Panel Session: Analysis of High Penetration of PV on Distribution Circuits

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Panel Session
Analysis of High Penetration of PV on Distribution Circuits

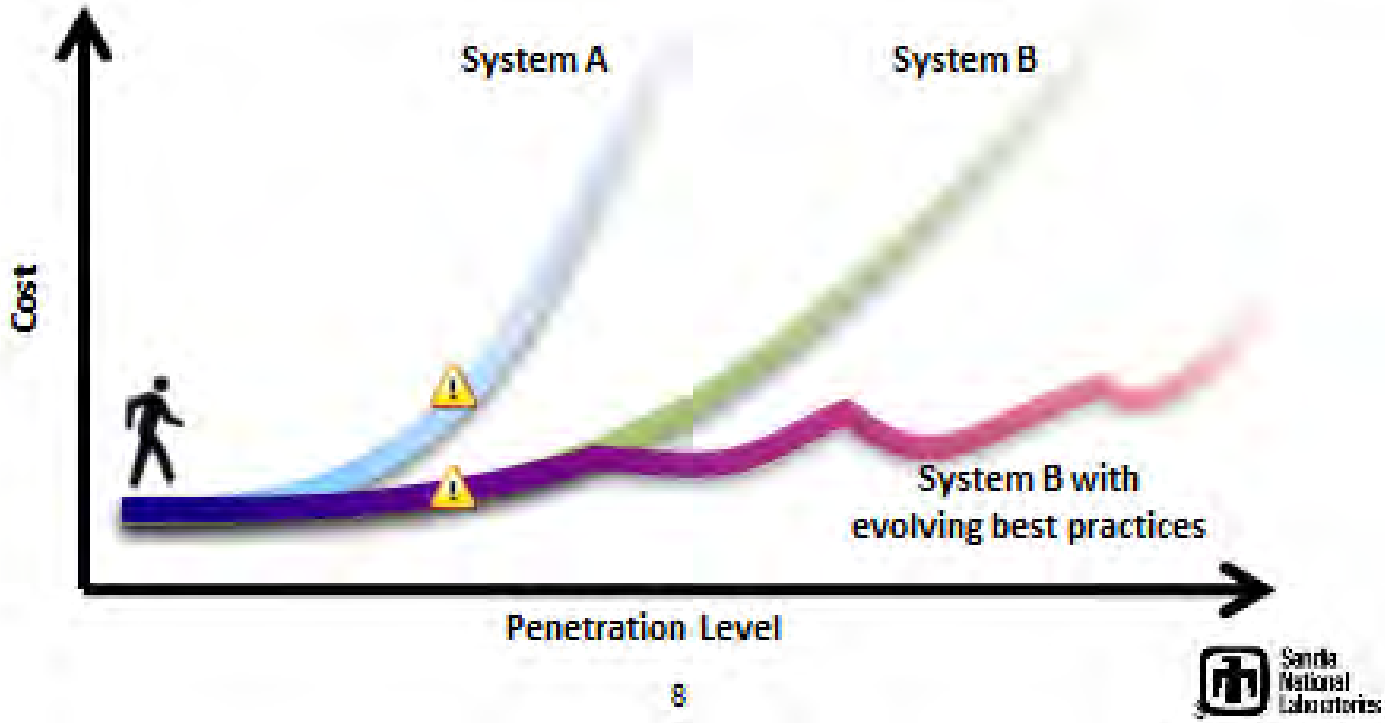
Introduction: Robert Broderick
Dennis Flinn
Greg Shirek
Paul Cote
Q&A/ Discussion

Understanding the effects of a High Penetration of PV

- The accelerating growth of both Centralized and Distributed PV presents numerous challenges.
- Utilities are confronted with an ever increasing number and complexity of PV projects seeking interconnection.
- What methods and tools are utilities, consultants and software companies using and developing to study the effects of High Penetration of PV and overcome the challenges?
- How do we plan for the future and focus our study efforts on those interconnections with the greater risk?

Are There Penetration Limits?

- **There are no <u>absolute</u> technical limits to PV penetration**
  - Cost is the issue, and this is system-specific



Grid Integration Challenge

- Are high penetration scenarios technically feasible?
- What are the impacts and mitigation? What is the cost?
- How should we plan the grid to enable high penetration?

SEPA

High Penetration Workshop
Tucson, Arizona
April 19, 2012

Public Service Company of NM

Paul Cote

Senior Engineer

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Installed PV

- Residential and commercial
  15.4 MW
- Utility Scale
  22.2 MW
- 1.8% of system peak

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PV projects to be evaluated

- Residential and commercial
  34.3 MW
- Utility Scale
  83.0 MW
- Manpower constraints

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Impact Studies

- GL Synergee program
- Use SCADA Min/max day light load
- Assume PV at maximum output
- Voltage impacts
- Equipment loading
- Voltage flicker
- Fault current

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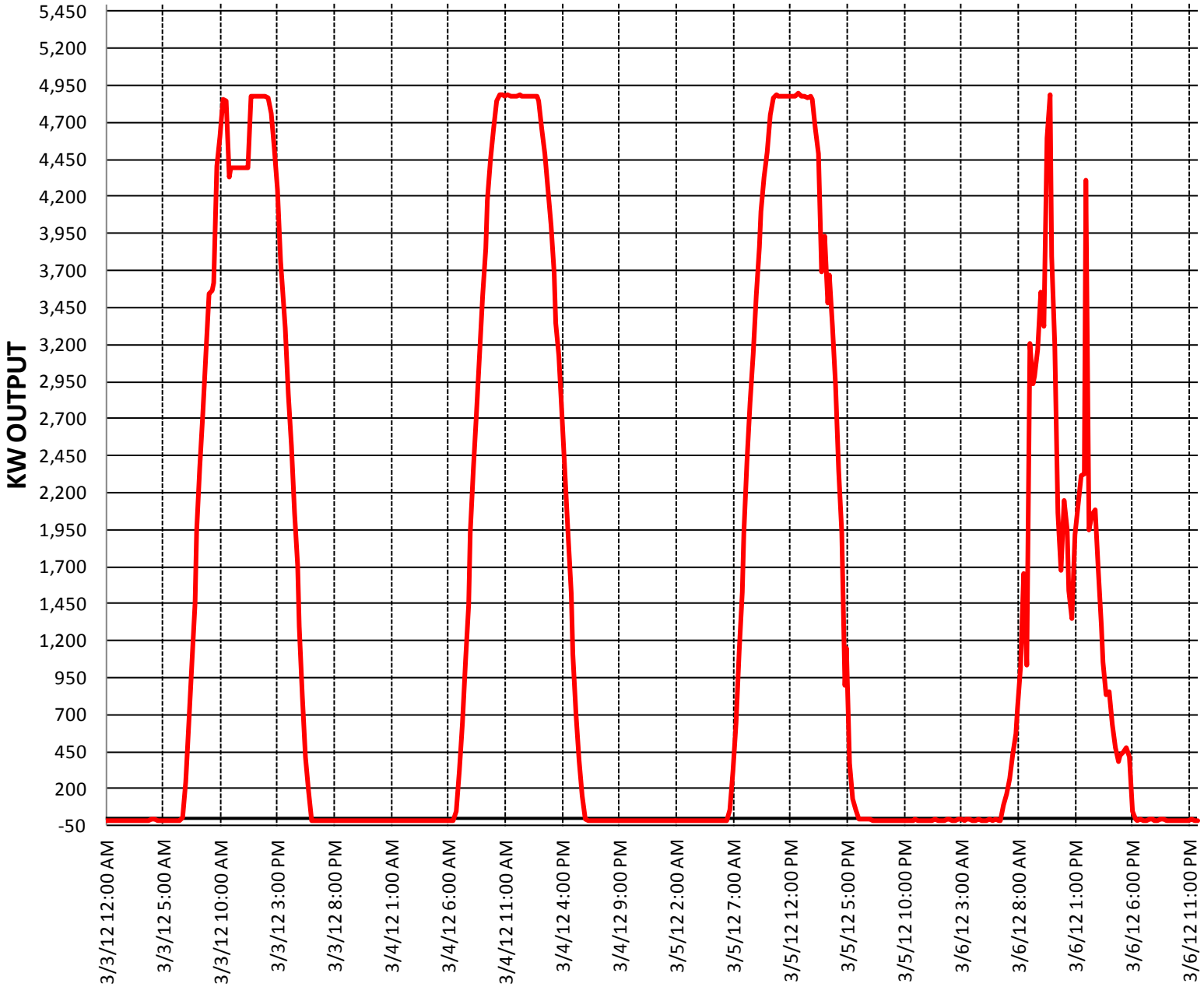
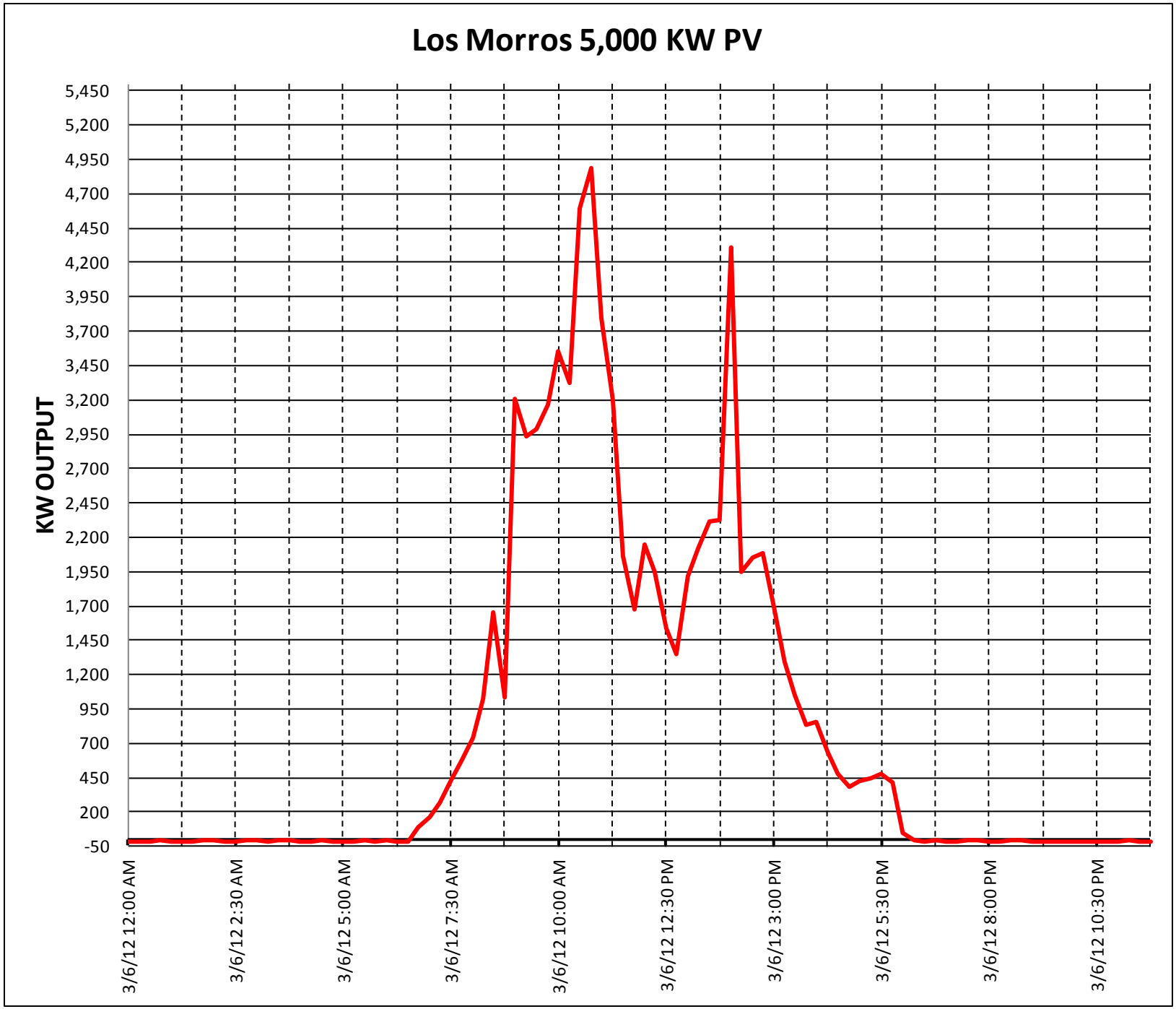
Impact Studies Issues

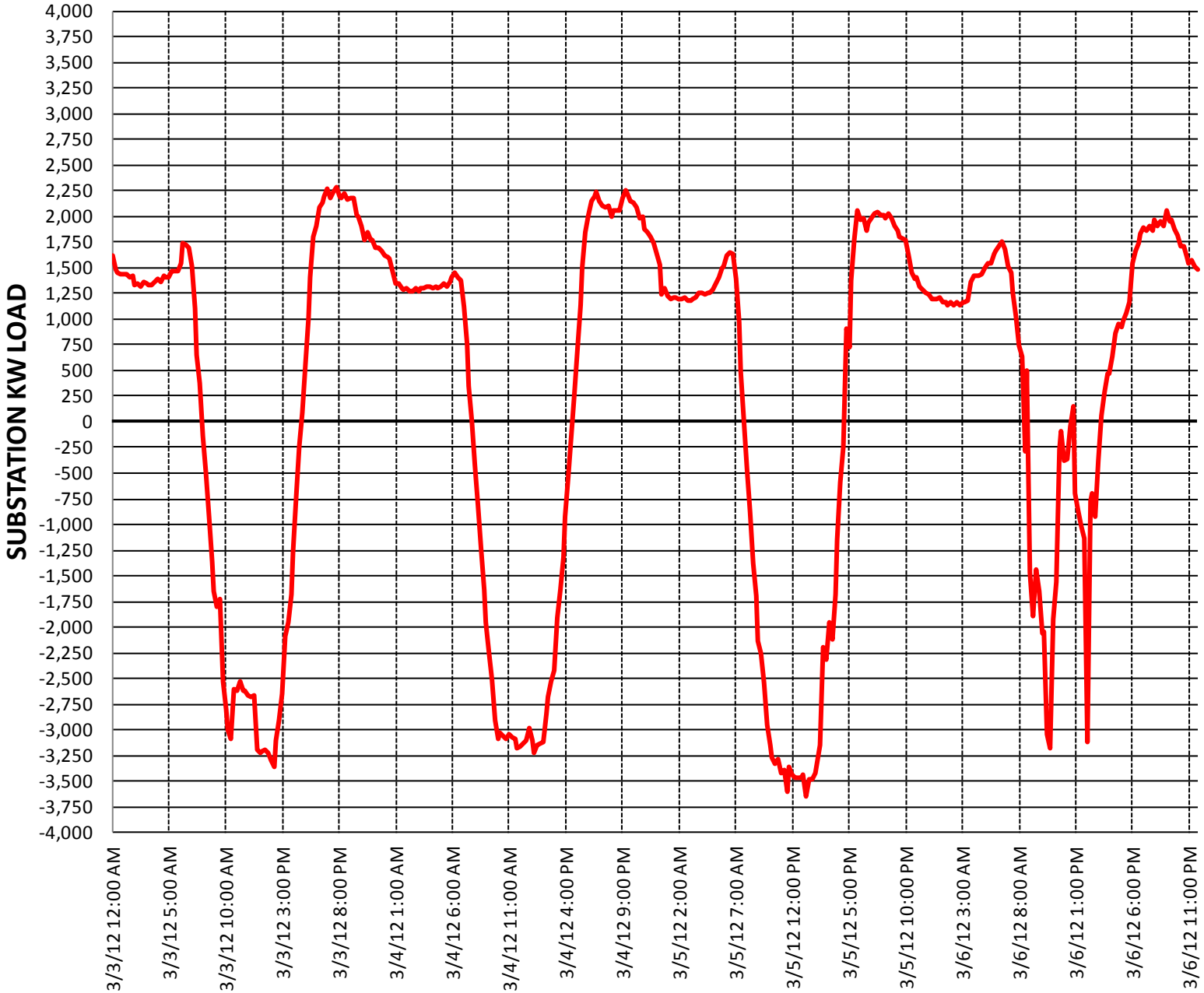
- Synergee does not have an inverter model
- Voltage rise dependent on PV size and distance from substation
- Equipment loading
- Substation LTC
- Voltage regulators
- Switched capacitors

Los Morros 5,000 KW PV

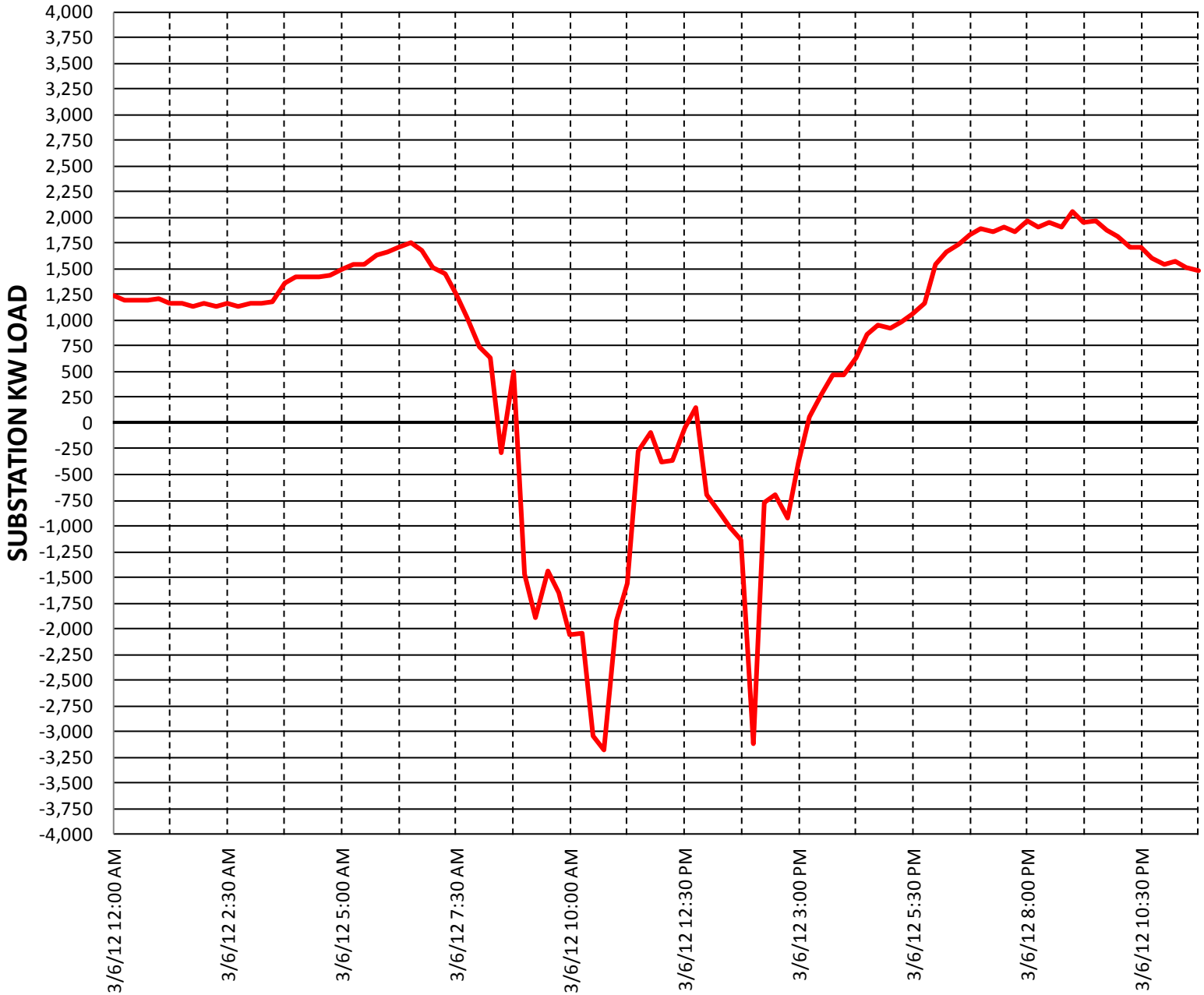


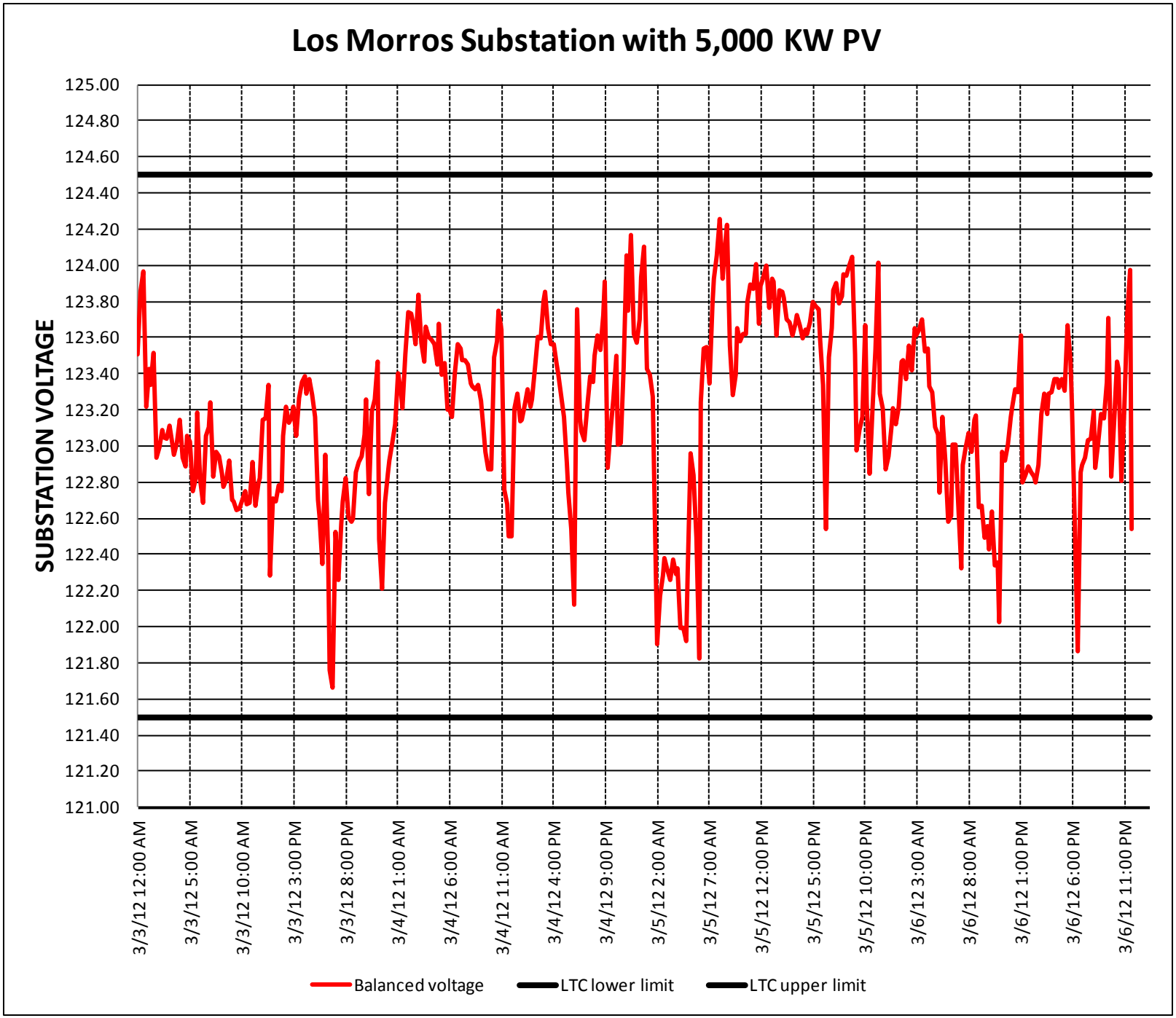

Los Morros 5,000 KW PV
KW OUTPUT
5,450
5,200
4,950
4,700
4,450
4,200
3,950
3,700
3,450
3,200
2,950
2,700
2,450
2,200
1,950
1,700
1,450
1,200
950
700
450
200
-50
3/6/12 12:00 AM
3/6/12 2:30 AM
3/6/12 5:00 AM
3/6/12 7:30 AM
3/6/12 10:00 AM
3/6/12 12:30 PM
3/6/12 3:00 PM
3/6/12 5:30 PM
3/6/12 8:00 PM
3/6/12 10:30 PM

Los Morros Substation with 5,000 KW PV



Los Morros Substation with 5,000 KW PV




Los Morros Substation with 5,000 KW PV
SUBSTATION VOLTAGE
125.00
124.80
124.60
124.40
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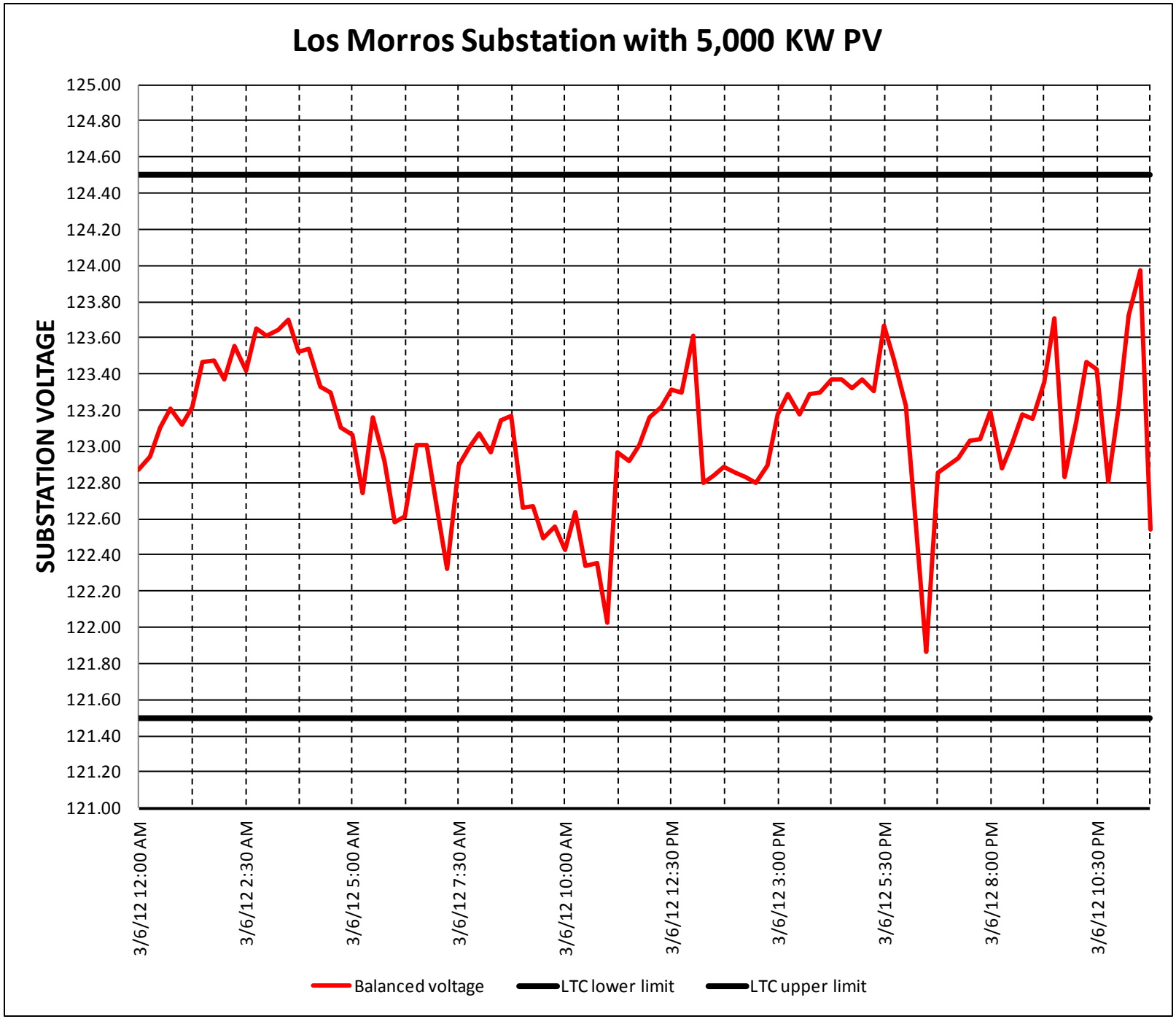
122.80
122.60
122.40
122.20
122.00
121.80
121.60
121.40
121.20
121.00
3/3/12 12:00 AM
3/3/12 5:00 AM
3/3/12 10:00 AM
3/3/12 3:00 PM
3/3/12 8:00 PM
3/4/12 1:00 AM
3/4/12 6:00 AM
3/4/12 11:00 AM
3/4/12 4:00 PM
3/4/12 9:00 PM
3/5/12 2:00 AM
3/5/12 7:00 AM
3/5/12 12:00 PM
3/5/12 5:00 PM
3/5/12 10:00 PM
3/6/12 3:00 AM
3/6/12 8:00 AM
3/6/12 1:00 PM
3/6/12 6:00 PM
3/6/12 11:00 PM
Balanced voltage
LTC lower limit
LTC upper limit


Los Morros Substation with 5,000 KW PV
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121.00
3/6/12 12:00 AM
3/6/12 2:30 AM
3/6/12 5:00 AM
3/6/12 7:30 AM
3/6/12 10:00 AM
3/6/12 12:30 PM
3/6/12 3:00 PM
3/6/12 5:30 PM
3/6/12 8:00 PM
3/6/12 10:30 PM
Balanced voltage
LTC lower limit
LTC upper limit

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Thank you

Questions?

Document number

DNV KEMA Energy & Sustainability
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ETD‘s Services / Products

Global Areas	Strategy & Planning	Power Systems Planning	Design & Engineering	Asset Management & Inspections
Technical Consulting	■ Due diligence ■ Market changes ■ Investment Decision ■ Market simulations ■ Regulatory and cost issues	■ Simulations studies ■ System planning ■ Reactive power studies ■ Protection studies	■ Feasibility studies, tech. comparison ■ Project planning & routing ■ Tender doc. & construction support ■ AC and DC substations, HVDC converter stations	■ Asset management process optimization ■ Condition & LOL assessment ■ Data modelling support ■ Evidence assessment ■ Mitigation plan development ■ Compliance program development ■ Power failure investigations
Smart Grid Offerings	■ Roadmaps ■ Pilot projects ■ Scenarios regarding DG, ES, energy efficiency	■ Analytical tools ■ Evaluate new technologies ■ DG & control ■ Dynamic protection	■ var compensation ■ Dynamic line rating ■ Smart cable guard ■ HVDC converter stations	■ Compliance with standards ■ New maintenance strategies ■ Black start procedures ■ Testing in labs

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PV Grid Integration Challenges

- Model Interaction
  - PV & ES
  - PV & EV
  - High Penetration
- Control Schemes
  - Variability
- Simulation Time Period
  - Years
  - Sub-Second

PV Grid Integration Challenges

- "Dynamic" Voltage Control
  - Outage Condition
  - Cloud Cover Mitigation
    - Short Term
    - Long Term
- Standards (IEEE 1547 & 519)
  - Islanding & Micro-Grids
  - Protection
- Economics

NREL/SEPA
PV Grid Integration Workshop

Greg Shirek, PE
Lead Support Engineer
Milsoft Utility Solutions
Abilene, TX

MILSOFT
Utility Solutions

Milsoft Overview

- *Incorporated in 1989, Headquarters in Abilene, TX*
- *Complete Engineering & Operations Product Line*
  - ***WindMil & LightTable -*** *T&D Circuit Modeling and Engineering Analysis (EA)*
  - ***DisSPatch*** *- Outage Management (OMS) Software*
  - ***Porche –*** *Interactive Voice Response (IVR) Software*
  - ***WindMilMap –*** *T&D Geospatial Information Mapping Software (GIS)*
  - ***Unplugged –*** *Mobile View for trucks, field work*
  - ***Field Engineering*** *– Line Design/Staking Software*
- *Core E&O – Real-Time Centralized Server Database for all E&O applications*
- *Market base – Over 1,200 electric cooperatives, utilities, municipals, consultants, and universities*

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Difficulties/Barriers to Integration Studies

- *IEEE 1547 Series*
  - *Significant barrier to potential PV voltage improvements due to active voltage regulation restriction. Have found utilities simply "accepting" this and not even considering contractual agreements to allow VAR capabilities*
  - *Forcing PV to disconnect during grid faults is cause for extreme voltage deviation after feeder protection device recloses. Recent study resulted in 9 volt drop from full generation to no generation*
  - *IEEE 1547-8 recommended practice will augment future 1547 revisions*
- *Inverters*
  - *Need to continue lab testing for inverter model validation in engineering software*
  - *Limited availability of inverter manufacturers' fault data (however becoming better)*

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Difficulties/Barriers to Integration Studies

- *Distribution Modeling*
  - *Transmission accumulated impedance modeled as lump Zsm limits analysis of reverse power flow impacts on substation transformer/OLTC, and transmission*
  - *How important is correct phasing and phase transposition, does conductor spacing matter, what ZIP model to use for loads?*
  - *How important is triplex and 120/240 Volt secondary modeling for distributed rooftop PV?*
  - *Verify impedance model is accurate. Use SCADA & AMI data for validation*
- *Lack of Irradiance data for Intermittency*
  - *If insolation/weather stations are not nearby planned PV plant location, estimating variability becomes more challenging, direct affect on SVR/Capacitor operations. Recent project resulted in 7 volt change over 30 second time period (unity pf inverter)*

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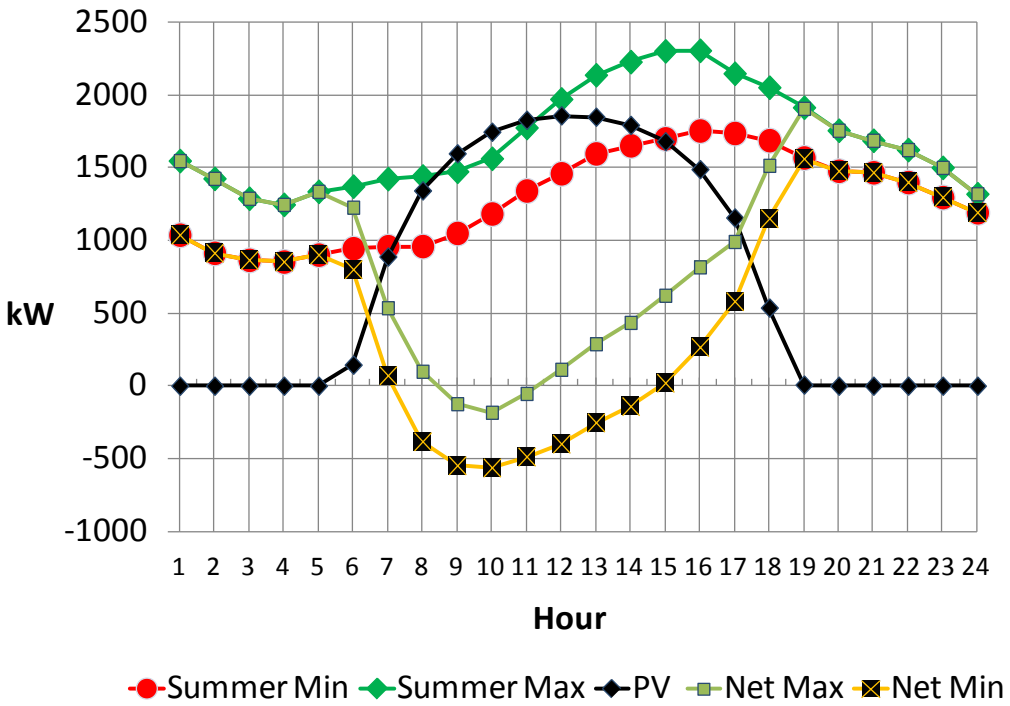
Case Study Summer Load



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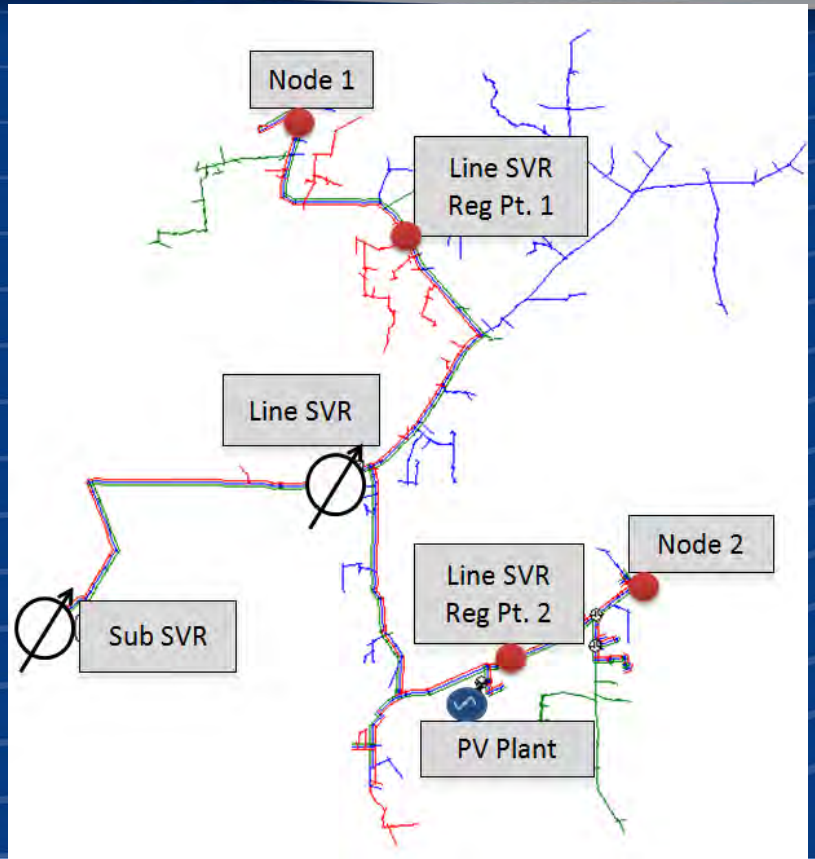
Case Study Feeder



Existing Regulator Settings			
	Sub SVR	Line SVR	Line SVR Reverse
Voltage	122	119	126
LDC R	0	5.7	0
LDC X	0	7.1	0
Time Delay	30	45	45
Bandwidth	2	2	2

Utility Solutions

Development Needs

- *GIS-EA*
  - *Update Conversion Programs to incorporate PV component data transfer between applications (CIM, NRECA MultiSpeak, etc)*
- *"Drag and Drop" from library of inverter manufacturers needs to be incorporated into engineering software*
- *Benchmark PV power flow results between software vendors*
  - *With IEEE DG Test Feeders*
  - *Validate results between all software vendors*
- *Real-Time*
  - *Information from SCADA, AMI and Distribution Photovoltaic monitoring needed to improve system operations and planning for higher penetration in future*
  - *May reduce the urgency for distribution state estimation*

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Development Needs

- *PV Optimization Analysis*
  - *Need capabilities for software to help recommend optimal sites per pre-defined criteria (e.g. PV size, operating mode(s), voltage, capacity, losses, economics, etc.)*
  - *Will help to determine various degrees of penetration levels*
  - *Will help find "Distribution-Ready" percentage levels*
- *Most importantly, need continued training to educate engineers on new tools and standards for high penetration scenarios*

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Thank You

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