**OPTIMIZATION LAYER — Overview**

**🎯 Objective:**

Use the monitored data (voltage, current, power, time) to:

* Analyze patterns in energy **consumption, efficiency, and waste**
* Identify **opportunities to reduce loss** and **shift usage** to off-peak times
* Automatically **recommend or trigger adjustments** to improve performance

**📐 Step-by-Step Breakdown:**

**✅ 1. Inputs (from Monitoring Layer)**

* Real-time data: Voltage, Current, Power
* Historical data: Daily logs (CSV), patterns over time
* Optional inputs: User-defined cost of electricity, peak/off-peak times

**🔍 2. Optimization Targets**

* Minimize:
  + Power loss (due to resistance)
  + Idle consumption (standby devices)
  + Peak-time usage (costly hours)
* Maximize:
  + Energy efficiency (power factor later)
  + Load shifting to solar or low-tariff periods
  + Battery use during expensive hours (future)

**🧠 3. Simple Optimization Methods (Phase 1)**

We’ll begin with **rules-based logic**:

* If power usage > threshold → send alert or auto cut non-critical load
* If usage is < expected → flag underutilized system
* If solar available & battery not charging → shift source

📝 These will be written as:

* Python rules or config JSON
* Schedule/thresholds set by user or AI-tuned

**⚙️ 4. Optimization Engine (Local Phase)**

**Python module**:

* Load CSV or live data
* Apply optimization rules
* Output: Actions, alerts, recommendations

**⚙️ What it does the optimization\_engine.py:**

* Monitors the latest data from your power\_log.csv
* Applies rules like:
  + ⚠️ Overcurrent detection
  + ⚠️ High power use
  + ⚠️ Low voltage
  + ⚠️ Power usage during peak hours
* Logs alerts to optimization\_alerts.log

This script is **expandable** — we can add:

* AI/ML recommendations later
* Smart device control signals
* Cloud sync or mobile alert integration

**1. Objective Defined**

* Reduce electricity waste
* Detect overuse or low efficiency
* Shift usage from peak hours
* Prepare for smart automation

**2. Rules & Logic Built**

* ✔️ Thresholds for:
  + Max current: **10A**
  + Max power: **500W**
  + Min voltage: **10V**
  + Peak hours: **18:00–22:00**
* ✅ optimization\_engine.py
  + Monitors real-time logs
  + Analyzes each reading
  + Triggers alerts
  + Logs warnings to optimization\_alerts.log