



# Economic Dispatch

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# What is Economic Dispatch?

- Answer:
  - The operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities [and regulatory requirements]

-FERC



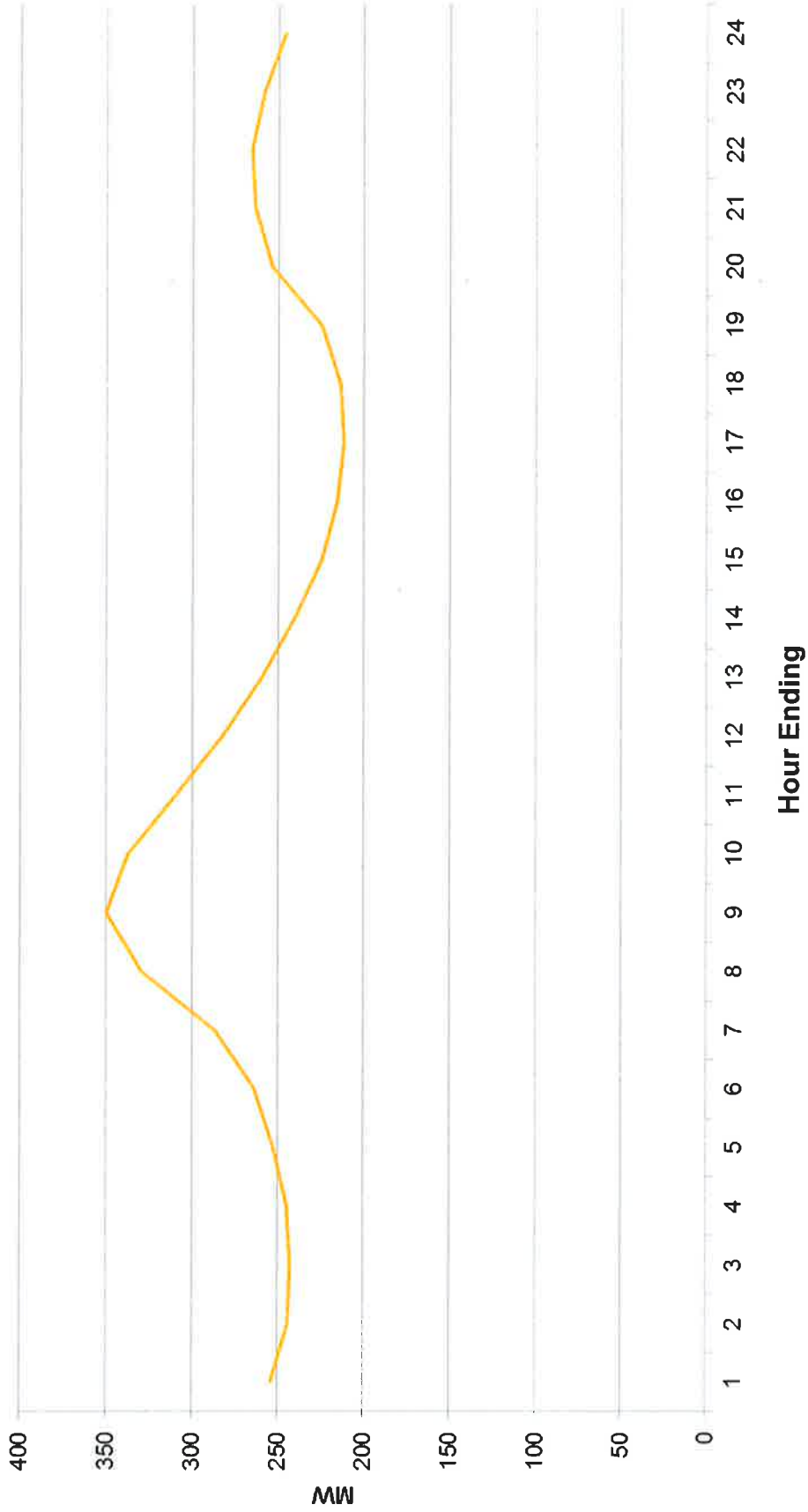
# Variables

## Considered in real time by the Generation Operator:

- **Primary:**
  - ATC
  - Fuel Pricing, Availability, & Constraints
  - Transmission Outages (Forced/Planned)
  - System Load
  - Unit Outages (Forced/Planned)
  - Weather
  - Power Market Dynamics
  - Regulatory Requirements
- **Secondary:**
  - Ramp rate (how quickly the generator's output can be changed)
  - Minimum "down" time - amount of time the generator must stay off once turned off
  - Maximum and minimum generation levels
  - Minimum "up" time - amount of time the generator must run once online
  - Spinning reserves vs. fast start
  - Unit testing/scheduling

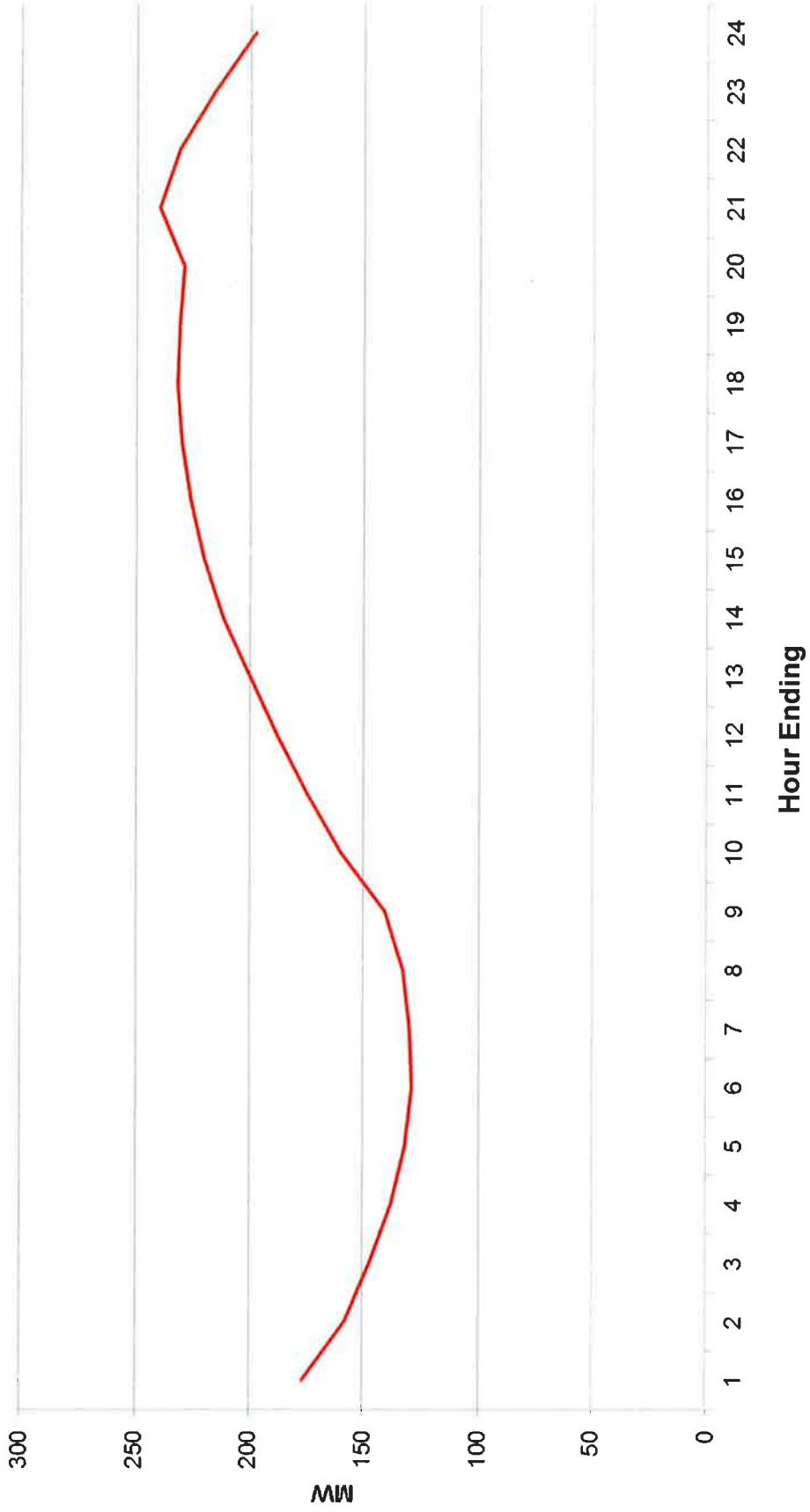
# Seasonal Load Shapes

Winter Day



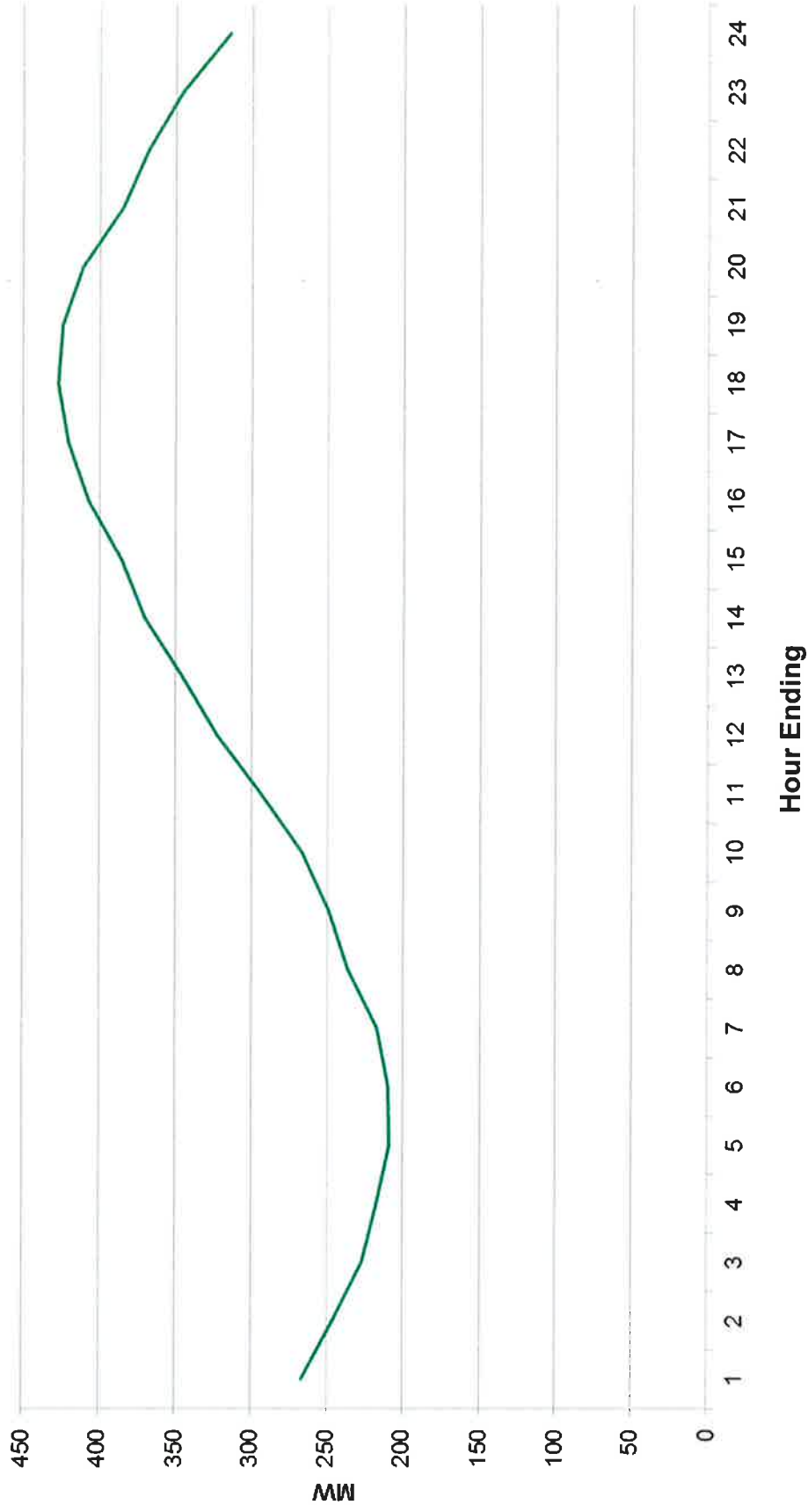
# Seasonal Load Shapes

— Spring Day



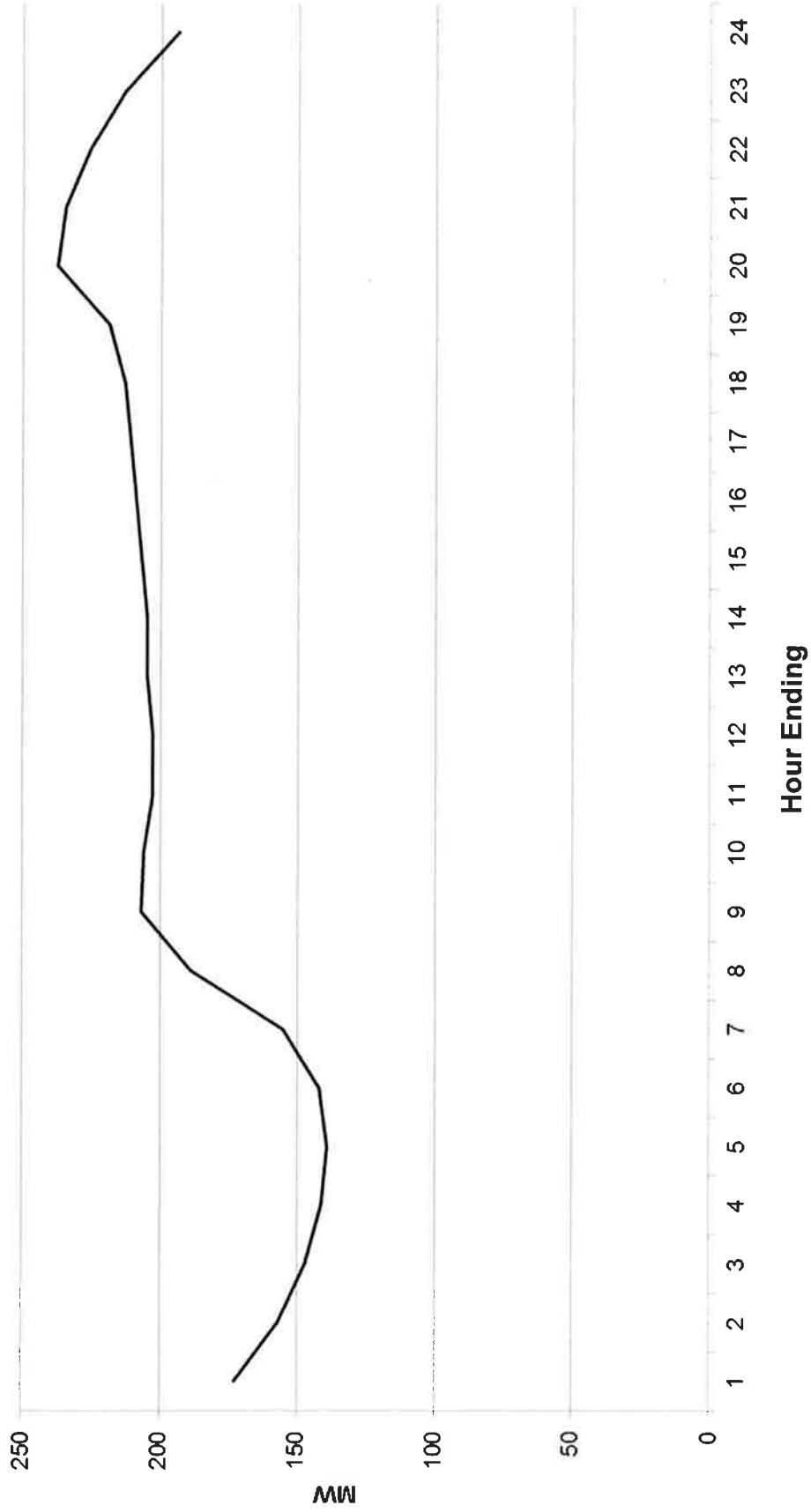
# Seasonal Load Shapes

— Summer Day



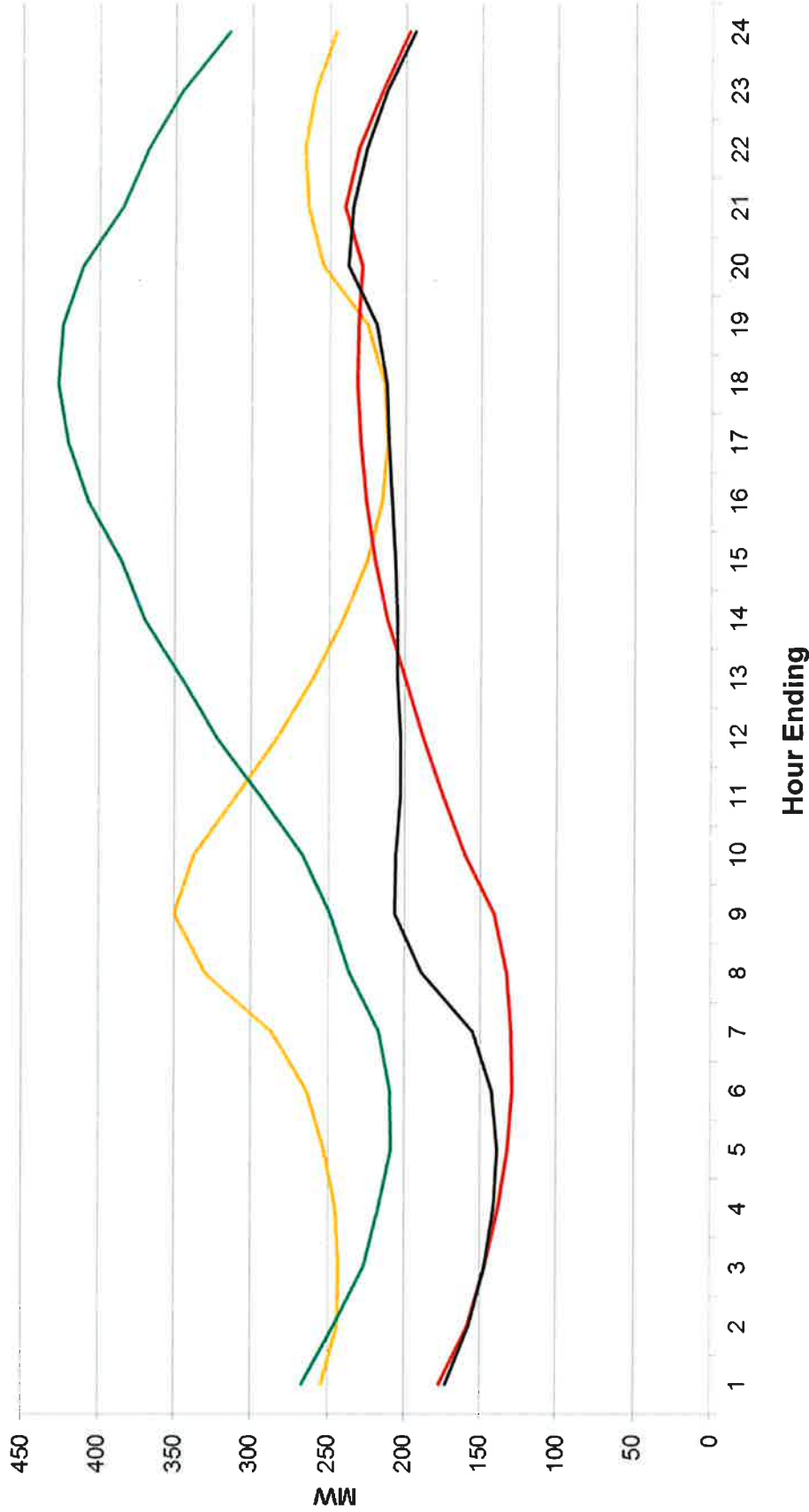
# Seasonal Load Shapes

— Fall Day



# Seasonal Load Shapes

Winter Day (Yellow) Spring Day (Red) Summer Day (Green) Fall Day (Black)





# Terminology

- Unit Commitment (UC)
  - Schedule of the most cost effective generation units to meet load forecasts and regulation and reserve requirements



# Terminology

- Average Net Operating Heat Rate (ANOHR)
  - The common measure of system efficiency for a generating unit

$$\text{HeatRate}(\text{Btu} / \text{kWh}) = \frac{\text{Energy Input}(\text{Btu} / \text{hr})}{\text{Power Output}(\text{kW})}$$

- Increasing heat rate – Lower efficiency
- Decreasing heat rate – Higher efficiency

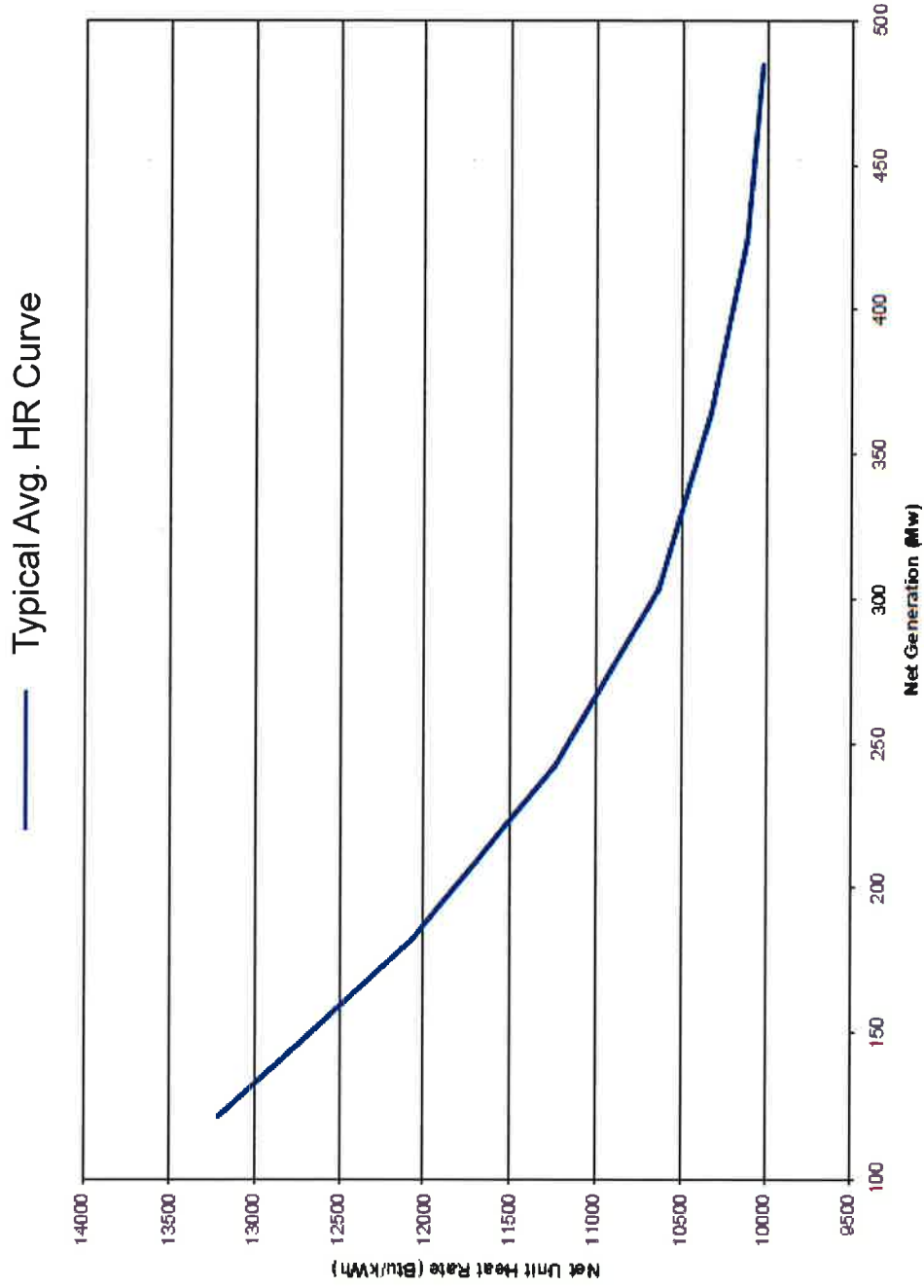


# Terminology

- **Incremental Heat Rate (IHR)** – the change in fuel/heat input for a one unit change in output
  - Total fuel input needed for one MW of output
  - Determines the next, most-economical MW
- **Start-up or Shut-down Cost** – costs of fuel, life-cycle maintenance, and other items related directly to the start-up or shutting down of a generating unit



# Typical Average Heat Rate Curve



# The Process

- Based on forecast load for the next day
- Select generating units to be running and available for dispatch the next day (operating day)
- Recognize each generating unit's operating limit, including its:
  - Ramp rate (how quickly the generator's output can be changed)
  - Maximum and minimum generation levels
  - Minimum amount of time the generator must run
  - Minimum amount of time the generator must stay off once turned off



# The Process

- Cost of generating, which depends on:
  - Its efficiency (heat rate)
  - its variable operating costs (fuel and non-fuel)
  - Variable cost of environmental compliance
  - Start-up costs

\*Fixed costs (fixed O&M, debt service, etc.) are never used in economic dispatch

# Road Trip

- Planning a road trip from Gainesville to the Grand Canyon:
  - What costs do you consider?
    - Fuel Costs (MPG, distance)
    - Necessary Maintenance (oil change, tire change/rotation, etc.)
    - Lodging
    - Food
  - Fixed Costs?
    - Car Note?      -Mortgage?

# The Process

- Load forecast and ANOHR are used to create the Unit Commitment:
  - What Units have the MW range to meet needs throughout the day
  - Dragster vs. Prius (unit ramp rates)





# Comparison of Avg. HR costs

Unit	Min. Load	Avg. Costs <sup>^</sup> (HR)	Max. Load	Avg. Costs <sup>^</sup> (HR)
CC1	86 MW	\$18.88/MWh (8.66)	108 MW	\$17.92/MWh (8.22)
DH2	51 MW	\$45.83/MWh (15.59)	232 MW	\$31.95/MWh (10.87)
DH1	22 MW	\$32.37/MWh (14.85)	75 MW	\$26.18/MWh (12.01)
CT3	49 MW	\$29.28/MWh (13.43)	71 MW	\$25.28/MWh (11.60)
GREC*	70 MW	~\$39/MWh (13.5)	102.5 MW	~\$39/MWh (13.5)

<sup>^</sup> Based on Fuel Dispatch Pricing on 5/31/16

-Coal - \$2.94/MMBtu -Nat. Gas - \$2.18/MMBtu

\*Contractual Values



# The Process

- Once units are online, the Incremental Heat Rate determines where the units are loaded



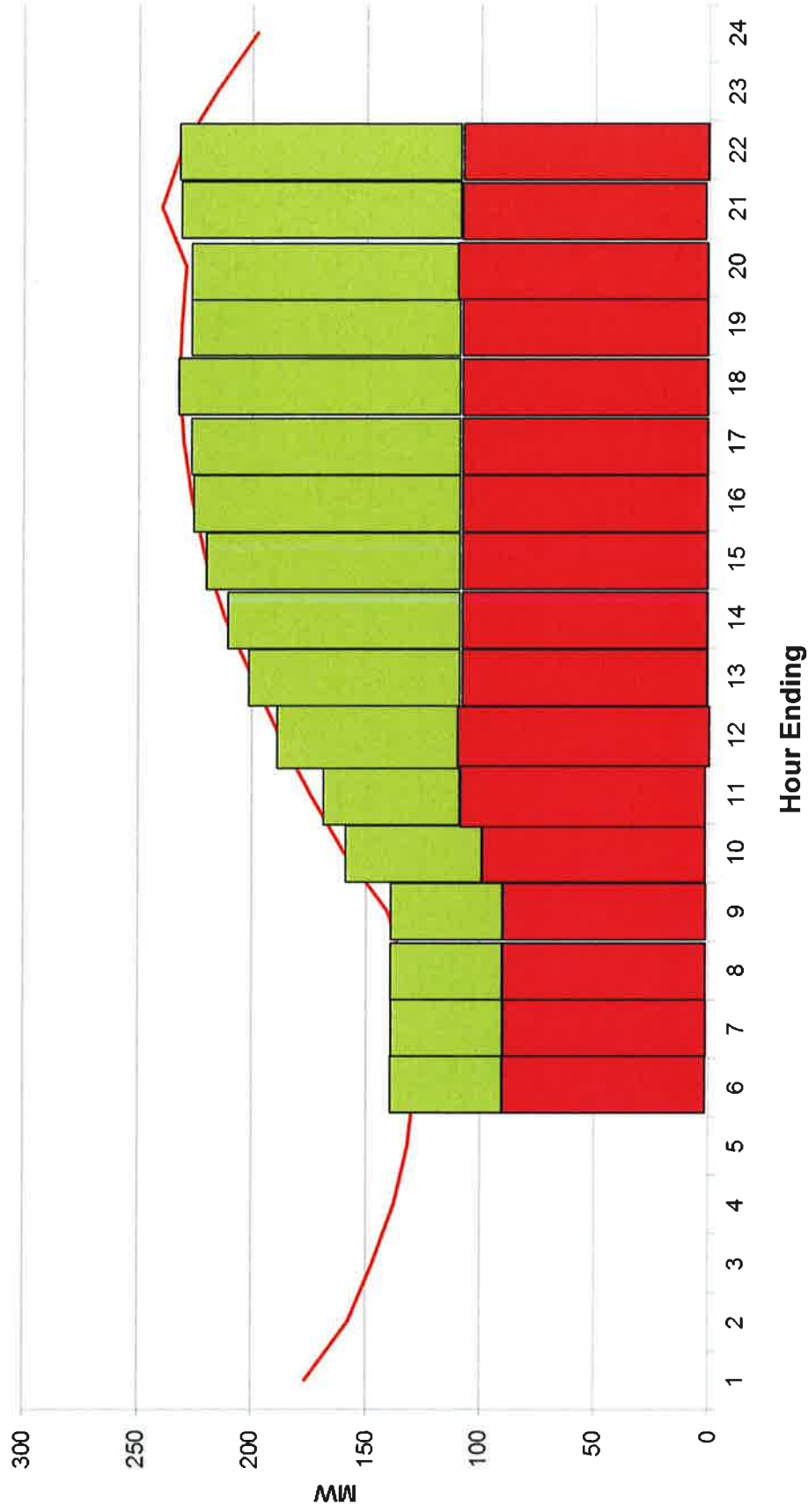
# Incremental Cost Decision

- Incremental costs of units at minimum load:
  - CC1 - \$14.80/MWh
  - DH2 - \$23.70/MWh
  - DH1 - \$19.25/MWh
- Where do we get the next, most economical megawatt?
  - CC1



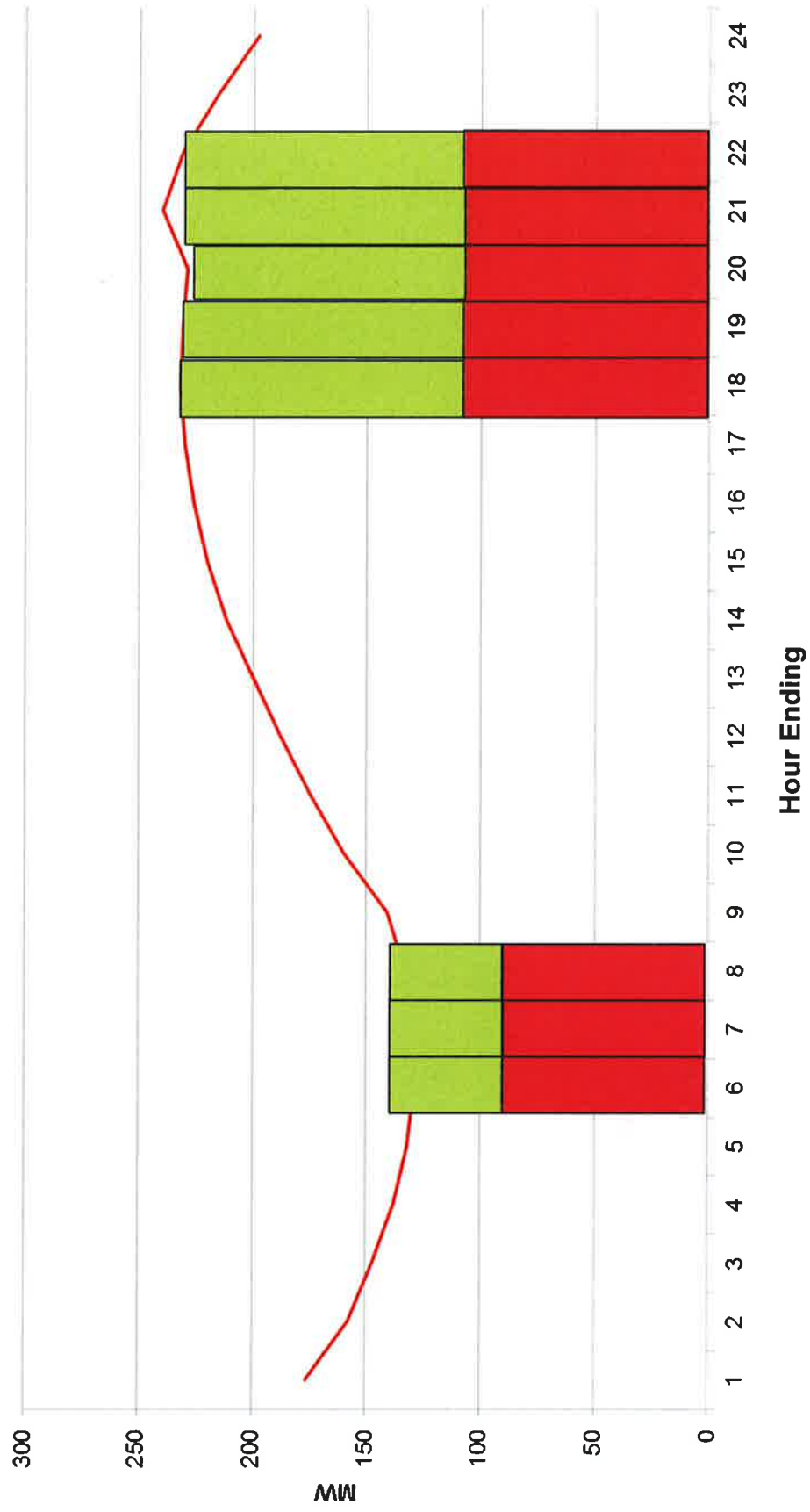
# Typical Spring Load Shape (Purely Economical)

■ CC1    ■ DH2



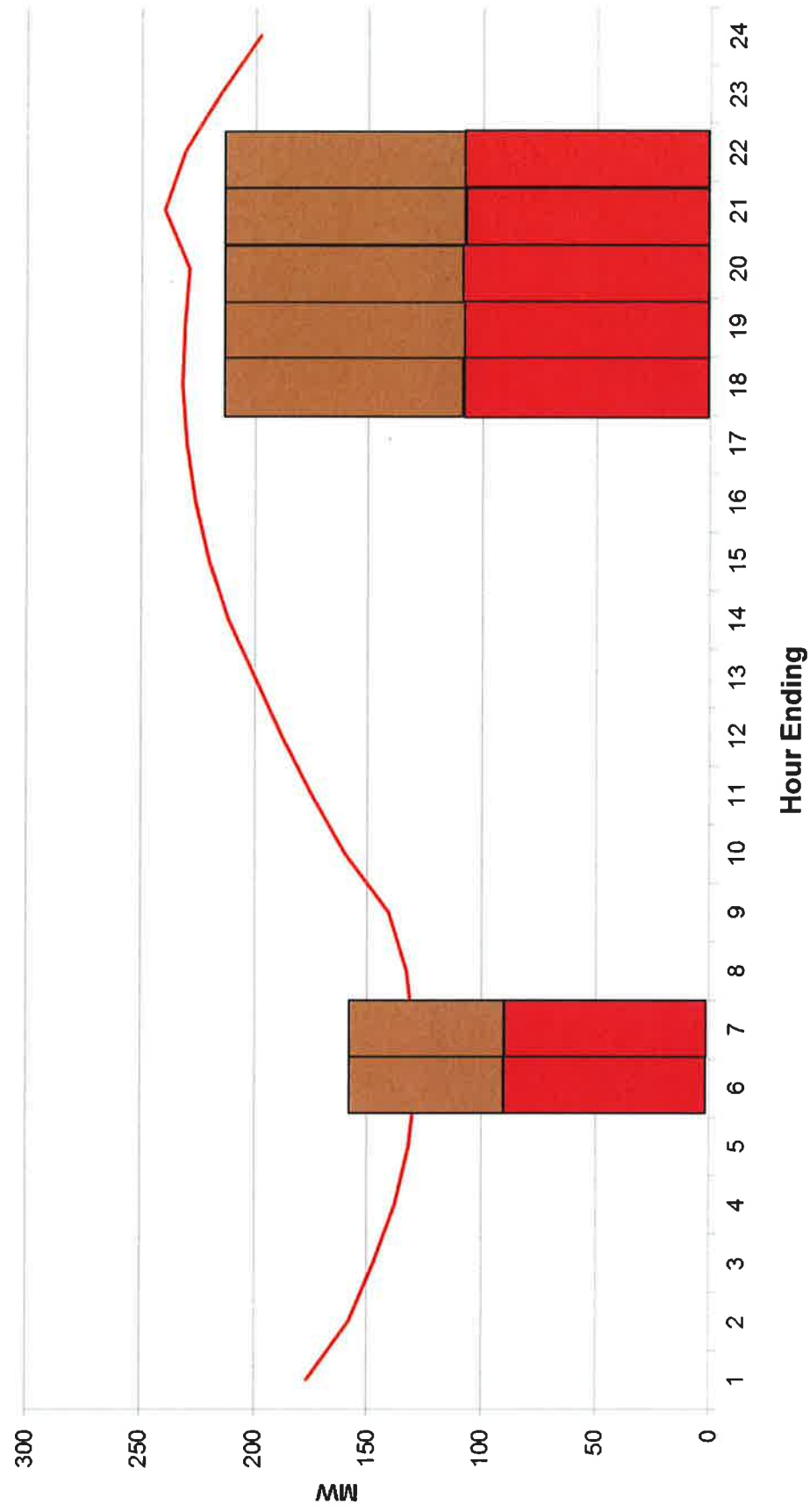
# Typical Spring Load Shape (Purely Economical)

■ CC1
 ■ DH2



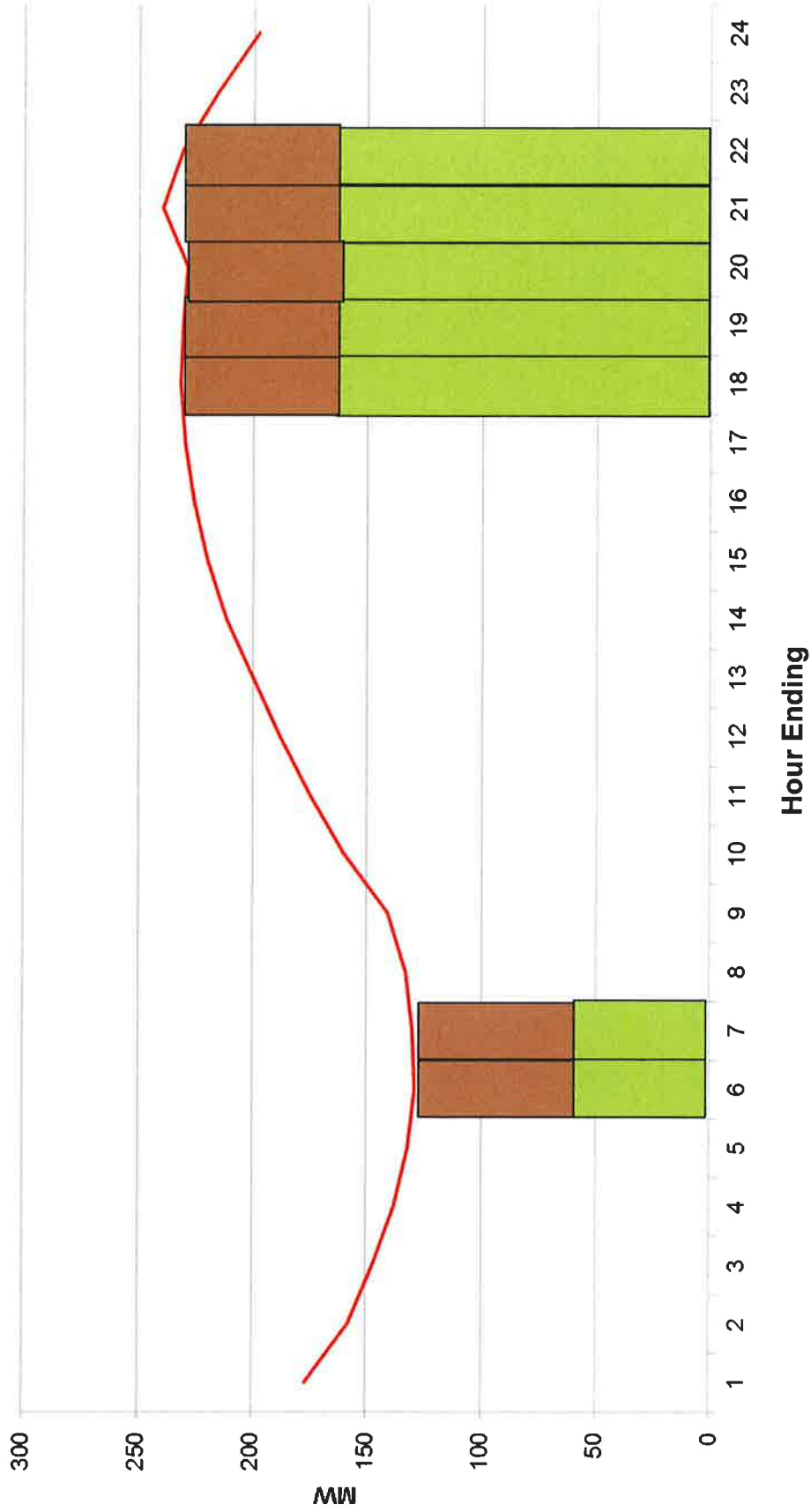
# Typical Spring Load Shape (w/ GREC)

■ CC1    
 ■ GREC

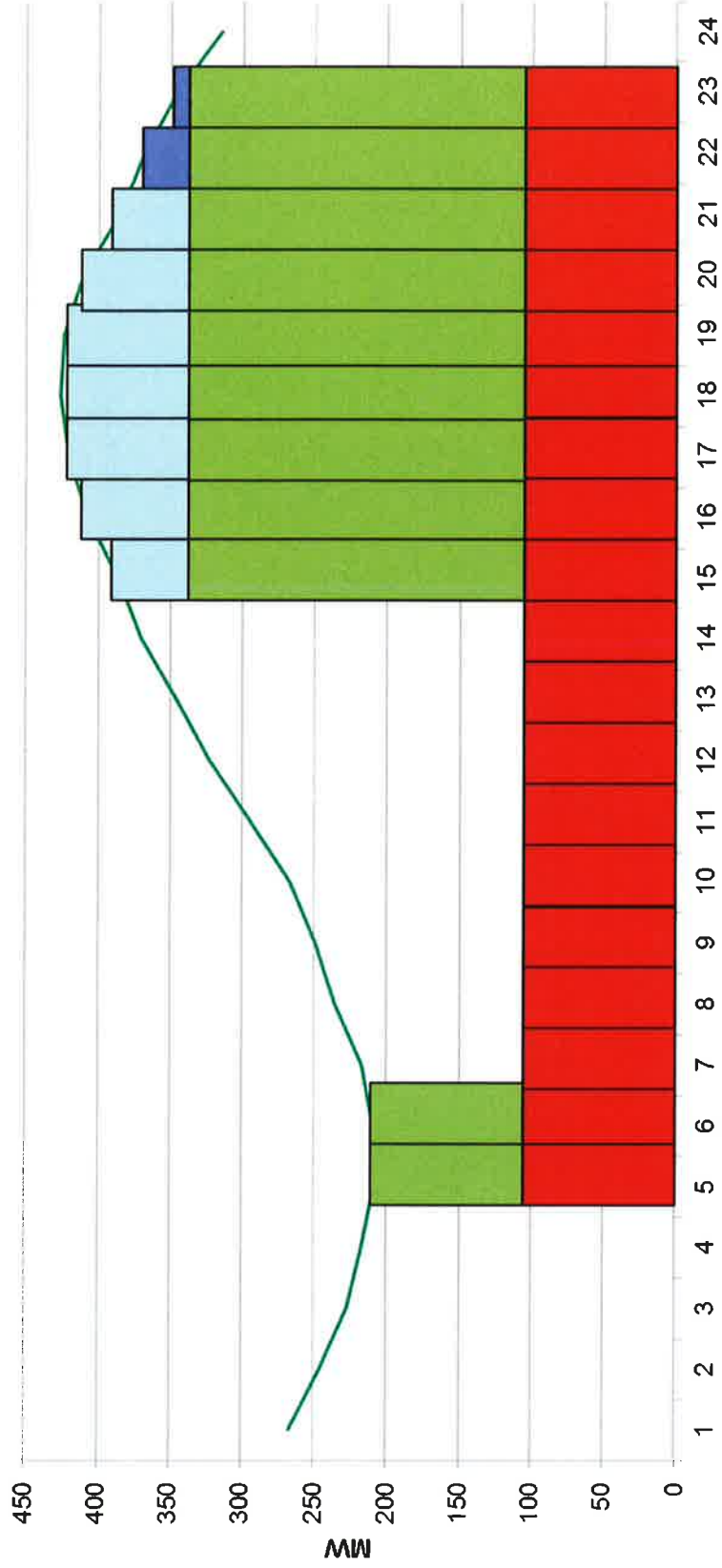


# Typical Spring Load Shape (w/ GREC)

■ DH2 ■ GREC

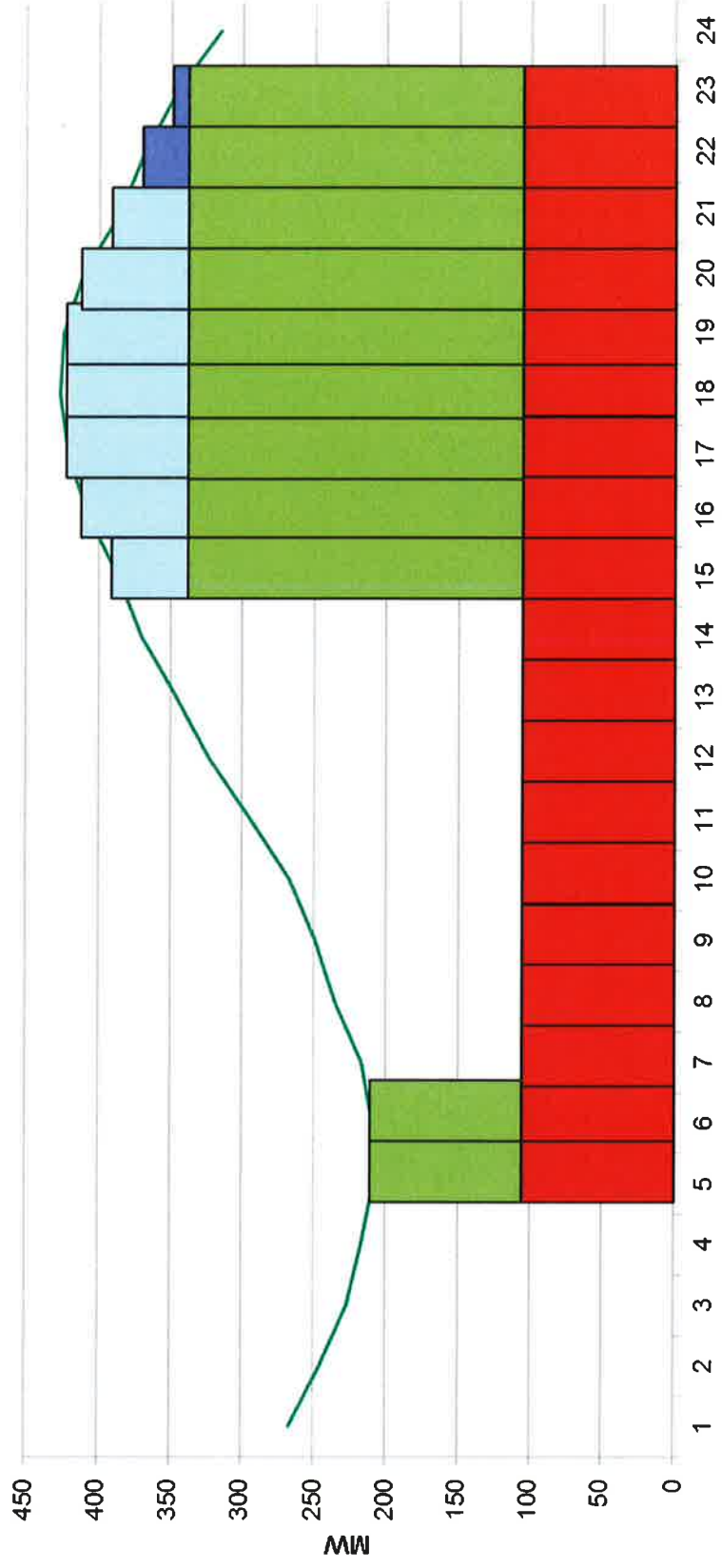


### Summer Load Shapes (Purely Economical)

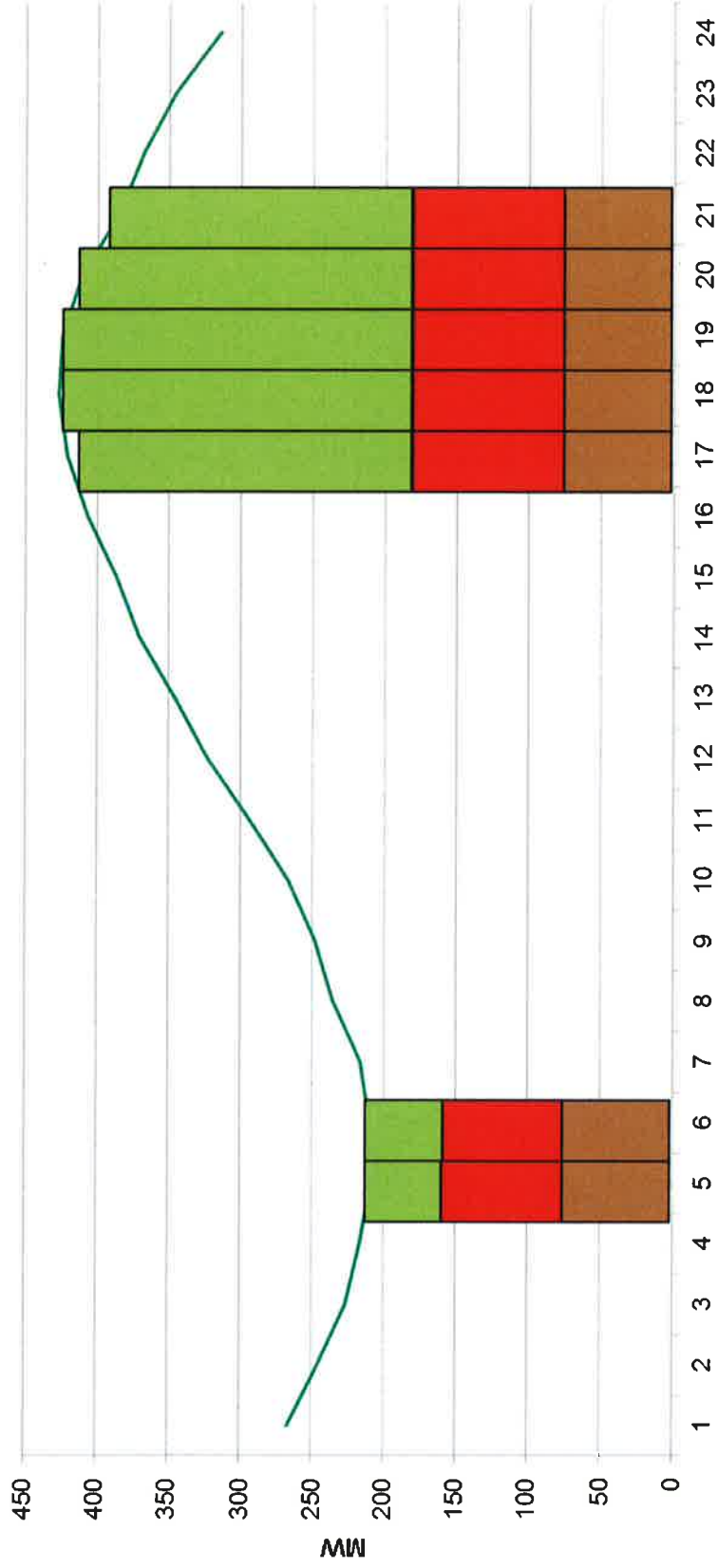




### Summer Load Shapes (Purely Economical)



# Summer Load Shapes (w/ GREC)



# Actual Day Comparison

- April 21, 2016
  - CC1 & Unit 2
  - 4990 MWh produced
  - Total Production Cost - \$119,153
- Review w/ GREC Running
  - CC1 & GREC
    - Total Production Cost - \$146,044 (~\$27,000 ↑)
  - DH2 & GREC
    - Total Production Cost - \$183,287 (~\$64,000 ↑)

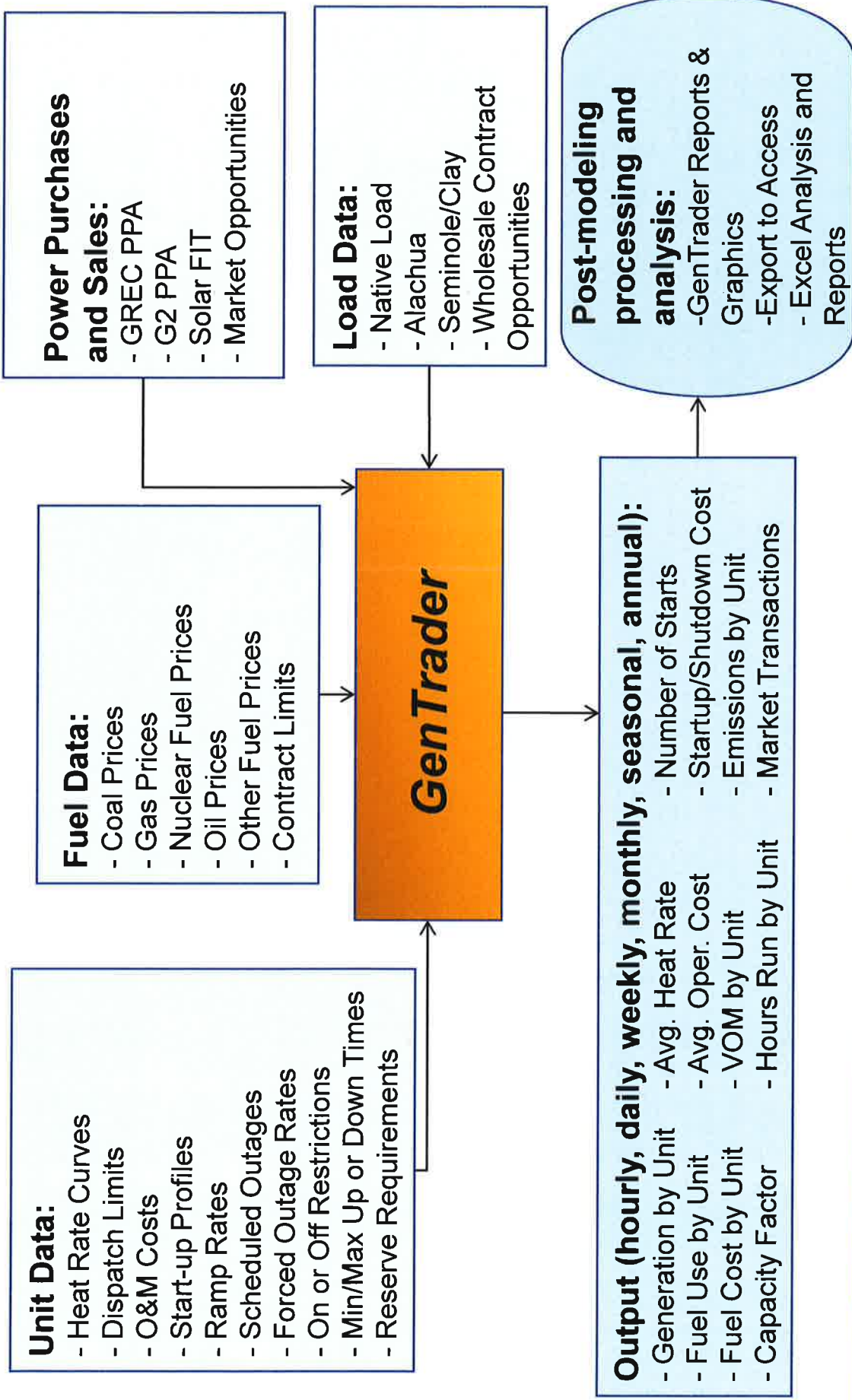


# What Crunches the Numbers?

- GenTrader®
  - Energy model that determines the most economical scenario
  - Used for Unit Commitment and long-term planning
- Energy Management System (EMS)
  - Used for real-time dispatch to optimize incremental costs

# What is GenTrader?

- GenTrader is a hourly production cost optimization model developed and marketed by Power Cost, Inc. (PCI)
- Production cost models simulate a utility system's available resources to optimize the system's unit commitment and economic dispatch
- GenTrader is not a dynamic generation capacity expansion model
- GenTrader only optimizes system operations and production costs



# Unit Commitment Example

Unit Name	Effective Date	Day of Week	HE ME
<b>Total Load</b>	<b>4/27/2016</b>	<b>3 We</b>	<b>188</b>
Suggested Purchase	4/27/2016	3 We	3
Dump	4/27/2016	3 We	0
Block Purchase	4/27/2016	3 We	0
Deerhaven 2	4/27/2016	3 We	51
Deerhaven 1	4/27/2016	3 We	23
JRK CC	4/27/2016	3 We	105
SEC_CHP	4/27/2016	3 We	4
<b>Total Load</b>	<b>4/28/2016</b>	<b>4 Th</b>	<b>189</b>

HE ME	HE ME	HE ME	HE ME	HE ME
16 60	17 60	18 60	19 60	
<b>308</b>	<b>318</b>	<b>321</b>	<b>315</b>	
0	0	0	0	0
0	0	0	0	0
29	30	30	30	30
117	131	135	129	
75	75	75	75	
105	105	105	105	
4	4	4	4	4
<b>317</b>	<b>326</b>	<b>327</b>	<b>321</b>	

# Questions

