WILDFIRE MITIGATION

EPIC POLICY + INNOVATION COORDINATION GROUP

David Saah,
SIG-GIS

Wildfire Mitigation

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Wildfire models and climate forecasting tools need better and more consistent input data.

As utilities seek to develop more granular predictions for wildfire risk, which impacts investment decisions and public safety power shutoff plans, presenters said many of those predictions use data that are out of date and infrequent.

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Workstream Highlighted Outdated or Infrequent Data:

- Fuel models were created in the 1970s off of significantly different landscapes
- Seismic earthquake forecasts are based on historical information from decades ago
- High winds are difficult to accurately forecast
- NOAA historical weather data may no longer be accurate. This is evidence by California’s recent trend of asymmetric warming

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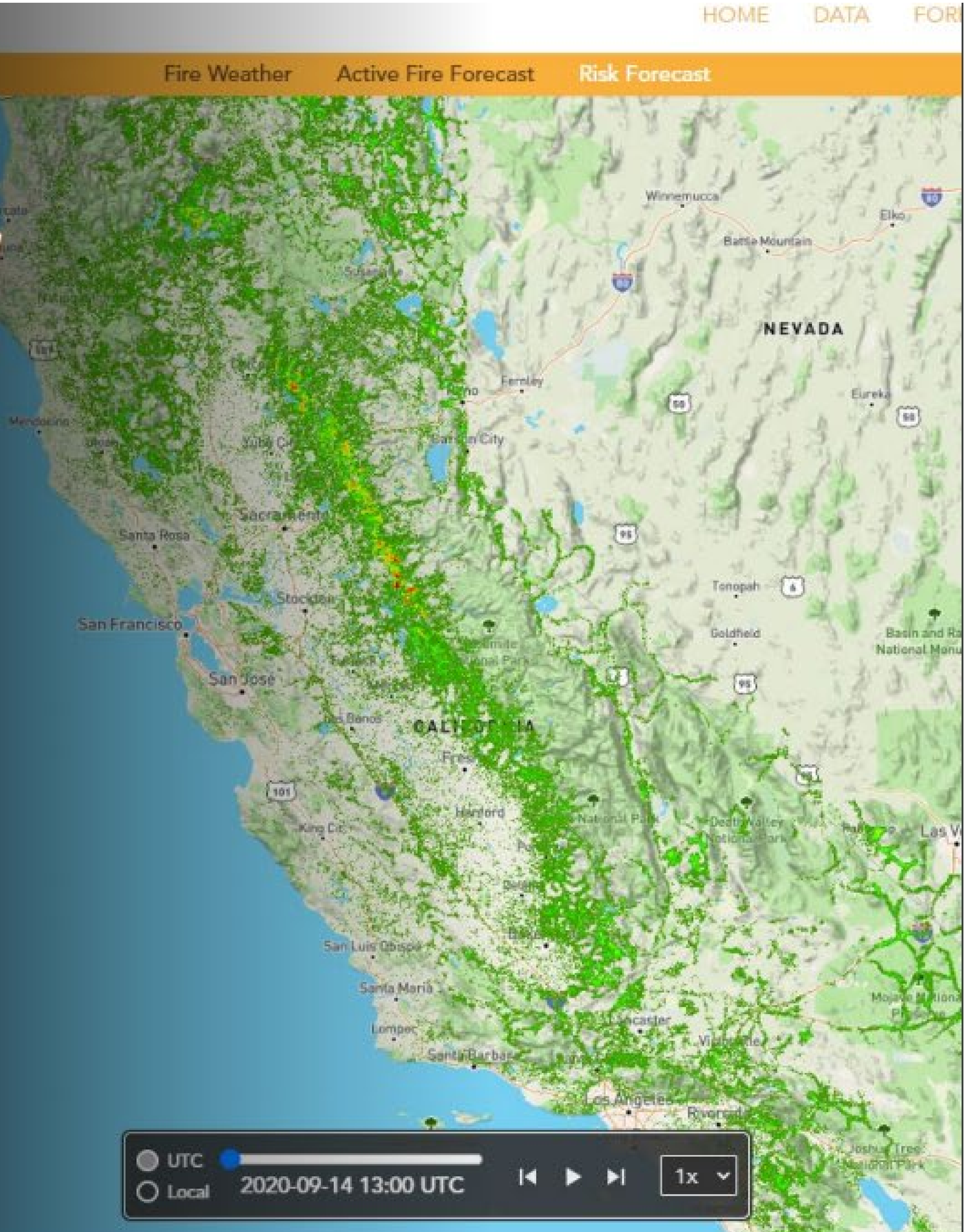
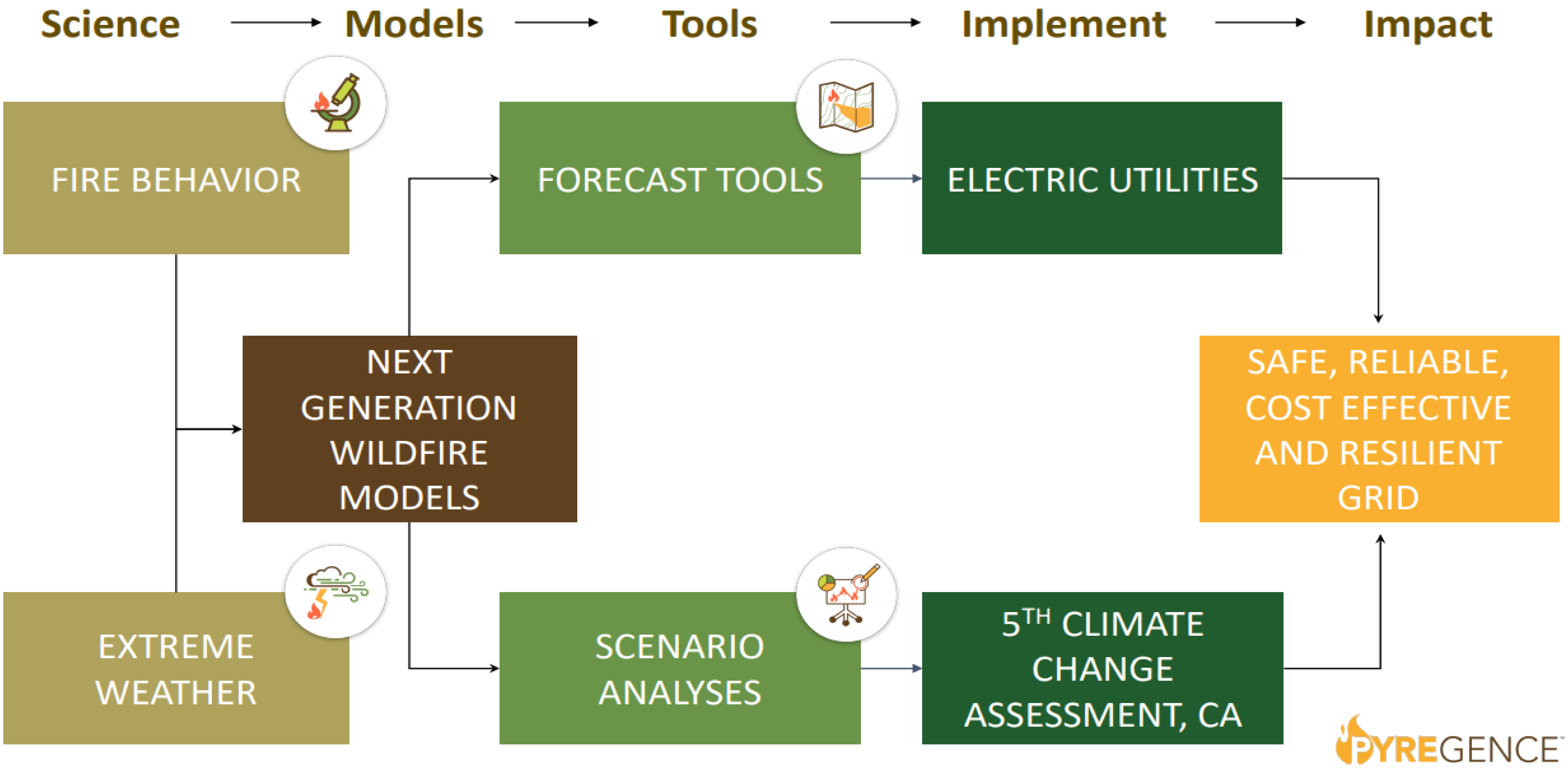
Open source and standardized weather data sets will accelerate research and modeling of wildfire threats and increase transparency of utility decision-making

The workstream meeting included robust conversation about methods to create a standardized, open source ecosystem for weather and climate data that could be used consistently by utilities, regulators, and researchers alike.

What models and forecasting tools do regulators and utilities need, but are not available or readily used today?

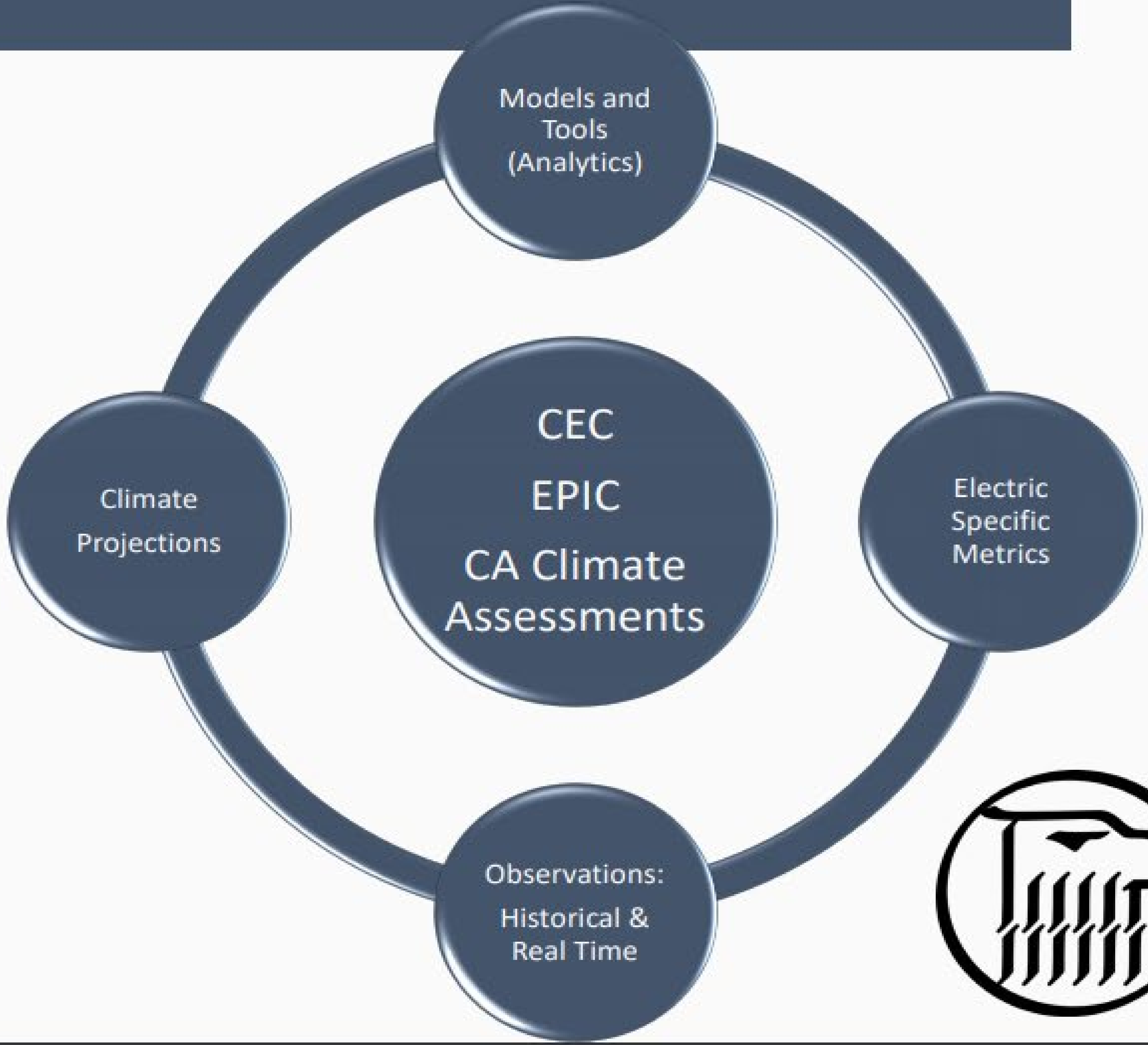
- Accurate forecast models linked to easy to use tools that include:
  - 0-7 day fire-weather forecast – situational awareness
  - Wildfire hazard and consequence mapping:
    - Active fire spread forecasts – support tactical/operation decisions
    - Season fire forecasts – workforce planning
    - Immediate future fire forecast (1 to 5 years) – mitigation planning and budgeting
    - Long-term fire forecast (to end of century) – vulnerability assessments




Science
Models
Tools
Implement
Impact
FIRE BEHAVIOR
FORECAST TOOLS
ELECTRIC UTILITIES
NEXT GENERATION WILDFIRE MODELS
SAFE, RELIABLE, COST EFFECTIVE AND RESILIENT GRID
EXTREME WEATHER
SCENARIO ANALYSES
5TH CLIMATE CHANGE ASSESSMENT, CA
PYREGENCE

Solution: A California Climate Data Enterprise

Image Source: NOAA



Source: Owen Doherty, Wildfire Mitigation Workstream Presentation (9/23/20)

Nisha Menon, San Diego Gas & Electric

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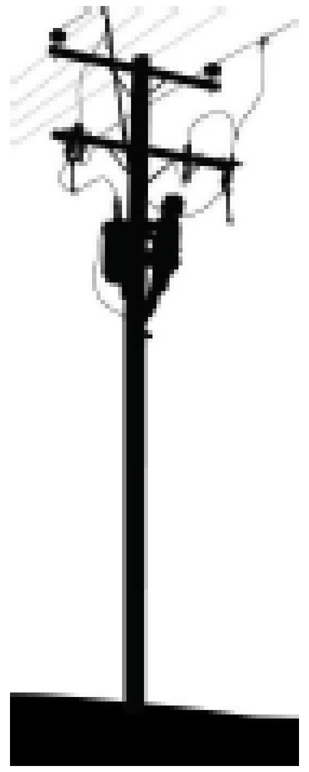
Cost-effective wildfire management depends on being able to granularly assess risk.

Being able to granularly assess asset and ignition risk enables grid operators to determine if, when, and what asset hardening, and wildfire mitigation strategies need to be deployed.

RISK-BASED GRID HARDENING

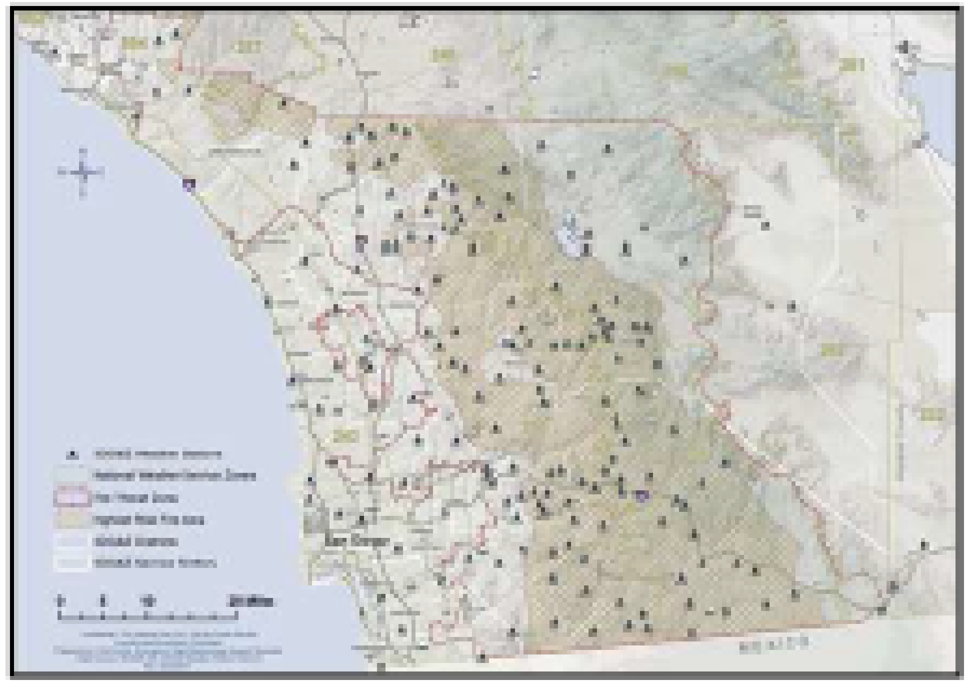
A Sempra Energy utility

***Current State**: Established methodologies for prioritizing wildfire mitigations at the asset level to inform system-level assessments across portfolio of wildfire mitigation programs*



Asset-Level Strategies

- Targeted investments to replace high risk equipment
- Use of Public Safety Power Shutoffs (PSPS) to reduce fire risk



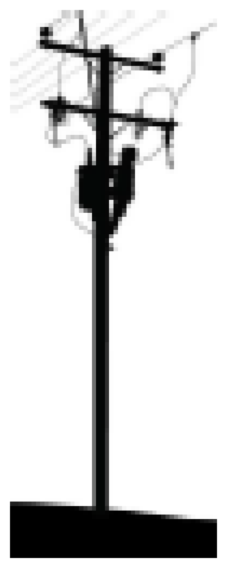
System-Level Strategies

- Annual enterprise risk management process
- Risk Spend Efficiency assessments at the program level (RAMP)

Spectrum of Granularity

RISK-BASED GRID HARDENING

***Future State:** Include a level of granularity between asset-level and system-level that accounts for PSPS and wildfire mitigation risk reduction relationship*



Asset-Level Strategies
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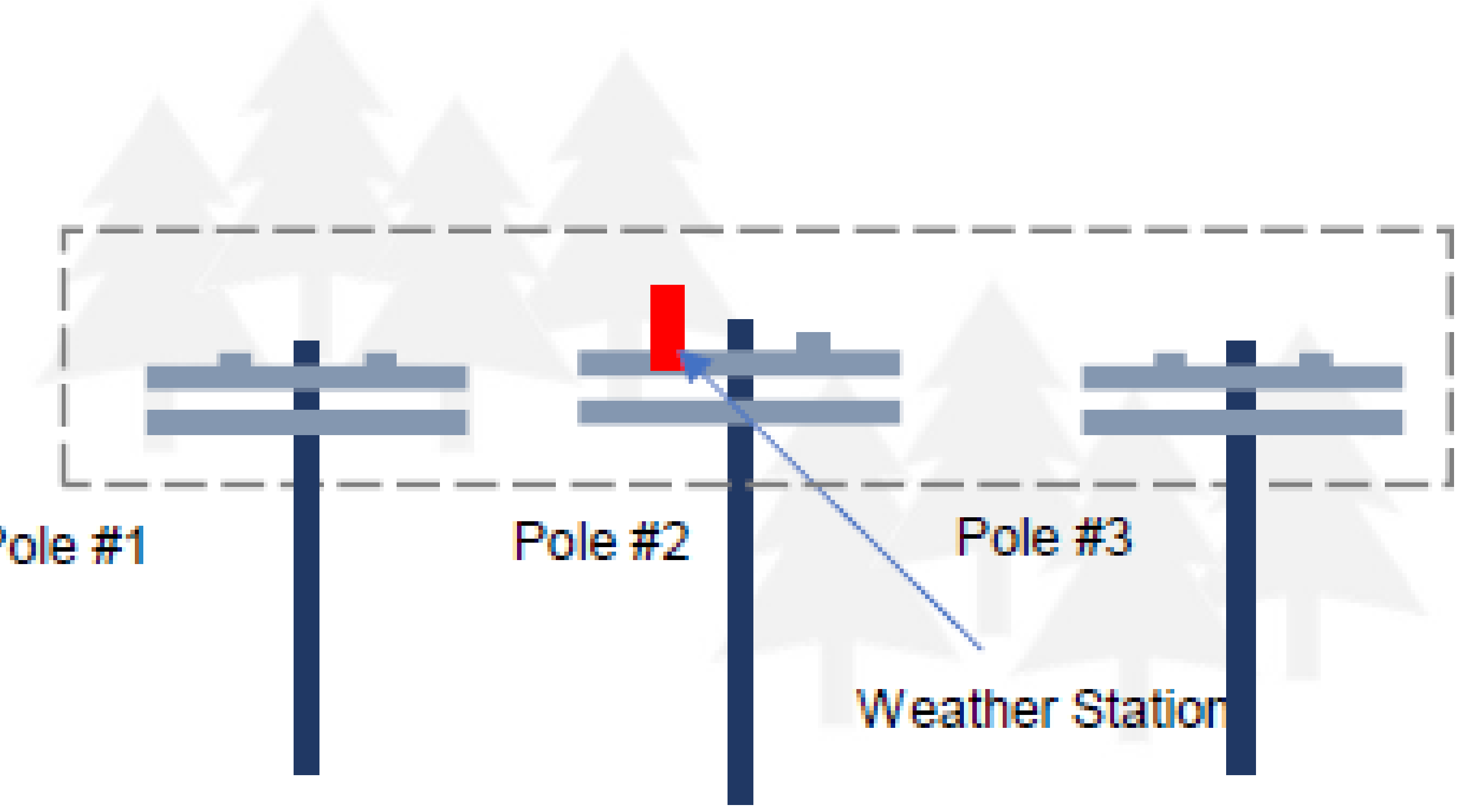
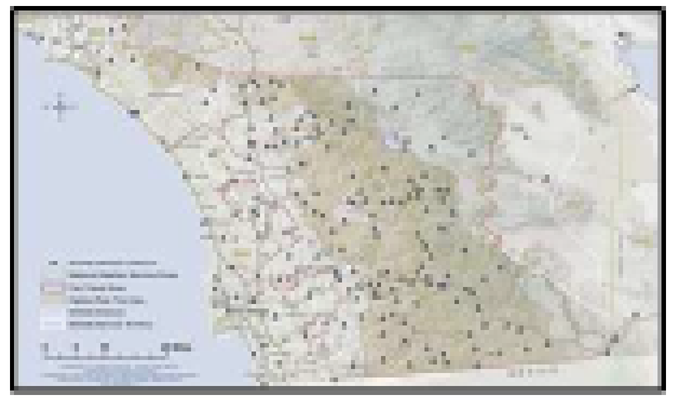


Segment-Level Strategies
- Targeted investments based on segment-level risk
- Includes review of wildfire risk and PSPS risk reductions



System-Level Strategies
- Annual enterprise risk management process
- Risk Spend Efficiency assessments at the program level (RAMP)

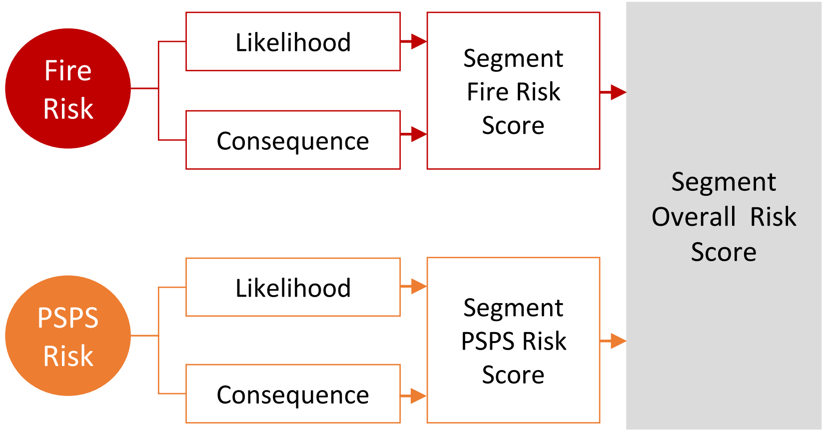
Spectrum of Granularity

WiNGS

A risk-based decision-support tool to determine **most cost-effective investments in terms of wildfire and PSPS risk reduction**

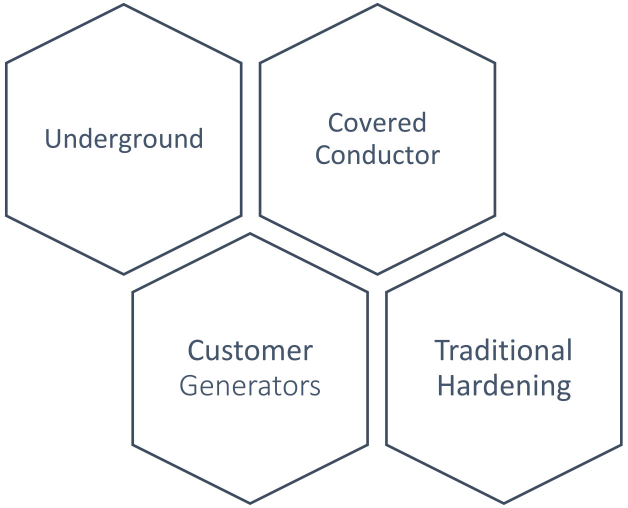
What's our current risk level today?

Baseline Risk Level



Which mitigation is most cost-effective?

Alternatives Analysis



What's the right mix of strategies to deploy?

Portfolio Analysis

1. Bare Conductor Hardening
2. Customer Generators
3. Significant Hardening
4. Limited Hardening
5. Optimal RSE

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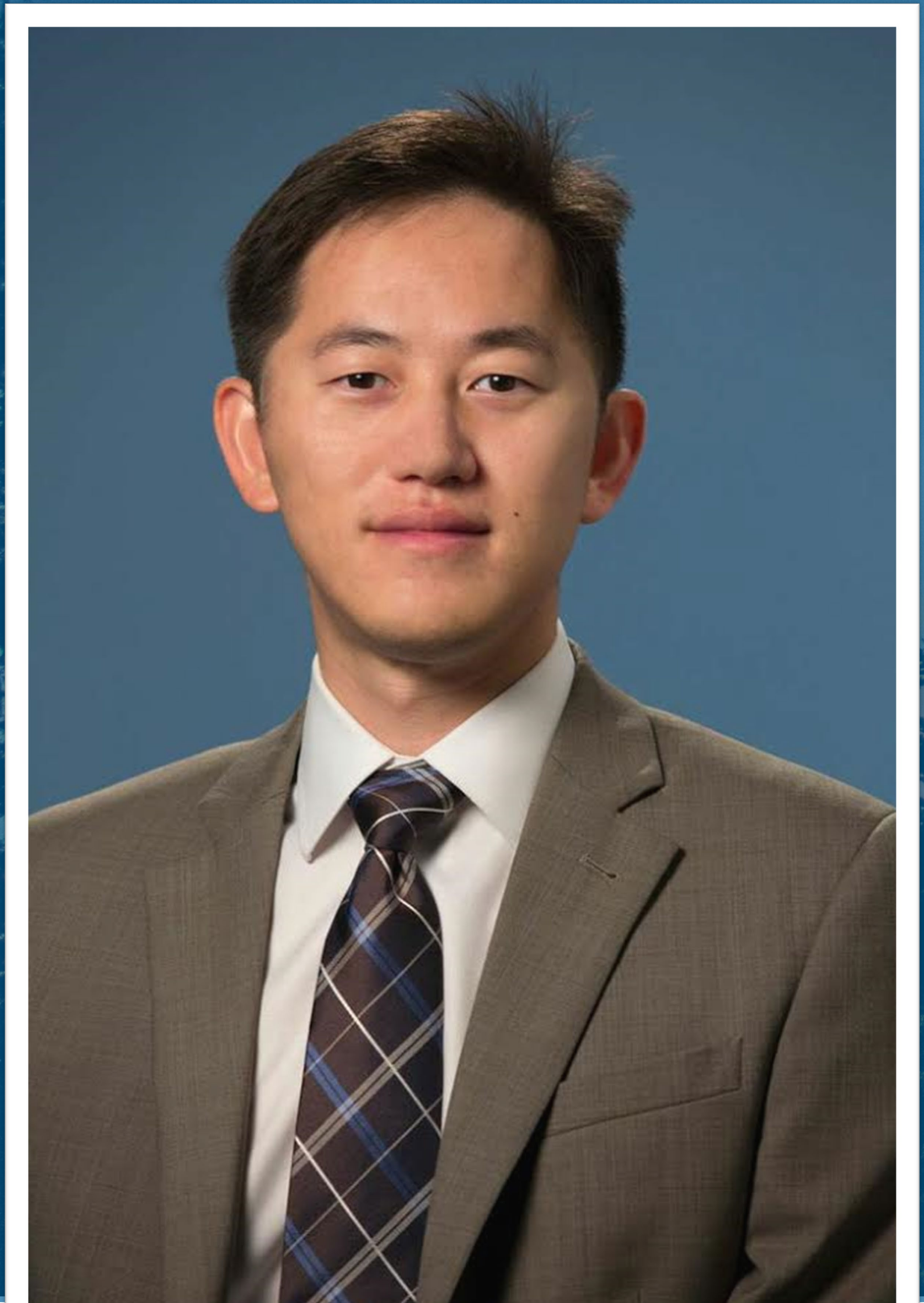
There is no playbook or "recipe" for wildfire mitigation strategies or deployment of technologies

Wildfire risk and mitigation strategies must be tailored to specific conditions and characteristics of the state's diverse geography and climate, including across and within utility territories.

Wildfire Mitigation

Factors Impacting Mitigation Strategies

- Local Topography
- Grid Topology
- Vegetation
- Asset Age
- Circuit Risk
- Asset Risk
- Asset and Operational Management
- Post Fire Window



Nanpeng Yu, University of California, Riverside

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Compiling complete and accurate data on electric grid assets is essential to performing predictive maintenance on the distribution grid.

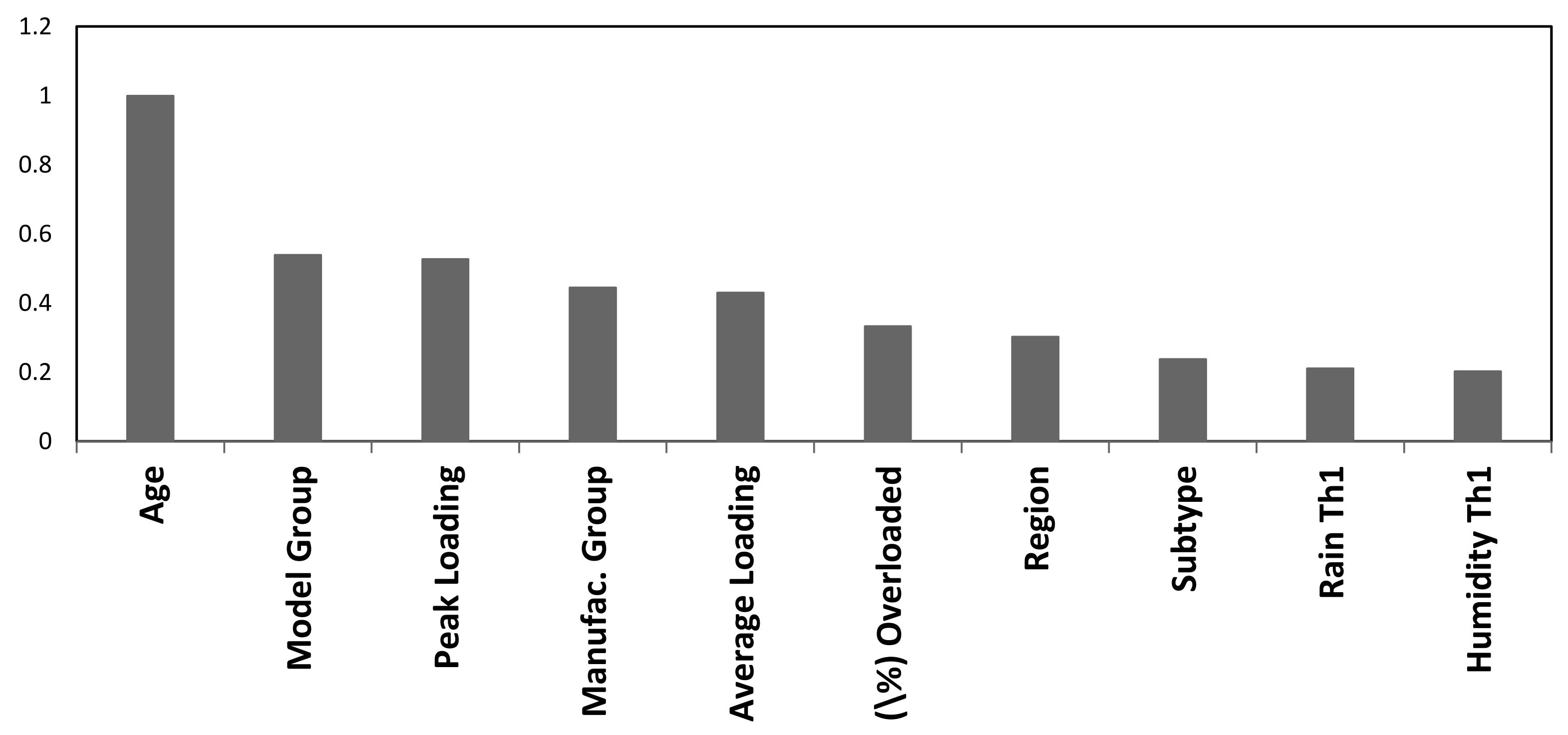
- ✓ Pinpointing grid assets that are at risk of failure and igniting wildfires can be a very cost-effective means of reducing wildfire risk.
- ✓ Machine learning-based predictive maintenance tools only work if the data on the grid assets and network topology are complete and accurate.
- ✓ However, data quality for most North American electric utilities need significant improvement.

Data set covering over 800,000 transformers in power distribution system in Southern California

Input Data Types	Missing %
Weather Related	4.7%
Location Related	9.4%
Loading Related	19.68%
Transformer Related	9.4%
Reason of Failure	>50%

Number of actual failures for Top 1000 Transformers Identified by Machine Learning Algorithm

Data Set	Age-based	Random Forest	RUSBoost
Validation	50	462	471
Test	50	312	359

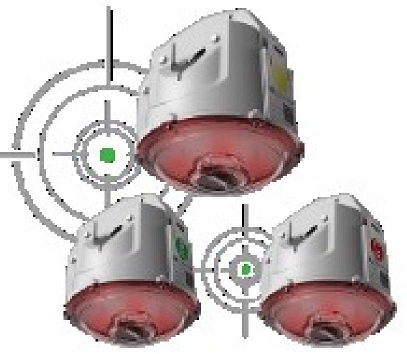


Variable Importance in Predicting Transformer Failures

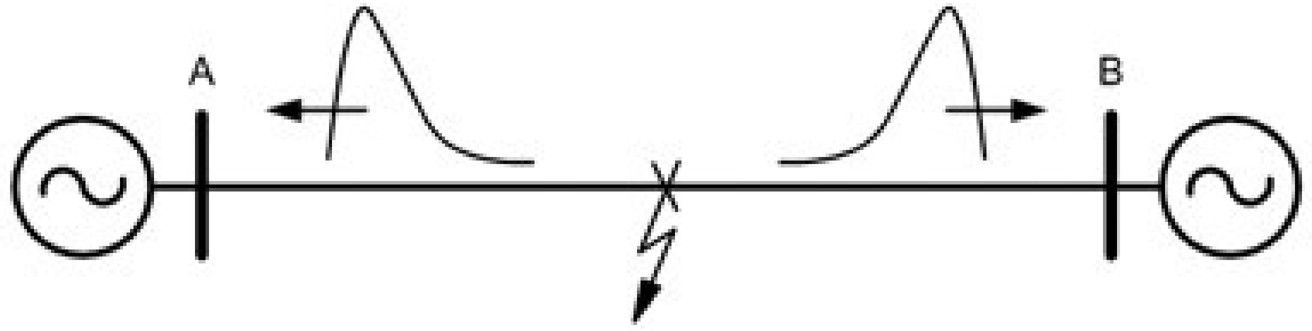
Farzana Kabir, Brandon Foggo, and Nanpeng Yu, "Data Driven Predictive Maintenance of Distribution Transformers," in the 8th China International Conference on Electricity Distribution, pp. 1-5 2018.

Applications of Machine Learning in Power Systems

Wildfire Monitoring
Remote Camera and Line Sensor Data Analytics



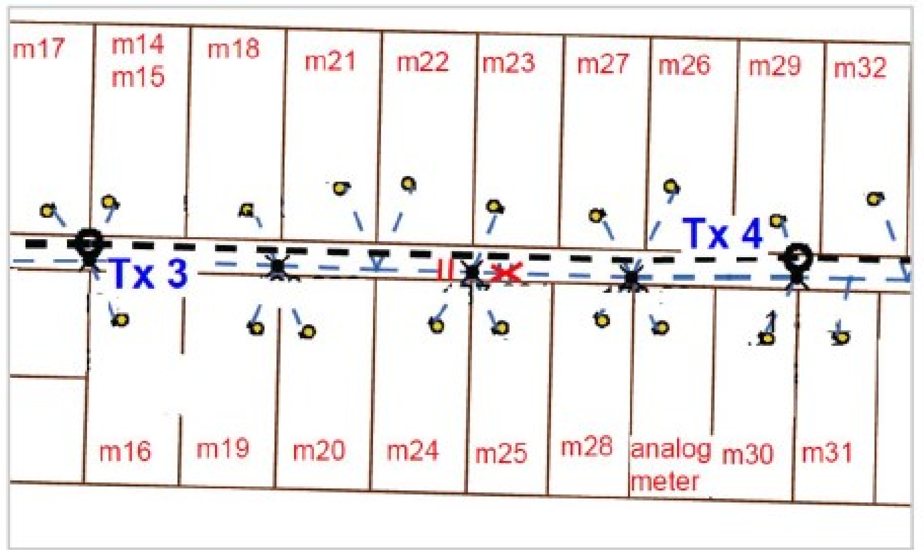
Fault Analytics
Fault Location
Identification with PMU



System Monitoring
State Estimation & Visualization

Equipment Monitoring
Predictive Maintenance
Online Diagnosis

Anomaly Detection
Electricity Theft,
Unauthorized Solar
Interconnection



Network Topology and Parameter Identification
Transformer-to-customer,
Phase connectivity,
Impedance estimation

Machine Learning Algorithms developed by Energy, Economics, and Environment (E3) Research Center

Faculty Director: Prof. Nanpeng Yu

Jie Shi, Brandon Foggo, and Nanpeng Yu, "Power System Event Identification based on Deep Neural Network with Information Loading," to appear in IEEE Transaction on Power Systems, 2021.

Jie Shi, Wei Wang, Yuanqi Gao, and Nanpeng Yu, "Optimal Placement and Intelligent Smoke Detection Algorithm for Wildfire-Monitoring Cameras," IEEE Access, vol. 8, no. 1, pp. 72326-72339, December 2020.

Yuanqi Gao, Brandon Foggo, and Nanpeng Yu "A Physically Inspired Data-Driven Model for Electricity Theft Detection with Smart Meter Data," IEEE Transactions on Industrial Informatics, vol. 15, no. 9, pp. 5076-5088, 2019. DOI:10.1109/TII.2019.2898171.

Jie Shi, Brandon Foggo, Xianghao Kong, Yuanbin Cheng, Nanpeng Yu, and Koji Yamashita "Online Event Detection in Synchrophasor Data with Graph Signal Processing," IEEE SmartGridComm, 2020.

Wei Wang and Nanpeng Yu, "Partial Discharge Detection with Convolutional Neural Networks," the 16th International Conference on Probabilistic Methods Applied to Power Systems, 2020.

Jie Shi, Wei Wang, Yuanqi Gao, and Nanpeng Yu, "Detection and Segmentation of Power Line Fires in Videos," IEEE ISGT North America, pp. 1-5, 2019.

Yuanqi Gao and Nanpeng Yu, "State Estimation for Unbalanced Electric Power Distribution Systems Using AMI Data," The Eighth Conference on Innovative Smart Grid Technologies (ISGT 2017), pp. 1-5, Arlington, VA.

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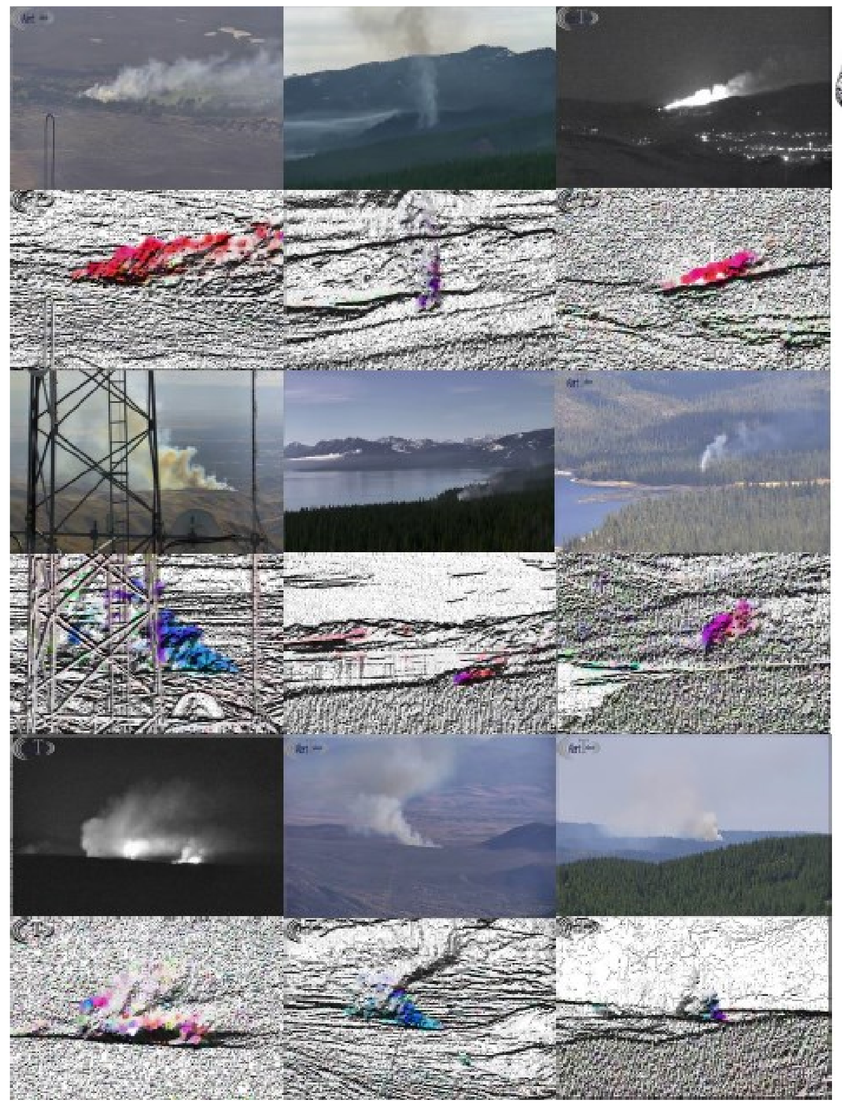
Early smoke detection algorithm to mitigate wildfire

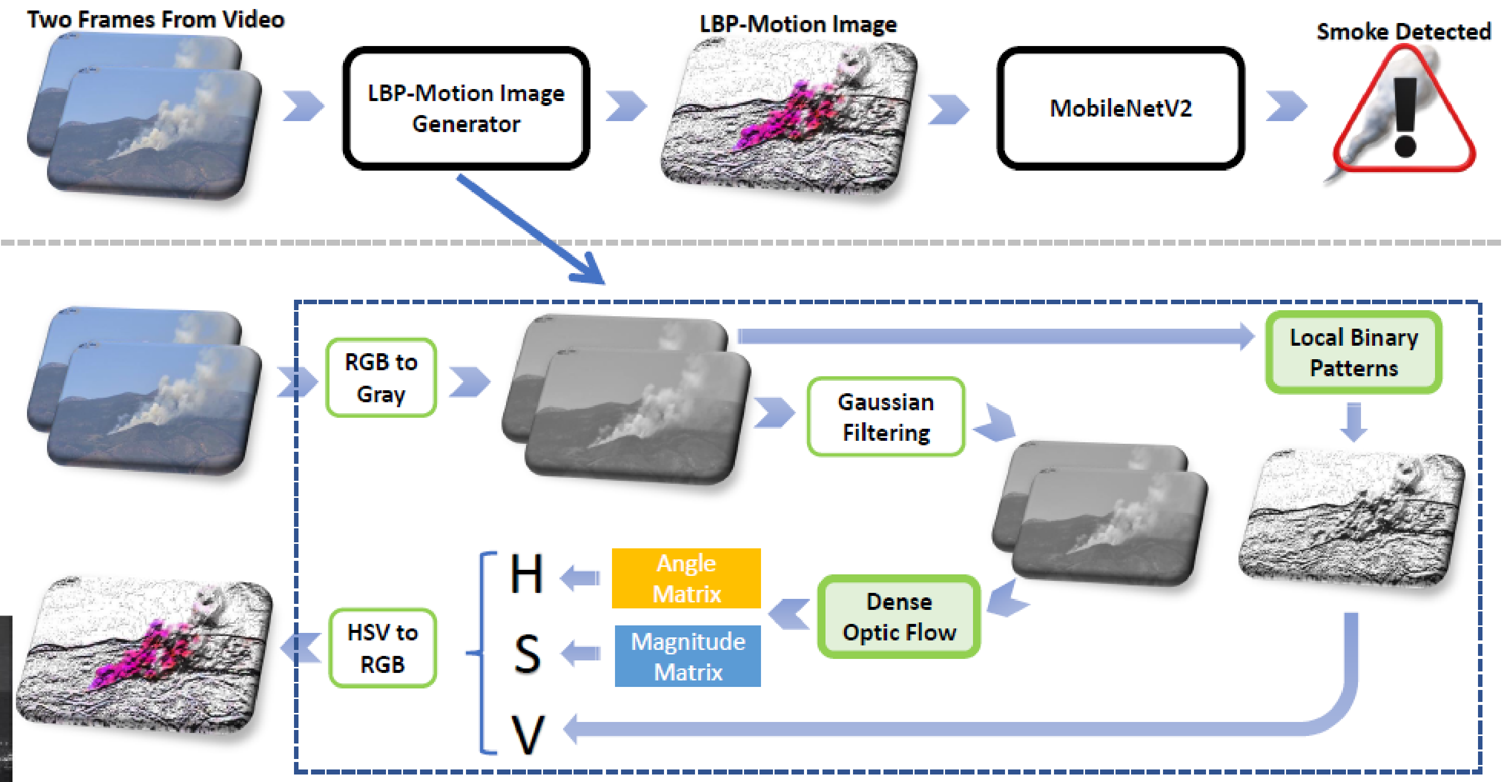
Automatic, high accuracy, lightweight

Edge Computing Unit: Raspberry Pi



Sample smoke video frames from ALERT Wildfire & LBP-motion images

Machine Learning-based mobile smoke detection framework

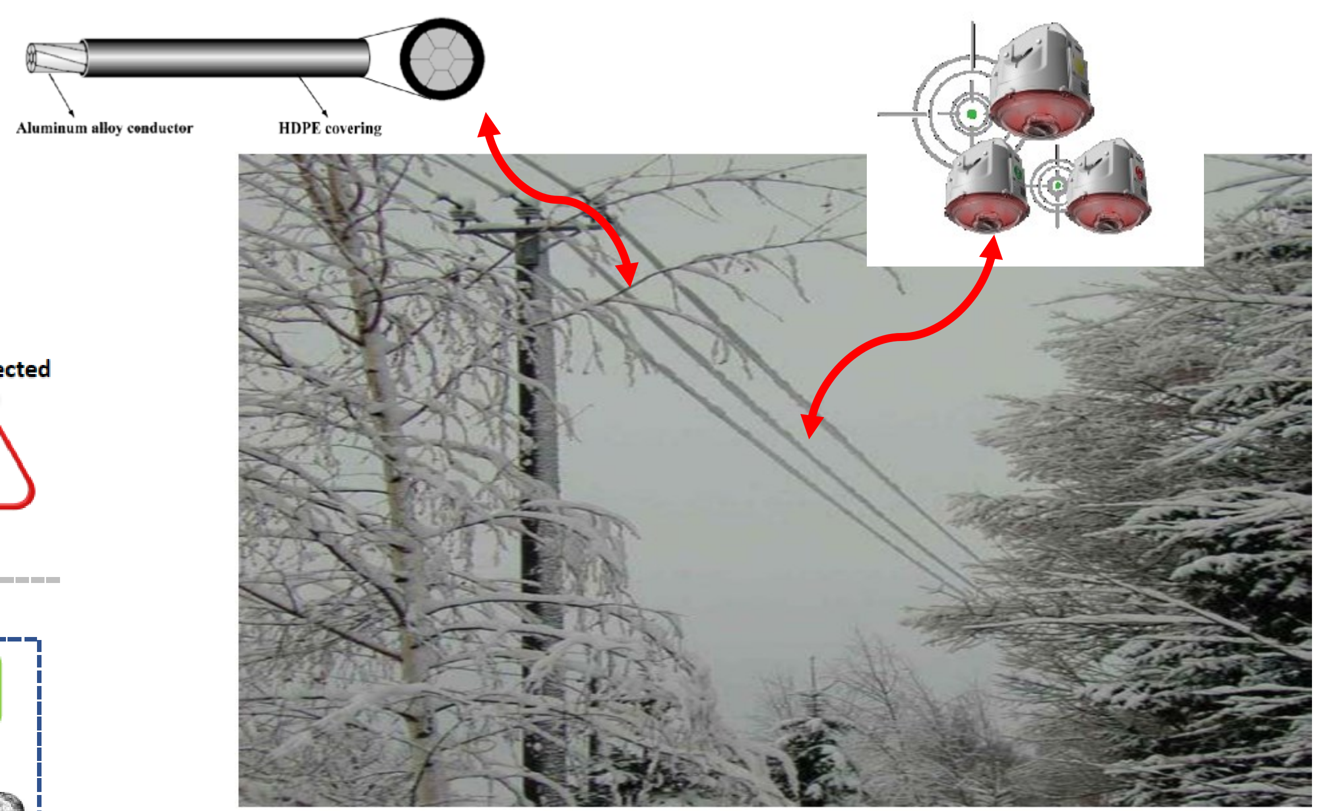


Neural Network	Detection Time	Memory
MobileNetV2	**0.117 ms**	8.9 MB
ResNet50	0.237 ms	90.2 MB
DenseNet169	0.367 ms	49.1 MB
InceptionV3	0.216 ms	83.6 MB
InceptionResNetV2	0.492 ms	208.4 MB

The proposed MobileNetV2 has the shortest detection time the least amount of memory requirement (low cost).

Covered Conductor

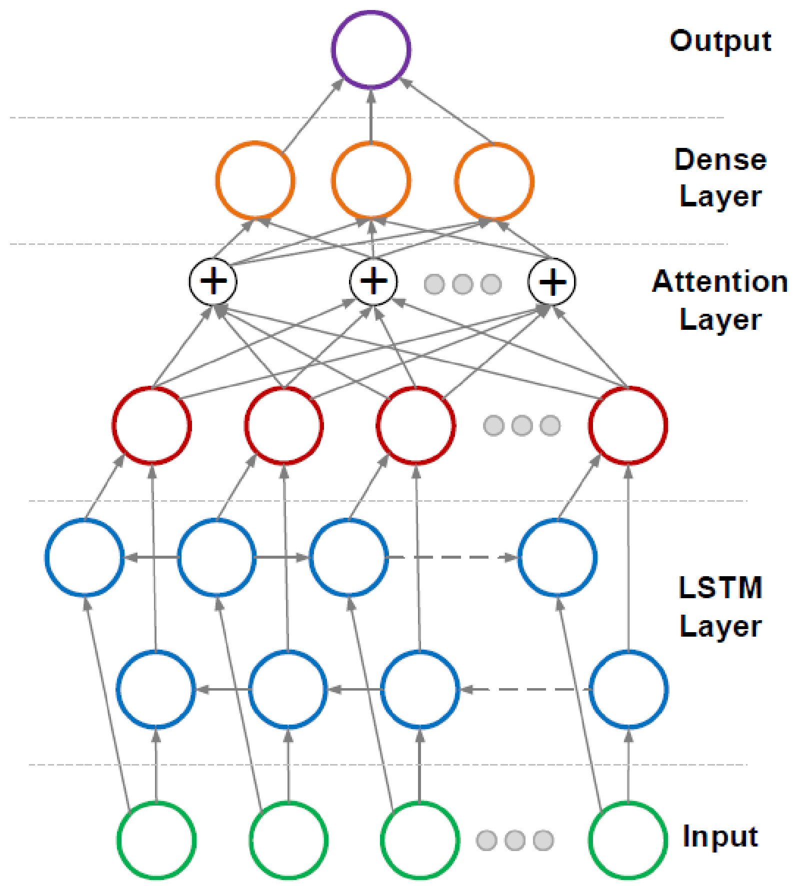
High Frequency Line Sensors

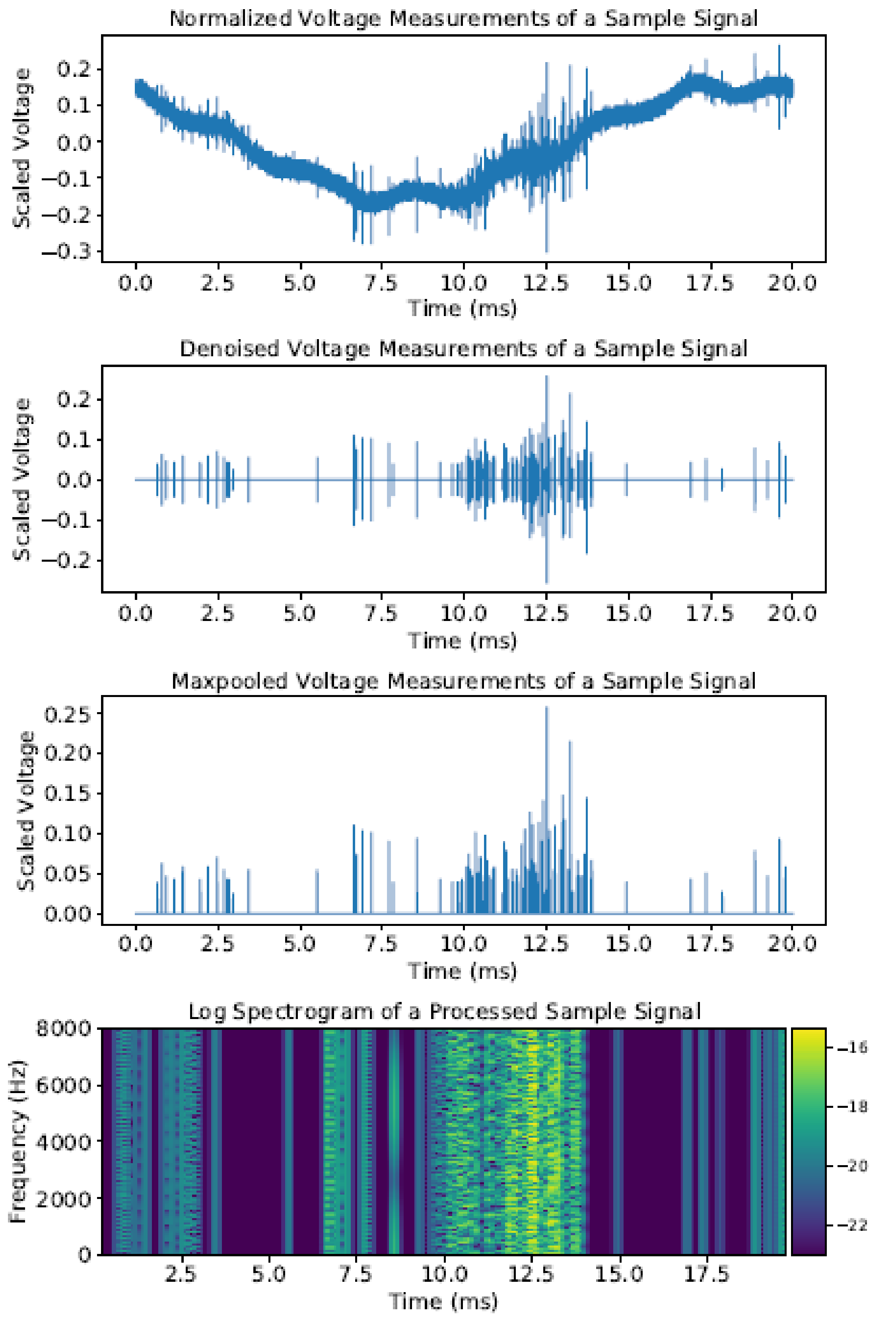


Leaning trees on covered conductor lines

Failed Conductor Due to Partial Discharge

Partial Discharge Detection with Machine Learning





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A centralized, integrated hub for data and situational awareness tools can create greater insights and quicker responses compared to the siloed systems that exist today.

- ✓ Panelists discussed that a possible area for future RD&D work was to develop pilots with a single assessment system incorporating information from the line sensors, smoke and heat detection cameras, continuous aerial inspection, supervisory control and data acquisition system, advanced metering infrastructure, outage management system, asset management system, geographical information system, and weather stations.
- ✓ In addition, there is a need to create a repository of the situational awareness and risk management tools, technologies, and strategies.