



The Internet of Wind as Enabler for Progressive Asset Management

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E.ON Climate & Renewables GmbH

OSIsoft EMEA User Conference 2016
Berlin, September 28th 2016

e-on

The Internet of Wind as Enabler for Progressive Asset Management

Setting the scene

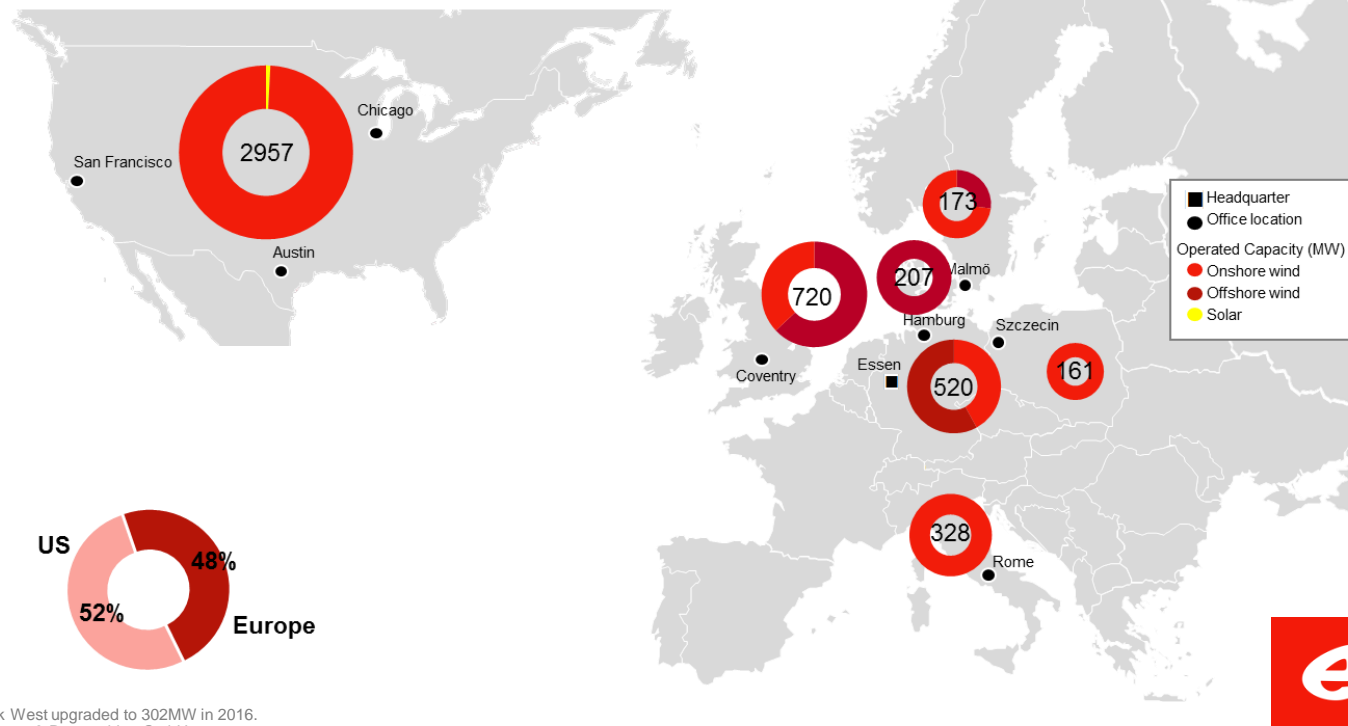
Use of existing data -
some use cases

More Data
– higher benefit?

What will come
next?

- Increasing expectations of what IoT can do for wind turbines
- Initial simple achievements trigger expectation for further advances
- Expectations lead to a boost in innovation and efficiency
- Gathering data from more intelligent sensors and systems
- Comparison with the growth of a child

E.ON Climate & Renewables Operates a Capacity of 5.1 GW Across Europe and North America¹



Our Interpretation of Progressive Asset Management Covers Various Initiatives, Tools and Processes

O&M contract modules/
framework agreements
and 3rd party providers

Spares strategy/
frameworks and
warehousing concepts

Hands-on O&M service
concepts

Smart maintenance
processes

EC&R Control Room

Fleet analysis and fleet
performance

EC&R fleet engineers/
best practice sharing

Offshore logistics and
subsea maintenance

SmartECR and
infrastructure (e.g. SAP
PM/MM)

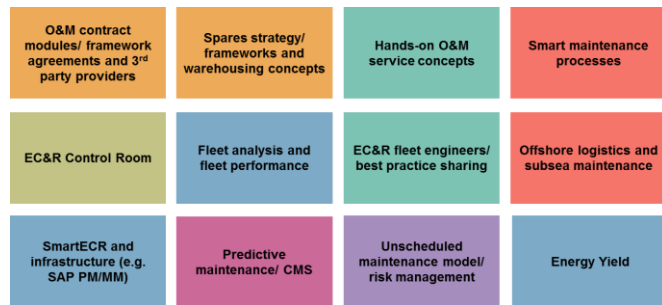
Predictive maintenance/
CMS

Unscheduled
maintenance model/ risk
management

Energy Yield

With Progressive Asset Management We Get More out of the Portfolio

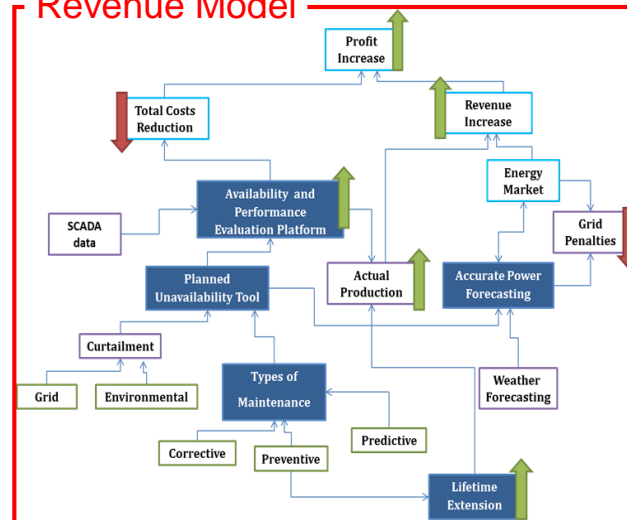
Prog. Asset Management



Result

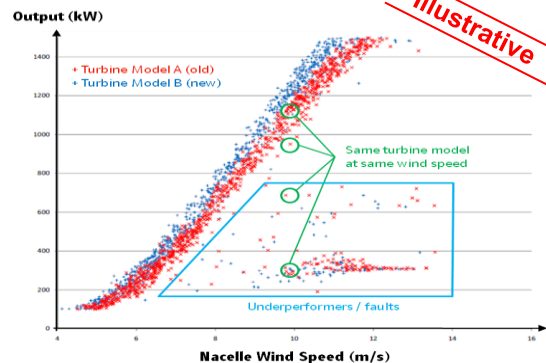
Higher levels of control to increase availability and drive down O&M costs significantly across on- and offshore wind

Revenue Model



Energy Yield Increases Turbine Performance Through Three Primary Levers

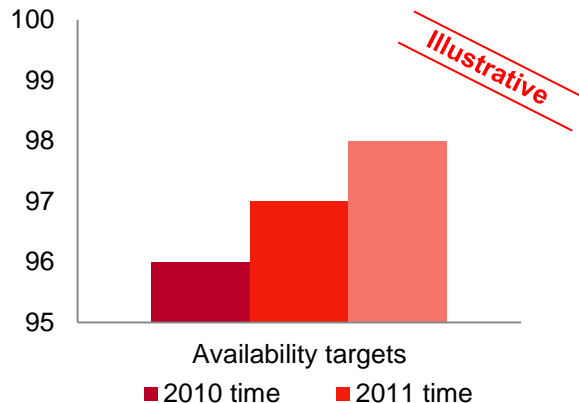
Efficiency



Source: E.ON SCADA (Supervisory Control and Data Acquisition)

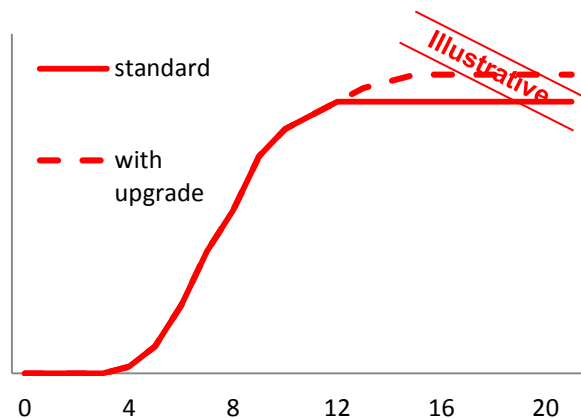
Identify performance deficits through pre-inspection analysis reports; support the correction of these issues; quantify the production improvement benefits

Availability



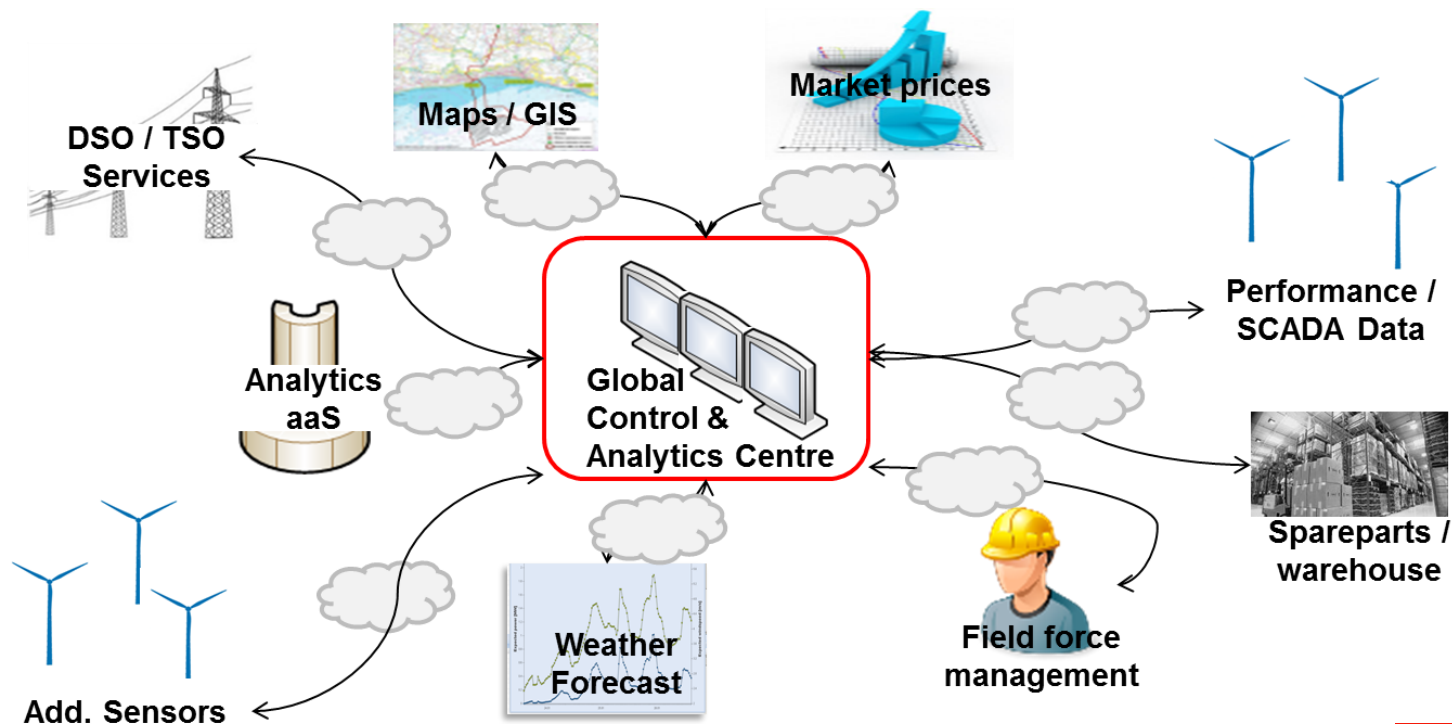
Improve reliability by identifying recurring issues in pre-inspection analysis reports; Control Room and site teams rapidly respond to faults aided by self-developed tools

Further Levers



Identify and implement performance enhancing solutions offered by turbine OEMs and third-parties

Mission Impossible: Analytics Without an Integration Layer



Proper integration layer is the key foundation for global operation

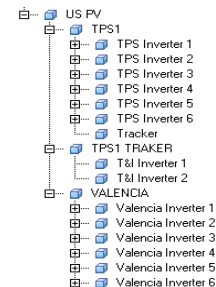
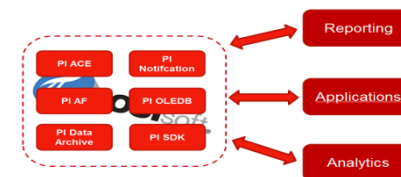
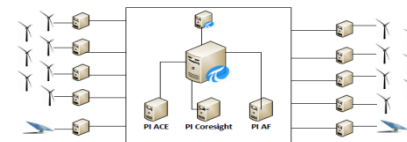
E.ON Climate and Renewables Uses the PI System as Integration Layer and Standardization

The renewables PI System architecture contains 3 PI Servers:

- EC&R Central
- US Central
- Development

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.

The data can be accessed using OSIsoft products like PI ProcessBook, PI DataLink and PI Coresight and analytical tools like Tableau. The most extensive usage happens through the PI SDK and PI OLEDB Interface.



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Setting the scene

Use of existing data -
some use cases

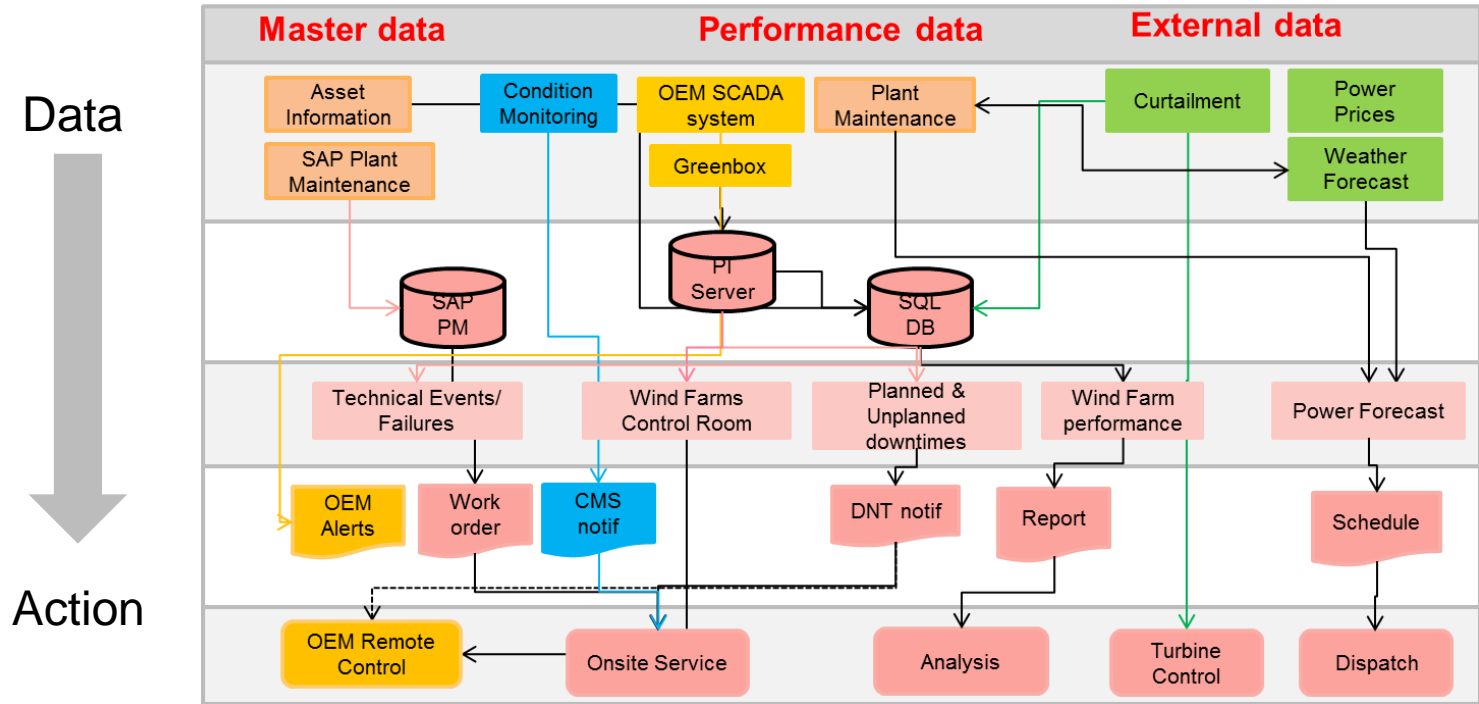
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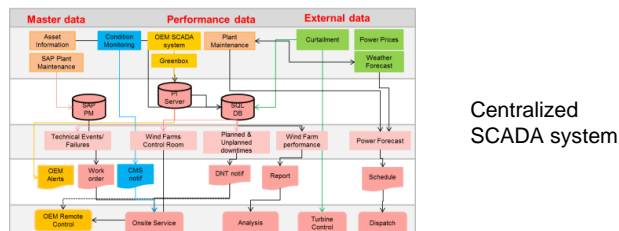
The logo for E.ON, featuring the text "e-on" in a white, stylized font on a red rectangular background.

From Data to Action - Many Sources Used Inside SmartECR Platform



.... To Manage Assets for EC&R Control Rooms and Analyst Teams

Concept



EC&R North
American Control
Room in Austin



Rationale and benefit

SmartECR:

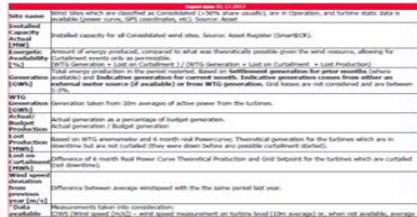
- Global OEM-independent SCADA system to ensure efficient operation and control of the entire fleet
- Integration of all SCADA data onto one single business process database and analytics platform
- Automated fleet-wide operational reports on yearly/ quarterly/ monthly/ weekly basis

EC&R Control Room:

- 2 EC&R owned and operated control rooms- Coventry for Europe and Austin for US sites- monitoring all EC&R operated sites
- Global real-time monitoring and control to realize full benefits of large-scale deployment

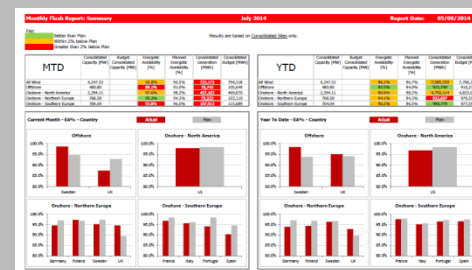
Let's have a look at some concrete use cases

Site Report

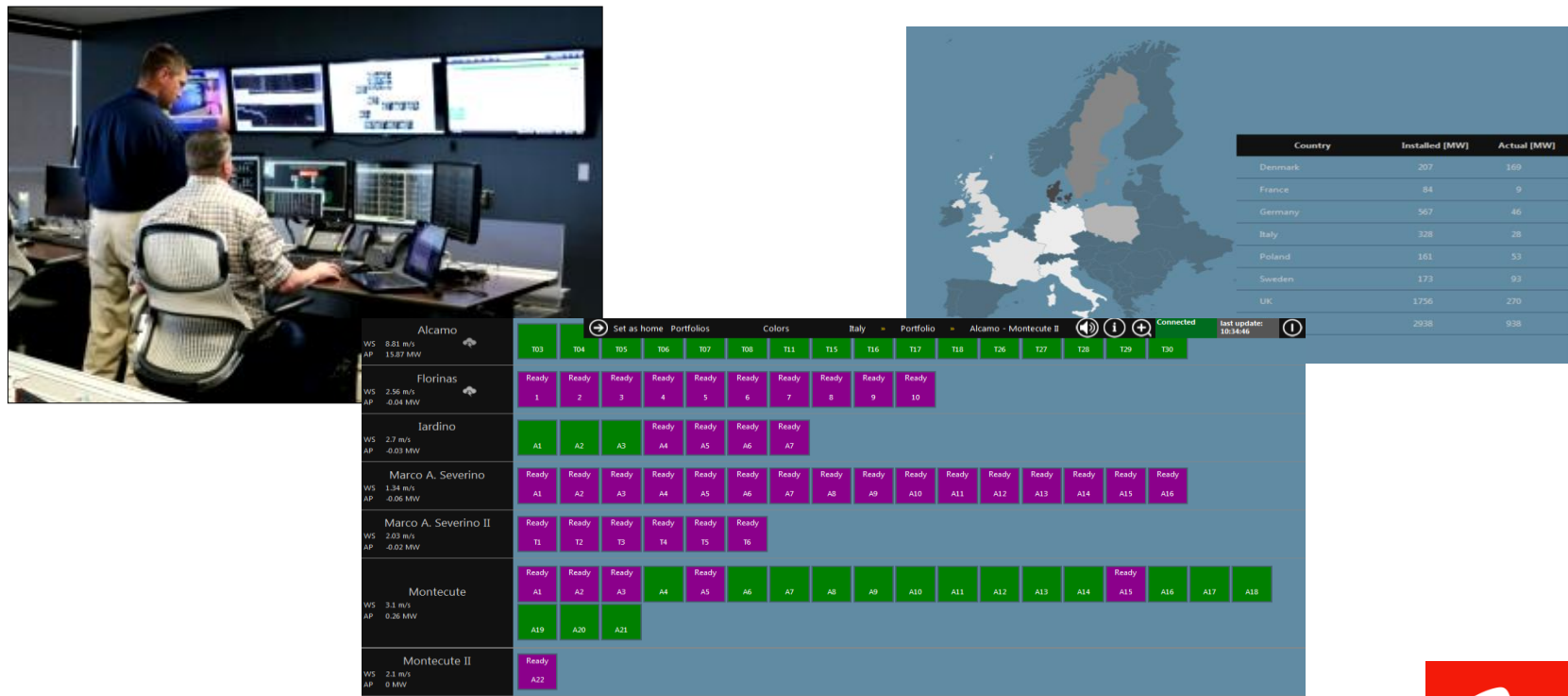


Weekly Performance Report: Consolidated Sites										01 January 2014	to	17 July 2014	Report Date:	18.07.2014
View To: 			Please Select											
Region	Country	Site	Consolidated Capacity [MW]	Electric Availability [%]	Consolidated Generation [MWh]	Consolidated Generation [MWh]	WTG Generation [MWh]	Downtime Loss [MWh]	Curtailed Loss [MWh]	Actual Production	Wind Speed [m/s]			
All Wind			4,207.53	96.2%	7,288.707	7,241.695	7,238.052	285.44	35.50	99%	6.5			
Offshore	North America		480.0	96.1%	851.40	862.48	862.80	35.59	0	100%	7.5			
		Onshore - North America	2,394.11	96.6%	4,571.37	4,530.05	4,524.24	160.02	26.83	99%	7.5			
		Onshore - Northern Europe	783.9	94.1%	186.52	172.82	168.48	55.82	4	90%	6.2			
		Onshore - Southern Europe	796.54	96.6%	977.38	925.73	941.50	33.61	7.88	100%	6.4			
Region	Country	Site	Consolidated Capacity [MW]	Electric Availability [%]	Consolidated Generation [MWh]	Consolidated Generation [MWh]	WTG Generation [MWh]	Downtime Loss [MWh]	Curtailed Loss [MWh]	Actual Production	Wind Speed [m/s]			
Offshore	Sweden		48.0	98.4%	335.37	314.04	335.42	1.75	0	100%	8.4			
		Sweden - Årehamn	48.0	98.4%	335.37	314.04	335.42	1.75	0	100%	8.4			
		UK	453.0	95.5%	777.73	765.94	777.41	33.64	0	100%	7.5			
		UK (B&S) (Offshore)	1.0	0.0%	0	0	0	14.41	0	0%	7.5			
Offshore	UK		245.0	95.5%	412.80	407.53	412.80	1.57	0	100%	7.5			
		UK - London Area LARH1-6	46.44	97.2%	384.34	366.67	385.98	2.60	0	90%	7.8			
		UK - London Area LARH1-2	47.52	98.0%	93.144	90.145	94.024	0.41	0	94%	7.7			
		UK - London Area LARH1-3	49.96	98.6%	89.636	101.905	95.591	2.875	0	88%	7.7			
Offshore	UK		47.52	97.9%	62.861	60.165	62.561	0.695	0	90%	7.8			
		UK - London Area LARH1-4	47.52	97.9%	62.861	60.165	62.561	0.695	0	90%	7.8			
		UK - London Area LARH1-5	47.52	97.9%	62.861	60.165	62.561	0.695	0	90%	7.8			
		UK - London Area LARH1-6	47.52	97.9%	62.861	60.165	62.561	0.695	0	90%	7.8			

Finance

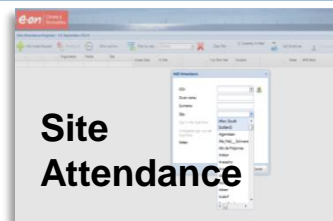


Use Case: Central Control Room for Monitoring and Control

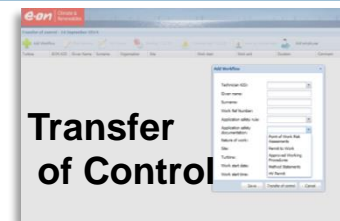


Central Monitoring Works on Different Layers

People Working
on wind farms



Site
Attendance



Transfer
of Control



Vessel/ people
tracking

Wind farms &
turbines



Status & Error Codes,
Remote Control & Resets,
Condition Monitoring

Infrastructure /
Network



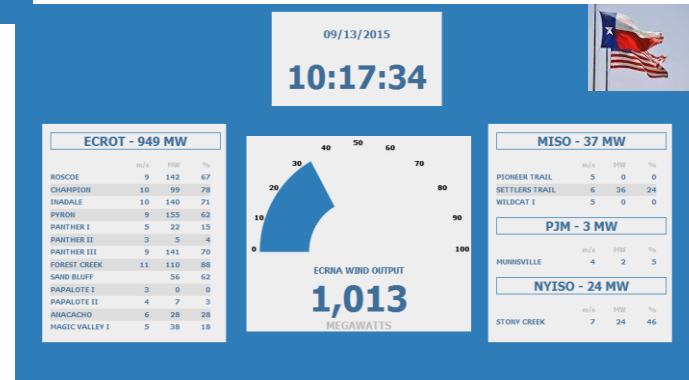
Connectivity
Network health

Lobby Screens in Every Office



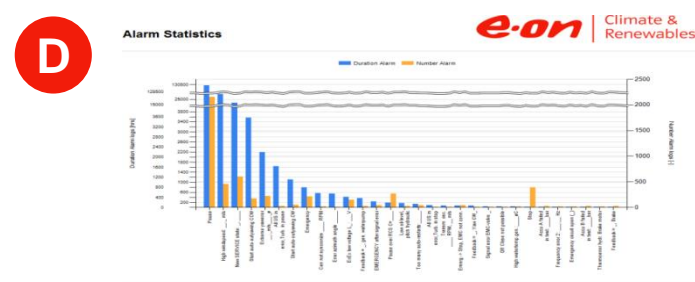
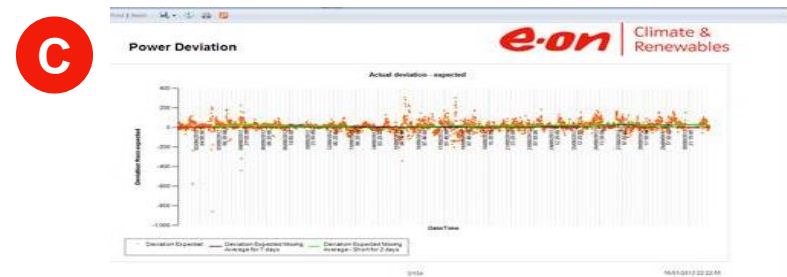
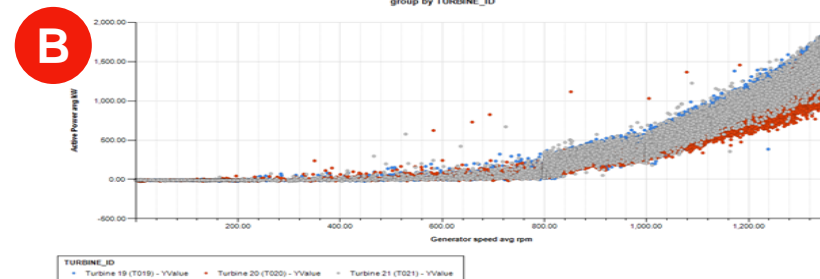
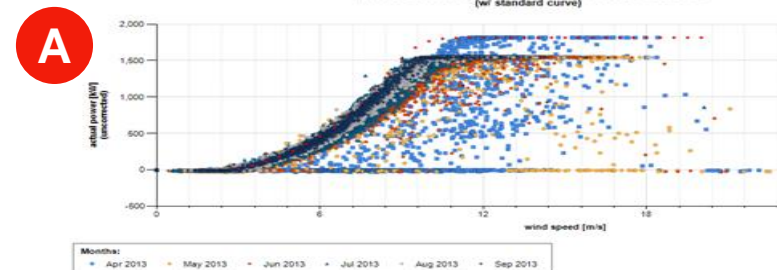
Global screen

U.S. screen per grid



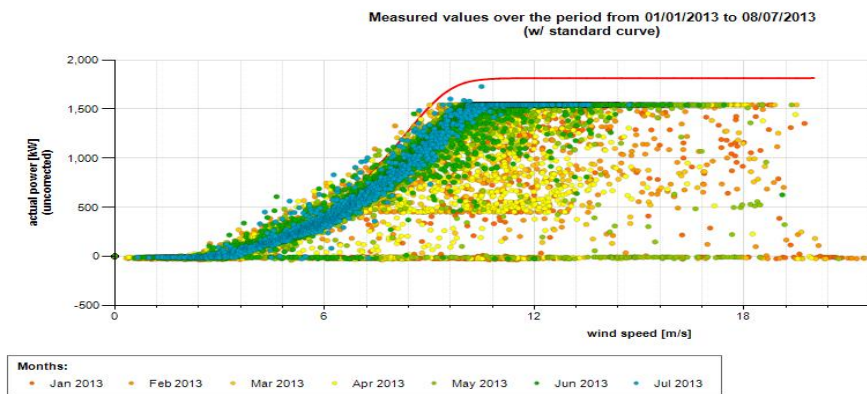
Easily Adapted to Local Needs

Use Case: Wind Turbine Performance Analysis

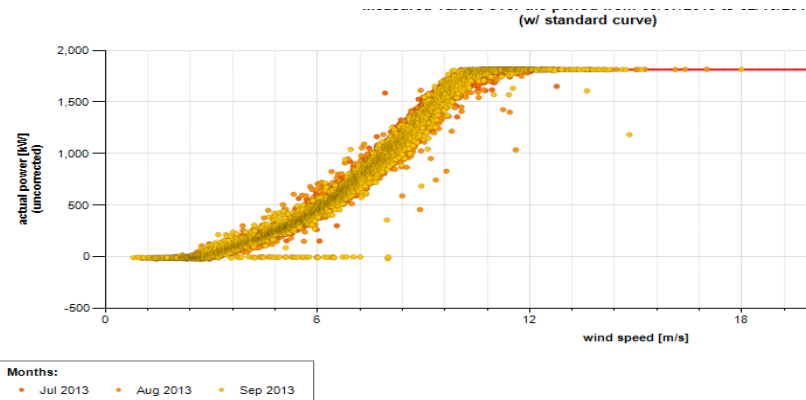


Peer-to-Peer Benchmark of Turbines Helps Identify Abnormal Behavior

Before Correction



After Correction



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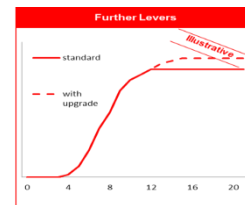
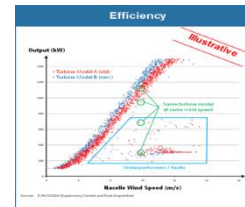
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Where Do We See Potential for IoT?

- Additional sensors
- Partial replacement of standard infrastructure
- Logistics – during construction phase and spare part management
- Condition monitoring
- Environmental monitoring
-



positive
business case
/ROI

Roscoe, Texas, one of the world's largest onshore wind parks (782 MW) – half the size of New York City



Valencia Solar PV Park, Arizona (10 MW)



Amrumbank West, Germany (302 MW)



Grandview I, Texas, E.ON's 19th wind farm in NA (211 MW)



London Array, the world's largest offshore wind farm (630 MW)



Bowbeat Wind Farm: an Example for New Sensors



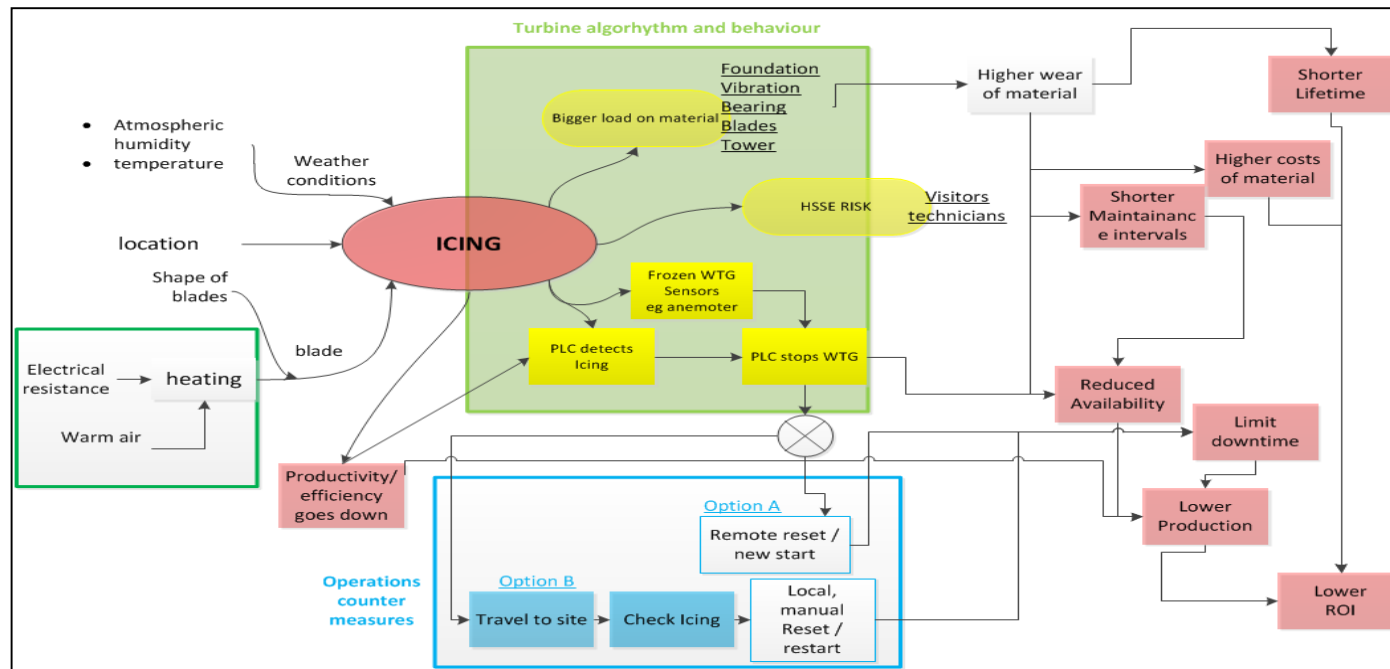
Problem:

- Ice detection and how to react

Impact:

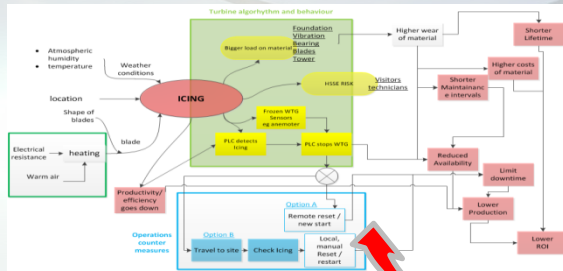
- HSSE - health and safety of people
- Production - how to minimize production losses

How the “System” Interacts with Icing: Influences and Parameters



Test and Evaluate Model and Decide on Business Case / Investment

Apply and test sensors



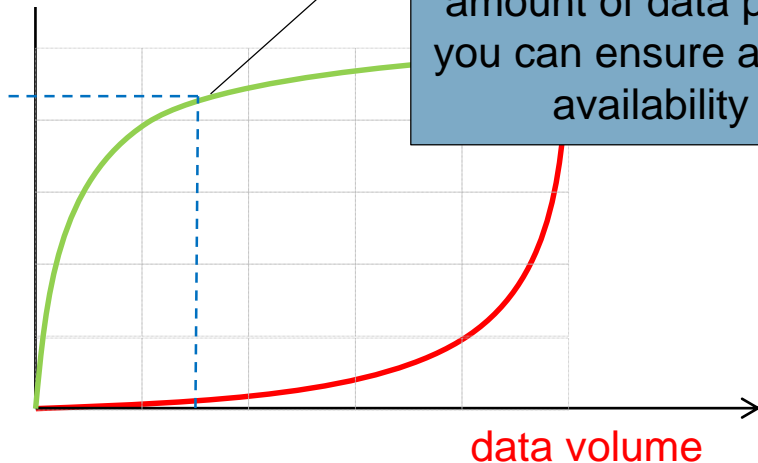
Re evaluate the model

Decision based on
business case



More Data Can Help, But Please Stay Smart: Pareto Principle Is Valid!

Benefits based
on availability



Category	M-Tag	Tag Name	EngUnit	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	M5802	Meteo Air Pressure	mBar	10s
Meteo	M5803	Meteo Air Temperature	°C	10s
Meteo	M5805	Meteo Site Wind Speed	m/s	10s
Meteo	M5806	Meteo Relative Humidity	%	10s

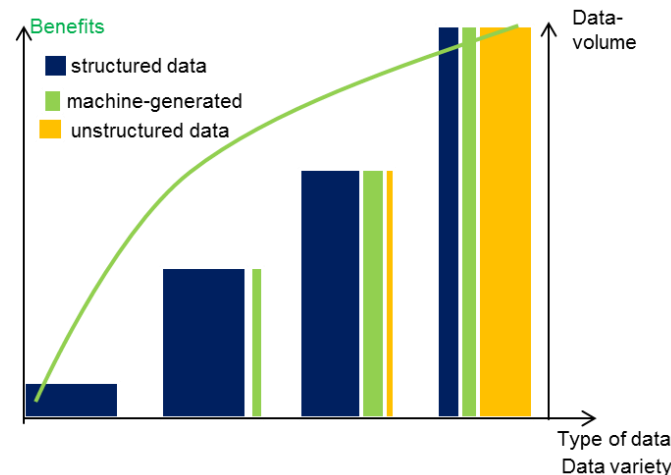
But it tells only the first half of the story...

To Get More out of It, You Have to Utilize More Data Sources

Future reality of Wind is characterized by:

- *Increased competition through auctions will drive cost pressures.*
- *Larger and geographically more diverse sites.*
- *Squeeze more from existing and new sites (scarcity of high yield options).*
- *Challenge of generating new revenues through third party services*

to get the full benefits you have to utilize all data sources and types



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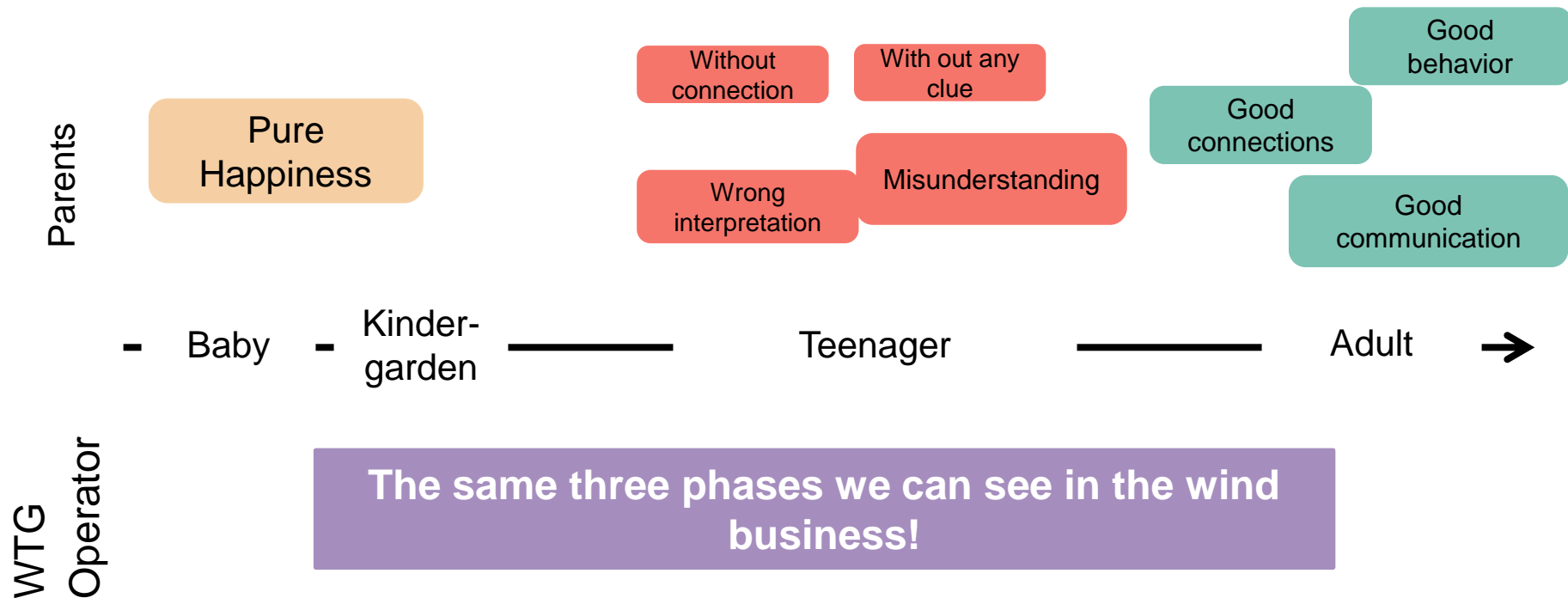
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Wind Turbines and Children – Anything in Common?



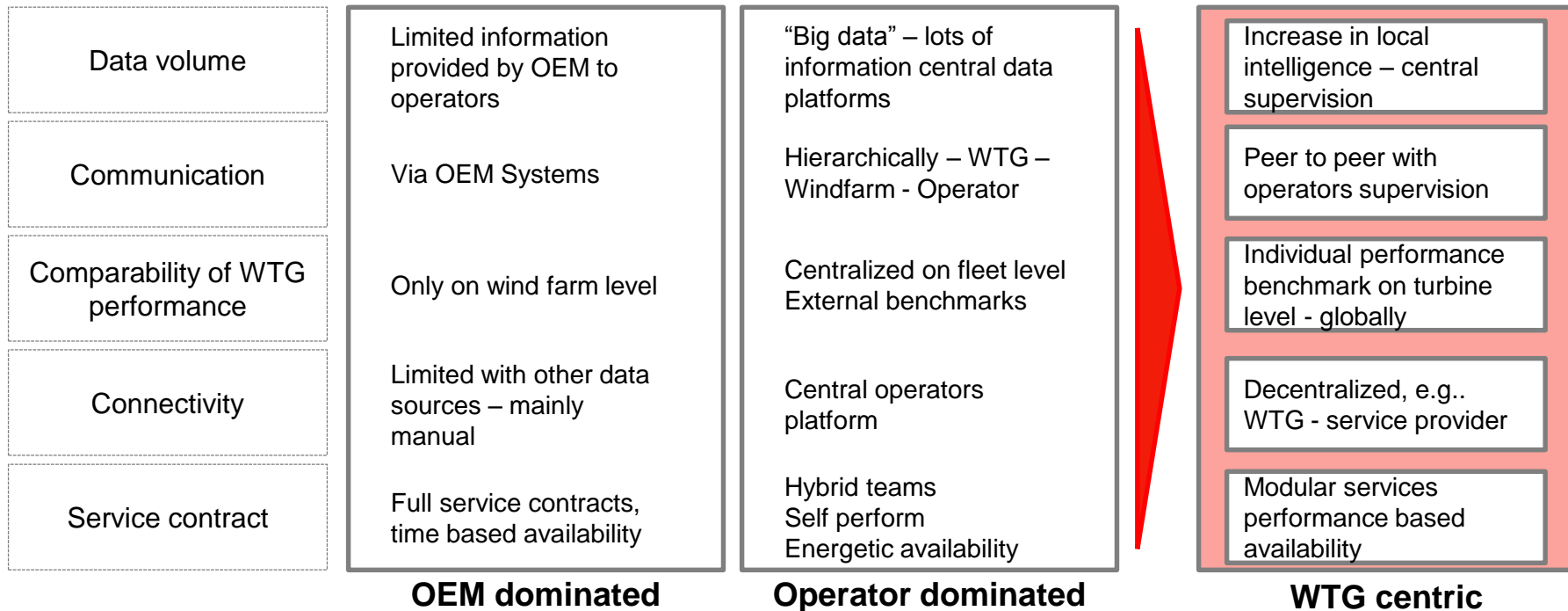
Source: Google search / newborn babies / teenager

An Analogy: Wind Turbines and Growth of Children

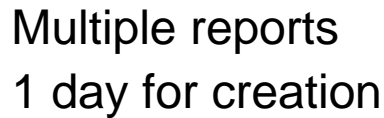




Development Will Follow Three Waves



Analytics since 2011



Pitch thyristor? fault 1.981MWh	Blade angle asymmetry 709MWh	Battery charging voltage not OK 326MWh	Gear oil temperature switching contact 228MWh			Motor				
	Line CCU collective faults 629MWh	Pitch control deviation axis ? 287MWh	Generator brushes worn 225MWh	Circuit	Tower	Top Box Fuse or	Wind vane failure		Wind	
		Gen. side CCU collective faults 272MWh	Battery voltage not OK axis 3 179MWh	Battery voltage						
	Safety chain 829MWh	Cable supervision pitch motor 475MWh	Line side CCU current fault 248MWh	Gen. side CCU fault current 177MWh	DTA DIN03					
Axis ? fault pitch controller 352MWh		Gearbox oil pressure too low 236MWh	Collective fault pitch controller 169MWh	Battery voltage						
			DTA DIN03 control breaker status MCB	No activity						

Interactive analytics

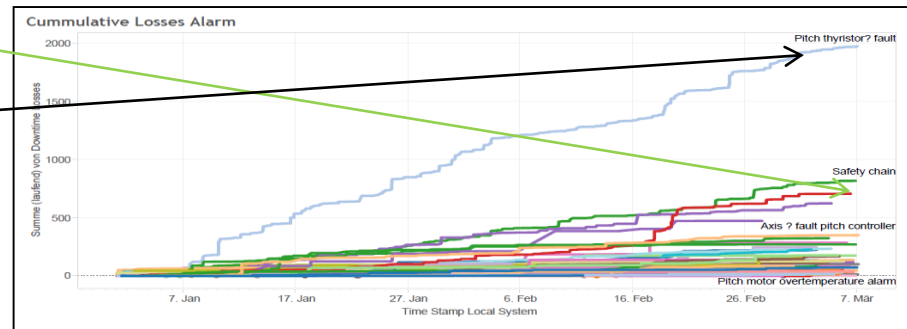
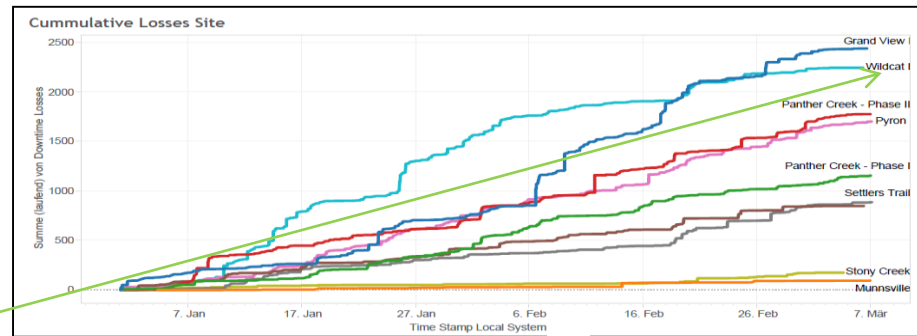
1/4 hour for creation

To Get a Better View into Turbine Performance and Behavior...

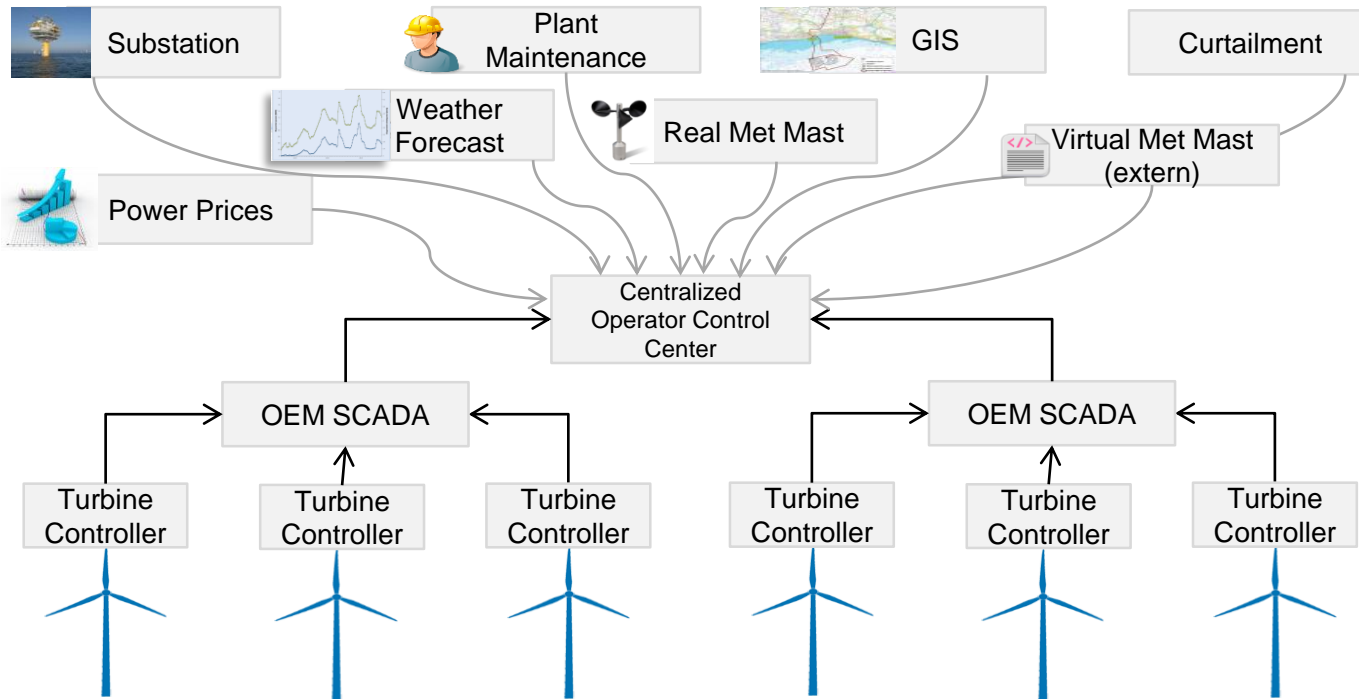
Cumulative losses

Good visualization to check if losses are under control.
Slope indicates that actions which have been taken are successful

- flat: under control
- raising: problem still not fixed



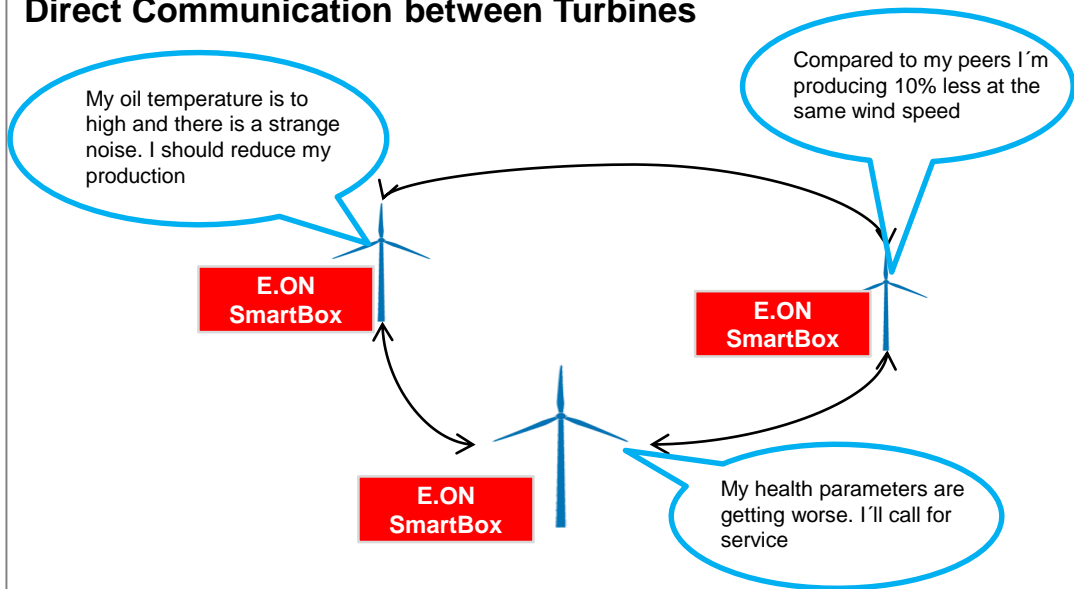
To Move from Hierarchical Turbine Communication Combined with Maintenance and Environmental Information ...



Into a World with New Turbines with Interactive Communication



Direct Communication between Turbines



- Increase production flexibility by having direct communication between turbines and with the other sources
- OEM independent SCADA system allows direct communication between turbines from different vendors
- Improve the maturity of wind turbines
- Turbine learn how to react to different situation via performance models
- Real-time decision are taken locally

Summary / Outlook – What Can Happen?



- Digitalization will massively influence the energy markets.
- The role of the electrical grid will change due to the usage of internet based services.
- Sensors are becoming cheaper and cheaper and computer power is constantly increasing: this leads to growing up of turbine's maturity
- Wind turbines and other decentralized generation units will play a more active role in the future.
- OEM in depended control modules and open protocols will be the standard in the future.

Contact information

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E.ON Climate & Renewables



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Questions

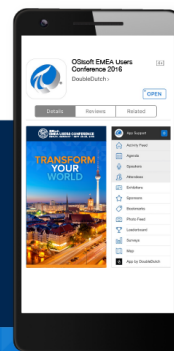
Please wait for the **microphone** before asking your questions



State your **name & company**

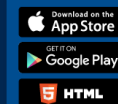
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