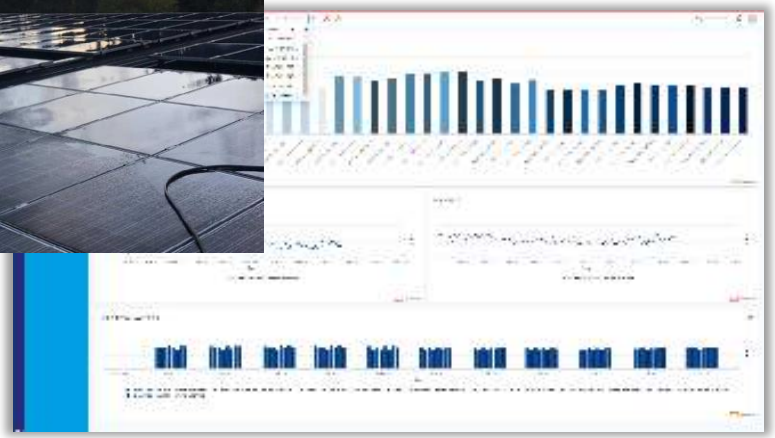

IEA PVPS

Optimized O&M
New webtool for data monitoring and analysis

Christian Reetz, Mondas GmbH

Freiburg, 2021/09/30

Mondas GmbH / Introduction

- Mondas is a Spin Off founded in 2018
  - Fraunhofer ISE, PSE AG, Hochschule Biberach
- Core Product: cloud-based software for time-series analysis.
- Fields of application: technical monitoring and system optimization
  - Especially for large numbers of distributed systems
- Generic but: focus on building and energy systems
  - Building technology (AHU, Heating/Cooling, …)
  - CHP's, district heating, power plants (wind, wood carpurators, …) and PV plants

Project OptOM

- **Cost Optimal Operations and Maintenance for PV Plants**
- Funded by: Federal Ministry for Economic Affairs and Energy (BMWi)

- Partners:
  - **Pohlen Solar/Centroplan**:
    resp. for O&M of nearly 3000 commercial PV Plants
  - **Fraunhofer ISE**:
    Scientific partner
  - **Mondas GmbH**:
    Cloud platform for O&M Data analysis

POHLEN SOLAR

Fraunhofer ISE

mondas®
DATEN. BEWERTEN. HANDELN.

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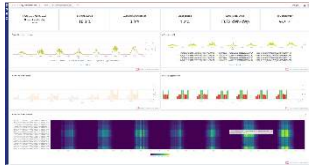
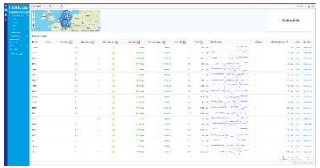
OptOM: Project Plan

Reference implementation
New web-base platform for monitoring and analysis

Cost optimization and prioritization of O&M tasks

Rule-Based
Operation analysis

Machine-learning-based
Operation analysis

Collecting longterm data
(Different Sources / Systems)

Monitoring Platform | Logger | Different metadata sources

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OptOM: Project Goals

- **Failure detection and predictive fault detection**
  - Rule-Based time-series analysis to detect failures automatically:
    → *Different inverter faults, decreasing performance, ...*
  - ML-based analysis to detect failures hard to detect by rule-based algorithms:
    → *Shading detection, soiling detection, degradation, …*
- **Prioritization**
  - Prioritize O&M efforts by cost factors and cost optimization
    → *Do the right (cost-optimal) things in the right order*
    → *Automated calculation of soiling losses and „best-time-to-clean“*
    → *Quantification of shading losses and their development*
- **Implementation as on-going analysis process (Platform)**

OptOM: Rule-Based Analysis Example

Rule Development (ISE / Pohlen Solar)

Platform: Rule Editor

Description

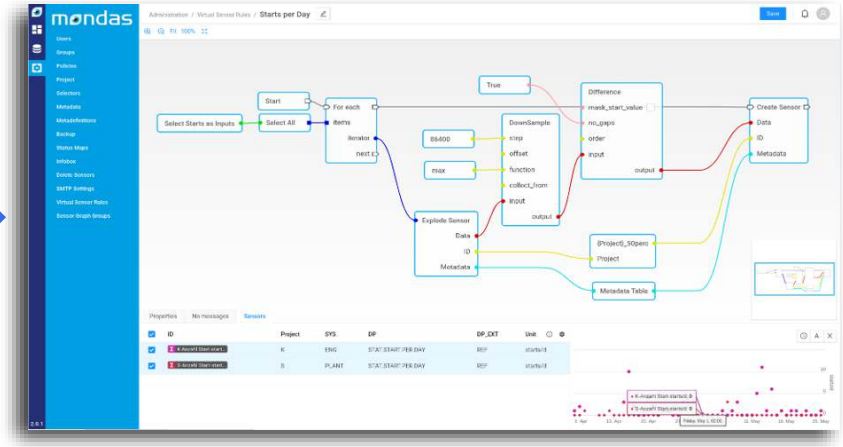
- This rule detects outliers in current-DC sensors.
  A fault is given by a sensor value:
  whose absolute deviation > certain threshold
- Do not apply to timeranges with other
  faults like “No AC Voltage”

Algorithm

For each Project (installation). For each System (inverter).

1. filter current-DC only when the rest of inputs are 0
2. apply z-score algorithm to current-DC
3. x0 = abs(currentDC – move_mean(currentDC))
4. y0 = x0 / move_std(currentDC)

…



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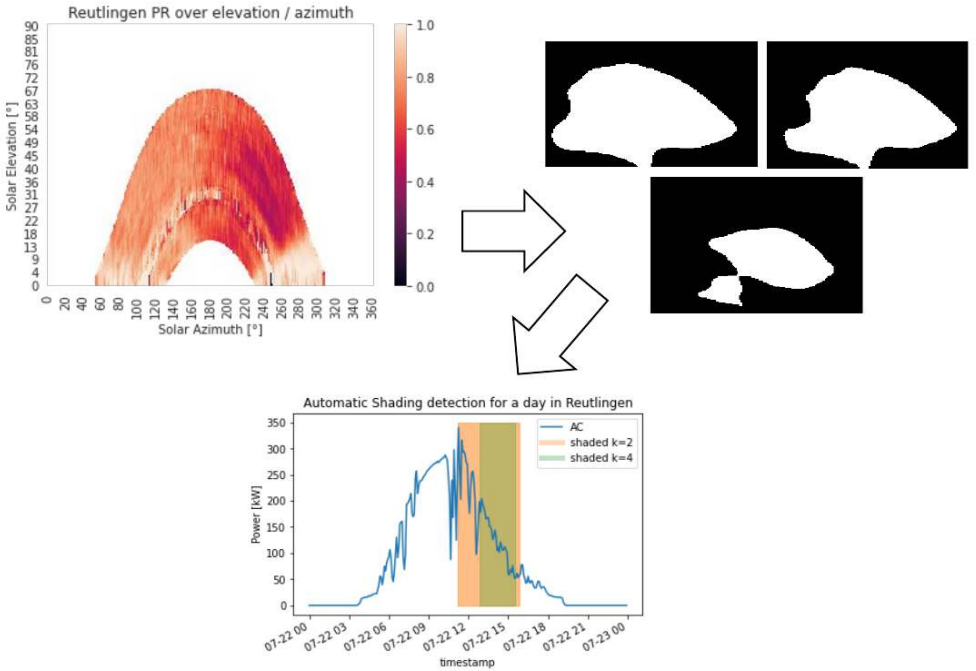
OptOM: ML-Bases Analysis Example

- **Shading detection Algorithm (Fraunhofer ISE)**
  - Eliminate “known” errors with rule-based analysis
  - PR Calculation (Based on Satellite data)
  - K-Means clustering (Two clusters, also more)
  - Result: 2D “Shading Mask”



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OptOM: Field Test

- **On-site analysis for 20 plants**
  - Assessment of system condition
  - Fixing measurement hardware errors (mounting of irradiance sensors, …)
  - Soiling assessment: Module cleaning and sample calibration measurements
  - Thermal conditions: Generators and selected Inverters




OptOM: Field Test

- **Deploy Methods to 200 commercial PV plants**
  - Different age, technology and setup
  - Up to 15 years of monitoring data per plant
  - Find correlations (Components, weather, location, maintenance logs, …)
  - Possible: New set of rule-base analysis on basis of cross comparison

OptOM: Data analysis automation

Both data analysis and visualization should be applied automatically

Algorithms “need to know” the time-series

- Which: plant, Inverter, string, measurement, …
- Component hierarchy and interconnection (“connect-to relation”)
- Parameters: nominal values, orientation, manufacturer, model

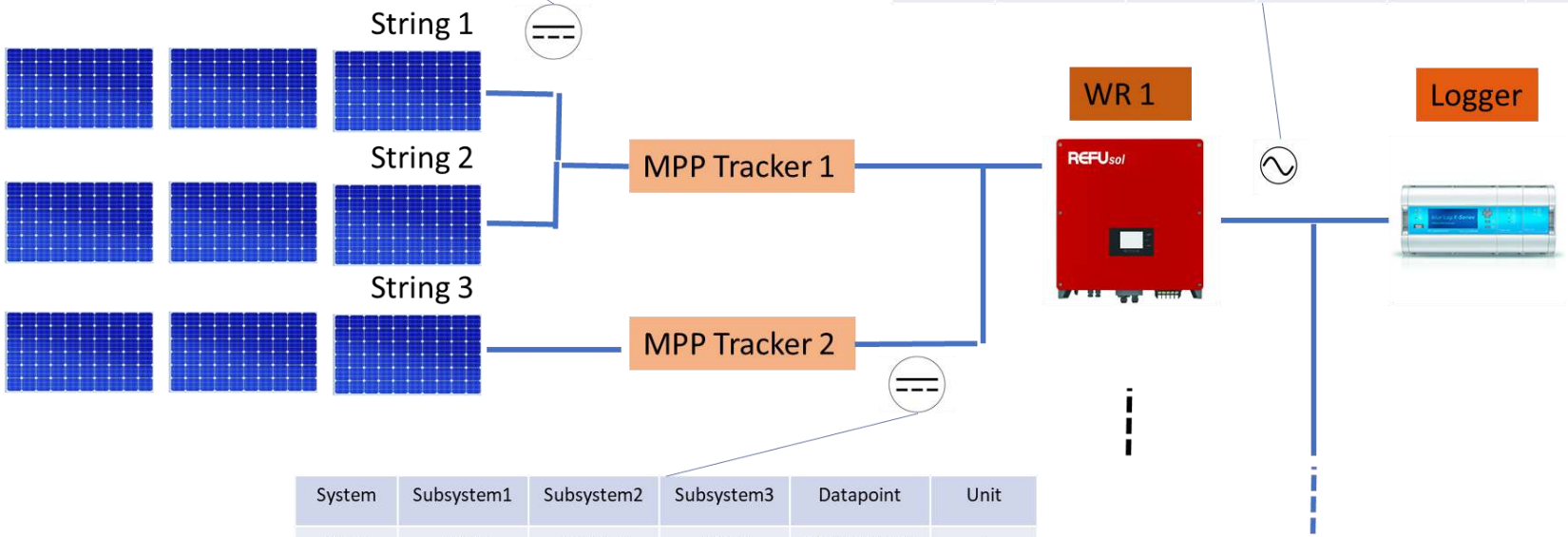
Approach:

- Use of a meta-data system, “describing” each sensor/time-series
- On basis of the system: “Work on sets of time-series”
  i.e.: find all irradiance sensors → apply certain analysis

OptOM: Metadata System

System	Subsystem1	Subsystem2	Subsystem3	Datapoint	Unit
PV-1	INV-1	MPPT-1	STR-1	MEA.CUR-DC	A

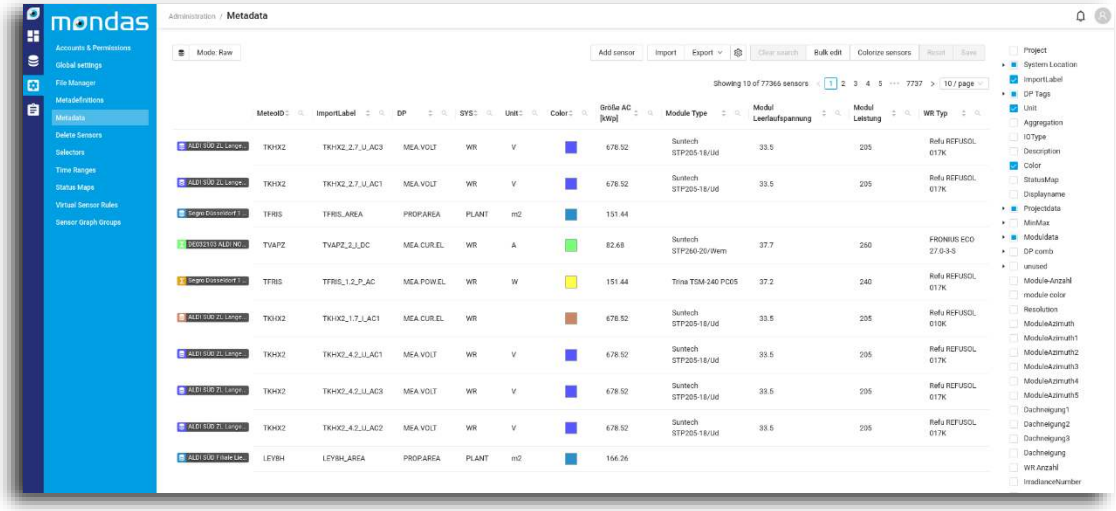
System	Subsystem1	Subsystem2	Subsystem3	Datapoint	Unit
PV-1	INV-1	MPPT-0	STR-0	MEA.CUR.AC	A



System	Subsystem1	Subsystem2	Subsystem3	Datapoint	Unit
PV-1	INV-1	MPPT-0	STR-0	MEA.CUR-DC	A

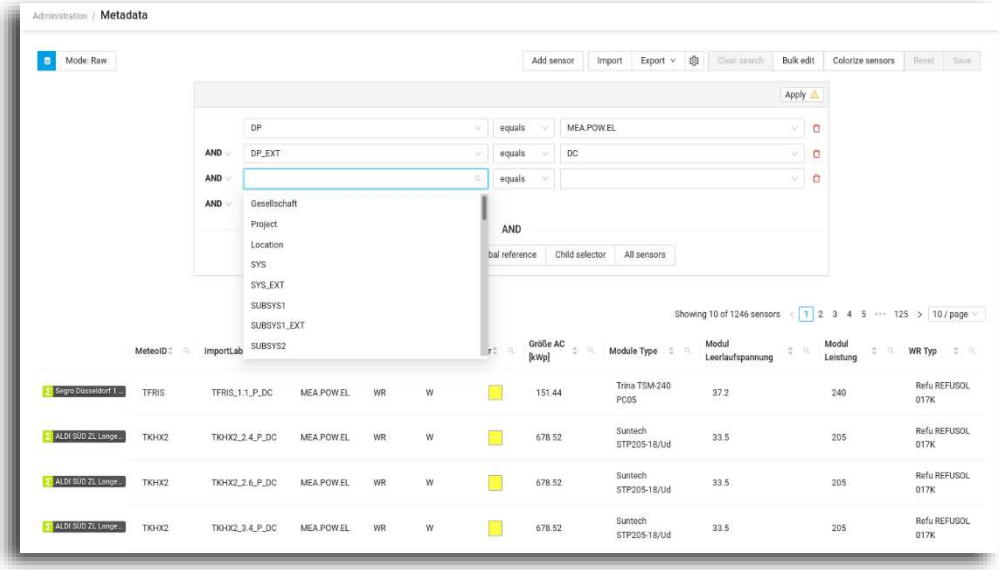
OptOM: Metadata System in Mondas

- Editable:
  Web-tool or excel
- Generic:
  Applicable to any system
- Combined analysis:
  e.g.: PV and battery
- Adaptable/extendable:
  Metadata system



Mondas: Metadata System

- Using „Selectors“:
  key for automation in Mondas
- Selectors:
  Logical expression on metadata
- Selecting sets of time-series
  based on their metadata
- Technique used for:
  - ➢Visualization
  - ➢Rule-based analysis
  - ➢External modules



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Mondas: Rule Editor

- Graphical Programming
- Input: one or more time-series
- Output: one or more time-series (virtual time-series)
- “Loops over” sets from selectors
- Many built-in functions
- Metadata is also processed:
  - Adapted for virtual time-series
  - Metadata consistency checks

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Mondas: Rule Editor

Applications

- Preprocessing
- Fault Detection and Prioritization
- Statistics
  Faults per Inverter model, etc.

Combination with ML Methods

- Preprocessing and
  “finding” training data
- Removing known
  errors from training data

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Mondas: Visualization

Dashboard System

- Generic design
- Configured for specific systems and applications
- Selector mechanism enables Template dashboards (Automatically applied to new systems)
- Common configuration:
  - Overview with prioritization
  - “Linked to”: several detail levels

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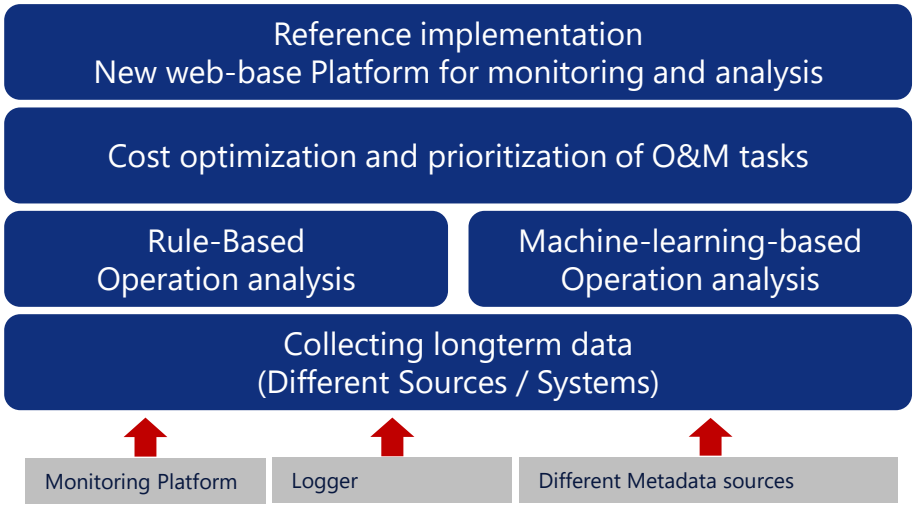
OptOM: Summary and outlook

- OptOM is on-going until 2023
- Rule-based fault analysis has already proven to be useful

→ Applicable to commercial plants

- ML-Methods are also promising
- On-going: Cost KPI integration
- Pohlen Solar plans application for all plants via the new Fraunhofer Spinoff and Mondas partner Enmova



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