

ENERGY SHARING DESIGN IN A PROSUMER ERA

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Collaborators:



MOTIVATION

- The integration of distributed energy resources and multiple energy carriers is reshaping our energy system from a **highly regulated, operator-controlled** network into a sophisticated **social-interactive infrastructure** with strategic agents.

Centralized operation → **Markets**

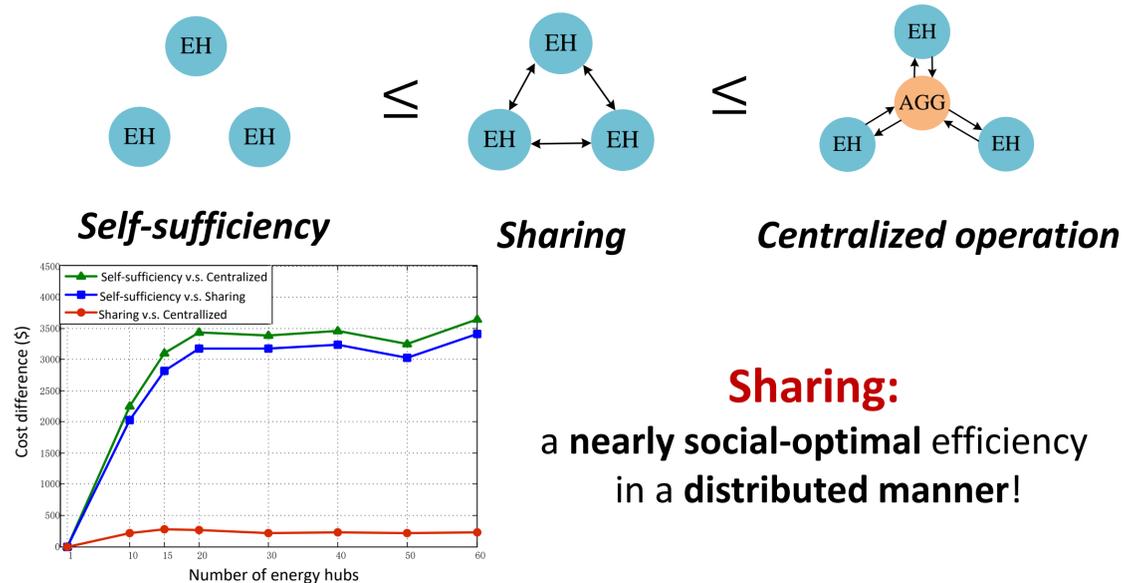
- Emerging sharing economy allows agents to exchange idle resources to fulfill unmet demand.



Can energy be shared?

WHY WE SHARE?

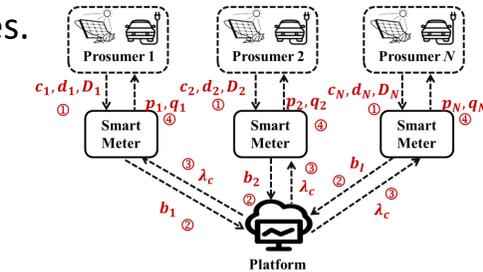
- We compare three typical approaches under a stochastic framework with uncertain loads.



Sharing:
a nearly social-optimal efficiency
in a distributed manner!

HOW TO SHARE?

- Distinct Features:** Endogenously determination of market roles.
Self-sufficiency: $p_i = d_i, \forall i$
Centralized: $\sum_i p_i = \sum_i d_i$ → **Sharing:** $p_i + q_i = d_i, \forall i$
Generalized demand function: $p_i = -a\lambda_c + b_i, \forall i, a > 0$



- More willing to buy i.e. $b_i > \bar{b}$, a buyer
- Otherwise, a seller

Key Designs

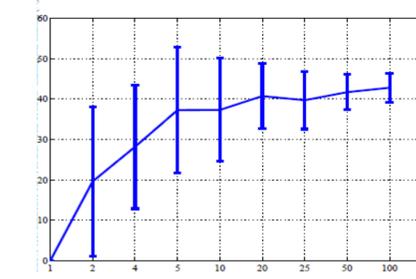
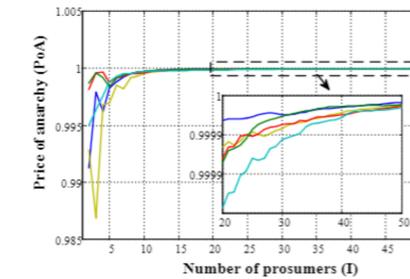
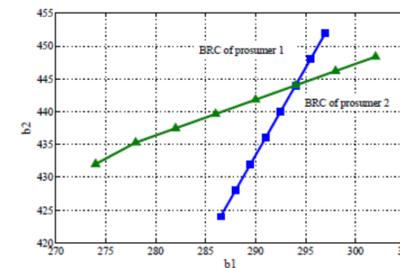
Minimize price discrimination

$$\begin{aligned} \min_{\lambda_i, \forall i} & \sum_i (\lambda_i - \bar{\lambda})^2 \\ \text{s.t.} & \sum_i (-a\lambda_i + b_i) = 0 \\ & -F_l \leq \sum_i \pi_{il} (-a\lambda_i + b_i) \leq F_l, \forall l \end{aligned}$$

Price regulation policy

$$\lambda_i^r = \begin{cases} \max \left\{ \lambda_i, 2c_i p_i + d_i - \frac{q_i}{a(I-1)} \right\}, & q_i \geq 0 \\ \min \left\{ \lambda_i, 2c_i p_i + d_i - \frac{q_i}{a(I-1)} \right\}, & q_i < 0 \end{cases}$$

Properties & Findings

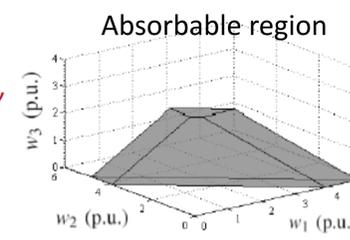
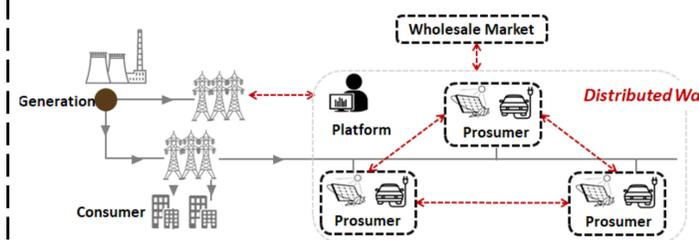


Unique equilibrium exists

Approaches social optimum

Diversity enhances performance

WHAT IF SHARE?



Though economy scarifies a little, **flexibility is retained**

FUTURE DIRECTION

- Internal design**
 - Bounded rationality
 - AC power flow
 - ...
- External design**
 - With conventional operation
 - With conventional markets

