

Bat Curtailment Compliance Reporting at Scale

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Deriva Energy – Our Company



- Formerly known as Duke Energy Renewables
- We manage approximately 5,900 MW of operating and underconstruction capacity at over 80 projects in 16 states.
- Deriva Energy is a portfolio company of Brookfield Renewables, one of the world's largest owners and operators of renewable power and climate transition assets.



Deriva Energy Site Locations







Addressing the Challenge



CHALLENGE

The U.S. Fish and Wildlife Service requires us to curtail for northern long-eared bats at all wind sites. We need a scorecard to prove that we are effectively curtailing for bats.

SOLUTION

Utilize Seeq Data Lab to scale the calculations needed for our entire wind fleet

RESULTS

An automated Power BI report that will produce a bat curtailment compliance score per wind site



What is Curtailment?



Curtailment is the reduction of output of a renewable resource below what it could have otherwise produced. At wind sites, turbine blades will angle parallel to the wind to slow or stop them from turning while curtailment is active.

We currently curtail for bats at all 21 wind sites. We have special conditions that need to be met for bat curtailment to occur. These conditions include:

- No daylight
- Windspeed is below cut-in speed
- Time of year





The U.S. Fish and Wildlife Service provides guidance for curtailment of turbines while northern long-eared bats are migrating during low wind speeds.

There have been a total of 35 northern long-eared bat fatalities recorded at wind facilities in the U.S. due to collision with wind blades.

This species is listed under the Endangered Species Act as of 2015.



Northern Long-Eared Bat







The Criteria for Bat Curtailment





105 conneqt

The Calculation for Bat Curtailment



106

Our calculation for bat curtailment looks at periods with no daylight while the rotor is stopped, meaning that the turbine is successfully curtailed.



The Calculation for Exception



Our calculation for exception looks at where bat curtailment should have occurred but failed. It takes windspeed, daylight, and cut-in speed into account. This calculation tells us the timeframes we need to investigate to improve our processes.





Workbench Analysis Results



We are able to get scorecard metric results for multiple turbines in a table view by utilizing the asset swap feature.

Seeq Data Lab gives us the option to scale further to all wind sites.

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Bat Curtailment Tool - Master								
⊞~	Simple	Condition Chart View	Rows Columns Headers	↑↓ Transpose Striped Striped	New Metric Copy			
Start	Time	Duration of Exception	Average Rotor Speed	Average Wind Speed	Ambient Temp (degree C)	Duration of Bat Curtailment	Assets 🕂	
Apr 1,	9:40 PM	-	-	-	-	670 min	CampbellHill.T15	
Apr 1,	9:40 PM	-	-	-	-	8.224 min	CampbellHill.T41	
Apr 1,	9:40 PM	-	-	-	-	670 min	CampbellHill.T51	
Apr 1,	9:40 PM	-	-	-	-	670 min	CampbellHill.T57	
Apr 1,	9:48 PM	-	-	-	-	3.1068 min	CampbellHill.T41	
Apr 1,	9:52 PM	-	-	-	-	1.5436 min	CampbellHill.T41	
Apr 1,	10:30 PM		-	-	-	567.76 min	CampbellHill.T41	
Apr 1,	11:41 PM		-	-	-	11.287 min	CampbellHill.T40	
Apr 2,	12:25 AM	-	-	-	-	452.65 min	CampbellHill.T40	
Apr 2,	2:51 AM		-	-	-	17.903 min	CampbellHill.T06	
Apr 2,	4:25 AM	-	-	-	-	3.142 min	CampbellHill.T24	
Apr 2,	4:30 AM	-	-	-	-	3.1393 min	CampbellHill.T24	
Apr 2,	4:35 AM	-	-	-	-	15.277 min	CampbellHill.T24	
Apr 2,	4:52 AM		-		-	98.019 min	CampbellHill.T06	
Apr 2,	5:07 AM	18.246 min	9.786 rpm	2.7518 m/s	0.772 °C		CampbellHill.T03	
Apr 2,	5:08 AM	18.451 min	11.194 rpm	2.7711 m/s	1.6389 °C		CampbellHill.T01	
Apr 2,	5:12 AM	14.384 min	11.263 rpm	2.7302 m/s	3.2251 ℃		CampbellHill.T25	
Apr 2, 5:49 AM		14.562 min	11.16 rpm	2.8031 m/s	-0.891 °C		CampbellHill.T32	
Apr 2,	5:57 AM	26.414 min	11.09 rpm	2.8619 m/s	0.2819 °C	•	CampbellHill.T01	
4/1/2024 2	2:17 PM ED	т			📢 📢 26 days 🕨 🚺			



Why use Seeq Data Lab?



Data Lab Project Develop scripts in a Jupyter notebook using Python, Dataframes and the Spy module to quickly build time series analytics and visualizations

Seeq Data Lab enables us to calculate capsule start time and end time for each instance of bat curtailment occurring or failing.

The calculation is done at the turbine level, but we need timeframes for all turbines at all sites. This can be achieved in Data Lab projects, using Python to scale the calculation.

The code runs automatically, adding new capsules each day.

After the capsules are created for each turbine at all wind sites, they can be added to a Workbench Analysis and exported through OData into Power BI.



Writing and Scaling the calculation in DataLab



```
my items = pd.DataFrame({
'Name': [
    'Rotor_Speed',
    'Ambient Temp',
    'Power Curve Minimum',
    'Daylight',
    'windspeed ms - Regression'
],
'Path': f'DER Unregulated Wind >> Non Regulated Generation >> Wind >> Wind Sites >> {site}'
})
# get the metadata and ids for all the signals we're interested in at this site
site signals = spy.search(my items)
# for each turbine at this site
for turbine in wind sites[site]:
   try:
        # get the metadata for the signals just for this turbine
        my signals = site signals.loc[site signals['Asset'] == turbine]
        # pull the actual data values
        data = spy.pull(my signals, start=data start, end=data end, grid=data grid, header='Name')
        # this was coming through as a string for some reason
        data['Power Curve Minimum'] = pd.to numeric(data['Power Curve Minimum'])
        # set up a place holder and default vaule for our calculated signal
        data['Bat Curtailment Non-Compliance'] = False
        data['Duration Bat Curtailment'] = False
        # define where it's true
        data.loc[(data['Rotor_Speed'] >= 2) &
                 (data['Daylight'] == 0) &
                 (data['windspeed_ms - Regression'] < data['Power Curve Minimum']),</pre>
                 'Bat Curtailment Non-Compliance'] = True
        # Duration of Bat Curtailment is when Daylight = False and Rotor Speed <= 2</p>
        data.loc[(data['Rotor Speed'] <= 2) &</pre>
                 (data['Daylight'] == 0),
                 'Duration Bat Curtailment'] = True
        # pull off just our calculated signal and when it's true from our big data frame
        bat = data.loc[data['Bat Curtailment Non-Compliance']==True, 'Bat Curtailment Non-Compliance']
        durbat = data.loc[data['Duration Bat Curtailment']==True, 'Duration Bat Curtailment']
        # convert it from a signal to a capsule format for Seeq
        # (see function definition for how to manipulate gap tolerance and min duration)
        cap df1 = df to capsule(bat, gap tolerance=0.25, min duration=0.1)
        cap df2 = df to capsule(durbat, gap tolerance=0.25, min duration=0.1)
        # the name here needs to match what's in your asset tree
        cap df1['Name'] = f'Duration of Exception Signal --- {turbine}'
        cap df2['Name'] = f'Duration of Bat Curtailment --- {turbine}'
```

Define the signals that we need from each turbine

Define each step of calculation

Push capsules to all defined turbines



Returning to Workbench Analysis



My Folder 👆 产 🥟 🚜 Share 🛛 🚨 Jordan 🚍 Bat Curtailment Test - From Data Lab Capsule 1↓ 🗠 ↓ 🗠 🍡 One Y-Axis Reset Labels Calendar **%** Chain 23 11 田 0°0 🗸 ٨., Ð \bigcirc ~ ∿ Compare One Lane One Y-Axis Labels Gridlines Summary Dimming Annotate Jul 8 Jul 9 Jul 10 Jul 11 Jul 12 Jul 13 Jul 14 Jul 15 Jul 16 Jul 17 Jul 18 ↓ 7/7/2023 3:40 AM EDT 📢 🖣 10.9 days 🕨 🕨 🕽 😋 7/18/2023 2:00 AM EDT 1 22 Jul 8 Jul 9 Jul 10 Jul 11 Jul 12 Jul 13 Jul 14 Jul 15 Jul 16 Jul 17 Jul 18 1 7/7/2023 10.9 days 7/18/2023 Capsules A Details

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- Data Lab will export to a new Workbench Analysis
- Multiple signals for multiple sites



Exporting the Results





Export to an OData client	×
OData Service URL	•
Export Name	
Bat_Curtailment_Test_Export_	ත
https://	ආ
OData Capsule Summary Table Endpoint	en
OData Export Instructions	40
<u>Excel</u> Tableau	>
Spotfire	>



Scorecard in Power BI



The final scorecard in Power BI is calculated by weighing total time in bat curtailment against total time in bat curtailment plus missed periods of bat curtailment.

This is a sample of some of our wind sites' scorecard performance.

Bat Curtailment Scorecard

Site	Scorecard T		
Frontier2	99.65%		
Maryneal	98.95%		
LV3	95.78%		
Mesquite Creek	95.76%		
LV5	95.56%		





Our Bat Curtailment Tool provides:

- Ensuring compliance with the U.S. Fish and Wildlife Services
- Automating of internal checks
- List of turbines and timeframes to troubleshoot where curtailment fails
- Template to scale other projects within Seeq Data Lab







As we grow our wind fleet, we can ensure that we're doing our part to reduce the impact on this bat species.

Seeq Data Lab can be utilized to scale calculations across an asset tree.

This project is a collaboration between our Performance Services and Data Science teams.

The team at Seeq Office Hours was very helpful in getting us in the right direction.







Thank You

