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Embracing Sustainable Farming: Unleashing the Circular Economy Potential of Second-Life EV Batteries in Agricultural Applications

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INTRODUCTION

In line with the global demand in decarbonising transportation sector and the noticeable increase of new electric cars owners, concerns are raised with regards to the expected quantity of Retired Electric Vehicle Batteries (REVB) exposed to the environment. When an EV battery reaches 70-80% of its original capacity (estimated average of 7-9 years) [1], it may no longer deliver the desired performance and range required for optimal use in the primary automotive application. A forecasting model utilized a time-based approach was used to estimate the projected number of EV, hybrid, and ICE registrations in the UK until 2040, as depicted in Figure 1. The model factored in certain conditions, including the UK government's announcements regarding the phase-out years for ICE and hybrid vehicles, which are set at 2030 and 2035, respectively. These considerations were incorporated to assess the impact on overall car registrations in the given time frame.

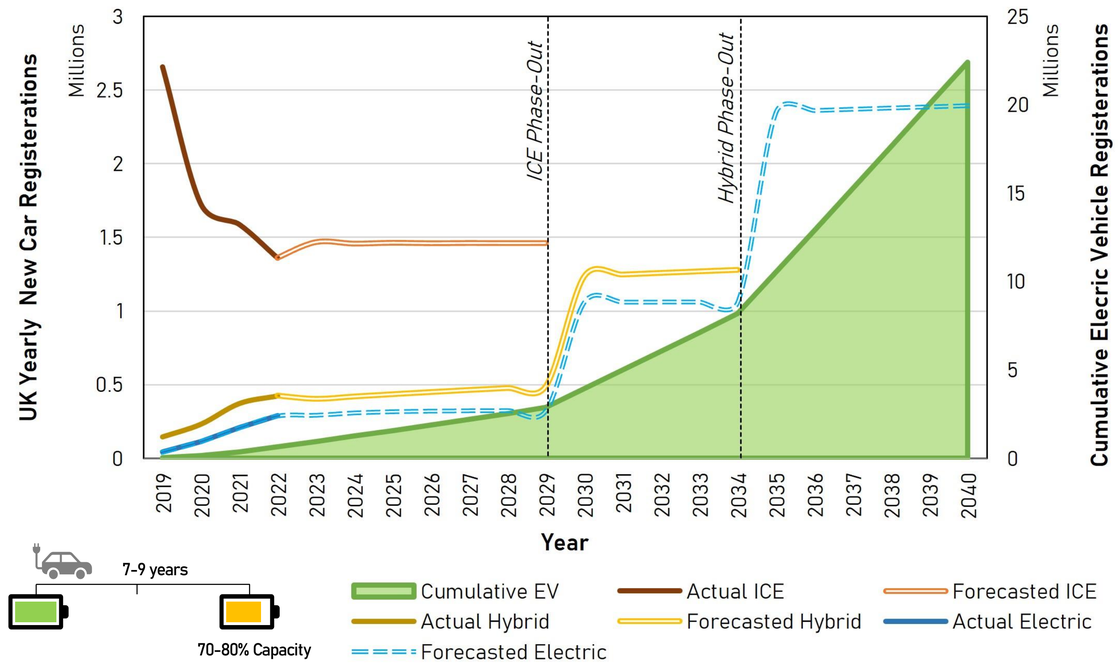
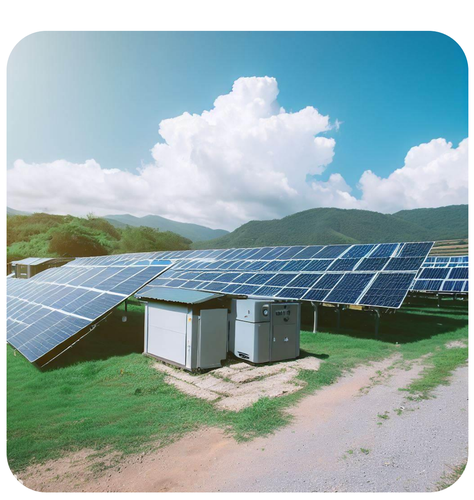


Figure 1: Car registrations in the UK and estimated EV units on UK's roads, Data retrieved from: (Department for Transport (DfT) and Driver and Vehicle Licensing Agency, 2022). Forecast using Seasonal Auto-Regressive Integrated Moving Average (SARIMA).

SYSTEMATIC REVIEW FINDINGS

A systematic review [1] was conducted to evaluate the findings of various studies on the repurposing of Retired Electric Vehicle Batteries (REVB) in second-life applications. The review highlighted several key conclusions.

- The reviewed studies confirmed the technical viability of repurposing REVB to address the unreliability of cleaner energy generation systems.
- Integrating REVB Energy Storage Systems (ESS) in grid-connected PV systems for residential load profiles showed promising technical and economic opportunities, reducing dependence on the grid and increasing self-consumption rates.
- Similar advantages were observed for commercial-scale applications. Although wind turbine and hydro plant integration received less attention, the studies highlighted the technical and financial benefits of incorporating REVB in these renewable energy systems.
- Grid services, such as energy arbitrage and frequency regulation, also demonstrated technical potential but raised concerns regarding accelerated battery degradation and financial viability.
- A major finding: there is significant uncertainty regarding the costs associated with repurposing REVB in second-life applications. The reviewed studies revealed a wide range of costs reported for different applications, indicating a lack of consensus and standardization in cost.
- Uncertainty on battery degradation behaviour during its second life.



Repurposing EV batteries offers a remarkable chance to transform and empower sustainable farming practices in the UK.

BENEFITS FOR UK FARMS

Extending the operational life of REVB provides potential to deliver significant benefits to farmers in Engalnd and elsewhere with positive impacts on productivity, sustainability and decreasing the negative environmental effects of farming.

Cold-Store Operations: Utilize stored energy to power refrigeration systems in cold-stores, ensuring optimal temperature control for agricultural produce and minimizing spoilage.

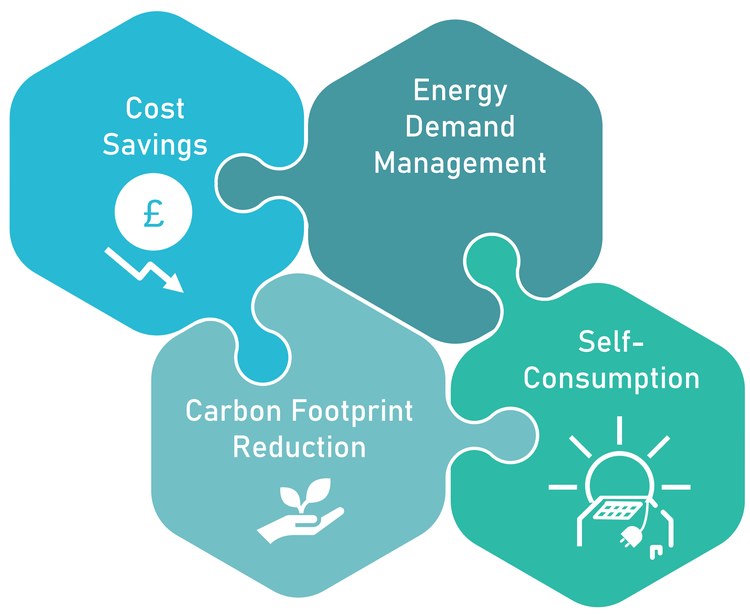
Electric Farm Vehicles: Power electric farm vehicles, such as tractors, loaders, or utility vehicles, with stored energy from repurposed EV batteries, reducing reliance on fossil fuel-based alternatives and promoting sustainable transportation.

Staff/Office Housing: Provide electricity to staff housing or on-site offices using stored energy, creating a self-sufficient and environmentally friendly power source.

Miscellaneous On-Farm Electricity: Meet various on-farm electricity requirements, such as powering irrigation systems, water pumps, lighting, and other electrical devices, optimizing energy usage and reducing operational costs.

Flexibility and Adaptability: The versatile nature of repurposed EV batteries allows for their integration into a wide range of on-farm applications, offering flexible and adaptable solutions to meet evolving electricity needs.

Enhanced Operational Efficiency: By utilizing stored energy for miscellaneous on-farm electricity requirements, farmers can improve operational efficiency, reduce reliance on external energy sources, and achieve greater sustainability in their farming practices.



FUTURE WORK

We are committed to further enhancing the repurposing of EV batteries by developing a robust, data-driven model. Our aim is to accurately estimate the state of health (SoH) of batteries during their second life, ensuring their optimal use without compromising safety or increasing the rate of degradation. By closely examining their behavior, we aim to better understand how they function throughout their extended lifespan. This involves analyzing key health factors that influence battery degradation, including operating conditions, charging/discharging patterns, and temperature effects.

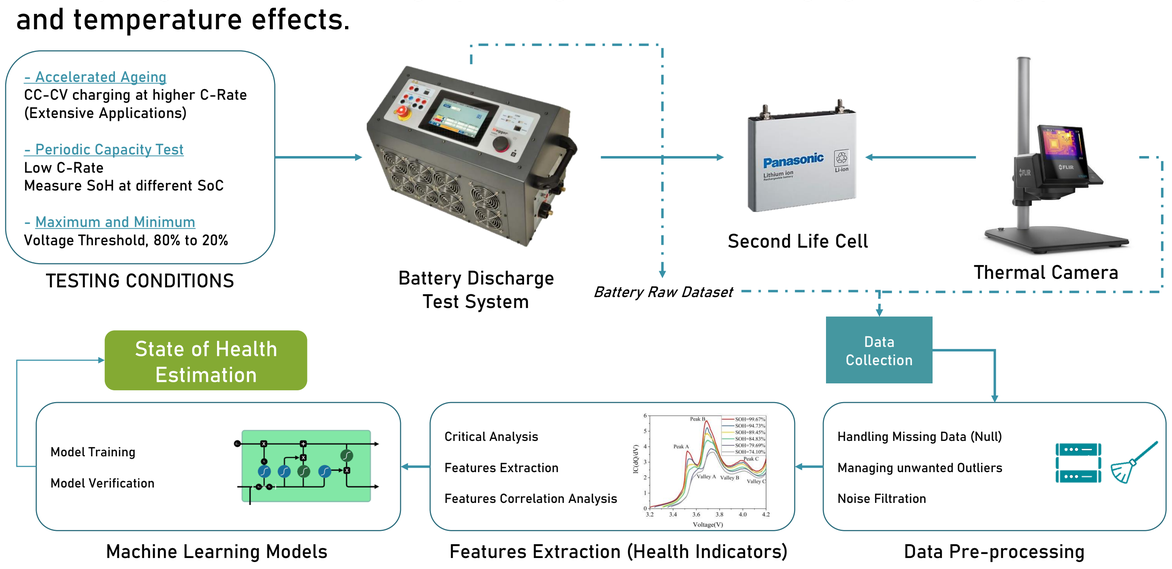


Figure 2: Accelerated Ageing Testing Setup with framework to develop a data driven model.

REFERENCES

[1] Al-Alawi, M.K., Cugley, J. and Hassanin, H. (2022) 'Techno-economic feasibility of retired electric-vehicle batteries repurpose/reuse in second-life applications: A systematic review', Energy and Climate Change, 3, pp. 100086 Available at: 10.1016/j.egycc.2022.100086

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