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*If it exists, we apply it; if it does not exist, we create it*

# Innovation for PV facilities and cost reduction in CAPEX


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# RENOVAGY ON THE INTERNATIONAL MARKET

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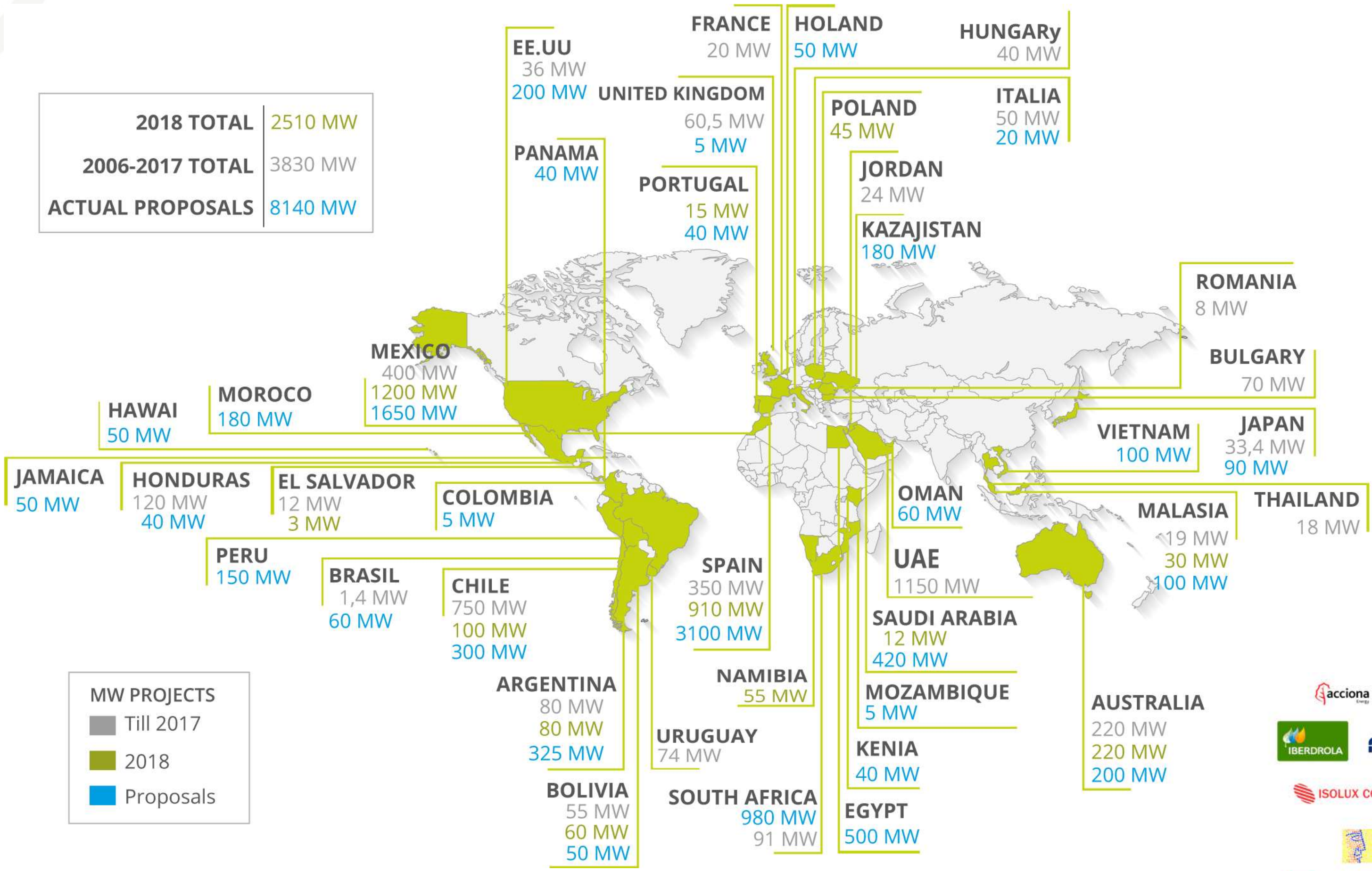
| | |
|---|---|
| 2018 TOTAL | 2510 MW |
| 2006-2017 TOTAL | 3830 MW |
| ACTUAL PROPOSALS | 8140 MW |



# THE BIG FIGHT IN THE SOLAR MARKET

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## CAPEX vs OPEX

# WHY IS NOW IMPORTANT?

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**01**

Energy Prices have fallen from 220 $ to 23,40 $ MW/h in only 7 years

**02**

Last bid in Saudi Arabia 23.40 MW/h Jan 2018

**03**

In the current situation a loss of 1% in the production hits the viability plan

| | Trend Energy Price | Construction costs | Pay Back (Years) |
|---|---|---|---|
| 2007 | 220 $ MW/h | 7,5 $ Wp | 13,72 years |
| | 7 Years | 7 Years | 7 Years |
| 2016 | 38 $ MW/h<br>April 2016<br>Enel Mexico | 1.05 $ Wp | 14 years |
| | 23,40 $ MW/h<br>Jan 2018<br>Saudi Arab | 0.68 $ Wp<br>(Estimated) | 18 years |

PROBLEM 1 (100 MW Example)

# PV FACILITIES ARE COMPLEX

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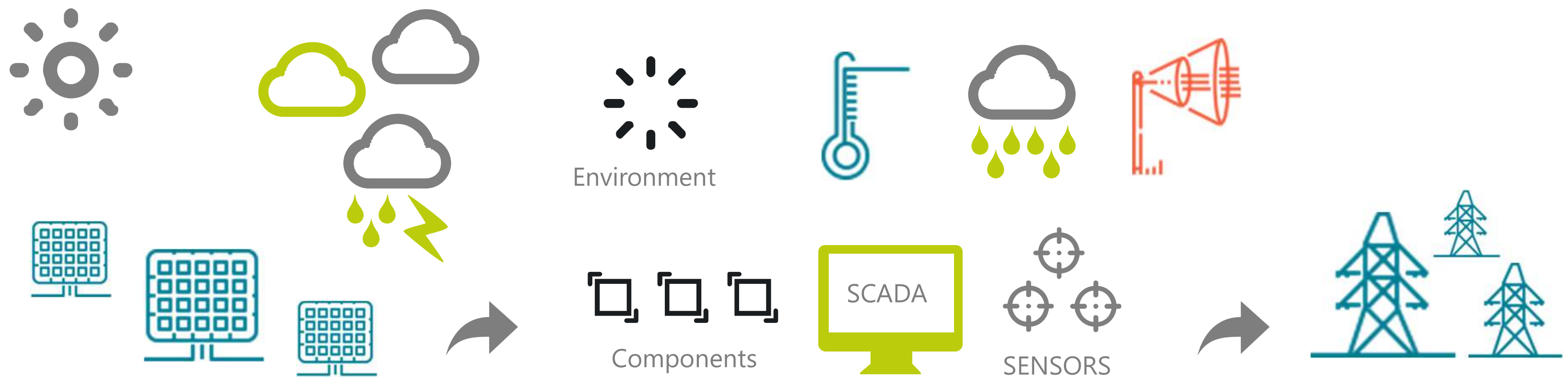
| 69 | 828 | 16.560 | 300.000 |
|---|---|---|---|
| INVERTER CENTERS | SMART COMBINER BOXES | STRINGS | SOLAR PANELS |




| COLLECTION LOSSES | SYSTEM LOSSES | OPERATIONS LOSSES | TRANSFORMATION LOSS |
|---|---|---|---|
| **-5,3 %** | **- 8,1 %** | **- 9,4 %** | **- 0,9 %** |

PROBLEM 2

# PV FACILITIES ARE IN COMPLEX ENVIRONMENT

SOILING

EXTREME TEMPERATURE

VARIATION

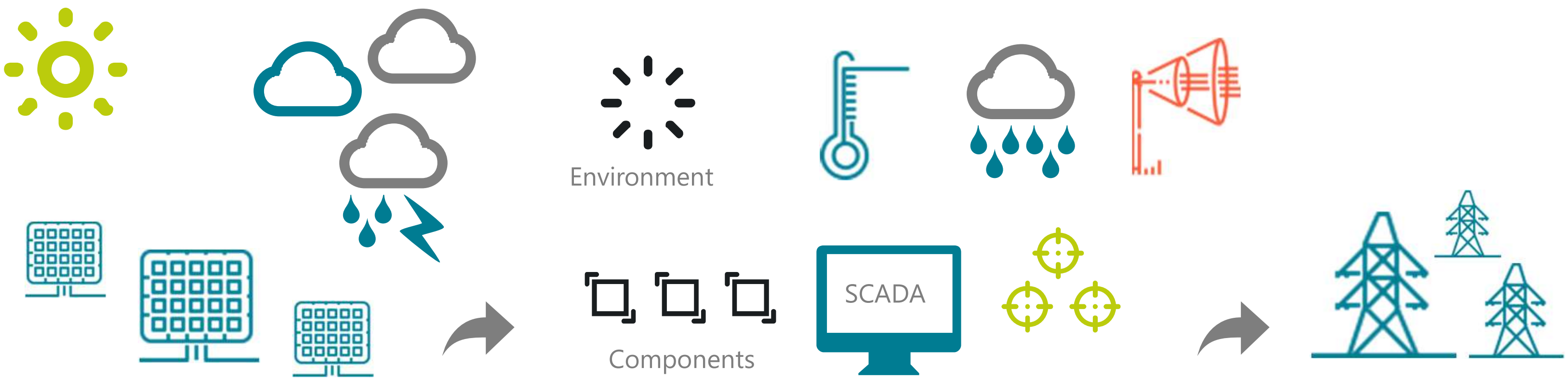
VEGETATION

ANIMALS

WEATHER

O&M INTERVENTIONS

EQUIPMENT FAILURES



PROBLEM 3

# PV FACILITIES HAS LOTS OF DATA

## MONITORING 40.000 PARAMETERS AVAILABLE

**DO YOU KNOW MONITORING SYSTEM CAN SAVE MORE THAN?**

17.000 parameters per second

2.280.000 parameters per minute

136.800.000 parameters per hour

1.368.000.000 parameters per day

41.040.000.000 parameters per month

492.480.000.000 parameters per year

1
TERABYTE
PER YEAR

**DO YOU KNOW HOW MUCH ARE ANALYSED IN THE LONG TERM?**

Less than 250.000

**WHY CAN´T IT BE ANALYSED?**

Hardware

Software

Skills

DATA CEMENTERY

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# HOW WE CAN FIND SOLUTIONS OF EFFICIENCY AND PRODUCTION IMPROVEMENT?

**INNOVATION IS THE ONLY WAY**

**WHICH ?**

Applying technologies that allow using the data that now falls into a big data cemetery without being analysed

**HOW?**

Reaching a biggest as possible granularity

The photovoltaic modules strings data are relevant to obtain the closest information of the main generation device → **The photovoltaic Module**

With the CAPEX pressure stress, some of the monitoring systems are being discard, which has two effects:

Data granularity loss (20 years OPEX)
Maintenance efficiency loss (20 years OPEX)

Trying to avoid that loss it has been developed wireless communication systems that allow to reduce 12% of monitoring systems costs despite the cabling versions

We will divide the use of the Wireless systems at a solar installation in two categories:

1. Data collection of field sensors of the main devices
    - Trackers
    - Combiner Box
    - Temperature probes
    - Pyranometers
    - Other devices

2. Data network to the SCADA system and perimeter security system.

# Field sensors data collect

| | Zigbee | LORA | Sub-1 GHz |
|---|---|---|---|
| **Transmission distance** | ✖ | ● | ● |
| **Noise immunity** | ✖ | ● | ● |
| **Transmission velocity** | ● | ✖ | ● |
| **Country permissions** | ✖ | ✖ | ● |

Sub-1 GHz technology allows to reduce the  CAPEX economic impact and to maintain the data granularity

# WIRELESS

The use of wireless systems at data network for SCADA systems is not recommendable because of the sensible and important information that the maintenance teams at the PV plants collect and analyse.

The wireless systems at 2.4 GHz and 5 GHz bandwidth are not completely immune to the climatological factors and ambient noise, so the use of that technologies can affect the quick action of the O&M team.

- The network operators of the different countries are increasingly demanding at the power management, voltage and PV plants frequency. The can even ask for a 500ms stop from the PV plant. That can make the optical fibre network systems with redundant rings the most recommendable and typical option.

- Regarding the security systems, there are the same problems in addition to the signal inhibitors and other devices that can cancel the transmission, so it is not recommended to use them.

The use of drones with thermal and infrared cameras at the photovoltaics installations applies to:

1. **Aerial thermography of solar panels**
2. **Hot spots detection**
3. **Panels cleaning**
4. **Perimeter security**

The data obtained from the thermography and hot spot detection can be used to increase the analysis and offer better conclusions.

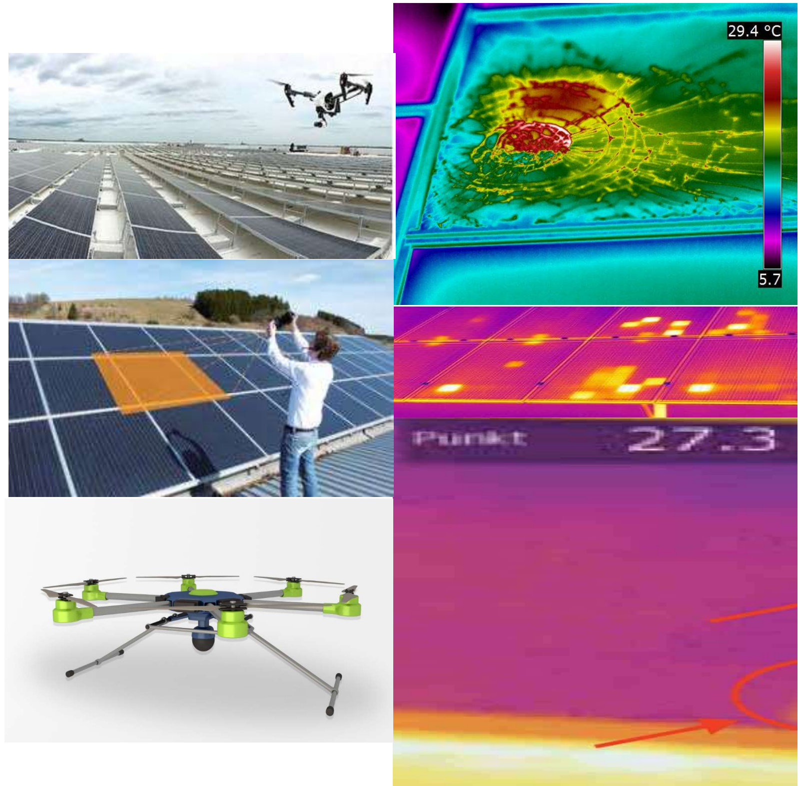
Nowadays the time of execution of the thermography process of the panels in a 10 MW PV plant is 25 days*.

- **walking with a thermal camera making photos panel to panel → 25 days**
- **Image analysis and  interpretation → 7 days**
- **Results**

Nowadays, the execution time of the thermography process of the panels using a drone is 3 days

- **Flight over an installation recording images between → 30 and 40 minutes depending on the PV plant size**
- **Image analysis and interpretation → 7 days**
- **Results**

<u>**THE MAIN CHALLENGE FOR THIS TECHNOLOGY IS TO ACHIEVE THAT THE DRONE SYSTEMS CAN MAKE THE ANALYSIS AT REAL-TIME**</u>




* Estimated for a 100MW PV plant and 4 workers

# BIG DATA AND MACHINE LEARNING

## Increase the Profitability

from energy generation for Fotovoltaic facilities through optimization of Operations and Maintenance. We bring the Big Data and Analytical Capabilities from the Industrial Internet of Things (IoT), to the PhotoVoltaic Monitoring Industry.

**PhotoVoltaic Monitoring Data**

Access to any source data from any monitoring system in the market

**External Data**

Weather Forecast, Energy market price, Replacement Parts Inventory, etc.

**Operations and Maintenance**

Operation & Maintenance Tasks recommendation and follow up

# PERFOMANCE MONITORING:
# WHY ARE WE DOING IT?

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1. Benchmark and track ongoing system performance vs weather adjusted model.

2. Benchmark production against Typical Meteorological Year.

3. Identify one-time and recurring system deficiencies and O&M issues.

4. Validate integrity of data being used for operational decisions.

5. Quantify system degradation.

6. Improve long-term reliability and economic viability of assets.

# DATA

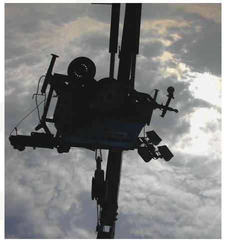
## INTERNAL DATA - PLANT

Park Location
Plant Layout and Topological Design
Monitoring Data
Meter Data
O&M Maintenance Plan and O&M Activities log
Failures Log
Replacement Pieces Inventory
Plant Organization Roles and Responsibilities
etc.

## EXTERNAL DATA - INDEPENDENT SOURCES

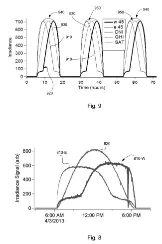
Irradiation Satellite
Irradiation Prediction
External Weather Information
Meter Data
Weather Prediction

## Radiation Analysis



**Satellite Images**

**NWP Forecast**



**Irradiance Measurements**

**Site specific horizontal irradiance prediction**

## PV Power Analysis

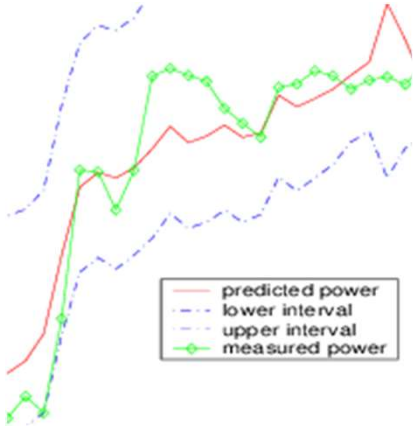
Nominal Power
Module Type
Inverter Type
Tilt Angle
Orientation

**PV- system description**

Irradiance module plane
PV simulation
Statiscal models

**Conversion to power**

**PV Power Measurement**




**Power Forecast with uncertainly Information**

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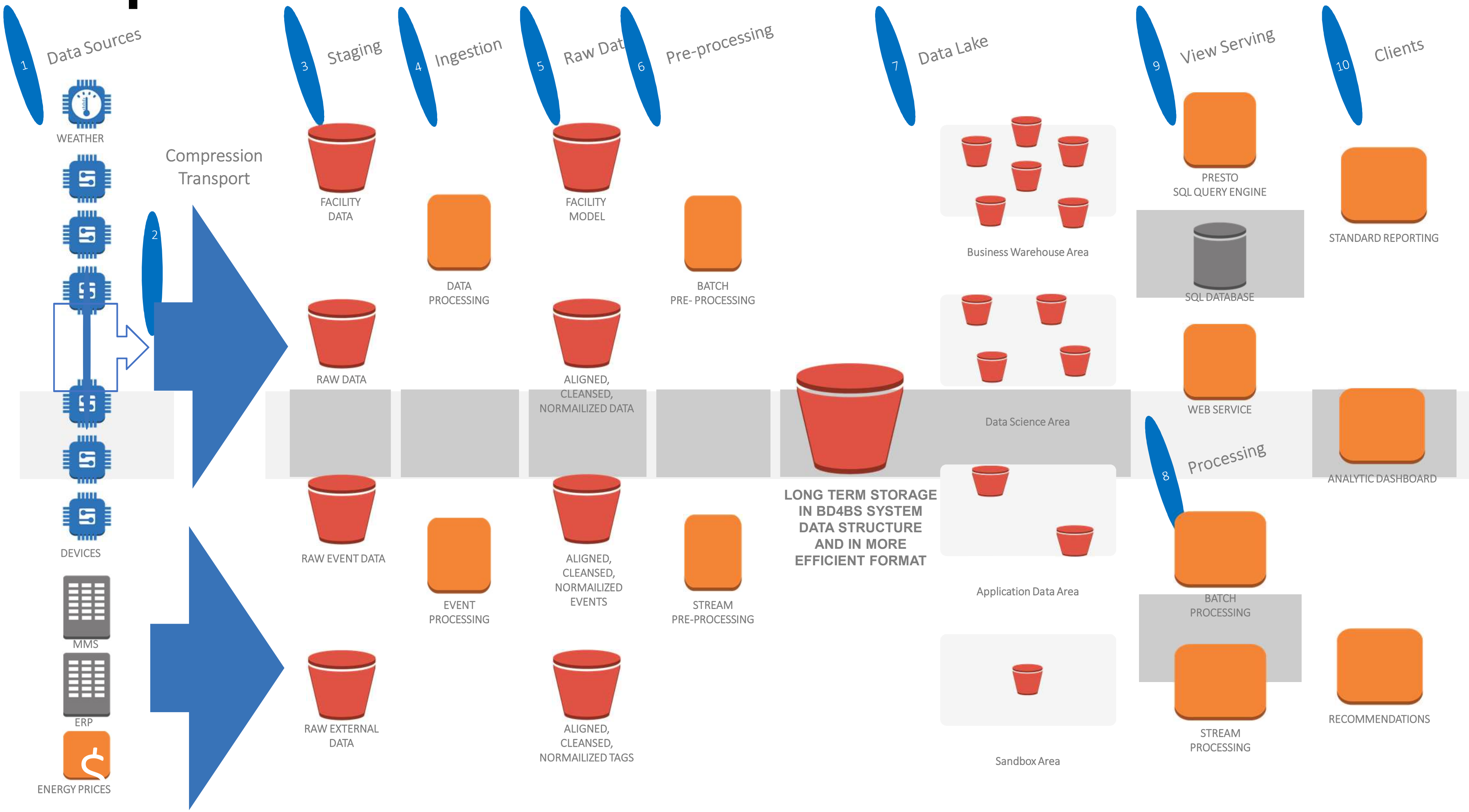
# Enterprise Data Lake Centric Architecture



# WHICH ISSUES

## Maximize yield

production for PV Facilities through the improvement in Operations and Maintenance

Weather corrected calculation for daily yield vs Actual

Energy Produced

Soiling and cleaning

Growing grass and mewing shadows

Predictive component failure
Combiner Box
Inverter
Transformer

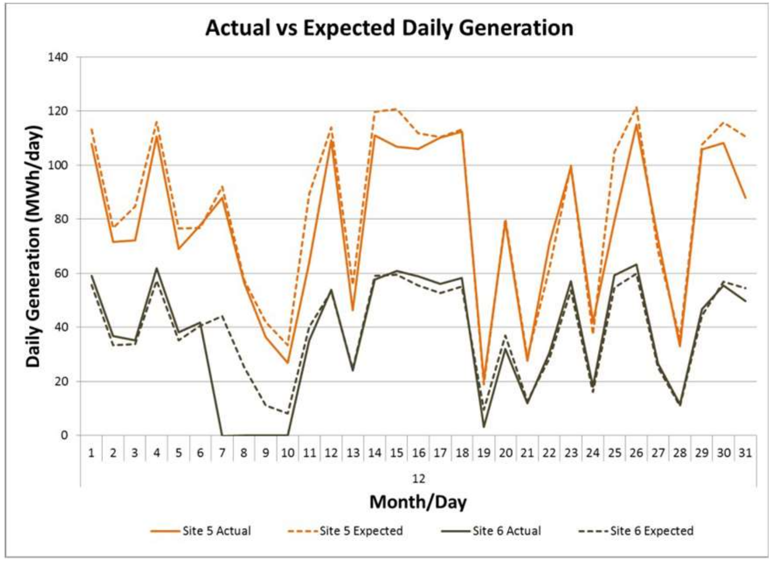
Weather correlated component failures

Bad / Broken Disconnected modules

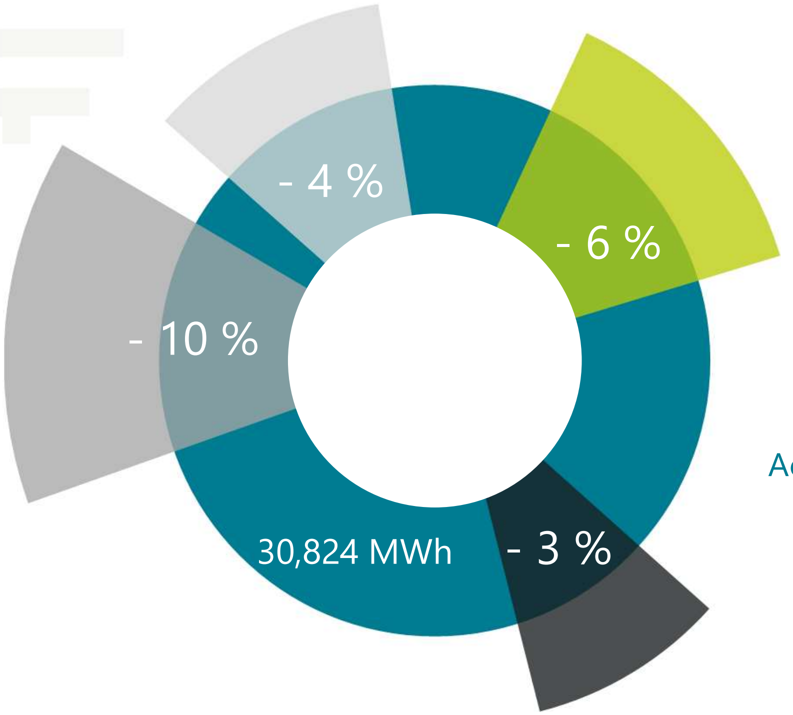
Temperature effects on inverters

# ISSUE CHARACTERIZATION PROCESS

- Compare weather adjusted modelled generation to actual metered generation
- Identify when deviations occur and utilise available data to characterise impacts
- Issues may result from metering, weather/soiling, substation/transmission issues, inverter faults, ADS curtailments, self-shading, and panel degradation/damage



# RECOMMENDATION PROCESS




## Quantify impact

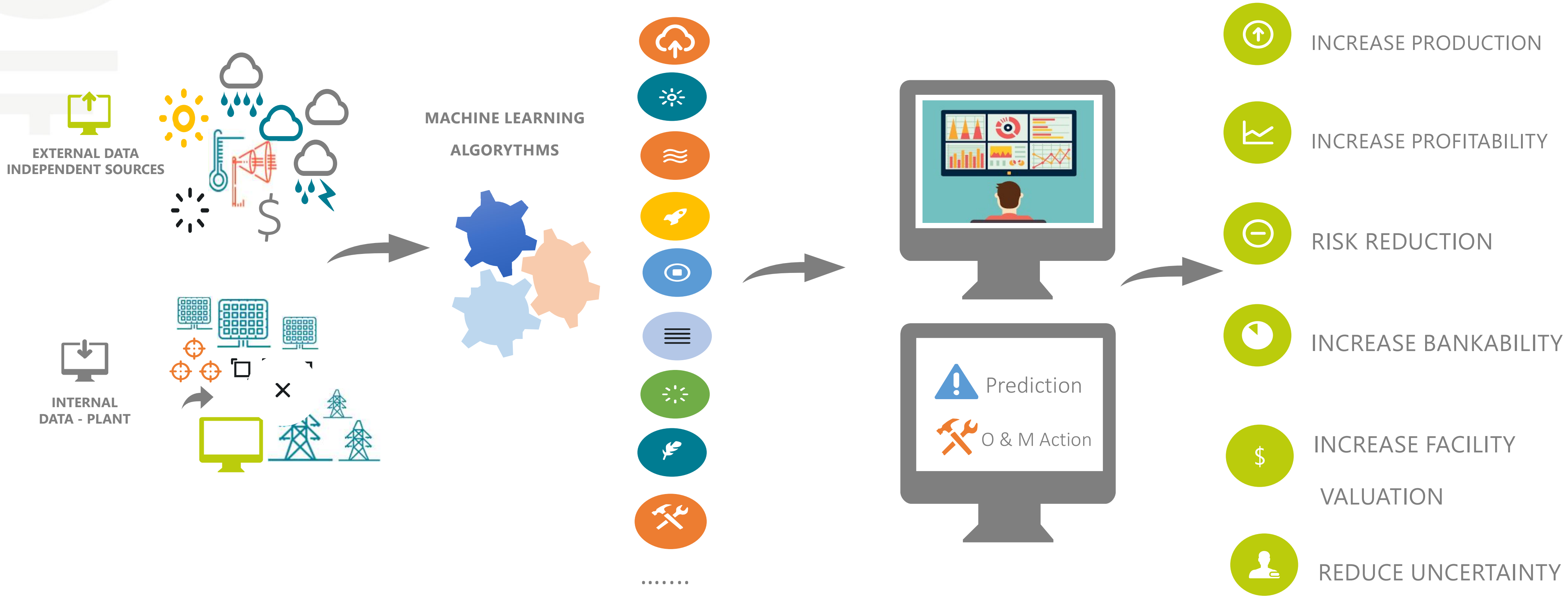
Categorically using modeling tools at appropriate interval (annual, monthly, daily, hourly)
Develop appropriate action plan for controllable events

| Actual metered Generation | Estimated ADS Impact | Estimated Weather and Soiling impact |
| --- | --- | --- |
| 30,824 MWh | - 10 % | - 6 % |

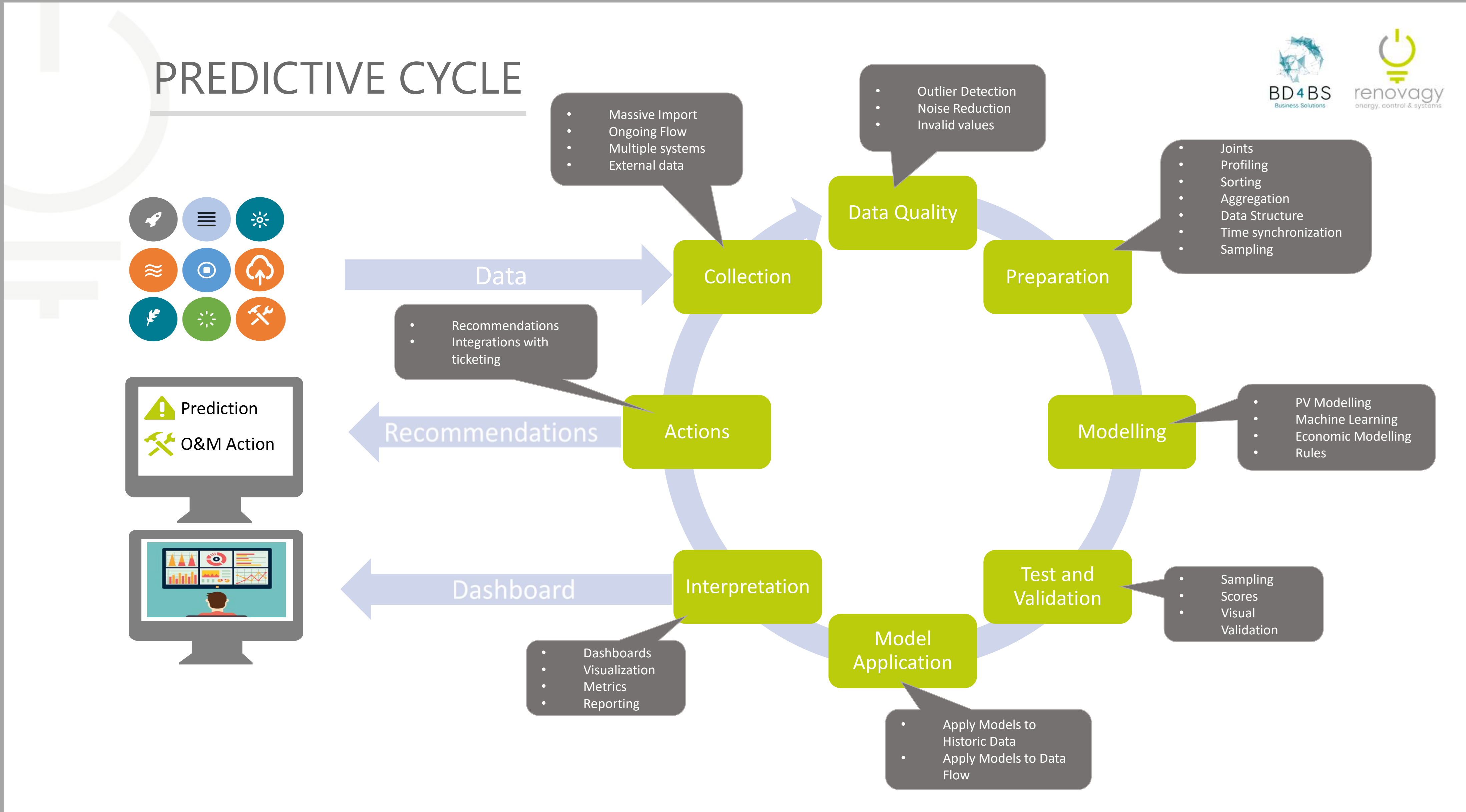
| Estimated Inverter Outage Impact | Estimated Plant Outage Impact |
| --- | --- |
| - 4 % | - 3 % |

OUR SOLUTION

# RECOMMENDATION ENGINE




**4% Increase in Yield** → **100 MW Facility ~ 1.000.000 Dollars/Year**
**In 20 years is having one more full year of production.**


PREDICTIVE CYCLE
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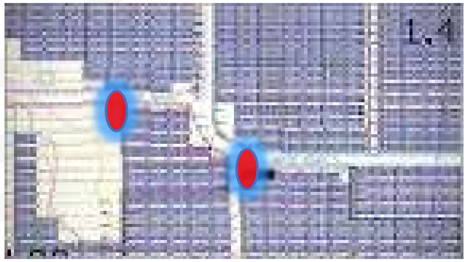
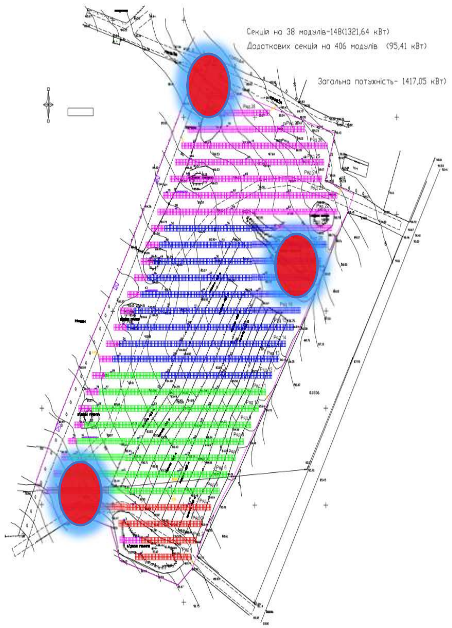
Prediction
O&M Action
Data
Recommendations
Dashboard
Massive Import
Ongoing Flow
Multiple systems
External data
Outlier Detection
Noise Reduction
Invalid values
Joints
Profiling
Sorting
Aggregation
Data Structure
Time synchronization
Sampling
Data Quality
Collection
Preparation
Recommendations
Integrations with ticketing
Actions
Modelling
PV Modelling
Machine Learning
Economic Modelling
Rules
Interpretation
Test and Validation
Sampling
Scores
Visual
Validation
Model Application
Dashboards
Visualization
Metrics
Reporting
Apply Models to Historic Data
Apply Models to Data Flow

## LOSES: IDENTIFY, ELIMINATE, MINIMIZE

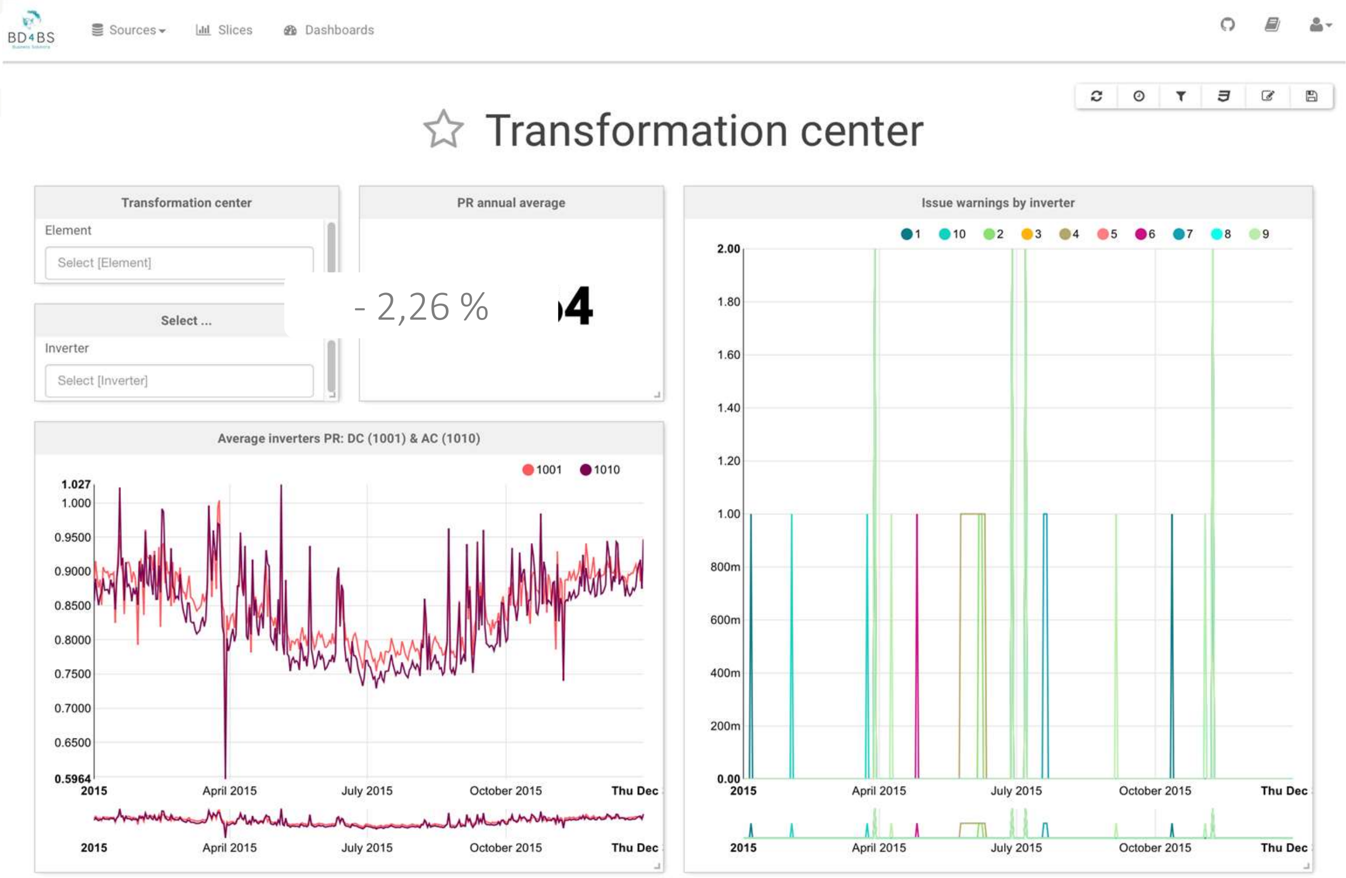
# IDENTIFY

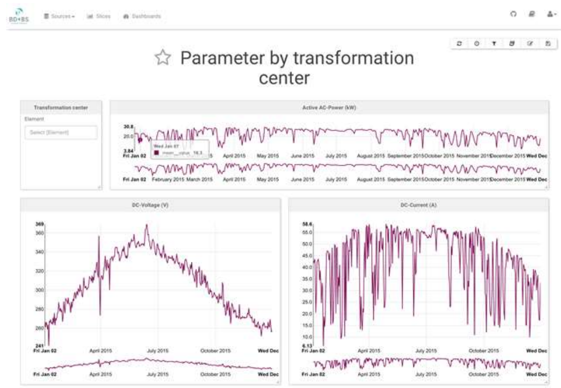



LOSES: IDENTIFY, ELIMINATE, MINIMIZE

# QUANTIFY




123,456 € *