Project Title: Engineering Documentation and Performance of a Solar/LiFePO4 Retrofit Kit on a TTU Club Car LSV

Background : Tennessee Tech University currently possesses a Club Car Low-Speed Vehicle (LSV) (Property Tag N00002078), sourced from a discontinued project (circa 2023). The original lead-acid battery configuration is currently inoperable due to battery failure and requires a full replacement.

Lani Solar, LLC has developed a standardized retrofit conversion kit that replaces the legacy lead-acid battery bank with a lightweight LiFePO4 (Lithium Iron Phosphate) power source integrated with a self-recharging solar roof panel. This project utilizes the TTU Club Car as a control vehicle to document the engineering process and validate the performance of this conversion kit.

Objective and Scope of Work

Objective: To document the complete engineering process of converting an existing Club Car LSV from a lead-acid battery bank to a Lani Solar LiFePO4 Solar-charging system, and to validate the post-conversion performance and document the projected environmental and economic benefits.

Goals and Objectives

Phase I: Conversion and Characterization

Goal 1: Characterize Initial Vehicle State

Goal	Description	Deliverable
G1.1	Document the “as is" condition and operational status of the TTU Club Car.	Initial Vehicle Condition Report: Includes photos, vehicle ID, current odometer reading, a diagnostic summary (e.g., "inoperable due to battery failure"), and a narrative of the initial state.
G1.2	Measure and document the initial weight and electrical configuration of the lead-acid battery bank.	Lead-Acid Baseline Specification Sheet: A technical sheet documenting total battery bank weight, voltage/amp-hour rating, wiring diagram/schematic (e.g., series/parallel), and terminal condition.

Goal 2: Document Conversion Methodology

Goal	Description	Deliverable

G2.1	Detail the full battery removal process and the installation of the single LiFePO4 unit.	Step-by-Step Battery Conversion Manual (Draft): A detailed, documented procedure (including photos/illustrations) for the physical removal of the old bank and installation of the new single unit.
G2.2	Document all necessary wiring changes, connections, and safety protocols.	Post-Conversion Wiring Schematic: A labeled electrical diagram showing the final LiFePO4 unit connections, any necessary voltage reduction, and associated safety protocols implemented.
G2.3	Document the removal of the OEM plastic roof and the installation of the solar-integrated roof panel.	Solar Roof Installation Log: A sequential log and photo journal documenting the roof swap process, including weight change (Delta/weight) and final panel mounting specifications.

Phase II: Post-Conversion Validation and Analysis

Goal 3: Measure Net Performance Post-Conversion

Goal	Description	Deliverable
G3.1	Design and specify the appropriate test parameters (e.g., speed, load, terrain) for performance evaluation.	Official Testing Protocol Document: A formal document detailing test variables, control groups, measurement tools, environmental constraints, and validation criteria for the "fill vs. drain" test.
G3.2	Execute the testing protocol to measure the "fill vs. drain" rates under the defined design parameter conditions.	Post-Conversion Performance Data Log: Raw and processed data tables and performance graphs plotting solar charge rates vs. discharge rates (motor amp draw) across specified conditions.

Goal 4: Quantify Environmental Impact

Goal	Description	Deliverable
G4.1	Quantify the net reduction in landfill waste and electrical grid strain achieved by the single converted unit.	Single-Unit Environmental Impact Assessment: Calculations documenting the reduced lead

		weight diverted from the landfill and the estimated annual reduction in grid kWh consumption.
G4.2	Extrapolate the potential carbon footprint reduction and utility savings at a state-level fleet scale based on G4.1 findings.	State-Level Environmental Extrapolation Model: A financial model and report estimating total carbon footprint savings and utility cost avoidance for a hypothetical state-wide fleet conversion.

Goal 5: Quantify Economic Impact

Goal	Description	Deliverable
G5.1	Quantify the net cost vs. savings (Return of Investment, ROI) for the single converted unit over a specified period.	Single-Unit ROI Analysis: A financial report detailing conversion cost, estimated annual operational savings (fuel, maintenance, labor), and the calculated ROI timeline.
G5.2	Extrapolate the potential net economic impact and ROI at a state-level fleet scale based on G5.1 findings.	State-Level Economic Extrapolation Report: A summary projecting the total ROI and cumulative net economic benefit for a hypothetical state-wide fleet conversion.

Expected Outcomes and Educational Value

The successful project will ensure the candidate is proficient in applying the scientific method to an authentic engineering problem. This involves determining the critical performance metrics and designing a rigorous, traceable experimental protocol for measurement and documentation. Lani EV, LLC will benefit from the objective validation (or disproval) of what is believed to be a transformative and immediately attainable benefit to the LSV market. The primary output will be a documented analysis showing the solar cart's self-sustaining capability, including a data table that plots charge and discharge rates across varying solar irradiance (foot-candles) and corresponding motor amp draw (speed and load).

Required Component Parts and Equipment:

I. Lani Solar Retrofit Kit Components (For Goals G2.2, G2.3) These are the primary physical parts supplied by Lani Solar, LLC to perform the conversion on the existing Club Car LSV.

LiFePO4 Battery System: Single LiFePO4 Battery Unit: The primary power source (replacing the lead-acid bank). LiFePO4 Battery Management System (BMS): Integrated into the battery or supplied separately, ensuring safe charging and discharging.

Mounting Tray/Adaptor: Any necessary hardware or custom tray to securely fit the single LiFePO4 unit into the space vacated by the multiple lead-acid batteries.

Solar Charging System: Solar-Integrated Roof Panel: The pre-assembled solar panel mounted within a replacement roof structure (replacing the OEM plastic roof). Solar Charge Controller (MPPT/PWM): The device that regulates the voltage and current from the solar panel to safely charge the LiFePO4 battery.

Electrical & Safety Hardware: Conversion Wiring Harness/Cables: All new high-current cables, connectors, and terminals necessary to connect the LiFePO4 unit to the vehicle's drive system and the solar charge controller.

Voltage Reduction/Conversion Module (if necessary): If the LiFePO4 unit voltage differs from the OEM accessory voltage (lights, horn), a converter for low-voltage accessories will be needed.

Safety Disconnect/Fuses: Appropriate safety disconnect switch and fusing for the new battery and solar circuits.

II. Measurement and Testing Equipment (For Goals G1.2, G3.1, G3.2)This equipment is necessary for the documentation and validation phase of the project, should be provided by the university's research lab or for accurate data collection.

Baseline Measurement Tools (G1.2):

Industrial Scale: To accurately measure the initial weight of the lead-acid battery bank and the final weight of the vehicle post-conversion.

Multimeter/Clamp Meter: For measuring OEM electrical configuration (voltage, current) and verifying post-conversion wiring.

Performance Validation Tools (G3.2): GPS/Odometer Logging Device: For accurately measuring distance traveled across test parameters.

Data Logger (or BMS Interface): A system capable of logging key electrical metrics over time, including Battery State-of-Charge (SOC) / Voltage Motor Amp Draw (Discharge Rate, Solar Current Input (Charge Rate) Solar Irradiance Meter (e.g., Pyranometer or Foot-Candle Meter): For accurately measuring the sunlight intensity during the "fill vs. drain" testing. Safety Gear: Appropriate personal protective equipment (PPE) for handling lead-acid batteries and performing electrical work.