Unit Commitment and Dispatch
Objectives

• Describe security constrained unit commitment

• Describe security constrained economic dispatch
“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.
Offers Received from Generators

- 40MW @ $5
- 10MW @ $30
- 20MW @ $10
- 15MW @ $25
- 25MW @ $15
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
SCUC - Example

Area 1

- 200 MW
- 300 MW
- 200 MW
- 100 MW

Load = 200MW

Area 2

- G3

Load = 600MW

Limit = 400MW

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

**Area 1**

- G1: 300 MW
- G2: 200 MW
- G3: 100 MW

Load = 200 MW

**Area 2**

- G3: 200 MW

Load = 600 MW

Limit = 400 MW

**400 MW FLOW**

Gen1: 200MW @ $50
Gen2: 300MW @ $30
Gen3: 400MW @ $80
Gen4: 200MW @ $10
Gen5: 100MW @ $40
Security Constrained Economic Dispatch (SCED)

- SCED follows 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” aspects of the transmission grid
- SCED must also consider operational limitations of generating plants, which may be different than limitations in SCUC
  - Ramp limitations are important
  - Start-up costs no longer a factor
Generation is economically dispatched to meet the demand across the entire RTO at the lowest cost.
Which function is performed respecting limitations of the transmission system and unit operating characteristics?

1. Unit Commitment
2. Security Constrained Unit Commitment
3. Economic Dispatch
4. Weather forecasting
Which function follows unit commitment and determines the level at which each committed resource should be operated?

1. FTR Market
2. RPM Auction
3. Lunch Break
4. Security Constrained Economic Dispatch
• 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 - Advanced Example

Area 1

- G1
- G2
- G4
- G5

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

Limit = 400MW
We know from the earlier example 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.
Total Production Cost = $48,000

Limit = 400MW

Area 1

G1
G2
G4
G5

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
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.....

\[
\text{Gen1} \ ($11,000) + \text{Gen2} \ ($10,000) + \text{Gen5} \ ($5,000) + \text{Gen3} \text{ for 200MW ($22,000) } = \text{ $48,000}
\]

<table>
<thead>
<tr>
<th>Resource</th>
<th>MW</th>
<th>$/MWh</th>
<th>Startup</th>
<th>BPC</th>
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<tbody>
<tr>
<td>Gen5</td>
<td>100</td>
<td>40</td>
<td>$1,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>Gen2</td>
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<td>30</td>
<td>$1,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Gen1</td>
<td>200</td>
<td>50</td>
<td>$1,000</td>
<td>$11,000</td>
</tr>
<tr>
<td>Gen4</td>
<td>0</td>
<td>10</td>
<td>$-</td>
<td>$0</td>
</tr>
<tr>
<td>Gen3</td>
<td>200</td>
<td>80</td>
<td>$6,000</td>
<td>$22,000</td>
</tr>
</tbody>
</table>

$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)

Load = 500MW

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

Area 1

Area 2
SCED - Advanced Exercise

- 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?
## SCED - Advanced Exercise

<table>
<thead>
<tr>
<th>Generator</th>
<th>Status</th>
<th>Available MW</th>
<th>Cost</th>
<th>Ramp Rate</th>
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</thead>
<tbody>
<tr>
<td>Gen1</td>
<td>On</td>
<td>100</td>
<td>$50</td>
<td>5 MW/Min</td>
</tr>
<tr>
<td>Gen2</td>
<td>On</td>
<td>100</td>
<td>$30</td>
<td>1 MW/Min</td>
</tr>
<tr>
<td>Gen3</td>
<td>Unavailable</td>
<td>300</td>
<td>$25</td>
<td>3 MW/Min</td>
</tr>
<tr>
<td>Gen4</td>
<td>On</td>
<td>100</td>
<td>$40</td>
<td>3 MW/Min</td>
</tr>
</tbody>
</table>
This was a difficult exercise 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?