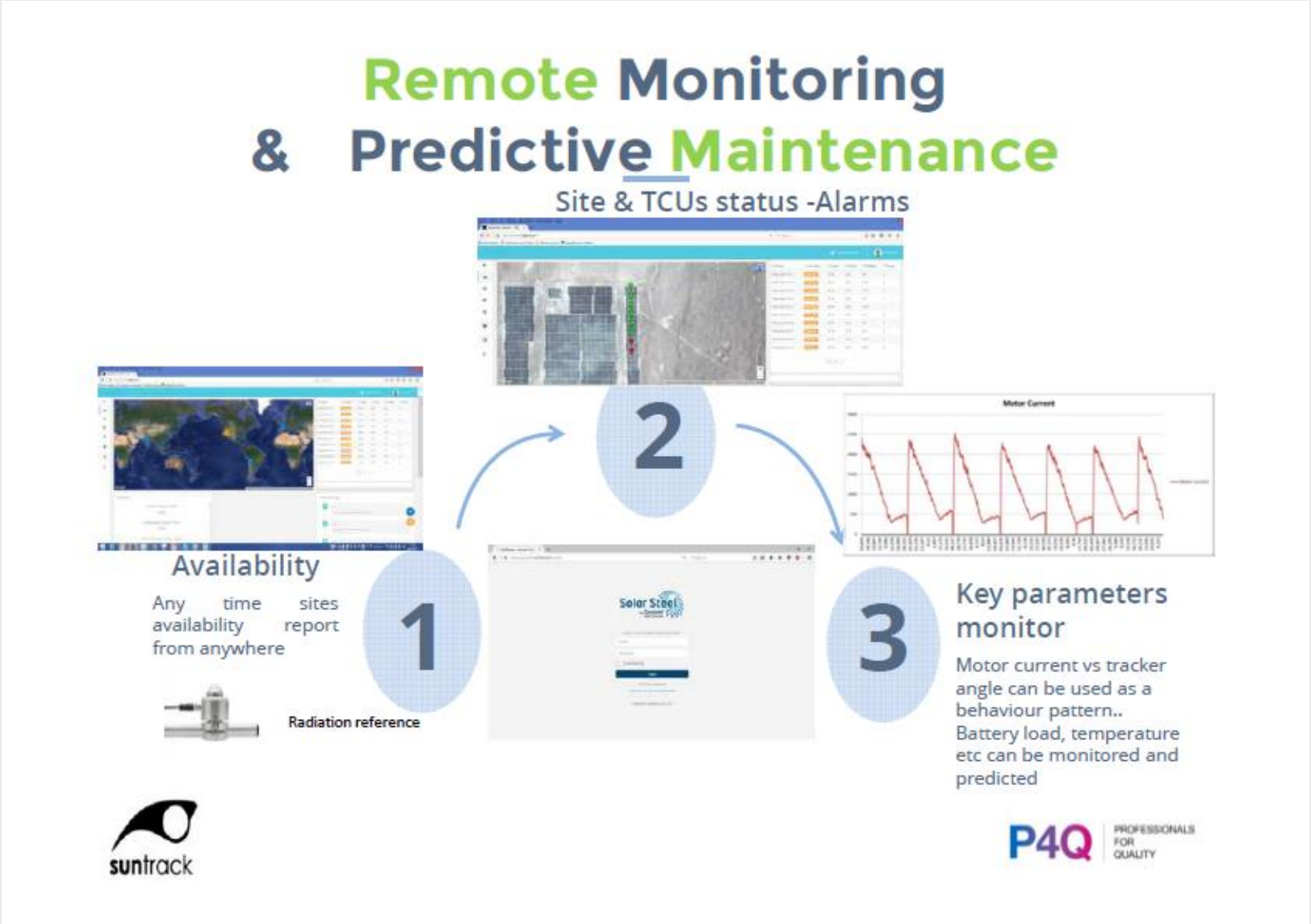
6. Control System

Monitoring Devices



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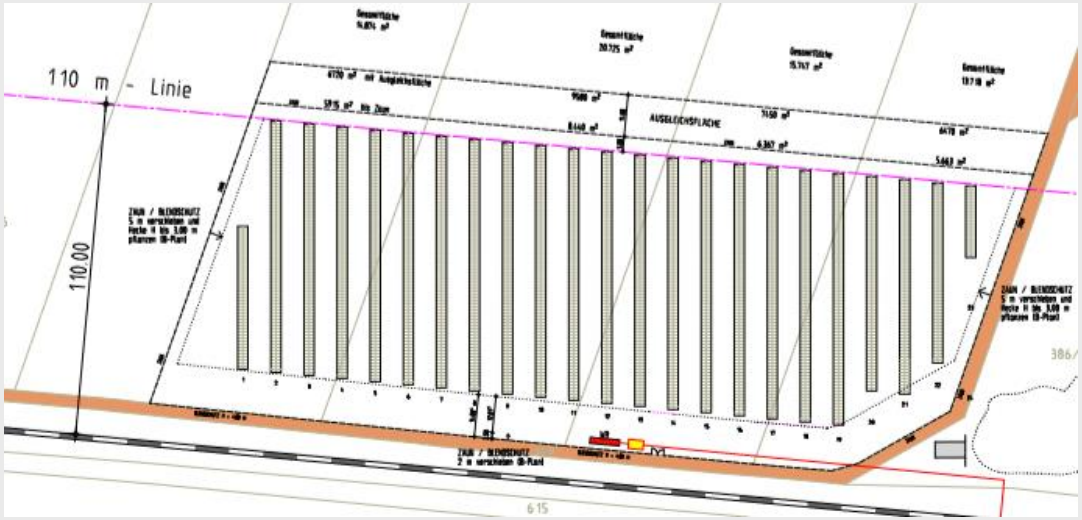
7. Field Application

Freihung (Germany)



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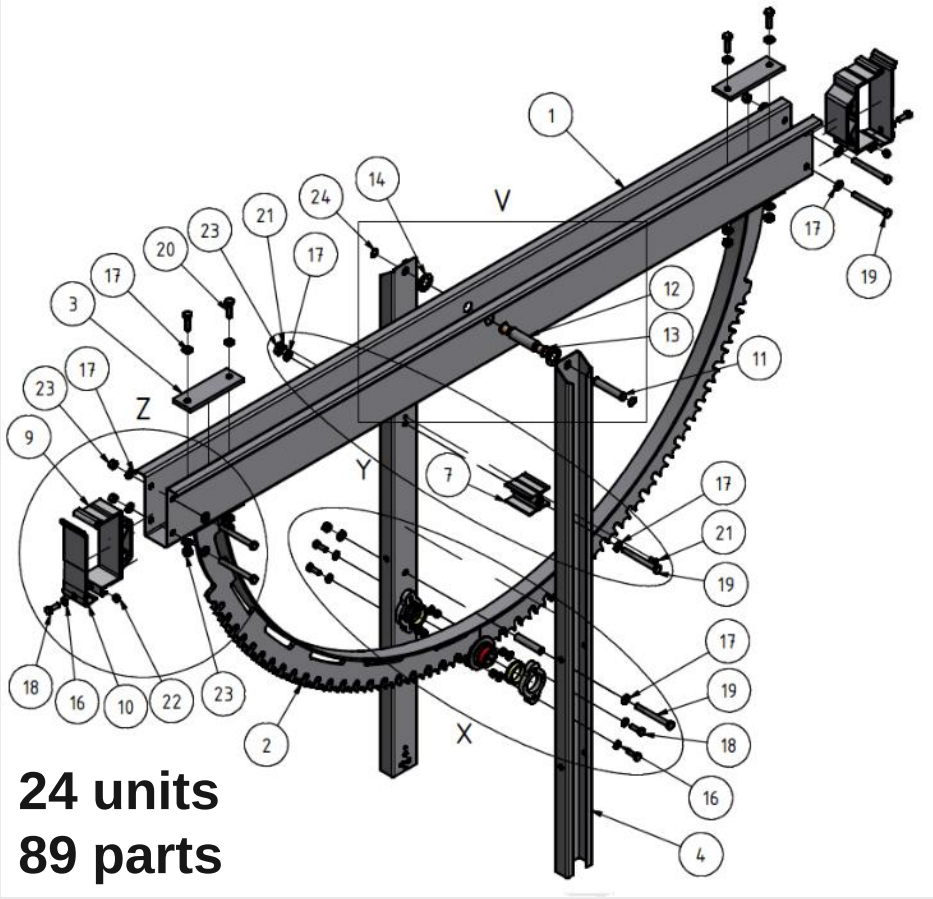
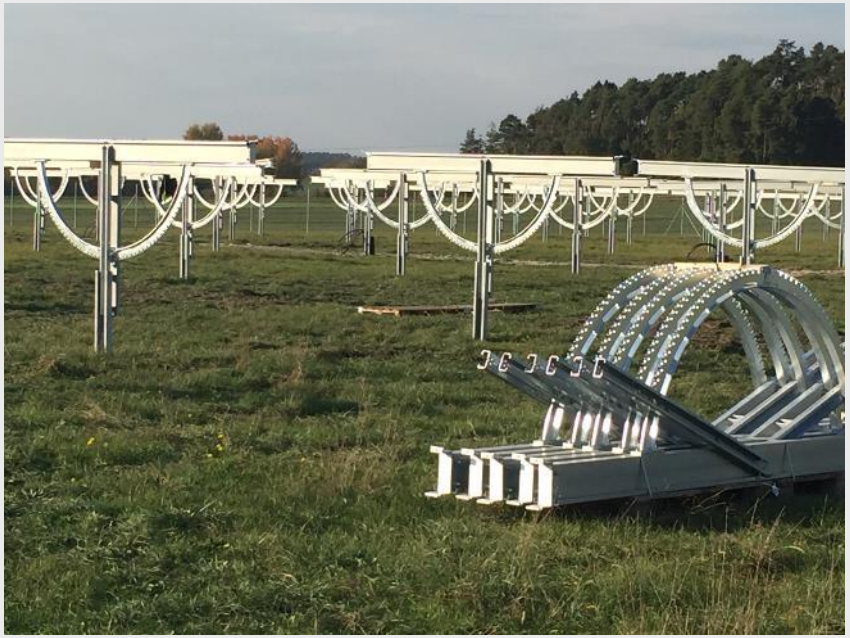
7. Field Application

Pre-Installed Girder-Assembly



24 units
89 parts



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7. Field Application

40 % Saving on installation time

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7. Field Application

Operation

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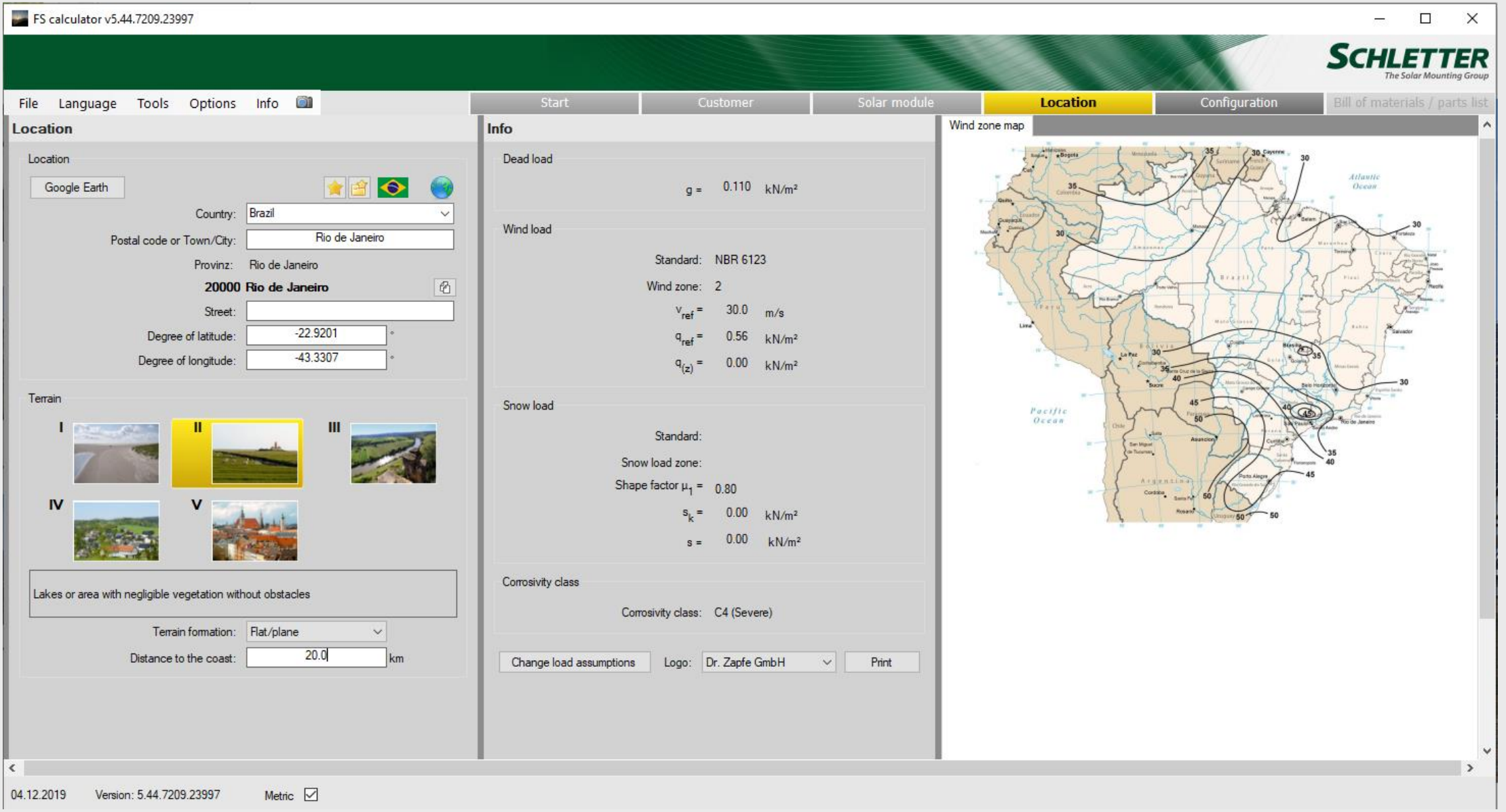
8. Planning and Design



- Structural Design based on local Technical Standards
- Durability Check according to the local Corrosivity Class
- Customized Design

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9. Summary / Discussion

- Lessons learned in terms of resonance vibrations
- New Tracker with innovative Sun-Stepper-Technology
- Pre-assembly allows fast mounting
- Structural design for most countries in the world


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