Decentralized Charging Algorithm for Electric Vehicles Connected to Smart Grid

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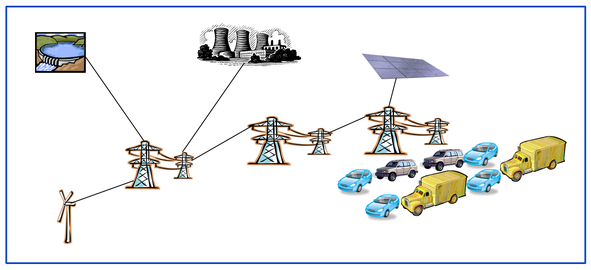
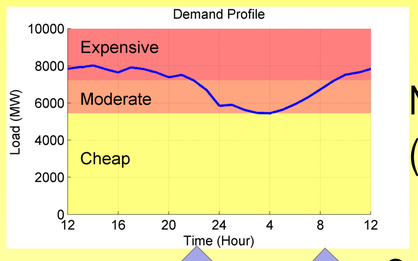
Motivation

- Plug-in hybrid vehicles (PHEV) and pure electric vehicle (EV)
  → More electric demand grid required in an undesired profile.
- EVs are *controllable* load. The charging power and time can be adjusted.

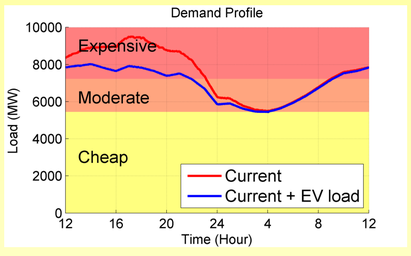


What happens if 2,000,000 vehicles are charging?



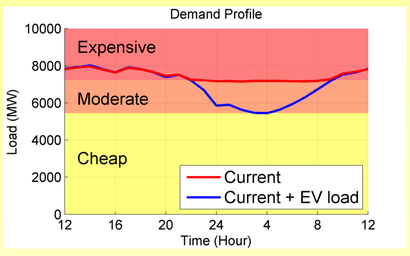
No Electric vehicles (Conventional demand)

No charging control



- Peak load increases
- More expensive plants are required

Smart charging control

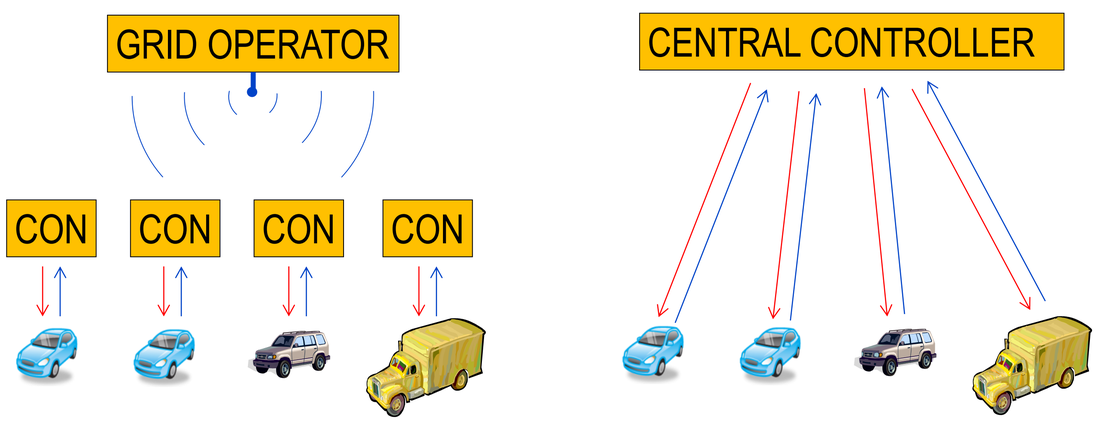


- No additional peak load
- Less expensive electricity is used.
- Less fuel consumption
- Less CO_2 emission

Objectives

- Develop a decentralized charging controller that
  - Can be located at each vehicle
  - Requires little information flow
  - Requires Little computation
- Minimize generating cost and CO_2 emission

Decentralized ↔ Centralized



Method

- Formulate an optimal centralized problem
- Obtain the optimal charging pattern by a LP technique
- Design a near-optimal decentralized control algorithm by emulating the optimal charging pattern

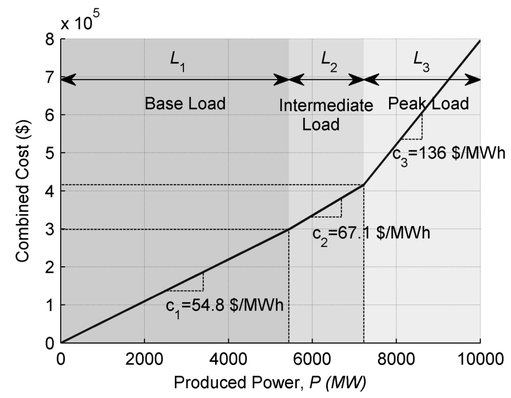
Optimal Problem

$$\min \sum_{t=0}^{T} C\left(P(t)\right),$$

$$P(t) = \sum_{n=1}^{N} P_{EV}(t,n) + P_{conv}(t),$$

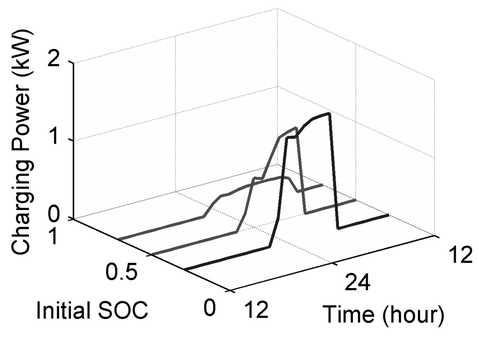
$$\sum_{t=0}^{T} P_{EV}(t,n) = B(n),$$

$$0 \le P_{EV}(t) \le P_{EV\,\lim}(t),$$

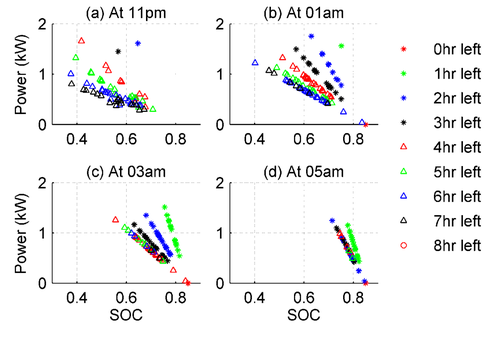


Optimal Solution

Optimal Charging Power Profile



Charging Power v.s. SOC



Decentralized Controller

- It depends on
  - local SOC information
  - Forecasted demand profile

$$P_{EV}(t,n) = \frac{C \cdot PR_{grid}(t)}{\int_{t}^{T_{end}} PR_{grid}(\tau) \cdot d\tau}\left(SOC_{\max} - SOC(t,n\right.$$

where

$$PR_{grid}(t) = \textit{forcated demand profile}$$

Performance Comparison