SUMMARY OF MICROGRID ACTIVITIES IN THE USA

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- Booming microgrid industry
- Government efforts
- Focus on resilience
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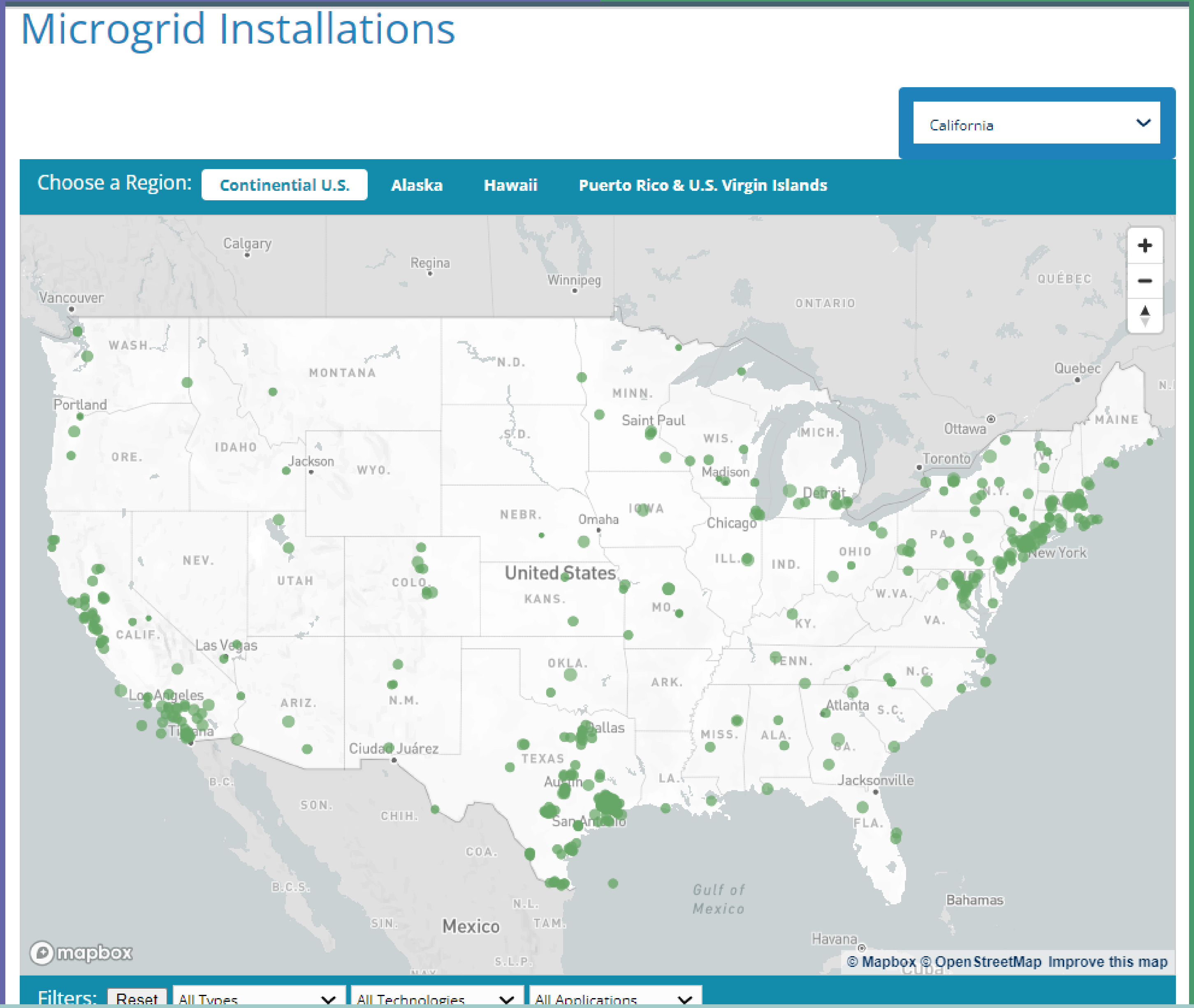
575+ MICROGRIDS IN UNITED STATES

Microgrids total 4,670 MW and rapidly growing

Live database available at:

https://doe.icfwebservices.com/microgrid



State Summary for California

Technology	Sites*	Capacity (KW)
Total	84	1,282,408.5
Biogas	0	45,730
CHP	30	511,020
Diesel	15	173,540
Fuel Cell	6	4,512
Hydro	1	1,250
Natural Gas	13	33,786
Solar	59	378,635.5
Storage	56	117,660.6
Wind	7	16,274.4

Column Heading Descriptions

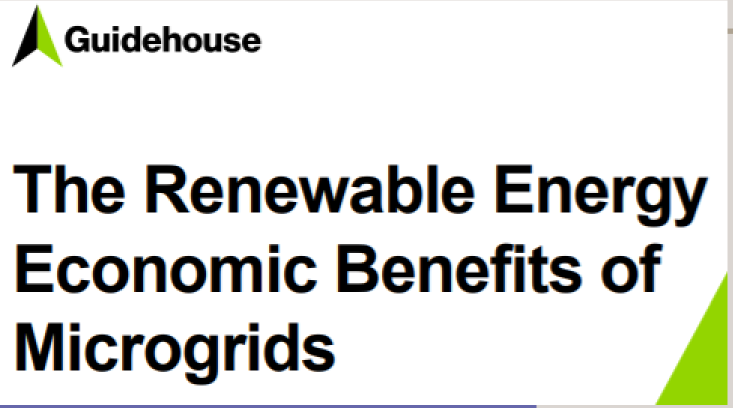
Heading	Description
Organization Name	Name of the owner or operator of the microgrid
Project Name	Name of the microgrid system
City	City name
Op Year	Year the microgrid first became operational (years of all system expansions are not shown)
Latest Install Year	Year of the most recent installation in the microgrid system
Primary Application	Primary market sector of the end-user(s) served by the microgrid
Grid Connected	Is the microgrid connected to a larger grid?
Microgrid Type	Continuous or conditional operation

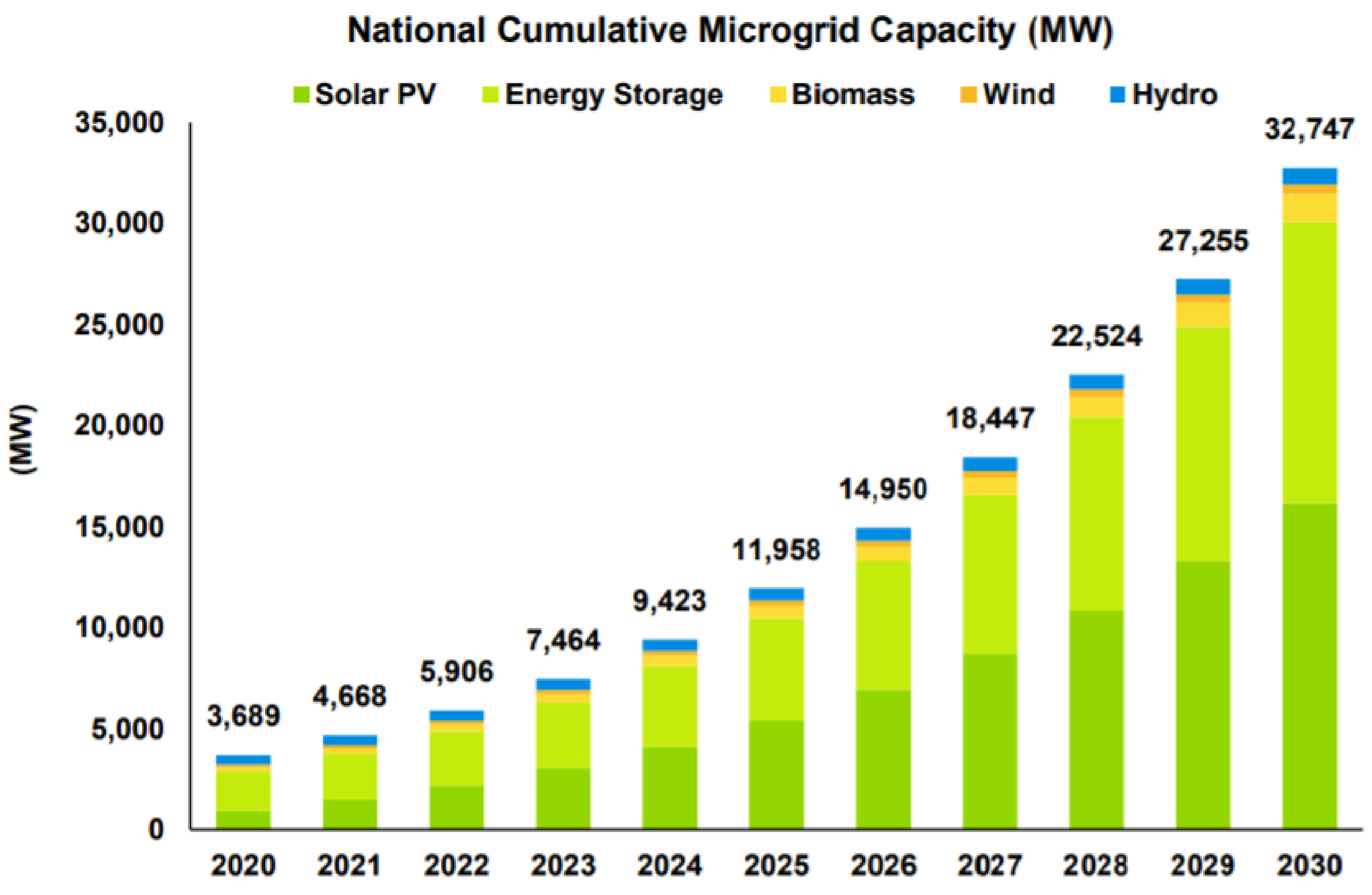
NATIONAL FORECAST

National renewable asset microgrid capacity is expected to grow 3.5 times, bringing total to **32,470 MW by 2030**.

Microgrid assets are a powerful engine for change, not only for our environment and for resiliency, but also for our economy.

Guidehouse Insights, 2021

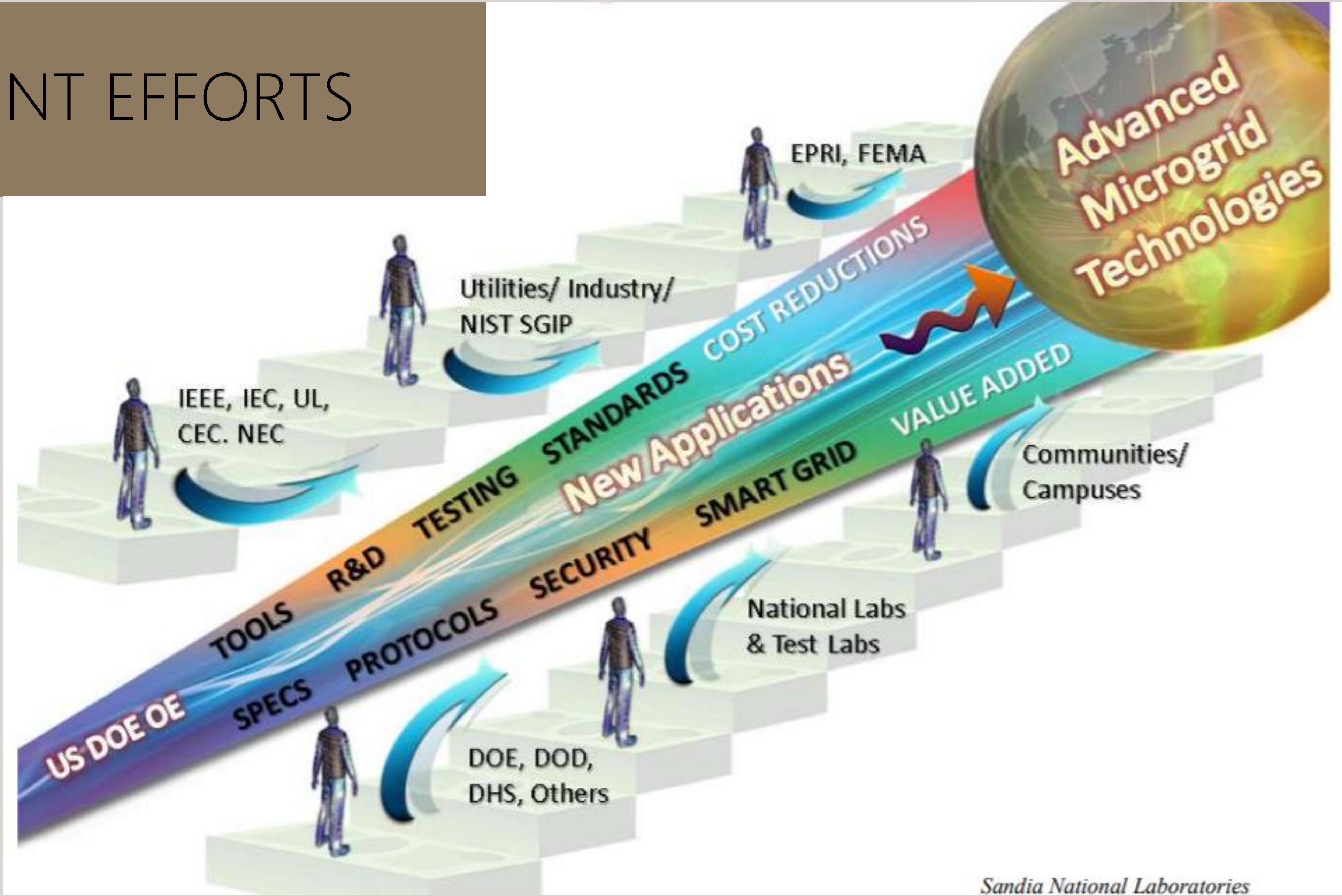




GOVERNMENT EFFORTS

Many years of efforts by multiple agencies have made a huge impact

Additional IEEE 2030 standards upcoming

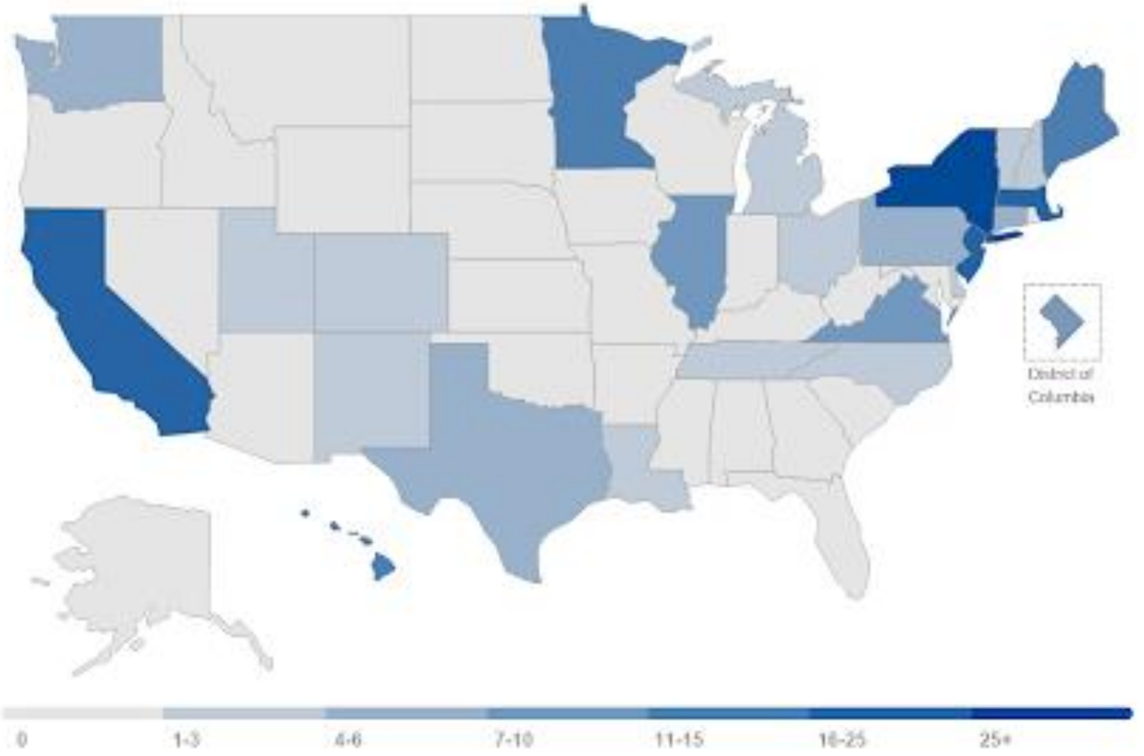


LEGISLATION

During the past six years, 21 states have proposed and enacted 53 microgrid-related bills largely for grid reliability and resilience.

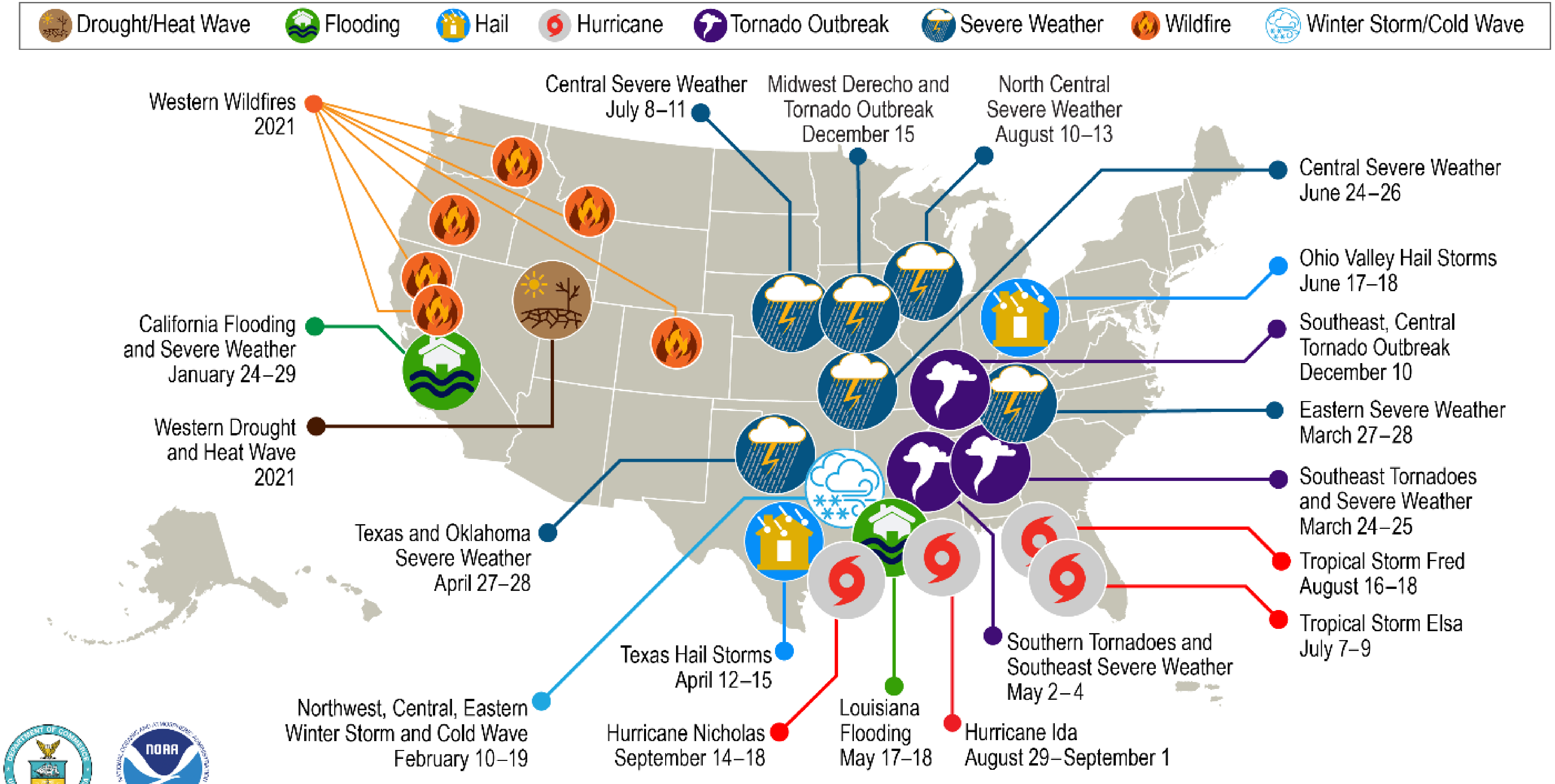
These often arise following an extreme weather event or prolonged outage.

Smart Electric Power Alliance (SEPA), 2021



"Resilience is the most commonly identified benefit of microgrids… most microgrids were initiated in the aftermath of a large-scale disaster or … interruption" (Analysis of the Microgrid Market, Thomas Hancock et al, 2021)

U.S. 2021 Billion-Dollar Weather and Climate Disasters



This map denotes the approximate location for each of the ***20 separate billion-dollar weather and climate disasters that impacted the United States in 2021***

https://www.ncdc.noaa.gov/billions/

VALUING RESILIENCE

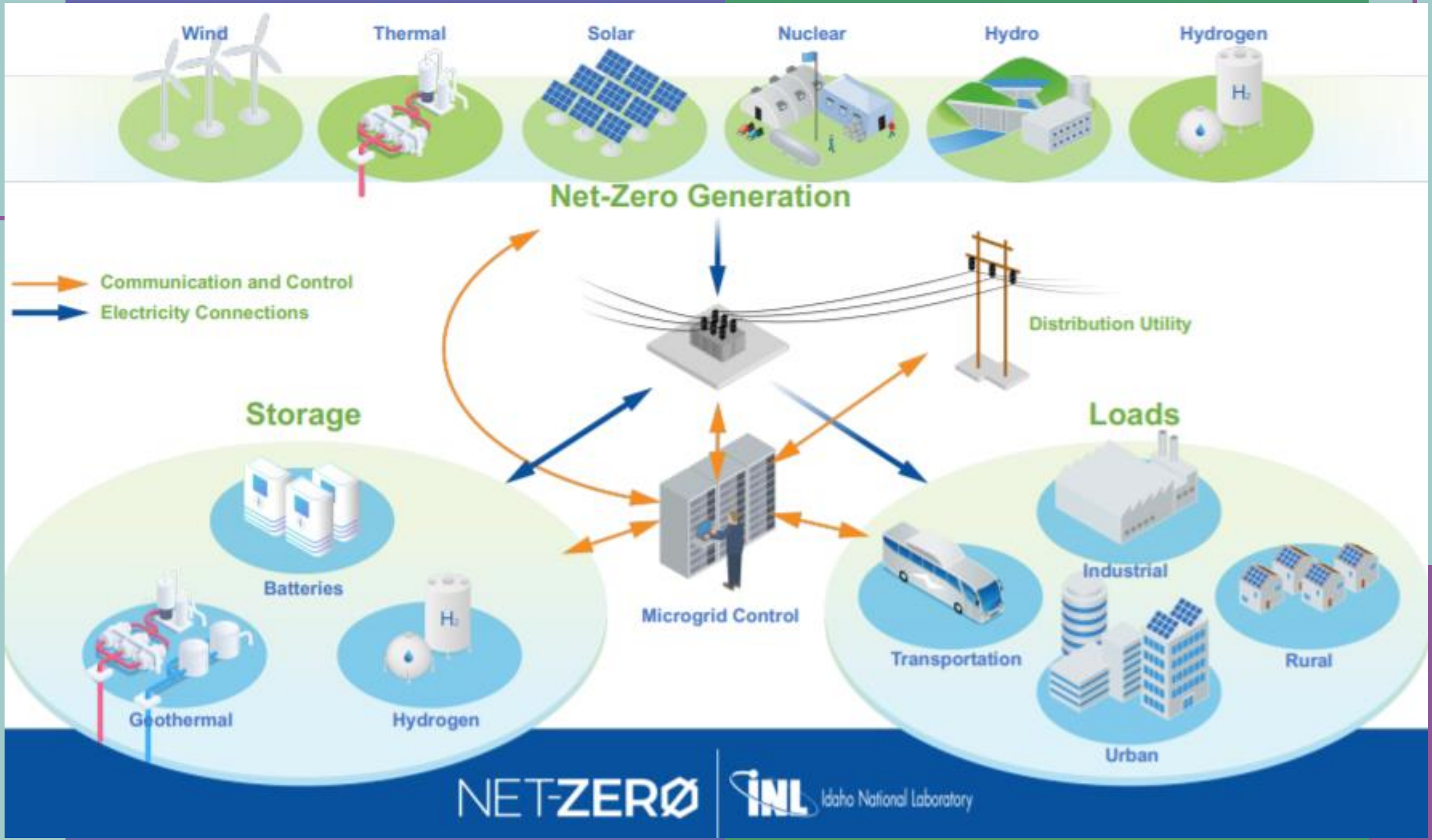
https://www.naruc.org/taskforce/topic-10-resilience/

Method / Tool	Advantages / New Additions	Available
Interruption Cost Estimator 2.0 Tool	• Updated calculations of power interruption costs. • New willingness-to-pay surveys that will populate the tool with more recent data and more geographic specificity for power interruption cost estimates. • New data on customer responses to longer-duration power interruptions	2023
Customer Damage Function Calculator Tool	• Helps individual facilities (or groups of similar facilities) calculate power interruption costs, based on the specific losses that they project will occur. • Guided questions lead facilities through their own assessments.	2021
Social Burden Method	• Provides a metric for the social burden of power outages that emphasizes the needs of communities during power outages, rather than protecting critical infrastructure for its own sake. • Adopts a more neutral treatment of the ability to pay for resilience, rather than willingness to pay.	Pilot 2021-2022
FEMA Benefit-Cost Analysis Tool	• Provides quantitative values for lost emergency services, such as police, fire, and emergency medical response. • New pre-calculated values specifically for hospitals published in 2021. • The use of FEMA values aligns with the application requirements of FEMA grant programs.	2021
Power Outage Economics Tool (POET)	• Estimates the economic impacts of longer-duration power outages. • Accounts for how utility customers adapt their behavior during long-duration power interruptions. • Uses surveys of utility customers to collect data on how they would behave during a power outage.	Pilot 2021-2022

NET-ZERO MICROGRIDS

Program will develop technical tools, analysis, and studies to promote the eventual transition to net-zero microgrids

New generation technology based on hydrogen or microreactors needed to retire fossil-based generation



[Idaho National Laboratory]

microgridUp

Microgrid Planning Utilizing an Open Modeling Framework for Resilient Installations Leveraging Their Utility Privatization

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Project Website
https://microgridup.org

2021	2022	2023
Develop Open Source Microgrid Planning Software	Comprehensive Microgrid Plans for 4 Military Installation	Final Goal: Accessible Microgrid Planning for all DoD

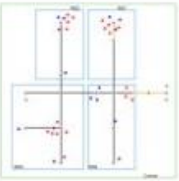
Components of Our Solution

Microgrids can offer a cost-effective option for multi-day installation resilience, but planning them is challenging.

Data Import	Leverage comprehensive data sets from utility privatization partners to locate microgrid opportunities across tens-of-thousands of grid components.
Network Segmentation	Segment the distribution network automatically, weighted by load criticality to find sets of maximum impact and mutually beneficial microgrid options.
Distribution Design	Add distribution upgrades to the system model to determine cost impacts and run automated interconnection to confirm nothing exceeds hosting capacity.
Generation Planning	Determine resilient and cost-optimal generation mixes of solar, wind, natural gas, energy storage and diesel for all candidate microgrids.
System Control	Execute detailed control simulations to determine load, generation, switching and protection changes needed to safely island/de-island and black start.

Bottom Line Output Example

- Tool identifies four load clusters suitable for microgrids (circuit diagram at right), compares to a central microgrid encompassing all load.
- Diverse mix of renewable and fossil generation identified as cost-optimal, providing resilience through critical period (24 hours of most difficult load behavior) but with average survival higher.
- Diverse set of net present values for the different microgrids identified–opportunity to stage deployment depending on funding available.
- Central microgrid has some cost savings and resilience benefits (c. 14 hours additional average survival) but requires bigger up-front investment.



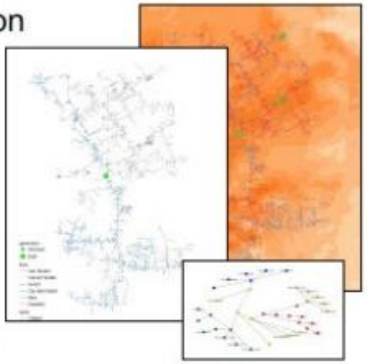
Microgrid Name	Min Load (kW)	Avg Day Load (kW)	Max Load (kW)	Diesel (kW)	Solar (kW)	Batt. Power (kW)	Batt. Capacity (kWh)	Total Gen on Grid (kW)	CO2 Reduced (%)	NPV ($)	CapEx ($)	CapEx w/ Incentives ($)	Outage Survived (Avg. h)
MG1	60	246	306	167	677	75	296	819	12%	-46,159	496,454	347,076	116
MG2	211	498	713	329	1,146	156	531	1629	16%	346,155	2,349,583	1,442,504	48.4
MG3	316	684	909	451	1,598	250	635	2299	20%	426,626	3,303,194	2,020,414	56
MG4	28	216	384	137	570	111	286	816	10%	126,771	1,180,502	733,021	144
MG1+2+3+4	-	1,645	-	1,082	3,990	592	1,950	5,565	14%	810,585	7,336,733	4,543,017	48.4
central	676	1,645	2,282	1,032	3775	470	1490	5,357	15%	797,296	6,672,724	4,232,251	70

Data Import – The UP Advantage

- Utility Privatization (UP) partners maintain comprehensive data on distribution systems, which we leverage to quickly generate microgrid solutions.
- Meter data ingest through importers for SCADA and AMI.
- Circuit data ingest from Engineering Analysis tools (Windmil, CYMDIST, PSSE, etc.)
- GIS/oneline tools used for edits to imported data for new equipment and output visualization.

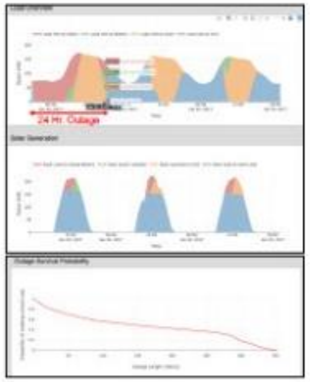
Network Segmentation

- Microgrid deployments benefit from economies of scale, but full-installation microgrids have high capital costs.
- We use critical facilities lists and the distribution model to automatically segment the network into sub-networks that can be supported by smaller microgrids.
- By applying a damage model based on past outages and forecasted threats, we identify deployment options that maximize support of critical loads.
- Network segmentation allows for incremental deployment while avoiding overlapping microgrids which are challenging to control.



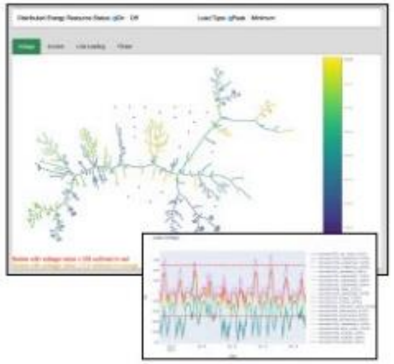
Generation Mix Planning

- Once the location of microgrids is decided, we generate a cost-optimal mix of generation to support the microgrid load.
- Climate data and fuel supply costs are used to specify the mix of solar, storage, and fossil generation needed.
- Generation mix is guaranteed to support the load through the critical outage limit (e.g. 14 days), and detailed survival probabilities are generated for all historical situations.



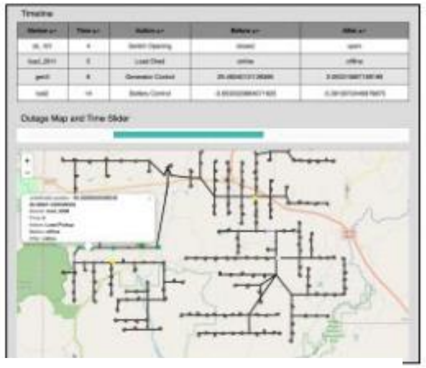
Distribution Design

- The distribution design module determines the set of sectionalizing, protection, and regulation changes that are necessary in the distribution system to host the microgrids.
- Changes are tested in an interconnection module to confirm that new distributed resources can be safely hosted.



Control

- We perform a control simulation to determine whether microgrid solutions can be effectively operated in concert.
- Simulation calculates generator, load, switching and protection changes that are necessary to safely island/de-island and black start.
- Final network with all upgrades is stored in OpenDSS format suitable for import into high-fidelity transient and HIL simulators such as TyphoonHIL.

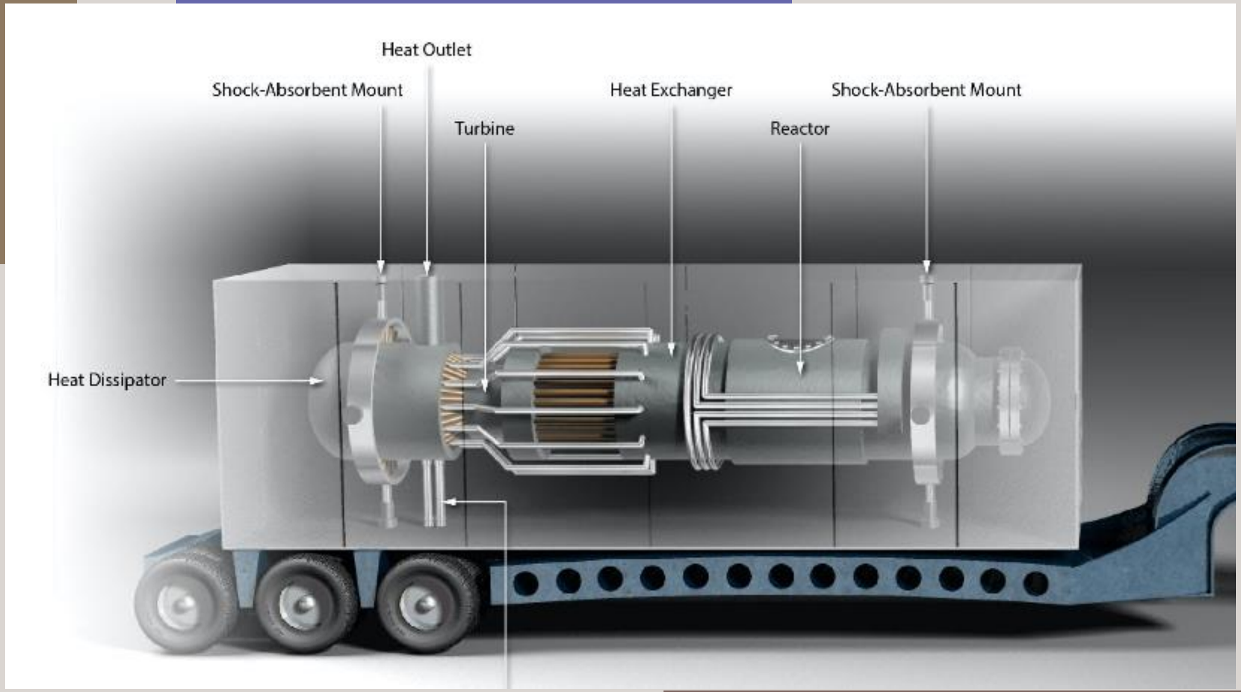


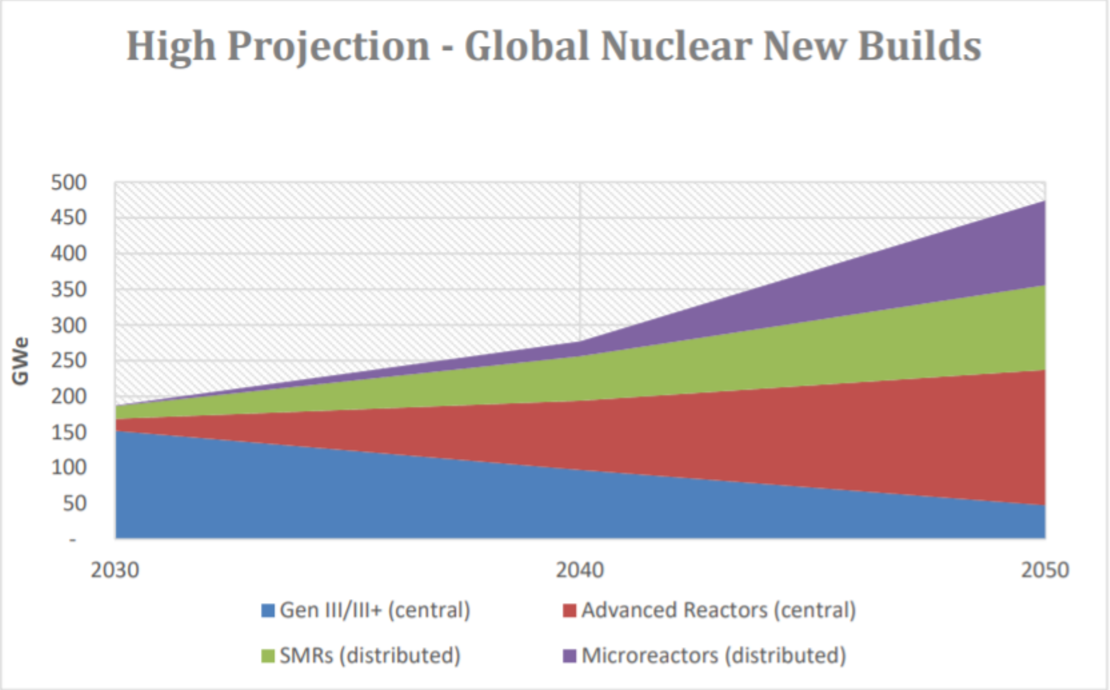
Demonstration Sites

https://microgridUP.org

THANK YOU

MICROREACTORS





- Transition to advanced central reactors
- Rise of distributed SMR and microreactors

Benefits: carbon; CHP/desalination

Source: [Idaho National Lab]