Repurposing Second-life EV Batteries for Integration with Photovoltaic Grids and Grid Stability Applications

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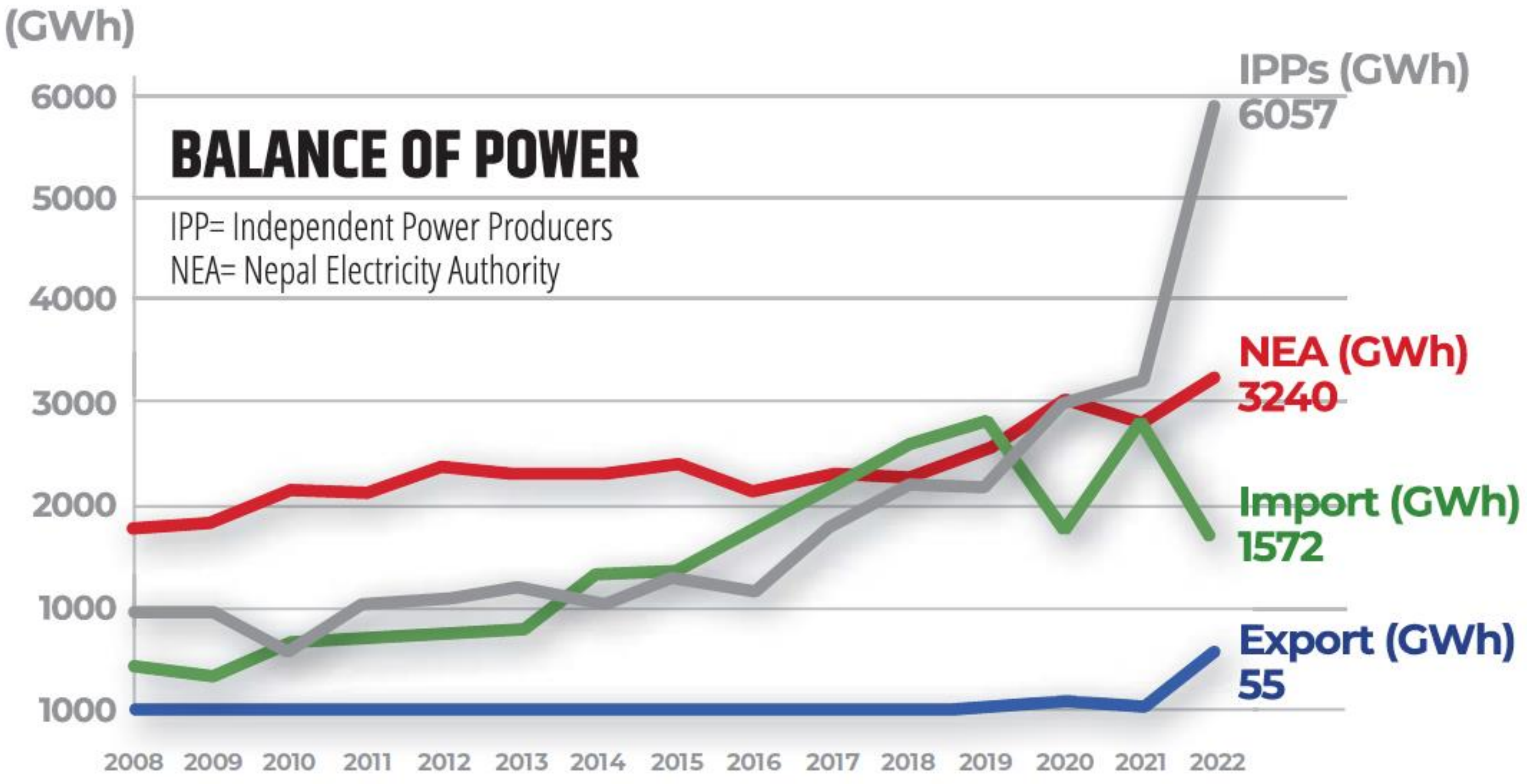
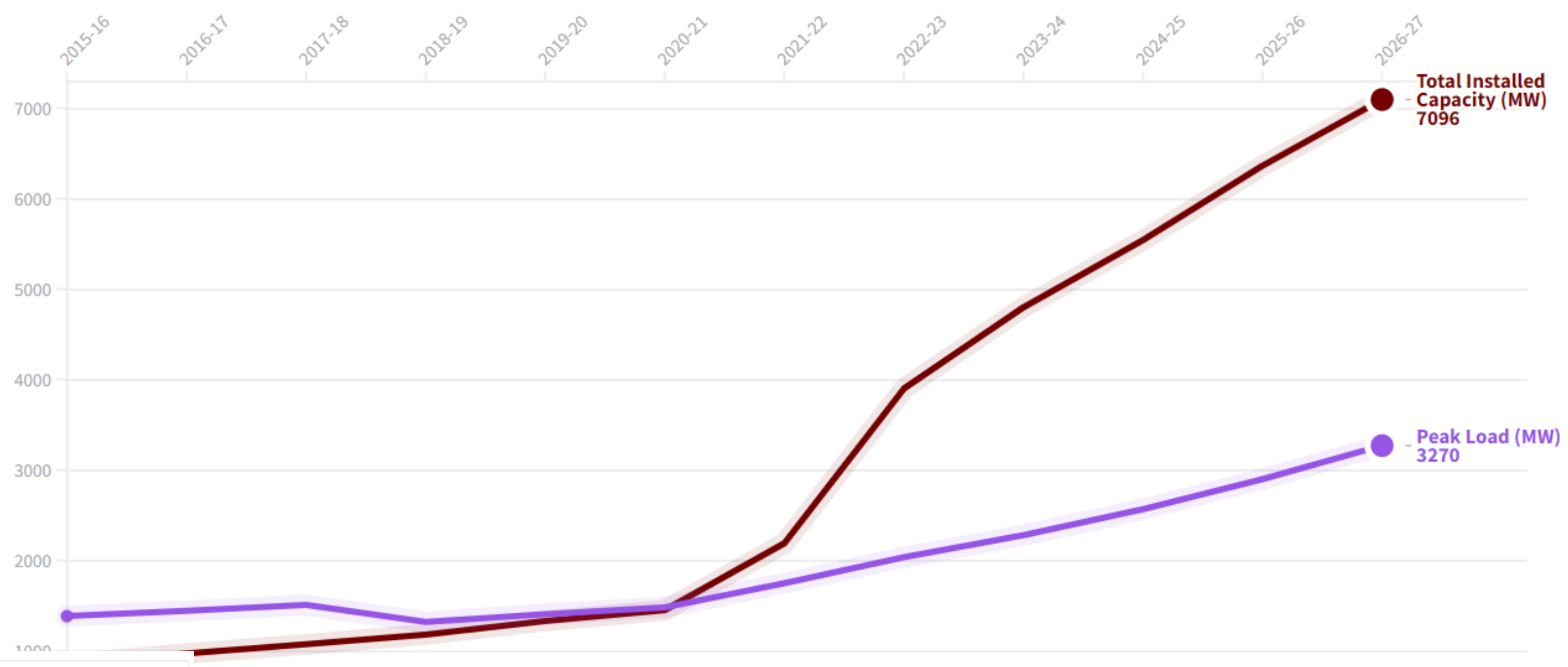
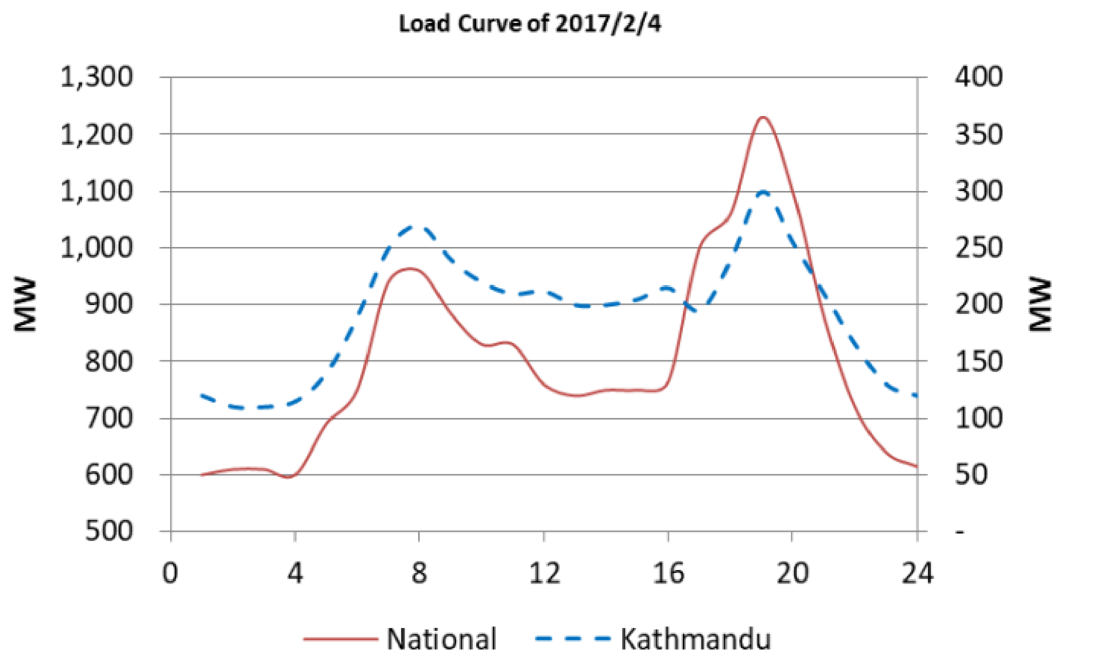
Background: Nepal’s Energy Status



SOURCE: NEPAL ELECTRICITY AUTHORITY. IPPs INCLUDE NEA SUBSIDIARIES

Opportunity for EVs

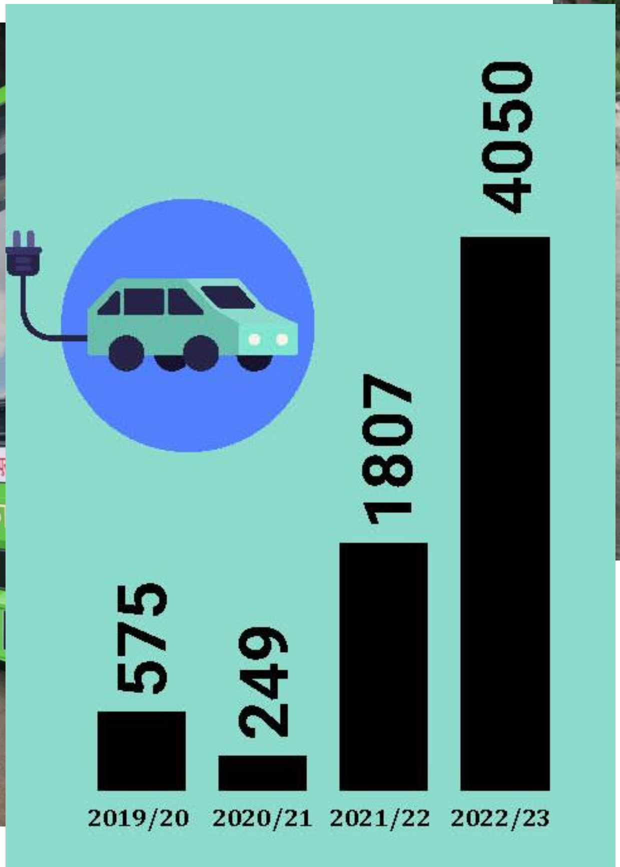




- Low Nighttime Demand – opportunity for ev (home charging)
- Use of hydro electricity in vehicle charging

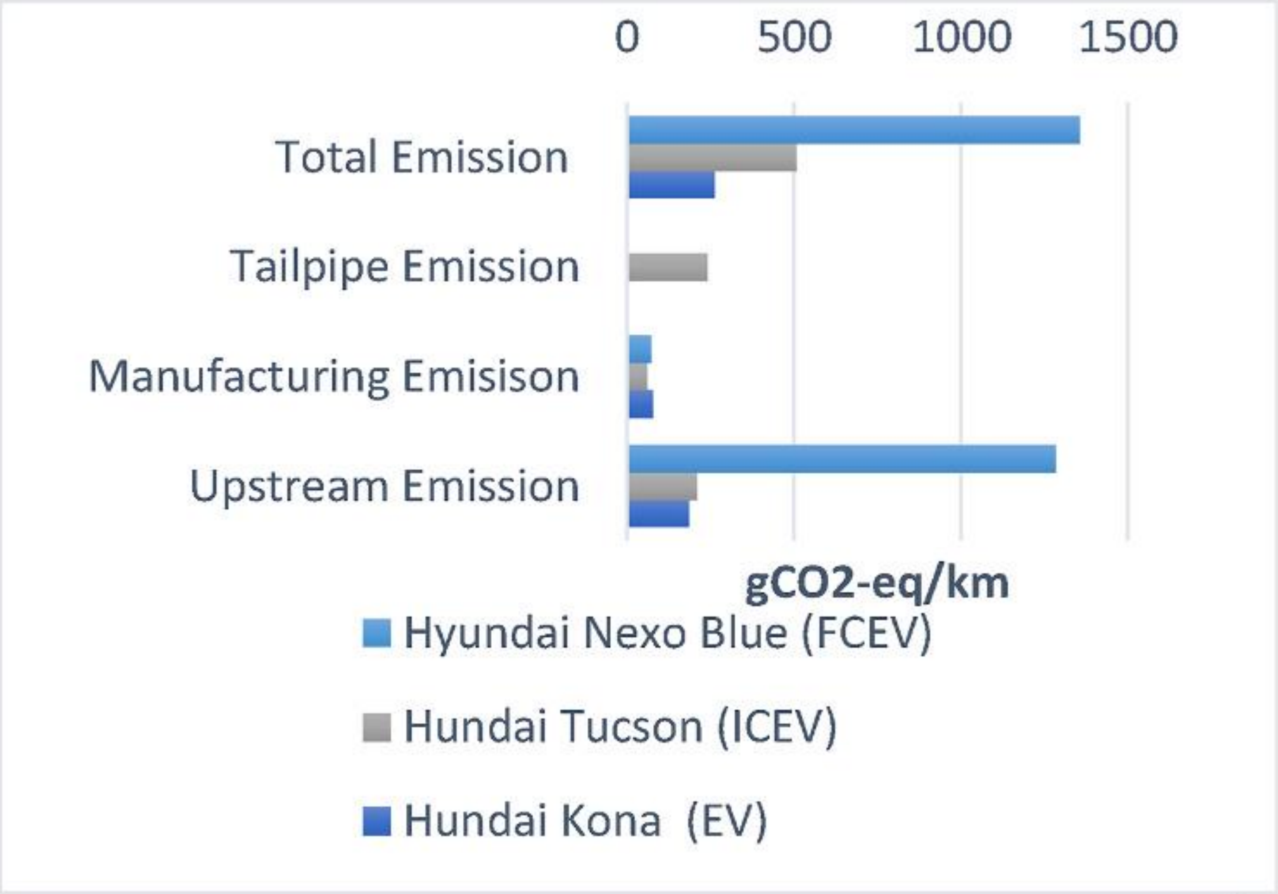
Electric vehicles in Nepal

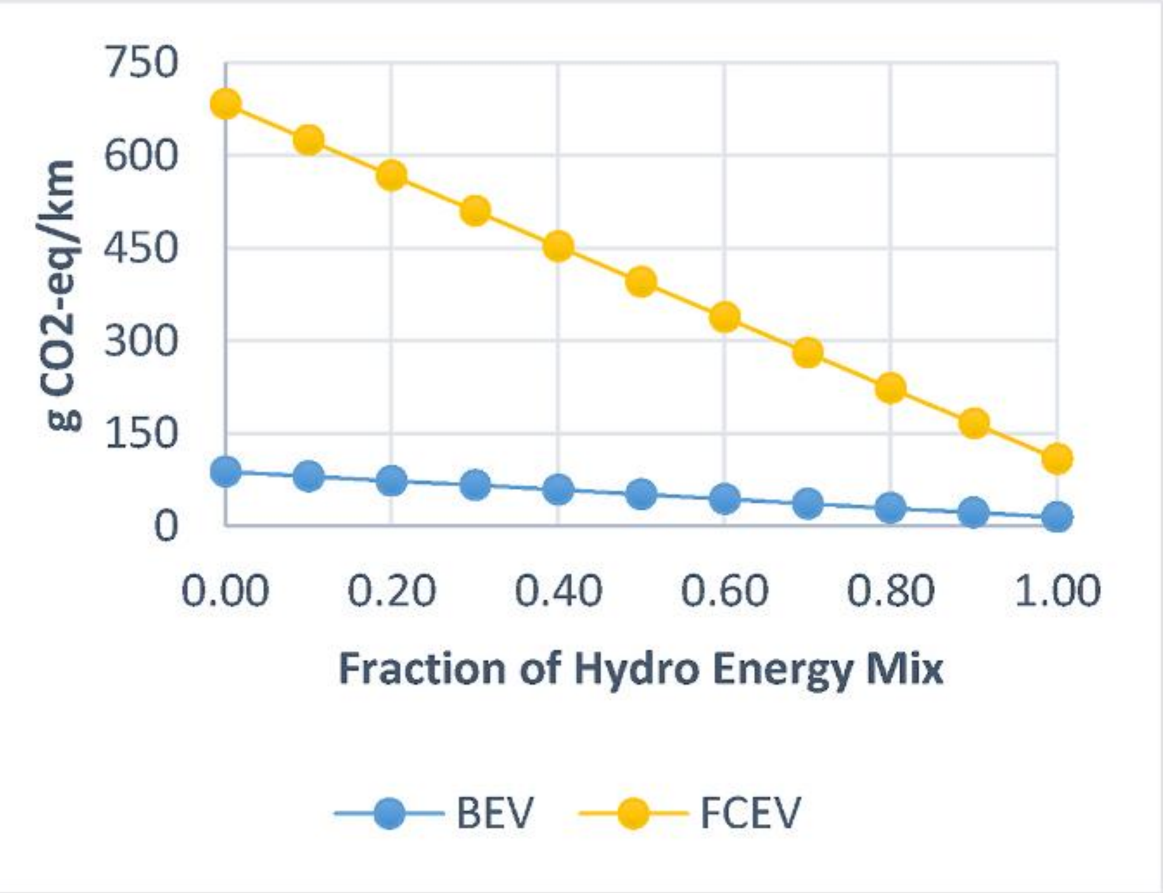
- Share of electric vehicles is growing rapidly
- lower import duty on EVs, ranging from 25% to 90%. The import duties on gas and diesel-fueled vehicles are 276% to 329%.
- Current share: 70% electric cars, 30% IC engines



Past 11 month the sales of ev is 10,304 units

Comparative Life Cycle Assessment

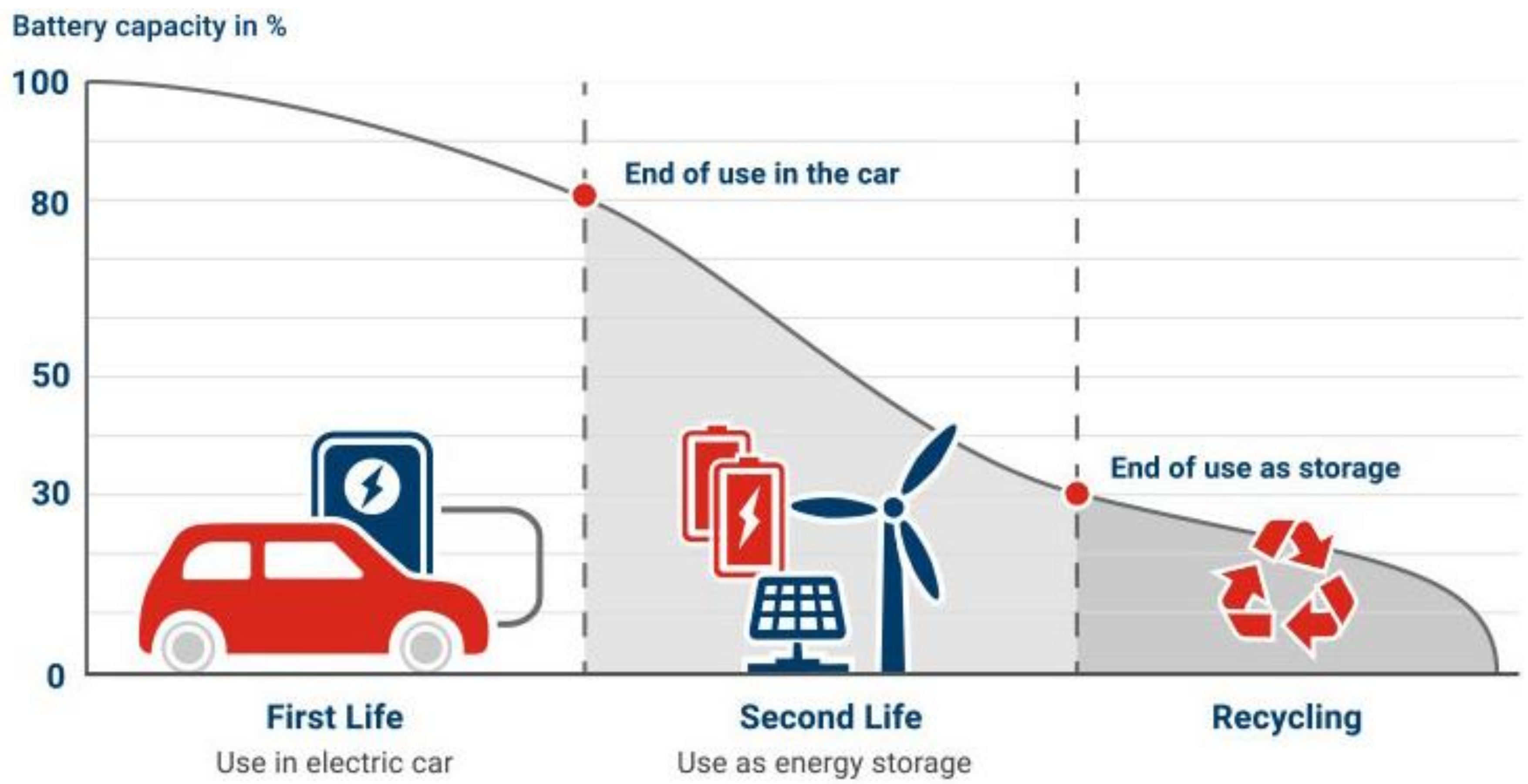




EV Promotion: Battery Repurposing

- ✓ **Giving a second life to used electric vehicle batteries** that no longer have sufficient capacity for automotive use but still retain enough charge for other less demanding applications. Instead of being discarded or recycled immediately, these batteries are repurposed for new uses
- ✓ **Extends battery life and reduces waste** and need for new raw material and energy
- ✓ Alternative application (energy storage, supporting EV charging infrastructure and renewable energy integration) **encourages further EV use**.

EV Promotion: Battery Repurposing



Why does this effort matter?

⚡ **Reliable Power Supply**

Grid Stability: Backup power for essential services (hospitals, schools, government offices)

Peak Shaving: Manages energy demand during peak hours to prevent power outage

🌞 **Clean Energy Integration**

Solar + Second-Life Batteries: Store solar energy for use during outages

Cost-Effective: Affordable storage for rural areas

Building a Sustainable & Local Economy:

♻️ **Circular Economy**

Repurposes EV batteries reduce waste, conserve raw materials

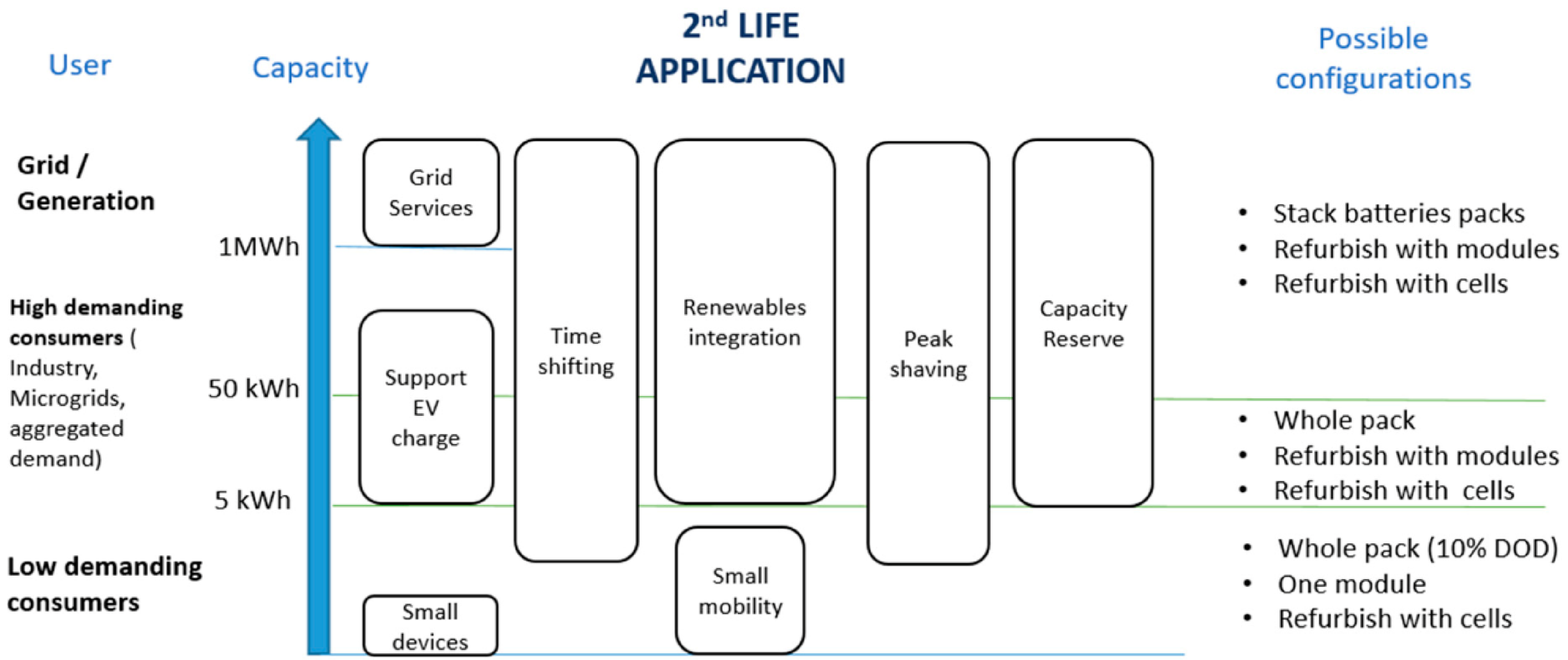
📈 **Job Creation**

Local jobs in solar PV, battery refurbishment, and grid management

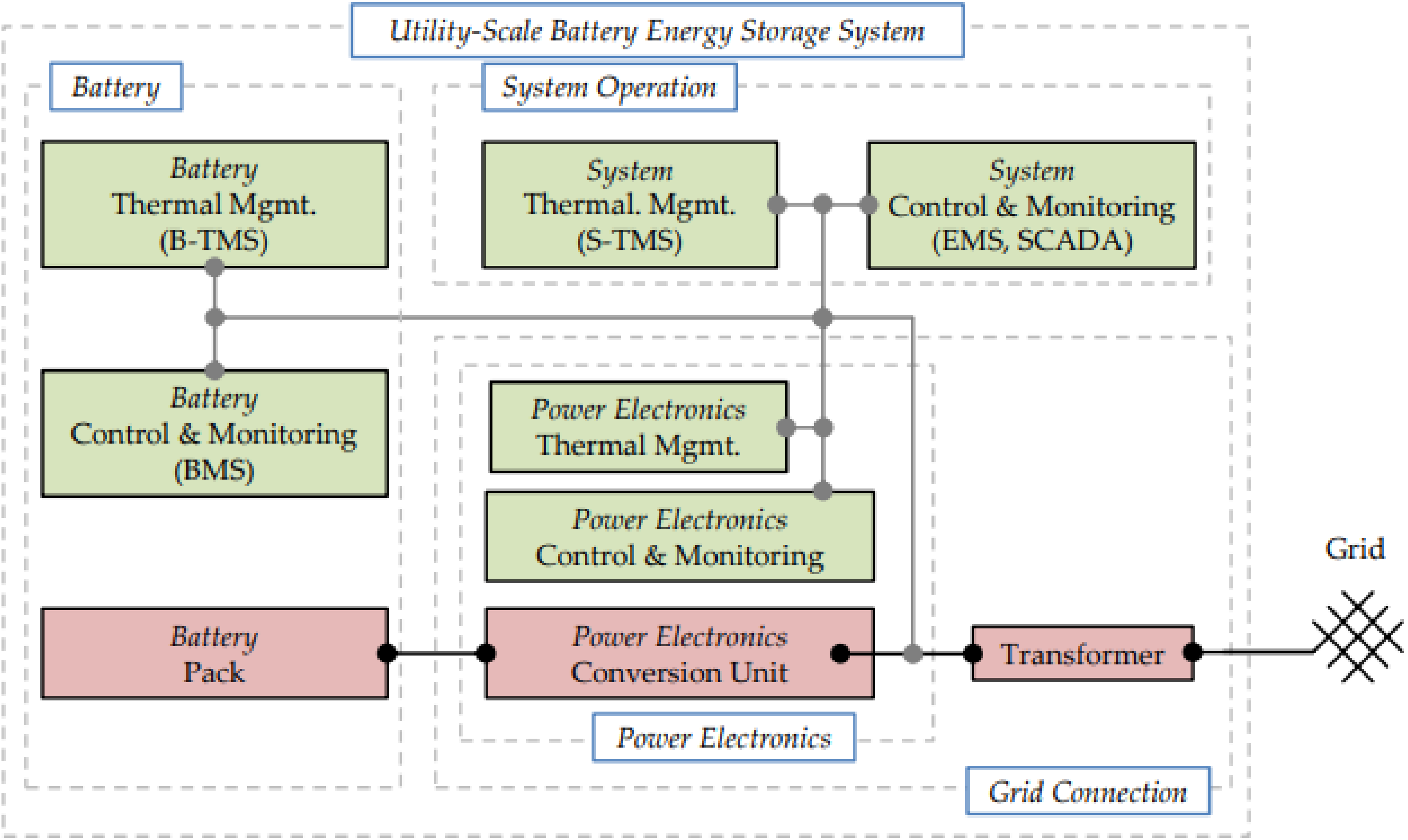
💡 **Access to Remote Areas**

Reliable electricity for remote communities, boosting economic and social development

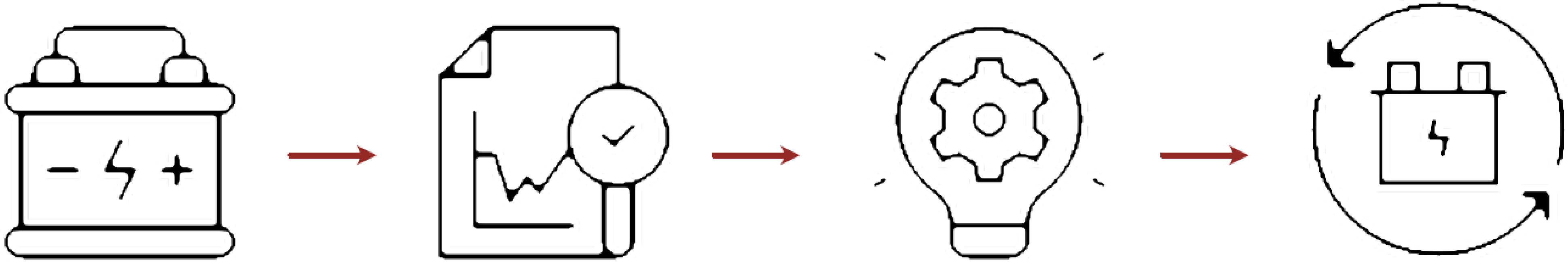
Second Life Application of EV Batteries



A Typical System



Steps of Battery Repurposing



STEP 1
Assessing Battery State of Health

STEP 2
Evaluating Battery Viability for a Second Life

STEP 3
Deciding on a Configuration

STEP 4
Reassembling the Battery Pack in the New Configuration

Challenges

- **Standardization challenges:** Lack of clear policies on warranty, insurance, battery ownership, and data access; no standard process for EV battery repurposing or recycling.
- **Designing for disassembly:** Complex battery designs, strong adhesives, and specific tools make disassembly difficult; intentional design can improve efficiency and safety.
- **Access to battery health data:** Reliable information on battery state of health is crucial for repurposing; onboard battery management systems need higher accuracy and standardized testing methods.
- **Safety concerns:** Lack of safety guidelines for battery disassembly and testing.

Challenges contd…

Competition over battery scrap: High demand for battery scrap by recycling companies can hinder battery repurposing, especially when large recycling companies have stronger partnerships. Regulatory support and incentives can help address this issue.

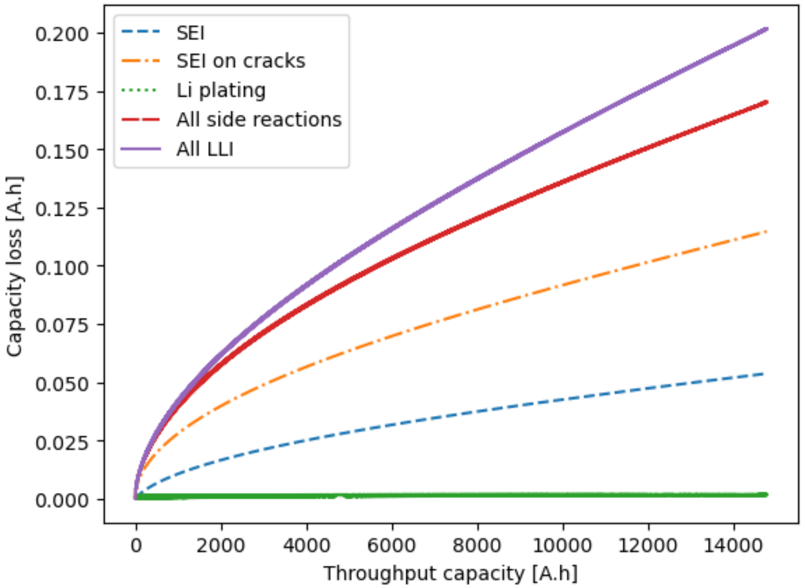
Copyright challenges: Proprietary battery management systems from manufacturers can limit access to crucial information, creating barriers for battery repurposing efforts.

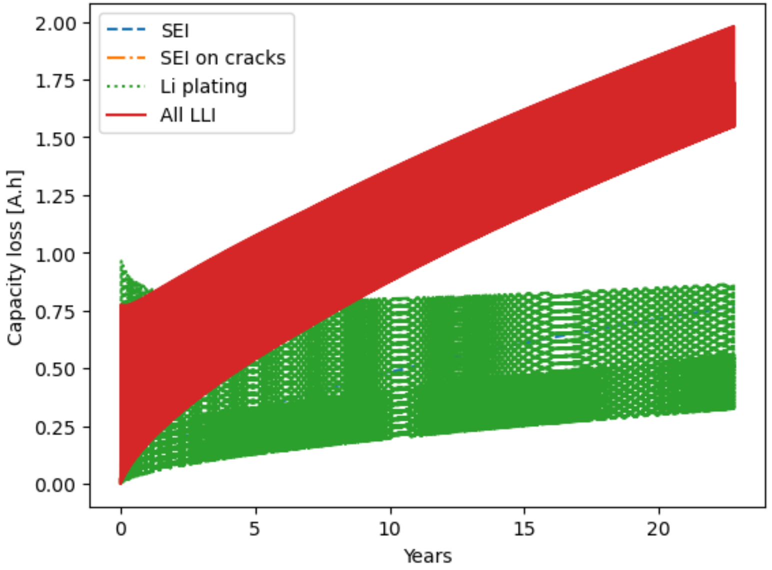
Current R&D Objective at ESTRL, Kathmandu University

- ✓ Development of tool for determining battery health (module level): Less challenging
- ✓ Design and computer modeling – parametric studies and optimization
- ✓ Laboratory scale test rig development and experimental studies
- ✓ Economic and Environmental Studies: LCA – with Repurposing and Recycling
- ✓ Design of a pilot scale facility

Prediction Model For Aging of Second-Life LFP Battery

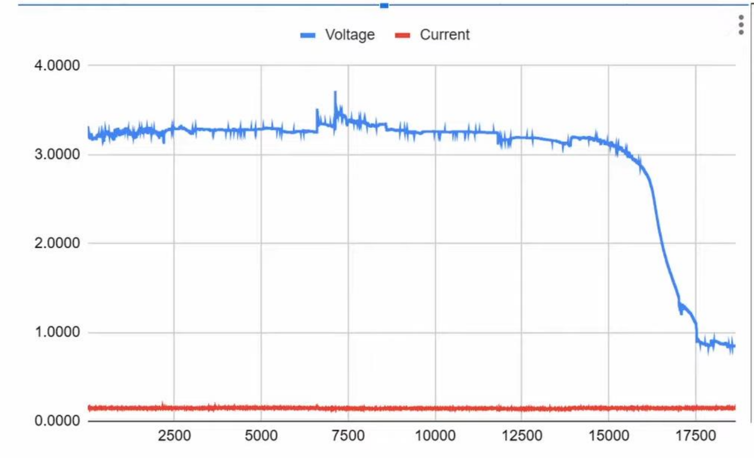
- **Simulation**: Performed using PyBaMM(Python Battery Mathematical Modelling)
- **Degradation Trends**: Significant degradation occurs in the first four years, especially with **discharge capacity loss**, critically affecting the battery's State of Health (SOH). Afterward, the degradation rate slows.
- **Lifespan Insights**: For a 5Ah battery, losing 1Ah takes **11 years**. The battery retains **80% capacity**, extending its life for grid use, and can function beyond **12 years** with **56% capacity** remaining.
- **Optimal C-Rate**: A **low C-rate** was considered, providing a safe charge/discharge method and helping to extend the battery's lifespan for grid storage applications.



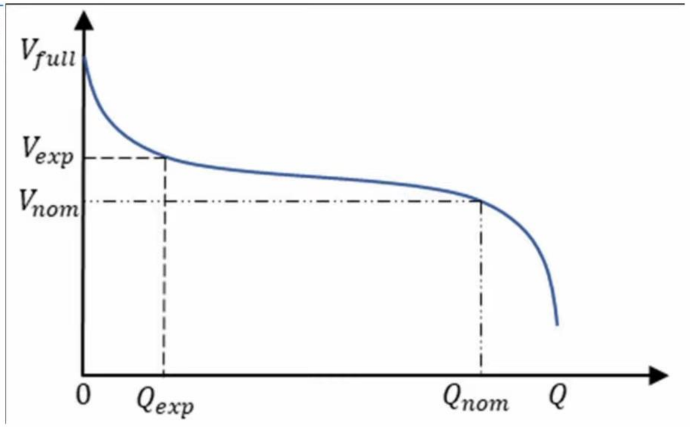


Experimental Setup for Parameter Modeling

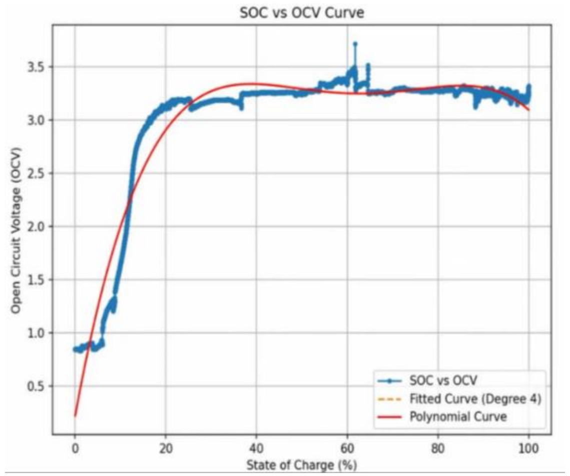
Actual



Expected



Discharging Curve



Charging Curve

Extended Kalman Filter (EKF) integrating physics-based and data-driven approach

Battery Type: LFP(Lithium Iron Phosphate)

Test Procedure

- Discharge from 100% SOC to 0% SOC.
- Charge from 0% SOC to 100% SOC.

Comparison Should be Made against the Standard Dataset

Prototype Design

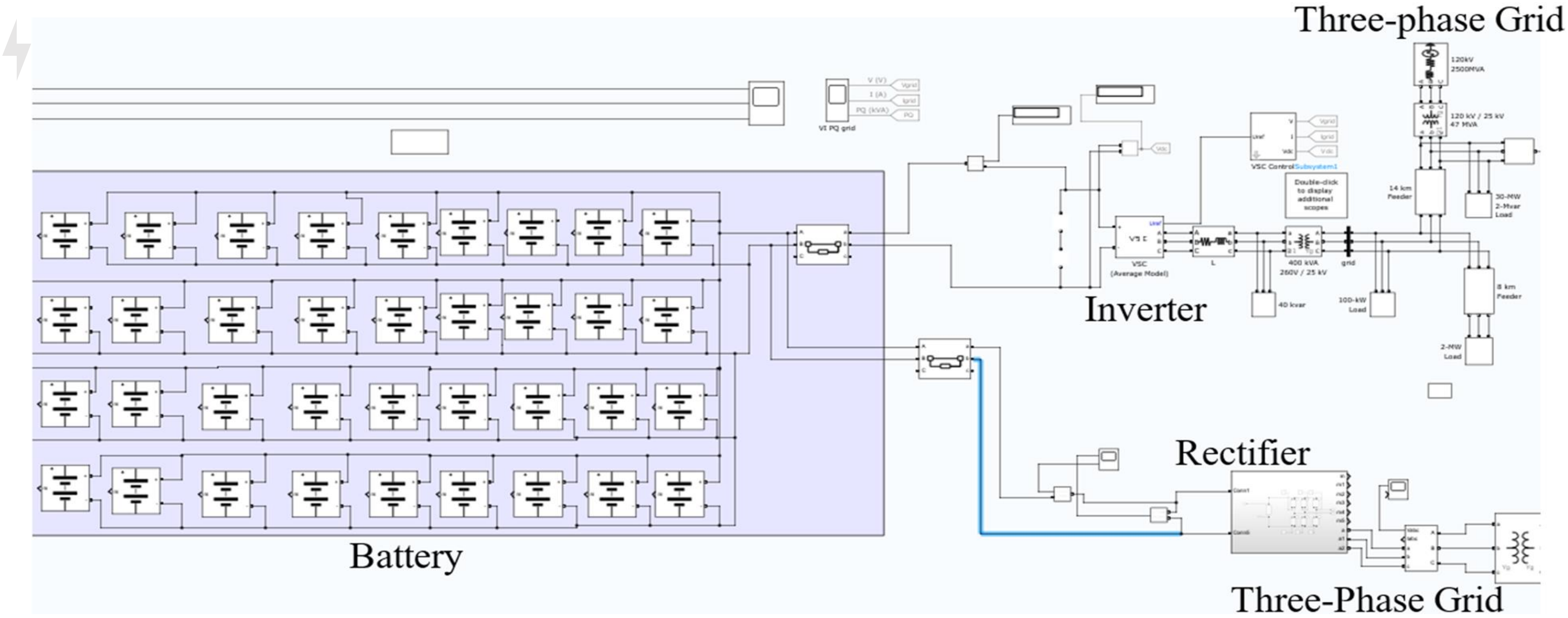


Figure: Prototype system design for SESS

Future Works

- ❑ Standard model development for proper screening of battery health parameters **(To compare experimental data).**

- ❑ Detailed Economic Analysis of SESS
  - With integration with **PV Grid**
  - Without integration with **National Grid**
  - Hybrid mode (both PV, and National Grid)

THANK YOU