

Hydrogen Fuel Cell Backup Power Systems

For ITS Applications in District 2

Jeremiah Pearce P.E., Caltrans District 2

Dave Torick, AHMCT UC Davis

Justin Ellis P.E., Caltrans METS



Presentation Overview

Acronyms

AHMCT – Advanced Highway Maintenance Construction Technology

BBS – Battery Backup System

CCTV – Closed Circuit Television

CMS – Changeable Message Sign

CPUC – California Public Utilities Commission

HAR – Highway Advisory Radio

HFC – Hydrogen Fuel Cell

ITS – Intelligent Transportation Systems

PG&E – Pacific Gas and Electric

PSPS – Public Safety Power Shutdown

SHOPP – State Highway Operation and Protection Program

TMS – Transportation Management System

UPS – Uninterruptable Power Supply

Presentation Overview

Presentation Outline

- **Need and Purpose – Jeremiah Pearce P.E.**
- **Research Project – Dave Torick**
- **Caltrans METS/TransLab Requirements – Justin Ellis P.E.**
- **Next steps**



Caltrans District 2



Caltrans District 2

- **Characteristics**

- **Geography – 27,307 square miles**
- **Terrain – Ranging from the Northern Central Valley to rugged high mountains, Mount Shasta Elev. 14,179 ft**
- **Vegetation – Ranging from valley grassland to heavily wooded mountain forest (oak woodland and mixed conifer forests) to high desert**
- **Climate – Hot dry summers and cool wet winters valley with dry mild summers and snowy winters in the mountains**

Northern California Wildfires

- **Recent Fires**

- **2017 North Bay (Tubbs, etc. Complex Fires)**

- **Started October 8, 2017**
- **Over 250 total fires**
- **Burned 245,000 acres through October 31, 2017**
- **8,900 structures destroyed**
- **\$14.5 Billion in damages**
- **44 Fatalities and 192 injuries**
- **Cause – Multiple electrical utility failures due to wind**



Photo: San Francisco Chronicle

Northern California Wildfires

- **Recent Fires**

- **Carr Fire**

- **Started July 23, 2018**
 - **Burned 229,651 acres through August 30, 2018**
 - **1,604 structures destroyed**
 - **\$1.659 Billion in damages**
 - **8 Fatalities and 11 injuries**
 - **Cause – Vehicle mechanical failure**



Northern California Wildfires

- **Recent Fires**

- **Delta Fire**

- **Started September 5, 2018**
 - **Burned 63,311 acres through October 7, 2018**
 - **42 structures destroyed**
 - **Merged with Carr fire September 18, 2018**
 - **2 fire suppression related injuries**
 - **Cause – Suspected Arson**



Northern California Wildfires

- **Recent Fires**

- **Camp Fire**

- **Started November 8, 2018**
 - **Burned 153,336 acres through November 25, 2018**
 - **18,804 structures destroyed**
 - **\$16.65 Billion in damages**
 - **85 fatalities and 17 injuries**
 - **Cause – Downed Transmission line due to wind**

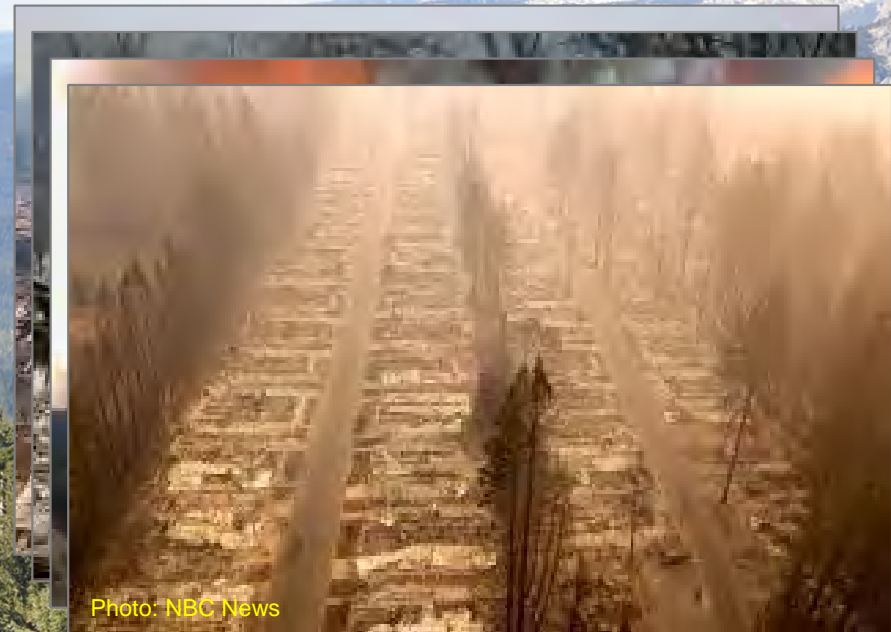


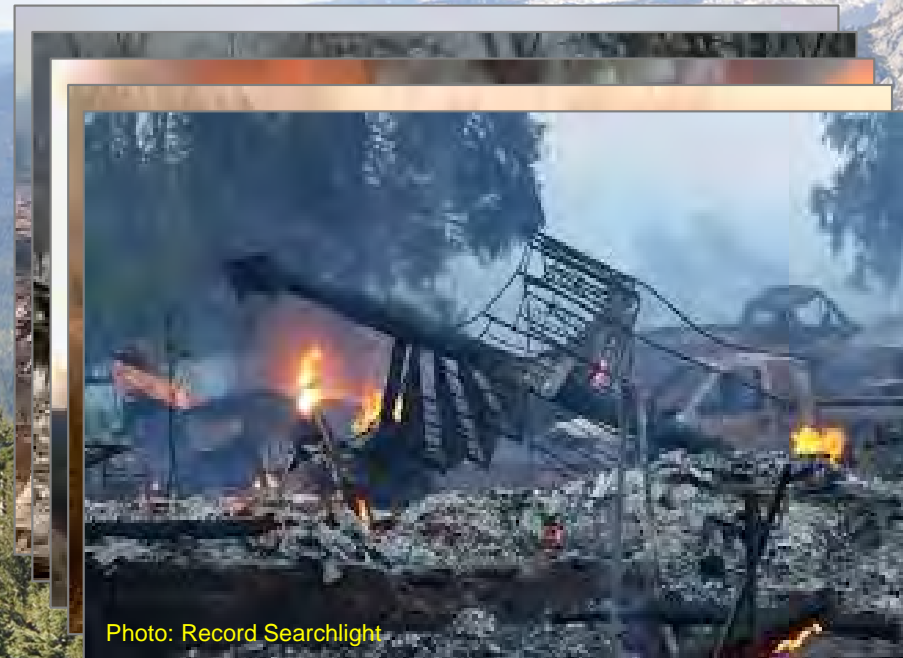
Photo: NBC News

Northern California Wildfires

- **Recent Fires**

- **Zogg Fire**

- **Started September 27, 2020**
 - **Burned 56,338 acres through October 13, 2020**
 - **231 structures destroyed**
 - **4 fatalities and 1 injury**
 - **Cause – Electrical distribution line in contact with trees due to wind**



Northern California Wildfires

- **Recent Fires**

- **Dixie Fire**

- **Started July 13, 2021**
 - **Burned 963,309 acres through October 25, 2021**
 - **1,424 structures destroyed**
 - **\$1.15 Billion in damages**
 - **1 fatalities and 3 injuries**
 - **Cause – Electrical distribution line in contact with trees due to wind**

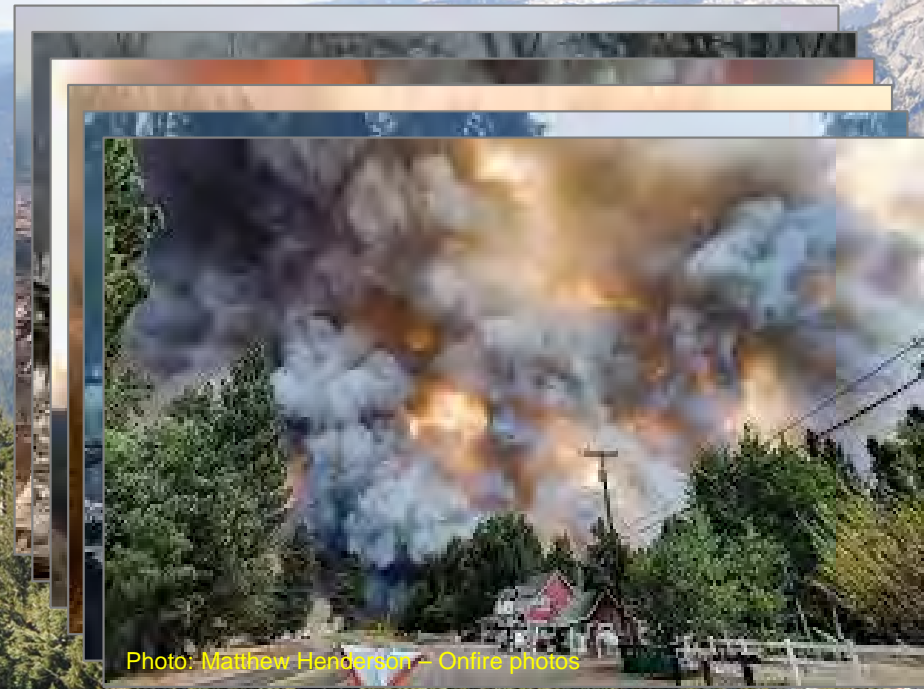


Photo: Matthew Henderson – Onfire photos

Northern California Wildfires



- **Cause of Fires**

- **2017 North Bay – Electric Utility (PG&E)**
- **Carr Fire – Vehicle Malfunction**
- **Delta Fire – Suspected Arson**
- **Camp Fire – Electric Utility (PG&E)**
- **Zog Fire – Electric Utility (PG&E)**
- **Dixie Fire - Electric Utility (PG&E)**

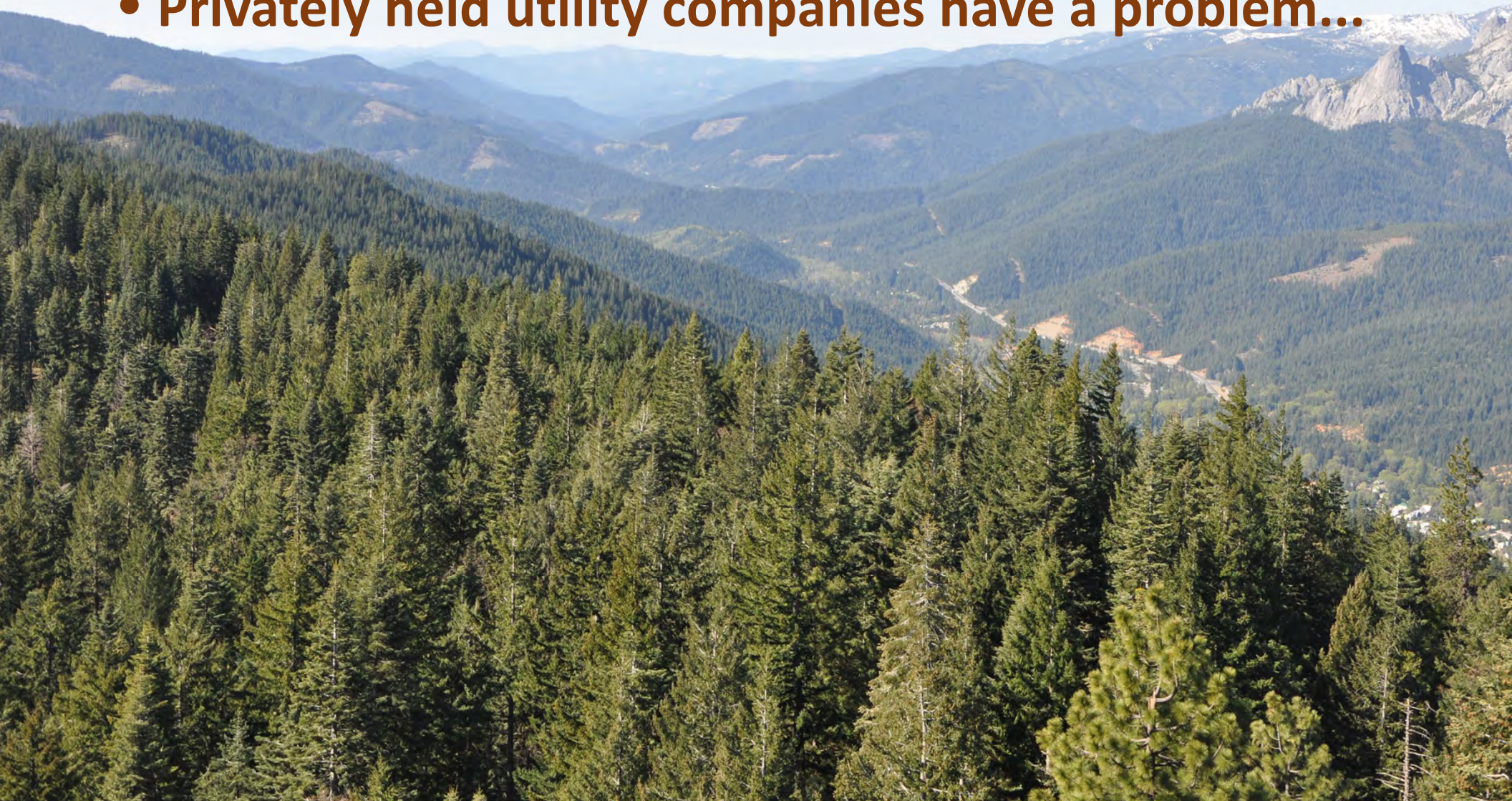
Northern California Wildfires

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- Carr Fire – **Vehicle Malfunction**
- Delta Fire – **Suspected Arson**
- Camp Fire – **Electric Utility (PG&E)**
- Zog Fire – **Electric Utility (PG&E)**
- Dixie Fire - **Electric Utility (PG&E)**

Northern California Wildfires

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Northern California Wildfires

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 - **Historically, electrical utility incidents caused less than 10% of reported wildfires**



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 - **Historically, electrical utility incidents caused less than 10% of reported wildfires**
 - **Recently, electrical utility incidents have caused over 50% of the most destructive wildfires in California history**
- **What are utility companies doing about it?**

Electric Utility Fire Mitigation



Electric Utility Fire Mitigation

- **Managing Existing Easements – Tree trimming, etc.**



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- **Public Safety Power Shutoff (PSPS)**

Public Safety Power Shutoffs

- **2012 California Public Utilities Commission (CPUC) ruled that CA Public Utilities Code sections 451 and 399.2(a) provides electric private utilities authority to de-energize infrastructure to protect public safety**
- **Private utility company makes the decision when to de-energize infrastructure, though there is alerting criteria established by the CPUC**
- **CPUC adopted PSPS Phase-1 rules May 2019 and the first major PSPS event in District 2 occurred Fall 2019**

Public Safety Power Shutoffs

- Impact to California – 2019 PSPS events

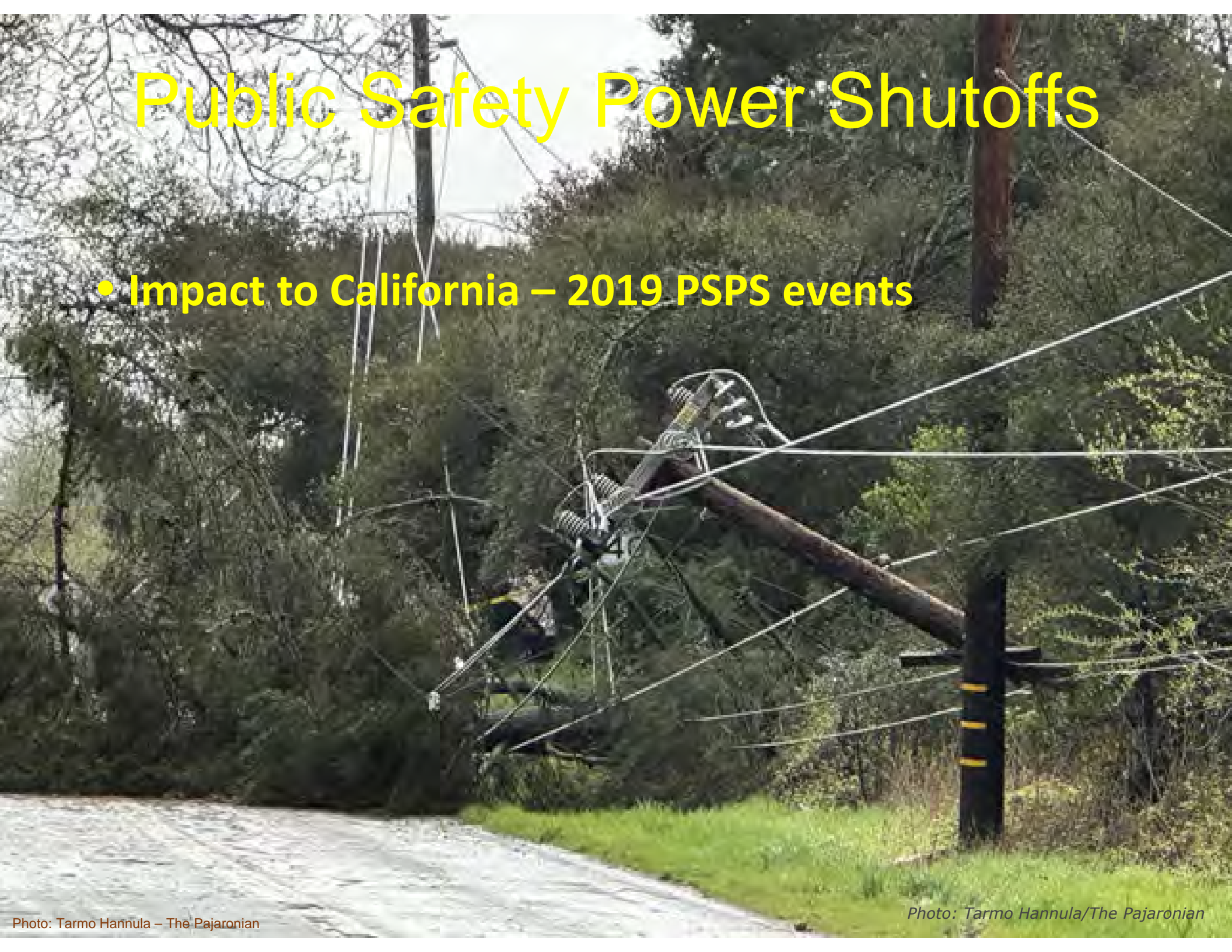


Photo: Tarmo Hannula – The Pajaronian

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Public Safety Power Shutoffs

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Public Safety Power Shutoffs



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 - Millions of customers in PG&E service areas lost power for several days
 - One fatality reported – power failure to medical patient’s oxygen tank
 - Total economic loss estimated at \$2.5 billion in 2019

Public Safety Power Shutoffs



Public Safety Power Shutoffs

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Public Safety Power Shutoffs



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Public Safety Power Shutoffs

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 - CPUC risk analysis reported 741 electrical infrastructure damage incidents, 630 of which could have ignited a wildfire
 - Modeling indicated hundreds of thousands of burned acres and tens of thousands of people impacted/displaced

Public Safety Power Shutoffs

- **Impact to the transportation system in District 2**



Public Safety Power Shutoffs

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 - **At grade intersection safety – dark traffic signals**



Photo: Karl Mondon Bay Area News Group

Public Safety Power Shutoffs

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 - At grade intersection safety – dark traffic signals
 - Loss of traveler information to and from affected ITS field elements (CCTV, CMS, HAR, etc.)

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Public Safety Power Shutoffs

- **Impact to the transportation system in District 2**
 - At grade intersection safety – dark traffic signals
 - Loss of traveler information to and from affected ITS field elements (CCTV, CMS, HAR, etc.)
 - Loss of highway lighting



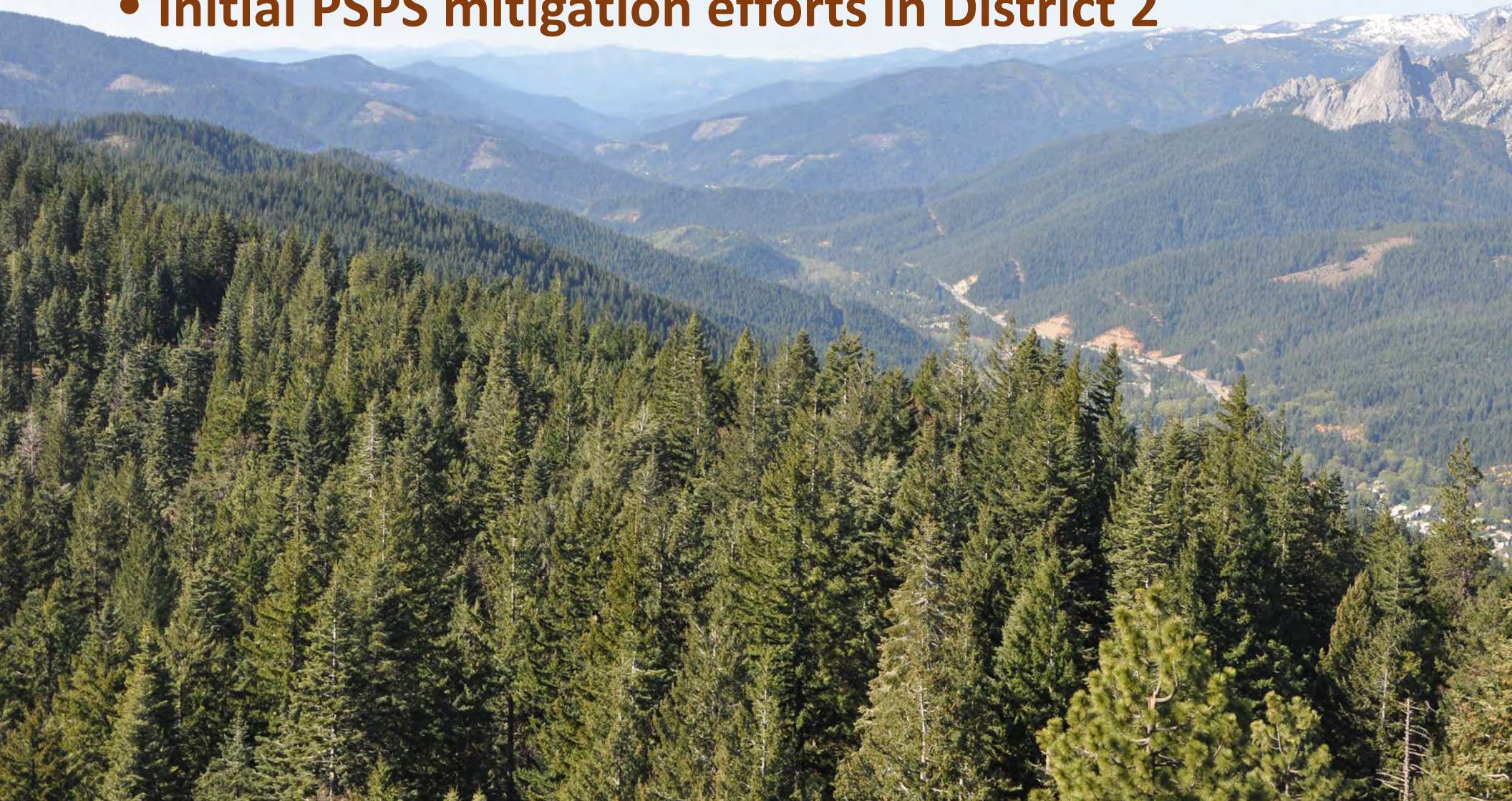
Photo: Karl Mondon Bay Area News Group

Public Safety Power Shutoffs

- **Impact to the transportation system in District 2**
 - **At grade intersection safety – dark traffic signals**
 - **Loss of traveler information to and from affected ITS field elements (CCTV, CMS, HAR, etc.)**
 - **Loss of highway lighting**
 - **No documented traffic incidents related to PSPS events**

Public Safety Power Shutoffs

- **Initial PSPS mitigation efforts in District 2**



Public Safety Power Shutoffs

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 - Install gas powered generators at “high-risk” traffic signals – operation and maintenance is very resource intensive!



Public Safety Power Shutoffs

- **Initial PSPS mitigation efforts in District 2**
 - Install gas powered generators at “high-risk” traffic signals – operation and maintenance is very resource intensive!
 - Install high visibility signal back-plates at all traffic signals



Photo: McCain, inc



Photo: Korman Signs

Public Safety Power Shutoffs

- **Impact to District 2 ITS Elements**



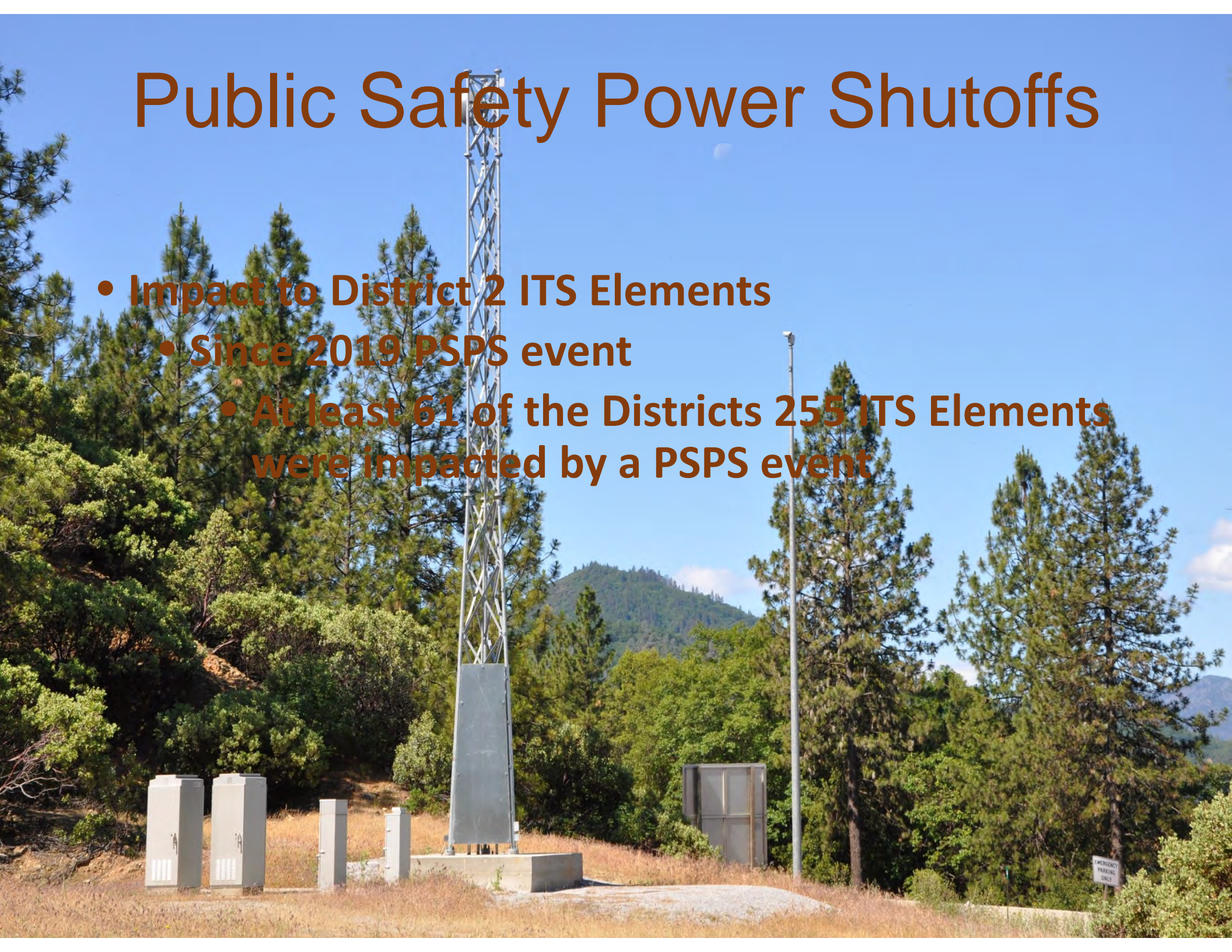
Public Safety Power Shutoffs

- **Impact to District 2 ITS Elements**
 - **Since 2019 PSPS event**



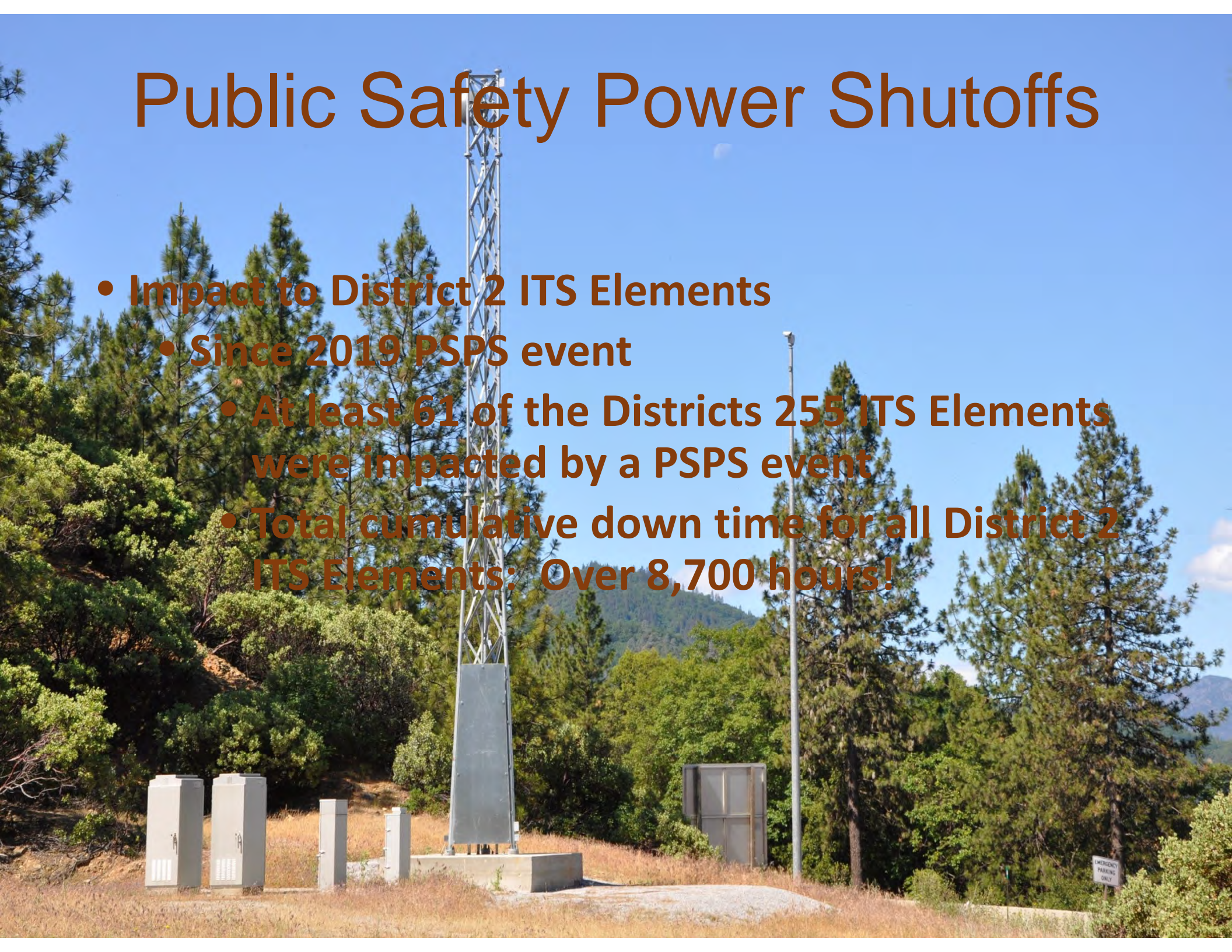
Public Safety Power Shutoffs

- **Impact to District 2 ITS Elements**
 - **Since 2019 PSPS event**
 - **At least 61 of the Districts 255 ITS Elements were impacted by a PSPS event**

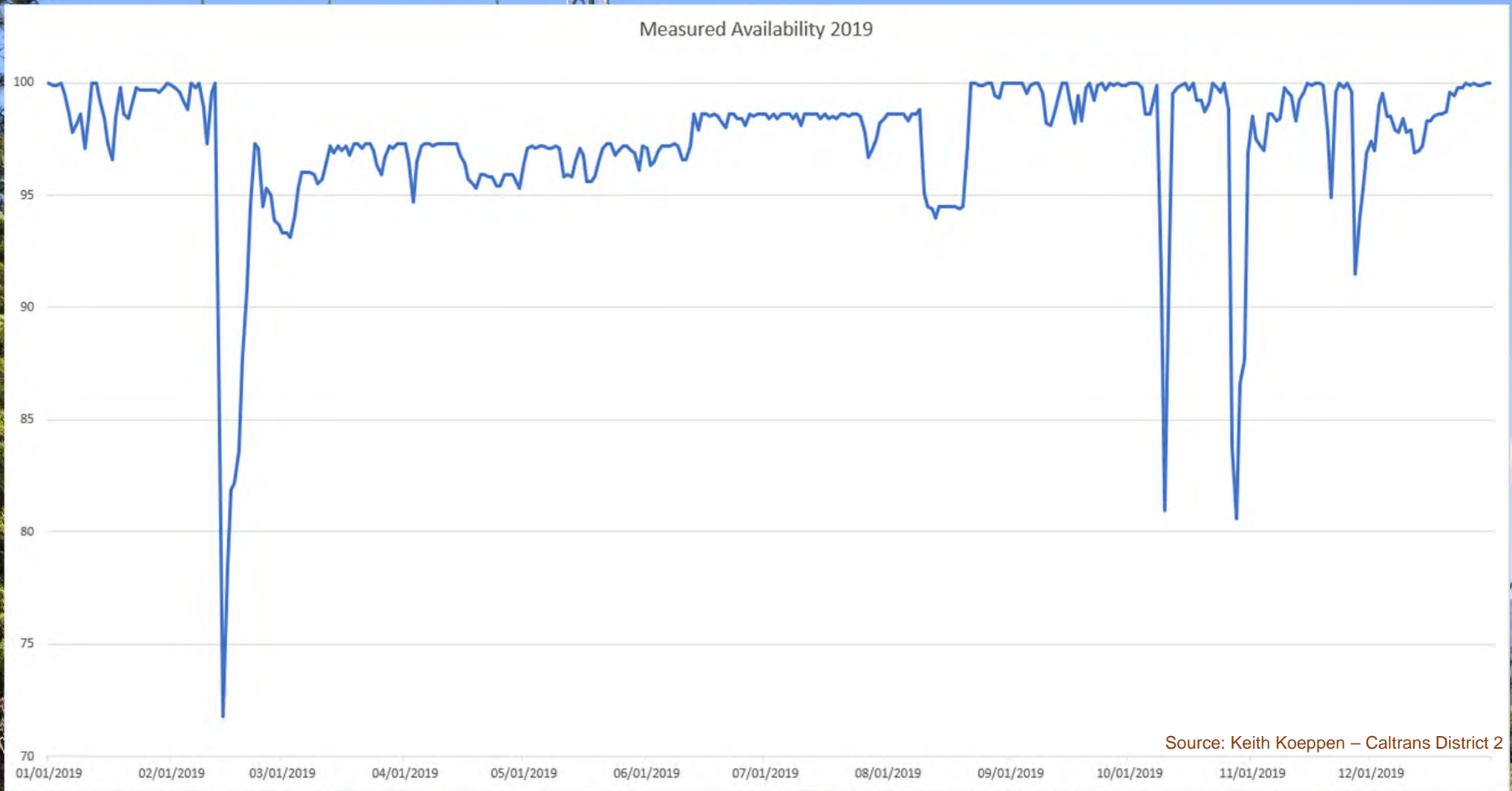


Public Safety Power Shutoffs

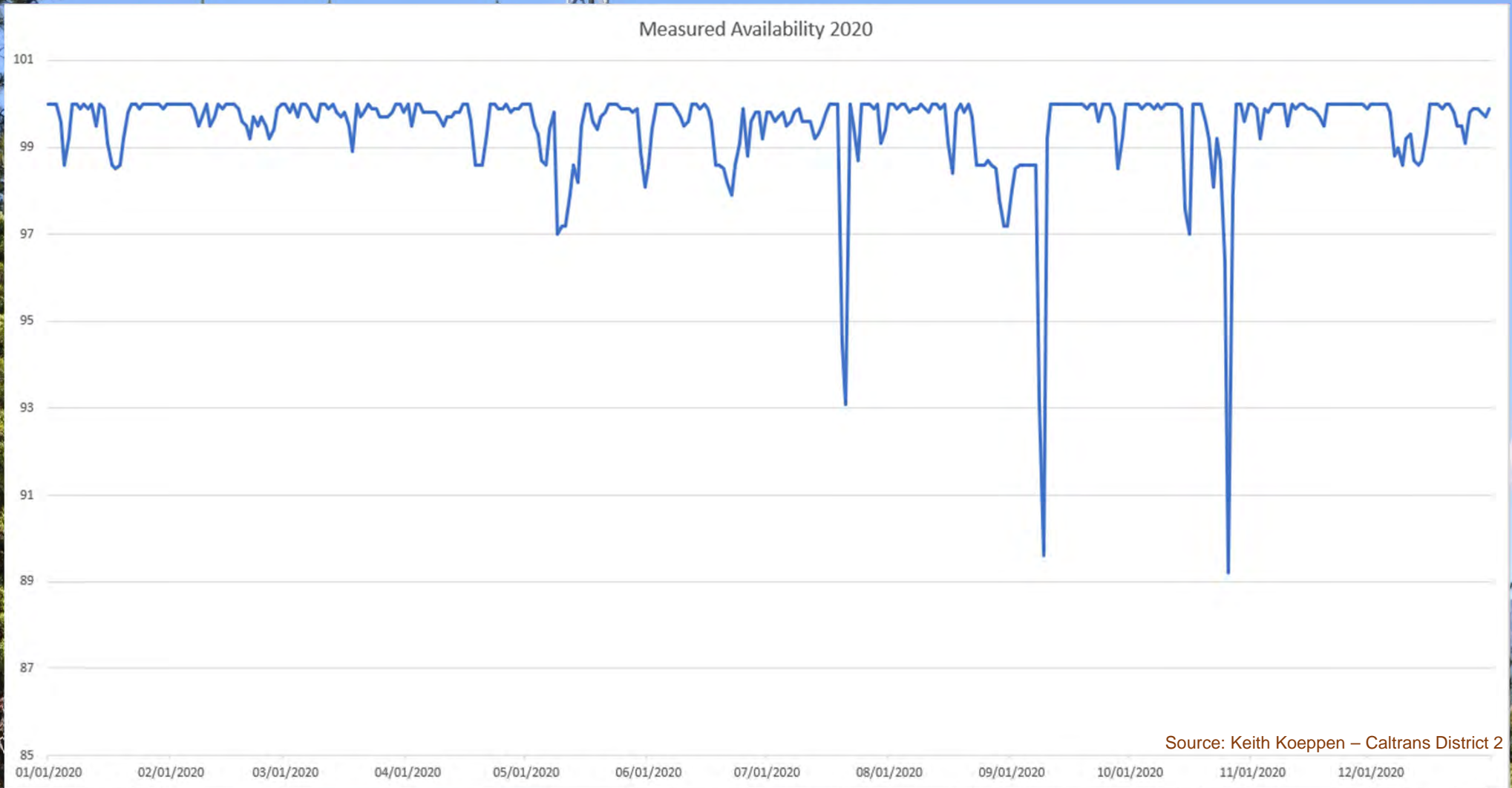
- **Impact to District 2 ITS Elements**
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 - **Total cumulative down time for all District 2 ITS Elements: Over 8,700 hours!**



Public Safety Power Shutoffs

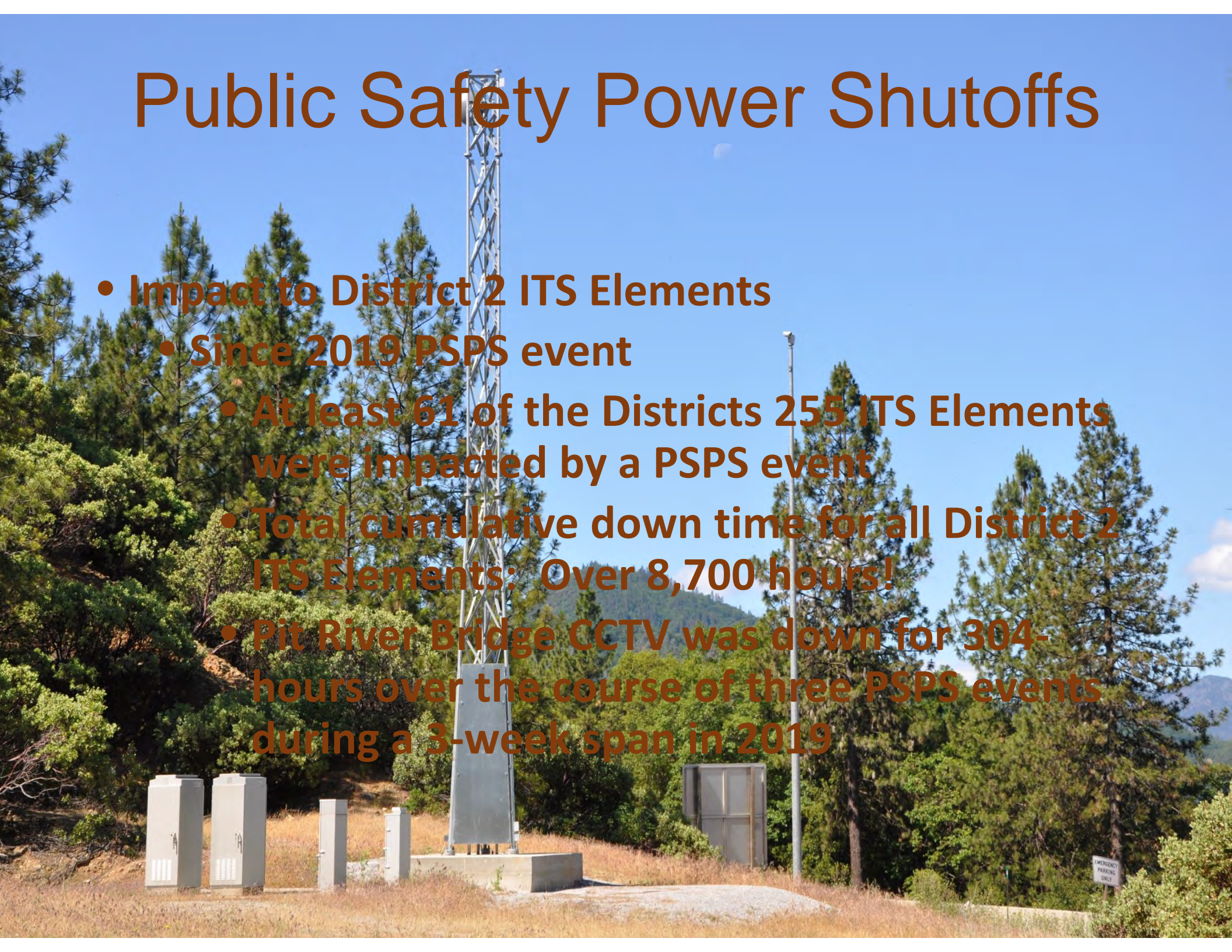


Public Safety Power Shutoffs



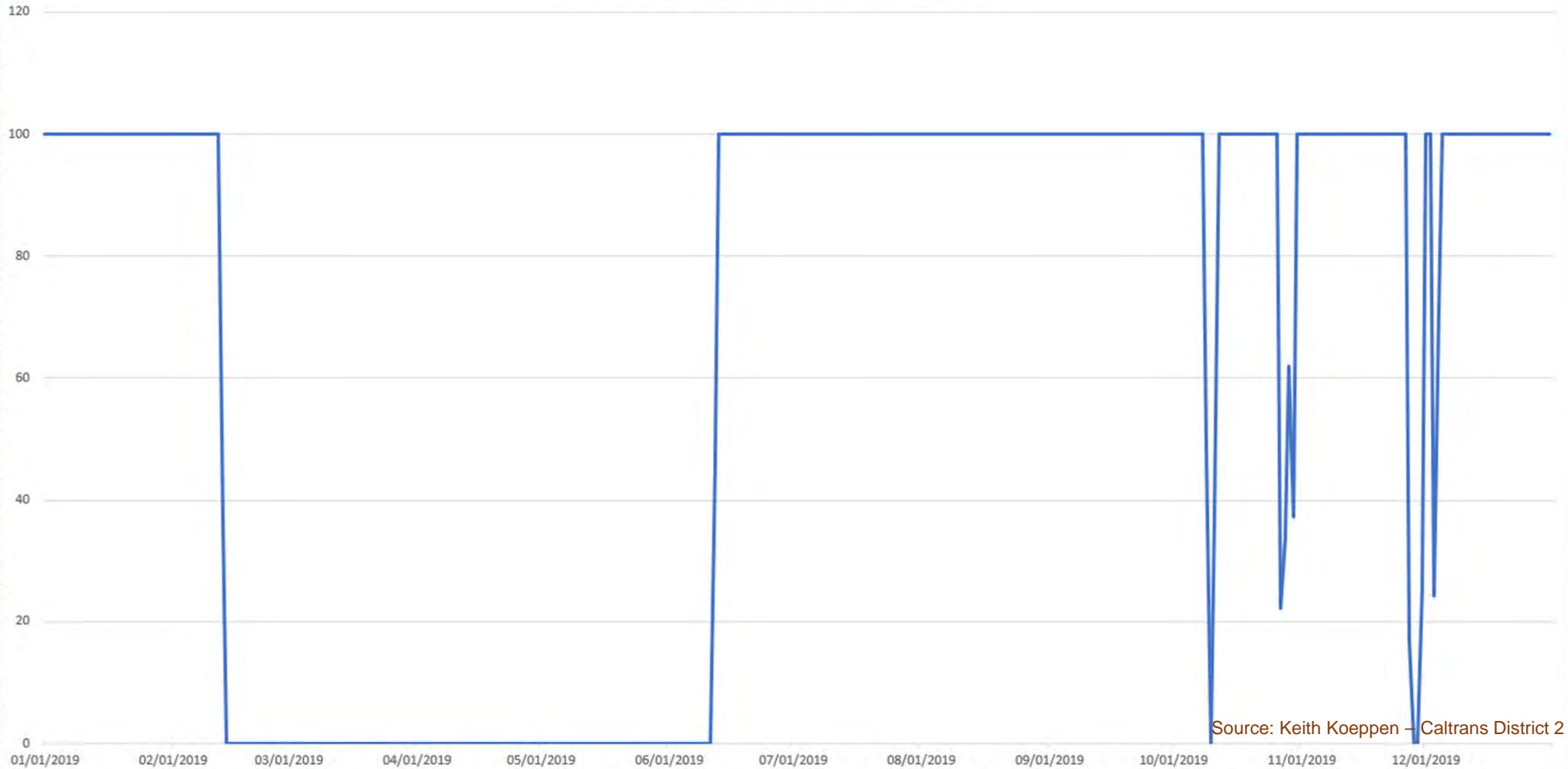
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 - **Pit River Bridge CCTV was down for 304-hours over the course of three PSPS events during a 3-week span in 2019**



Public Safety Power Shutoffs

Pit River Bridge Measured Availability 2019



Source: Keith Koeppen - Caltrans District 2

EMERGENCY
PARKING
ONLY

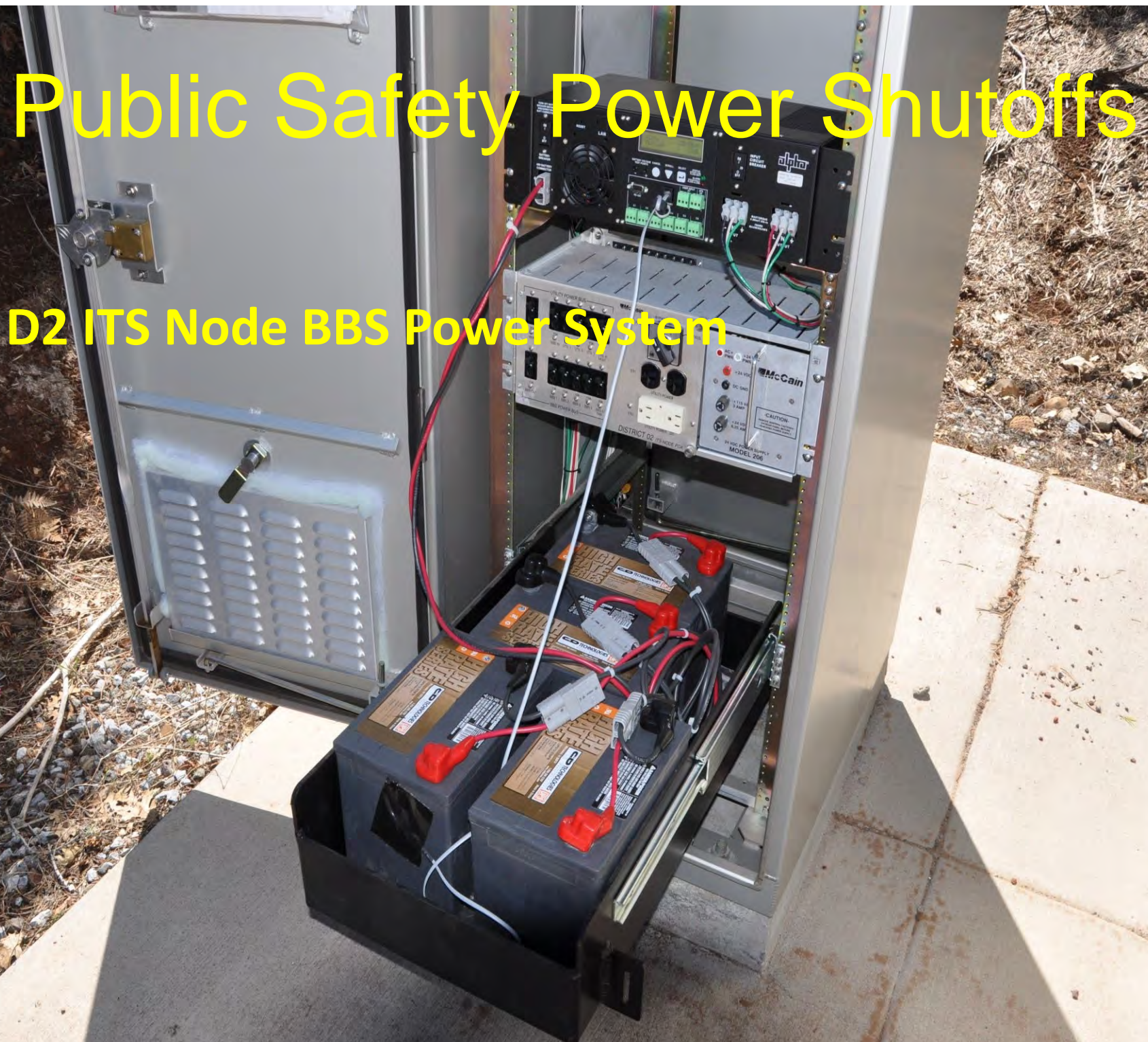
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 - **Frequency and magnitude have decreased in most areas since 2019 PSPS event**

EMERGENCY
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Public Safety Power Shutoffs

- D2 ITS Node BBS Power System



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 - District 2 ITS Node BBS system:
 - Inverter – Alpha FXM-1100



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Photo: Ian Turnbull

Public Safety Power Shutoffs

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 - All elements are supplied power from the utility grid
 - ITS Node BBS was designed to provide reliable power rather than carrying the load for long term power outages
- District 2 ITS Node BBS system:
 - Inverter – Alpha FXM-1100
 - Four (4) 77.8 AH Lead Acid batteries in series
 - Average runtime is 12-hours



Public Safety Power Shutoffs

- **PROBLEM!**



Public Safety Power Shutoffs

- **PROBLEM!**
- **How do we keep ITS Elements and Traffic Signals powered during PSPS events for up to weeks at a time?**

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Photo: Karl Mondon Bay Area News Group

Public Safety Power Shutoffs

- **OPTIONS**



Public Safety Power Shutoffs

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- **Generator** – Currently used to provide backup power to most traffic signals. Limitations include, high cost of operation and maintenance, refueling outages, theft, etc.



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- **Anything else?**

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- **Generator** – Currently used to provide backup power to most traffic signals. Limitations include, high cost of operation and maintenance, refueling outages, theft, etc.
- **Anything else?**
- **Fuel cell!**

HFC Research Project

- **Research project initiated September 2021 to evaluate a hydrogen fuel cell system to provide backup power to ITS/TMS elements during PSPS events at four locations across Districts 2 and 3**



Photo: Altery



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Photo: Alteryg



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HFC Research Project

- Research project initiated September 2021 to evaluate a hydrogen fuel cell system to provide backup power to ITS/TMS elements during PSPS events at four locations across Districts 2 and 3
- Partnered with AHMCT – UC Davis
- Fuel type investigated was hydrogen, though other fuel options are available



Photo: Alteryg



Photo: Alteryg

HFC Research Project

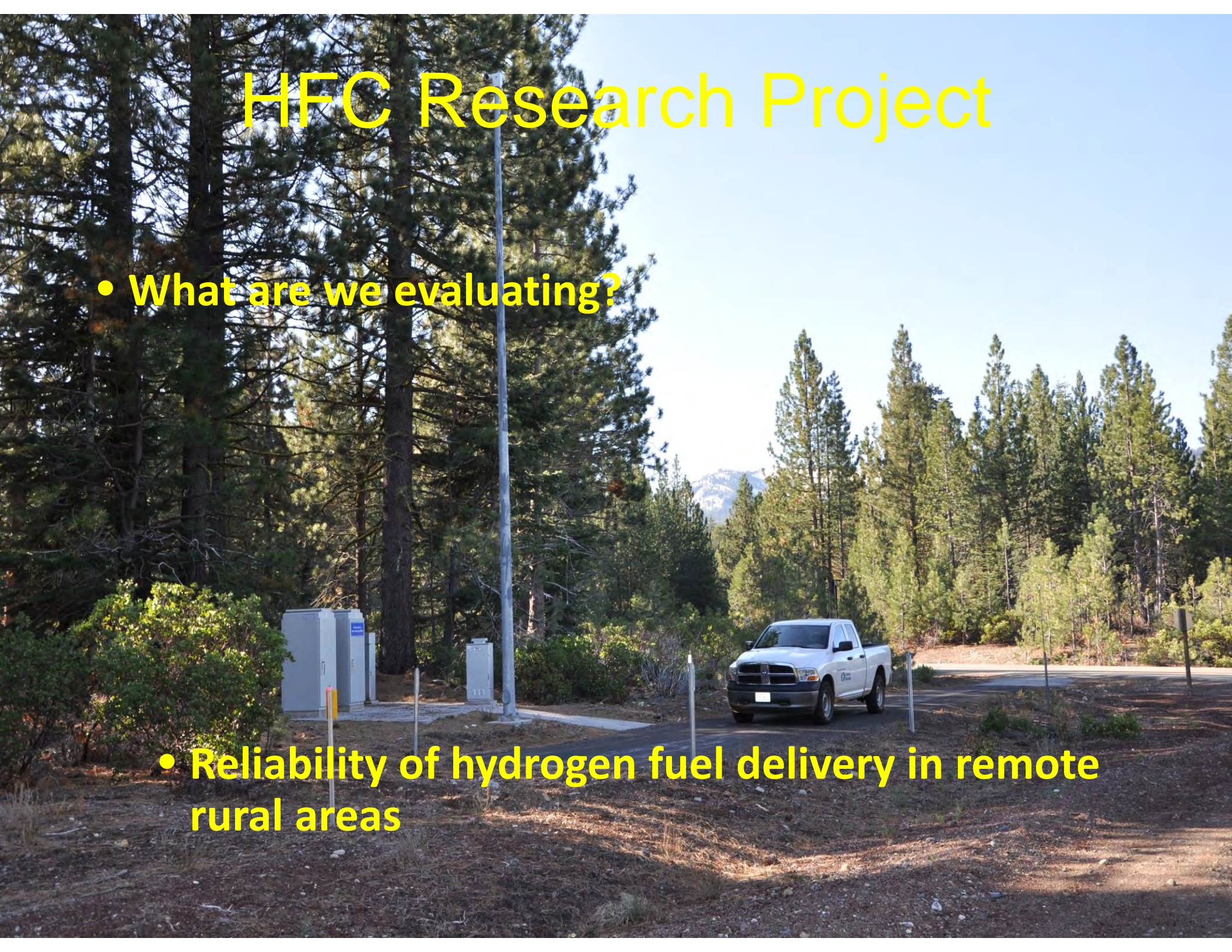
- What are we evaluating?



HFC Research Project

- **What are we evaluating?**

- **Reliability of hydrogen fuel delivery in remote rural areas**



HFC Research Project

- **What are we evaluating?**

- **Performance during various extreme weather conditions (heat, heavy snow, etc.)**

HFC Research Project

- What are we evaluating?

- Does the system meet power performance requirements, run time, and specs?

HFC Research Project

- What are we evaluating?

- 334/332 Traffic style cabinet/enclosure



HFC Research Project

- What are we evaluating?



- Integration with existing BBS/UPS systems

HFC Research Project

- What are we evaluating?

- Safety



HFC Research Project

- D2 Sites
 - Lassen Park CCTV



HFC Research Project

- D2 Sites
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- D2 utilized “Day-Labor” projects using SHOPP funds to construct the foundations for two HFC systems included in a 334 cabinet.



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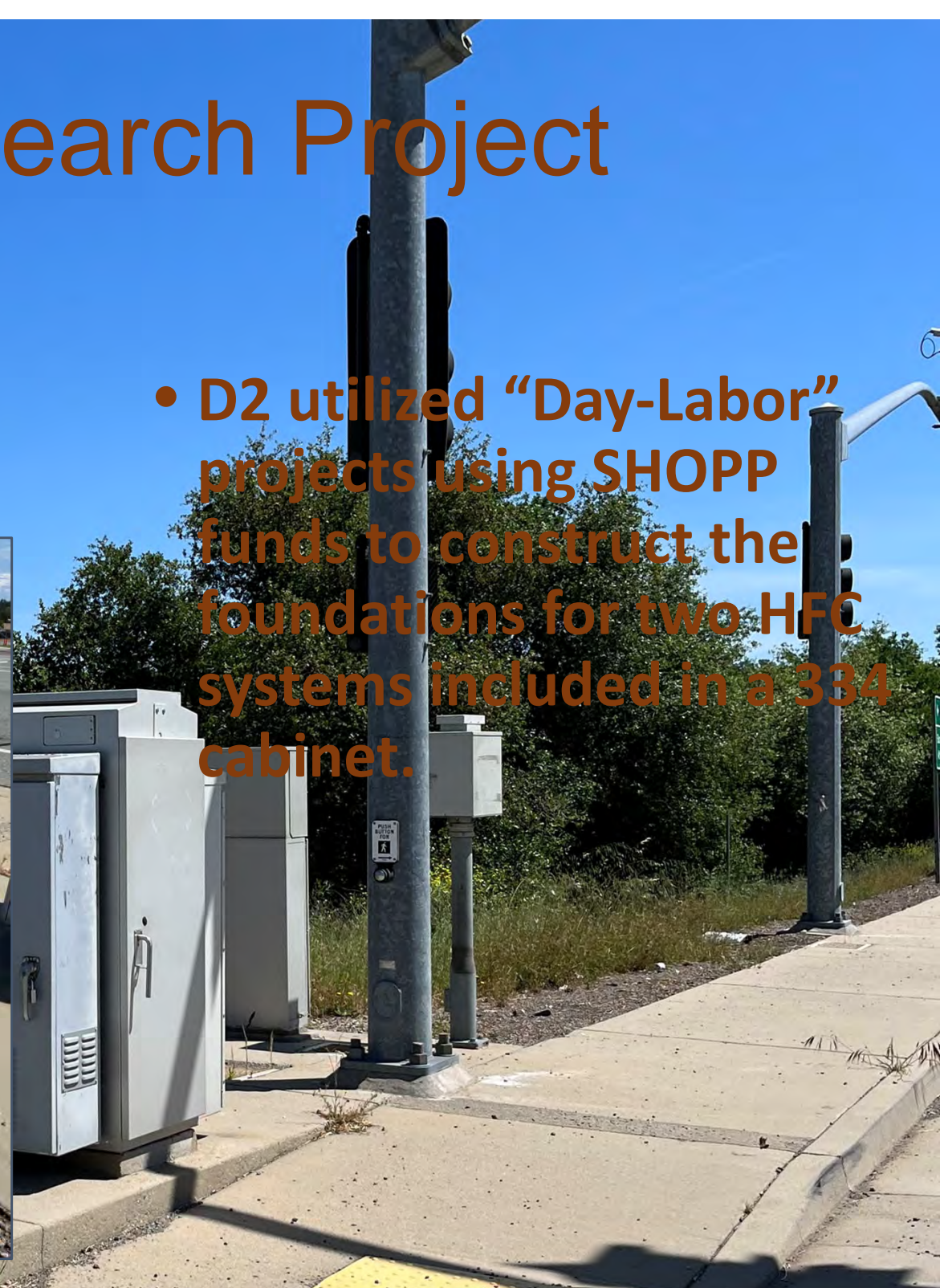
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HFC Research Project

- **The outcome of the research project will be highlighted in the next presentation...**

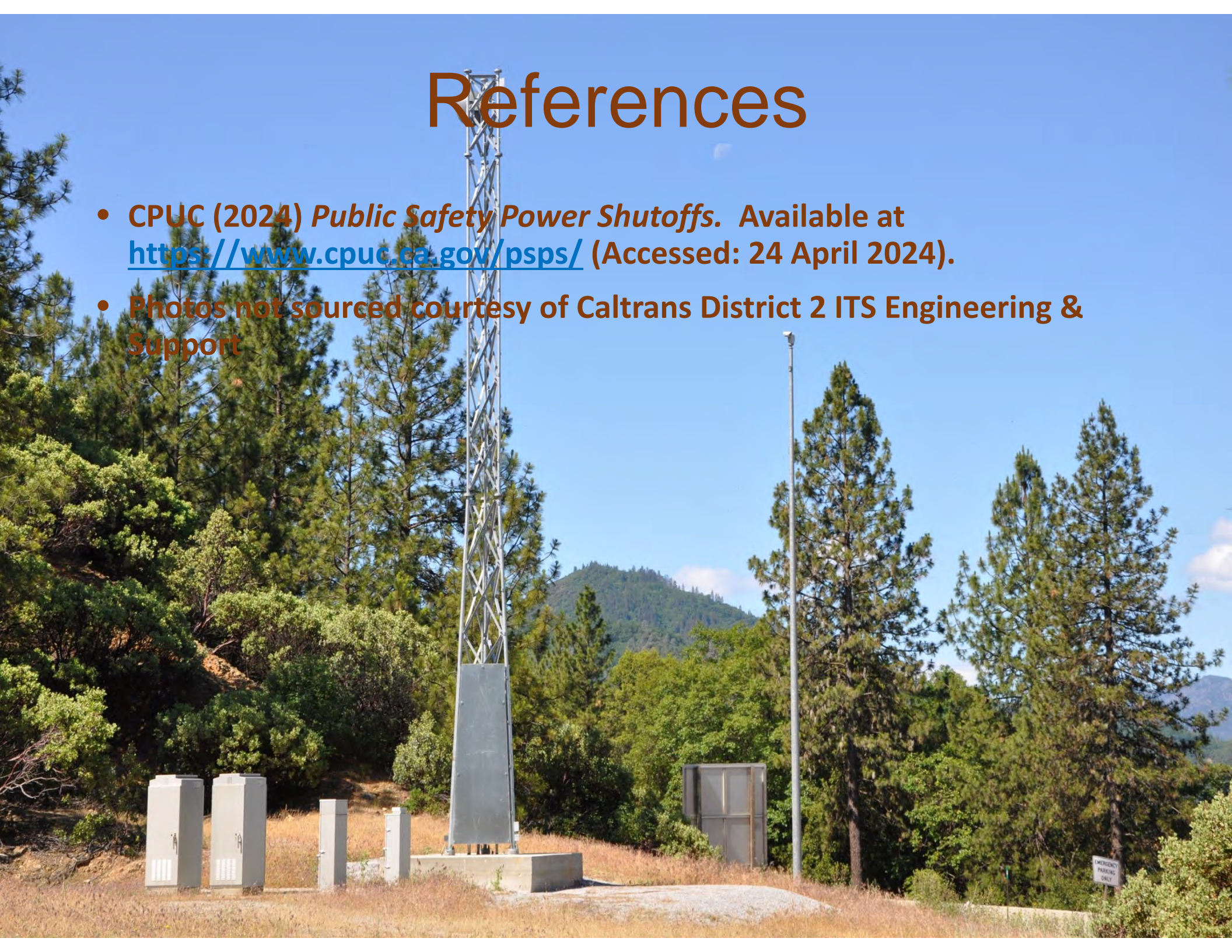


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- Photos not sourced courtesy of Caltrans District 2 ITS Engineering & Support





Questions?