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Intelligent Optimization

Digital twints and conventional solutions connectivity for a better efficiency

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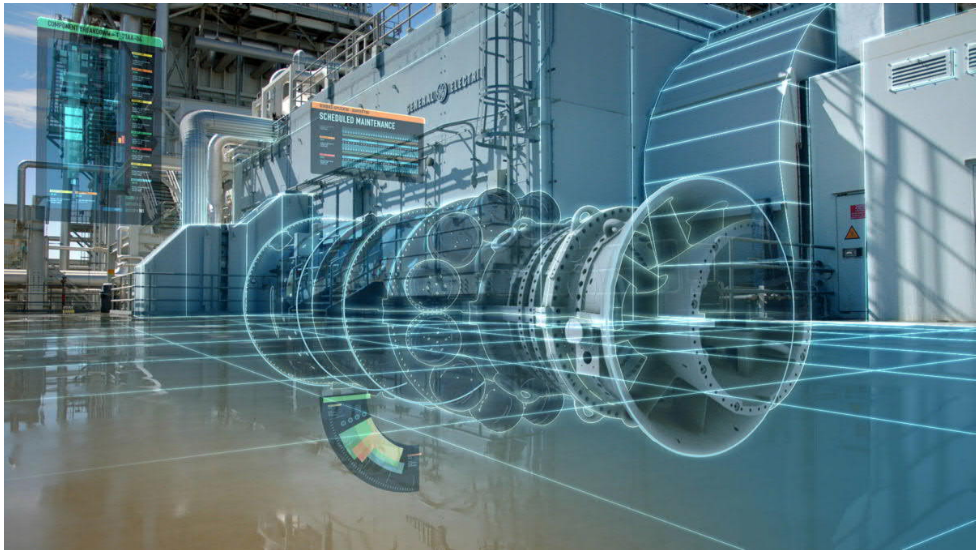
Digital twints and conventional solutions connectivity for a better efficiency

Rise to Intelligent Optimization

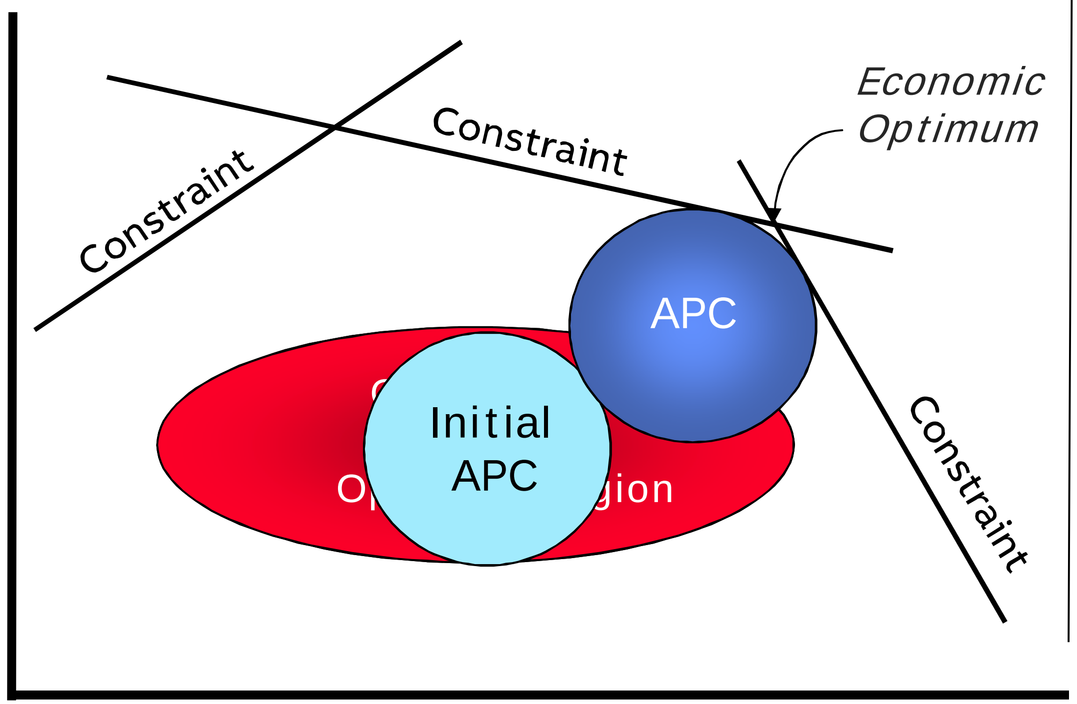
SUMMARY

- Advanced Process Control
- Plant Optimization
- Large Systems Optimization
- Asset Performance Management
- Perspectives



Advanced Process Control

APC for Unit Efficiency improvement

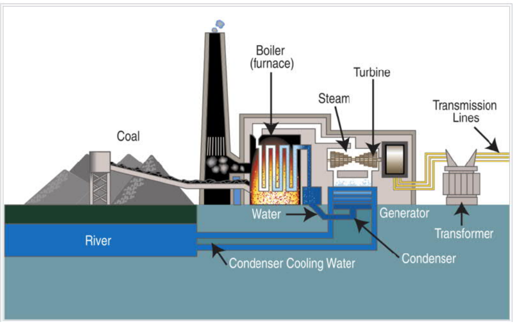


Overview

- Advanced Process Controls are typically added to basic plant control to address particular performance or economic improvement opportunities in the process and its market is continuously growing (almost $1.5 billion by 2020).
- APC is often based on a digital twin (dynamic multivariable model) of the process. The dynamic model predicts the output response to input changes allowing the optimization of the future trajectory. This allows incorporating also possible future disturbances, operating priorities and process constraints.
- The APC capabilities allow the repositioning of operating area passing from the Comfortable region (safe but not really efficient) to the Optimal region (more critical but more profitable).
- Typical applications are: Combustion Optimization to improve efficiency and reduce NOx pollution, Steam Temperature Advanced Control, Fast Startup and plant dynamics improvement to increase flexibility, cogeneration network optimization to reduces the losses, etc.

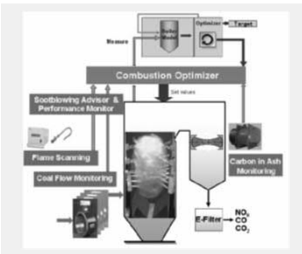
Advanced Process Control

Coal Fired Plant



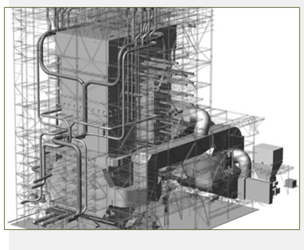
3 new hyper-supercritical boilers with a total of 1,850 MW.
The plant has undergone advanced controls projects which support competitive economic participation wholesale market, as well as more stringent environmental requirements

ABB Applied Solutions



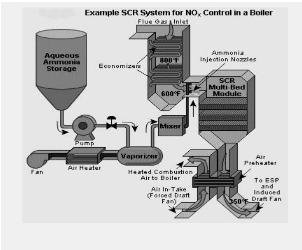
Combustion Optimization

- Enhanced Boiler Efficiency
- NOx reduction
- CO reduction



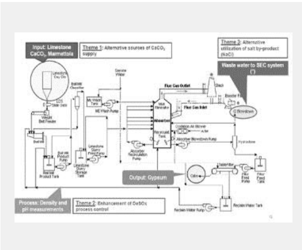
Steam Temperature

- Reduction of the variance of steam temperature
- Safe increase of the steam temperature target
- Increase of load and efficiency



DeNOx

- Chemicals (Ammonia) consumption reduction at same conditions
- Avoid ash contamination with ammonia



DeSOx

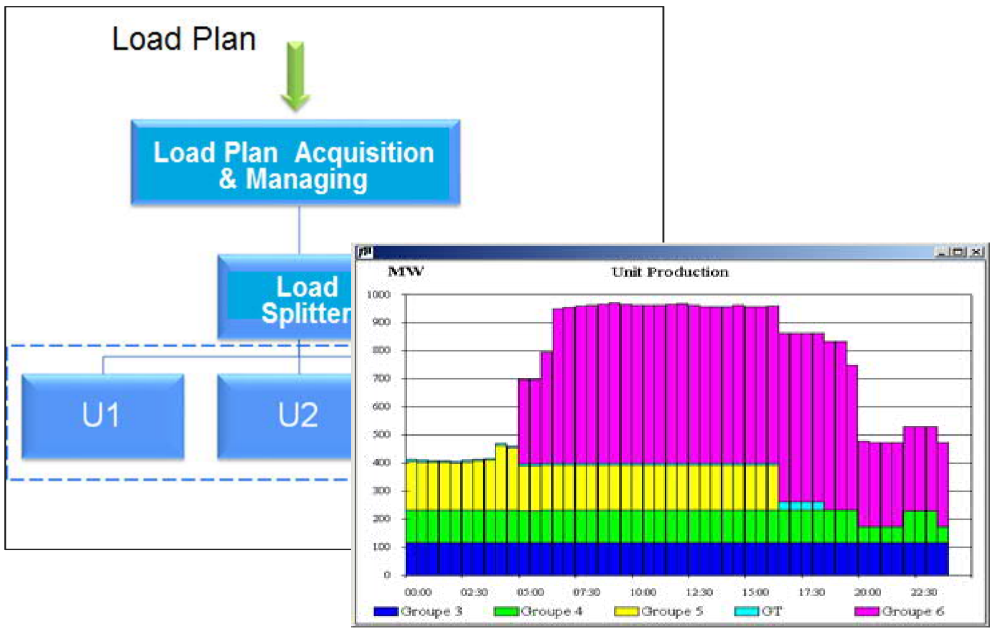
- Chemicals (limestone) consumption reduction at same conditions
- Better quality of gypsum produced by the reaction with limestone.

Challenge based on economic benefits and not only the cost!

Plant Optimization

Optimization of Multi-Units Plant

Overview



– Digital Twin
- Each unit model takes into account efficiency, production limits and other constraints, effect of the external conditions, simplified dynamics.
- Common models like cogeneration header pressure and temperature, storage, etc.

– Scope
- Optimal Load Sharing
- Optimal management of external requests (e.g. from Authority)
- Automatic start-up/shutdown of the units according to the optimization strategy

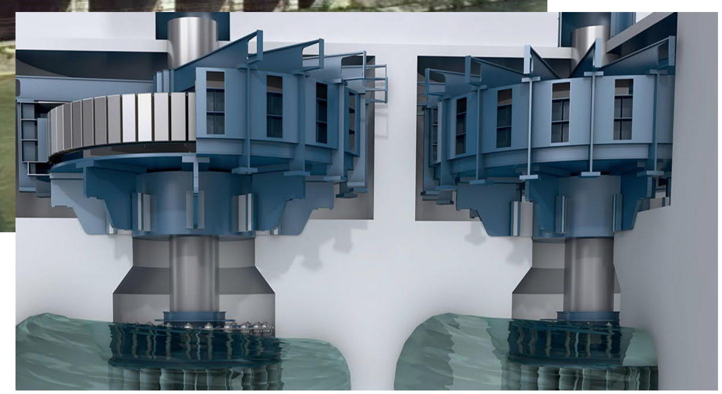
– Benefits
- From 1 to 5 % of the efficiency improvement respect to conventional strategies based on priority.
- Simplified devices management for the operation personnel
- Reduction of unbalance penalties
- Higher operation flexibility

Plant Optimization

Hydro Power Plant

ABB Applied Solution

- Objective: Increase the power maintaining the total flow required by the basin level control for a plant composed of 7 Francis turbines 1.5 MW each.
- Solution: Installation of optimization system instead of already existing management based on priority.
- Activities:
  - Description of the problem in terms of optimization problem and its implementation inside the HMI station, exchanging data via OPC
  - a control based on priority remains as degraded operating mode.
- Advantages: comparing with the previous system the relevant benefit was a load increasing of about 3-5% during the period of partial load, with additional profits of 0.15 M€/ year and a payback period all inclusive of about 4-6 months.



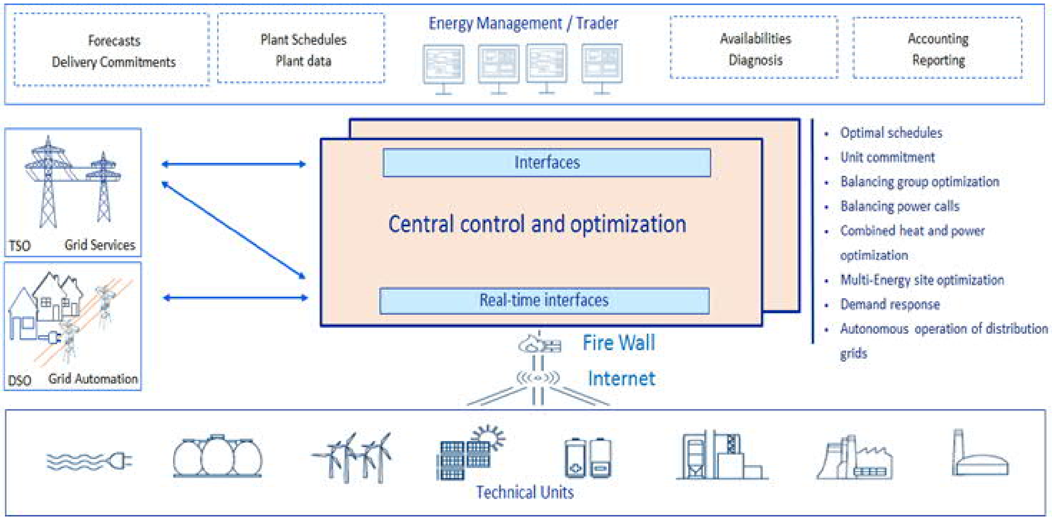
HPP Tombetta
AGSM Verona

Large Systems Optimization

Optimization of a Fleet of Plants

Overview

- Strategic Resources Optimization for a Fleet of plants: short term (minutes), mid term (from hours to few days), long term (weeks or months).
- The Digital Twin of a single plant is substantially represented by the load capability (min-max), efficiency curve (load vs. consumption) with relevant correction curves and other constraints (e.g. cogeneration constraints).
- For large time horizons the system takes into account not only technical and economical boundary conditions, but also other aspects (prices trend, maintenance, etc.).
- The core of the system is a quite complex Optimizer and the plant digital twins with a feedback mechanism.
- Typical applications are:
  - Productive park like industrial compounds
  - Micro-Grids
  - Virtual Power Pools



Large Systems Optimization

Virtual Power Pool: why this new energy subject ?

Virtual Power Pool definition

When the penetration of renewable is high (greater than 20-25%) it is required to adopt adequate countermeasures to ensure the grid stability. One of them is the Virtual Power Pool, which aims at smoothly integrating a high number of energy units into existing energy systems. The flexibility coming from all networked units and allows Virtual Power Plants gradually take over the role of traditional power plants, selling their output on wholesale markets and assuming responsibility for a balanced grid.

Virtual Power Pool Typologies

- Virtual Power Plant (UVAP) aims at smoothly integrating a high number of energy production units into existing energy systems.
- Demand-Response (UVAC) is a change in the power consumption of an electric utility customer to better match the demand for power with the supply. Demand response seeks to adjust the demand for power instead of adjusting the supply.
- Mixed Virtual Power Pool (UVAM) is a mix of UVAP and UVAC.

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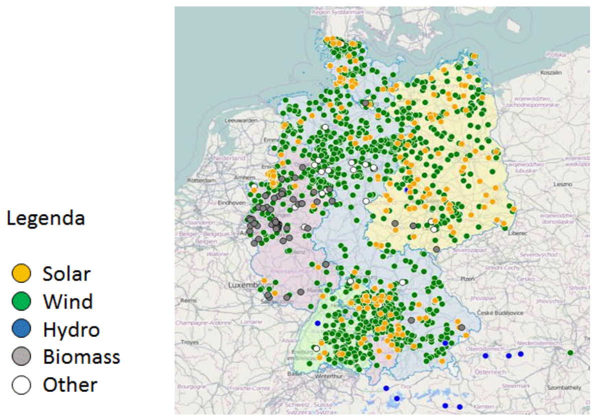
Large Systems Optimization

Virtual Power Plant

ABB Applied Solution

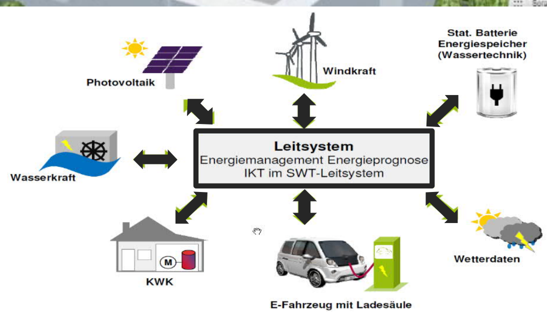
- Virtual Power Plant 2.800 units and 1.5 GW installed base (one of Europe's biggest virtual power plant)
- Ancillary services for secondary and tertiary balancing power
- Direct marketing at European Power Exchange
- Central control and optimization system including Optimal unit commitment for secondary and tertiary reserve
- Large-scale enabling technology to connect all kind of assets
  - Biogas, Biomass
  - CHP / MicroCHP
  - Water / Hydro
  - Solar, Wind
  - Industrial Sites
  - Power-2-Heat
  - Standby-Sets,…



Next Kraftwerke VPP (Germany)

Large Systems Optimization

Municipalized Company



Power Pool Balancing

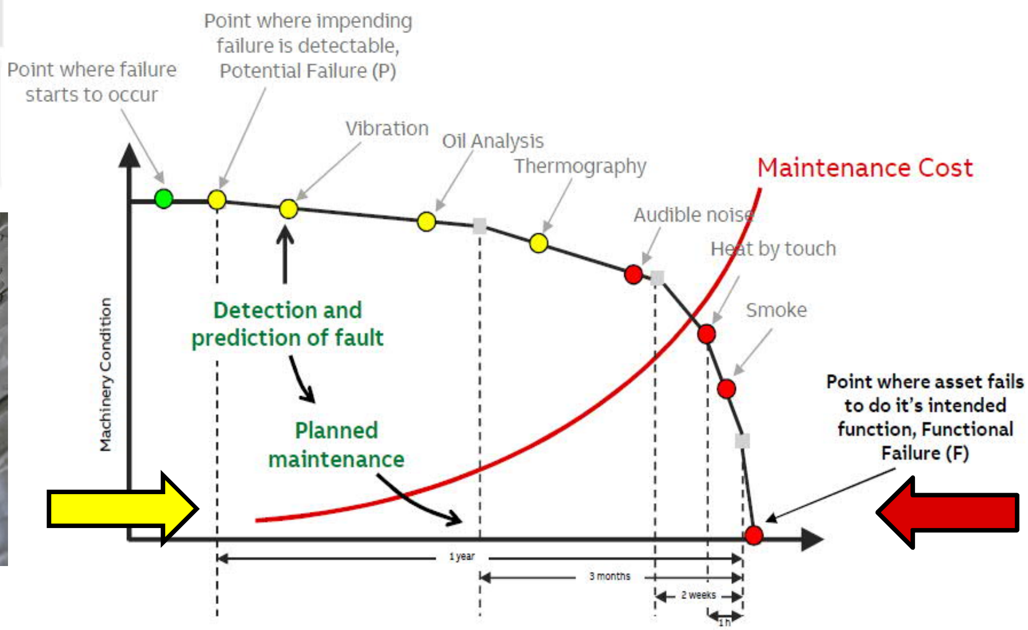
Customer	Stadtwerke Trier (Germany)
Customer Requirements	3-phase optimization for balancing of power production subject to fluctuating renewables – Day-Ahead next 24-72 hours – Intra-Day next 4-6 hours – Intra-Period within last 15 minutes
ABB Solution	Integration of a hybrid system including: – Wind farms, PV, Biomass, CHP – Battery storage and DC-Charger – Hydro & hydro pump storage – Controllable consumers
Customer benefit	– Reduce penalties by 10% – Reduce primary energy cost by 5%

Asset Performance Management

Why can I save my money? The case of Rotating Equipment Early Detection

Increase of **Availability & Reliability**

Reduction of yearly **OPEX**

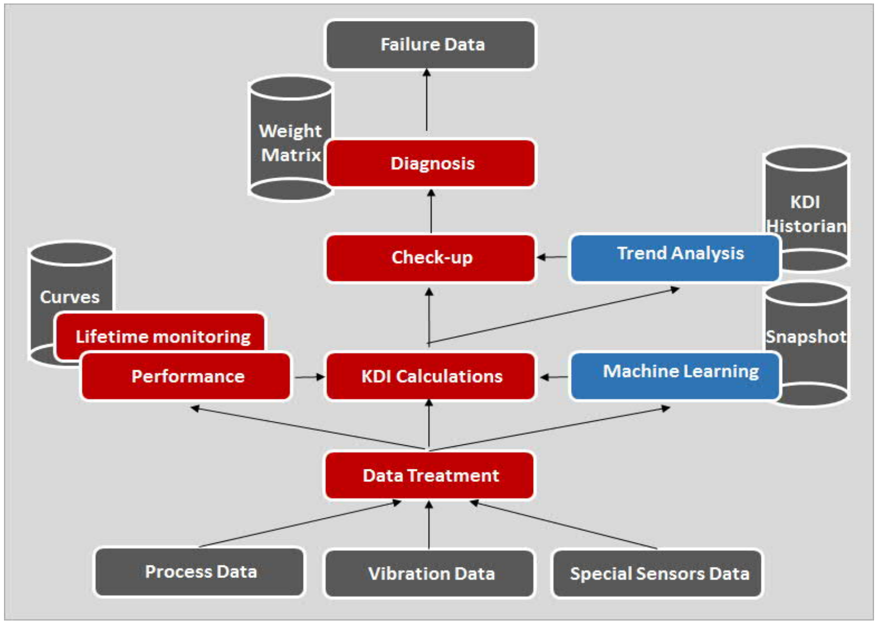


Asset Performance Management

A Digital solution for Availability and Reliability improvement

Predictive Diagnostics thru ABB APM

- A digital twin also can be used for monitoring, diagnostics and prognostics to optimize asset performance and utilization. In this field, sensory data can be combined with historical data, human expertise and fleet and simulation learning to improve the outcome of prognostics.
- The equipment model behavior in good condition is obtained by the use of a Machine Learning applied to the historical data. This allows the Anomaly Detection (Check Up)
- Another AI, the Expert Analyzer, provides the Diagnosis of the apparatus failure based on the elaboration of the *Symptoms*. The initial knowledge inside the Expert is provided by ABB but could be enlarged manually (e.g. from maintenance personnel) or automatically by special tools able to analyze the failure data and extract the relevant rules.



Asset Performance Management

Benefit and differentiator: root cause analysis and maintenance actions indications

Failure Mode, Effects and Criticality Analysis

Based upon ABB's extensive power generation process kowledge, solid diagnoses are provided.

Site specific expert knowledge - from e.g. plant operators and maintenance personal - can at any time be incorporated into the system. In an easy way, by the power producer himself.

	Medical Case	Technical Case
System:	Human Blood System	Hydro Turbine No. 5 Bearings
Check-up:	Failed	Failed
Diagnosis:	Sideropenic Microtyc Anemia (Doctors Experience)	Insufficient lubrication due to dirty oil filter or obstructed oil filter (Expert Knowledge)
Corrective actions:	1. Step: Oral iron supplements 2. Step: Intravenous iron supplements	1. Step: Filter cleaning 2. Step: Filter substition

Readings (Medical Case):

	Actual	Reference*
Hemoglobin [g/ml]	8	13-18
Red Blood Cells [Mil/µ]	4	4-6
Mean Corpuscolar Vol. [fl]	70	81-96
Serum Iron [µ/100mg]	10	37-147
Ferritin	5	50-177
Transferrin	400	50-200

Readings (Technical Case):

	Actual	Reference**
Bearing 1 Temperature [°C]	65	40-50
Bearing 2 Temperature [°C]	58	40-50
Bearing 3 Temperature [°C]	60	40-50
Bearing 4 Temperature [°C]	62	40-50
Filter Pressure Drop [mbar]	800	100-200
Pump Pressure [bar]	2	1.5-2.5

Asset Performance Management

Hydro Power Fleet

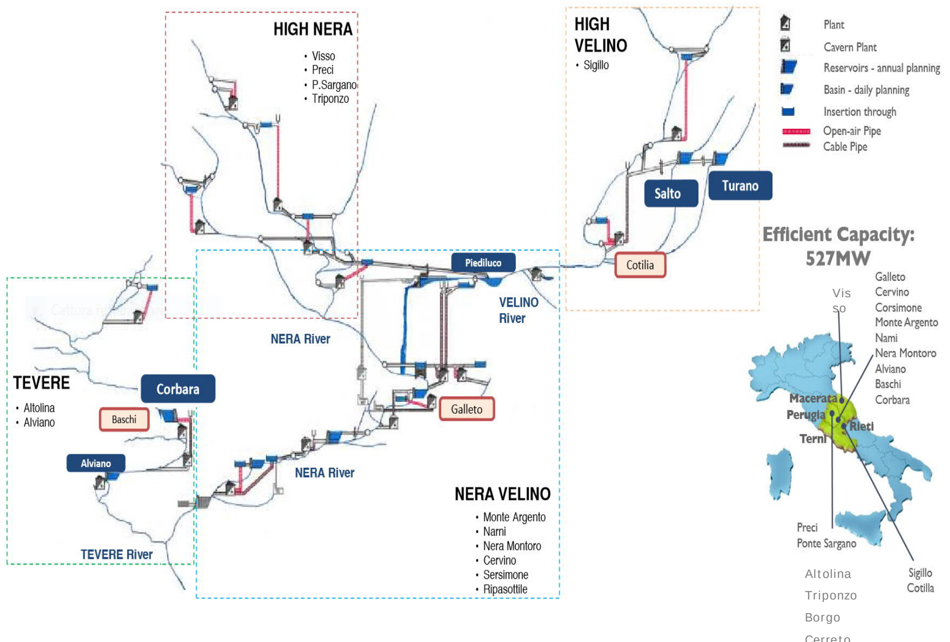
ABB Applied Solution

Condition Based Maintenance

- quick check and recognition of potential faults and damages prevention and consequent cost saving for unplanned events;
- scheduling improvement for on condition maintenance and inspection activities and cost saving for planned maintenance;
- real-time control of main components (performance and machinery vibrations analysis);
- equipment lifetime increase due to on-line control and malfunctioning correction.
- On-line monitoring and diagnostic systems fall into the National Plan Industry 4.0 aimed to support and incentivize companies that invest in new capital goods, in tangible and intangible assets (software and IT systems) functional to the technological and digital transformation of production process

Benefits

- Total maintenance costs saving equal to 5% on a mid-term period 2021-2029: about 50 k€/year saving, starting from year 2021, against about 15 k€/year of OPEX



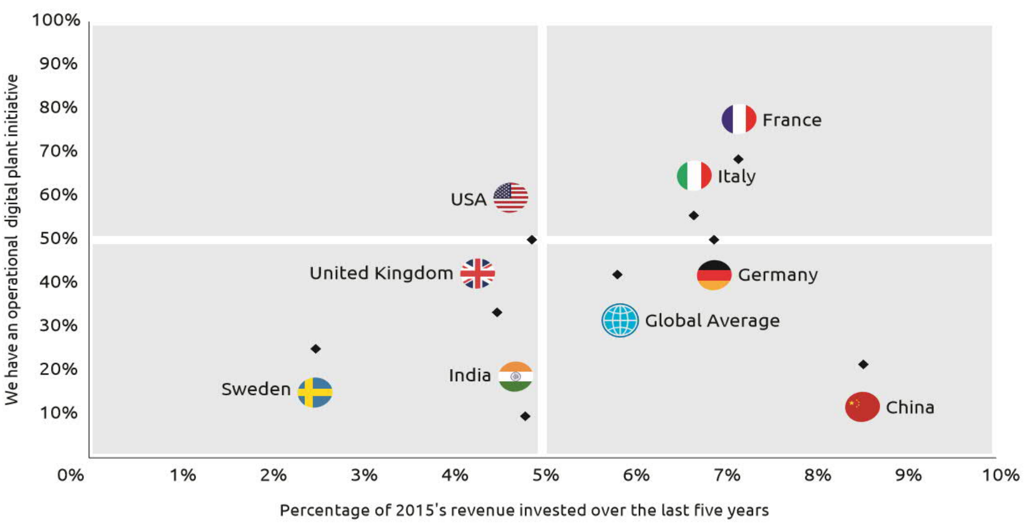
ERG – Nucleo Idroelettrico di Terni

Perspectives

Utilities invested in the past and are planning to power up digital plant investment in the next 5 years

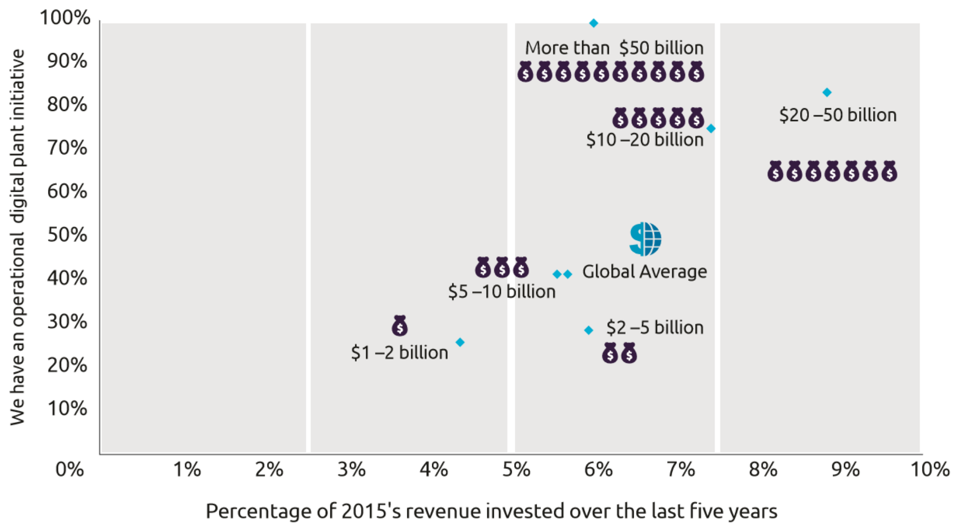
$330Mn the average investment on digital plants made by utility companies over the last five years.
Larger utilities are more likely to have an operational plant than smaller utilities. However, smaller utilities are not far behind in terms of the investment they are making as a percentage of revenue. Much of the considerable investment from smaller utilities is an investment for the future. Many of these smaller companies (nearly 50%) have plans for digital plants rather than plants in operation.
More in general the digital market shall be 13 $ Billions in the next 5 years https://www.key4biz.it/il-mercato-mondiale-dei-gemelli-digitali-varra-13-miliardi-di-dollari-nel-2023/

Utilities in France, Italy, and Germany have been aggressively investing in digital plants



Source: Capgemini Digital Transformation Institute, digital utilities survey, February-March 2017

Smaller players are not far behind in investing in digital plants



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