PI System as sustainable component of our Data Infrastructure

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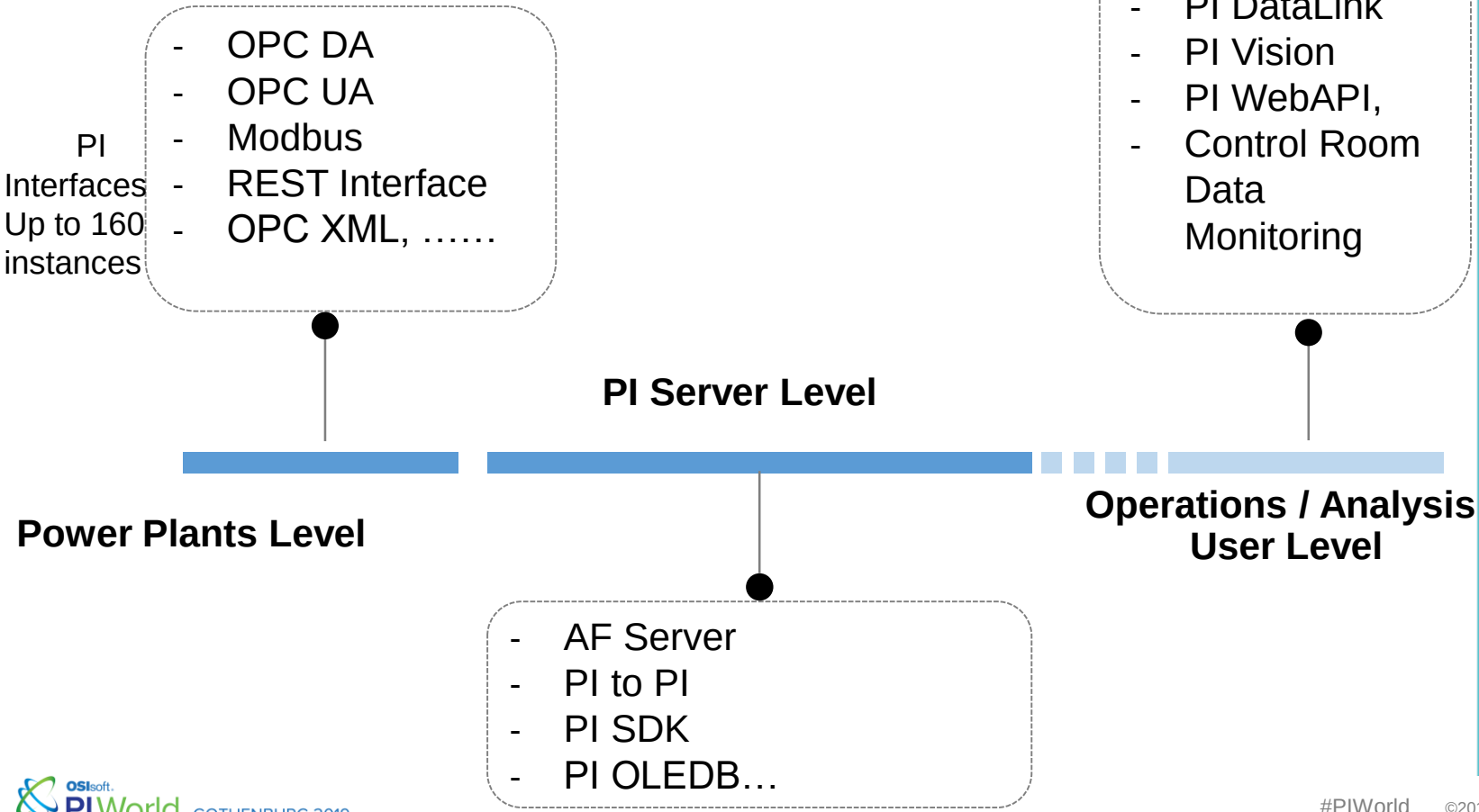
PI System as sustainable component of our Data Infrastructure

Our PI System background



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4 – How individual Product Capabilities solved the Business challenge

5 – Conclusion

1- E.ON Climate & Renewables at a glance

Capacity[1]

3.9 GW

Onshore wind

Solar

3.6 GW

1.8 GW		0.2 GW	
0.9 GW		0.2 GW	
0.3 GW		0.2 GW	

Total gross capacity under construction and repowering: 1.3 GW[2]

1. Total gross capacity irrespective of the E.ON share
2. Including one repowering project

Highlights

- €0.5 bn EBIT 2018 (~19% of core EBIT)
- ~96% Long-term contracted or hedged until 2020
- Strong track record with 7.5 GW[1] delivered, and 1.3 GW[1,2] under construction
- Active in 3 generation technologies and in batteries

4351 WTGs, 159 WPP, 17MW Solar

1- E.ON Climate & Renewables at a glance

Technologies

Offshore wind

Onshore wind

Utility scale PV

Energy storage (ES)

Energy solutions

Green energy

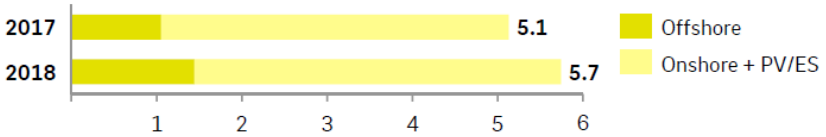
Green assets

Services

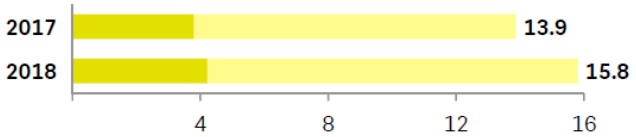
What we do

- We are among the largest renewable energy players in our core markets (Europe and US), looking to expand globally (to Latin America and Asia-Pacific)
- Our strategic focus is to grow at scale in onshore and offshore wind, rise from boutique to industrial in utility-scale solar business, and grow the utility-scale energy storage business
- We provide third-party services[1] with an owner's eye
- We manage holistically the commercial and technical risks, and partner with investors at different stages of a project's life cycle, allowing us to maximize value
- 1,370 E.ON employees work in Renewables

Owned capacity[2] (GW)



TWh produced[2]



1. Operations & Maintenance, Asset Management and Energy Management via our "E.ON Energy Services" department
2. Pro rata

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2- Business Challenge

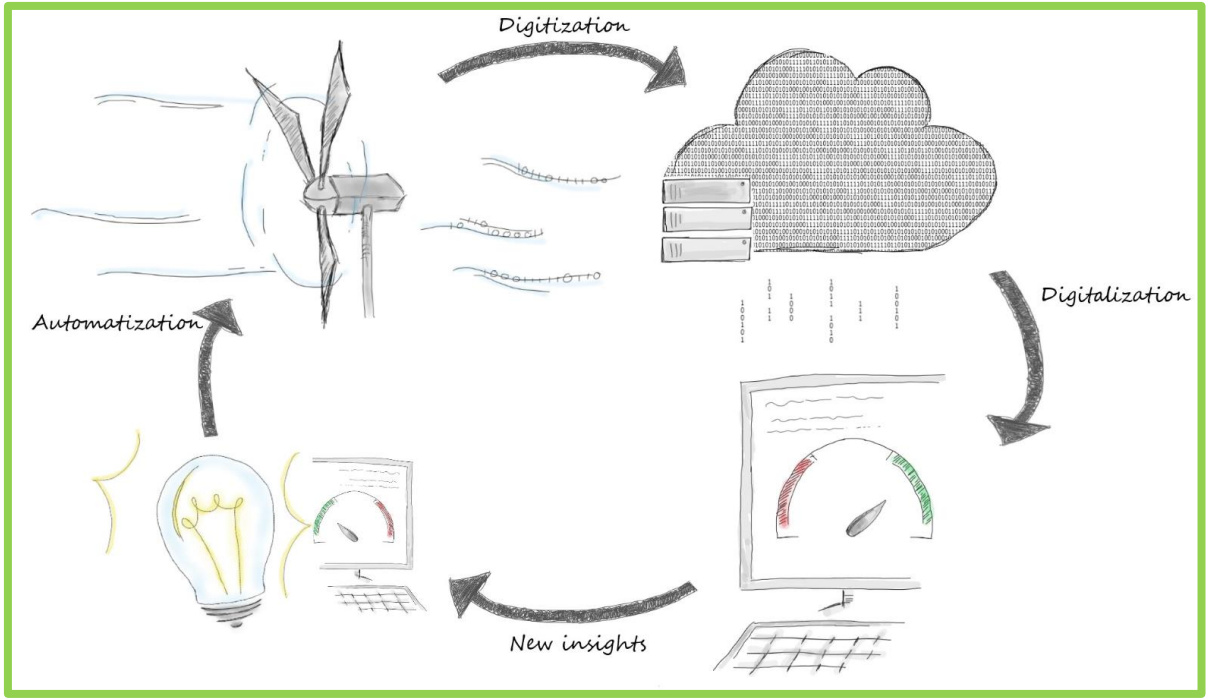
PI System has an important role in Data Management Processes as data backbone for:

a) **Digitization**

b) **Digitalization**

c) **New insights**

d) **Automation**



2- Business Challenge - continuously IT challenge

How to make the most from our PI System:

a) Making PI System flexible to data sources (Real Time data / Aggregated data / REST Interfaces)

b) Enhancing Data acquisition quality (data completeness monitoring)

c) High Level of harmonization needed to handle a big mix of non-standardised Vendor Technologies

d) Providing Real time and Power Grid data to ECR Control Rooms

Last but not least:

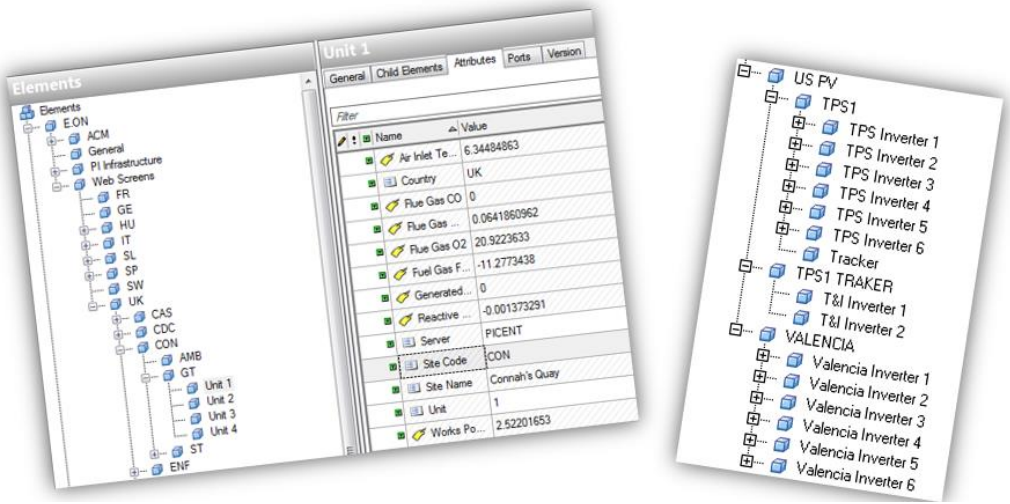
Providing quickly and complete data set to the entire EC&R Business for the purpose of asset performance monitoring, asset commercialization, maintenance planning, etc.

2- Business Challenge

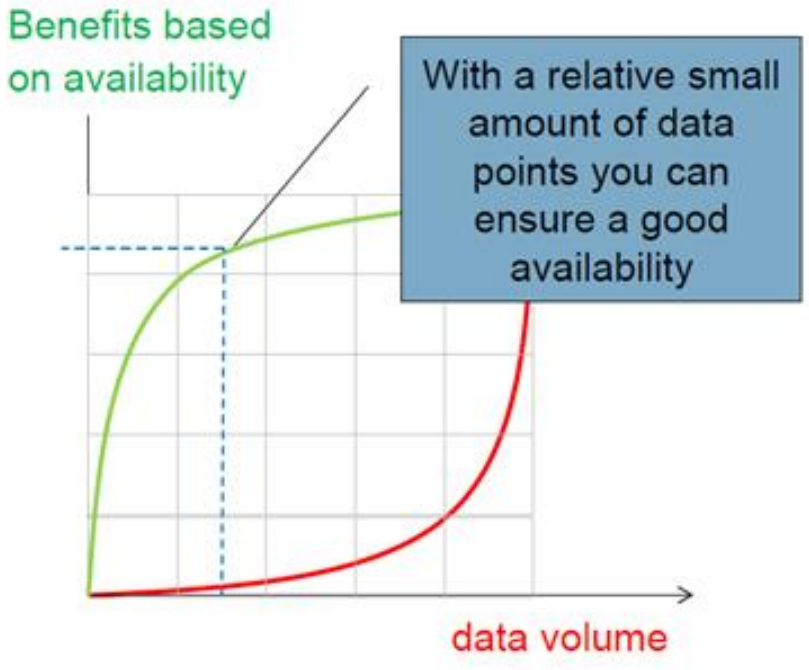
PI as Standardization layer

At more than 140 locations different types of PI Interfaces (OPC / PI to PI / RDBMS / Modbus) collect data from the OEM systems and send it to the central PI server.

By using the Asset Framework E.ON standardized the individual signals from the plant to a global standard.



2- Business Challenge



Category	M-Tag	Tag Name	Eng Unit	Scan Interval
Turbine	M0002	Turbine Active Power	kW	10s
Turbine	M0003	Turbine Wind Speed	m/s	10s
Turbine	M0004	Ambient Air Temperature	°C	30s
Turbine	M0009	Turbine Generator Current L1	A	10s
Turbine	M0010	Turbine Generator Current L2	A	10s
Turbine	M0011	Turbine Generator Current L3	A	10s
Turbine	M0012	Turbine Generator Power Factor	cos phi	10s
Turbine	M0013	Turbine Wind Direction	°	10s
Turbine	M0015	Turbine Generator Temperature	°C	10s
Turbine	M0016	Turbine Gearbox Temperature	°C	10s
Turbine	M0110	Nacelle Orientation	°	10s
Turbine	M0113	Blade Pitch Angle	°	10s
Turbine	M0114	Generator Voltage 1	V	10s
Turbine	M0115	Generator Voltage 2	V	10s
Turbine	M0116	Generator Voltage 3	V	10s
Turbine	M0143	Generator Winding Temperature	°C	10s
Turbine	M0144	Generator Bearing Temperature - DE	°C	10s
Turbine	M0145	Generator Bearing Temperature - NDE	°C	10s
Turbine	M0149	Gearbox Bearing Temperature	°C	10s
Turbine	M0150	Gearbox Oil Temperature	°C	10s
Turbine	M0154	Rotor Speed	rpm	10s
Turbine	M0155	Generator Speed	rpm	10s
Turbine	M0158	Ambient Air Pressure	mBar	10s
Turbine	M0328	Blade A Pitch Angle	°	10s
Turbine	M0329	Blade B Pitch Angle	°	10s
Turbine	M0330	Blade C Pitch Angle	°	10s
Site	M5002	Site Active Power	MW	10s
Site	M5101	Site Wind Speed	m/s	10s
Site	M5102	Site Ambient Temperature	°C	30s
Site	M5103	Site Air Pressure	mBar	10s
Site	M5329	Curtailment Flag	FLAG / INT	10s
Site	M5330	Site Active Power Limitation	MW	10s
Site	M5340	Site Generation Price (Feed-in tariff)		10s
Site	M5501	Means that we're in a curtailment period (goes on each night)		10s
Site	M5512	Instantaneous estimation of curtailed power		10s
Meteo	M5602	Meteo Air Pressure	mBar	10s
Meteo	M5603	Meteo Air Temperature	°C	10s
Meteo	M5605	Meteo Site Wind Speed	m/s	10s
Meteo	M5606	Meteo Relative Humidity	%	10s

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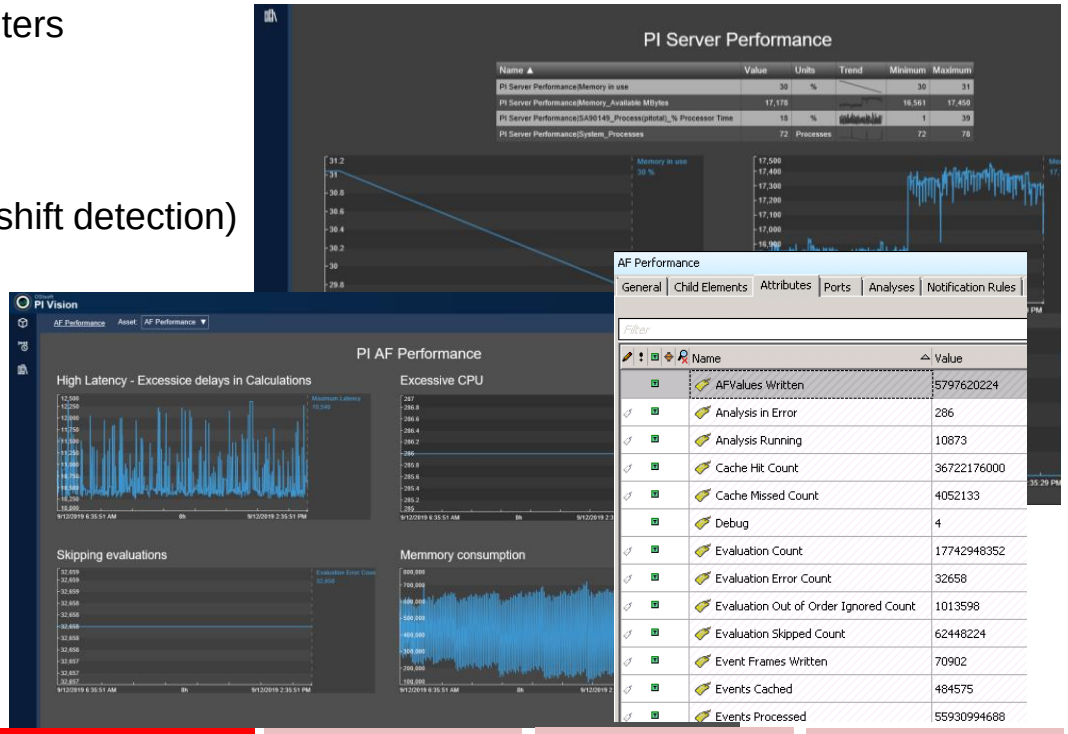
3- Application and Use case / How PI is applied

- How to make the most of our PI System (answer to the challenge question) in a nutshell:
  - PI System Infrastructure monitoring
  - PI Notifications (i.e. Grid Curtailment detections)
  - PI Vision
  - PI OLEDB driver
  - PI WebAPI
  - PI SDK
  - PI Asset Framework
  - Timestamp shift Detection

3- Application and Use case / How PI is applied

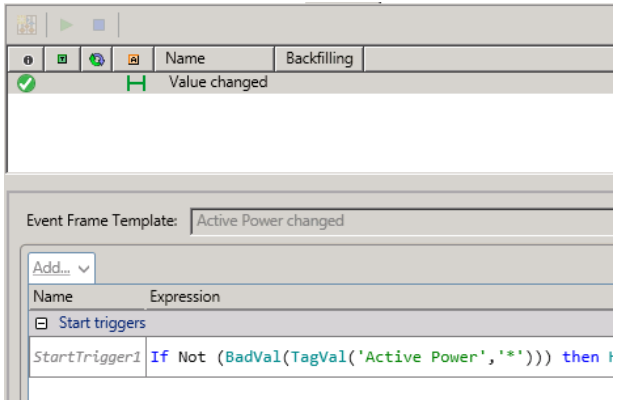
- **PI System Infrastructure monitoring and Notifications**
  - PI Performance Counters
  - Health Points
  - Performance Points
  - NTP Monitoring (timeshift detection)
  - Interface Status

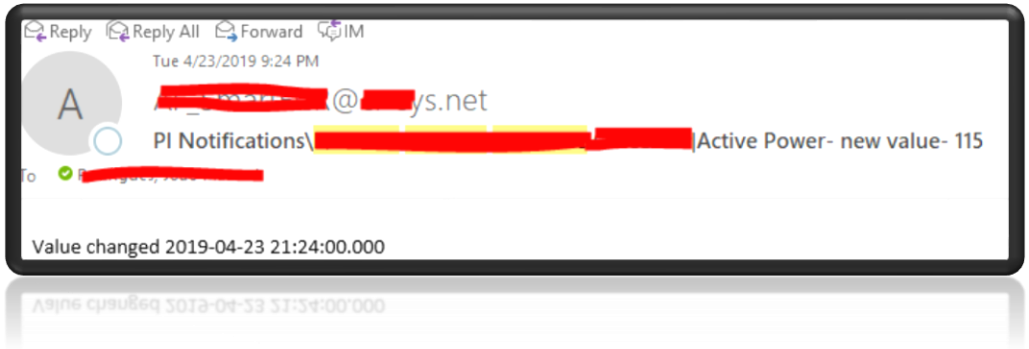


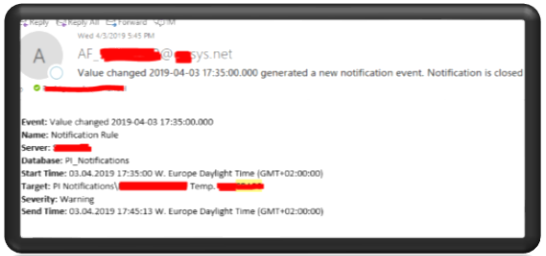
- PI Server Performance
- PI AF Performance

3- Application and Use case / How PI is applied

- **PI Notifications (i.e. Grid Curtailment detections)**

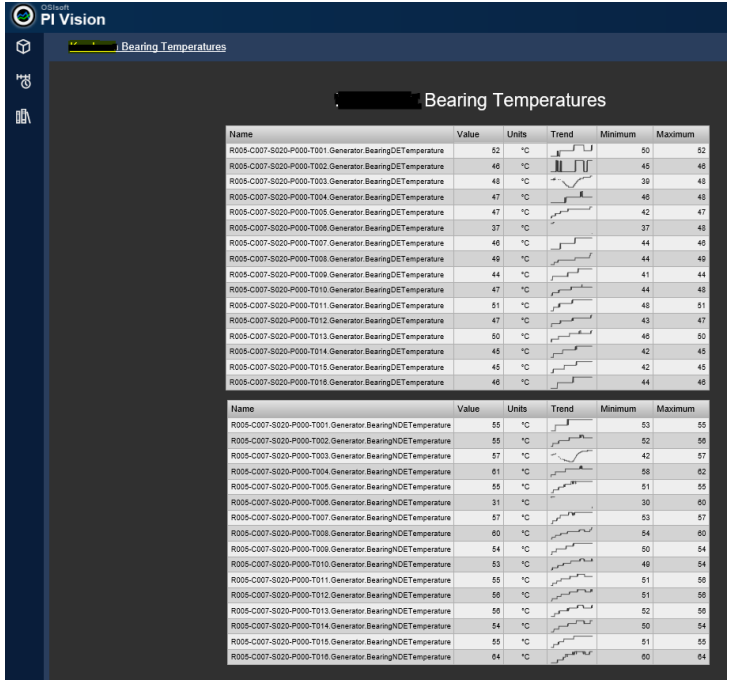






3- Application and Use case / How PI is applied

- **PI Vision**



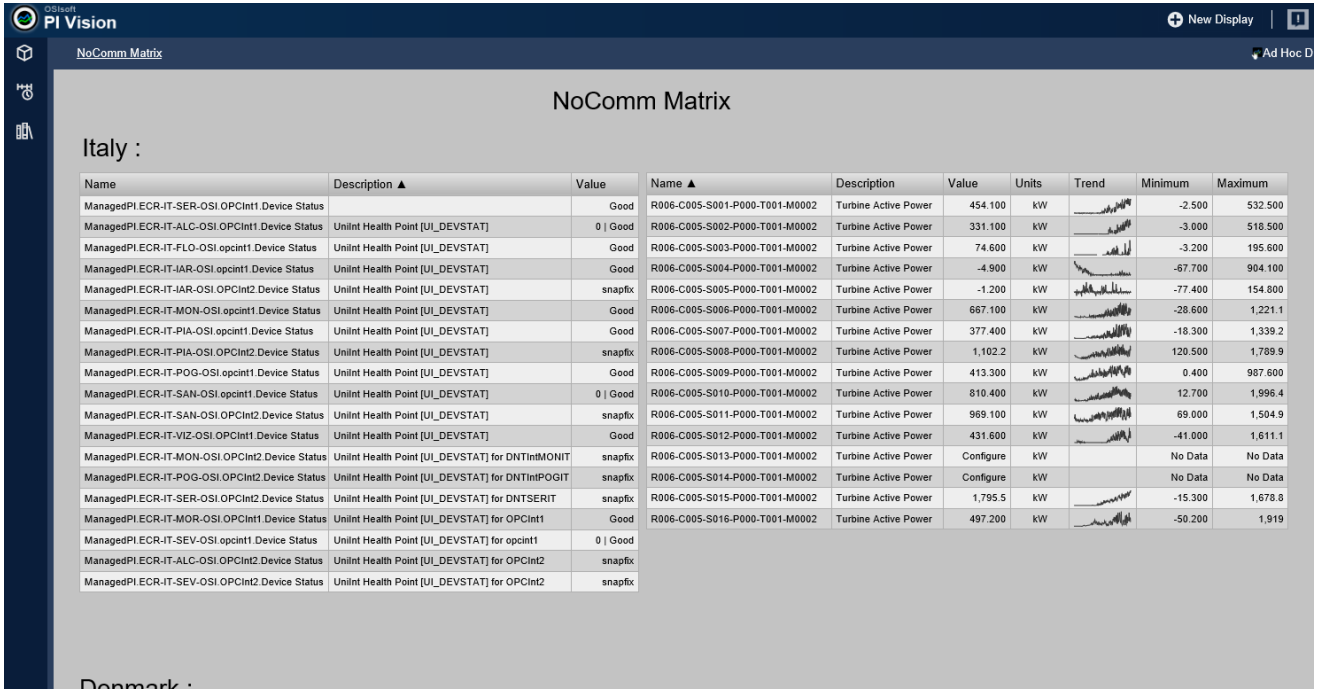
Name	Value	Units	Trend	Minimum	Maximum
R005-C007-S020-P000-T001.Generator.BearingDETemperature	52	°C		50	52
R005-C007-S020-P000-T002.Generator.BearingDETemperature	46	°C		45	46
R005-C007-S020-P000-T003.Generator.BearingDETemperature	48	°C		39	48
R005-C007-S020-P000-T004.Generator.BearingDETemperature	47	°C		46	48
R005-C007-S020-P000-T005.Generator.BearingDETemperature	47	°C		42	47
R005-C007-S020-P000-T006.Generator.BearingDETemperature	37	°C		37	48
R005-C007-S020-P000-T007.Generator.BearingDETemperature	46	°C		44	46
R005-C007-S020-P000-T008.Generator.BearingDETemperature	49	°C		44	49
R005-C007-S020-P000-T009.Generator.BearingDETemperature	44	°C		41	44
R005-C007-S020-P000-T010.Generator.BearingDETemperature	47	°C		44	48
R005-C007-S020-P000-T011.Generator.BearingDETemperature	51	°C		48	51
R005-C007-S020-P000-T012.Generator.BearingDETemperature	47	°C		43	47
R005-C007-S020-P000-T013.Generator.BearingDETemperature	50	°C		46	50
R005-C007-S020-P000-T014.Generator.BearingDETemperature	45	°C		42	45
R005-C007-S020-P000-T015.Generator.BearingDETemperature	45	°C		42	45
R005-C007-S020-P000-T016.Generator.BearingDETemperature	46	°C		44	46

Name	Value	Units	Trend	Minimum	Maximum
R005-C007-S020-P000-T001.Generator.BearingNDETemperature	55	°C		53	55
R005-C007-S020-P000-T002.Generator.BearingNDETemperature	55	°C		52	56
R005-C007-S020-P000-T003.Generator.BearingNDETemperature	57	°C		42	57
R005-C007-S020-P000-T004.Generator.BearingNDETemperature	61	°C		58	62
R005-C007-S020-P000-T005.Generator.BearingNDETemperature	55	°C		51	55
R005-C007-S020-P000-T006.Generator.BearingNDETemperature	31	°C		30	60
R005-C007-S020-P000-T007.Generator.BearingNDETemperature	57	°C		53	57
R005-C007-S020-P000-T008.Generator.BearingNDETemperature	60	°C		54	60
R005-C007-S020-P000-T009.Generator.BearingNDETemperature	54	°C		50	54
R005-C007-S020-P000-T010.Generator.BearingNDETemperature	53	°C		49	54
R005-C007-S020-P000-T011.Generator.BearingNDETemperature	55	°C		51	56
R005-C007-S020-P000-T012.Generator.BearingNDETemperature	56	°C		51	56
R005-C007-S020-P000-T013.Generator.BearingNDETemperature	56	°C		52	56
R005-C007-S020-P000-T014.Generator.BearingNDETemperature	54	°C		50	54
R005-C007-S020-P000-T015.Generator.BearingNDETemperature	55	°C		51	55
R005-C007-S020-P000-T016.Generator.BearingNDETemperature	64	°C		60	64

PI Vision allows quickly, easily and securely monitor. We use PI Vision to monitor and make the best usage from real time data (approximately 35 signals per turbine around 220K signals covering all assets in ECR Portfolio) making use of Customizing PI Vision with Extensibility

3- Application and Use case / How PI is applied

- **PI Vision Infrastructure Monitoring PI health point from Interface**

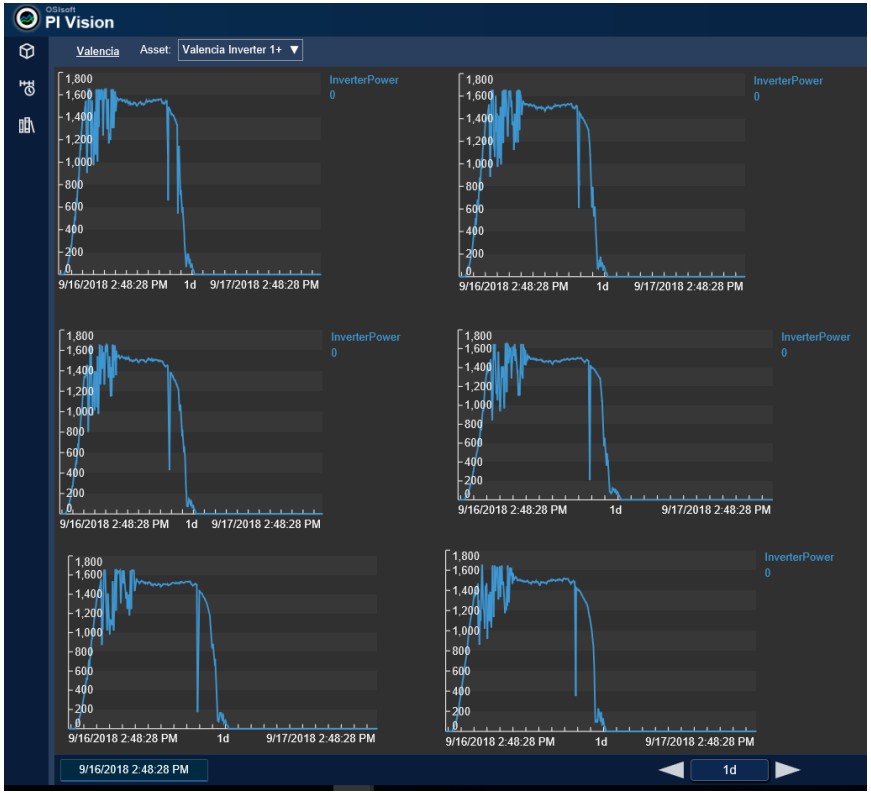


Name	Description ▲	Value
ManagedPI.ECR-IT-SER-OSI.OPCInt1.Device Status		Good
ManagedPI.ECR-IT-ALC-OSI.OPCInt1.Device Status	UniInt Health Point [UI_DEVSTAT]	0 | Good
ManagedPI.ECR-IT-FLO-OSI.opcint1.Device Status	UniInt Health Point [UI_DEVSTAT]	Good
ManagedPI.ECR-IT-IAR-OSI.opcint1.Device Status	UniInt Health Point [UI_DEVSTAT]	Good
ManagedPI.ECR-IT-IAR-OSI.OPCInt2.Device Status	UniInt Health Point [UI_DEVSTAT]	snapfix
ManagedPI.ECR-IT-MON-OSI.opcint1.Device Status	UniInt Health Point [UI_DEVSTAT]	Good
ManagedPI.ECR-IT-PIA-OSI.opcint1.Device Status	UniInt Health Point [UI_DEVSTAT]	Good
ManagedPI.ECR-IT-PIA-OSI.OPCInt2.Device Status	UniInt Health Point [UI_DEVSTAT]	snapfix
ManagedPI.ECR-IT-POG-OSI.opcint1.Device Status	UniInt Health Point [UI_DEVSTAT]	Good
ManagedPI.ECR-IT-SAN-OSI.opcint1.Device Status	UniInt Health Point [UI_DEVSTAT]	0 | Good
ManagedPI.ECR-IT-SAN-OSI.OPCInt2.Device Status	UniInt Health Point [UI_DEVSTAT]	snapfix
ManagedPI.ECR-IT-VIZ-OSI.OPCInt1.Device Status	UniInt Health Point [UI_DEVSTAT]	Good
ManagedPI.ECR-IT-MON-OSI.OPCInt2.Device Status	UniInt Health Point [UI_DEVSTAT] for DNTIntMONIT	snapfix
ManagedPI.ECR-IT-POG-OSI.OPCInt2.Device Status	UniInt Health Point [UI_DEVSTAT] for DNTIntPOGIT	snapfix
ManagedPI.ECR-IT-SER-OSI.OPCInt2.Device Status	UniInt Health Point [UI_DEVSTAT] for DNTSERIT	snapfix
ManagedPI.ECR-IT-MOR-OSI.OPCInt1.Device Status	UniInt Health Point [UI_DEVSTAT] for OPCInt1	Good
ManagedPI.ECR-IT-SEV-OSI.opcint1.Device Status	UniInt Health Point [UI_DEVSTAT] for opcint1	0 | Good
ManagedPI.ECR-IT-ALC-OSI.OPCInt2.Device Status	UniInt Health Point [UI_DEVSTAT] for OPCInt2	snapfix
ManagedPI.ECR-IT-SEV-OSI.OPCInt2.Device Status	UniInt Health Point [UI_DEVSTAT] for OPCInt2	snapfix

Name ▲	Description	Value	Units	Trend	Minimum	Maximum
R006-C005-S001-P000-T001-M0002	Turbine Active Power	454.100	kW		-2.500	532.500
R006-C005-S002-P000-T001-M0002	Turbine Active Power	331.100	kW		-3.000	518.500
R006-C005-S003-P000-T001-M0002	Turbine Active Power	74.600	kW		-3.200	195.600
R006-C005-S004-P000-T001-M0002	Turbine Active Power	-4.900	kW		-67.700	904.100
R006-C005-S005-P000-T001-M0002	Turbine Active Power	-1.200	kW		-77.400	154.800
R006-C005-S006-P000-T001-M0002	Turbine Active Power	667.100	kW		-28.600	1,221.1
R006-C005-S007-P000-T001-M0002	Turbine Active Power	377.400	kW		-18.300	1,339.2
R006-C005-S008-P000-T001-M0002	Turbine Active Power	1,102.2	kW		120.500	1,789.9
R006-C005-S009-P000-T001-M0002	Turbine Active Power	413.300	kW		0.400	987.600
R006-C005-S010-P000-T001-M0002	Turbine Active Power	810.400	kW		12.700	1,996.4
R006-C005-S011-P000-T001-M0002	Turbine Active Power	969.100	kW		69.000	1,504.9
R006-C005-S012-P000-T001-M0002	Turbine Active Power	431.600	kW		-41.000	1,611.1
R006-C005-S013-P000-T001-M0002	Turbine Active Power	Configure	kW		No Data	No Data
R006-C005-S014-P000-T001-M0002	Turbine Active Power	Configure	kW		No Data	No Data
R006-C005-S015-P000-T001-M0002	Turbine Active Power	1,795.5	kW		-15.300	1,678.8
R006-C005-S016-P000-T001-M0002	Turbine Active Power	497.200	kW		-50.200	1,919

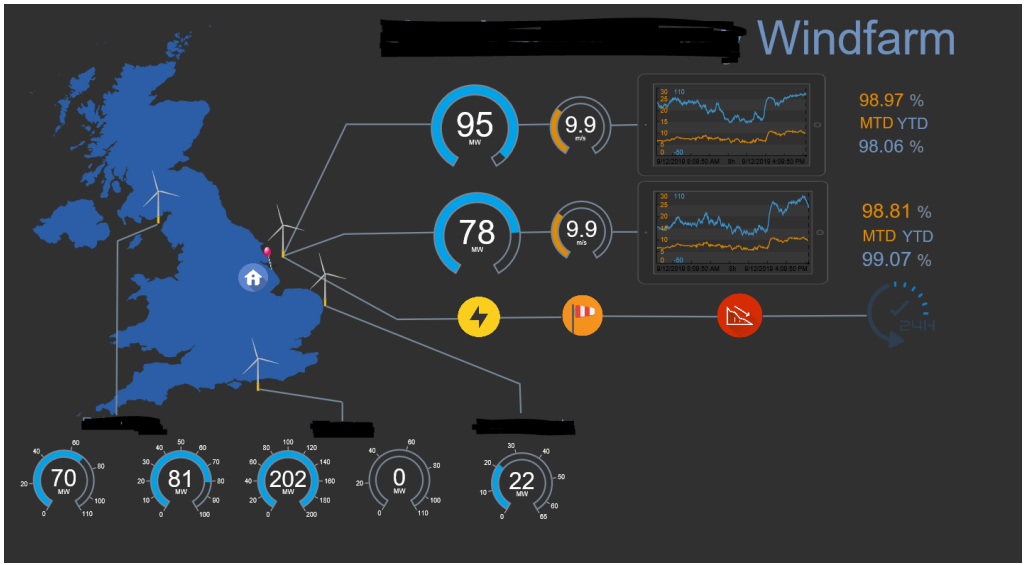
3- Application and Use case / How PI is applied

- **PI Vision Solar Power Plant**



3- Application and Use case / How PI is applied

- **PI Vision Wind Farm Monitoring**



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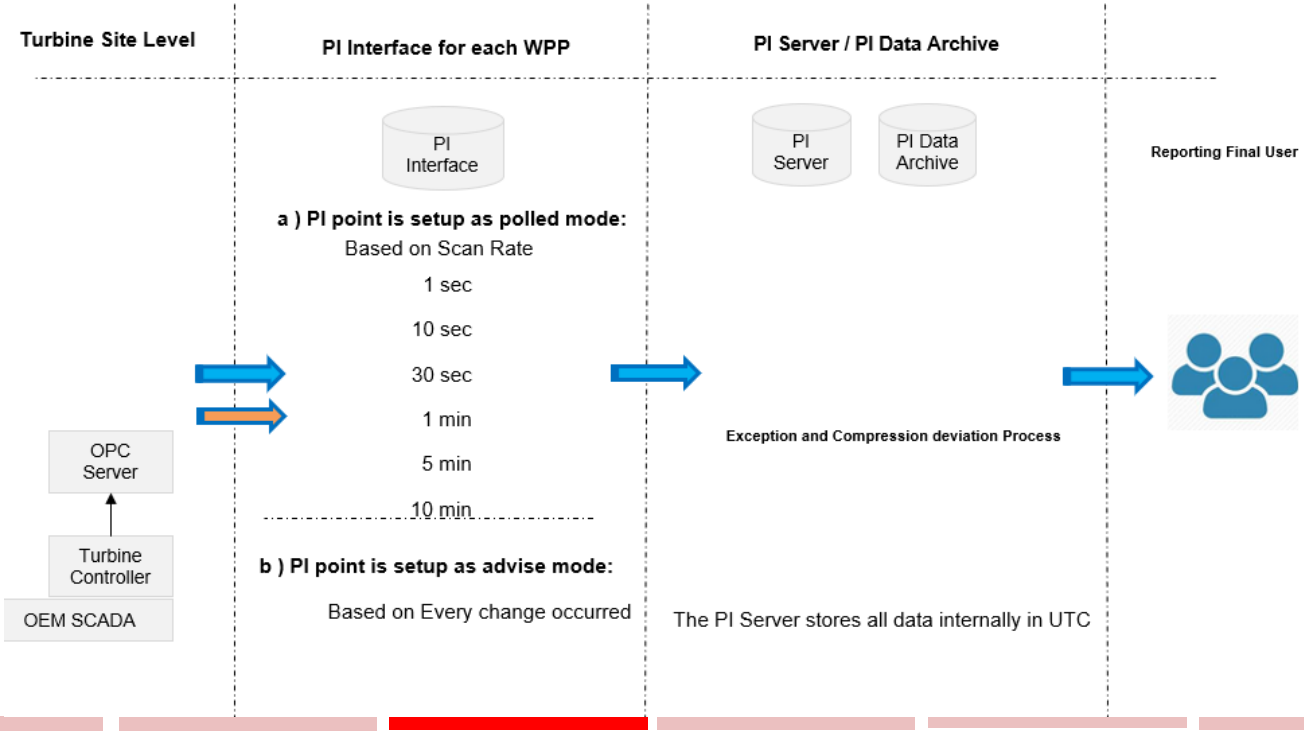
3- Application and Use case / How PI is applied

a) Timestamp Shift Detection - Possible Layers where time shift can occur and how to mitigate

a) Dataflow layers - how time stamping occurs in PI



3- Application and Use case / How PI is applied

Consequences of a Time shift occurred inside PI Infrastructure:

a) Positive Time shift – PI tag will not receive future data

b) Negative Time shift – PI tag already have a value for that point in Time

How we do Time shift detection and major impacts? (PI Message Logs, NTP Monitoring)

Interface Configuration

Using PI Server Timestamp?
Or PI Interface Timestamp?
or Timestamp from Protocol (example OPC server) ??

3- Application and Use case / How PI is applied

- **PI OLEDB driver**
- **PI WebAPI**
- **PI SDK**

The most extensive usage happens through the PI SDK and PI OLEDB Interface.

PI OLEDB provides access to the PI System in a relational view, accessible through SQL queries. Also provides read-only access to time series data from the PI Data Archive, since attributes can be configured to reference PI points.

The PI SDK is a programming library providing access to PI Servers. The PI SDK uses an object-oriented, hierarchical approach to provide access to features of the PI Server

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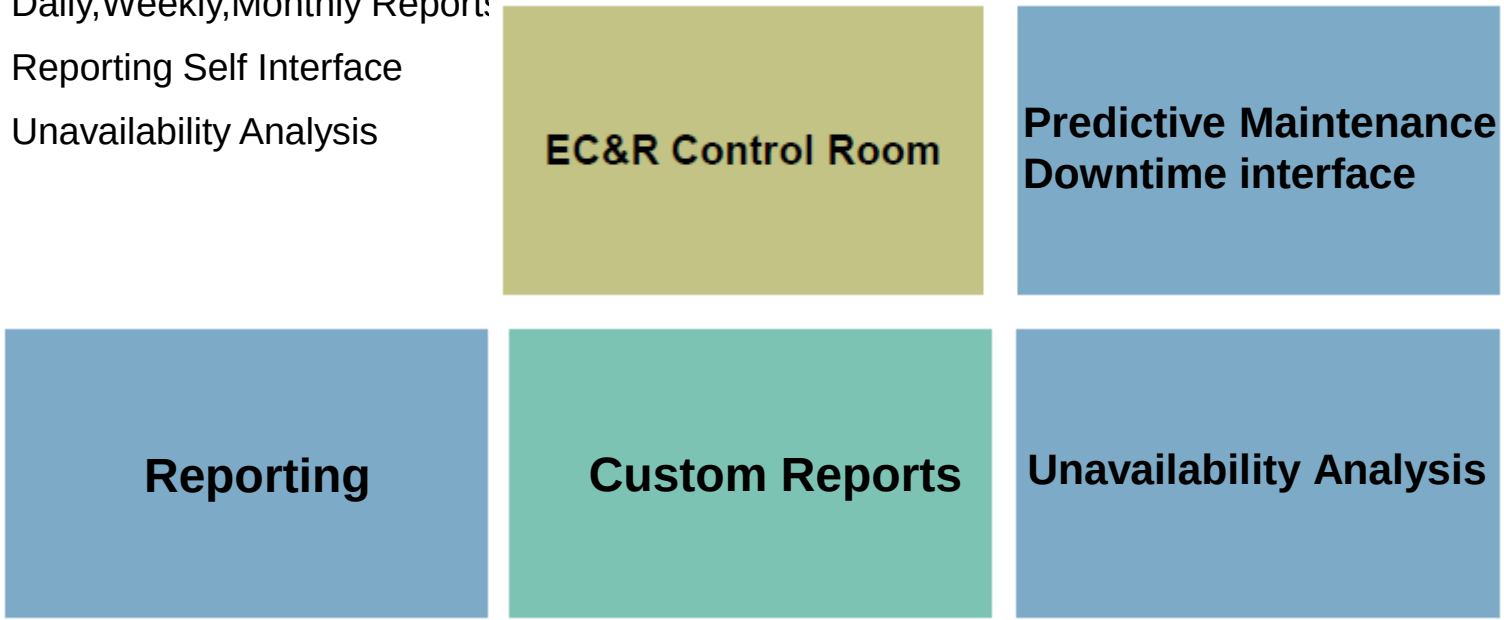
4- How individual Product Capabilities solved the Business challenge

Examples:

- Data Monitoring Tool to Control Room (Power Grid)
- Predictive Maintenance / downtime prevention interface
- Daily,Weekly,Monthly Reports
- Reporting Self Interface
- Unavailability Analysis



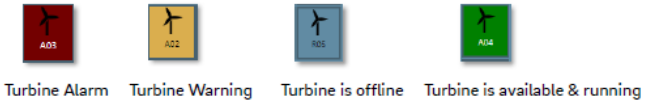
4- How individual Product Capabilities solved the Business challenge

Example 1 : Data Monitoring Tool to Control Room (T&D Power Grid data)

Data Monitoring Tool visualizes various real time data about sites and Turbines, it integrates real time data from different manufacturers in one interface. By customizing your own portfolio, all turbine manufacturer and sites you wish to monitor are displayed at one view. Used in CR UK and US for remote monitoring. HMTL5 web application using PI SDK

4- How individual Product Capabilities solved the Business challenge

Example 2: Predictive Maintenance / downtime prevention tools



Predictive Maintenance / Downtime tool enables an efficient and reliable WTG condition monitoring and downtime prevention with the help from analysis methods to detect trends and provides expected WTG values derived by a machine learning algorithm

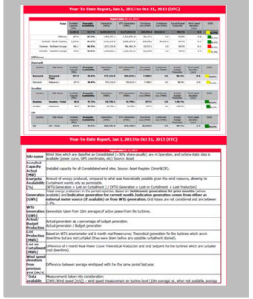
4- How individual Product Capabilities solved the Business challenge

Example 3: Daily,Weekly,Monthly Reports

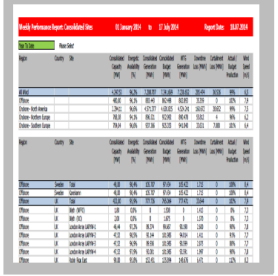
Automated daily, weekly and monthly reporting

- Emission monitoring and reporting
- Electrical generation
- Imbalance reporting
- Plant performance reporting
- Shift Reports

Site Report



Weekly Report



Finance

KPI reporting – same data used for different target groups

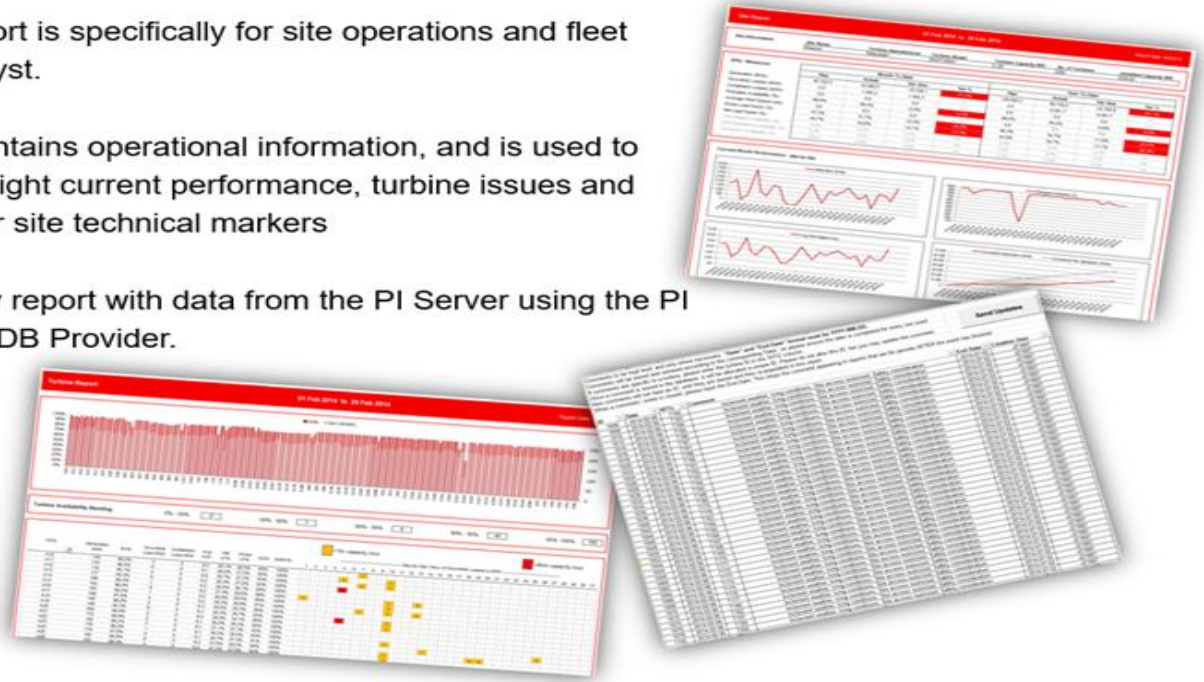
4- How individual Product Capabilities solved the Business challenge

Example 3: Daily,Weekly,Monthly Reports

Report is specifically for site operations and fleet analyst.

It contains operational information, and is used to highlight current performance, turbine issues and other site technical markers

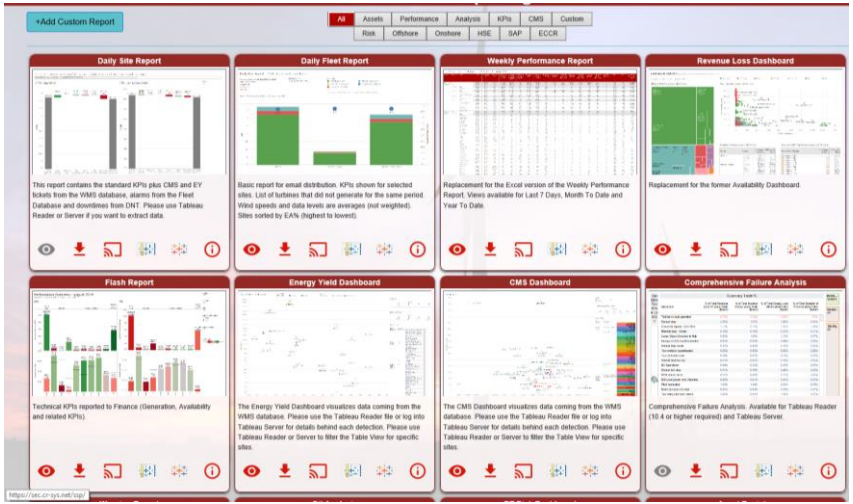
Daily report with data from the PI Server using the PI OLEDB Provider.



4- How individual Product Capabilities solved the Business challenge

Example 4: Reporting Self Interface

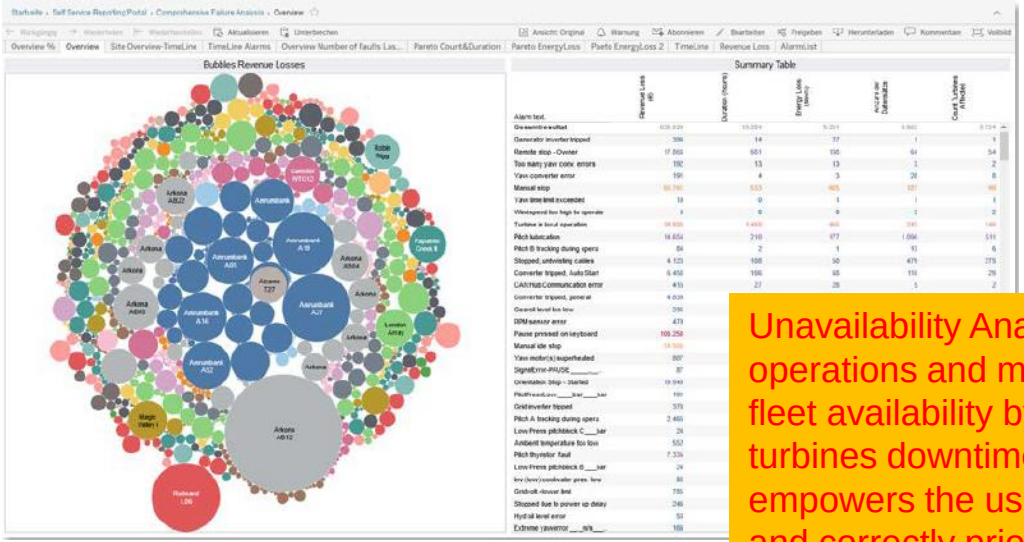
Performance data is collected directly form turbines
Data is reliable, consistent and accurate
Easy-to-use interface for a quick access to all performance analysis reports



Reporting Self Service Interface to the results of performance analysis for EC&R fleet. It allows to create Custom Reports and also subscribe reports to receive automatically and periodically the desired report via email

4- How individual Product Capabilities solved the Business challenge

Example 5: Unavailability Analysis



Unavailability Analysis is a tool that enables the operations and maintenance teams to maximize fleet availability by identifying the root causes of turbines downtimes, as well revenue losses. It empowers the users to improve decision-making and correctly prioritize actions for optimal maintenance and troubleshooting actions

1 – About the Company

2 – Business challenge

3 – Application and Use case / How PI is applied

4 – How individual Product Capabilities solved the Business challenge

5 –Conclusion

Making PI System sustainable

CHALLENGES

- Applying Business needs for the renewable world by taking the individual requirements into account

SOLUTION

- Continuously implement a global IT infrastructure and provide customized solutions based in PI tools and PI Components

BENEFITS

- Reliable indicators and processes in real time
- Improving accessibility and sharing of information
- One consistent system across all plants for Eon Climate & Renewables world

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