ELECTRIFICATION | DIGITAL

# ABB Ability™ electrification solutions

Reliability and Asset performance management

ABB

# Global growth drivers require more reliability


## Data and digitalization

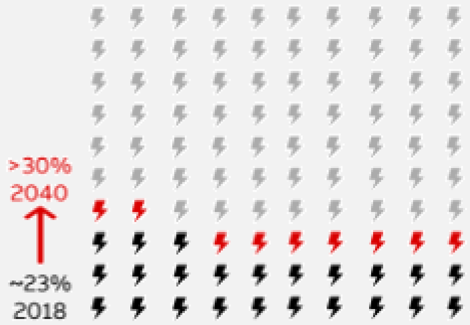
**7.5x**

Increase in data processed outside of originating core


## Urbanization

**+2 billion**

people living in cities




## Shift to electricity

**+35 %**

share of electricity in the energy consumption mix

# How digitalization helps electrification reliability and power availability

*Asset performance management (APM) systems act to improve the reliability and availability of physical assets while minimizing risk and operating costs.*

**Keep production up and running**
Mega-trends are challenging industries to get higher availability, sustainability, and flexibility.

**Installed base**
Getting older, so with higher risks in terms of safety, flexibility, scalability and security.

**Optimize maintenance**
Decreasing maintenance budgets, higher system complexity and quicker troubleshooting

**Risk of failure**
Direct and indirect costs, getting higher nowadays due to reasons above.

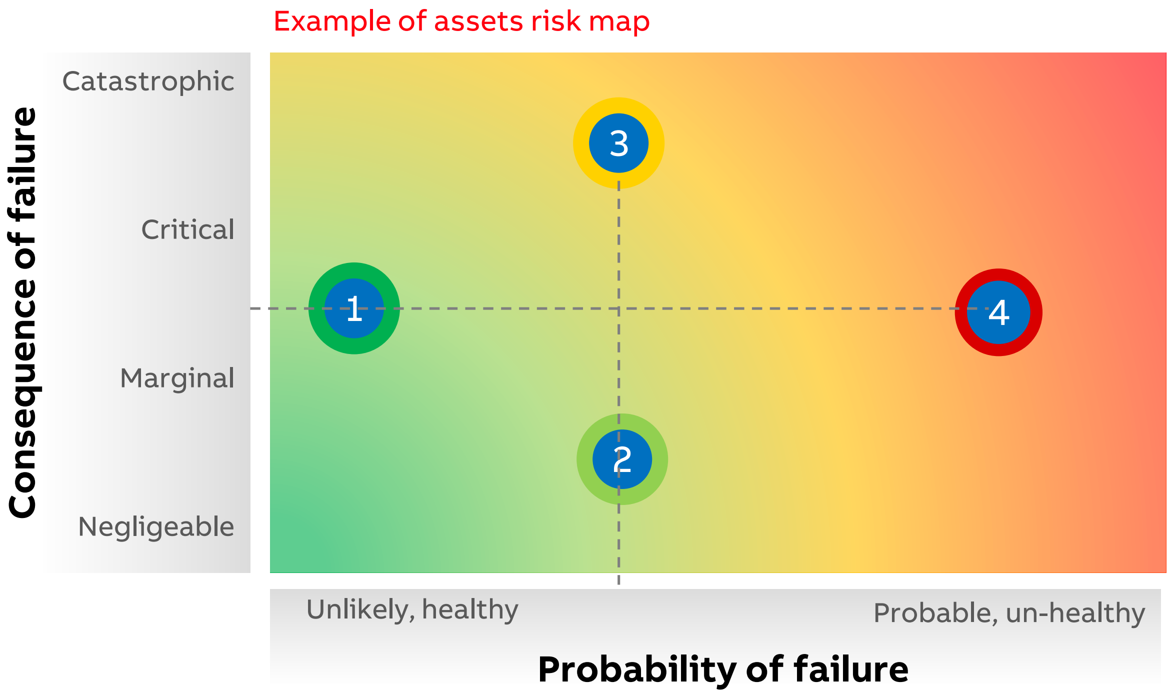
# Risk of failure (RoF)

Asset managers, facility managers, maintenance managers apply (maintenance and asset life cycle) strategies to keep under control the risk of failure. It is made of two factors: consequence of failure (CoF) and probability of failure (PoF).

Example in the risk map:

Asset (1) and (4) have same level of criticality but different health condition.
(4) needs to be addressed first.

Asset (2) and (3) have same health condition, but different critical level.
(3) needs to be addressed first.



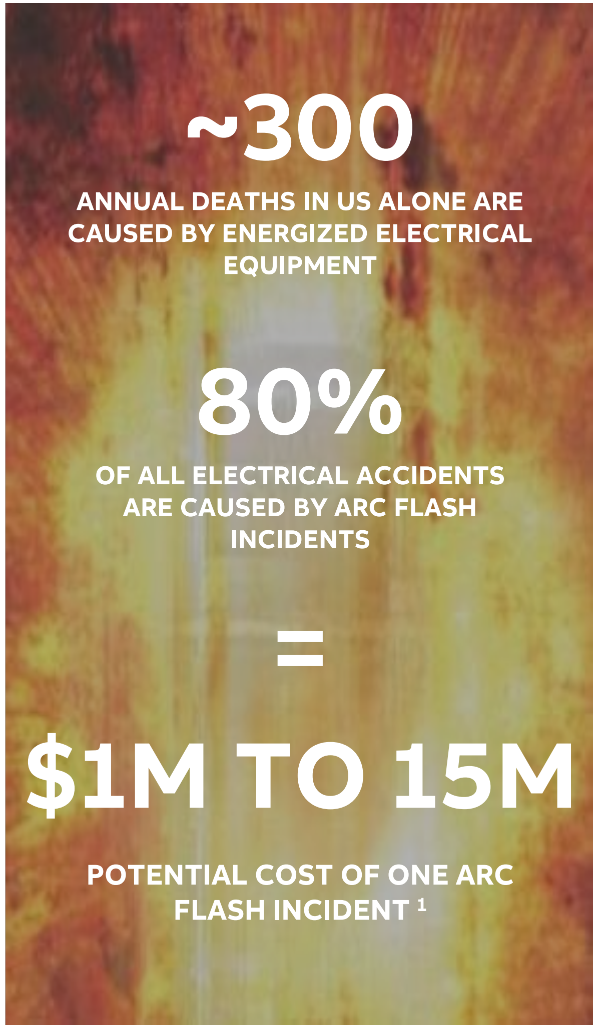

**Risk = Probability x Consequence**

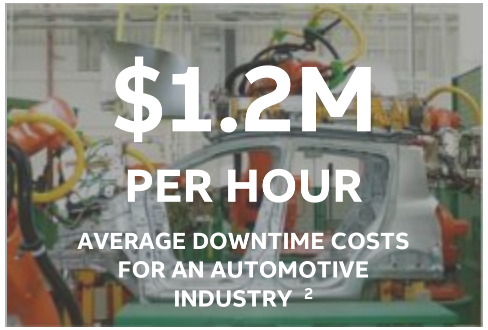
# Consequence of failure

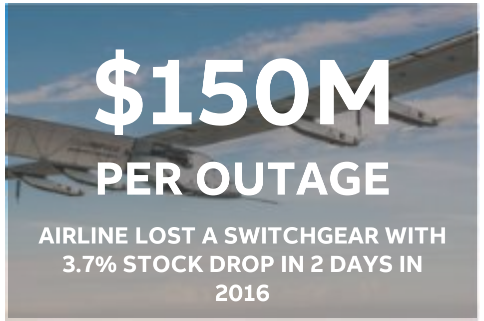
It is the severity of the consequences of failure.

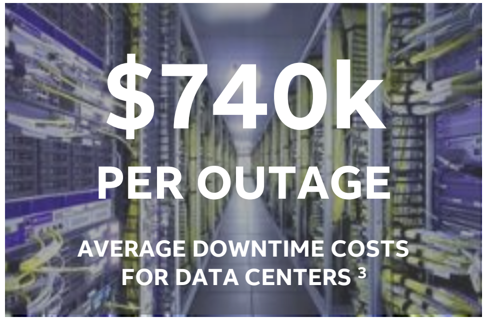
It can go from “negligible”, like a spare feeder, up to “catastrophic“, like a main incomer - which might include matters such as loss of life and injury to persons.

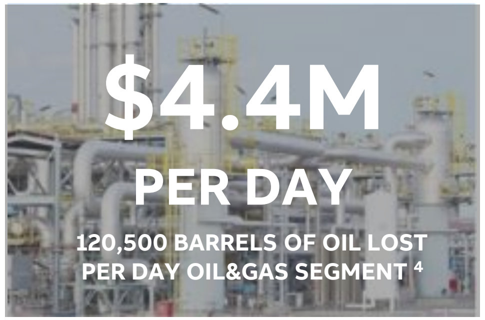
Type of Consequences:
- Physical (e.g. assets disruption)
- Financial (e.g. increased costs, loss of production)
- Legal (e.g. fines, penalties)
- Social/psychological/community






1) A 1999 Electric Power Research Institute (EPRI) study pegged total direct and indirect costs of an arc flash incident
2) News.thomasnet.com/company story/downtime-costs-auto-industry-22k-minute-survey-481017
3) Cost of Data Center Outages, Ponemon Institute
4) The Economic Impact of August 2003 Blackout done by ELCON

# Maintenance strategy

To keep under control the probability of failure of an asset, different maintenance strategies are available:

- **Corrective maintenance**, or run-to-failure: do maintenance only when problems occur
- **Preventive maintenance** regularly scheduled, using either time intervals, usage (operations/cycle count) as a trigger. It can be enhanced with root-cause analysis and troubleshooting instructions **(proactive).**
- **Condition-based maintenance**, is a preventive maintenance supported by condition monitoring of the asset, with basic diagnosis on read values.
- **Predictive maintenance**, combines various sensor readings (condition monitoring), sometimes external data sources and performs powerful analytics on thousands of logged events/data (e.g. simulation, statistical analysis, etc). It can be enhanced further adding **prescriptions** to support the mitigation actions

| | Corrective maintenance | Time-based maintenance | Condition-based maintenance | Predictive maintenance |
|---|---|---|---|---|
| **Indirect costs (consequence of failure)** | Probability of failure not under control. Highest risk of production/ service loss | Probability of failure under control just after the recurrent inspections | 24/7 monitoring of data correlated to relevant potential failure causes | Continuous prediction of probability of failure and remaining life |
| **Direct costs (maintenance and spares)** | No maintenance, just CAPEX to restore at failure | High maintenance costs, due to recurring equipment inspections | Less maintenance costs due to reduced inspections | Lowest maintenance costs only when required |

# Predictive maintenance

**Preventive maintenance (time-based)**
It assumes that the probability of equipment failure increases with use, which is not often the case (usually there is a random pattern [1]). Every asset has a maintenance plan, based on manufacturer instructions or experience.

**Predictive maintenance**
It is based on condition monitoring data to predict failure. Maintenance when (date) and where (asset) required. It can go also further by combining multiple variables with analytics to predict failure with a higher degree of confidence and fewer false positives.

[1] Source NASA and US Navy: 18% of failures are age related, and 82% have a random pattern. So, preventive maintenance (PM) provides a benefit for just 18% of assets.

Example based on ABB experience

| Equipment | Maintenance | Frequency | Time/ asset | Predictive |
|---|---|---|---|---|
| MV circuit breaker | Visual/Basic | 2 years | 2 h | 0 h |
| | Advanced | 5 years | 2 h | 1.4 h |
| MV switchgear | Visual | 0.5 years | 0.5 h | 0 h |
| | Basic | 5 years | 0.75 h | 0 h |
| | Advanced | 10 years | 2.5 h | 1.75 h |
| | | | **USD 336 /y** | **USD 168 /y** |
| Low Voltage Motor | Basic | 1 year | 1 h | 0.25 h |
| | Advanced | 1 year | 4 h | 0 h |
| | | | **USD 250 /y** | **USD 113 /y** |

**100%**

**PREDICTION AVOID HIGH COSTLY UNPLANNED LABOR**

**30%**

**DECREASE MAINTENANCE TIME**

**=**

**40%**

**OPEX COST REDUCTION**

# ROI: case of a manufacturing plant

**Predictive maintenance on existing MV switchgear (20 panels/breakers)**

Historical information about failure avoidance savings:

- Avg CoF, caused by MV switchgear[1] (partial production loss + restoration) = $50K / h
- Avg downtime in last 10 years due MV switchgear = 0,2h/y (avg costs = $10k/y)
- Savings using predictive analytics (70% monitorable failure causes) = $7K/y

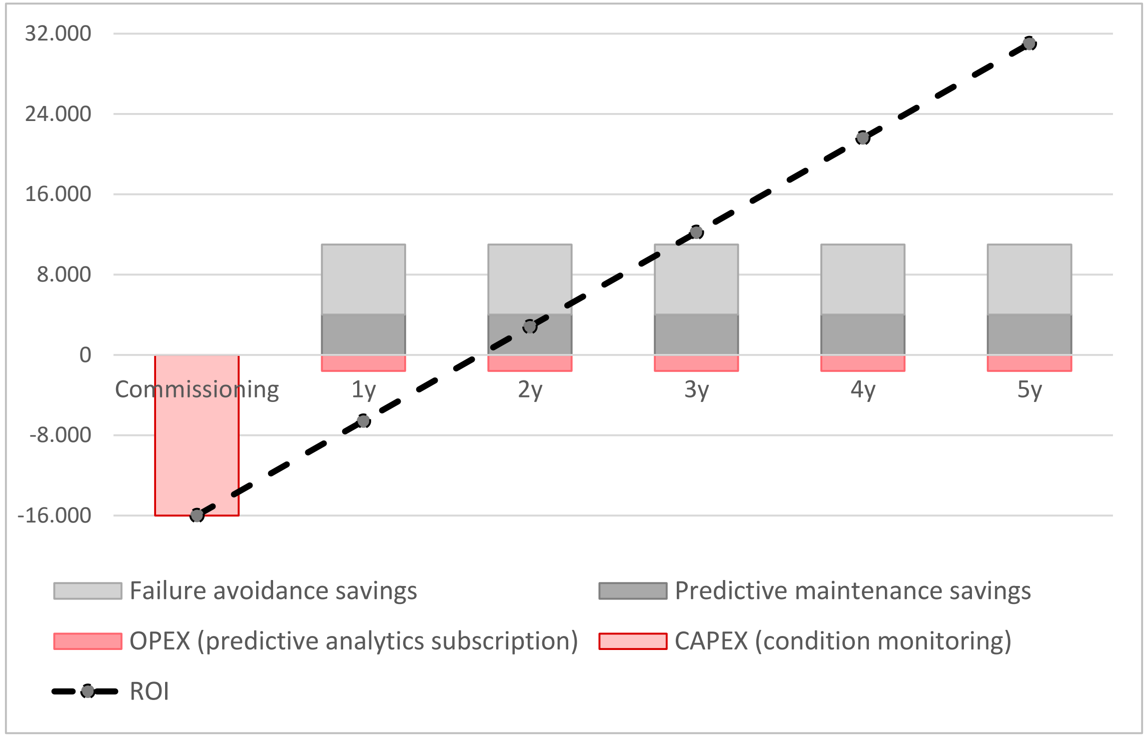
Historical information about maintenance savings:

- Average time-based maintenance costs = $8k/y
- Average predictive maintenance costs = $4k/y

Information about smart equipment, sensors and analytics costs:

- Digital equipment (condition monitoring, sensors [2]) + commissioning = $16k
- Yearly subscription for predictive analytics = $1,6k/y

[1] One failure 5 years ago interrupted unexpectedly partly the production for 2h
[2] Includes: circuit breaker mechanical and electrical monitoring, environmental condition monitoring and switchgear main joints thermal monitoring.



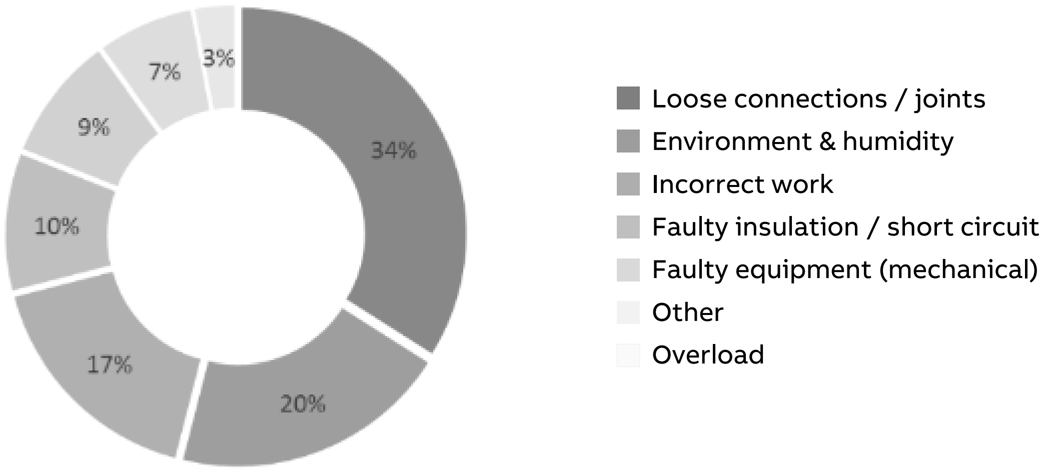

**ROI = 1,6y**

# Monitoring main electrical failure causes

An efficient and effective condition monitoring solution focuses on most important **failure causes**.

**Sensors** and other data sources support the potential failure causes monitoring, substituting the usual manual time-based inspection and maintenance.

A **diagnostic** algorithm typically is required to highlight an abnormal condition (e.g. a temperature over a threshold), which could lead to a potential failure.




| **Manual (corrective or time based)** | **Automatic (condition monitoring)** |
|---|---|
| Temperature power parts inspection (require shutdown) | Continuous joints temperature monitoring |
| Environment assessment (might require shutdown) | Continuous environmental monitoring (temperature, humidity, etc) |
| Insulation inspection and tests (might require shutdown) | Continuous partial discharge monitoring |
| Circuit Breaker Periodical tests (requires shutdown) | Continuous operations monitoring with protection relays |

# Running predictive maintenance

**Why?**
Predictive maintenance provides benefits that improve the bottom line, with a focus on maintenance and retrofit cost optimization. It is not just cost effective maintenance with maintenance based on best predicted scenario, but also full visibility on assets risk analysis, used to prioritize remedial actions. Accurate prediction saves from costly breakdowns.

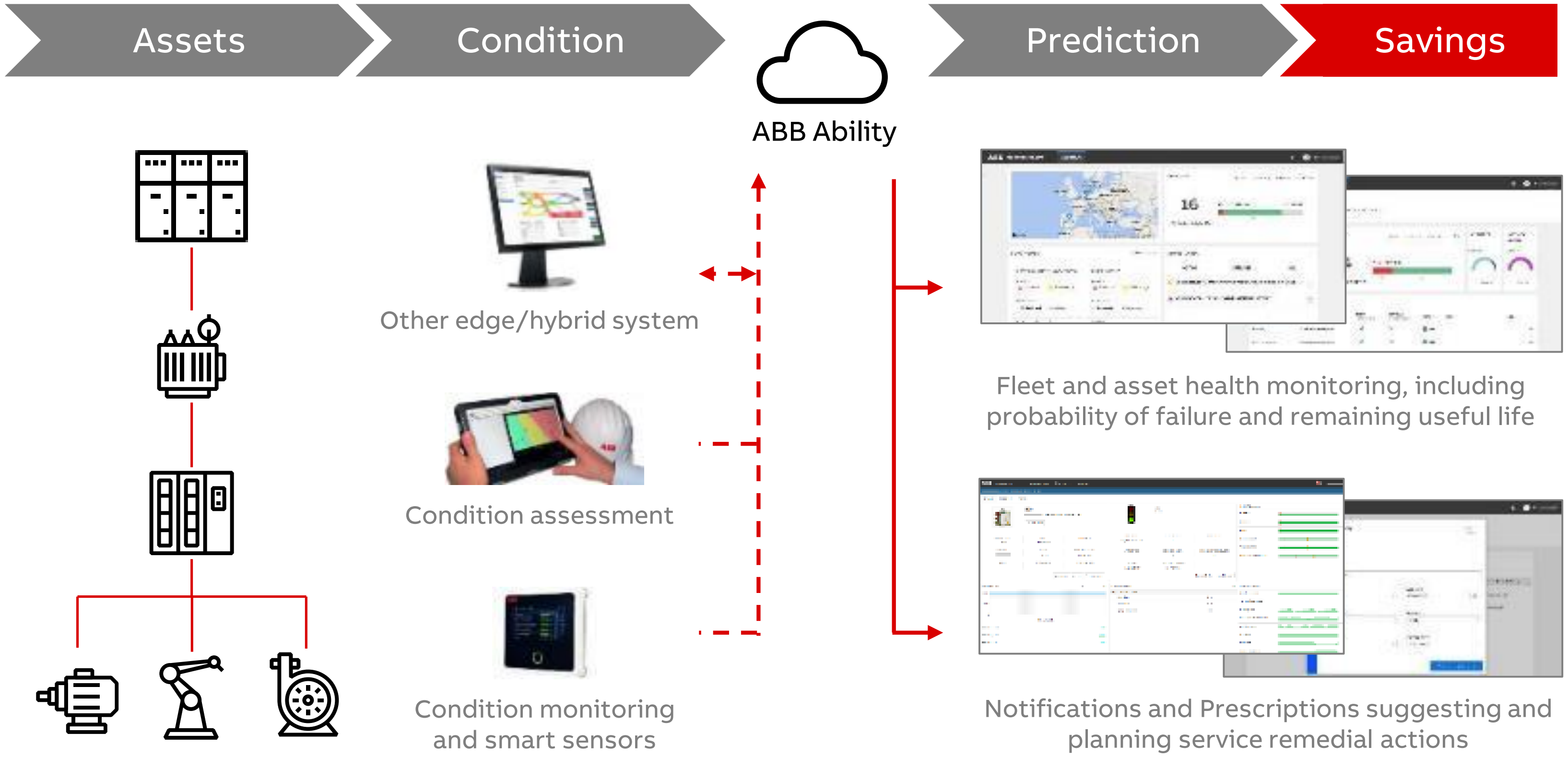
**How?**
Predictive maintenance is based on predictive analytics, which exploits collected data with offline assessment and/or online condition monitoring.
Typical calculated outputs are probability of failure within a year, remaining useful life, service prescriptions, and risk map analysis.

## Asset condition data collection

Relevant electrification assets in the plant can be monitored to track condition. Raw and calculated data can be predictive analytics.

## ABB Ability™: gain insights on assets

ABB Ability solutions offers asset health dashboard, and predictive analysis to optimize maintenance and improve availability, reliability.

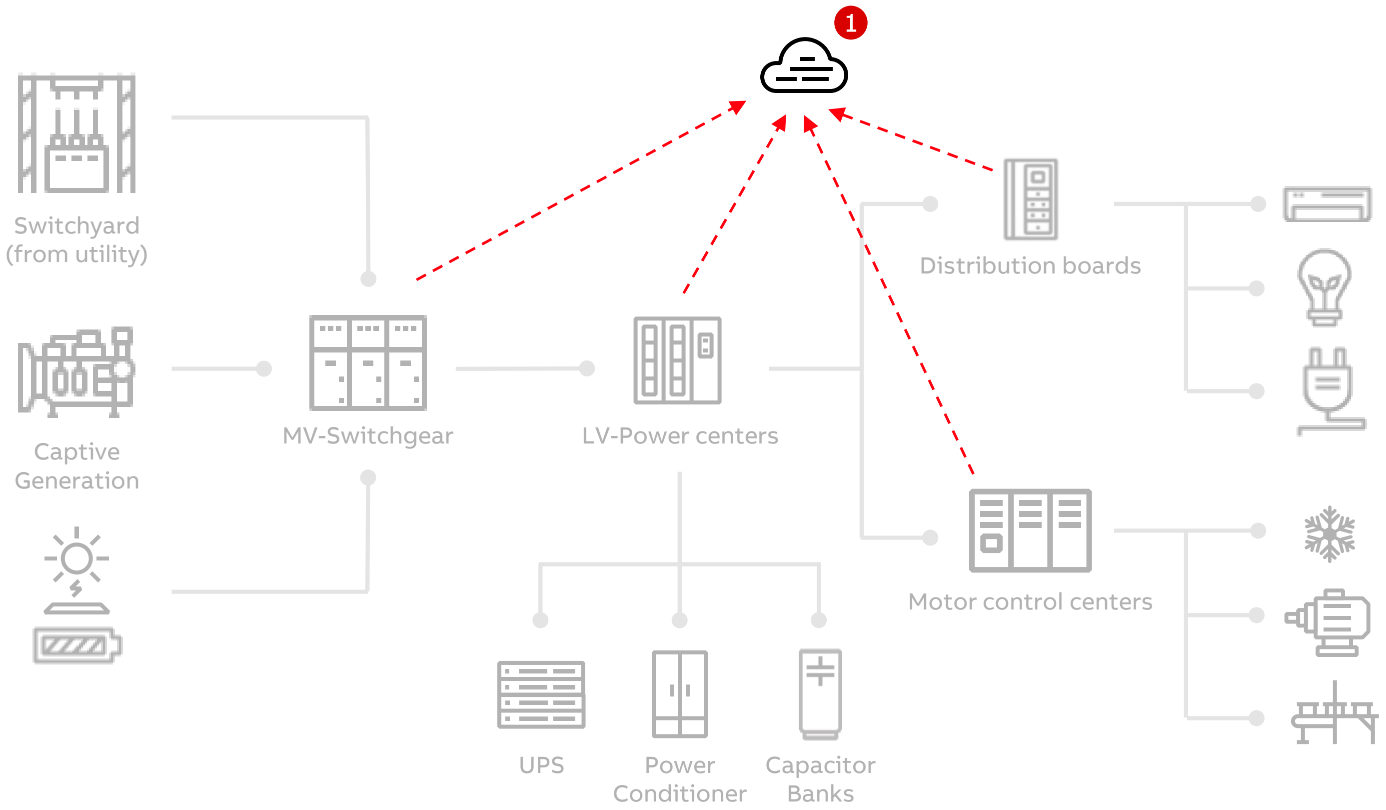


# Predictive maintenance: analytics

Site and multi-site asset health analysis to predict and notify potential faults, minimizing maintenance, while increasing safety and asset lifetime.

Typical algorithms:

- Statistical modeling/regression analysis of physically observable characteristics in a piece of equipment, recorded over a period of time
- Proprietary algorithms, based on physical models
- Monte Carlo simulation, to estimate probability of failure in next 12 months and remaining useful life.
- Other advanced techniques (machine learning, neural network analysis) can be applied on specific failure modes, equipment and sensors




1 ABB Ability™

# Predictive maintenance: example

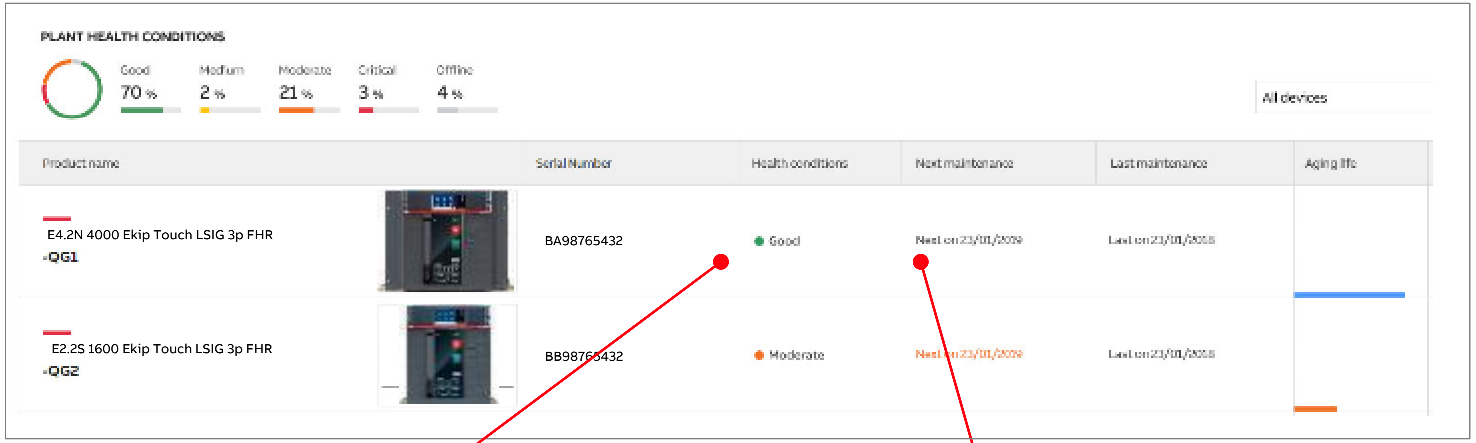
ABB Ability™ enables a digital twin of the electrical system, with health information and maintenance planning (prediction).

Remote supervision of the facility (multi-site): owner or service provider can take action everywhere, anytime.

Ease of use: interactive images through tags & markers.

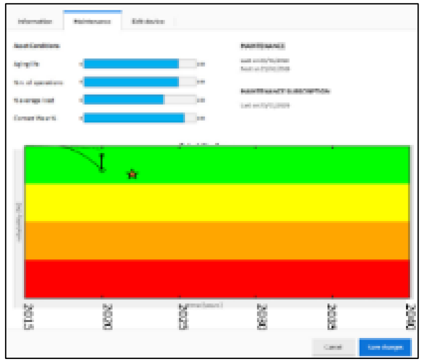
Alerts management: reduce downtime and service planning

**Plant and asset health conditions**




**Digital twin of each monitored component**

**Next maintenance plans**



# Digitalization support from design to service

## Digital specialists

Local technical teams, able to consult on how to digitalize the electrification system and apply asset management solutions.

## Service centers

Supporting the customer in adoptive predictive maintenance, offering Power Care service agreements with remote support and extended warranty.


ABB