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Replacing Transmission Infrastructure with Solar and Energy Storage Systems: An Islanded Microgrid Case Study

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Abstract

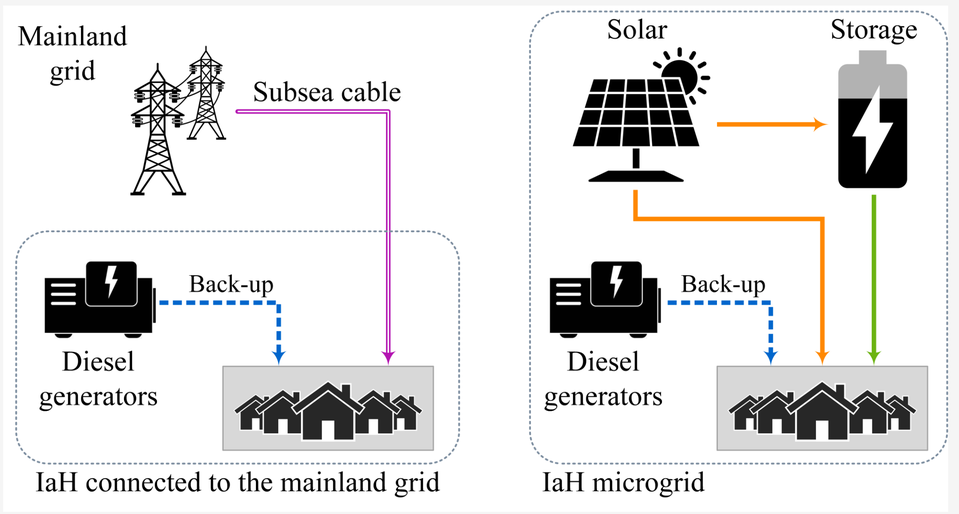
Substantial decreases in the cost of solar and energy storage systems create suitable conditions for implementing microgrids that operate independently from the main grid. Such microgrids concept is particularly of interest for islanded and remote communities, which oftentimes rely on expensive energy resources to supply their demand. This work presents the design of a microgrid for an island community, in which transmission infrastructure (an aging subsea cable that connects to the mainland grid) is replaced by solar and energy storage systems. Based on historical demand data and solar generation forecasts, an optimization framework is proposed to determine sizes of the microgrid components such that the local generation resources are self-sufficient and reliable. Results of this analysis show that, indeed, solar and energy storage systems are viable choices for implementing a microgrid and replacing transmission infrastructure.

Background

- Isle au Haut (IaH) is a small unbridged island in the coast of Maine.
- The current distribution system is connected to the mainland via an aging subsea cable (35+ years).
- IaH is considered an *extremely high cost community* according to USDA guidelines.
- Electricity consumption is around 285 MWh/year, with a peak in the summer.

IaH Microgrid

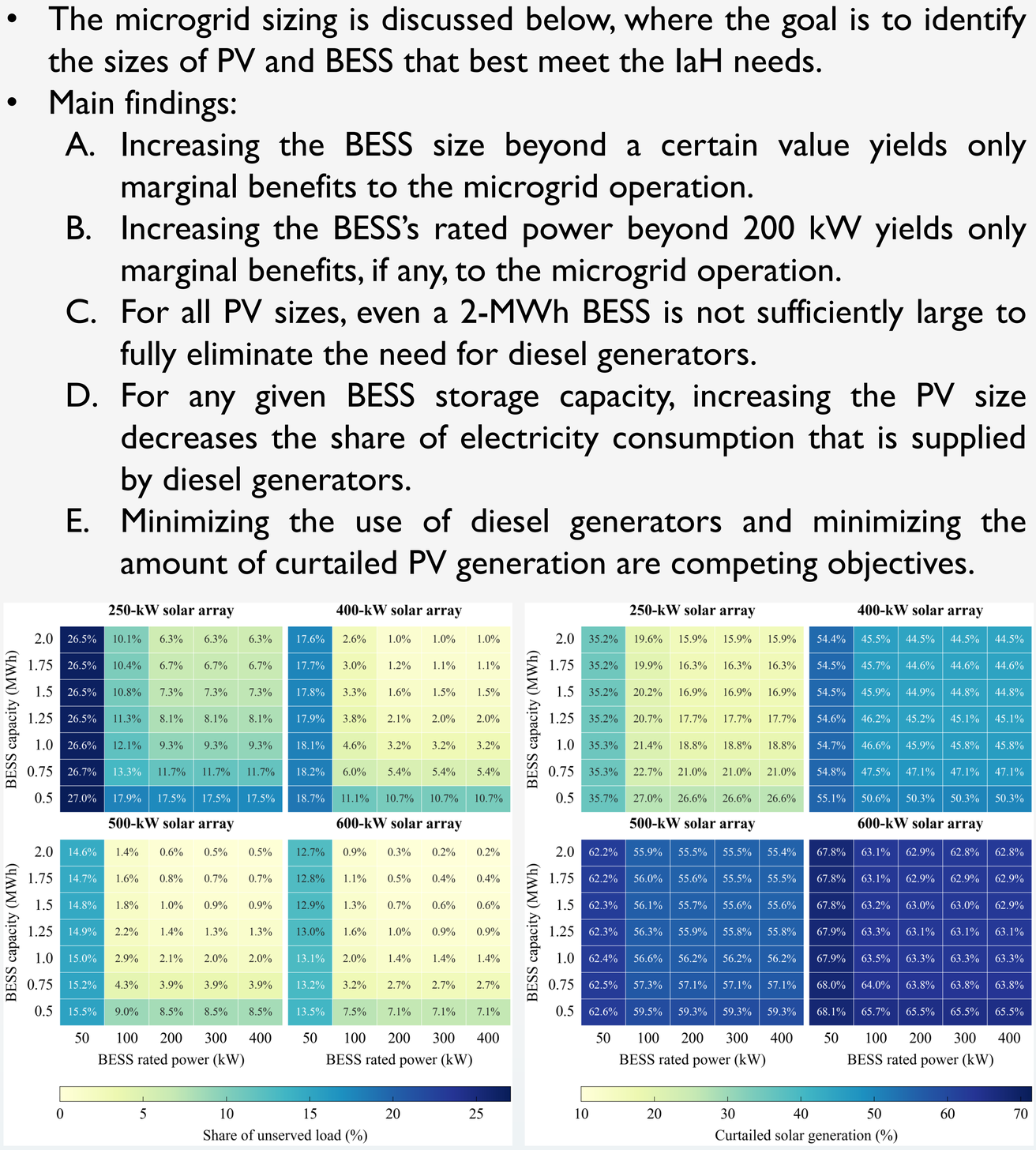
- As the subsea cable is expected to fail in the near future, IaH is exploring alternatives to its replacement.
- The current plan is to migrate the island's power infrastructure to a microgrid framework, containing:
  - Solar arrays (PV)
  - Energy storage system (BESS)
  - Diesel generators (backup)



Results

Sizing of the microgrid components:

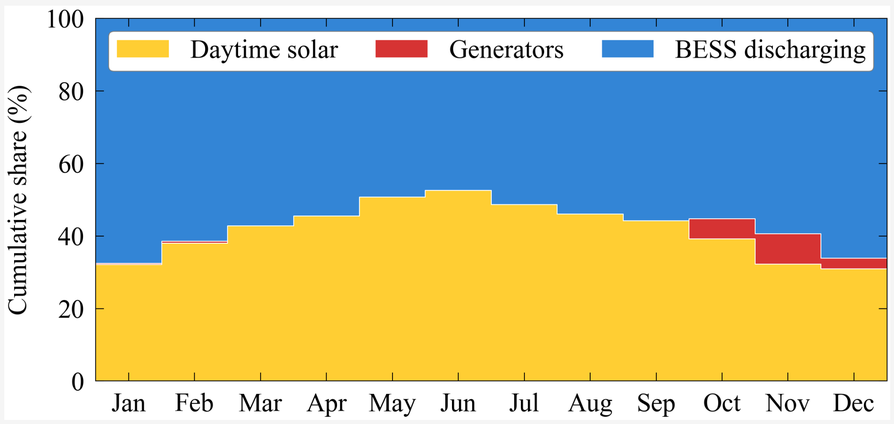
- The microgrid sizing is discussed below, where the goal is to identify the sizes of PV and BESS that best meet the IaH needs.
- Main findings:
  A. Increasing the BESS size beyond a certain value yields only marginal benefits to the microgrid operation.
  B. Increasing the BESS's rated power beyond 200 kW yields only marginal benefits, if any, to the microgrid operation.
  C. For all PV sizes, even a 2-MWh BESS is not sufficiently large to fully eliminate the need for diesel generators.
  D. For any given BESS storage capacity, increasing the PV size decreases the share of electricity consumption that is supplied by diesel generators.
  E. Minimizing the use of diesel generators and minimizing the amount of curtailed PV generation are competing objectives.



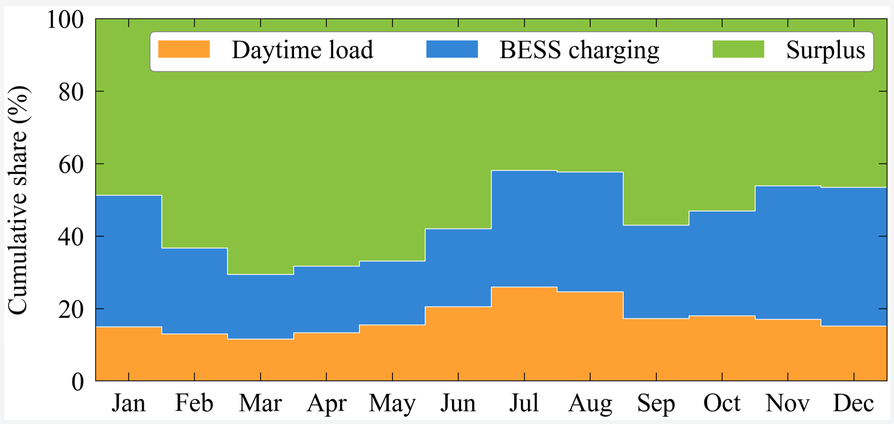
Note: *unserved load* corresponds to demand met through the backup diesel generators.

Case Study:

- Based on this analysis, the scenario with a 500-kW PV and a 1.25-MWh, 200-kW BESS represents one of the best combinations for IaH.
- Mix of resources supplying the total monthly electricity consumption:



- Breakdown by usage of the total monthly PV generation:



- These results show that a PV+BESS microgrid is a viable alternative to replacing the subsea cable at IaH.
- The surplus in PV generation represents an opportunity for IaH to implement demand response programs.

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