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Site Resilience and Energy Assessment Process for Key Assets

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1 Executive Summary

"Resilience depends on the whole community and is a shared responsibility for all levels of government, private and nonprofit sectors, and individuals. Working together, we can promote and implement mitigation activities and increase our awareness and resilience to threats, hazards, and vulnerabilities, and coordinate the development of mitigation strategies, actions, and plans to manage risk and create long-term sustainability for our state."

2013 State of California Multi-Hazard Mitigation Plan

Energy assurance is a process to identify and establish resilient energy sources for critical infrastructure to support continued operation of essential services following a natural hazard. By following this process, a local government is better prepared and able to help a community to survive and recover from a catastrophic event.

Energy assurance is a valuable step toward resilience for all key assets, but some services are acutely important based on the heightened dependence on their services immediately following a natural hazard event. Time also plays a role, in that some services demand immediate local delivery, such as search and rescue and fire suppression, while other services are easier to support with extra-regional services such as food distribution. Until long-range planning occurs for all essential services, interim steps help prepare communities with the most critical services to endure catastrophic hazards and minimize suffering and the loss of lives.

This report discusses how to identify natural hazards that affect essential services, identify key assets, and assess energy requirements for a specific asset. The report works in parallel with a spreadsheet to collect and track data.

The approach addresses a small subset of a much broader, more comprehensive energy assurance planning methodology. For example, the Department of Energy defines a 10-Step Energy Assurance Planning Framework[1], which in turn was the basis for work on the CaLEAP[2] process to establish guidelines for local governments in California. Our goal is to encourage small, stop-gap efforts to establish pockets of resilience until communities are able to fund and staff the development and implementation of more comprehensive approaches. More information can be found at the Local Government Energy Assurance Planning webpage[3].

1.1 Goal of this Report

The goal of this report is to help jurisdictions and agencies to identify and develop high-level energy assessment plans for critical key assets, prepare demonstration sites for future energy independence and resilience funding opportunities, and to promote and sustain awareness of energy assurance planning among local jurisdictions beyond a recent catastrophe.

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[1] https://dl.dropboxusercontent.com/u/60849267/Local-Government-Energy-Assurance-GuidelinesV2.pdf
[2] http://www.caleap.org/
[3] http://www.energyassurance.us/

1.2 Design Approach

The proposed approach is to identify and prioritize hazards, evaluate and expand existing key asset lists, prioritize the most critical services based on their ability to survive a natural hazard and for their need during emergencies, determine the energy requirements of these facilities, and identify methods to meet some of all of these energy requirements through onsite or mobile generation and storage solutions. Rather than develop a new analytical approach, the project uses a high-level energy analysis as a useful existing methodology to profile energy resilience opportunities for existing buildings. As sites become prioritized, more detailed energy analysis, such as an ASHRAE[4] Level 2 energy audit, will likely be necessary to accurately specify site requirements and secure funding. Additional EAP analysis will be required in various situations to address factors such as loss of grid power, load management, system redundancy, industrial settings such as water treatment plants, and so on.

Ideally a team will be able to establish an engaged group of stakeholders with time and energy to commit to developing a coordinated, robust plan and actions. However, with many competing priorities it can take time to develop the political momentum often found immediately following a disaster. Our recommendation is to start small with readily available information, make it available to interested and responsible parties, and create examples of resilience in the community wherever funding and motivated decision-makers arise. Over time these sites will serve as valuable demonstrations and encourage further work.

1.3 Scope of effort

A key-asset plan emphasizes critical infrastructure that relates to public health and safety, and interim operation of the local economy:

- **Basic community services**: the foremost interest is to maintain basic local community services for public health and safety. It is not meant to address state or national goals.
- **Emphasis on resilience:** prepare a site to maintain sufficient on-site power for basic services. It is not an emergency response or hazard mitigation plan.
- **Local economy:** address the basic necessities of life such as water, food, hygiene products, and basic survival supplies.
- **Natural hazards:** threats posed by naturally-derived hazards, such as flooding, fire, and earthquakes. Other serious “threats” resulting from human activity, such as terrorism, hazardous spills, or gas releases, deserve attention but are outside the scope of this project.
- **Finite sites:** The report evaluates assets within a constrained space, such as a single building or small cluster of buildings with similar attributes. It does not address community-wide or region-wide infrastructure, such as gas pipelines, electric transmission lines, and similar large-scale infrastructure.

[4] https://ashrae.org/

Note that some facilities, such as an airport or harbor, may be a critical link for isolated communities following a disaster. In these situations a community may best focus on these assets in depth rather than on pockets of services throughout a community.

This report supports a grassroots effort to initiate some degree of resilience while awaiting a more comprehensive EAP methodology. It is also not an emergency response or hazard mitigation plan, but it intended to help communities to improve their resilience before an actual emergency.

This plan deviates from the CaLEAP "all hazards" approach. The reason is pragmatic: early in the planning stages, there is plenty of work to at least begin some efforts. Human-derived threats, such as toxic releases and terrorism, can be complex to characterize and address, and are relative newcomers compared to natural disasters. In the long term, local governments are encouraged to build a more comprehensive approach once they have experience with familiar phenomenon in their region and as funding sources arise to tackle more wide-reaching initiatives.

1.4 Alignment with other initiatives

Energy assurance planning (EAP) activities in the region include the recent California CaLEAP initiative funded through the California Energy Commission (CEC). Humboldt County government officials participated in this effort in conjunction with hazard mitigation planning in 2013. The April 2014 CEC proposed 2015-2017 Triannual Investment Plan states "The Energy Commission sponsored the CaLEAP program to assist local governments with developing energy assurance plans that focus on energy and functionality of key assets within a community. CaLEAP used American Recovery and Reinvestment Act funding to develop its program and began accepting applications in December 2012, through the CaLEAP website. Funding for technical support of the website expired in July 2013." CaLEAP was suspended in 2014 and recent inquiries to the CEC indicate that it is suspended indefinitely. The Triannual Investment Plan mentions a proposed funding initiative, S20.1, which may use CaLEAP, Cal-Adapt, or other tool in the future.

This report considered work to date on the CaLEAP initiative in the County and sought to follow the CaLEAP framework[5], align with future CaLEAP efforts, and be consistent with other CaLEAP community work. Although the project will shift from a region-wide, top-down approach

CaLEAP recommends a three-tiered process to energy assurance planning:

Tier 1: *Establish resilient energy systems for core emergency services, including 911 call centers and essential services at police, fire, and emergency medical dispatch stations. Also address coupled infrastructure such as third-party communications equipment, cell phones being a key example.*

Tier 2: *Address power requirements for dispatch services supporting road clearing and directing crews, utility repair, and non-emergency services for baseline government crisis management and civil order. Evaluate energy needs for services and organizations that perform non-emergency restoration activities.*

Tier 3: *Provide power to support socio-economic recovery following a disaster. Focus first on services supporting shelter, water, waste water, emergency power generation, and communication. Follow this with business restoration.*

[5] http://www.caleap.org/index.php/tgp1/more/121

(regional resilience) to a site-specific, bottom-up approach (site resilience), the project team sought to generate useful data and plans that still work within the broader CaLEAP context.

The figure below displays the full CaLEAP EAP methodology, with red circles around the elements adopted by this report's bottom-up process. Regarding team formation, it is expected that an ad hoc team will emerge around a specific opportunity or goal, which also provides the motivation to pursue funding and bring a project to fruition.

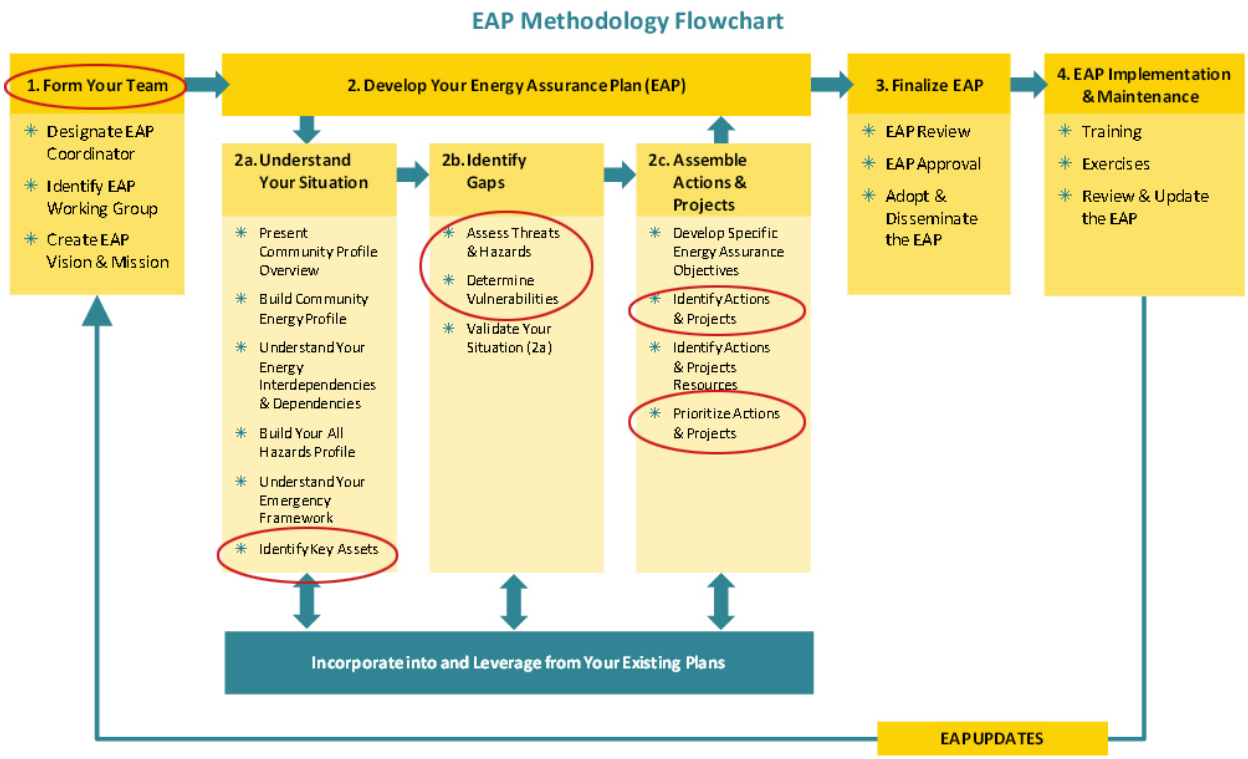


Figure 1: Selected elements of the CaLEAP methodology

1.5 Disclaimer

The Redwood Coast Energy Authority makes no representation or warranties regarding the accuracy of data or maps and their respective sources. This discussion is not a legal document and does not meet disclosure requirements for real estate transactions or for any other regulatory purpose. Please contact the agencies responsible for the regulatory maps or contact a natural hazard disclosure firm to verify hazard zone determinations. Other hazard zone determinations may be locally mandated; check with your city or county offices for more information. Not being within a regulatory hazard zone does not guarantee safety from unknowns, such as unmapped or undiscovered earthquake faults. In addition, not all areas of the state have been mapped for all hazards so the hazard level may not be known in some cases. It is advisable to be prepared for emergencies regardless of your location.

2 Assemble a team

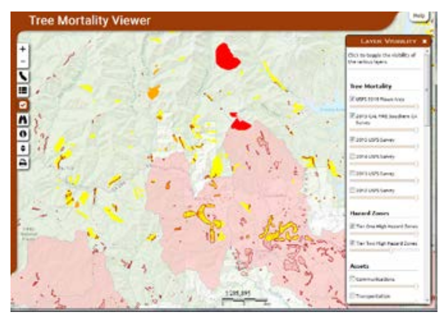
If you are in a single facility and are interested in or assigned to improve onsite resilience, you can probably skim the identification and prioritization process and spend the majority of your time assessing your facility (Section 5). Otherwise, you'll want to form a team to tackle the various activities to identify and assess hazards, prioritize and select key assets, and assess energy requirements and potential projects. Teams can range from small, mission-directed offices, to region-wide partnerships. They may be informal and led by a public office champion and other advocates, or set up as part of a formal government initiative.

As the team forms, identify a leader who will coordinate all activities, monitor progress, manage communications, and generally keep activities and projects on track. Depending on the degree of formality and obligations surrounding the initiative, a team can evolve to have a core group of members to tackle routine activities, and stakeholders or steering committees to represent various interests, address trade-offs, make final decisions, and authorize projects and funding commitments. Existing local agencies, committees, and stakeholder groups can serve as models for what works in your community.

Partnerships organized around planning activities can be valuable where the region of interest includes multiple responsible agencies with their own mandates and focal areas. For example, state, federal and local agencies may share areas of responsibility within the same region, and need to represent their interests and authorize relevant projects.

Forests in California are under stress from drought and bark beetle infestation. The U.S. Forest Service estimates that over 29 million trees have died as a consequence, up from 3.3 million in 2014.

Beyond the impact to wild lands, the high number of dead trees increases wildfire potential. The increased fuel in forests can lead to hotter, larger, and more devastating fires, increasing the need to protect, and provide, more firefighting assets. Dead and burned forests also change water retention, exacerbating drought conditions.



Screenshot of CALFIRE Tree Mortality Viewer, which identifies areas of beetle infestation and higher fire risk; http://egis.fire.ca.gov/TreeMortalityViewer/

3 Identify natural hazards

This section discusses the process to identify, characterize, and compare natural hazards for a particular community. This report generally defines a community as the physical terrain that encompasses a human population under a specified government structure such as township, city, or county. However, not all areas are easily or strictly defined by political boundaries, as discussed in section 3.1.

3.1 Define area of interest

To start identifying natural hazards, first define the area of interest. Areas of interest are often defined by:

- **Political boundaries:** This is the most common boundary since it conveniently follows formal governance and associated oversight, funding, and public engagement. Typical political boundaries include townships, cities, and counties. Political boundaries may also span multiple jurisdictions with shared interests such as regional associations of government, air basin districts, or transportation agencies.

- **Community boundaries:** Beyond typical political boundaries, communities may also be bound by historic place names, defined by a shared economy such as ski resorts and recreational districts, or defined by social guidelines such as a focus on environmental justice, poverty, or similar motivation.

- **Landscape features:** Landscape defines familiar areas of interest, and is often an obvious fit when identifying populations with shared risk. Landscape features include watersheds, river frontages, mountain ranges, air basins, coastlines, bays and estuaries, volcanoes, fault-line valleys, landslide features such as scarps, and so on.

Figure 2: Tomales and Bodega Bays, a submerged fault-line valley (Source: USGS)

- **Event boundaries:** These identify the historic extent of previous disasters. They may be obvious, such as volcanic craters, or subtle such as buried layers of ocean sediment deposited far upriver decades or centuries earlier.

Well-defined boundaries are the most likely candidates for a bottom-up approach. If a region becomes large and complex, it is challenging to clearly document various hazards and assets and to prioritize efforts. Political boundaries are relatively simple since they clearly define a population with associated governance. However, other features may make sense. For example:

- A group addressing poverty could focus on a river delta where economically disadvantaged populations congregate in areas with frequent flooding. This example combines a community boundary (economic) and event boundary (flood plain).

- An interagency or community-based group may focus on a specific hazard of interest to a community, such as earthquakes or tsunamis.

Once you've identified the area of interest, continue to section 3.2 to characterize the natural hazards that affect the area. If your project focuses specifically on a hazard, continue to section 3.2.2 to characterize that selected hazard.

The Redwood Coast Tsunami Work Group is a diverse mix of agencies, tribes, relief and service groups, land managers, and businesses from multiple counties, and is instrumental in promoting awareness and coordinating mitigation activities along our tsunami-prone coastline. For example, they installed tsunami hazard zone signs along low-lying coastal areas, which serve to simultaneously inform and educate local community members.

http://www.humboldt.edu/rctwg

3.2 Characterize natural hazards

Each community has a variety of natural hazards that typically occur in their area, such as flooding, earthquakes, fire, and hurricanes. Follow this process to identify your particular hazards and determine their characteristics.

3.2.1 Identify naturally-occurring hazards

Start with a general survey of historical records to identify the naturally-occurring hazards that affected the region. Local sources of information include hazard mitigation plans, historic logs, local weather service, newspapers and journals, government records, universities, insurance records, and land surveys. Historians, curators, elders, librarians, and similar community members are very helpful to identify when and where to look for local information. Additional Information is also available for larger regional areas through state and federal bureaus and agencies.

Beyond historical records, consider environmental changes in the recent past. While this is more subjective than long-term observations, it helps to identify hazards that are new to the region or may be emerging based on natural and human-made changes to the landscape. For example, warmer, wetter winters and longer summers may produce increased fire hazard from plant growth; extended industrial farming may increase the risk of dust storms and erosion; and insect infestation can create large stands of dead trees and increased fire risk. These trends provide insights to changes in the size, shape, and location of the area affected by existing hazards, and also helps to identify new, previously unrecorded hazards.

3.2.2 Characterize each hazard

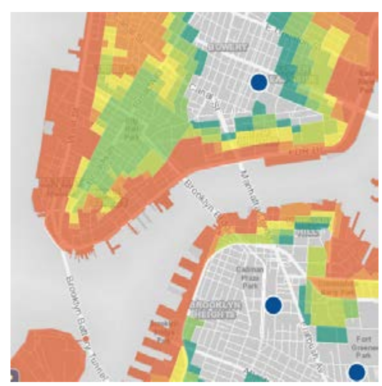
Once you've identified your list of local natural hazards, collect information on their particular characteristics. In many cases you can start with the same reference sources and materials used to identify the primary hazards in the region. Also seek more in-depth information, data and analysis from scientific disciplines such as the National Oceanic and Atmospheric Administration[6] and the U.S. Geological Survey[7]. See Section 8, "Resources" for a list of sites and publications with hazard data.

Natural hazards require a multi-faceted approach to identify consequences for a community and key assets.

For example, FEMA flood zone maps show the statistical average of a flood based on historic records. On a 100-year flood zone map, "100-year flood" means that there is a 1% (1 out of 100) chance of flood in the mapped zone each and every year.

What the map doesn't show is the actual flood frequency. A community could witness 100-year floods in consecutive years, where each year has the same 1% chance of a flood. Several 100-year floods can even occur in the same year.

Proximity also plays a role. In the flood example, if an asset is within a 100-year flood zone but is also near the flooding source, use a 50- or 25-year flood map for a more realistic understanding of risk.



Detail of New York City hurricane evacuation zones; https://maps.nyc.gov/hurricane/

[6] http://www.noaa.gov/
[7] https://www.usgs.gov/

For each hazard, determine the:

- **Probability or frequency of occurrence:** this is a measure of how often a hazard is likely to affect the region.
- **Magnitude:** this measures the quantitative scale of a hazard. For example, earthquakes are measured in the Richter Magnitude Scale, which calculates the amount of seismic energy released during an earthquake.
- **Intensity/severity:** A descriptive scale to assess the strength of an event, typically at a specific location. For example, earthquake intensity can be assessed using the Modified Mercalli Intensity Scale, which measures how people feel and react to the event.
- **Warning time:** the amount of time that a community has to prepare for a hazard. Is there an advance notice of a hazard, or is it sudden? Are warning systems in place? This determines if sites can receive some degree of preparation immediately preceding a hazard.
- **Potential location and size of affected area:** Determine the typical pattern of each hazard, and how much of the community is likely to be affected. For example, floods may be identified by 10, 25, 50, and 100-year flood zones. Maps are particularly useful to visually show affected areas. Affected zones may also include outlying regions that rely on but may be cut off from services obtained from an urban center, and deserve additional consideration.
- **Duration of impact:** this is the typical amount of time until a community can return to normal routines. During this time, additional or disaster-specific services are required above and beyond typical community services.
  Note: Events beyond the scope of this exercise are those that are so catastrophic that they define a new norm, such as the Japanese Fukushima 2011 combined earthquake, tsunami, and nuclear disaster.
- **Historical occurrences:** The recorded events in community memory for the hazard. This is particularly helpful for hazards that are significant but infrequent, such as larger earthquakes or tsunamis.
- An Excel workbook accompanies this guide to help organize this information in one location. The toolkit can be found at http://northcoast.habitatseven.work/resource/critical-essential-services-model-excel-workbook-and-toolkit/

Some assets are considered strategic by nature, and may have security restrictions on who receives information, or even that they are considered strategic. These sites will already receive dedicated resources based on their critical role to a community, and can be excluded from asset identification. However, it is worthwhile to include emergency planning and response personnel in your review process to get their feedback and encourage collaboration on mutually-dependent (coupled) assets.

3.2.3 Sources for hazard information

See Section 8. “Resources”, for a list of general hazard information sources for California communities. Note that additional local resources may be available, such as through a regional office of emergency services.

4 Identify and prioritize key assets

Once you compile a record of the natural hazards affecting the area of interest, the next step is to identify the key assets. Key assets provide or support the basic services necessary for civil operation before, during, and after an emergency. To identify your key assets:

- Revisit the area of interest, which was defined while determining local hazards. The goal is to stay focused on a specific agreed area and avoid scope creep, and to ensure that the area realistically captures important assets. For example, a simple adjustment to a boundary could include a fire station or coast guard station.
- Prioritize assets based on quantitative and qualitative factors.
- Conduct final prioritization: using information collected to date, the team works through the final selection process to identify the initial candidates for resilience efforts.

It is valuable to initiate contact with decision makers and local experts early in this process. This provides time for them to schedule time, consider their own priorities, review internal plans, and investigate potential funding sources for their particular area of responsibility. This information is invaluable during final decision making since existing plans and funding dramatically improves the feasibility of a project and can escalate an asset up the list of priorities.

4.1 Identify key assets within the area of interest

Similar to identifying natural hazards, the first step is to determine the area of interest (Section 3.1 documents this process). Next, use the area of interest to inventory relevant assets. This is done by meeting with local subject matter experts and conducting a literature review.

Excellent sources of information are community leaders already responsible for natural disaster planning and response activities. This includes city managers, public works officials, fire and police, operation staff at key infrastructure sites such as hospitals, airports, and ports, and so on. These are often the same people who deliver traditional community services, and will have an intimate understanding of buildings and assets that matter most following a disaster. They can also provide reference material and other contacts. Reference librarians and historians are also excellent sources of information, and provide essential narrative about how natural disasters unfold, the ensuing civic challenges, and the results of different responses.

Coupled infrastructure is a growing challenge in our increasingly complex world. For example, traditional telephone "land lines" provide redundancy: during power outages, land line phones are powered remotely over telephone wires from batteries at phone switching offices.

State law requires central switching offices to operate at 100% capacity even though 85% of California households no longer use land lines, a costly commitment for service providers. As a result, AT&T is lobbying to drop land lines and focus exclusively on wireless and internet-based services.

Cell and internet phone services rely on a web of powered devices, creating more points of potential power loss during an event. Dropping land lines would eliminate a redundancy in our phone systems, particularly for seniors and rural customers who often rely on traditional services.

Batteries at a central office.

While waiting for various stakeholders to schedule a meeting with you, start a preliminary literature review to identify any readily available information. Do this before meeting with the experts to increase your personal knowledge and uncover questions to ask during your investigative meetings.

Based on conversations and research, create a master list of all assets in the area of interest. Ideally, also create a map of the assets: this will simplify the process to identify the location of assets within various hazard zones. Once your team completes a comprehensive list of assets, the next step is to sort them by priority.

4.2 Prioritize assets using logistical and societal factors

After identifying key assets in the region, the next step is to prioritize them for future resilience efforts. This section describes the process to identify the technical and societal factors to consider for your portfolio of assets.

4.2.1 Determine logistical priorities

Logistical priorities identify those assets that are essential to human safety and community recovery. CaLEAP recommends a three-tiered process to energy assurance planning:

- **Tier 1:** Establish resilient energy systems for core emergency services, including 911 call centers and essential services at police, fire, and emergency medical dispatch stations. Also address coupled infrastructure such as third-party communications equipment, cell phones being a key example.
- **Tier 2:** Address power requirements for dispatch services supporting road clearing and directing crews, utility repair, and non-emergency services for baseline government crisis management and civil order. Evaluate energy needs for services and organizations that perform non-emergency restoration activities.
- **Tier 3:** Provide power to support socio-economic recovery following a disaster. Focus first on services supporting shelter, water, waste water, emergency power generation, and communication. Follow this with business restoration.

These tiers provide a solid method to develop a prioritized list of assets. These tiers also align well with traditional emergency response planning, so most identified assets should fit well within these tiers.

Once logistical sorting is complete, the next step is to consider local societal priorities such as existing governing principles, vulnerable populations or environments, funding, and so on.

4.2.2 Determine local societal priorities

At some point decision makers must consider social and political factors to move the key asset selection process forward. These factors bring human interests and motivation into the conversation, and address the practical realities of current priorities in the community. For example, topics might include environmental justice, vulnerable populations, known deficiencies in local infrastructure, and so on. Rather than displacing logistical factors, societal factors work in parallel to retain an emergency-service focus while respecting societal interests.

Funding is another factor that can determine if certain projects occur earlier than if just based on a pure technical review, and is also discussed in this section.

4.2.2.1 Identify existing local government principles

Many local governments have already defined guiding principles as part of a hazard mitigation process, and these principles can serve a dual purpose to help prioritize a short list of key assets. For example, here are the guiding principles developed by the Steering Committee and Planning Partnership of the Humboldt County Hazard Mitigation Program[8]:

> **Guiding Principle** —"Through partnerships and careful planning, identify and reduce the vulnerability to hazards in order to protect the health, safety, quality of life, environment, and economy of the communities within the Humboldt Operational Area."
>
> **Goals**
>
> – G-1: Protect Health and Safety
>
> – G-2: Protect Property
>
> – G-3: Protect the Economy
>
> – G-4: Protect Quality of Life
>
> – G-5: Protect Environment
>
> – G-6: Promote Partnerships in Planning

In this example, the group also identified objectives that would fulfill one or more of the goals. Here is the list of objectives, which include some straightforward items that help to prioritize key assets.

HUMBOLDT OPERATIONAL AREA HAZARDS MITIGATION PLAN OBJECTIVES		
Objective Number	Objective Statement	Goals for which it can be applied
O-1	Eliminate or minimize disruption of local government operations caused by hazards.	1, 2, 3, 4
O-2	Increase resilience of (or protect and maintain) infrastructure and critical facilities	1, 2, 3, 4
O-3	Reduce hazard-related risks and vulnerability to the populations in the County of Humboldt	1, 2, 3, 4
O-4	Sustain reliable local emergency operations and facilities during and after a disaster.	1, 2, 3, 4
O-5	Seek to enhance the emergency response capability within the planning area.	1, 2, 3, 4, 6
O-6	Enhance understanding of hazards and the risk they pose through public education that emphasizes awareness, preparation, mitigation, response, and recovery alternatives.	1, 2, 4, 5
O-7	Continually improve understanding of the location and potential impacts of hazards that impact the planning area utilizing the best available data and science as it becomes available and share this information with all stakeholders.	1, 2, 4, 5
O-8	Establish a partnership among all levels of government and the	2, 3, 5, 6

[8] http://humboldtgov.org/DocumentCenter/View/1028

	business community to improve and implement methods to protect property	
O-9	Develop and implement hazard mitigation strategies that reduce losses to wildlife habitat and protect water supply and quality, while also reducing damage to development.	2, 3, 4, 5

Similar goal-setting efforts may be found in emergency response plans from local governments, health and safety providers, and local utilities.

4.2.2.2 Consider environmental justice

Environmental justice is an ongoing issue that is gaining recent traction in California and elsewhere. Many at-risk populations find themselves in areas of environmental degradation as a consequence of social inequalities. These sites may be downwind of a power plant or resource extraction site, exposed to contaminated soil and water, and so on. Tools such as CalEnviroScreen[9] can help to identify the most disadvantaged communities.

4.2.2.3 Address vulnerable populations

Beyond clearly articulated local goals, there are other broad societal drivers to consider. Some members of the public are more vulnerable to hazards based on physical limitations, economic constraints, isolation, and other factors that affect self-sufficiency and access to public services. Local health and human service groups can provide valuable feedback on where to consider resiliency opportunities that support the most vulnerable communities. Foundations and non-profit organizations are also excellent sources of information and guidance regarding their focal areas and served community.

4.2.2.4 Identify funding opportunities

Funding often enables a site to move up in priority. For example, non-profit organizations may operate within a specific region or business sector, and may provide critical match funds for a resiliency project. This may be in the form of improving an existing emergency assembly point such as a school, or upgrading a local community center. Non-profit organizations, such as food distribution centers and shelters, are also worthwhile candidates for potential projects.

Figure 3: Fremont Fire Station #11

One source of funding is through state agencies. For example, the California Energy Commission awarded roughly $1.8 million to fund a microgrid project[10] for

[9] http://oehha.ca.gov/calenviroscreen/report/calenviroscreen-version-20
[10] City of Fremont Fire Stations Microgrid Project; http://innovation.energy.ca.gov/SearchResultProject.aspx?p=30084

three fire stations in the City of Fremont. As stated on the Commission website:

> California needs to make better use of locally available renewable energy to increase resiliency and address climate change impacts such as increased fires, severe storms, and heat waves. Critical facilities are especially vulnerable to climate change impacts that disrupt the normal delivery of energy needed for their operation. Microgrids could help increase the resiliency of critical facilities through maximizing use of local renewable energy. Microgrid demonstrations at fire stations are needed to develop a case study to assess their ability to support fire station operations and safely island from the grid.

This project will design and build a microgrid with an energy management system, parking lot canopy photovoltaic system, and battery energy storage. The microgrid is designed to provide at least three hours a day of power for critical loads.

Communities with an adopted hazard mitigation plan are eligible for FEMA grants, such as the Pre-Disaster Mitigation grant program[11]. Local governments submit applications to a State office, which forwards eligible applications to the FEMA Regional Office and finally FEMA Headquarters. This is a highly competitive grant program so is best for projects with strong eligibility and cost-effectiveness.

4.3 Conduct final asset prioritization

Final prioritization follows when a team completes the logistical analysis, identifies existing societal factors and goals, and considers funding sources. Preferably, the team and associated stakeholders review all compiled material and conduct sessions to discuss trade-offs and generate an informed, prioritized list of key assets to receive EAP funds.

Beyond the stakeholders already working on the EAP process, this is the time to engage others with specific interest, motivation, and responsibility within the area of interest. For larger groups, consider some organizational structure to manage the volume and diversity of feedback. This might include organizing a core project team, technical advisory group, citizen group, and so on.

Recognizing that this may be a small bottom-up approach to kick-start a few demonstration projects, this process can also be done by an individual contributor or small team. In this case the long-term goal is to broaden engagement with relevant agencies, government officials, and interested community members over time.

Non-hazard vulnerabilities may affect the decision making process, including age of the infrastructure, deferred maintenance, and legal issues. These complex situations may be best deferred, but difficult sites also present an opportunity where funds arise to fix deficiencies. For example, if a bond measure is under consideration to improve infrastructure, seek to include resilience into the project design.

New facilities present the best opportunity. For example, in 2006 the Marin County Fire Department rebuilt their Throckmorton Ridge fire station, which includes a 38 kW solar array. Adding onsite energy storage to the design would create a ready supply of clean energy during extended grid outages.

[11] http://www.fema.gov/pre-disaster-mitigation-grant-program

Using the prioritized list of assets, the next step is to overlay the impact of hazards on the target assets. The California State Hazard Mitigation Plan[12] states,

> "Differences in diversity, geographic variation, and levels of risks and vulnerability make it difficult to assign priority to one type of hazard over another on a statewide basis. California's disaster history since 1950 indicates that the primary hazards of earthquakes, floods, and wildfires require priority attention because they account for the largest losses."

Despite complexities, a bottoms-up approach requires a starting point, and general conclusions can be drawn by overlaying assets with hazards to inform discussion and decision making.

Along with general hazards, consider additional hazards based on local knowledge and experience. Also, familiar hazards may also increase the frequency of new hazards. For example, wildfires can change the water absorption of soils, which can increase the risk of landslides during future storms. Maintaining an ongoing historical narrative of the local landscape and hazards can do much to inform future decisions.

To prioritize your short list of assets, evaluate the potential impact of hazards on each asset. For an asset to be useful, factors include:

- Vulnerability: a measure of the direct risk that a hazard places on an asset.
- Survivability: the ability of an asset to survive a hazard more or less intact.
- Accessibility: the probability that the asset can still serve and be reached by the community.
- Dependence: the degree that an asset relies on other services to function successfully.

4.3.1 Assess asset vulnerability

Vulnerability is defined as the direct risk that a hazard places on an asset. For example, an asset is vulnerable if it is in a frequent floodplain, at risk of wildfire, over an earthquake fault line, and so on. The degree of vulnerability increases depending on both the number of applicable hazards and their frequency. Vulnerability is also influenced by changes over time, such as vegetative succession, shifting waterways and land movement.

Although lists of location names and geographic areas can work, maps are invaluable to visualize the interaction of hazards and key assets. Ideally, a geographic information system (GIS) is available to collect, store, and present information. This dramatically accelerates the ability to overlay different data sets, visualize complex information, conduct what-if scenarios, and make reasoned decisions. Where digital data is unavailable, paper-based maps are still a good alternative.

Once you assemble your data, create hazard maps of the region. Complexity depends on the number of hazards, their degree of overlap, and characteristics of the landscape. Consider the following options:

- **Master hazard map:** this map overlays all hazards into a single visual tool. If scale allows, include place names, highways and roads, streams and rivers, and water bodies.

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[12] http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp

- **Individual hazard maps:** these maps focus on each specific hazard to support dialogue around characteristics such as frequency and location, and the specific threat of each hazard to communities and assets. These maps are also helpful during discussions with stakeholders responsible for specific assets, such as fire stations.
- **Critical facility map:** map of critical facilities, or assets, in the region. A dedicated asset map ensures that assets are properly inventoried and placed on the map. It also shows the physical relationship between all assets, and encourages assessment of critical assets and any coupled infrastructure such as communication towers.
- **Detail maps:** detailed view of locations that deserves extra scrutiny, such as areas of intersecting hazards, clusters of assets, densely developed areas, or coupled infrastructure.

The following figures illustrate mapping options for the Eel River Valley, near the termination of the Eel River into the Pacific Ocean. In this case the area of interest is the valley itself, which demonstrates numerous examples of how areas of interest often overlap:

- The topography of the river and associated estuary define a fertile floodplain that makes for excellent dairy farming.
- Natural terrain and waterways define many roadways. A convenient and lower-cost way to travel across a landscape, it also makes roads vulnerable to flooding and landslides.
- Valleys, rivers, and other geological features reflect underlying tectonic formations.
- Infrastructure tends to sit on top of hills and mountains, run along low-lying flat terrain and ridgelines, or reside along the edge of two zones such as a forest and field.

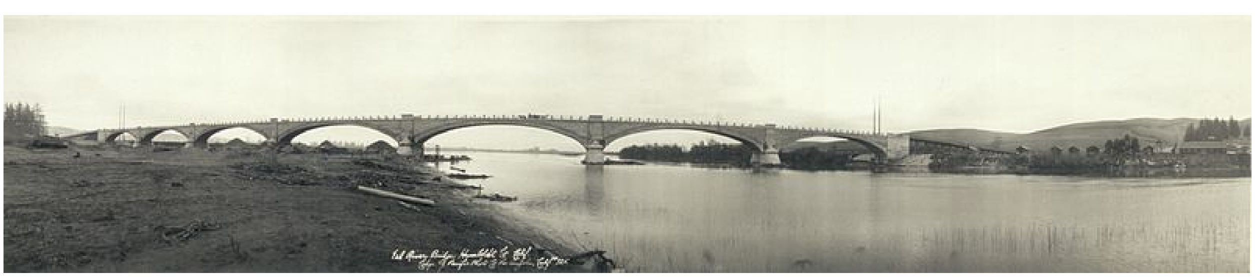
This intersection of natural terrain and economic opportunity is a common story for human habitation, and often establishes well-defined boundaries to assess resilience.

The historic Fernbridge is a key gateway into the Eel River Valley. Built in 1911, it is listed as the world's longest operating poured concrete bridge. It has withstood numerous floods and earthquakes, and is a proven lifeline for the Eel River Valley.

Without a reliable bridge over the Eel River, the entire valley is at risk of isolation following a major disaster. Alternative road routes are over rugged mountain roads, at risk to landslides and flooded crossings. Airlifts and boat crossings become expensive but necessary solutions to support the community.

The bridge is symbolic of infrastructure built to provide steadfast service to the community and to withstand the test of time.

Credit: By Panoramic Photographs Collection, Library of Congress - http://www.loc.gov/pictures/item/2007660511/ Public Domain, https://commons.wikimedia.org/w/index.php?curid=20415102



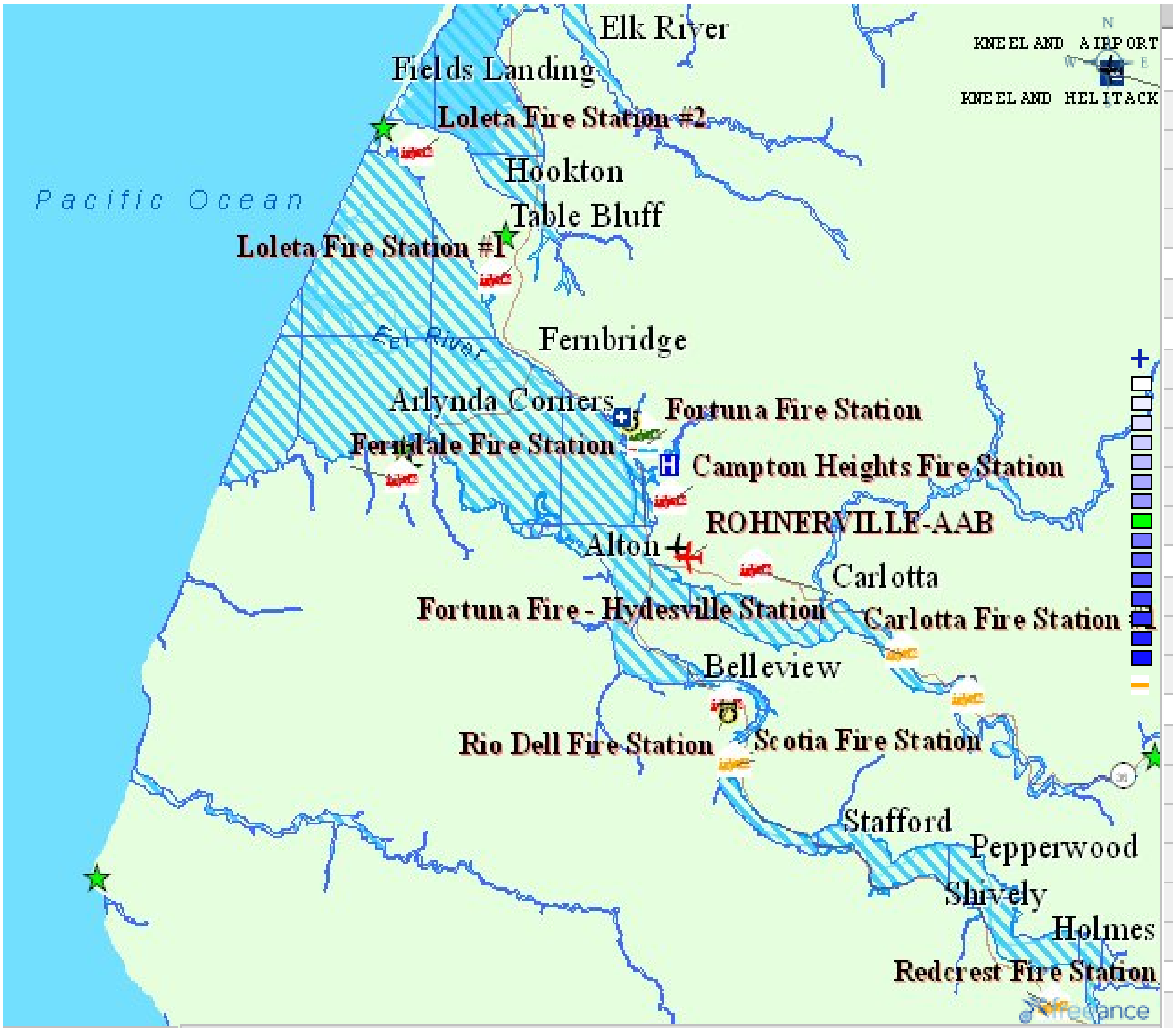


Figure 4: Eel River Valley FEMA flood zones compared with places, highways, roads, and selected key assets.

Figure 4 compares one hazard, in this case flooding, with a variety of assets such as fire stations, air fields, and medical facilities. Like many communities, roads follow natural features in the landscape, particularly waterways. In this situation, observations include the potential for isolation south of Fortuna, flooding of Carlotta and Loleta assets, total isolation for Belleview, borderline location of medical services, and so on. Given these vulnerabilities, one scenario would be to expect probable disruption of services south of Fortuna, which could be addressed with operations out of Rohnerville Airport. Planners can then choose to focus on the resiliency of the airport first, which benefits nearby communities with at-risk assets.

This map is derived from a GIS system[13], which greatly simplifies the ability to show various layers of information and compare different combinations of hazards and potentially affected assets.

[13] Humboldt County Web Graphical Information System; http://webgis.co.humboldt.ca.us/HCEGIS2.0/

Figure 5: Eel River Valley earthquake and tsunami zones with selected key assets.

In Figure 5, earthquakes are illustrated as partially broken lines along fault zones, and tsunami inundation is shown in yellow. The selected key assets appear to be generally safe from tsunami inundation, but several are near or directly on earthquake fault lines. Other considerations include inundation and debris on long stretches of the main roadway and potential loss of bridges, which would severely restrict vehicle travel for indeterminate periods. Since ground and water transportation may be limited, air-based services increase in importance.

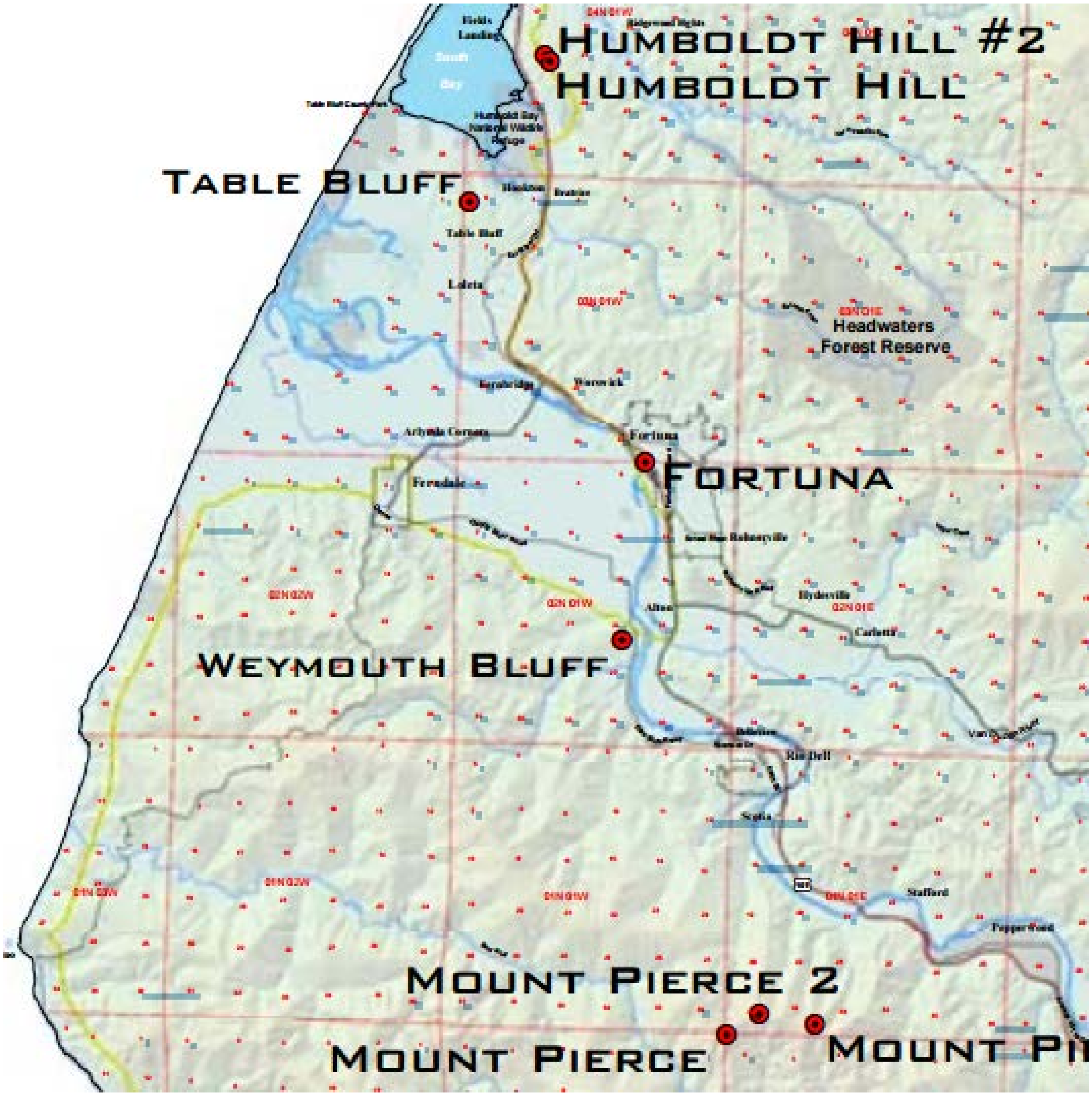


Figure 6: Cell towers in the Eel River valley.

Cell towers are a universal service for many agencies, and if not directly used as coupled assets, serve as backup communication. By design, cell towers are mounted high and out of inundation zones. However, they remain vulnerable to earthquakes and wildfire. They are also vulnerable to power outages unless they have independent or backup power sources, and their remote placement increases the potential for disruption and service delays as crews face heightened challenges to reach these sites. The ability of these sites to operate autonomously for long periods without human intervention would greatly improve the delivery of many essential services following a disaster.

4.3.2 Evaluate asset survivability

While vulnerability determines the level of risk that a hazard represents for an asset, survivability examines the ability of the asset to withstand an actual event. The first consideration is the physical structure of the asset. This is typically one building or a cluster of buildings, but could include a tower, tank, well, or similar structure.

To evaluate physical structure, document the construction method and materials. Determine the year each structure was built to identify the applicable building codes in effect at that time. These codes can provide essential clues into how hazards were addressed for specific time periods. Also note any remodels and additions, which can identify areas with more recent code requirements and potentially enhanced survivability.

Next, evaluate the overall condition of the structures. Review maintenance records to get a sense of the types of conditions already observed, and to identify current issues. Previous repairs are also good to note, along with documented outcomes. Repairs highlight potential issues since repairs by nature are disruptive and may not have addressed an underlying issue, such as an eroding foundation. Facility personnel, particularly those with a long history at a site, are an invaluable resource to learn about the health of a structure, known weaknesses, and suggestions for improvement. Make a special effort to inspect hard-to-reach areas such as attics, crawlspaces, foundations, drains, and retaining walls. Also look for water and fire damage, modifications to structural components (such as penetrations for computer cables and electric upgrades, or cuts in joists for heating ducts), settling and crumbling foundations, signs of moisture and insect damage, and so on.

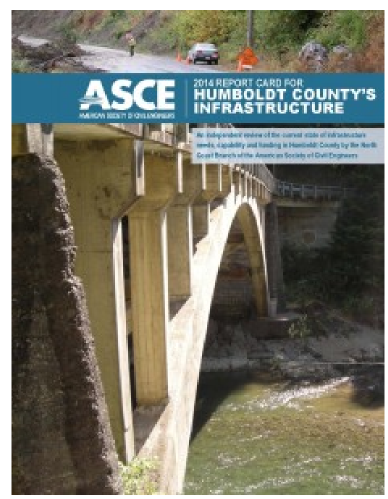
Depending on the number of identified issues, decide if it is realistic to continue with energy assurance activities, or if this work is best deferred until structural issues are resolved.

After evaluating the general structural condition, the next step is to evaluate the survivability of the services within each structure based on factors[14] such as reliability, availability, security, and safety. The following sections describe these factors in more detail for critical systems housed within a physical asset.

In some cases it may be more cost-effective to replace a building than repair and remodel an existing one. New building science, methods, and materials continually arise, resulting in stronger, safer, and more efficient buildings.

The American Society of Civil Engineers issues periodic report cards on the state of infrastructure around the nation. In 2016 they released a report card on Humboldt County's water and transportation infrastructure. As of writing, the most recent report card for California is 2012.

http://www.infrastructurereportcard.org/california/california-infrastructure/



[14] Energy Infrastructure Survivability, Inherent Limitations, Obstacles And Mitigation Strategies; http://web.ornl.gov/~webworks/cppr/y2001/pres/119766.pdf

4.3.2.1 Reliability

Reliability is the ability of a system to provide intended functionality for a specified time and under specific conditions. It generally describes the amount of time that the system will operate before failing.

The reliability of an asset often relates to its complexity. Fewer moving parts, simple design, and robust construction contribute to higher reliability. Complexity also tends to decrease reliability based on environmental conditions such as temperature, humidity, dust, and vibration.

For simple assets, inventory the various systems and key components. For example, a simple well site could include a submersible pump, pump controller, meter, and storage tank. More advanced sites might add alarms and telemetry, lighting, water treatment, and perimeter security. For each system, document the following for each key component: expected useful life, age, and maintenance history. When feasible, evaluate the general operating condition, and any adverse factors such as a corrosive environment, vibration, temperature, humidity, and so on. Once data is collected, evaluate potential weak spots and devise an action plan to update them in parallel with energy assurance activities.

For complex systems, schematics, flowcharts, and similar diagrams are essential tools to create an overview. Follow the same general procedure to document key components. Then, review the component list and highlight any deficiencies on the system schematic. This will help to focus attention on weak points prone to failure during and following a disaster.

Also document any redundancy. This can be in the form of backup power and emergency lighting, electronic tools such as laptops for control and operating data and instructions, spare equipment such as switching gear, or consumables such as filters and fuses.

Note that most vulnerable systems are often those that are used intermittently. Not only can mechanical issues arise, but personnel are less familiar with these systems and their operation. Backup generators, emergency lighting, and alarm systems are examples of equipment that can silently fail unless they are routinely tested and inspected. Ensure that each asset includes periodic system tests, along with clear, printed documentation within visible reach of each system.

A grading scale for reliability could include:

- High: simple and robust design, in routine operation, good remaining useful life, generally unaffected by or sheltered from environmental conditions, minimal or properly conducted maintenance, full redundancy for critical components.
- Medium: somewhat complex design with several vulnerable components, used occasionally, aging but functional equipment, some exposure to environmental conditions, fix-on-fail maintenance routines, some redundancy.
- Low: complex design with fragile components, used intermittently, outdated, exposed to environmental degradation, little or no maintenance or spare parts, no redundancy.

4.3.2.2 Availability

Availability is the probability that a system has not failed or is undergoing maintenance. This is often measured in terms such as uptime, net available time, utilization, and so on. For example, if a computer server is stated to have a 95% uptime, it is expected to be available roughly 345 days out of 365 days, running 24/7. For the purpose of this report, the goal is to designate a simple score to help rank and prioritize different assets for attention. An asset with low availability is a better candidate for replacement rather than energy assurance planning.

Availability can also be affected by extreme conditions that overload a system. This may be caused by loads beyond normal operating capacity that result in overheating, fatigue, and other issues. Imbalances between components can also lead to failure during extended use, such as frequent pump cycling caused by a lack of proper storage buffering. These situations can be assessed by conducting simulated drills, which are particularly helpful for staff to gain familiarity and experience working under unusual circumstances.

Asset availability is often affected by staffing, or lack of clearly documented procedures. In a disaster situation, trained and seasoned personnel may be unavailable, and less familiar staff may need to cover critical functions. In these situations, documentation is essential to guide inexperienced staff on basic operations.

A simple scoring method to grade the availability of a system:

- High: system consistently operates at normal loads and performs well, receives routine preventive maintenance, operation is well understood and performed frequently by staff, alternate staff is cross-trained, spare parts are on hand, and procedures are documented and up-to-date.
- Medium: system is aging and suffers occasional issues, some staff is versed in periodic operation, maintenance is performed on an as-needed basis, spare parts aren't on hand but are readily available or easily fabricated, and documentation exists but may be out of date.
- Low: experiences regular failures, staff are poorly trained in operation, documentation is poor or absent, parts are hard to obtain.

4.3.2.3 Security

Security determines how well a system is protected from accidental and deliberate disruption. Security includes both passive and active elements. Passive elements could include fences and locked entries, equipment racking and strapping, protective guards such as shields and bollards, and elevation for flood protection. Active elements can include door alarm systems, video and audio surveillance, environmental monitors such as fire and temperature alarms, emergency lighting, and so on.

Electronic systems require additional attention, such as power conditioning and electrical protection, hardware and software firewalls, and so on.

A ranking scale to grade the overall security of an asset:

- High: complete physical protection from unauthorized access, robust system for authorized access, applicable protection from likely environmental threats, active alarms and failsafe systems with stand-alone power supplies or emergency circuit, secured electronics.
- Medium: some physical protection from unauthorized access, critical personnel have necessary access at a minimum, some protection from major environmental threats, some alarms and hardened and secured electronics.
- Low: little or no physical barriers or protective devices, undefined access control for authorized personnel, no preventative measures for probable environmental threats, no alarms or electronic safeguards.

When space is at a premium, poor storage practices often emerge. For example, hazardous waste and other items may be stored near emergency supplies, utilities, exits, and other dubious locations. This can seriously hamper operational recovery following an event, particularly if waste is released. It is far easier and much safer to do housekeeping before a disaster strikes.

This exposed electric panel is enough of a problem without the maze of fluorescent tubes blocking access.

Example of unsecured gas cylinders and flammable liquids stored against combustible materials.

4.3.2.4 Safety

A site and associated systems must be safe to operate as intended. In this case, safety is regarding human occupants only, and determines whether conditions allow the site to be occupied. The safety of physical equipment is captured under “Security”.

Following an event, building condition, air quality, water intrusion, smoke damage, and other factors may require mitigation before personnel can enter the facility. Code-compliant buildings will include alarms for routine conditions including fire and carbon monoxide. Other alarms to consider include water intrusion, gas detection (such as chlorine for water treatment facilities) and temperature sensors.

Equipment must also be safe to operate following an event. This includes remaining physically secured, all utility connections are operable, hazardous materials are secure, and so on. The preferred solution is to clearly designate areas for hazardous materials and store them diligently, and to eliminate unnecessary or expired supplies. Also use signage at key locations such as emergency exits to reinforce their importance during time of need. Routine staff training and awareness is also essential to ensure that safety protocols are in place at all times and reduce potential complications during a disaster.

Some onsite materials are generally safe until disturbed by an event. For example, historic building materials such as lead and asbestos can become disturbed during an earthquake. Review the facility archives to evaluate for suspect material, containment methods, and probability of exposure following an event.

Human habitation requires biological support, so alternative services may be necessary onsite to manage basic necessities and hygiene. This includes potable water, waste disposal, and so on.

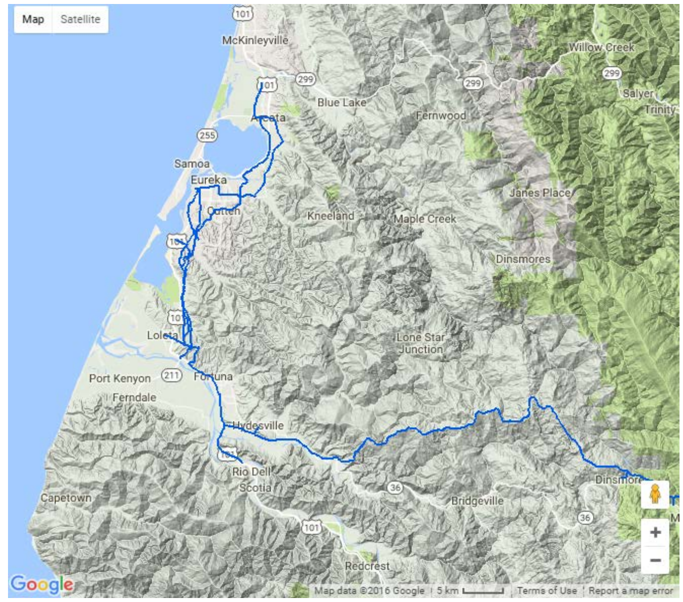


Figure 7: PG&E natural gas lines in Humboldt County

Beyond onsite considerations, an asset may be located near external sources of hazardous materials, including industrial storage, chemical processing, natural gas pipelines, power lines, wastewater, and so on. For each asset, identify nearby potential hazards and their potential impact to the physical location. Your local utilities and regulatory agencies can provide valuable information for regarding utility placement and industrial activity in your area. For example, the figure to the right[15] identifies Critical assets located near these lines may be disrupted by gas leaks, potential explosions, and blocked roads.

Here's one scale to grade the safety of an asset:

- High: building is constructed well with safe materials and is in good condition, utility attachments are robust, site is protected from environmental threats such as wind damage and flooding, safety monitoring equipment is in place and routinely tested, no or minimal hazardous materials are stored onsite or full response gear and mitigation supplies are on hand, no heavy or overhead equipment is present, surrounding area is clear of hazardous infrastructure, alternative biological support is available onsite.
- Medium: building is constructed well, any suspect materials are fully encapsulated or in small quantities, utilities remain isolated if physically damaged, site is secure from most common environmental threats, safety alarms are in place and tested annually, onsite hazardous materials are isolated and contained, some biological services are available onsite or nearby, some minor hazardous infrastructure is present.
- Low: building is old and contains various suspect materials, site is affected by several environmental threats, hazardous materials are present throughout the facility, heavy equipment is present and potentially unsecured to foundations, safety alarms are absent or not tested and maintained, biological support is unavailable if main services are out of order, hazardous infrastructure is nearby or can affect access to facility.

[15] Source: http://www.pge.com/en/safety/systemworks/gas/transmissionpipelines/index.page

4.3.3 Determine accessibility

Although an asset may be safe itself, it can become physically isolated from the served community by situations such as roads blocked by landslides, flooding along rivers, and earthquake damaged bridges. These issues prevent workers from staffing onsite operations, or for operating out of a facility to deliver field-based services such as fire and police protection. Some isolating factors include flooded roadways, damaged levees, unsafe bridges, buckled roads, roadside fires and heavy smoke, fallen trees and structures, ruptured gas lines, sinkholes, chemical releases, traffic jams and abandoned vehicles, and tsunami debris.

For each asset, identify potential obstacles between it and the served community. To simplify the exercise, assume that the served community also includes the residences of at least several key personnel. Use this information to develop an accessibility score for your assets for comparison purposes. Factors to consider include the level of autonomous operation for the asset in question, staff access to and from their residents to the asset, and access from the asset to the served community for field-based services. Also evaluate chain-of-command requirements to ensure that command personnel have realistic access from home to their headquarters, or that alternate decision capability is defined and assigned.

For remote communities, an additional step is needed to assess whether key personnel live within the community, or have commutes that present additional challenges. If staff has long commutes over challenging or at-risk terrain, reflect this in your scoring.

When addressing a diverse range of situations it's challenging to define consistent criteria that address all hazards. For example, wind storms, fires, and earthquakes all present different issues. The goal is to think broadly about the most probable situations rather than address each possible contingency. An example scoring for accessibility:

- High: asset can operate autonomously, the majority of key staff live near the asset, most or all field sites are easy to reach through major routes, bridges, overpasses, and infrastructure is minimal or in excellent condition along all major access routes.
- Medium: asset has some degree of autonomous operation, a sufficient number of key personnel have realistic access to headquarters and at least half of their field territory, most critical access routes are likely to remain open following an event, and good alternatives routes exist.
- Low: asset has no autonomous operation, key personnel are likely to be cut off from headquarters and field operations, major routes are likely blocked by damaged infrastructure, and limited alternative routes exist.

4.3.4 Evaluate dependence on other services (coupled infrastructure)

While some assets can stand alone the vast majority require additional services to operate as expected. For example, sites typically need some form of utility service such as power, water, electricity, and communications. Some sites may store fuel onsite, but eventually need local refueling options. This dependence is called “coupled infrastructure”, where an asset is considered unable to operate properly or for extended periods unless other assets are intact and available.

To evaluated dependence, the first step is to list all coupled infrastructure for each asset. Next, consider each applicable coupled infrastructure to determine if it will remain available during events, recovery time if impacted, and level of importance for the asset in question.

Also evaluate the degree of inter-dependence across coupled infrastructure. For example, a fire agency relies on radios to communicate between an operations center, field crews, and inter-agency coordination. This requires equipment at the command center, radio repeaters and towers, vehicle and personnel radios, and all associated electric systems. For example, a radio tower may be fully autonomous with onsite power generation and storage, have limited backup capability, or be fully dependent on the local electric utility.

Similar to assets, coupled infrastructure benefits from attention to good design, construction, and maintenance. Evaluate if the asset in question relies extensively on infrastructure that is outdated, poorly maintained, understaffed, is prone to isolation, and so on.

In some situations alternative services are available. For example, emergency radio communication traffic can be shifted to cellular service, or even amateur (ham) radio. However, these alternatives have the same considerations, and the more complex the system, the more probability of failure. Cellular service in particular is vulnerable since it is fundamentally a public service.

Utilities are often already evaluated and enhanced for critical services. For example, an electric grid serving a hospital may include redundancy or be on a prioritized list for restoration. Other assets that share this circuit have a better chance for sustained electricity or shorter recovery periods.

The Amateur Radio Emergency Service (ARES) is a corps of trained volunteers able to assist in public service and emergency communications. Amateur radio, also known as Ham radio, provides a community-based alternative when other technologies fail.

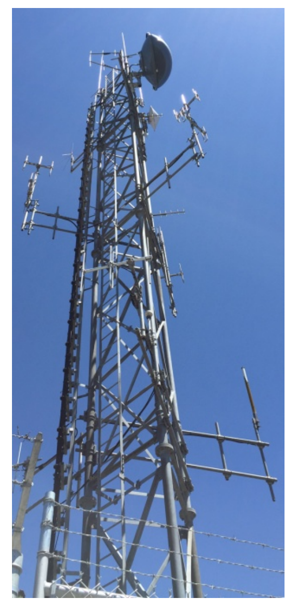
ARES groups are often registered with local government emergency management agencies to authorize operation under Federal Communications Commission rulings (Radio Civil Emergency Services, or RACES).

These community volunteers often fulfill an essential role during natural disasters, providing communication when conventional services fail. New technologies such as cell phones and Skype have dramatically changed the landscape for ham radio operators and how they practice their hobby, but hopefully they remain a viable alternative means of communication until more robust replacement technologies emerge.

A grading scale for dependence on other infrastructure:

- High: asset has minimal or no dependence on coupled infrastructure, infrastructure is well maintained and service recovery is historically quick, alternative infrastructure is readily available, limited inter-dependence between various coupled infrastructure.
- Medium: asset is dependent on some coupled infrastructure, services are typically restored in an acceptable period, some infrastructure is dated but properly maintained, infrastructure is cross-dependent but generally a priority to restore.
- Low: asset relies on numerous coupled infrastructure, subject to long delays for recovery, relies on dated or poorly maintained services with untrained or unavailable staff, no alternatives are readily available.

4.3.5 Develop strategy for key assets at high risk



Some critical infrastructure will be identified in high hazard areas or at risk of disruption or loss during a disaster. Identify these assets to local jurisdictions and agencies so that they can develop strategies and pursue funding to replace, relocate, or protect highly vulnerable assets.

Where an entire community may be at risk to specific hazards, such as wildfire or earthquake, it may be physically impossible to establish resilience for any assets. These situations rely on neighboring communities, state, and federal support. It may be possible to strategically place some assets, such as firefighting, first responder, and communications equipment near the perimeter of identified hazard zones. Cooperative agreements are a valuable tool to build reciprocal support among regions.

Depending on the degree that your team adopts the practices outlined in this process, there are numerous opportunities to identify improvements at many levels. Agencies can address weaknesses in key components such as power conditioning and electrical circuits, local government can work with utilities and agencies to tackle siting and interconnection issues, and regional groups can enhance long-range plans to prioritize at-risk public works and to develop regional redundancy.

5 Energy assessment of a key asset

Once key assets have been identified and prioritized the next step is to work towards energy assurance of these assets. Many critical facilities already have backup power onsite, often in the form of a generator and fuel. However installing a backup system that is powered with renewable energy can provide benefits during normal operations in addition to during an emergency event. While installing a renewable backup system with energy storage can have a high initial cost, if designed properly such a system can reduce costs during normal operations. For example, a solar photovoltaic (PV) system with battery backup can reduce the energy costs of a facility and offer opportunities for load shifting and demand reduction, thus reducing demand charges in addition to providing electricity service in an emergency situation. A system designed to increase resilience can also potentially open up grant opportunities for funds available for energy assurance planning. Ideally a backup energy system would be installed to meet the full energy and power requirements for the site for an indefinite amount of time. However, cost, space, and generation constraints often make this impractical with current technology. To ensure a properly sized backup energy system it is therefore important to properly characterize the energy and power requirements of the essential equipment and assess the resource potential for you generation source.

This section describes the overall process to analyze, prepare, and conduct an energy assessment of a key asset. Note this is not meant to replace a detailed analysis from a qualified professional with knowledge of building electrical code and infrastructure, and backup power systems, (e.g. a licensed electrician with knowledge of backup power systems), but it should offer enough information to begin the planning process.

5.1 Assess energy requirements

The first step in developing an energy assurance plan is to determine the energy requirements of the asset. This requires determining the level of service and duration of interim operations for the asset during an event. Some facilities may need to operate at full capacity and are unable to shed loads at any time, while others have non-essential functions that can be dropped for at least short periods. Existing backup generation are excellent benchmarks on what is expected or hoped from the facility in an emergency. Check the total output of onsite generation, as well as designated onsite emergency fuel. Regulations also define minimum emergency operating periods for critical infrastructure, and this can be a good starting point for other projects. Check with your Office of Emergency Services to identify existing forecasted interruptions for your region, and then work with your stakeholders to establish a reasonable minimum operational period for the asset in question.

Next, identify essential equipment. These are the components and systems that must operate so that the asset can deliver community services. Start with equipment directly involved in performing essential services such as electronics, communications, pumps and so on. Also consider equipment that supports human habitation of the facility, such as ventilation, space conditioning, and hygiene.

After identifying essential equipment there are several important considerations:

- Is it feasible to electrically isolate the essential equipment from non-essential loads?
- What are the power and energy requirements, including maximum power, duty cycle, and time of day requirements?

An excellent approach to determine the above is an investment grade energy audit[16] performed by a licensed professional. In the absence of such an audit there are steps operators can still take to get a high-level assessment. Examine utility bills to get an upper estimate of the energy and power

[16] The U.S. Department of Energy provides “A Guide to Energy Audits”; visit http://www.pnnl.gov/main/publications/external/technical_reports/pnnl-20956.pdf

requirements of a facility. If possible, use web-based utility accounts for access to digital data which simplifies analysis, such as the PG&E "My Energy" portal[17]. For looking at equipment in isolation there are a variety of tools available for purchase or loan through tool lending libraries.[18] Looking at the power and energy requirements of essential equipment will give an approximate size to a generation system.

An important consideration to all energy assurance planning is that *some is better than none*: even if there is limited space or budget to install a renewable backup system that meets the complete energy needs of the equipment, this does not mean that it's not worth the time and effort. If there is currently a backup generator with fuel available at the site, even an undersized renewable backup system can increase the interim runtime of an existing generator by reducing it existing load. Any effort to collect data will also prove helpful once a formal energy audit is undertaken.

5.2 Characterize onsite resource potential

After the power and energy requirement for essential equipment is approximated and the length of interim operation has been estimated, the next step is to assess the resource potential for onsite generation. Proper siting of a renewable generation facility is important to maximize output. For example, siting a large PV installation in a location with extensive shade during the day or certain seasons will decrease generation and reduce the rate of return for a project. If a site has excellent wind generation potential, consider whether there is sufficient battery storage space to compensate for variable wind speeds. Looking at already existing remote services in the area, such as communication towers or remote weather stations, can provide excellent insight and local history on what works well for particular situations.

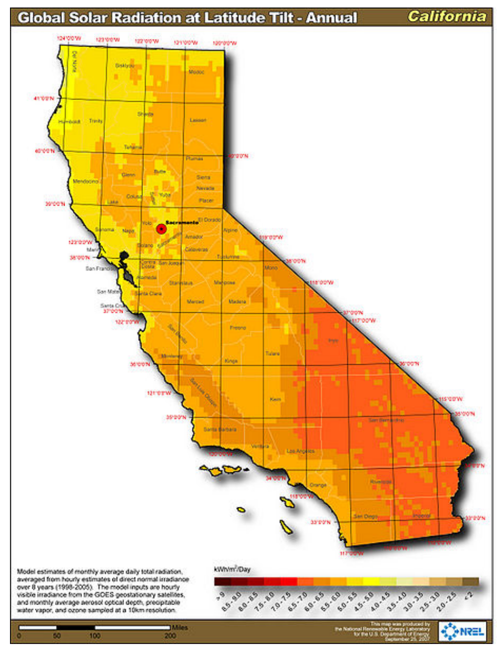


Figure 8: NREL map of monthly average daily total radiation.

There are several resources for getting a preliminary estimate of the resource potential at a location. The National Renewable Energy Laboratory (NREL) publishes maps for various types of renewable resources[19]. While these maps can give a first impression on whether a site is worth pursuing for generation, a more detailed assessment of a location is necessary to determine if a location is suitable for the type and scale of generation desired. For solar PV this can be a shading analysis, coupled with weather data from a reliable source nearby. For wind energy, more comprehensive (and expensive)

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[17] Utilities often provide a variety of tools and guides for analyzing energy consumption. For Pacific Gas and Electric Company customers, visit https://www.pge.com/en_US/business/save-energy-money/analyze-your-usage/business-tools-overview/business-tools-overview.page?WT.ac=Biz_BEC

[18] RCEA has a tool lending library as does PG&E's Pacific Energy Center
http://redwoodenergy.org/services/library-and-tools
http://www.pge.com/mybusiness/edusafety/training/pec/toolbox/tll/form/index.jsp?WT.mc_id=Vanity_pectll

[19] http://www.nrel.gov/renewable_resources/

monitoring is needed with an anemometer, ideally situated at the desired height of the generator hub, for at least a year.

A detailed measurement of the resource availability will enable a facility to make an estimate of the footprint of a generation project. NREL[20] regularly updates cost and size data for common types of renewable generation projects. These estimates are a good start for rough first-order estimates of size and cost for a project, but a comprehensive planning tool will eventually be needed to support decision-making and justify investment.

Another consideration for a project that will act as backup power in the event of an emergency is energy storage, for use when the renewable resource is unavailable (such as at night in the case of a PV system). Storage is most commonly in the form of batteries. Sufficient space and siting requirements need to be met to house a battery bank. Certain battery chemistries have environmental requirements, such as temperature and ventilation, which need to be met for safe and reliable operation.

5.3 Develop scenarios

It is likely that after a preliminary analysis of power and energy requirements, resource availability, and cost, a project that achieves all desires proves to be infeasible. In this case, the project team and other stakeholders can develop alternative scenarios and evaluate the merits of each before selecting one to investigate further. Some example scenarios include:

- Basecase: A base case scenario may be one in which all essential energy requirements are met by renewable generation and onsite storage. For many assets this scenario may be infeasible due to resource, space, and/or financial constraints unless there are other compelling motivators such as extreme isolation and power peak shaving incentives.
- Essential services: Develop a system that can provide the bare minimum energy requirements for essential equipment for a period of 72 hours.
- Increased runtime: Increase the operation time for an existing conventional backup power system, by migrating high-value essential services onto a dedicated renewable energy and storage system.
- Increased fleet operation: Where vehicles and facilities share an emergency fuel supply, deploy a system that supports facility operations and allows liquid fuels to be reserved for vehicle refueling.

The scenario process helps the team to identify potential pathways to secure stand-alone power capability for the most essential services.

5.4 Develop preliminary system design

There are many tools available to get preliminary estimates of energy generation. By far the most common form of contemporary onsite energy generation is solar power, although wind and water-

[20] http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html

based systems have their applications as well. NREL provides a well maintained tool, PVWATTS[21], which allows users to estimate the production of a solar PV system given inputs of location, orientation and system size. Default values for many inputs are provided, allowing novice users with a solid starting point for thinking about system design. A more sophisticated tool also from NREL is the System Advisor Model (SAM)[22]. SAM allows for a more comprehensive analysis for many different renewable generation resources. This planning tool allows a user to obtain estimates for a utility scale project. Again there are many defaults in place that will allow a novice to get a first order estimate of costs and revenue. A user with more expertise can refine the analysis to get more reliable numbers. SAM is also a useful tool for thinking about the necessary equipment for a given project. For example the tool allows users to configure a PV system in a variety of ways, changing the number of sub-arrays and inverters for example. In this way a user can get a sense of how different system configurations affect system output.

5.5 Next Steps

After the initial energy assessment is complete the next steps for implementation are to:

- Find a qualified contractor – the Contractors State Licensing Board had information on how to find and hire a licensed contractor.[23]
- Resolve known issues – work to address known issues at the site that may hinder future projects, such as possible asbestos-bearing materials, PCBs, and lead paint. Tackling remediation projects in advance allows future projects to proceed unhindered, and reduces liability and potential for contamination at a site following a disaster that disturbs and releases hazardous building materials.
- Perform energy efficiency upgrades – an audit will likely identify efficiency retrofits and upgrades, which reduces the energy use of the building and reduces the size of onsite generation and storage.
- Assess any zoning or permitting issues – contact local planning offices early to avoid surprises later in the process. This information can be collected in advance to streamline future efforts, which may have a short timeline such as when pursuing grant funds.
- Prioritize measures to be implemented – this process should be driven by an organization's project goals and budget. Implementation can also happen in phases, planned systematically, and implemented incrementally.
- Line up adequate financing – finding the funds for a project will likely be easier for plans that are more thoroughly developed, particularly with investment-grade audits at hand.

[21] PVWATTS is specifically for grid-tied PV systems, but is an excellent start to understanding onsite solar production potential; http://pvwatts.nrel.gov/

[22] Although SAM is configured for utility-scale projects, small systems share the same basic design elements; https://sam.nrel.gov/

[23] http://www.cslb.ca.gov/Consumers/Hire_A_Contractor/

The details for implementation are site and project specific and therefore it is outside the scope of this document. It is the authors' hope however that this section provides a good overview of the energy assessment and implementation process.

Finally, as you evaluate and implement various measures, always consider future expansion opportunities. For example:

- If a wastewater treatment plant needs to build new drying sheds, orient them to maximize future solar potential.
- If a building is getting a new roof, install conduit to support rooftop solar.
- If a generator room is being renovated, designate space for future battery storage.

This "future proofing" can greatly simplify efforts to improve the resilience at a site as opportunities arise.

6 Asset Prioritization Toolkit

The process outlined in this document is available as a toolkit to help conduct analysis and develop an energy assurance plan for key assets in other regions. The toolkit includes:

- This document: provides background information, rationale, and discussion of the overall process.
- Sample Plan: a demonstration plan for Humboldt County, which can also be used as a template.
- Assets and Hazards Inventory spreadsheet: A spreadsheet to inventory and prioritize assets, and to capture basic data on the various natural hazards affecting a region.

7 Resources

This section provides examples of various resources for hazard identification, research, mitigation, working groups, and so on.

7.1 California and National Resources

- **CAL FIRE:** CAL FIRE's mission "emphasizes the management and protection of California's natural resources; a goal that is accomplished through ongoing assessment and study of the State's natural resources and an extensive CAL FIRE Resource Management Program."[24] They provide essential knowledge on fire in the State of California, including planning, permitting and inspection, incident management, enforcement of forest practice regulations, training, and related activities. CAL FIRE maintains extensive critical assets to respond to an average of more than 5,600 wildfires annually. They also assist or provide leadership during disasters, providing

[24] (California Department of Forestry and Fire Protection, 2012)

valuable insights for risk mitigation activities.
Website: http://calfire.ca.gov/

- **California Geological Survey:** The California Geological Survey (CGS, under the California Department of Conservation), provides historical and current data on seismic activity in the state. Maps include subjects such as recent and historical earthquakes, regulatory maps, representation of ground shaking, and probabilistic seismic hazards and zones. The site also provides links to other state and national seismic resources.
  Website: http://www.conservation.ca.gov/cgs
- **California Department of Conservation:** This website provides seismic hazard regulatory maps, and information on landslides, mineral lands classification (helpful to identify soils-based hazards), and tsunamis.
  Website: http://www.conservation.ca.gov/

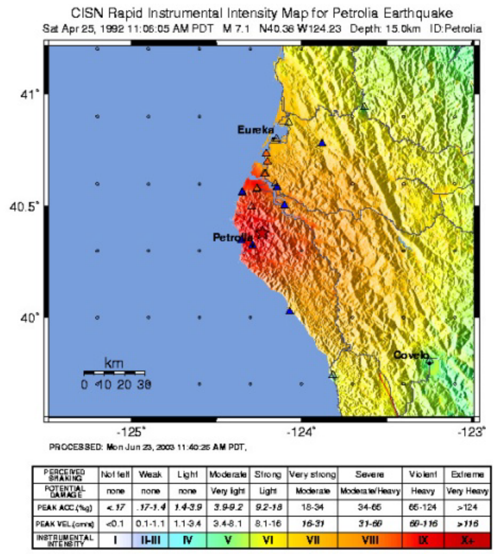
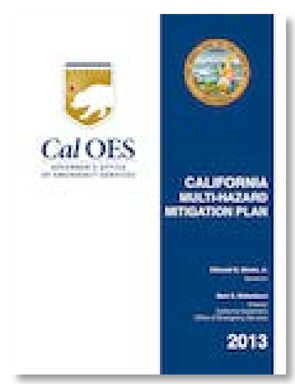


Figure 9: CGS Intensity ShakeMap of 1992 Petrolia earthquake. (California Geological Survey, 2015)

- **California Department of Water Resources:** This resource provides information on water-related topics, including droughts, flood and safety, water supply and use, and resource management.
  Website: http://www.water.ca.gov/
- **Tree Mortality viewer:** A web-based tool to identify ongoing tree mortality and the potential impact on hazard zones and assets.
  Website: http://egis.fire.ca.gov/TreeMortalityViewer/
- **California Seismic Safety Commission:** A resource on seismic events in California, including earthquakes, tsunamis, and volcanoes. The Commission monitors and responds to legislation, advocates for selected issues, and provides publications on seismic safety, awareness, and preparedness.
  Website: http://www.seismic.ca.gov/
- **California State Hazard Mitigation Plan:** Available through the California State website, the California State Hazard Mitigation Plan (SHMP) is a valuable resource that “continues to build upon California’s commitment to reduce or eliminate the impacts of disasters caused by natural, technological, accidental, and adversarial/human-caused hazards, and further identifies and documents progress made in hazard mitigation efforts, new or revised state and federal statutes and regulations, and emerging hazard conditions and risks that affect the State of California.” The website also provides links to background guidance and regulations, other State mitigation plans (as of 2016, 20 states have federally approved



hazard mitigation plans).
http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp

- **State of California Energy Assurance Plan:** Although primarily focused on an energy disruption or emergency for the state as a whole, this plan provides a broad perspective into the California electric, natural gas, and transportation fuel energy sectors, energy resources, and associated infrastructure.
Website: http://www.energy.ca.gov/2014publications/CEC-600-2014-006/CEC-600-2014-006.pdf
- **California Department of Education:** The California Department of Education provides useful information and tools to help identify and address various hazards facing school campuses. Topics include health and safety, disaster preparedness, onsite hazards such as asbestos and lead, and renovation.
Website: http://www.cde.ca.gov/eo/in/
- **California MyHazards web portal:** Available through the California Governor's Office of Emergency Services, the "MyHazards" web portal provides a searchable database hazard risk zones for earthquake, flood, fire, and tsunami. Although meant for the general public, it is a source of information for hazards that require State-mandated regulatory mapping.[25]
Website: http://myhazards.caloes.ca.gov/

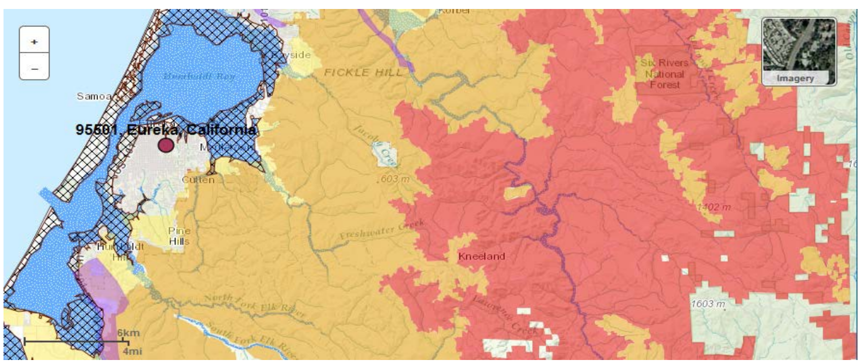


Figure 10: sample screenshot of MyHazards, showing hazards affecting Eureka, CA and surrounding area.

- **Federal Emergency Management Agency (FEMA):** FEMA provides numerous resources regarding disaster preparedness and response. For example, in *Asset Value, Threat/Hazard, Vulnerability, and Risk,* FEMA has presented multiple helpful figures displaying methodologies and processes that are helpful methods of defining asset value (table 1-1), categorizing hazards (table 1-3), rating threats (table 1-4), and building vulnerability assessments (table1-22). This document only focuses on cyber attacks, armed attacks, vehicle bombing, and CBR attacks as the threat (rather than natural hazards).Nonetheless, the document informs the planning process in EAP efforts.
Website: http://www.fema.gov/media-library-data/20130726-1455-20490-5292/fema426ch1.pdf

[25] (CalOES, 2015)

- **National Oceanic and Atmospheric Administration (NOAA):** This scientific agency provides extensive oceanic and atmospheric data including current and historic weather data, climate change, and coastal topics such as charting, sea level rise, and storm intensity.
  Website: http://www.noaa.gov/

- **2013 State of California Multi-Hazard Mitigation Plan:** Provides a broad perspective on state-level mitigation planning.
  Website: http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp

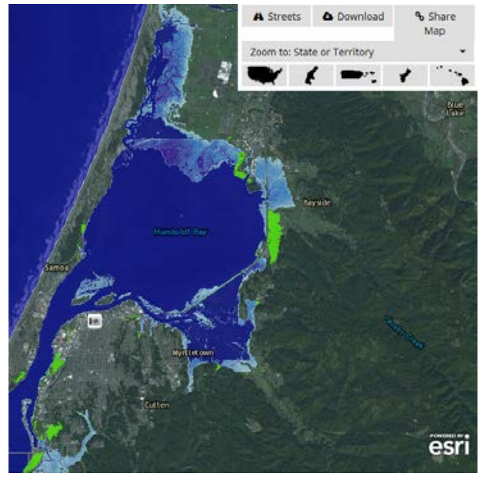


Figure 11: Screenshot detail of the NOAA sea level rise mapping tool. (NOAA)

- **California Emergency Management Agency Hazard Mitigation Web Portal:** Web resource with state-level information on planning, grants, resources and education, and hazards.
  Website: http://hazardmitigation.calema.ca.gov/

7.2 Humboldt County Resources

These resources provide specific information for projects in or near Humboldt County, California.

- **Humboldt County Fire Hazard Severity Zones:** Maps of fire hazard severity for both the state responsibility area (SRA) and local responsibility area (LRA).
  Website: http://www.fire.ca.gov/fire_prevention/fhsz_maps_humboldt

- **Redwood Coast Tsunami Work Group:** This is an interagency group working to reduce earthquake and tsunami hazards and coordinate mitigation activities on California's North Coast. Their website provides Tsunami evacuation maps, education materials, news, and links to related information.
  Website: http://www2.humboldt.edu/rctwg/

- **Tsunami inundation maps:** A Humboldt resource identifying probable tsunami inundation areas.
  http://humboldtgov.org/documentcenter/view/807

- **Humboldt County Local Hazard Mitigation:** This webpage provides details on local hazard mitigation for Humboldt County, California. A specific benefit of this effort is eligibility for grant funds through the Federal Emergency Management Agency.
  Website: http://ca-humboldtcounty.civicplus.com/506/Local-Hazard-Mitigation

- **Humboldt Operational Area Hazard Mitigation Plan Update, Volume 2: Planning Partner Annexes:** These annexes document jurisdiction-specific natural hazard event history, hazard risk ranking, an overview on capability assessment, administrative and technical capability, fiscal capability, and similar factors.
  Website: http://ca-humboldtcounty.civicplus.com/DocumentCenter/Home/View/1002

- **County of Humboldt Emergency Operations Plan. (2015):** This Plan includes all resources and stakeholders involved in addressing planned responses to emergency situations in Humboldt County. Mitigation strategies are established, policies, responsibilities, and procedures required to protect the health and safety of communities are identified, and a framework is created to carry out multiple emergency management systems. Section 1.6.10 (page 50/390) labeled 'Emergency Functions/Emergency Support Functions Chart' identifies which primary assisting agencies will be tasked with corresponding duties to assist the County. In addition, section 1.8.1 (page 69/390) labeled 'Hazards and Threat Analysis' may be useful in identifying which events are most relevant and damaging to the County.
  Website: http://www.humboldtgov.org/DocumentCenter/Home/View/51861

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