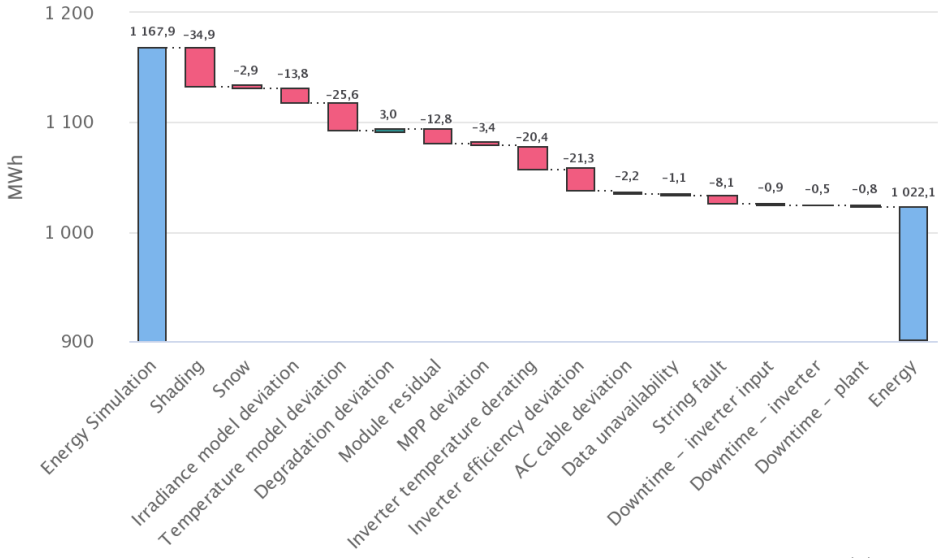

IEA PVPS

Strategies for Early Fault Detection and Diagnostics

Julien Deckx, 3E, Belgium

Data Driven Mitigation Measures in Advanced PV Plant Monitoring, 06 October, 2021

Contents

- Introduction
- Expected system losses
- Observed system losses
- Examples
- Future work

Introduction

3E timeline

1999
3E foundation as a spin-off of IMEC

2014
Launch of Solar Data Services

2021
Launch of Wind Analytics LivLiner Inside

1999 - 2007
Organic growth, international presence

2017
Launch of Solar Analytics & Sensor Check

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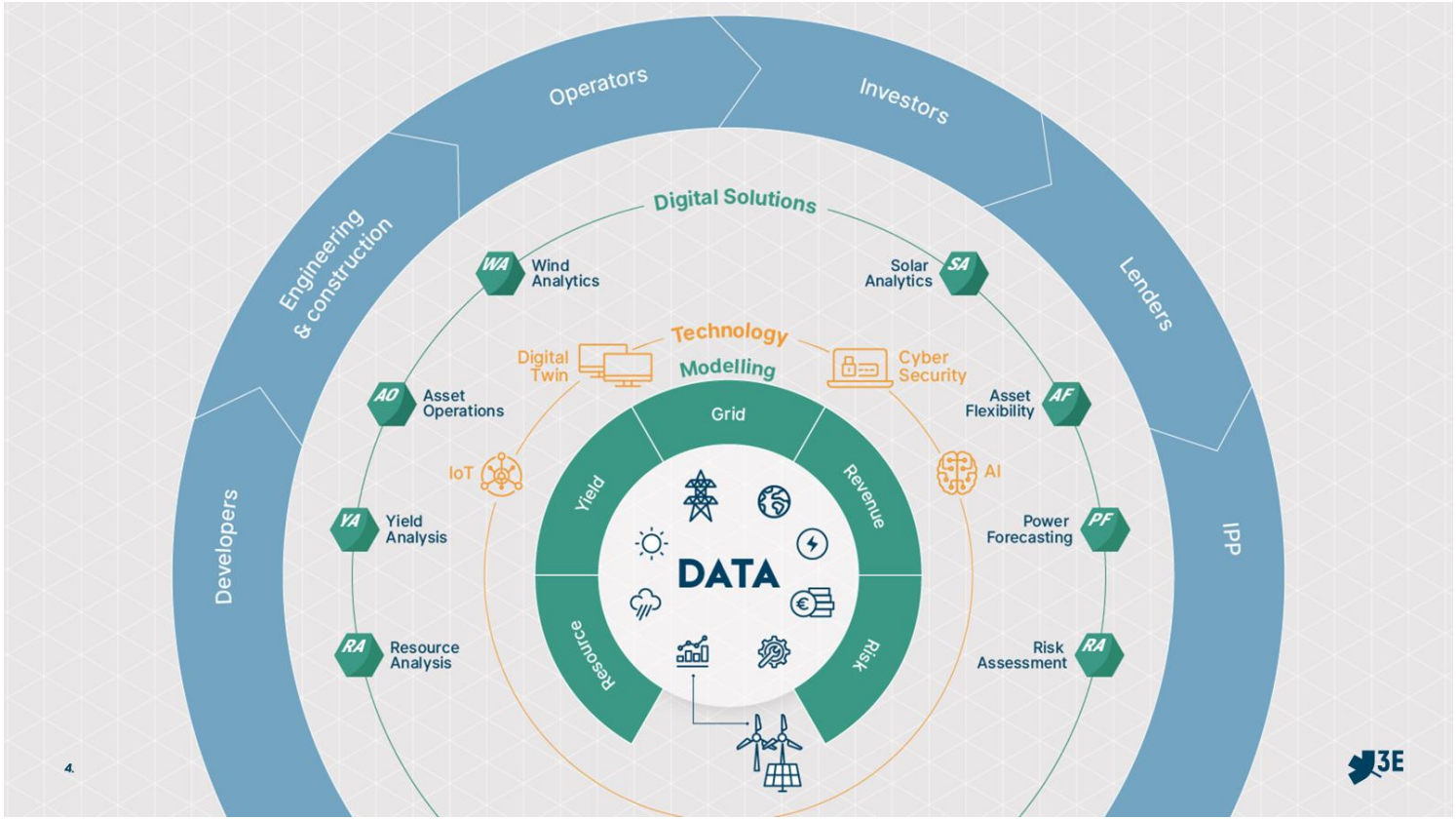
3E digital solutions



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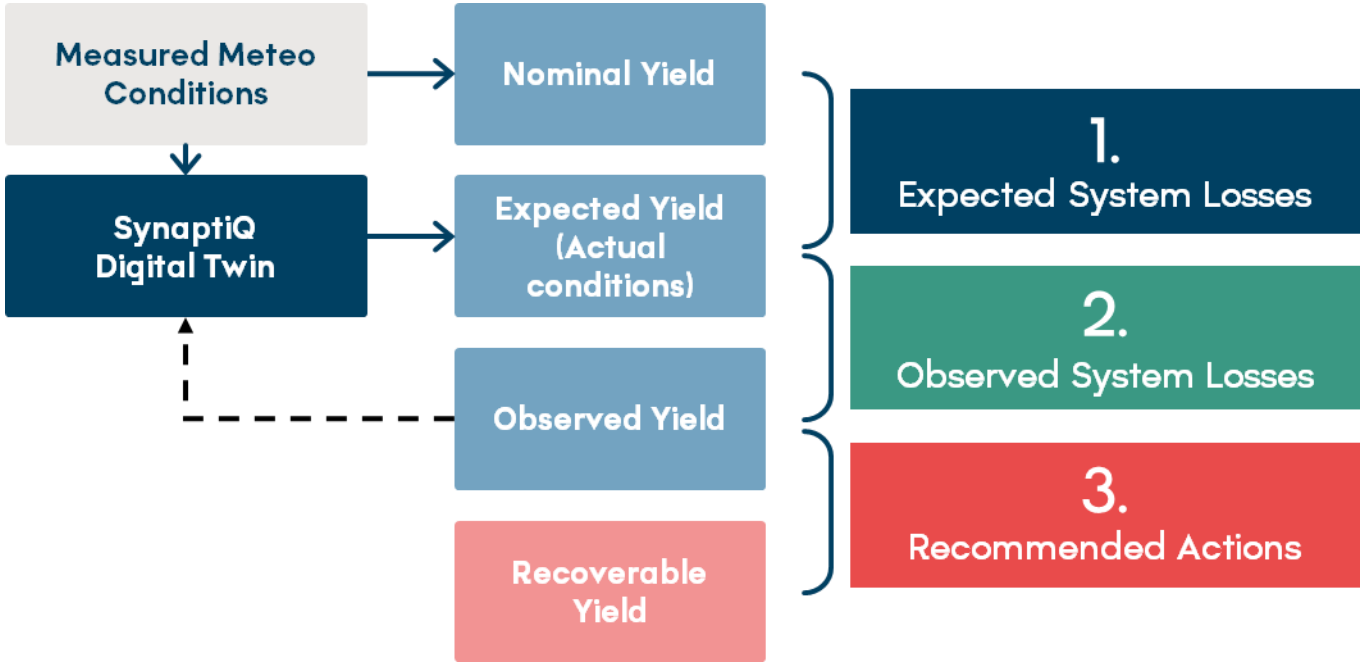
From meteorological data to recommended actions



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Expected System Losses

SynaptiQ Simulation Model 2.0.

$$P_{ac} = ILM * \sum_{inverter-inputs} I_{mpp} * V_{mpp} * number - of - strings * modules - per - string$$

where:

- ILM is the Inverter loss modifier
- I_{mpp} is the Module MPP current
- V_{mpp} is the Module MPP voltage

The module MPP current is simulated using following formula:

$$I_{mpp} = I_{mpp,ref} * G_{poa}/G_{STC} * SHM * SLM * IAM * SMM * MQM * DLM$$

where:

- $I_{mpp,ref}$ is the reference MPP current at Standard Test Conditions
- G_{poa} is the irradiance in the plane-of-array
- G_{STC} is the reference irradiance at Standard Test Conditions (= 1000 W/m²)
- SHM is the shading loss modifier
- SLM is the soiling loss modifier
- IAM is the incidence angle modifier
- SMM is the spectral mismatch modifier
- MQM is the module quality modifier
- DLM is the degradation loss modifier

The module MPP voltage is simulated using following formula:

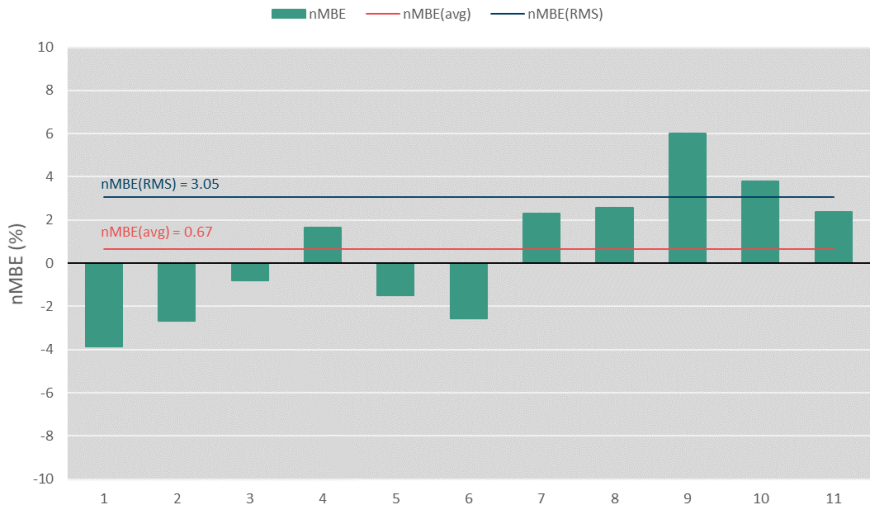
$$V_{mpp} = V_{mpp,ref} * TMM * IMM * DCM$$

where:

- $V_{mpp,ref}$ is the reference MPP voltage at Standard Test Conditions
- TLM is the temperature model modifier
- ILM is the irradiance model modifier
- CLM is the dc cable loss modifier

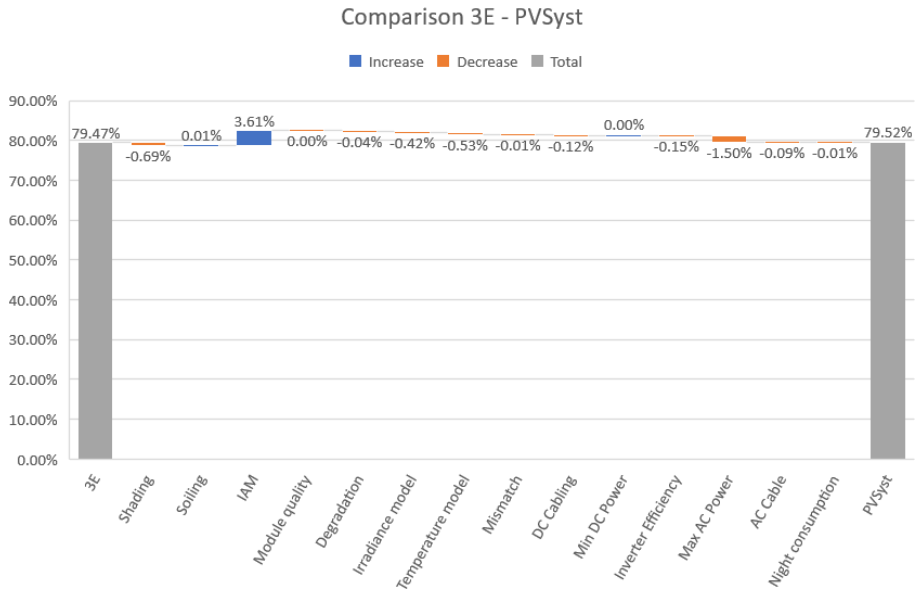
Simulation Model Validation (1)

- Validation against operational plants
  - 11 selected well-operating plants
  - 15-min granularity
  - Dependent on
    - Measurement accuracy
    - Operational issues
  - White paper upcoming



Simulation Model Validation (2)

- Validation against PVSyst
  - Various projects
    - rooftop
    - ground-based
    - Single-axis tracker
  - Each loss component
  - Dependent on assumptions

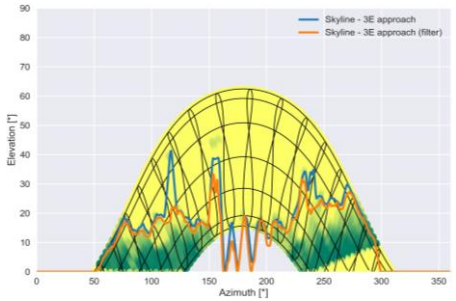


Observed System Losses

Detailed loss analysis

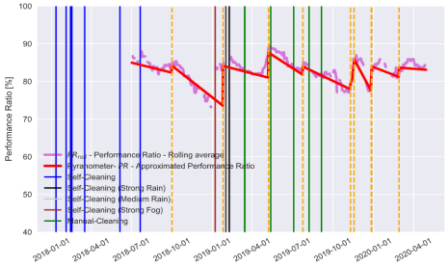
Shading

- From data
- Skyline
- Solar access



Soiling

- Soiling rate
- Cleaning event
- Residual

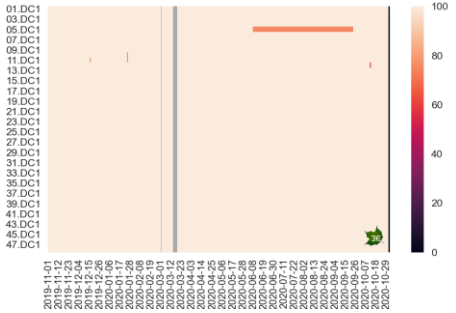


Degradation

- Statistical approaches
- Degr. rates
- Warranties

String Failure

- Daily calc.
- Failure duration
- Fast detection



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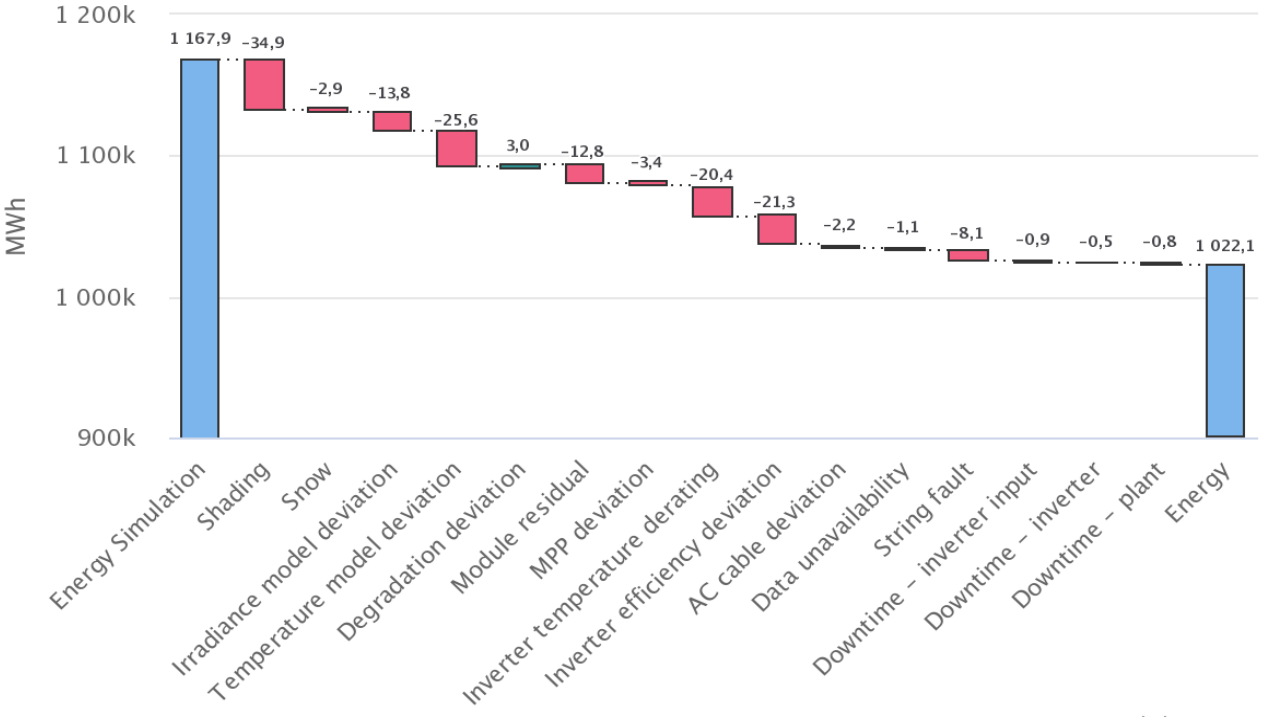
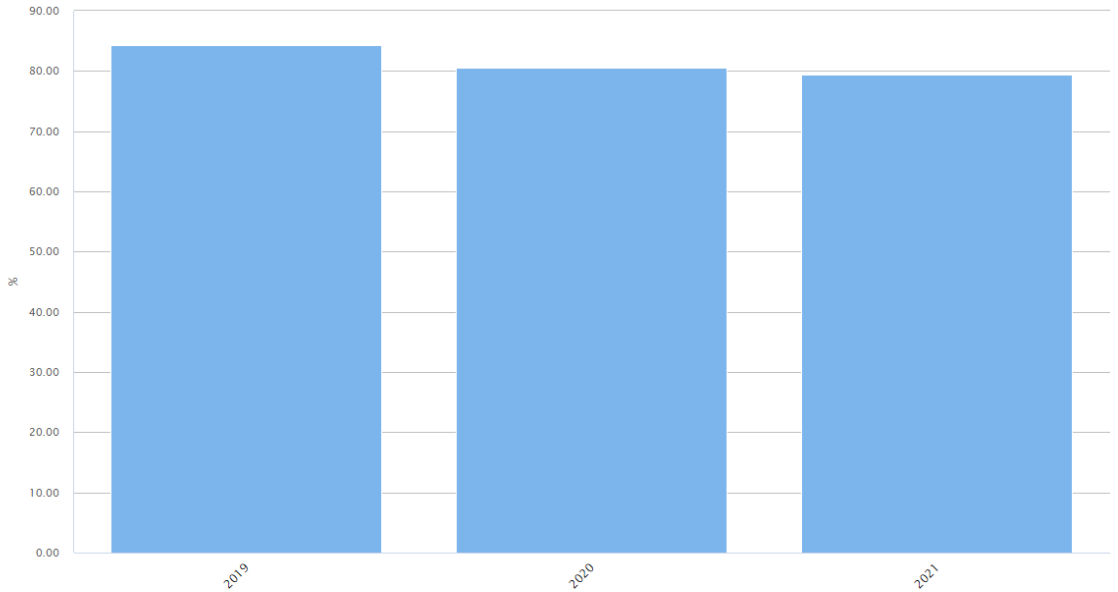
Automated performance loss identification



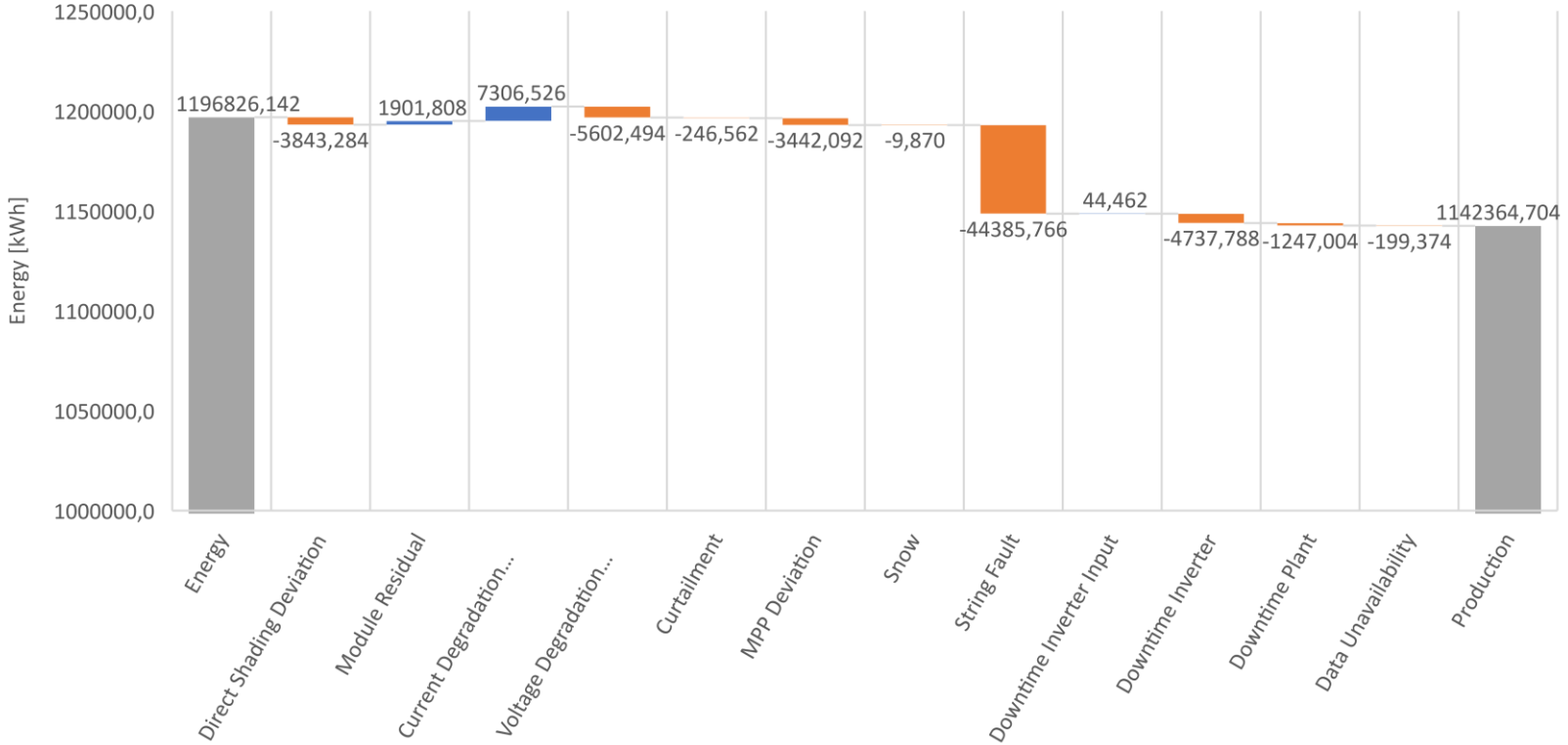
Example

Example

- Large rooftop installation
- 1,39 MWp
- Rapidly declining PR



Yearly loss breakdown



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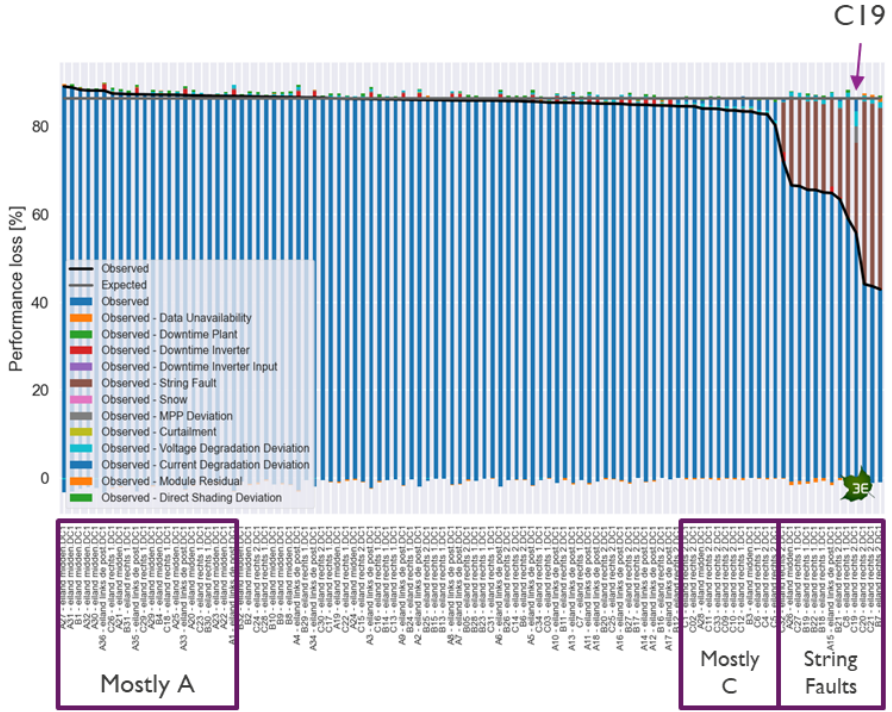
Loss breakdown – inverter level

- Observations
  - Area A performs best
  - Higher current degradation in area C
  - 16 string faults, mostly in area B and C

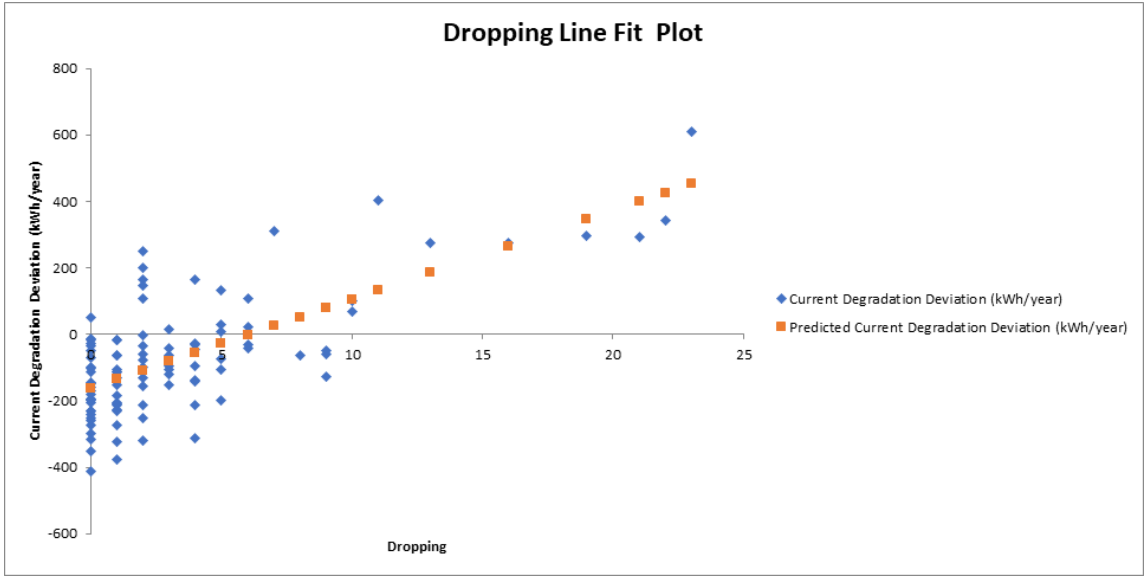


Validation: drone inspection (1)

- String faults confirmed
- High degradation in area C due to bird droppings
- One string fault missed by drone
- One inverter (C19) with three additional open modules

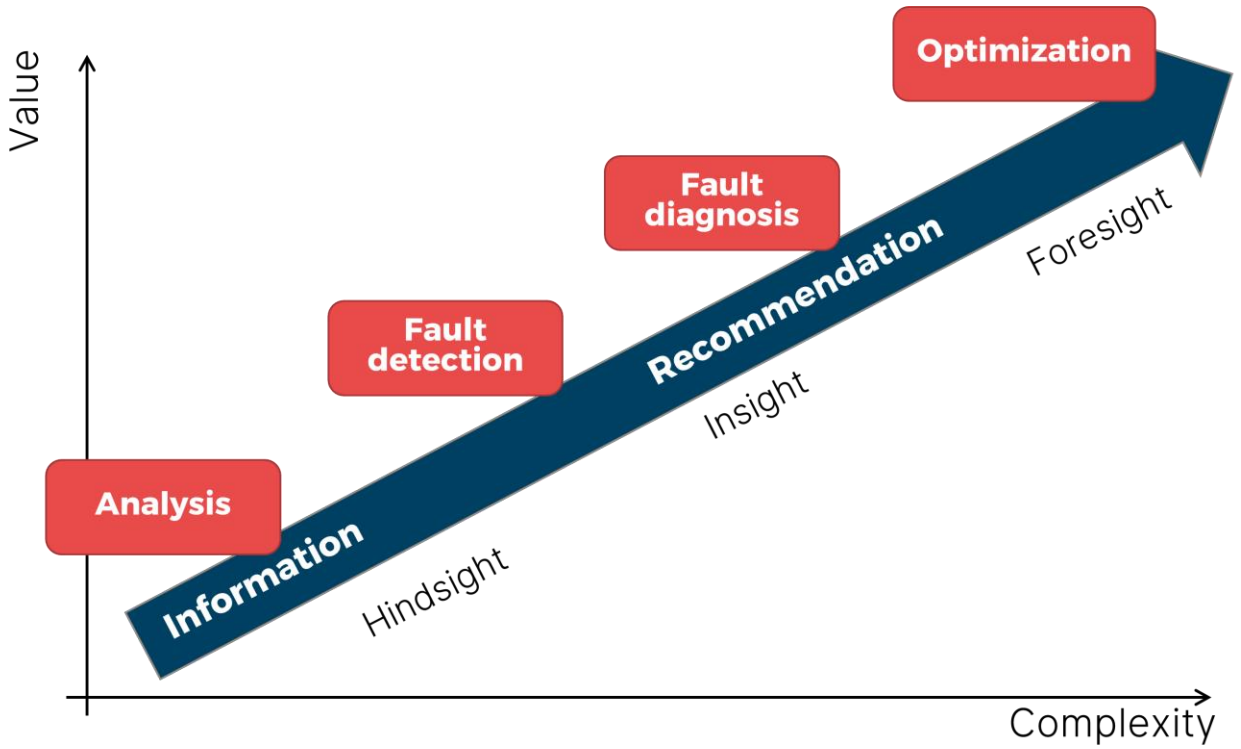
Validation: drone inspection (2)

- High correlation between current degradation deviation and hotspots
- In average one bird dropping causes loss of 27 kWh/year



Future work

From hindsight to foresight



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