



Global Perspectives of Sustainability, Resilience and Distributed Generation

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CENTRAL
THERMAL

RENEWABLES
REVOLUTION

DISTRIBUTED
SOLID-STATE

Each phase drove benefits, but also unintended consequences ... grid innovations required



PHASE 01

Central Thermal

*reliable access and capacity to fuel
economic growth*

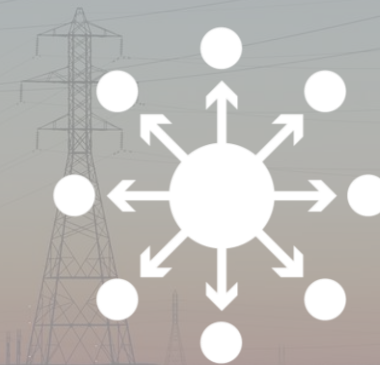
- Generation near major load centers ... economies of scale
- Generation follows demand
- Fuel diversity for reliability and energy independence

PHASE 01

Central Thermal Grid Response

reliably connecting supply and demand

- Hub and spoke design
- One-way flows
- Energy Management Systems to monitor/control grid



PHASE 02

Renewables Revolution

*sustainable solutions to address
global warming*

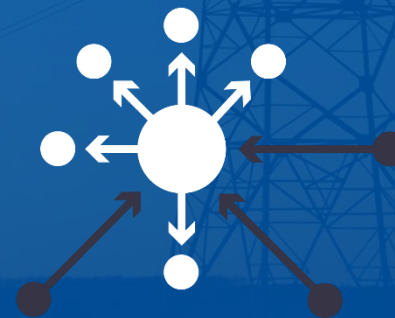
- Generation near good renewable resources ... economies of scale
- Generation follows intermittent supply
- Policy and incentive driven at start

PHASE 02

Renewables Revolution Grid Response

*interconnect renewables and address
intermittency challenges*

- Interconnect renewables over long distances
- Address power quality and duck-curve challenges
- Digital ... plant, fleet and grid system optimization



PHASE 03

Distributed Solid-State

*Resiliency, affordability and transparency
for end consumers*

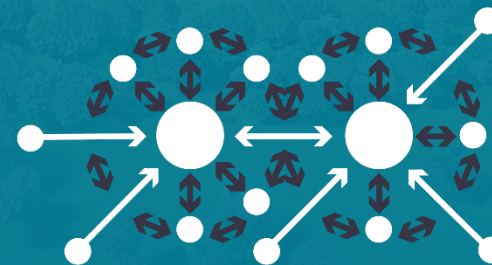
- Generation at point of consumption ... diseconomies of scale
- Renewables become more dispatchable and accessible
- Retail driven ... could strand existing grid assets/costs

PHASE 03

Distributed Solid-State Grid Response

interconnect distributed generation and address cyber threats

- Enable two-way flows and interconnected grids
- Storage and DERMS to balance supply/demand
- Cyber Security ... detect, isolate and repair threats



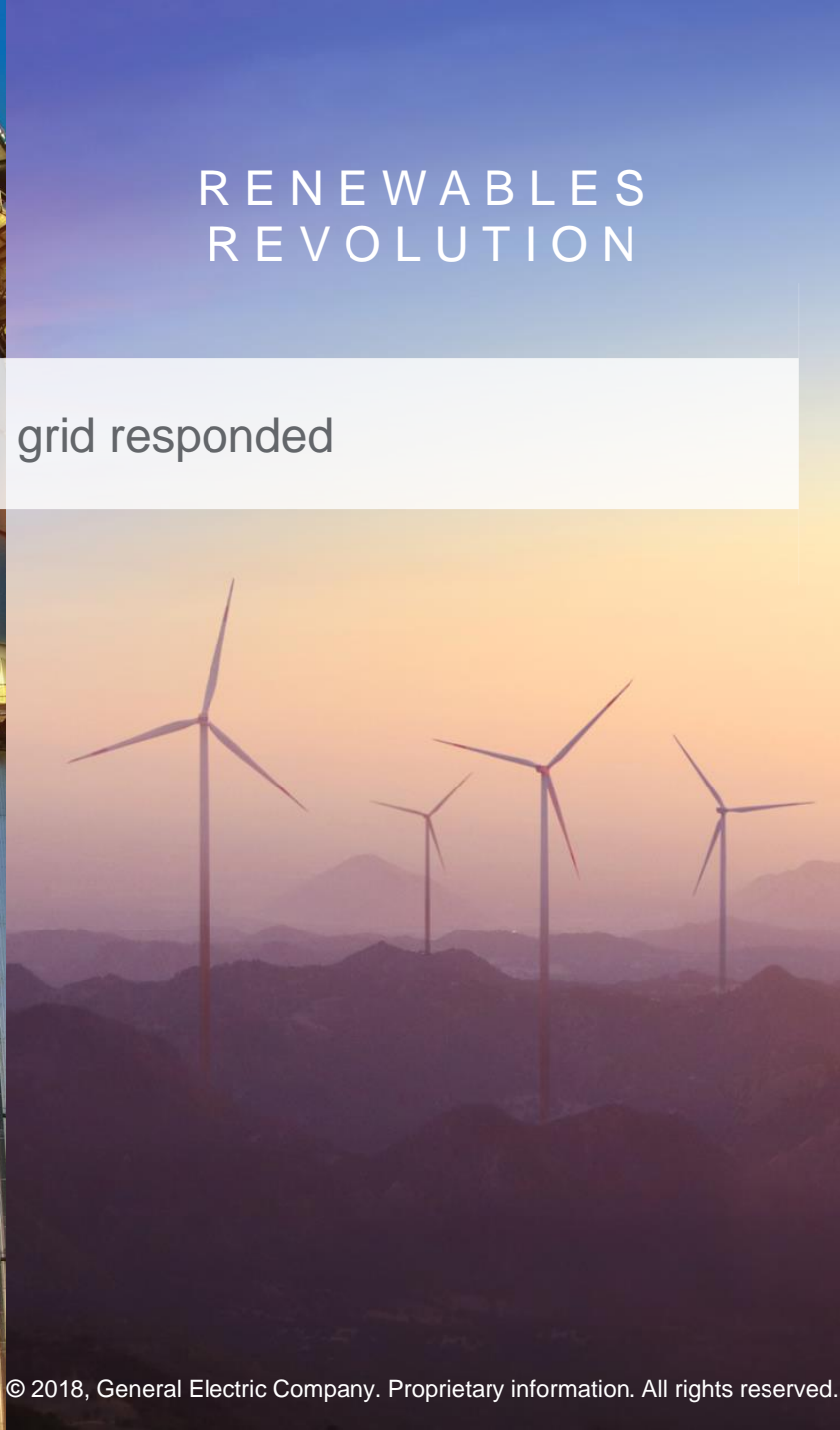
CENTRAL THERMAL

Generation led, grid responded

RENEWABLES REVOLUTION

DISTRIBUTED SOLID-STATE

Digital, grid, generation
holistic design





THE CHALLENGE:

- Think and act long-term
- Anticipate unintended consequences
- Integrate digital, grid and generation as a system of systems

