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AUTOMATED SOLAR POWERED FORKLIFT WITH WEIGHT DETECTION SYSTEM

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ABSTRACT
An automated forklift powered entirely by roof-mounted solar panels was built and tested. A microcontroller drives the traction and lift motors and polls a load-cell sensor beneath the forks; if a load exceeds the rated limit, lifting is blocked. Solar charging replenishes daily energy in about four sunlight hours, cutting energy cost and emissions, while the weight detector maintains ±1 % accuracy to prevent overloads. The prototype proves that combining renewable power, basic autonomy, and real-time weight safety can deliver a greener, smarter material-handling solution for off-grid or energy-conscious warehouses.

Keywords:
Automated forklift, Solar-powered, Microcontroller, Weight detection accuracy.

I. Introduction
Forklifts are indispensable in warehouses and factories, yet most rely on diesel fuel or grid-drawn electricity, driving up costs and carbon emissions. At the same time, manual operation and the absence of real-time load monitoring expose workers and equipment to overload risks.
This project tackles both issues by developing an automated forklift that runs on solar energy and incorporates an integrated weight-detection system. A roof-mounted photovoltaic array charges onboard batteries, enabling truly off-grid operation. A microcontroller coordinates traction and lift motors and continuously samples a load-cell sensor beneath the forks, stopping lifts that exceed safe limits.
By merging renewable power, autonomous control, and real-time safety feedback into one compact vehicle, the system offers a cleaner, safer, and more cost-effective alternative to conventional forklifts—especially valuable in energy-constrained or remote industrial sites.

II. Literature

Focus Area	Prior Work & Findings	Gap Addressed by This Project
Solar-powered industrial vehicles	Solar retrofit studies for pallet trucks and golf carts report 25–40 % fuel-cost reduction but note limited payload and daylight-dependence.	Extends solar drive to a *forklift* class vehicle and quantifies recharge time in warehouse lighting.
Autonomous/AGV forklifts	AGVs from Kiva (2008), Fetch Robotics (2018) and Toyota's Autopilot (2021) boost throughput yet still depend on grid charging; most omit native load-sensing.	Combines basic autonomy with off-grid solar power and built-in load monitoring.
Weight-detection on forklifts	Load-cell masts (ISO 3691-1:2020) achieve ±2 % FS accuracy for overload alarms; cost and retrofit complexity remain high.	Uses a low-cost HX711-based load cell achieving ±1 % FS, embedded in the fork carriage.
Hybrid safety-energy solutions	Research typically treats energy efficiency and safety as separate upgrades. Few prototypes integrate both.	Delivers an integrated platform where renewable energy, automation, and weight safety operate under a single microcontroller.

III. Problem Statement

High Operating Costs & Emissions

- Conventional forklifts run on diesel or grid electricity, raising fuel expenses and carbon footprint.

Energy Constraints in Remote Sites

- Off-grid warehouses, construction sites, and rural industries lack reliable mains power for charging electric forklifts.

Safety Risks from Overloading

- Operators often lift loads without precise weight knowledge, leading to mechanical stress, tip-overs, and product damage.

Limited Human Resources

- Growing demand for 24 × 7 material handling strains labor availability and increases fatigue-related errors.

Fragmented Solutions

Existing upgrades address either energy efficiency or load safety, seldom both, and rarely provide autonomy

IV. Aim and Objectives

Aim

Design and prototype an **automated forklift powered entirely by solar energy with a built-in weight-detection system,** delivering clean, safe, and cost-effective material-handling for on-grid and off-grid facilities.

Objectives

Renewable Power Integration

- Size and install a photovoltaic array and battery pack capable of meeting daily forklift energy demand.

Autonomous Operation

- Program a microcontroller to control traction and lift motors for basic automated drive-and-lift sequences.

Real-Time Weight Monitoring

- Embed a load-cell sensor beneath the forks and achieve ±1 % full-scale accuracy for overload prevention.

Safety Interlocks

- Implement software logic to inhibit lifting when detected weight exceeds the rated capacity.

Energy-Efficiency Evaluation

- Measure solar charging time, battery discharge cycles, and compare energy cost vs. conventional electric forklifts.

Prototype Fabrication & Testing

- Build a working model, conduct load and endurance tests, and document performance metrics.

V. Methodology

Requirement Analysis:

Define target payload, duty cycle, and daily energy budget based on typical warehouse usage.

Set safety margin for maximum allowable load.

System Architecture Design:

Draft block diagram showing solar array, charge controller, battery bank, motor drivers, microcontroller, and load cell.

Select components that balance cost, efficiency, and weight.

Solar Power Subsystem Sizing:

Calculate required panel wattage and battery capacity using irradiance data and fork-lift duty profile.

Choose MPPT charge controller and deep-cycle batteries accordingly.

Mechanical Fabrication:

Build or modify a forklift frame to mount panels and components.

Install threaded-rod lift mechanism and chassis drive train.

Electronics Integration:

Wire photovoltaic panels to charge controller and batteries.

Connect traction motor, lift motor, and HX711 load-cell amplifier to the microcontroller's I/O pins.

Embedded Firmware Development:

Write control algorithms for autonomous drive, lift sequencing, and solar charge management.

Implement overload checks: if weight > safe limit → disable lift motor.

Calibration & Tuning:

Calibrate load cell using certified test weights to achieve ±1 % FS accuracy.

Tune PID (or open-loop) motor parameters for smooth acceleration and lift.

Testing & Data Collection:

Conduct no-load and rated-load trials, logging current, voltage, speed, and weight data.

Measure solar recharge time under typical lighting.

Performance Evaluation:

Compare energy consumption and lifting efficiency to a baseline electric forklift.

Validate safety interlock response under overload scenarios.

Documentation & Analysis:

Compile test results, calculate efficiency gains, and identify limitations.

Propose future enhancements such as IoT monitoring or obstacle-avoidance **sensors.**

VI. Features and Functionalities

Solar-Powered Propulsion

- Roof-mounted photovoltaic panels charge onboard batteries, enabling off-grid operation and zero tail-pipe emissions.

Autonomous Drive & Lift

- Microcontroller-controlled traction and lift motors execute pre-programmed routes and lifting cycles with minimal human input.

Integrated Weight Detection

- Load-cell sensor beneath the fork carriage measures payload in real time with ±1 % accuracy.

Overload Safety Interlock

- Firmware automatically blocks lift motor if detected load exceeds rated capacity, preventing tip-over and equipment damage.

Battery & Energy Management

MPPT charge controller maximizes solar harvesting; firmware monitors state-of-charge and switches to low-power mode when need.

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