# When Turbines Go Bump in the Night – Shedding Light on Lost Revenue

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#### **EDF Renewables North America**

- Provides Grid-Scale Power, Distributed Solutions, and Asset Optimization
- 16 GW of renewable energy installed
- 26 GW planned or in construction





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#### Problem – Turbines Go Bump

- Common reasons turbine fault
  - Gearbox oil temperature too high
  - Excessive vibrations
  - Equipment voltage spikes
- Typical solutions
  - Operation Control Center remote reset
  - Site personnel remote reset
  - Climb turbine



# But what if turbines go down on nights/weekends?

- Site crew work typical hours
- Operation Control Center (OCC) monitors 24/7/365
- OCC can notify the site and have a repair team come in for afterhours repairs
- · Each site had its own criteria





#### Site Callout Criteria

Wind Speed	1 wtg off line	vtg off 2 wtg off line		4 wtg off line	5 wtg off line		
5	DNC	DNC	DNC	Call Out	Call Out		
6	DNC	DNC	Call Out	Call Out	Call Out		
7	DNC	Call Out	Call Out	Call Out	Call Out		
8	Call Out	Call Out	Call Out	Call Out	Call Out		
9	Call Out	Call Out	Call Out	Call Out	Call Out		
10	Call Out	Call Out	Call Out	Call Out	Call Out		
11	Call Out	Call Out	Call Out	Call Out	Call Out		
12	Call Out	Call Out	Call Out	Call Out	Call Out		

#### 4.3 Call Out Chart 24/7 - 365



#### There must be a better way!

- 1. Take into account future state wind speed forecasts
- 2. Describe callout criteria in dollars, for simple and consistent decision making
- 3. Capture history to assess effectiveness



#### Outline the solution

- Provide real-time monitoring
- Forecast lost revenue of down turbines
- Integrate rules for when to do a callout
- Provide notifications and store events





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#### **ORCA – Enterprise Level**





#### **ORCA – Project Level**





#### **ORCA – Asset Detail Level**



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#### **ORCA** – Other Visualizations

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<b>}</b>					01	/ERVIEW TURBIN	ES METS	MAP S	UBSTATION					1:05:52 PM (CDT)
Turbines (56/82)								Sort D Nam	rder e	<ul> <li>Running</li> </ul>	(55) 🔽 Ready (1)	🗸 Stopped (25) 🔽 (	Offline (1) 🛛 🔽 RS	(0) 🔽 OEM (82)
T01	201 KW 0.2 m/s	TO2	1,729 KW 9.0 m/s	T03	2,337 kW 9.8 m/s   🗡	T04	2,244 kW 9.9 m/s	T05	1,867 KW 6.9 m/s 🔹 🕨	TO6	2,205 kW 10.1 m/s	T07	2,544 kW 8.9 m/s	0
T08	726 kW 2.0 m/s I 🔺	T09	2,039 KW 10.8 m/s	T10 (Connection)	1,917 kW 8.6 m/s	T11 (-3) Run Up / Idling	-16 kW 11.7 m/s	T12 Stopped (-5) Repair	-3 kw 🛛 🔺 73.3 m/s	T13	2,729 kW 10.2 m/s	T14 Stopped (-5) Repair	-8 KW 6.5 m/s 🖬 ┥	
T15 Stopped	-2kW 9.2 m/s 1	T16	2,717 kW 11.9 m/s 🛛 🗡 ection	T17 Stopped (-5) Repair	-2 kW 12.2 m/s	T18	1,114 kW 7.6 m/s E	T19 Stopped (-5) Repair	-6 kW 9.7 m/s 🛯 📐	T20	2,339 kW 9.3 m/s	(-2) Turbine With Grid Conne	2,029 kW 8.4 m/s	
(-2) Turbine With Grid Connection	337 kW 8.9 m/s 🛯 📐	T23	2,190 kW 10.4 m/s	T24	1,682 kW 8.4 m/s 🔹 🕨	T25	2,528 kW 9.4 m/s 🛙 🕨	T26 Stopped (-5) Repair	-2 kW 10.0 m/s 🛙 🕨	T27 Stopped (-5) Repair	-11 kW 11.8 m/s	T28 (-2) Turbine With Grid Conne	2,555 kW 9.0 m/s	
T29 (-2) Turbine With Grid Connection	,510 kW 9.3 m/s 🖡 🕨	T30 Stopped (-5) Repair	-7 KW 10.9 m/s 🛯 👗	T31 Stopped (-5) Repair	-7 kW 7.7 m/s 🛯 🕨	T32	2,128 KW 8.8 m/s 🛯 🕨	T33	2,213 KW 9.8 m/s	<b>T34</b>	2,515 kW 10.4 m/s	(-2) Turbine With Grid Conne	2,082 kW 6.2 m/s	
T36     2       (-2) Turbine With Grid Connection	489 kW 0.3 m/s 🛛 🕨	T37 Stopped (-5) Repair	-2 KW 11.0 m/s	T38	1,779 kW 7.9 mJe 🛯 🕨	T39 Stopped (-5) Repair	-9 kW 11.7 m/s 🛙 📐	T40	2,364 kW 7.6 m/e <b>F</b>	T41	2,767 kW 10.0 m/s	(-2) Turbine With Grid Conne	2,556 kW 0.9 m/c	
T43 (-2) Turbine With Grid Connection	813 kW 9.3 m/s 1 💎	T44	2,319 kW 8.4 m/s TV ection	T45 Stopped (-5) Repair	-2 KW 8.5 m/s 👔 👗	T46 Stopped (-S) Repair	-3 kW 8.0 m/s 🛯 🕨	T47 Stopped (-5) Repair	-2 kW 9.3 m/s 📲 📥	T48	2,509 kW 9.4 m/s	T49 Stopped (-5) Repair	-2 kW 9.4 m/s 🛯 🕨	
T50 Stopped <sub>1</sub> (-5) Repair	-1 KW 3.7 m/s 🛛 🗡	T51 Stopped (-5) Repair	-2 KW 11.5 m/s 🛛 🔻	T52	2,198 kW 9.7 m/s 👔 🕨	T53	2,847 kW 9.2 m/s 🛯 📐 ection	T54	1,498 kW 11.2 m/s	T55 Stopped (-5) Repair	-2 kW 8.1 m/s	(-2) Turbine With Grid Conne	1,693 kW 9,4 m/s 🖡 🕨	
(-2) Turbine With Grid Connection	,674 KW 7.7 m/s 🛯 📐	T58	1,801 kW 8.1 m/s	(-2) Turbine With Grid Connes	2,476 kW 11.0 m/s	(-2) Turbine With Grid Conn	2,470 kW 8.9 m/s 🛯 🕨	T61 Stopped (-5) Repair	-9 kW 10.0 m/s 🛯 🕨	T62	2,349 kW 9.3 m/s	T63 Stopped (-5) Repair	-2 KW 6.5 m/s 🔹 🕨	
C-2) Turbine With Grid Connection	843 kW 8.6 m/s 🛙 🥆	T65	2,378 KW 8.9 m/s 👔 🕨	T66	2,506 kW 10.6 m/s	(-2) Turbine With Grid Conn	2,239 KW 9.4 m/s 🛛 🏲 ection	T68	1,588 KW 7.5 m/s T	T69 Stopped (-5) Repair	-1 kW 10.2 m/s 🛯 👗	T70 (-2) Turbine With Grid Conne	2,030 kW 9.0 m/s	
T71 2 (-2) Turbine With Grid Connection	071 kW 9.9 m/s 🖡 🕨	T72	1,569 kW 7.5 m/s 🔹 📐	T73 (-2) Turbine With Grid Connec	2,472 kW 9.6 m/s 🔹 🕨	T74	1,508 KW 7.1 m/s 🛯 🕨	(-2) Turbine With Grid Cor	1,919 KW 7.9 m/s I	T76 Stopped (-5) Repair	-1 KW 12.1 m/s	T77 Stopped (-5) Repair	-2 kW 10.5 m/s	
T78 Comm Error (0) Bad Data		T79 (-2) Turbine With Grid Conne	2,503 kW 11.0 m/s	T80 Stopped (-5) Repair	-15 kW 8.9 m/s 👔 🔺	T81 Stopped (-5) Repair	-2 kW 11.2 m/s	T82	2,359 KW 9.3 m/s					

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#### **ORCA** – Other Visualizations





# The Ingredients **Forecasted Energy** +**Energy Price** +Schedule +**Operational Status**



#### **The Ingredients - Forecast**

Create a power forecast for each turbine

- Weather forecast data via the Dark Sky API
- Convert wind speed to hub height
- Manufacturer power curve







#### The Ingredients – Business Data

• Fixed Price (PPA) or Market Price (LMP)

Turn turbine forecast power into revenue

• Crew shift times

Know how long until crew comes back to the site

Callout threshold

How much revenue loss is worth sending crew out?



# The Ingredients – Turbine Eligibility

Active Power

Must be 0 or negative

Turbine State

Must be a code that's considered a fault – for at least 15 minutes

Long Term Downtime Status

Must not already be tracked in our Long Term Downtime Tracker (LTDT)



#### The Recipe



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#### **Callout Dashboard**

allouts														Upo	lated 11:42:55 A
Project	Down Turbines	Current Shift End	Time to Shift End (hh:mm)	Next Shift Start	Time to Next Shift (hh:mm)	Timezone	Forecasted Lost A Revenue to Next Shift	Callout Threshold	Status		Manually Add/Remove	•			
1.00	20 (1)			Tomorrow 5:00 AM	17:17	CDT	\$4,470 (USD)		Monitoring						
de mes	2 (2)			Tomorrow 6:00 AM	18:17	PDT	\$3,023 (USD)	\$800 (USD)	Monitoring	Callout					
110	1 (1)			Tomorrow 3:00 AM	15:17	EDT	\$1,697 (USD)	\$800 (USD)	Callout Inprogress	Reset					
	2			Tomorrow 5:00 AM	17:17	CDT	\$1,630 (USD)		Monitoring						
(teres)	4			Tomorrow 5:00 AM	17:17	CDT	\$1,585 (USD)		Monitoring						
	2(1)			Tomorrow 5:00 AM	17:17	CDT	\$1,584 (USD)	\$800 (USD)	Callout Inprogress	Reset					
-	1 (1)			Tomorrow 5:00 AM	17:17	CDT	\$1,118 (USD)	\$800 (USD)	Monitoring	Callout					
	2(0)			Tomorrow 5:00 AM	17:17	CDT	\$1,052 (USD)	\$800 (USD)	Monitoring	Callout					
all set	2			Tornorrow 4:00 AM	16:17	EDT	\$977 (USD)	\$800 (USD)	Monitoring	Callout					
1000	1	-	-	Tomorrow 4:00 AM	16:17	EDT	\$953 (USD)	\$800 (USD)	Monitoring	Callout					
	2			Tomorrow 5:00 AM	17:17	CDT	\$783 (USD)	\$800 (USD)	Monitoring	Callout					
	2(1)			Tomorrow 5:00 AM	17:17	MDT	\$752 (USD)	\$800 (USD)	Monitoring	Callout					
teres teres	2 (1)	-	•	Tomorrow 5:00 AM	16:17 17:17 17:17	CDT MDT	\$783 (USD) \$783 (USD) \$752 (USD)	\$800 (USD) \$800 (USD) \$800 (USD)	Monitoring Monitoring	Callout Callout Callout					
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													Wind Sp	beed (m/s)	Temperature (
ines															

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# **User Input Still Needed**

Callouts									Updated 11:34:38
Project	Down Turbines	Current Shift End	Time to Shift End (hh:mm)	Next Shift Start	Time to Next Sl (hh:mm)	ift F Timezone	Forecasted Lost へ Revenue to Next Shift	Callout Threshold Status	Manually Add Remove
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	2			Tomorrow 5:00 AM	17:25	1000	1	-	
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## **Initiating a Callout**

Tomorrow 5:00 AM	17:17	CDT	\$1,585 (USD)		3	Monitori	ing		
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Tomorrow 5:00 AM	17						ng	Callout	
Tomorrow 5:00 AM	17			Exit	Call	lout	ng	Callout	



#### **Callout Notification**

 From: OCC < \_\_\_\_\_>

 Sent: Saturday, March 21, 2020 7:14 PM

 To:
 Notifications < \_\_\_\_\_>

 Subject: OCC has made an ORCA callout
 down turbine(s)

OCC has made an ORCA callout for down turbine(s) due to forecasted lost revenue of \$2212 with a callout threshold of \$800.

Additional Notes:

Informed site of two down turbines; D24/D13

Please go to ORCA Callouts to view additional information.



#### Insights

- About \$5 million in revenue lost annually
  - Not great to see, but exciting to have room for improvement
- Taxing on site crews
  - Callouts increased by 50%
  - Decided to increase threshold to \$3200 if within 7 hours of next shift
  - Unnecessary callouts more easily avoided
- Down turbine auto detection not 100% accurate
  - Still need humans in the loop



#### Results thus far

700 callouts to date

Estimated savings of \$2 million per year

Talk of hiring more site personnel

"We are now able to track callouts and know the value we are gaining, which allows us to further refine our callout criteria to capture additional value. Our most significant callout to-date resulted in just over \$30,000 in saved revenue."

- Bob Sullivan, OCC Projects Manager

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## What's next?

- Planned improvements
  - Change to industry-specific weather forecast service
  - Day ahead pricing for market sites
  - Improve callout threshold logic, based on corrective action
  - Improve down turbine auto-detection with better fault classification
  - Unsupervised monitoring and operators notified as needed
- Reuse real-time and forecasted revenue for better decision making in other areas



## **Thanks for Listening!**



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#### **Questions?**

Please wait for the **microphone** 

State your name & company



#### Save the Date...



AMSTERDAM October 26-29, 2020







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