Nexans

Clearing the Fog of Assumptions

Dynamic Line Ratings Provides Real Time Visibility and Market Efficiency

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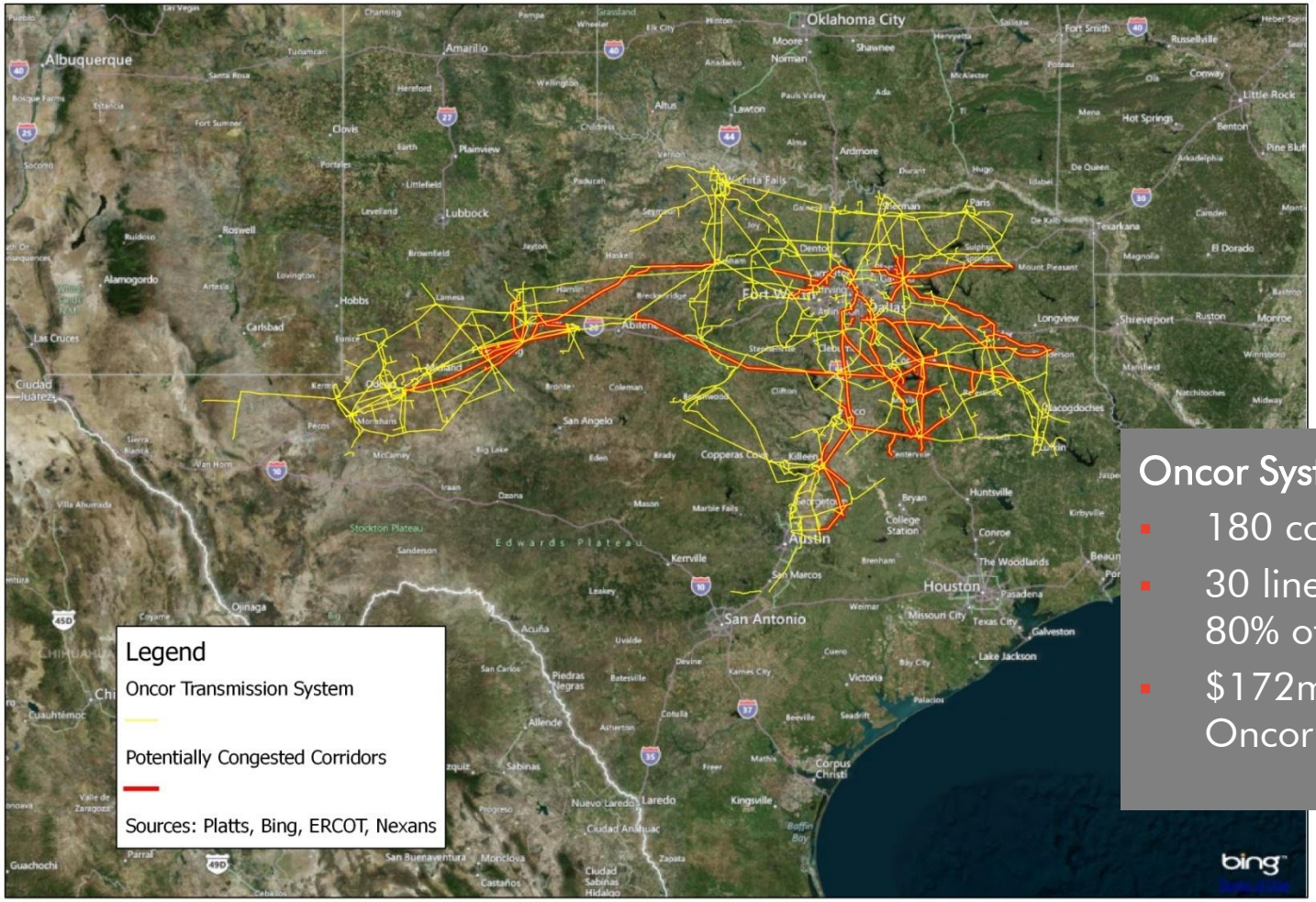
Results from DOE SGDP

- Project Description and Scope
- Economic Cost of Thermally Constrained Lines
- Comparison of Static Limits to Dynamic Limits
- Integration of Dynamic Line Ratings into Economic Dispatch
- Results from Deployment in Texas
- Expansion of DLR into additional areas

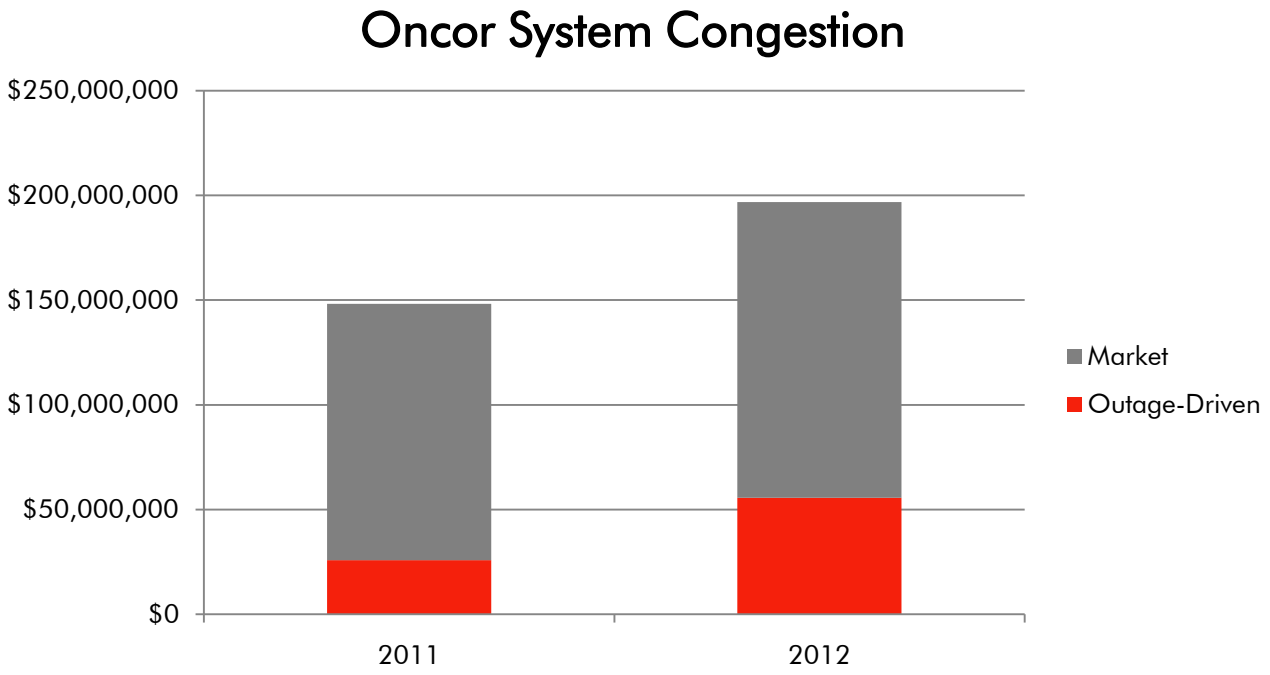
Oncor System Attributes



Oncor System Attributes

- 180 congested lines
- 30 lines responsible for 80% of congestion
- $172m average annual Oncor congestion

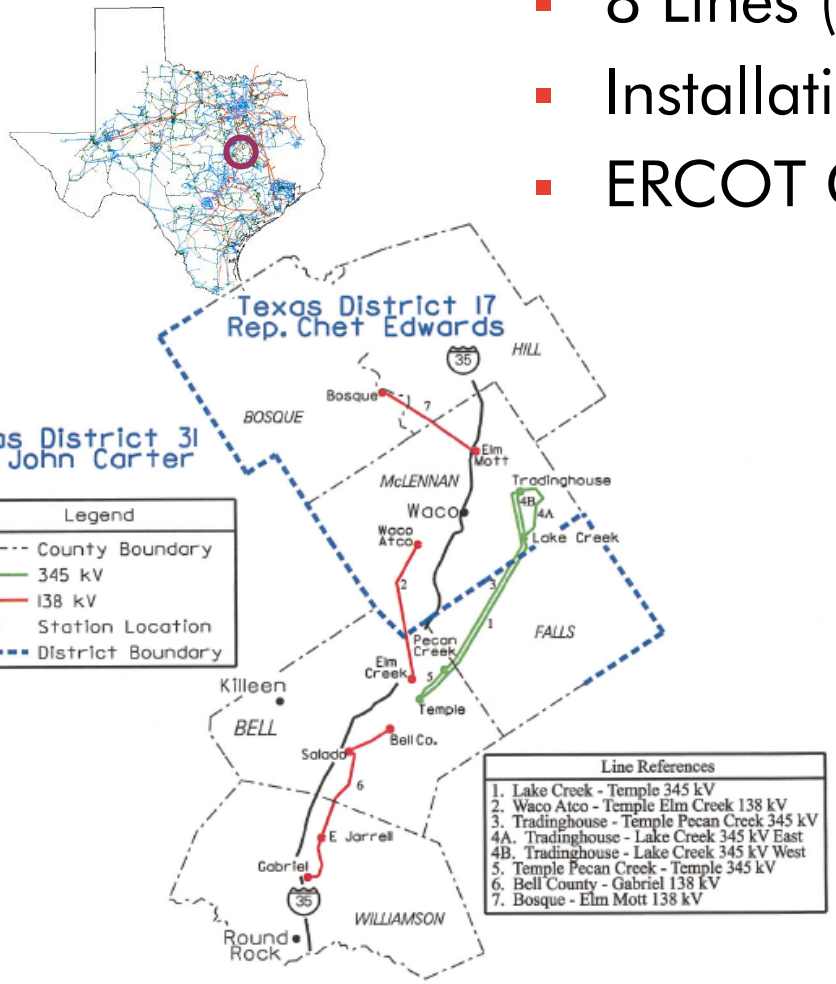
Problem and Opportunity



- Situation: Overhead thermal lines responsible for significant congestion costs
- Obstacle: Static assumptions force operators to use artificially low limits
- Next Generation SCADA Hypothesis:
  Real time line information can significantly reduce congestion costs

Oncor SGDP Project Scope

- 8 Lines (138kV-345kV)
- Installation 2010-2011
- ERCOT Go-Live 5/2012



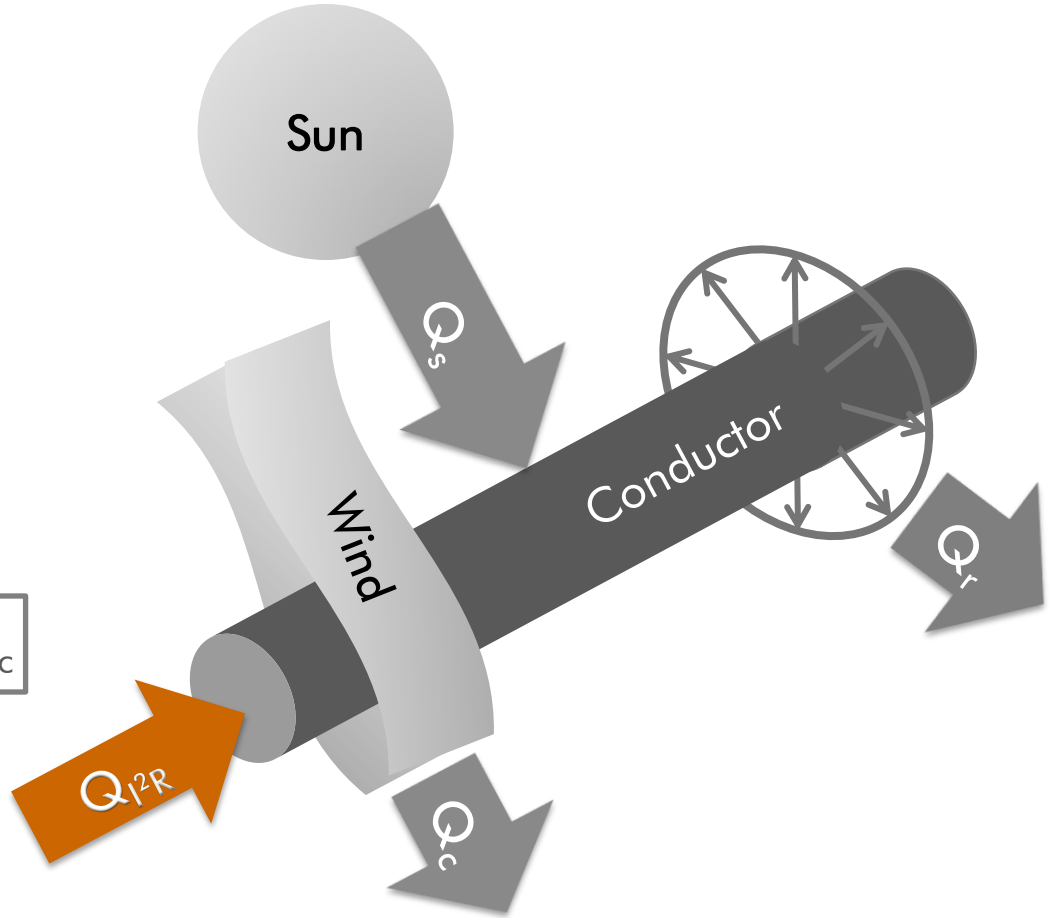
Static Ratings

IEEE 738

$$\Delta T = I^2R + Q_s - Q_r - Q_c$$

$$I^2_{max}R = T_{max} - \boxed{Q_s} + \boxed{Q_r} + \boxed{Q_c}$$

Assumed



Ambient Adjusted Ratings

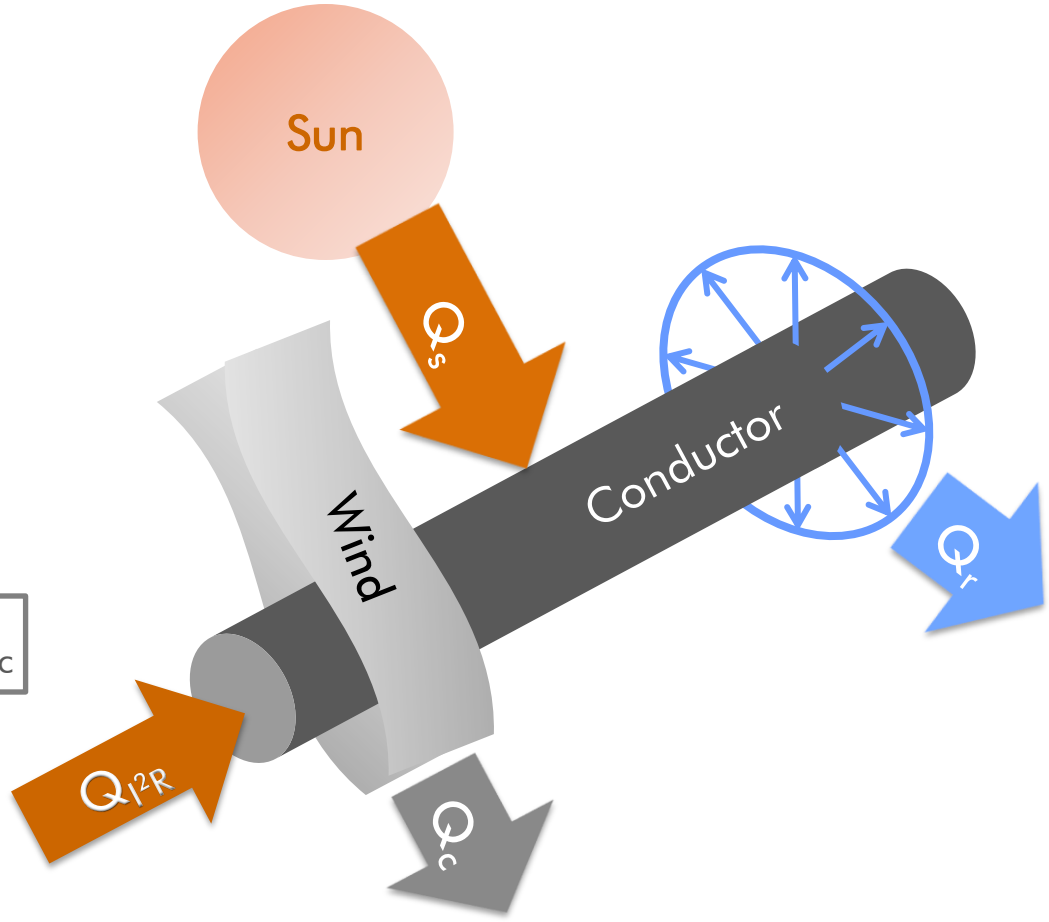
IEEE 738

$\Delta T = I^2R + Q_s - Q_r - Q_c$

$I^2_{max}R = T_{max} - Q_s + Q_r + Q_c$

Assumed

Measured



Full Dynamic Line Ratings

IEEE 738

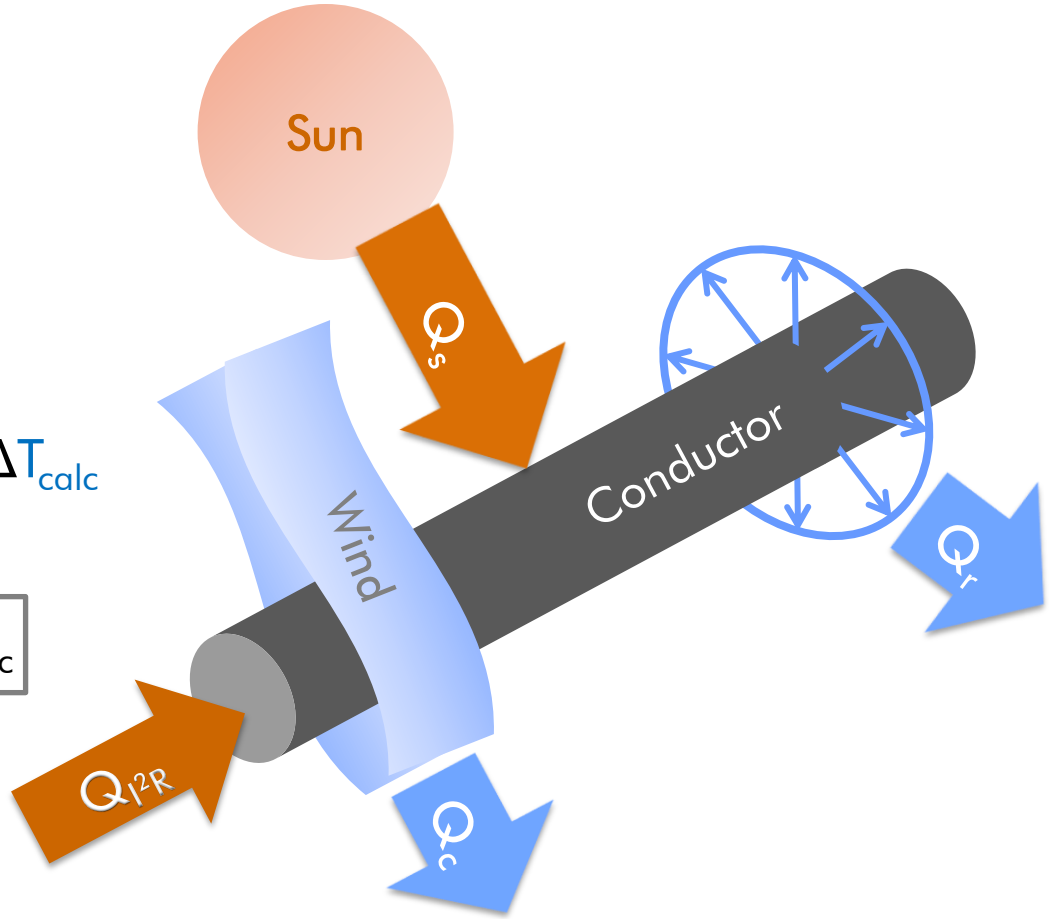
$$\Delta T = I^2R + Q_s - Q_r - Q_c$$

$$Q_c = I^2_{meas}R - Q_s + Q_r - \Delta T_{calc}$$

Calculated

$$I^2_{max}R = T_{max} - Q_s + Q_r + Q_c$$

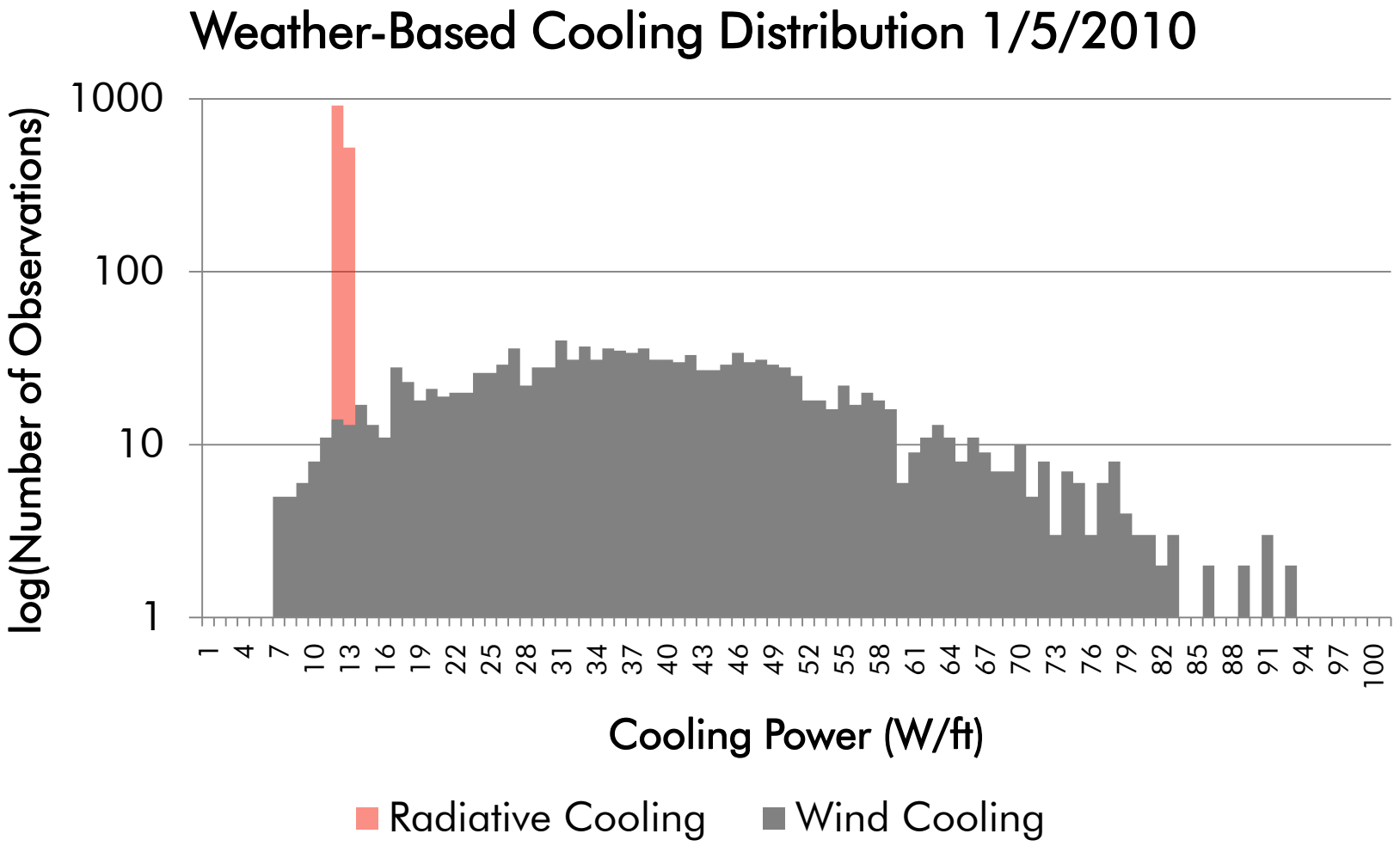
Measured



Comparison of Ratings Methodologies

Parameters	Static Ratings	Ambient Adjusted Ratings	Dynamic Ratings
Solar and Ambient Conditions	Assumed	Measured (regional)	Measured (corridor specific)
Wind Speed	Assumed	Assumed	Calculated
Tension	Assumed	Assumed	Measured
Sag or Clearance	Assumed	Assumed	Calculated
Maximum Rating	Artificially limited to worst case scenario	Does not take into account wind (greatest cooling factor)	Calculated based on measured conditions

Importance of Wind on Conductor Temp



Based on Seppa, Mohr, Stovall, "Error Sources of Real-Time Ratings Based on Conductor Temperature Measurements, Report to CIGRE WG B2.36, May 20, 2010

Integrated Dynamic Line Rating Systems

Load Cell measures tension

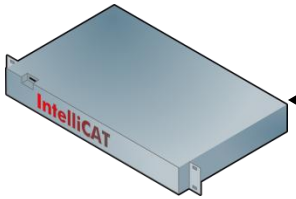
Net Radiation Sensor measures conditions as seen by an unloaded conductor

CAT Unit transmits data from tower to substation

CAT Master loads sensor data onto utility network

Operator Display

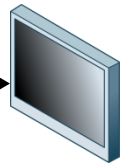
Capacity Engine



CAT-1™ and line load data from EMS

Line capacity and temperature to EMS

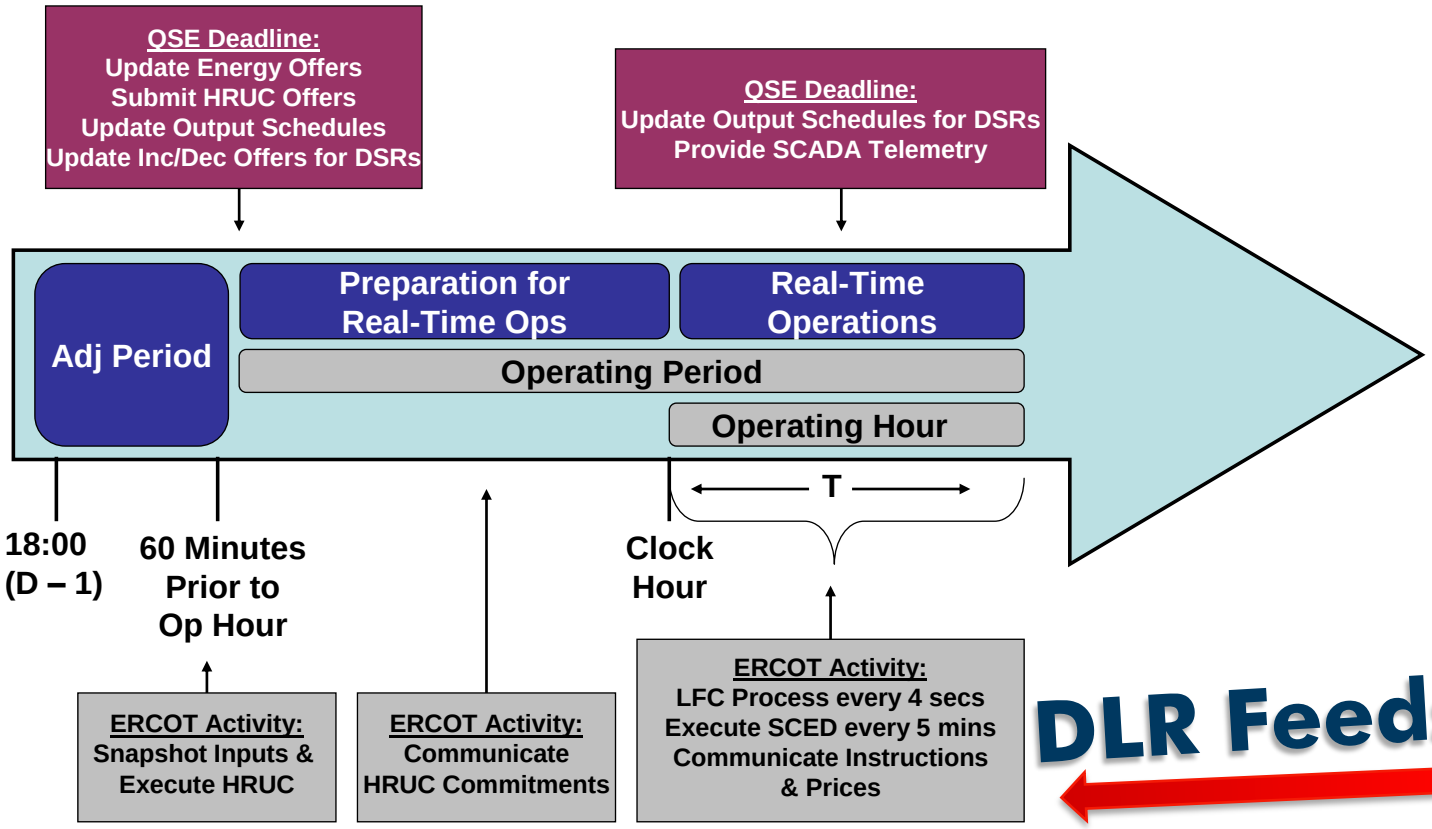
Oncor SCADA



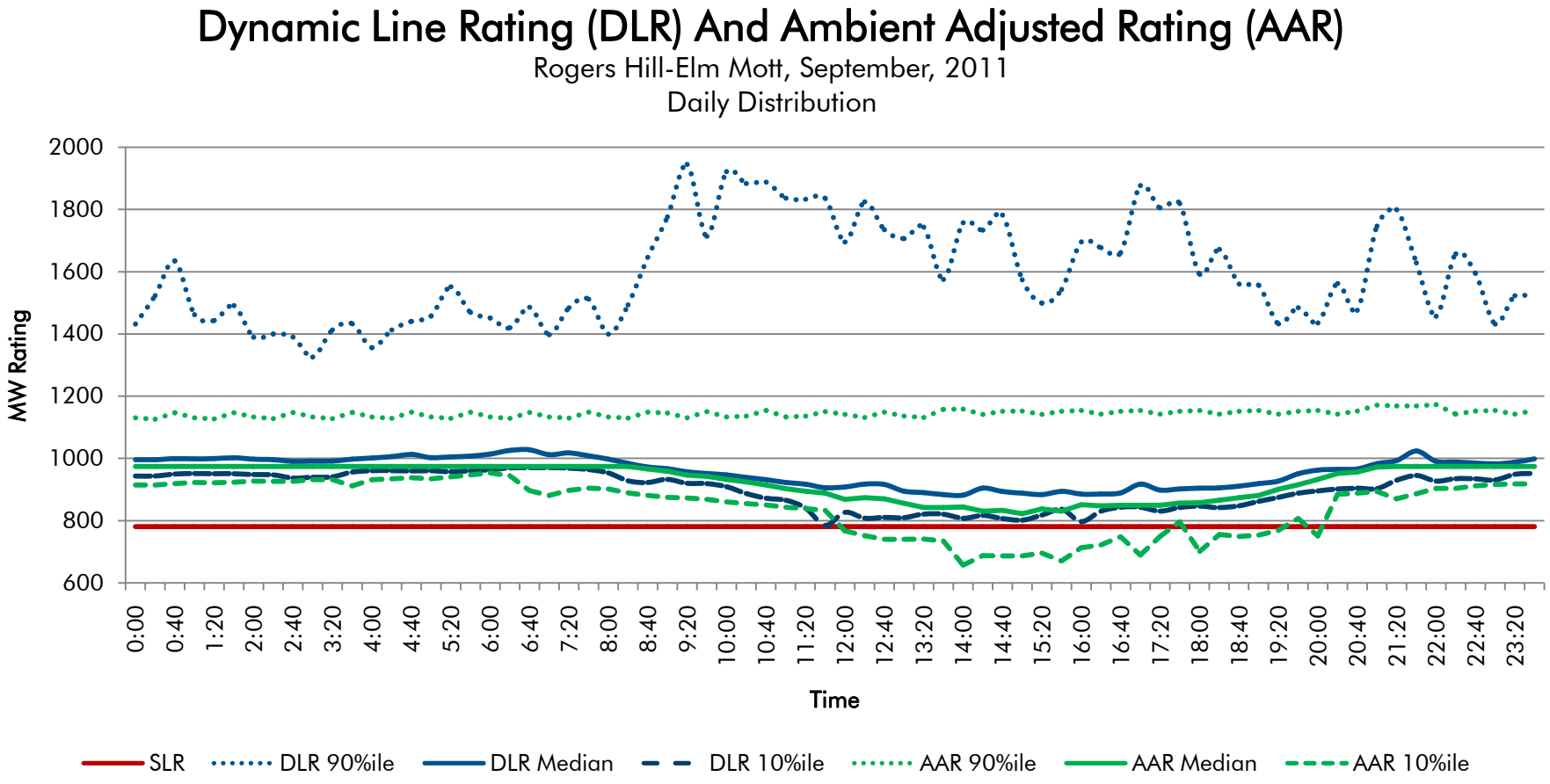
SGDP Breakthrough:
live streaming to ERCOT SCED

DLR Integration Into ERCOT SCED

Adjustment Period & Real-Time Operations

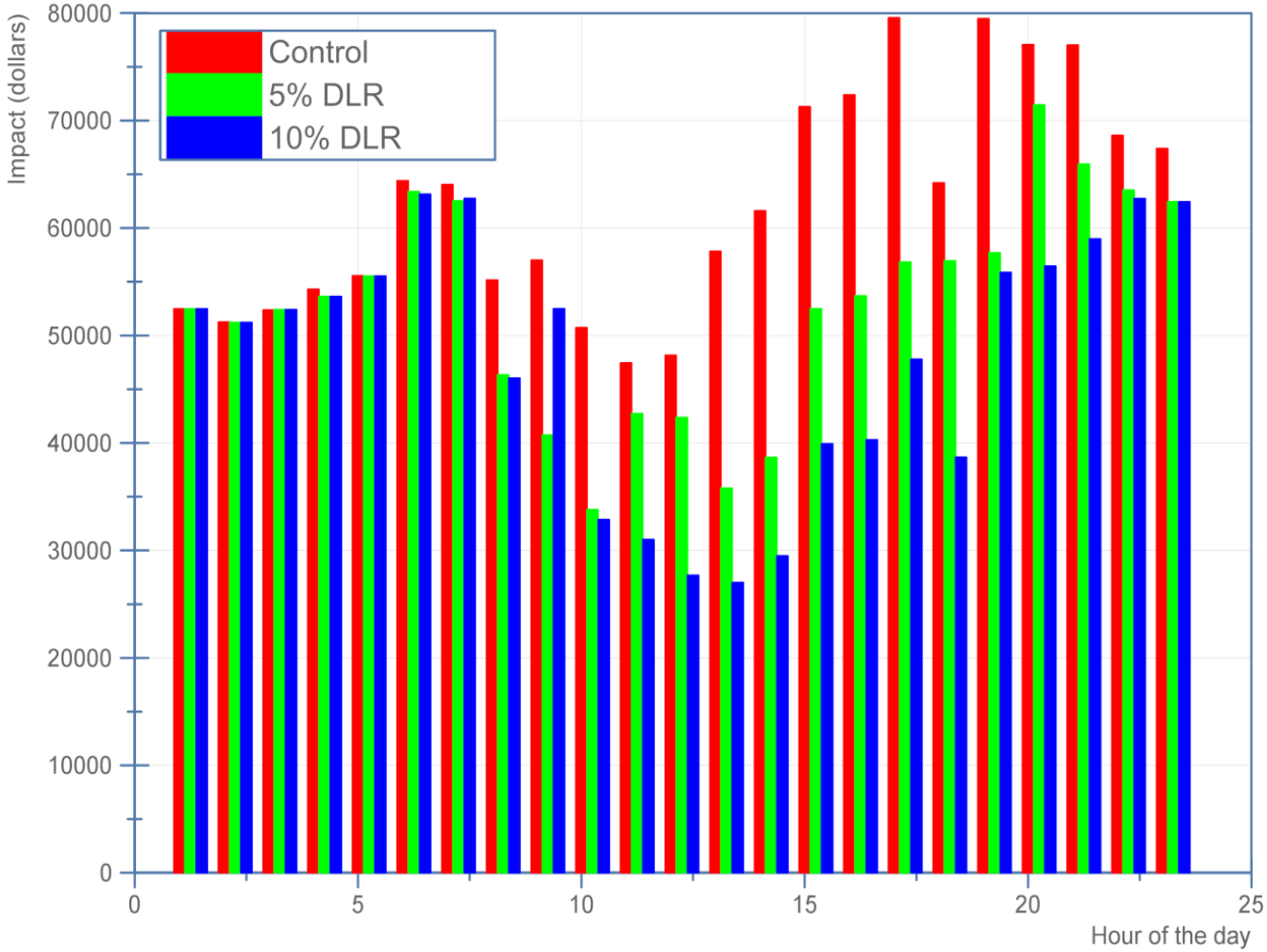


Capacity Increases from DLR



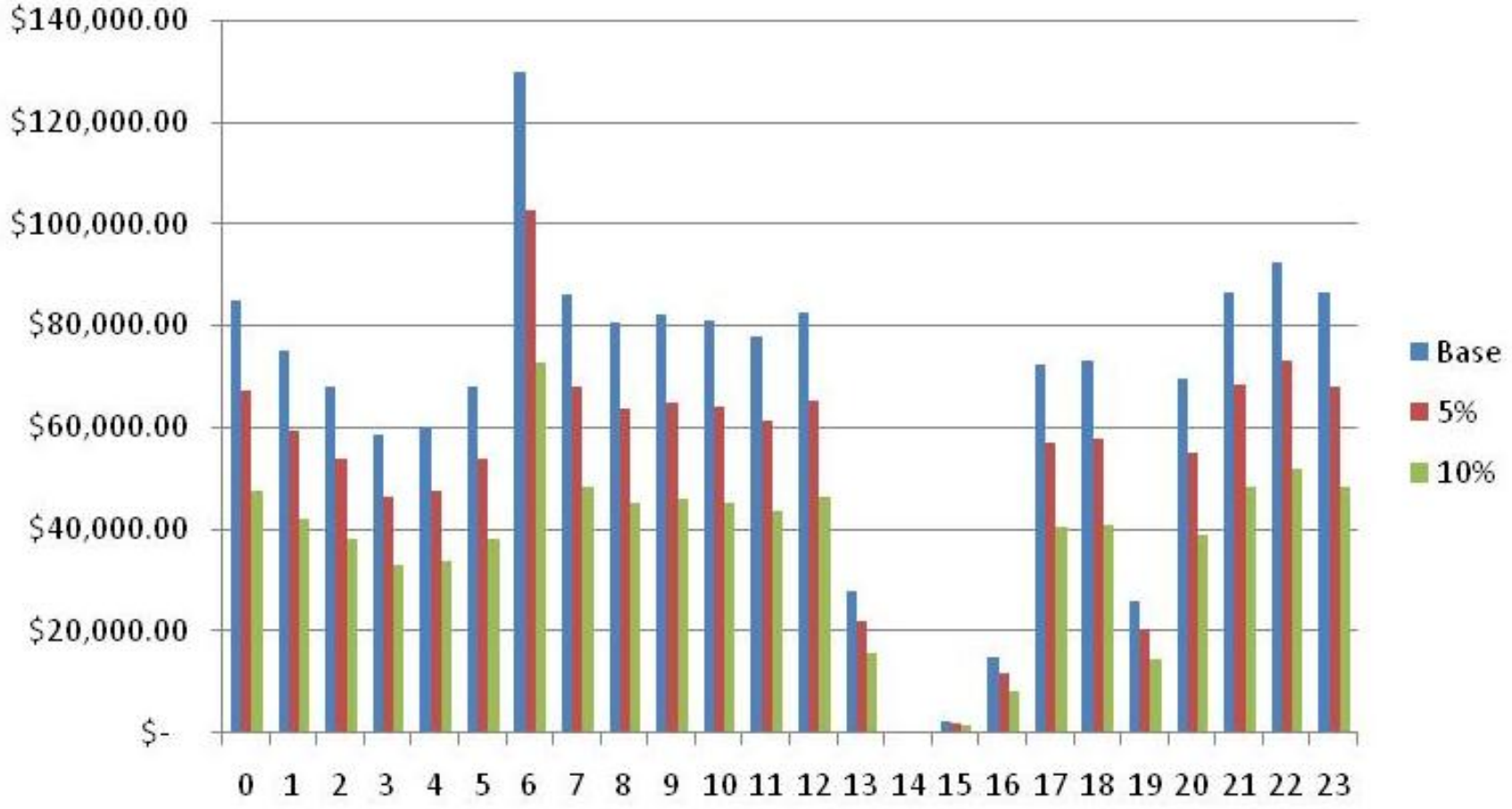
Savings in Day-Ahead Market

Congestion Cost Per Hour 11/1/11 DAM



Savings in SCED (5-min Dispatch)

Extrapolated Congestion Cost Per Hour 11/1/11 SCED



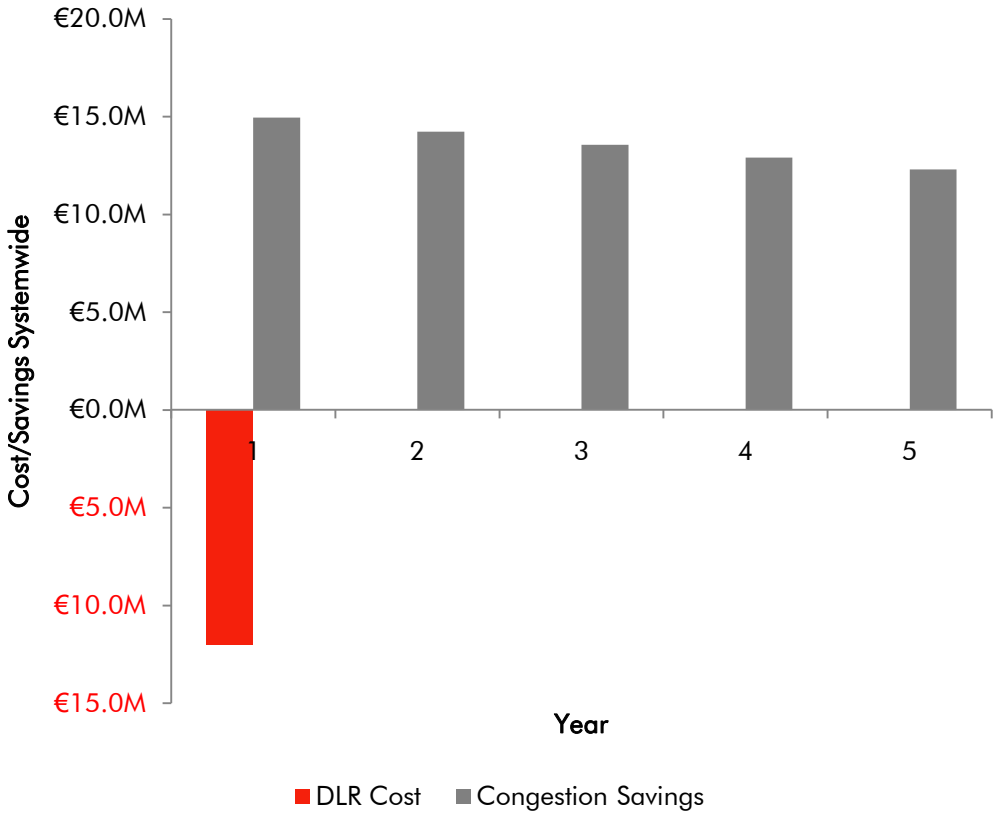
Congestion Reduction Results

Congestion Reduction Projections			
		Direct Line	Peripheral Lines
Peak Day	Control	-	-
	Plus 5%	68%	54%
	Plus 10%	78%	100%
Annual	Control	-	-
	Plus 5%	60%	56%
	Plus 10%	100%	58%

- Control: dispatch with selected (direct) lines rated at static capacity
- Plus 5%/10%: dispatch with selected lines at "dynamic" capacity
- Peripheral Lines: any line sharing a substation with a direct line
- Percentage Reduction: change in congestion cost attributable to line(s)
- Peak Day: 7/27/2011
- Annual: interpolation based on 12 sample days throughout the year

Indicative Oncor DLR Value and ROI

Value Analysis for DLR in Oncor



If DLR installed on 30 of Oncor's likely congested lines:

- NPV Cost (Installation): €12.0m
- NPV Savings (Congestion over 5 years): €68.0m
- ROI: 467%
- Payback: 9.6 Months

Second Deployment After SGDP Success

Projects to Address 2012 West Texas Congestion

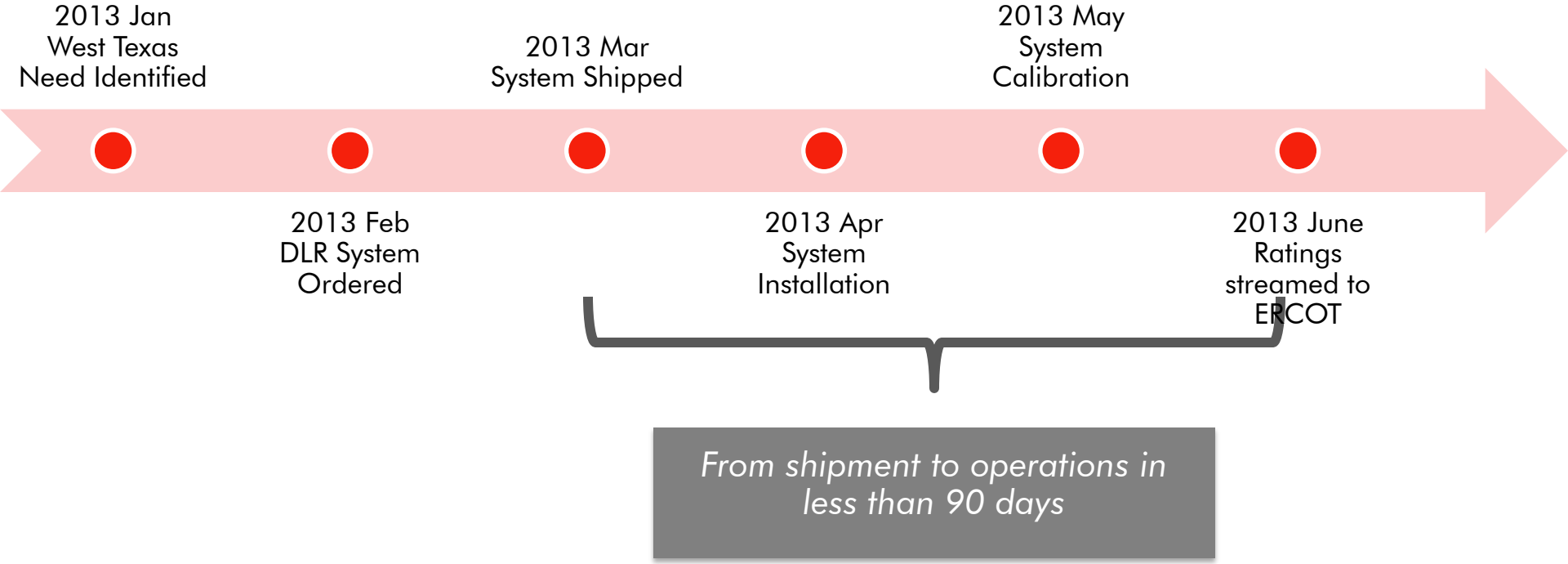
Constraint	2012 Congestion Rent	Projects	Expected Congestion Relief
Odessa North 138/69 kV autotransformer	$132,736,881	Odessa North 138/69 kV autotransformer with a larger capacity transformer (87 MVA to 125 MVA emergency rating)	Nov-12
China Grove-Bluff Creek Switch 138 kV line	$54,362,222	New WETT and Oncor Faraday/ Willow Valley 345/ 138 kV autotransformer will connect CREZ 345 kV facilities to the 138 kV	Jun-13
Odessa-Odessa North 138 kV line	$17,531,349	Reconductor the Odessa-Odessa North 138 kV line	Dec-13
Odessa North-Odessa Basin Switch 69 kV line	$7,264,839	New Odessa North-Goldsmith Junction-Holt 138/69 kV double circuit	May-14
Midland East-Windwood 138 kV line	$4,820,128	ERCOT and Oncor are continuing to study the long-term solution	TBD

Short-term Improvements:

- Oncor will create a new temporary 138 kV circuit between Moss and Holt via Goldsmith Junction by June 2013
- The temporary circuit will lessen the loading on the Odessa North circuits but will not completely relieve the congestion
- Oncor will install dynamic line rating equipment on the Odessa-Odessa North 138 kV line to lessen congestion by summer 2013
- Oncor will install dynamic line rating equipment on the Midland East-Windwood 138 kV line by summer 2013

Source: ERCOT, "Update on Transmission Planning for West Texas Congestion", May 14 2013

Fast Deployment for Critical Needs



Conclusions: Drawing New Connections

- Connection: Sensor to Next-Generation SCADA
  - Incorporation of real time, individual line capacity data into SCED
  - First stages of grid operations that rapidly adapt to changing conditions
  - Framework for future, high-definition closed-loop systems
- Connection: Concept to SGDP to Business Case
  - Theory: dynamic line ratings can provide customer savings
  - Results: significant efficiencies from reduced congestion costs
  - Practice: sufficient evidence to justify full commercial deployments

Integrated Dynamic Line Rating Systems

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