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THROUGH INNOVATION



CINCINNATI, OHIO  
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# Customer Damage Function Calculator

Create a baseline of costs incurred from an outage and justify  
investments in resilient solutions



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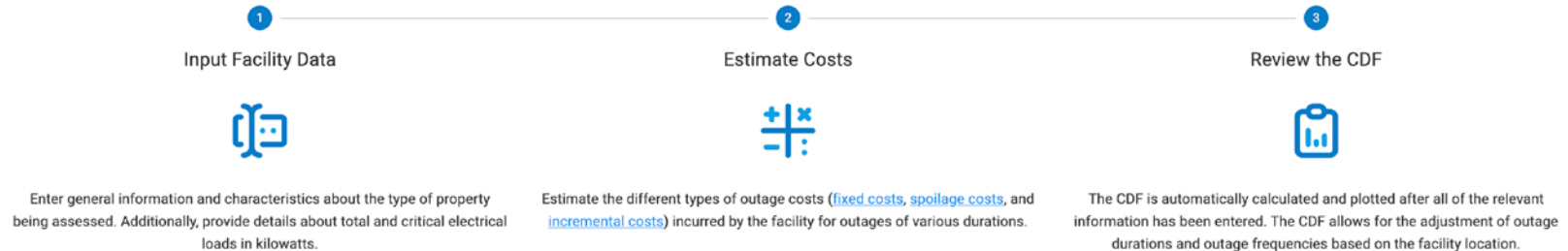
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National Renewable Energy Laboratory

# Customer Damage Function Calculator

- NREL developed / FEMP funding and support / Calculator
- Generate monetary values to justify investments in resilience solutions to prevent or lessen the impact of a grid outage at a facility
- Screening tool that provides justification to site/HQ leadership for resilience investments
  - Weighing the cost of a resilience investment against the benefit it provides
- Value of Resilience (VoR)
  - Understanding VoR is important for informing investment decisions in power systems resilience

## How the CDF Calculator Works



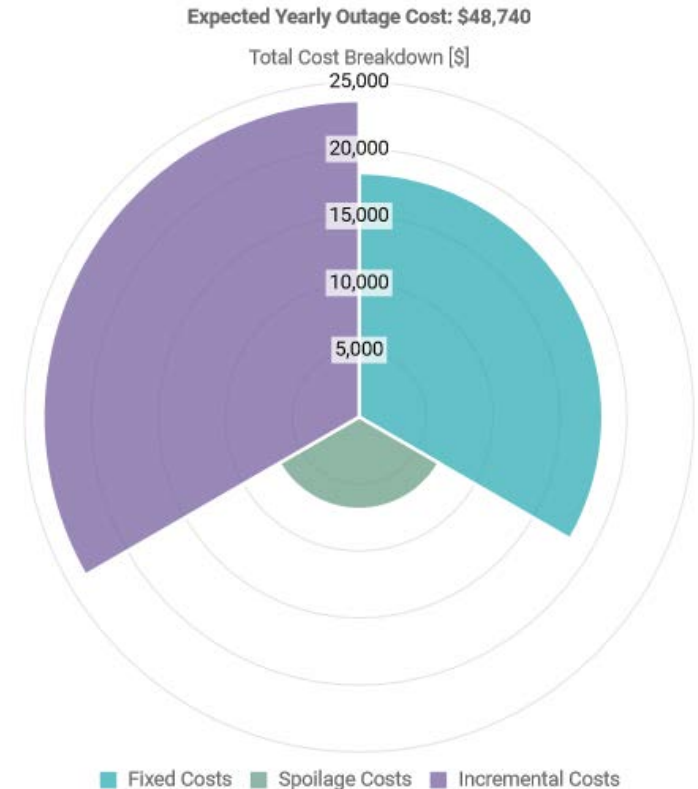
# Impact

## ■ Purpose

- Provide a simple method for estimating site-specific power outage costs
- Process elicits facility outage vulnerabilities and estimates of how costs vary with outage duration and frequency
- First step in determining possible avoided costs with resilience investments
- Agnostic to how the power outage occurs


## ■ Audience

- Assist facility owners, energy managers, consultants, and resilience planners to understand the costs of a grid outage at their site



# Cost Categories

- Fixed Costs occur immediately and are independent of outage duration
  - Computer data loss
  - Restart costs i.e., additional labor hours
  - Damaged equipment
- Spoilage Costs occur after outage exceeds a given duration
  - Food spoilage
  - Other temperature-controlled products
- Incremental Costs increase each hour the power is out
  - Lost production and customer sales
  - Backup fuel costs

Name of Cost  
Restart cost   Show Methodology

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Restart Costs (\$) = C x H + M

*C = average fully-burdened hourly employee costs (wage plus overhead)*  
*H = hours of staff time required to restart*  
*M = additional restart costs*

Average Fully-Burdened Hourly Employee Costs  
\_\_\_\_\_

Hours of Staff Time Required to Restart  
\_\_\_\_\_





Additional Restart Costs  
\_\_\_\_\_

Cost (calculated from the inputs above)  
\$0.00

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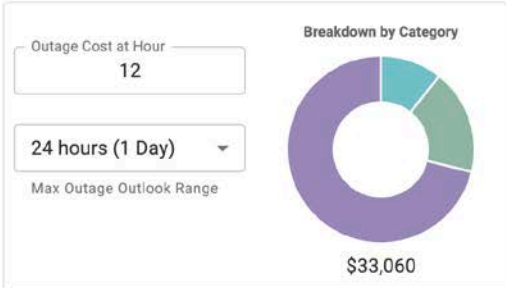
# Process

- Prompts user on potential types of outage costs
- Provides support for inputting values to calculate costs

 FIXED COSTS 2	 SPOILAGE COSTS 1	 INCREMENTAL COSTS 1	 SUMMARY 4
<b>Fixed Costs</b> →			
Restart cost		\$1,040.00	UPDATE
Damaged equipment cost		\$2,500.00	UPDATE
<b>Spoilage Costs</b> →			
temperature-controlled research		\$12,000.00	UPDATE
<b>Incremental Costs</b> →			
Staff productivity cost		\$1,960.00/hr	UPDATE

# Results

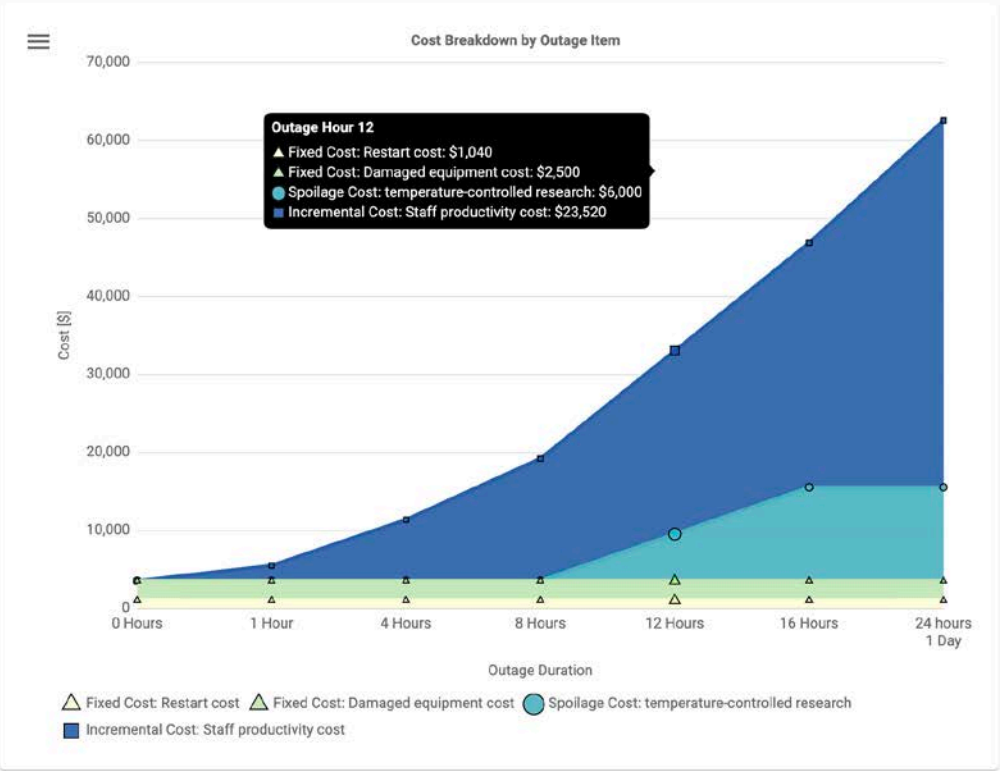
Calculates estimated outage costs over time from user inputs



- Visualize outage costs evaluated by category
- Visualize individual outage cost items
- View all costs as a table
- Calculate costs based on duration and frequency
- Calculate costs over an analysis period

SAVE AS PDF

SAVE DATA

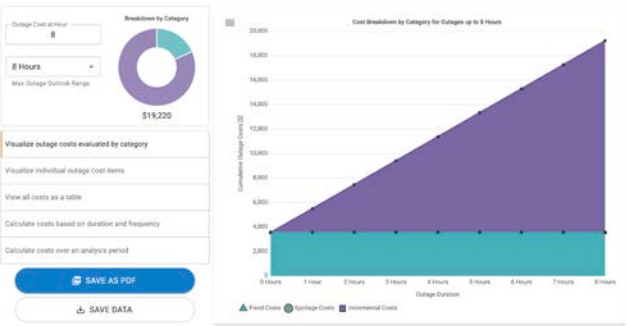




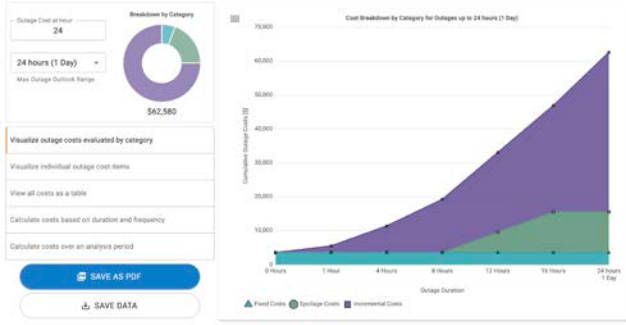
# Results (continued)

- Calculates estimated outage costs over time for any outage duration
- Produces graphs and tables of cumulative outage costs
- Compiles results into pdf report or a local file download

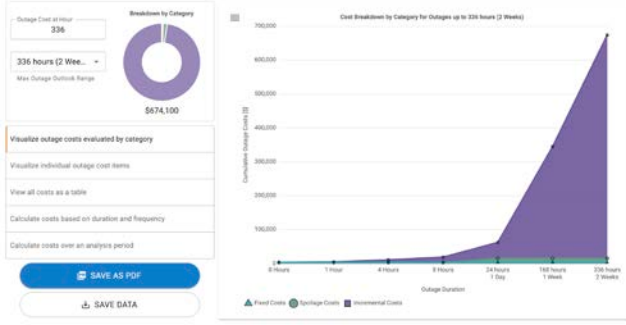
8-hour outage



1-day outage

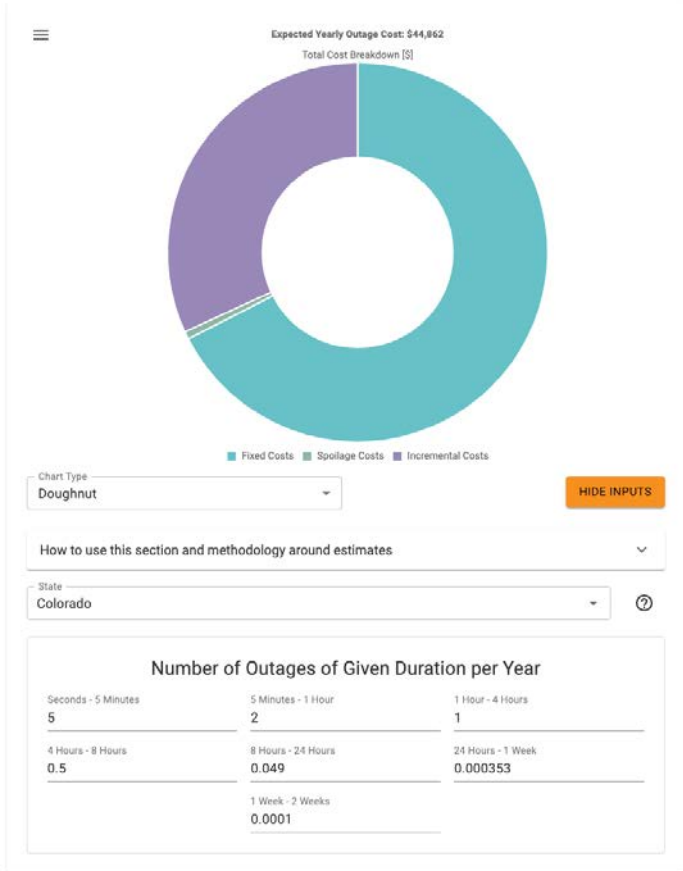


2-week outage




# Calculating Cost of Inaction and Value of Resilience

- Tool uses power outage frequencies and durations to convert CDF into estimate of annual or custom analysis period (years) outage costs.
- Creates an easy-to-use cost of inaction for reliability and resilience upgrades.
- Refined insight into how frequent outages impact the value of resilience upgrades and other outage mitigation steps



# What Now?

- Entry point for resilience planning
  - TRN
  - REopt
- Justifying resilience investments
  - Leadership engagement
  - Export report to assist in decision making
- Data security
  - No authentication or user accounts
  - No data stored on NREL servers or databases



**CDF Calculator Results**

Facility Name: test  
 Location: Colorado  
 Primary Use: Data Centers  
 Annual Electrical Load: 4,693,900 kWh / Peak: 1,608 kW  
 Annual Critical Electrical Load: 2,346,950 kWh / Peak: 804 kW  
 Created: Tue Jul 19 2022

NREL is a national laboratory of the U.S. Department of Energy  
 Office of Energy Efficiency & Renewable Energy  
 Operated by the Alliance for Sustainable Energy, LLC

### Input Breakdowns

Below is a breakdown of all the inputs provided for the CDF along with any variables that were set.

⊙ Indicates a variable that involves time which affects when the cost is incurred or mitigated.

#### Fixed Costs Breakdown

Fixed costs occur immediately when power is lost and are independent of outage duration (e.g. computer data loss, damage to machinery, or process interruption resulting in failed output).

Restart cost		\$1,040.00
Type	Restart cost	
Average Fully-Burdened Hourly Employee Costs	\$65	
Hours of Staff Time Required to Restart	16	
Damaged equipment cost		\$2,500.00
Type	Damaged equipment cost	
Average Cost of Equipment Repair or Replacement	\$500	
The Number of Pieces of Equipment Damaged	5	
Probability of Damage from Outage	100%	

### Costs Over Time

The tables below provide a breakdown of your costs over time for the specified duration of 2 Weeks.

\* Fixed Costs do not have a temporal aspect.

#### Fixed Costs

Restart cost		\$1040
Damaged equipment cost		\$2500
<b>Total Fixed Costs</b>		<b>\$3540</b>

#### Spoilage Costs Over Time

	1 Hour	4 Hours	8 Hours	1 Day	1 Week	2 Weeks
temperature-controlled research	\$0	\$0	\$0	\$12,000	\$12,000	\$12,000
<b>Total Spoilage Costs</b>	<b>\$0</b>	<b>\$0</b>	<b>\$0</b>	<b>\$12,000</b>	<b>\$12,000</b>	<b>\$12,000</b>

#### Incremental Costs Over Time

	1 Hour	4 Hours	8 Hours	1 Day	1 Week	2 Weeks
Staff productivity cost	\$1,960	\$7,840	\$15,680	\$47,040	\$329,280	\$658,560
<b>Total Incremental Costs</b>	<b>\$1,960</b>	<b>\$7,840</b>	<b>\$15,680</b>	<b>\$47,040</b>	<b>\$329,280</b>	<b>\$658,560</b>

# Next Steps – Collaboration – Integration

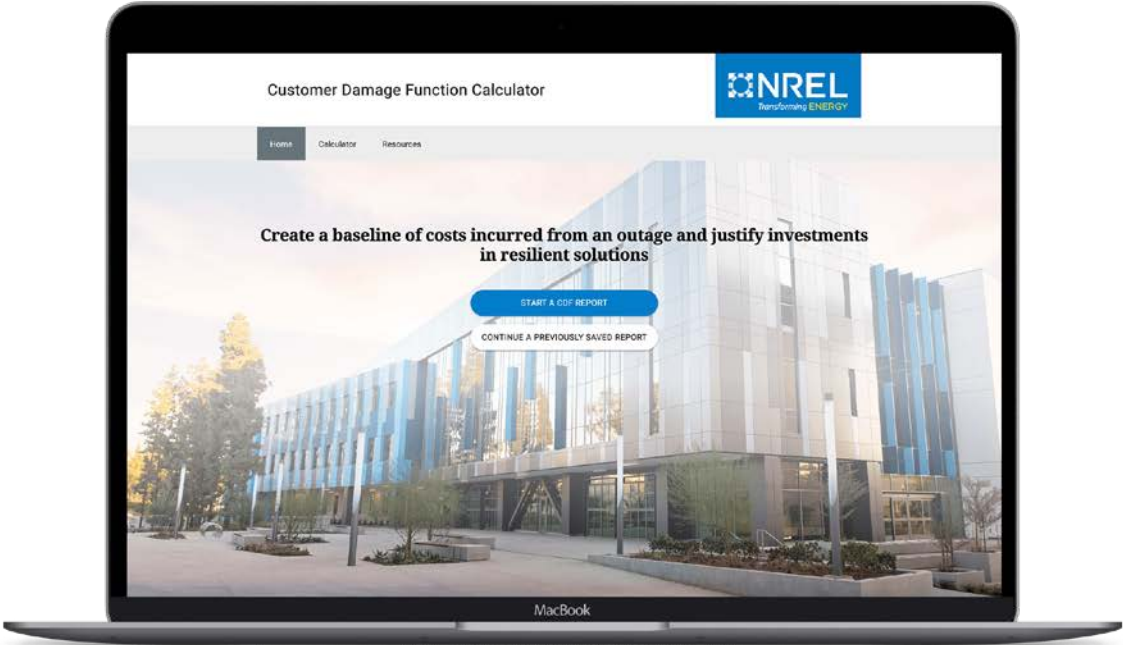
- Promote tool as a final product
  - Understand user base
  - Find unknown gaps that can be addressed to improve the experience
- Future work could integrate outputs with tools such as REopt and TRN
- Integration of resilience valuation metrics into contracting
- For updates on the tool or to learn more, please reach out to [ethan.epstein@ee.doe.gov](mailto:ethan.epstein@ee.doe.gov)

CDF Calculator is developed and maintained by the National Renewable Energy Laboratory with funding and support from the U.S. Department of Energy's Federal Energy Management Program



# Live Demo

[cdfc.nrel.gov](https://cdfc.nrel.gov)



# Thank you!

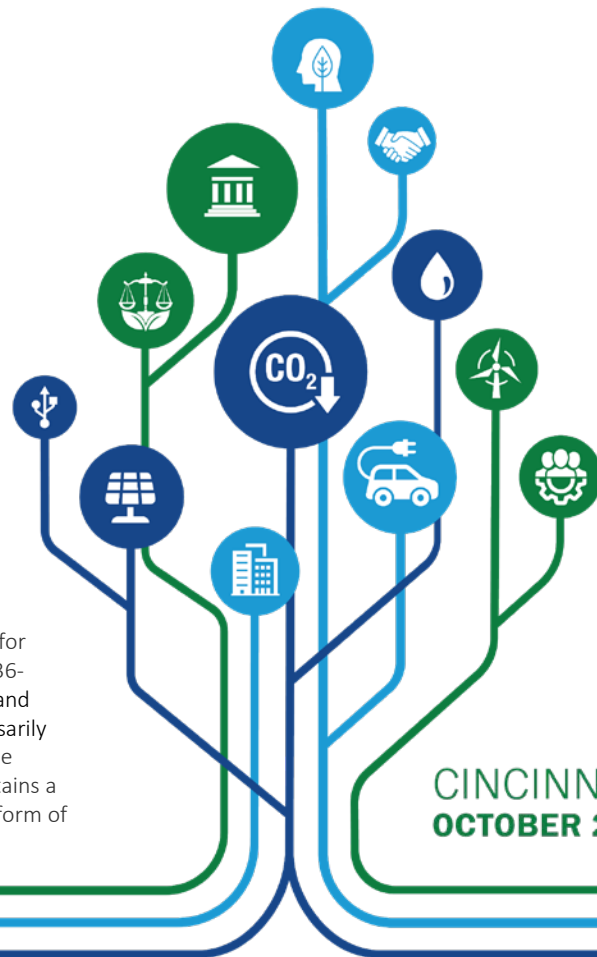
Questions?





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