6. Energy

Introduction

The Pacific Northwest has a high likelihood of a magnitude 9.0 earthquake on the Cascadia subduction zone, which would produce minutes of strong ground shaking, coastal subsidence, landslides, liquefaction, lateral spreads, and a coastal tsunami. Seismic provisions in Oregon's building codes were first explicitly adopted in 1993. In contrast, Oregon's critical energy infrastructure (CEI) is not governed by a uniform set of design and construction codes. Much of the existing CEI has been constructed with seismic design deficiencies. To minimize extensive direct earthquake damage, indirect losses, and possible ripple effects, substantial improvements to the critical energy infrastructure are necessary.

GOAL

The goal of the Energy Task Group is to provide policy recommendations to the state legislature to make Oregon's critical energy infrastructure more resilient against a Cascadia subduction zone earthquake and tsunami within 50 years.

WHAT DOES BEING RESILIENT MEAN

The Oregon Seismic Safety Policy Advisory Commission (OSSPAC) has defined resilience as follows: "*Oregon citizens will not only be protected from life-threatening physical harm, but...because of risk reduction measures and pre-disaster planning, communities will recover more quickly and with less continuing vulnerability following a Cascadia subduction earthquake and tsunam*i."

SCENARIO

Because the impacts of the scenario M9.0 subduction zone earthquake and tsunami will vary depending on location, the steering committee recommended that, for the purposes of this study, the state be divided into separate regions. In addition to the tsunami, significant levels of shaking are expected, which will lessen in intensity the further one is from the coast.

The Energy Task Group adopted the following impact regions within Oregon, as recommended by the steering committee for all sectors:

- Coast/Tsunami Region: This is the part of the Oregon coast that is in or adjacent to the projected tsunami inundation zone.
- Coast/Seismic Region (earthquake-only): This is the part of the Oregon coast that is outside the tsunami inundation zone, but likely to experience peak ground acceleration (g) from .3 to .45.
- Willamette Valley Region: This region is likely to experience peak ground acceleration (g) from .15 to .3.

- Eastern Oregon Region: This region is likely to experience peak ground acceleration (g) from .01 to .15.

HISTORY

Over the course of the past five years, the Oregon Department of Geology and Mineral Industries (DOGAMI), the Oregon Public Utility Commission (OPUC), and the Oregon Department of Energy (ODOE) have been promoting awareness of the seismic vulnerabilities of Oregon's critical energy infrastructure by communicating with local, state, and federal government officials, energy operators, Oregon citizens, and the media through high profile activities, such as the following:

- April 2, 2007—Conducted a full-day leadership forum and workshop on the seismic readiness of critical energy infrastructure. This event was held at the OPUC's Main Hearing Room. The goal was to promote the importance of seismic vulnerability studies of critical energy infrastructures to utilities' executives and senior engineers, bringing together speakers from across the United States with expert knowledge on seismic readiness. The workshop addressed four critical areas:
  - Cascadia earthquake hazards and risk
  - Critical energy infrastructure vulnerability to earthquake damage
  - State-of-practice lifeline seismic vulnerability studies and application
  - Case studies of vulnerability studies by BPA and Pacific Gas and Electric (PG&E)
- August 21, 2007—The OSSPAC chairman sent a letter (based on input from DOGAMI and the OPUC) to Governor Kulongoski and members of the legislative assembly. The letter, which emphasized the urgent need to ensure the reliability of energy in earthquakes, addressed several key points:
  - Restoration of electricity and gas after a localized earthquake event are likely to be addressed relatively quickly, depending on the level of damage, with support for response coming from the region and potentially from across state borders.
  - Because of the potentially catastrophic impacts to critical energy infrastructures, the restoration of the energy sector after a Cascadia subduction zone earthquake is expected to take much longer should it occur today. The initial and immediate response, such as obtaining emergency generators for critical facilities, will likely require assistance from the Oregon National Guard and from other states.
  - The critical element of educating Oregonians on their level of responsibility should ideally be done in cooperation with the other West Coast states and the Canadian province of British Columbia so that everyone affected will be receiving the same information on how to be self-sustaining. Without exception, everyone on the West Coast will be assuming more responsibility (public, private, personal), so the better informed and educated people are, the more responsive everyone will be when the need to help each other arises.

- The letter also recommended that the governor take three immediate actions:
  - Oregon needs to mobilize on vulnerability assessments of pre-disaster inventories and systems.
  - Oregon needs to form cooperative agreements (by a specified timeframe) with other states before the earthquake disaster. These states should include Idaho, Utah, and others east of Oregon. Agreements should include the Oregon PUC. Note that making arrangements after the disaster would be inefficient. It is appropriate to acknowledge that the natural gas and electric IOUs and many COUs already have mutual aid agreements in place with other operators, some well outside the potentially affected areas.
  - Proactive education is needed for families and individuals; this should include instructions to be self-sustaining for weeks or months (not days). Without personal preparedness, local and state agencies and private companies alike will not have the personnel/staff they need to meet the multitude of demands involved in emergency response.
- August 26, 2009—ODOE, DOGAMI, and OPUC, via a hazard mitigation grant, conducted a Seismic Event Tabletop Exercise with most energy and fuel operators in the northwest industrial area of Portland (on the Willamette River). About five miles of the riverfront in this area near the St. Johns Bridge includes a concentration of critically important infrastructure on very poor soils that are highly susceptible to earthquake-induced permanent ground deformation. The purpose of the exercise was to promote awareness and resilience of critical energy infrastructures in Oregon. The outcomes were used to better understand the risk associated with earthquake hazards, and findings were shared with city and state leaders. One result of the exercise was to increase the urgency of taking immediate pre-disaster mitigation steps, preparing to take additional steps in the future, and improving planning for future disasters. Another result was a proposal to advance the seismic portion of the OPUC safety and reliability audits by specifying requirements for seismic vulnerability assessments. This work provided the basis for the Energy Assurance Plan Grant with NASEO.

- January 04, 2010—ODOE in partnership with OPUC and DOGAMI (Team) applied for the Energy Assurance Program (EAP) Initiative sponsored by the National Association of State Energy Offices (NASEO). The grant program required completion of the EAP within three years. The Oregon EAP was completed this past June (Wang et al., 2012). The main goal of establishing an Energy Assurance Plan for Oregon was to help all stakeholders make the state of Oregon resilient against any major incident, catastrophic or otherwise, so that Oregon will not go for long periods of time without the proper energy supply to meet its needs. In the application process, the Team identified the Cascadia subduction zone earthquake as the most severe catastrophic event Oregon will experience. With this perspective, the Team focused its attention on the most vulnerable energy area in our state, which was identified in the Hazard Mitigation Grant Tabletop Exercise, addressed above.

The Energy Assurance Plan and Oregon's Critical Energy Infrastructure Hub

The Energy Assurance Plan (EAP) (Wang et al., 2012) has become the main plan for our state, and even though it is focused primarily in the NW Industrial area of Portland along the Willamette river (CEI Hub), its findings and recommendations are applicable throughout the state's western region. It is also appropriate to acknowledge that the EAP work has been the driving force behind the Energy Task Group in its pursuit of policy recommendations to make our critical energy infrastructures resilient against a Cascadia subduction zone earthquake. Six magnitude 5.0 or greater earthquakes have occurred within the Portland metropolitan area in the past 150 years. The Cascadia subduction zone has produced more than 40 large magnitude earthquakes in the past 10,000 years. The most recent, which occurred on January 26, 1700, was an estimated magnitude 9.0. These occurrences and extensive scientific understanding of seismic processes indicate that it is highly likely that a Cascadia subduction zone earthquake will strike the region again.

Figure 6.1: Fuel tank farms and marine terminals along the Willamette River's edge near US Highway 30. For geographic reference to Figures 29 and 31, note the three parallel water inlets (Basemap: Google Earth)

Oregon's critical energy infrastructure hub (CEI Hub) covers a six-mile stretch on the lower Willamette River between the southern tip of Sauvie Island and the Fremont Bridge on U.S. Highway 30. This relatively small area in Portland is the site of liquid fuel, natural gas, and electrical infrastructure and facilities; it is also an area with significant seismic hazard. The energy sector facilities in the CEI Hub include:

- All of Oregon's major liquid fuel port terminals.
- Liquid fuel transmission pipelines and transfer stations.
- Natural gas transmission pipelines.
- A liquefied natural gas storage facility.
- High voltage electric substations and transmission lines.
- Electrical substations for local distribution.

More than 90 percent of Oregon's refined petroleum products come from the Puget Sound area of Washington State. Oregon imports the liquid fuel by pipeline and marine vessels; it passes through the CEI Hub before it is distributed throughout Oregon to the end users. (One large consumer is the Portland International Airport.) In addition, a portion of the state's natural gas fuel supply passes through the CEI Hub; and a high voltage electrical transmission corridor both crosses the area and supplies power to it.

Figure 6.2: Site Map of the Critical Energy Infrastructure (CEI) Hub on the western bank of the Lower Willamette River area in NW Portland, Oregon. The CEI Hub, outlined in red, stretches for six miles. (Google Earth)

Figure 6.3: Oil Terminals in the CEI Hub. (DOGAMI photo)

EARTHQUAKE RISK STUDY FOR THE CRITICAL ENERGY INFRASTRUCTURE HUB

The Oregon Department of Geology and Mineral Industries (DOGAMI) conducted an earthquake risk study on Oregon's CEI Hub as part of the Oregon Energy Assurance Project (EAP) with the Oregon Department of Energy (ODOE) and Public Utility Commission of Oregon (OPUC). The study focuses on a large-magnitude Cascadia earthquake, which, because of widespread shaking and vulnerable infrastructure, poses a high risk to the health and safety of Oregonians and the region's economy. The study identifies and defines the CEI Hub area, assesses the seismic hazards, and identifies the vulnerabilities of the petroleum (liquid fuel), natural gas, and electrical energy facilities in the CEI Hub.

Oregon's Natural Hazards

Oregon has numerous natural hazards. These range from high probability (fires) to low probability (volcanic eruptions). Earthquakes are considered to have a moderate probability because earthquakes in Oregon are rare. The earthquake vulnerability score for Oregon, however, is very high because a portion of Oregon's existing infrastructure has been designed and constructed without seismic resistance considerations. The earthquake consequence score is also very high because damage will likely be widespread and, in many places, severe. Finally, the earthquake overall risk score is very high because when a major earthquake occurs, it may result in loss of life, economic damages, and long-term impacts.

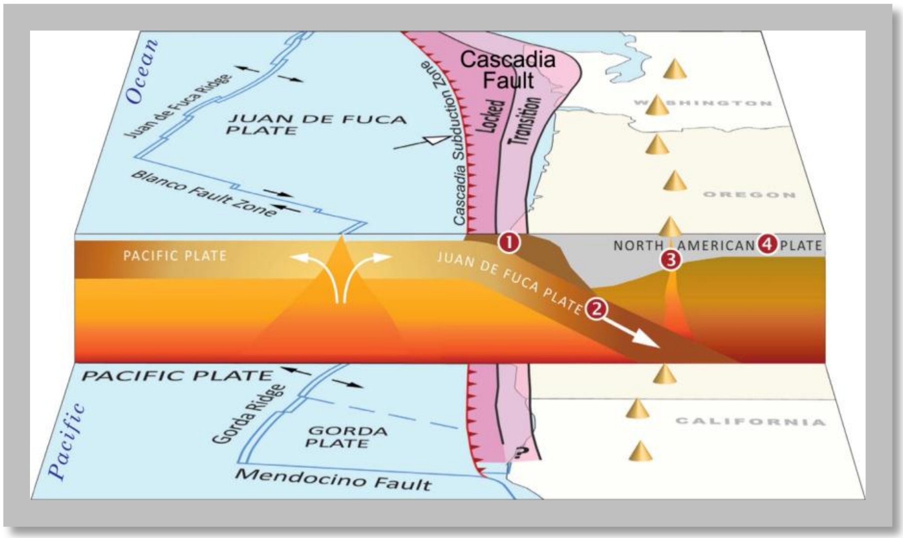


Figure 6.4: Cascadia seismic source is Oregon's most threatening fault and can produce a magnitude 9 earthquake and accompanying coastal tsunami waves. (Source: DOGAMI)

Potential Effects of an Earthquake

A portion of Oregon's electricity and natural gas infrastructure, as well as a majority of its fuel oil infrastructure, is concentrated in the CEI Hub. A magnitude 8 or 9 Cascadia subduction zone earthquake would impact the CEI Hub with:

- Ground shaking
- Liquefaction (a phenomenon in which a water-saturated soil, such as sand, softens and loses strength during strong earthquake ground shaking)
- Lateral spreading (where layers of soil at the surface of the land permanently move laterally due to earthquake shaking)
- Landslides
- Co-seismic settlement (where the ground surface is permanently lowered due to seismic shaking)
- Bearing capacity failures (when the foundation soil cannot support the structure it is intended to support)

In addition, secondary seismic hazards could be initiated. These include:

- Seiches (waves that oscillate in water bodies; such waves are often initiated by ground shaking)
- Fire
- Hazardous material releases (including by sloshing of liquid agitated by ground shaking)

- Tsunamis (Tsunami waves are expected to damage coastal areas, including ports along the coast and Columbia River mouth, but are not expected to cause significant damage in Portland's waterways.)

Liquefaction and lateral spreading hazards are of primary concern to the oil terminals that handle Oregon's liquid fuel supply. The CEI Hub is adjacent to the Willamette River and has extensive deposits of highly liquefiable soils. These soils (made of sands, silts, gravels, and clays) have been deposited both by natural river activity and by human activities, such as the hydraulic placement of material dredged from the river or debris deposited as landfill. For this reason, DOGAMI performed ground deformation analyses to better understand the nature of the hazard and the possible mitigation that will be needed to address it. A section on the deformation analyses is included in this study.

Energy Facilities in the CEI Hub

DOGAMI staff and others visited all relevant energy companies with facilities in the CEI Hub. DOGAMI and ODOE staff conducted site visits at these petroleum facilities: BP, Chevron, ConocoPhillips, KinderMorgan (KM) fuel terminals and pipeline, McCall Oil, Nustar, and Shell. The liquid fuel facilities often include transmission and distribution pipelines, piers or wharves, tank farms, loading racks, control buildings, electrical distribution equipment, and many other components. The liquid fuel transmission system includes gate stations and transmission and distribution pipes at the Columbia and Willamette river crossings. DOGAMI and OPUC staff also conducted site visits of natural gas and electrical facilities owned by NW Natural, Portland General Electric, and the Bonneville Power Administration (BPA).

General Findings

The CEI Hub facilities have infrastructure that ranges from about 100-years–old and built to no or very antiquated standards to new infrastructure built to the current state-of-practice standards. Because of the wide range of ages and associated construction practices, the seismic vulnerability of the facilities also spans a wide range. Based on visual observations, engineering judgment, and information from facility operators, major seismic vulnerabilities exist in the CEI Hub. The vast majority of the facilities are constructed on soils susceptible to liquefaction. Some critically important structures appear to be susceptible to significant damage in a major earthquake, while structures that were installed more recently are expected to have better seismic performance. In addition, DOGAMI discovered that older building codes and practices did not adequately address many non-building structures that exist in the CEI Hub, such as tanks, pipes, and piers. Current building codes do not adequately address the seismic deficiencies in existing CEI Hub facilities.

Sector Specific Findings

- Liquid Fuel
    - *Liquid fuel pipeline:* The CEI Hub's petroleum facilities receive liquid fuel via two methods: 1) the liquid fuel transmission pipeline and 2) marine vessels. The

transportation method and amounts vary due to product demand, transportation costs, weather, and other conditions. The liquid fuel pipeline was largely constructed in the 1960s when the regional seismic hazards were unknown and state-of-practice construction techniques did not include any reference to seismic standards. The regional seismic hazards are now known to be significant, and the soils at the river crossings are known to be susceptible to liquefaction and lateral spreading. The 1960s vintage pipeline design did not consider ground movements from lateral spreading at river crossings or other earthquake-induced stresses on the pipelines that may cause damage and multiple breaks. A break in the pipe would have a significant impact on all of the petrochemical facilities in the CEI Hub and could result in a statewide fuel shortage.

- *Liquid fuel supply:* Liquefaction vulnerabilities are known to have been addressed in the case of only three existing tanks. The tank farms in the fuel terminals of the CEI Hub have on average a three- to five-day supply of regular unleaded gasoline and diesel fuel. Premium gasoline is subject to daily delivery and is heavily dependent on whether the intercompany pipeline on Front Avenue is operational. If the supply chain is disrupted by pipe breaks north of the CEI Hub and by closure of the shipping channel to the west, fuel would quickly become scarce. Options to transport fuel from the east and south and by air are very limited.

- *Shipping channel:* The navigational channel from the mouth of the Columbia River to the lower Willamette River is used by marine vessels to transport fuel. The mouth of the Columbia River is expected to have tsunami damage, and the channel is expected to experience slope failure, which would close the channel to traffic. It is possible that bridges and other overhead river crossings would also be damaged and could temporarily block the waterway. Closure of the shipping channel would prevent marine vessels from delivering either liquid fuel or emergency response and recovery equipment.

- *Marine terminals:* All of the port facilities in the CEI Hub have significant seismic risks due to liquefaction, lateral spreading, and seiches. Some older piers were constructed without any seismic protection, have deteriorated, and are likely to fail even in a moderate earthquake. If oil products are released and contaminate the navigable waterway, the waterway may be closed to river traffic, thus impeding emergency response activities as well as the supply chain. The local capacity to fight fires and clean up hazardous material spills is limited.

- *Portland International Airport (PDX):* PDX airport receives 100 percent of its liquid fuels from a terminal in the CEI Hub. The airport has a limited on-site fuel supply. If the pipeline between the CEI Hub and the airport fails, then the airport would likely experience a shortfall, and operations would be impacted.

Figure 6.5 Lateral timber bracing for steel plumb piles in the CEI Hub is considered inadequate by California's MOTEMS standards. (DOGAMI photo)

Figure 6.6: An example of a damaged pier in the 2010 Chile earthquake (ASCE Technical Council on Lifeline Earthquake Engineering – TCLEE, 2010)

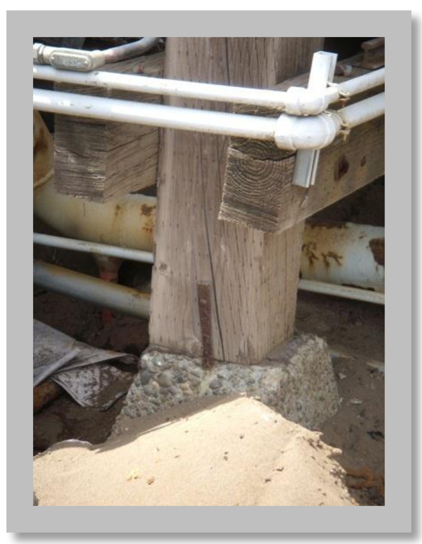


Figure 6.7 and 6.8: This under-designed oil terminal pier foundation (left) in area with high susceptibility for liquefaction and lateral spreading in the CEI Hub and the poor timber-to-concrete oil terminal pier connection and exposed rebar foundation (right) in the CEI Hub are considered inadequate (Source: DOGAMI photo)

Figure 6.9: The connection on this pier in the CEI Hub appears to have deteriorated due to a split in the timber beam. This type of damage suggests that the condition of the structure may not be routinely monitored and maintained and that the overall pier is seismically vulnerable (Source: DOGAMI photo)

Figure 6.10: The approach (foreground) to the 1966 Astoria-Megler Bridge that spans the Columbia River has major structural deficiencies that could lead to a collapse following an earthquake. Damaged bridge sections could block waterway access to the CEI Hub. (DOGAMI photo)

- Natural Gas. Oregon's largest natural gas service provider receives the majority of its natural gas from pipelines that cross under the Columbia River near St. Helens, Sauvie Island, and also between Washougal, Washington, and Troutdale, Oregon. One of the natural gas pipelines crosses under the Multnomah Channel near the gate station at the southern end of Sauvie Island. The soils at these river crossings are subject to liquefaction and lateral spreading, and the pipes are of 1960s vintage. However, natural gas pipelines constructed after the mid-1950s have been found to perform very well during significant seismic events. Oregon’s largest natural gas supplier has the strategic advantage of on-system storage (within the company's service territory), which would allow the company to provide natural gas service to unaffected customers while any damaged natural gas pipelines supplying the area are being restored.

- Electricity
  - Electrical facilities and systems have significant seismic risk due to ground shaking and ground failure, including liquefaction and lateral spreading. Seismically vulnerable facilities include substations and transmission lines in the CEI Hub as well as facilities outside of the CEI Hub, including power plants, substations, and transmission lines, all of which are important for distribution. Major vulnerabilities in the CEI Hub include the control buildings, transformers, and other electrical equipment in yards at the substations, and transmission towers near the Willamette River. Damage is likely to occur to both the transmission system and the distribution system in the CEI Hub. Damage to the electrical grid will likely result in a blackout in the CEI Hub and elsewhere.

Findings of the Bonneville Power Administration

Bonneville Power Administration (BPA) has conducted a comprehensive seismic vulnerability study of their system and has had a long-term seismic mitigation program in place since 1993. This program includes:

- Investment protection (e.g. anchoring transformers).
- Power system recovery of critical paths (e.g. hardening of equipment at one of multiple bays within a major substation).

The first phase of BPA's mitigation program includes bracing and restraining critical equipment and seismically upgrading critical building facilities west of the Cascade Range. Seismic strengthening in the substation yard would typically include: anchoring high-voltage power transformers, bracing transformer conservators and radiators, replacing seismically vulnerable live tank circuit breakers with more robust dead tank circuit breakers, adding damping systems to existing live tank circuit breakers, hardening transformer bushing storage facilities, and replacing rigid bus connections with flexible bus. These mitigation techniques will improve the reliability of seismic performance. Additional phases of the seismic mitigation program will include facilities east of the Cascade Range.

BPA has a critical 115 kV and 230 kV high voltage transmission river-crossing in the CEI Hub as well as a substation. At the substation in the CEI Hub, some of the high-voltage equipment had been anchored and braced to withstand earthquake motions. BPA is in the process of conducting seismic strengthening of the control building and equipment inside the control building (for example, bracing computer floors, control cabinets, battery racks, ceilings, and pipes) and additional mitigation in the yard. BPA has conducted subsurface, liquefaction and lateral spreading analyses at one of the transmission tower sites at the Willamette River crossing and has concluded that severe ground movement (up to 25 feet) towards the river channel is possible. Until mitigated, it is likely that at least two transmission towers would experience extensive damage, be inoperable, and require repair or replacement; and power lines could temporarily block river traffic, including the pathway to the oil terminals. The BPA transmission towers at the Willamette River crossing are scheduled to be seismically analyzed, to have a seismic mitigation design completed in 2013, and to be mitigated by 2014.

Recent unpublished BPA Cascadia earthquake scenario studies of the existing transmission line system indicate that BPA's main grid would require between 7 and 51 days for completion of emergency damage repairs to the transmission line system (Oregon and Washington) after a magnitude 9.0 Cascadia earthquake. This scenario assumes many ideal conditions (for example, that BPA employees and contractor resources are immediately available, all roads and bridges are passable, and sufficient fuel is available), which is optimistic.

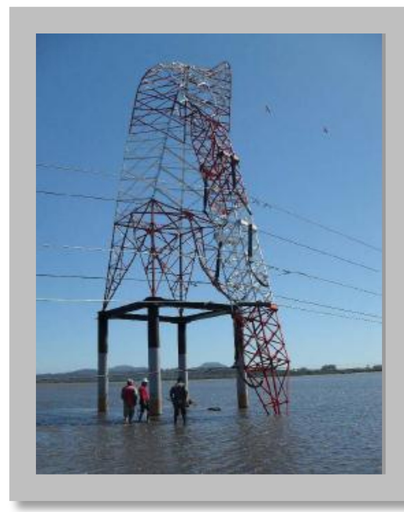


Figure 6.11 and 6.12: Left: These high voltage electrical transmission towers are built on a river bank in the CEI Hub susceptible to lateral spreading. (DOGAMI photo) Right: Structural damage to a high voltage transmission tower located at a river crossing in 2010 Chile earthquake. (ASCE Technical Council on Lifeline Earthquake Engineering – TCLEE)

Impacts to Oregon

Based on visual observations, engineering judgment, limited analyses, information from the facility operators, city records, and available literature, significant seismic risk exists in the CEI Hub. Some critically important structures appear to be susceptible to substantial damage in a major earthquake—with catastrophic consequences. Breaks in liquid fuel and natural gas transmission pipes are possible. Damage to liquid fuel, natural gas, and electrical facilities in the CEI Hub is also possible. The waterway may be closed as a result of the damage and may need to be cleaned up before it can be reopened.

Due to the existing seismic hazards, the vulnerability of the exposed infrastructure, and the potential consequences of an earthquake given both these factors, Cascadia earthquakes pose substantial risk to the CEI Hub and to Oregon. Not only are the energy sector facilities in the CEI Hub dependent on other sectors and systems in Oregon, including transportation and communication, they are interdependent upon each other. A major Cascadia earthquake and tsunami would likely produce impacts larger than any event the state has previously faced. Western Oregon may face a temporary electrical blackout, isolated natural gas service outages, and liquid fuel shortages. Mitigating the risk that a future major Cascadia earthquake poses to the energy sector can lessen energy infrastructure damage and enable faster recovery of services to support other critical lifeline services.

OPERATOR EFFORTS TO PREPARE FOR A CASCADIA SUBDUCTION ZONE EVENT

For decades, the energy sector has recognized the need to prepare its systems for seismic events and other disasters that could have an impact on customers, and energy operators have made progress toward improving their resilience to a major seismic event. Operators are constantly updating and replacing their energy infrastructure, and in the process of replacement, they upgrade the new facilities to current design standards.

Energy providers comply with federal standards and regulations related to the siting, design, construction, and safe operation of infrastructure to make sure that risks, such as earthquakes, are evaluated and addressed as necessary to ensure the safe and reliable operation of the electrical grid and interstate and intrastate natural gas pipelines. At the state level, the providers of those utilities regulated by the Public Utility Commission of Oregon meet on a regular basis to provide updates to regulators regarding their preparations for disasters and response and to continually evaluate how they can improve and strengthen energy systems.

Within the energy sector, the operators improve their approach to building resilient systems by participating in professional organizations that set the industry's standards and address risk evaluation. Further benefits are gained from interaction with companies that have experienced low frequency, high impact events, such as earthquakes, because these companies are able to share tactics that proved to be beneficial in preparing and recovering from such events. Moreover, the operators have entered into mutual aid agreements with other energy providers outside the region. Such agreements will make it possible to mobilize significant quantities of skilled personnel and materials to support the response to a major natural forces disaster. Finally, on an ongoing basis, the operators have built internal planning processes to ensure an orderly and effective response to any event that significantly disrupts business operations. These actions are significant and have made the energy sector better prepared to respond to major events today than it was previously.

Over the past 25 years, NW Natural has implemented an aggressive, enhanced pipeline safety program to replace older infrastructure that may not be as resilient to a Cascadia subduction zone event. The company completed the replacement of all cast iron pipe in 2000 and will complete the replacement of its bare steel piping infrastructure in the near future. The current underground piping systems have a high level of ductility (flexibility) which allows the pipe to perform well in a seismic event. Since 2002, the company has implemented new Integrity Management Programs for its transmission and distribution systems to address threats (including seismic events) to the safe and reliable operation of the pipelines.

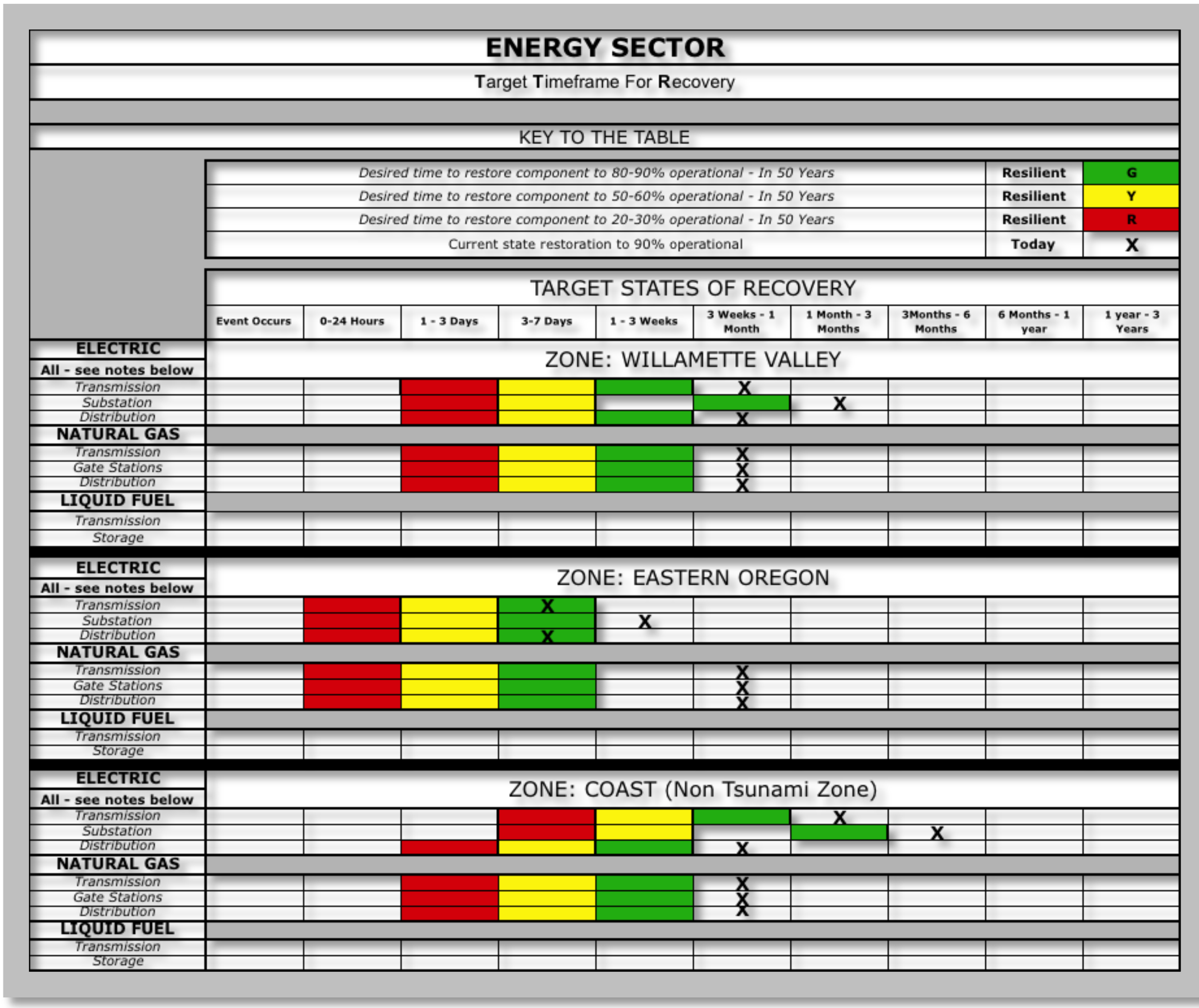
Expected Service Restoration Time Frames

The expected service restoration time frames (see Figure 6.13) are based on the assumption that roads and telecommunications are functioning so as to support restoration of the energy infrastructure. In areas where service restoration is impractical, the service provider is not expected to meet the restoration timeframes. Establishing target timeframes for the tsunami inundation zone, beyond a minimal level of capability to support response, is not practical. For that reason the tsunami inundation region is not depicted in the matrix presented below. A large amount of planning and prioritizing will need to be undertaken to identify which areas will be rebuilt first.

Recommendations

- **The Oregon Public Utility Commission (OPUC) should provide oversight for the seismic preparedness of those energy providers that are currently jurisdictional.**
- **Develop regulatory oversight for energy sector companies that are not regulated by the OPUC and create engagement in seismic mitigation efforts for those companies, including appropriate cost recovery for such oversight function.**
- **The state should provide immunity of liability, in statute, for those seismic vulnerabilities that are identified by the operators during their seismic vulnerability assessments.**
- **To identify vulnerabilities of operator-defined Critical Energy Infrastructure (CEI) facilities, energy sector companies should conduct seismic vulnerability assessments. Operators should then develop plans to mitigate the seismic risks associated with the identified CEI vulnerabilities.**
- **Energy sector companies should institutionalize long-term seismic mitigation programs and should work with the appropriate oversight authority to further improve the resilience and operational reliability of their Critical Energy Infrastructure (CEI) facilities.**
- **Form a public-private partnership with the objective of reducing the state's vulnerability to seismic events by evaluating the diversification of locations for the storage of liquid fuels and identification of new liquid fuel energy corridors (new locations to be defined).**
- **The state of Oregon should require that, in emergency situations, liquid fuel wholesale and retail operators provide both access to and alternate means of delivering fuels to the end users.**
- **Evaluate the options for improving power supply to coastal areas located outside of the tsunami inundation zone.**
- **Utilize the Oregon Office of Emergency Management's public-private sector position to help ensure coordinated planning, information sharing, and interoperability among critical organizations and agencies. The position will also ensure that work being performed by this entity and its partners helps provide public education and outreach to local, county, and state agencies and organizations.**

► **The state of Oregon should provide statutory authority for a prescriptive waiver of routine permitting requirements and processes for the design, construction, and restoration of energy infrastructure and subsequent actions, if it is determined that the waiver is in the public interest and is necessary to address an actual or impending emergency caused by a natural or manmade disaster.**



Restoration Status Assumptions - Cascadia Subduction Zone Earthquake
1- Transportation routes including roads, airports, bridges, etc. will be available for energy provider use to perform assessments, deliver materials and rebuild infrastructure as required.
2- All fuel needs will be available to support energy provider restoration operations.
3- For areas dependent upon third party electric transmission providers, restoration times assume their system will be available to support restoration efforts.
4- Interstate gas transmission pipelines will be able to provide service in advance of the restoration times for local distribution.
5- Roseburg / Medford areas are included with Willamette Valley for evaluation purposes.
6- The % of restoration references it to customers who are able to take natural gas or electric service delivery.
7- Communication systems will be available for energy provider's use.
8- For Pacific Power the coastal service territory includes a combination of tsunami and non-tsunami prone areas. Where facilities provider service to non-tsunami prone areas pass through or reside in tsunami impact areas, the estimated impact of tsunami on these facilities is included in restoration times.
9- The State of Oregon has provided statutory relief and/ or waiver from typical permitting requirements and processes associated with the design, construction and/ or restoration of the energy infrastructure.
10- The bulk of generation is outside of the Willamitte Valley , so the focus is on the Transmission.

Figure 6.13: Energy Sector Target Timeframe for Recovery

References

1. Wang, Y., Bartlett, S.F., and Miles, S.B. (2012). *Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub*. Final Report to Oregon Department of Energy & Oregon Public Utility Commission. Oregon Department of Geology and Mineral Industries, August. The full EAP report is accessible at http://www.oregon.gov/puc/docs/DOGAMICEIHubreport-8-1-12-R1.pdf.

2. Nojima, N. (2012). "Restorations and System Interactions of Lifelines in the Great East Japan Earthquake Disaster, 2011," *Proceedings of the International Symposium on Engineering Lessons Learned from the 2011 Great East Japan Earthquake*, March 1-4, Tokyo, Japan.

3. ASCE TCLEE (2011). *Preliminary Report on the 27 February 2010 Mw 8.8 Offshore Maule, Chile Earthquake*. Technical Council on Lifeline Earthquake Engineering (TCLEE), American Society of Civil Engineers.