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Foundations of Energy System Resilience

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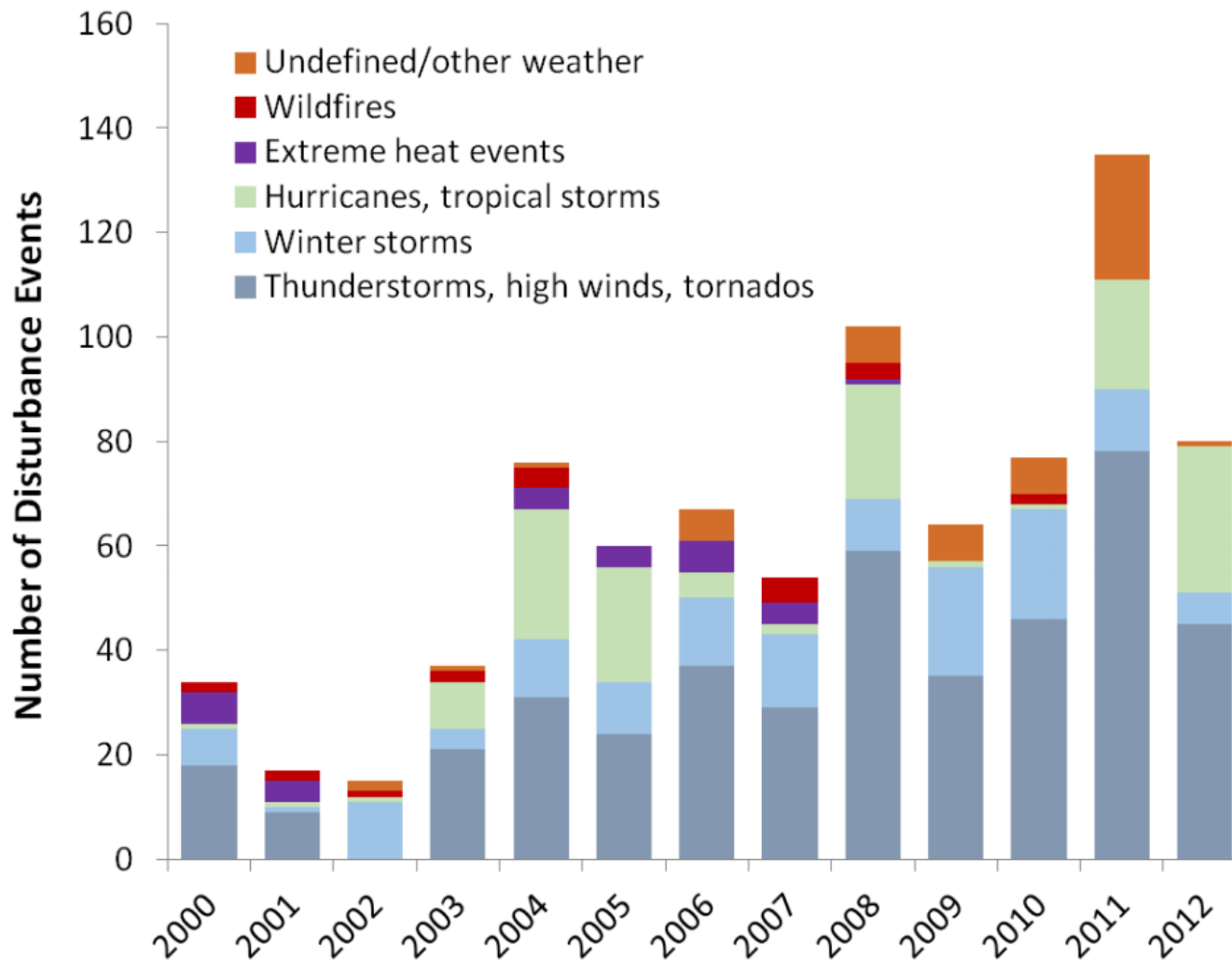
Reliability and resilience overlap but are different

Resilience, from the root, “resilio”, meaning to leap or spring back, is concerned with the ability to anticipate, absorb, adapt to, and rapidly recover from a disruptive event.



Reliability can be defined as the ability of the power system to deliver electricity in the quantity and with the quality demanded by users

Weather related grid disruptions are increasing



Source: "Electric Disturbance Events (OE-417)." U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability

Climate projections prescribe a range of outcomes implying the need to select “a specific future” to plan for



Longer, hotter, **more frequent** heat waves



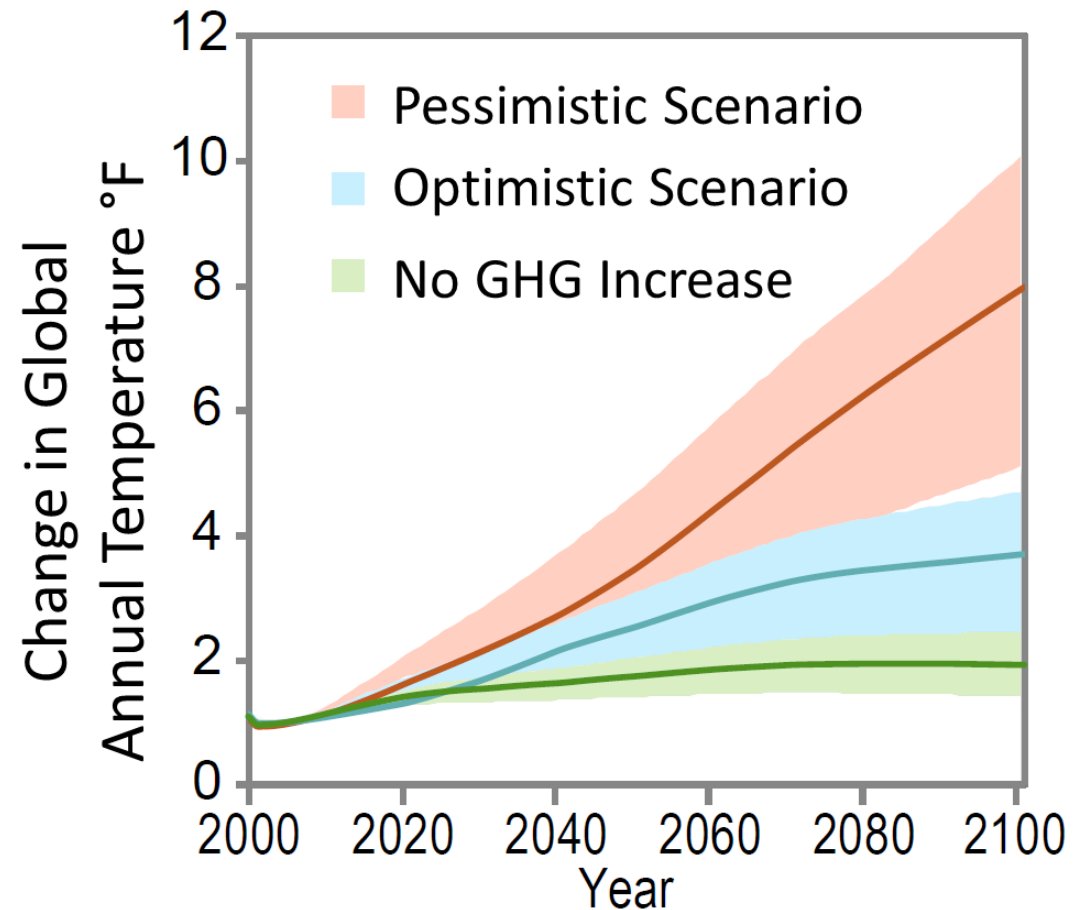
Rising sea levels



More **intense** rain events



More **severe** hurricanes and Nor'easters

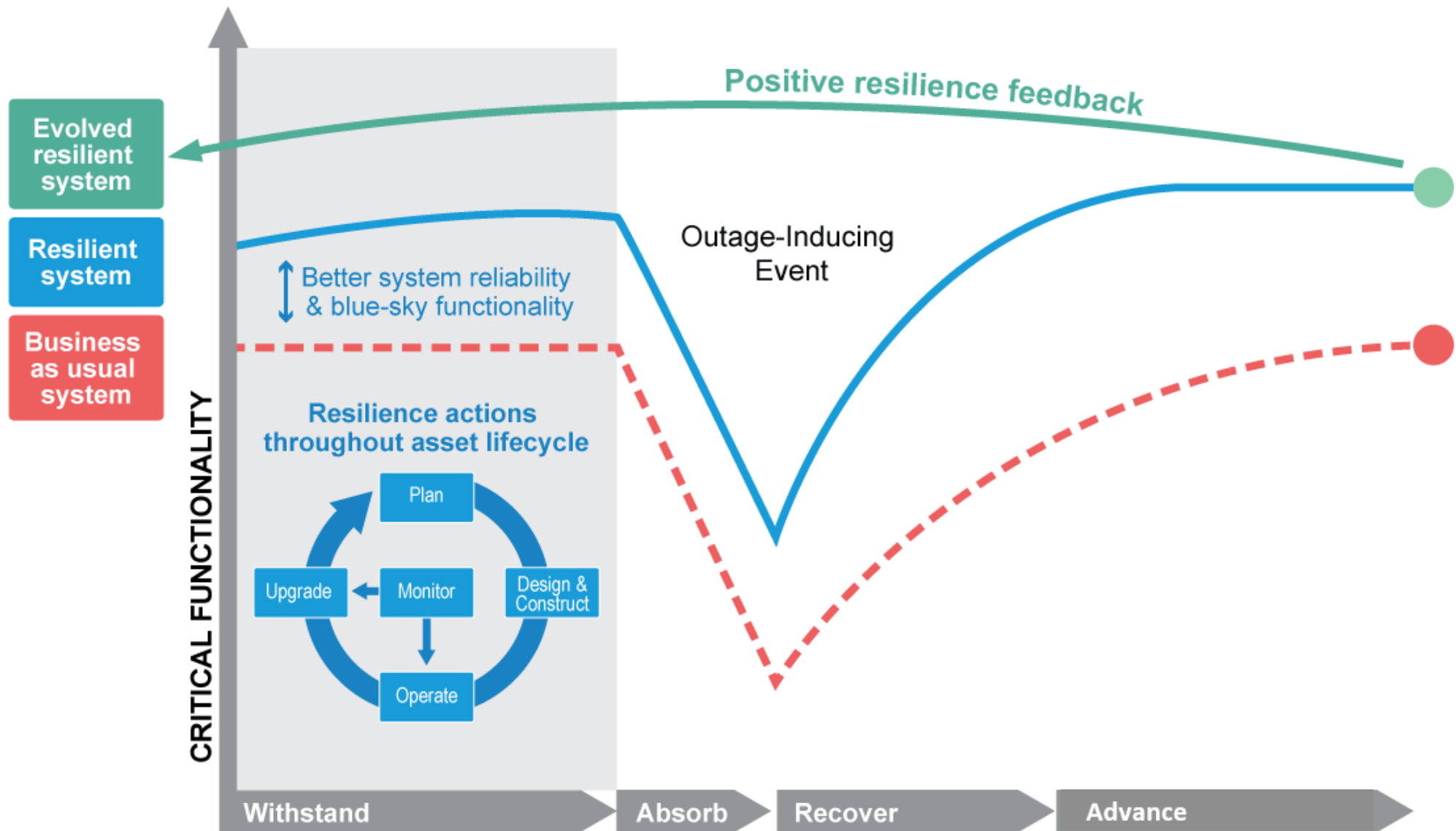


Source: U.S Climate Science Special Report, p. 138.

Climate change can have broad impacts across energy infrastructure

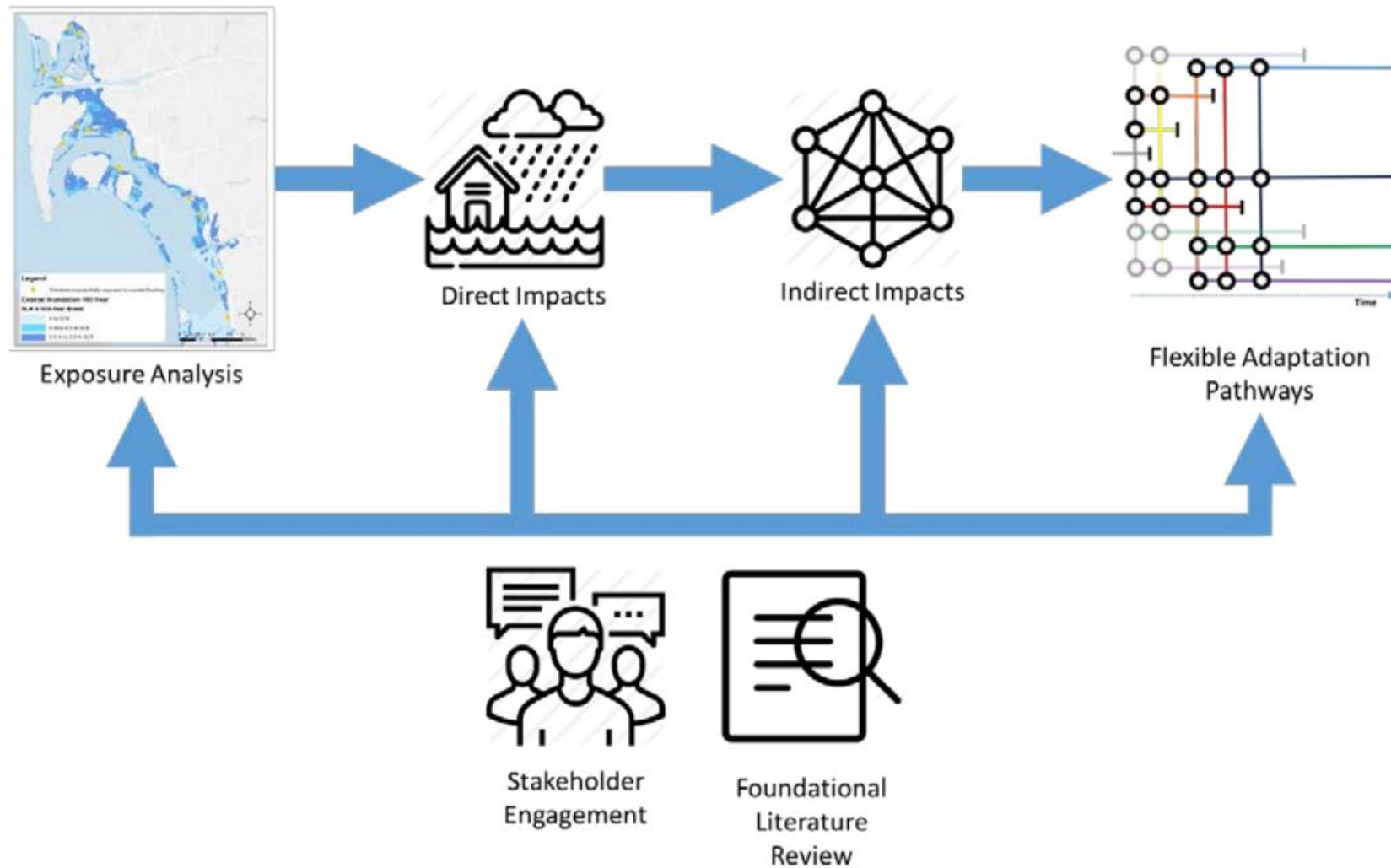
Dimension	Impact
Generation	<ul style="list-style-type: none">• Reduce efficiency due to higher ambient air and water temperatures• Reduced reliability due to water shortages• Reduced output due to lower wind speeds• Vulnerable to physical damage from extreme events
T&D Systems	<ul style="list-style-type: none">• Reduced capacity due to higher ambient air temperatures• Need to meet higher peak demand driven by higher air temperatures• Reduced reliability due to increasing heat waves• Vulnerable to physical damage from extreme events• Potential to increase the risk of wildfires
Energy Demand	<ul style="list-style-type: none">• Increased demand due to higher ambient temperatures• Increased vulnerability to long-duration outages due to public safety power shutoffs or to extreme events

This comprehensive resilience framework considers four dimensions of resilience



Source: ICF framework for Con Edison Climate Change Vulnerability Study

An example approach for building resilience



Source: ICF Framework from California's Fourth Climate Change Assessment

Clarifying Questions?

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