Dynamic Line Ratings
Smart Grid Technology Delivers Increased Transmission Grid Capacity

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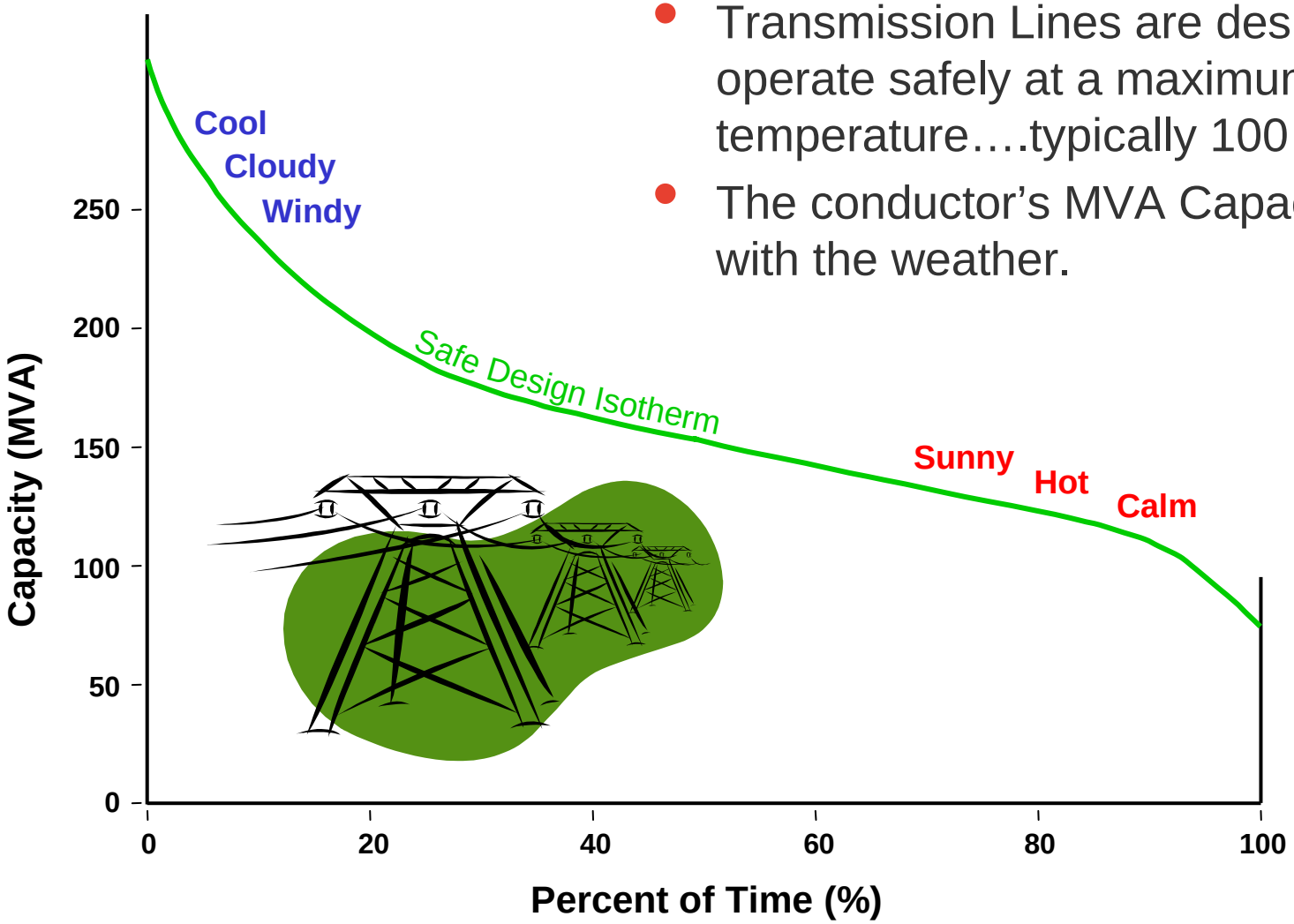
The Valley Group, a Nexans company

Agenda

- What Are Dynamic Line Ratings (DLR)?
- Complete System Integration with EMS/SCADA
- Dynamic Line Ratings and the Smart Grid
  - Increased Grid Capacity, Reduced Capital Investment
  - Increased Reliability and Efficiency
  - Reduced Congestion
  - Enhanced Wide Area Situational Awareness (e-WASA)
  - Rapid Integration of Renewable Energy into the (existing) Transmission Grid
  - Lower Cost of Power for the Consumer
- Impact on Transmission Grid Operations
- Case Studies – Operational Use Translated To Results
- Summary

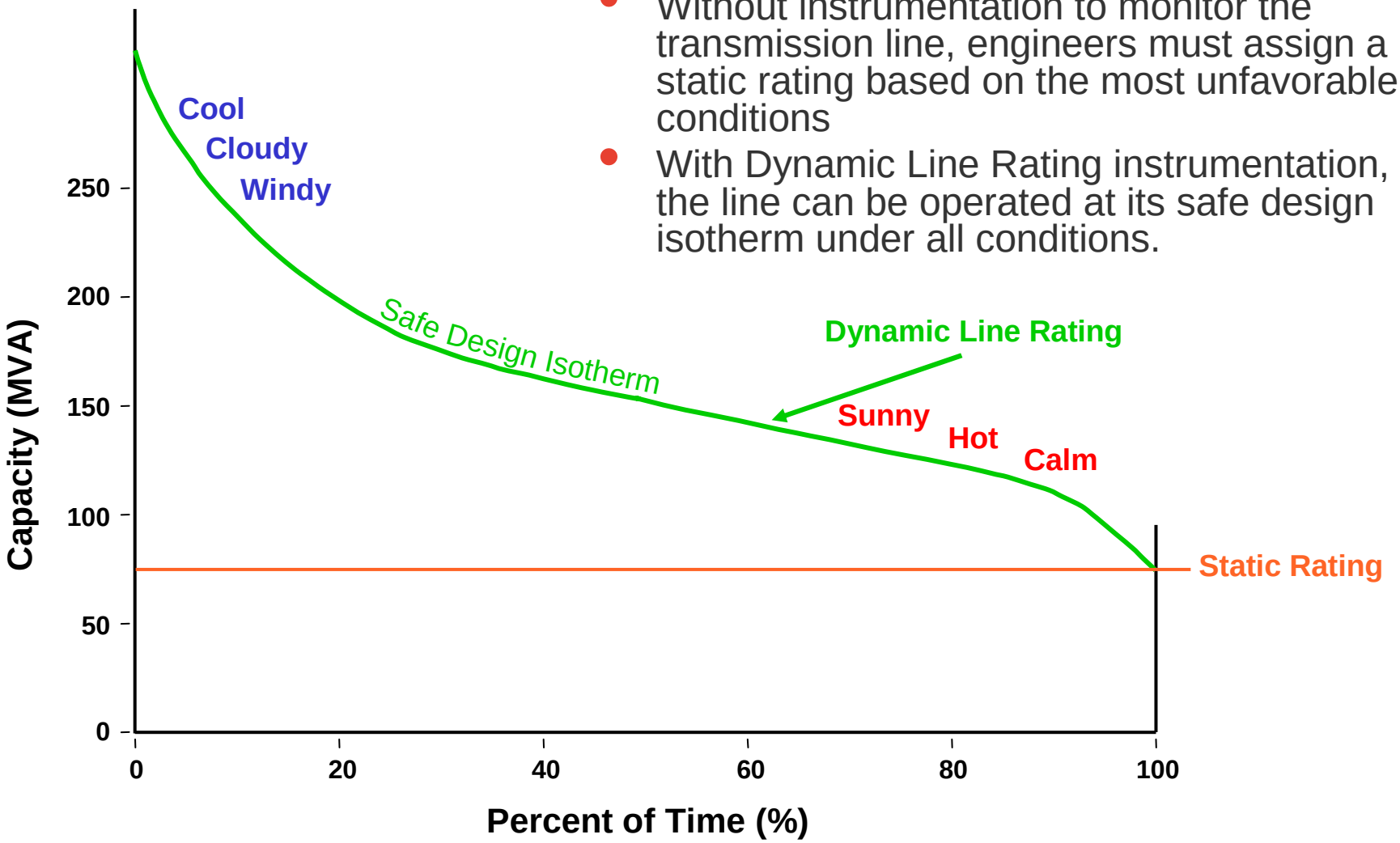
What Are Dynamic Line Ratings?



- Transmission Lines are designed to operate safely at a maximum conductor temperature….typically 100 ^{o}C.
- The conductor's MVA Capacity varies with the weather.

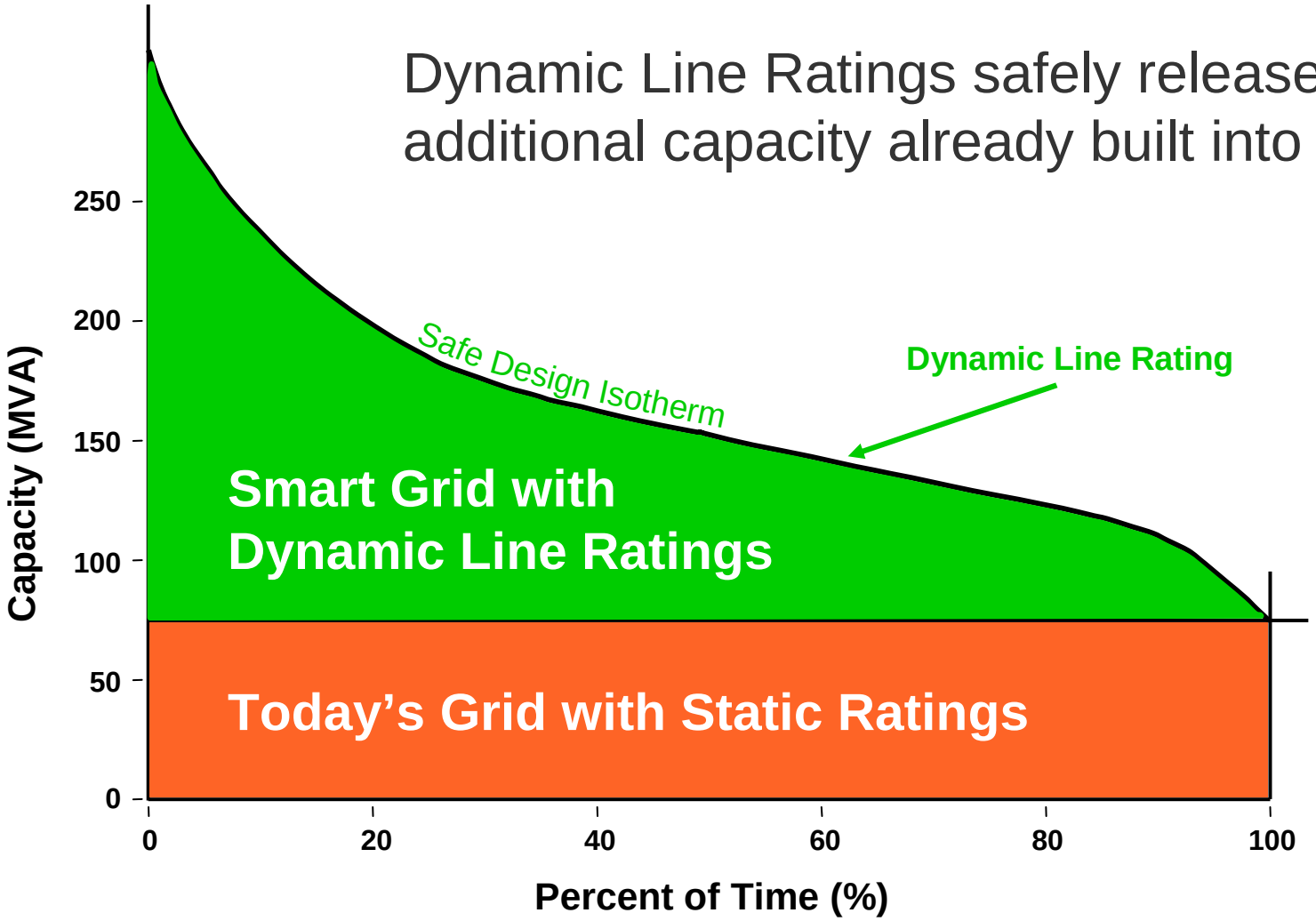
What Are Dynamic Line Ratings?

- Without instrumentation to monitor the transmission line, engineers must assign a static rating based on the most unfavorable conditions
- With Dynamic Line Rating instrumentation, the line can be operated at its safe design isotherm under all conditions.



What Are Dynamic Line Ratings?

Dynamic Line Ratings safely release the additional capacity already built into the Grid.

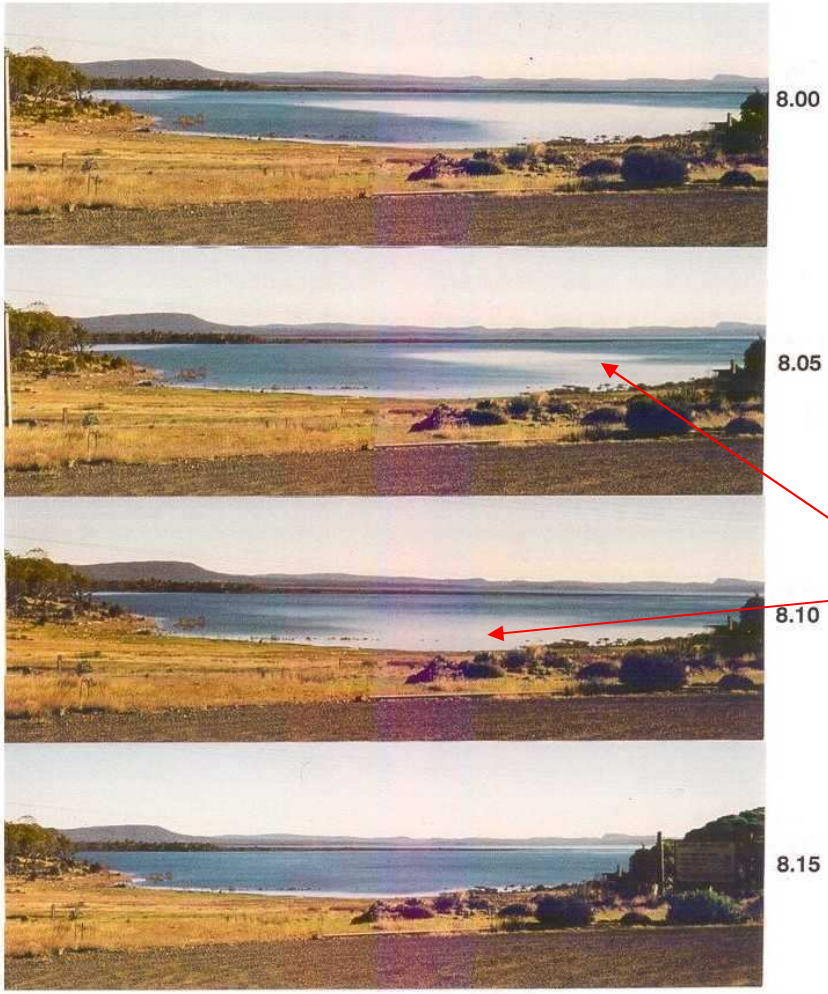


Relative Impact of Ambient Conditions on Line Ratings

30 km transmission line (795 ACSR) with a **static** thermal rating of 787 amps at 40^0C ambient, zero wind, and mid-day summer

Ambient Temperature:			
2^0C fluctuation	→	**+/-2% capacity**	
10^0C drop in ambient	→	**+ 11% capacity…**	**874 amps**
Solar Radiation:			
Cloud shadowing	→	**+/- a few percent**	
Middle of night	→	**+ 18% capacity…**	**929 amps**
Wind increase 1m/sec:			
45^0 angle	→	**+ 35% capacity…**	1,060 amps
90^0 angle	→	**+ 44% capacity**	

Spatial Variability of Wind Impact on Line Ratings

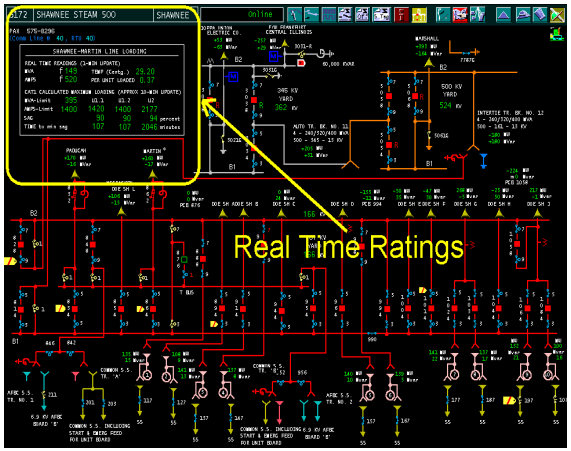


- Wind patterns on a bay of Great Lake, Tasmania
- Five Minute Intervals
- 8:00 a.m. to 8:15 am, 8 March 1998

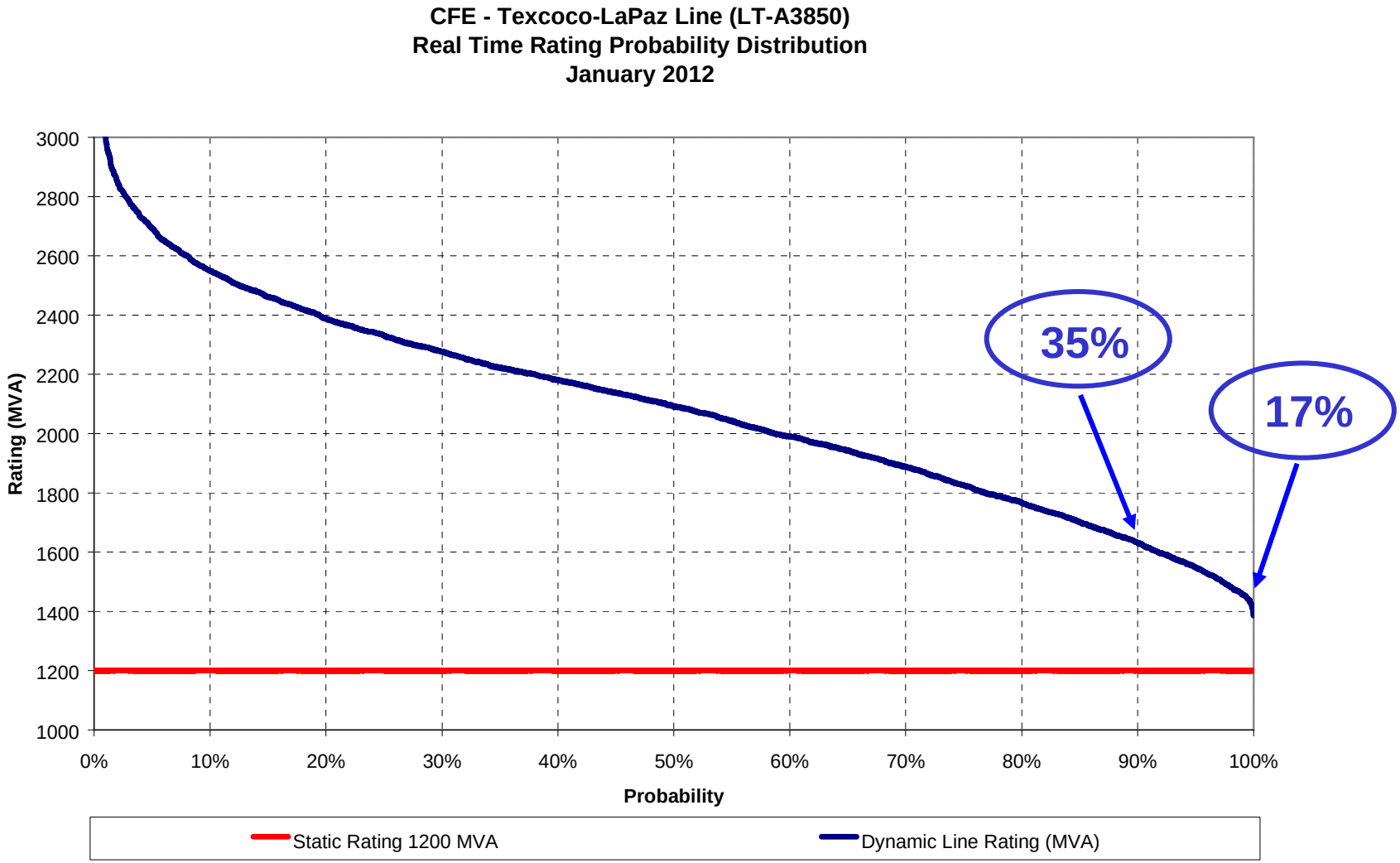
A transmission line across this lake would see different conditions along its length, in that 15 minute period, affecting its transmission transfer capacity

Integrating Dynamic Line Ratings Into The Smart Transmission Grid

- Mechanical tension of the conductor captures the spatial variability of wind
- Releases the additional capacity built into the line.
- Protects line from clearance violations and ice events
- Integrated, end-to-end solution to Control Room



Increased Grid Capacity



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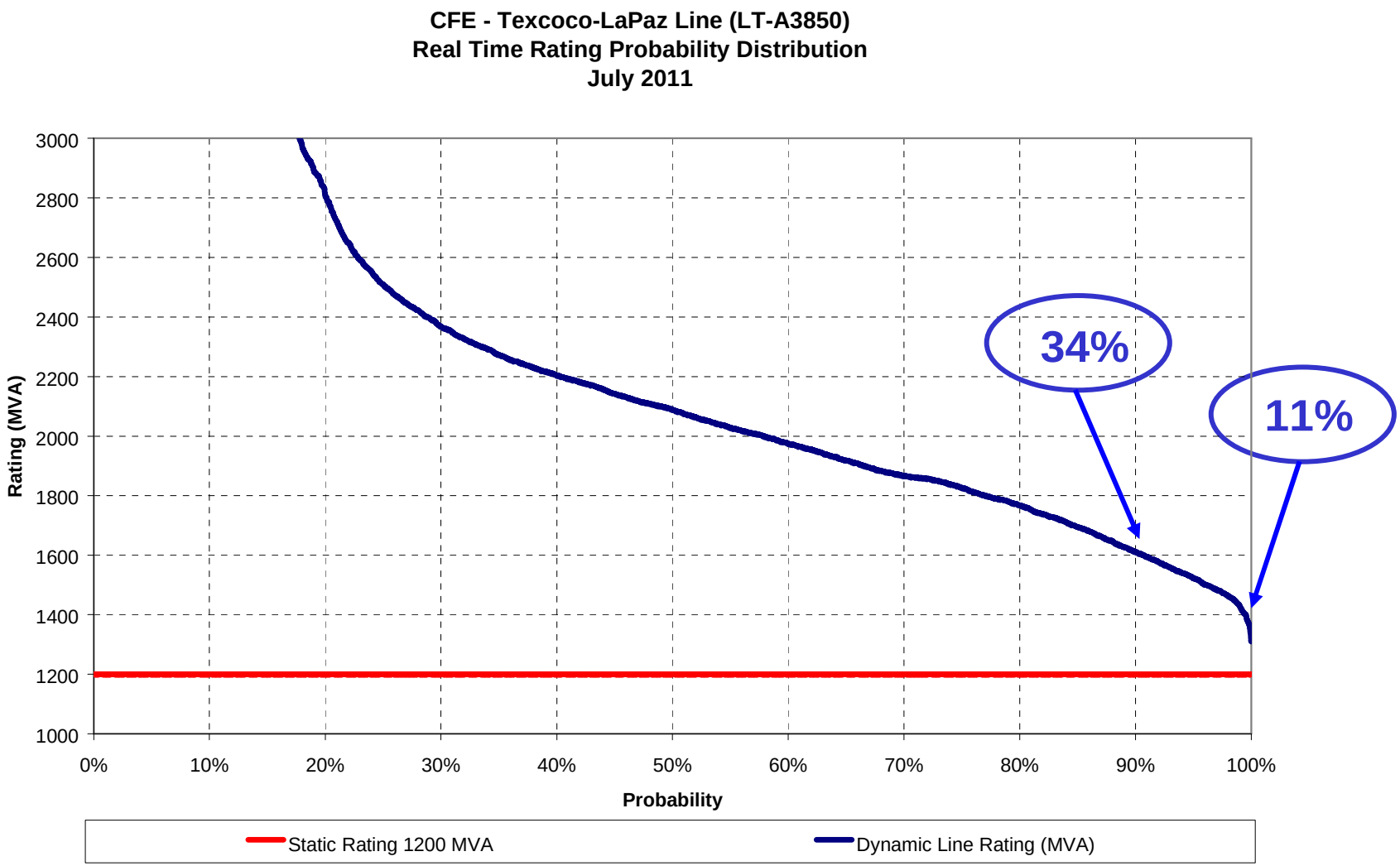
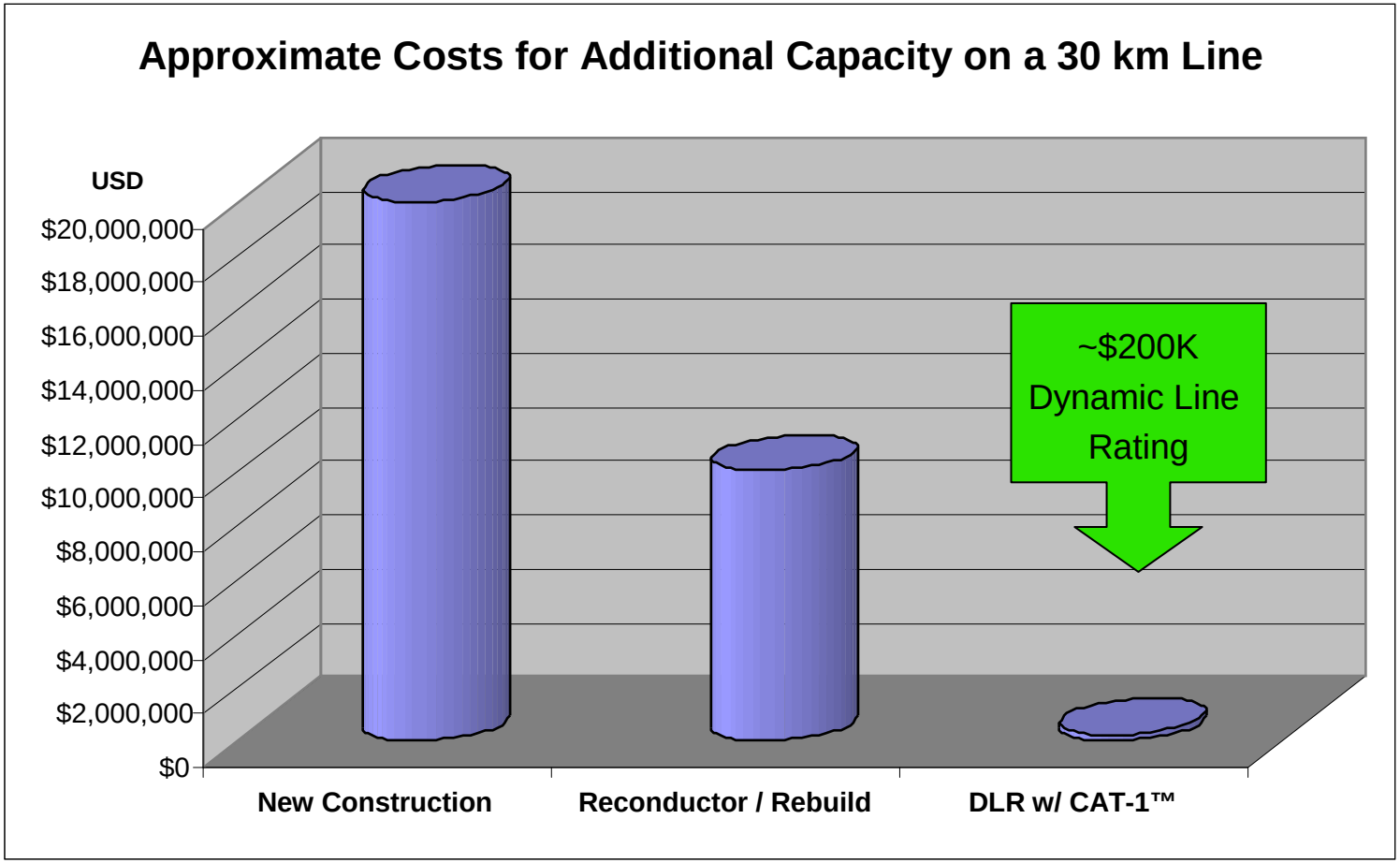


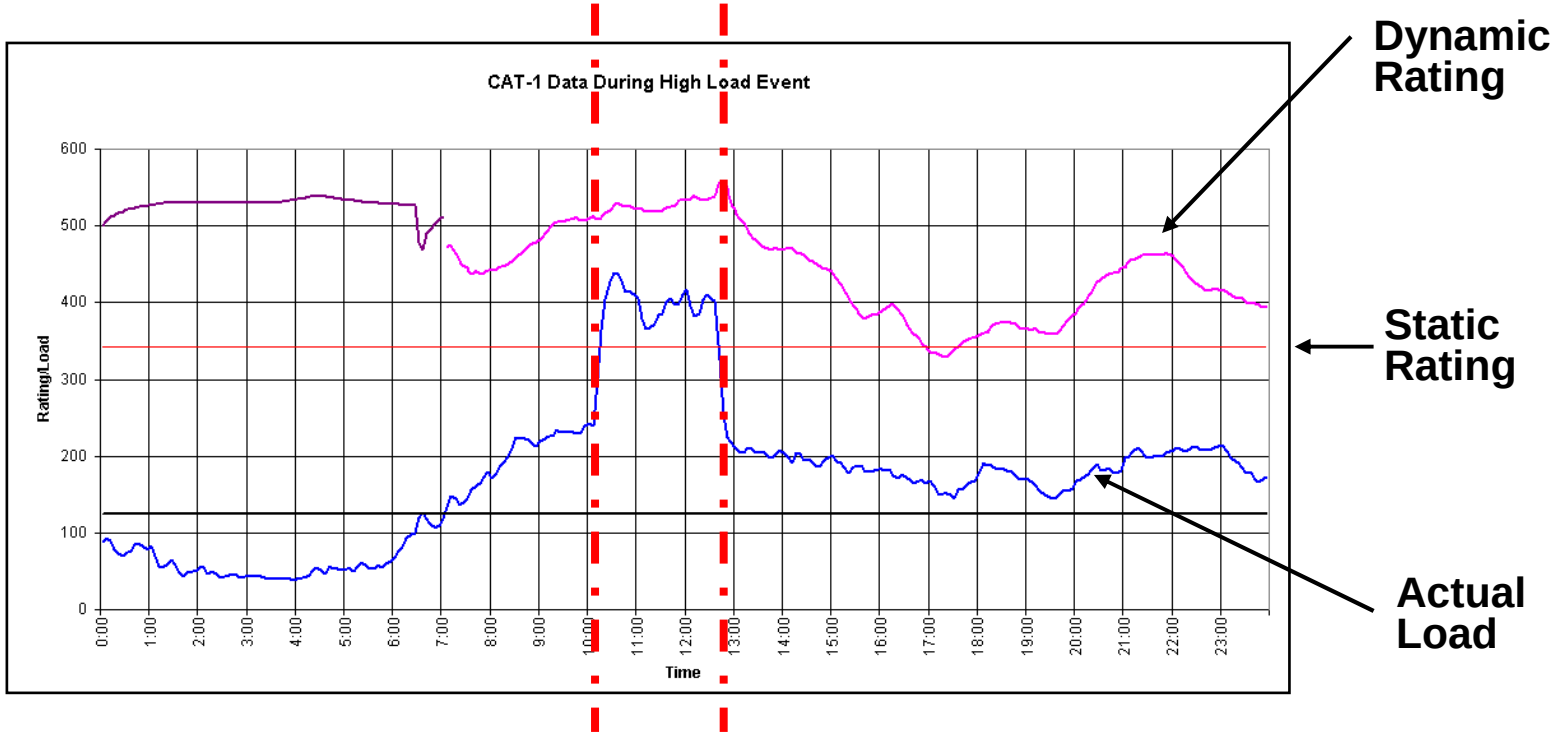
Dynamic Line Rating - Most Cost Effective Solution



Dynamic Line Ratings and Transmission Grid Operations

- The most recent gains in the technology have been focused on ease of use and improved integration within the control center
  - Automatic integration with EMS applications including security analysis and state estimators
    - Real time ratings are available as data points within the EMS/SCADA
    - Ratings are delivered real time to advanced EMS/SCADA applications
  - Tools enable operators to **reduce** the number of times they have to intervene to make system adjustments
    - Continuous ratings with dynamic alarms
    - Short term emergency ratings
    - Minutes until a clearance violation occurs

Dynamic Line Ratings and Transmission Grid Operations

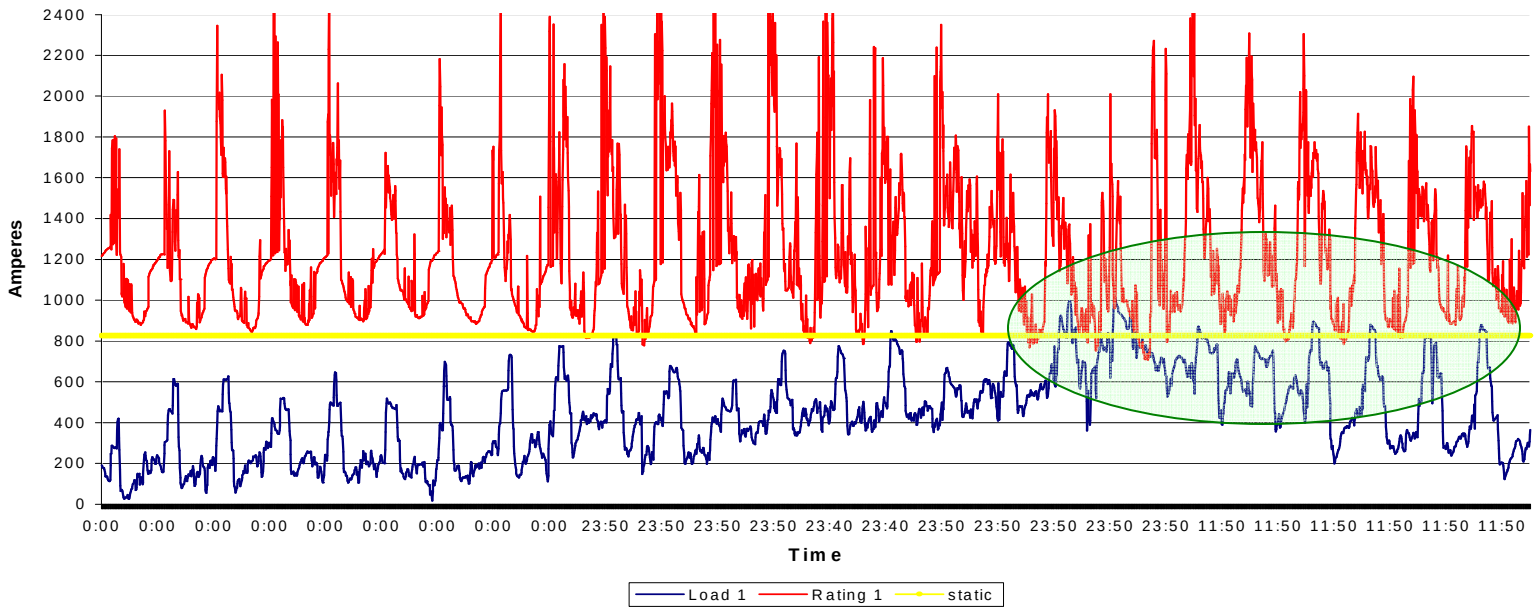


- Line was operating within limits in accordance with NERC standards; without DLR, this event must be reported as a violation
- The operator would have been forced to move the grid off its *optimum (most secure) dispatch*

Example Of Safely Managed Contingency
Improved Transmission Grid Reliability

Dynamic Line Ratings and Transmission Grid Operations

230 kV Transmission Line
Load and Dynamic Line Rating vs. Time



Reduced Need For Operator Intervention

Dynamic Line Ratings and Transmission Grid Operations

If this 230 kV line were operated according to present NERC rules:

Operator Intervention	Without Dynamic Line Ratings	With Dynamic Line Ratings
Number of Days Required in Month	**9 days**	**2 days**
Number of Hours Required in Month	**45 – 65 hrs**	**4 – 5 hrs**
Longest Curtailment	**10 hrs**	**2 hrs**

In addition, curtailments would have been less severe using Dynamic Line Ratings.

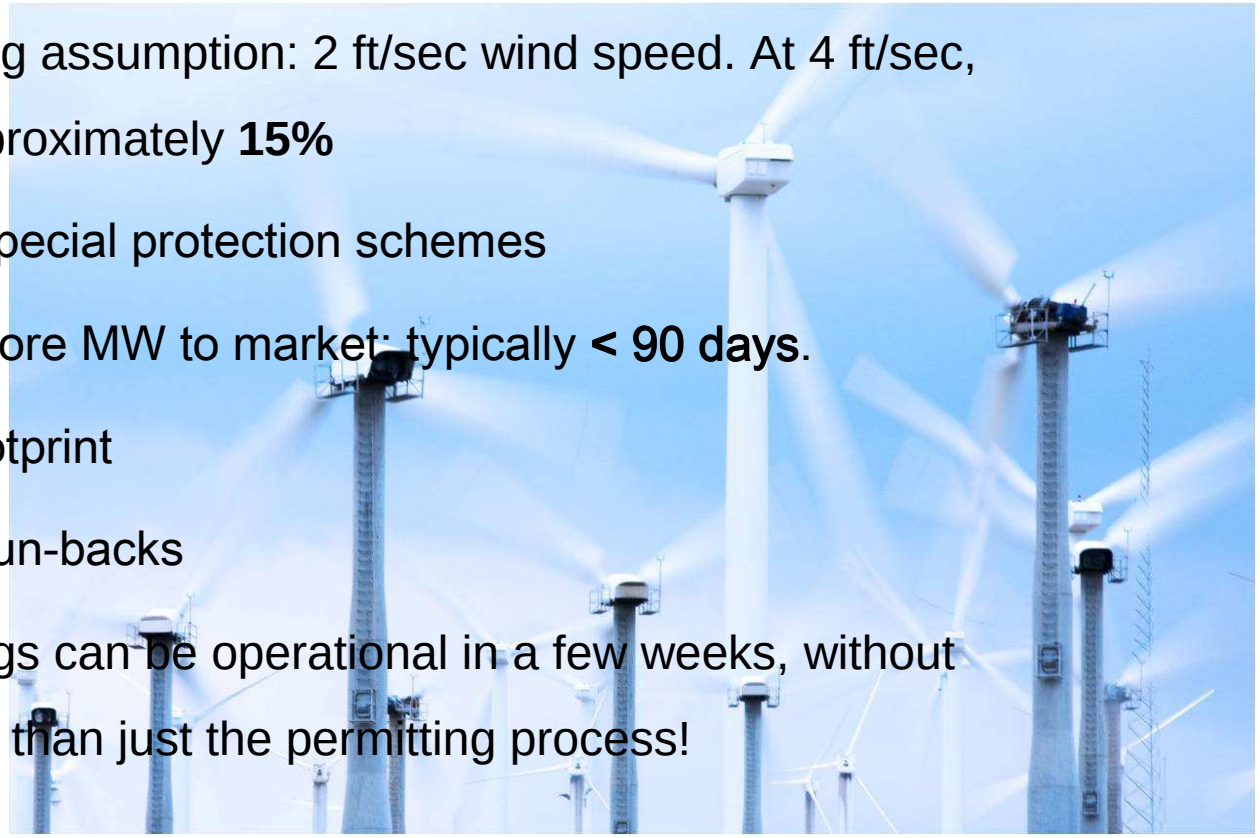
Optimum Dispatch Maintained – Improves Reliability

Reduced Service Curtailments

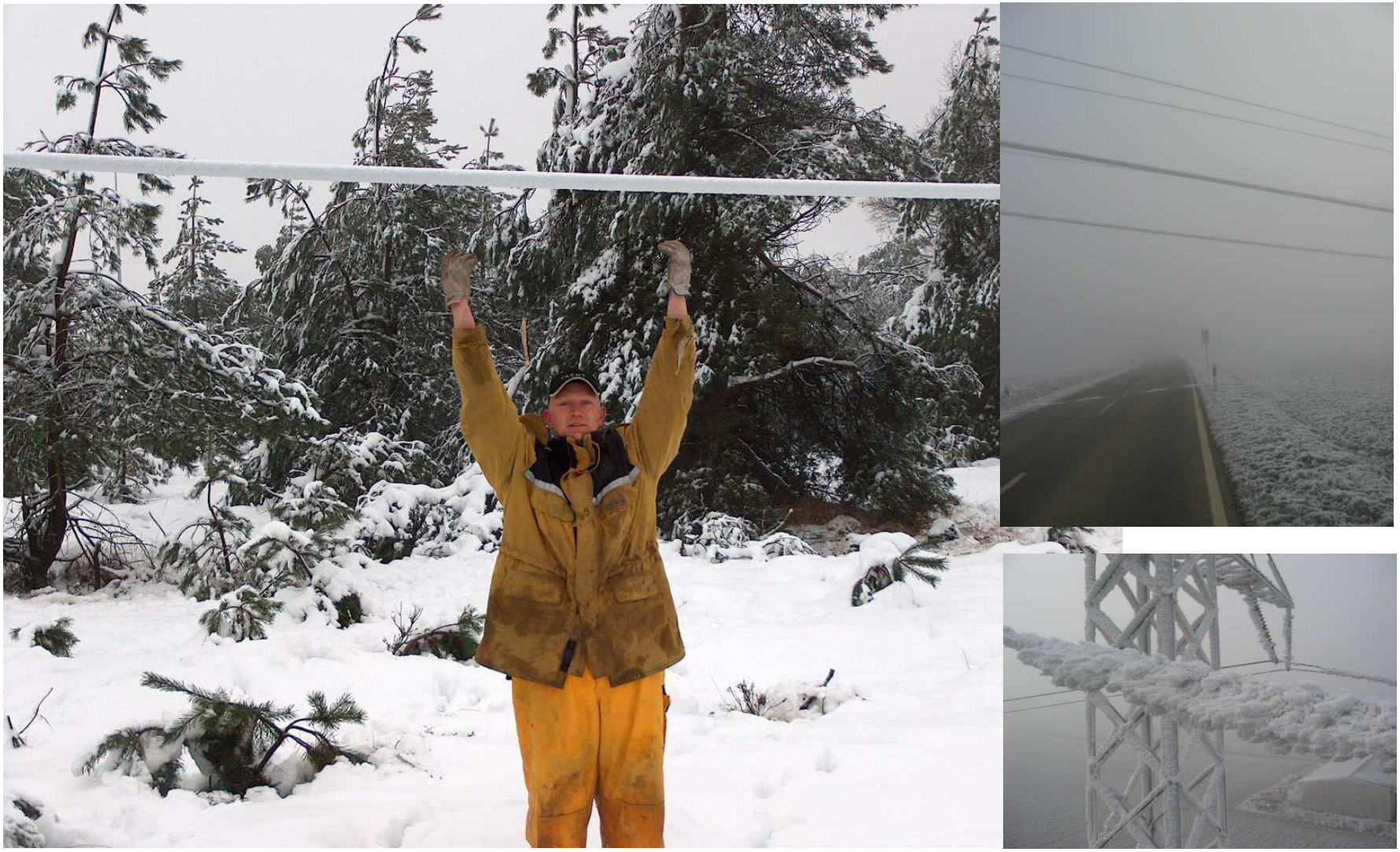
Dynamic Line Ratings and Integration of Wind Energy

Wind generators are located in windy regions, which can benefit *substantially* from Dynamic Line Ratings

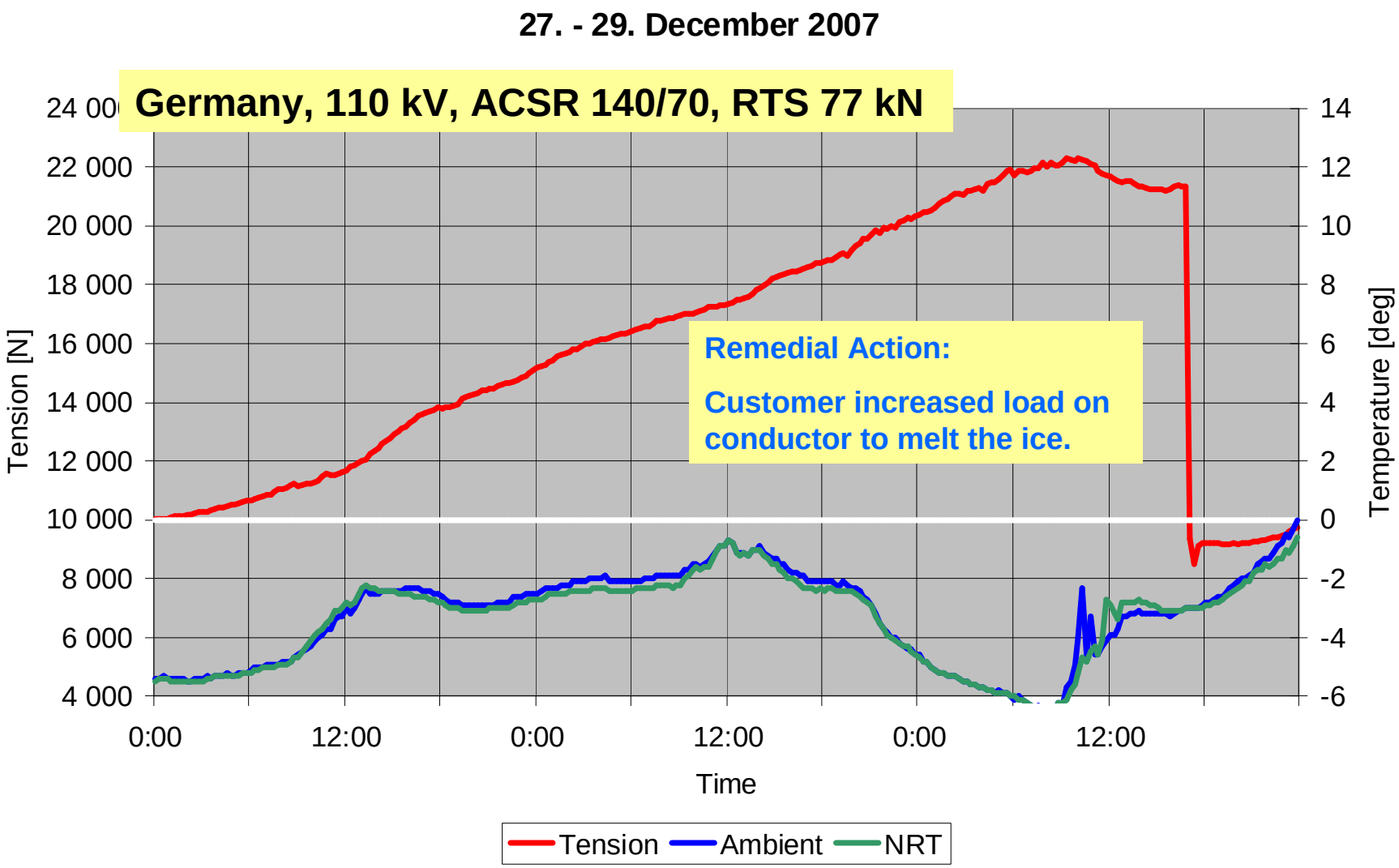
- Increased line ratings on existing **and** new transmission lines
- Common static rating assumption: 2 ft/sec wind speed. At 4 ft/sec, rating increases approximately **15%**
- Reduced need for special protection schemes
- Earlier delivery of more MW to market: typically **< 90 days**.
- Reduced carbon footprint
- Reduce wind farm run-backs
- Dynamic Line Ratings can be operational in a few weeks, without permits, at less cost than just the permitting process!



Dynamic Line Ratings and Ice Monitoring



Dynamic Line Ratings and Ice Monitoring



Summary

- **Optimization** - Smart Grid is not only about building new transmission but also about "optimizing" existing or new assets - DLR is an advanced optimization technology

- **Reliability** - Smart Grid is about enhanced grid reliability – Increased DLR capacity stiffens the grid and makes it more resilient to blackouts as it provides visibility the operator never had in the past

- **Integration** of Renewable Generation – DLR adds capacity in weeks bringing renewable energy to market when it is needed….now.

- **Cost/Benefit** – 10% to 30% additional capacity is realized at only 5% to 10% of the cost of alternative solutions.

- **Ultimately**, DLR brings an element of intelligence to the Smart Grid that results in reduced electricity costs for consumers….today.

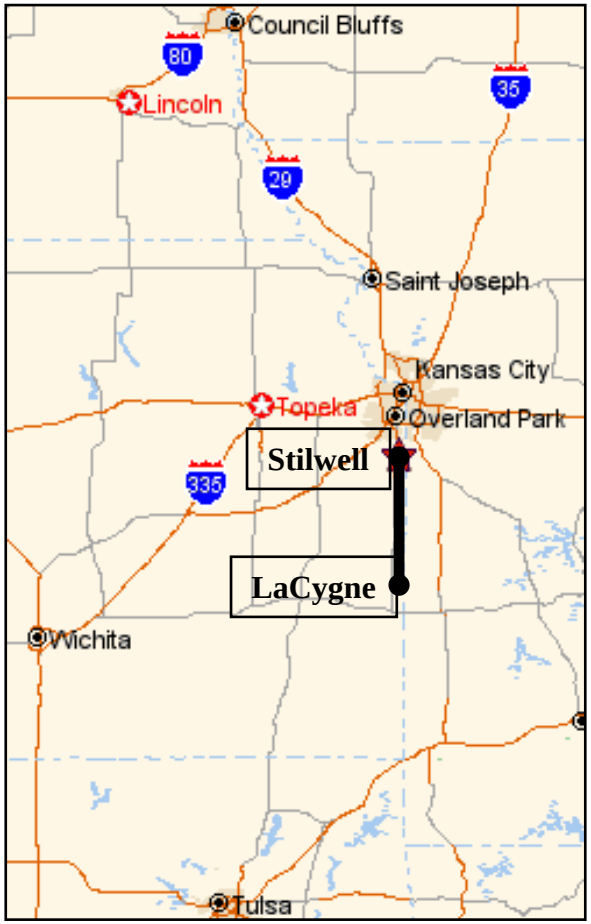
A *Smart* Grid is a *Happy* Grid

Case Studies

- Three Major Utilities
- Same Technology
- Different Applications

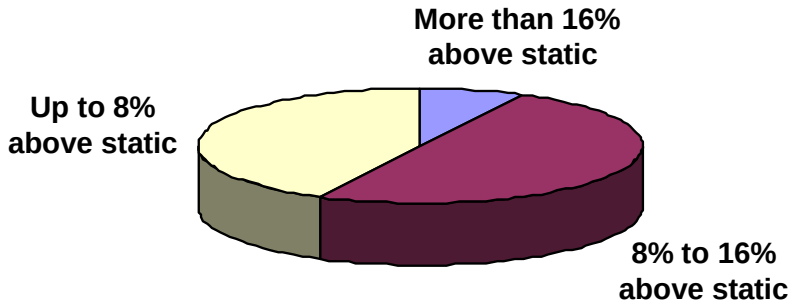
KCP&L – Congestion Relief

- LaCygne-Stilwell Flowgate in Southwest Power Pool
- 345KV, 32 miles
- 1251 MVA static rating
- 1 of top 5 bottlenecks on Central U.S. North-South power corridor
- Access to low cost power limited by the LaCygne-Stilwell flowgate
  - Summer – Lower cost power in North flows to South to meet cooling demand
  - Winter – Lower cost power in South flows to North to meet heating demand



KCP&L – Congestion Relief

- Line was operated above static limit for **167 hours** late June to early September**:**



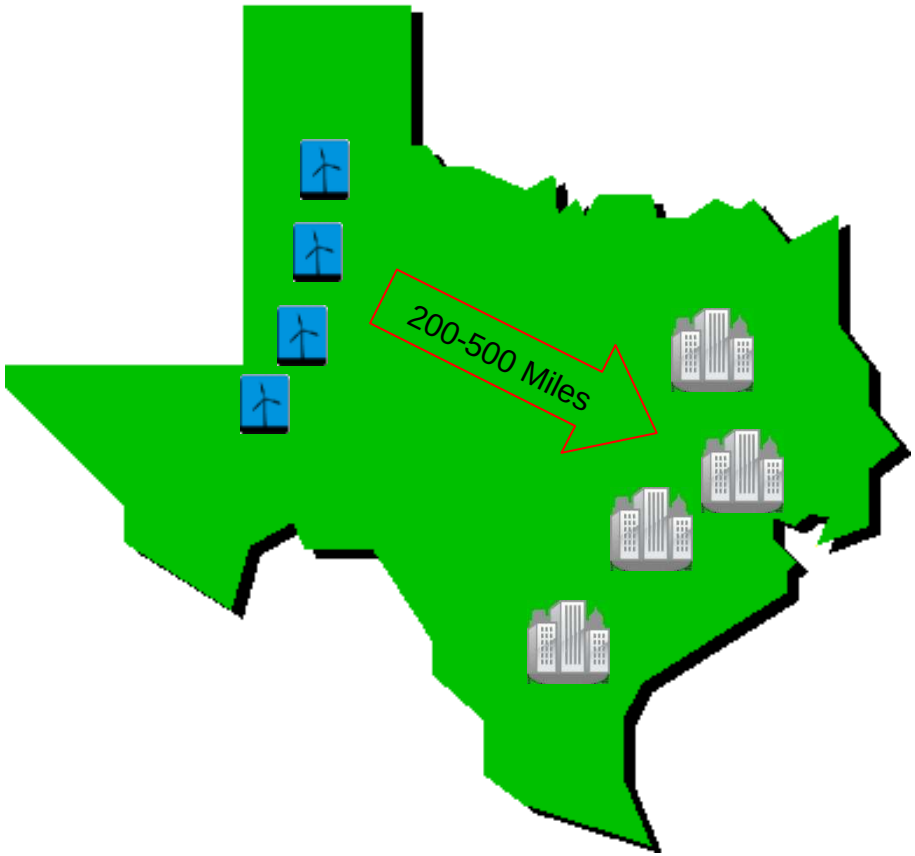
- KCPL avoided "a significant amount" of energy redispatch
- Calculated less than 3-month payback for total installed cost
  - Acquisition, installation and calibration
  - Engineering project management
  - Field verification of readings

KCP&L – Congestion Relief

- Before installation of real time ratings
  - Firm and Non-firm power contracts were curtailed by the flowgate's constraint
- After installation of real time ratings
  - No curtailment of firm power contracts; increased capacity for non-firm contracts
  - Least cost power delivered to consumers

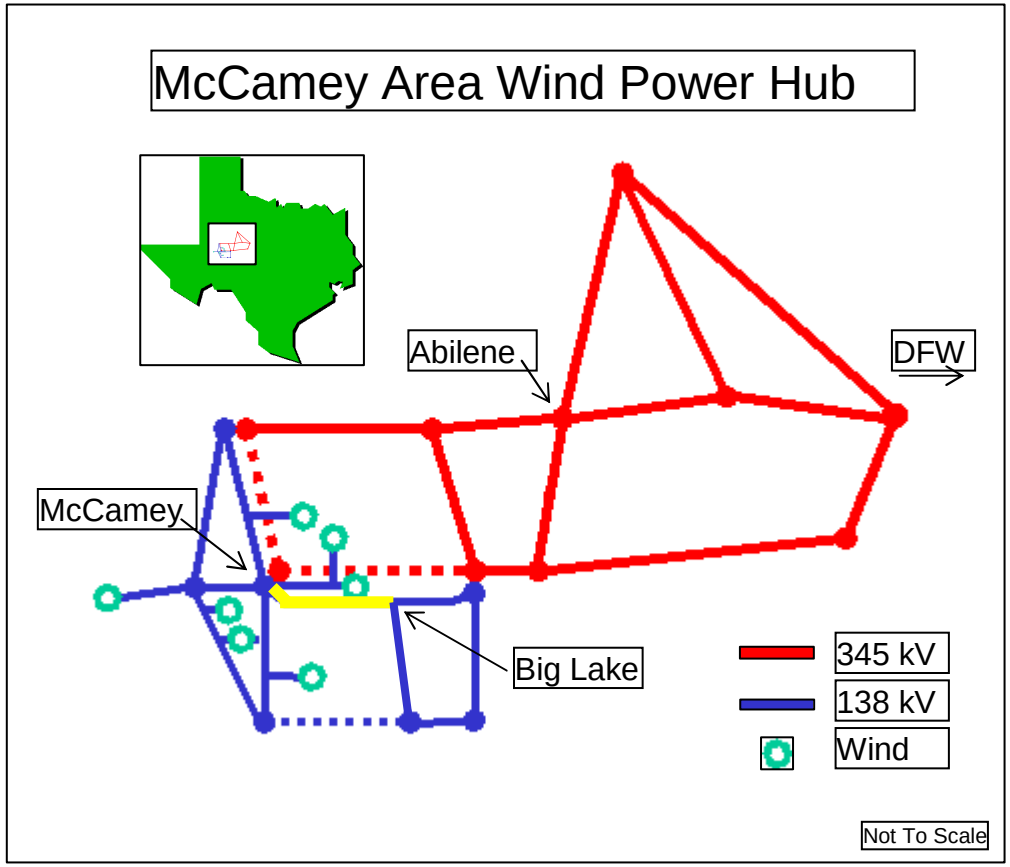
AEP West
Wind Farm Integration

- The best wind is located far from load centers
- Existing transmission capacity is modest in the vicinity of wind farms, and limits the amount of wind power that can be delivered to load centers
- Wind farms are being added faster than transmission lines can be built
- New transmission capacity is planned, but will take years to build



AEP West
Wind Farm Integration

- The power output of several wind farms is concentrated at the McCamey transmission hub
- The amount of wind power that can be delivered to load centers in East Texas is limited by the rating of the 138 kV transmission line from McCamey to Big Lake



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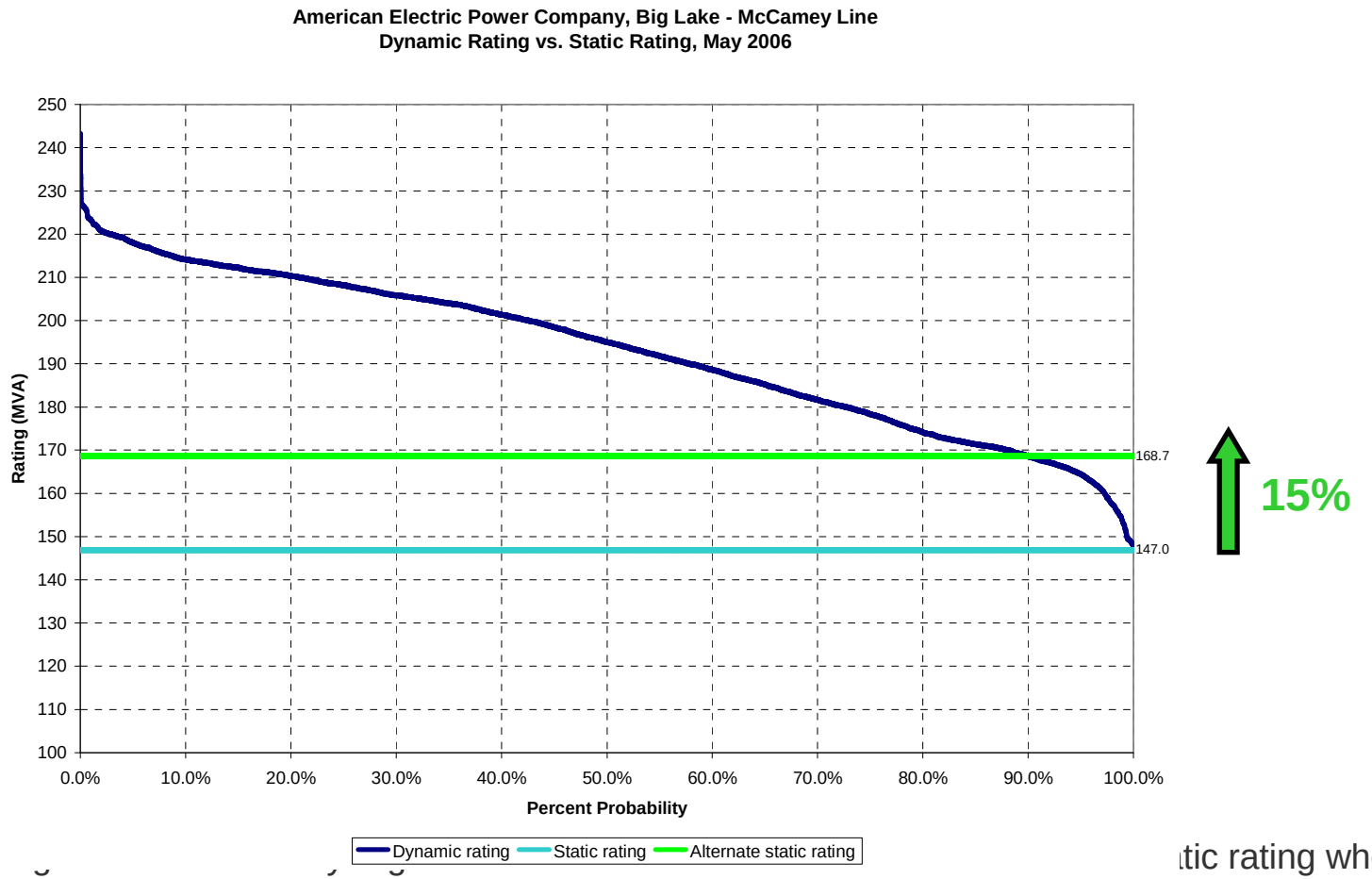


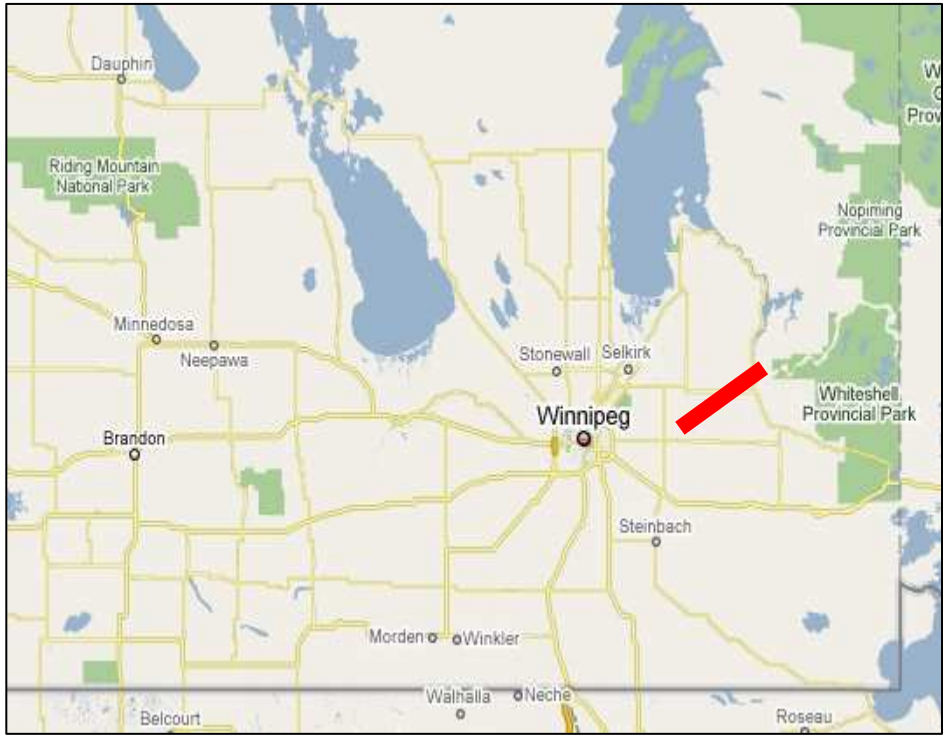
Real time ra tic rating when needed to accommodate wind power

AEP West
Wind Farm Integration

- Real time ratings enabled an immediate 10-15% (minimum) increase in the delivery of wind power over existing transmission assets
  - More renewable energy to market, faster, and at lower cost
  - Maximized use of existing transmission assets
- Real time ratings deferred a physical line upgrade estimated at $20M
  - The line upgrade would be of no use when planned new transmission lines were completed. A stranded asset was avoided.

Manitoba Hydro
Avoiding Curtailment

- Seven Sisters – Vivian Tap (ST6)
- 115 kV, 45 km
- 232 A static rating
- Intermittent loading constraints result in curtailing low cost hydro generation needed to optimize economic dispatch
- Maintenance and capacity upgrades are planned, but not scheduled for years



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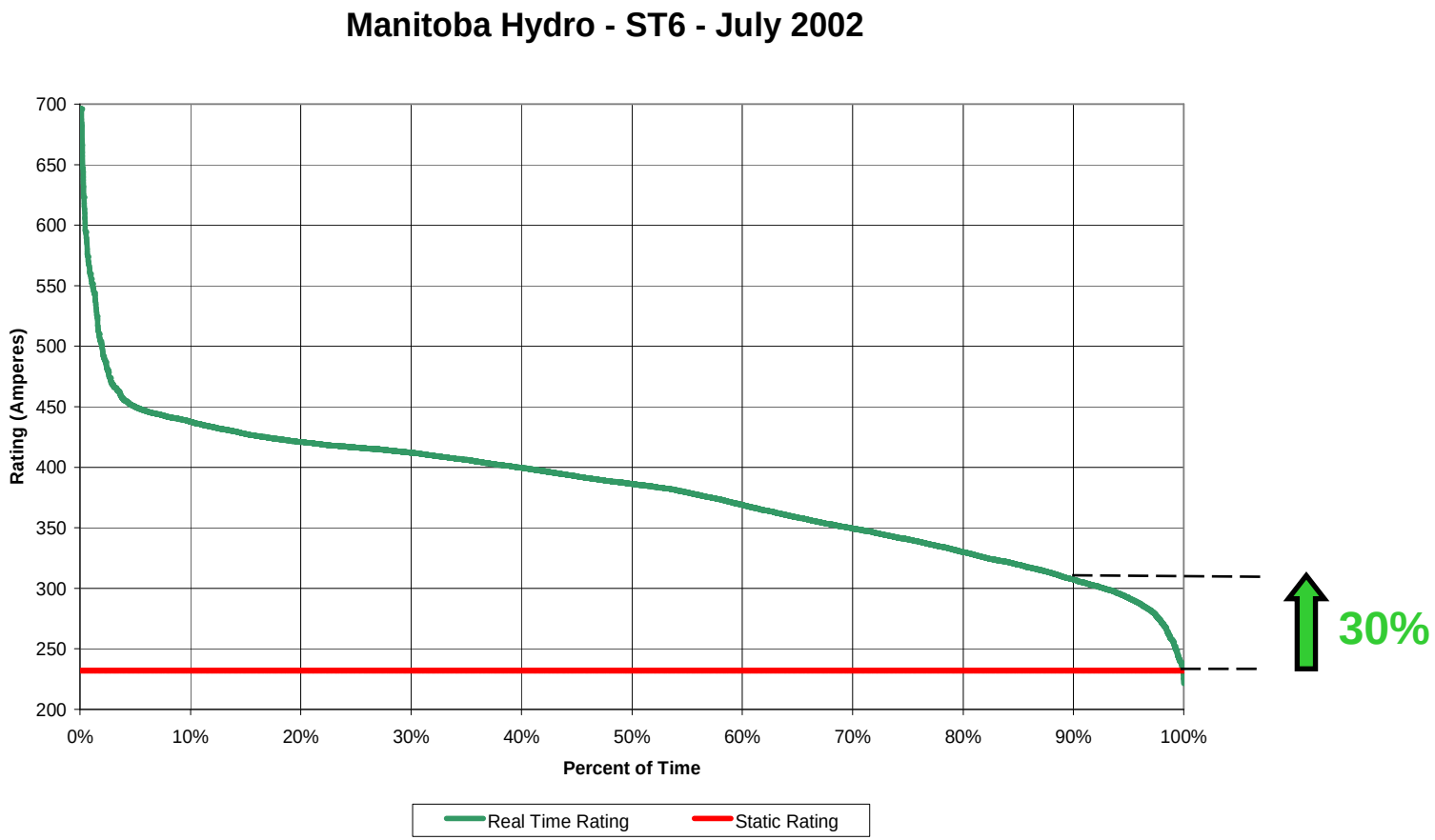

Real time ratings on ST6 are above the static rating 99.9% of the time and 30% above the static rating 90% of the time

Manitoba Hydro
Avoiding Curtailment

- Real time ratings provide access to existing transmission capacity above the static rating
  - Curtailment of hydro generation avoided
  - Lowest cost power delivered to consumers
  - Unnecessary, and potentially reliability threatening, redispatch avoided
- Maximum utilization of the existing transmission asset.
  - Greater ROI
  - Planned upgrades stay on schedule. No artificial and costly acceleration to accommodate unexpected constraints

Additional Information

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