

AVEVA PI WORLD

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# Revenue Based Operational Intelligence

## A Practical Guide

Presented By: David Rodriguez and Tom Schnoor

**AVEVA**

“It’s like the more money we come across, the more problems we see .”

Notorious B.I.G.



# David Rodriguez

Sr. Analytics & Intelligence Engineer

# Tom Schnoor

Sr. Analytics & Intelligence Engineer



# EDF Renewables North America

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



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# First Thing's First!

1. Personnel Safety and Wellbeing
2. Sustainability
3. Profits

# Revenue Based Operational Intelligence – What is it?

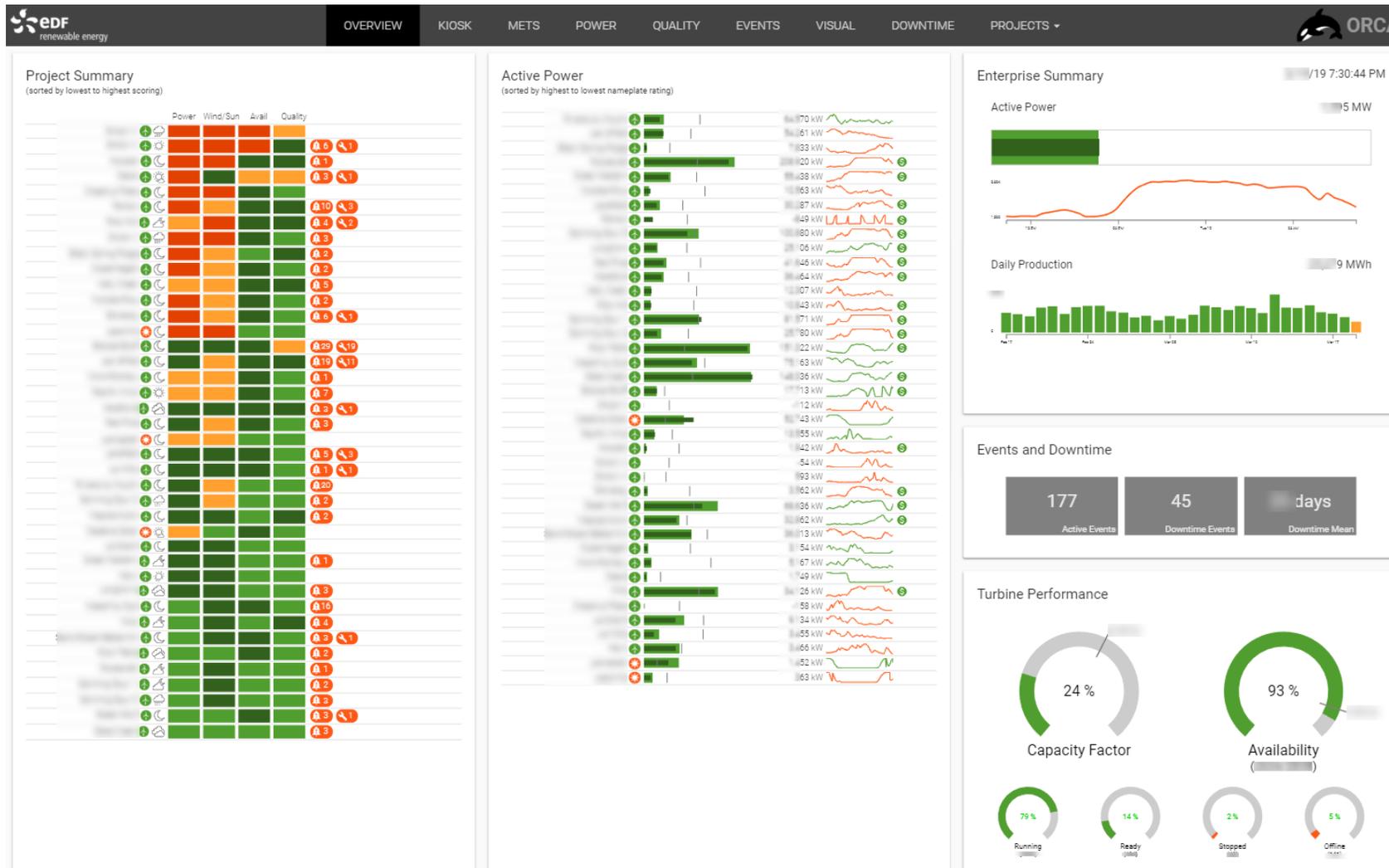
**R.B.O.I 😊**

**Making operational decisions based on quantified financial impact**

Asking questions like

- “Our asset is running at a limited capacity. Is it worth expediting its repair?”
- “How much is this asset downtime costing us? How much will it cost over the next day?”
- “When’s the best time to schedule maintenance so we minimize revenue loss?”

# Operational Intelligence Team and ORCA (Operational Readiness & Contextual Awareness)



# Callouts – The Epiphany



## 4.3 Call Out Chart 24/7 - 365

Wind Speed	1 wtg off line	2 wtg off line	3 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				
9	Call Out				
10	Call Out				
11	Call Out				
12	Call Out				

# Callouts – The Epiphany

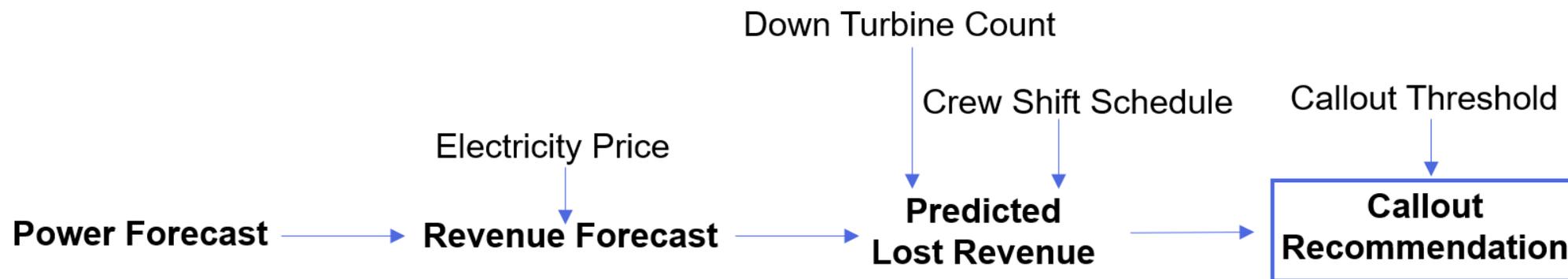


## Callouts

Project	Down Turbines	Current Shift End	Time to Shift End (hh:mm)	Next Shift Start	Time to Next Shift (hh:mm)	Timezone	Forecasted Lost Revenue to Next Shift	Callout Threshold	Status	
	20 (1)	-	-	Tomorrow 5:00 AM	17:17	CDT	\$4,470 (USD)	-	Monitoring	
	2 (2)	-	-	Tomorrow 6:00 AM	18:17	PDT	\$3,023 (USD)	\$800 (USD)	Monitoring	Callout
	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	
	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
	2	-	-	Tomorrow 4:00 AM	16:17	EDT	\$977 (USD)	\$800 (USD)	Monitoring	Callout
	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

Manually Add/Remove

# Callouts – The Problem



## Limitations

- Prices used are static values – Not always true
- Many sites have complicated financial agreements

**We need to lay a proper “analytical foundation”**

# Production Revenue Tool

## Purpose

- Insight to daily, monthly & yearly revenue based on contractual accounting codes
- Provide a tool for analyzing actual production vs. invoiced production using different views and intervals

## Inputs

- MV90: Generation data from the off taker
- ZEMA: Market data via ZEMA API

## Outputs

- Revenue data at the lowest possible interval level for each accounting code required

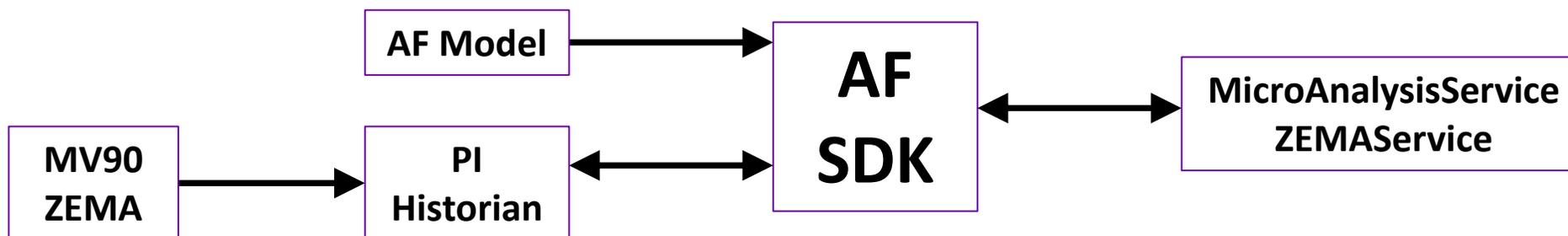
The screenshot shows the EDF Production Revenue Tool interface. The top navigation bar includes 'OVERVIEW', 'PROJECTS', 'EVENTS', 'DOWNTIME', 'CALLOUT', 'QUALITY', 'VISUAL', 'PRODUCTION', and 'ANALYTICS'. The 'PRODUCTION' tab is active. Below the navigation bar, there are filters for 'Project/Meters', 'Portfolio', 'Month to Date', and 'Budget'. The 'Project' filter is selected, and the 'Interval' is set to 'Hourly' with a '15 min' interval. The 'Start' and 'End' dates are '9/19/2021' and '9/20/2021' respectively. The 'Additional Fields' section shows 'Primary', 'Effective Price', 'Revenue Generated', and 'Day Ahead Award No...' selected. The 'Timezone' is set to 'EST, DST Observed: true'. The main data table has the following columns: Start Time, End Time, Primary (MWh), Day Ahead Award Node (MWh), Real Time LMP Node (US\$/MWh), Real Time LMP Hub (US\$/MWh), Day Ahead LMP Node (US\$/MWh), Day Ahead LMP Hub (US\$/MWh), Effective Price (US\$/MWh), Electricity Sales Real Time (US\$), Electricity Sales Day Ahead (US\$), and Revenue Generated (US\$). The table displays data for various time intervals on 09-19-2021.

Start Time	End Time	Primary (MWh)	Day Ahead Award Node (MWh)	Real Time LMP Node (US\$/MWh)	Real Time LMP Hub (US\$/MWh)	Day Ahead LMP Node (US\$/MWh)	Day Ahead LMP Hub (US\$/MWh)	Effective Price (US\$/MWh)	Electricity Sales Real Time (US\$)	Electricity Sales Day Ahead (US\$)	Revenue Generated (US\$)
09-19-2021 12:00 AM EDT	09-19-2021 12:15 AM EDT				\$46.38		\$38.21				
09-19-2021 12:15 AM EDT	09-19-2021 12:30 AM EDT				\$46.38		\$38.21				
09-19-2021 12:30 AM EDT	09-19-2021 12:45 AM EDT				\$46.38		\$38.21				
09-19-2021 12:45 AM EDT	09-19-2021 01:00 AM EDT				\$46.38		\$38.21				
09-19-2021 12:00 AM EDT	09-19-2021 01:00 AM EDT				\$46.38		\$38.21				
09-19-2021 01:00 AM EDT	09-19-2021 01:15 AM EDT				\$34.55		\$32.92				
09-19-2021 01:15 AM EDT	09-19-2021 01:30 AM EDT				\$34.55		\$32.92				
09-19-2021 01:30 AM EDT	09-19-2021 01:45 AM EDT				\$34.55		\$32.92				
09-19-2021 01:45 AM EDT	09-19-2021 02:00 AM EDT				\$34.55		\$32.92				
09-19-2021 01:00 AM EDT	09-19-2021 02:00 AM EDT				\$34.55		\$32.92				
09-19-2021 02:00 AM EDT	09-19-2021 02:15 AM EDT				\$33.80		\$29.08				
09-19-2021 02:15 AM EDT	09-19-2021 02:30 AM EDT				\$33.80		\$29.08				
09-19-2021 02:30 AM EDT	09-19-2021 02:45 AM EDT				\$33.80		\$29.08				

# Production Revenue Tool

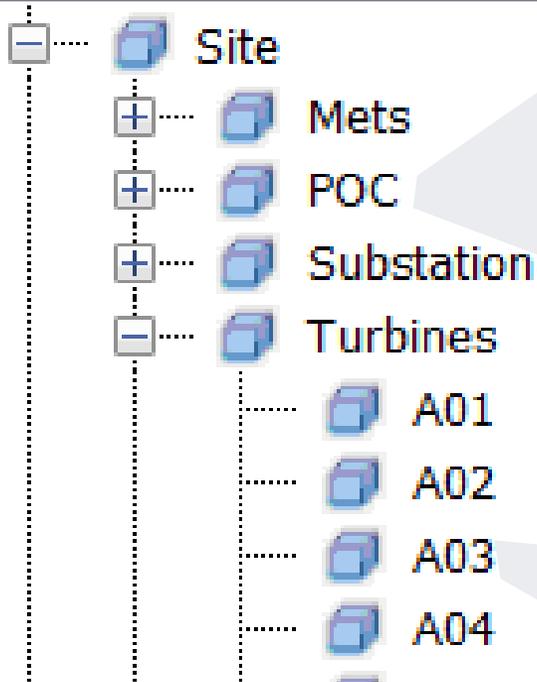
## How does this all come together?

- Utilizing the many features of AF
  - AF templates, tables and mappings incorporated into our existing model
  - Standardized for easy deployment to new and existing sites
  - Heavy use of the AF SDK to create custom applications for processing the complex revenue accounting codes



# Process Architecture

## Elements



Category: Accounting Codes	
✎	Hedge Revenue
✎	Electricity Sales Real Time
✎	Electricity Sales Day Ahead

Category: Inputs	
✎	Real Time LMP Node
✎	Hedge Fixed Volume
✎	Hedge Fixed Price
✎	Energy Produced
✎	Day Ahead LMP Node

Category: Calculated	
✎	Marginal Revenue

Category: Calculated	
✎	Possible Revenue
✎	Revenue Stream

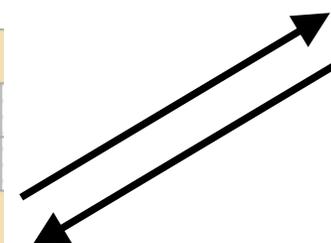
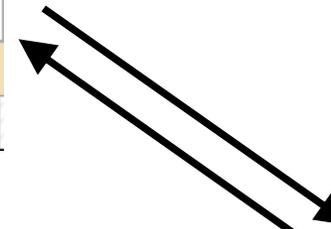
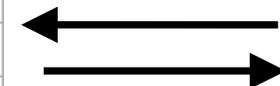
  

Category: Measured	
✎	Active Power

AFSDK Apps

MicroAnalysis Service

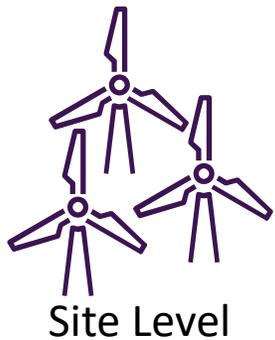
GreenVisor



# The Foundation – What are we building?

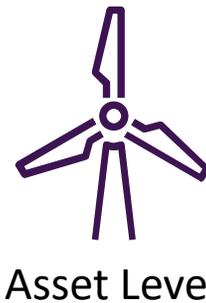
## Marginal Revenue (\$/MWh)

- Revenue gained from an additional MWh generated



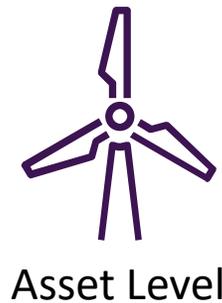
## Revenue Stream (\$)

- Revenue an asset produces in a given time interval



## Expected Revenue (\$)

- Revenue an asset should be producing given available wind/sun



# The Foundation – Marginal Revenue

## Invoiced Revenue ≠ Generated Revenue

$$\begin{array}{l}
 \frac{\text{Accounting Code 1}}{(\text{EP}-\text{DAV}) \times \text{RTN}\$} + \frac{\text{Accounting Code 2}}{\text{DAV} \times \text{DAN}\$} + \frac{\text{Accounting Code 3}}{\text{EP} \times \text{HFP}\% \times (\text{HP}\$-\text{RTH}\$)} \\
 (\text{EP} \times \text{RTN}\$) - (\text{RTN}\$ \times \text{DAV}) + (\text{DAV} \times \text{DAN}\$) + \text{EP} \times \text{HFP}\% \times (\text{HP}\$-\text{RTH}\$)
 \end{array}$$

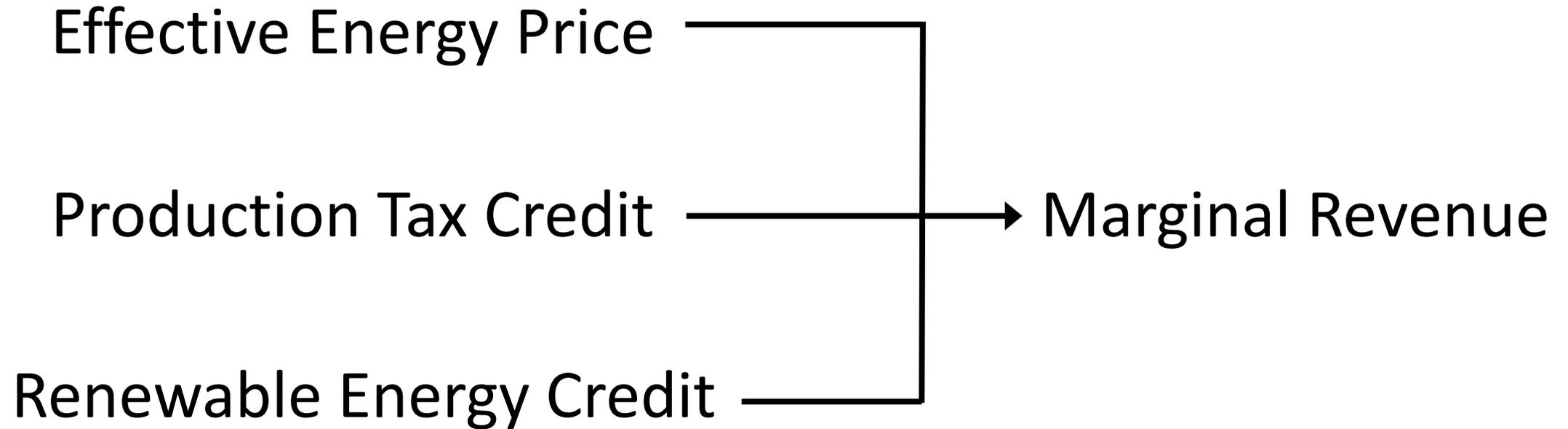
### Effective Energy Price

**Energy  
Produced**

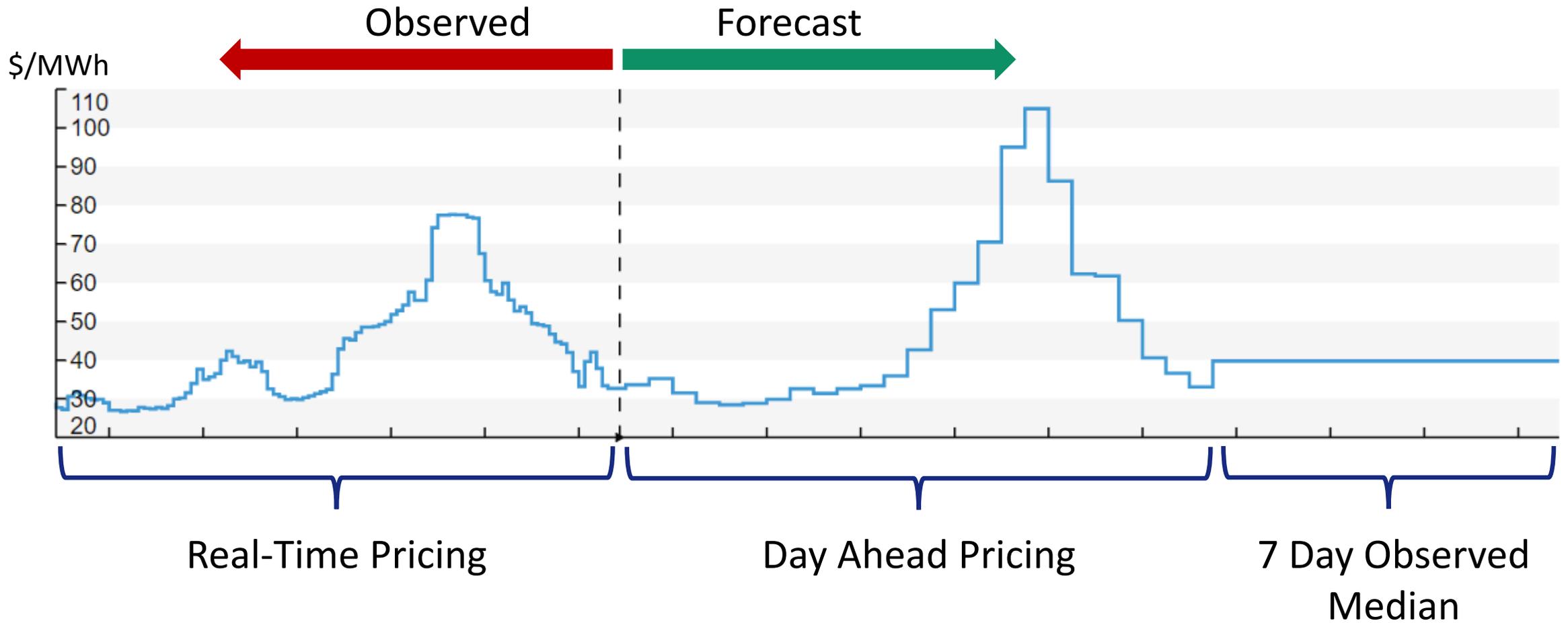
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$$\text{Real-time Node Price} + \text{Hedge Fixed Percent} \times \left( \text{Hedge Price} - \text{Real-time Hub Price} \right)$$

# The Foundation – Marginal Revenue



# The Foundation – Marginal Revenue



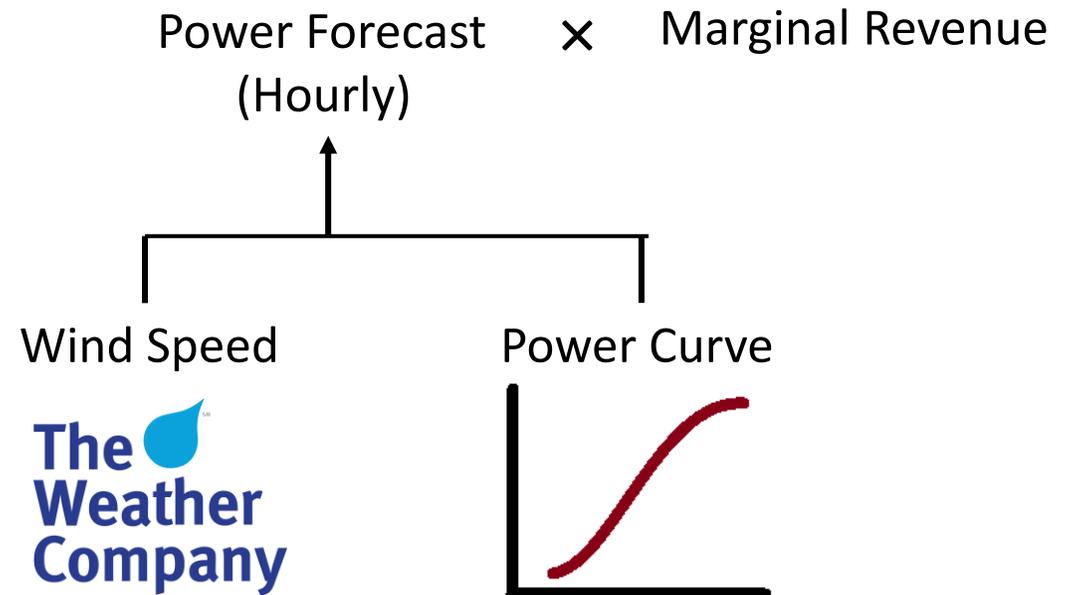
# The Foundation – Revenue Stream

Observed

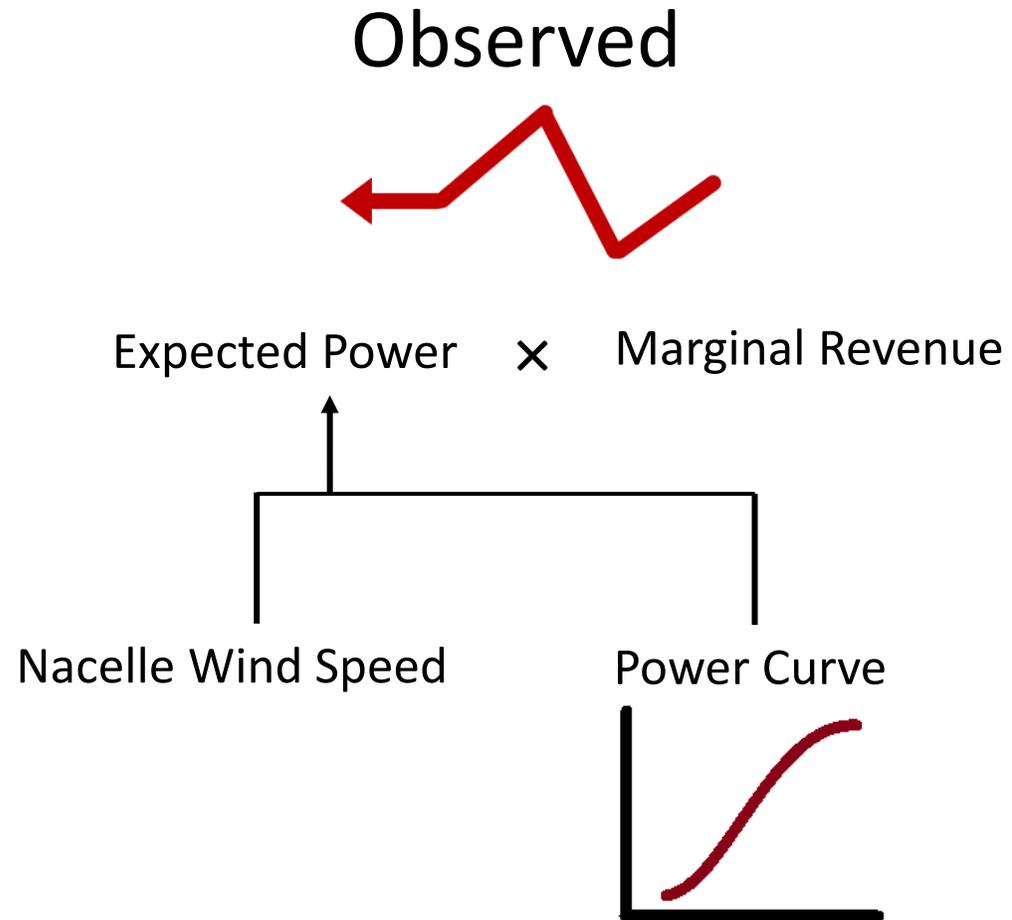


Forecast

Active Power  
(10 Minute Average) × Marginal Revenue

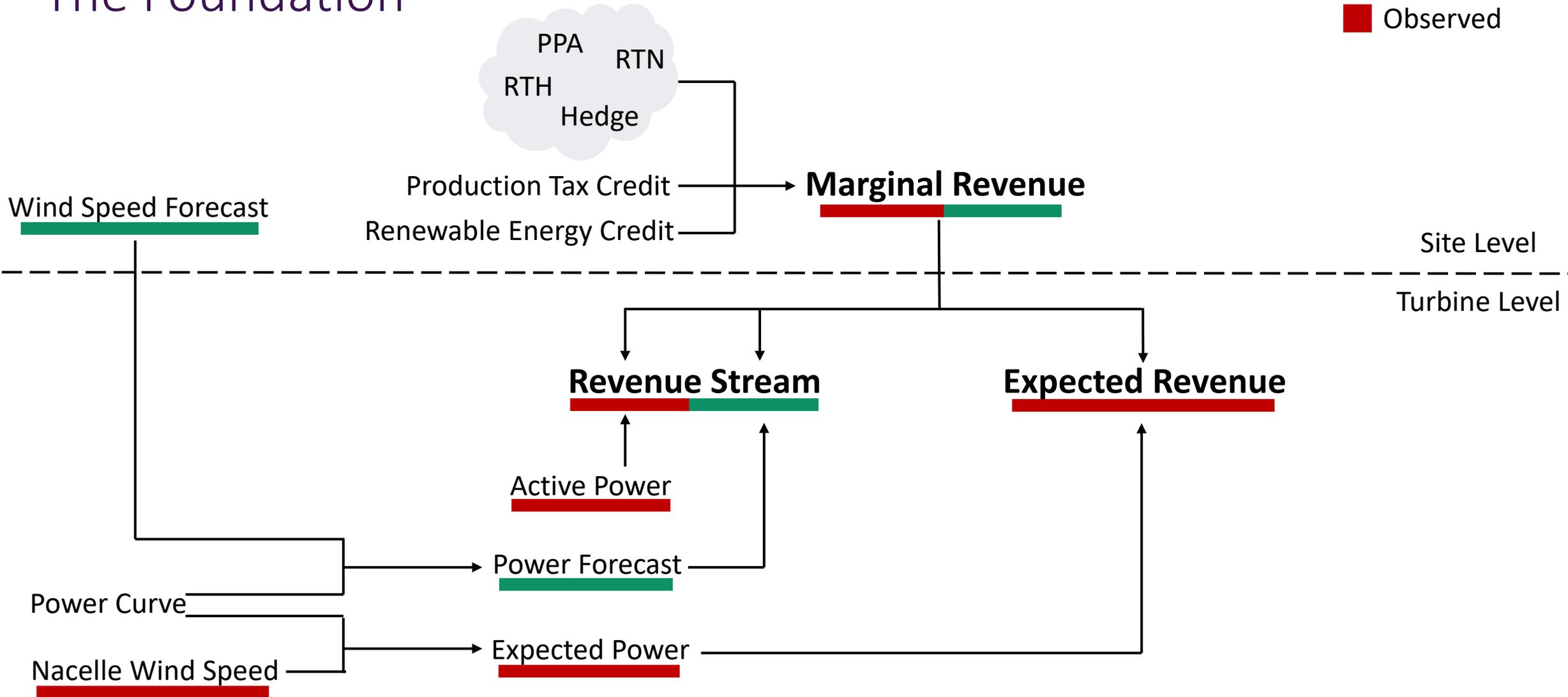


# The Foundation – Expected Revenue



# The Foundation

Forecast  
Observed

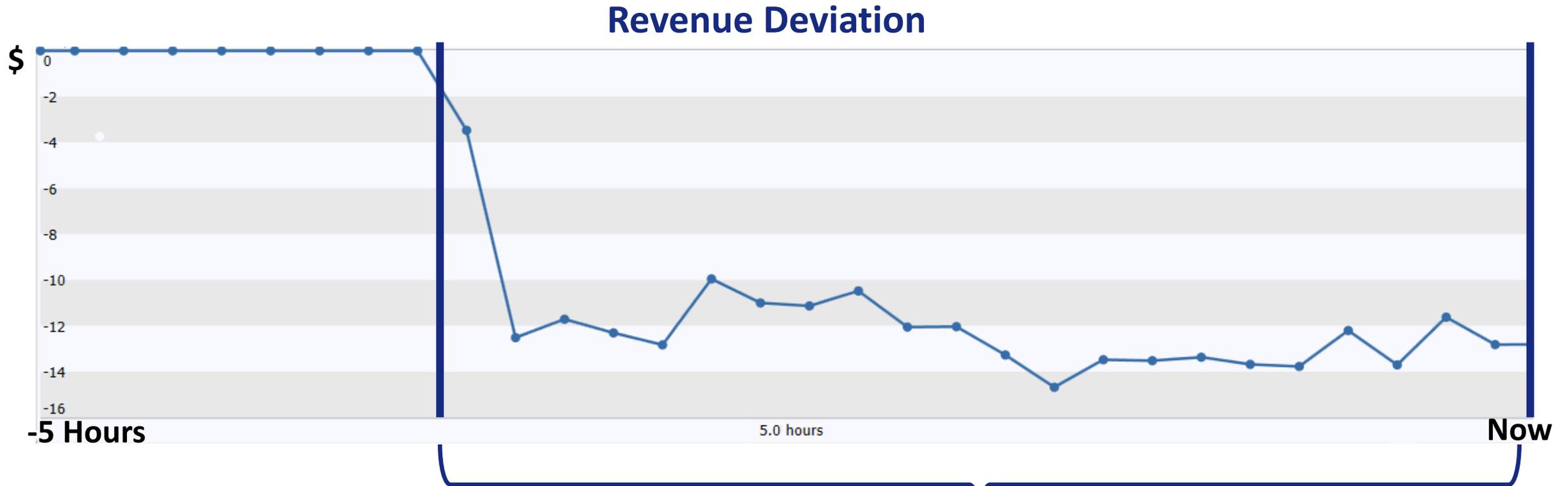


# The Foundation

- Forecast
- Observed

$$\text{Revenue Stream} = \text{Reported Revenue}$$

“Our asset is running at a limited capacity. Is it worth expediting its repair?”

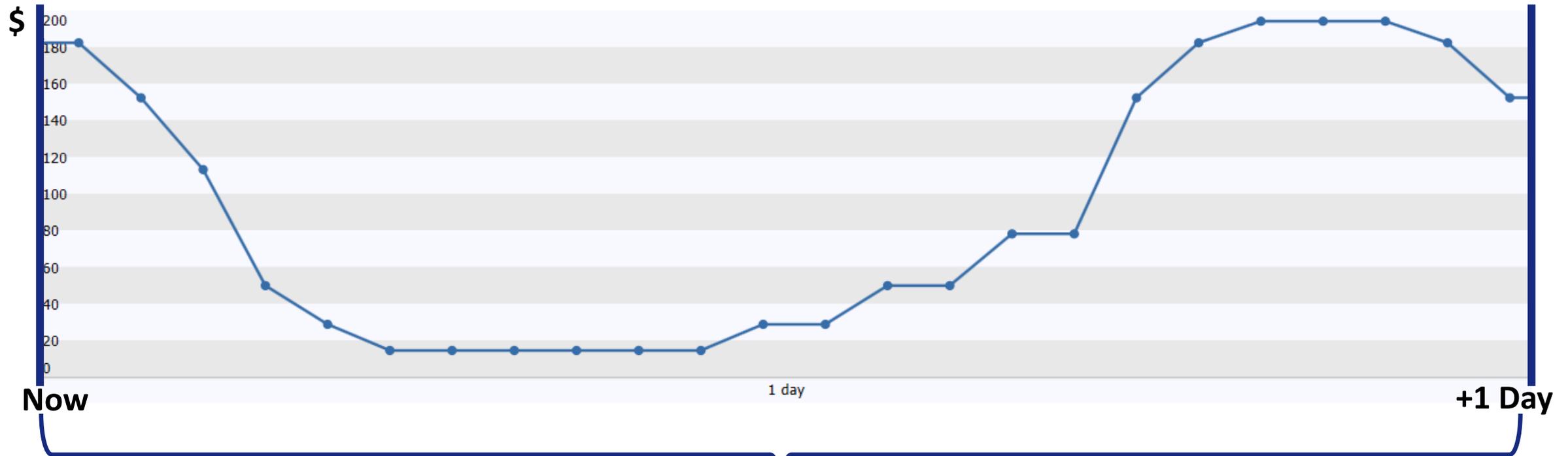


Total = \$272

Revenue lost since beginning of event

“How much is this asset downtime costing us?  
How much will it cost over the next day?”

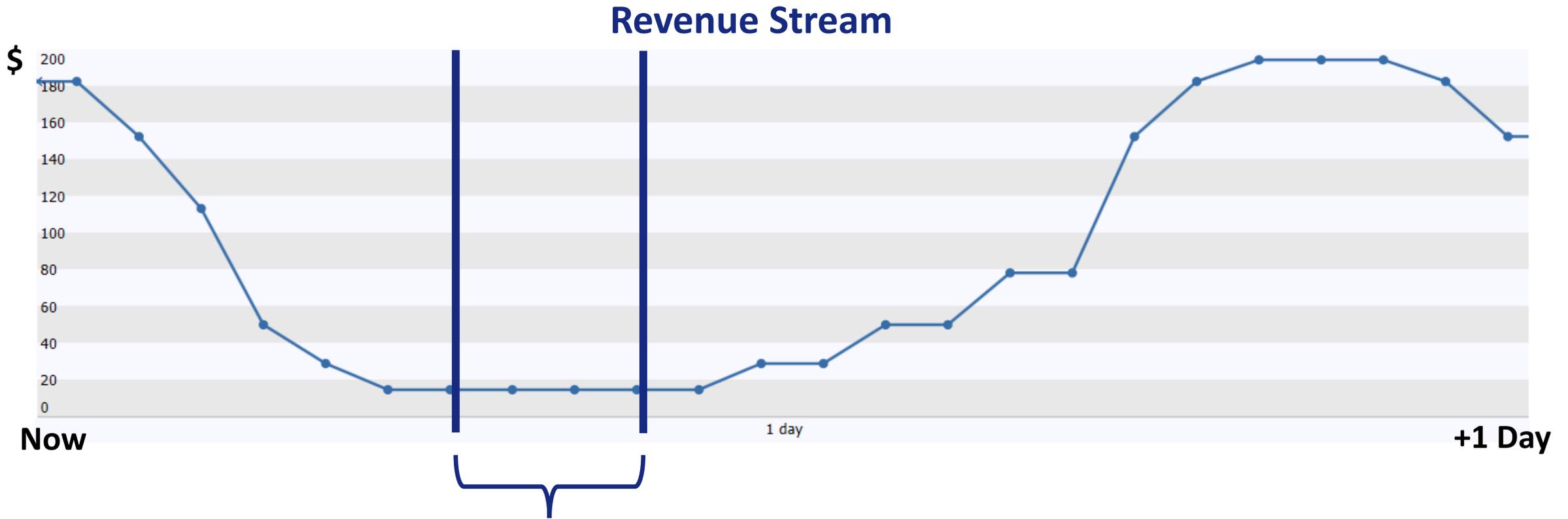
### Revenue Stream



Total = \$2,190

Forecast revenue loss over next day

“When’s the best time to schedule maintenance so we minimize revenue loss?”



Total = \$60

3 hour time window with lowest forecast revenue

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# Technical Tips

- For combined Forecast/Observed tags, forecasts must be cleaned up
- Storing price data frequency makes revenue calcs much easier
- If reading and updating 1000's of attributes, use bulk queries
- Handle some lag by re-evaluating the last hour every iteration
- Set up a backfilling service



**Nerd Alert!**

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## So, what's next?

- New end-user tools!
- Account for line loss
- More sophisticated market price forecasting
- Integrate currency conversion rates to normalize revenue across all sites



Thanks for listening!

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