PJM Markets 201

Unit Commitment and Dispatch

PJM State & Member Training Dept.

Student will be able to:

- Explain the differences between security constrained unit commitment (SCUC) and security constrained economic dispatch (SCED)
  - Describe security constrained unit commitment
  - Describe security constrained economic dispatch

SCUC and SCED - FERC Definition

"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"

Source: September 30, 2005 order, p14

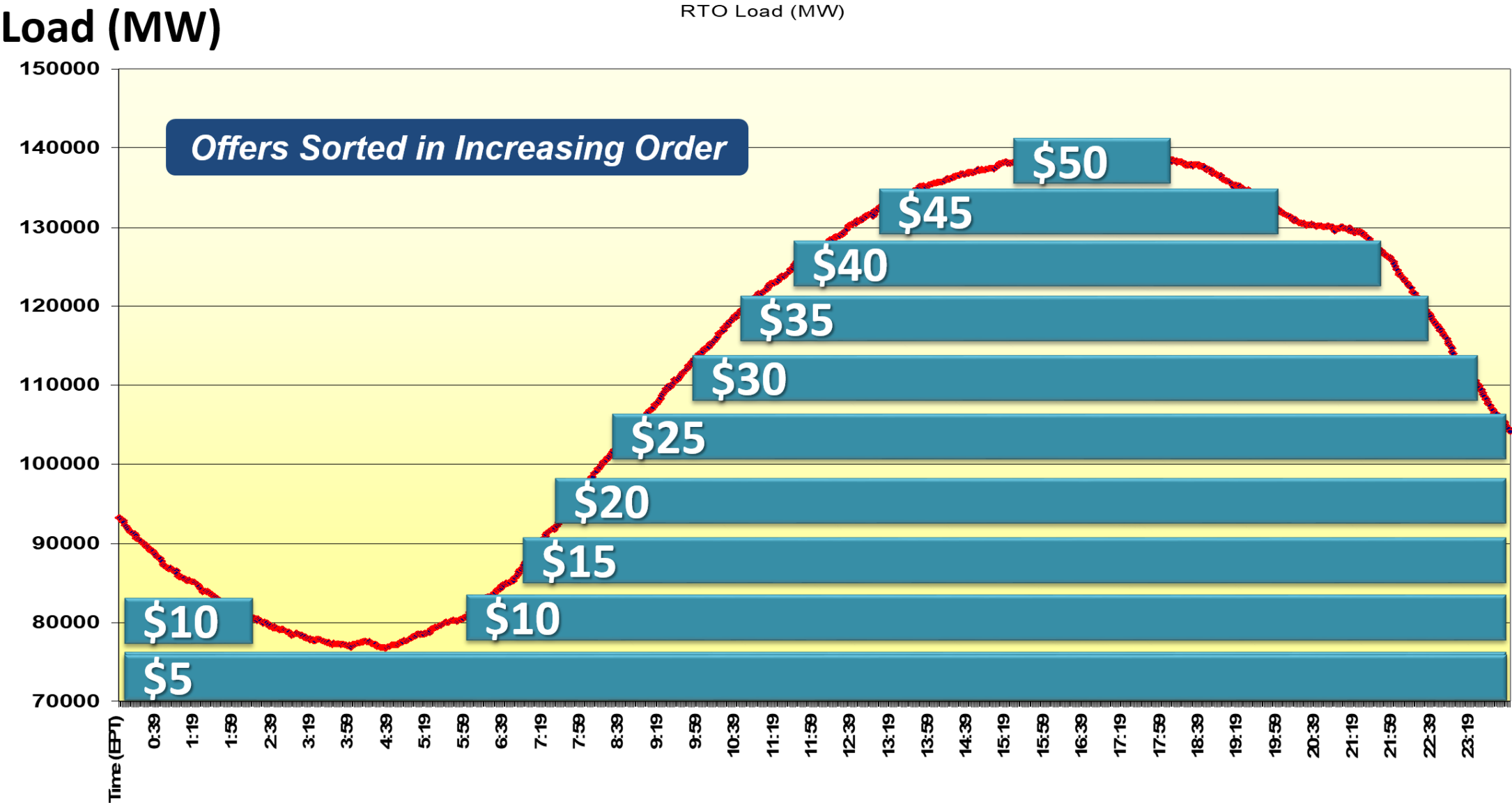## *Sounds like an optimization problem!*

Security Constrained Unit Commitment

- *Unit Commitment* is the process of turning on (committing) resources to meet load and other market requirements

- *Security-Constrained Unit Commitment* (SCUC) commits units while respecting limitations of the transmission system and unit operating characteristics

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Offers Received from Generators

40MW @$5

10MW @$30

20MW @$10

15MW @$25

25MW @ $15

Supply Dispatched to Meet Demand

Load (MW)

RTO Load (MW)

Offers Sorted in Increasing Order

$50
$45
$40
$35
$30
$25
$20
$15
$10
$10
$5

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Unit Commitment Example

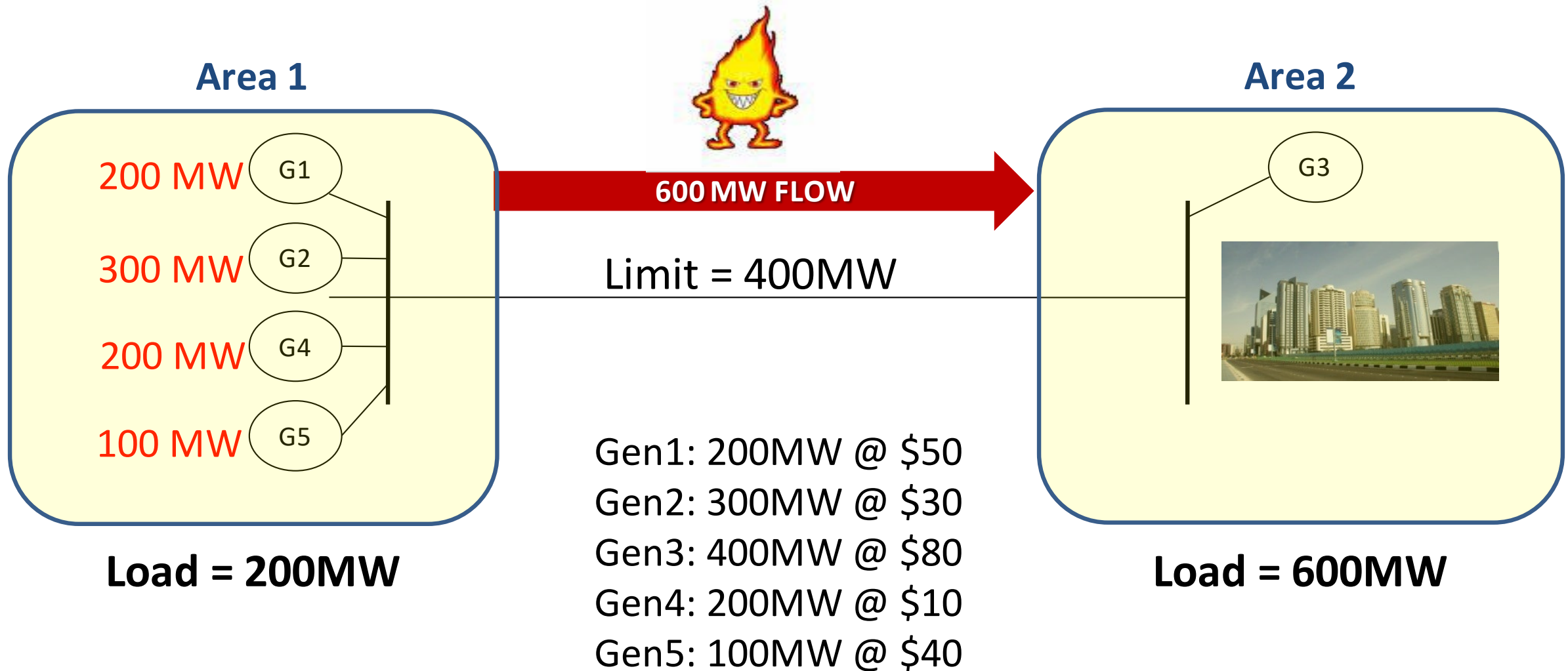Gen1: 200MW @ $50

Gen2: 300MW @ $30

Gen3: 400MW @ $80

Gen4: 200MW @ $10

Gen5: 100MW @ $40

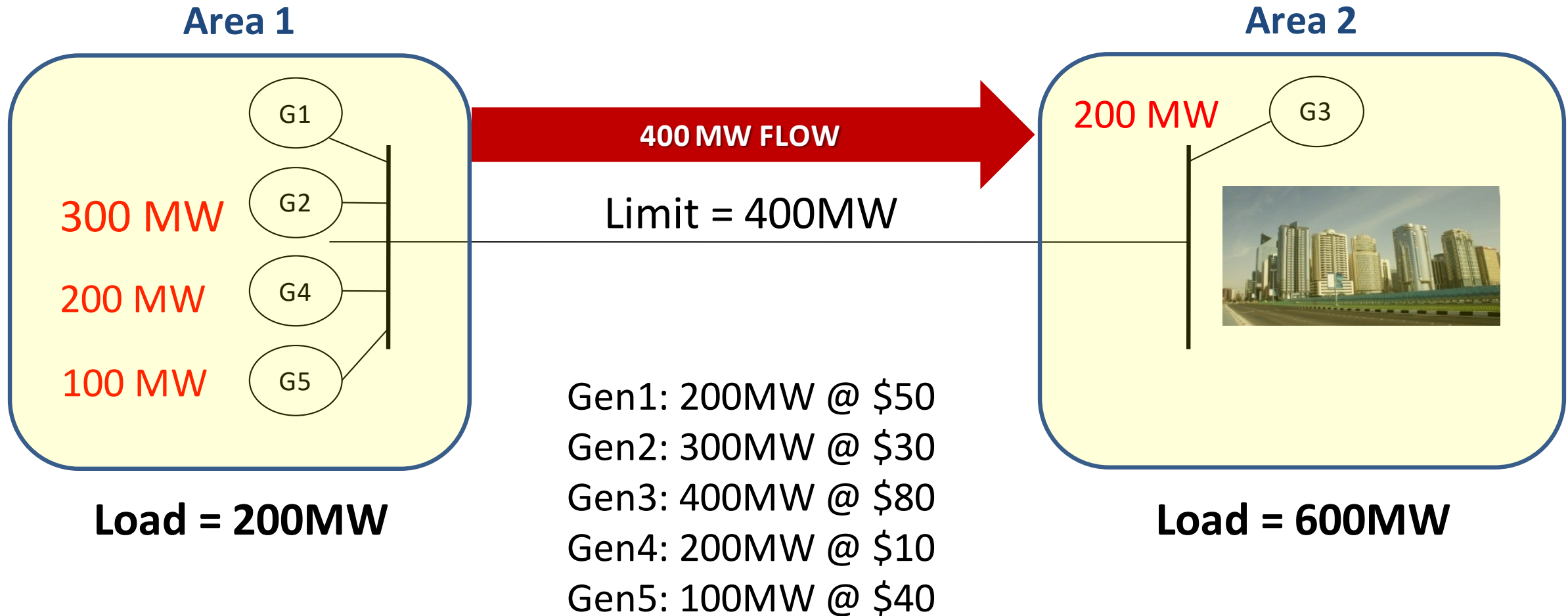In an unconstrained system, units are committed
in simple economic order:

Gen4 – Gen2 – Gen5 – Gen1 – Gen3

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SCUC - Example

Area 1

200 MW — G1

300 MW — G2

200 MW — G4

100 MW — G5

Load = 200MW

600 MW FLOW

Limit = 400MW

Area 2

G3

Load = 600MW

Gen1: 200MW @ $50
Gen2: 300MW @ $30
Gen3: 400MW @ $80
Gen4: 200MW @ $10
Gen5: 100MW @ $40

SCUC - Example

Area 1

300 MW

200 MW

100 MW

Load = 200MW

400 MW FLOW

Limit = 400MW

Gen1: 200MW @ $50
Gen2: 300MW @ $30
Gen3: 400MW @ $80
Gen4: 200MW @ $10
Gen5: 100MW @ $40

Area 2

200 MW

Load = 600MW

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Security Constrained Economic Dispatch (SCED)

- SCED honors unit commitment and determines the level at which each committed resource should be operated

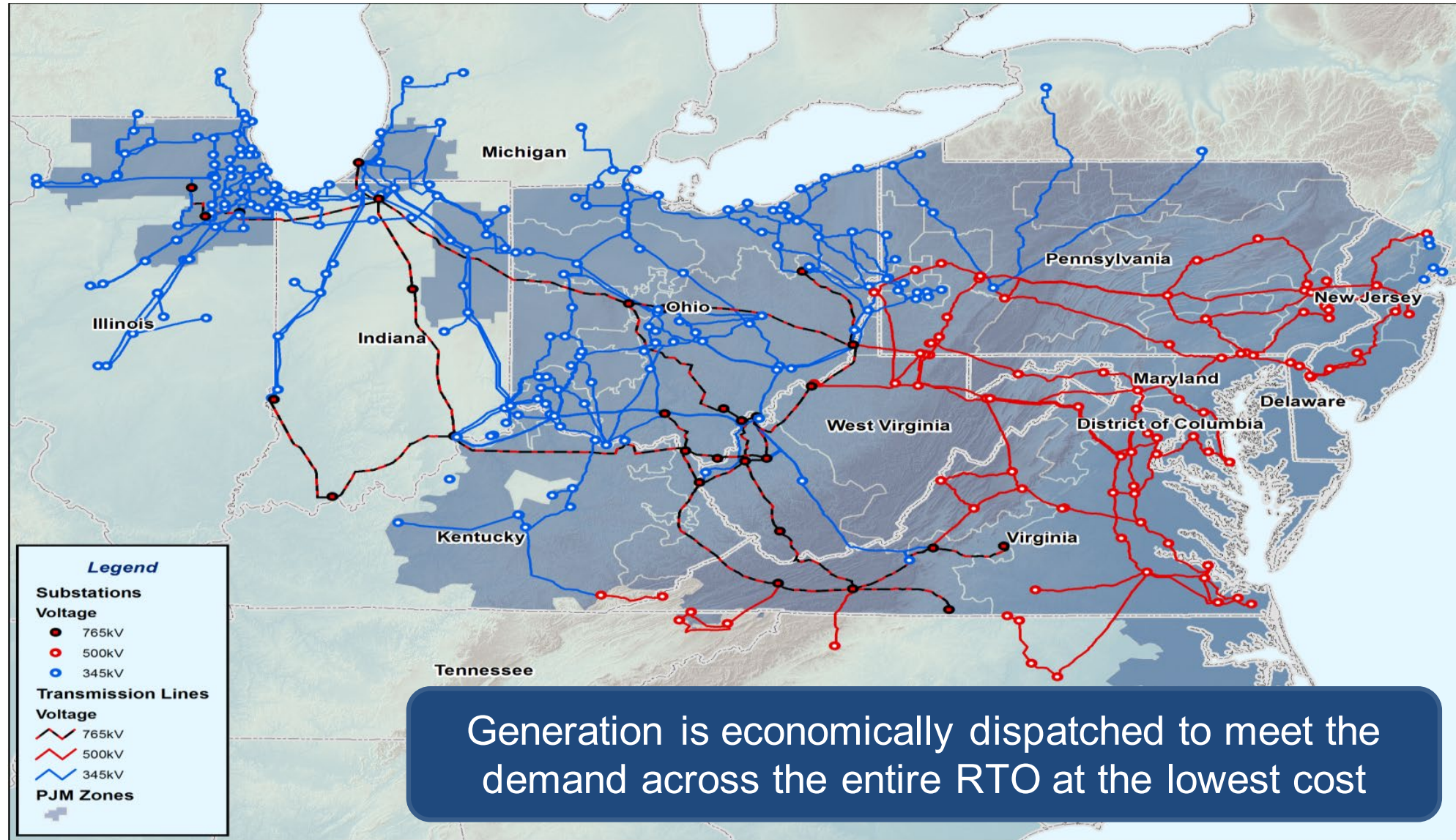 - Hourly solution interval in DA

  - 5 minute solution interval in RT

Security Constrained Economic Dispatch (SCED)

- SCED, like SCUC, enforces the "security" (limitations) aspects of the transmission grid

- SCED must also consider operational limitations of generating plants, which may be different than limitations in SCUC

  – Ramp limitations, max run times, etc

  – Start-up costs no longer a factor

Generation Dispatch

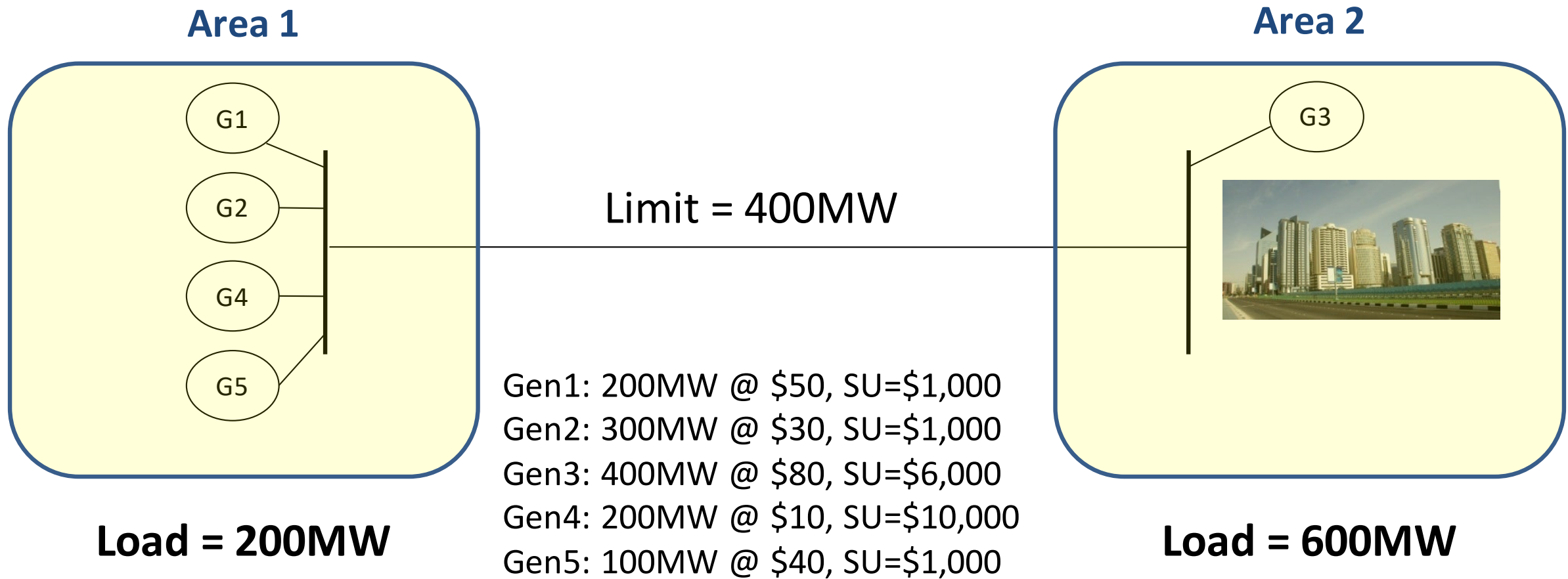Generation is economically dispatched to meet the demand across the entire RTO at the lowest cost

SCUC + SCED and Operating Parameters

- SCUC and SCED become extremely complex with the addition of operating parameters

- Resources that may, on the surface, appear to be attractive to the optimization may contribute significantly to total bid production cost

- Optimization software may need to test several different scenarios to determine the least cost solution and still reliably meet demand

SCUC/SCED - Advanced Example

Area 1

Area 2

Limit = 400MW

Load = 200MW

Load = 600MW

Gen1: 200MW @ $50, SU=$1,000
Gen2: 300MW @ $30, SU=$1,000
Gen3: 400MW @ $80, SU=$6,000
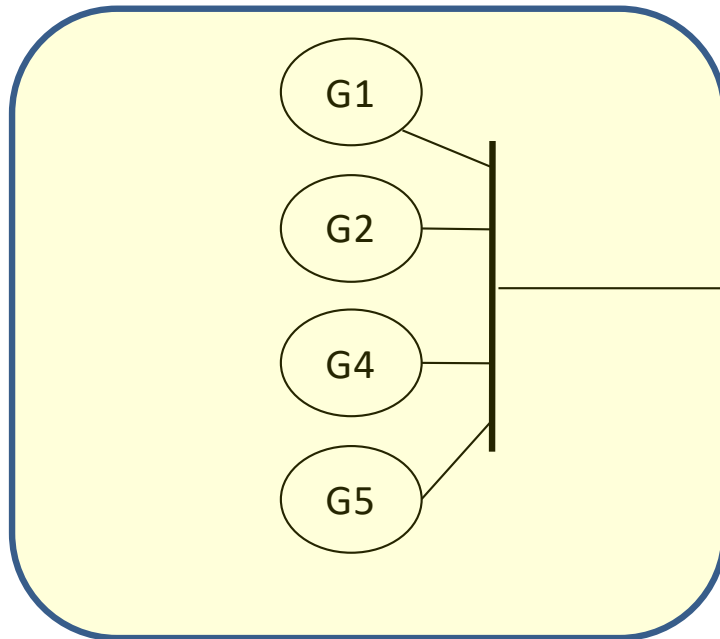Gen4: 200MW @ $10, SU=$10,000
Gen5: 100MW @ $40, SU=$1,000

SCUC/SCED - Advanced Example

- We know that Gen3 must be on-line to serve load in the congested area

- The question becomes which Area 1 units to commit to serve up to 600MW demand (200 local + 400 transfer)

  – Will now need to consider start-up costs as part of the total production cost

SCUC - Advanced Example
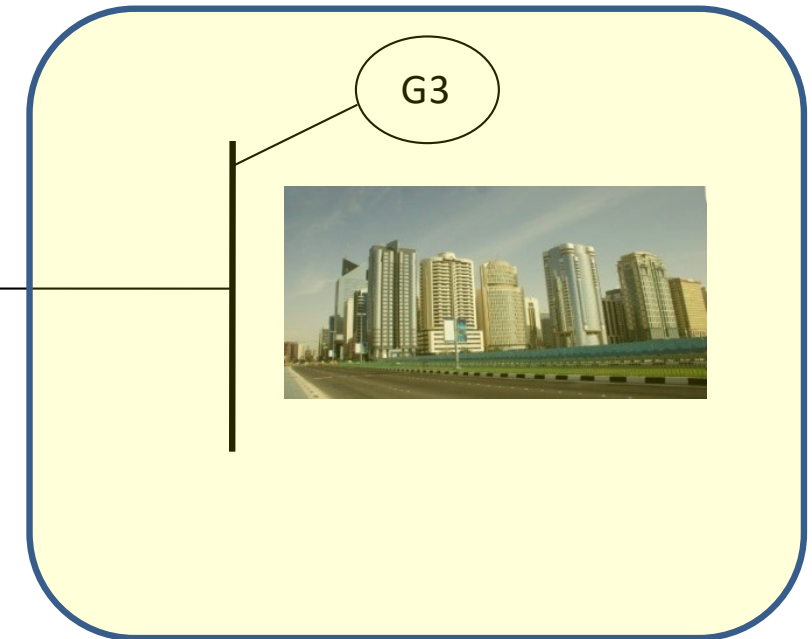
Total Production Cost = $48,000

Area 1

G1
G2
G4
G5

Limit = 400MW

Load = 200MW

Gen1: 200MW @ $50, SU=$1,000
Gen2: 300MW @ $30, SU=$1,000
Gen3: 400MW @ $80, SU=$6,000
Gen4: 200MW @ $10, SU=$10,000
Gen5: 100MW @ $40, SU=$1,000

Area 2

G3

Load = 600MW

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SCUC/SCED - Advanced Example

- Note that you will only end up dispatching Gen3 for 200MW of its 400MW available

- Would it be cheaper to use all 400MW from Gen3 and only transfer 200MW instead of 400MW?

As it stands now…..
Gen1 ($11,000) + **Gen2** ($10,000) + **Gen5** ($5,000) + **Gen3** for 200MW ($22,000) = **$48,000**

| Resource	MW	$/MWh	Startup	BPC
Gen5	100	40	$ 1,000	$5,000
Gen2	300	30	$ 1,000	$10,000
Gen1	200	50	$ 1,000	$11,000
Gen4	0	10	$ -	$0
Gen3	200	80	$ 6,000	$22,000
				$48,000

Alt Option 1: All energy from **Gen2/Gen5/Gen3** = **$53,000**
Alt Option 2: Gen1/Gen5/partial **Gen2/full Gen3** = **$58,000**

SCUC/SCED - Class Exercise

Determine the units that will serve the demand, minimizing production cost and considering the constraint (assume all gens are dispatchable)
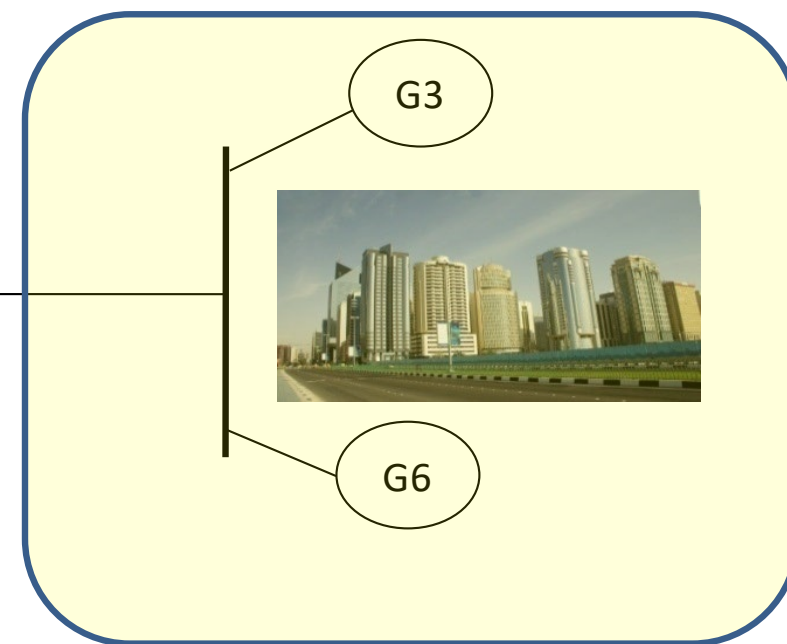
Area 1

Area 2

G1

G2

G4

G5

Limit = 300MW

G3

G6
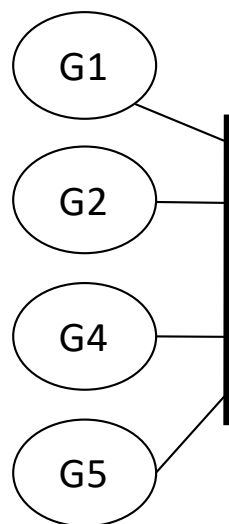
Gen1: 400MW @ $40, SU=$10,000
Gen2: 500MW @ $50, SU=$7,000
Gen3: 300MW @ $100, SU=$2,000
Gen4: 200MW @ $20, SU=$5,000
Gen5: 200MW @ $60, SU=$3,000
Gen6: 200MW @ $90, SU=$6,000

Load = 500MW

Load = 500MW

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New Exercise: SCED Advanced

- Problem: There is an increase in demand of 100MW from one hour to the next

- The generators on the next slide have to serve that additional load, but some have restrictions

- What units can fully serve the additional 100MW?

- What units will the optimization select?

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SCED - Advanced Exercise

Generator	Status	Available MW	Cost	Ramp Rate
Gen1	On	100	$50	5 MW/Min
Gen2	On	100	$30	1 MW/Min
Gen3	Unavailable	300	$25	3 MW/Min
Gen4	On	100	$40	3 MW/Min

SCUC/SCED Exercise Comments

- These were difficult exercises that shows the complexity of SCUC and SCED and the reason why software calculations may be time consuming

- This exercise may also help demonstrate why some generators may or may not have been committed

- Complexity increases with additional parameters, transmission limits, generators, etc.

Questions?

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