Electrical & Power Control Interfaces

AOFS defines the electrical and power control architecture to **safely operate pumps, valves, and irrigation loads** under any power source. It is designed to **ensure fail-safe operation, energy efficiency, and compliance with AOFS standards**, independent of whether the farm uses grid, generator, or solar power.

1. Core Power Principles

- AOFS is **power-source agnostic**: it works with grid, generator, solar, or hybrid systems.
- Controllers must enforce **fail-safe operation** for irrigation and actuation regardless of the power source.
- Voltage and current monitoring is **recommended** where helpful, but **not required** for compliance.
- Systems must support **safe shutdowns** in case of power anomalies or failures.
- AOFS must track **energy consumption of pumps and actuators**, even if optional solar monitoring is not in place, to support logging, reporting, and operator awareness.

2. Optional Solar Integration

AOFS supports optional solar monitoring for farms that want to optimize energy usage:

- **Level 1 – Minimal Monitoring (Recommended for off-grid / weak-grid farms)**
  - Field Controllers may monitor battery voltage and current.
  - Supports reliable irrigation operation when solar/battery power is used.
  - Fully optional for farms with stable grid or generator power.
- **Level 2 – Integrated Monitoring (Optional Advanced Module)**
  - Controllers can read solar generation metrics from panels/inverters via standard protocols (e.g., Modbus, MQTT, RS485).
  - Enables dynamic irrigation scheduling based on energy availability.
  - Supports advanced PUE analytics and reporting.
  - Completely optional — AOFS compliance does **not depend** on it.

3. Energy-Aware Operation

- AOFS controllers must **measure power consumption** of pumps, valves, and other actuators while running.
- Controllers must **estimate battery drain or energy availability** for upcoming scheduled irrigation events.
- If insufficient energy is available:
  - The system can **delay or reschedule non-critical irrigation events** until enough energy is available.
  - Operators receive **warnings or alerts** via Farm/HQ controllers.
- All energy measurements and operational decisions must be **logged for analysis**:

    - Enable visualization of energy usage over time.
    - Allow operators to determine if battery capacity, solar panels, or load scheduling needs improvement.

4. Implementation Guidelines

- AOFS compliance does **not require any specific power source or monitoring**, but **energy-aware operation is strongly recommended** for PUE optimization.
- Optional monitoring modules should follow AOFS **data logging and offline-first principles**.
- All controllers and modules, regardless of power source, **must enforce local fail-safes** for pumps, valves, and critical irrigation operations.

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