Charging Pricing Incentives-Enabled Coordinated Dispatching for Improved Overall Benefits of Electric Vehicles and Islanded Photovoltaic Charging Stations

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Paper number: 0328

1. Introduction

- This paper considers an application scenario in which a coordinated dispatching center (CDC) coordinates the dispatching of a relatively large number of electric vehicles (EVs) to multiple photovoltaic charging stations (PVCSs) equipped with energy storage batteries (ESBs).
- This paper proposes a coordinated dispatching strategy for EVs by introducing charging pricing incentives to improve the overall benefits of all the EVs and PVCSs operating in the islanded mode.

2. Application Scenario

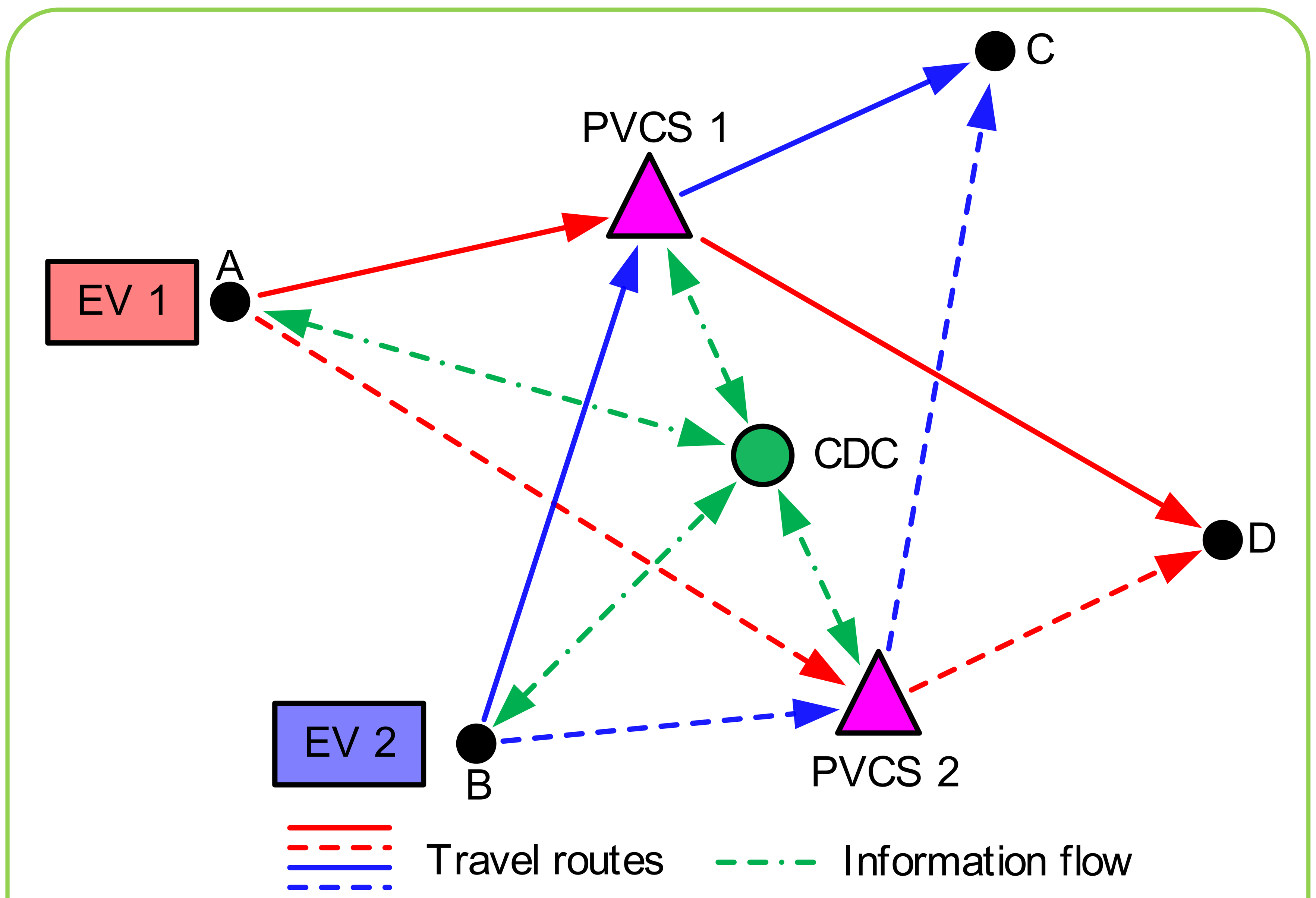


Illustration of application scenario

3. Problem Formulation

- Objective function

$$\min_{\pi_{j,t}} f = \sum_{i \in \mathcal{N}} C_i$$

- EV route cost & trip cost

$$C_{i,j} = C_{i,j}^{energy} + C_{i,j}^{time} + C_{i,j}^{charge}$$

$$\min_{s_{i,j}} C_i = \sum_{j \in \mathcal{M}} s_{i,j} C_{i,j}$$

- EV route cost: energy cost

$$C_{i,j}^{energy} = \lambda \alpha \left(L_{i,j}^{a} + L_{i,j}^{b} \right)$$

- EV route cost: time cost

$$C_{i,j}^{time} = \eta_i \left(t_{i,j}^{road} + t_{i,j}^{charge} \right)$$

- EV route cost: charging cost

$$C_{i,j}^{charge} = \sum_{t \in \left[t_{i,j}^{start}, t_{i,j}^{stop} \right]} \pi_{j,t} P_i^{ev} \Delta t$$

- Constraints

$$P_{max}^{discharge} \le P_{j,t}^{b} \le P_{max}^{charge} \quad \forall j \in \mathcal{M}, t \in \mathcal{T}$$

$$P_{j,t}^{pv} \gamma = \frac{P_{j,t}^{load}}{\gamma} + \frac{P_{j,t}^{ev}}{\gamma} + \frac{P_{j,t}^{b}}{\gamma}$$

$$P_{j,t}^{pv} \gamma - P_{j,t}^{b} \gamma = \frac{P_{j,t}^{load}}{\gamma} + \frac{P_{j,t}^{ev}}{\gamma}$$

$$\sum_{j \in \mathcal{M}} s_{i,j} = 1$$

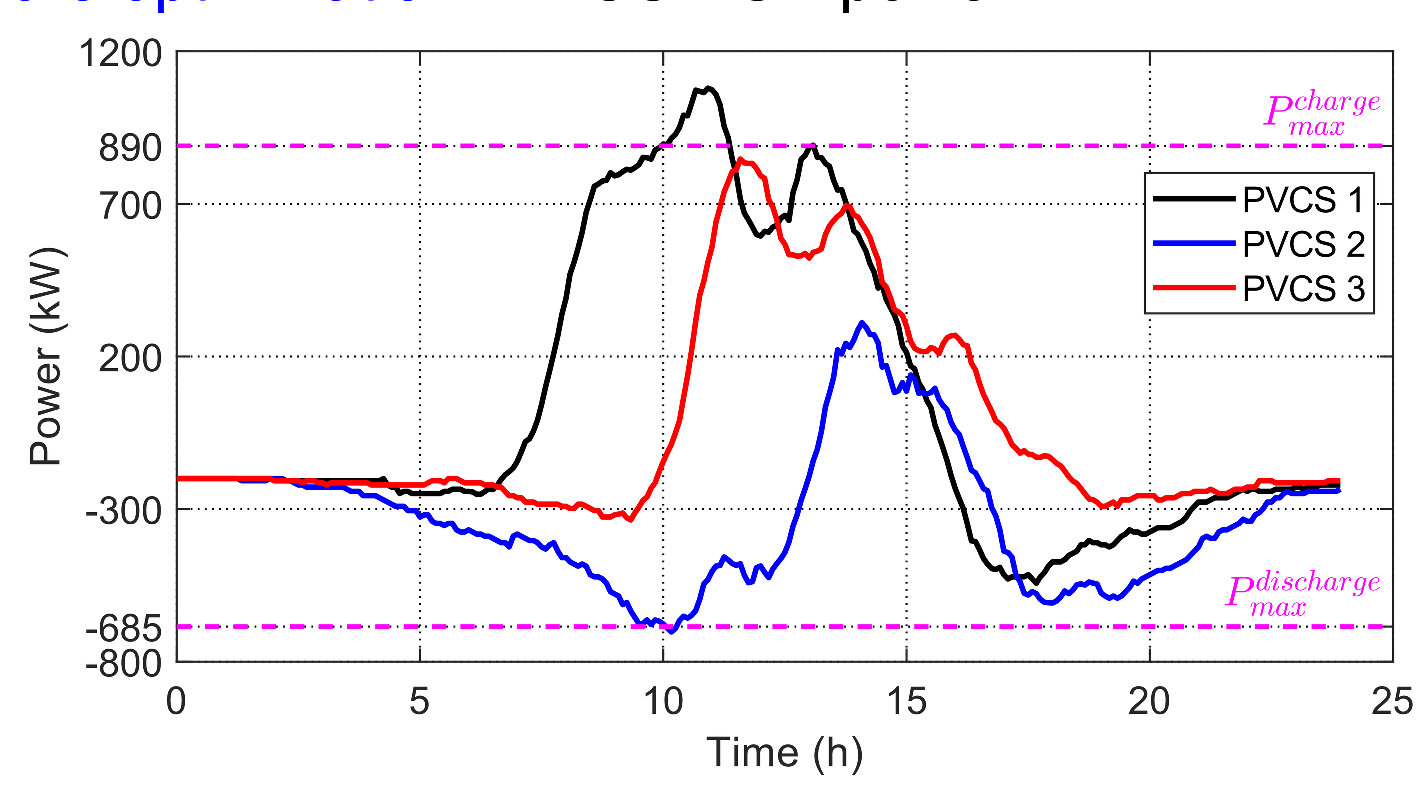
4. Simulation Setup

- 1000 EVs, 3 PVCSs, each PVCS array area is 2700 m^2
- Each day is partitioned into 288 time slots (5 min. per slot)
- $SOC^{init} \sim U(20\%, 80\%)$, $t^{init} \sim N(144, 48^2)$ (units: time slots)

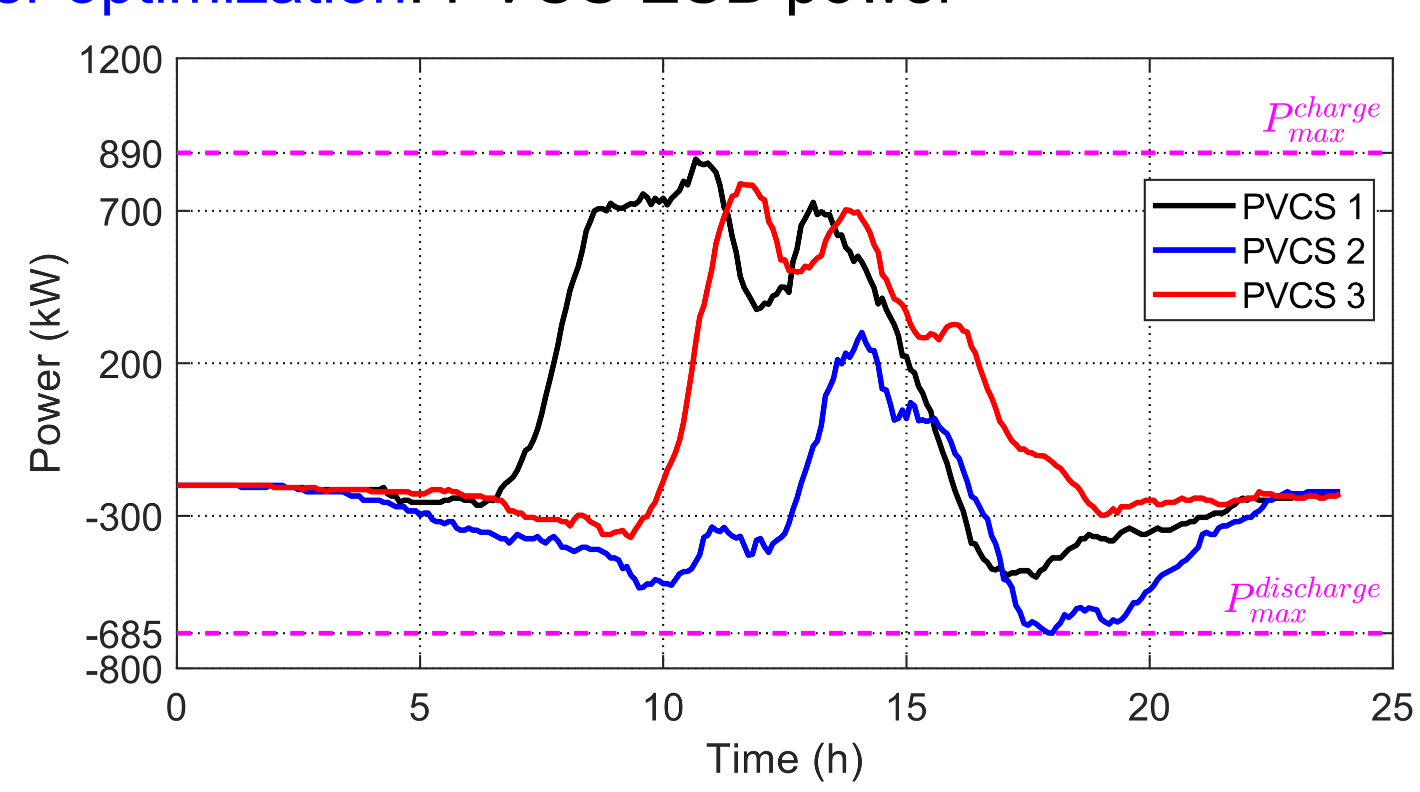
Parameter	Value	Parameter	Value
λ	0.67 ¥/kWh	P_{max}^{charge}	890 kW
α	0.13 kWh/km	$P_{max}^{discharge}$	-685 kW
η	$U(0.36, 2.88)$ ¥/h	$P_{j,t}^{load}$	200 kW
P_i^{ev}	7 kW	γ	0.85

5. Simulation Results

- Total cost of all the EVs is reduced by 20.61%
- Number of EVs with reduced trip costs is 978 out of 1000
- Before optimization: PVCS ESB power



- After optimization: PVCS ESB power



6. Conclusion

- Proposed dispatching strategy works as expected
- Total cost of all the EVs as a whole is reduced
- Safety and efficiency of the PVCSs are boosted