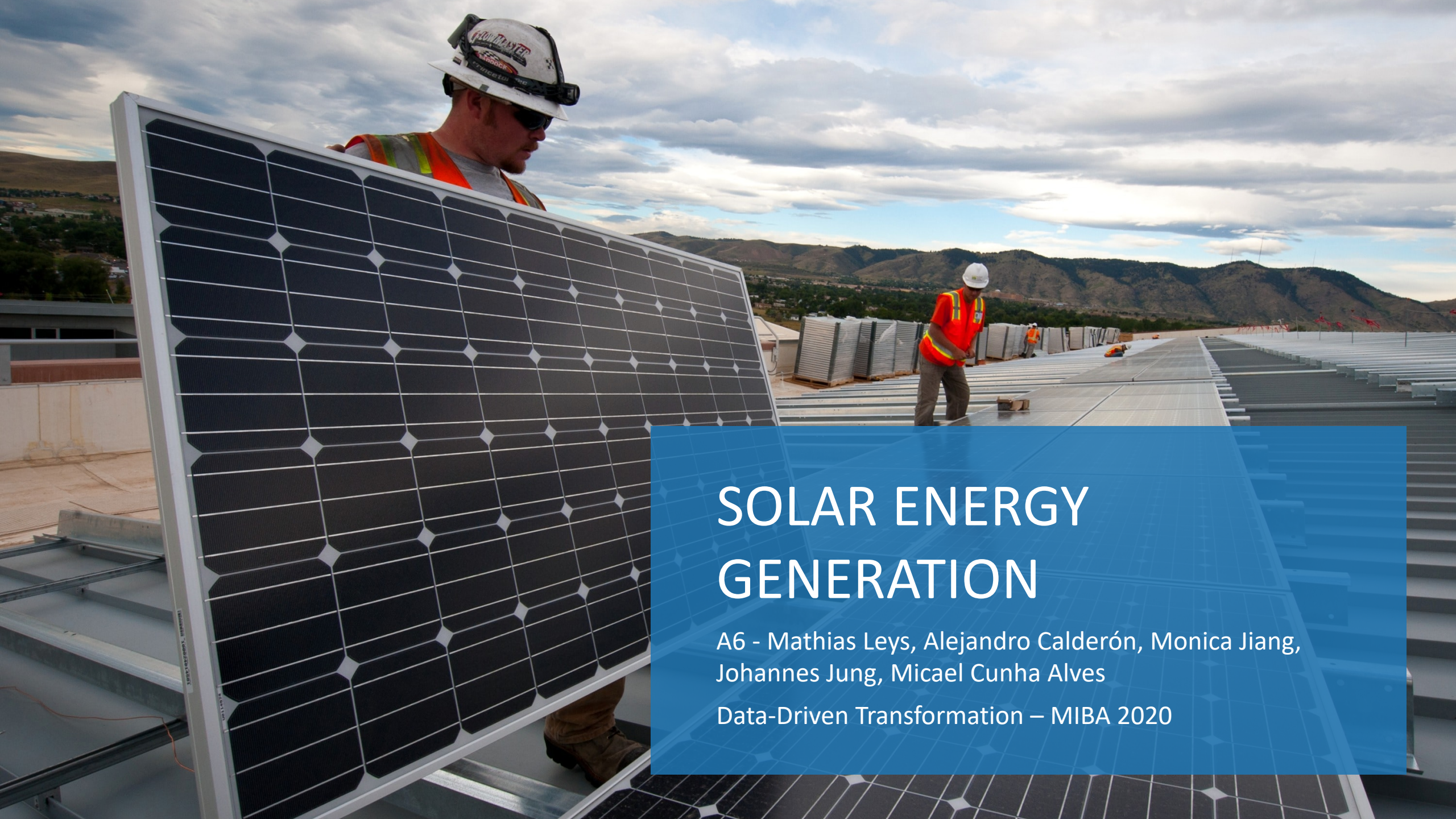


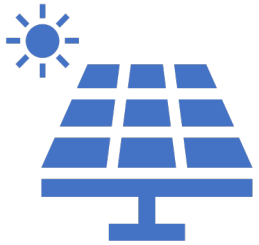
SOLAR ENERGY GENERATION

A6 - Mathias Leys, Alejandro Calderón, Monica Jiang, Johannes Jung, Micael Cunha Alves

Data-Driven Transformation – MIBA 2020

Company Presentation

WHO ARE WE?



We are an Indian solar power provider with a plant in Gandikota (plant A) and Nashik (plant B). Each plant has 22 inverters

An inverter converts Dc Power produced by solar panels to Ac Power which goes to the clients. Inverters are connected to a fixed number of panels (typically 10 to 15)

Currently, we have 15-minute interval power sensors at the inverter level. Our historical data ranges from May 15th 2020 to June 17th 2020

Main Goals

Using this dataset, we aim to answer three main questions:

- Can we make short-term generation forecasts to improve our operations?
- Can we apply a predictive maintenance system to our inverters?
- How can we move towards a data-driven company growth strategy?

Data Strategy

KEY OBJECTIVES

DEFFENSE

- Reduce operating expenses by avoiding unnecessary maintenance
- Mitigate operational risks
- Improve the data completeness

OFFENSE

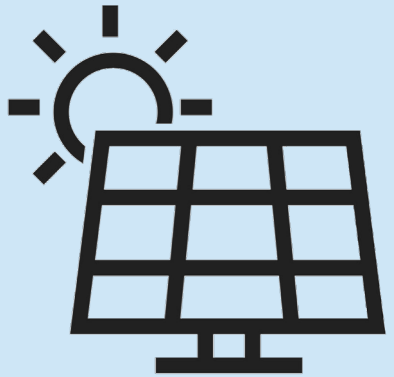
- Leverage new sources of information: both internal and external data
- Improve the generation performance by detecting faulty equipment
- Generate return on investment for the existing IoT infrastructure
- Identify new business opportunities based on our models

BALANCED APPROACH

Data Strategy

CORE ACTIVITIES

- **Improve data collection** and extend current database
- Find, use and **connect reliable third-party meteorological data**
- **Improve our IOT equipment** to improve completeness of the data
- **Create models** based on internal and external data
- **Implement** the **models**, **adapt** current **systems**, and **educate employees**
- **Improve** our **models with** the **increased** collection of **data**
- **Find novel uses of our models**



Current vs Future State

	AS - IS		TO - BE
BUSINESS	Manual Processes & Expert Opinions	→	Automated Processes & Data-driven Operations
TECHNOLOGY	Legacy IT & Incomplete IoT	→	Streamlined IT & Richer IoT
MODELS	Descriptive	→	Predictive And Prescriptive
GOVERNANCE	Distributed Ownership	→	Performance Control & Specialized Ownership

Model Training

TRAINING PROCEDURE

Training on Plant A Data

Better represents the relationship between weather and AC power that an inverter **should** generate

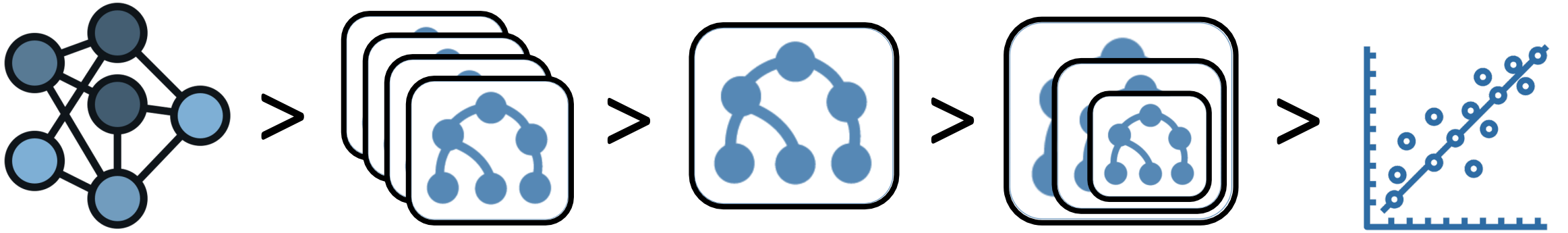
Time-based train-test split*

Our aim is to predict future generation. Therefore, our validation strategy should reflect this so that our validation metrics better represent actual model performance

*Concretely the training data ranges from May 15th to June 11th (80%) and the test data from June 11th to June 17th (20%)

Model Selection

MODEL PERFORMANCE

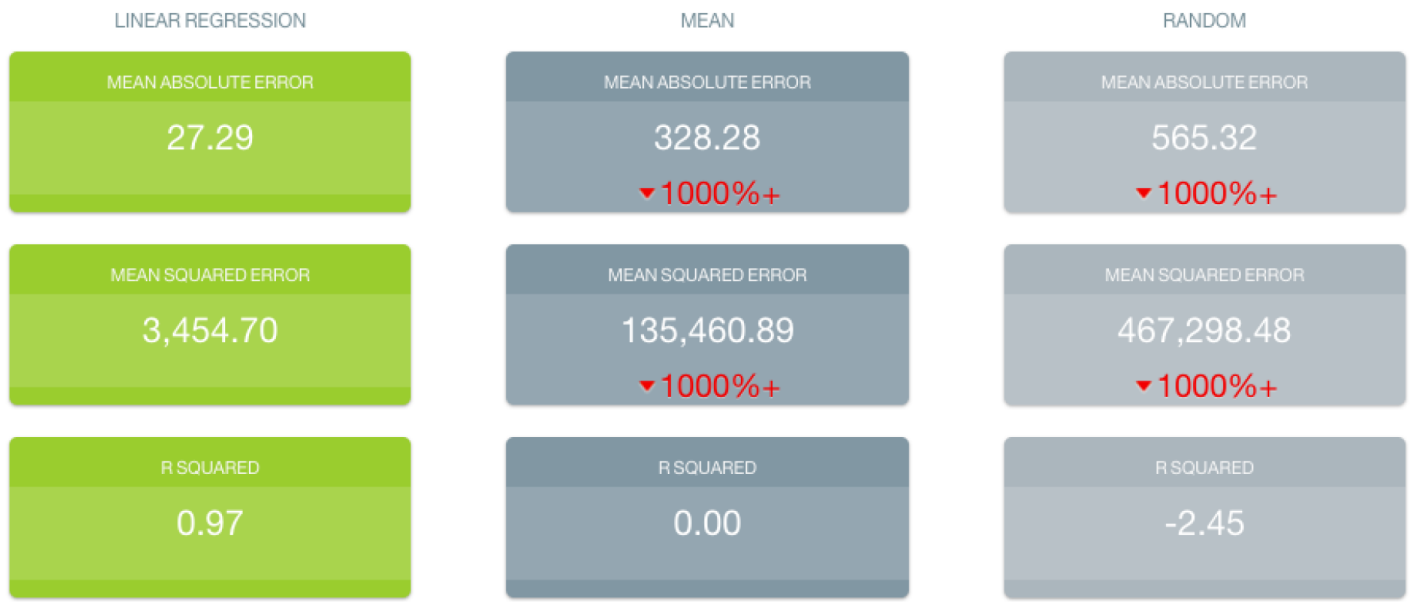


See appendix for detailed model comparison

Model Selection

LINEAR REGRESION

- Worst performer (albeit slightly*) but highest interpretability
- Good enough performance for our use cases
- Two relevant explanatory variables: ambient temperature and solar irradiation



*The best performing model (Deepnet) had an MAE of 17.8 and an R-Squared of 0.98

Model Implementation

MODEL PRACTICALITIES

Inverter Over-Underperformance
Difference between Predicted Ac Power and Actual Ac Power

Error Correction
Any underperformance smaller than -100 kWh is corrected to 0 and any underperformance larger than -100 kWh gets corrected by 100 kWh.

Solcast
External data source for weather data

Business Case

POWER GENERATION PREDICTION

Understand and predict relationship between weather and power generation in the plants.

To increase the company's revenues, three aspects:

IDENTIFY FAULTY EQUIPMENT

PREDICT GENERATION

EXPAND INTO NEW CITIES

Use Cases

IDENTIFY FAULTY EQUIPMENT

Compare levels of generated power with levels expected under full functionality to identify power inverters that require maintenance.

PREDICT GENERATION

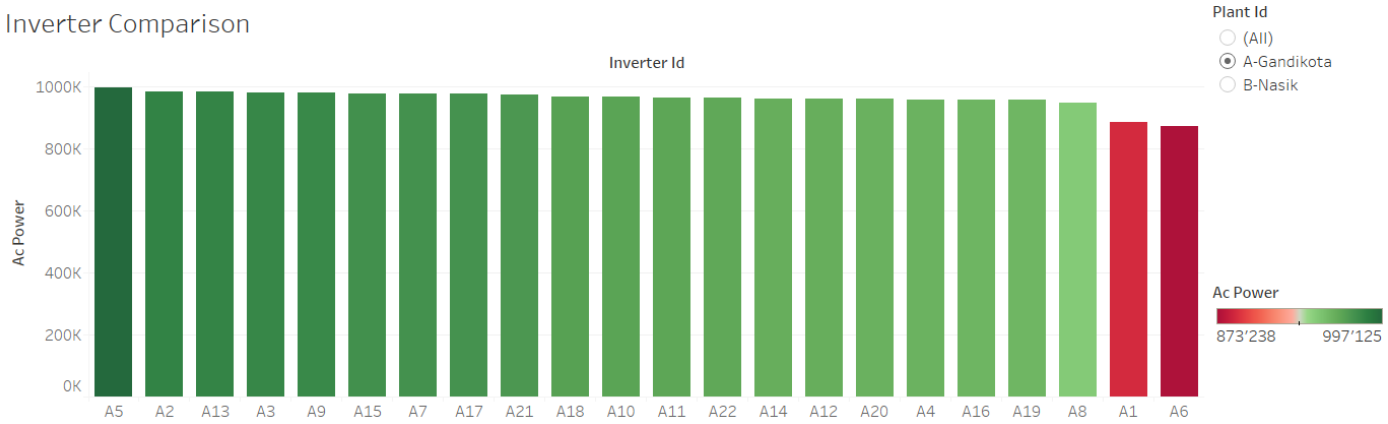
Keep solar power supplies balanced with demand and to keep power systems operating within tightly constrained limits.

EXPAND INTO NEW CITIES

Determine which city in India with relatively higher and stable irradiation level for installation of our new plant to create higher revenue for the company.

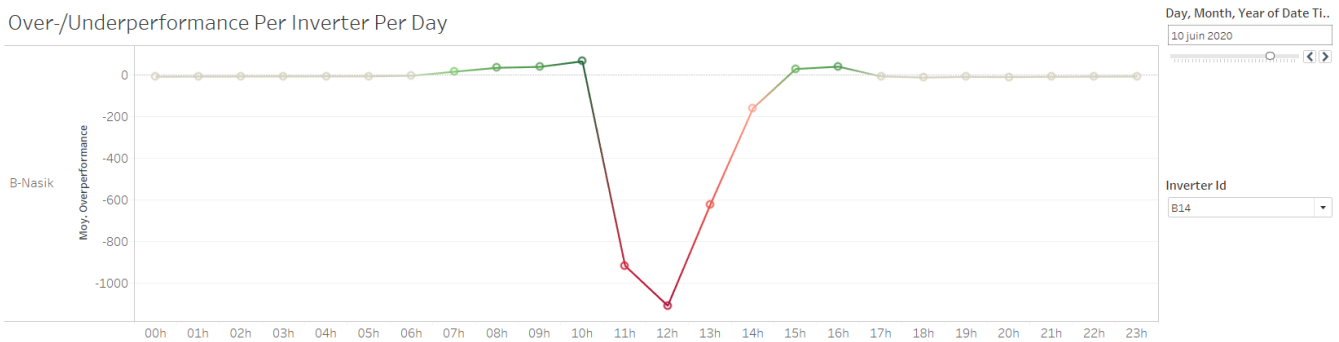
Use Case 1 - Identifying Faulty Equipment

General Overview



Extracted from the dashboard

Power Generation Analysis



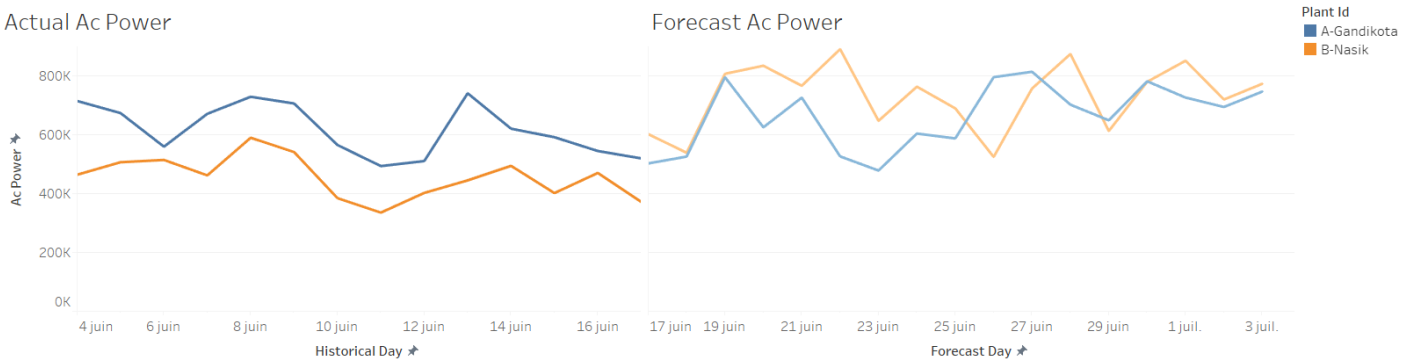
Extracted from the dashboard

Dashboards Goals

- Descriptive comparison of the two plants and of the inverters
- Descriptive comparison of the predicted vs actual power generation
- Real-time view and information on performance
- Short-term and long-term issue identification

Use Case 2 – Short-Term Generation Predicitons

Model Insights



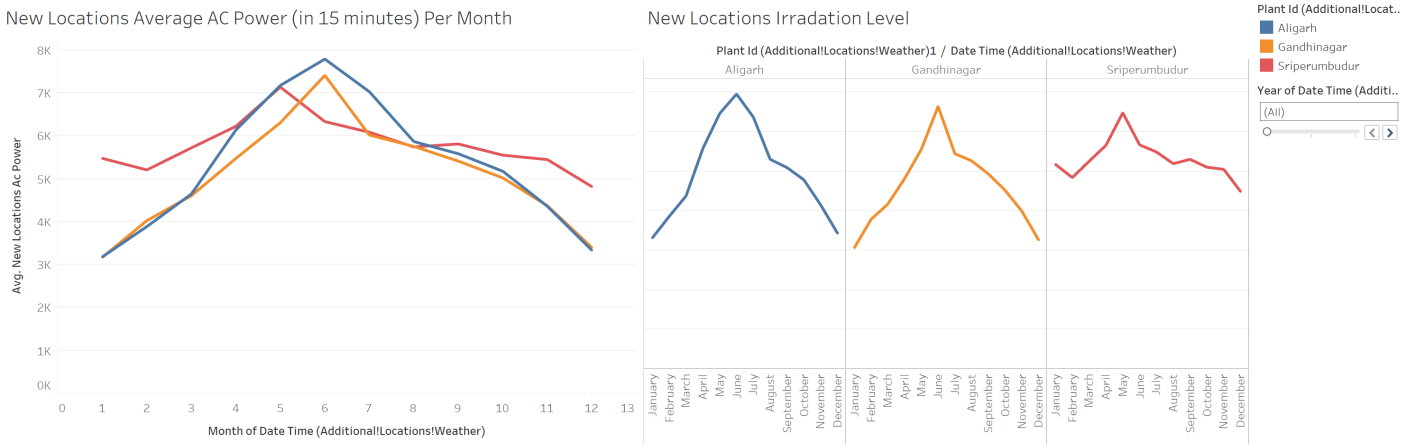
Extracted from the dashboard

Dashboards Goals

- Overview of near past and future energy generation
- Information on near future daily generation to improve grid management
- Detect low future power generation day for important maintenances

Use Case 3 – New Plant Location Evaluation

New Plant Location Evaluation



Extracted from the dashboard

Dashboards Goals

- Comparison of the power generation of potential new locations
- Understanding of the power generation circle of each location
- Information on total expected production and revenue for each option
- Information for better executive decision-making

Financial Impact Per Use Case

IDENTIFY FAULTY EQUIPMENT

Prevent losses due to underperformance.

Lost power w/o real time detection intervention:

5,000,000 kWh per Month

+4,140,000€ per month

PREDICT GENERATION

Operational adjustments to short term predictions.

Efficient operational planning

Reduced maintenance cost

+1,200,000€ per year

EXPAND INTO NEW CITIES

Assessing suitability of site location.

Data-based decision for major investments

Avoid false decision

+936,000€ per year (illustrative estimation)

Roadmap

Forecasting model creation

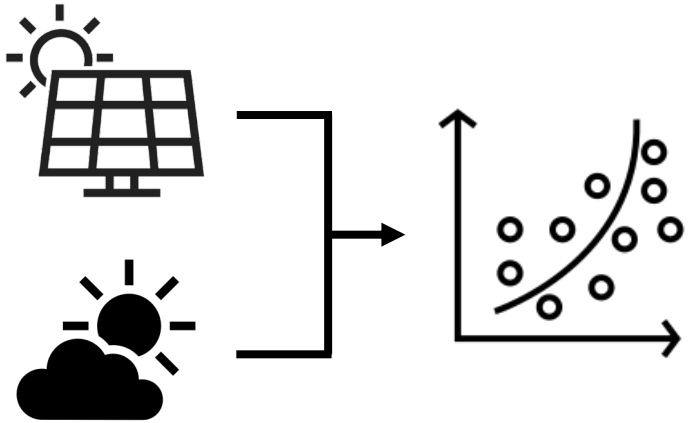
Days 1-2

Faulty equipment identification

Grid management

New plant location

Next steps



Identify relationships

Feasible in short time period

Predictive

Roadmap

Forecasting model creation

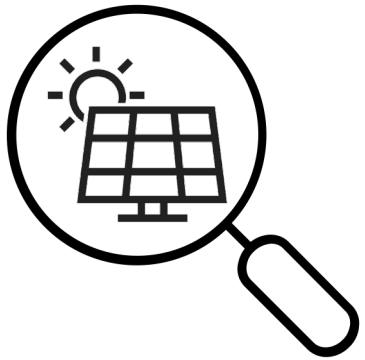
Faulty equipment identification

Week 1-2

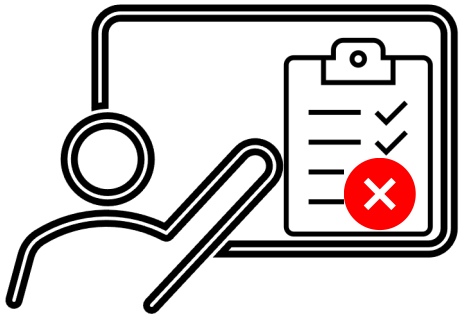
Grid management

New plant location

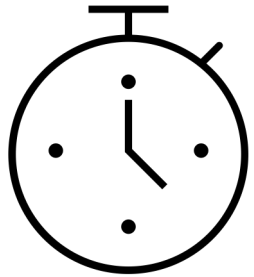
Next steps



Real time detection



Effective data visualization



Fast response from engineers

Descriptive

Roadmap

Forecasting model creation

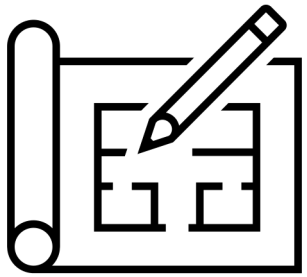
Faulty equipment identification

Grid management

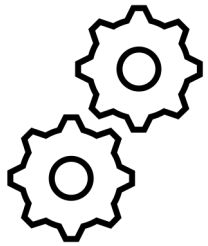
Week 3-4

New plant location

Next steps



Implement new grid management system



Analyze most efficient production settings according to predictions

Predictive

Roadmap

Forecasting model creation

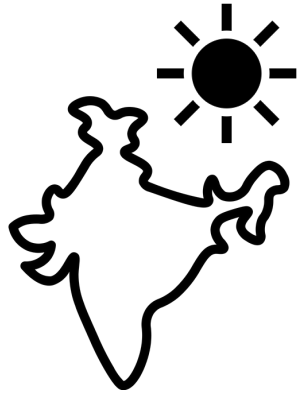
Faulty equipment identification

Grid management

New plant location

Week 5-8

Next steps



Data-driven business development

Prescriptive

Roadmap

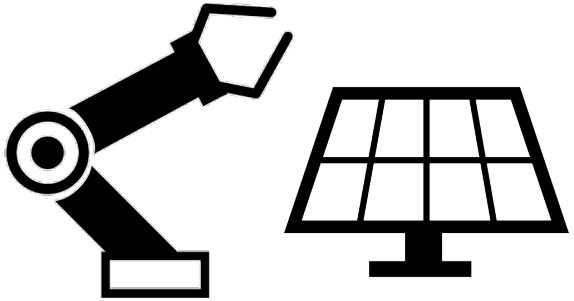
Forecasting model creation

Faulty equipment identification

Grid management

New plant location

Next steps



Automated grid management

Holistic location analysis model

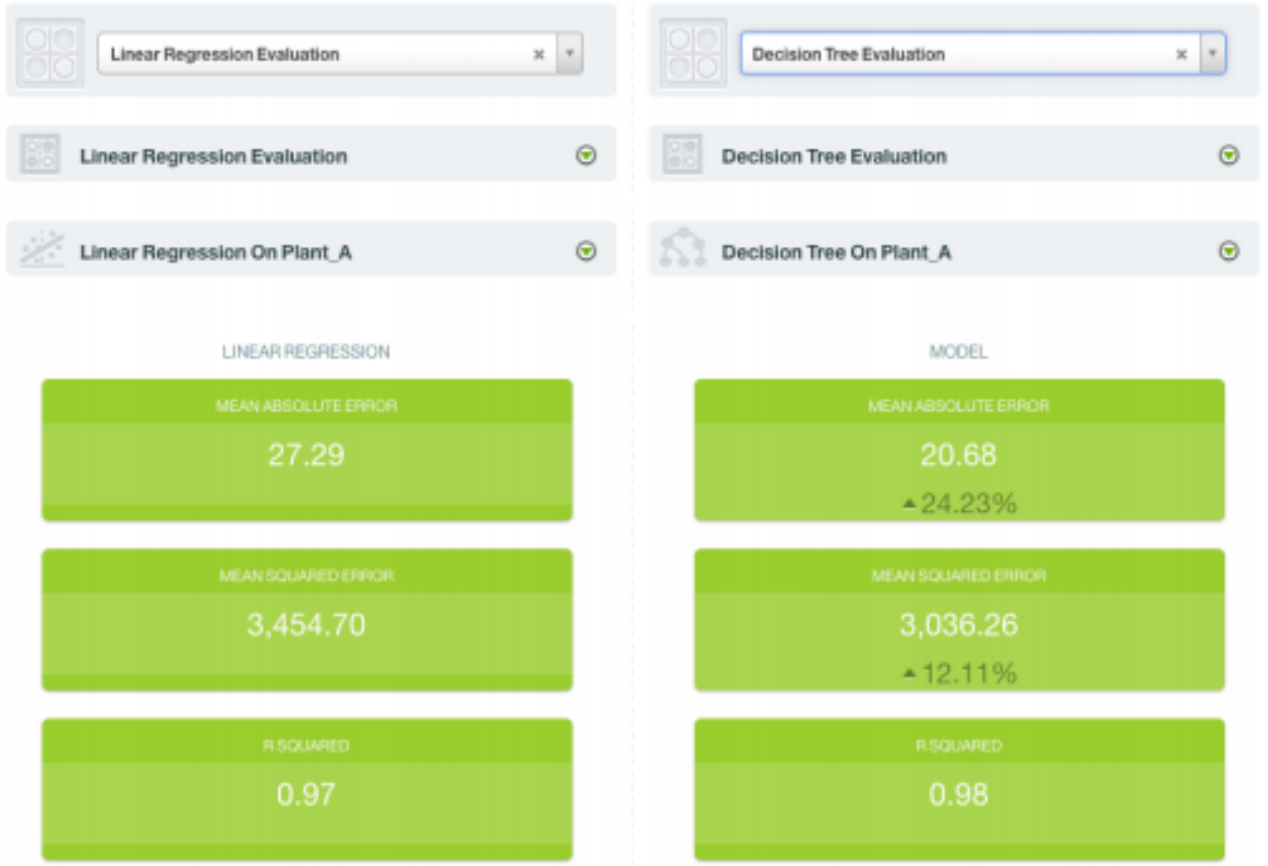
AI-Driven

THANK YOU

APPENDIX

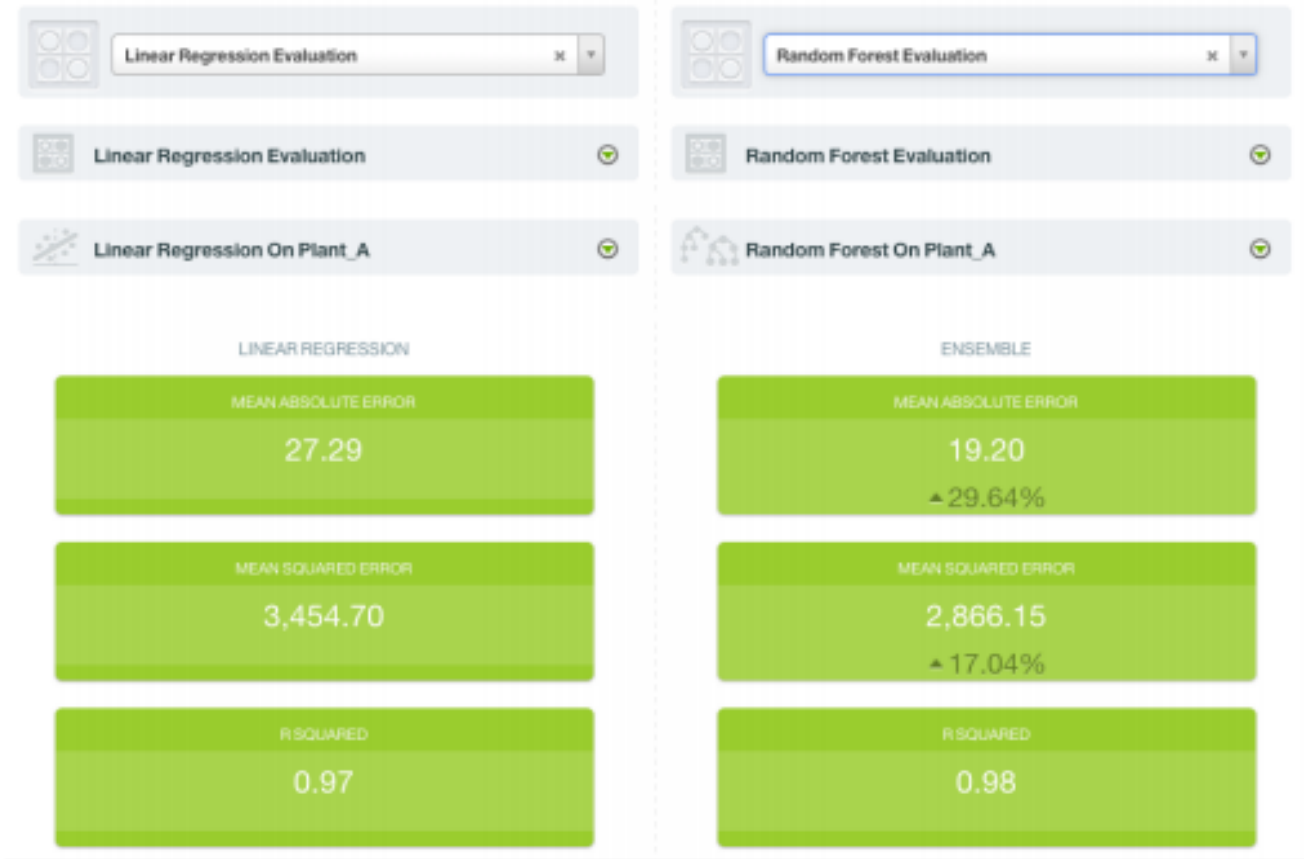
Detailed Model Comparison

LINEAR REGRESSION VS DECISION TREE



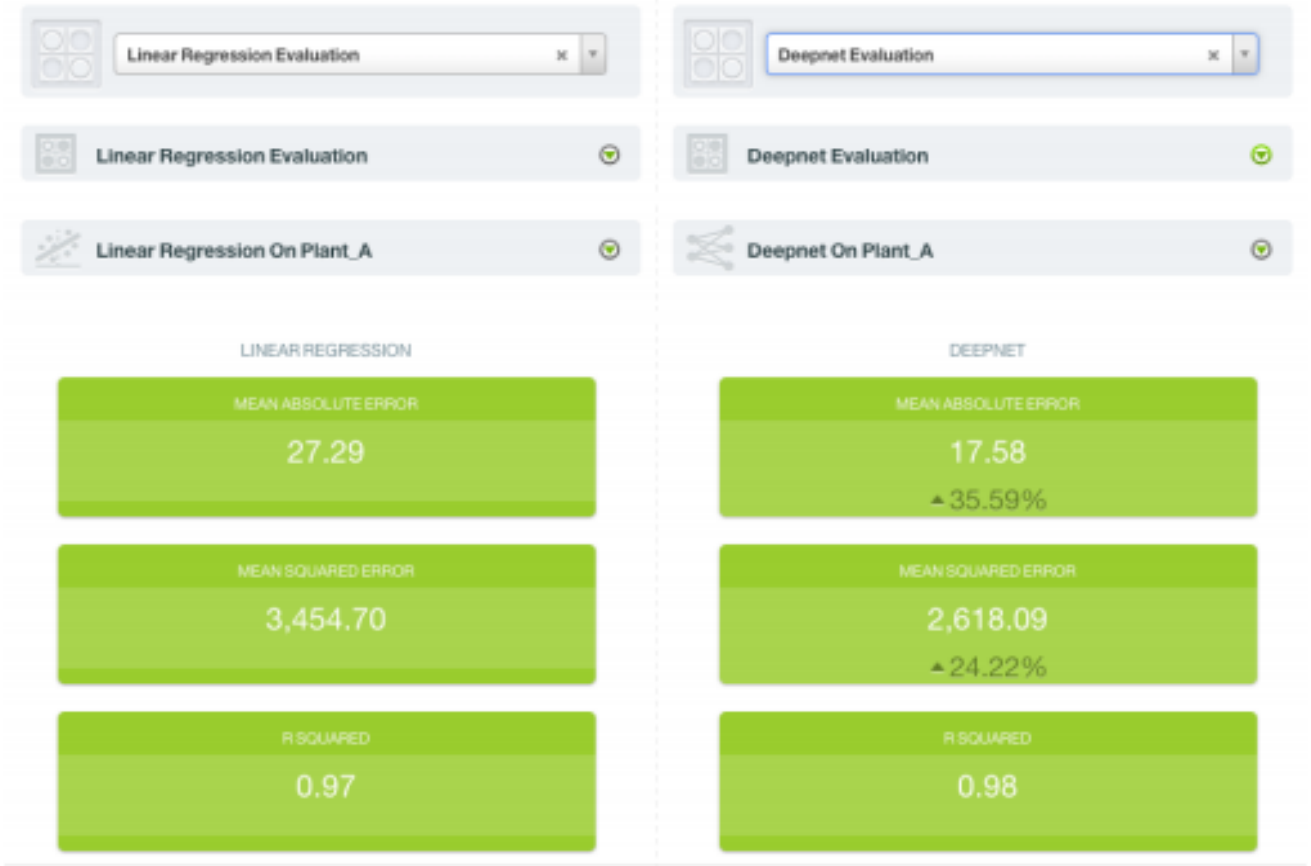
Detailed Model Comparison

LINEAR REGRESSION VS RANDOM FOREST

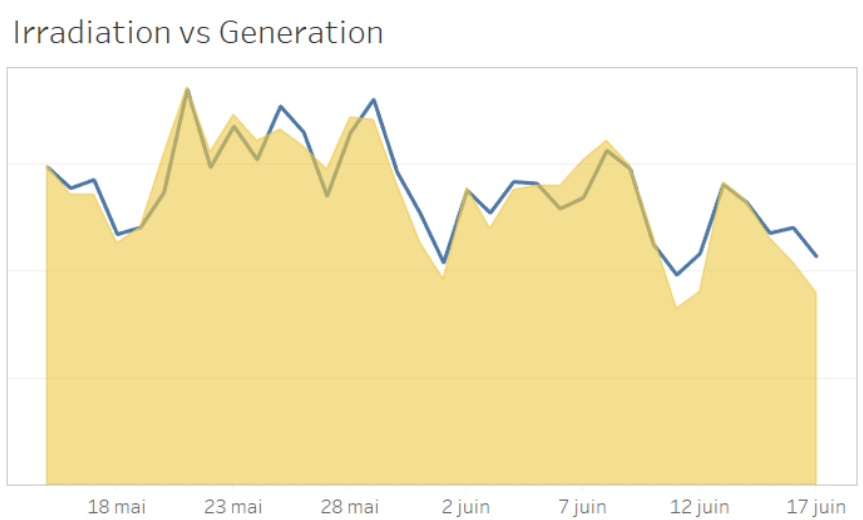


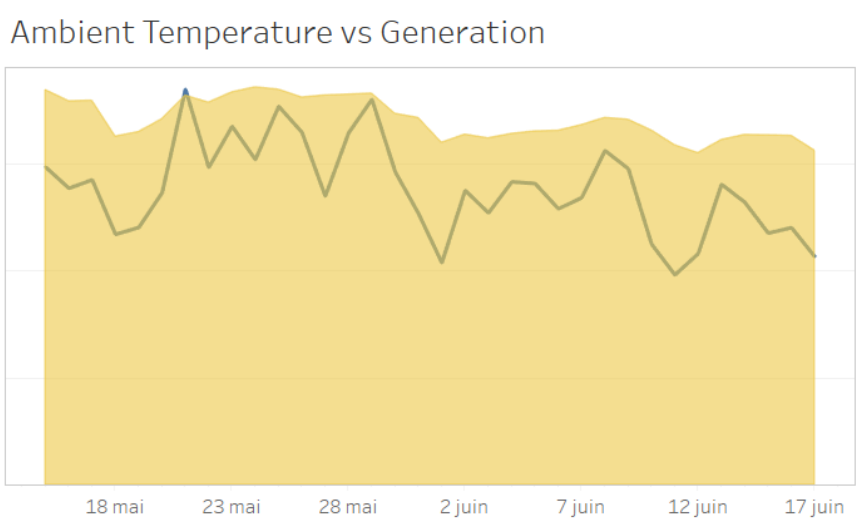
Detailed Model Comparison

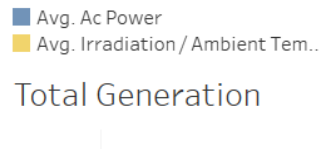
LINEAR REGRESSION VS DEEPNET

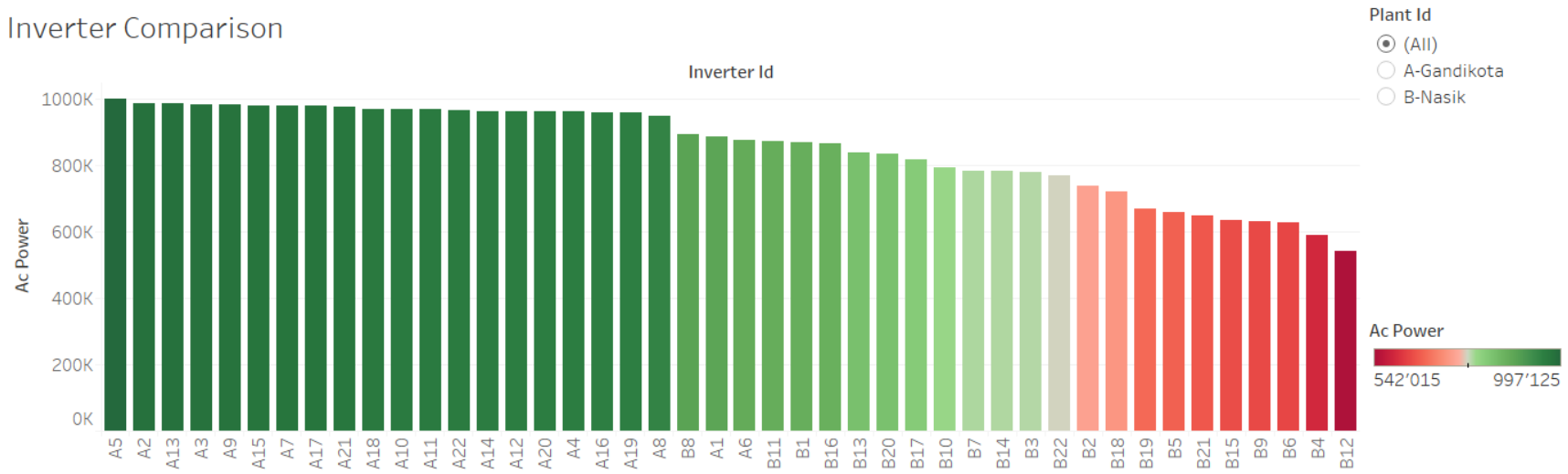


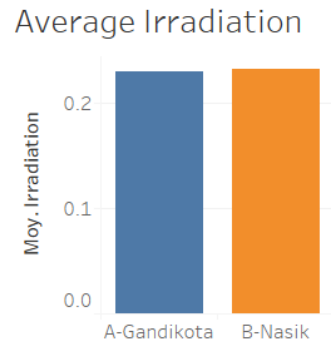
Dashboard – General Overview



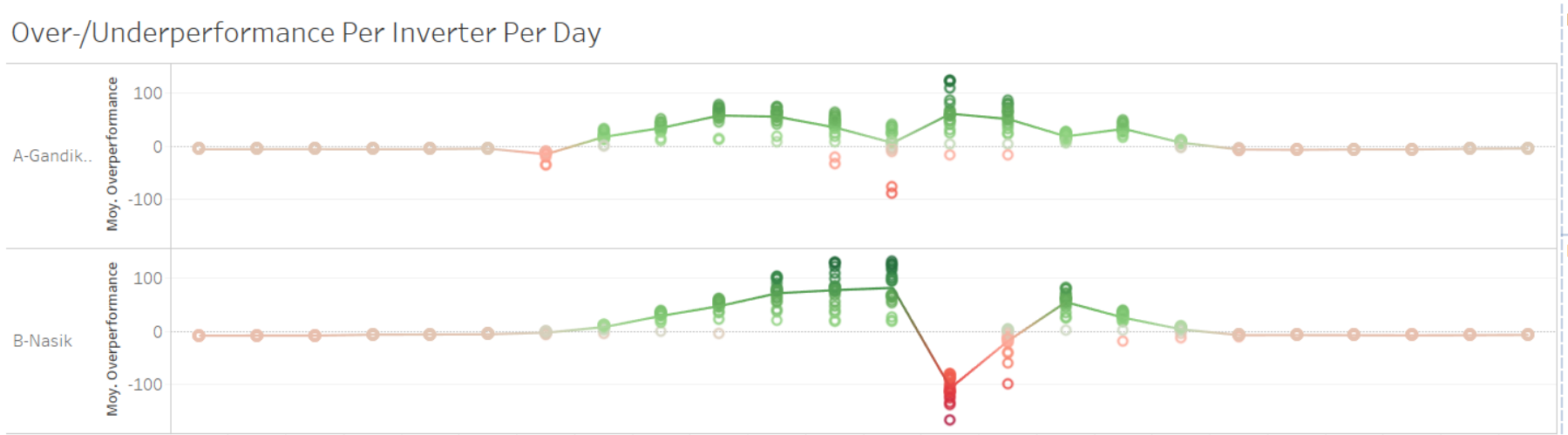


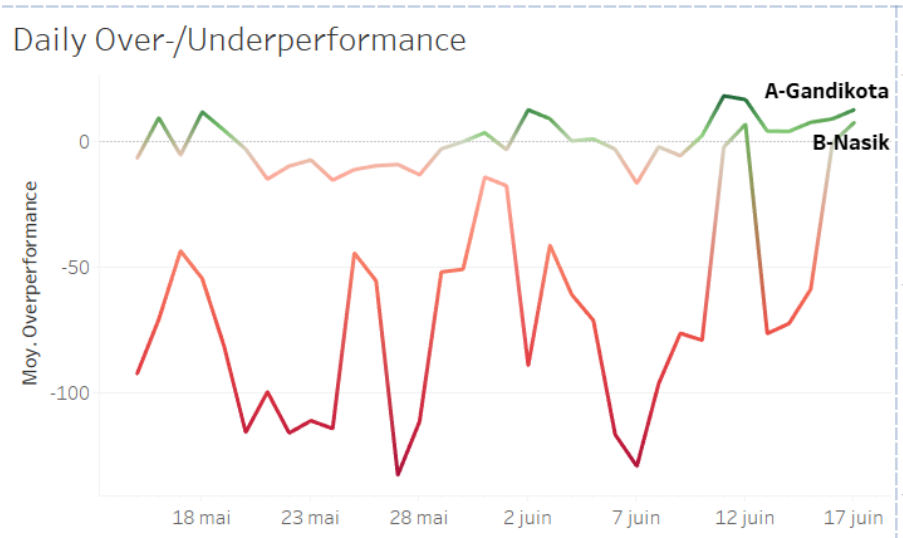


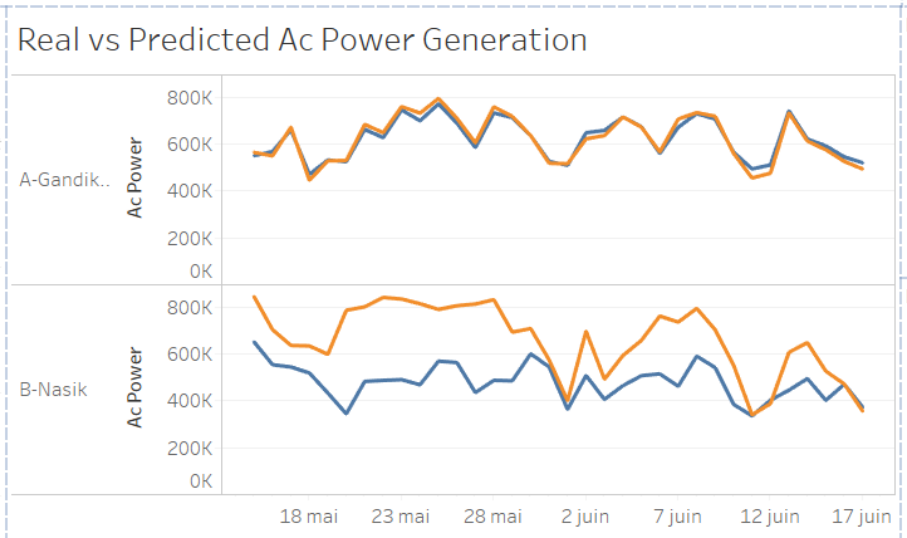


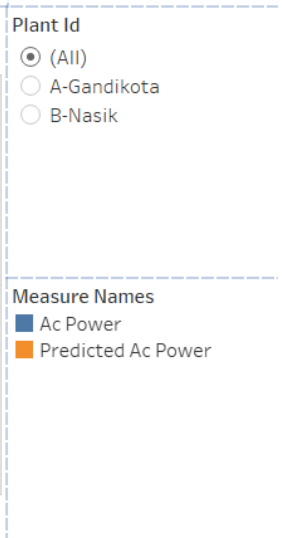


Dashboard – Power Generation Analysis

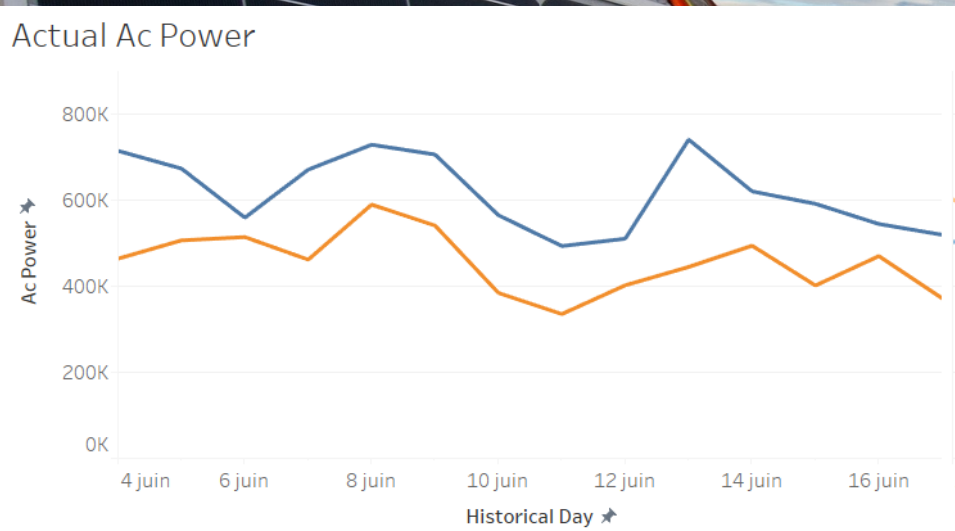


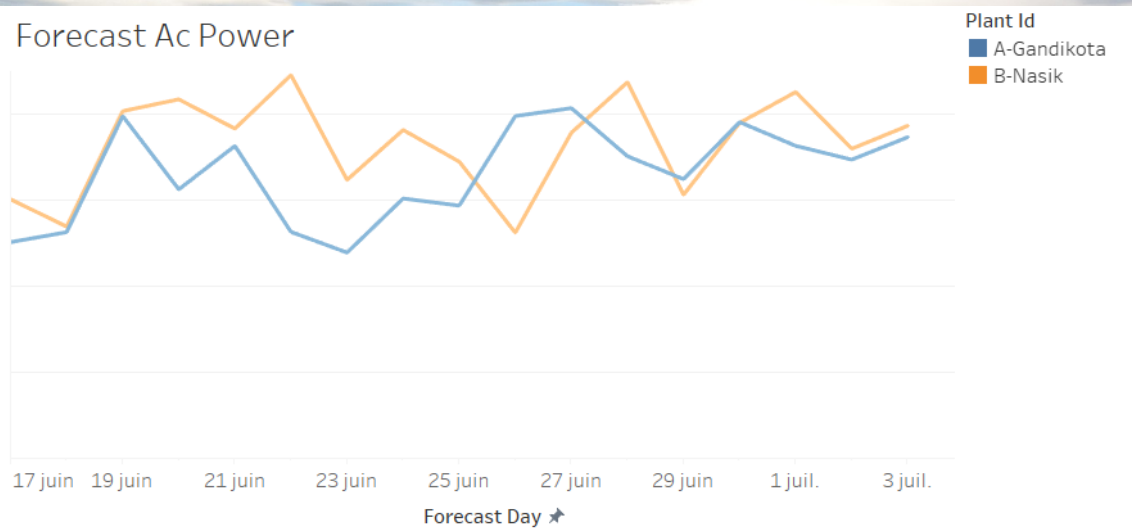






Dashboard – Model Insights



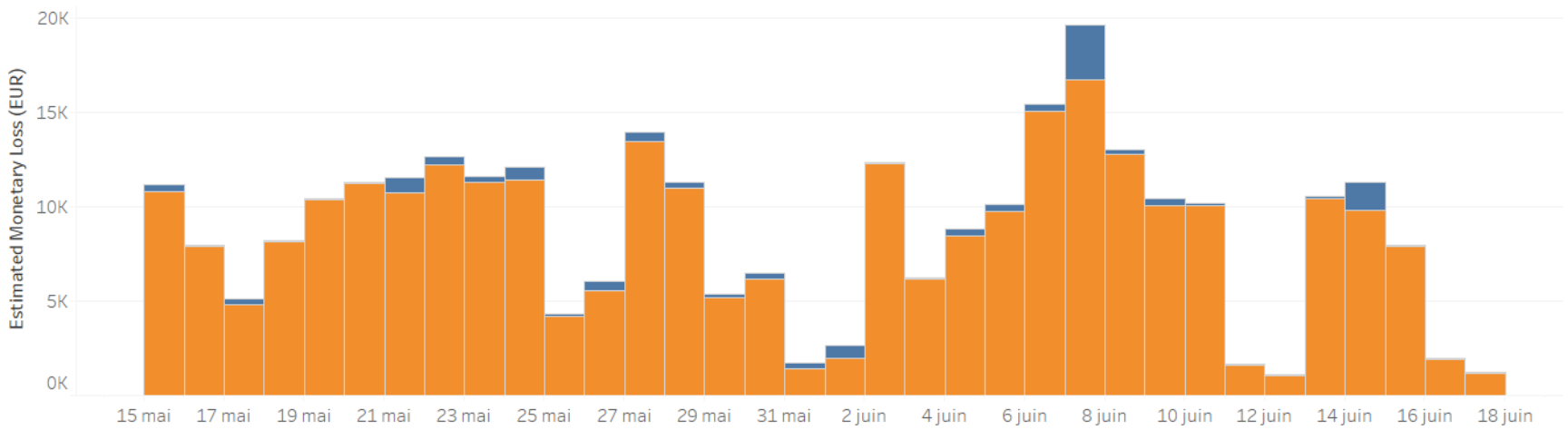


Monthly Estimated Monetary Loss (EUR)

295'914

Monthly Revenue (EUR)

2'587'782



Dashboard – New Plant Location Evaluation