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Behind the Meter Storage for Electric Vehicle Charging, Electrochemical and Thermal Energy Storage, and Solar Photovoltaic

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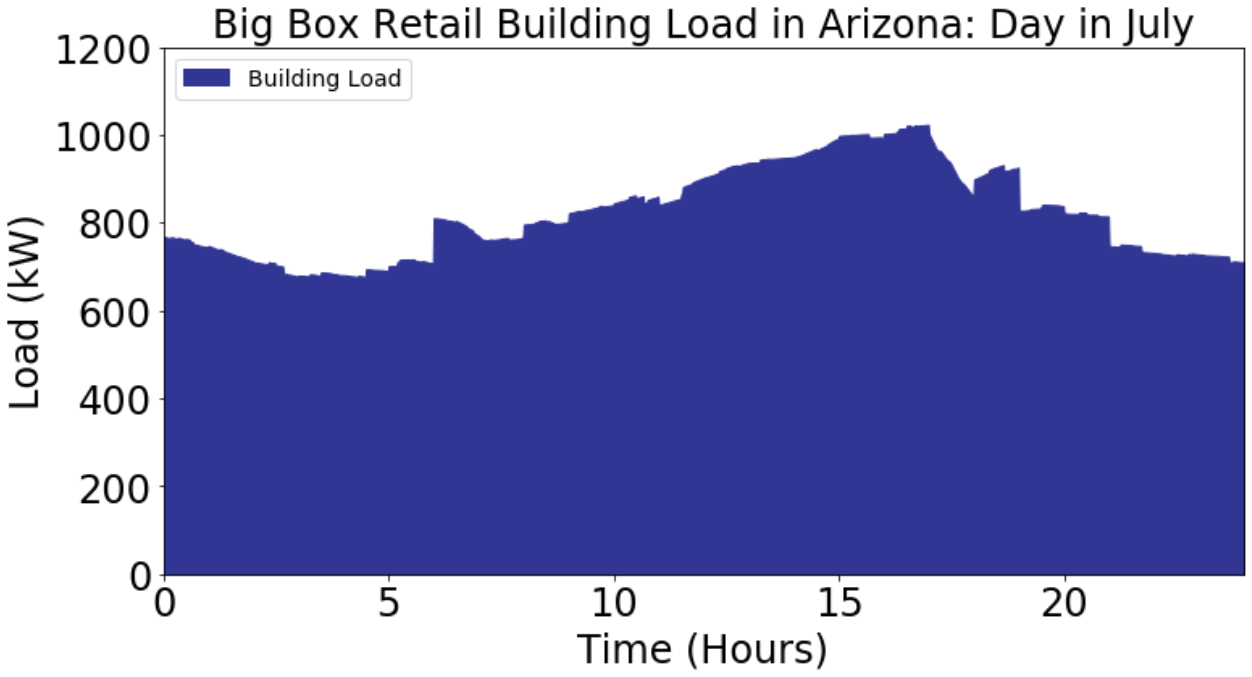
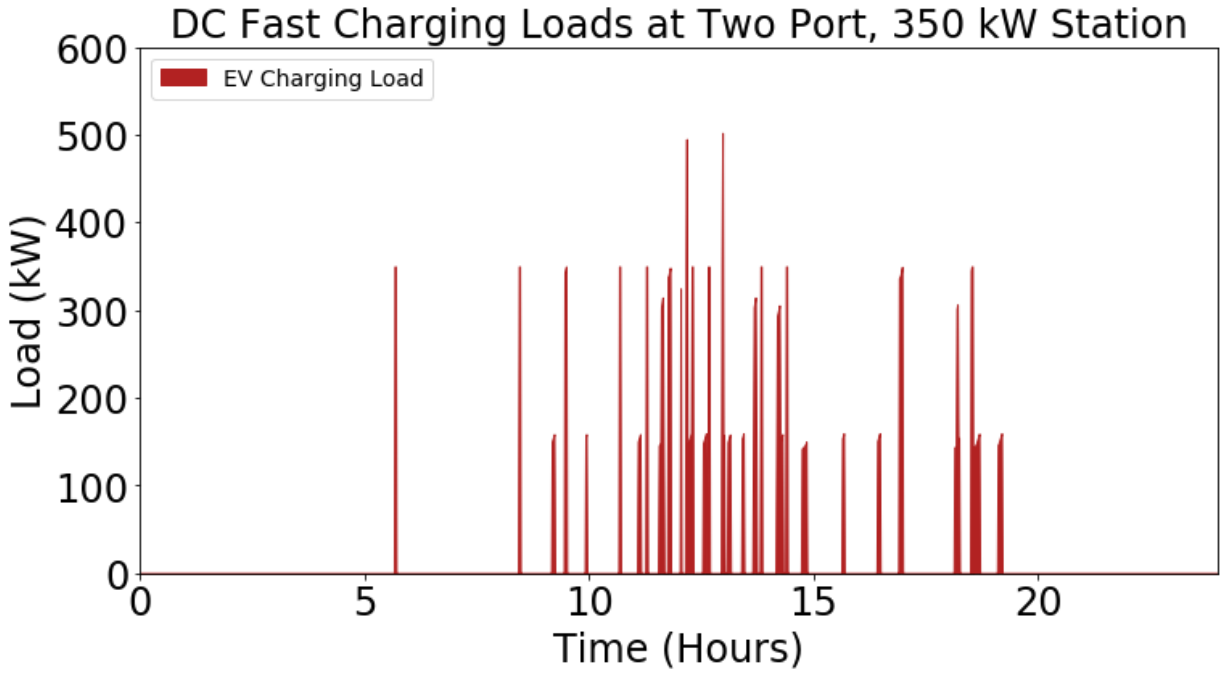
Why Behind the Meter Energy Storage?

- Significant electrical loads in buildings, largely due to thermal loads for HVAC and refrigeration
- Potentially large and irregular demands due to electric vehicle (EV) fast charging
- Potentially high penetrations of on-site intermittent renewable energy (i.e., solar PV)

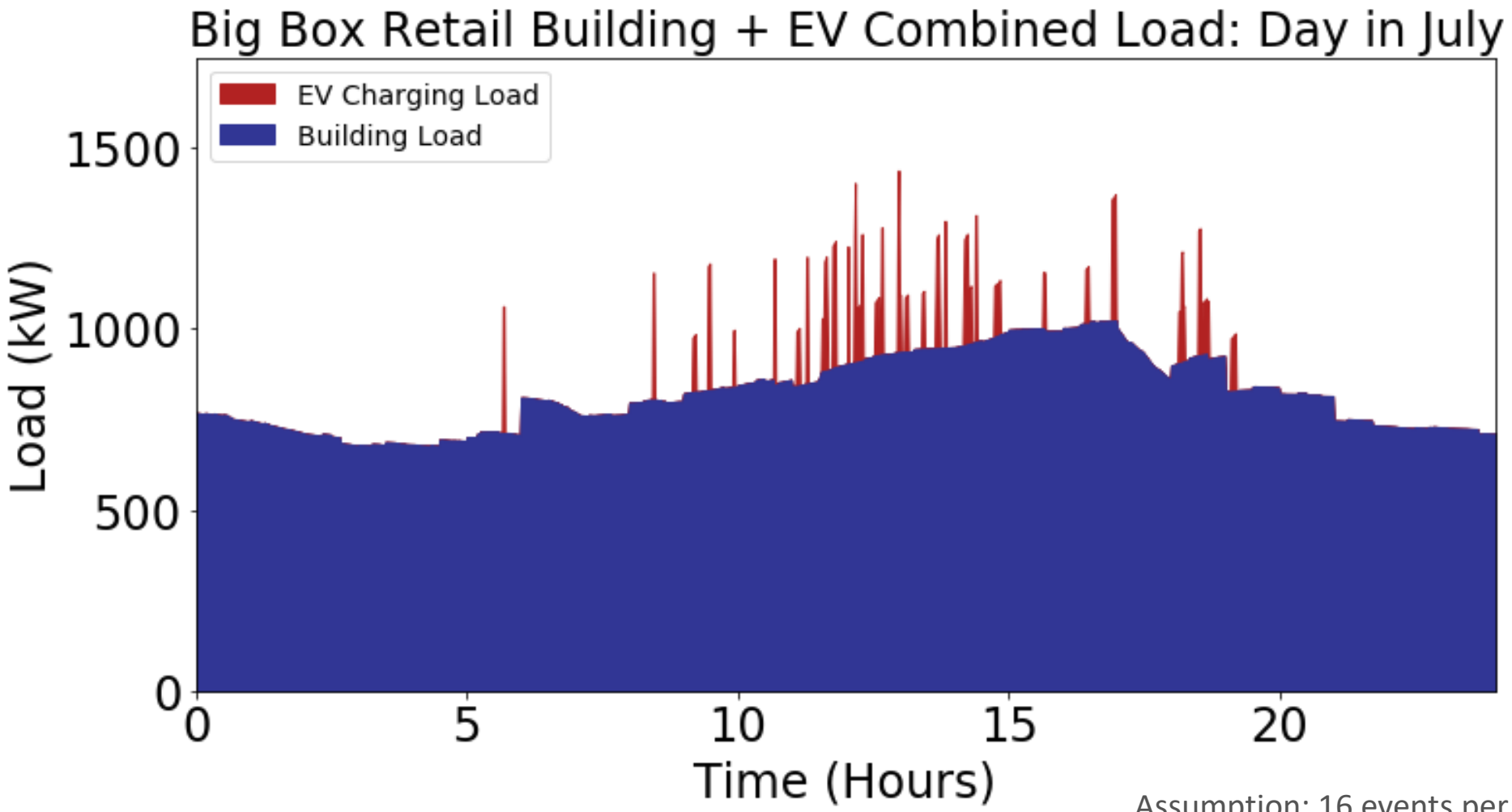




Assumption: 16 events per port per day

Combined Building and EV Charging Loads

A big box retail grocery store with extreme fast charging would have high electricity demands that are unpredictable due to EV fast charging



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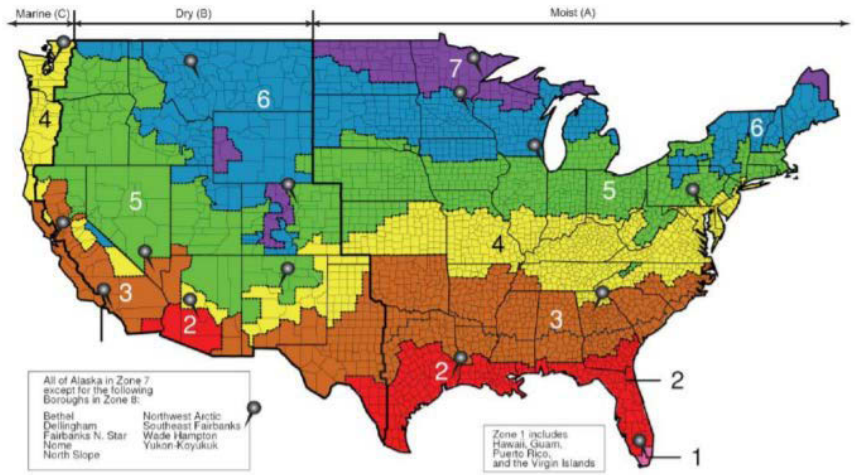
Behind the Meter Storage (BTMS) Analysis

What are the **optimal system designs** and **energy flows** for thermal and electrochemical behind-the-meter-storage with on-site PV generation enabling fast EV charging?

Vary climate



Vary building type

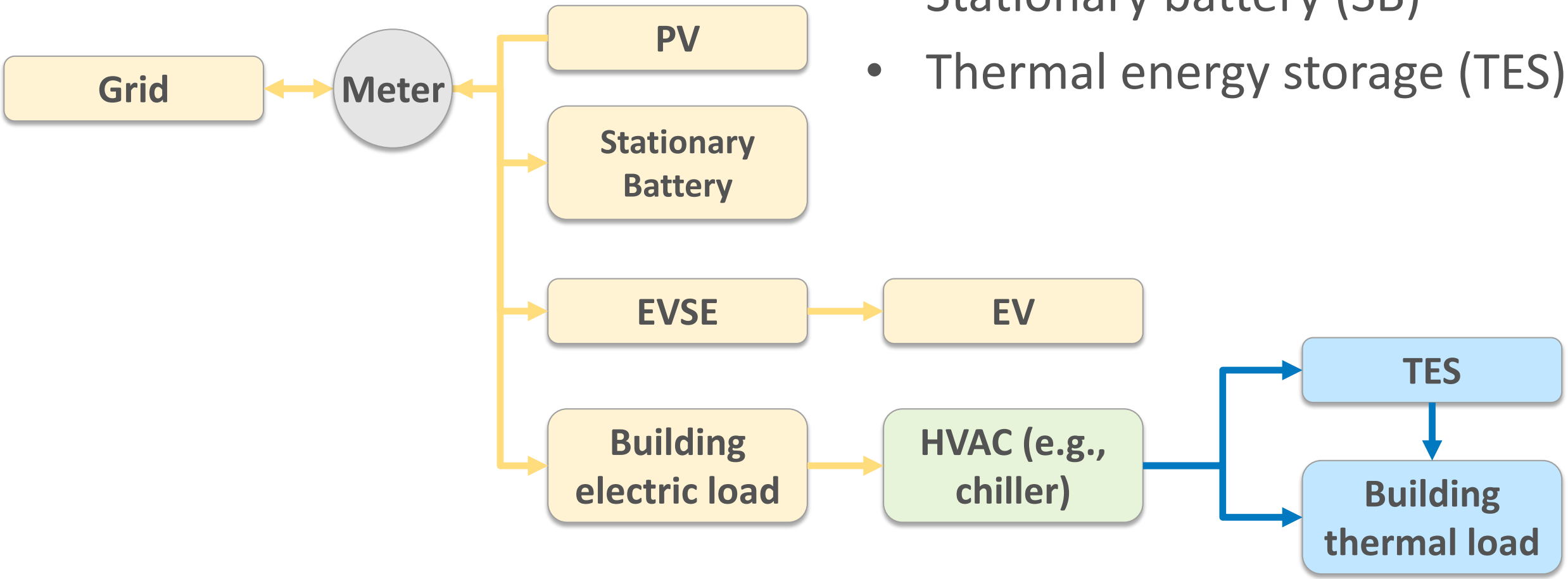
Vary electric rate tariff

Weekday Schedule

	12 am	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm
Jan	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Feb	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Mar	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Apr	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
May	1	1	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4	4	3	3	3	1	1	1
Jun	1	1	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4	4	3	3	3	1	1	1
Jul	1	1	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4	4	3	3	3	1	1	1
Aug	1	1	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4	4	3	3	3	1	1	1
Sep	1	1	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4	4	3	3	3	1	1	1
Oct	1	1	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4	4	3	3	3	1	1	1
Nov	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Dec	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1

Optimize System Sizing to Minimize Cost: PV + SB + EV + TES

- Solar photovoltaic (PV)
- Stationary battery (SB)
- Thermal energy storage (TES)



Multi-tool Simulation Platform: EnStore

- To complete this analysis, the team is developing a multi-tool simulation platform called **EnStore** (Energy Storage)
- EnStore leverages several existing tools, allowing for detailed simulation of:
  - Building energy loads and thermal energy storage technologies
  - Battery performance and lifetime models

Developing EnStore Tool for Multi-Model Optimization

EnStore tool will use **REOPT**, SAM, and EnergyPlus/OpenStudio:

- **REopt:** REopt uses a mixed-integer linear programming (MILP) approach to recommend the optimal mix of renewable energy, conventional generation, and energy storage technologies to meet cost savings, resilience, and energy performance goals. This MILP approach requires simplified, linearized models
- **SAM:** the System Advisor Model (SAM) is a techno-economic software model that can model many types of renewable energy systems, including photovoltaic systems, battery storage, concentrating solar power, and wind power
- **EnergyPlus:** EnergyPlus is a whole-building energy simulation engine that engineers, architects, and researchers use to model both energy consumption and water use in buildings; **OpenStudio:** OpenStudio is a suite of complementary tools that can expand EnergyPlus capabilities

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Reason for Tool Incorporation


REopt

- Determine preliminary optimal PV and stationary battery sizes for each application

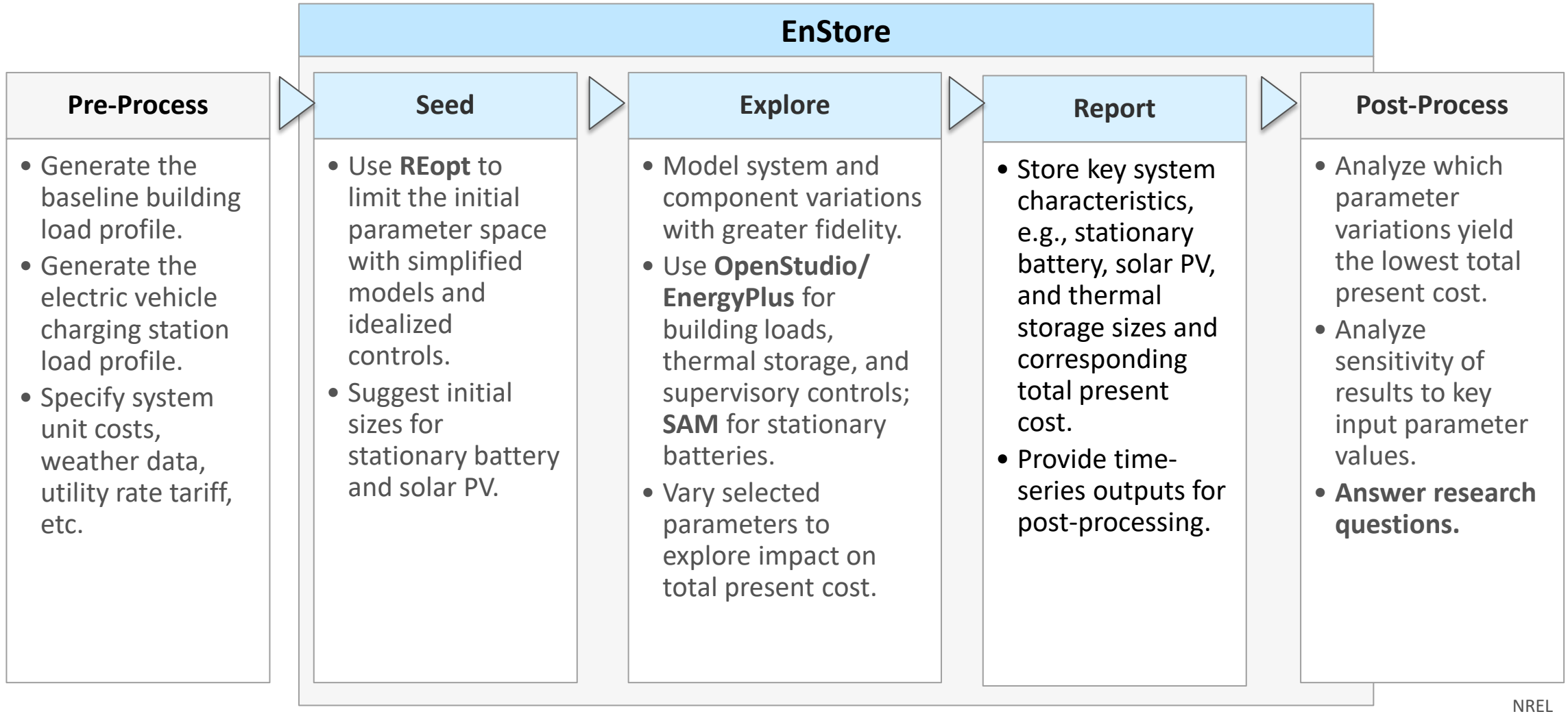
SAM

- Use detailed battery degradation models, utility bill calculator and discounted cash flow model

EnergyPlus/OpenStudio

- Model detailed building loads and thermal energy storage

High-Level Draft Model Architecture



EnStore Unique Capabilities

- Capture physical properties that may affect financial metrics (e.g., TES heat loss rates)
- Model coordinated dispatch of multiple storage systems
- Capture interactions between disparate technologies with high fidelity
  - Explore novel battery chemistries with SAM
  - Explore novel thermal storage systems with EnergyPlus

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