Microgrids: the Essential Architecture for Smart Energy

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Grid-Interop
Driving to Grid 2020

We want rapid innovation and distributed energy

- Central control requires simplification and homogeneity
- Volatility of Supply
- Rapid change of Technology
- Unable to determine changing best application of changing supply to changing demand.

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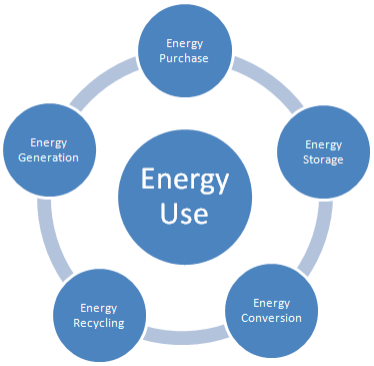
Break up the span of control, isolate diversity, empower consumers:

Microgrids



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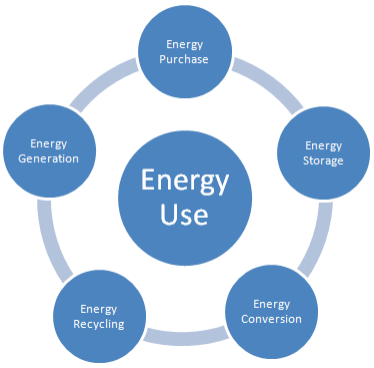


WHAT ARE THE CHARACTERISTICS OF MICROGRIDS

What Are Microgrids?

- Each microgrid may always or sometimes be disconnected from other grids.
- Microgrids are self-managing
- Different microgrids have different purposes
- A microgrid MAY be a component in a larger microgrid
- A microgrid may be composed of smaller microgrids

Microgrids are already all around.

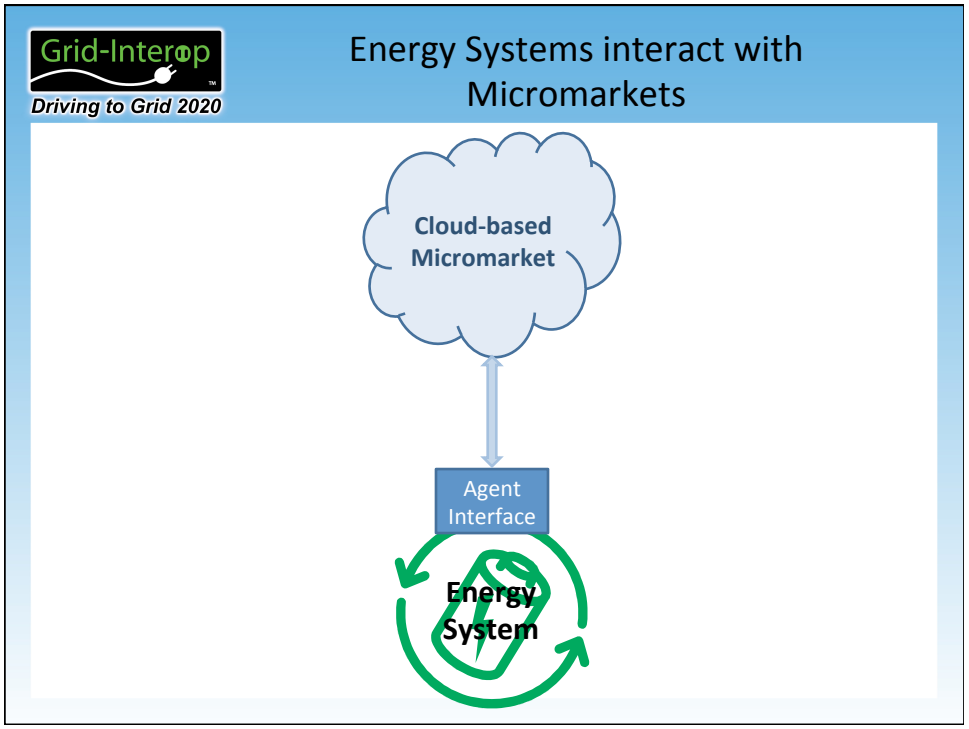
- Industrial Microgrids
  - Includes District Energy
- Isolated Microgrids
- Development Microgrids
- Military Microgrids
- Motivational Microgrids
- Hidden Microgrids
  - Post-Sandy Experience

The central issue for each microgrid is optimum allocation of energy

- Distributed Energy is local energy
- Priorities and purposes for each source and use of energy are ever changing
- Each microgrid presents a classic knowledge problem
- Markets are tested means to operate control systems
- OASIS Energy Operation defines market interface for any agent or system.

OASIS Energy Interoperation provides semantics and interaction patterns for energy market operation

USE TRANSACTIVE MARKETS TO SOLVE KNOWLEDGE PROBLEM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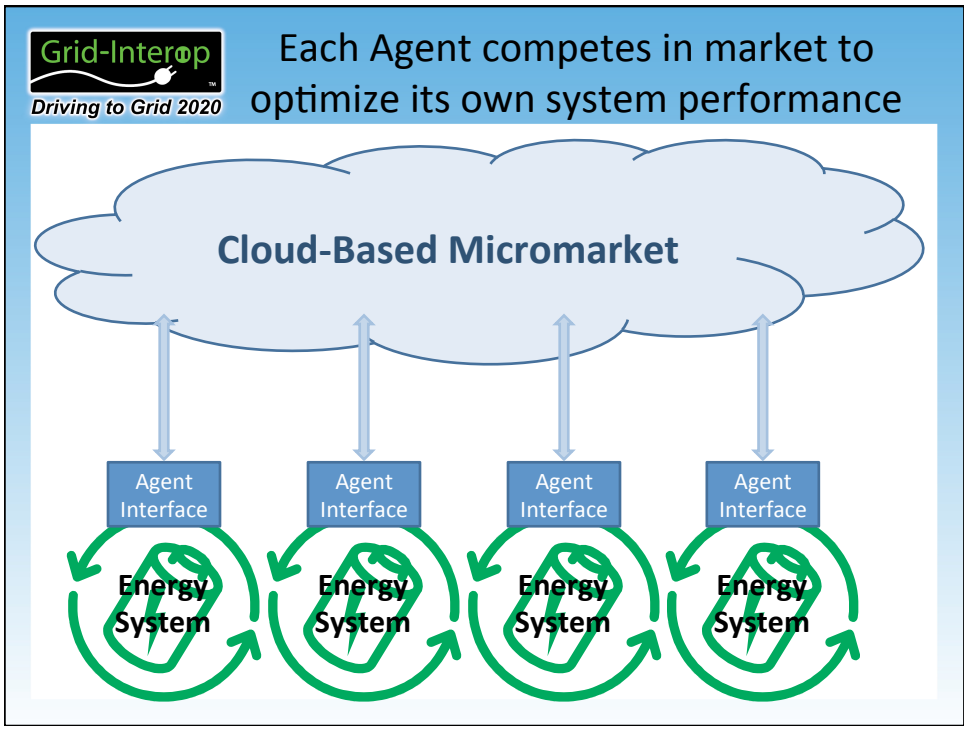
Energy Systems interact with Micromarkets
Cloud-based Micromarket
Agent Interface
Energy System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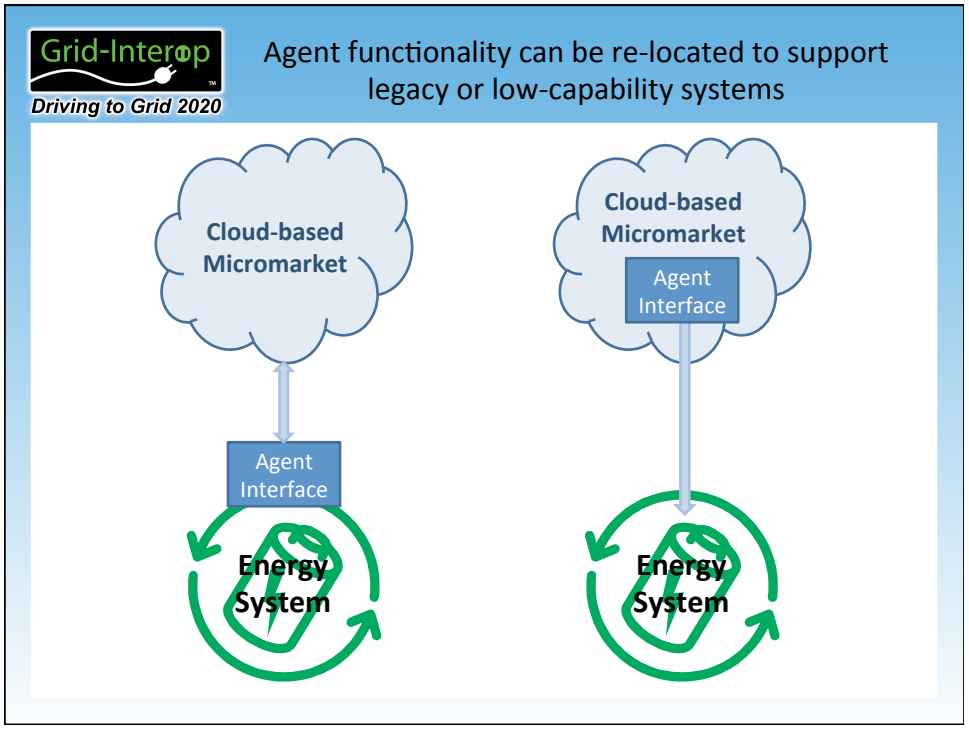
Each Agent competes in market to optimize its own system performance
Cloud-Based Micromarket
Agent Interface
Agent Interface
Agent Interface
Agent Interface
Energy System
Energy System
Energy System
Energy System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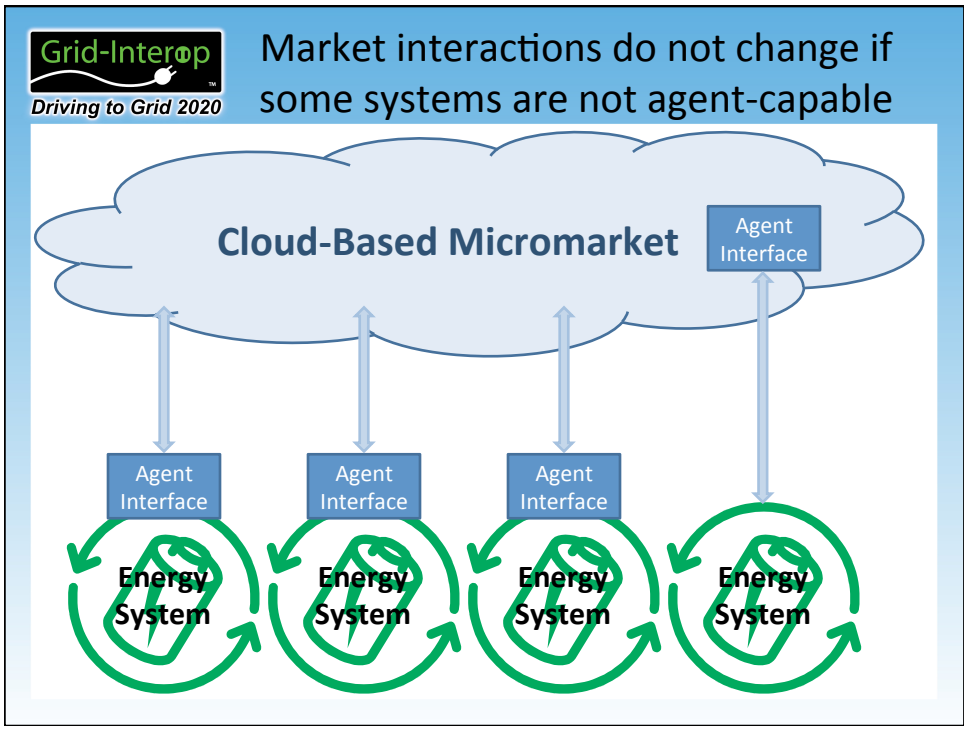
Agent functionality can be re-located to support legacy or low-capability systems
Cloud-based Micromarket
Agent Interface
Energy System
Cloud-based Micromarket
Agent Interface
Energy System


Grid-Interop
Driving to Grid 2020
Market interactions do not change if some systems are not agent-capable
Cloud-Based Micromarket
Agent Interface
Agent Interface
Agent Interface
Agent Interface
Energy System
Energy System
Energy System
Energy System

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Many grids means diversity of purpose as well as of technology

THE ARCHITECTURE OF MICROGRIDS

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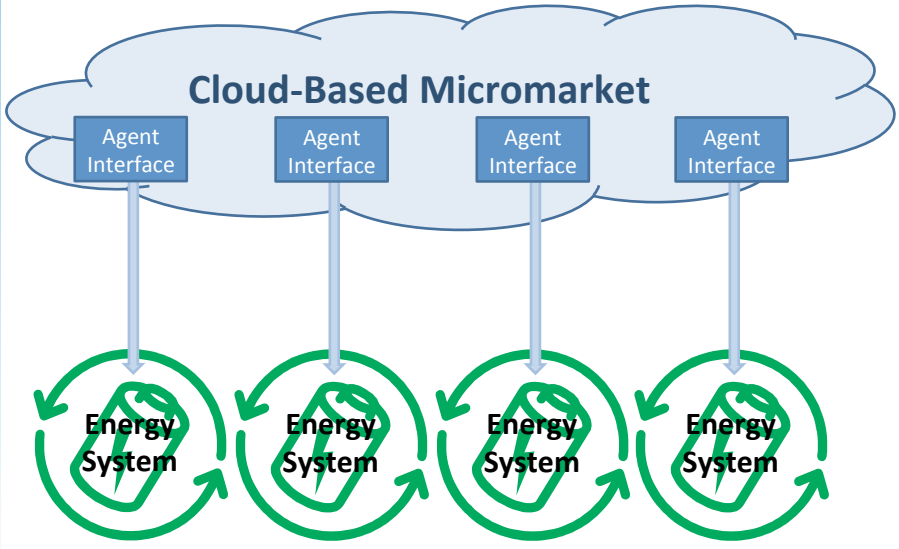
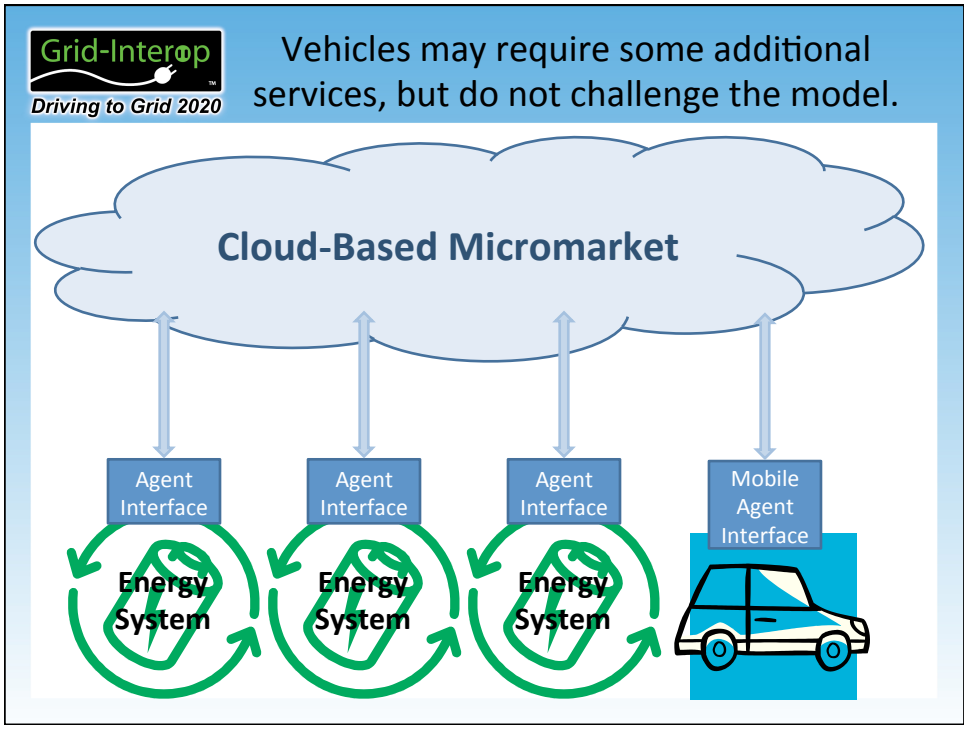
At the edge, Micromarkets of low-capability systems can resemble legacy integration

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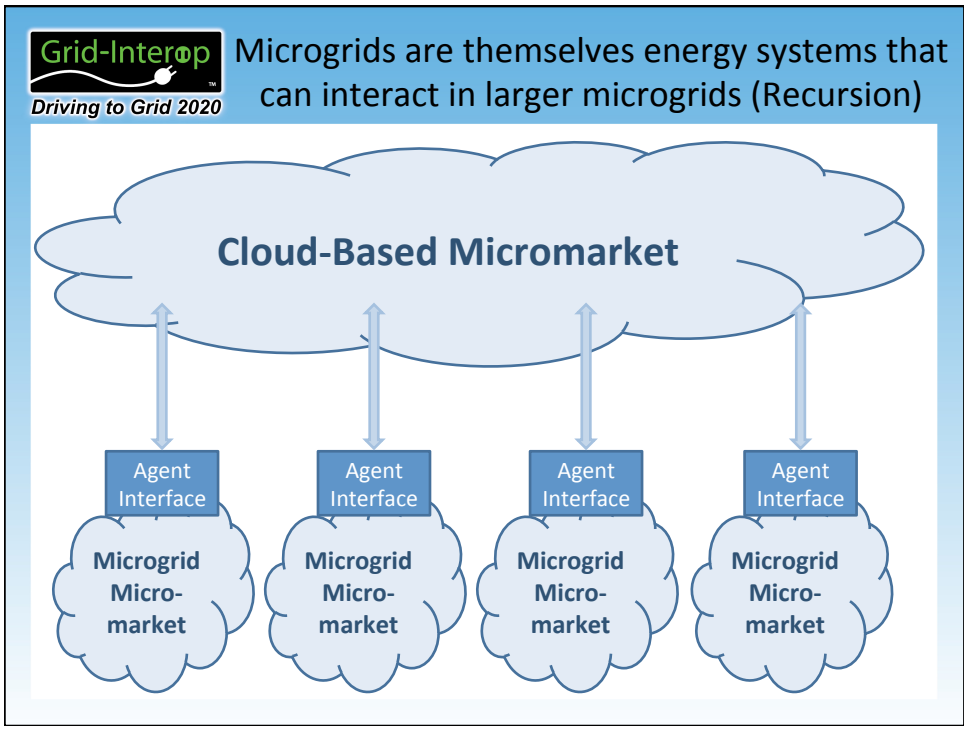
Vehicles may require some additional services, but do not challenge the model.
Cloud-Based Micromarket
Agent Interface
Agent Interface
Agent Interface
Mobile Agent Interface
Energy System
Energy System
Energy System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Microgrids are themselves energy systems that can interact in larger microgrids (Recursion)
Cloud-Based Micromarket
Agent Interface
Agent Interface
Agent Interface
Agent Interface
Microgrid Micro-market
Microgrid Micro-market
Microgrid Micro-market
Microgrid Micro-market

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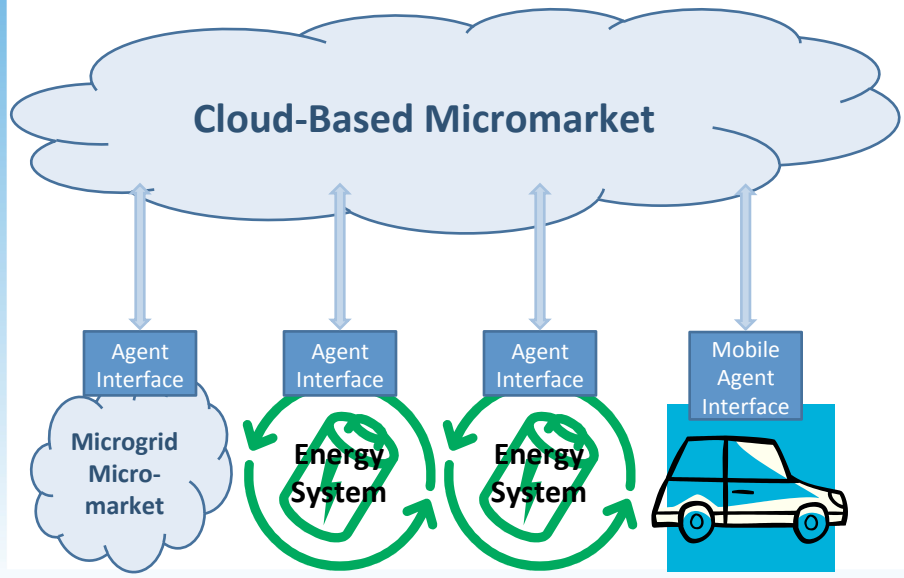
The type of system represented by the agent does not change the market interaction



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Questions

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Markets for Control

- B. Huberman and S. H. Clearwater, "Thermal markets for controlling building environments," Energy Engineering, vol. 91, no. 3, pp. 26-56, January 1994.
- B. Huberman and S. H. Clearwater, "A multi-agent system for controlling building environments," in First International Conference on Multiagent Systems, 1995.

Energy-Related OASIS Specifications

- OASIS Energy Interoperation
  - Designed to work to, from, inside, and outside microgrids
  - Committee Specification ballot in process
  - http://www.oasis-open.org/committees/energyinterop
- OASIS Energy Market Information Exchange
  - Price and product definition/description
  - Transactional EMIX Notes
  - Committee Specification pending publication
  - http://www.oasis-open.org/committees/emix

Knowledge Problems and Spontaneous Order

- F. A. Hayek, "The Use of Knowledge in Society," The American Economic Review, vol. 35, no. 4, pp. 519-530, 1945.
- L. Kiesling, "The Knowledge Problem, Learning, and Regulation: How Regulation Affects Technological Change in the Electric Power Industry," Studies in Emergent Order, vol. 3, pp. 149-171, 2010.