EVERBESS: END OF LIFE CONSIDERATIONS FOR STATIONARY ENERGY STORAGE SYSTEMS

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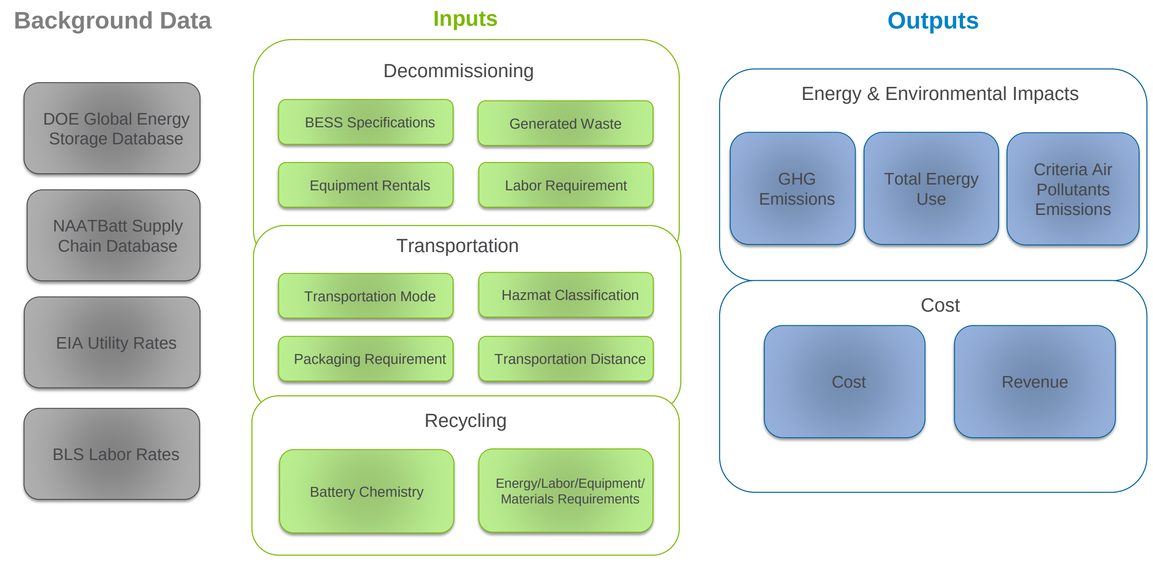
MOTIVATION

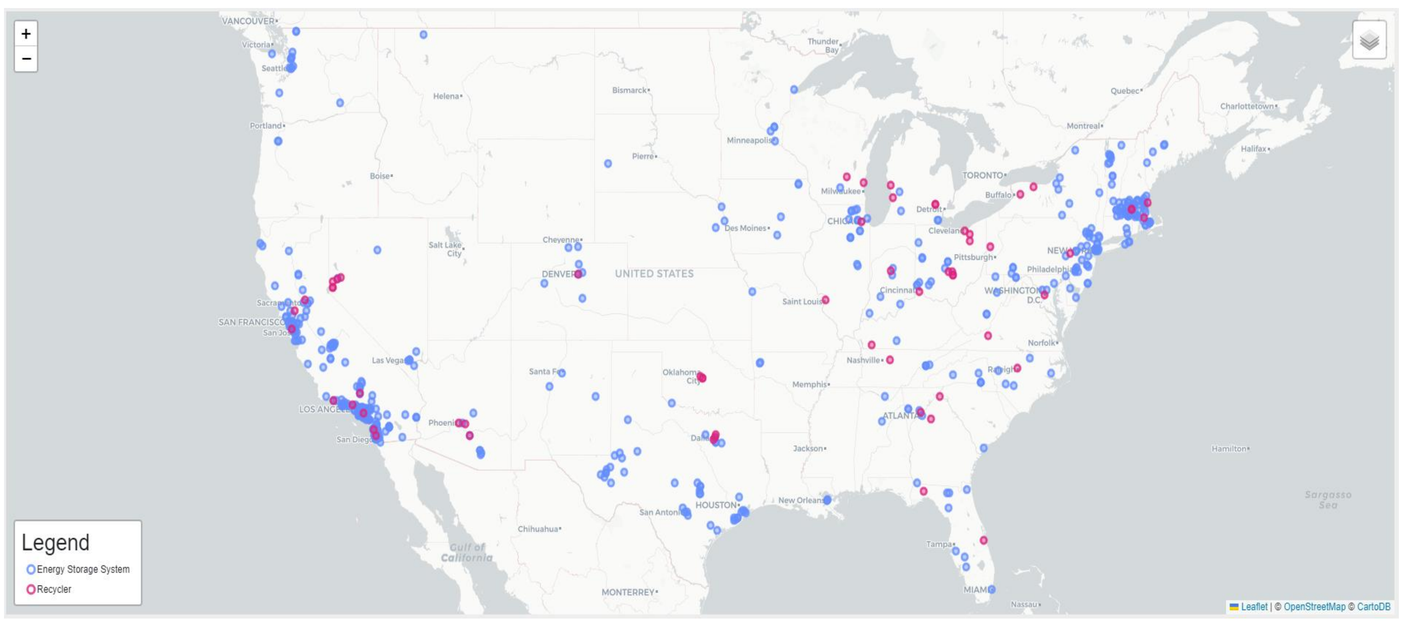
EverBESS is a modeling tool that assesses the cost and environmental impacts associated with end-of-life (EOL) battery energy storage systems (BESS). The model considers the decommissioning, transportation, and recycling of the entire system as part of its EOL considerations. The goal of EverBESS is to improve the understanding of EOL management for these systems and to share this knowledge with stakeholders. Current EOL management plans, if even available, do not include the necessary details to make informed estimates of the required costs or produced emissions. The EverBESS model aims to provide the following benefits:

- Improve cost and environmental impacts over the life cycle of BESSs
- Provide better decision making in the planning and design stages
- Promote awareness of potential EOL options



MAJOR ACCOMPLISHMENTS

We have created the preliminary version of EverBESS that allows users to select known energy storage systems and recycling facilities in the U.S. to determine the EOL costs and emissions. Users may also define their own custom BESS or recycling facility to create EOL management scenarios.



Decommissioning
- De-energizing
- Disconnection and covering of module electrodes
- Removal and packaging of modules
- Removal of all other system components
- Site cleanup

Transportation
- Transport of modules to a capable recycler
- Transport of other system components to a scrap yard or resale
- Hazardous material requirements may exist

Recycling
- Battery modules disassembly or size reduction
- Recovery of critical minerals and metals from batteries
- Recycle non-battery components

IMPACT

- Holistic look at all EOL management steps for battery and non-battery components
- Identify resale or reuse opportunities for common BESS components
- Assist in the creation of EOL management plans
- Inform R&D for new BESS technologies
- Can be used to help identify sites for new recycling plants

Battery Modules
- Must be securely packaged with electrode ends covered
- Hazardous transportation requirement

Power Conversion System
- Specialized labor required, if liquid cooled
- Resale or recycled for scrap value

Transformer
- Specialized labor required, if liquid cooled
- Established resale market
- Recycled for scrap value if specialized equipment

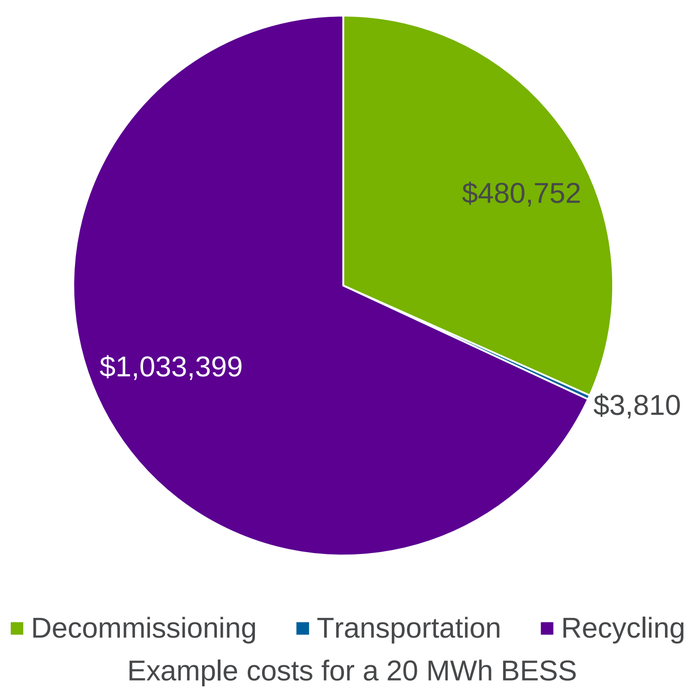
HVAC Thermal Management
- Refrigerant removal requires a certified specialist
- Newer systems opt for liquid cooled over forced air

Fire Suppression System
- Fire suppression agent may be classified as hazardous
- Suppression agent can be recycled

Battery Racks, BMS, Connector Cables
- Metal can be recycled for scrap value
- Some parts sent for electronics recycling for more recovered value

System Controls and Communications
- Metal can be recycled for scrap value
- Some parts sent for electronics recycling

System Container
- Established resale market
- Container modifications may impact resale value



CONCLUSIONS AND FUTURE WORK

- EverBESS can help improve life-cycle cost and emissions and enable a circular economy for BESSs
- Next steps in model development
  - Expand EverBESS to include other battery technologies such as vanadium flow and Na-ion batteries
  - Improve model granularity (e.g., add state-level data) and accuracy
  - Streamline the web interface to put less burden on the user
  - Identify revenue streams from decommissioning BESS to improve accuracy of total cost estimates

ACKNOWLEDGMENTS

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