Nodal Market Tools to Manage Wind Generation

DISCLAIMER

This presentation provides a general overview of the Texas Nodal Market Implementation and is not intended to be a substitute for the ERCOT Nodal Protocols (available at http://nodal.ercot.com/protocols/index.html), as amended from time to time. If any conflict exists between this presentation and the ERCOT Nodal Protocols, the ERCOT Nodal Protocols shall control in all respects.

The presentation materials, including any statements by ERCOT, its employees or contractors is intended for the general education of its audience and should not be considered a recommendation of ERCOT, its employees or contractors of any particular operating strategy or statement of fact. All Market Participants and public consultants assisting Market Participants are encouraged to read and understand the approved protocols, ERCOT operating guides, interface and communication guides and any other ERCOT procedures which may be applicable to the topics presented.

- **Generation Resource Parameters**

- **System Parameters in a Nodal Operation**

- **Special Activities - Wind Generation in the Day Ahead**

- **Real Time Wind Generation Dispatch in a Nodal Market**
  - Typical Operation
  - Energy Offer Curves
  - Output Schedules

- **Dynamic Transmission Line Limits**

- **Base Point Deviation - Wind Generation Resources**

- **Conclusions**

What is a Wind Generation Resource?

A Wind Generation Resource (WGR) is a collection of wind generators that inject power onto the transmission grid at one point
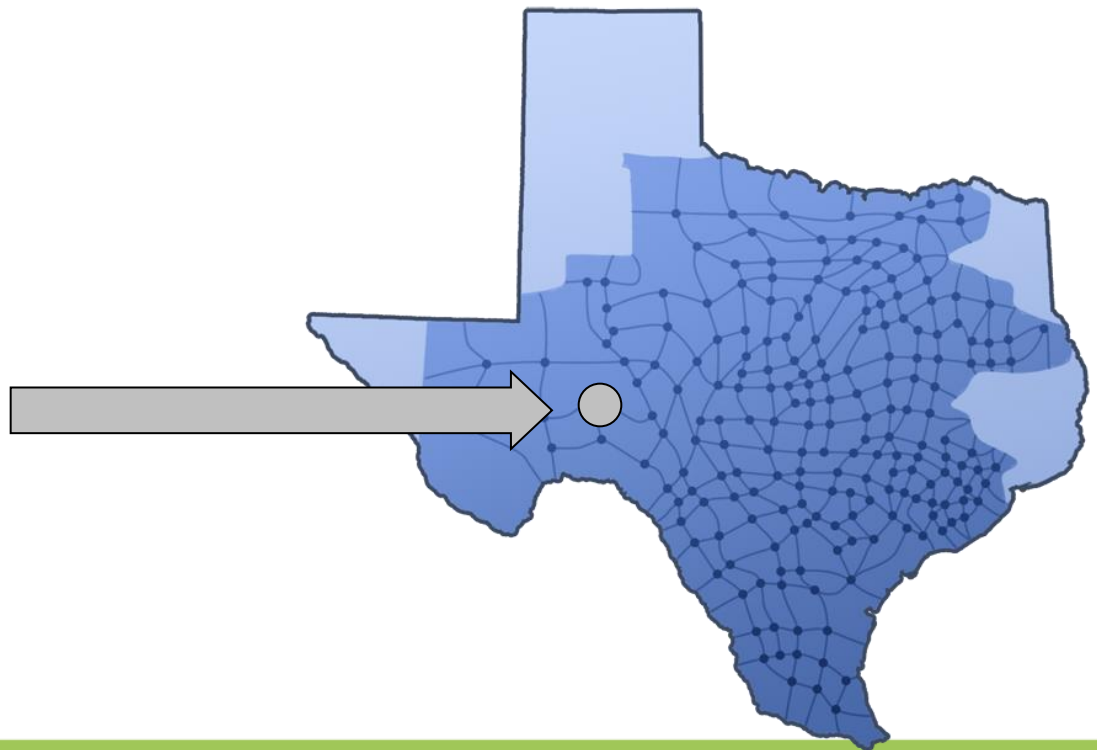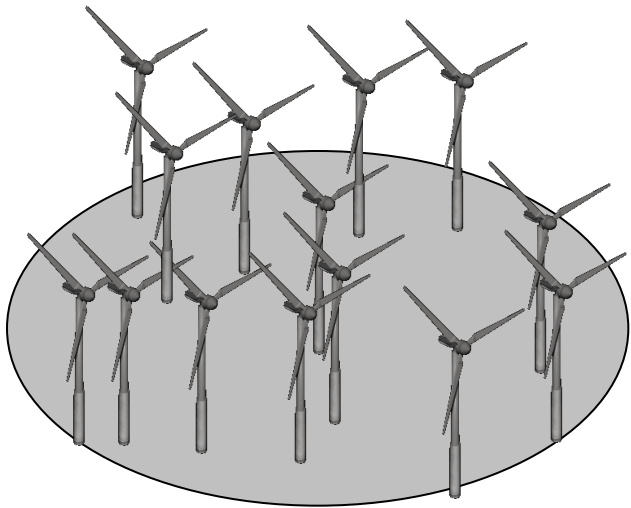
Generation Resource Parameters

- **Nodal Systems will dispatch all Generation Resources individually and therefore must "reserve" capacity by individual unit to support Ancillary Services requirements**
- **Generation Resource Limits**
  - HSL – High Sustained Limit*
  - HASL – High Ancillary Services Limit**
  - HDL – High Dispatch Limit**
  - LDL – Low Dispatch Limit**
  - LASL – Low Ancillary Service Limit**
  - LSL – Low Sustained Limit*

* - Telemetered by QSEs for Real Time Dispatch; COP for future studies

** - Calculated by ERCOT for each Generation unit

Generation Resource Parameters

HSL

- Established by QSE to represent the maximum amount of available generation capacity in real time
  - May be equal to the Net Dependable Capability

LSL

- Similar to HSL but for the minimum amount of generation capacity
  - May be updated at QSE's discretion

Day Ahead Operations
Special Activities for Wind Generation

- **Wind Generation Resources must update the Current Operating Plan (COP) every time there is a change in Capacity or Resource Status**
  - Plan for each Resource for each hour of the next 168 hours showing HSL, LSL, Resource Status, etc. that is used by Reliability Unit Commitment (RUC) and capacity forecasts required by protocol
- **ERCOT will publish on the MIS Certified Area the Wind Generation Resources Production Potential (WGRPP) for the next 48 hours.**
  - WGRPP is specific to each Wind Generator and is based on information provide by each WGR, meteorological information, and data collected directly by ERCOT
    - Pending NPRR 210 makes changes to the methodology used to produce this forecast
  - ERCOT also publishes each hour Total ERCOT Wind Power Forecast (TEWPF)
- **Wind Generation Resources through their QSEs must use the WGRPP to show this production potential as their HSL in the COP for each of its registered Resources.**
  - The COP HSL must be less than or equal to the WGRPP
  - The balance of the 168 hours beyond 48-hours in the COP must also be provided using the Resource Owner's best judgment

Generation Resource Parameters

HASL

- The maximum capacity a Generation Resource may be dispatched while maintaining its scheduled ancillary services
- Calculated as the HSL minus the Ancillary Service Schedules for Responsive and Non-Spin minus Ancillary Services Responsibility for Reg-Up
- Critical that QSEs not "withhold" capacity or overstate true generation capacity

LASL

- Similar to HASL but for the minimum amount of generation capacity
- Calculated as the LSL plus the Ancillary Service Responsibility for Reg-Down

Generation Resource Parameters

- Generation Resource Ramp Rates
  - ❑ Normal Curve and an Emergency Curve are provided by the QSE at time of Registration
  - ❑ Curves may be updated anytime by API
  - ❑ QSE also sends current ramp rate by telemetry; but only for information and IMM monitoring

Ramp Rate
Mw/ Minute

Ramp Rate Curve

LSL_G

HSL_G

Gross Generation
Mw
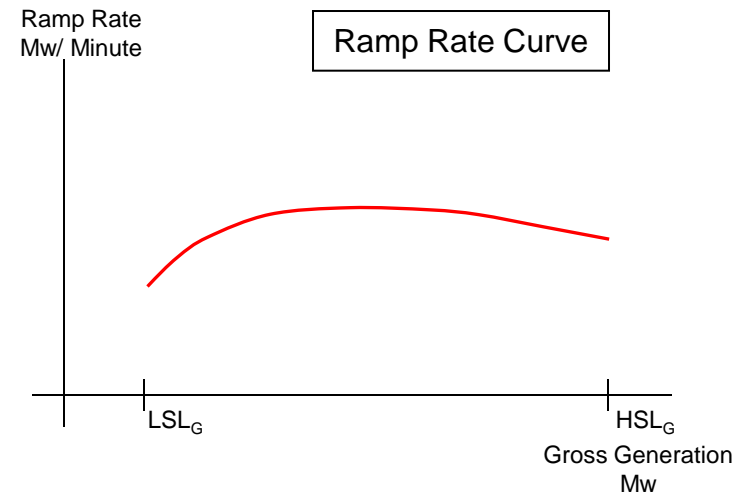
- Ramp Rate used for HDL and LDL calculation must first back out any ramp rate reserved for Regulation

- Deployment of Responsive Reserve assumes the QSE will use "Emergency Ramp Rate Curve" to assure delivery capability within 10 minutes

- Deployment of Non-Spin Reserve assumes the QSE will use normal ramp rate curve because delivery is over 30 minutes

Generation Resource Parameters

HDL

- Calculated by ERCOT as the maximum net generation achievable within 5 minutes given the current Mw generation and the units SCED Up Ramp Rate but not to exceed HASL/HSL

- SCED-Up Ramp Rate is the normal ramp* rate given the current generation less any ramp rate reserved for Reg-Up

LDL

- Calculated by ERCOT as the minimum net generation achievable within 5 minutes given the current Mw generation and the units SCED Down Ramp Rate but must be greater than LASL/LSL

- SCED Down Ramp Rate is the normal ramp rate* given the current generation less any ramp rate reserved for Reg-Down

* - Emergency Ramp Rate if Responsive is Deployed

Nodal Protocols require the calculation of various reserves in Real-Time and for future hours

- RT reserves are based on telemetry of Generation limits and actual net generation
- Future projections are based on COP and ERCOT's Load Forecast

All calculation results are used by ERCOT operators and are posted to the market
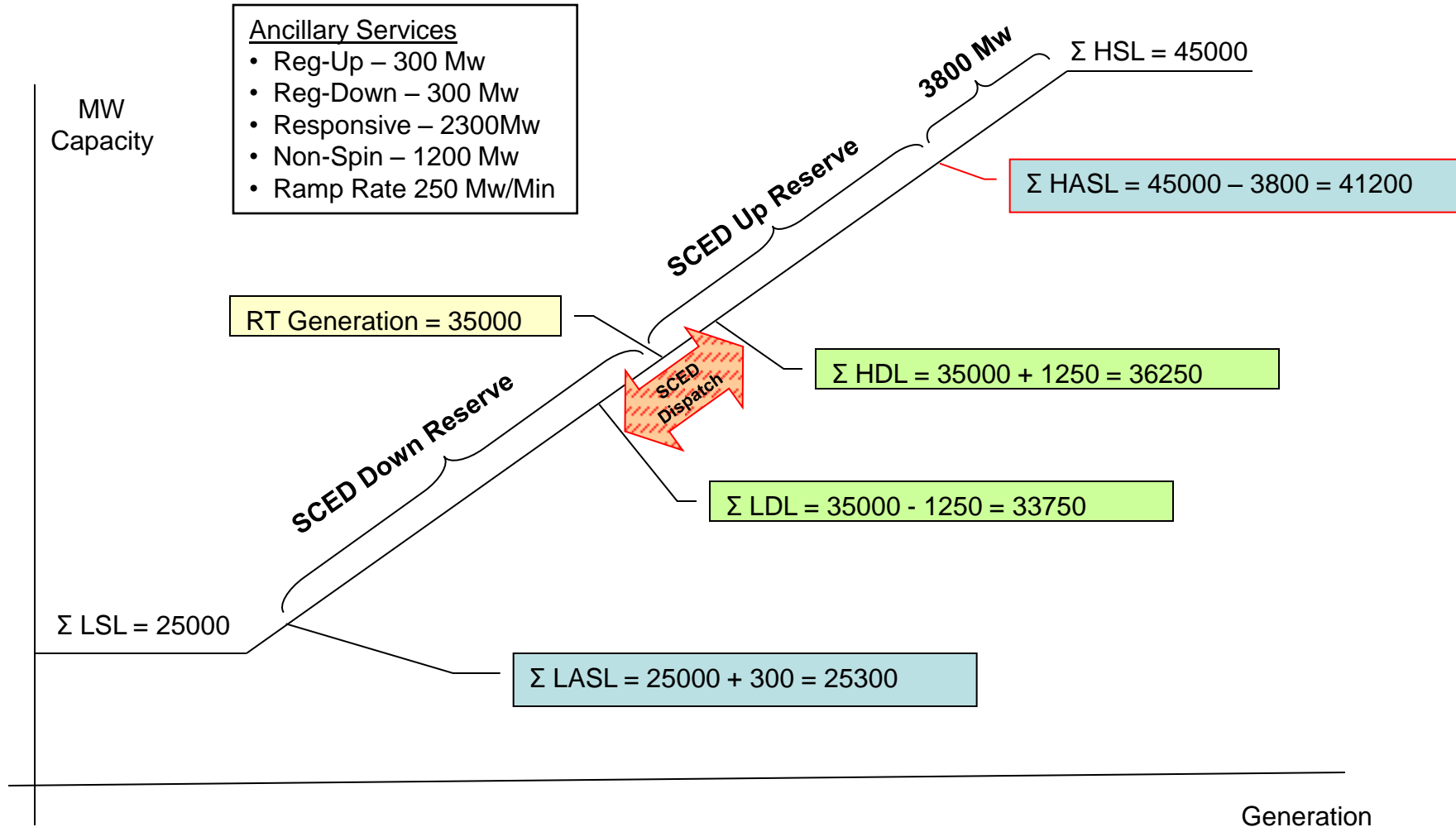
- RT updates made every 10 seconds via ICCP
  - Updates on the MIS occur every 5 minutes
- For future hours, updates occurs every time LF is changed or if the hour changes

ERCOT posts transmission constraints that have a high probability of binding the generation dispatch in SCED

- Postings occur in the Day Ahead before 6:00 AM for the next operating day
- Updated in Real Time

System Parameters
Example

Ancillary Services
- Reg-Up – 300 Mw
- Reg-Down – 300 Mw
- Responsive – 2300Mw
- Non-Spin – 1200 Mw
- Ramp Rate 250 Mw/Min

MW Capacity

Σ HSL = 45000

3800 Mw

SCED Up Reserve

Σ HASL = 45000 – 3800 = 41200

RT Generation = 35000

SCED Dispatch

Σ HDL = 35000 + 1250 = 36250

SCED Down Reserve

Σ LDL = 35000 - 1250 = 33750

Σ LSL = 25000

Σ LASL = 25000 + 300 = 25300

Generation

System Parameters
Example

MW Capacity

Ancillary Services
- Reg-Up – 300 Mw
- Reg-Down – 300 Mw
- Responsive – 2300Mw
- Non-Spin – 1200 Mw
- Ramp Rate 250 Mw/Min

Σ HSL = 45000

3800 Mw

SCED Up Reserve

Σ HASL = 45000 – 3800 = 41200

RT Generation = 35000

SCED Dispatch

Σ HDL = 35000 + 1250 = 36250

SCED Down Reserve

Σ LDL = 35000 - 1250 = 33750

Σ LSL = 25000

Σ LASL = 25000 + 300 = 25300

Generation

System Parameters
Example

MW
Capacity

Σ HSL = 45000

SCED Up Reserve

3800 Mw

RT Generation = 38000

Σ HASL = 45000 – 3800 = 41200

SCED Dispatch

Σ HDL = 38000 + 1250 = 39250

SCED Down Reserve

Σ LDL = 38000 - 1250 = 36750

Ancillary Services
- Reg-Up – 300 Mw
- Reg-Down – 300 Mw
- Responsive – 2300Mw
- Non-Spin – 1200 Mw
- Ramp Rate 250 Mw/Min

Σ LSL = 25000

Σ LASL = 25000 + 300 = 25300

Generation

- **Security Constrained Economic Dispatch (SCED) prioritizes the dispatch of all generation**
  - Determines the Base Points for all generation units in the system including wind generation
  - Subject to Wind energy offer curves, assures the maximum wind generation is delivered to the ERCOT Load centers
  - Allows wind generation to compete on a even field with other types of generation including other forms of renewable generation
- **Correctly determines the price to be paid to wind generation for their energy when there are shortages and when there are excess amounts of generation**
- **Manages transmission congestion for ERCOT dispatch**

Offer Curves & Output Schedules

- **Each Generation Resource provides either an Energy Offer Curve (EOC) or an Output Schedule (OS) for ERCOT's use in determining how to dispatch the generation on the grid**

  - An EOC is a curve that provides a price at any point for the full output range of the resource

  - A OS is a list of predetermined outputs for each 5 minute dispatch
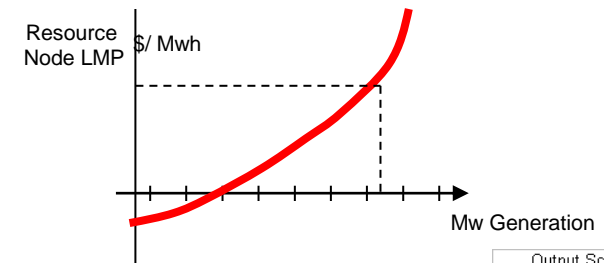

Output Schedule	
Time	Mw
0:00	100
0:05	100
0:10	100
0:15	100
0:20	100
0:25	100
0:30	100
0:35	100
0:40	100
0:45	100
0:50	100
0:55	100
1:00	100

- **The EOC or OS must be provided to ERCOT prior to the Operating Period and have restrictions on how they may be updated and changed**
- **When SCED runs and no EOC is provided, ERCOT will create a proxy Offer Curve for the Resource**

  - The proxy offer curve provides a steep price change at HSL similar to the one at the right providing a supply price for the full output range of the WGR

- **Dispatch Priority is driven by Supply Prices for each Generation Resource**
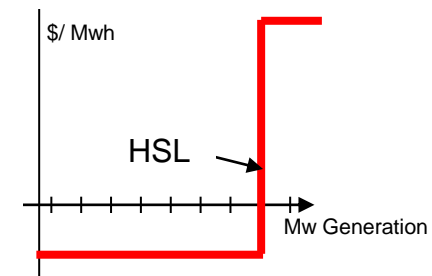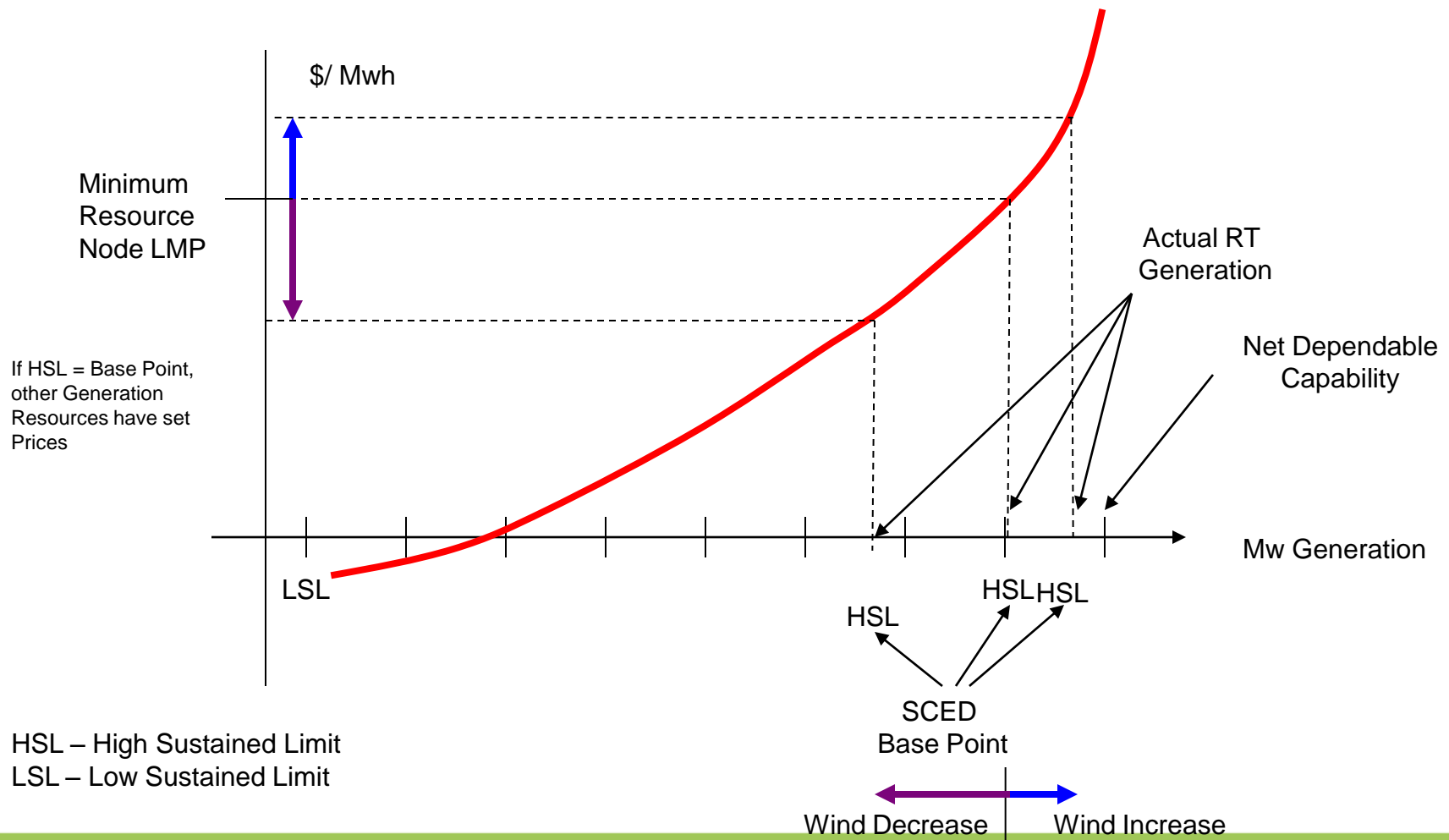
SCED Dispatch
Special Features for Wind Generation

- **Nodal Market requires wind generators to send their HSL via high speed telemetry (ICCP at 4 sec scan) to ERCOT for use in every SCED cycle (nominally 5 minutes)**

  - Normally, HSL is set at the current amount of wind production, adjusted up or down if significant generation change is expected over the SCED period, always providing ERCOT with the best estimate of the WGRs true production potential

- **SCED uses this HSL to restrict dispatches to amounts that the wind generator can produce given current wind conditions**

- **SCED determines if individual WGRs can be set to the maximum or if a reduction is needed to manage the transmission system**

- **SCED produces a Base Point for each wind Resource**

  - Sent to the controlling QSE via ICCP each SCED cycle

No Requirement for Congestion Management

Ramp rates not considered as constraining

$/ Mwh

Minimum
Resource
Node LMP

Actual RT
Generation

Net Dependable
Capability

If HSL = Base Point,
other Generation
Resources have set
Prices

Mw Generation

LSL

HSL HSL
HSL

SCED
Base Point

HSL – High Sustained Limit
LSL – Low Sustained Limit

Wind Decrease   Wind Increase

Ramp rates not considered as constraining

$/ Mwh

Requested Generation Decrease

Resource Node LMP

Actual RT Generation

Net Dependable Capability

Mw Generation

LSL

HSL

SCED Base Point

QSE must maintain HSL telemetry at the WGRs maximum production potential when BP is reduced by SCED

HSL – High Sustained Limit
LSL – Low Sustained Limit
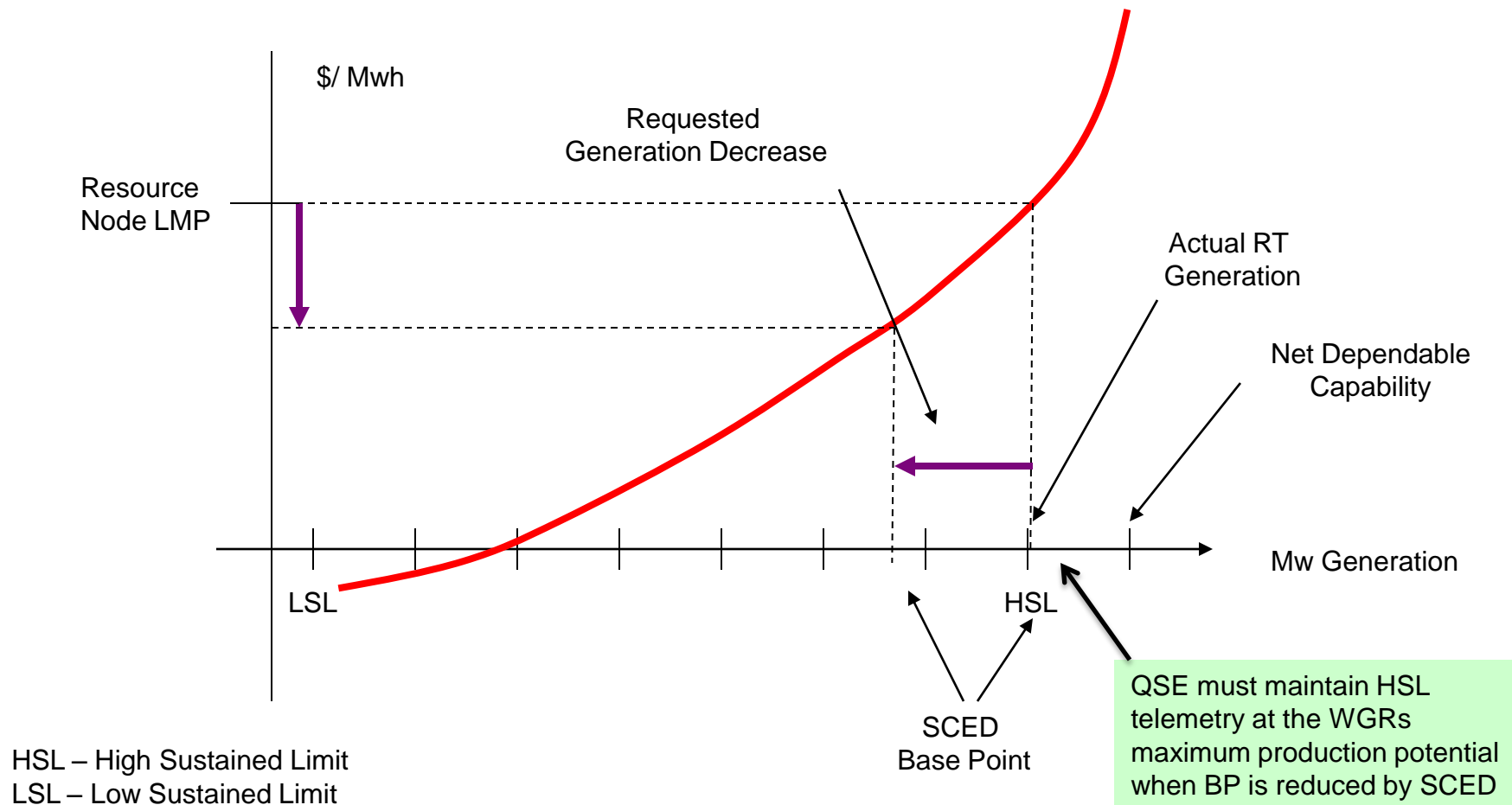
Typical Output Schedule
No Requirement for Congestion Management
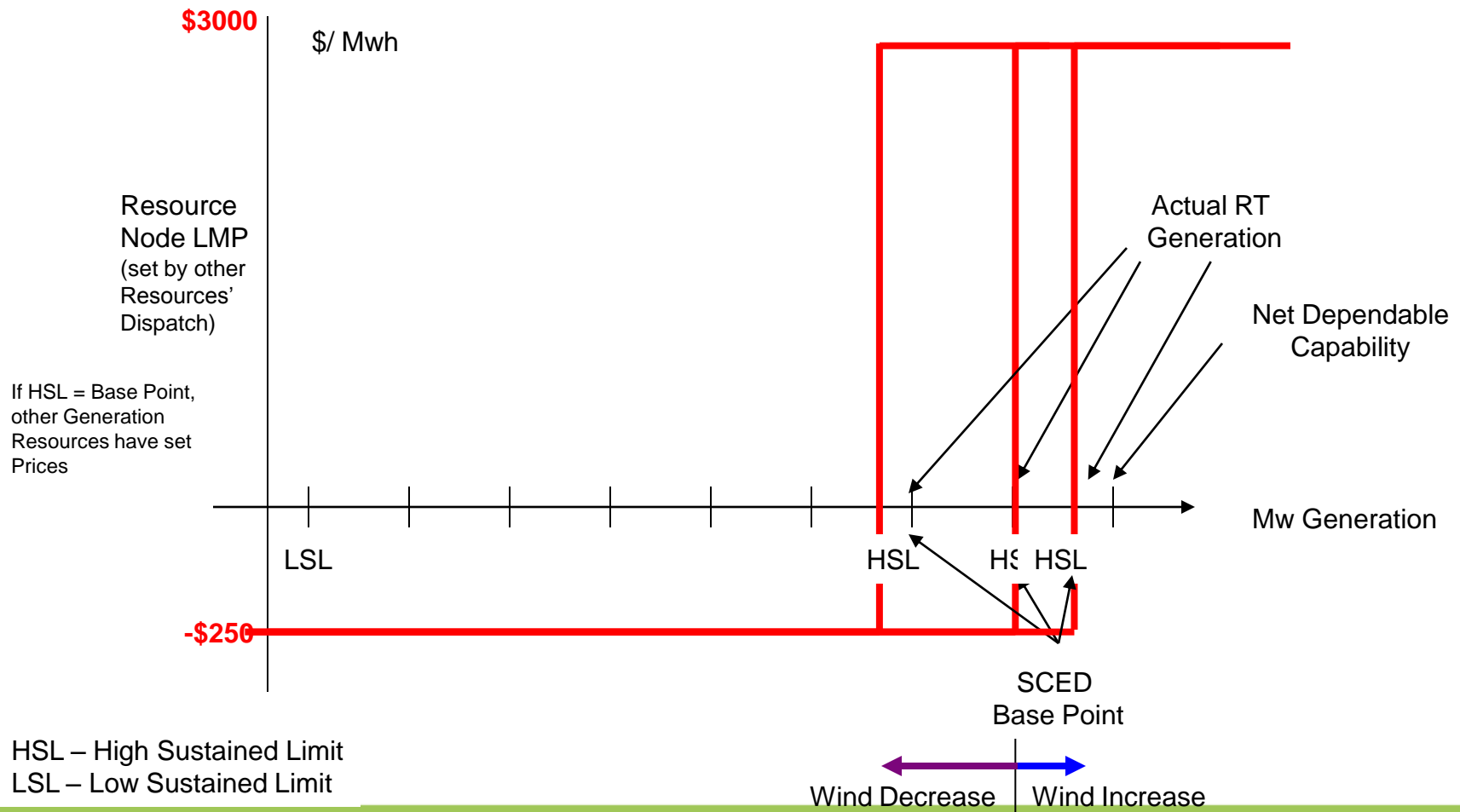
Ramp rates not considered as constraining

$3000

$/ Mwh

Resource
Node LMP
(set by other
Resources'
Dispatch)

If HSL = Base Point,
other Generation
Resources have set
Prices

Actual RT
Generation

Net Dependable
Capability

Mw Generation

LSL

HSL   HS HSL

-$250

SCED
Base Point

HSL – High Sustained Limit
LSL – Low Sustained Limit

Wind Decrease   Wind Increase

Ramp rates not considered as constraining

$3000

$/ Mwh

Requested
Generation Decrease

Resource
Node LMP

Actual RT
Generation

Net Dependable
Capability

Mw Generation

LSL

HSL

-$250

SCED
Base Point

LMP is
set at -$250

QSE must maintain HSL
telemetry at the WGRs
maximum production potential
when BP is reduced by SCED

- ## Regulation
  - Deployed as a provider ratio share to the QSEs who are providing Regulation
    - QSEs deploy energy to individual Resources according to those Resource's AS Resource Responsibility
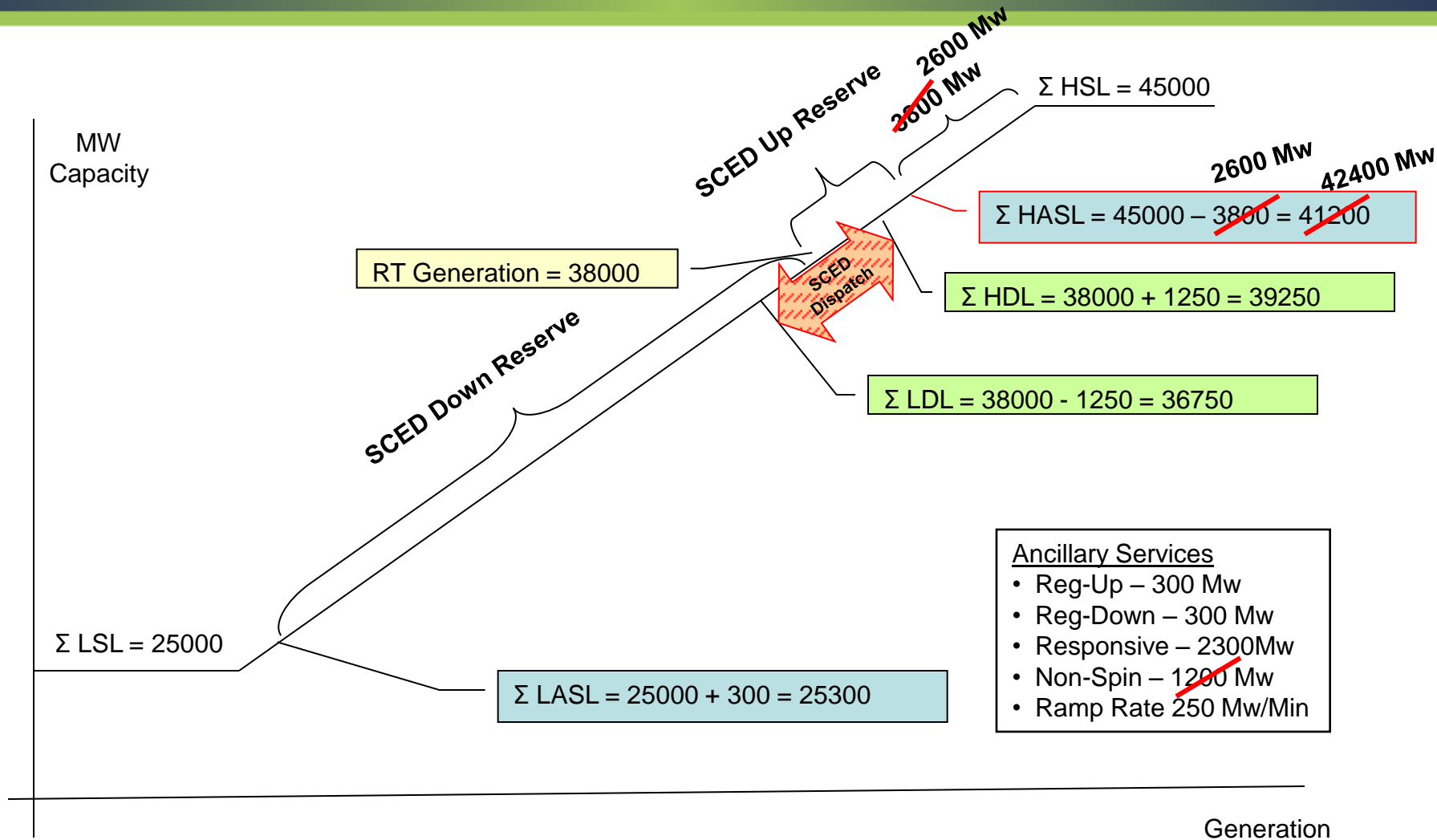- ## Responsive Reserve
  - Deployed via signal to QSEs who reduce the telemetered Ancillary Service Schedule according to the amount of deployment
  - A new HASL is calculated for each Generation Resource using Emergency Ramp Rate Curves; Effect is to add previously reserved AS capacity to Real Time Reserves
  - SCED provides new Base Points to Resources
- ## Non-Spin
  - For Resources with Energy Offer Curves, deployed similar to Responsive Reserve but uses Normal Ramp Rate
  - For Resources with Output Schedules, deployed as an increase to the OS provided by the QSE
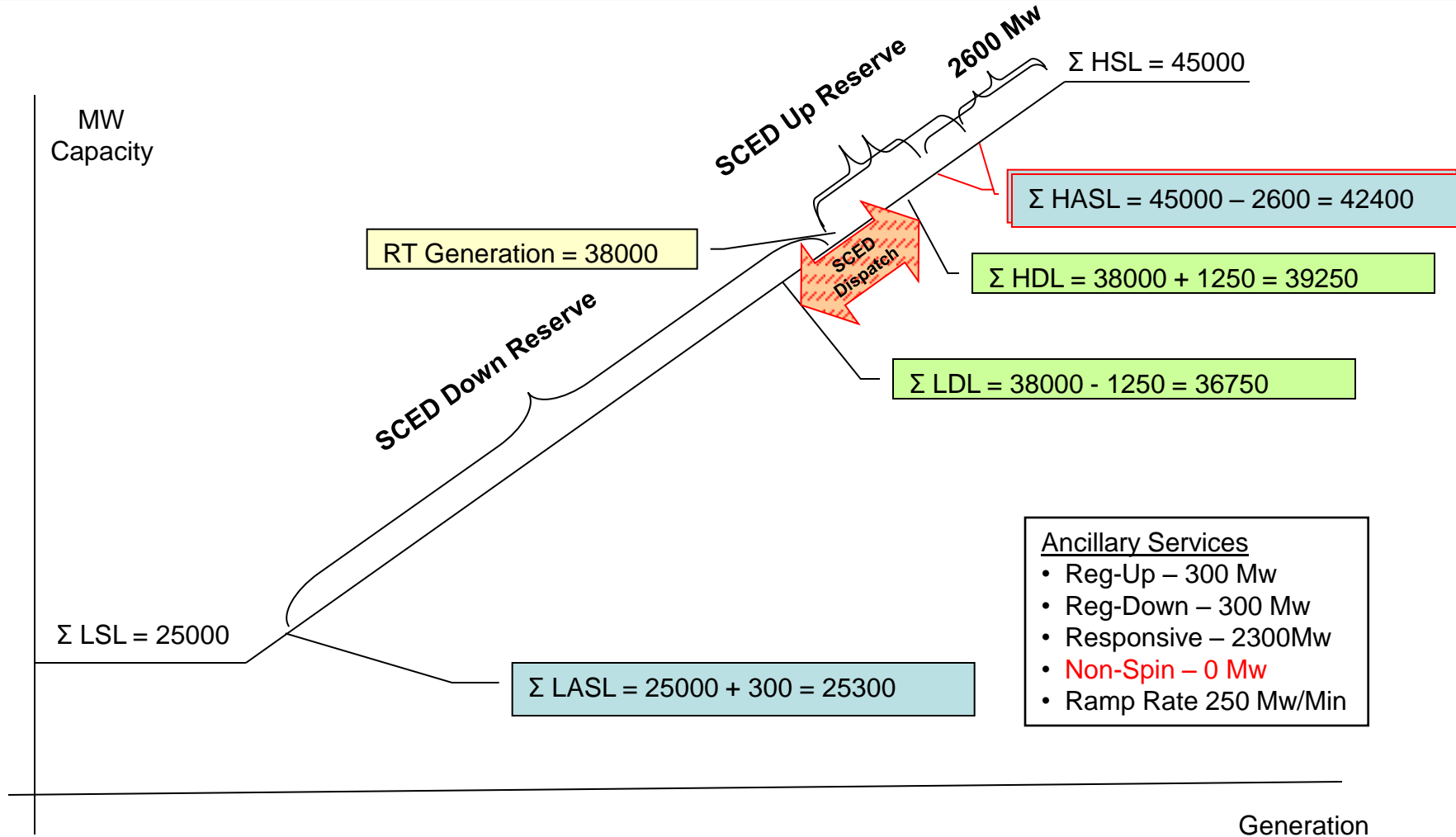
System Parameters
Deployment of Non-Spin Reserve Ancillary Service

MW
Capacity

SCED Up Reserve

2600 Mw

~~3800 Mw~~

Σ HSL = 45000

2600 Mw

42400 Mw

Σ HASL = 45000 – ~~3800~~ = ~~41200~~

RT Generation = 38000

SCED Dispatch

Σ HDL = 38000 + 1250 = 39250

SCED Down Reserve

Σ LDL = 38000 - 1250 = 36750

Σ LSL = 25000

Σ LASL = 25000 + 300 = 25300

Ancillary Services
- Reg-Up – 300 Mw
- Reg-Down – 300 Mw
- Responsive – 2300Mw
- Non-Spin – 1200 Mw
- Ramp Rate 250 Mw/Min

Generation

System Parameters
Deployment of Non-Spin Reserve Ancillary Service

MW Capacity

2600 Mw

SCED Up Reserve

Σ HSL = 45000

Σ HASL = 45000 – 2600 = 42400

RT Generation = 38000

SCED Dispatch

Σ HDL = 38000 + 1250 = 39250

SCED Down Reserve

Σ LDL = 38000 - 1250 = 36750

Ancillary Services
- Reg-Up – 300 Mw
- Reg-Down – 300 Mw
- Responsive – 2300Mw
- Non-Spin – 0 Mw
- Ramp Rate 250 Mw/Min

Σ LSL = 25000

Σ LASL = 25000 + 300 = 25300

Generation

Base Point Deviation

Base Point Deviation Penalties for a WGR

- **Nodal Market Design Use of WGR Capability**
  - The Nodal Market design provided for wind generation to be free running in the sense that SCED would maximize use of the WGR capability available in Real Time, subject to prices offered for the generation and system constraints (e.g. transmission flow constraints).

  - When there is no binding constraint that requires a limitation of a WGR's output, the SCED typically returns the WGR's telemetered HSL value as its SCED Base Point consistent with any Energy Offer Curve. In the case of a binding constraint, SCED may send a Base Point requiring the WGR to reduce its output. All else being equal, the generator with the least cost Resources in the total ERCOT generation mix, will be among the last resources selected when a down dispatch is required to relieve a binding constraint.

  - To provide an economic incentive for WGRs to reduce production when needed, the Protocols include a charge for a WGR's Base Point Deviation if the WGR fails to follow its down dispatch Base Point instructions

(1) ERCOT shall charge a QSE for an IRR a Base-Point deviation charge if the IRR metered generation is more than 10% above its Adjusted Aggregated Base Point and if the Adjusted Aggregated Base Point is two MW or more below the IRR's HSL.

The deviation charge may be refunded if the IRR shows, to ERCOT's satisfaction, that the IRR was taking the necessary control actions to produce at levels equal to or less than the Base Point but was unable to comply solely due to increasing renewable energy input.

The IRR must always take the necessary control actions, in its capability, to comply with Base Point Dispatch Instructions if the Base Point is two MW or more below the IRR's HSL as soon as practicable.

Base Point Deviation Amount Billing Determinant

If $\text{AABP}_{q, r, p} > (\text{HSL}_{q, r, p} - \text{QIRR})$

   $\text{BPDAMT}_{q, r, p} = \quad 0$

Otherwise

   $\text{BPDAMT}_{q, r, p} = \quad \text{Max}(0, \text{RTSPP}_p) * \text{Max}(0, \text{TWTG}_{q, r, p} - \frac{1}{4}$
   $* \text{AABP}_{q, r, p} * (1 + \text{KIRR}))$

Where

BPDAMT is the charge to the QSE for the WGR at Resource Node *p*, for its deviation from Base Point, for the 15-minute Settlement Interval.

TWTG is the telemetered generation of WGR at Resource Node *p*, for the 15-minute Settlement Interval.

AABP is Aggregated Base Point of the WGR at Resource Node *p*, for the 15-minute Settlement Interval.

HSL is the QSE's COP reported HSL of the WGR at Resource Node p for the hour that includes the 15-minute Settlement Interval.

KIRR is the percentage tolerance for over-generation of a WGR - 10%.

QIRR is the threshold to test the AABP against the HSL for a WGR - 2 MW.

RTSPP is the Real-Time SPP at Resource Node *p*, for the 15-minute Settlement Interval.

Conclusions

- **ERCOT will provide to all Market Participants information on the current and projected amount of reserves to serve the load**

  - QSEs who are watching the reserves, can respond to provide SCED with more generation when needed or take generation off when not needed

- **SCED is an effective means of determining the dispatch of wind generation and assures correct price relationships to all types of generation**

- **SCED produces the least cost of power and manages the grid when transmission congestion is present**

  - Prices paid to wind generators for their energy will effect their willingness to generate under limiting conditions

    - LMPs can be as low as -$250

- **Base Point Deviation Penalties provide incentives to Wind Generation Resources to follow their SCED Base Points**

Questions