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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Reliability Assessment: August 21, 2017 Solar Eclipse

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Solar Eclipse Wide Area Assessment

Purpose:

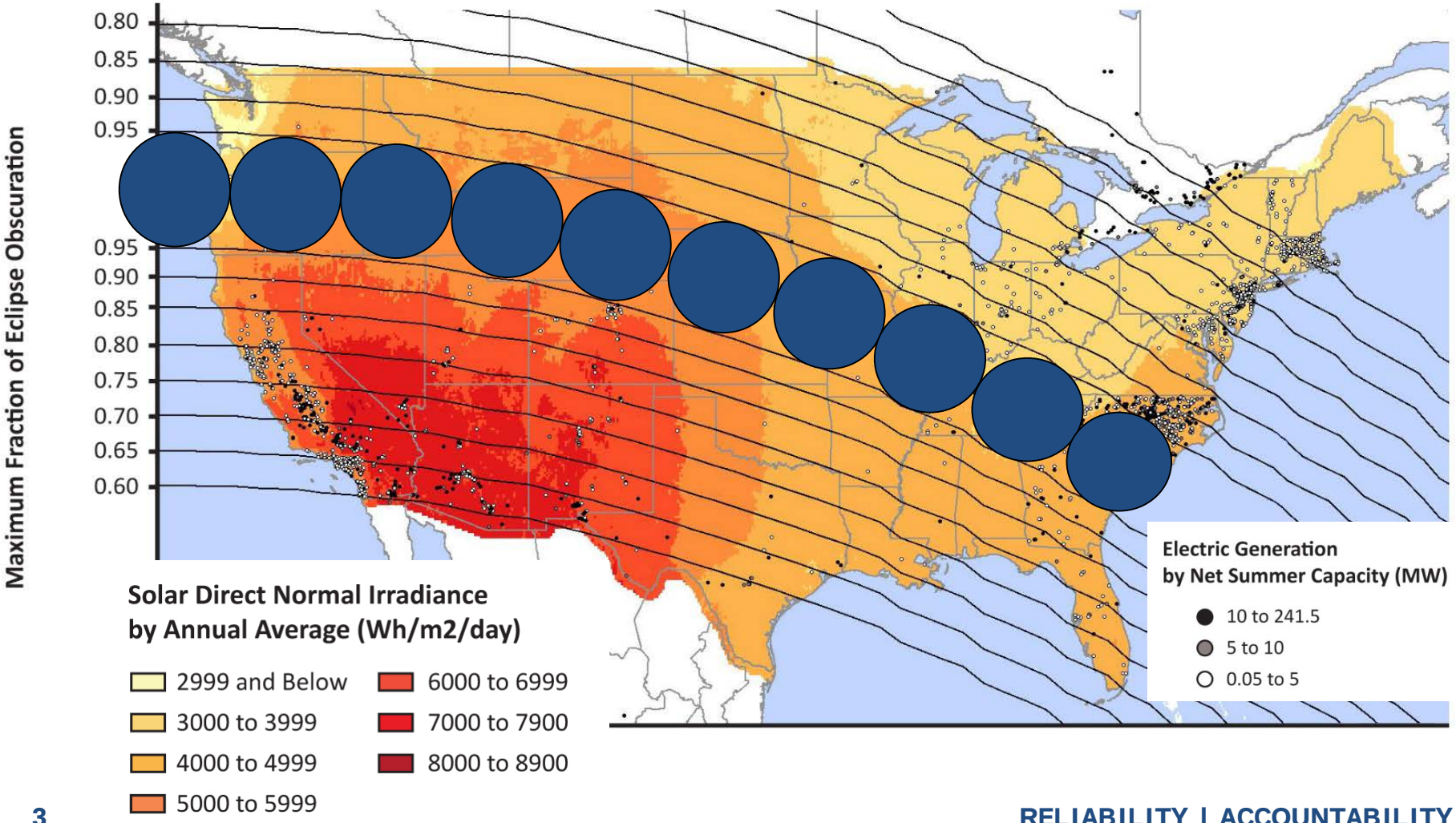
To evaluate potential reliability consequences of the August 21, 2017 total solar eclipse on the BPS

Main Objectives:

- Develop an extreme case using ideal weather conditions under peak system operations
- Scenario eclipse test case which includes hourly load data, forecasted photovoltaic generation with a built in range
- Identify and assess the eclipse test cases for any potential system reliability and/or operational impacts in areas with:
  - High penetration of utility photovoltaic (PV) resources (*nameplate capacity*)
  - High penetration of DER resources (*total aggregated nameplate capacity*)
  - Significant sunlight reduction due to the eclipse (*eclipse bands*)

Eclipse Path and Eclipse Bands

Figure 1. U.S. Map showing direct normal irradiance by annual average (Wh/m²/day), eclipse bands and locations of transmission photovoltaic generators

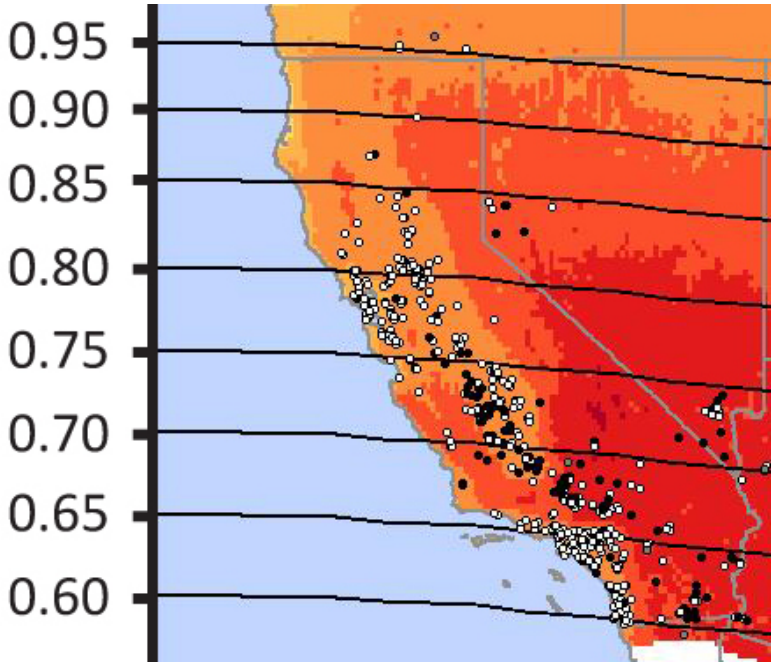


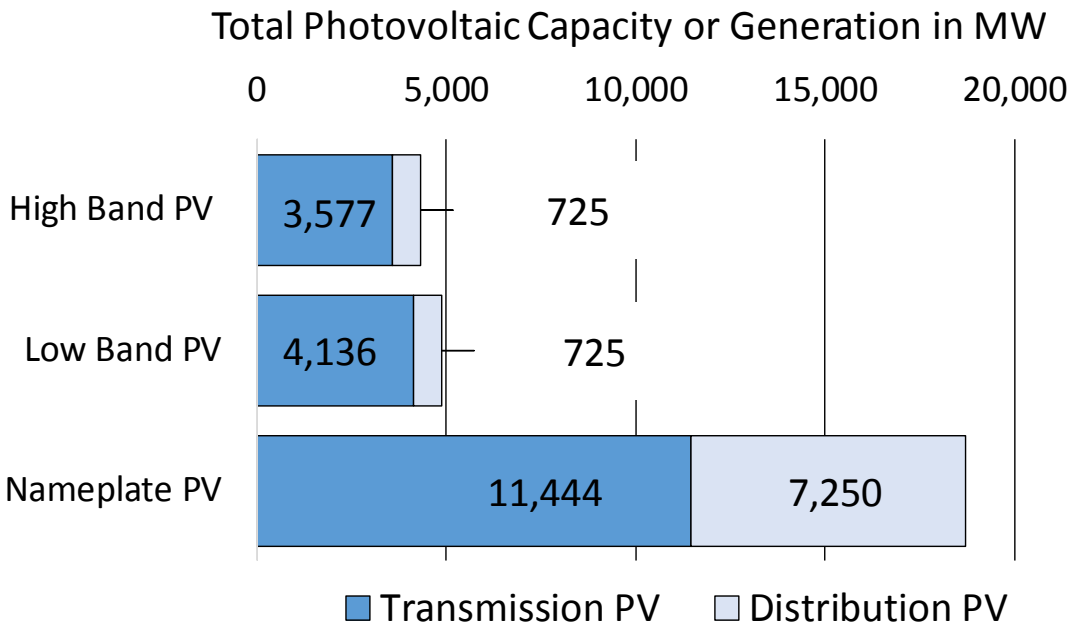
By the Numbers

- The eclipse will first be observable in Oregon at 10:15 a.m. local
- 1 hour and 33 minutes to traverse the country
- Total coverage at any point is about 5 minutes
- Cumulative impact of about 9,000 MW (non-coincident)
- Over 1,000,000 PV installations in the U.S
  - Over 100,000,000 panels
- Growth in solar from 5 MW in 2000 to 42,619 MW in 2016
  - 15,000 MW of non-utility PV generation
- 19 GW in California, 4.5 GW in North Carolina
- 1,000,000 NEST thermostats expected to participate in conservation efforts

California Eclipse And PV Generation for High and Low Bands Scenarios

Figure 2. California Projected PV generation for high and low band PV scenarios in comparison to the total installed nameplate capacity



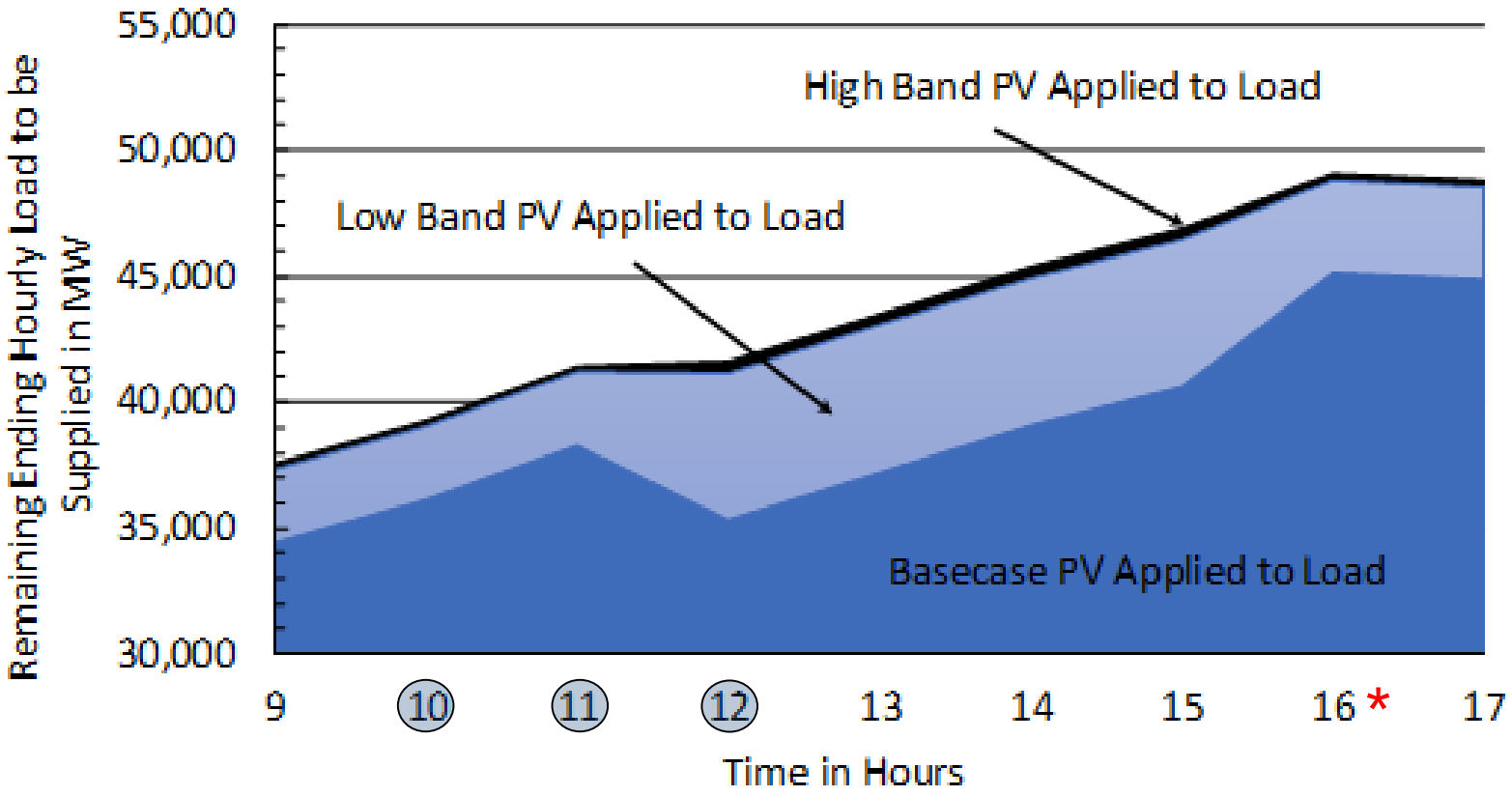


- Forecasted peak load: 51,233 MW (4 PM)
- Eclipse Time ≈ 9:01 AM - 11:45 AM

California Total System Load Increases During Eclipse

- Results from the Assessment focused on an areas total system load:

Figure 3. California remaining ending hour load (MW) to be supplied by Non-PV resources for the basecase, low band PV and high band PV scenarios



notes: * *forecasted ending hour peak load: 51,233 MW (hour 16 or 4 PM)*

Hour ending for actual 2017 eclipse occurrence

North Carolina Eclipse And PV Generation for High and Low Bands Scenarios

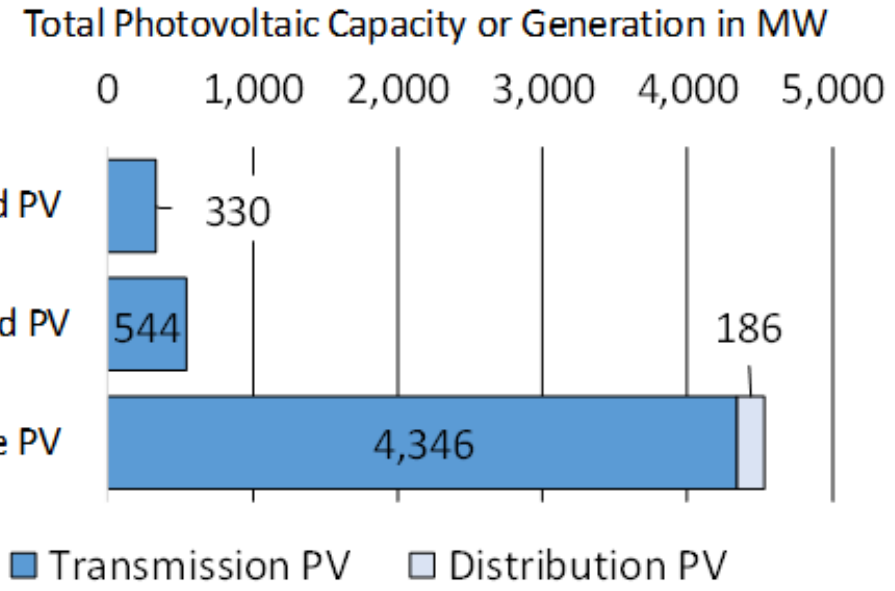
Figure 4. North Carolina Projected PV generation for high and low band PV scenarios in comparison to the total installed nameplate capacity

Total Obscuration

0.85

0.90

0.95



Solar Direct Normal Irradiance by Annual Average (Wh/m2/day)

- 2999 and Below
- 3000 to 3999
- 4000 to 4999
- 5000 to 5999
- 6000 to 6999
- 7000 to 7900
- 8000 to 8900

Electric Generation by Net Summer Capacity (MW)

- 10 to 241.5
- 5 to 10
- 0.05 to 5

- Forecasted peak load: 24,539 MW (5 PM)
- Eclipse Time ≈ 1:05 PM - 4:07 PM

2017 Solar Eclipse Key Results

- Results of the total eclipse:
  - Showed no impacts to the reliability of BPS operations
  - Some states with a large amount of PV resources are expected to have:
    - Increased load
    - Possible ramping and balancing concerns that will require coordination
    - Significant gas generation ramping
- General Recommendations:
  - Areas should secure Non-PV resources for eclipse system operations
  - Recall voluntary maintenance
  - Perform advance coordination with neighboring systems for transfers

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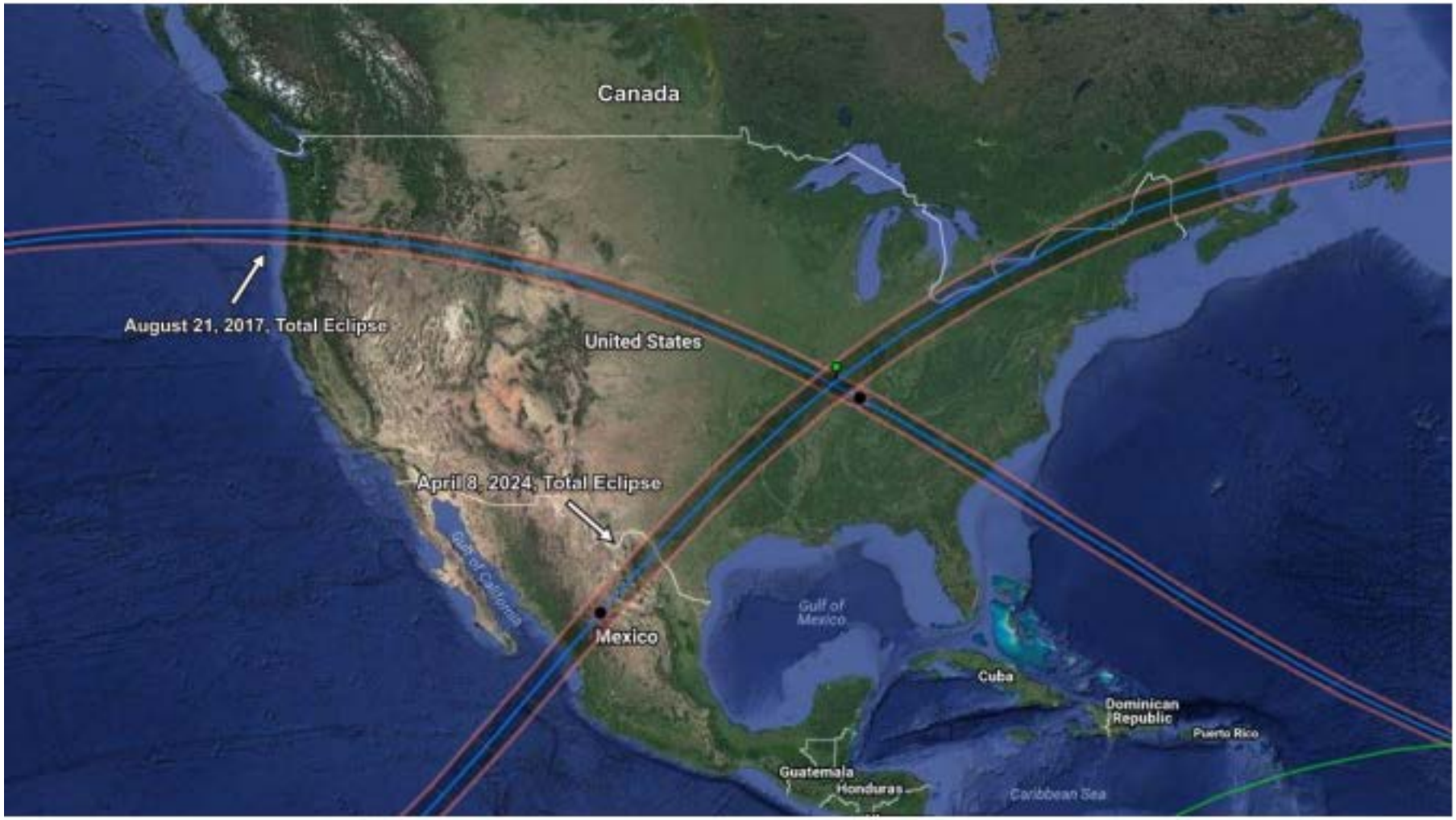
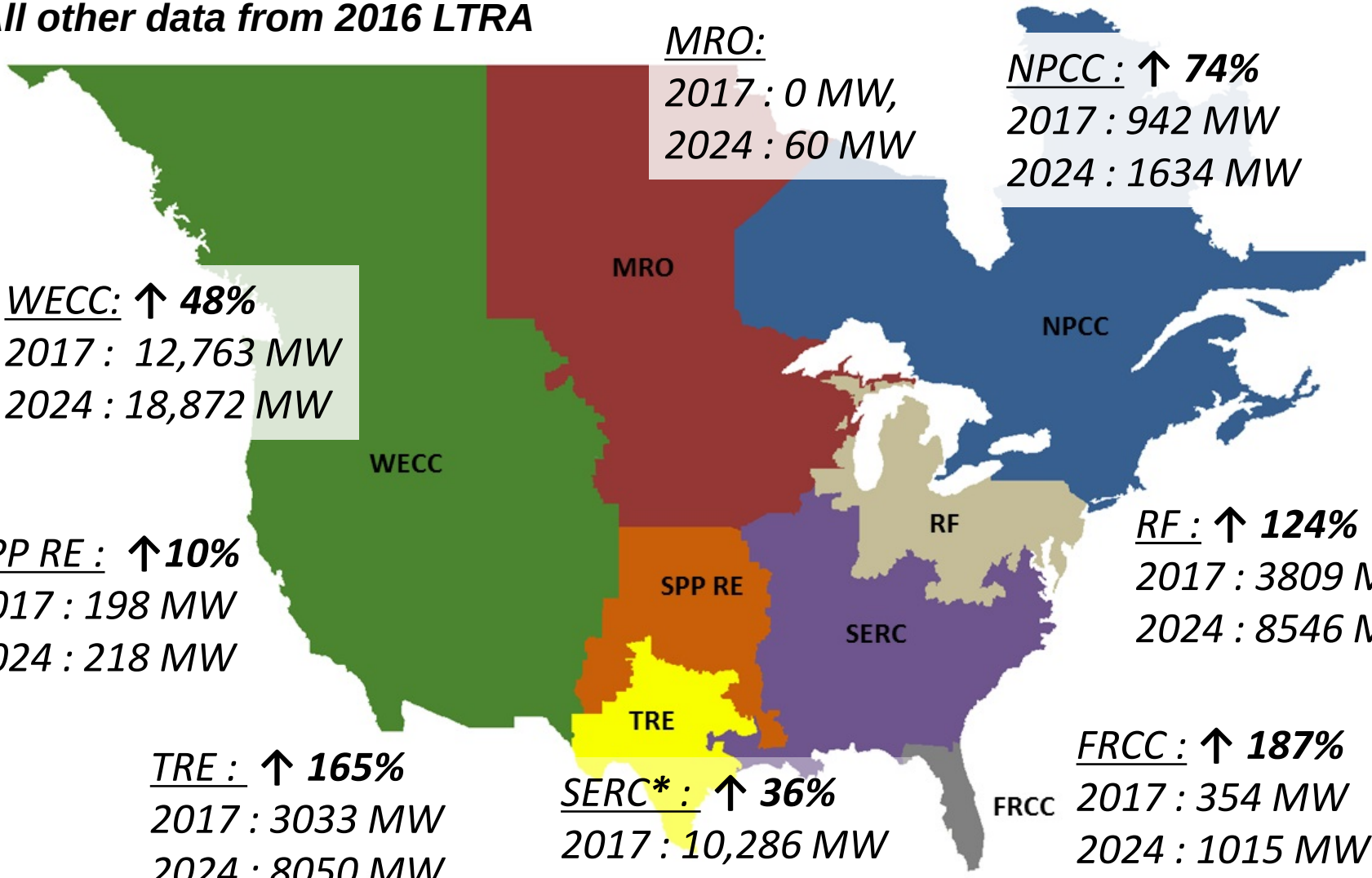
Prepare for 2024



Monday, April 8, 2024 Total Eclipse[1]

***Data from ABB Velocity Suite Tool**
***All other data from 2016 LTRA**



MRO:
2017 : 0 MW,
2024 : 60 MW

NPCC : ↑ ***74%***
2017 : 942 MW
2024 : 1634 MW

WECC: ↑ ***48%***
2017 : 12,763 MW
2024 : 18,872 MW

SPP RE : ↑***10%***
2017 : 198 MW
2024 : 218 MW

RF : ↑ ***124%***
2017 : 3809 MW
2024 : 8546 MW

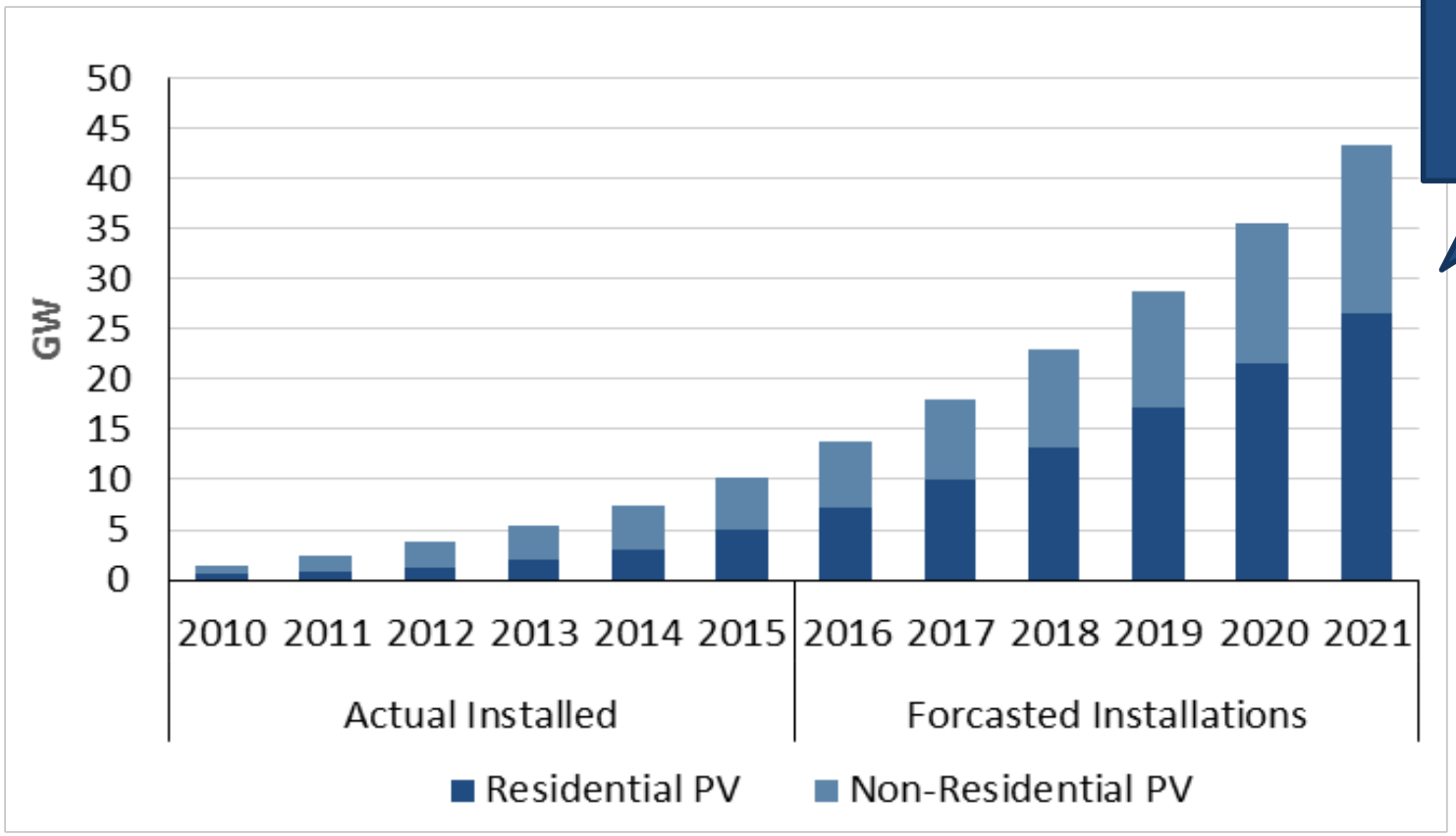
TRE : ↑ ***165%***
2017 : 3033 MW
2024 : 8050 MW

SERC :* ↑ ***36%***
2017 : 10,286 MW
2024 : 13,997 MW

FRCC : ↑ ***187%***
2017 : 354 MW
2024 : 1015 MW

Trend of Distribution Photovoltaic (PV) Systems

U.S. Cumulative Installations of Non-Utility PV Generation



Over 100 GW by 2022 when considering utility-scale PV

[4] *GTM Research: Solar Market Insight Report 2016 Q2*

Questions and Answers