Balancing Wildfire Risks and Power Outages due to Proactive Public Safety De-Energizations

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Abstract

Faults on overhead power line infrastructures in electric power distribution systems (DS) can potentially ignite catastrophic wildfires, especially in areas exposed to high wind regimes, low humidity and dense vegetation. The common practice adopted by electric utilities to build resilience against such electrically-induced wildfires is called public-safety power-shutoff (PSPS): strategies to intentionally and proactively de-energize power line infrastructures to prevent wildfire risks. Our research aims to generate an optimal PSPS plan for mitigating the risk of costly wildfires while keeping the intentional power outage minimal. This objective is achieved by strategic deployment of transportable energy backup technologies in the DS, i.e., mobile power sources (MPSs).

Introduction

➢ Background

- ❖ Wildfire incidents have been evidenced, in the past decade, with an increased frequency and intensity, threatening communities, disrupting social and organizational ecosystems, harming natural resources, damaging homes and structures, and taking lives;
- ❖ In 2020, 58,950 wildfire incidents burned 10.1 million acres within the U.S., the second-most impacted acreage in a year since 1960.

Figure 1. California Wildfires

Figure 2. Alaska Wildfires

➢ Motivation

- ❖ While wildfires could be triggered by various means, those resulted from disruptions in the electrical infrastructures are recorded as the fifth highest cause at the rate of about 8%.
- ❖ A number of catastrophic electrically-induced wildfires has been recorded in recent years in the Western United Status, majorly due to power lines faults under precarious vegetation conditions, poor line maintenance, and severe weather.

Introduction (Cont.)

Figure 3. Falling trees and power lines.

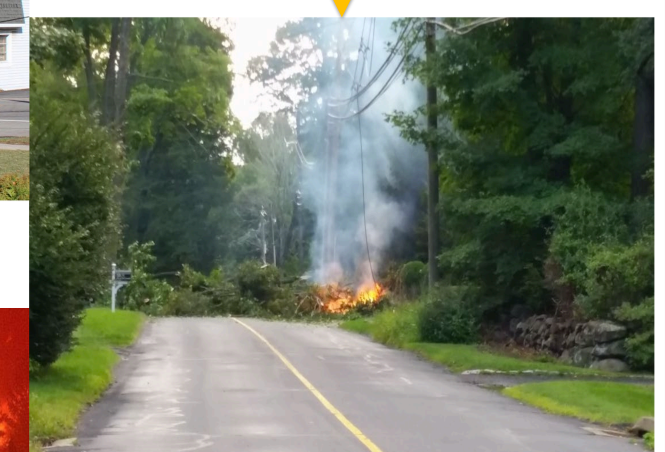

Figure 4. Arc ignition and sparks.

Figure 5. Wildfire incident.

➢ Existing Practice for Wildfire Prevention

The operational practice for wildfire prevention adopted by many electric utilities is referred to as PSPS: when dangerously-high winds arise, the electric utility anticipatively and intentionally pursues power line de-energization and black-outs the fire-prone areas that are home to millions of people.

Figure 6. PG&E's command center for PSPS decisions.

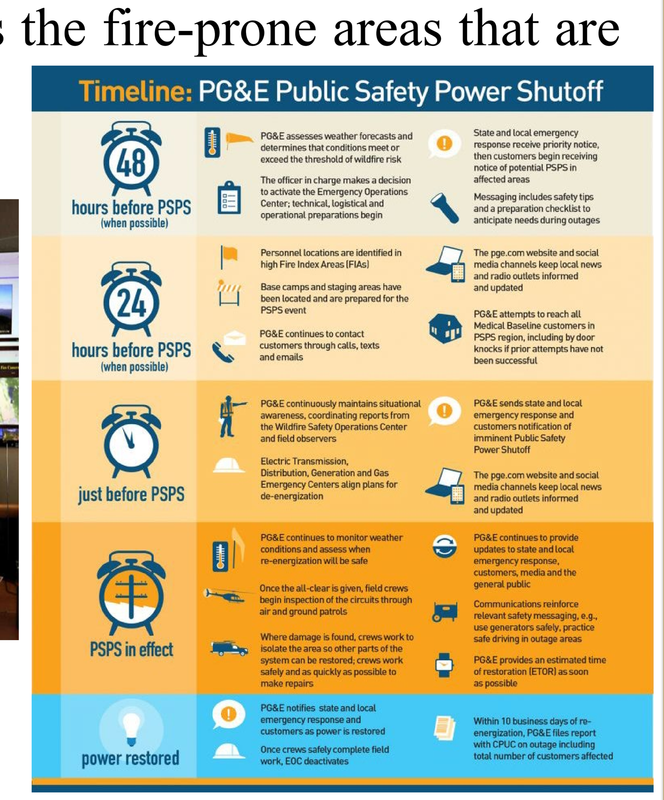

Figure 7. PG&E's PSPS timeline.

However, power line de-energization could challenge the electric power grid operation and the resulted power outages would lead to unfavorable consequences to the end-use customers and businesses.

Proposed Approach

We propose a new proactive risk-averse framework for integrated PSPS planning and MPSs dispatching decisions over a short-term horizon which accounts for undesirable weather conditions that raise the risk of electrically-induced wildfires.

Proposed Approach (Cont.)

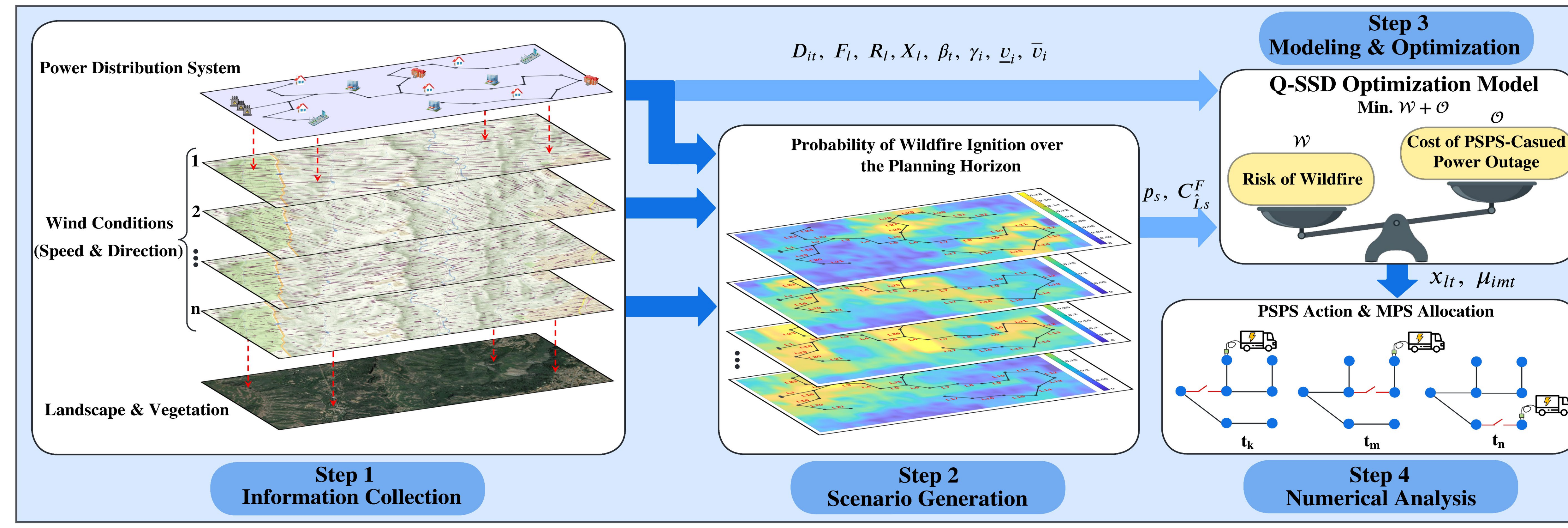

Figure 8. Proposed framework for balancing wildfire risk and PSPS-caused power outages.

- ❖ **Step 1:** Information is gathered on: targeted DS, weather conditions, geographical landscape and vegetation;
- ❖ **Step 2:** Scenarios generation based on the evaluated probabilities of faults and fire ignition;
- ❖ **Step 3:** A risk-averse optimization model is proposed to balance wildfire risks and PSPS-caused power outages;
- ❖ **Step 4:** DS operators are provided with optimal decisions to execute by solving the proposed PSPS problem.

Numerical Results

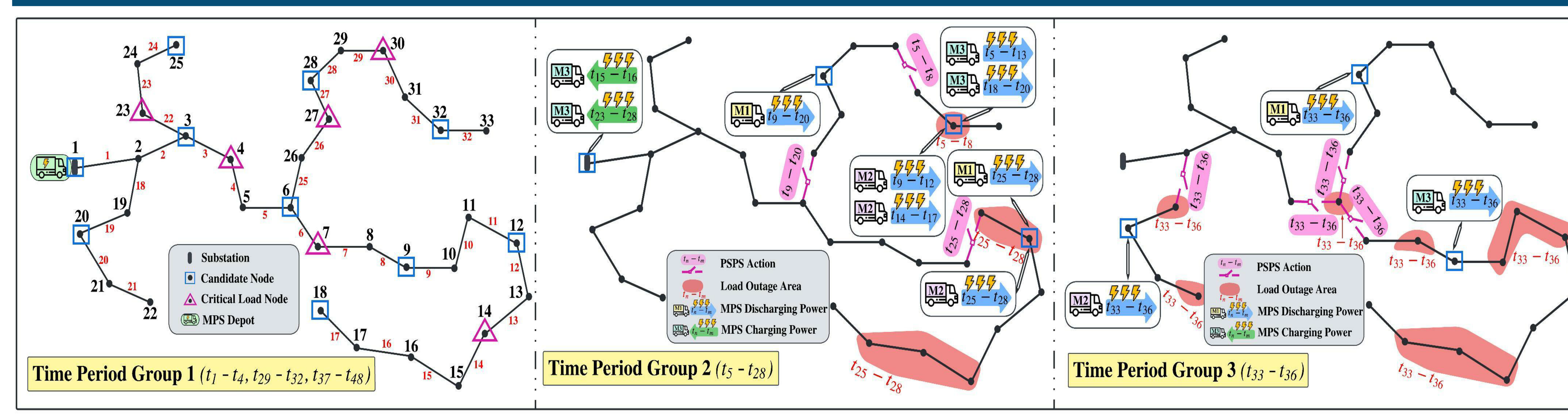

Figure 9. Optimal decisions on PSPS action and MPS dispatch in the wind-exposed wildfire-prone IEEE 33-node test power system.

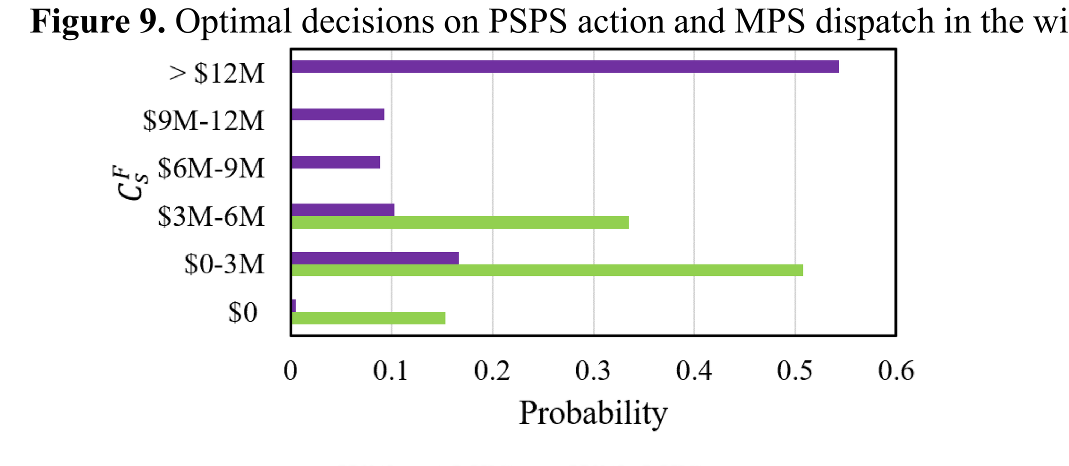

Figure 10. Probability distribution of different wildfire cost range when using the proposed model with and without MPS utilization and dispatch

With the joint decisions on PSPS actions and MPS dispatch, the expected cost of wildfire decreases from $11,466,492 to $2,473,985, i.e., a cost reduction 78%. Meanwhile, the extent of PSPS-caused power outages is found 4,299.16kW when employing MPSs, accounting for nearly 2.8% of the total electrical demand during the 12-hour planning horizon. With the utilization of MPSs, DS operators can make PSPS decisions more flexibly to reduce the risk of wildfire catastrophes.

Conclusion

Our research proposes an optimization problem to mitigate the risk of electrically-induced wildfires through optimal decisions on joint proactive power line de-energization and MPSs dispatch. Numerical results clearly demonstrated the promising performance of the solutions provided by the proposed approach for wildfire risk mitigation while keeping the cost of PSPS-caused power outage minimal.

Acknowledgement

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