

Decision-Making Framework for the Future Grid (5.1)

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Context

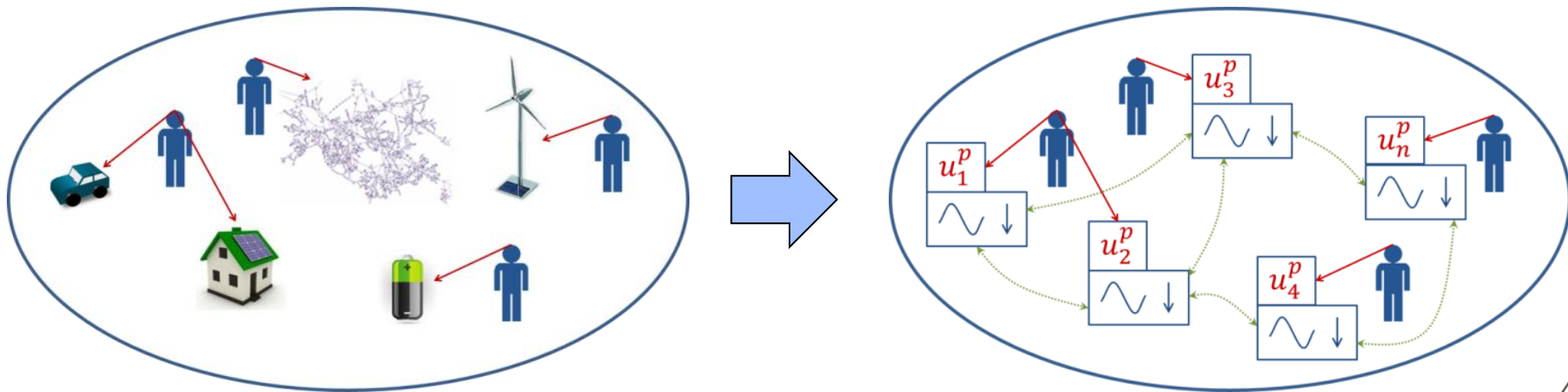
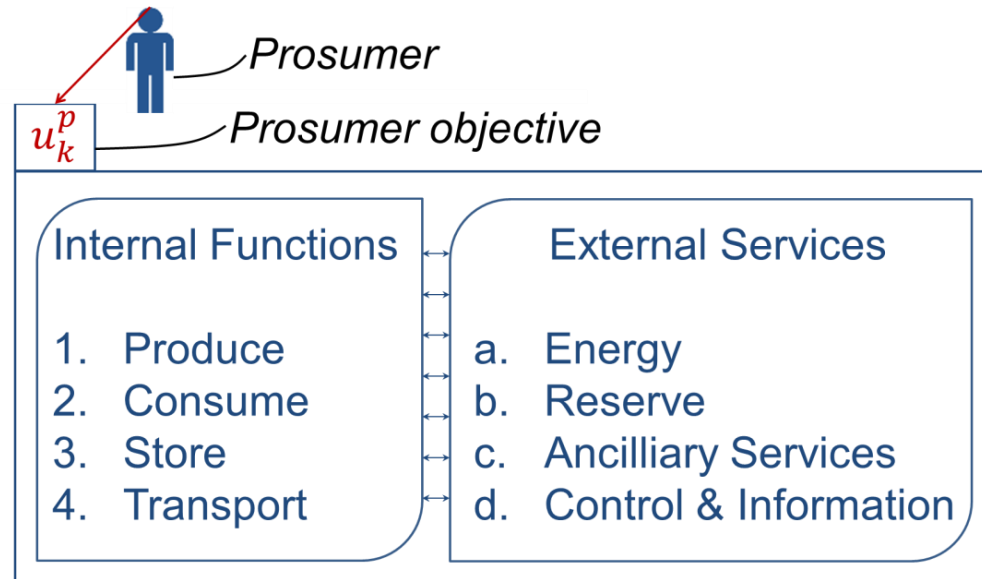
- The Future Grid = a billion devices and millions of decision-makers that will pursue their **own** objectives
- New goals, more stringent requirements, and increased uncertainty and complexity
- Residential Energy Users = New Decision Makers
“Enabling Informed Participation by Customers...”
 - What role will they play in the future grid?
 - How will they respond to incentives?
 - Value of the new capabilities deployed at the residential level?
 - How to accurately and dynamically model their future behavior?

Research objectives

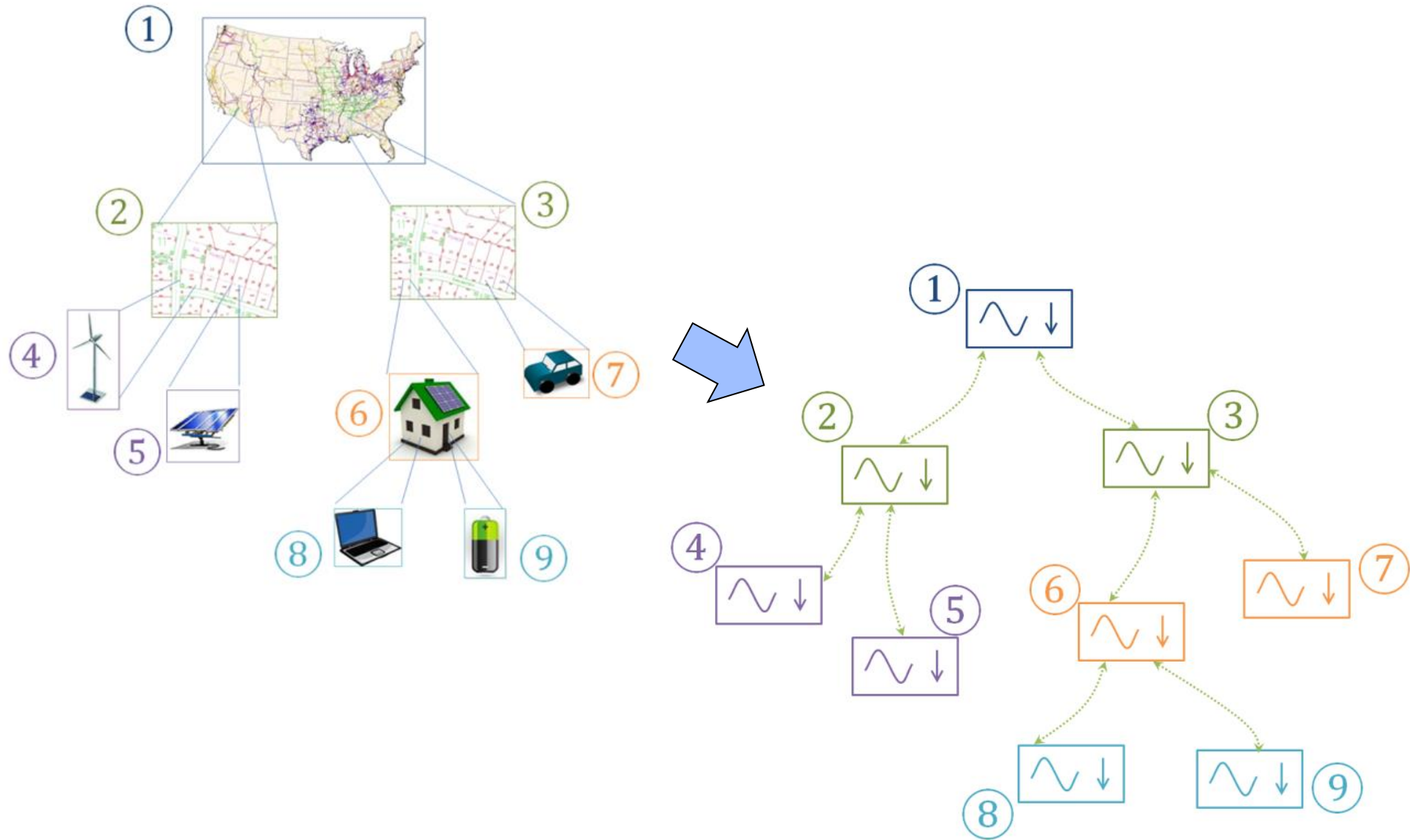
1. To develop a decision-making framework:
An electricity industry model that describes who will be making decisions, what decisions, when, where and how.
 - a. Scalable to millions of decision-makers
 - b. Addresses decision complexity through layered abstractions.
 - c. Covers multiple spatial and temporal decision scales.
2. To develop specific decision-making mechanisms:
 - a. scheduling algorithm to allow residential users to optimally schedule their energy use in a dynamic pricing environment.
 - b. method to optimally design electricity price signals on retail markets.

A Shared Representation: Prosumers

- Need a **shared representation** of the future grid that improves collective intelligence for decision making.
- The **prosumer** abstraction is flexible enough to be adaptable across multiple view points and scales.

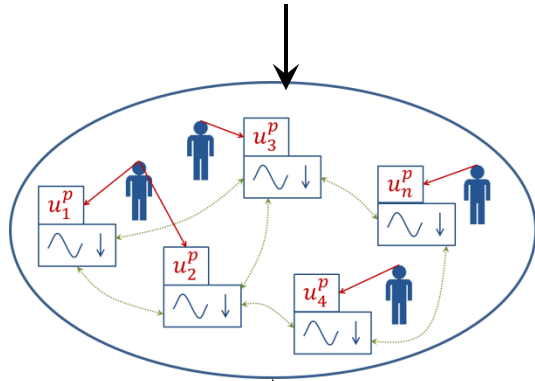


A Scalable Representation



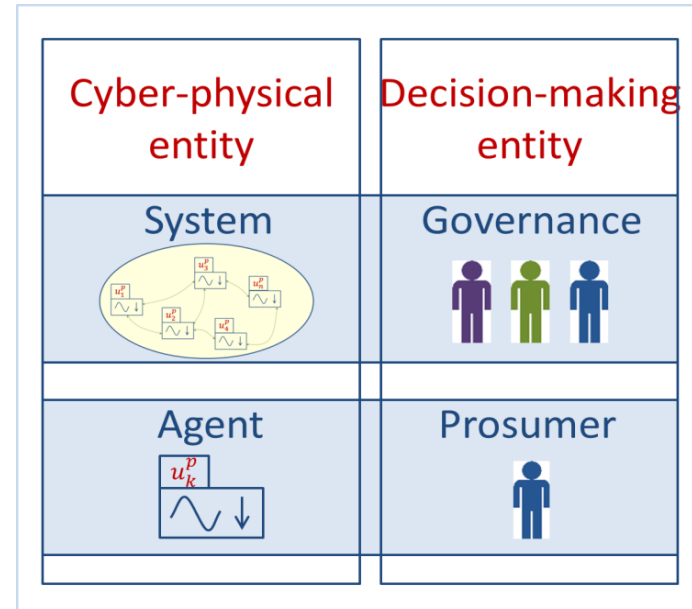
Decision-Making Framework

System level: “set rules” applicable to prosumer functions and services



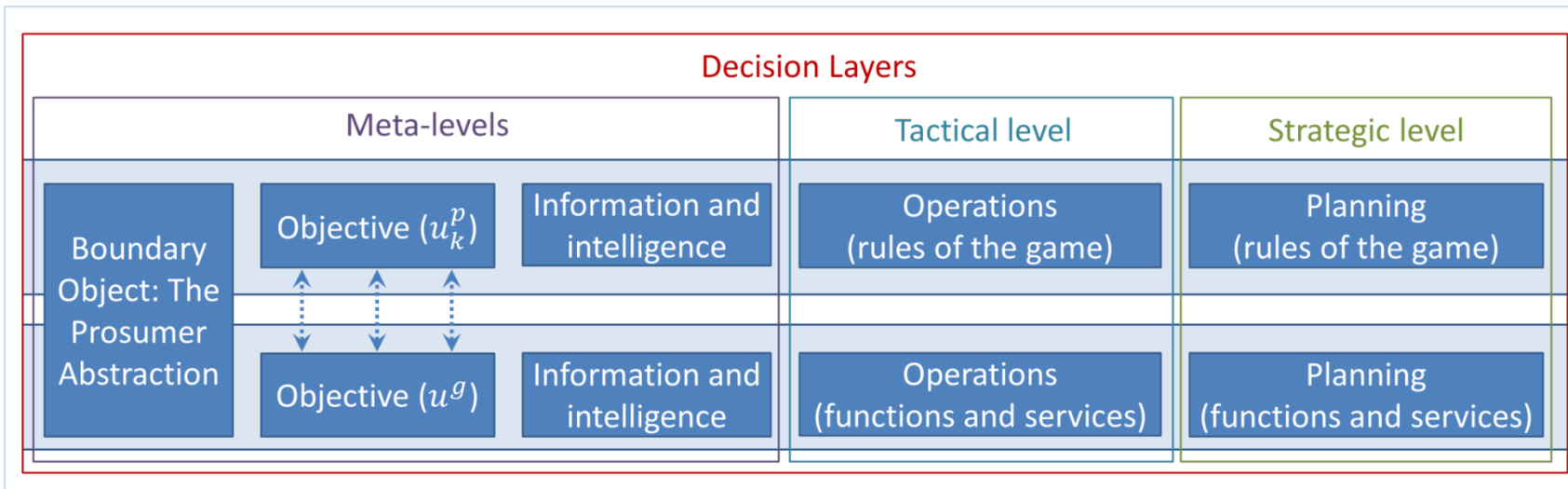
Our focus

Prosumers: “set mechanisms”



System
→

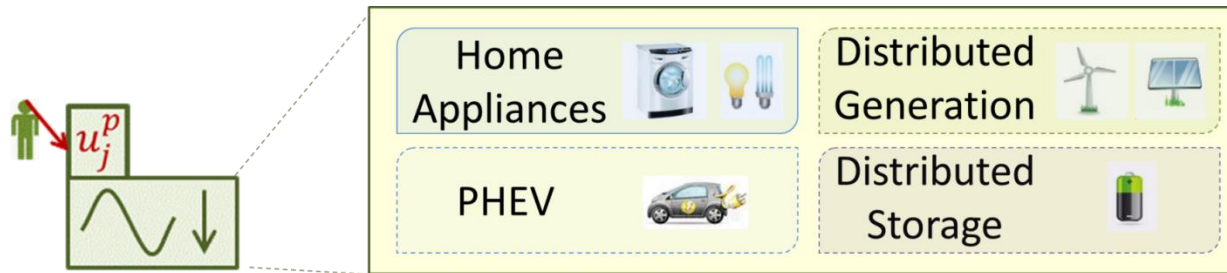
Agent
→



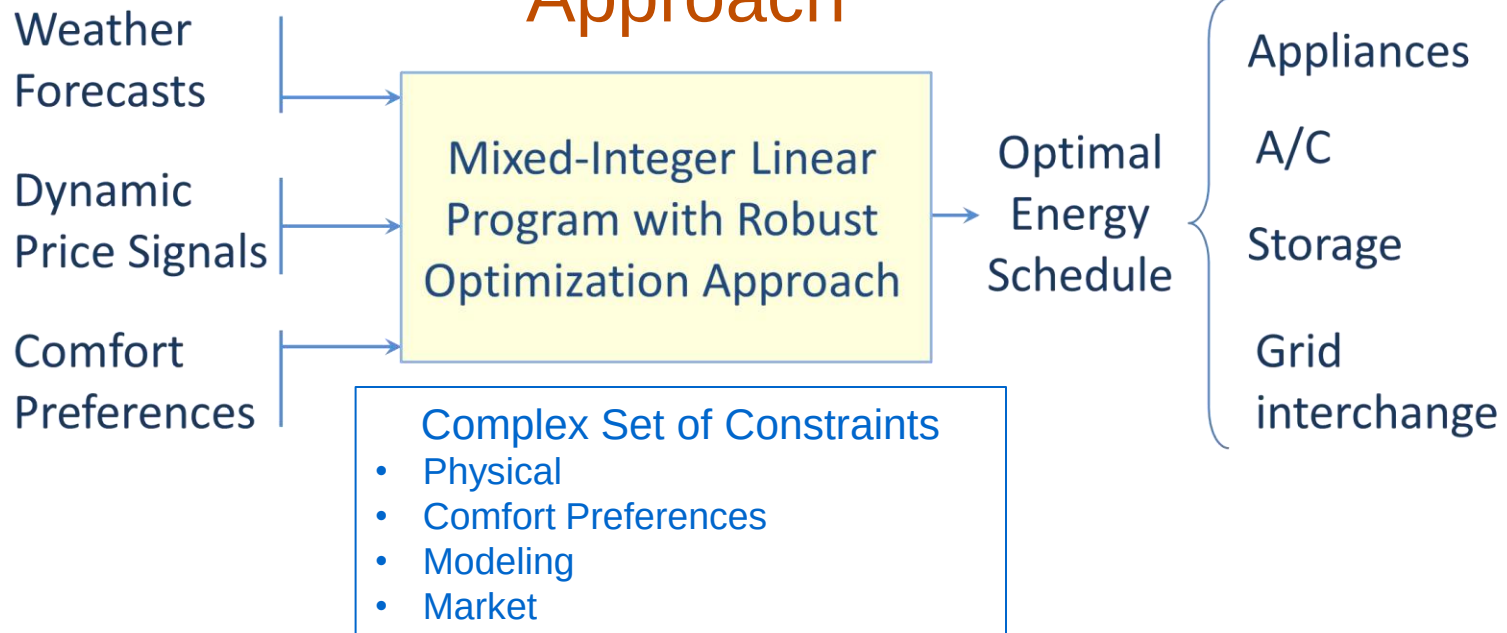
Mechanism 1: Residential Prosumers

Prosumer: residential electricity user

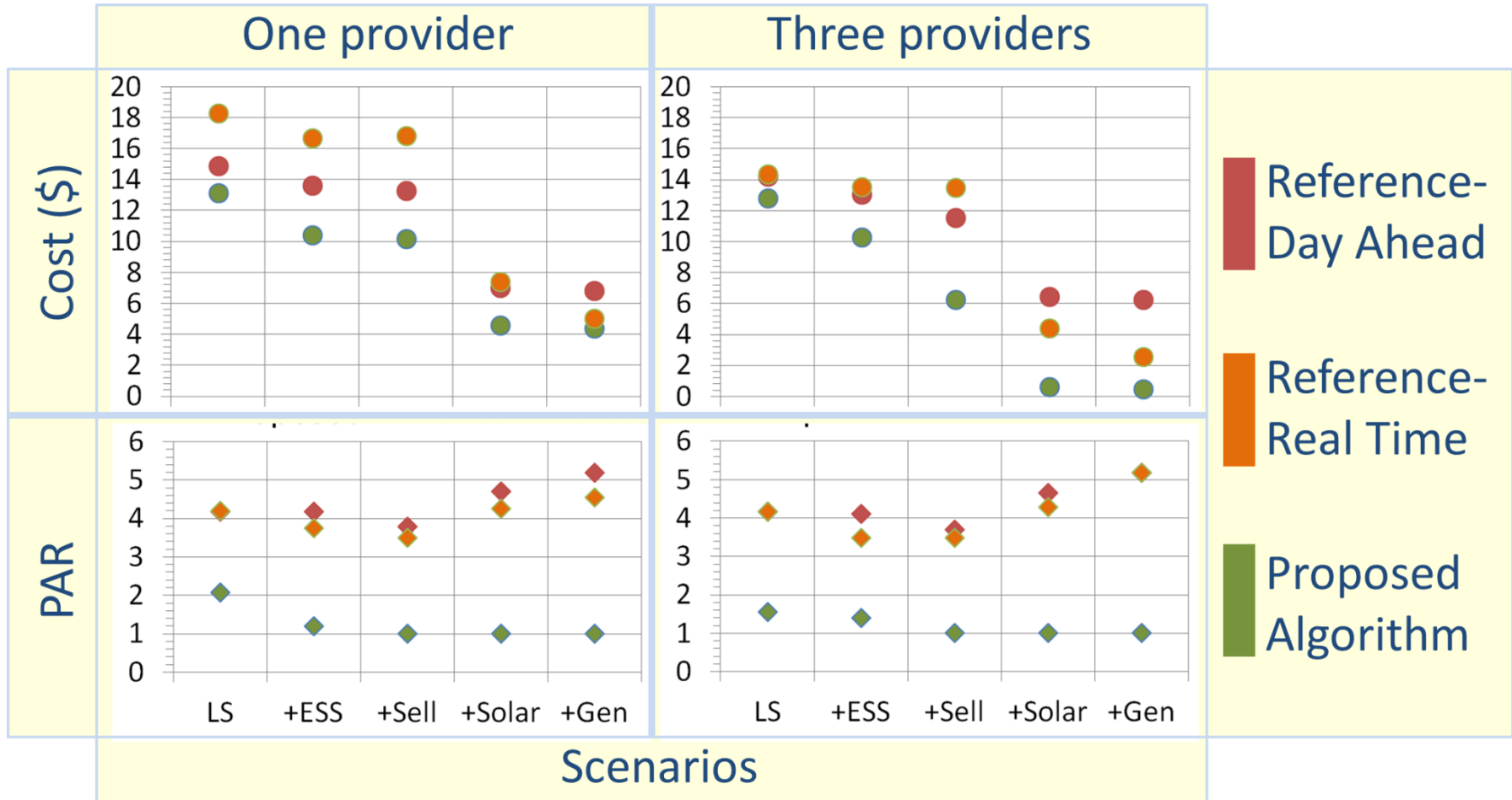
Mechanism: optimize energy usage in dynamic pricing environment



Approach



Results



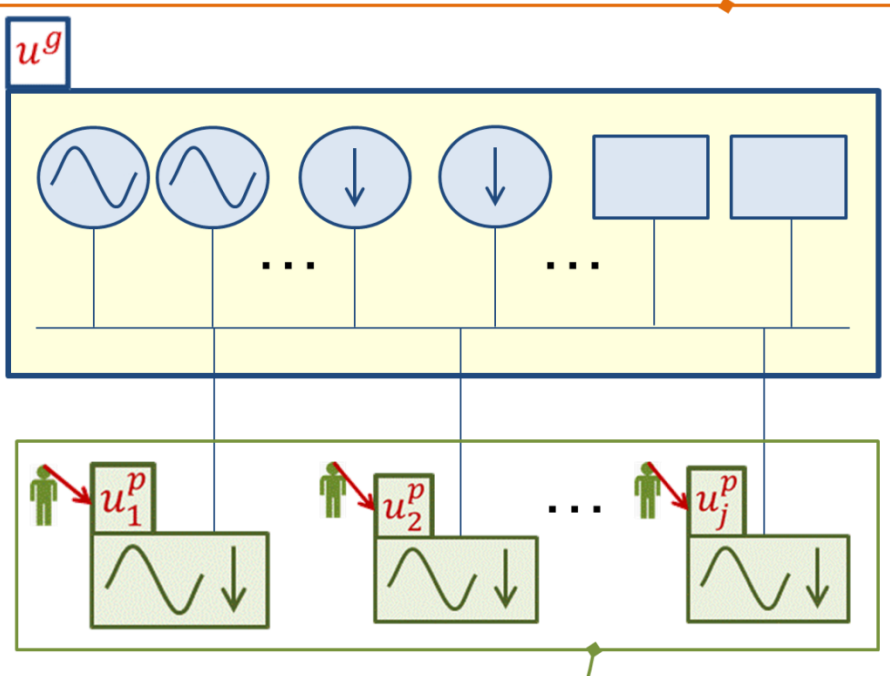
T. Hubert, S. Grijalva, "Modeling for Residential Electricity Optimization in Dynamic Pricing Environments", IEEE Transactions on Smart Grid, Dec 2012

Mechanism 2: Utility Prosumers

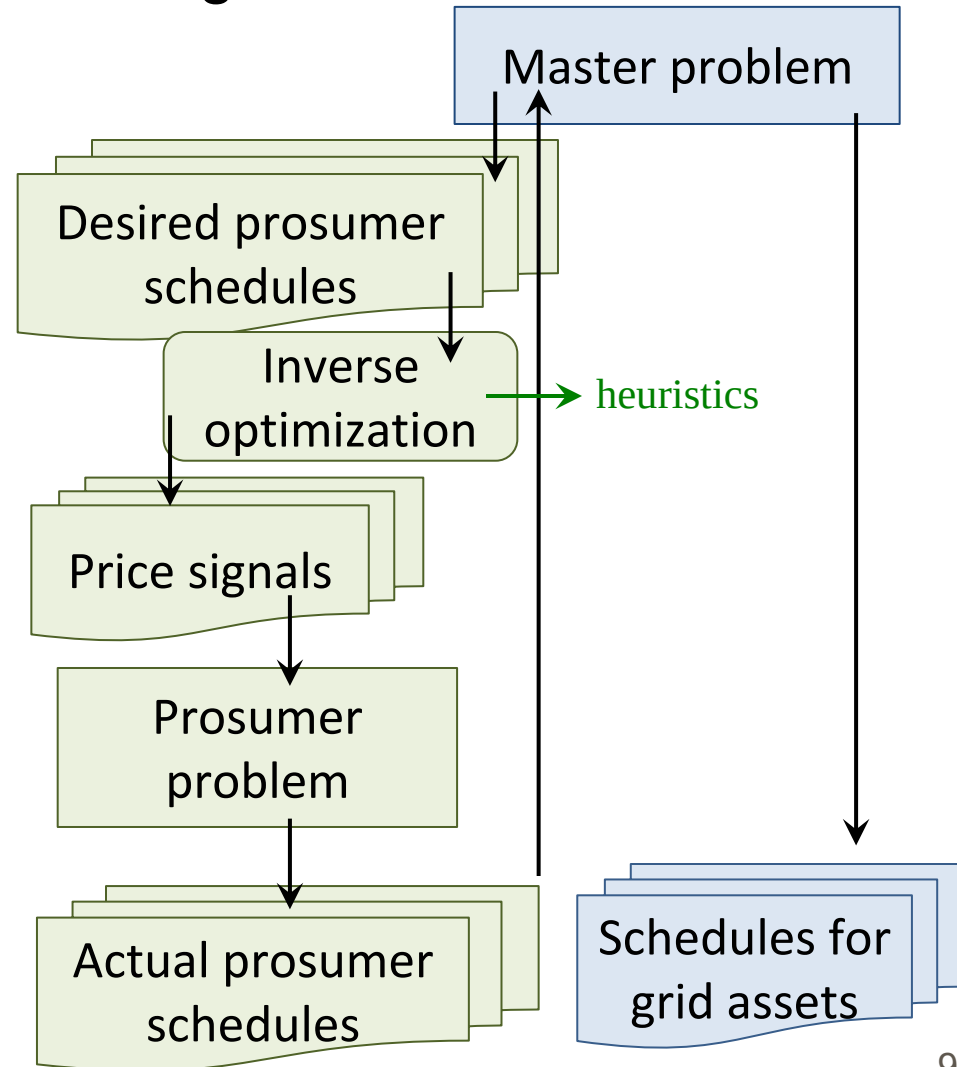
Prosumer: utility serving electricity prosumers

Mechanism: optimally design price signals

Master Problem



Prosumer Problems



Results

Pilot simulation: 1,000 distinct residential prosumers

Optimization Problem

Running time (4-core machine)

Master Problem (initial)

20.49 s

Price generation algorithm (1 prosumer)

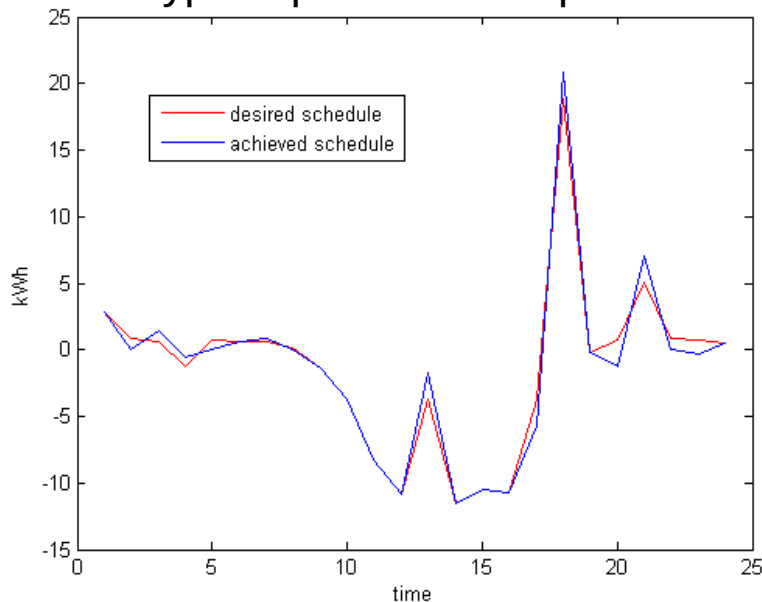
Average = 1.94 s

Std = 1.95 s

Master Problem (final balancing)

<1s

Typical prosumer response



Performance

Error

Value

Error on individual
desired schedules

Average = 11.4%
Std = 16.5%

Error on aggregated
schedules (daily)

4.9%

Potential Uses and Benefits

Prosumer concept & general framework

- | | | | |
|------|--|-------|---|
| Who | Prosumers & gouvernance | When | Tactical and strategic |
| What | Decisions associated with energy optimization and goals definition | Where | Locally (prosumers),
Centralized (gouvernance) |
| | | How | Mechanisms and rules |
- Enable multidisciplinary teams to collaborate on the future grid research and foster long-term innovation

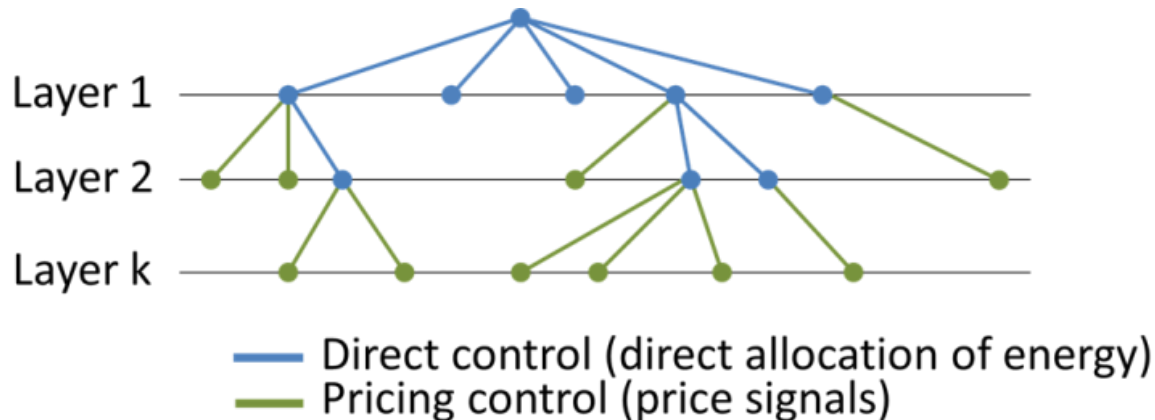
Energy scheduling algorithms:

- Simulate and analyze impact of: Smart Appliances, DG, use of dynamic pricing, V2G, H2G, etc.
- Implement home energy controllers:
“Decision Making = Information + Intelligence”
- Potentials:
 - Prescriptive: provide concrete guidance on how to act
 - Descriptive: illustrate why to make these changes
 - Normative: demonstrate how decisions should be made

Potential Uses and Benefits

Pricing design method:

- Enhance dispatch: new control strategies based on engineered price signals
- Bridge differences between local and system objectives
- Decompose the optimization problem into distributed problems coordinated by the master problem



- New business models as electricity providers transition to the future grid and adapt to its new rules and mechanisms.

Project Publications to Date

Hubert, Tanguy, and Santiago Grijalva. "Modeling for Residential Electricity Optimization in Dynamic Pricing Environments." In *Smart Grid, IEEE Transactions on*, vol.3, no.4, pp. 2224-2231, Dec. 2012.

Costley, M., and Santiago Grijalva. "Efficient distributed OPF for decentralized power system operations and electricity markets." In *Innovative Smart Grid Technologies (ISGT), 2012 IEEE PES*, pp.1-6, 16-20 Jan. 2012.

Hubert, Tanguy, and Santiago Grijalva. "Realizing smart grid benefits requires energy optimization algorithms at residential level." In *Innovative Smart Grid Technologies (ISGT), 2011 IEEE PES*, pp.1-8, 17-19 Jan. 2011.

Grijalva, Santiago, and M. U. Tariq. "Prosumer-based smart grid architecture enables a flat, sustainable electricity industry." In *Innovative Smart Grid Technologies (ISGT), 2011 IEEE PES*, pp.1-6, 17-19 Jan. 2011.

Q&A