Energy Management System Operations Overview

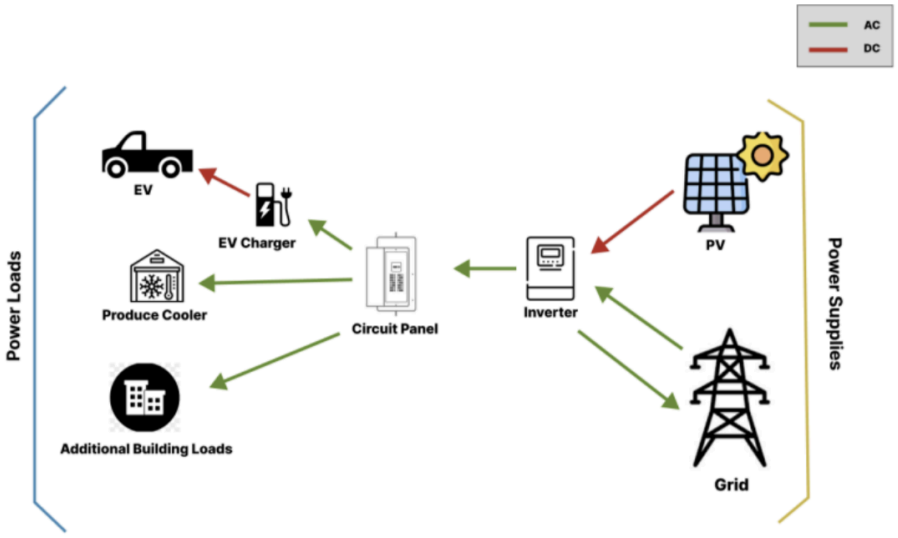

Figure 1: Campus Farm Energy Flow Diagram

The **energy management system** balances **solar power usage, grid power usage** and **energy needs** of two main components: a Campus Farm produce **cooler** (temperature-controlled storage) and Campus Farm **electric delivery vehicle (EV)**. The system uses a rule-based algorithm in an attempt to minimize carbon emissions, while ensuring necessary conditions for cold storage and delivery schedules are met and ensuring safety for the equipment. Here is a basic overview of the goals followed by a few case examples to help illustrate how the system works.

Basic Overview:

The system uses solar energy during the day to prioritize:

1. EV charging when possible.
2. Cooler temperature adjustments to take advantage of surplus energy.

At night or during low solar power periods, it:

1. Uses grid energy targeting grid clean periods (periods of lower marginal emissions rates).
2. Optimizes cooler settings to balance performance and energy efficiency.

3. Only charges EV when absolutely necessary to meet delivery requirements

The system constantly adjusts its decisions based on available power, grid cleanliness, and safety rules, ensuring energy is used efficiently and sustainably.

Key Concepts:

1. **Daytime Solar Power (`pv_output`)**
    - Solar power is used first before pulling energy from the grid.
    - The system decides whether to charge the EV or adjust the cooler settings based on how much power is available.
2. **Cooler Settings:**
    - The cooler has multiple modes:
        - **Default Mode** (`SETPOINT_DEFAULT`): Normal operation.
        - **Coolth Mode** (`SETPOINT_COOLTH`): Lower temperature for cooling.
        - **Economy Mode** (`SETPOINT_ECON`): Higher temperature to save energy.
    - The system ensures the cooler is not at coolth or economy mode by monitoring indoor temperature and limiting operation time to avoid damage.
3. **EV Charging:**
    - The EV can be connected and ready for charging.
    - If enough solar power is available, the system charges the EV.
    - Charging is allowed only during **"clean periods"** when the grid is producing greener energy.
    - A cleaner grid has a higher proportion of renewable or low-emission energy, resulting in lower greenhouse gas emissions for each unit of electricity generated.
    - The number of clean periods extracted depends on the delivery schedule of the EV and the time remaining for that delivery to be made.

Case Examples of How the System Works:

1. **During the Day (High Solar Output):**
    - If **solar power (`pv_output`) exceeds total power needs**:
        - **If the EV is charging:**
            - The cooler is set to "Coolth Mode" to use the surplus energy.
            - A timer ensures "Coolth Mode" doesn't damage the cooler if it's overused.
        - **If the EV isn't charging but is connected:**
            - Check if enough surplus energy exists to charge the EV. If so:
                - Start charging the EV.

        - Also, switch the cooler to "Coolth Mode" to use excess solar power.
    - **If solar power is low:**
        - Use default cooler settings unless special conditions (e.g., grid cleanliness) apply.
2. **During Clean Periods (for Grid Energy):**
    - The system checks for **"clean periods"**, times when grid energy is environmentally friendly.
    - If it's clean and the EV is connected, it starts charging. Otherwise, charging stops.
3. **Cooler Economy Periods:**
    - During low energy availability, the cooler switches to **Economy Mode** to save energy.
    - A timer ensures it doesn't overheat.
4. **Timers:**
    - For both "Coolth Mode" and "Economy Mode," the system uses timers to avoid prolonged operation that could damage the cooler.

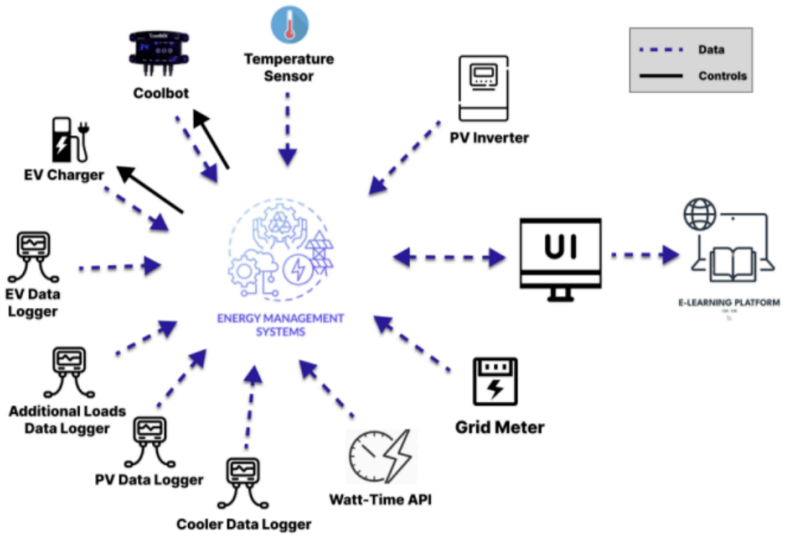

Figure 2: Campus Farm Data/Controls Diagram