NREL
NATIONAL RENEWABLE ENERGY LABORATORY






Solar Eclipse – How did we do?

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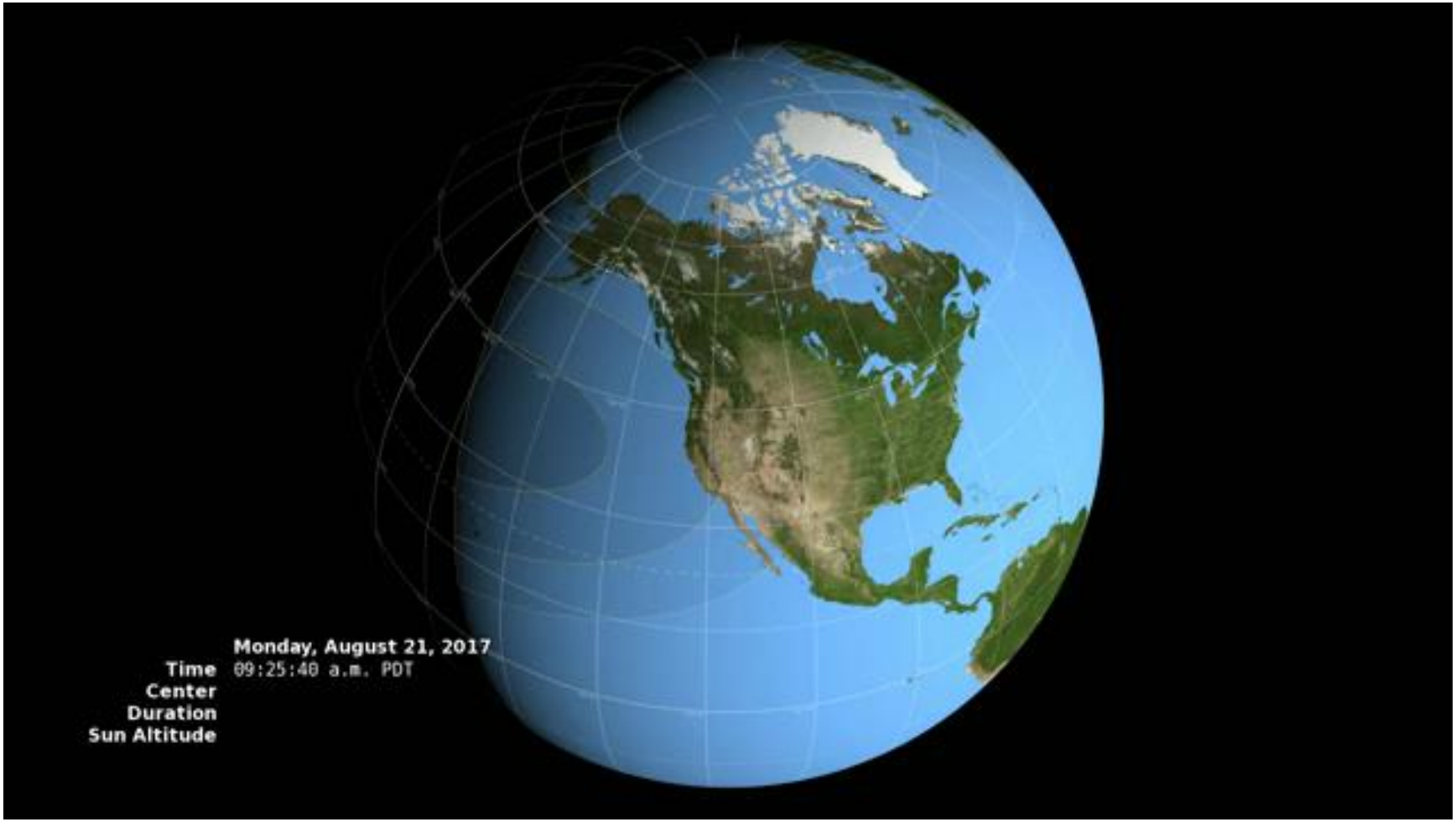
Outline

- Project Overview
- Review of the Europe total eclipse
- Technical Approach
  - GIS Study
  - Production Simulation Study
  - Data Analytics
  - Transient Simulation Study
- Summary

Solar Eclipse Impact Study – Project Overview

- Funded by DOE SETO
- Partnering with Peak Reliability
- Three Phases
  - Pre-Event: Estimate the impact on PV
  - Post-Event: Estimate impact on grid operations & PV Site Testing at NREL's NWTC (on-going)
  - Extend Framework for Future Events (to begin)
- Focus on developing tools and technical approach

August 21 Solar Eclipse



Source: https://svs.gsfc.nasa.gov/vis/a000000/a004300/a004314/eclipse2017usa_360p30.mp4

Review of the Total Eclipse in Europe

- Primary Recommendations
  - PV forecasts and output control
  - preparation of high-reserve
  - strategic use of pump storage power plants
  - reduction of interchange between TSOs
  - strengthening of management and coordination across CE
- German TSOs and Terna (Italy) took special measures

Effects of Solar Eclipse on Grid Operations

- PV Output
  - Utility-scale
  - Distribution-scale
- Loading Impact
  - Behavioral change
  - Transient cooling effect
  - Distributed PV
- Change in wind speeds
- Ramp rate considerations

Overview of Technical Approach

- GIS Study
  - Determine size and location of PV
  - Estimate expected PV output on eclipse day
  - Estimate impact on PV output due to eclipse
- Production Simulation Study
  - How will the interconnection respond to loss of PV
- Transient Simulation Study
  - Contingency studies and small-signal stability
- Data Analytics
  - Estimate impact from actual data

GIS Study – Determine PV Capacities

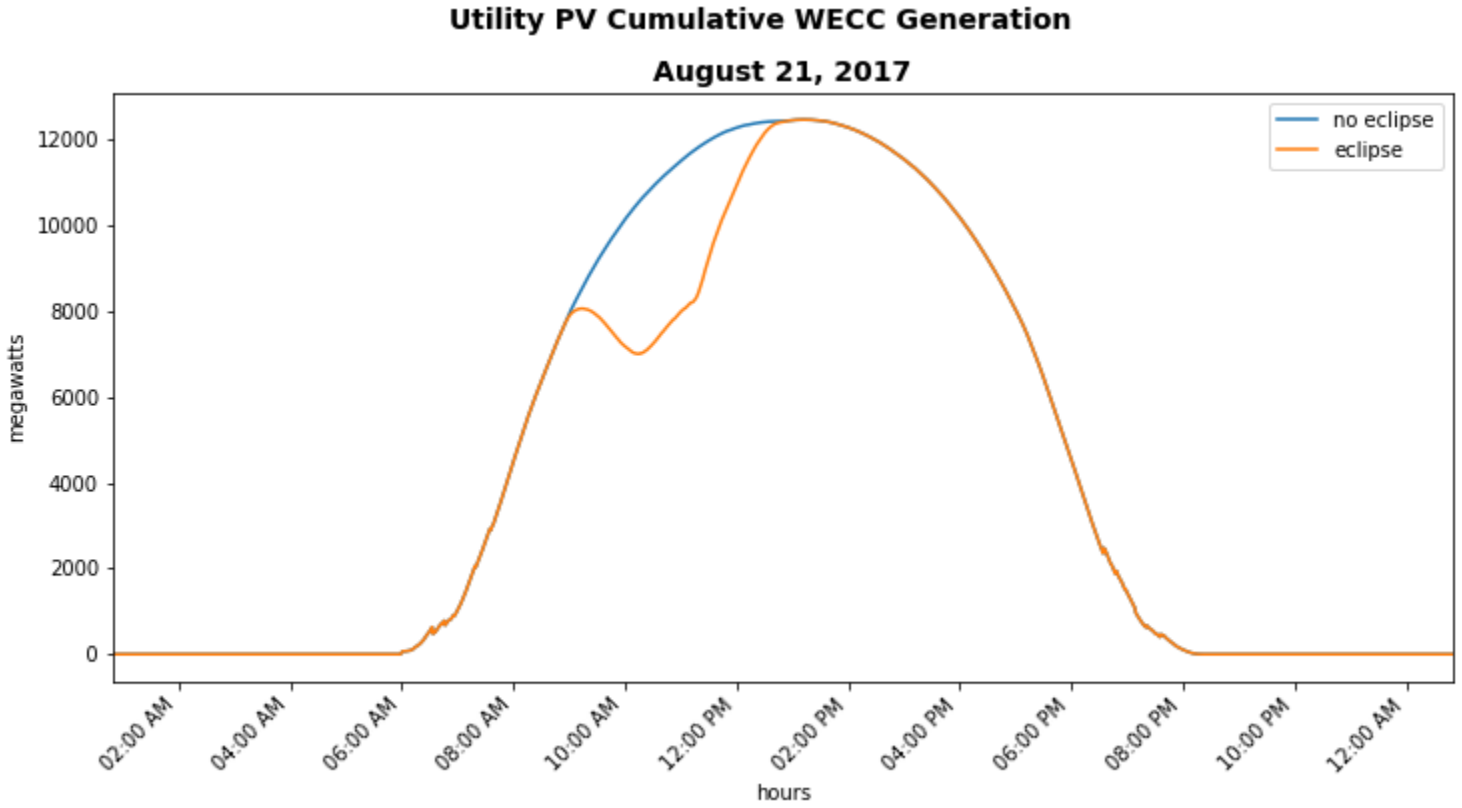
- Utility PV
- Distributed PV (Estimated 9.2GW)

Utility Area	Estimated Distributed PV Capacity (MW)	Utility Area	Estimated Distributed PV Capacity (MW)
APS	2160	PACE	57
BPA	109	PG&E	1513
El Paso	261	PSCO	101
IID	201	SCE	2016
IPCO	453	SDGE	522
LADWP	1077	Sierra	97
NM	449	WAPA	81
NVP	169		

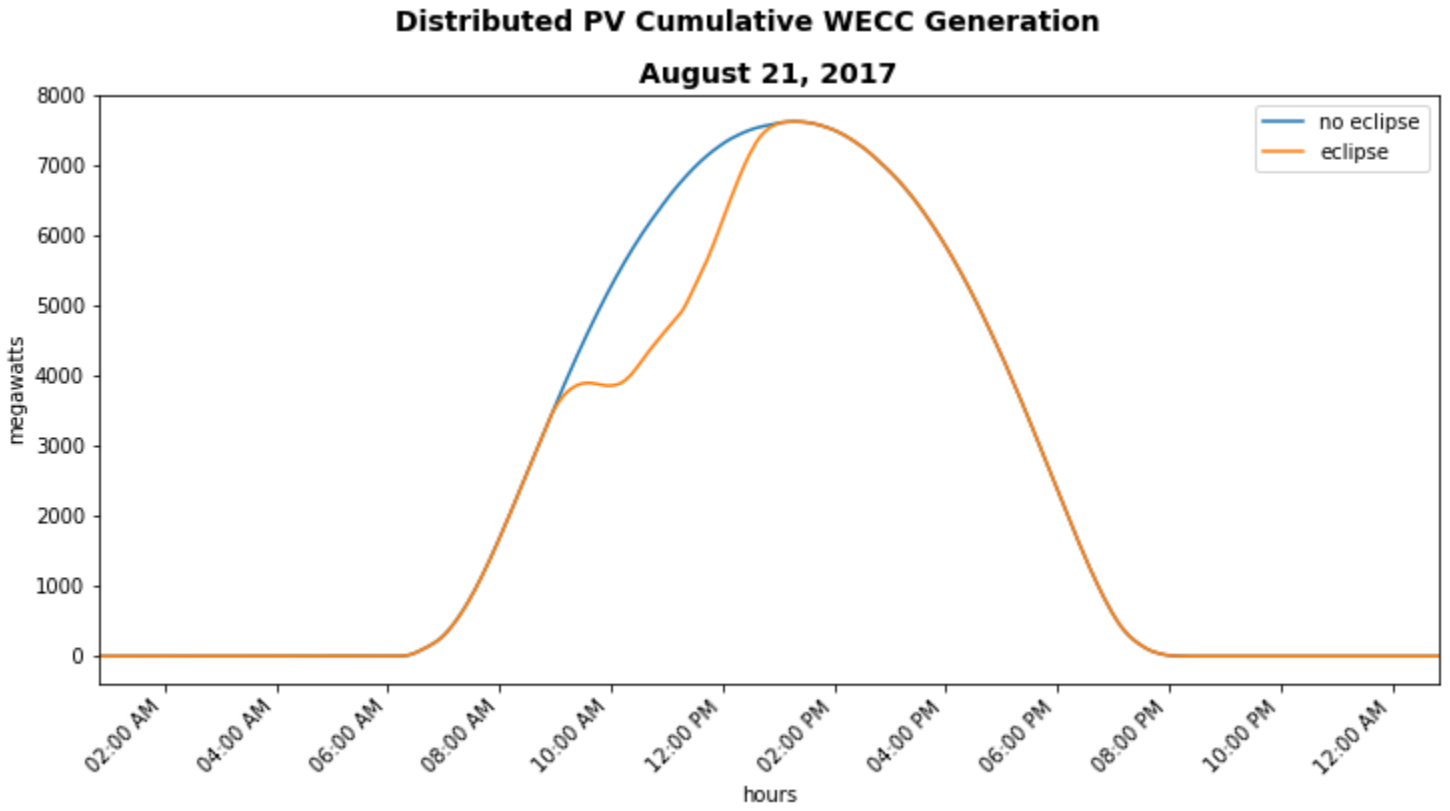
GIS Study – Estimate expected PV output

- PV Output Estimation for Non-eclipse day
  - NREL's SAMPA to provide insolation profiles
  - Weather data from NSRDB supplemented by NASA's MODIS
  - NREL's System Advisor Model (SAM) and PVWatts used to calculate PV outputs
- PV Output Estimation for Eclipse day
  - NASA's obscuration profiles applied at each generator location

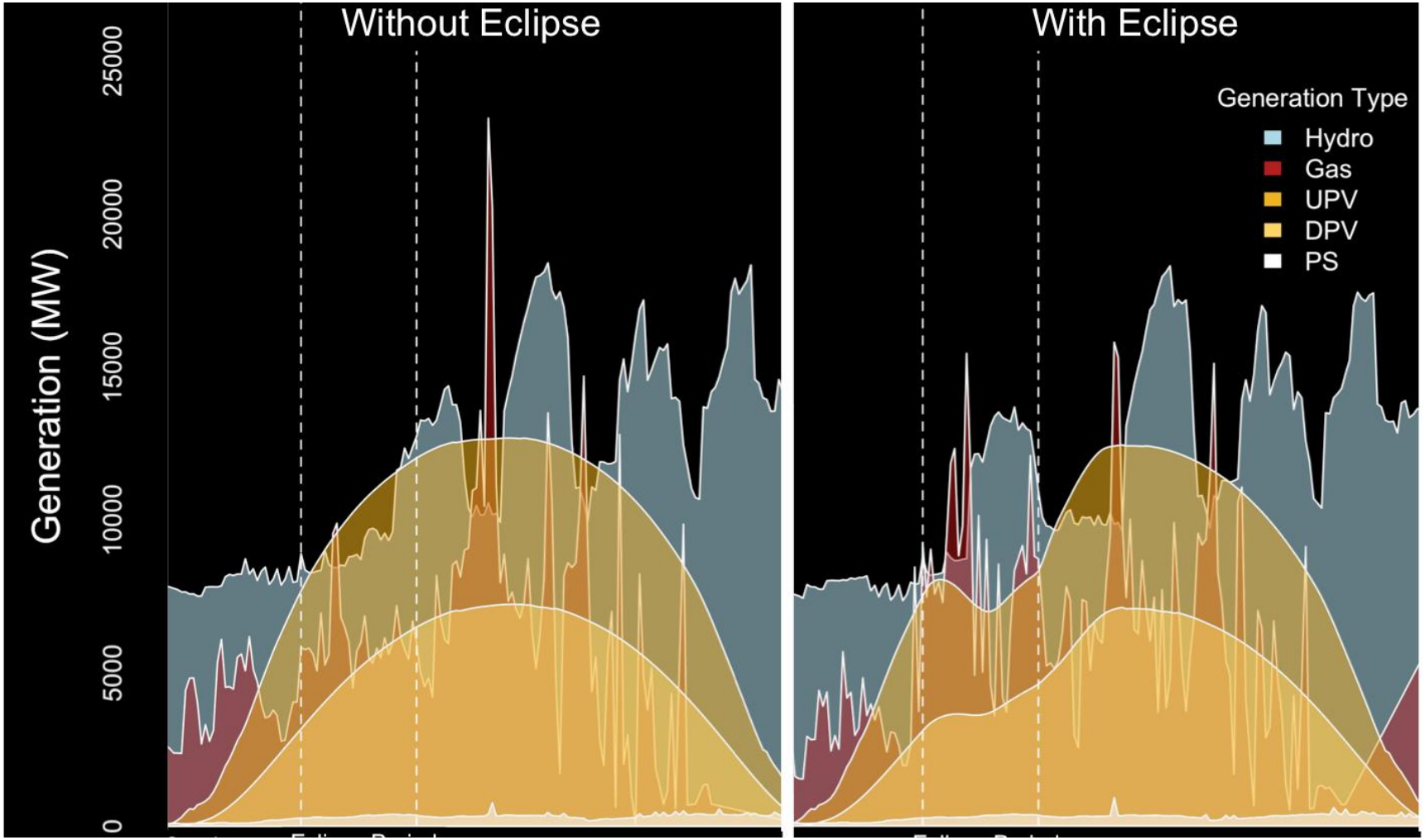
GIS Study – Estimated PV Output



GIS Study – Estimated PV Output



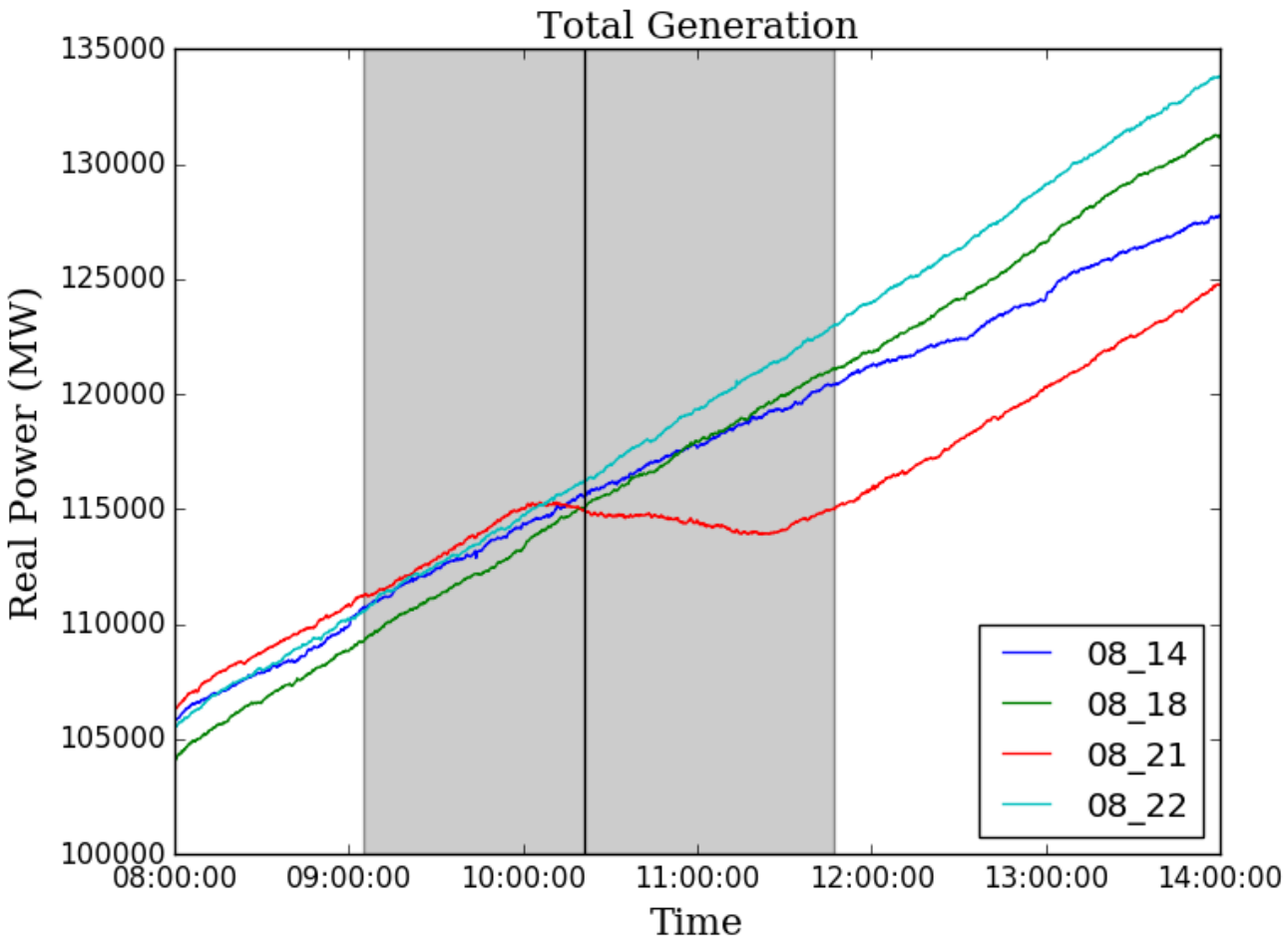
Production Simulation Study



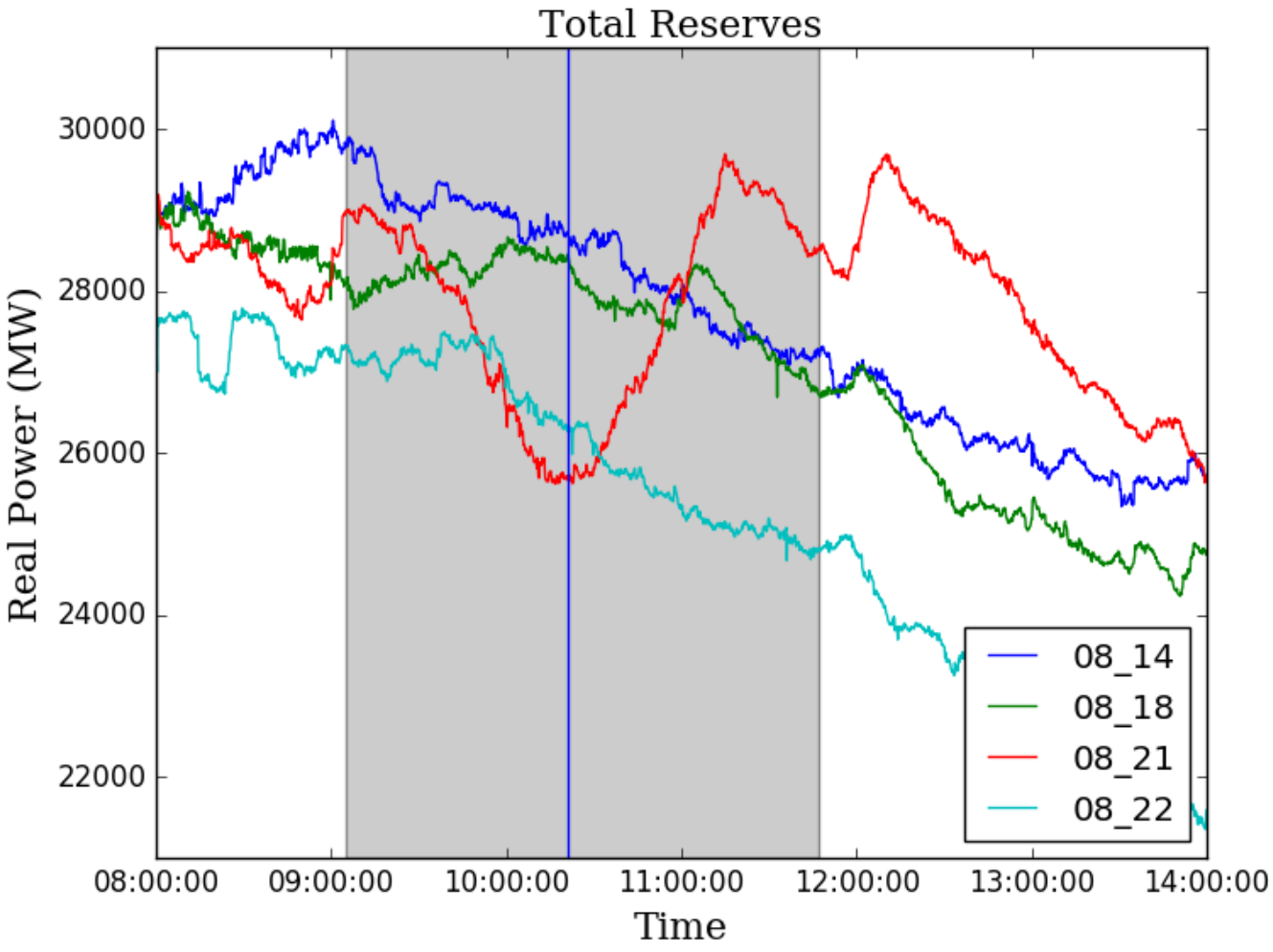
Data Analytics

- PI data to determine area-level generation, reserves and interchanges
  - Days Selected for Benchmarking
    - August 21 – Eclipse day (Monday)
    - August 14 – Previous Monday
    - August 18 – Friday before Eclipse
    - August 22 – Day after Eclipse
- EMS case data to determine path-level and plant-level flows

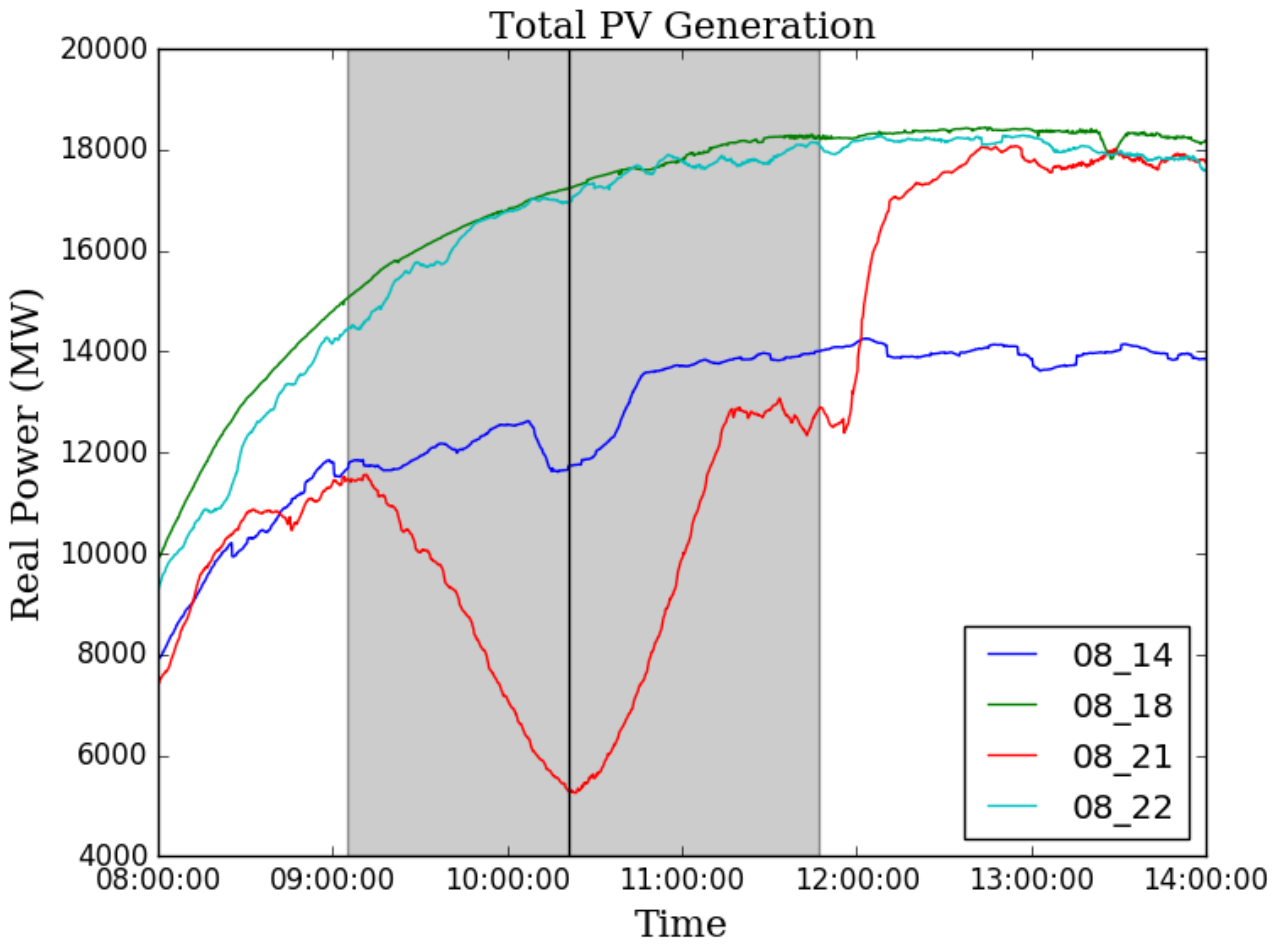
WECC Total Generation



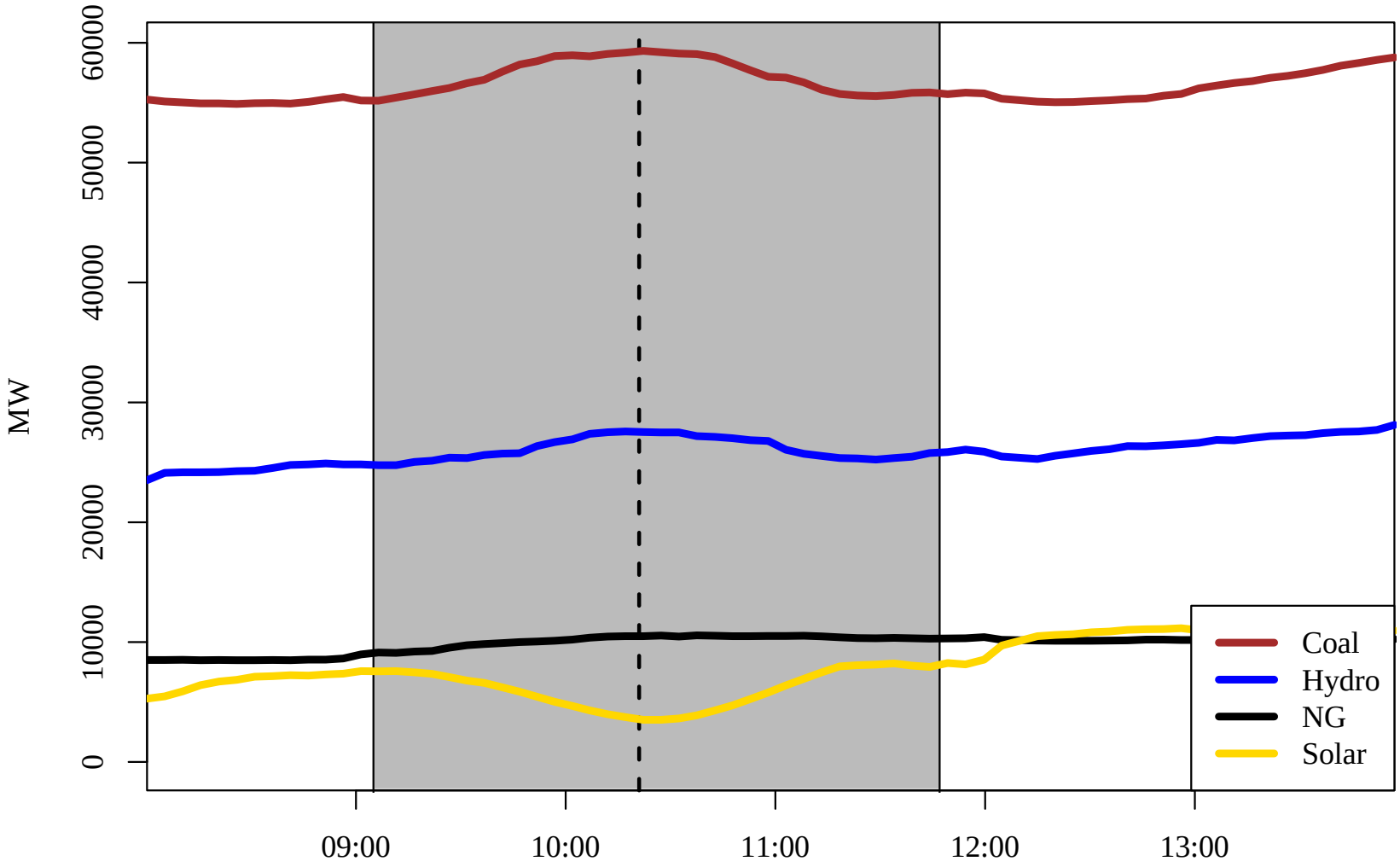
WECC Total Reserves



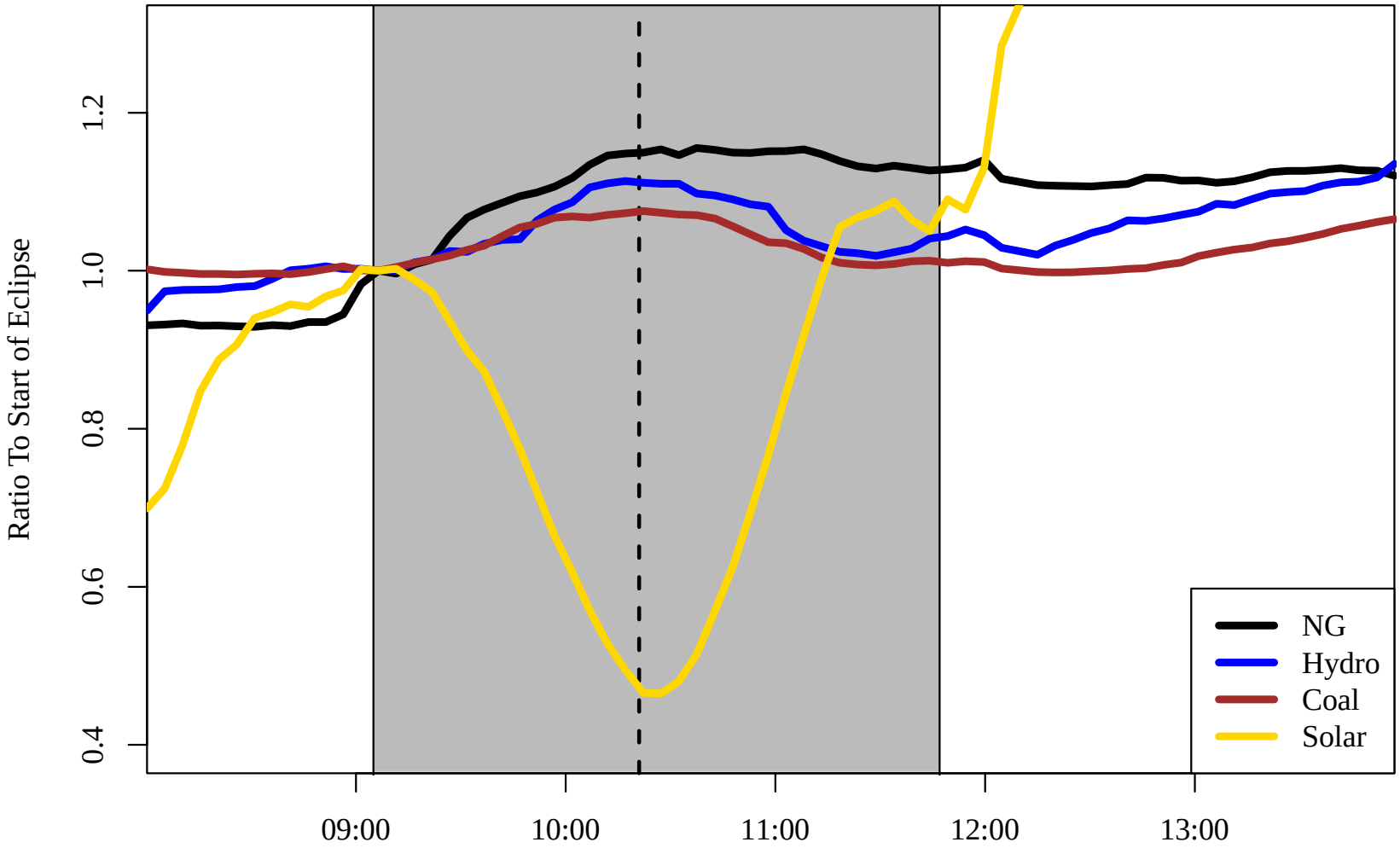
WECC Total PV



WECC-level Generation by Fuel Type



Generation Trends by Fuel Type



Transient Simulation Study

- Merge operation case with planning dynamic models to perform transient study
- Study transient and small-signal stability using contingency analysis

Summary

- Eclipse event provided an opportunity to study PV penetrations
- Preparation undertaken by Peak Reliability and WECC utility members
- Tools developed for studying impact of wide-area phenomenon
- Framework being developed to incorporate the tools for future events