Project Proposal: Optimized Load Scheduling in a Smart Office: Demand Response with PV Integration Under Dynamic Pricing

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Article Automated Demand Response From Home Energy Management System Under Dynamic Pricing and Power and Comfort Constraints

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Case Study This case study focuses on a **medium-sized factory** (500 m^2, 5 m ceiling height) with offices in Zurich with 30 employees, equiped with **rooftop photovoltaic (PV) panels**. The building is equipped with an Energy Management System capable of performing Automated Demand Response (ADR) under dynamic pricing and comfort constraints. The aim is to optimize the appliance operations to minimize electricity costs, while respecting the consumer satisfaction and load diversity constraints.
Appliances in the office are categorized based on flexibility:

1. **Nonflexible Deferrable Appliances:** The factory has Additive Manufacturing (AM) machine to produce metal parts. The AM machine could be delayed to night-time, out of working hours and without personel supervision, but are non-interruptible once started. The considered AM process last 4 hours [4]. The average power consumption of the machine during operation is 2,76 kW.

2. **Flexible Deferrable Appliances:** Half of the employees cars are Electrical Vehicules (EV), which are charged during work hours, i.e. from 9:00 to 18:00, in the office's parking. The charging of each EV can be interrupted or delayed and corresponds to 6 kWh of electrical energy. The EV's charger has a maximum power of 4 kW [1].

3. **Thermal Appliances:** Office heating system, maintaining comfort with a setpoint around 19°C within a ±2°C dead-band. The parameters of the space heater are the following: 40 kW space heater (Based on 15 W/m^3) with inertia factor $\epsilon = 0.98$, thermal conductivity A = 2 kW/°C and the COP set to 2.5.

4. **Curtailable Appliances:** 2 kW Office dishwasher and a 1 kW coffee machine, which can be switched-off without the need to turn them on later, at the expense of consumer satisfaction.

5. **Critical Appliances:** Lighting and computers, required to be continuously available during office hours.

Research Question: How can ADR strategies minimize electricity costs in a professional office environment under varying pricing structures, while integrating rooftop PV and maintaining operational comfort?
Subquestions:
How does demand-side flexibility support local PV integration and reduce reliance on the grid?

What is the comparative impact of dynamic vs. fixed electricity tariffs on energy costs?

How can comfort levels be preserved while adapting to real-time price and temperature signals?

Methodology: The study uses a model-based optimization framework simulating the ADR to intraday variations in price, temperature, and PV output.
The objective is to **schedule the appliance's operations on an 15 minutes time-resolution basis**, incorporating constraints specific to flexibility, comfort (thermal dead-band), and user-defined priorities. PV generation is also modeled in one scenario, considering that each module measures 1.5*1 m, has a nameplate capacity of 400 W, a performance ration of 80% and module efficiency (in standard test condition) of 20% [5]. To avoid shading, we assume an interrow spacing of 1.5 m. On the 500 m^2 rooftop, we dedicate 200 m^2 for the installation of PV.
Furthermore, we will conduct the cost analysis according to **two tariff scenarios**: the first applies time-variable energy prices based on intraday spot market values and the second scenario uses a grid tariff with fixed base and peak rates. To evaluate the **impact of pricing and PV generation**, we consider four distinct scenarios:

- **Scenario 1**: Time-variable Pricing [3] + PV Generation
- **Scenario 2**: Time-variable Pricing without PV Generation
- **Scenario 3**: Fixed Base/Peak Pricing[2] + PV Generation
- **Scenario 4**: Fixed Base/Peak Pricing without PV Generation

This allows for a comparative analysis of how dynamic pricing and local renewable generation individually and jointly affect electricity costs and appliance operation patterns.

Furthermore, to avoid demand clustering during low-price periods (which could create grid congestion), a **power threshold** is introduced. When office demand exceeds this limit, a penalty (modeled as a higher electricity price) is applied to encourage load diversity.
Finally, the model uses a **rolling horizon operation** to continuously update and reschedule appliance operations in response to intraday changes in electricity prices, outdoor temperatures and solar irradiation.
In the framework of this work, we have evualate the thermal profiles, electricity prices as well as the solar irradiance on the 1Oth of April 2025.

References

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