Impact of Fuel Supply Chain Disruptions on Energy Resilience: A case for Nuclear Energy

Guillaume L’Her, Mark Deinert
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- Natural hazards cause large energy network disruptions
  - Hurricanes, seismic, landslides, floods, temperature extremes, …
  - Hurricanes are notably important in the Caribbean region as they can cause high wind, flooding, and landslides
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- Resilience:
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- Most developing countries and at risk regions in developed countries do not have a resilient enough power infrastructure

- Three main avenues for resilience:
  - Impact on transmission lines
  - Impact on power plants
  - Impact on fuel supply chains
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Context by example: Harvey

- Harvey hit Texas, USA on August 26, 2017
- Diverse energy sources allowing for anecdotal comparisons of impacts:
  - Oil/Gas shortages
  - High wind, no sun: renewables offline
  - Nuclear stayed online
Keeping climate change in mind

- Climate change will increase the frequency and severity of natural hazards

- Fossil fuels need to be replaced by carbon-free energy sources, notably:
  - Hydroelectricity
  - Wind
  - Solar
  - Nuclear
An Open ‘Green Energy’ Market

- Developing countries predominantly rely on fossil fuels
  - Imported fuel supply chain becomes a critical factor in the system resilience
  - Critical dependence on the road network
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- Nuclear energy is a clean and stable energy source
  - Designed to be resilient to external events
  - Remove the need for frequent refueling
Our Analysis

- Quantify the fossil fuel refueling risk
  - Stochastic method based on network analysis to assess the resilience of existing power infrastructure
  - Assessment of the supply chain in the face of natural hazards
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- Assess the SMR/MMR potential
  - Siting possibilities
  - Follow US Nuclear Regulatory Commission rules
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- Demonstrate on the Commonwealth of Dominica
Dominica
Existing Infrastructure In Dominica

- **Hydropower**: Roseau river → 6.6 MW
- **Diesel plants**:
  - Fond Cole (south) → 13.3 MW
  - Sugar Loaf (north) → 6.8 MW
- **Seaport**
- **3 Ports**
Exposure Assessment and Informed Probabilities

An example of road exposure to natural hazards

Failure probabilities are obtained for each road segment
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A: Road network  B: 0.02 annual flood probability (“50-year”) extent
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Monte Carlo analysis:
- 1000 simulations
- The network is disrupted according to the road segment failure likelihood in a 50-yr flooding situation.
- Supply chain impact is obtained (in terms of time)

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Stranded asset!
Market Opportunity For Nuclear Energy

- 20 MW of fossil fuel power to transition
  - 6.8 MW at high risk of supply disruptions
- Another 6.6 MW at high flooding risk (run-of-the-river hydro plants)

- Between 6.8 and 26.6 MW market on this developing island nation
Local Potential of Nuclear Energy

- The potential of Small Modular Reactor (SMR) is assessed locally
  - Using NRC siting regulations, find siting locations of interest to show viability

- Use Geospatial Information System analysis
  - Combine all relevant map data layers to reveal suitable nuclear siting locations
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- Land within a volcanic high risk area is excluded.
Siting Potential for Small Modular Reactor

1 issue
2 issues
3 issues
4+ issues
no issue

30 arcsecond → 1x1 km
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Sugar Loaf power plant site infrastructure could even be reused for a small modular reactor.
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  - Reliable (high capacity factor)
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- **Emerging grids: SMR and MMR market**
  - Adapted to small grids in development
  - Scalable
  - Suitable locations exist