

Resilient Energy Systems: Risks and Challenges

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IEA EGRD System Resilience and Flexibility

National Renewable Energy Laboratory

At a Glance

2,050

Employees,
plus more than

400

early-career researchers
and visiting scientists



World-class

facilities, renowned
technology experts

nearly
820

Partnerships

with industry,
academia, and
government



Campus

operates as a
living laboratory

Programs NREL Supports Internationally



- ❑ NREL provides technical support and partnership facilitation within ~20 programs, including the 21st Century Power Partnership, Clean Energy Ministerial, Clean Energy Solutions Center, International Smart Grid Action Network, Carbon Capture Utilization, and Storage, International Energy Agency Technology Collaboration, International Energy Agency, South Asia Regional Grid Integration, Leadership Compact and the Low Emission Development Strategies Global Partnership.

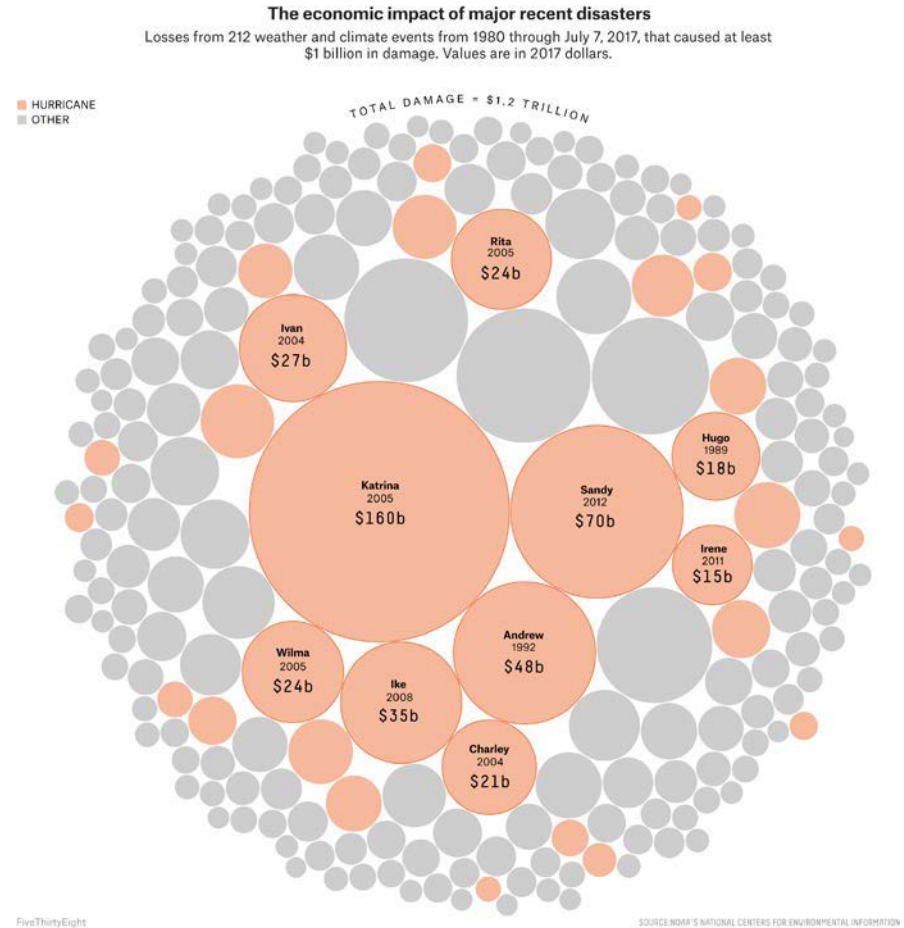
- ❑ Links to more information:
 - ❑ [Clean Energy Ministerial](#)
 - ❑ [Clean Energy Solutions Center](#)
 - ❑ [21st Century Power Partnership](#)
 - ❑ [International Smart Grid Action Network](#) (ISGAN)
 - ❑ [CCUS Initiative](#)
 - ❑ [LEDS GP](#)
 - ❑ [Nuclear Innovation: Clean Energy \(NICE\) Future Initiative](#)
 - ❑ [IEA Technology Collaboration Programs](#)
 - ❑ [International Renewable Energy Agency](#)



Why Conduct Resilience Planning?

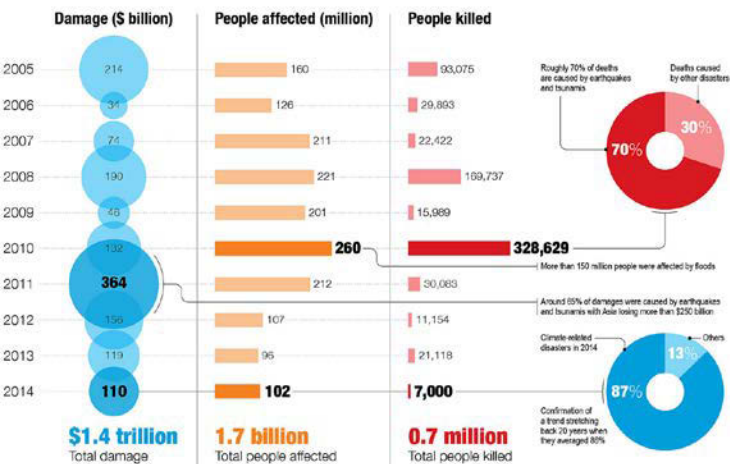
We can't afford not to!

Preparing for and strengthening assets and processes **to lessen impacts and recover quickly** from hazards and other threats will help ensure viability of the organization.

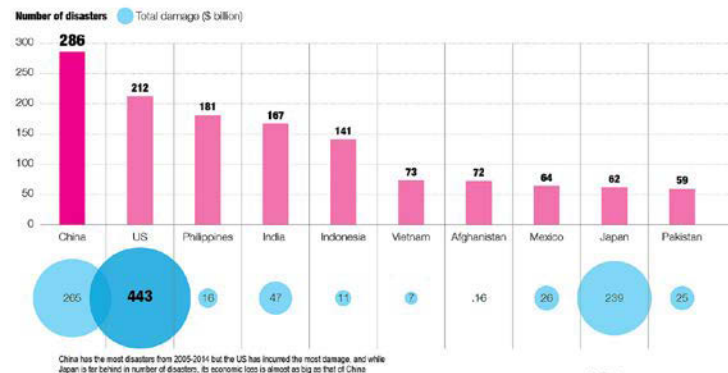


[NOAA National Centers For Environmental Information](https://www.noaa.gov/ncei)

The Economic and Human Impact of Disasters in the last 10 years



Top 10 countries with most disasters, 2005-2014



Economic and Human Impact of Disasters is Growing

Increasing threats to and vulnerabilities in our infrastructure systems indicate there is **great need for resilience science** and integration of solutions.

WHAT IS RESILIENCE?

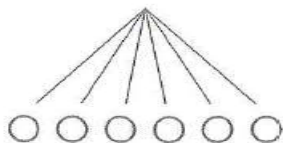
“the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through **adaptable and holistic planning and technical solutions**”.

www.nrel.gov/tech_deployment/resilience-planning-roadmap/

NREL's Projects in Resilience Take an Integrated Approach



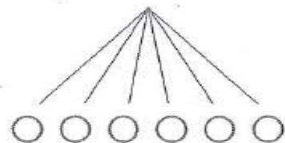
ELECTRICITY



- Microgrids
- Cyber security
- ReOpt analyses
- Energy storage
- Risk assessments
- Strategic planning



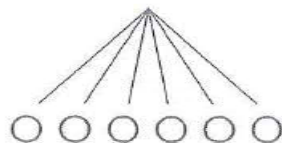
TRANSPORTATION



- Infrastructure siting
- Fuel diversification
- Vehicle diversification



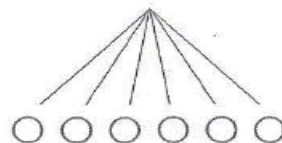
AGRICULTURE + WATER



- Food security
- Supply chain analysis
- Biofuels
- Water-Energy nexus



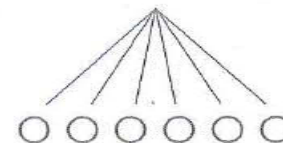
ECONOMICS



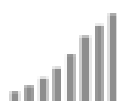
- RE technologies manufacturing (CEMAC)
- Economic development
- Diversification
- Project finance



BUILDINGS



- ReOpt Analyses
- Open Studio + BCL
- Passive survivability
- EE measures
- Load shedding
- Critical infrastructure
- UrbanOpt





Tools, Analysis, Technical Assistance, and Research

Need

Access to tools, analysis, technical assistance, and research to enhance energy security, resilience, and economic stability.

Key Factors

- Renewable energy, energy efficiency, and improved designs can reduce operational costs and provide emergency backup power
- Spatial diversification can build system resilience overall
- Becoming resilient is a big challenge and many entities do not know a) what it means, b) what the technical solutions are, c) how to implement solutions, or d) where to find resources (funding, expertise).
- Resilience means different things to different organizations, so there is no one-size-fits-all solution.
- NREL experts are creative problem solvers.



Technical Assistance Example

Need

Caribbean country requested assistance through CTCN for a workshop to enhance resilience within codes, energy sector, and workforce development.

Key Factors

- Island nation susceptible to tropical storms and storm surges, making energy infrastructure vulnerable.
- Training is mostly done at universities off-island, meaning capacity building within workforce needs to be coordinated across country boundaries.
- Codes and metrics did not exist at the time for resilience measures/standards to be incorporated.



Tools and Analysis Example

Need

Training was requested from Asian countries for resilience planning within the energy sector.



Key Factors

- Hydro and wind power projects need to be sited in locations that have long-term viability, but changing conditions make those locations difficult to identify.
- Variable weather conditions prove challenging for energy stability.
- Information and resources are not readily available.



Risks and Challenges



- Lack of robust, scientific **data and information**
- **New topics** take longer to integrate into industry (e.g., training is needed, codes are needed, enforcement is challenging)
- **Metrics** are not fully developed for resilience
- **Valuation** of resilience varies significantly
- **Validation** of technical solutions and policies is hard to get
- Buy-in and investment are needed at all levels of government, requiring **significant coordination**
- Energy systems and aging infrastructure are **vulnerable**
- It's challenging to **stay ahead** of threats and hazards
- **Financing** resilience solutions is not readily available
- **Technical solutions** are not broadly known

Resources for Resilience

Resilience Roadmap

A Collaborative Approach to Multi-Jurisdictional Planning



To mitigate hazards and risks, the Resilience Roadmap offers comprehensive guidance for federal, state, and local entities to effectively convene at the regional level for adaptable and holistic planning. This multi-jurisdictional approach requires major cooperation across boundaries, considerable reliance on partnerships and multi-agency collaborations, and significant utilization of interdisciplinary teams.

Step-by-Step Process

To constructively lead intergovernmental planning efforts with tangible outputs, follow these steps in order:

- 1 Intergovernmental Preparation and Coordination
- 2 Planning and Strategy Development
- 3 Plan Adoption, Implementation, and Evaluation

WHAT IS RESILIENCE?

The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions.

The National Renewable Energy Laboratory developed this application with support from the U.S. Department of Energy's Federal Energy Management Program. For information about working with NREL on resilience planning, contact Eliza Hotchkiss.

Planning Tool

Resilience Roadmap

(www.nrel.gov/resilience-planning-roadmap)

Publications

Bridging Climate Change Resilience and Mitigation in the Electricity Sector Through Renewable Energy and Energy Efficiency

(www.nrel.gov/docs/fy18osti/67040.pdf)

Distributed Generation to Support Development-Focused Climate Action

(www.nrel.gov/docs/fy16osti/66597.pdf)

Distributed Energy Planning for Resilience

(www.nrel.gov/docs/fy18osti/71310.pdf)

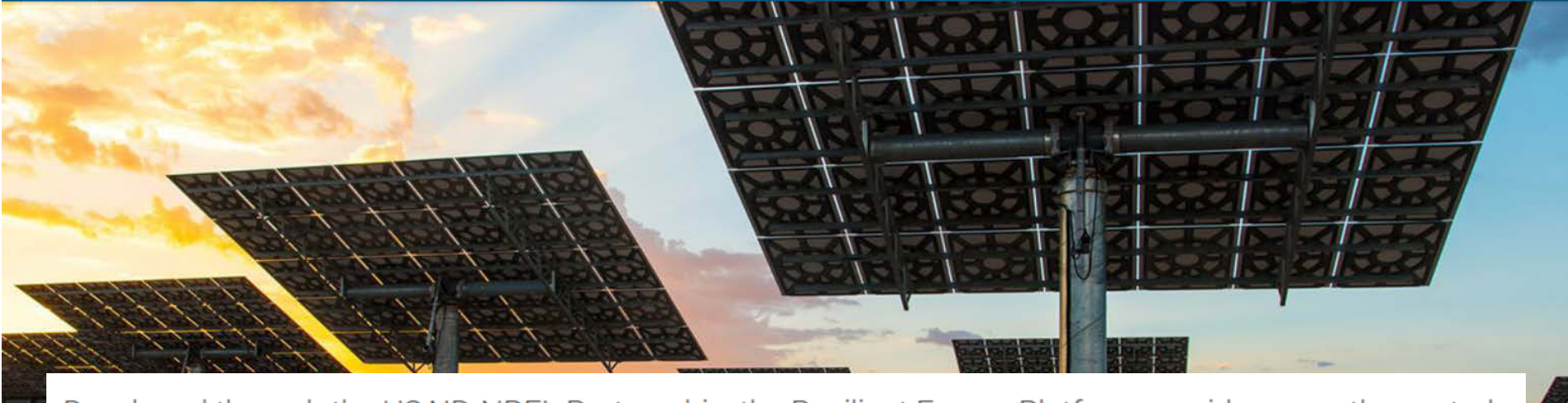
Coming soon!




Resilient Energy
Platform

☐ only in current section

[Home](#) [About](#) [Guidebook](#) [Training and Resources](#) [Ask an Expert](#) [News and Events](#) [Where We Work](#)



Developed through the USAID-NREL Partnership, the Resilient Energy Platform provides expertly curated resources, training materials, data, tools, and direct technical assistance in planning resilient, sustainable, and secure power systems.



collaboration
is **everything**

Research and Partnerships Will Help!

Questions?

Please ask any questions or email them afterwards to



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Thank you

www.nrel.gov

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