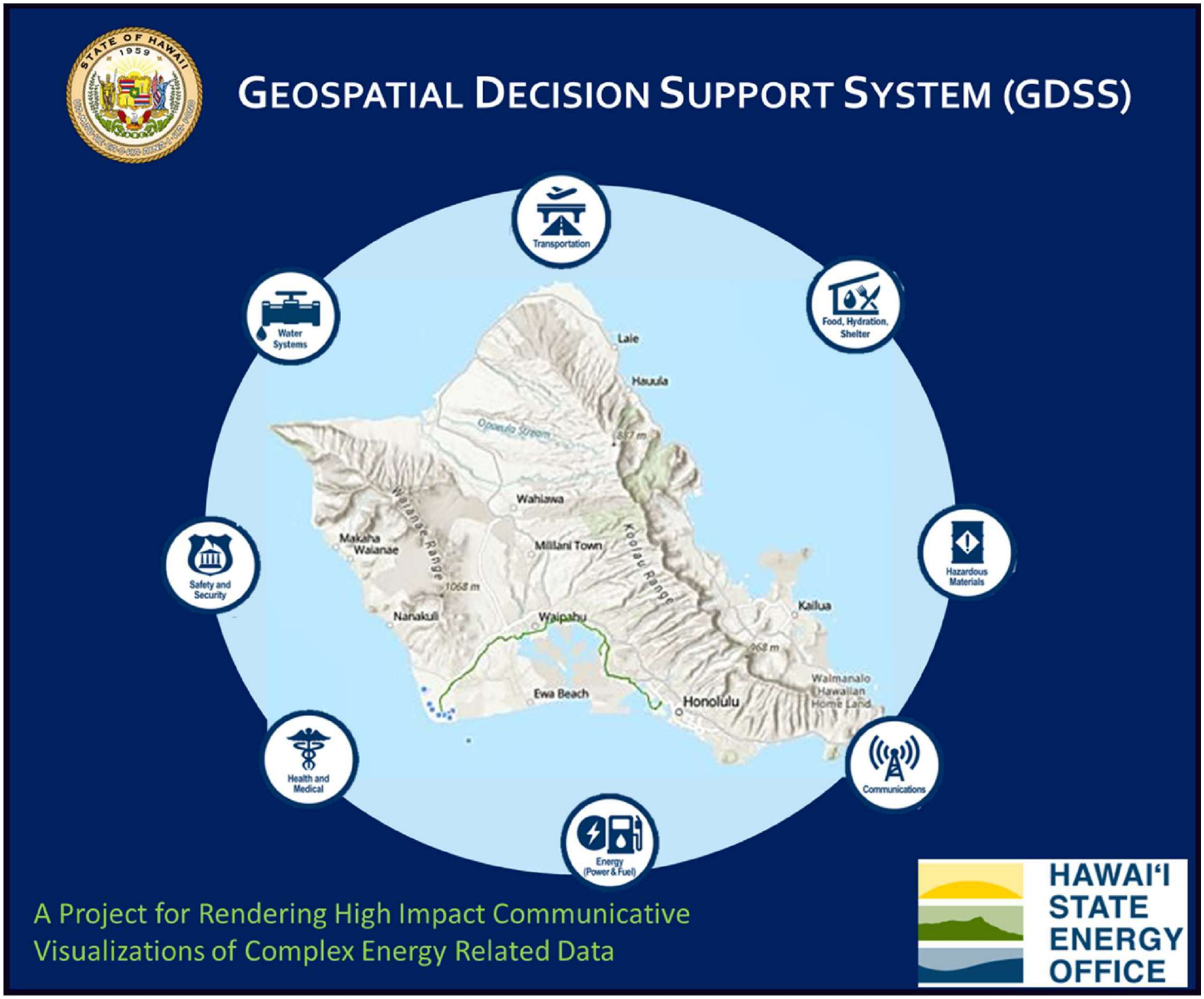

As one of the primary deliverables of the Oʻahu Energy and Critical Infrastructure Vulnerability and Resiliency Assessment (commonly called the Advance Assistance (AA) project), the Geospatial Decision Support System (GDSS) improved energy system situational awareness, energy security and hazard mitigation planning, emergency response, and disaster impact analysis via a novel GIS-based advanced visualization displaying dependencies of Community Lifelines on Critical Energy Infrastructure.

Category: **Emerging & Innovative Technologies**

State: **Hawaiʻi**

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NASCIO STATE IT RECOGNITION AWARDS

Executive Summary

The Geospatial Decision Support System (GDSS) tool was developed by the Hawaiʻi State Energy Office (HSEO) through a Federal Emergency Management Agency Hazard Mitigation Grant Program project (Advance Assistance (AA) project) in partnership with the Hawaii Emergency Management Agency (HIEMA), Office of Homeland Security (OHS), Statewide GIS Program, ICF, various critical energy infrastructure (CEI) owners and operators including Hawaiian Electric Company, PAR Hawaiʻi, Island Energy Systems, Aloha Petroleum, Hawaiʻi Gas, and Hawaiʻi Fueling Facilities Corporation, and community lifeline key customers (CLKC).

The Advance Assistance project was born out of a collaborative initiative started in 2018. The Interdependencies of Critical Energy Infrastructure (ICE-I) working group included partners from US INDOPACOM, U.S. Department of Homeland Security (DHS), U.S. Department of Energy (DOE), HIEMA, OHS, and HSEO and sought to understand interdependencies of energy infrastructure with other lifeline sectors. From the ICE-I, HSEO was committed to creating a common operating picture (COP) of the energy system and characterizing interdependencies, which ultimately led to the development of the AA project.

HSEO undertook the Advance Assistance (AA) project from May 2022 to October 2023. This initiative played a critical role in strengthening Hawaii's preparedness for energy emergencies and disruptions. The AA project allowed HSEO to achieve two key objectives:

- **Comprehensive Data Collection and Risk Analysis:** The project facilitated the collection of essential data needed for a robust and thorough risk analysis of the state's energy infrastructure. This data is used to identify vulnerabilities, pinpoint areas at high risk, and inform future mitigation strategies.
- **Development of a Novel Geospatial Decision Support System (GDSS):** A significant outcome of the AA project was the creation of a groundbreaking geospatial tool - the GDSS. This innovative platform positions Hawaii as a leader in the field of energy security planning and emergency response.

As the designated lead agency for Emergency Support Function 12 (ESF-12), HSEO plays a crucial role in coordinating response efforts during various emergencies. These emergencies encompass a wide range of events, including natural disasters like hurricanes and volcanic eruptions, as well as energy-specific disruptions such as fuel shortages, energy market instability, and supply chain issues. Given HSEO's critical role in emergency response, maintaining clear visibility into the state's energy system is paramount. This visibility allows HSEO to anticipate how potential hazards might affect essential downstream assets, particularly Community Lifeline Key Customers (CLKC). CLKCs represent the backbone of society – they encompass critical infrastructure and services like hospitals, emergency response centers, and communication networks. Ensuring the continued operation of these services during emergencies is vital for maintaining public safety and facilitating a swift recovery.

The Geospatial Decision Support System (GDSS) is a web-based mapping and data exploration tool that was built to provide end users the ability to explore, query, and understand CEI, CLKC and hazard geospatial data compiled throughout the development of the energy hazard mitigation project. Esri's ArcGIS environment, as the preferred GIS platform of the State of Hawaii, was utilized to build out the GDSS. The project team evaluated options from within the ArcGIS suite of tools to meet project needs. Based on consultation with HSEO and HI-EMA, the GDSS is currently hosted in an instance of the ESRI ArcGIS Enterprise platform within the Office of Homeland Security. The platform contains out of box tools for managing data and implementing analysis tools including Experience Builder, Insights and Portal. GDSS data is stored in an Enterprise geodatabase with feature services that can be viewed and managed through the ArcGIS Enterprise Portal. Storing the data in an enterprise geodatabase provides one source of authoritative data for the GDSS tool and allows flexibility for future enhancements in functionality. A variety of layer types can be stored and published as web layers through the database such as trace network services.

Idea

In an era marked by the challenges of climate change and evolving natural and man-made hazards, the urgency for continuous energy security planning and the ensuing identification of robust mitigation measures to protect the energy system has become increasingly clear. The COVID pandemic brought about unprecedented impacts on the energy system in Hawaii. Energy demand dropped off virtually overnight revealing the need for State energy policy and regulatory agencies to understand the cascading impacts of pronounced demand loss or other major disruptions across the energy system and how it might impact community lifelines and the health and safety of Hawaiʻi residents. Responding to this need, HSEO sought to develop a common operating picture for situational awareness in the energy sector, to understand the dependencies of other critical sectors on energy, to understand which energy assets presented the highest risk, and to identify key mitigation activities to enhance resilience of the energy system against disruptions.

The idea was to visualize these complex relationships and dependencies through an interactive system for effective energy security and hazard mitigation planning and emergency response. The GDSS became the answer to this need.

Implementation

HSEO and ICF carried out the project and followed closely DHS' Infrastructure Resilience Planning Framework, a guide for assessing critical infrastructure systems. The following is a high-level project roadmap:

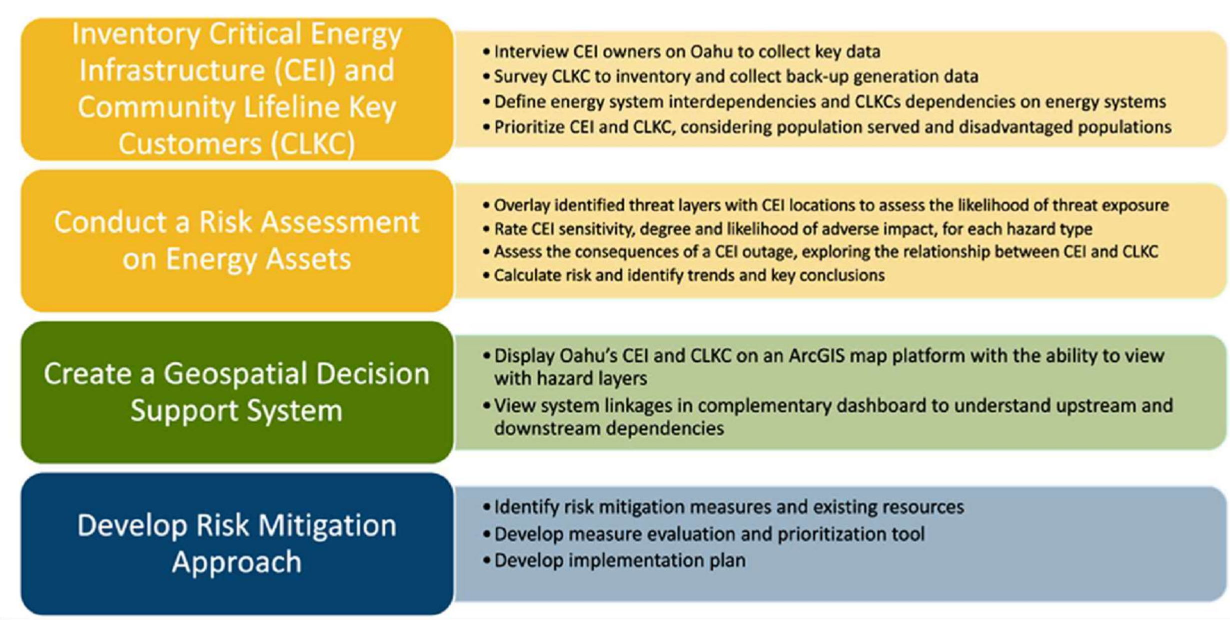

Figure 1: High-level project implementation roadmap

To start, the team engaged stakeholders on Oʻahu, including major energy providers (e.g. electric and gas utilities, refinery, and terminal operators) to understand their hazard and risk concerns, capabilities, and interdependencies with other energy infrastructure or other sectors. The team also engaged with community lifeline key customers (CLKC) such as hospitals, emergency services, water supply, wastewater treatment, and vital government buildings to understand their service capacity and constituency, dependence on energy infrastructure, any backup power capabilities, and energy requirements. This data collection was instrumental for HSEO to conduct the risk assessment described below.

After identifying the set of hazards to include in the analysis (below), the team conducted an in-depth risk assessment to determine an overall risk score for each CEI asset. The analysis used the calculation:

Risk = Sensitivity x Exposure x Consequence

For sensitivity, the HSEO team developed a matrix, enabling HSEO to gauge the impact of various hazards on different types of CEI. Essentially, the matrix describes the likely severity of impact of types of threats on types of infrastructure. Exposure of CEI to each hazard was determined using geospatial mapping. Finally, the consequence was the downstream impact determined by the CLKC supported by each CEI node. With that, the team was able to calculate a risk score for all CEI, which would factor into the development of hazard mitigation measures.

These are the potential primary hazards examined:

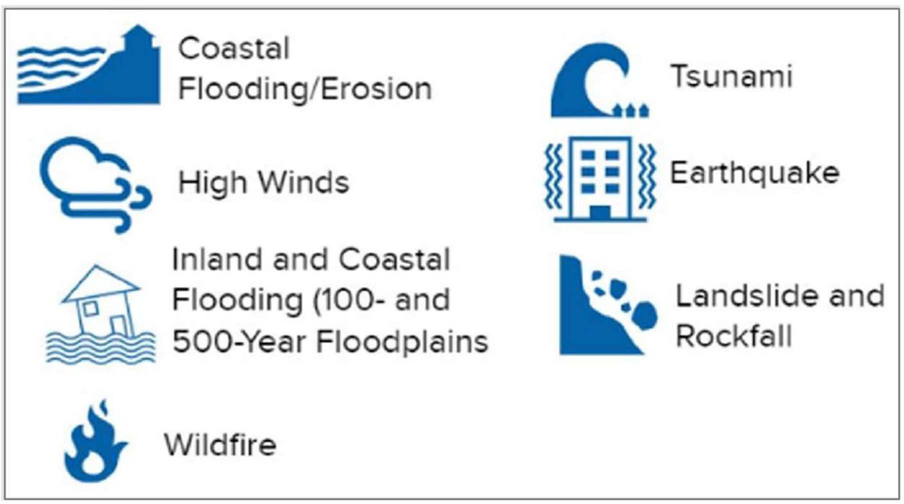

Figure 2: Seven potential hazards identified used for risk assessment analysis

The next step of the project was the development of mitigation measures and a risk mitigation approach. Protection of the highest risk assets was a focus of the measures. In total, 28 measures were developed and an implementation sheet produced for each highlighting the approximate cost, possible funding sources, responsible parties, partners, and timelines. The team also established localized goals and objectives, developed criteria for evaluating mitigation measures, completed a capabilities assessment, and developed an implementation strategy.

Throughout the project, the team was developing and iterating on the GDSS. As stated above, the team wanted to be able to see the energy system on Oahu geospatially, but also visualize the dependencies of CEI and CLKC to show the downstream impact of the loss of any node. The GDSS has two core components, (1) the Infrastructure – Hazards Tab and (2) the Dependencies – Insights Tab. The two tabs can be used together to explore vulnerabilities and answer specific questions about critical energy infrastructure on Oʻahu and the community lifelines that depend on it.

For example, the GDSS can support the following use cases:

- Determine assets most likely to be impacted by hazard and focus on potential impacts
- Evaluate vulnerable Critical Energy Infrastructure (CEI) with risk and hazard data
- Evaluate downstream impacts of the loss of or threat to a CEI node
- Determine which CLKC have backup power in an outage area

The platform contains out of box tools for managing data and implementing analysis tools including Experience Builder, Insights and Portal. GDSS data is stored in an Enterprise geodatabase with feature services that can be viewed and managed through the ArcGIS Enterprise Portal. Storing the data in an enterprise geodatabase provides one source of authoritative data for the GDSS tool and allows flexibility for future enhancements in functionality. A variety of layer types can be stored and published as web layers through the database such as trace network services.

The GDSS web tool was built with ArcGIS Experience Builder. Experience builder is an Esri low code platform for building configuration web applications with a focus on spatial data. Development of a custom web application utilizing ArcGIS JS API for the map development was considered but ArcGIS Experience Builder was chosen for rapid implementation and simpler maintenance of the tool. The low code platform reduced the complexity of managing and developing a tech stack, data storage and web hosting while still providing the ability to code custom features to support specific workflows.

ArcGIS Insights excels in data analysis, exploration, and visualization. It allows users to conduct in-depth spatial and non-spatial analysis, create interactive visualizations, and gain valuable insights from their data. Integrating these analytical insights into an ArcGIS Experience Builder application enhances the understanding of data for end-users. In addition to viewing and querying data, the GDSS web tool includes the ability to visualize connections across CEI and CLKC infrastructure networks. A few ESRI tools were considered for building out this functionality including ArcGIS Knowledge, the network tracing tool, and ArcGIS Insights. ArcGIS Insights was selected because it allowed us to build out a link chart with the available network data.

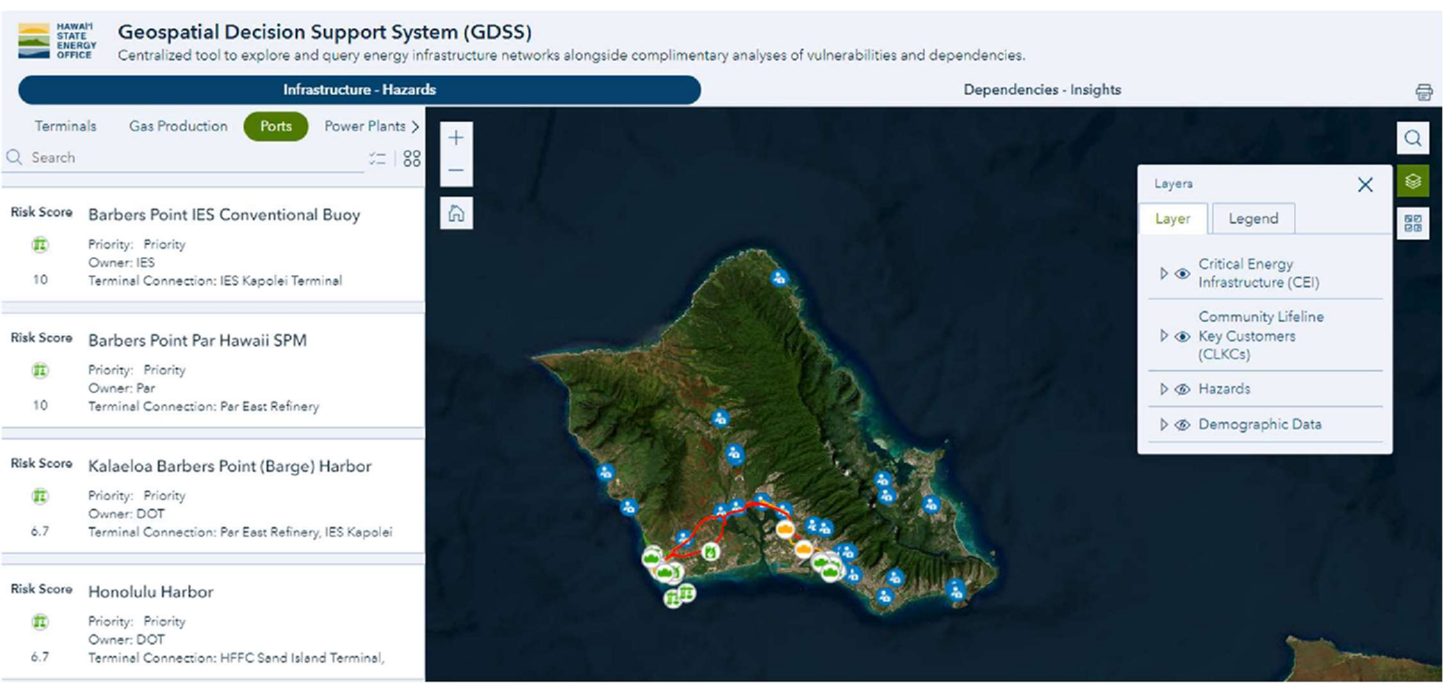

Figure 3: GDSS display of energy infrastructure networks alongside complimentary analysis of vulnerabilities and dependencies

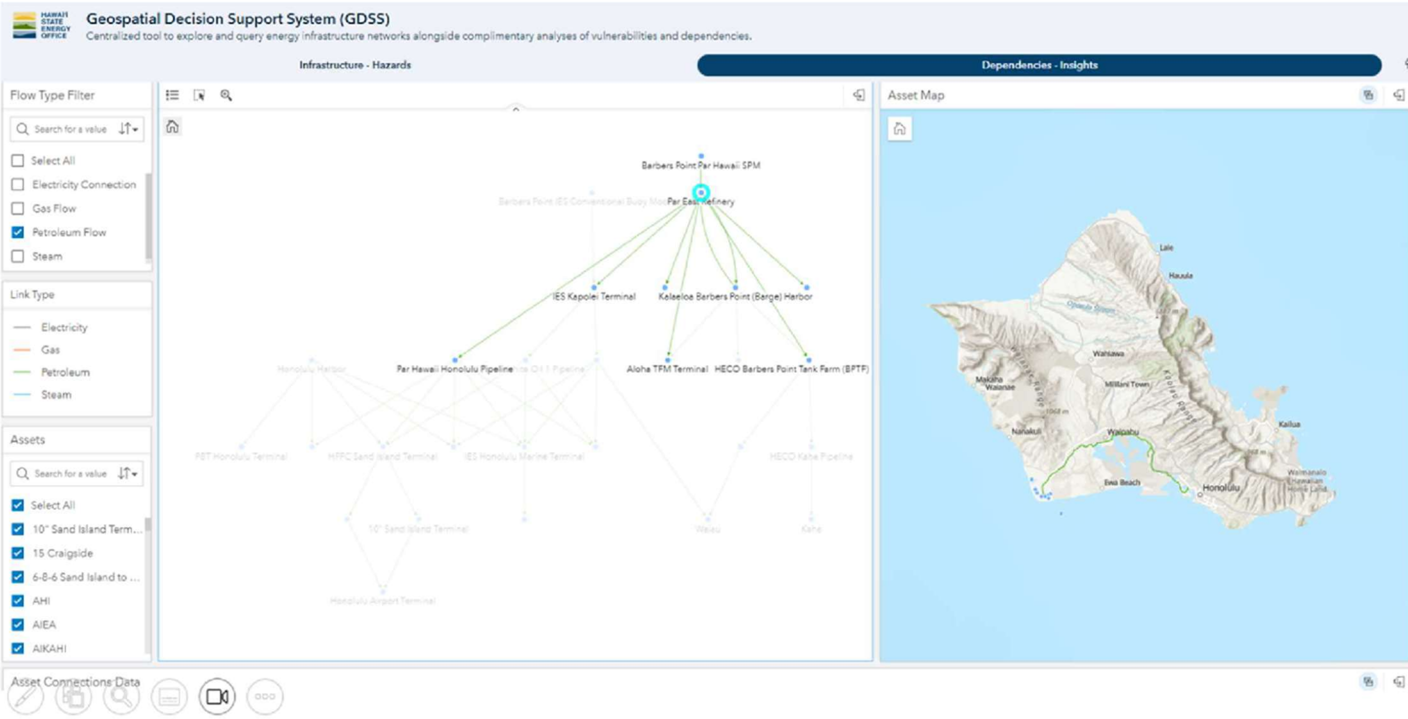

Figure 4: GDSS display of petroleum flow dependencies for Barbers Point Par Hawaii SPM

Impact

HSEO has made significant strides in enhancing energy security preparedness through the development of the Geospatial Decision Support System (GDSS). This cutting-edge platform goes beyond simply visualizing the energy system; it delves deeper to reveal the intricate network of connections between nodes within the system and their ultimate impact on critical community lifeline services (CLKC).

The GDSS serves as a game-changer for HSEO's understanding of the state's energy infrastructure. It provides a comprehensive and interactive view of the entire system, allowing users to:

- Visualize Connectivity: The GDSS depicts the complex web of interconnected nodes within the energy grid, offering a clear understanding of how disruptions at specific points can cascade throughout the system.
- Identify Critical Nodes: By analyzing the network through the GDSS, HSEO can readily pinpoint the nodes that are most critical for maintaining the functionality of CLKC services. These critical nodes become a high priority for mitigation efforts, ensuring the uninterrupted operation of essential services during emergencies.

The GDSS serves not only as a diagnostic tool but also as a springboard for action. With a clear understanding of vulnerabilities within the energy system, HSEO can now move forward with targeted hazard mitigation measures. These measures could encompass a variety of strategies, such as infrastructure hardening, redundancy plans, and vegetation management programs around critical nodes.

The GDSS is also designed to provide quantifiable metrics. These metrics include the potential number of CLKCs impacted by a specific hazard and the estimated population affected; this is something not previously or readily available. By quantifying risk, HSEO can bolster the strength of hazard mitigation applications and proposals. This can be particularly impactful for securing funding through programs like FEMA's Building Resilient Infrastructure and Communities (BRIC) program. Projects identified and prioritized through the GDSS planning process hold a higher chance of receiving additional points and gaining approval for funding.

Next Steps

The decision to place the GDSS under the Office of Homeland Security (OHS) has a strategic purpose. OHS envisions a larger initiative where the GDSS will serve as a central platform for visualizing interconnectivity across critical infrastructure sectors. This means conducting similar assessments for other sectors like water, transportation, and communications, and then integrating that data into the GDSS. By creating a platform and comprehensive picture of how critical infrastructure systems in Hawaii are interconnected, OHS can identify potential cascading effects of emergencies and develop more robust mitigation strategies that encompass multiple sectors. HSEO fully supports and collaborates with OHS in this endeavor, as it strengthens overall preparedness and response capabilities for a wider range of emergencies.

HSEO has been designated as the sole entity within the state to administer grant funding allocated by the Infrastructure Investment and Jobs Act (IIJA) Section 40101(d). This section specifically focuses on enhancing grid resiliency. HSEO plans to utilize the findings and recommendations from the Advance Assistance (AA) project on Oahu to guide its investment strategy for the first two years (Year 1 & 2) of the 40101(d) funding. The AA project offered a comprehensive evaluation of Oahu's energy infrastructure, identifying vulnerabilities and prioritizing areas for improvement. There is approximately $6M available.

Recognizing the diverse needs statewide, HSEO is intent on conducting similar analyses for the other counties (Maui, Kaua'i and Hawai'i) and integrate that information and data into the GDSS. HSEO will shift its focus to Maui for the third year (Year 3) of 40101(d) funding. While the specific details for project selection in Maui haven't been outlined, it's likely that HSEO will follow a similar approach of conducting a targeted assessment or leveraging existing data to identify Maui's most pressing grid resiliency challenges. HSEO believes that an AA 2.0 effort for Maui County, in particular, can help in the rebuild in the wake of the Lahaina wildfire.