Renewable assets performance management
ONSHORE WIND CASE STUDY – AI DRIVEN

OCTOBER 2022

AFRY
ÅF PÖYRY

Agenda

We are a global engineering, design, and advisory company with 17,000 experts serving clients in more than 100 countries across the globe

AFRY AT A GLANCE

EMPLOYEES GLOBALLY

~ 17,000

(at the end of 2021)

NET SALES

€ 2.0 bn

(in 2021)

NUMBER OF COUNTRIES WITH OFFICES

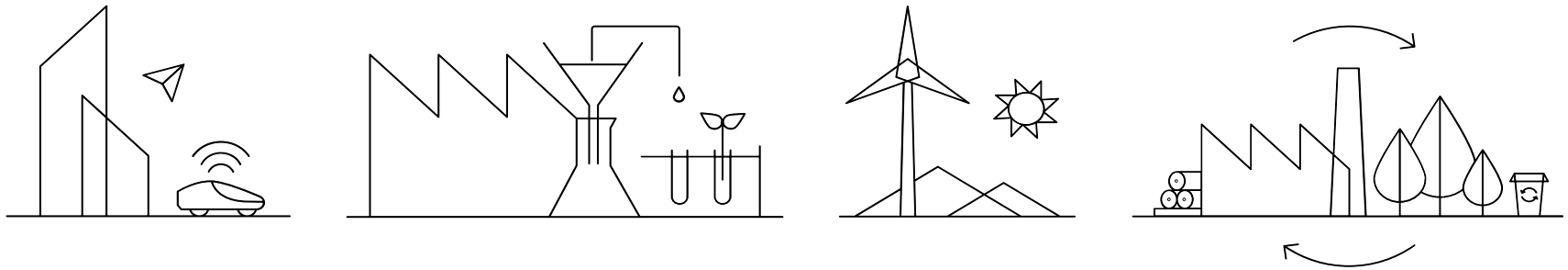
> 40

NUMBER OF COUNTRIES WITH PROJECTS

> 100

AFRY CORE EXPERTISE

AFRY GROWTH DRIVERS



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AFRY ÅF PÖYRY

AFRY AT GLANCE

Our organization falls into 6 divisions to bring a unique value proposition of a rare combination of consulting, engineering and digital capabilities

INFRASTRUCTURE

- Transportation
- Buildings
- Water
- Environment

INDUSTRIAL SOLUTIONS

- Advanced Automation
- Automotive R&D
- Experience Design
- Food & Pharma

PROCESS INDUSTRIES

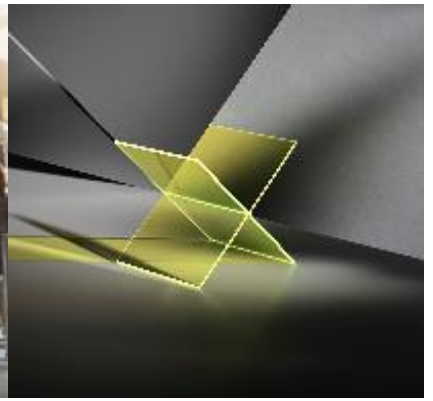
- Pulp & paper
- Mining & Metals
- Steel Industry
- Chemical

ENERGY

- Renewables
- Hydro
- Thermal
- Transmission & Distribution

MGT CONSULTING

- Sustainability
- Operational & Digital transformation
- Market Analysis
- Strategy
- Transaction services



AFRY X

- Digital services
- Digital products
- Artificial intelligence
- Data analytics

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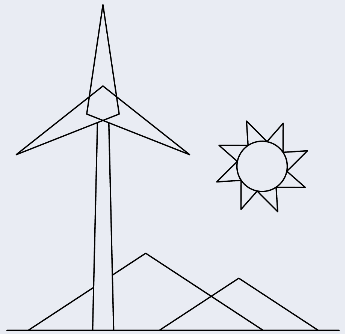
Agenda

CASE STUDY - OBJECTIVES

Assess observed production degradation and explore optimization potential

CONFIDENTIAL

ASSET OVERVIEW



#Turbines	Hub height
7	80m
	Rotor diameter
	90m

Total capacity	Rated power per turbine	Data history
17.5 MW	2,500 kW	+6.5 years

CHALLENGES

DIFFICULTIES TO ACHIEVE THE PLANNED POWER PRODUCTION:

1. ASSESS PRODUCTION DEGRADATION OVER TIME FOR SOME TURBINES AND INVESTIGATE ROOT CAUSES
2. EXPLORE PRODUCTION OPTIMIZATION POTENTIAL

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CASE STUDY – APPROACH & VALUE

AFRY's multidisciplinary team has leveraged farm data to investigate the challenges, outline improvement potential and associated value

APPROACH

DIGITAL TWIN (ACCURACY: 99%)

Simulate power production provided weather conditions and operational settings

PRODUCTION DEGRADATION ASSESSMENT

LOSS DETECTION & ASSESSMENT

PRODUCTION EFFICIENCY (SENSITIVE) ANALYSIS

POWER PRODUCTION OPTIMIZATION

DAY AHEAD POWER PREDICTION @ FARM LEVEL

WAKE SIMULATION AND DAY AHEAD POWER PERDITION @ TURBINE LEVEL

OUTCOMES

1. Production degradation confirmed
   - ▶ **4 TURBINES**
   - Potential losses for each turbine
     Excluding shutdowns and optimization potential
     ▶ **3 TO 5%** (VS FARM: 2,2%)
2. Production optimization potential confirmed
   - ▶ **3 TURBINES**
   - Potential optimization for each turbine
     Based on operational settings' optimization, excluding shutdowns and low production period
     ▶ **+4,1 TO 7,3%** (VS FARM 2,3%)
3. Improved Day Ahead power Production
   - ▶ **+ 4%**
   - Accuracy of prediction based on wake effect vs "Std" prediction (same algorithm)

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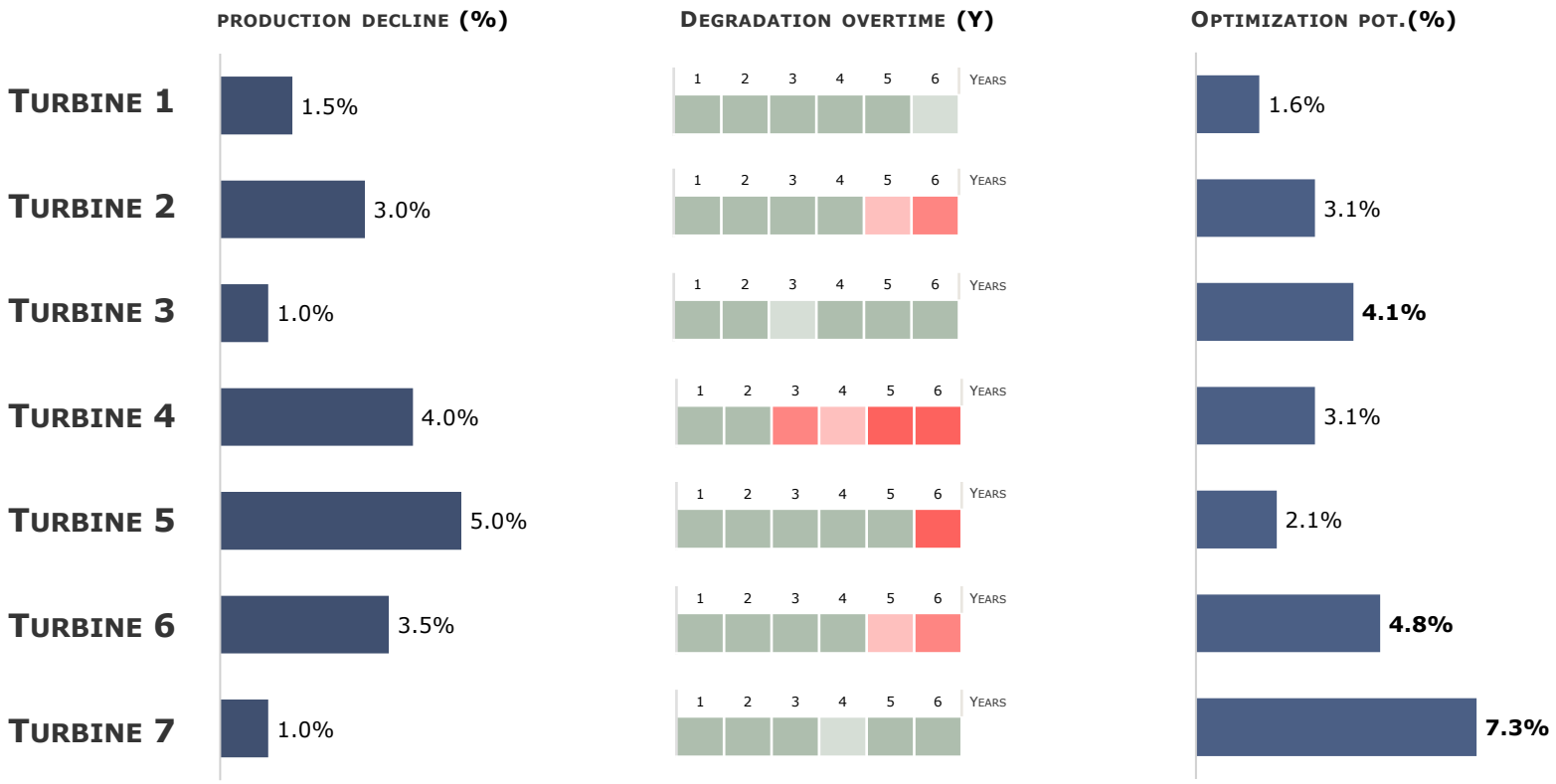
CASE STUDY –CONCLUSIONS

Furthermore, the study has confirmed the status of each turbine and recommended further priorities & investigations to secure the value



- CONSISTENT BEHAVIOR
- POSSIBLE STARTING ASSET INTEGRITY ISSUE
- STABLE - OPTIMIZATION POTENTIAL
- POSSIBLE ASSET INTEGRITY ISSUE
- POSSIBLE STARTING ASSET INTEGRITY ISSUE
- POSSIBLE STARTING ASSET ISSUE – OPTIMIZATION POTENTIAL
- STABLE OPTIMIZATION POTENTIAL

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APPENDIX 1

Case study results (e-DAP) - Illustration

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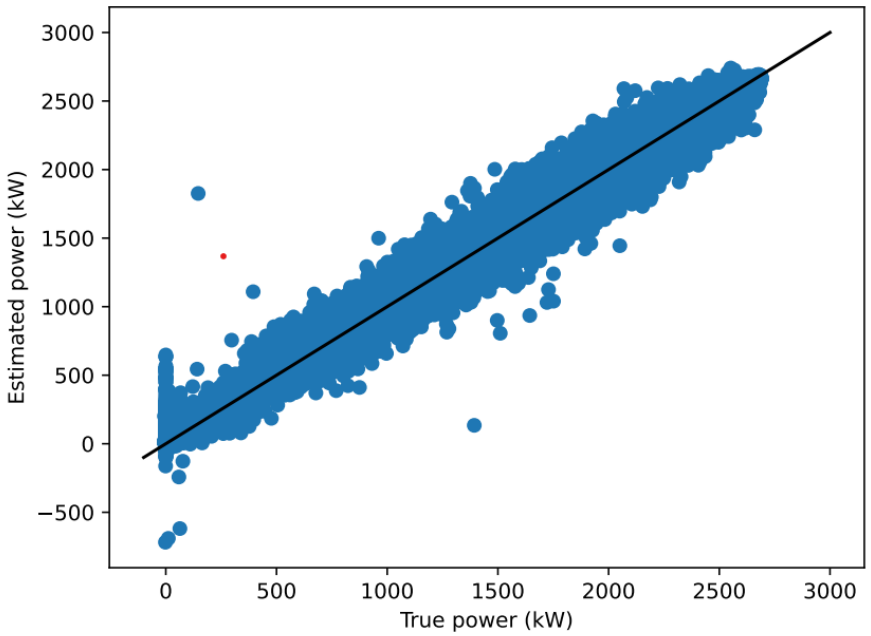
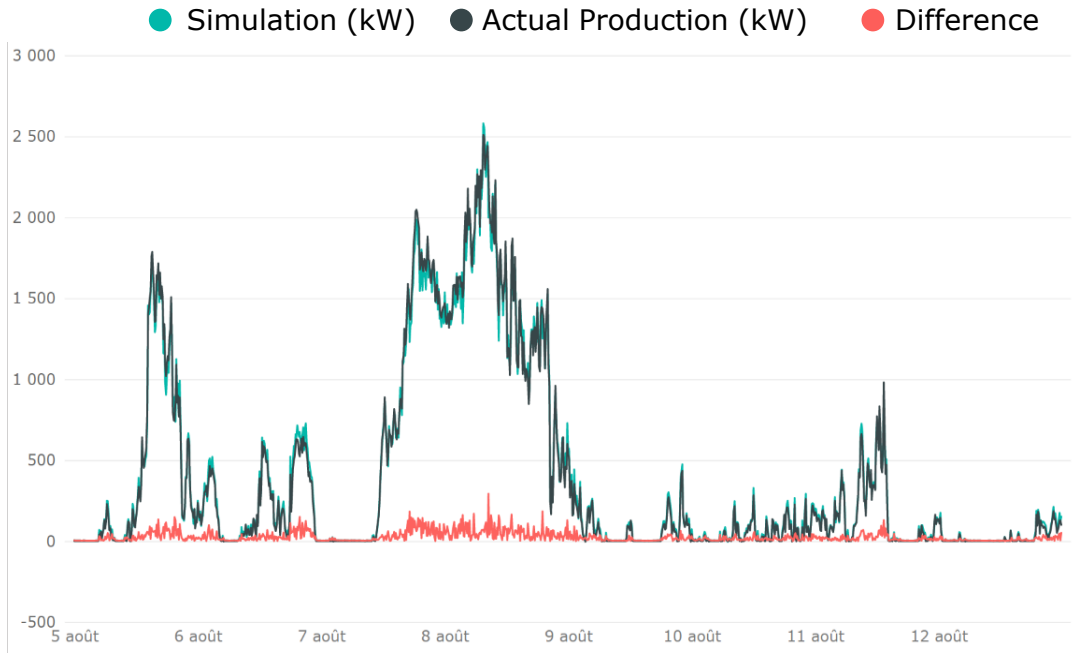
AFRY's "digital twin" considers both weather information and operational settings to estimate the power production for each turbine. It comes with 99% of accuracy

TURBINE 7 – ACTUAL VS SIMULATED PRODUCTION CORRELATION – R2=0,9956



TURBINE 7 - ACTUAL VS SIMULATED PRODUCTION (KW) – ONE WEEK



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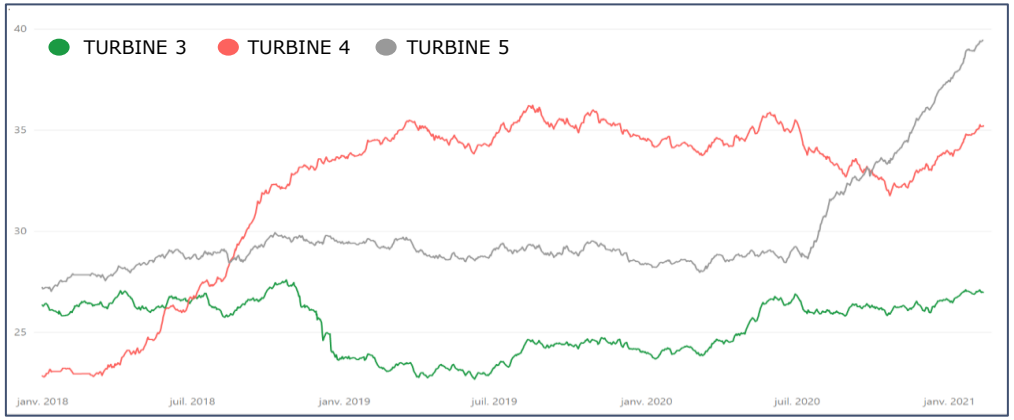
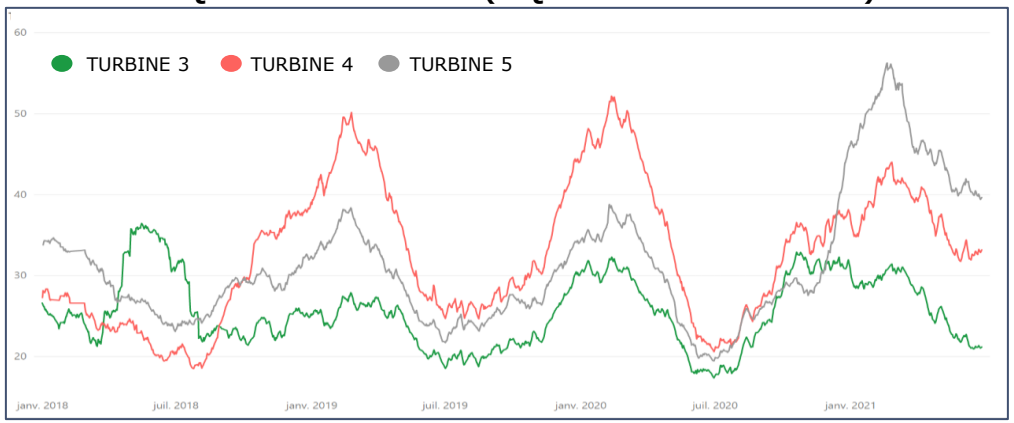
PRODUCTION DEGRADATION

A mid-term and long-term assessment confirm the power production degradation over time for 4 turbines

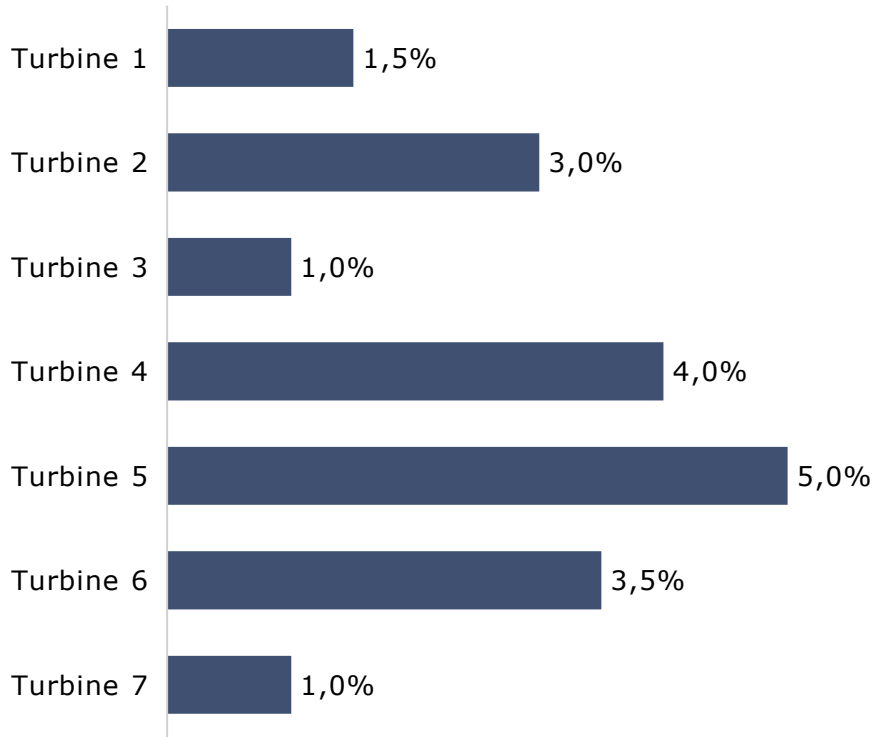
LOW FREQUENCY DEVIATION (1 YEAR MOVING AVG) TURBINE 3,4,5



MEDIUM FREQUENCY DEVIATION (1 QUARTER. MOVING AVG) TURBINE



POWER PRODUCTION DEGRADATION OVER 6 YEARS



Vs a std degradation factor of 0,5 to 10% during the first 10 years of operations

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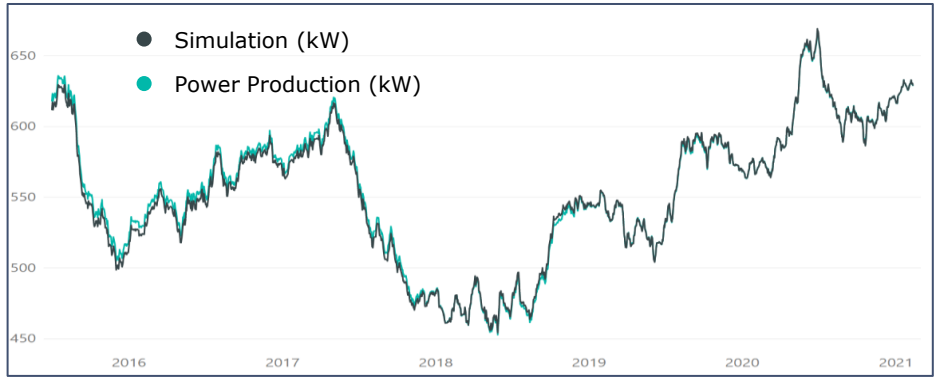
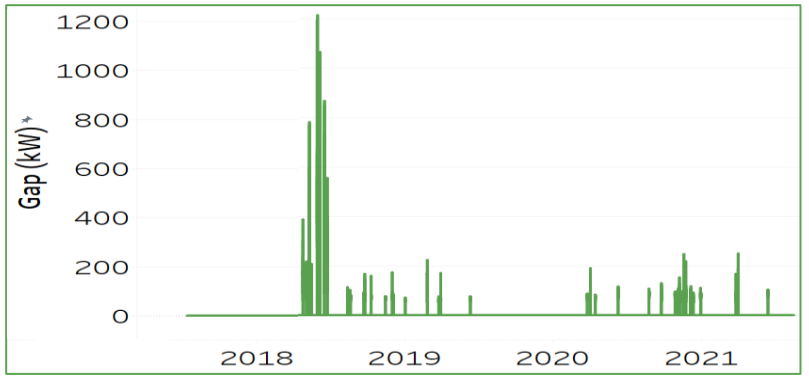
PRODUCTION DECLINE

Turbines with a power production degradation show high losses (value and frequency) that could have been anticipated with predictive maintenance

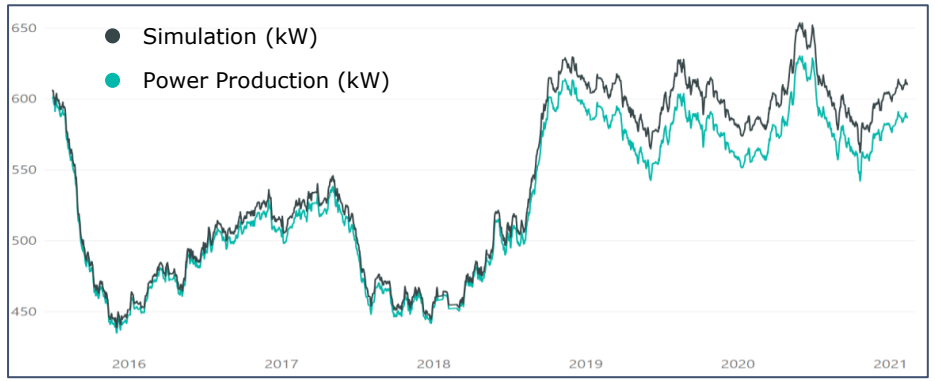
TURBINE 3 - ACTUAL VS SIMULATED AVERAGE PRODUCTION* (KW)



TURBINE 3 – LOSSES*

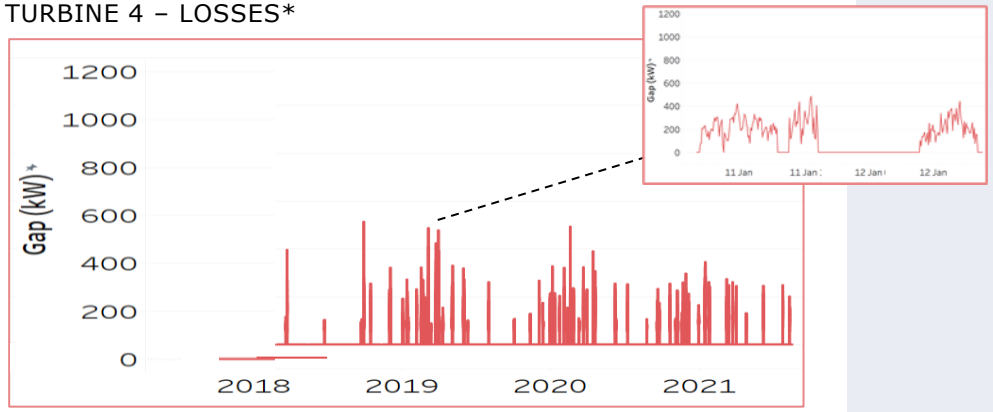


TURBINE 4 - ACTUAL AND SIMULATED AVERAGE PRODUCTION* (KW)



*Moving average production (to focus on long term behavior)

TURBINE 4 – LOSSES*



*Losses Value > 2 times simulation errors with a duration higher than 3 hours (Excluding shutdown)

- 4% OF PRODUCTION LOSSES THAT COULD HAVE BEEN ANTICIPATED
- HIGH LOSSES FREQUENCIES COULD TRIGGER A PREVENTIVE MAINTENANCE ACTION

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