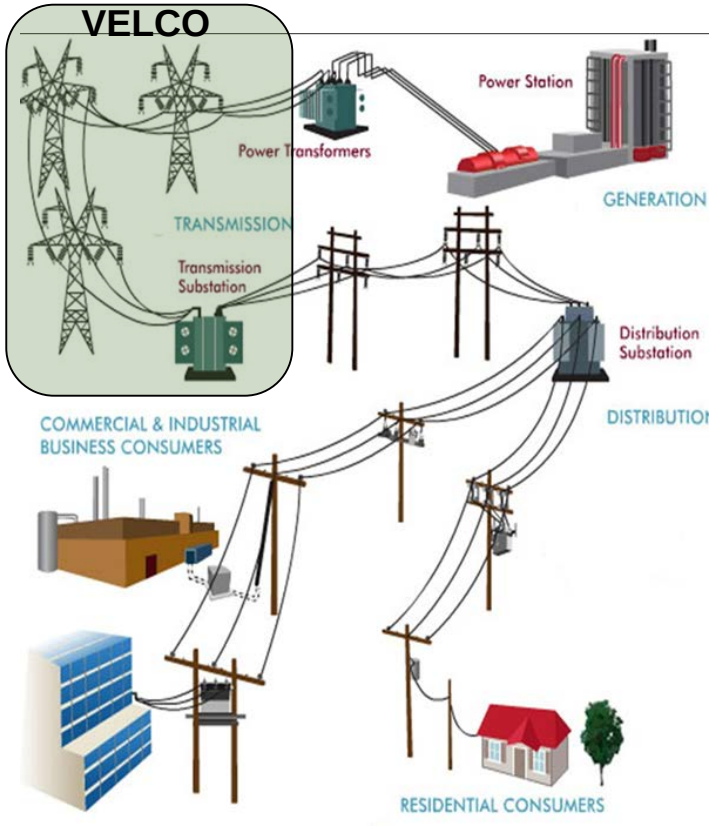
# Utilization of the PI System Data in Transmission System Planning

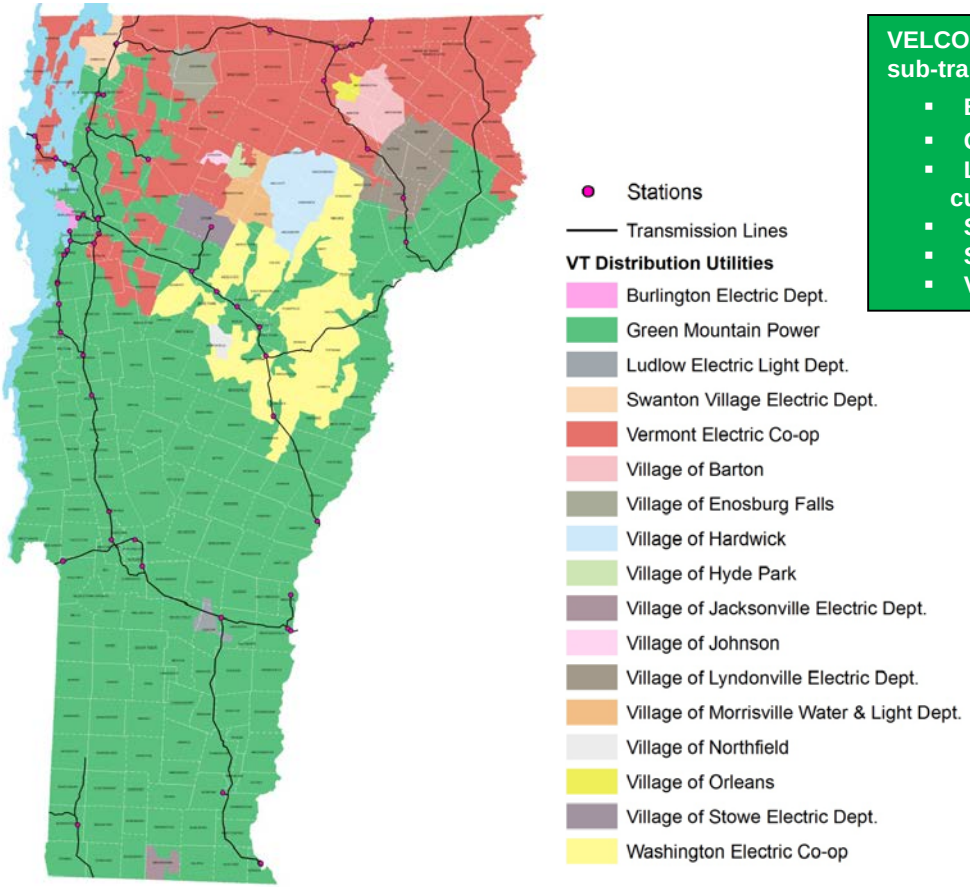

Hantz A. Présumé
Principal Engineer
System Planning

# VELCO Background




- Nation's first statewide, "transmission-only" company formed in 1956 by local utilities
- Owned by Vermont's 17 local utilities and VLITE (public benefits corporation)
- 738 miles of transmission,115 kV, 230 kV, 345 kV, and 450 kV
- 55 substations, switching stations and terminal facilities
- 225 MW HVDC Converter connecting VELCO to Hydro-Québec
- 1 STATCOM, 4 Phase Shift Transformers & 4 Synchronous Condensers
- 1400 miles of looped fiber optic networks

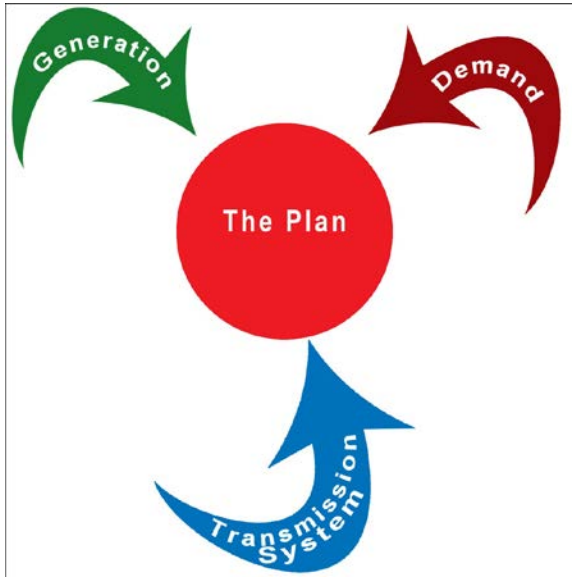
# Vermont distribution utility owners of VELCO




**VELCO substations connect to the sub-transmission systems of…**

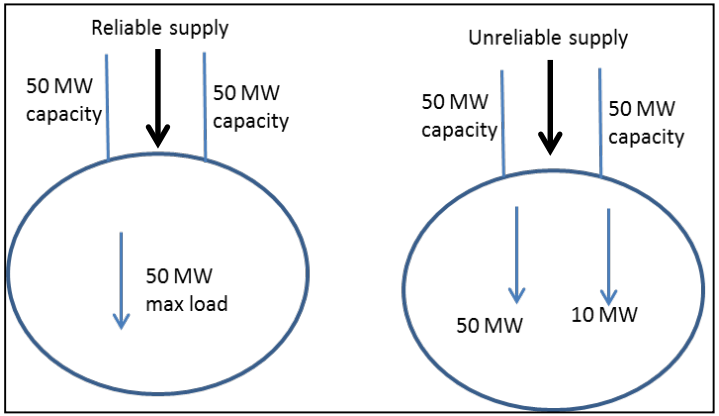
- **BED (20,000 customers)**
- **GMP (254,000 customers)**
- **Lyndonville (5,200 customers)**
- **Swanton (3,500 customers)**
- **Stowe (3,942 customers)**
- **VT Electric Co-op (34,000)**

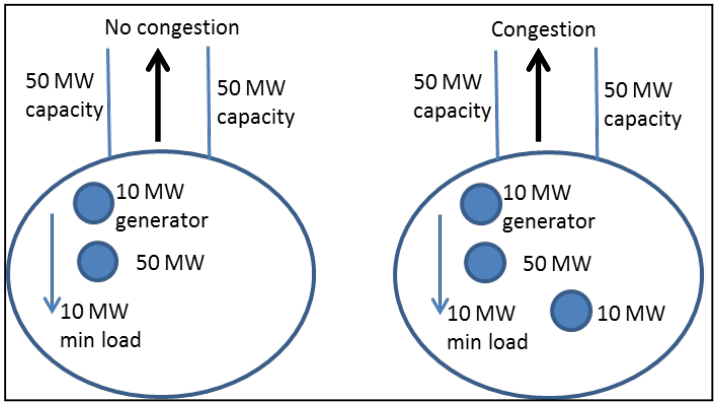
# Transmission planning




- Why prepare a transmission plan
  - Federal requirement to assess the system annually
  - State requirement to file a 20-yr plan every 3 years
  - Society expects a high level of reliability
  - It takes several years to implement a solution
- Assess system performance under a wide-ranging set of operating scenarios varying:
  - Load level
  - Generation output and status
  - Transmission system topology and status
- General steps
  - Agree on system assumptions
  - Model and test scenarios
  - Interpret results and identify system deficiencies
  - Resolve system deficiencies

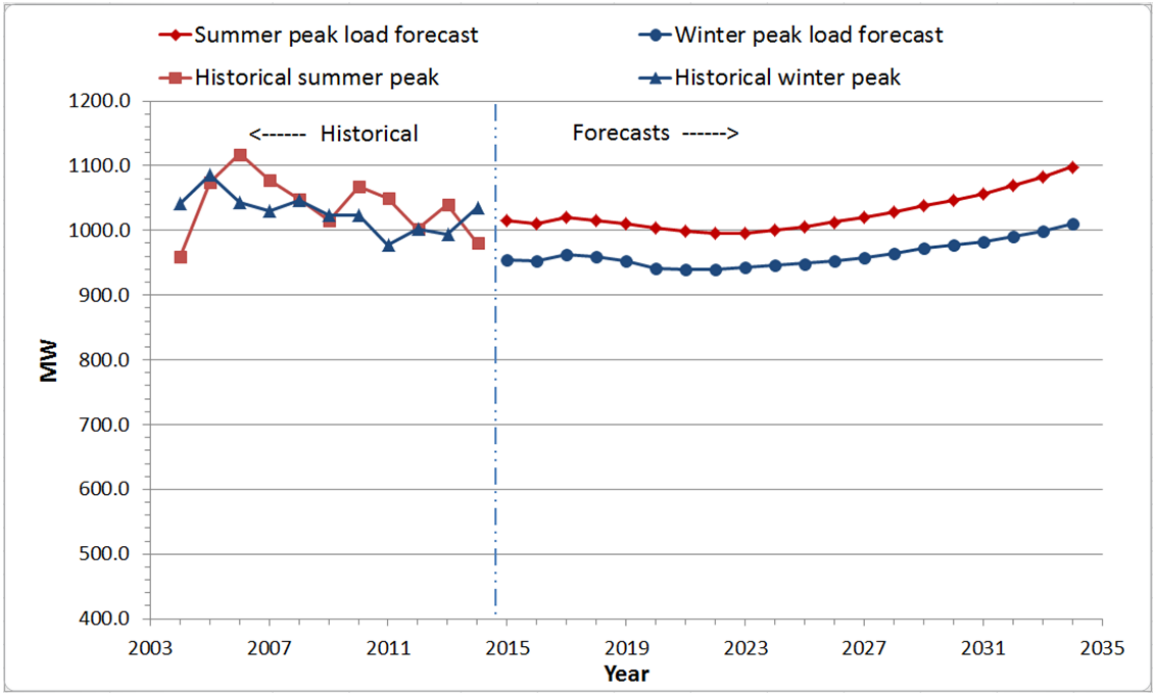
# Simplified examples of transmission planning




- Load serving (Import) problem
  - Transmission solutions
    - Add a third line
    - Upgrade both lines
  - Non-transmission solutions
    - Energy efficiency, voluntary pre-arranged load disconnection (demand response)
    - Add generation
- Generation congestion (Export) problem
  - Transmission solutions
    - Add a third line
    - Upgrade both lines
  - Non-transmission solutions
    - Do nothing – increased competition
    - Storage
    - Control scheme to reduce generation

# Serving load reliably




**The transmission grid is designed to serve maximum demand/load**

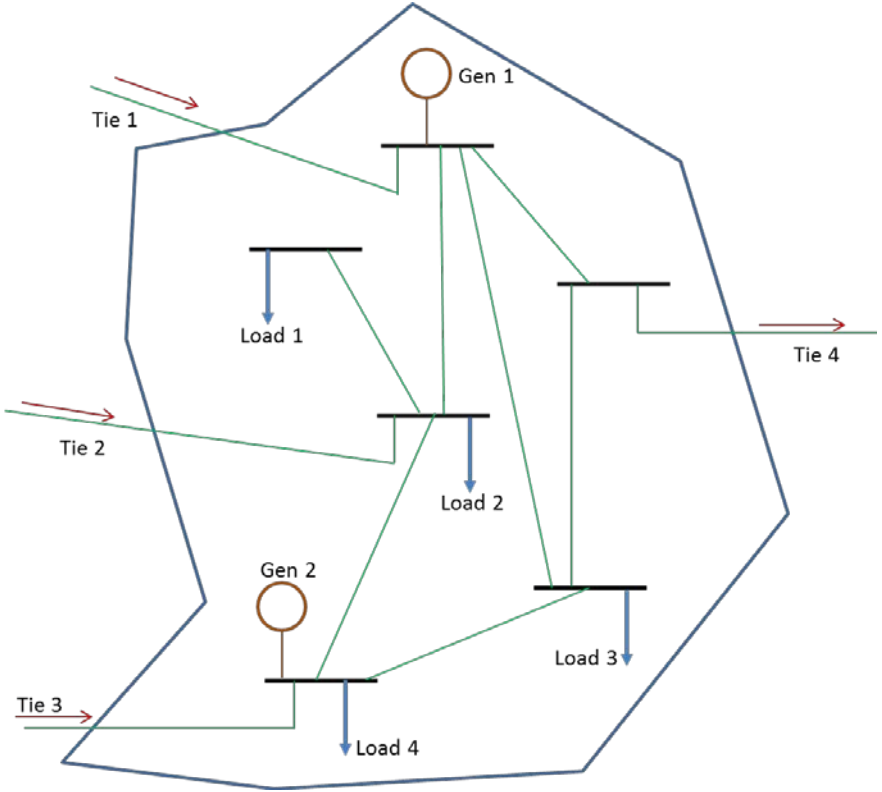
**PI System data analysis helps us understand the characteristics of electric demand**

# Load characteristic is as essential as the amount of load

- The PI System allows us to monitor and understand evolving load behavior
  - Relatively constant versus spiky load curve on the peak day
    - Gives a sense of duration of a potential emergency exposure
    - Affects the type of solution: demand response, peaking generation, energy efficiency, or transmission upgrade
  - Timing of the peak load is in the winter or summer, in the morning, afternoon, or in the evening
    - Affects the type of solution: solar power, efficient lighting
    - Evolution: timing of daily peak demand is occurring later due to solar PV
  - Geographic distribution of the load – allocate total load into zones
    - Understanding which part of the system is growing faster, or behaves differently, e.g. one region peaks in the summer vs. the winter

# Utilizing the PI System to calculate zonal loads

- VELCO has limited access to distribution loads
- Zonal loads are calculated by adding generation located in the zone to the tie line flows into the zone
- Load = Gen1 + Gen2 + Tie1 + Tie2 + Tie3 -Tie4



# Example of load zone calculation

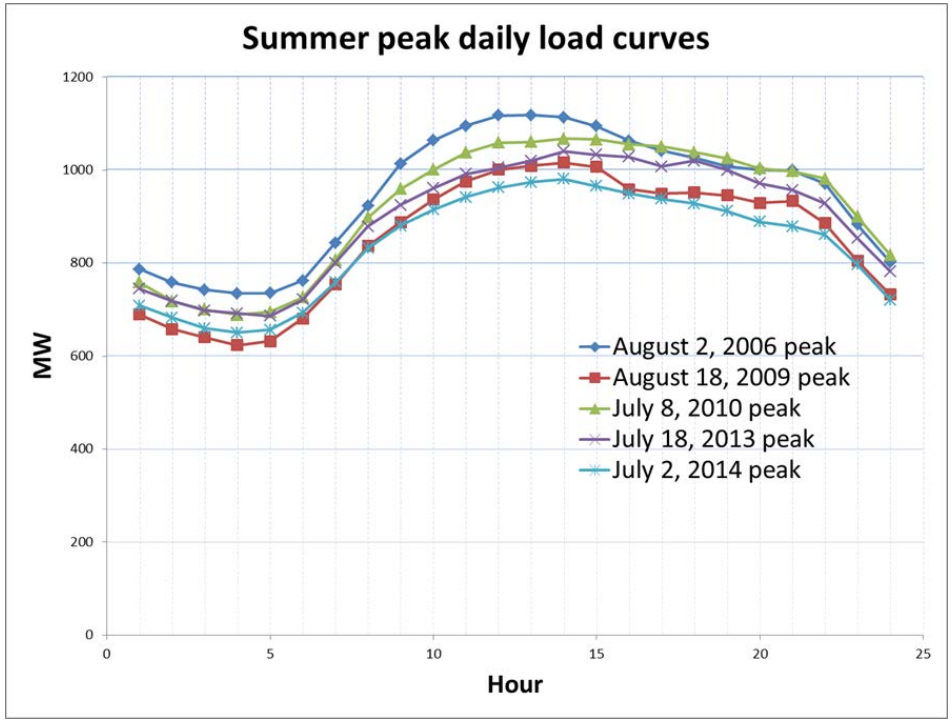
K80819 =(-B80819-C80819-D80819+E80819+F80819+G80819+H80819+I80819+J80819)

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | -A | -A | -A | +A | +A | +A | +A | +A | +A | |
| 2 | **Time Stamp** | Line 1 | Line 2 | Line 3 | Generator 1 | Generator 2 | Generator 3 | Generator 4 | Generator 5 | Generator 6 | **Total** |
| 80819 | 22-Mar-14 09:00:00 | -17.051 | -11.499 | -15.063 | 2.083 | 3.720 | 0 | 0.429 | 9.17 | 0 | **59.02** |
| 80820 | 22-Mar-14 10:00:00 | -18.897 | -12.721 | -16.321 | 2.086 | 3.654 | 0 | 0.183 | 6.92 | 0 | **60.78** |
| 80821 | 22-Mar-14 11:00:00 | -17.315 | -11.719 | -14.797 | 2.089 | 3.648 | 0 | 0.27 | 6.654 | 0 | **56.49** |
| 80822 | 22-Mar-14 12:00:00 | -17.139 | -11.546 | -15.813 | 2.084 | 3.646 | 0 | 0.311 | 9.347 | 0 | **59.89** |
| 80823 | 22-Mar-14 13:00:00 | -16.997 | -11.485 | -15.979 | 2.078 | 3.665 | 0 | 0.19 | 9.3 | 0 | **59.69** |
| 80824 | 22-Mar-14 14:00:00 | -16.550 | -11.196 | -15.723 | 2.079 | 3.727 | 0 | 0.126 | 9.581 | 0 | **58.98** |
| 80825 | 22-Mar-14 15:00:00 | -16.664 | -11.224 | -14.663 | 2.083 | 3.771 | 0 | 0.172 | 9.526 | 0 | **58.10** |
| 80826 | 22-Mar-14 16:00:00 | -16.260 | -10.957 | -13.330 | 2.085 | 4.086 | 0 | 0.174 | 9.529 | 0 | **56.42** |
| 80827 | 22-Mar-14 17:00:00 | -16.172 | -10.996 | -12.766 | 2.086 | 4.076 | 0 | 0.138 | 9.259 | 0 | **55.49** |
| 80828 | 22-Mar-14 18:00:00 | -19.336 | -13.096 | -17.666 | 2.084 | 3.914 | 0 | 0.024 | 4.17 | 0 | **60.29** |
| 80829 | 22-Mar-14 19:00:00 | -18.633 | -12.583 | -15.877 | 2.081 | 3.873 | 0 | 0 | 2.251 | 0 | **55.30** |
| 80830 | 22-Mar-14 20:00:00 | -19.336 | -13.067 | -17.893 | 2.079 | 3.878 | 0 | 0 | 2.687 | 0 | **58.94** |
| 80831 | 22-Mar-14 21:00:00 | -19.776 | -13.184 | -16.714 | 2.077 | 3.886 | 0 | 0 | 1.09 | 0 | **56.73** |
| 80832 | 22-Mar-14 22:00:00 | -18.106 | -12.232 | -15.996 | 2.078 | 3.868 | 0 | 0 | 0.844 | 0 | **53.12** |
| 80833 | 22-Mar-14 23:00:00 | -16.477 | -11.192 | -15.545 | 2.080 | 3.658 | 0 | 0 | 1.999 | 0 | **50.95** |
| 80834 | 23-Mar-14 00:00:00 | -13.219 | -8.936 | -10.490 | 2.019 | 3.642 | 0 | 0 | 4.63 | 0 | **42.94** |
| 80835 | 23-Mar-14 01:00:00 | -12.246 | -8.307 | -9.741 | 1.944 | 3.651 | 0 | 0 | 9.552 | 0 | **45.44** |
| 80836 | 23-Mar-14 02:00:00 | -12.627 | -8.526 | -9.588 | 1.903 | 3.652 | 0 | 0 | 8.134 | 0 | **44.43** |
| 80837 | 23-Mar-14 03:00:00 | -13.757 | -9.317 | -9.600 | 1.867 | 3.649 | 0 | 0 | 6.662 | 0 | **44.85** |
| 80838 | 23-Mar-14 04:00:00 | -14.090 | -9.484 | -10.056 | 1.854 | 3.714 | 0 | 0 | 3.991 | 0 | **43.19** |
| 80839 | 23-Mar-14 05:00:00 | -14.151 | -9.545 | -9.895 | 1.844 | 3.798 | 0 | 0 | 5.99 | 0 | **45.22** |

# Geographic distribution varies over time, by season and load level

| Date and time | Z1 | Z2 | Z3 | Z4 | Z5 | Z6 | Z7 | Z8 | Z9 | Z10 | Z11 | Z12 | Z13 | Z14 | Z15 | Z16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/2/2006 | 133.47 | 81.99 | 77.60 | 104.75 | 21.64 | 41.31 | 181.33 | 69.81 | 67.70 | 104.65 | 26.41 | 16.50 | 64.20 | 45.72 | 36.58 | 32.24 | 1105.91 |
| 7/18/2013 | 122.48 | 78.44 | 71.45 | 98.71 | 23.72 | 37.67 | 168.75 | 64.32 | 60.52 | 90.07 | 32.14 | 12.51 | 63.70 | 38.08 | 35.28 | 27.60 | 1025.43 |
| 9/11/2013 | 105.81 | 67.61 | 60.79 | 86.72 | 19.52 | 33.39 | 149.31 | 59.57 | 56.70 | 78.00 | 30.00 | 11.95 | 58.30 | 37.62 | 32.18 | 25.51 | 912.99 |
| 10/29/2013 | 97.78 | 63.18 | 60.67 | 87.03 | 24.62 | 28.13 | 116.40 | 44.65 | 44.09 | 73.67 | 26.34 | 12.31 | 50.09 | 30.89 | 30.95 | 26.18 | 816.97 |
| 1/2/2014 | 139.60 | 100.99 | 81.37 | 94.64 | 24.68 | 34.87 | 146.21 | 52.25 | 44.69 | 99.51 | 39.68 | 18.67 | 56.19 | 40.08 | 41.70 | 30.73 | 1045.86 |
| 3/3/2014 | 115.57 | 92.96 | 66.09 | 84.22 | 24.96 | 30.28 | 129.06 | 45.44 | 43.95 | 84.06 | 31.05 | 14.65 | 51.87 | 36.19 | 36.07 | 27.58 | 914.00 |
| 5/15/2014 | 83.56 | 69.54 | 48.89 | 62.21 | 26.93 | 25.87 | 106.42 | 42.98 | 51.98 | 71.64 | 23.60 | 10.20 | 47.96 | 30.75 | 26.44 | 20.42 | 749.38 |
| | | | | | | | | | | | | | | | | | |
| 8/2/2006 | 12.07% | 7.41% | 7.02% | 9.47% | 1.96% | 3.74% | 16.40% | 6.31% | 6.12% | 9.46% | 2.39% | 1.49% | 5.80% | 4.13% | 3.31% | 2.92% | 1.00 |
| 7/18/2013 | 11.94% | 7.65% | 6.97% | 9.63% | 2.31% | 3.67% | 16.46% | 6.27% | 5.90% | 8.78% | 3.13% | 1.22% | 6.21% | 3.71% | 3.44% | 2.69% | 1.00 |
| 9/11/2013 | 11.59% | 7.41% | 6.66% | 9.50% | 2.14% | 3.66% | 16.35% | 6.53% | 6.21% | 8.54% | 3.29% | 1.31% | 6.39% | 4.12% | 3.53% | 2.79% | 1.00 |
| 10/29/2013 | 11.97% | 7.73% | 7.43% | 10.65% | 3.01% | 3.44% | 14.25% | 5.47% | 5.40% | 9.02% | 3.22% | 1.51% | 6.13% | 3.78% | 3.79% | 3.20% | 1.00 |
| 1/2/2014 | 13.35% | 9.66% | 7.78% | 9.05% | 2.36% | 3.33% | 13.98% | 5.00% | 4.27% | 9.51% | 3.79% | 1.78% | 5.37% | 3.83% | 3.99% | 2.94% | 1.00 |
| 3/3/2014 | 12.64% | 10.17% | 7.23% | 9.21% | 2.73% | 3.31% | 14.12% | 4.97% | 4.81% | 9.20% | 3.40% | 1.60% | 5.67% | 3.96% | 3.95% | 3.02% | 1.00 |
| 5/15/2014 | 11.15% | 9.28% | 6.52% | 8.30% | 3.59% | 3.45% | 14.20% | 5.74% | 6.94% | 9.56% | 3.15% | 1.36% | 6.40% | 4.10% | 3.53% | 2.72% | 1.00 |

# Reviewing PI System data to monitor the rapidly evolving system




The transmission grid is undergoing a profound transformation

- Renewable energy
- Smart grid

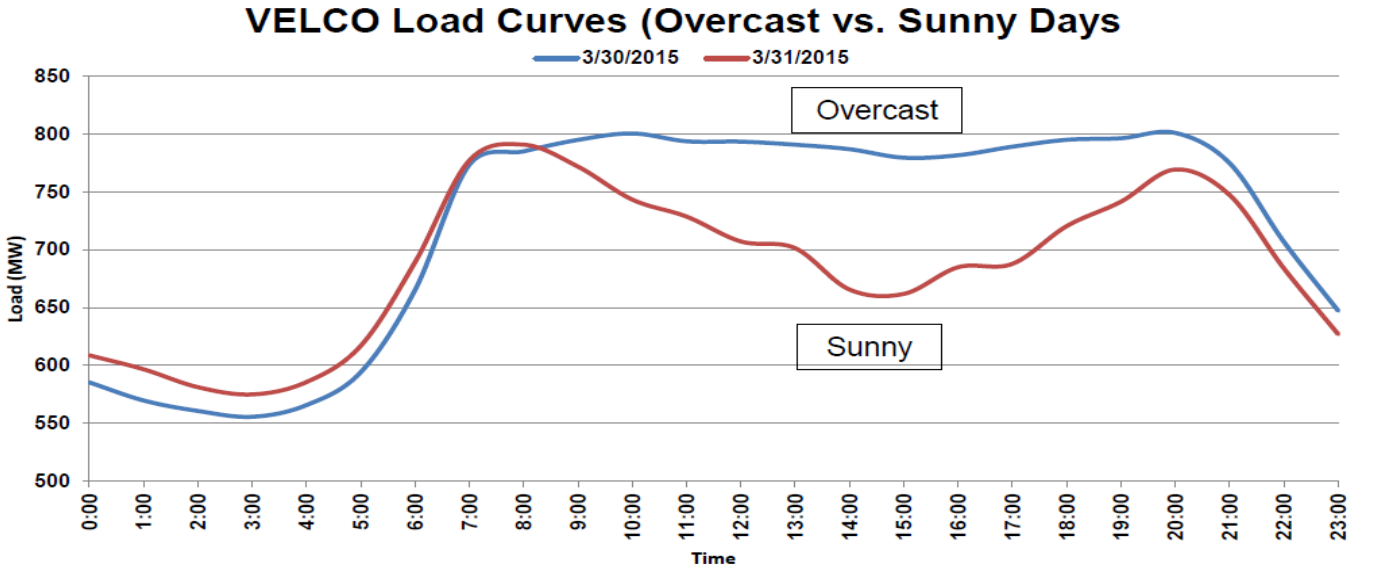
PI System data analysis helps us adjust our study assumptions as the system evolves

# VELCO Load Curve Study

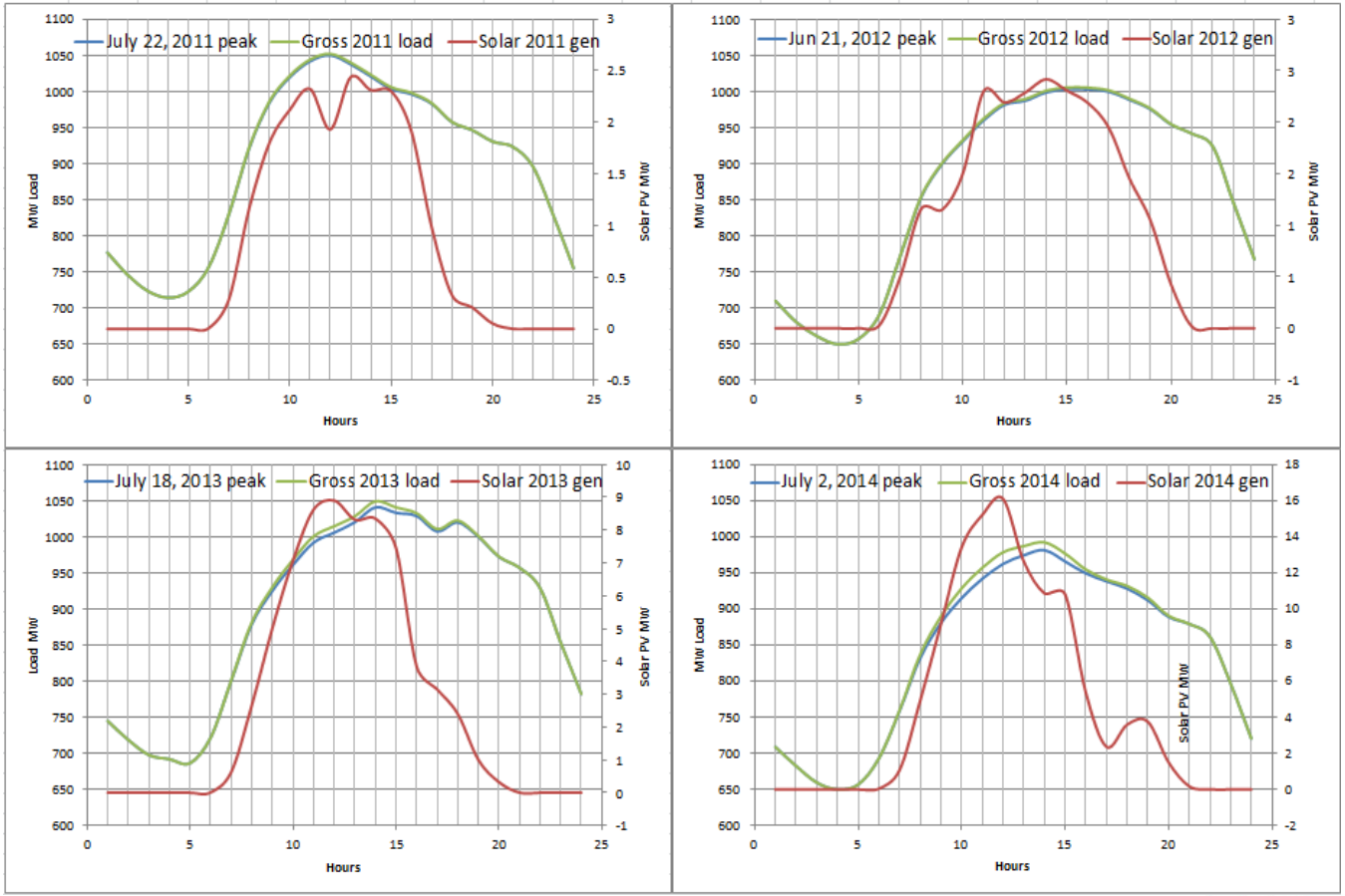
## Case #1

Increase of solar generation “behind the meter” is offsetting VELCO demand curve

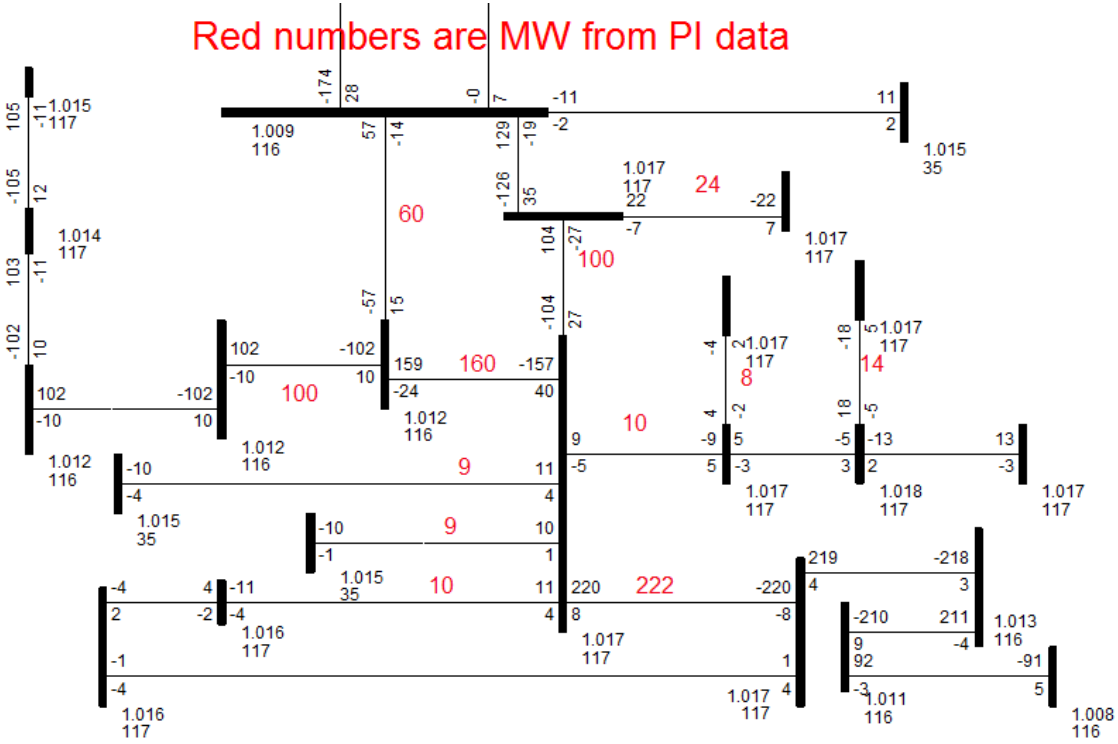
| | 3/30/2015 | 3/31/2015 |
|---|---|---|
| Cloud Cover | Overcast | Sunny |
| High/Low (°F) | 41/26 | 42/24 |
| Max Radiation (w/m^2) | 241 | 965 |



# Solar generation is reducing the summer peak

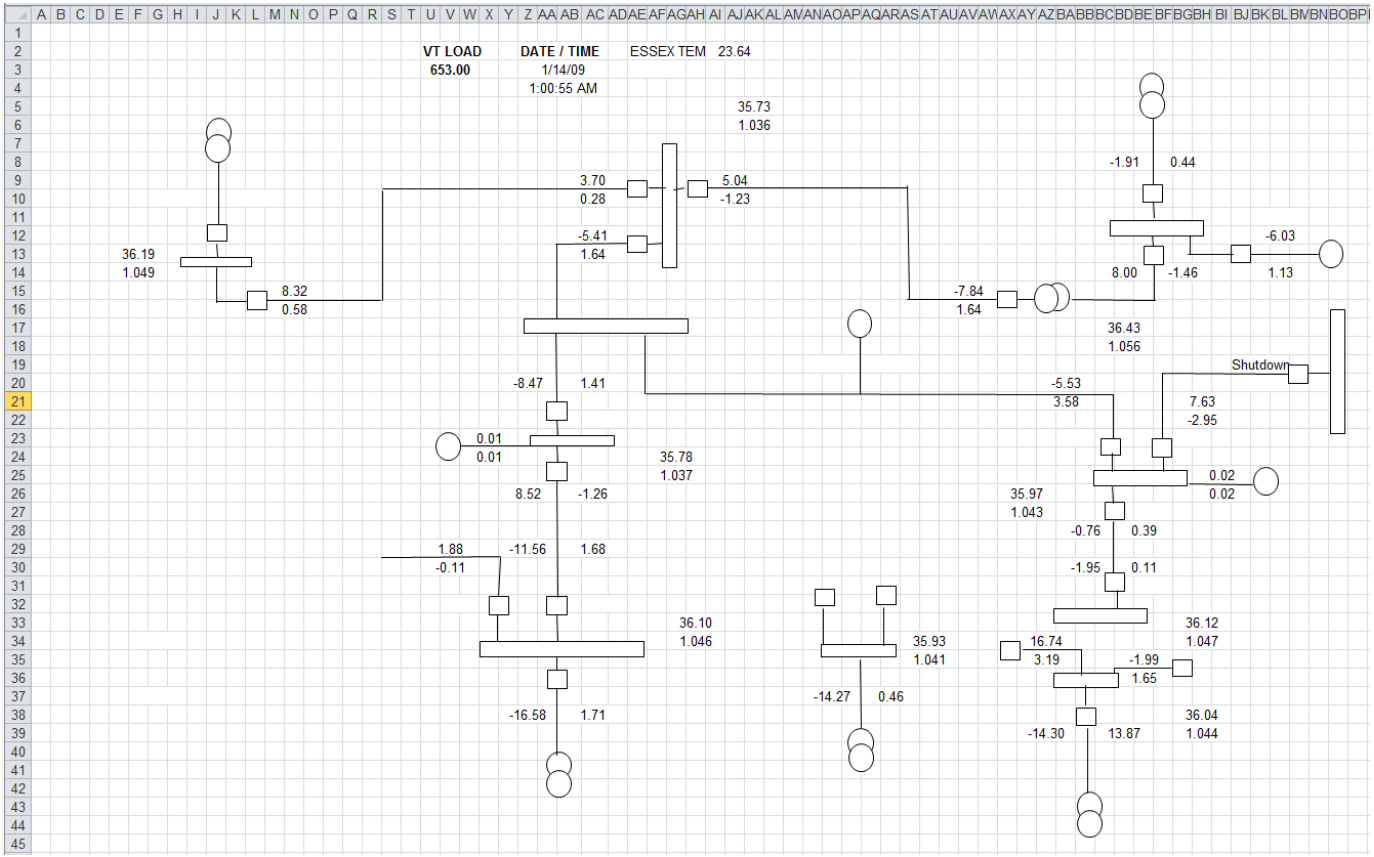


# Model accuracy is critical

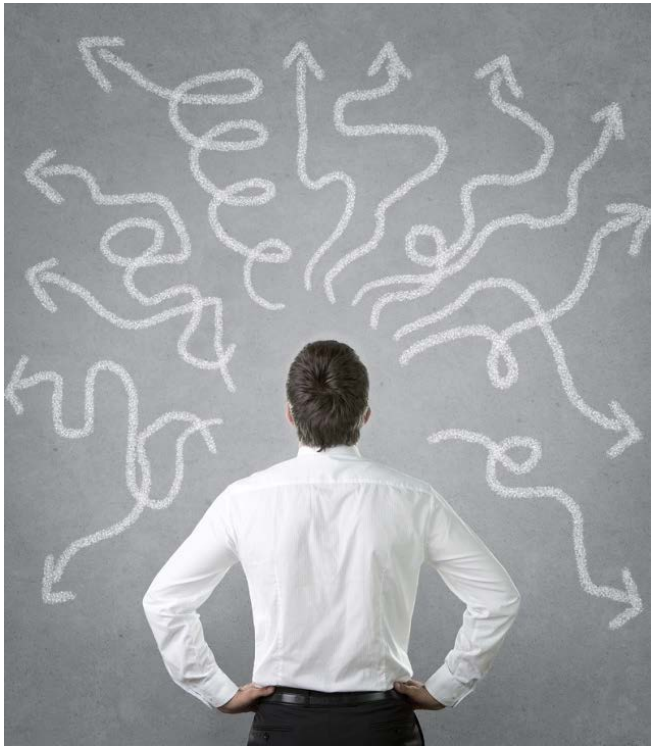



- The model includes tens of thousands of generators, loads, lines and other equipment
- Many opportunities for errors
- PI System data analysis to compare the computer results to system measurements

# PI System snapshot can be displayed in an Excel diagram



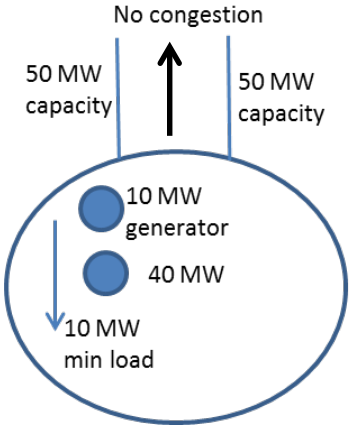
# The right solution is not always obvious

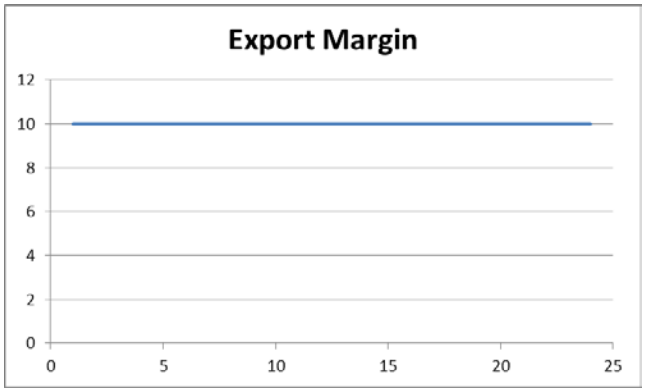


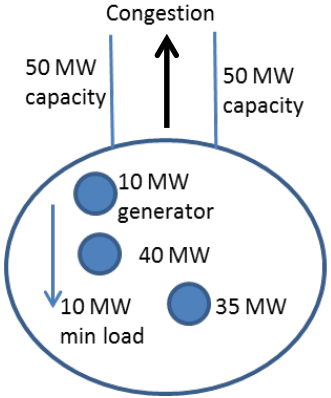
Selecting the preferred option involves weighing tradeoffs

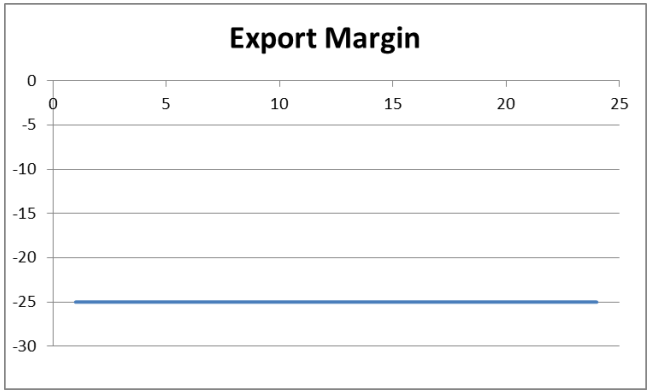
PI System data analysis  can help us select the most appropriate solution

# Simplified example of an export constraint



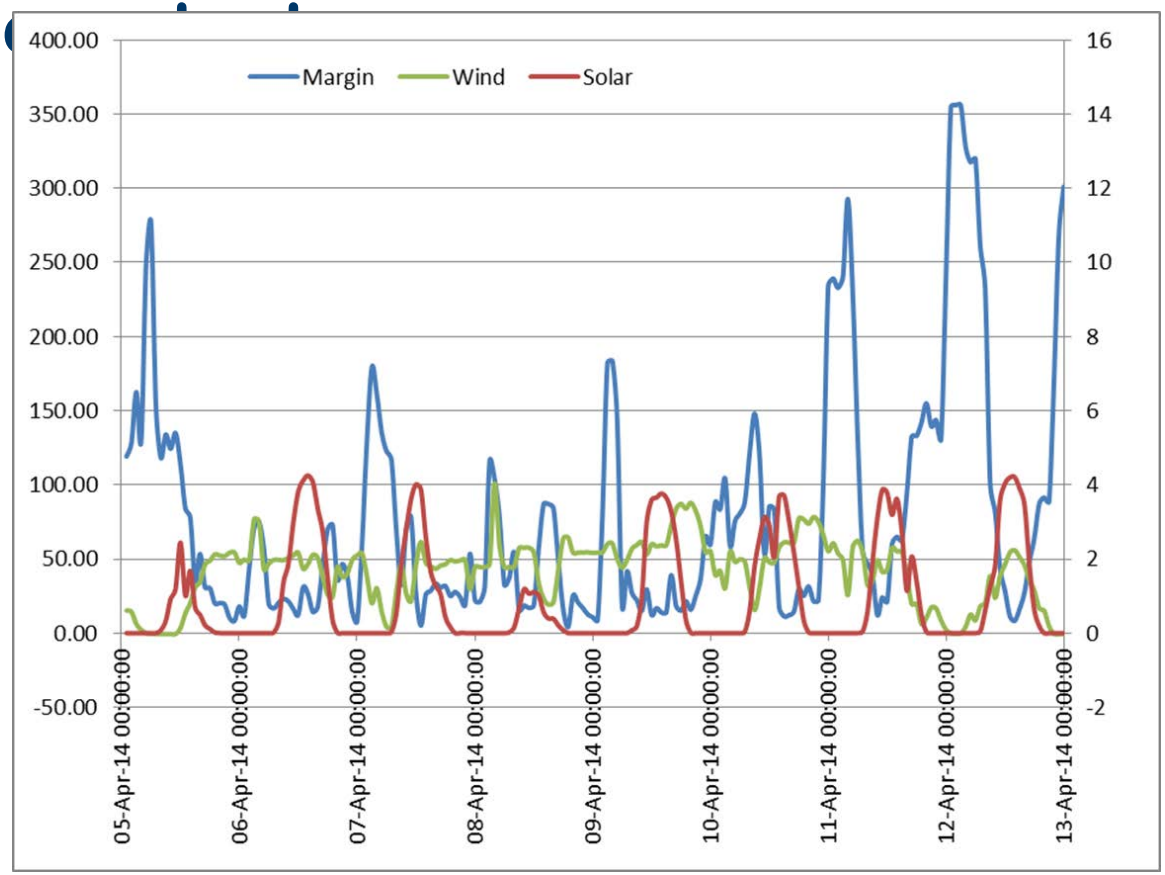



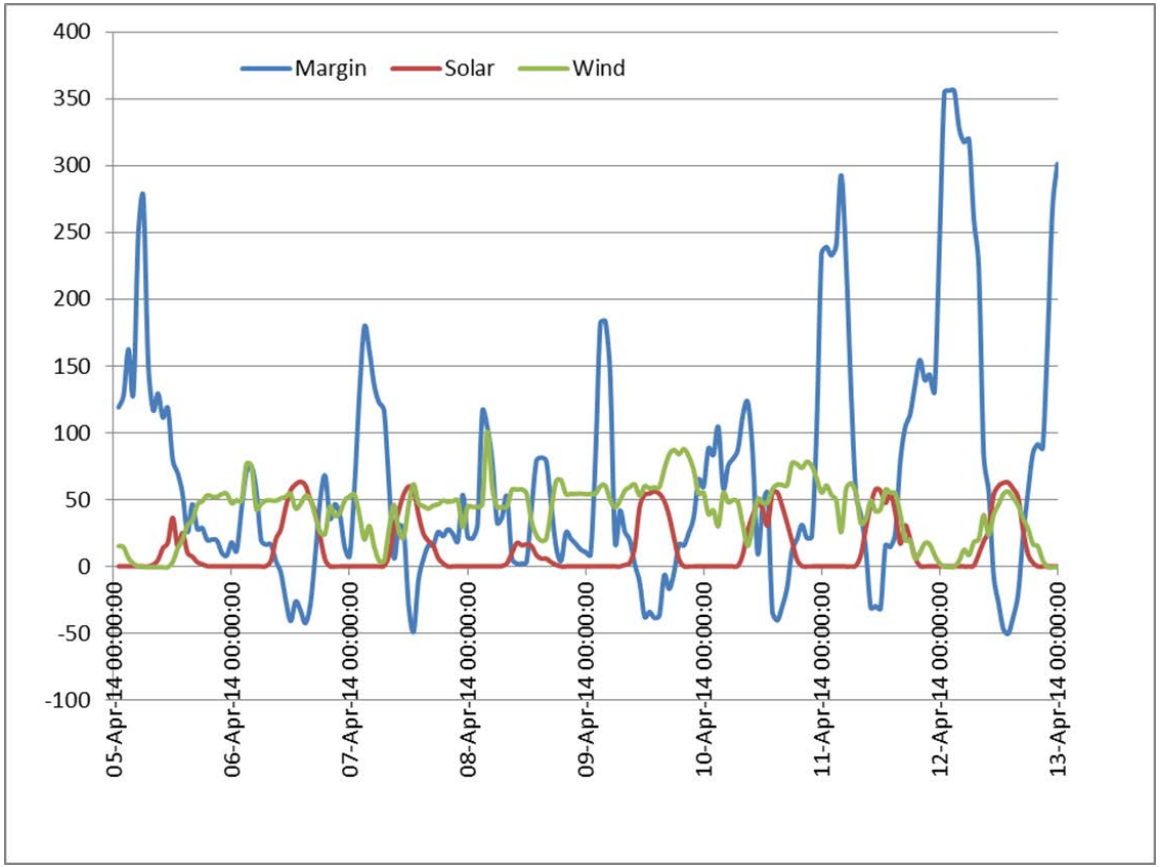

- Assumptions
  - Load is constant
  - Generation is constant
  - The constraint is due to line capacity only
- Export problem
  - Generation is always restricted
  - Transmission solutions
    - Add a third line
    - Upgrade both lines

# PI System data show that the export margin is not




- Reality
  - Load is not constant
  - Generation is not constant
  - The constraint itself can vary based on several factors

# Spreadsheet what-if analysis: Added 60MW Solar




- Scaled existing solar generation by 60 MW
- Negative margin is the estimated amount of additional curtailment of generation
  - Nearly daily occurrence
  - Exposure estimated to be about 10% of the time
- The solution may be other than transmission, ~ $80M for a 20-mi line
- A less costly option may exist
  - Restriction, ~ $XM / year
  - Storage
  - Hybrid solution

# Next Steps

- Upgrade to PI Server 2015
  - Look into Future Data storage for peak load forecast data
  - Look into Asset Analytics to automate the load calculations and move away from using a spreadsheet
  - Look into PI Notifications to receive real-time alerts in case of failure events (or near-failure events)



20

# PI System improves transmission planning

## COMPANY and GOAL

VELCO is Vermont's transmission-only utility. Its functions include:

Plan, design, operate, maintain, and construct the transmission system in a cost-effective manner

vermont electric power company VELCO

## CHALLENGE

Design a reliable system in the midst of an evolving regulatory, public policy and market environment.

- Forecast load while accounting for future effects of efficiency spending, renewable energy goals
- Check model for unknown changes
- Account for intermittent generation

## SOLUTION

Review PI System data more frequently to detect trends in system behavior, and adjust study approaches.

- Compare real time system events against computer simulations
- Review the same type of data regularly over time
- Look for new ways of analyzing data

## RESULTS

Realistic system model.

Methods evolving with system.

Cost-effective solutions.

- The PI System is a window into the real system
- Transmission upgrades can be very costly
- Better models and methods result in more cost-effective solutions

# Contact Information

**Hantz A. Présumé**
hpresume@velco.com
Principal Planning Engineer
VELCO

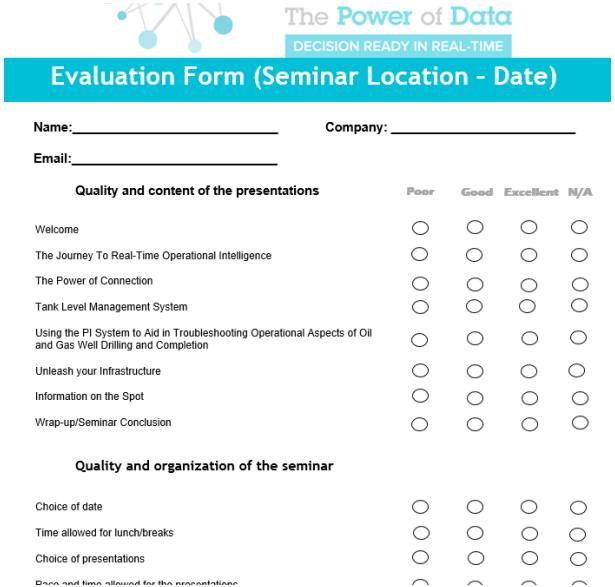
# Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

# Please don't forget to…

Complete the Survey for this session



The Power of Data

DECISION READY IN REAL-TIME

**Evaluation Form (Seminar Location - Date)**

Name:_____ Company: _____

Email:_____

| Quality and content of the presentations | Poor | Good | Excellent | N/A |
|---|---|---|---|---|
| Welcome | ○ | ○ | ○ | ○ |
| The Journey To Real-Time Operational Intelligence | ○ | ○ | ○ | ○ |
| The Power of Connection | ○ | ○ | ○ | ○ |
| Tank Level Management System | ○ | ○ | ○ | ○ |
| Using the PI System to Aid in Troubleshooting Operational Aspects of Oil and Gas Well Drilling and Completion | ○ | ○ | ○ | ○ |
| Unleash your Infrastructure | ○ | ○ | ○ | ○ |
| Information on the Spot | ○ | ○ | ○ | ○ |
| Wrap-up/Seminar Conclusion | ○ | ○ | ○ | ○ |

| Quality and organization of the seminar | | | | |
|---|---|---|---|---|
| Choice of date | ○ | ○ | ○ | ○ |
| Time allowed for lunch/breaks | ○ | ○ | ○ | ○ |
| Choice of presentations | ○ | ○ | ○ | ○ |
| Pace and time allowed for the presentations | ○ | ○ | ○ | ○ |

감사합니다

谢谢

Danke

Gracias

Merci

# Thank You

ありがとう

Спасибо

Obrigado