ENERYIELD

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AI-driven and Sensor-Less Fault Prediction and Analytics

ENERYIELD

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What we do.

- Predict power Faults
- Localize faults
- Root cause identification
- Explainable AI
- Work proactive

Less power failures

Reduced downtime

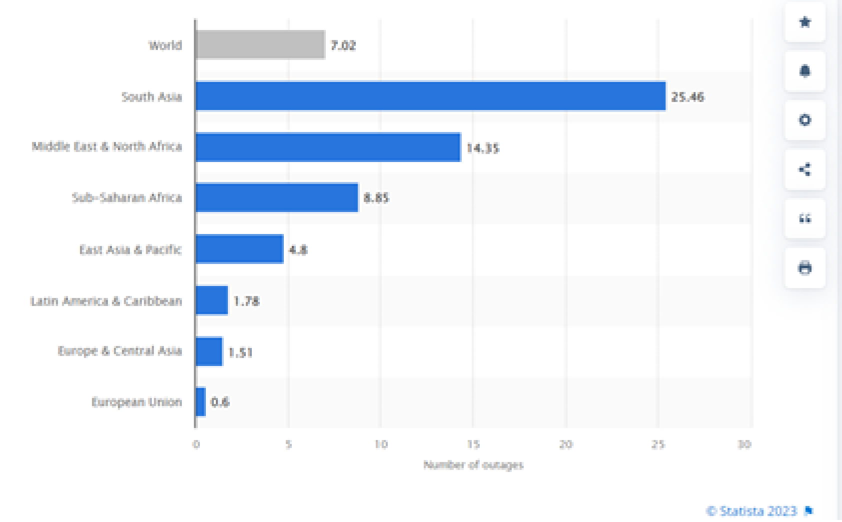
Reduced O&M costs

Challenge

Number of electrical outages in firms in a typical month worldwide in 2010-2020

Economy	Percent of firms experiencing electrical outages	Number of electrical outages in a typical month	If there were outages, average duration of a typical electrical outage (hours)	If there were outages, average losses due to electrical outages (% of annual sales)	Percent of firms owning or sharing a generator	If a generator is used, average proportion of electricity from a generator (%)
All Countries	50.1	4.9	4.1	4.2	32.2	17.6
East Asia & Pacific	47.3	5.2	3.5	3	35.2	14.5
Europe & Central Asia	30.5	0.7	3.1	0.9	17.4	6.8
Latin America & Caribbean	59.2	1.8	2.9	1.7	20.7	11.1
Middle East & North Africa	39	6.6	4.8	4.6	37.2	31.1
South Asia	58.3	20.5	6.1	12.8	37.2	26.2
Sub-Saharan Africa	75.8	8.4	5.7	8.3	52.6	29.7

Number of electrical outages in firms in a typical month worldwide in 2018, by region



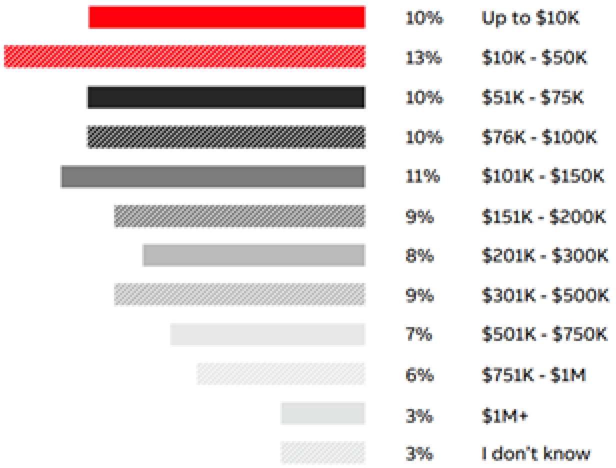
<u>Estimation for Power Utilities</u>

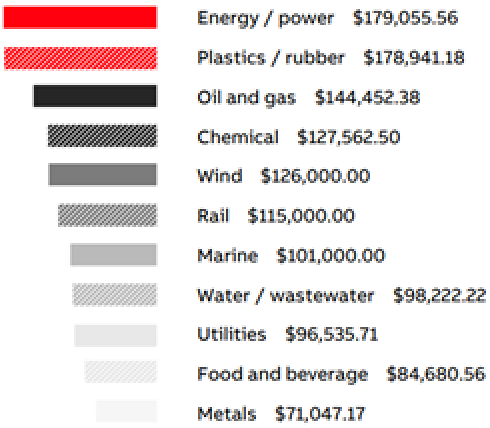
- 8.5 Billion EUR/year in losses costs, due to electrical breakdowns and failures (predictable)
- 1.5 Billion EUR/year spent on inspections to inspect 1% of the network (15% would be required)
- In France (Enedis source) 800 MEUR/year in losses due to electrical failures

The cost of downtime

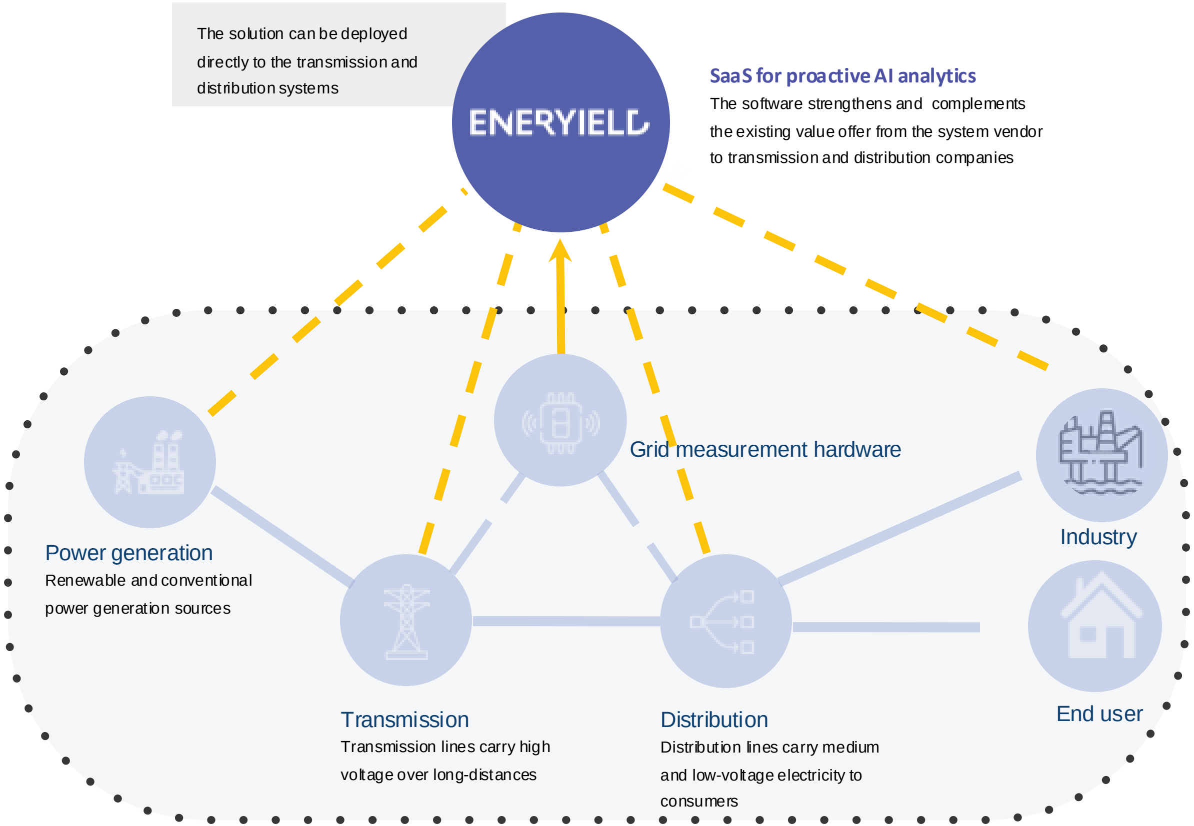
median **124,669 USD** per hour

Aside from safety or environmental mishaps, unplanned or unscheduled downtime represents one of the costliest events in any industrial or manufacturing facility. By calculating the median value, we found that outages cost the typical industrial business a hefty $124,669 USD per hour. The variations between regions are likely influenced by the relative labor cost in these regions. Differences by sector could be regulatory, as well as being related to the cost of lost production and raw materials.





The Value Chain



Where Eneryield provides value

The enclosed region depicts the current operational paradigm of power grid systems. This intricate value chain operates effectively in numerous facets. However, it falls short of adequately addressing the full spectrum of vulnerabilities to which these systems are exposed to.

→ **Artificial intelligence**
Enables for prediction of failure by analyzing historical and current data.

→ **Utilization of existing infrastructure and partnerships**
Allows for smooth implementations and creates an advantageous position in the value chain.

→ **No additional measurement hardware**
Our technology utilizes our customers' existing measurement hardware and infrastructure. This means no costs related to sourcing materials or production are needed.

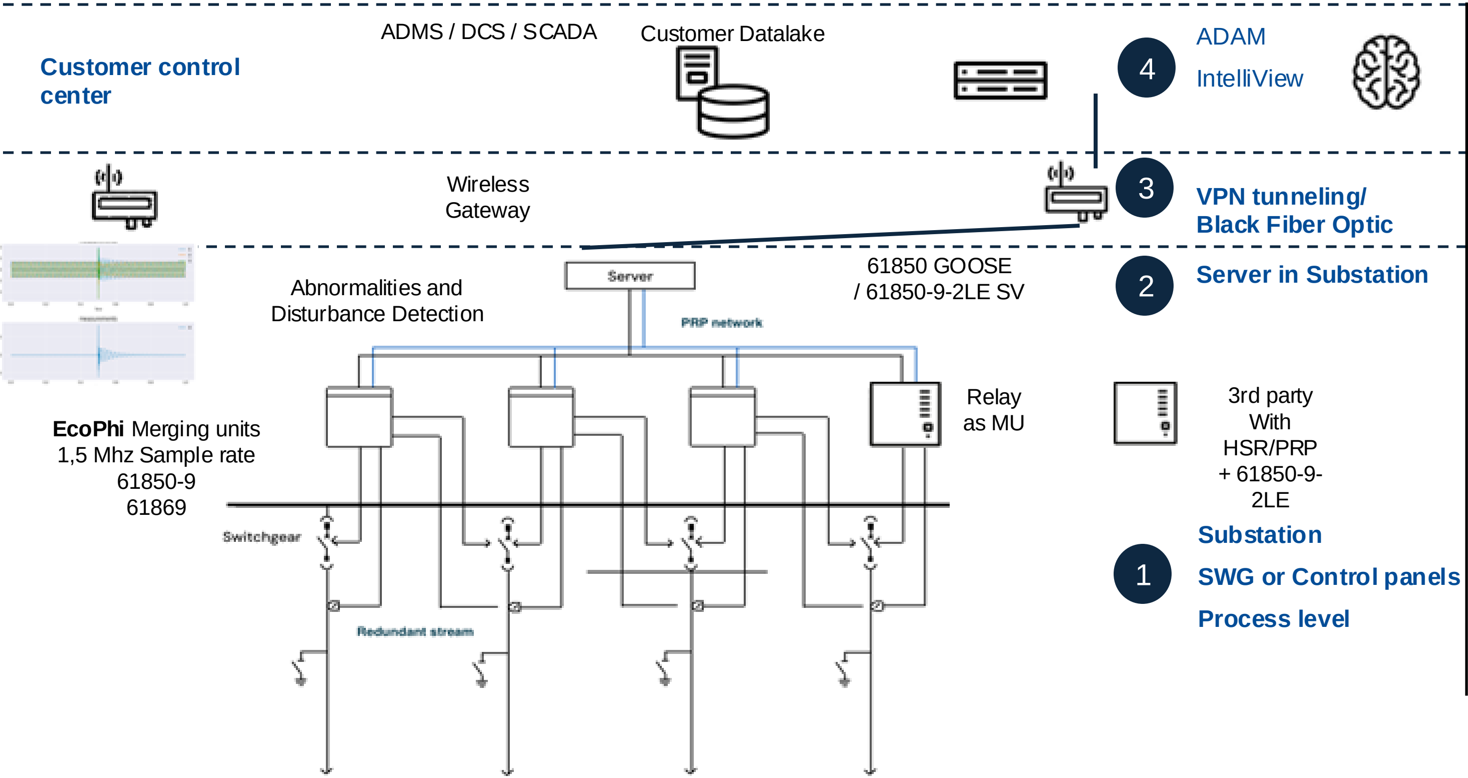
→ **Reduces costs related to O&M**
Related to interruptions, damaged equipment, components, etc.

→ **Easier integration of renewable energy**
A more stable grid is equal to easier implementation of renewable energy, which otherwise is more likely to create disturbances than "traditional sources" due to its limited supply.

Intelliview Platform

- Architecture

Costs / investments
Steps need to be taken



4 Stream to
to Data Center and GUI
Prepare M2M gateway
with Arctic Patrol VPN Gateway

3 Provided by or
Customer own VPN wireless GW

2 Stream Sample values to server such
as Dell XR12/Advantech
Anomaly Detection,

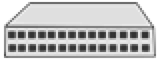
1 Investigate the Possibilities of
Streaming sample values from
Relays with 61850-9-2LE /
Installing EcoPhi Merging Unit
or 3rd party MU's with 61850-9-2LE
from all feeders

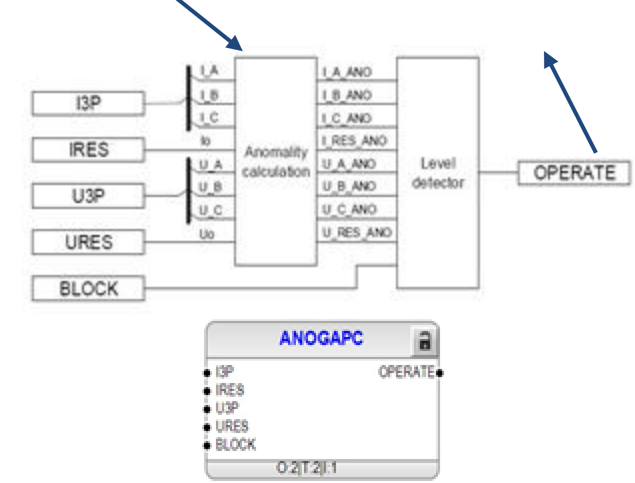
How it works

Technology Process

1. Anomaly Aggregation

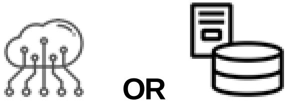
Eneryields' solution is compatible with customers existing measurement and data collection infrastructure, using SSC600 ABB relays. Consequently, no additional hardware is needed.





2. Data lake

The module can be cloud-based or stored on own internal server (on-premise).



3. IntelliView

Using an in-house developed state-of-the-art ML engine, the Intelliview software module processes voltage and current signals efficiently.

Analytics platform

- Detect anomalies with AI
- Identify underlying volatile data features
- Complete AI-powered disturbance analysis
- Predict incipient cable faults

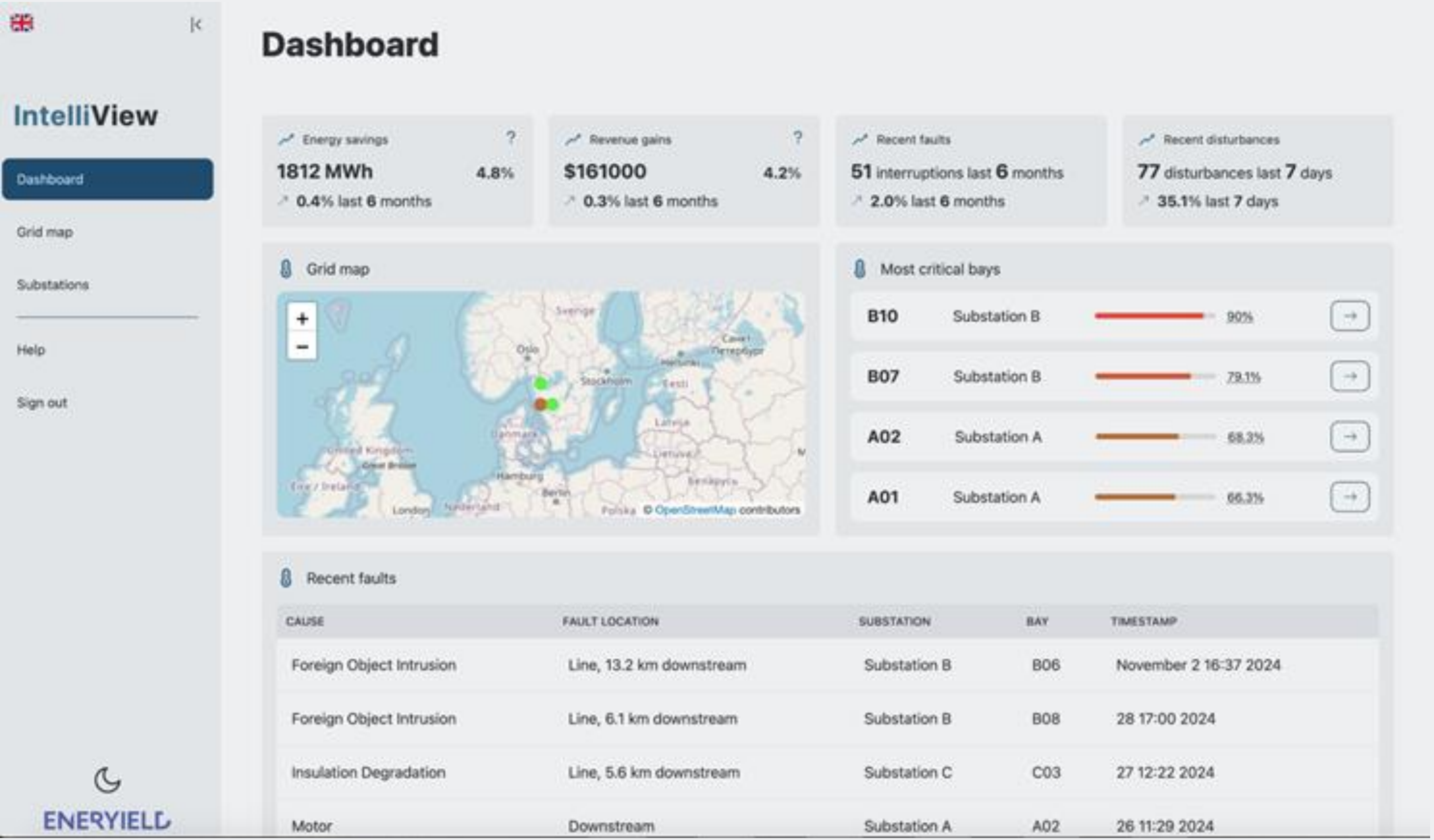
GUI

The interface is designed to be intuitive, ensuring easy navigation and leveraging explainable artificial intelligence for seamless management.

4. Insights

Ultimately, IntelliView is able to answer the following questions regarding a power failure:

When? Fault forecasting
Where? Fault localization
How? Root cause analysis
Why? Explainability



Dashboard explained

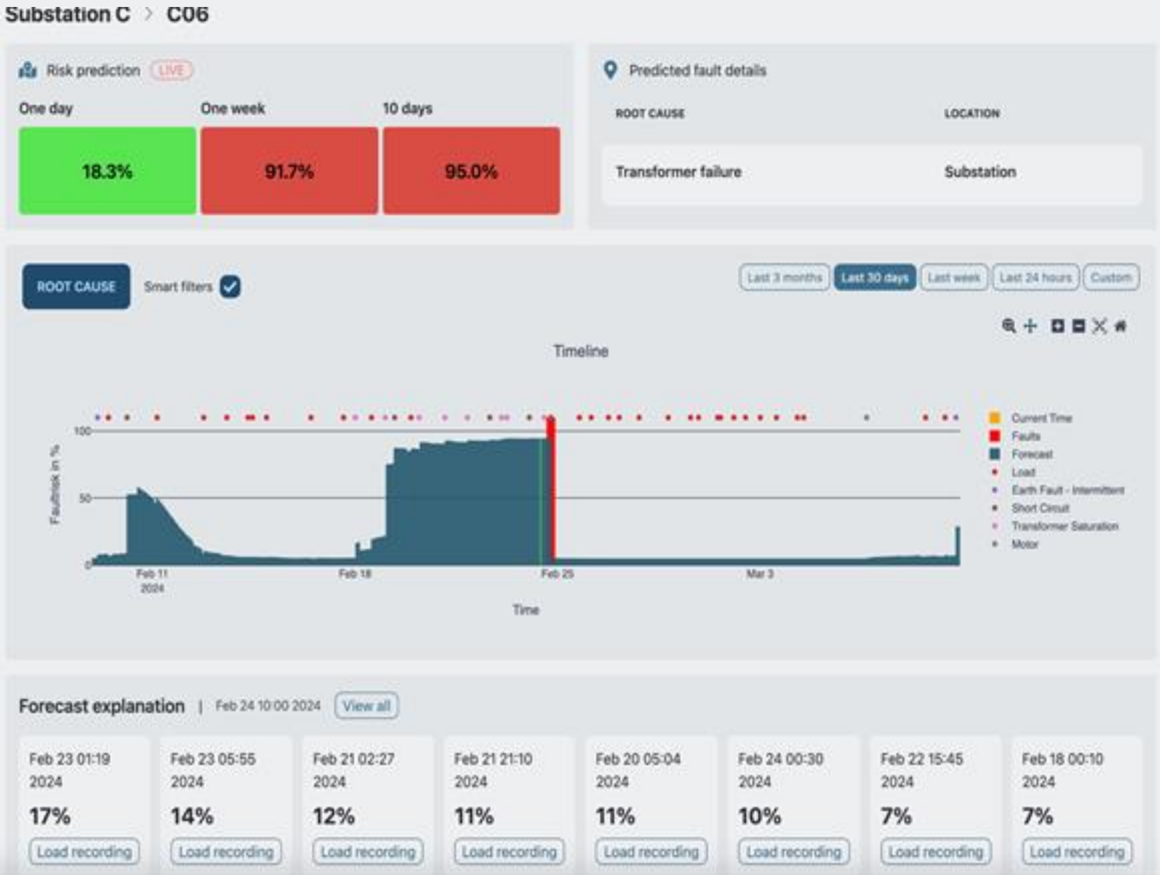
1. Experience the power of our GUI's energy optimization feature. Track your energy savings/technical losses in kWh and their percentage fluctuations over the past week, as well as witness the growth in revenue from saved kWh and its percentage change. Moreover, stay ahead with insights into predicted faults for the upcoming week, as well as understanding the impact of the last disturbance on operations in kWh. All in all, maximize efficiency, anticipate issues, and boost savings with this all-inclusive functionality.

2. Introducing the Grid Map feature in the GUI, providing an interactive layout of the grid with measurement points. Effortlessly maneuver the map, clicking on points to reveal specific details. Additionally, access single-line diagrams for a clear representation of each grid site. This functionality offers a user-friendly overview, aiding easy navigation and insightful analysis. Moreover, you can overview upcoming events by observing the colors of the substations and lines with Red (high risk of fault), Yellow (medium risk), Green (low risk).

3. Summary of the most critical locations for effortlessly accessing to site timeline and more insights.

4. View a concise list of root causes of recent disturbances, including type, severity, time, and location details.

Timeline - Prediction of fault (time, type & location)



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Timeline explained

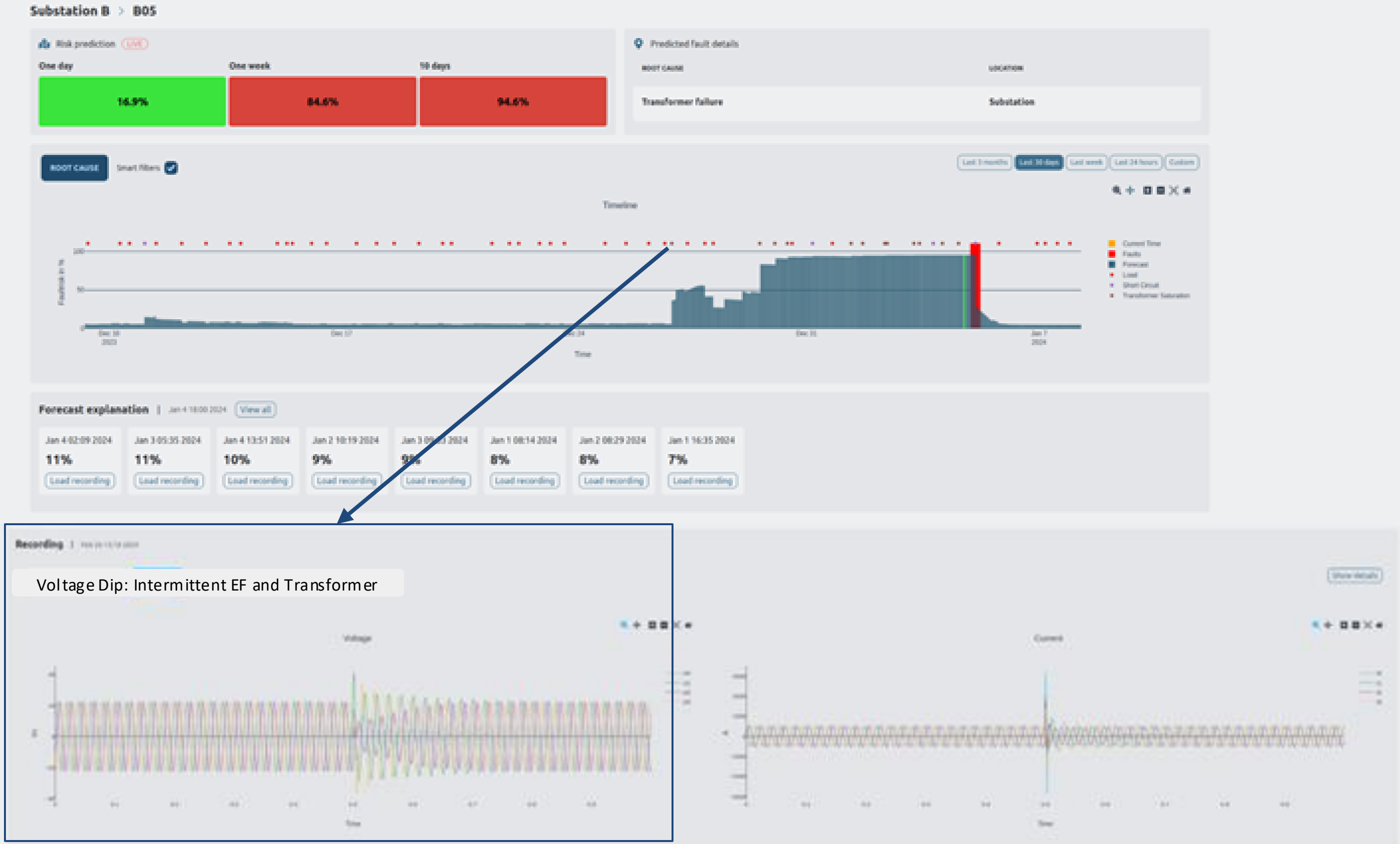
1. An intuitive way of surveilling the probability of a fault happening in various periods of time.

2. From the predicted fault details root cause and location are displayed. The software is capable of giving insights about the underlying reason of the fault as well as suggesting where it most likely has occurred.

3. In the zoomable timeline the historical faults are demonstrated as the orange lines. The smaller disturbances are visualized as colored dots, which can be filtered in and out by using the class filter button. The blue shadow is the forecast, and when it rises, it implies an increased risk for an incipient fault to happen. As seen in the example, it goes up well in advance before a fault occurs.

4. In the forecast explanation, explainable AI is used to e.g. highlight what smaller disturbances contributed the most to any fault probability at any given time. The recordings are easily accessed to be examined by the operator.

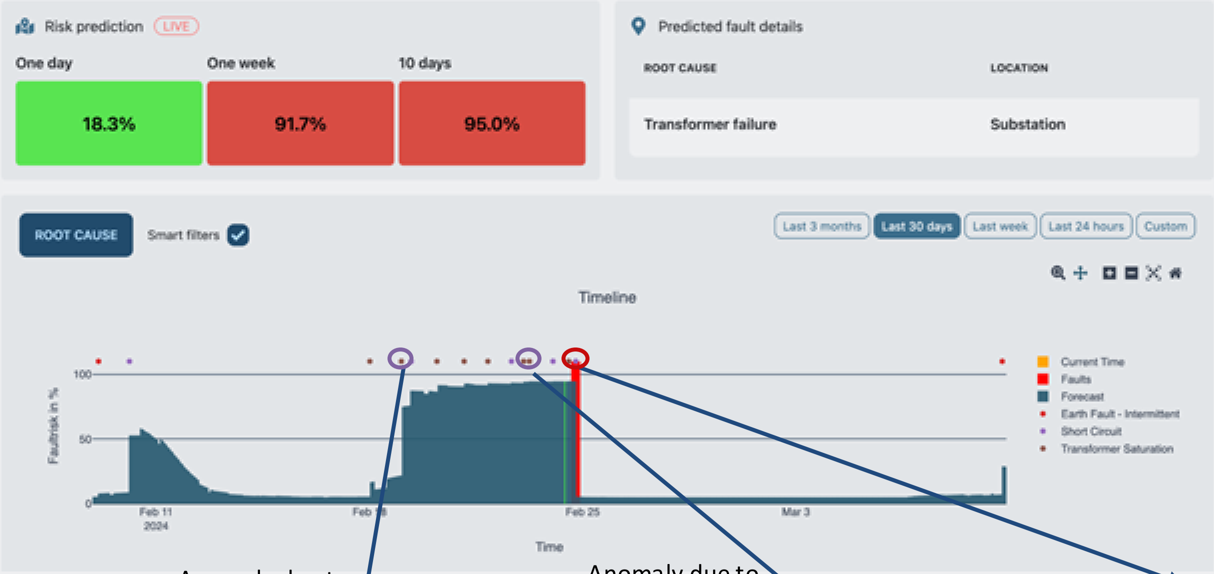
Anomalies Analysis



ROOT CAUSE LIST FOR ANOMALIES

- Voltage Dip
  - Faults
    - HI
    - LI
    - Intermittent
    - Short Circuits
  - Load Behaviour
  - Motors
  - Transformers
  - others
- Voltage Swell
- Transients
  - Intermittent EF
  - Switching
- Harmonics
- Unbalance

Understanding the underlying reason



Type and root cause of predictable faults

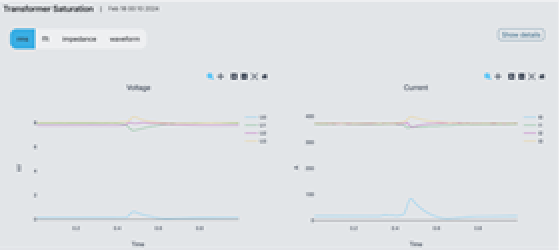
Faults on Substations

- *Joints*
  - Crack
  - Installation
  - Temperature
- *Transformers*
  - Bush
  - Core
  - Temperature
  - Tap changer
- *SG*
  - Jam

Faults on the Bays

- *Foreign object on the line*
- *Faults from Load behaviour*
- *Wear and tear in insulations*
- *Faults Due to Motors*
- *Motors failures*
  - Bearings
  - Short circuits
  - Overvoltage
  - Harmonics

Anomaly due to transformer



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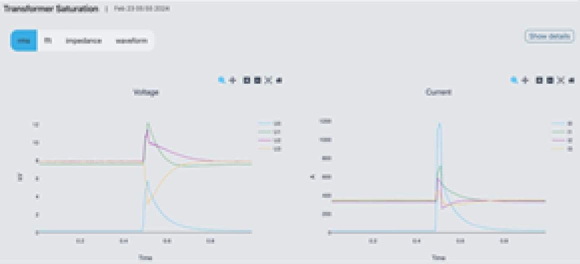
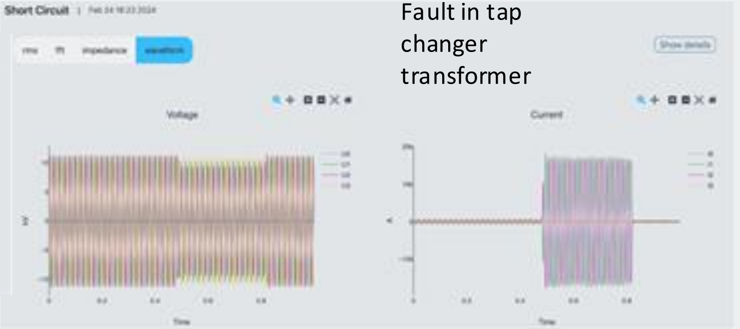
Anomaly due to transformer





Fault in tap changer transformer

Explainability

Explainability explained

Explainable AI refers to the methods and techniques in the application of artificial intelligence technology such that human experts can understand the results of the solution. It contrasts with the "black box" concept in machine learning, where even their designers cannot explain why the AI arrived at a specific decision.

By clicking the load recording button in the forecast explanation the user will have easy access to the disturbances that contributes the most to a high fault risk.

Here is a user friendly tool where the user can screen the disturbance utilizing various features such as rms, fft, impedance, waveform etc.

From the information the user will understand better how fault develops and thus how faults can be avoided using corresponding proactive measures

WITHOUT ADDING ANY NEW HARDWARE!

Warning

The module is able to generate an alarm for days, or even weeks before a severe fault occurs.

Cause

It understands and explains the underlying reason for the event, allowing the user to be aware and also avoid failure.

Location

It understands and explains where the fault has occurred, allowing the user to save time and resources to prevent the failure.

Explainability

The module uses explainable AI and is therefore capable of explaining why something is likely to occur by demonstrating features contributing to the high risk.

POSITIVE EFFECTS

- Reduced number of outages
- Reduced outage time
- Reduced O&M cost

- Increased life-lengths of components
- Increased grid stability
- Eased implementation of renewable energy sources

Results

10-20%

in cost savings

related to O&M

67%

Reduction in Outages

99%

successful prediction

on a weekly horizon

highlights the vast landscape of forthcoming opportunities.

New York Power Authority

Prediction of incipient faults in underground transmission cable

Project Overview

In October 2021, Eneryield together with New York Power Authority (NYPA), and Electric Power Research Institute (EPRI), initiated a collaborative project with the purpose of identifying interruptions in an underwater cable running between Long Island and mainland New York. The project focused on collecting and combining historical data from various sources and applying AI/ML techniques with the goal of identifying small anomalies, deviations, and patterns that can be used to predict incipient but larger cable disturbances/faults with as long a time horizon as possible. Key research questions include the following:

- Can AI/ML techniques identify data correlations, indicators, and characteristics to help predict incipient failure of buried/underwater cables, going beyond the capabilities of more conventional analysis techniques?
- What are the minimum data requirements for getting high value from AI/ML techniques in this application, what level of confidence can be assigned to specific uses, and what are the key drivers?

To support the project, NYPA facilitated access to data resources - including historical records from power quality meters, relays, and phasor measurement units - relevant to the condition and performance of the Y-49 cable system, an underground and undersea connector between the two locations. A total of 155 Comtrade-format data files were initially identified, of which 87 were found to have potentially useful data. The data were divided into two sets, the first used for training the AI/ML system and the second for validating its ability to predict faults before they happened, using a blind data set from an existing Y-49 cable failure. High-pressure fluid-filled (HPFF) cables underpin the majority of U.S. underground transmission systems, and many more of these cables are reaching or have exceeded their design lifetime of 40 years. Innovative methods for detecting incipient cable failures are needed to prevent high-impact events, improve reliability, and optimize asset management and maintenance interventions. This project was initiated to test Eneryield's machine learning (ML) algorithms and other AI-based techniques for generating data-driven insights and predicting imminent disturbances or HPFF cable faults.

Outcome

Preliminary results show that initial cable faults can be predicted within 2 months of occurring and with an 80% level of confidence. Even more impressive, subsequent faults following the initial one can be predicted within 24 hours of occurring and with a near 99% level of confidence.

"A system that can predict problems and identify causes could be invaluable in maintaining the resilience of the transmission system not only for NYPA but other utilities as well"
- Alan Ettlinger
(Senior Director of Research, Technology Development and Innovation for NYPA)

ENERYIELD ABB | Vaasa Electricity Network

Prediction of grid faults using relay data

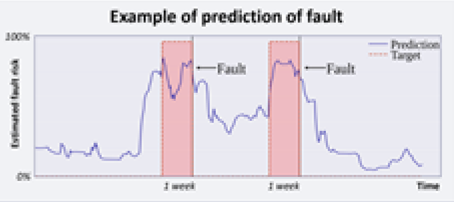
Project Overview

ABB, a global leader in power and automation technologies, is stepping up to the challenge of an increasingly electrified society's reliance on uninterrupted power supply. ABB has decided to use a solution from Eneryield after conducting several successful pilot projects both in distribution and transmission lines.

The solution addresses the need for improved networks and operational practices among transmission/distribution system operators (T/DSOs). These improvements aim to reduce the number of interruptions in the power supply and enhance fault localization, isolation, and supply restoration processes to minimize the duration of faults when they do occur. Eneryield's solution utilizes a machine learning-based fault prediction method, designed to foresee incipient faults. This forward-thinking approach allows T/DSOs to take preventative action before a fault occurs, thus helping prevent customer outages. By using Eneryield's solution, ABB is taking a proactive stance in ensuring the reliability of its power supply, significantly enhancing its ability to predict and prevent faults, and ultimately improving customer experience by minimizing potential outages.

In summary, the collaboration yielded the following outcome:

Sensitivity: Successful prediction of 67% of the faults
Reliability: 99%



*The blue line represents the forecasting of incipient faults.

One week prior to their occurrence, faults could be accurately predicted. Furthermore, the prediction was achieved solely by utilizing existing measurements of current and voltage, eliminating the need for any additional sensor installations.

ENERYIELD ABB VAASAN SÄHKÖVERKKO

Live Demo?

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