Anti-icing Investment in the Electric Grid: A preliminary case study of Climate Resilient Infrastructure

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Introduction

- The black out in Texas in early 2021 illustrates how important it is to prepare infrastructure for climate disasters.
- In early 2008, Southern China also experienced a massive black out due to unexpected wet-cold weather, which paralyzed the regional electric grid.
  - A lack of resilience considerations in designing/engineering standards
  - A lack of monitoring system and high-tech equipment
- Following the disaster, billions were invested to ice-proofing the grids and related infrastructure, enhancing the climate-resilience of the national grid.
  - RMB 14 billion were devoted to upgrade existing wires, towers, and poles
  - Leveraging new technologies to conduct online-monitoring
  - Developing new equipment to melt ice, even with firing drones

Massive black out in Southern China in 2008

- In early 2008, the lasting weather of coldness and humidity led to severe wire icing
  - Electricity supply in 13 out of 34 provinces were affected
    - In Guizhou: 80% of 10 KV wires and 83% of substations suspended out of service
  - 130 out of the 2859 counties in China experienced black out
  - 36,700 pieces of wires and 2018 transformer substations were destroyed
  - Major railway networks of Beijing-Guangzhou and Shanghai-Kunming, which were electrified, were out of services

A grid tower fallen because of the heavy ice in 2008 in China

Reasons Behind

- A lack of resilience in designing/engineering standards
  - By 2008, the major grids (500 KV) in Southern China were designed to survive in a once-in-30-year disaster, while branch grids (220 KV and below) were designed to survive a once-in-15-year disaster
  - By these standards, the major grids can only shoulder icing thinner than 20 mm, while the actual icing in 2008 were almost all above 30mm (maximum >= 110 mm)

Reasons Behind

- A lack of anti-icing system, consisting of
  - A model to predict icing conditions
  - A monitoring system to detect wire-icing events
  - A standardized ice-removing process tailored to different scenarios and conditions
  - A mechanism to take anti-icing into considerations when designing and constructing electric grids

Reasons Behind

- A lack of equipment/technologies/innovations for ice-removal
  - To remove ice, workers had to rely on bare hands and the sun

"We had to knock off the ice with bamboo sticks and hammers, or to wait for the sun to melt it", said Chief Technology Officer of Guizhou Electricity Institute.

Anti-icing Efforts in the past 12 years

- Anti-icing upgrades to existing grid facilities
  - RMB 14 billion were spent since 2008 to enhance the resilience of 2098 pieces of existing wires, mostly completed by 2012 in Southern China
- A system of icing monitoring
  - For instance, in Guizhou Province, online-monitoring sensors/cameras were installed in all 256 spots which have a medium or high risk of icing
  - A warning-inspecting mechanism consists of provincial grid companies, regional grid companies, and transformer substations were set up
  - Close cooperation between grid companies and meteorological companies were established

Anti-icing Efforts in the past 12 years

- Research and innovations in ice-removing/monitoring equipment
  - DC ice-melting devices (usually stationary, used for major grids)
    - With remote access and control by only two personnel
  - AC ice-melting technology (melt ice without suspending operations, branch grids)
  - Mobile ice-melting devices
  - Drone-based ice-melting devices

Drone-based ice-melting devices in Yunan Province, China

Recent Tests

- In Guizhou: two rounds of wet-frozen weather in 2014 and 2011
  - Major grid networks remained functional through out the periods
  - No falling towers in the critical networks (220 KV and above)
- A 35-day wet-frozen weather period in early 2018 in Southern China
  - Major grid networks remained functional through out the period
  - only 225 towers/poles were damaged (in 2008: 271,236)

Some questions worth further exploring

- How are the cost and benefits of resilience shared among stakeholders?
  - How were the investment funded, especially those in research?
    - Government subsidy?
    - Debt?
  - How are the benefits shared?
    - By the National Grid (increase transmission fee)?
    - By the consumers?
- What are the practical lessons that can be learned in making infrastructure resilient?
  - Awareness?
  - Implementation?
  - Costs/benefits-sharing mechanisms?