**TRN Resource: Dual-Impact Hazards and Threats**

In the Technical Resilience Navigator (TRN), dual-impact hazards and threats are defined as hazards and threats that have the potential to impact both offsite and onsite energy and water systems. In other words, in the event of a disruption to the primary supply system, there is a chance that the redundant systems would also be impacted.

The general structure of scenarios in the TRN can be used to capture realized hazards and threats based on the following structure:

1. **Hazards and Threats:** A hazard or threat is realized, resulting in loss of primary resource (quantified as the hazard or threat frequency and primary resource outage duration). For a *dual-impact threat*, it is assumed the attacker has targeted onsite redundant systems as well as the offsite resource.
2. **Vulnerability:** Site redundant systems fail (quantified as vulnerability, which is the probability that there is failure to initiate and operate the backup resources).
3. **Consequence:** Critical load outage occurs (quantified as the critical load outage duration).

The TRN web tool provides estimates of annual frequencies for 12 natural hazards at a county level, based on data from FEMA’s National Risk Index (NRI)[[1]](#endnote-1). However, estimating threats, which are caused by people with malicious intent, is challenging. Therefore, this resource also describes the process through which the user could consider the quantification of frequency, consequence, and vulnerability associated with threats.

**Dual-Impact Hazards**

Suggested dual-impact hazards that may be relevant for your site’s analysis can be found using the TRN hazard pick list, along with estimates of the frequency with which those hazards may occur at your site. These frequencies specifically consider hazard thresholds and include only levels that are likely to cause infrastructure damage. For example, the frequencies of earthquake hazards are determined considering only earthquakes with a shaking intensity (Modified Mercalli Intensity) ≥ VI, or strong shaking that can cause slight damage[[2]](#endnote-2).

The table below lists examples of potential dual-impact hazards that may impact the site, as well as questions to consider when determining whether onsite systems are designed to withstand those hazards (design basis considerations).

| **Dual-Impact Hazards** | **Hazard Description (NRI)i** | **Design Basis Considerations** |
| --- | --- | --- |
| Coastal Flooding | Coastal Flooding is when water inundates or covers normally dry coastal land as a result of high or rising tides or storm surges. | Is the system elevated above flood and storm surge levels, or does the system have rated enclosures to protect against inundation? Are the foundations designed for high water tables? Are controls elevated? Is drainage designed to cope with the hazard? |
| Earthquake | An Earthquake is a shaking of the earth’s surface by energy waves emitted by slowly moving tectonic plates overcoming friction with one another underneath the earth’s surface. | Are the system, its enclosure, and adjacent structures designed to withstand the anticipated seismic load? Do refueling procedures and equipment remain viable given such a seismic event? |
| Hail | Hail is a form of precipitation that occurs during thunderstorms when raindrops, in extremely cold areas of the atmosphere, freeze into balls of ice before falling towards the earth’s surface. | Are the system and its enclosure designed to withstand the anticipated impacts? |
| Hurricane | A Hurricane is a tropical cyclone or localized, low-pressure weather system that has organized thunderstorms but no front (a boundary separating two air masses of different densities) and maximum sustained winds of at least 74 miles per hour (mph). The NRI Hurricane data also include tropical storms for which wind speeds range from 39 to 74 mph. | ***Flood-related:*** Is the system elevated above flood and storm surge levels, or does the system have rated enclosures to protect against inundation? Are the foundations designed for high water tables? Are controls elevated? Is drainage designed to cope with the hazard?  ***Wind-related:*** Are systems or system enclosures designed to cope with anticipated wind loads and generated missiles? |
| Ice Storm | An Ice Storm is a freezing rain situation (rain that freezes on surface contact) with significant ice accumulations of 0.25 inches or greater. | Are systems or enclosures designed to withstand snow/ice loads? Is there freeze protection? Is the system ice-resistant? |
| Riverine Flooding | Riverine Flooding is when streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow and water overflows the banks, spilling into adjacent low-lying, dry land. | Is the system elevated above flood and storm surge levels, or does the system have rated enclosures to protect against inundation? Are the foundations designed for high water tables? Are controls elevated? Is drainage designed to cope with the hazard? |
| Strong Wind | Strong Wind consists of damaging winds, often originating from thunderstorms, that are classified as exceeding 58 mph. | Are systems or system enclosures designed to cope with anticipated wind loads and generated missiles? |
| Tornado | A Tornado is a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground and is visible only if it forms a condensation funnel made up of water droplets, dust, and debris. | Are systems or system enclosures designed to cope with anticipated wind loads and generated missiles? |
| Tsunami | A Tsunami is a wave or series of waves generated by an earthquake, landslide, volcanic eruption, or even a large meteor hitting the ocean and causing a rise or mounding of water at the ocean surface. A Tsunami can travel across open ocean at about 500 mph and slow down to about 30 mph as it approaches land, causing it to grow significantly in height. | Is the system located at an elevation higher than the expected tsunami inundation zone? |
| Volcanic Activity | Volcanic Activity occurs via vents that act as a conduit between the Earth’s surface and inner layers, and erupt gas, molten rock, and volcanic ash when gas pressure and buoyancy drive molten rock upward and through zones of weakness in the Earth’s crust. | Are systems protected from potential ash exposure (e.g., air intakes), and are any enclosures designed to withstand ash loads? Are systems located outside of potential lahar zones? |
| Wildfire | A Wildfire is an unplanned fire burning in natural or wildland areas, such as forest, shrub lands, grasslands, or prairies. | Are there built-in fire-suppression systems? Is the system or its enclosure designed to withstand the anticipated fire load? Is it located in an area away from flammable materials? |
| Winter Weather | Winter Weather consists of winter storm events in which the main types of precipitation are snow, sleet, or freezing rain. | Are systems or enclosures designed to withstand snow/ice loads? Is there freeze protection? Is the system ice-resistant? |

**Dual-Impact Threats**

The TRN uses a widely accepted terminology in which potential challenges to a site are categorized as either *hazards* or *threats*. The distinction is that for a threat the potential challenge is deliberate, whereas for a hazard, it is not. So the potential for attacks and other malicious acts, such as terrorism and vandalism, are threats. The potential for random system failures, human errors and damaging natural phenomena (as discussed above) are examples of hazards. The TRN tool can be used to model threats, but in contrast to the hazard analysis, it does not provide tentative frequency estimates for threats due to a lack of generalized data available for such estimates. Rather, the user must provide their own estimates of threat frequencies.

***Quantifying the frequency and consequence of threats in the TRN***

While the structure of a threat scenario conforms to the TRN risk approach, there are challenges associated with modeling threats. These challenges are not specific to TRN, but are general challenges for risk and resilience analysis stemming from the nature of threats.

One challenge is in quantification of threat frequencies. First, the specific nature of a threat would need to be defined before the step of quantification. This requires answers to questions such as: what is the intent and target of the attacker, and what is the level of capability (sophistication, knowledge, and available assets) of the attacker? Second, even given insights into intent and capability, frequency quantification is problematic. Progress on threat quantification modeling is limited and without technical consensus. Finally, threat frequencies would not likely be static, but rather change over time.

Another challenge is that knowledge of the attacker’s motivation is necessary to project what consequences may occur. In particular, for a cyber-attack, there’s the question of the attacker’s intent once they have seized control of cyber assets, as this is necessary to estimate consequences. In the context of TRN, this aspect may be simplified in that attention is confined to attacks intended to (or with the collateral effect of) knocking-out energy and water resources.

***Quantifying the vulnerability of systems to threats in the TRN***

In the TRN, the key component of vulnerability that must be considered with respect to specific dual-impact threats is the design basis of redundant systems. To address this question for specific threats, some factors that the user might take into account (among others) are:

* for physical attacks, is the system secure (guards and gates in place) and housed behind robust barriers?
* for cyber-attacks, is the redundant resource control system behind firewalls or isolated from external connectivity?

An approach often adopted in threat analysis is to avoid distinguishing between threat frequencies (by assigning the same frequency to each threat), and focus on the vulnerability portion of the analysis. TRN is amenable to this approach.

***Modeling risk resulting from threats in the TRN***

Because of the deeper uncertainty associated with threat frequency quantification, it may unadvisable to include both hazards and threats into a single TRN framework as the basis for allocating resilience solution resources. Significant overestimation or underestimation of the frequencies of threats could distort the ultimate risk insights that are provided by the TRN process. This issue can be addressed by developing a separate framework to address threats to energy and water systems at a site.

1. Zuzak, C., D. Kealey, E. Goodenough, and C. Stanton. 2020. [National Risk Index Technical Documentation](https://www.fema.gov/sites/default/files/documents/fema_national-risk-index_technical-documentation.pdf). Federal Emergency Management Agency, Washington, DC. [↑](#endnote-ref-1)
2. <https://www.usgs.gov/natural-hazards/earthquake-hazards/science/modified-mercalli-intensity-scale?qt-science_center_objects=0#qt-science_center_objects> [↑](#endnote-ref-2)