MICROGRID KNOWLEDGE

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Check the Stack: A State Policy Framework for Supporting Resilient Microgrids

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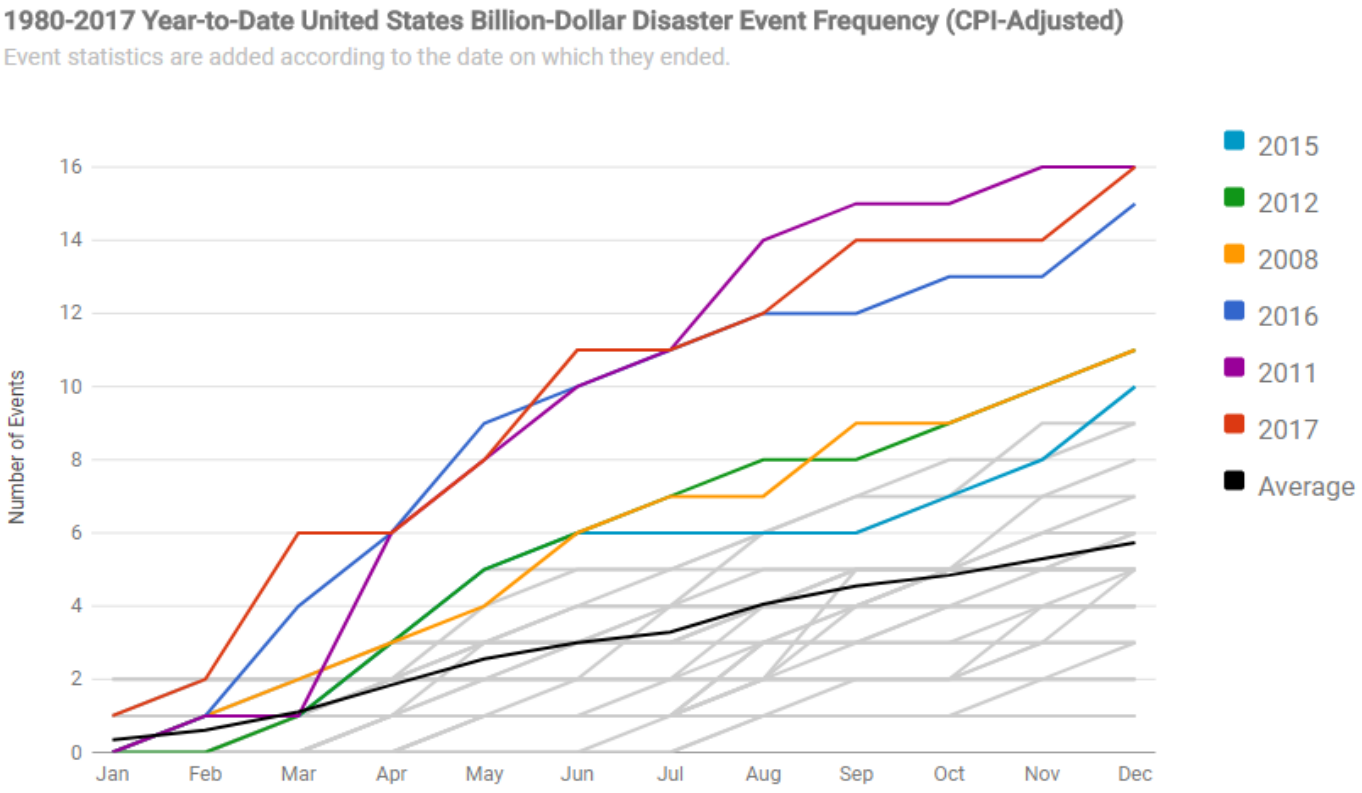
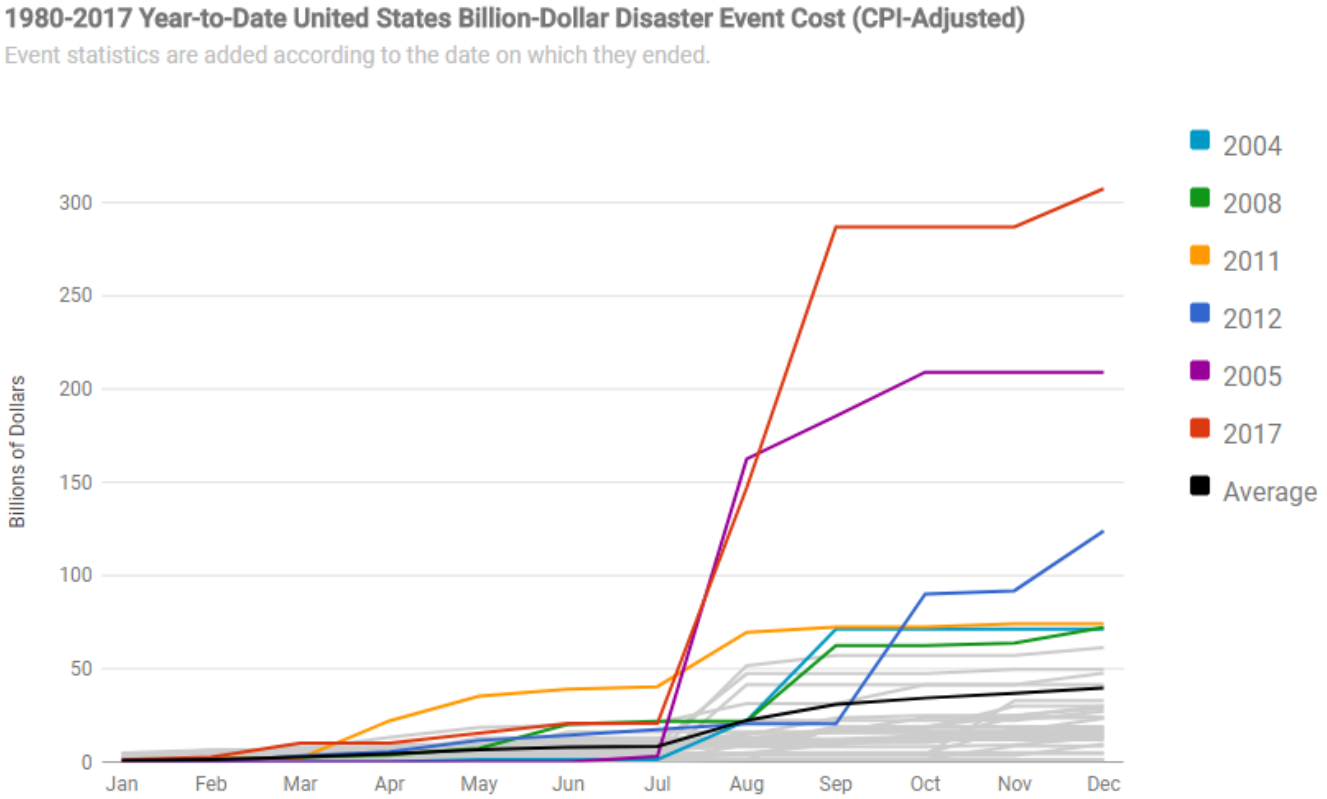
Background

- This work was funded by the Department of Energy Solar Technology Office and the Solar Technical Assistance Team (STAT) Network
- STAT provides technical assistance to state and local policymakers to answer policy and technical questions
- This research is associated with a technical assistance request from a southeastern state that is focused on resilience planning and prioritization for certain critical infrastructure in the state.

Understanding the Need for Resilience



Understanding the need for Resilience

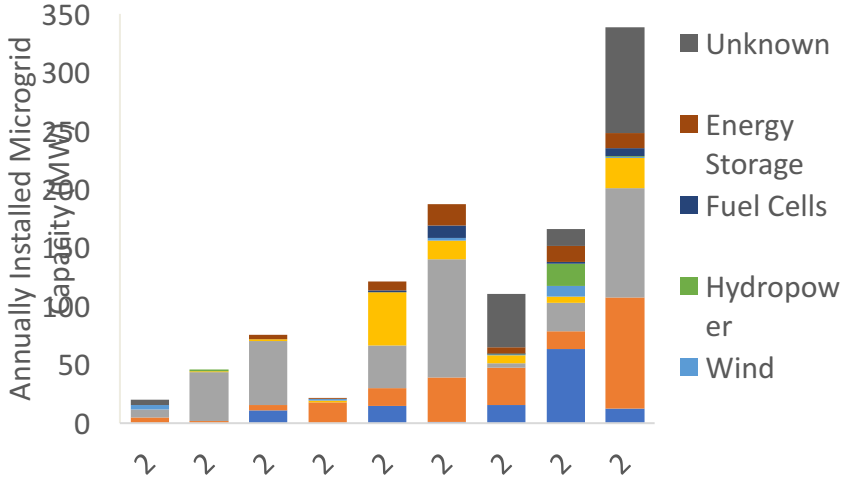


Natural Disasters, Electricity Outages, and Critical Infrastructure

- Hurricane Maria left all 3.4 million residents of Puerto Rico without power.
  - 35% of the island was without power a full 90 days after landfall
  - Hospitals struggled to provide services, even with backup diesel generators
- These and other natural disasters have exposed vulnerabilities in critical infrastructure operation amidst grid outages
- Critical infrastructure refers to facilities and services if incapacitated would have a detrimental impact on society
  - Communication
  - Emergency services
  - Water and wastewater treatment

Microgrids as a Resilience Solution

- Microgrids can be used to extend the operation of critical infrastructure during a grid outage including:
  - Level 1, Level 2, and Level 3 configurations
- Microgrid capacity has increased since 2008



Annual commissioned microgrid capacity by technology through 2016 (recreated from GTM, 2016)

Renewable Energy and Microgrids

- Benefits of incorporating renewable energy:
  - Prolonged operation during a long-term outage, especially when renewables are paired with batter storage
  - Zero emission electricity generation that can provide environmental and health benefits
  - Year-round, though intermittent electricity generation that can provide economic value to microgrid owner
- Prolonging operation during an outage, is especially important for improving the resilience of critical infrastructure
- **Policymakers may be interested in understanding how renewable-based microgrids can be used to support critical infrastructure**

Research Agenda

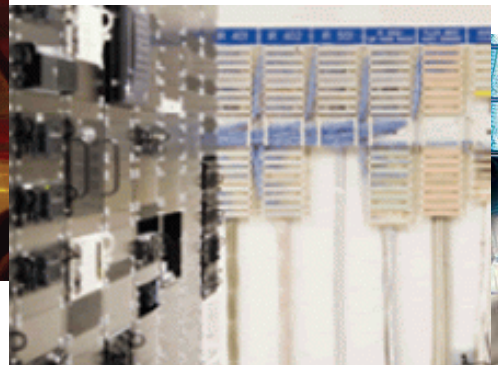
- Explore the critical infrastructure market and the potential impact of outages at these facilities
- Survey the policy landscape for resilient microgrids nationwide
- Generate a policy stack to guide state policymakers considering building a resilient microgrid market
- Provide pathways for future work to build out this policy stack

Exploring the Critical Infrastructure Market

- Critical infrastructure is:

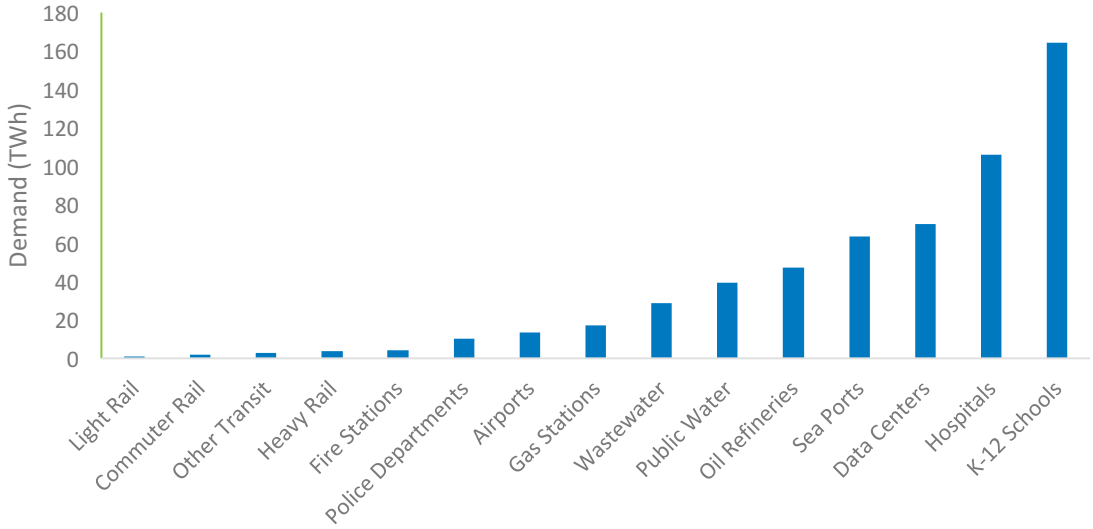
"systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters."

- The U.S. Department of Homeland Security designates 16 critical infrastructure sectors


Assessing Certain Critical Facility Load

- This analysis catalogued 15 million facilities across 7 of the 16 critical infrastructure sectors and estimated electricity load.



Average Annual Electricity Load for Certain Critical Infrastructure Subsectors by System or Facility

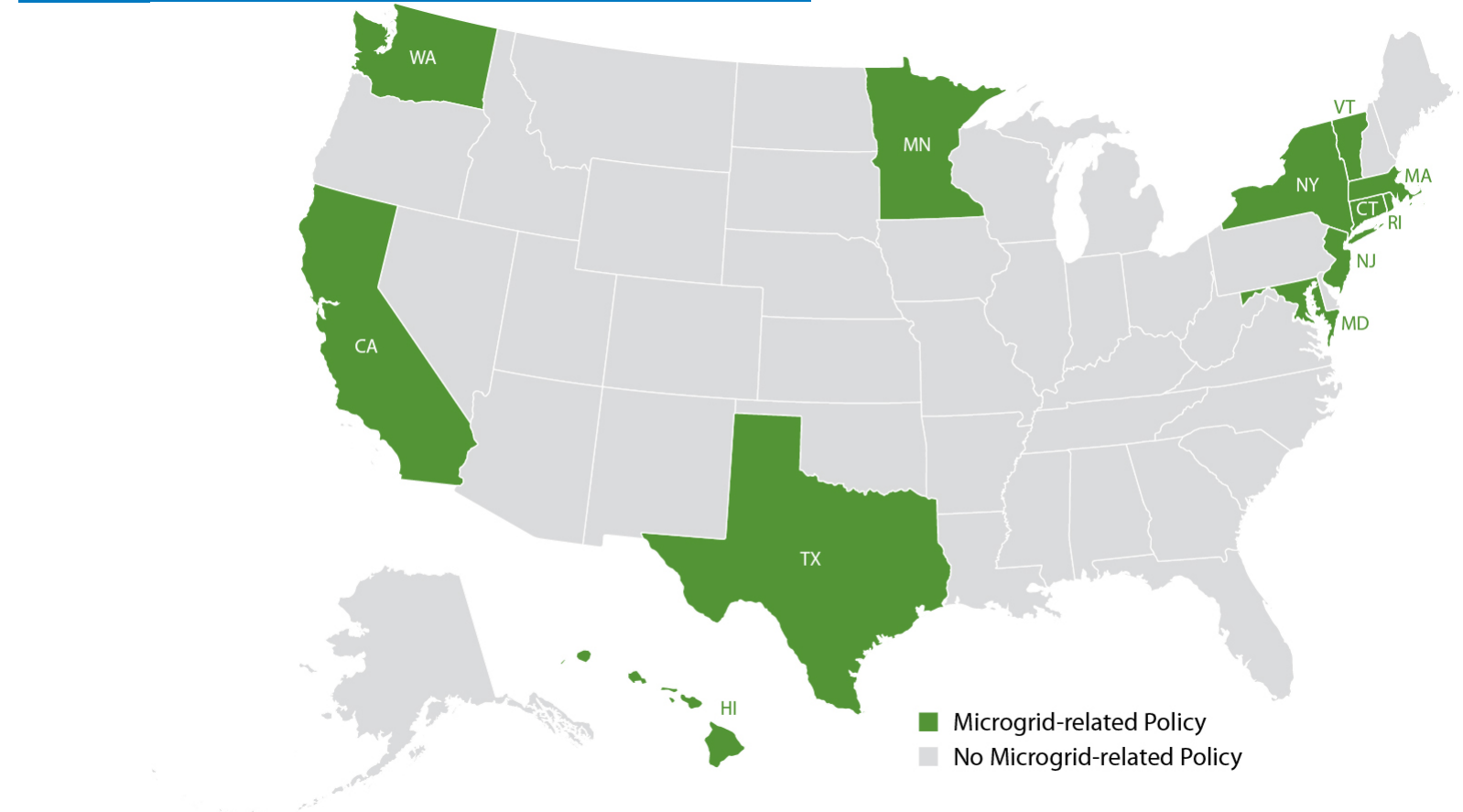
Exploring Economic Impacts

- Lawrence Berkeley International Laboratory has developed an Interruption Cost Estimate for 4 and 16 hour outages.
  - Estimated 4 hour outage cost: $39 billion
  - Estimated 16 hour outage cost: $178 billion
  - Long-term outage cost (exceeding four days): ~$700 billion
- These estimates are highly speculative and consider only value of lost load (based on commercial and industrial facility assumptions)
- Outages at critical facilities would likely have higher impacts, though outages are unlikely at all facilities at once
- Nevertheless, critical infrastructure represents a large market for resilient microgrids

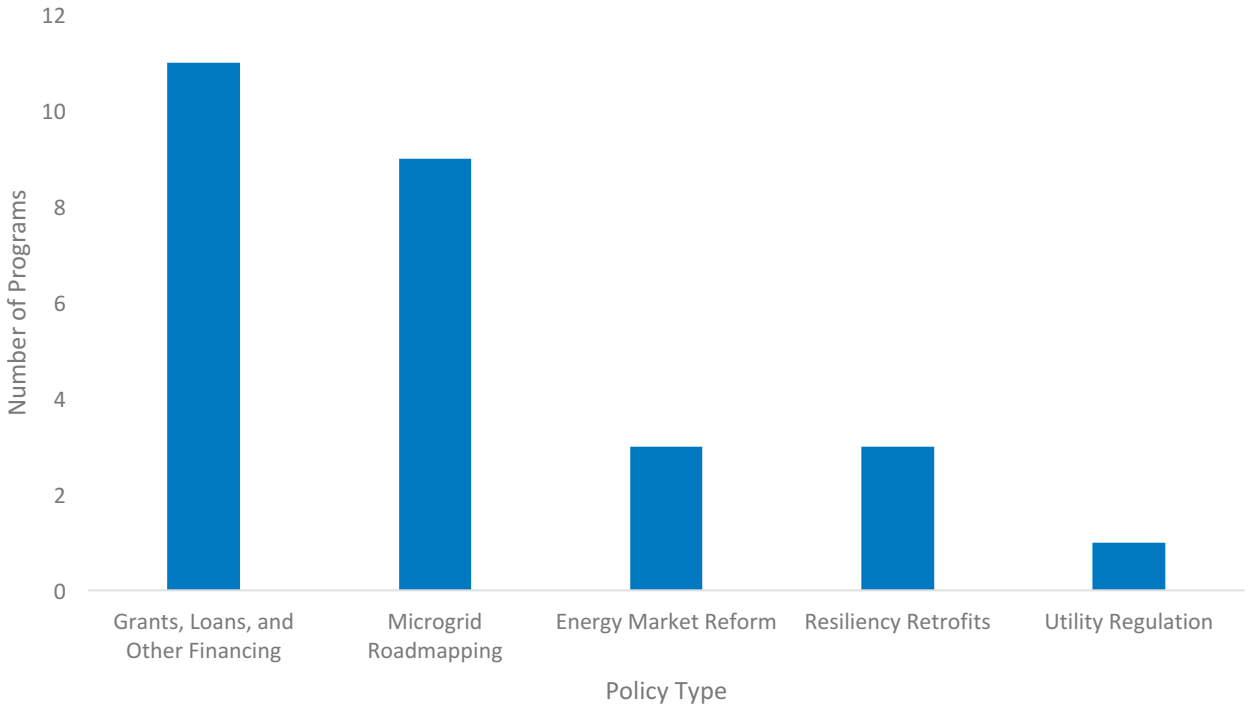
Surveying the Policy Landscape

- Some policymakers have identified this opportunity and developed policy to support resilient microgrids
- NREL conducted a literature review and relied on interviews with 22 subject matter experts nationwide to identify policies that directly support the resilient microgrid market
- This analysis identified 27 policies across 12 states

Surveying the Policy Landscape

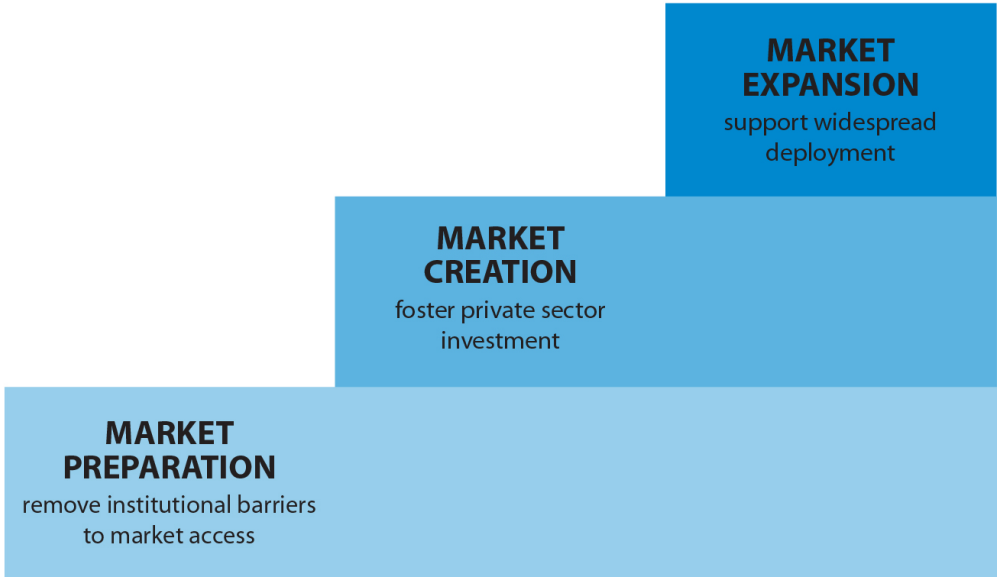


Microgrid-related Policies by State



Building a Policy Stack for Microgrids

- Policy survey illustrates few states have adopted microgrid policies.
- Policymakers may benefit from understanding how to sequence policy to foster a broader market, with private sector investment



Resilient Microgrid Policy Stack

MARKET EXPANSION

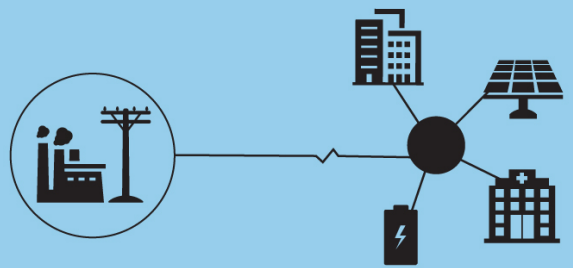
- Financing
- Foster innovation
- Energy market reform

MARKET CREATION

- Pilots
- Utility procurement
- Mandate

MARKET PREPARATION

- Energy, microgrid, and resiliency planning
- Value streams
- Regulatory treatment
- Interconnection standards



Market Preparation

- Energy, resilience, and microgrid planning
  - Provides policymakers with information on how resilient microgrids may fit into broader policy priorities
- Quantifying value streams
  - Provides policymakers and developers with the relevant information to understand costs and benefits
- Regulatory treatment
  - Provides regulatory certainty for microgrid developers
- Interconnection standards
  - Clarify how microgrids may connect and interact with the grid

Market Creation

- Policymakers could select a wide variety of market creation policies we consider three:
  - Pilots
  - Utility Procurement
  - Mandates
- These options track from lowest to highest impact and policymakers will need to consider which approach is best to achieve their policy objectives

Market Expansion

- Policymakers also have a multitude of options for expanding markets, some highlighted by the interviewees included:
  - Adopting innovative financing options
    - Public private partnerships
    - ESPCs
    - Tax incentives
  - Fostering innovation through supporting research and development into business models and new technologies
    - Clean energy technology incubators
  - Reforming energy markets
    - Some policymakers are considering new regulatory models that leverage emerging technologies like microgrids in innovative ways

Conclusions and Next Steps

- Policymakers are actively considering approaches to support resilient microgrid markets in their states
- This research offers a guide to help policymakers understand how they might sequence their policy to get the best results
- Pathways for Future Work:
  - Develop prioritization strategies for states to identify prime critical infrastructure for microgrid deployment
  - Assess the impact of each policy in the stack on microgrid deployment to clarify which policies are most critical to the market
  - Build on the policy stack as more states experiment with resilient microgrid policy approaches

Thank You!

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Microgrid Cost Study

Francisco Flores-Espino
Microgrid 2018, Chicago, IL
May 9, 2018

Microgrid Cost Study

- Find the variables that have the most significant* impact on costs and potential areas for cost reduction

Phase One

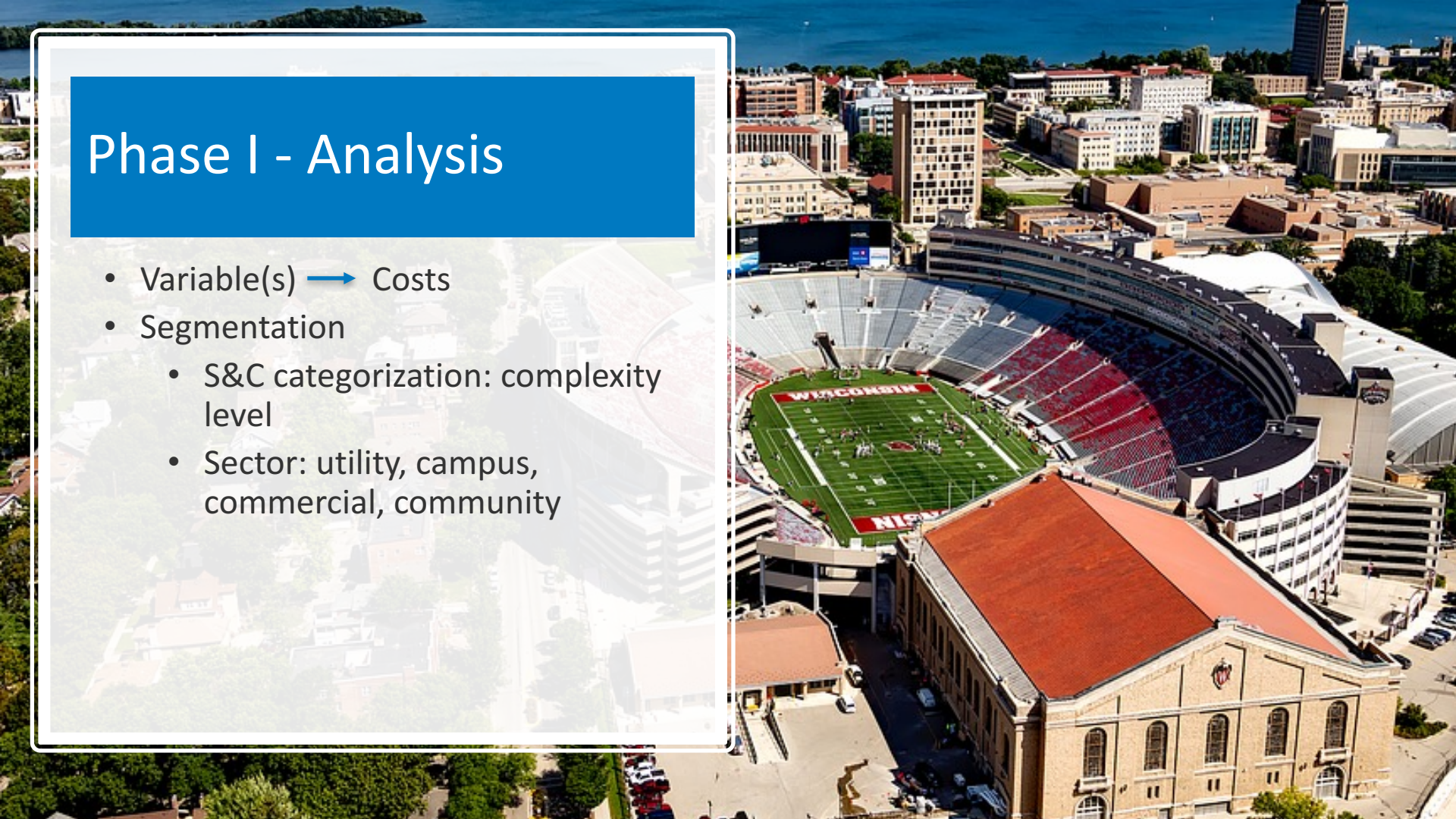
Cost data collection and analysis

Phase I - Database

- 80+ projects, costs by category
- Survey, online information, Navigant partnership

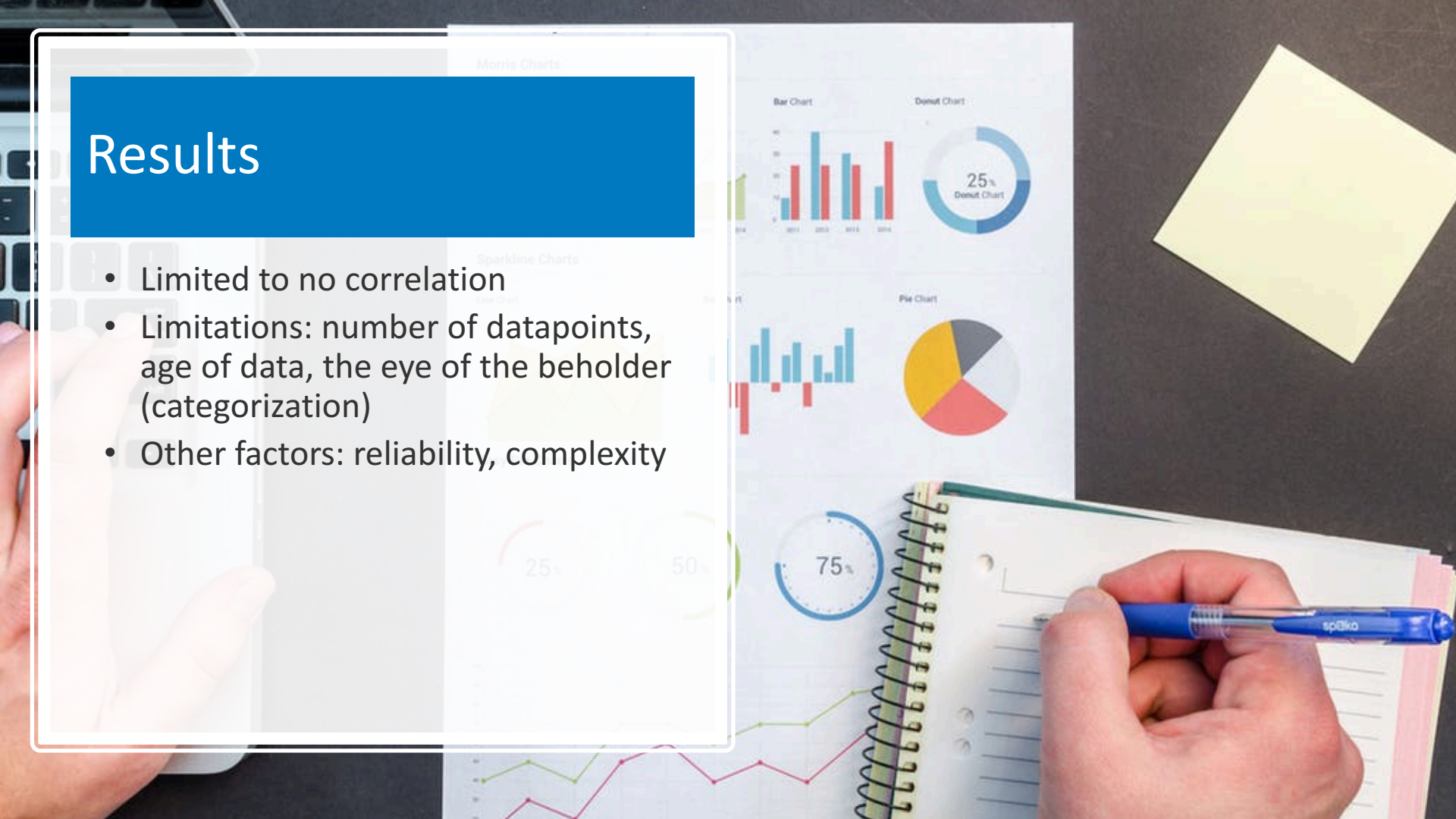
Phase I - Analysis

- Variable(s) → Costs
- Segmentation
  - S&C categorization: complexity level
  - Sector: utility, campus, commercial, community

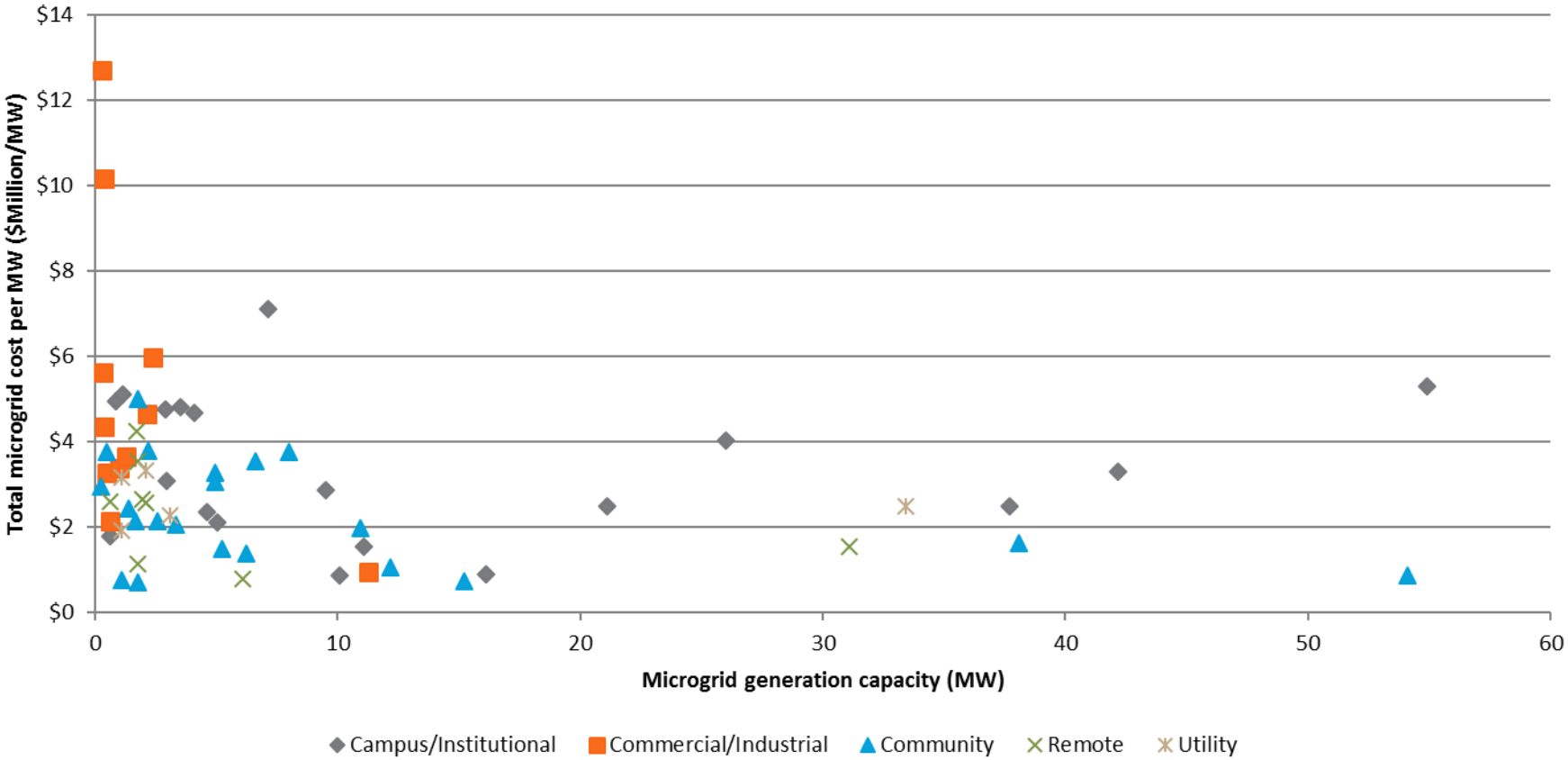


Results

- Limited to no correlation
- Limitations: number of datapoints, age of data, the eye of the beholder (categorization)
- Other factors: reliability, complexity



Total Cost per MW by Segment



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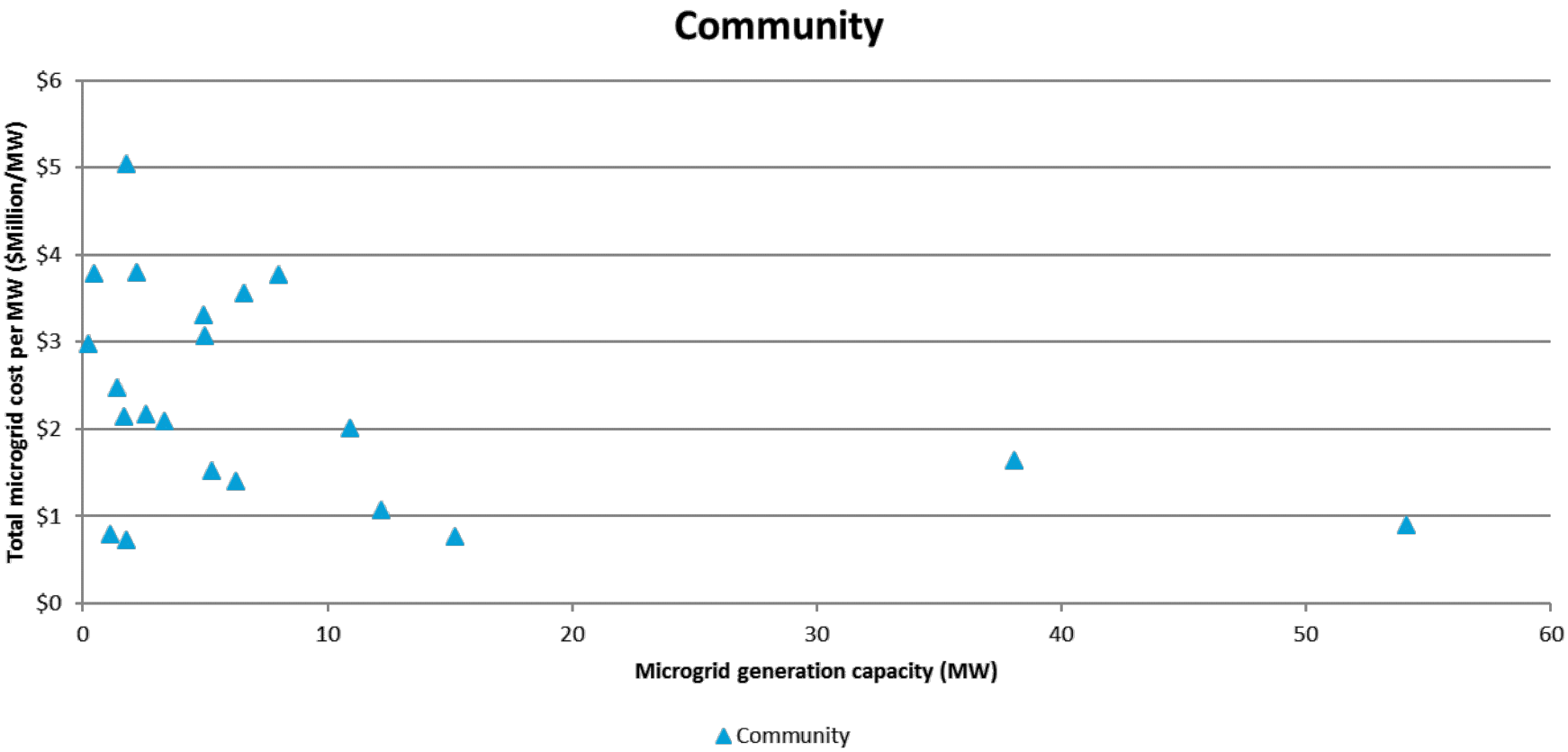

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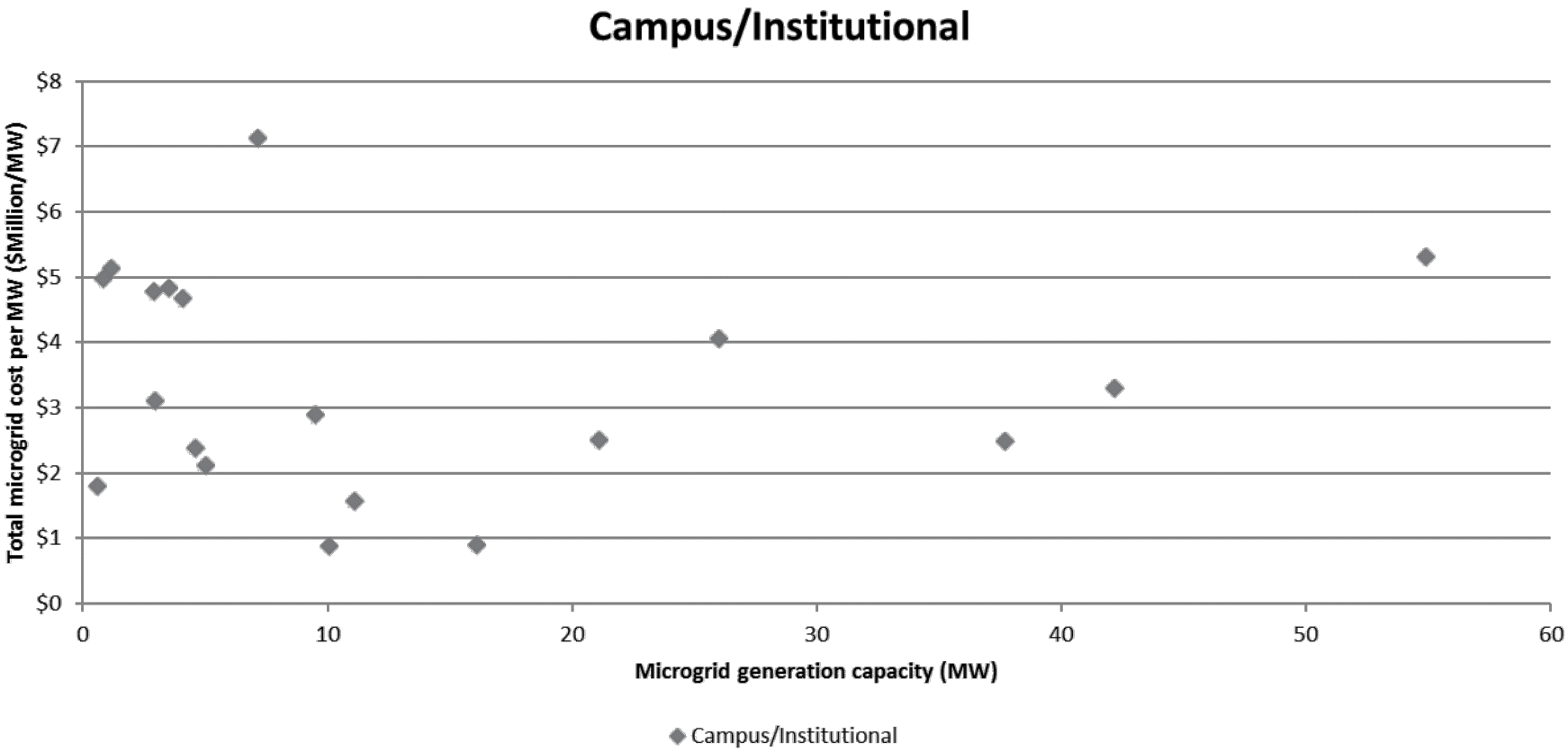


Phase Two

Cost Model and Barrier Analysis

Cost Model

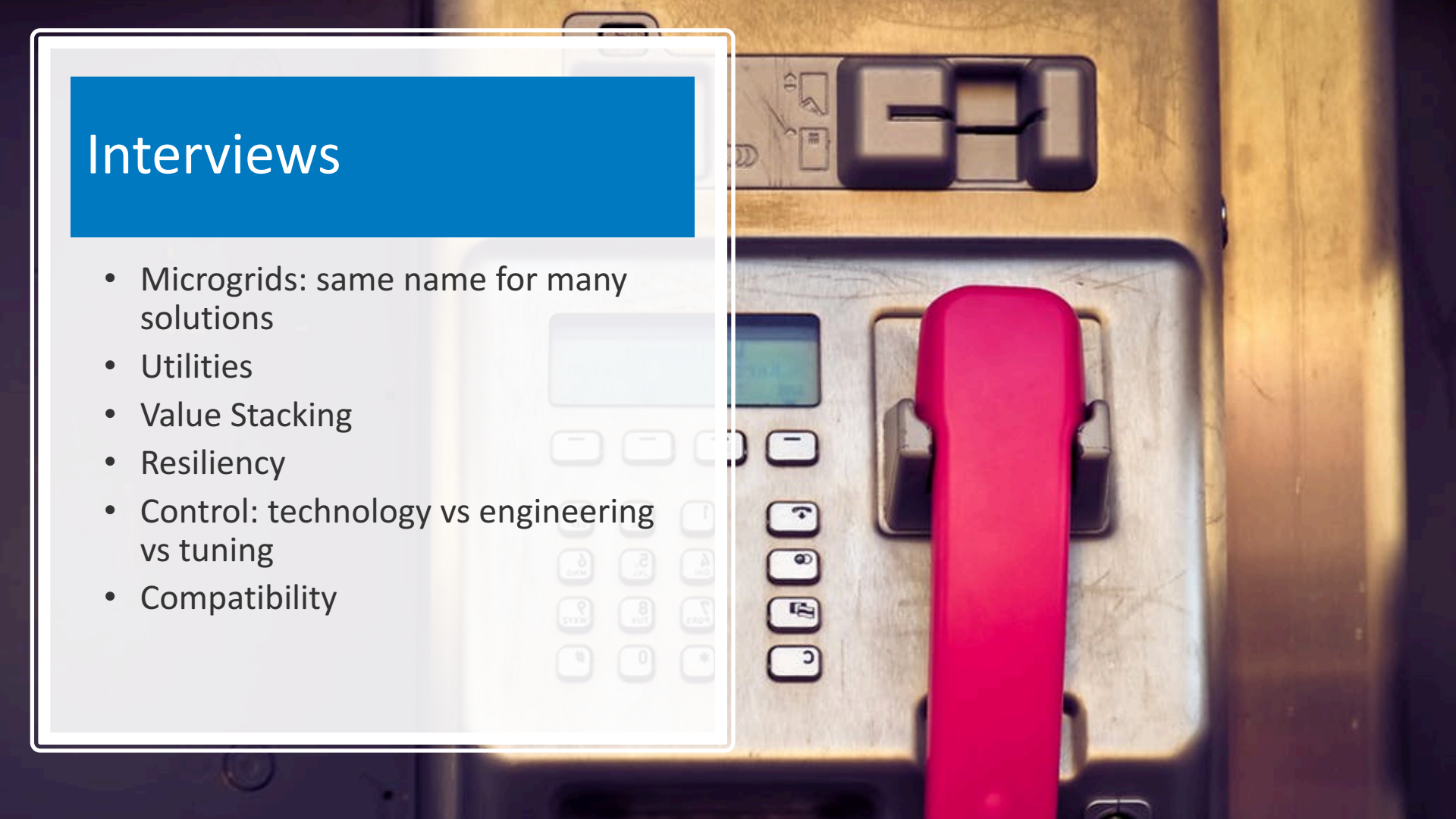
- Work in progress: conceptual phase
- Simple characterization
- Cost reduction opportunities

Barriers Analysis

- Interviews
- Survey
- Event
- Report

Interviews

- Microgrids: same name for many solutions
- Utilities
- Value Stacking
- Resiliency
- Control: technology vs engineering vs tuning
- Compatibility



Next Steps

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