Screening Tool for Industrial Resilience

User Guide

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Acronyms

IAC		U.S. Department of Energy’s Industrial Assessment Centers
POC		Point of Contact
STIR		Screening Tool for Industrial Resilience
TDD		Tolerable Disruption Duration

Introduction to Screening Tool for Industrial Resilience

The Screening Tool for Industrial Resilience (STIR) is a risk-informed high-level resilience planning web tool designed for use by the U.S. Department of Energy's Industrial Assessment Centers (IACs). The STIR provides users with a short list of potential solutions to mitigate risk and improve resilience at IACs based on key risk drivers identified in the STIR risk assessment. These findings are meant to complement the traditional findings of the IAC assessment process, which primarily focus on energy efficiency improvements. The STIR focuses on characterizing risk associated with three main risk sources: energy and water outages, disruptions due to failure of a critical asset, and supply chain disruptions. The STIR is located at https://stir.pnnl.gov/

Resilience for Industrial Businesses

Resilience refers broadly to the ability to anticipate, prepare for, and adapt to changing conditions and to withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions. Key elements and outcomes of resilience planning include:

- Optimized operations to reduce energy and water use, as well as peak demand, that enable the site to meet energy and water requirements
- Trained personnel and capabilities to anticipate, prepare for, adapt, withstand, respond to, and rapidly recover from disruptions due to planned and unplanned events
- Actionable strategies for diverse solutions that address resource and infrastructure needs to minimize the consequence of interruptions to key processes during normal and disrupted operations.

Resilience evaluations help sites manage the risk to their production associated with energy and water outages, asset failure, or supply chain disruptions. The STIR can help sites in this effort by calculating high-level risk, based on individual risk scenarios within these three failure and disruption categories. Resilience solutions identified in the STIR are meant to provide IACs with a starting point on how to address key risk drivers. Potential solutions can be further refined to develop more targeted and site-specific solutions. The STIR is not meant to be a traditional, comprehensive quantitative risk assessment; rather it is intended to help provide a relatively less time- and data-intensive screening to those sites who know they need to consider resilience as a part of an IAC assessment but don't know where to start.

The outputs of the STIR can be useful to a business that is trying to mitigate a loss of profit due to time loss caused by an outage or equipment failure. The STIR provides tailored risk analysis and visuals that can help the business determine which areas may be resilience weaknesses. If funding for resilience solutions is limited, the STIR can help demonstrate where the funds will be best spent in order to mitigate profit loss during a resilience event. Additionally, the STIR provides solution suggestions as a starting place and links to resources to learn more.

Primary Risk Types

The STIR analyzes risk in three primary areas: energy or water outages, failure of critical assets, and supply chain disruptions. Each of these risk areas has the potential to cause stoppage of work and loss of profits for industrial business.

Energy or Water Outage

If the primary supply of energy or water to the site is lost, then the plant is likely to experience some impact to its production line, making energy and water outages a key consideration in resilience planning and in the calculation of risk within the STIR. The risk associated with outages in the energy or water supply is calculated based on the likelihood of an energy or water supply outage (hazard), the conditional probability that redundant energy or water systems supporting critical assets will fail given loss of supply (vulnerability), and the amount of time the key processes of the manufacturing plant will be unable to function if the hazard is realized and the redundant system fails (consequence). For this risk source, the risk scenario is the unique combination of hazard (i.e., outage scenario) and the critical asset impacted by that hazard.

Failure of Critical Asset

Critical asset failure can result in unplanned disruptions of key processes at the plant. Therefore, reliability of critical assets is an important consideration in resilience planning. It is important to note that within the STIR, critical asset failure is not based on formal reliability modeling methods. Rather, the risk associated with the failure of a critical asset is based on the identification and characterization of high-impact failure scenarios. To characterize these risk scenarios, the expected disruption duration, defined as the time needed to repair or completely replace the asset, and the frequency associated with each asset failure scenario is used.

Supply Chain Disruption

Supply chain risk is an important resilience consideration for manufacturing plants. In many cases, if a critical input is unavailable, the manufacturing process cannot proceed, leading to a loss of production and therefore a loss of revenue. To characterize this risk, data is collected on supply disruptions of sufficient length to cause a notable disruption to the manufacturing plant's operations as opposed to shorter-duration supply disruptions that might be considered nuisances but are built into the plant's business model. In this case, risk scenarios are defined as a unique combination of a critical input and a supply chain disruption (duration and frequency) impacting that critical input.

STIR Tool Overview

The STIR is broken out into four key sections:

1. Site-Wide Information
2. Asset Information
3. Disruptions
4. Outputs

The first three sections will require user input, from data collected both pre-site visit and during the site visit. The Outputs section will provide a short list of potential resilience solutions based on key risk drivers identified in the previous sections. Users can think of resilience solutions as potential projects, operational updates, or institutional changes that could reduce risk identified in the tool and enhance the site's resilience posture by strengthening their overall ability to withstand, respond to, and recover rapidly from disruptions. This section of the User Guide will provide an overview of each section and then a summary table of data inputs at the end.

1. Site-Wide Information

Site-Wide Information collects general information about the site, key processes, and critical inputs. The majority of the information used in Site-Wide Information can be gathered during the pre-site visit data collection process. Some information, such as utility information and major energy using equipment, may already be being gathered as part of the traditional IAC assessment process. Other data items will need to be compiled for the site to fill out.

Key Terms used in Site-Wide Information:

Critical Input: The material or component input required to accomplish a key process. A lack of this input will cause the plant to be unable to accomplish the key process. Critical inputs must be identified at the beginning of the resilience assessment process. Critical inputs may include materials, components, or other items that are necessary to complete any work in the key process. An example of a critical input for a lumber mill that makes wooden home furnishings is the logs or wood that are imported to the mill. It should be noted that critical inputs do not include energy sources such as electricity, natural gas, or water, because these are accounted for separately in the risk analysis.

Key Process: A process that must be operational to produce a key product for the manufacturing plant. Key processes must be identified at the beginning of the resilience assessment process. Key processes may be defined as distinct parts of the plant's operation such as "Production Line 1" or "Pre-process welding". At least one key process must be identified, but it may be useful to include more. Each key process will be assigned a criticality weight, allowing sites to identify if some of their key processes are more impactful on the plant's overall functionality, business production, or revenue than others (which is reflected with a criticality weighting). Key processes with the same criticality weighted are grouped together in a Tier in the tool (Tier 1 would have the highest weight and thus be considered the most "impactful" if lost). As a simplification for this screening tool, all key processes are assumed to be independent of each other.

Tolerable Disruption Duration for Key Process: The tolerable disruption duration for the key process (TDD_P) is the length of time that the plant can continue operations without this key process before there are unacceptable consequences, such as impact on revenues or failures to fulfillment of contracts. For example, a key process at a winery is the labeling of bottles. Bottle labeling can be delayed for a day, but after one day the bottling production line has switched to a different type of wine and mislabels become imminent. In this scenario, the key processes' tolerable disruption duration would be considered 24 hours. Some plants or key processes may be able to tolerate a disruption longer than others, and it is important to work with site points of contact (POCs) to determine the appropriate length of time. Users must specify if all key processes have the same TDD_p. If is the same for all key processes, users only need to specify the value for TDD_p once. However, if at least two key processes have different values for TDD_p, then users must specify TDD_p for each key process.

Tolerable Disruption Duration for Critical Inputs: The tolerable disruption duration for the critical input (TDD_S) is the length of time that the plant can continue operations without a critical input before there are unacceptable consequences, such as impact on revenues or failures to fulfillment of contracts.

Key Process Restart Time: The duration of time it takes for the key process to restart after the supply of the critical input or energy and/or water supply has resumed. For example, a key process at a paper mill is a cardboard box process line that was temporarily shut down due to supply chain disruptions for the glue used in making the boxes. After the glue is received, the cardboard box process line takes up to 6 hours to return to regular operations.

Site-Wide Information Section Use

The following table shows which information is used in the Site-Wide Information section.

Data Collection Item	Input Format	When is Input Collected?	Tips
Site zip code	Numerical	Pre-Site Visit	Users should enter a U.S. 5-digit zip code
Offsite electric utility	Text	Pre-Site Visit	Select from drop-down or enter free text
Is the site in a location that has the potential to experience flooding?	Yes/No	Pre-Site Visit	If the area near the site has flooded in the past or is in a flood zone, answer "Yes"
Key process	Text	Pre-Site Visit	Use unique, but brief names
Key process weighting factor	Numerical	Pre-Site Visit	Weights should reflect the relative importance of key processes to the plant. For example, putting "5" as the weight for Key Process A and "1" for Key Process B would tell the model that Key Process A is considered to be five times more important to the overall plant than Key Process B (while still maintaining that Key Process B is critical overall).
Key process tier	Pre-populated	Pre-Site Visit	Tiers are automatically pre-populated after the user enters weighting factors. Users may have as many tiers as desired, but most use 3-4 tiers. Tier 1 is the most important to the site.
The tolerable disruption of key process is the same?	Multiple Choice (choose one of two answers)	Pre-Site Visit	The plant may be able to continue meeting its goals for some amount of time even if one or more key processes is interrupted. Select "Same" if the tolerable disruption duration of the key process is the same for every key process at the site. Select "Unique" if at least two key processes have different tolerable disruption durations of the key process.
Tolerable disruption	Numerical (hours)	Pre-Site Visit	For users who have selected "Same", they will answer once

duration of key process/key processes			with a numerical value for all key processes. For users who have selected "Unique", they will answer this question independently for each of the previously defined key processes.
Critical input	Text	Pre-Site Visit	Use unique, but brief names.
Associated Key Processes	Select from existing key processes	Pre-Site/On-Site	Map the critical input to previously identified key processes. A critical input can be used in multiple key processes.
Once there is a supply chain disruption for this critical input, how long does it take to interrupt the key process?	Numerical (hours)	Pre-Site Visit	A supply chain disruption may not have an impact right away, it could take hours/days to reach a critical point for the key process.
Duration of time to restart the key process after the supply of the critical input has resumed	Numerical (hours)	Pre-Site Visit	Users may get an estimated range from SMEs; decide if using the lower end, mid-point, or upper end of the range and carry that logic through for the rest of data inputs.
Number of sources the plant has for supplying each critical input	Dropdown (choose one of two answers)	Pre-Site Visit	Users need to select if there is a single supplier or multiple suppliers of each critical input.

2. Asset Information

The Asset Information section identifies critical assets, describes the condition of these critical assets, identifies redundant systems, describes the characteristics of the redundant systems, and maps the redundant systems to the critical assets. The information used in this section may come from pre-site visit data collection or from on-site data collection. The STIR user guide divides the inputs for this section into two parts, the first describes information related to critical assets while the second describes information related to redundant systems, for ease of understanding.

Key Terms used in Asset Information Related to Critical Assets:

Critical Asset: An asset required to accomplish a key process. A disruption to this asset will prevent the plant from being able to accomplish the key process. Critical assets must be identified to complete the resilience assessment process. Examples of critical assets might include pieces of equipment such as furnaces, mechanical saws, pumps, paint booths, chillers, or any items that are critical to the key processes and the plant's production.

Tolerable disruption Duration for Asset: The Tolerable disruption Duration for assets describes how long each critical asset can cease to operate before its failure leads to a disruption to the key process that it serves. Work with site POCs to determine the length of time that a critical asset can be unavailable before it leads to a disruption to the key process.

Critical Asset Restart Time: The duration of time it takes for the key process to restart after the critical asset has been fixed or supply of energy or water to the critical asset has resumed. For example, a critical asset might need to run through a 30-minute startup cycle before it can resume its function within the key process after it has been fixed following a failure event.

Critical Asset Lifetime: Critical assets serving key processes may be at different stages of their estimated lifecycle. The reliability of critical assets is expected to decrease as they near and pass their expected lifetime.

Preventive Maintenance (PM) of Critical Asset: Actions performed on a time- or machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.

Section Use

The following table shows which information is used in the Asset Information section related to critical assets.

Data Collection Item	Input Format	Stage Gathered In	Tips
Critical asset	Text Field	Pre-Site/On-Site	Use unique, but brief names.
Associated resource requirements	Multiple Choice	Pre-Site/On-Site	Select from Electricity, Water, and/or Natural Gas. Users must select at least one response option
Associated Key Processes	Select from existing key processes	Pre-Site/On-Site	Map the critical asset to previously identified key processes. A critical asset can be used in multiple key processes.
Once the critical asset ceases to function, how long does it take to interrupt the key process?	Numerical (hours)	Pre-Site/On-Site	This should be answered without consideration of any existing redundant systems. Consider, if this critical asset were to no longer be functioning, how long would it take to cause a disruption in the key processes?
Once the critical asset is available again, how long does it take for the key process to restart after a critical asset-driven	Numerical (hours)	Pre-Site/On-Site	Consider all components of startup time requirements for the overall key process to determine this input.

interruption of the key process?			
Critical asset lifetime	Multiple Choice (choose one of three answers)	On-Site	Chose the option that best describes how close the critical asset is to its anticipate lifetime (relatively new, middle, or end/past end).
Preventive maintenance of critical asset	Multiple Choice (choose one of three answers)	On-Site	Chose the option the best describes how PM practices supporting this critical asset relate to manufacturer recommendations (are less than, meet, or exceed)
On-site replacement parts	Yes/No	On-Site	Select if the site stores replacement parts for this critical asset on-site (or not).

Key Terms used in Critical Asset Information Related to Redundant Systems:

Redundant System: A redundant system refers to an onsite system able to supply energy or water to a critical load in the event of an energy or water utility disruption. A backup generator, UPS, building-integrated PV system, or microgrid with PV and battery storage are all examples of redundant energy systems to a utility supply. To be considered redundant, an on-site energy system must not be reliant on grid power to function and supply the critical load. Redundant water systems may include items like onsite water cisterns connected to a critical load, portable water tanks, or reverse osmosis purification systems.

Run Time: The runtime is informed by the backup system capacity, efficiency, and resource demands of the loads that it supports. When determining the run time, consider any on-site supply (e.g., diesel tanks) that may be used to extend its support. Do not include any considerations of refueling in this run time estimate unless there is a documented agreement with a fueling company that the site will get priority in the event of a widespread outage.

Preventive Maintenance (PM) of Redundant System: Actions performed on a time- or machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.

Section Use

The following table shows which information is used in the Asset Information related to redundant systems. Redundant system information can be collected both pre-site and on-site. Some clients may have documented information about their redundant systems readily available, and others it may be easiest to view the system on-site and speak with the personnel who maintain and operate the system.

Data Collection Item	Input Format	Stage Gathered In	Tips
Redundant system name	Text Field	Pre-Site/On-Site	Use unique, but brief names. Each redundant system should support at least one critical asset (must be selected from previously defined input).
Time to initiate system	Numerical (hours)	On-Site	This is how long after primary supply is lost it will take for the redundant system to turn on and support the associated critical assets. Consider any manual actions involved in this process carefully.
Estimated run time	Numerical (hours)	On-Site	This is how long the redundant system can run given the resource requirements of the loads it is connected to. If calculating, remember to incorporate resource demands of any non-critical assets that the redundant system also supports.
Supply type supported	Multiple Choice	On-Site	Identify if the redundant system supports critical assets that run on electricity, water, and/or natural gas. The model makes a simplifying assumption that if a critical asset requires electricity, the redundant system
Preventative Maintenance of the redundant system reliability question(s)	Yes/No (Potentially multiple)	On-Site	The user must first answer if the redundant system has a PM system in place. If "No" is selected, the user will go to the next category of responses. If "Yes", the user will be prompted to answer additional questions on written schedules, procedures, and testing as well as documentation of performance of those schedules, procedures, and testing activities.
Start-up responses	Yes/No (Potentially multiple)	On-Site	The user must first answer if the redundant system is configured to start automatically. If "Yes", the form is complete. If "No", the user will be prompted to answer an

	additional question on if the manual start-up is supported by written, up-to-date procedures, and training.

After all critical asset and redundant system information has been entered into the STIR, the user will assign (or “map”) the redundant systems to the critical assets by reviewing each critical asset and its associated supply type and selecting the appropriate redundant system from the dropdown menu. If the critical asset does not have a redundant system, the user will select “none” from the dropdown.

3. Disruptions

The Disruptions section includes information on hazards, identifying any existing hardening measure of critical assets and redundant systems to those hazards , critical asset failures, and supply chain disruptions.

Key Terms used in Disruptions:

Hazard: A natural or accident-based driver with the potential to disrupt a plant’s key process(es). Examples of natural hazards include earthquakes, storms, and wildfires. Examples of accident-based hazards include events such as maintenance-related equipment failures or human-caused fires. In the STIR risk assessment, the hazard can refer to a specific natural hazard that causes an energy or water outage or an energy or water outage of a given duration that could be started by a variety of different causes. Natural hazards are considered to have the ability to impact onsite systems, including critical assets and redundant systems. Hazard is quantified as the expected annual frequency of occurrence and the duration of the associated energy or water outage caused by the hazard. In the STIR, hazards and threats are considered together.

Critical Asset Failure: In addition to hazards external to the plant, disruptions to key processes can result from failure of critical assets serving those processes. In the STIR, users can define critical asset failure scenarios as unique frequency/ duration pairs for each critical asset. Each critical asset failure scenario defined in the STIR can include failures associated with different root causes, but all such failures must lead to the asset being unavailable for approximately the same amount of time (time to repair or replace the asset).

Supply Chain Disruption: Finally, the STIR also models risk associated with supply chain disruptions. These are disruptions to the supply of critical inputs that are required to support the key process(es). In the STIR, users can define supply chain disruption scenarios as unique frequency/ duration pairs for each critical input. Each supply chain disruption scenario defined in the STIR can include disruptions with different root causes, but such disruptions must lead to the input being unavailable for approximately the same amount of time.

Section Use

The following table shows which information is used in the Disruptions section. Most of the data gathered in this stage may be gathered easiest through interviews with site personnel rather than via data collection form pre-site visit.

Data Collection Item	Input Format	Stage Gathered In	Tips
Hazard name	Text Field	On-Site	Identify each hazard that is applicable to the site. Use the Select a Potential Hazard tool to help determine which hazards are common for the geographic location of the site.
Hazard affected supply type	Multiple Choice	On-Site	Select which supply types (electricity, gas, water) are affected by the hazard.
Outage Duration	Drop Down Menu	On -Site	For each supply type selected, choose how long an outage is likely to occur for.
Outage Frequency	Drop Down Menu	On-Site	For each supply type selected, choose how often an outage is likely to occur.
Potential impact to assets or redundant systems	Yes/No	On-Site	If a hazard is likely to adversely affect an asset or a redundant system, mark 'Yes'.
Critical asset failure scenario description	Text Field	On-Site	If an asset fails, it could lead to a major disruption. Provide a name to each failure scenario, such as "failure due to motor breaking".
Critical asset failure disruption duration	Drop Down Menu	On-Site	For each asset failure, choose how long an outage is likely to occur for.
Critical asset failure disruption frequency	Drop Down Menu	On-Site	For each asset failure, choose how often an outage is likely to occur.
Supply chain failure scenario description	Text Field	On-Site	If a portion of the supply chain fails, it could lead to a major disruption. Provide a name to each failure scenario, such as "shipping canal blocked".
Supply chain failure disruption duration	Drop Down Menu	On-Site	For each supply chain failure, choose how long an outage is likely to occur for.
Supply chain failure disruption frequency	Drop Down Menu	On-Site	For each supply chain failure, choose how often an outage is likely to occur.

The following subsections explain each part of the Disruption section of the tool in more depth:

Hazards

In the Hazards step of the Disruptions section, the user may use the Select a Potential Hazard tool to determine which hazards are likely to occur in the geographic location of the site (e.g., hurricanes often occur in coastal areas of the Southeastern part of the United States) and categorize the frequency of the hazards. Some hazards may be likely (once a year), while others may be extremely unlikely (1 in 1,000 years).

The user will add all hazards that are applicable to the site and will fill out information for each included hazard. Hazard information includes the affected supply type, the outage duration, the outage frequency, and whether the hazard has the potential to impact on-site assets or redundant systems.

Hazards can then be mapped to appropriate redundant systems and critical assets. For each hazard, the user will select redundant systems that can withstand the hazard. For example, if a generator is in a weatherized enclosure, it may be able to withstand some hazards, such as a winter storm. The user will then repeat the mapping process to select which hazards each critical asset is hardened against. For example, a chiller located inside a building may withstand the strong winds of a hurricane but could still be damaged by an earthquake.

Critical Asset Failures

For each critical asset, the user will identify relevant failure scenarios. This process explores the various ways that each asset could fail, leading to a major disruption to the key process served by that asset. If the critical asset fails, how long might it take to repair or replace it? It is possible that several failure modes may lead to the same duration of disruption? If this is the case, these failure modes can be grouped together. How frequently is the asset expected to fail in such a way as to be unavailable for this duration? Failure modes resulting in different disruption durations can be defined uniquely, and up to four may be chosen. For each chosen failure scenario, the user will enter the disruption duration and the frequency.

Supply Chain Disruptions

Similar to the critical asset failures, the process will be repeated for supply chain disruptions. Supply chain failures can occur for many reasons and could happen in different points in the supply chain process. Examples of supply chain disruptions include domestic labor disputes, port congestion, or material shortages. The user will determine how likely supply chain failures are for each critical input (material, etc.) may be, and how long the disruption might be for each.

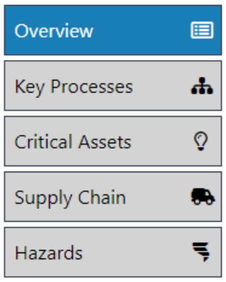
4. Outputs

The Outputs section provides a site overview, and summaries of key processes, critical assets, critical inputs, and hazards that are driving risk for the site. The Outputs also include high-level solutions that are mapped to applicable processes, assets, and hazards.

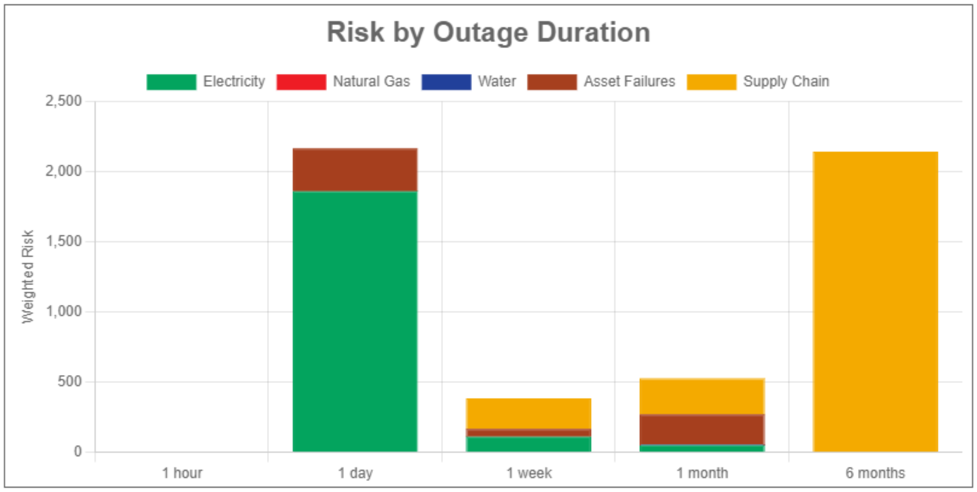
Risk Driver Outputs

Overview

The Overview provides the top risk drivers in each area, as well as the associated weighted risk. The top three risk drivers are shown by default, but more can be shown using the dropdown menu.



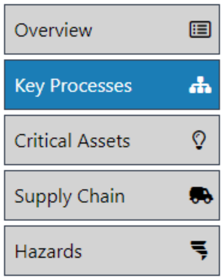
What characteristics of hazards are driving risk?



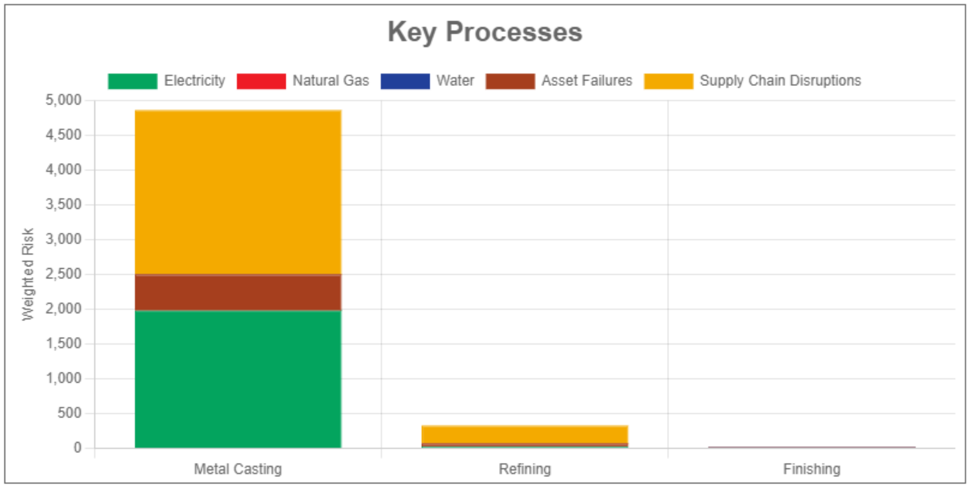
Duration	Electricity	Natural Gas	Water	Asset Failure	Supply Chain
1 hour	-	-	-	-	-
1 day	1,860.0	-	-	307.5	-
1 week	111.1	-	-	56.1	217.5
1 month	51.3	0.6	3.3	215.6	255.3
6 months	-	-	-	-	2,143.5
Weighted Risk by Category	**2,022.4**	**0.6**	**3.3**	**579.2**	**2,616.3**

Key Processes

The Key Process screen provides a graph of the top key processes that are driving risk.



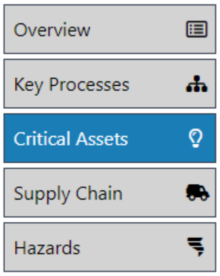
The top three key processes driving risk are:
Metal Casting; Refining; Finishing



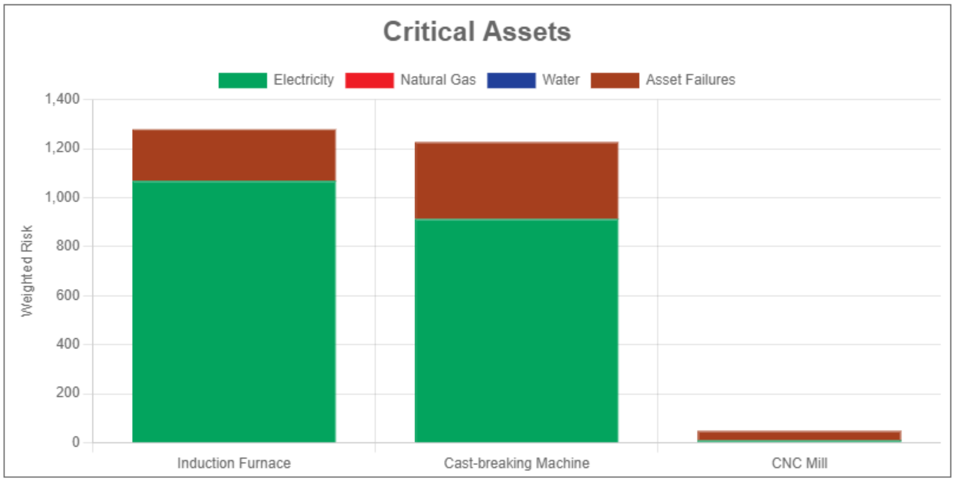
Key Processes	Electricity	Natural Gas	Water	Asset Failure	Supply Chain
Metal Casting	1,981.2	-	-	523.5	2,361.0
Refining	28.9	-	-	44.8	255.0
Finishing	9.8	-	3.3	5.9	-
Weighted Risk by Category	**2,019.9**	**-**	**3.3**	**574.1**	**2,616.0**

Critical Assets

The Critical Assets screen provides a graph of the top critical assets that are driving risk.



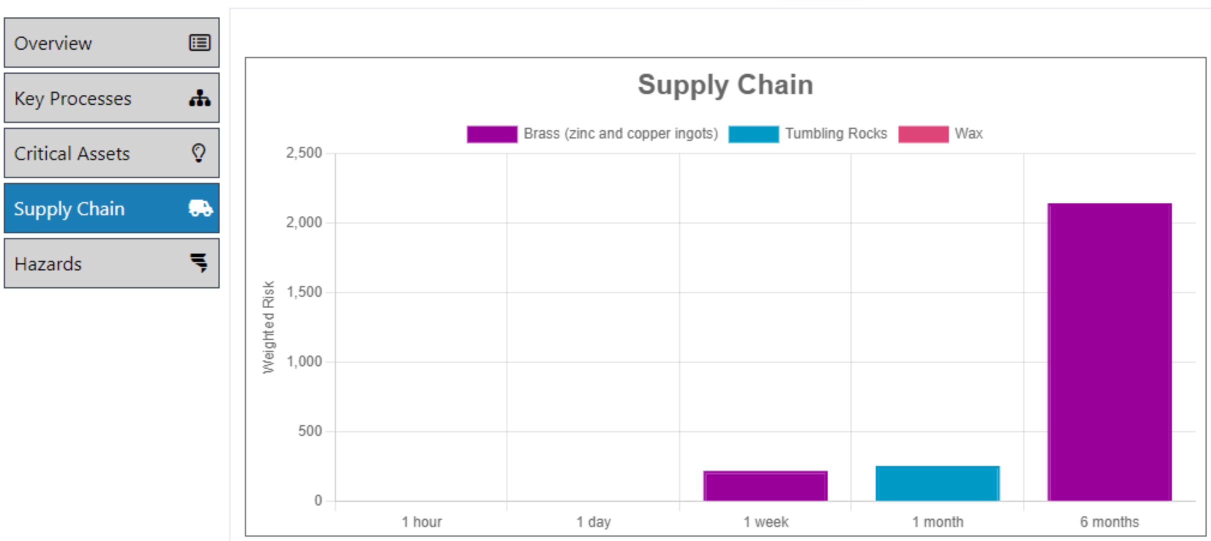
The top three critical assets driving risk are:
Induction Furnace; Cast-breaking Machine; CNC Mill



Critical Assets	Electricity	Natural Gas	Water	Asset Failure
Induction Furnace	1,068.4	-	-	209.8
Cast-breaking Machine	912.8	-	-	313.8
CNC Mill	10.1	-	-	38.4
Weighted Risk by Category	**1,991.3**	**-**	**-**	**561.9**

Supply Chain

The Supply Chain screen provides a graph of the top supply chain components that are driving risk.



Critical Inputs	1 hour	1 day	1 week	1 month	6 months	Total Weighted Risk
Brass (zinc and copper ingots)	-	-	217.5	-	2,143.5	2,361.0
Tumbling Rocks	-	-	-	255.0	-	255.0
Wax	-	-	-	0.3	-	0.3
Weighted Risk by Category	**-**	**-**	**217.5**	**255.3**	**2,143.5**	**2,143.5**

Hazard

The Hazards screen provides a graph of the top hazards that are driving risk.

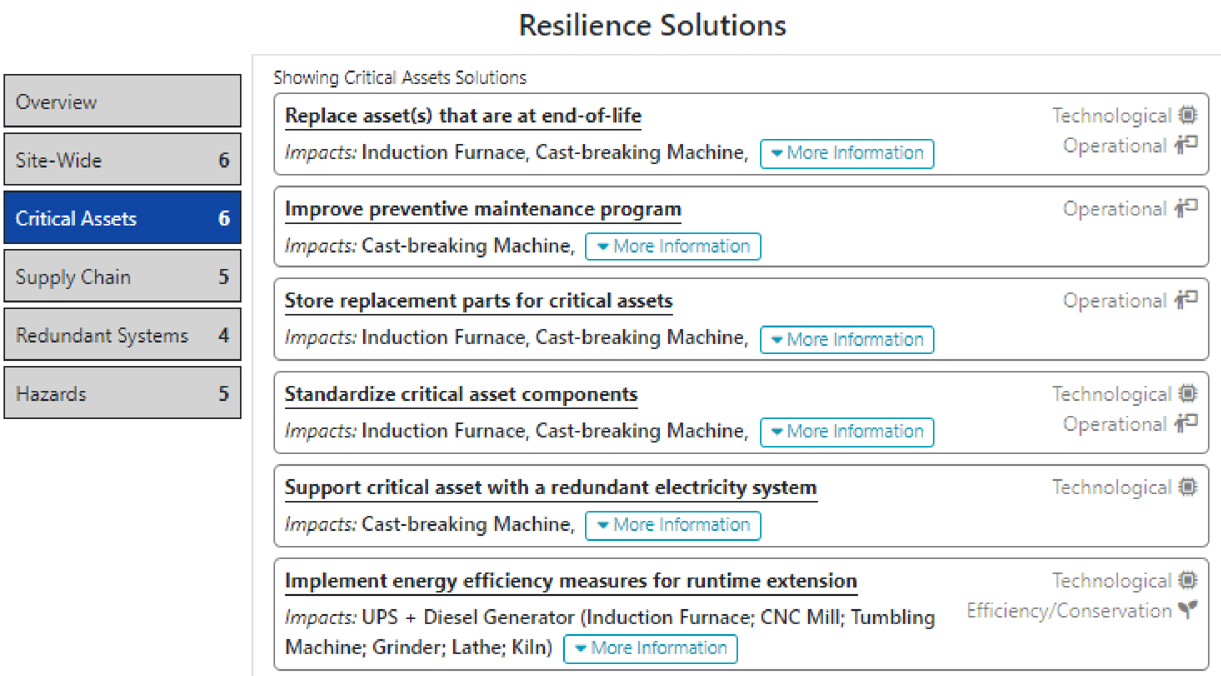
Hazards	Electricity	Natural Gas	Water
Hail	600.0	-	-
Strong Wind	600.0	-	-
Ice Storm	600.0	-	-
Weighted Risk by Category	**1,800.0**	**-**	**-**

Solution Outputs

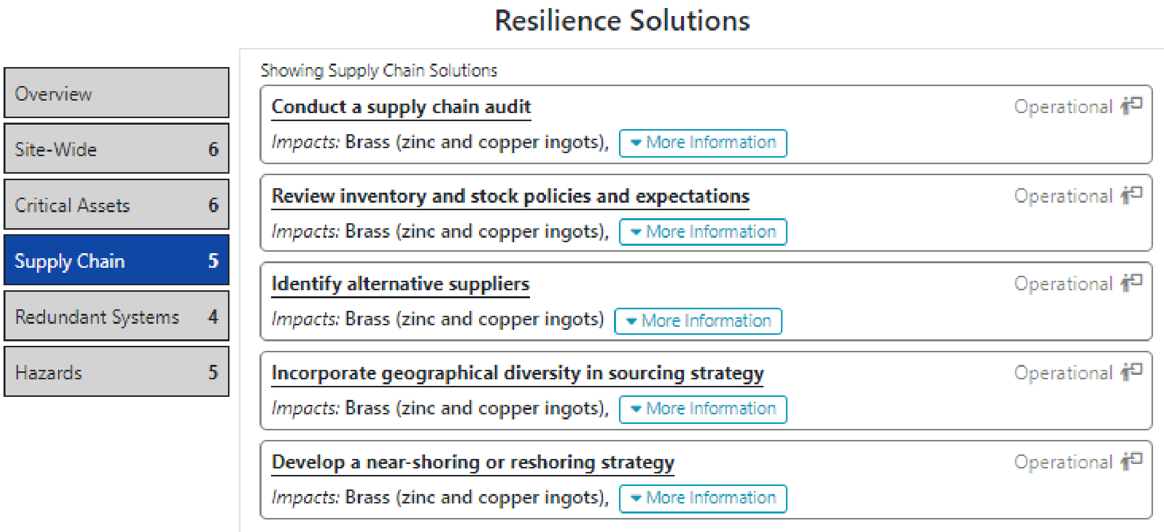
The solutions page will provide a short description of solutions based on the key risk drivers identified in the STIR. For each solution, a longer description will be provided, as well as links to additional resources or information. Each solution will have icons associated with various tags, such as “efficiency/conservation” or “emissions impact” to help categorize solutions. Solutions will be provided for specific key processes, critical assets, redundant systems, supply chain inputs, or hazards. Examples of each solution type are shown below.

Site-wide Solutions:

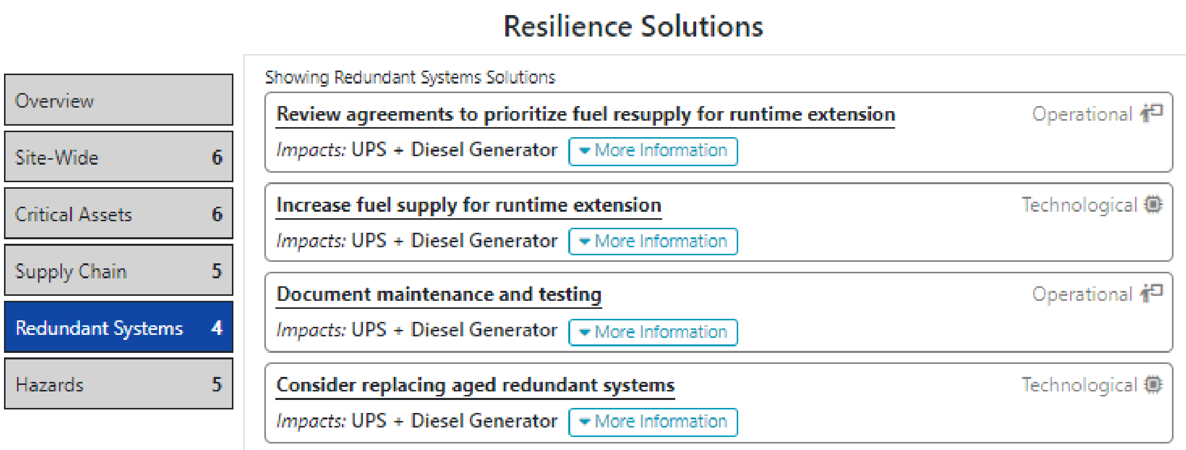
Critical Asset Solutions:



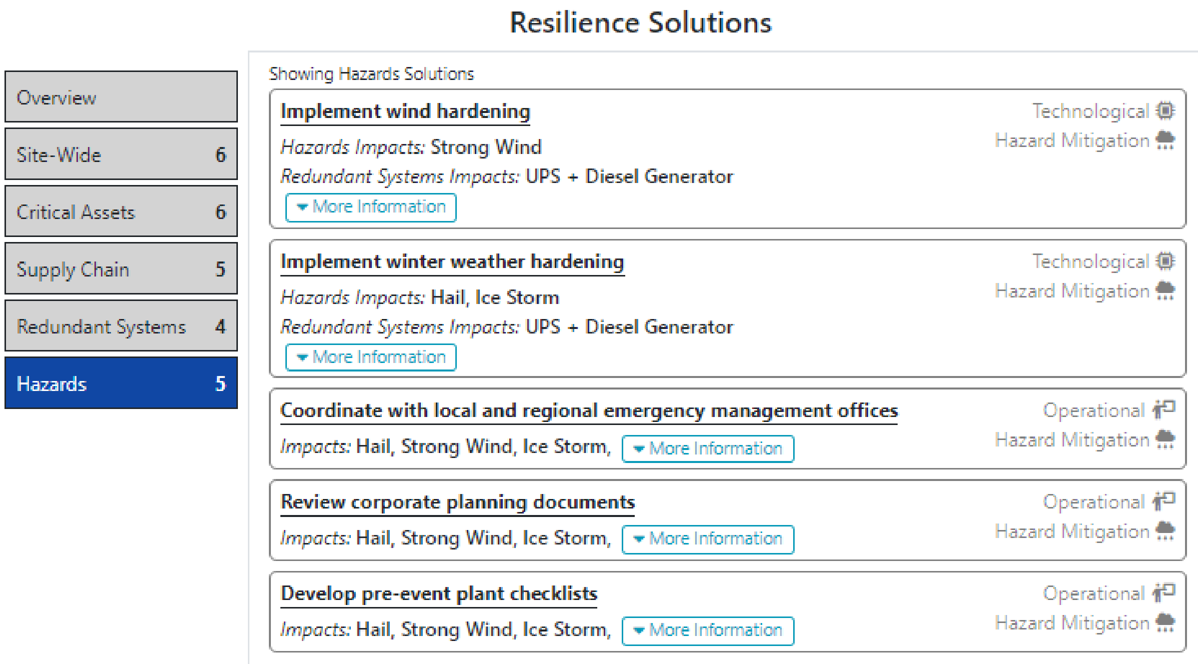
Supply Chain Solutions:



Redundant Systems Solutions:



Hazard Mitigation Solutions



Glossary

Term	Definition
Consequence	The impact of a disruption to a plant's key processes. The severity of impact associated with a scenario in which a threat or hazard is realized and protective safeguards fail.
Criticality Weighting	A relative-importance measure of the importance of a key process to the site's ability to manufacture their products.
Critical Asset	An asset required to accomplish a key process. A disruption to this asset will prevent the plant from being able to accomplish the key process. Note that critical assets do not need to use energy or water to be included in this assessment given that risk related to intrinsic asset failure is also calculated. Critical assets must be identified at the beginning of the resilience assessment process.
Critical Input	A material or component input required to accomplish a key process. A lack of this input will cause the plant to be unable to accomplish the key process. Critical inputs must be identified at the beginning of the resilience assessment process.
Dependencies	Systems, processes, or people that rely on another entity or system to perform a specific function. For example, water systems typically rely on energy systems for treatment and distribution. When power is disrupted, it is essential to understand the cascading impacts on those non-energy specific, but reliant, processes.
Resilience Planning	Key elements and outcomes of resilience planning include: • Optimized operations to reduce energy and water use, as well as peak demand, that enable the site to meet energy and water requirements • Trained personnel and capabilities to anticipate, prepare for, adapt, withstand, respond to, and rapidly recover from disruptions due to planned and unplanned events • Actionable strategies for diverse solutions that address resource and infrastructure needs to minimize the consequence of interruptions to key processes during normal and disrupted operations.
Frequency	The recurrence of a hazard or threat. In the STIR, frequency refers to the number of times the hazard or threat is expected to occur each year (annual frequency), and is analogous to probability. This includes natural hazards as well as general asset failure events or supply chain disruptions.
Hazard	A natural or accident-based driver with the potential to disrupt a site's key process(es). Examples of natural hazards include earthquakes, storms, and wildfires. Examples of accident-based hazards include dam failures, train derailments, and industrial accidents. In the STIR risk assessment, the hazard can refer to a specific hazard that causes an energy or water outage or can refer to an expected energy or water outage duration that could happen for a variety of reasons. Additionally, hazards include asset failure events and supply chain disruptions. Hazard is quantified as the probability of a hazard being realized and the duration of disruption caused by the event (assuming no mitigations). In the STIR, hazards and threats are considered together.

Key Process	A process that must be operational to produce a key product for the manufacturing plant. Key processes must be identified at the beginning of the resilience assessment process.
Key Process Tier	A group of key processes with the same criticality weight. Tier 1 captures the highest weighted key processes. These key processes would be the most impactful to the site's operations, functionality, or revenue. Users may create as many Tiers as they would like within the Site-Wide Information section.
Likelihood	Synonym for probability, likelihood is generally applied to the probability of a hazard or threat being realized (represented as the event frequency) or of the failure or success of safeguard (vulnerability).
Mutual Aid Agreement	Establishes the terms under which one party provides resources (e.g., personnel, teams, facilities, equipment, and supplies) to another party.
Natural Hazard	Hazards associated with natural events such as severe weather (e.g., severe winter storms, riverine floods, hurricanes, and tornadoes). In the risk equation, the hazard refers to the probability or frequency of a hazard being realized.
Plant	A plant is considered any facility or collection of facilities that are included in the industrial assessment.
Resilience	Resilience refers broadly to the ability to anticipate, prepare for, and adapt to changing conditions and to withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions.
Resilience Planning	Resilience planning seeks to reduce potential impacts to operations from planned or unplanned disruptions via integrated and diverse solution sets. It is an iterative process that needs to be regularly revisited as a part of an organization's operations.
Resilience Solution	Resilience solutions are potential projects, operational updates, or institutional changes that could reduce risk identified in the tool and enhance the site's resilience posture by strengthening their overall ability to withstand, respond to, and recover rapidly from disruptions.
Risk	Risk is the potential for an unwanted outcome resulting from an event or sequence of events and is quantified in terms of the event likelihood and associated consequences. (Note: Within the STIR, consequence and impact are used interchangeably.)
Risk Scenario	Risk is calculated as the sum of individual risk scenarios. A scenario can be considered a unique, individual "what if" case. Each risk scenario is defined by an initiating event and the impact that it has on the plant. These risk scenarios can be summed based on different characteristics including the initiating event (hazard) or critical asset/ input impacted by that event.
Technological Hazards and Threats	Hazards associated with the potential for adverse impacts resulting from accidents or the failures of systems and structures to meet their design or operational intent (e.g., bridge collapse, grid outage). Could be due to random failures within a system or due to external influences, such as vehicle impact.
Threat	An adverse event associated with malicious intent to create negative consequences. Threat is quantified as the probability of a threat being realized. In the STIR, hazards and threats are considered together.

Tolerable disruption Duration	The tolerable disruption duration (TDD) is the length of time that an input can continue operations before there is major consequence • TDD for the key process (TDD_P): the length of time that the plant can continue operations before there are major consequences, such as impact on revenues or failures to fulfillment of contracts. • TDD for critical assets (TDD_A): the length of time that key process can continue without access to the asset. • TDD for critical input (TDD_S): the length of time that a key process can continue without access to the critical input.
Vulnerability	The probability of a consequence occurring given that the hazard or threat has been realized. It is the probability that safeguards or protections intended to mitigate the hazard or threat fail. In the STIR, vulnerability is estimated through a characterization of redundant energy or water systems. For asset failure and supply chain risk sources, vulnerability is not quantified separately, and should be implicitly incorporated into the event frequency estimates.