

AVEVA PI WORLD

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.



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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



First Thing's First!

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

Revenue Based Operational Intelligence – What is it?

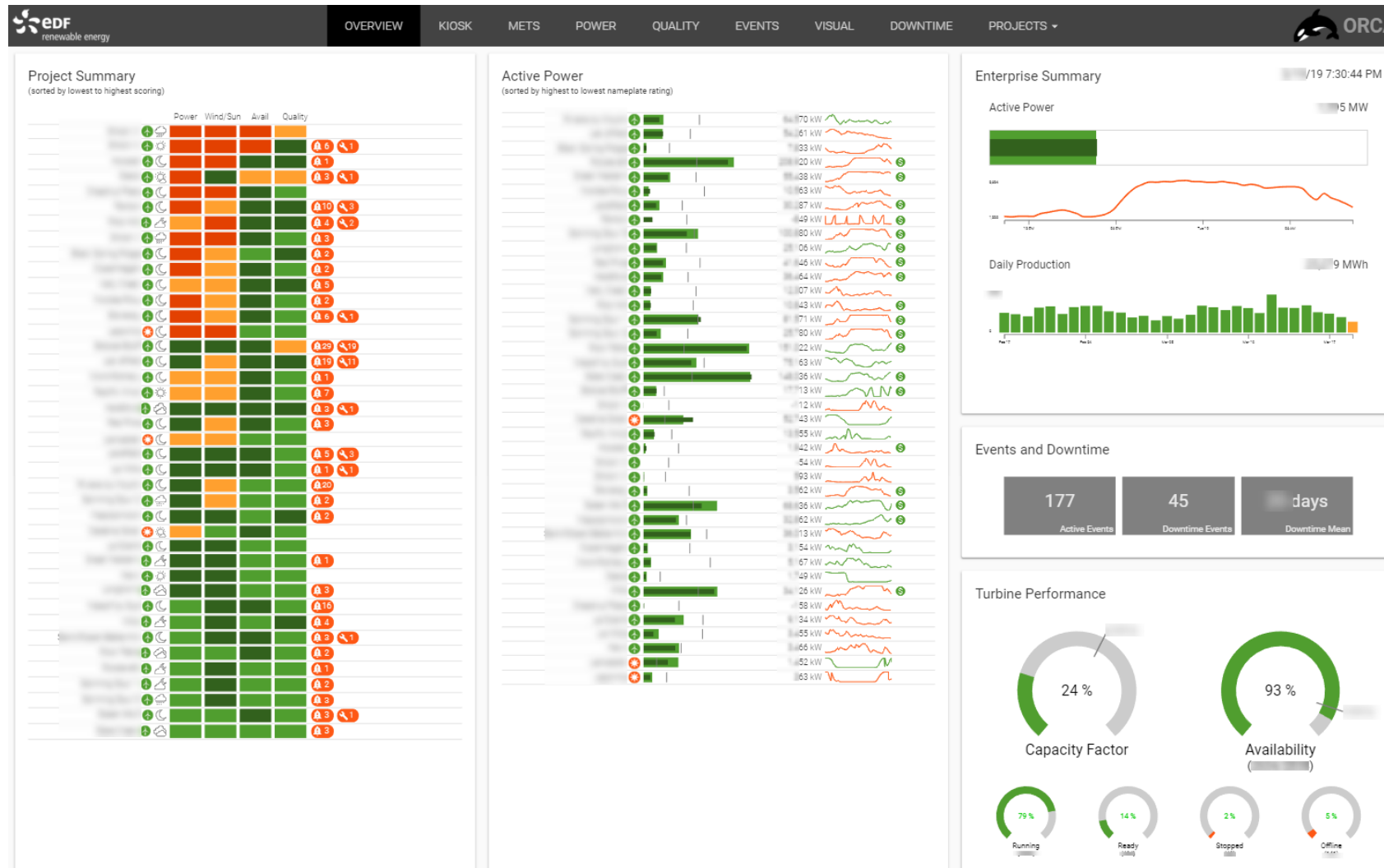
R.B.O.I 😊

**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	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

Callouts – The Epiphany

OVERVIEW

PROJECTS

EVENTS

DOWNTIME

CALLOUT

QUALITY

VISUAL

POWER

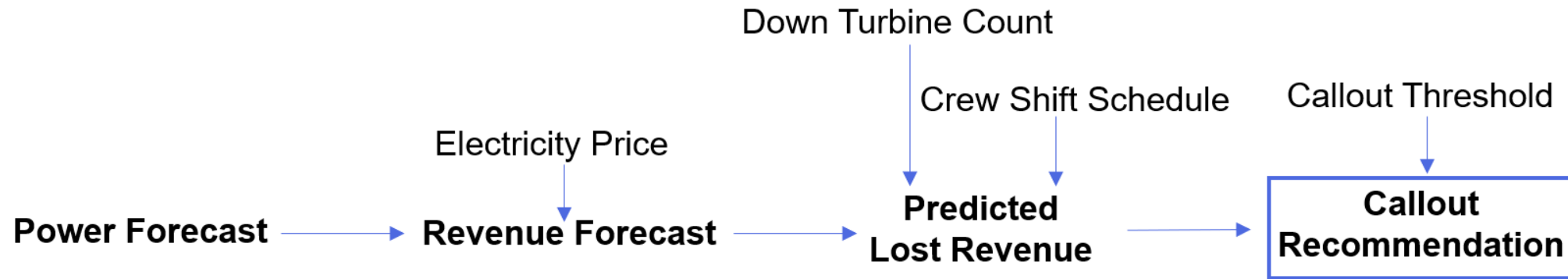
Callouts

	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

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

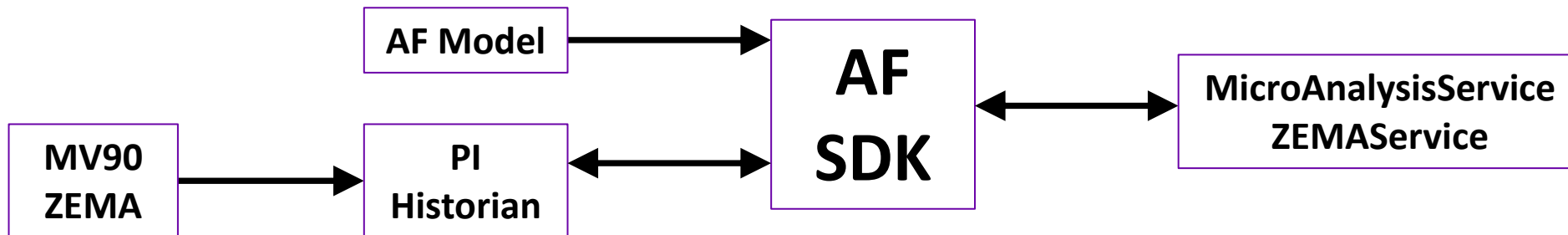
- Revenue data at the lowest possible interval level for each accounting code required

Start Time	End Time	Primary (MWh)	Day Ahead Award Node (MWh)	Real Time LMP Node (USD\$/MWh)	Real Time LMP Hub (USD\$/MWh)	Day Ahead LMP Node (USD\$/MWh)	Day Ahead LMP Hub (USD\$/MWh)	Effective Price (USD\$/MWh)	Electricity Sales Real Time (USD\$)	Electricity Sales Day Ahead (USD\$)	Revenue Generated (USD\$)
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				

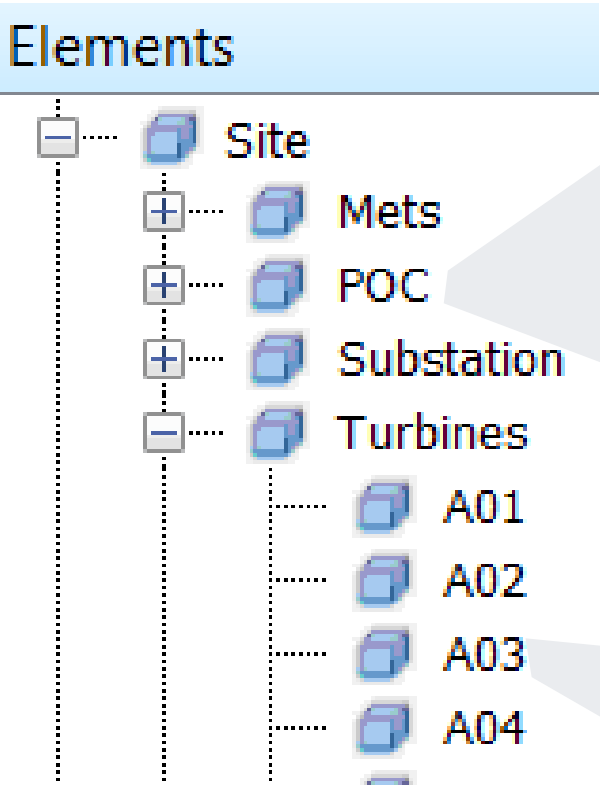
Production Revenue Tool

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



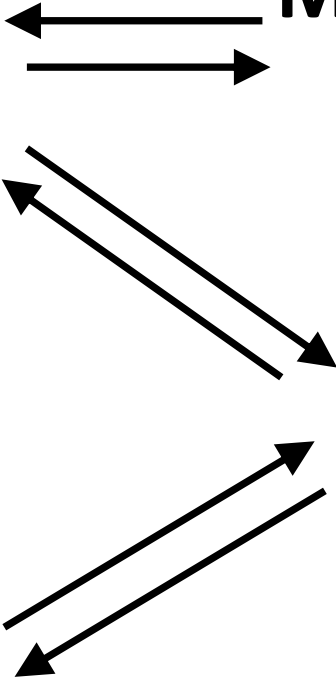
Category: Accounting Codes	
	Hedge Revenue
	Electricity Sales Real Time
	Electricity Sales Day Ahead
Category: Inputs	
	Real Time LMP Node
	Hedge Fixed Volume
	Hedge Fixed Price
	Energy Produced
	Day Ahead LMP Node
Category: Calculated	
	Marginal Revenue

Category: Calculated	
	Possible Revenue
	Revenue Stream
Category: Measured	
	Active Power

AFSDK Apps

MicroAnalysis
Service

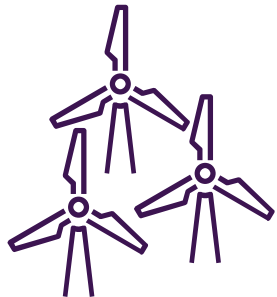
GreenVisor



The Foundation – What are we building?

Marginal Revenue (\$/MWh)

- Revenue gained from an additional MWh generated



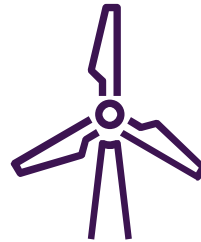
Site Level



Observed and Forecast

Revenue Stream (\$)

- Revenue an asset produces in a given time interval



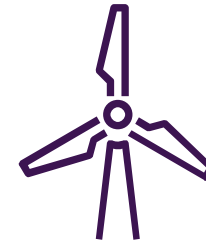
Asset Level



Observed and Forecast

Expected Revenue (\$)

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



Asset Level



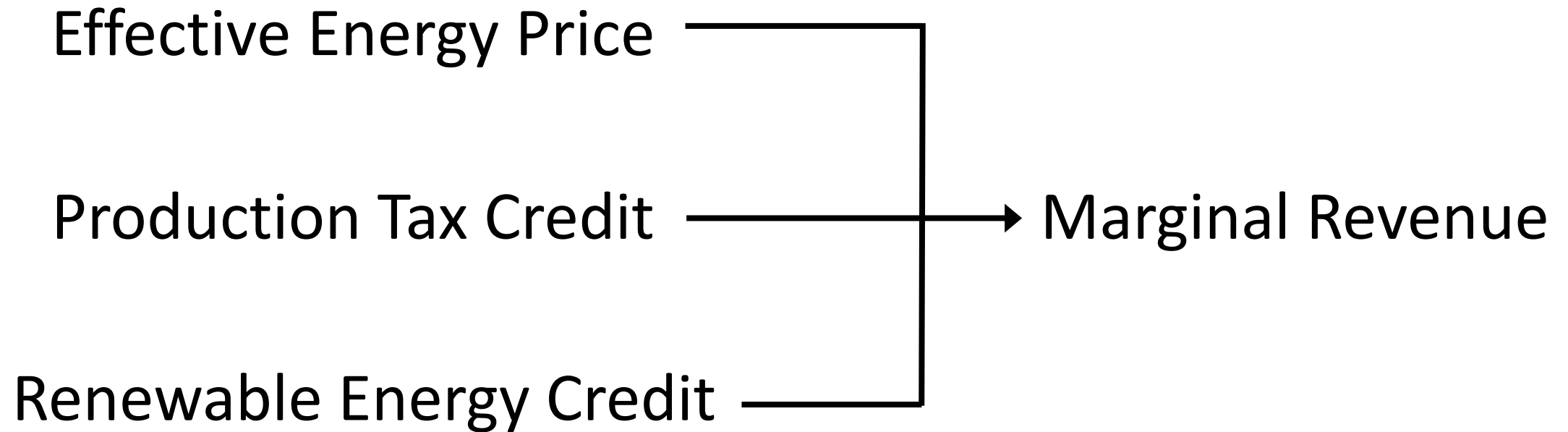
Observed only

The Foundation – Marginal Revenue

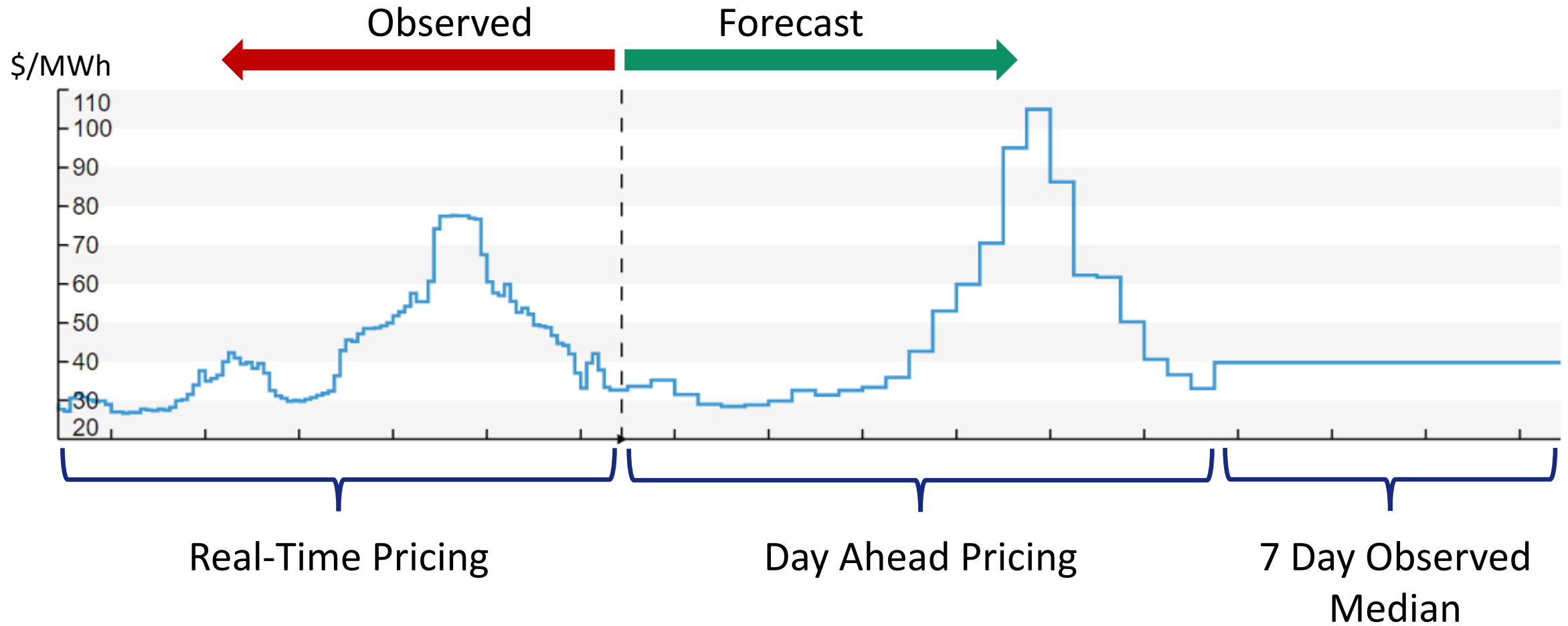
Invoiced Revenue ≠ Generated Revenue

$$\begin{aligned} & \frac{\text{Accounting Code 1}}{(\text{EP}-\text{DAV}) \times \text{RTN\$}} + \frac{\text{Accounting Code 2}}{\text{DAV} \times \text{DAN\$}} + \frac{\text{Accounting Code 3}}{\text{EP} \times \text{HFP\%} \times (\text{HP\$}-\text{RTH\$})} \\ & (\text{EP} \times \text{RTN\$}) - (\cancel{\text{RTN\$} \times \text{DAV}}) + (\cancel{\text{DAV} \times \text{DAN\$}}) + \text{EP} \times \text{HFP\%} \times (\text{HP\$}-\text{RTH\$}) \\ & \text{Energy Produced} \times \text{Effective Energy Price} \\ & \text{Real-time Node Price} + \text{Hedge Fixed Percent} \times \left(\text{Hedge Price} - \text{Real-time Hub Price} \right) \end{aligned}$$

The Foundation – Marginal Revenue



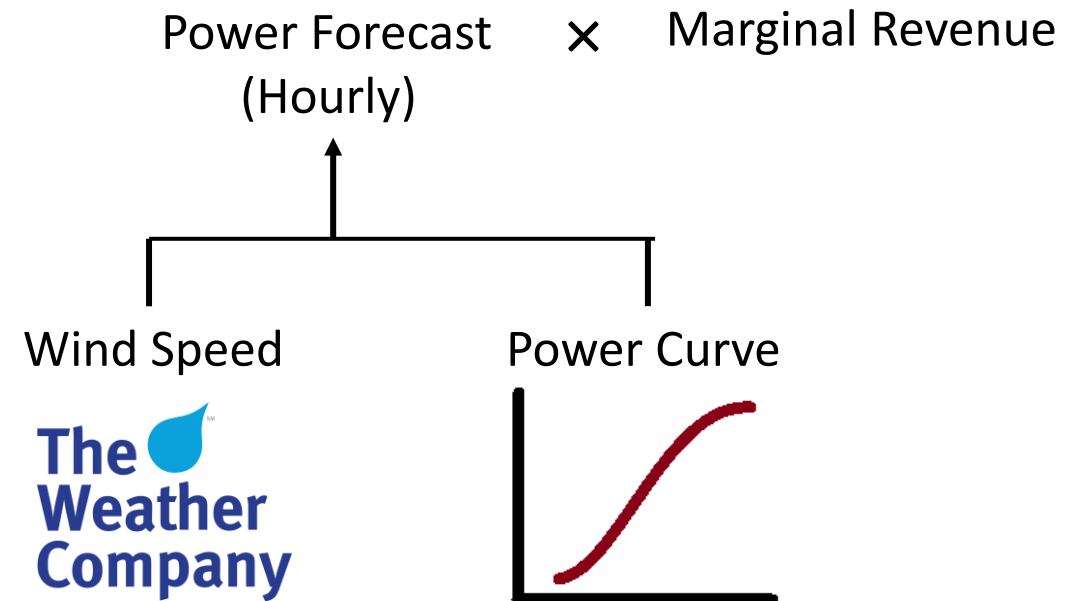
The Foundation – Marginal Revenue



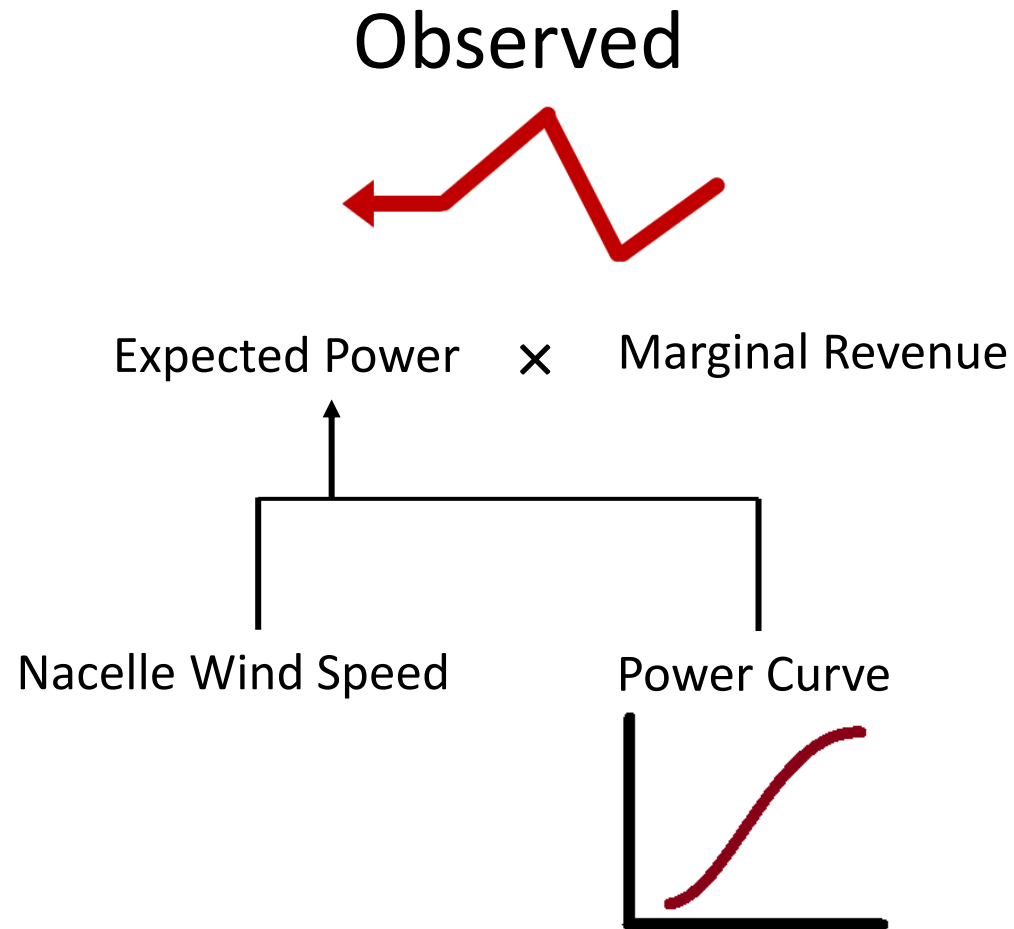
The Foundation – Revenue Stream



Active Power
(10 Minute Average) × Marginal Revenue

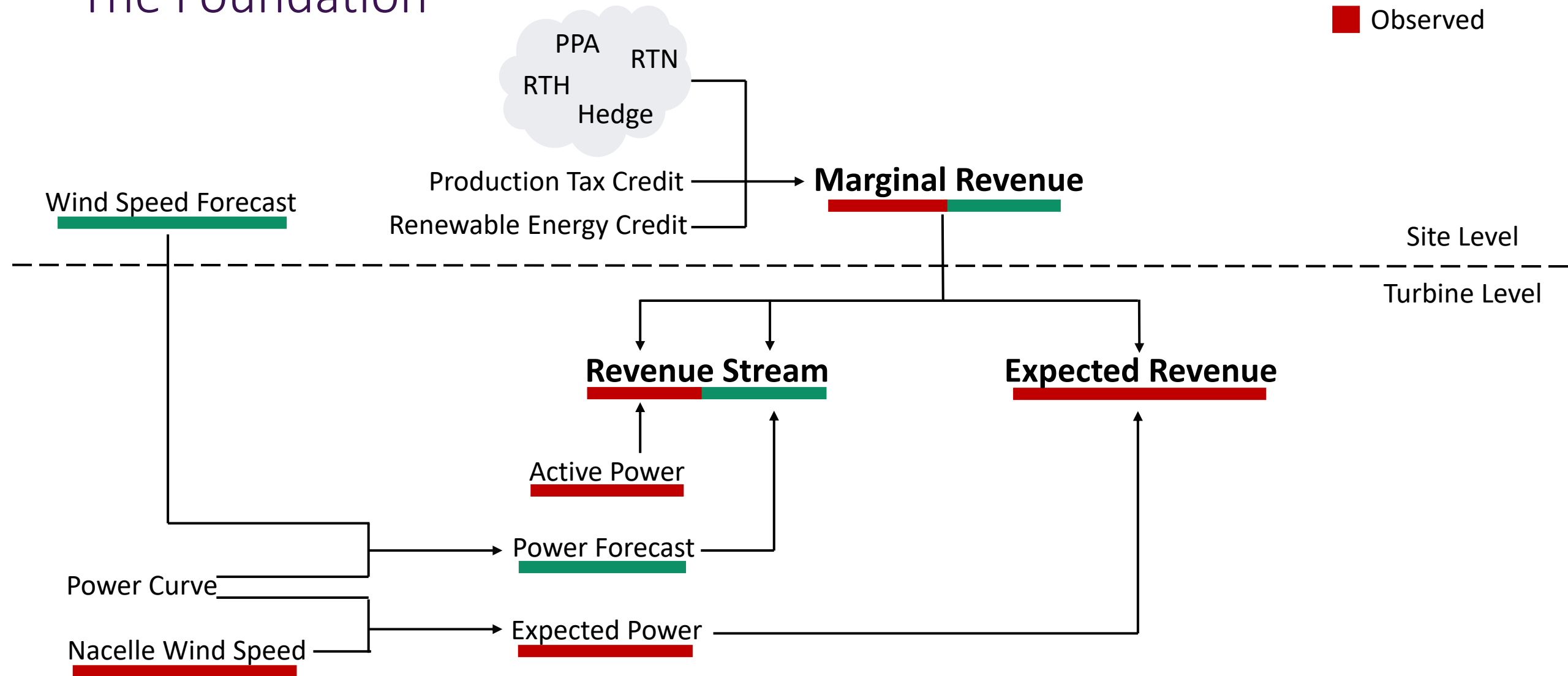


The Foundation – Expected Revenue



The Foundation

Forecast
Observed

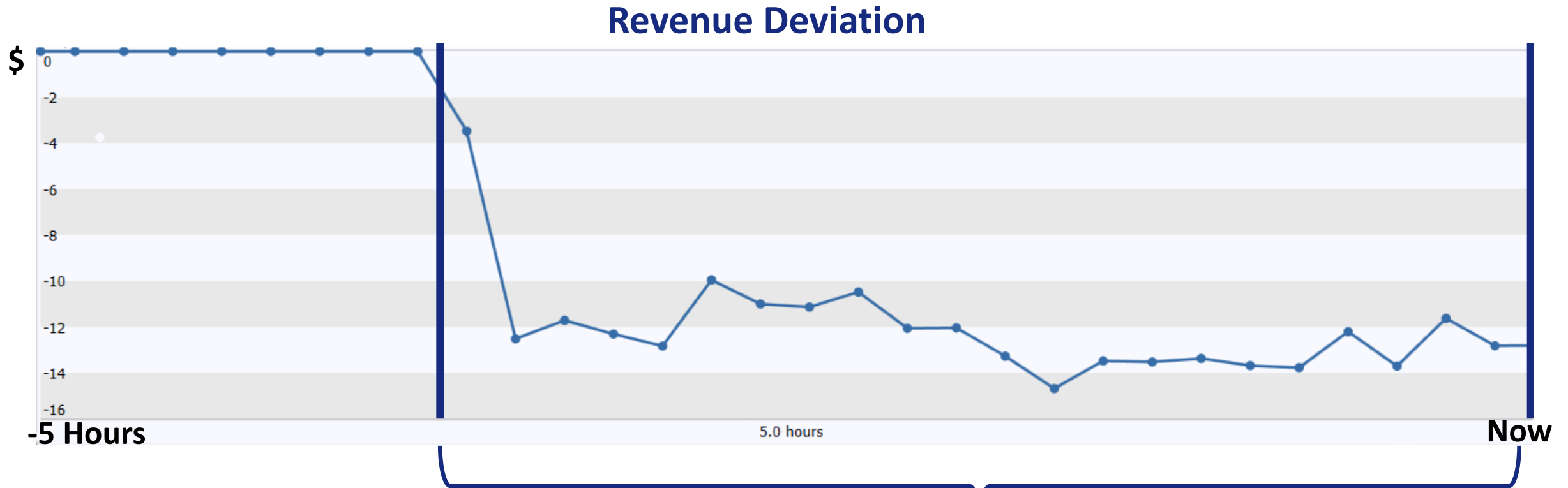


The Foundation

■ Forecast
■ Observed

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

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

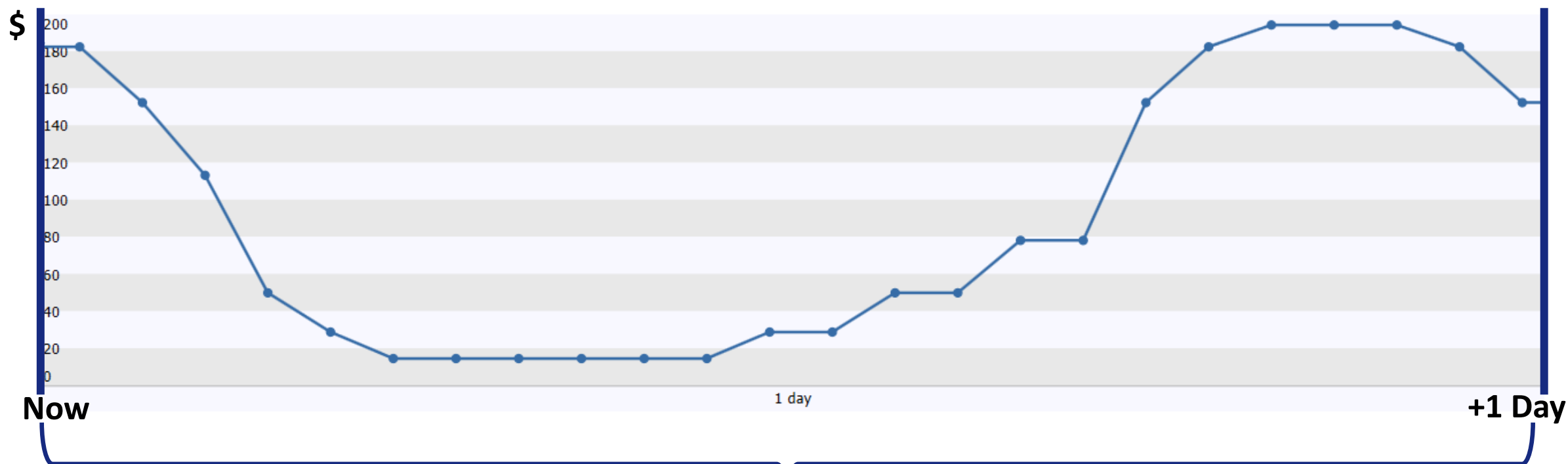


Total = \$272

Revenue lost since beginning of event

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

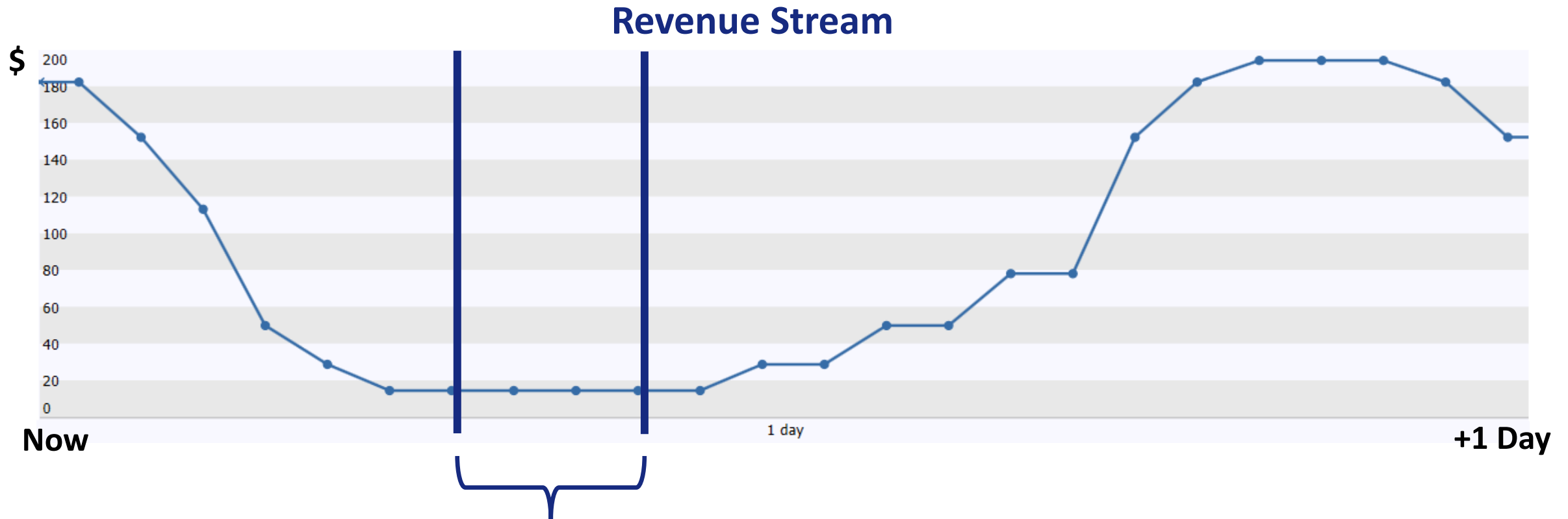
Revenue Stream



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

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!



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



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