Smarter Air-Cooled Condensers: Using Digital Twins to Monitor Performance and Optimize Cleaning Strategies Year-Round

Hexwise

Speakers:

Niels Bergsma
CEO Hexwise

Roy Manting
CTO Hexwise

Air-cooled condenser user group conference 2026 |
14-16 July
Clarksville, USA

The problem

10% Production Cut in Europe and U.S. refineries

In 2024, the Australian investment bank Macquarie estimated a 1 Million barrels a day production cut in Europe and U.S. refineries due to high ambient temperatures.

Vikas Dwivedi
Global oil and gas strategist at
Macquarie Group

In the mediterranean the cuts can go up till 15%.

The problem is expected to increase.

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The problem

Power

Data centers

(Petro) chemicals

Gas

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And many more industries…

Significant production and energy losses occur in many industries due to inefficient cooling **performance** and **control**.

With static control setpoints, the system cannot adapt to fluctuating weather and process conditions.

Resulting in missed opportunities for increased production and energy efficiency.

Recently in the news
"Heat is forcing oil refineries to cut down their production due to cooling issues."

fd. BusinessMirror

Resulting in significant losses in production and energy efficiency and unnecessary flaring.

We envision a world where every cooling system operates at its exact optimal state at every moment in time.

Digital Twins for industrial cooling systems

Air-Cooled Heat Exchangers | A-Frame Condensers | Cooling Towers

Performance

Performance Insights

“See what’s happening and know how, why and when to act.”

Control

Intelligent Optimization

“From static control to dynamic, value-driven process optimization.”

The monitoring challenge

Most plants have plenty of operating data, but very little true ACC performance tracking.

Observed cooler performance

Backpressure/fan power/process temperature

1. Changing conditions

Steam load, ambient temperature, humidity, wind and process demand are constantly moving.

2. Fan control compensation

Fans often compensate automatically by increasing speed or staging, masking degradation.

3. Degradation mechanisms

External fouling, wind effects, hot-air-recirculation, fan issues, et. can look similar.

4. Simple methods mislead

Using simple trends or just a few reference points does provide the right insights.

Without a proper monitoring tool, performance loss is hidden and impact cannot be quantified.

Example project

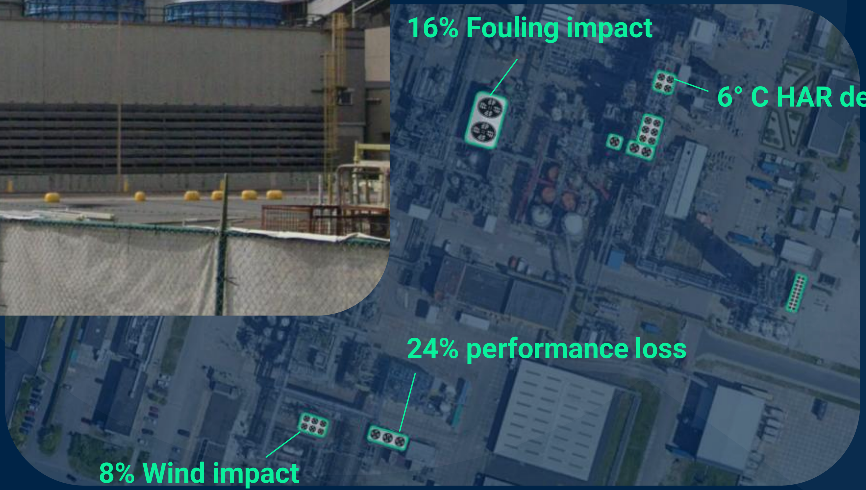
Medegefinancierd door de Europese Unie

EFROOOST

Programma Oost-Nederland 2021-2027

Europees Fonds voor Regionale Ontwikkeling

HUNTSMAN NOBIAN



Digital twin development

- Air-cooled condensers
- Air-cooled heat exchangers
- Cooling towers

Overhead condensers

Chiller pre-coolers

Chiller condenser coolers

Compressor coolers

Case study

External Fouling Monitoring at a **Waste-to-Energy** plant

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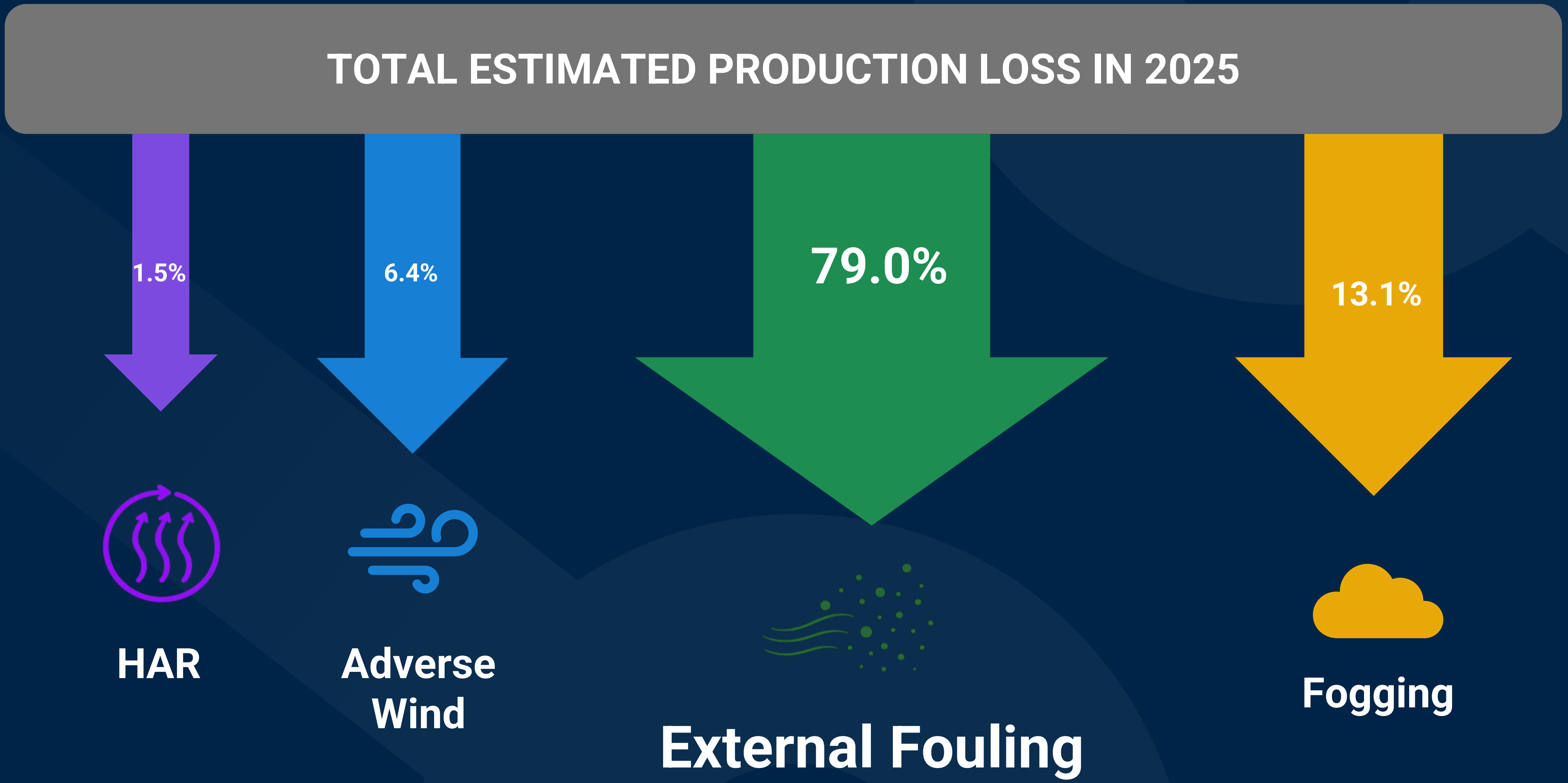
Case introduction

Challenges
- Increased back pressure during warm weather
- Lack of insight in / and quantification of - performance losses
- Clear problem with external fouling, but no good cleaning strategy

Specs
- Simple rankine cycle
- 29 MW generator
- A-Frame condenser
    - 6 fans
    - Wind protection screens
    - Water wash cleaning system

Breakdown of losses



What is ext. fouling?

- Air side problem
- Build up of material layer on heat exchanger surface
  - Like dust, bugs, pollen, etc.

In this case

- Caused by the fluffy seeds produced by the **poplar tree**

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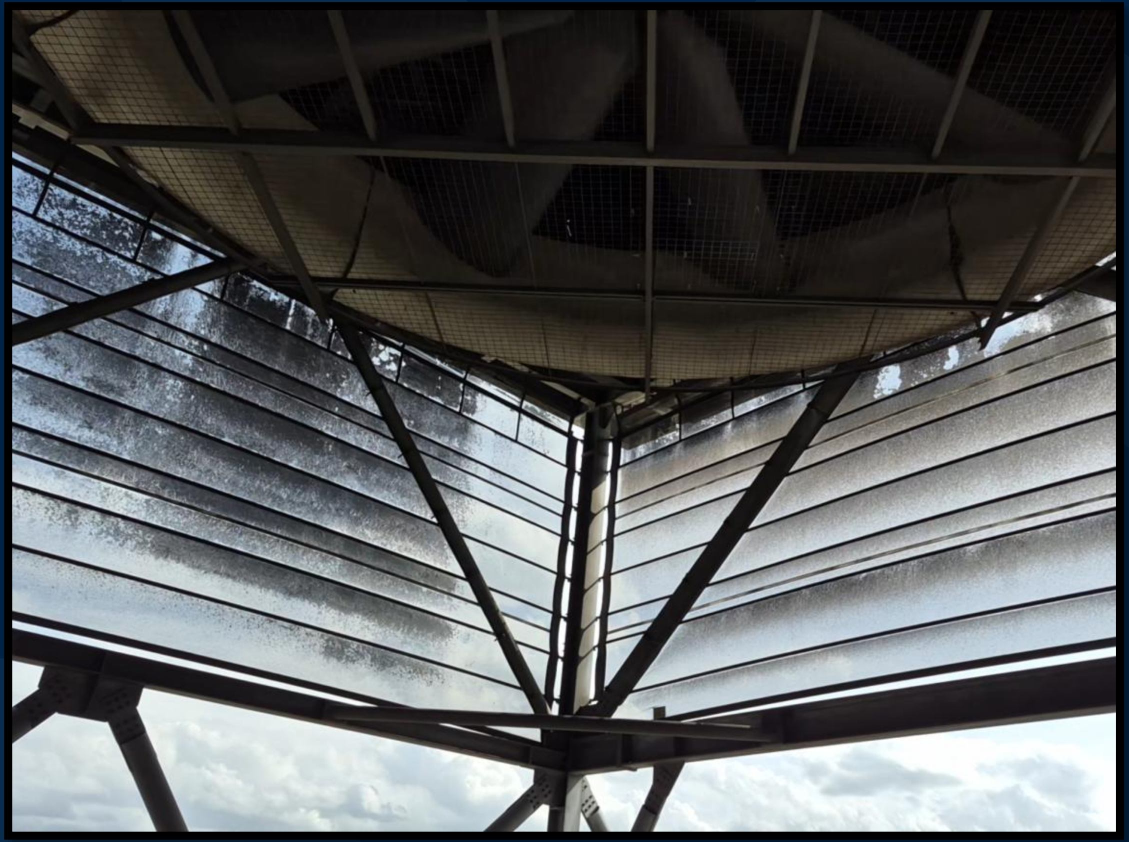

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Double negative effect

Heat Transfer

Heat Transfer Coefficient

Area

Temperature difference

$$\dot{Q} = h \cdot A \cdot \Delta T$$

Double negative effect

Heat Transfer
Heat Transfer Coefficient
Area
Temperature difference

$$\dot{Q} = h \cdot A \cdot \Delta T$$

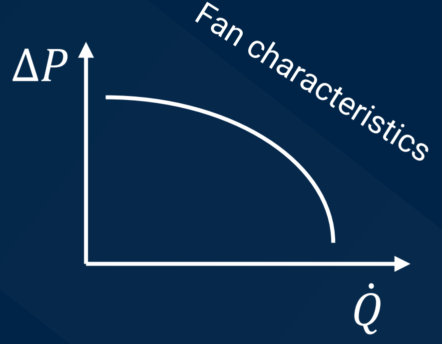
1) Increased insulation

$$\Delta T = T_{tube} - T_{air}$$

Thermal transmittance

$$T_{tube} = f(U, T_{process})$$

Double negative effect



Heat Transfer

Heat Transfer Coefficient

Area

Temperature difference

$$\dot{Q} = h \cdot A \cdot \Delta T$$

1) Increased insulation

$$h = f(\dot{m})$$

Heat transfer coefficient is a function of the mass flow of air

$$\Delta T = T_{tube} - T_{air}$$

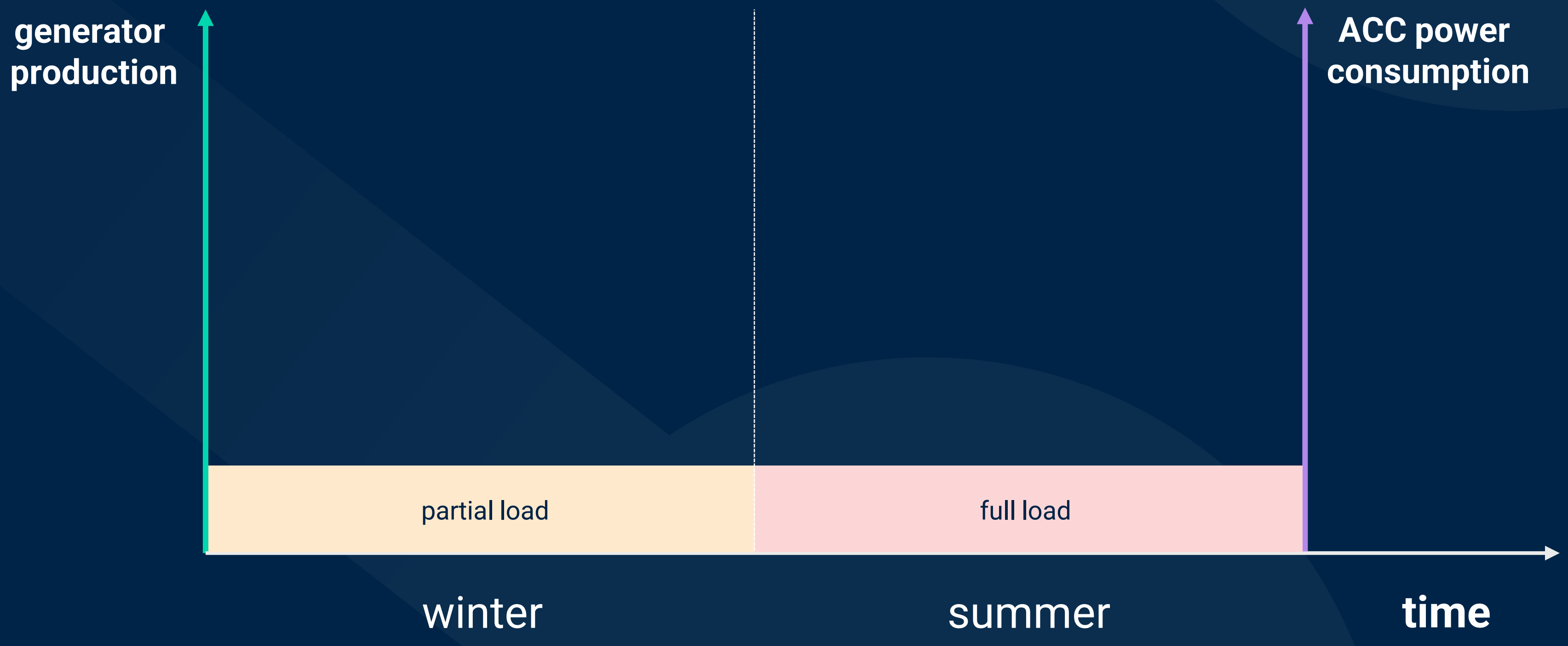
Thermal transmittance

$$T_{tube} = f(U, T_{process})$$

2) Increased pressure resistance

Effect on process performance

- Fans operating in partial or full load state?
- Closed-loop-temperature control



Effect on process performance

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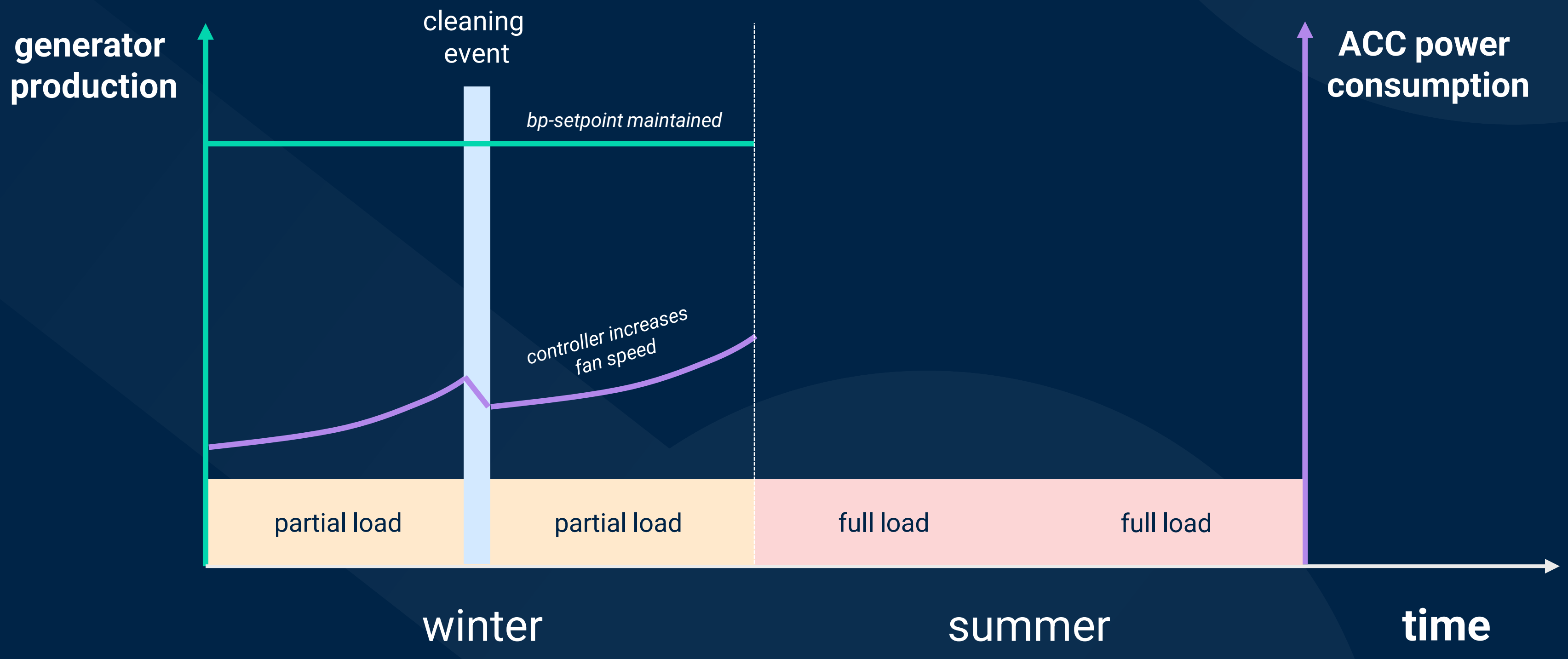

Effect on process performance

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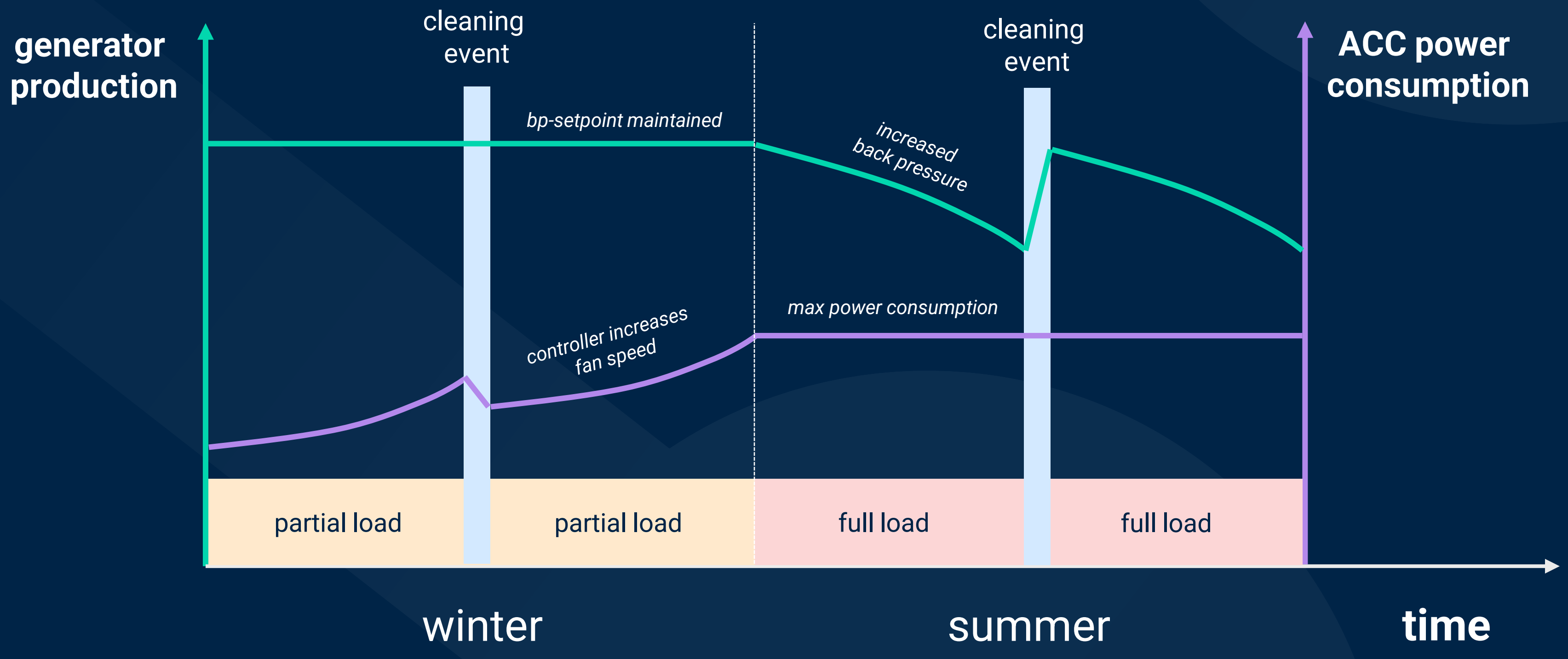
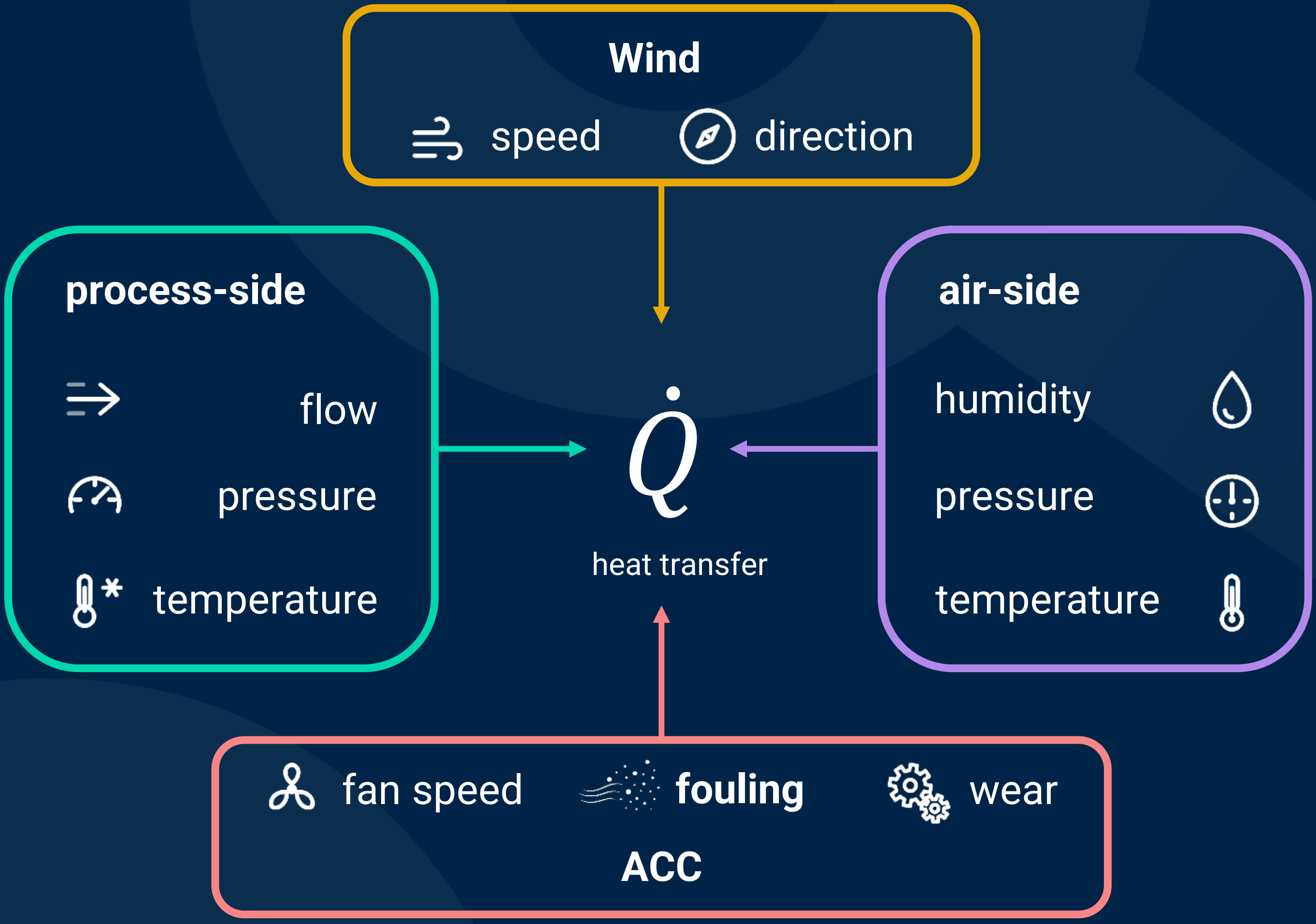


Complexity of Monitoring

Slow creep
- No sudden event
- No visible performance cliff

Not directly measurable
- Derive effects indirectly from other parameters

Many external effects
- Normalization or filtering required



Conventional monitoring approach

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fixed speed fans

fouling build up

↓

back pressure ↑

↓

turbine output ↓

✓

VSD driven fans

fouling build up

↓

controller compensates

↓

turbine output unchanged

✗ **BLIND SPOT**

Fixed speed uitdaging, vsd nog meer uitdaging

With the **rise of VSD's** the conventional approach of monitoring causes **blind spots,** especially happening during the **colder months**

The **most important question** often remains **unanswered:**

What is the right moment to clean?

Our Solution

What we do differently

- Target variable: Fan Control Pct
- Calculate optimal cleaning date

Operational Space Discretization

- Filter out **anomalies**
- Define all **operational states** to filter out external effects

Baseline Estimation

- Define ACC performance at its **optimal state**
- Needed for comparison

Sliding Window Comparison

- Trend analysis
- Outputs the **fouling factor**

Fouling Impact

- Calculates **production losses** and excess ACC **energy consumption**

* No additional sensors required, just process data

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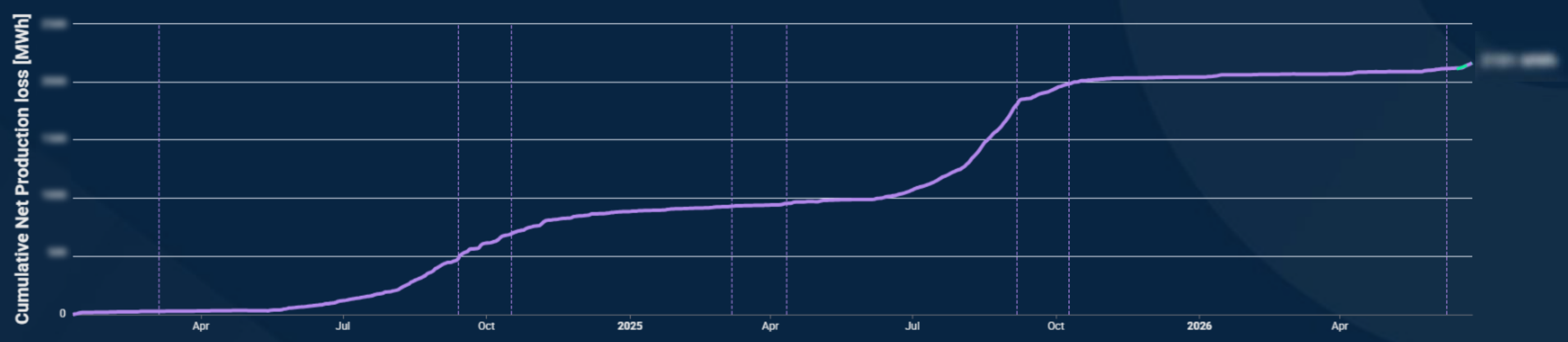
External Fouling Monitoring

2024-01-09

2026-06-24

Net Production Loss



Optimal Cleaning Date

Show in €

Regression

Regression days
10 dagen

Kosteninvoer

Euro per MWh
150 €/MWh

Personeelskosten
0 €

Overigekosten
0 €

FEEDBACK

Fouling Factor

	Cleaning datum
☑	08-06-2026
☐	09-10-2025
☐	06-09-2025
☐	11-04-2025
☐	07-03-2025
☐	17-10-2024
☐	13-09-2024

1 record selected.

Optimal Cleaning

- Production loss
- Increased energy consumption

Too late — Trade-off — Too often

- High cleaning costs
- Lots of down-time

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Optimal Cleaning

- Production loss
- Increased energy consumption

Too late | Trade-off | Too often

- High cleaning costs
- Lots of down-time

Lost Profit

=
generator prod. Loss
+
ACC excess energy consumption

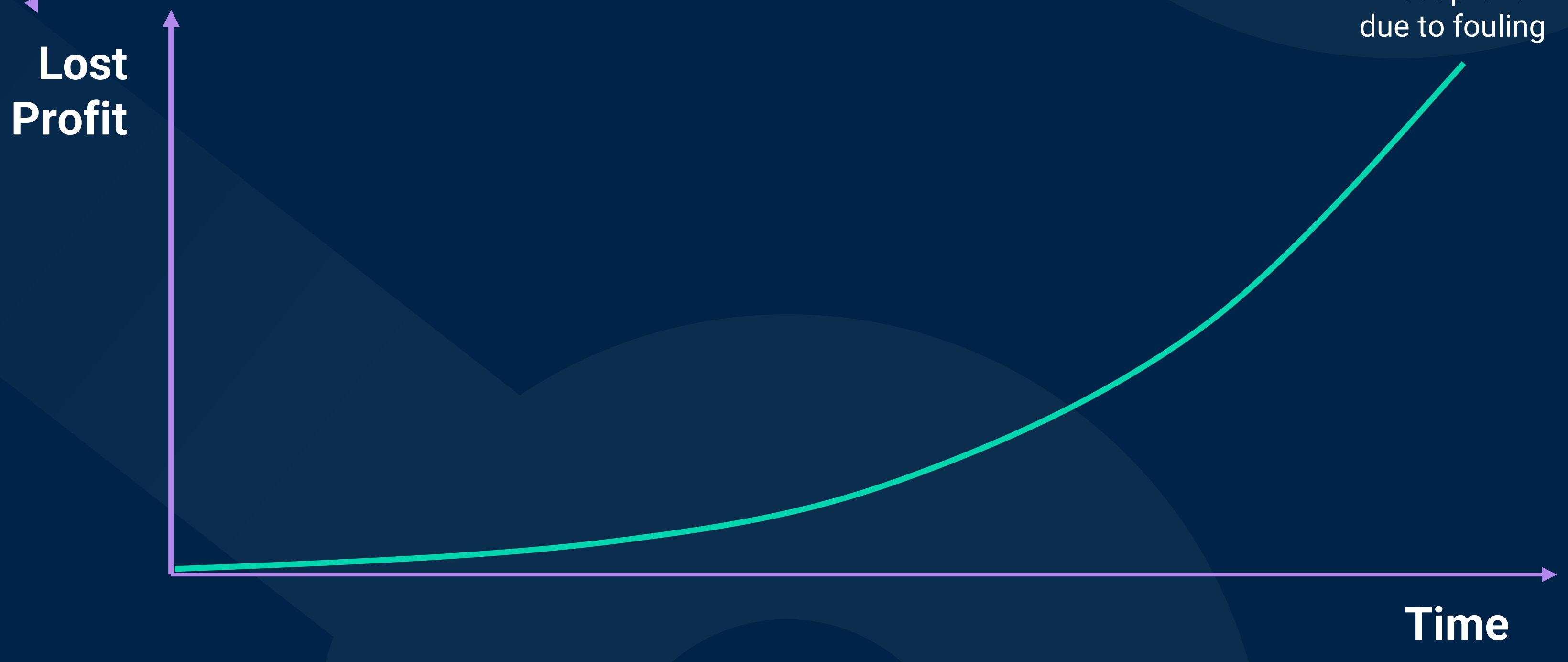
Time

Optimal Cleaning

- Production loss
- Increased energy consumption

Too late — **Trade-off** — **Too often**

- High cleaning costs
- Lots of down-time



=
generator
prod. Loss
+
ACC excess
energy consumption

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Optimal Cleaning

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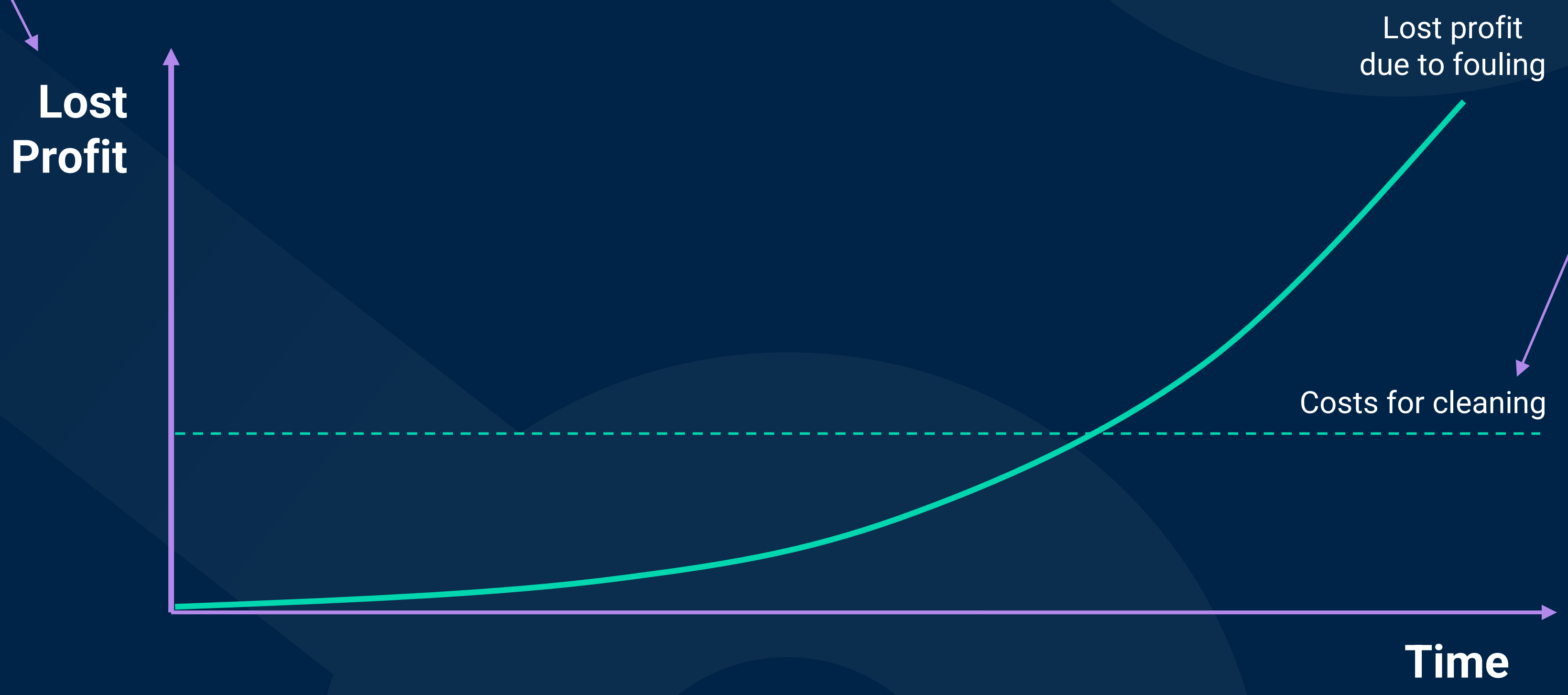
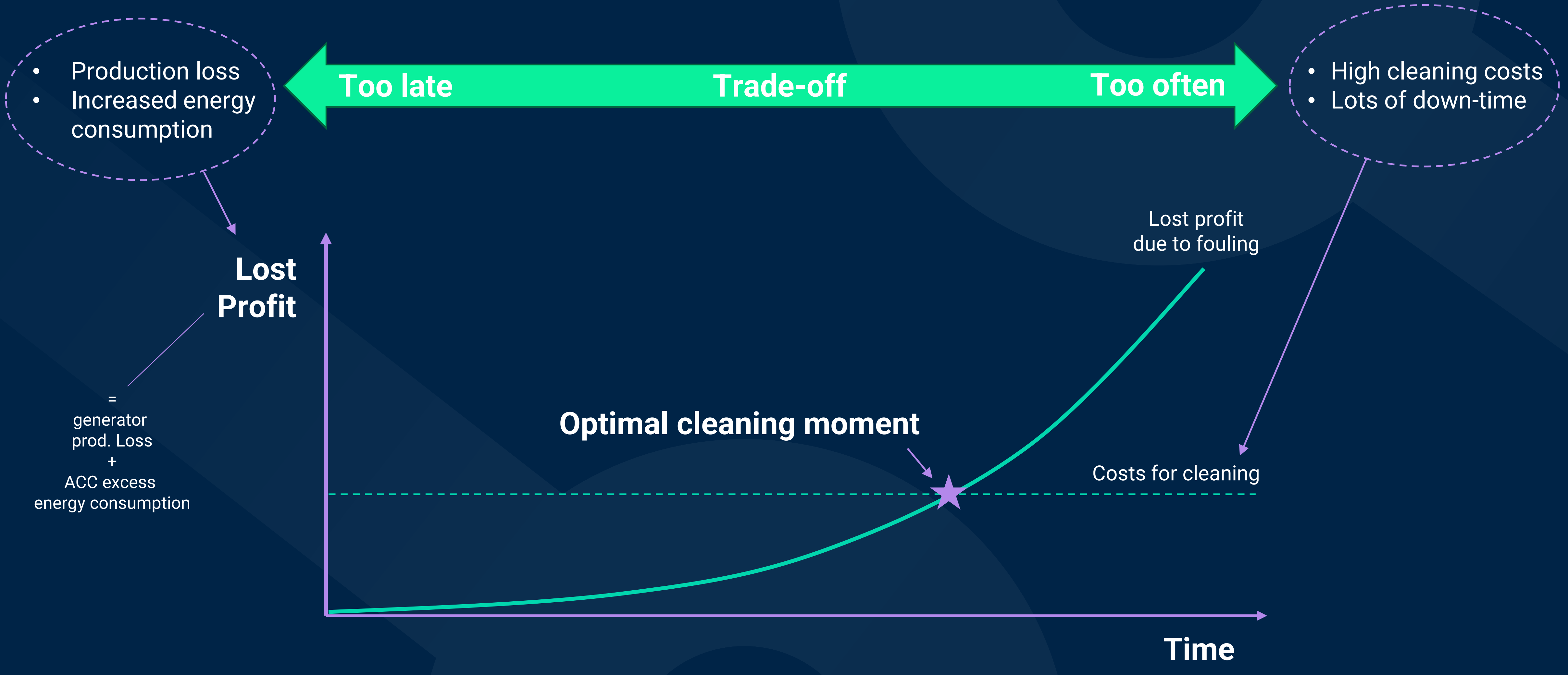


= generator prod. Loss + ACC excess energy consumption

Optimal Cleaning



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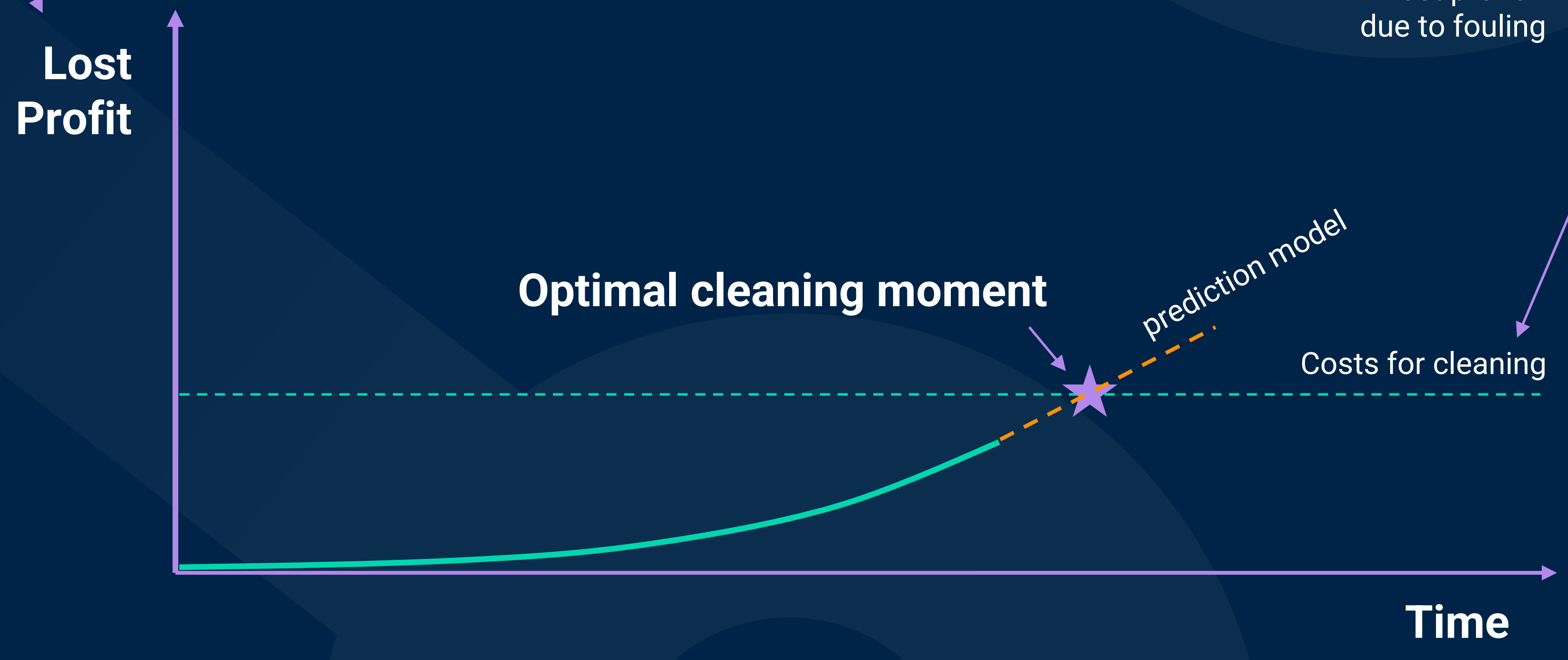

=
generator
prod. Loss
+
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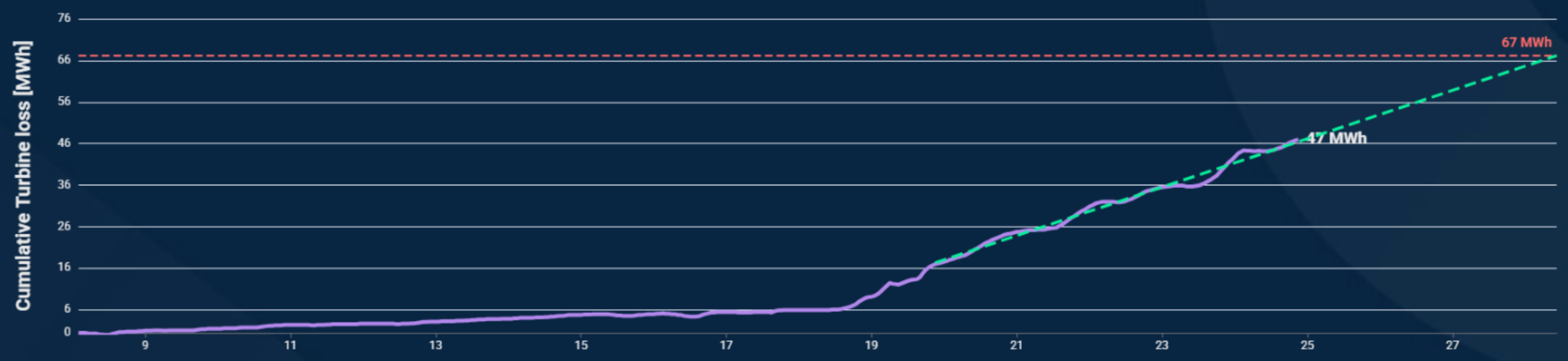
External Fouling Monitoring

2026/06/08

2026-06-24

Net Production Loss



28-06-2026

Optimal Cleaning Date

Show in €

Regression

Regressie dagen

5 dagen

Cost Input

Euro per MWh
150 €/MWh

Personnel costs
10000 €

Miscellaneous costs
0 €

FEEDBACK

Fouling Factor

	Cleaning date
☑	08-06-2026
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☐	07-03-2025
☐	18-02-2025
☐	06-02-2025

1 record selected.

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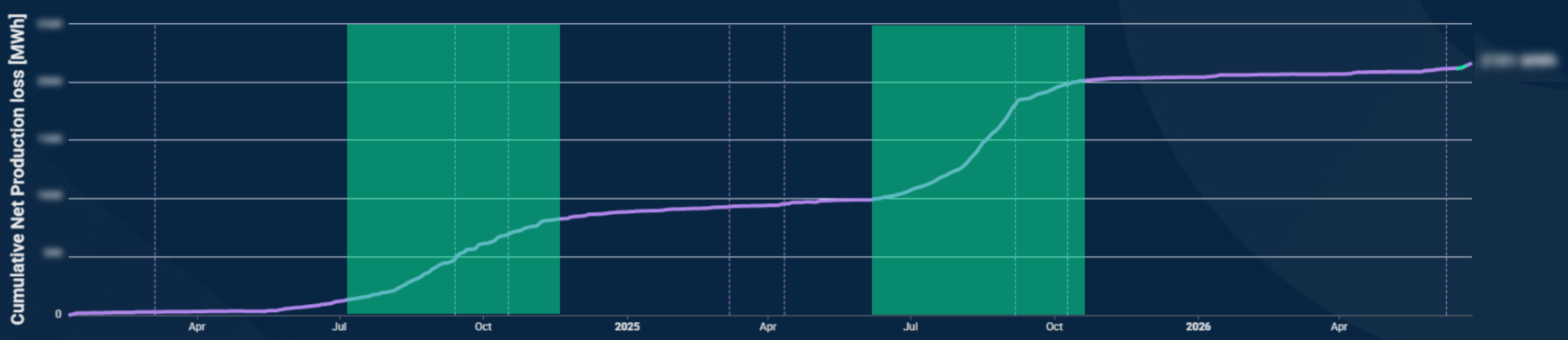
External Fouling Monitoring

2024-01-09

2026-06-24

Net Production Loss



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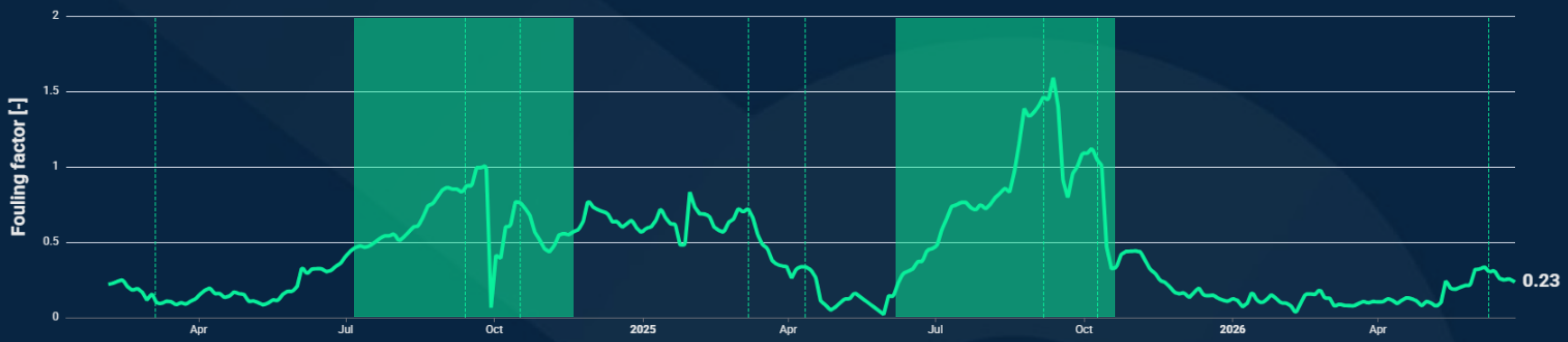
FEEDBACK

Fouling Factor



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Good business case?

The numbers..

	2025
Total realized plant production	100.00 %
Net production loss due to ACC inefficiencies	1.02 %
Net production loss due to fouling	**0.77 %**
Identified Recovery Potential with Optimized Cleaning Schedule	**0.54 %**

How we can help you

Cooling assessment

How has ACC performance changed, and what is it costing us?

- Analysis of historical operational data
- Track how ACC performance developed over time normalized for changing conditions.
- Quantify energy losses from degradation
- Identify drivers such as fouling and wind impact.
- Evaluate improvement potential from fogging.

How we can help you

How do we keep losses visible and under control?

- Tracking of ACC performance normalized for changing conditions
- Detect degradation as it develops
- Track hidden losses and fan compensation
- Support decision making on cleaning and maintenance based on quantified effects upfront

Continuous monitoring

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How we can help you

Maintenance impact assessment

How effective were specific maintenance actions?

- Measure ACC performance recovery after cleaning or repairs (condition normalized).
- Quantify the impact on energy use, backpressure and/or production.
- Separate real impact from weather, load, and fan control effects.
- Compare effectiveness of historical maintenance actions.

How we can help you

Cooling assessment

How has ACC performance changed, and what is it costing us?

Maintenance impact assessment

How effective were your cleanings or other maintenance?

Continuous monitoring

How do we keep losses visible and under control?

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Questions?

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Master your process.
Master your cooling.
Always.

Let's talk

Niels Bergsma
CEO and co-founder
nielsbergsma@hexwise.nl
+31 6 15 23 68 94

Roy Manting
CTO and co-founder
roymanting@hexwise.nl
+31 6 28 81 81 53