Unit Commitment and Economic Dispatch

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Course Objectives

- Provide an understanding of how Unit Commitment (UC) and Economic Dispatch works
  - Objectives
  - Process
  - Factors impacting Unit Commitment
  - How Unit Commitment impacts Economic Dispatch

I am always ready to learn, although I do not always like being taught.
~Winston Churchill

DOCENDO DISCIMUS – We learn by teaching

Three Primary Responsibilities of ISO New England

Operate New England's Bulk Electric Power System

- Dispatch New England's resources as a single system to:
  - Maintain reliability throughout the region.
  - Minimize cost of electricity production in New England.
  - Adhere to national, regional, and local operating procedures and policies.

Manage New England's Wholesale Electricity Marketplace

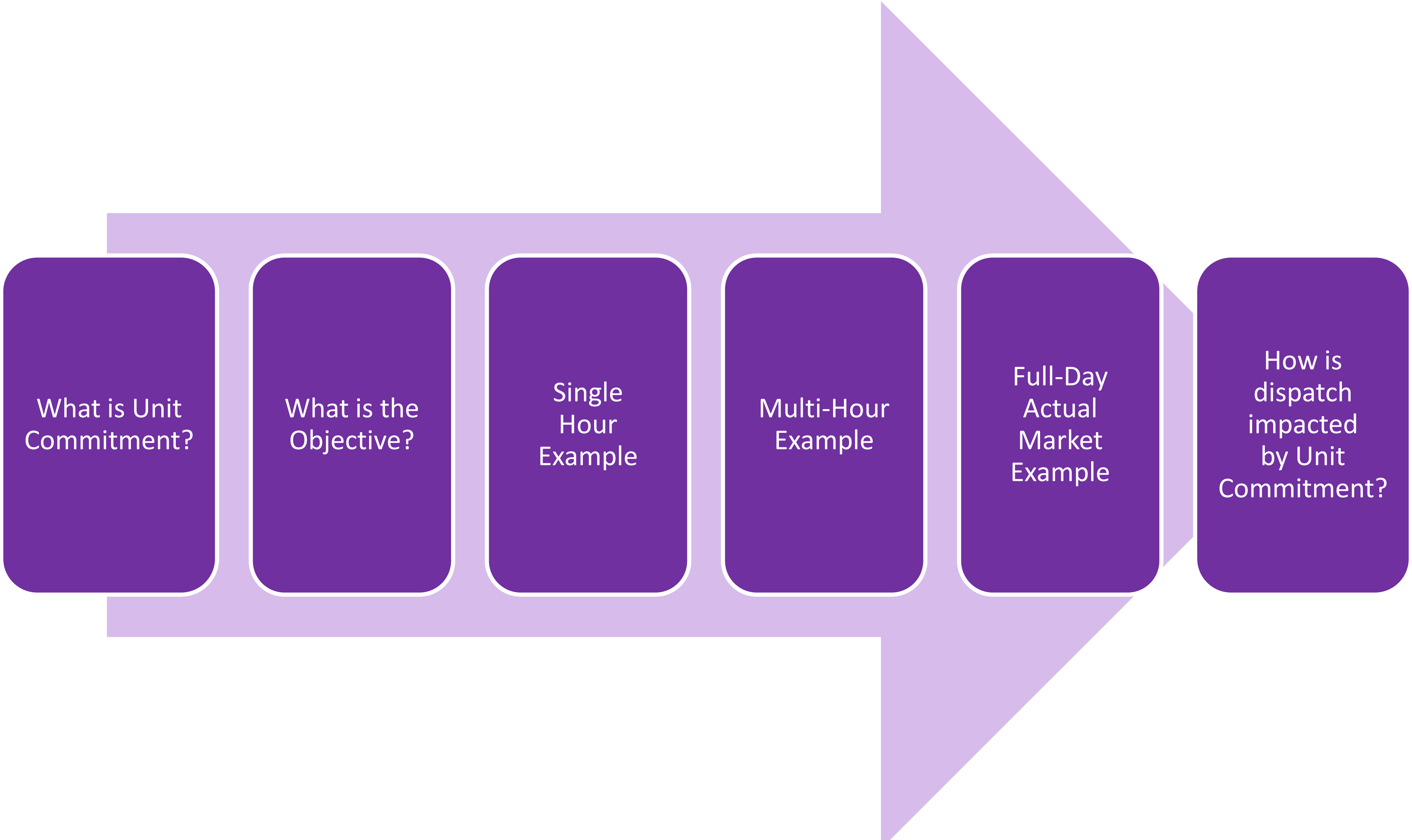
- Ensure a fair and reasonable marketplace

Develop and manage long-term planning process in New England

Application of ISO Responsibilities

Minimize cost of electricity production in New England.

- The ISO shall determine the least cost security-constrained unit commitment and dispatch
  - Least cost means of serving load at different locations in the New England Control Area based on:
    - Scheduled or actual conditions existing on the power grid
    - Prices at which Market Participants have offered to supply and consume energy in the New England Markets. MR1


What is Unit Commitment?
What is the Objective?
Single Hour Example
Multi-Hour Example
Full-Day Actual Market Example
How is dispatch impacted by Unit Commitment?

- **What is Unit Commitment?**
- What is the Objective?
- Single Hour Example
- Multi-Hour Example
- Full-Day Actual Market Example
- How is dispatch impacted by Unit Commitment?

What is Unit Commitment?

- Decision making process
- On/Off scheduling for a defined period
- System-wide Unit Commitment has been in place in New England well before markets (part of the implementation of NEPOOL in the 70's)
- Techniques and tools for Unit Commitment have changed and been updated over the years.
  - This training is not focused on the techniques for solving the Unit Commitment problem, complex mathematical techniques are used to quickly solve these large problems

What is Unit Commitment?

What is the Objective?

Single Hour Example

Multi-Hour Example

Full-Day Actual Market Example

How is dispatch impacted by Unit Commitment?

What is the Objective of Unit Commitment?

- With demand bidding, the objective is to maximize social welfare
- Without any demand bidding, the objective is to minimize the overall committed cost of the resources needed to meet the load and reserve requirements.
- In both cases, UC takes into account all of the costs of producing the energy, including no load costs and startup costs. At the same time, UC respects each resource's characteristics such as minimum up time, minimum down time.

Parameters Used in Unit Commitment

- Incremental Energy Offer Curves
- Startup Costs $ (Hot, Cold, Intermediate)
  - Costs incurred per startup of the resource
  - Type of start is based upon number of hours down since previous run
- No Load Costs $
  - Fixed cost that is incurred every hour the resource is running
- Minimum Run Time (in hours or fractions of hours)
- Minimum Down Time (in hours or fractions of hours)
- Economic Minimum and Economic Maximum

Other Information That Can Be Used to Impact Unit Commitment

Startup Profiles

Shutdown Profiles

Combined Cycle configurations

None of the above are currently used in ISO New England systems

Basic Terms and Concepts

Unit Commitment & Dispatch

- Pool Schedule (ISO Committed)
  - Action by the ISO to schedule a resource for which the Participant submitted supply offers to sell energy. The ISO can schedule these resources in the DA Market as well as commit them to provide energy in the RT dispatch.

- Self Schedule (Self Committed)
  - Action of a Participant in committing and/or scheduling its resource, to provide service in an hour, whether or not in the absence of that action the resource would have been scheduled or dispatched by the ISO to provide the service.

How Dollar Values Impact Unit Commitment

- Total Production Cost ($)
  - Fixed Costs (not dependent on loading level), if Unit is on cost is incurred
    - Startup Costs are included in the cost calculation for every start (based on Hot, Cold and Intermediate) of the Unit
    - No Load Costs are included in the cost calculation for every hour the Unit is on-line
  - Incremental Energy Costs
    - Based on the hourly Economic Dispatched MWh needed from each resource to meet the demand
- Minimizing the **total** of the fixed and incremental costs is the basic objective.

Impacts of Time Data on Unit Commitment

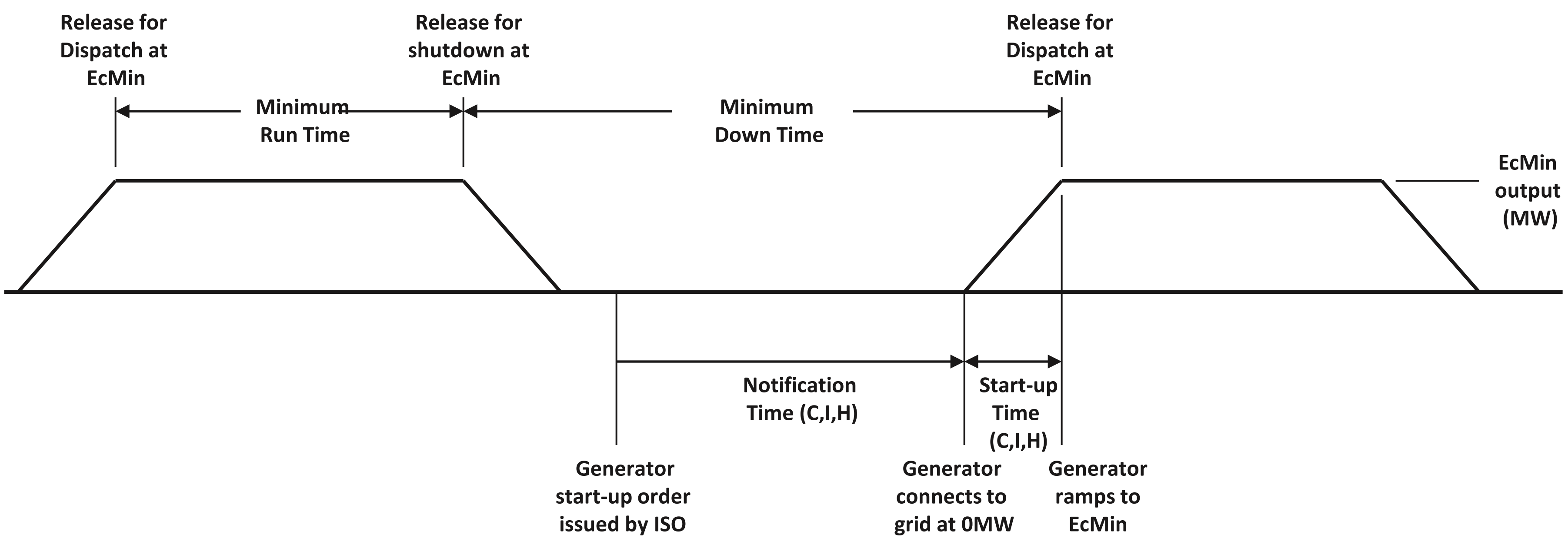
- Generally classified as "Intertemporal Parameters"

Minimum Run Time	Minimum Down Time
When a Unit is Committed, it must run for at least this many hours before being shut down	When a Unit is Decommitted, it must stay down for at least this many hours before starting up again

Graphical Representation of Unit Commitment

Notification Time
Start-up Time
Minimum Run Time
Minimum Down Time

What do these terms mean?

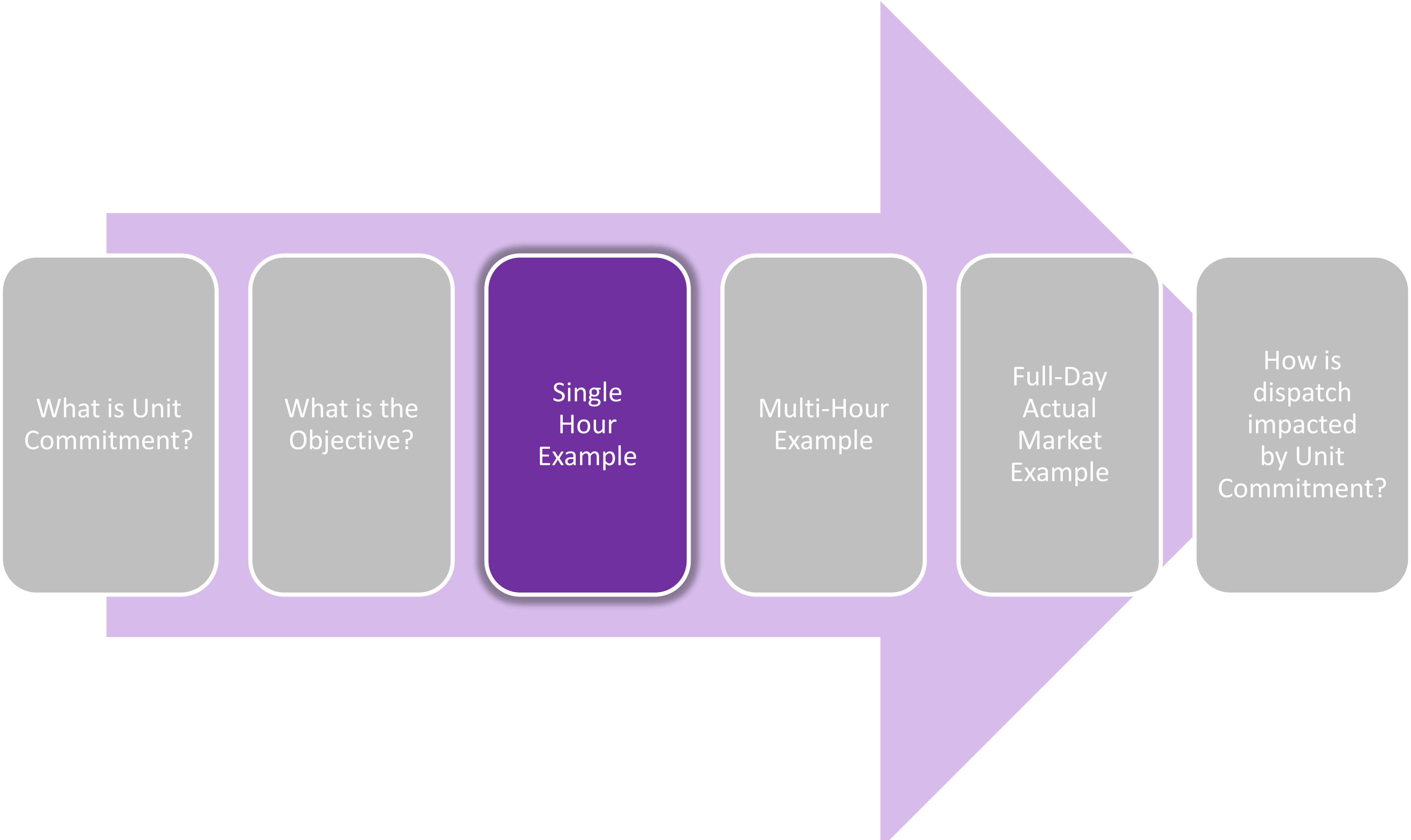


Important Factors We Have Learned So Far…

- Objective Function of Minimizing Costs
- Factors that impact the Objective Function
- Difference between
  - Self Scheduled (Self Committed)
  - Pool Scheduled (Pool Committed)

I cannot teach anybody anything, I can only make them think.

~Socrates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Examples

Objectives

- Show how combinations of Units are evaluated against the Production Cost Objective Function
- Use a Single Hour for ease of use
- Expand to show Multiple Hours
- Further expand and graphically show the Daily Commitment problem

Single Hour Example

Unit	Cost $/MW	ECO MIN (MW)	ECO MAX (MW)	No Load $/hr
X	$20	300	325	$5000
Y	$30	200	275	$1200
Z	$35	125	400	$700

Single Hour Example (cont.)

- For a single hour, 8 possible combinations (each unit could be on or off so 2^3 is the number of unique combinations)
- Table shows all combinations possible

Comb.#	X	Y	Z
1	On	On	On
2	On	On	Off
3	On	Off	On
4	Off	On	On
5	On	Off	Off
6	Off	On	Off
7	Off	Off	On
8	Off	Off	Off

Single Hour Example (cont.)

- Each combination has a Minimum and Maximum Output based on the sum of the minimums and maximums of the resources that are on in that combination.
- These Minimum and Maximum values will represent the range of load levels that can be achieved with this combination.

Comb.#	∑Min	∑Max
1	625	1000
2	500	600
3	425	725
4	325	675
5	300	325
6	200	275
7	125	400
8	0	0

Single Hour Examples (cont.)

- Try three different load levels (no reserve requirement)
  1) 350 MW
  2) 475 MW
  3) 525 MW
- Find the Total Dispatch Cost (objective function) for each of the eight combinations at each load level.
  - Since we can look at dispatch of all 8 solutions, rather than just commitment, we are looking at commitment and dispatch.

Single Hour Example – 350 MW Load

Comb.#	X No Load $	X MW & Cost $	Y No Load $	Y MW & Cost $	Z No Load $	Z MW & Cost $	Total Production Cost $
1	$5000	300 MW $6000	$1200	200 $6000	$700	125 $4375	$23,275
2	$5000	300 MW $6000	$1200	200 $6000	$0		$18,200
3	$5000	300 MW $6000	$0		$700	125 $4375	$16,075
4	$0		$1200	225 $6750	$700	125 $4375	$13,025
5	$5000	325 MW $6500	$0		$0		$11,500
6	$0		$1200	275 $8250	$0		$9,450
7	$0		$0		$700	350 $12250	$12,950
8	$0		$0		$0		$0

Excess Generation   Capacity Deficient

Single Hour Example – 475 MW Load

Comb.#	X No Load $	X MW & Cost $	Y No Load $	Y MW & Cost $	Z No Load $	Z MW & Cost $	Total Production Cost $
1	$5000	300 MW $6000	$1200	200 $6000	$700	125 $4375	$23,275
2	$5000	300 MW $6000	$1200	200 $6000	$0		$18,200
3	$5000	325 MW $6500	$0		$700	150 $5250	$17,450
4	$0		$1200	275 $8250	$700	200 $7000	$17,150
5	$5000	325 MW $6500	$0		$0		$11,500
6	$0		$1200	275 $8250	$0		$9,450
7	$0		$0		$700	400 $14000	$14,700
8	$0		$0		$0		$0

Excess Generation (rows 1–2, green) | Capacity Deficient (rows 5–8, red)

Single Hour Example – 525 MW Load

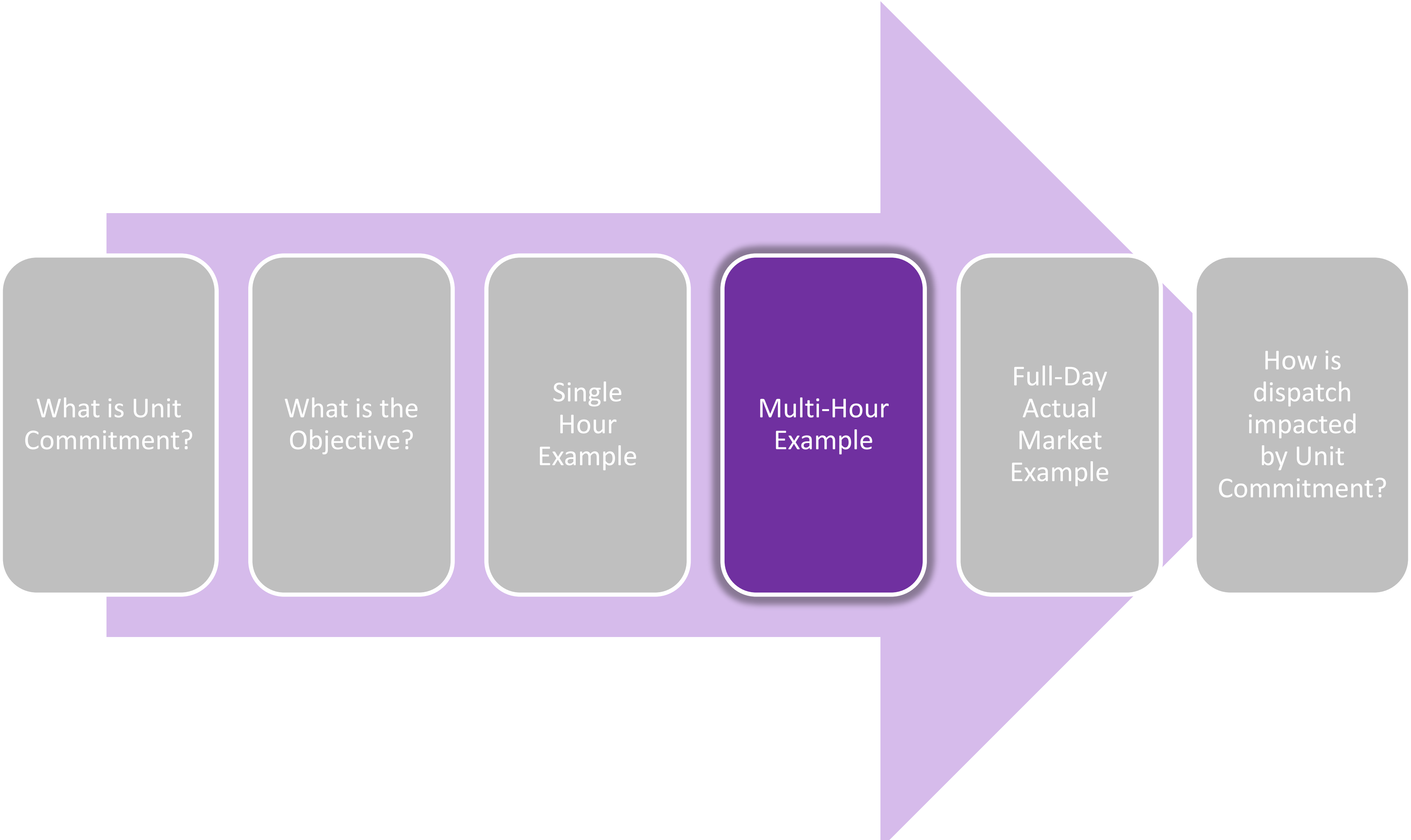
Comb.#	X No Load $	X MW & Cost $	Y No Load $	Y MW & Cost $	Z No Load $	Z MW & Cost $	Total Production Cost $
1	$5000	300 MW $6000	$1200	200 $6000	$700	125 $4375	$23,275
2	$5000	325 MW $6500	$1200	200 $6000	$0		$18,700
3	$5000	325 MW $6500	$0		$700	200 $7000	$19,200
4	$0		$1200	275 $8250	$700	250 $8750	$18,900
5	$5000	325 MW $6500	$0		$0		$11,500
6	$0		$1200	275 $8250	$0		$9,450
7	$0		$0		$700	400 $14000	$14,700
8	$0		$0		$0		$0

Excess Generation | Capacity Deficient

Single Hour Examples – Summary

- Three different load levels – three different best commitment and dispatch solutions
- Each of the eight combinations may have at least one load level where that combination is the lowest cost
- These single hour examples don't take into consideration previously discussed "intertemporal parameters".

You cannot teach a man anything.
You can only help him discover it within himself.
~ Galileo Galilei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Multi-Hour Example

- The number of possible combinations that could be evaluated in a multi-hour example increases exponentially.
- With our previous set of 3 resources, one hour has 8 combinations. If we look at 4 hours, there are 8^4 or 4096 possible combinations of those 3 units towards meeting those 4 hours load.
- As we have seen before, many of the hourly 8 combinations may not be viable (excess generation or capacity deficient), so the actual number of viable combinations will be much smaller.

Multi-Hour Example (cont.)

- Example will use the same resources as single hour examples
- Assume the following loads for the 4 hours:
  - Hour 12 – 475 MWh
  - Hour 13 – 525 MWh
  - Hour 14 – 525 MWh
  - Hour 15 – 350 MWh
- What are the possible combinations that are viable?
- What is the cost of each of these combinations?

Multi-Hour Example (cont.)

Comb.#	Production Cost $ @ 475 MWh Load Hour 12	Production Cost $ @ 525 MWh Load Hour 13	Production Cost $ @ 525 MWh Load Hour 14	Production Cost $ @ 350 MWh Load Hour 15
1	$23,275	$23,275	$23,275	$23,275
2	$18,200	[illegible]	[illegible]	$18,200
3	$17,450	[illegible]	[illegible]	$16,075
4	$17,150	[illegible]	$18,900	[illegible]
5	$11,500	[illegible]	[illegible]	$11,500
6	$9,450	$9,450	$9,450	$9,450
7	$14,700	$14,700	$14,700	$12,950
8	$0	$0	$0	$0

Combination #2

2x3x3x2=36 Combinations

Excess Generation | Capacity Deficient

Multi-Hour Example – No Intertemporals

Comb.#	Production Cost $ @ 475 MWh Load Hour 12	Production Cost $ @ 525 MWh Load Hour 13	Production Cost $ @ 525 MWh Load Hour 14	Production Cost $ @ 350 MWh Load Hour 15
1 X,Y,Z	$23,275	$23,275	$23,275	$23,275
2 X,Y	$18,200	$18,700	$18,700	$18,200
3 X, Z	$17,450	$19,200	$19,200	$16,075
4 Y,Z	$17,150	$18,900	$18,900	$13,025
5 X	$11,500	$11,500	[illegible]	$11,500
6 Y	$9,450	$9,450	$9,450	$9,450
7 Z	$14,700	$14,700	$14,700	$12,950
8	$0	$0	$0	$0

Lowest Cost = $67,500

Excess Generation | Capacity Deficient

Introduction of Intertemporals

- Minimum Run Time
  - Unit X = 3
  - Unit Y = 2
  - Unit Z = 1

Multi-Hour Example – Intertemporals

Comb.#	Production Cost $ @ 475 MWh Load Hour 12	Production Cost $ @ 525 MWh Load Hour 13	Production Cost $ @ 525 MWh Load Hour 14	Production Cost $ @ 350 MWh Load Hour 15
1 X,Y,Z	$23,275	$23,275	$23,275	$23,275
2 X,Y	$18,200	$18,700 ✓	$18,700 ✓	$18,200
3 X, Z	$17,450 ✓	$19,200	$19,200	$16,075
4 Y,Z	$17,150	$18,900	$18,900	$13,025
5 X		$11,500		$11,500
6 Y	$9,450	$9,450	$9,450	$9,450
7 Z	$14,700	$14,700	$14,700	$12,950 ✓
8	$0	$0	$0	$0

Unit X cannot run for only two hours

Lowest Cost = $67,800

Excess Generation | Capacity Deficient

What If We Change the Intertemporals?

- Minimum Run Time
  - Unit X = 2
  - Unit Y = 1
  - Unit Z = 3

Multi-Hour Example – Intertemporals

Comb.#	Production Cost $ @ 475 MWh Load Hour 12	Production Cost $ @ 525 MWh Load Hour 13	Production Cost $ @ 525 MWh Load Hour 14	Production Cost $ @ 350 MWh Load Hour 15
1 X,Y,Z	$23,275	$23,275	$23,275	$23,275
2 X,Y	$18,200	$18,700	$18,700	
3 X, Z	$17,450	$19,200	$19,200	
4 Y,Z	$17,150	$18,900	$18,900	$13,025
5 X	$11,500	$11,500		$11,500
6 Y	$9,450	$9,450	$9,450	$9,450
7 Z	$14,700	$14,700	$14,700	$12,950
8	$0	$0	$0	$0

Unit Z must run for at least 3 hours cannot use these

Lowest Cost = $67,900

Excess Generation | Capacity Deficient

Summary of Multi-Hour Examples

- Determine the “Cost” every hour
- With no intertemporal limits (min run/down) lowest cost will be the lowest cost each hour at each load level
- Intertemporal limits will only make the final solution more expensive
- Because the objective is to minimize the cost for multiple hours, any one hour may have a higher cost than its minimum.

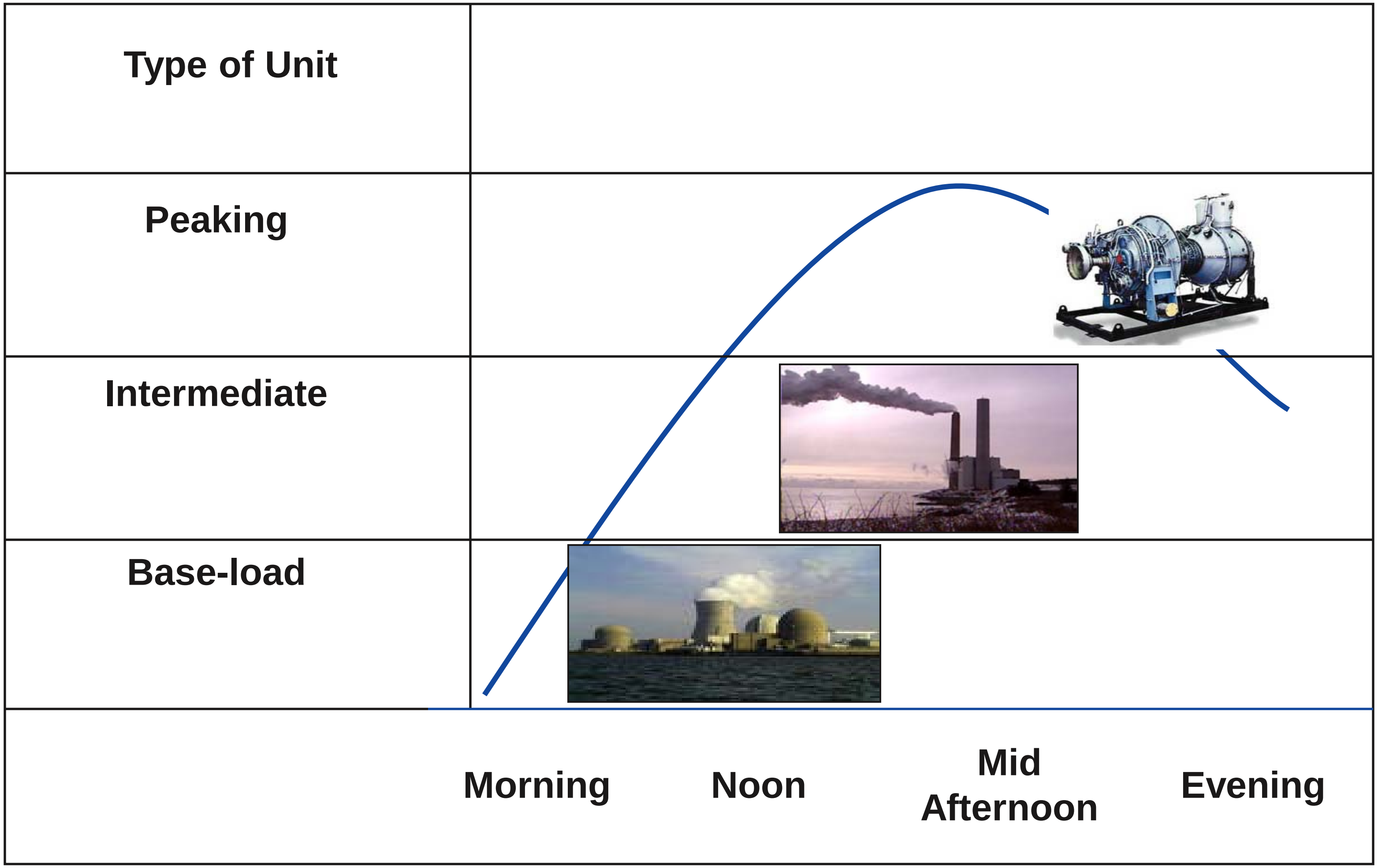
Man's mind, once stretched by a new idea,
never regains its original dimensions.
~Oliver Wendell Holmes

Full-Day Actual Market Examples

Full-Day Actual Market Examples

- Actual problem that must be solved by ISO New England is usually around 10-50 resources needing to be committed per hour for all 24 hours of a day.
- Obviously trying every possible combination is not possible given the time limits (it would take a day to run a day).
- Other mathematical techniques are used to determine a solution.

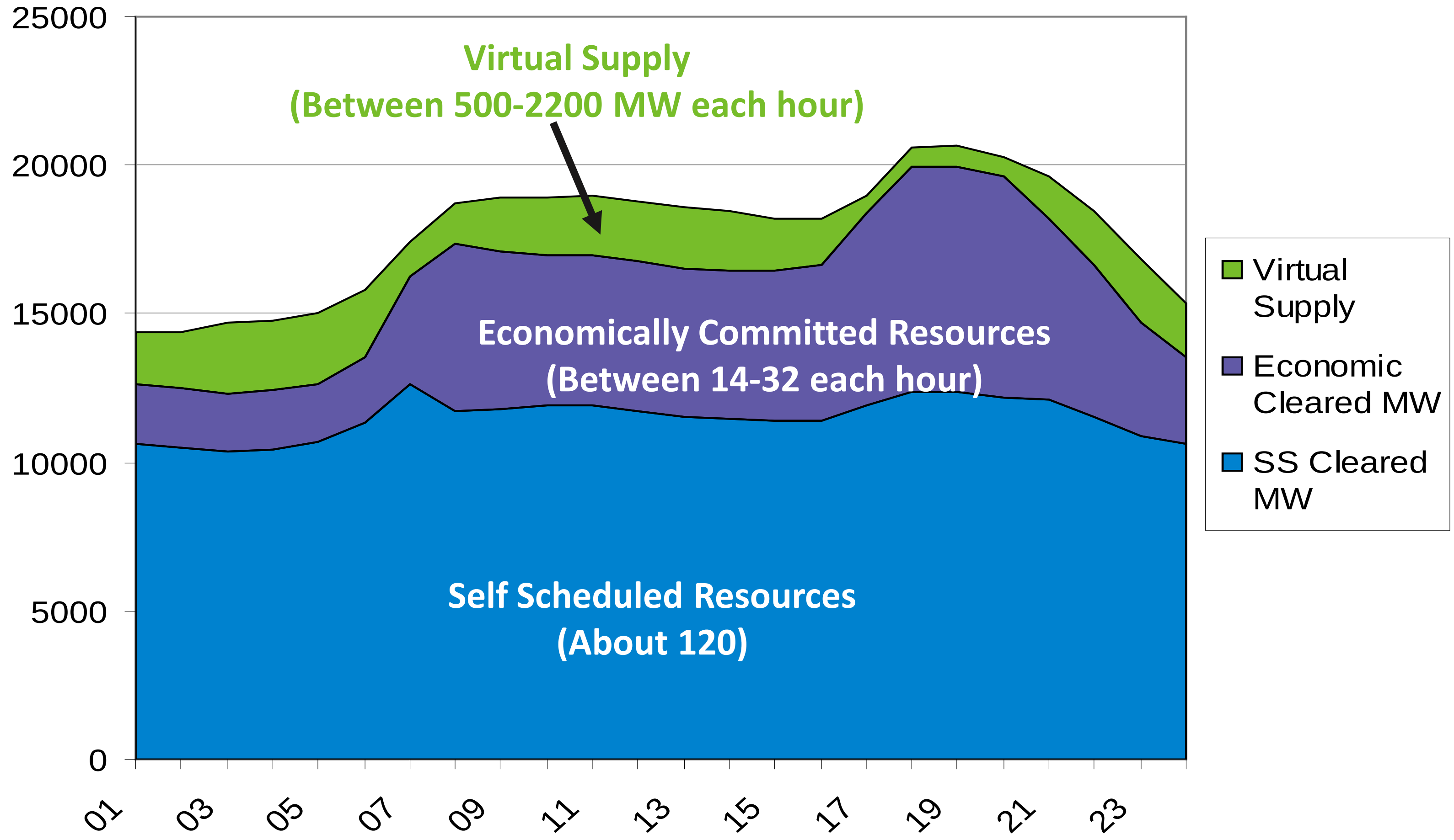
Major Classification of Generators



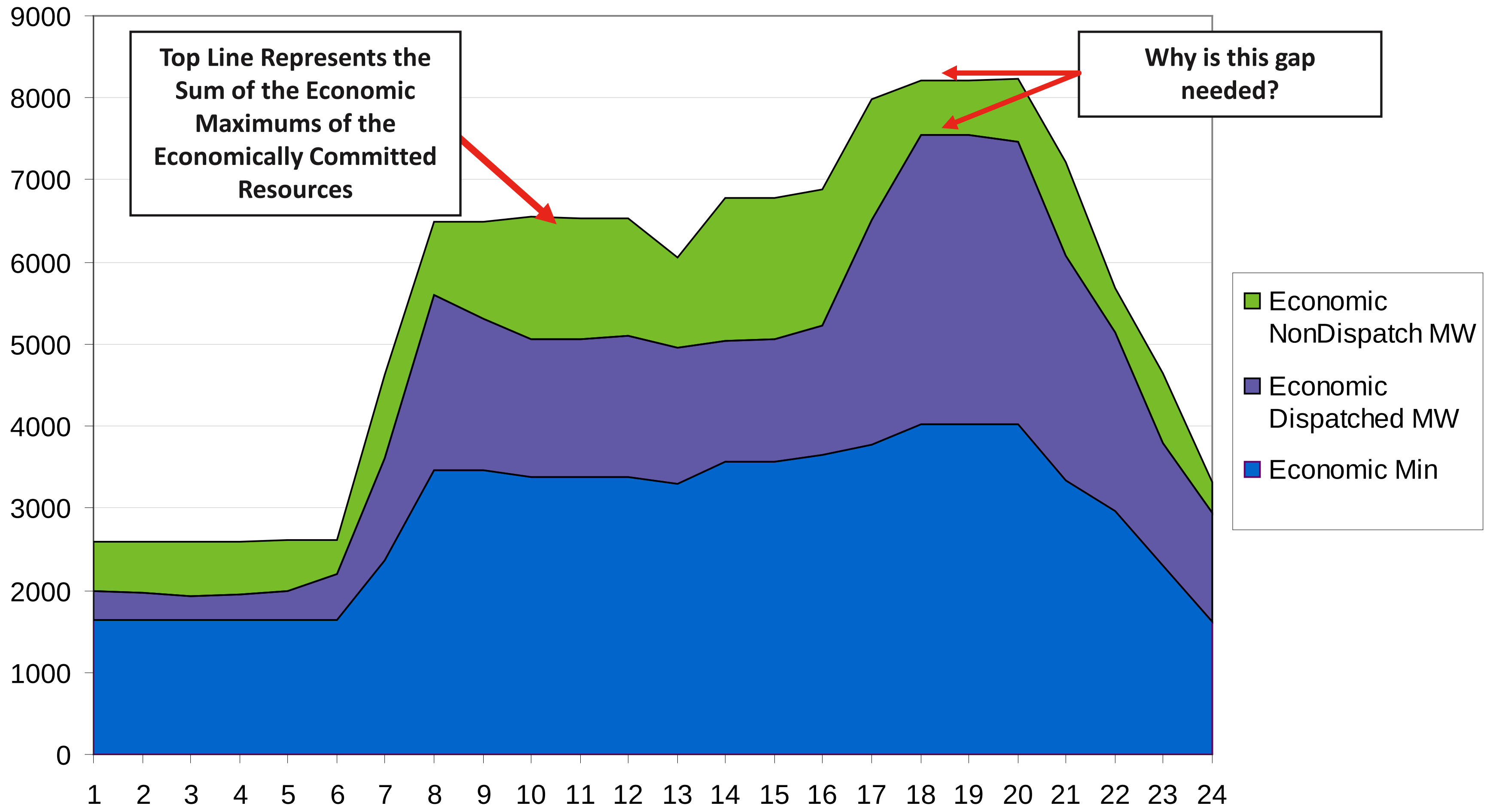
Commitment Schedule (Operating Plan)

- Commitment software determines which generators are scheduled to run for which hours
- Only an on/off schedule, the MW levels are not used.
- In the Day-Ahead Market, we run the commitment schedule through a dispatch algorithm to determine loading levels and demand clearing as well as final costs and LMPs.
- In the Real-Time, the commitment schedule (also known as Current Operating Plan) is used to determine actual on/off times for resources; actual dispatch of those resources is done on a five-minute basis.

Full Day Example (Day-Ahead Market)



Economically Committed Resources



Actual Commitment Schedule

Economically Committed Resources (32 Resources)

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
S	12	8	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
T	12	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
DD	12	12	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Q	13	7	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
I	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	13	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
G	16	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
J	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FF	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	12	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

0 = Off for this Hour   1 = On for this Hour

Focus on Baseload Committed Resources

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
S	12	8	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
T	12	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
DD	12	12	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Q	13	7	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
I	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	13	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
G	16	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
J	0	0																				1	1	1	1	1
K	0	0																				1	1	1	1	1
FF	0	0																				1	1	1	1	1
C	1	0																				1	1	1	1	1
D	0	0																				1	1	1	1	1
M	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	12	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

These Resources have a 24 hour Minimum Run Time once Committed must be run for the day (unless they were running the previous day)

0 = Off for this Hour   1 = On for this Hour

Focus on Baseload Committed Resources

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11																				1	1	1	1	1
S	12	8																				1	1	1	0	0
T	12	8																				1	1	1	0	0
DD	12	12																				1	0	0	0	0
Q	13	7																				1	1	1	0	0
I	14	8																				1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	13	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
G	16	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
J	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FF	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	12	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

These Resources have a <24 hour Minimum Run Time, but due to Economics are Committed for whole day (some even have little to no Minimum Run/Down Times.

0 = Off for this Hour   1 = On for this Hour

Economically Committed Resources

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0																						1	1
S	12	8	0																						0	0
T	12	8	0																						0	0
DD	12	12	0																						0	0
Q	13	7	0																						0	0
I	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	13	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
G	16	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
J	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FF	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	12	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

These Resources have not run for Hour 24, which means that if they will need to meet Minimum Down Time next Day before running again.

0 = Off for this Hour 1 = On for this Hour

Long Minimum Run Times / Minimum Down Times

- A single day unit commitment can only take into account that days needs, but from a next day reliability perspective can we turn every unit off at hour 23?

  What if we cannot meet the next morning load?

Next Day Committed Resources

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0
U	8	4	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	8	9	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
T	12	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
DD	12	12	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Q	13	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I	14	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
H	16	64	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V	15	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F	6	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
R	13	6	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
G	16	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FF	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
C	1	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
D	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
M	12	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
E	12	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Units R and G met their Minimum Down Time.
What about Unit V?

0 = Off for this Hour **1 = On for this Hour**

Starting Status for Hour 1 of Unit Commitment

- Each Daily Unit Commitment must start with a status for each resource from the previous day
  - On or Off
  - How many hours in that state?
- This status is based on two values:
  - The previous day's Day-Ahead Market Unit Commitment
  - Any changes made to the Current Operating Plan (Current Commitment Schedule) by the RAA process or by the Participant Self Scheduling additional or Decommiting additional hours by the time the next Day-Ahead Market is being executed.

Daily Cycling Committed Resources

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
S	12	8	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
T	12	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
DD	12	12	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Q	13	7	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
I	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
R	13	6	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	0
G	16	11	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	0
J	0	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
K	0	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
FF	0	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
C	1	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
D	0	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
M	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	12	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

These Resources have 8 to 12 hour minimum runs and total min. run + min. down < 24 these resources generally have the ability to come on for one period a day (peak).

0 = Off for this Hour   1 = On for this Hour

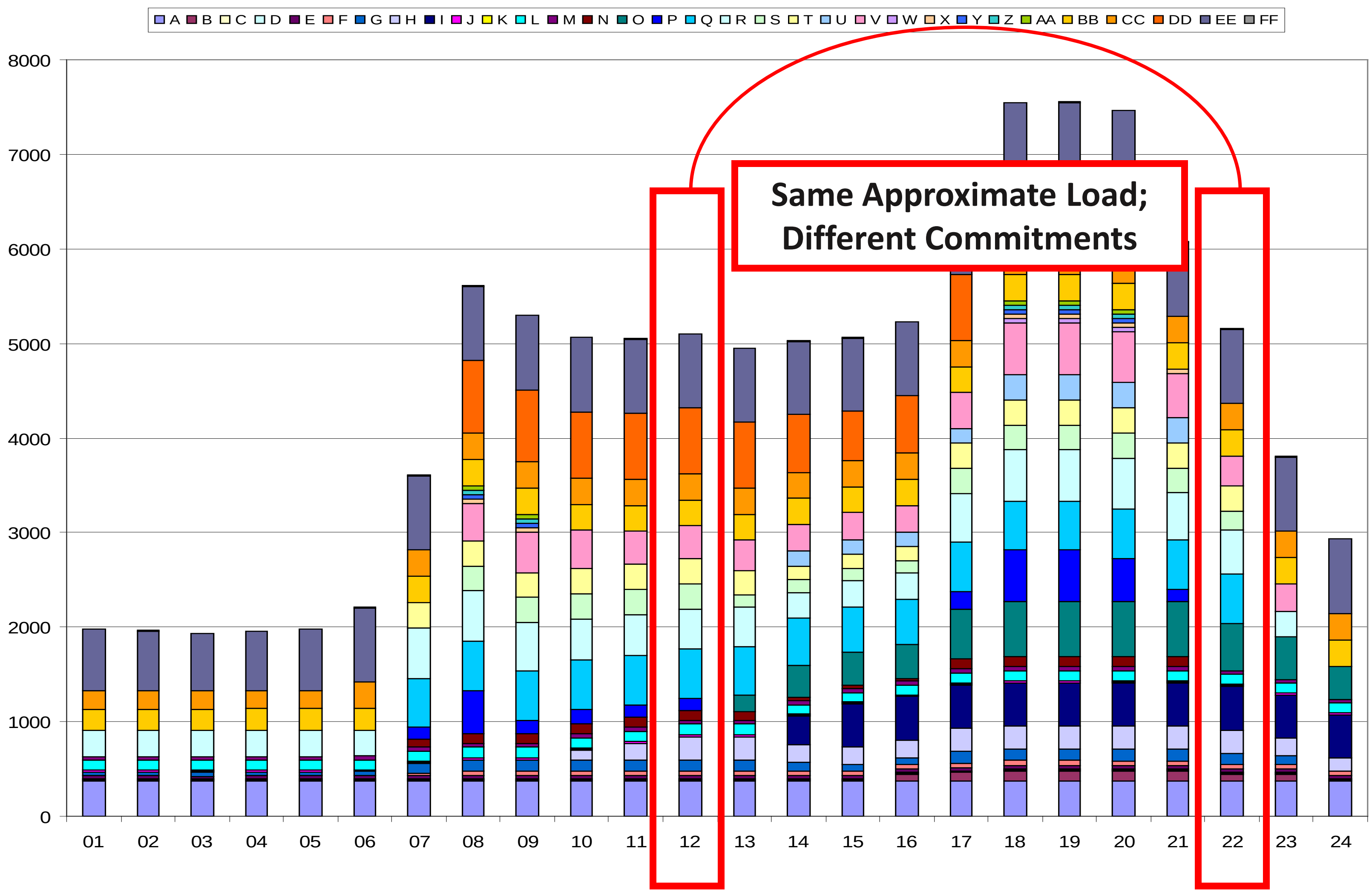
Committed Peaking Resources

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1
S	12	8	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	0	0
T	12	8	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	0	0
DD	12	12	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0
Q	13	7	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
I	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	13	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
G	16	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
J	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FF	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	12	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Peaking Resources 1 hour or less Min. run and Min. Down

0 = Off for this Hour 1 = On for this Hour

Economically Committed Resources



Comparison of Committed Resources

Hours 12 and 22

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
S	12	8	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
T	12	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
DD	12	12	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Q	13	7	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
I	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	13	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
G	16	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
J	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	0	0	1	1	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	1	1	1	1
FF	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	12	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

LMP in 22 ~ $3 less than LMP in 12

0 = Off for this Hour   1 = On for this Hour

Limited Energy Resources and Commitment

- Resources with limited amount of energy, as expressed by the quantity submitted by the resource owner, are used by the Commitment to optimize the overall cost of the daily dispatch.
- These Resources may or may not be used in the most expensive hours of the day (or those with the highest LMPs) since the commitment is using this resource in conjunction with other resources towards the overall objective.
- Will not optimize the profit of that generator but will optimize the impact on the objective function.

Comparison of Committed Resources

Hours 12 and 22

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
S	12	8	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
T	12	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
DD	12	12	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Q	13	7	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
I	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	13	6	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
G	16	11	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
J	0	0	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
K	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FF	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	12	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	12	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

What if this Resource had only 6 hours of full output available?

0 = Off for this Hour **1 = On for this Hour**

Economic Dispatch

Commitment Impact on Economic Dispatch

- Economic Dispatch is the least-cost usage of the committed generators to meet the demand
- Economic Dispatch does not have to adhere to inter-temporal parameters, since commitment has adhered to them
- Both in the Day-Ahead and Real-Time Markets, the set of resources are committed to maximize the social welfare
- Economic Dispatch is what determines the LMPs (not the commitment)

Actual Commitment Schedule

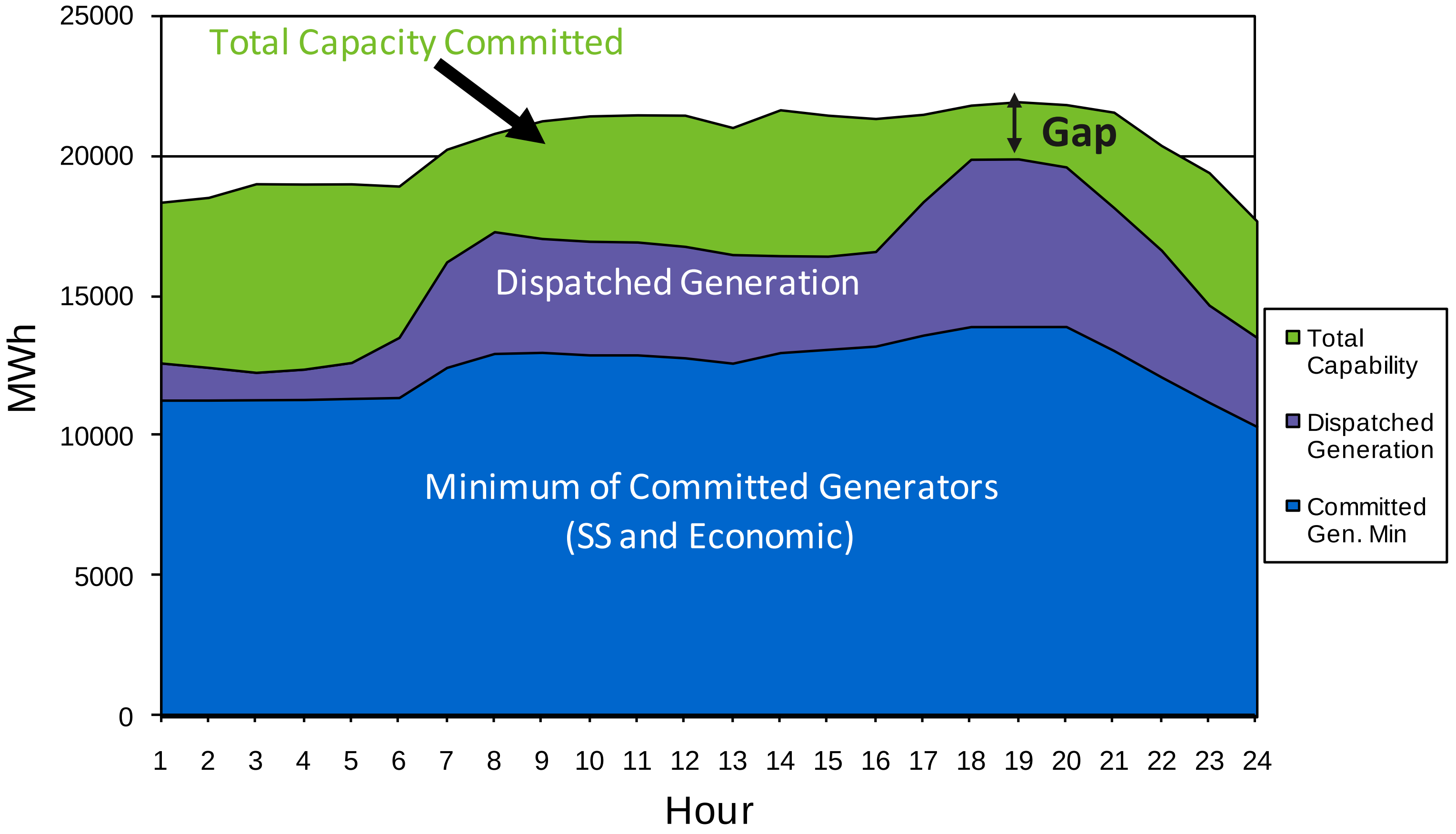
Dispatchable Resources (32 Resources)

Unit Name	Min Run	Min Down	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P	1	0.2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0
W	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
X	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Y	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Z	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
AA	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
U	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
N	8	9	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
O	8	11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
S	12	8	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
T	12	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
DD	12	12	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Q	13	7	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
I	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
H	16	64	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V	15	7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
F	6	8	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	13	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
G	16	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
J	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	0	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1
FF	0	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1
C	1	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1
D	0	0	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1
M	12	8	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1
E	12	12	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1
BB	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CC	14	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	24	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EE	24	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

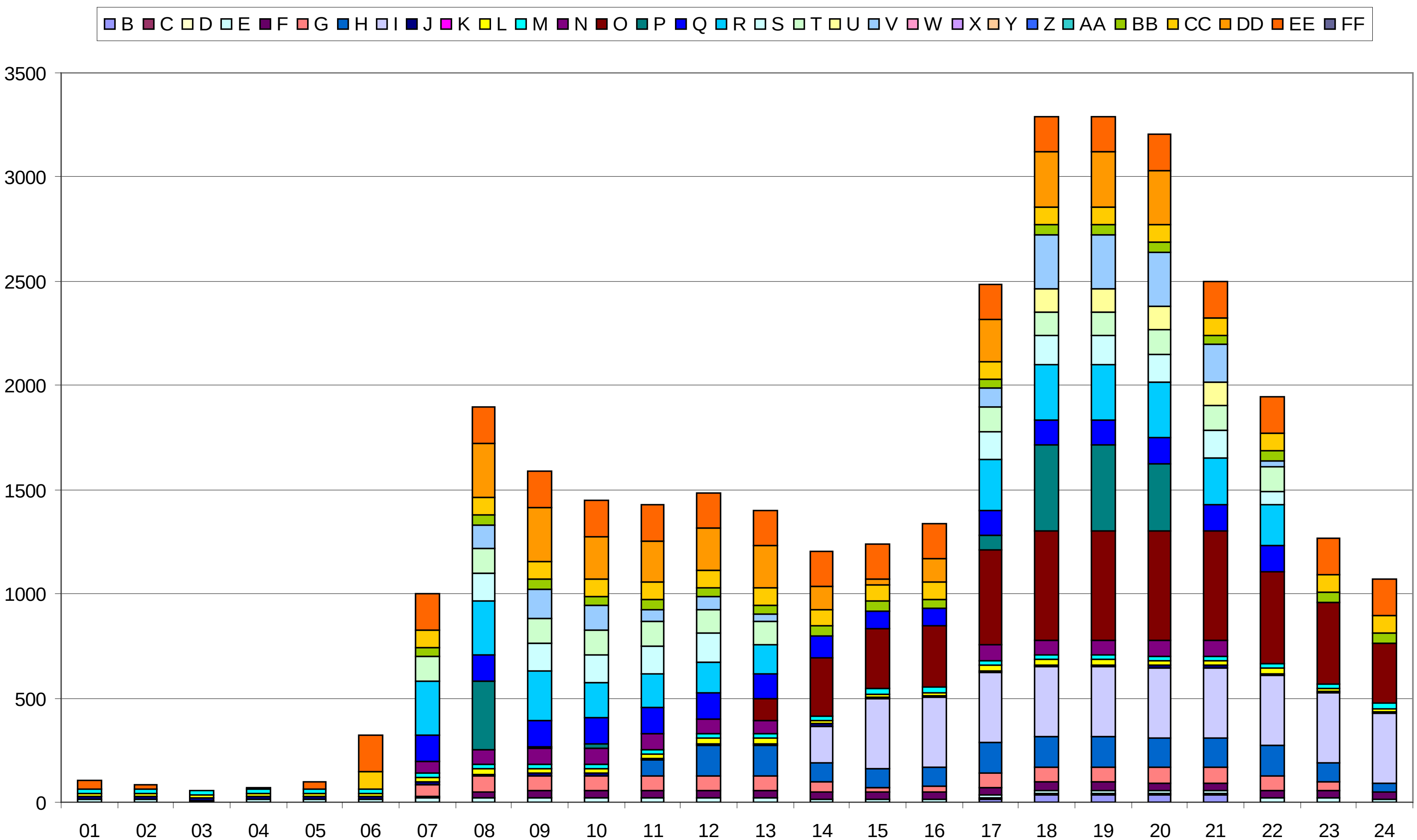
Each of the committed resources will need to be economically dispatched between the resource's minimum and maximum every hour

0 = Off for this Hour **1 = On for this Hour**

Dispatched Generation



Pool Scheduled – Dispatched MW



Wrap-up – Course Objectives

- Provide an understanding of how Unit Commitment and Dispatch works
  - Objectives
  - Process
  - Factors impacting Unit Commitment
    - Examples
  - How Unit Commitment impacts Dispatch
    - Examples

What I hear, I forget.
What I see, I remember.
What I do, I understand.
~Confucius

Questions