



# Microgrids: the Essential Architecture for Smart Energy

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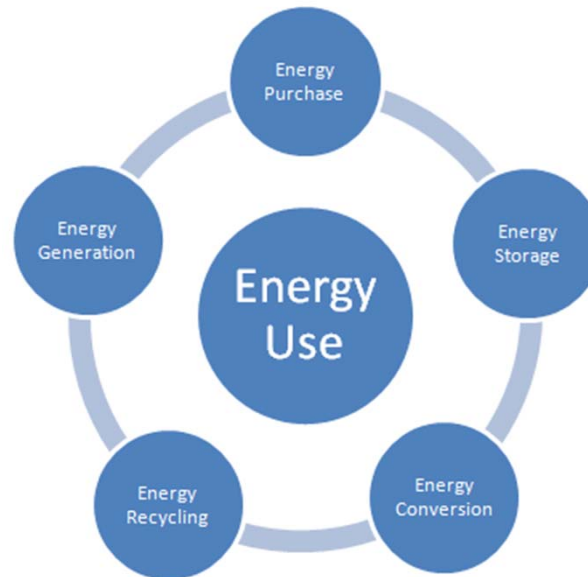
## We want rapid innovation and distributed energy

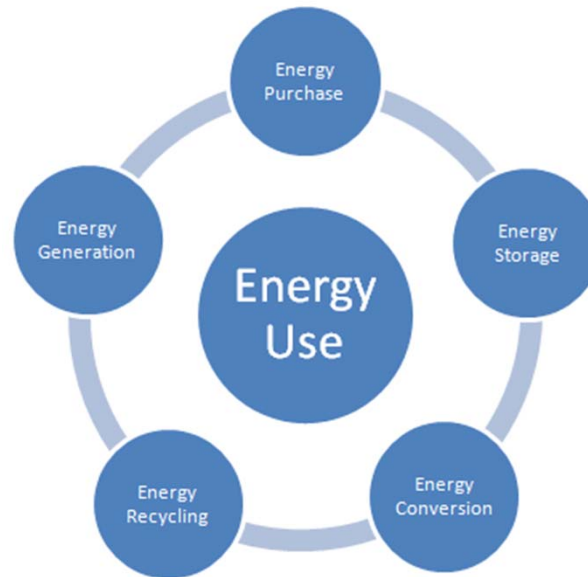
- Central control requires simplification and homogeneity
- Volatility of Supply
- Rapid change of Technology
- Unable to determine changing best application of changing supply to changing demand.



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

# Microgrids





## 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

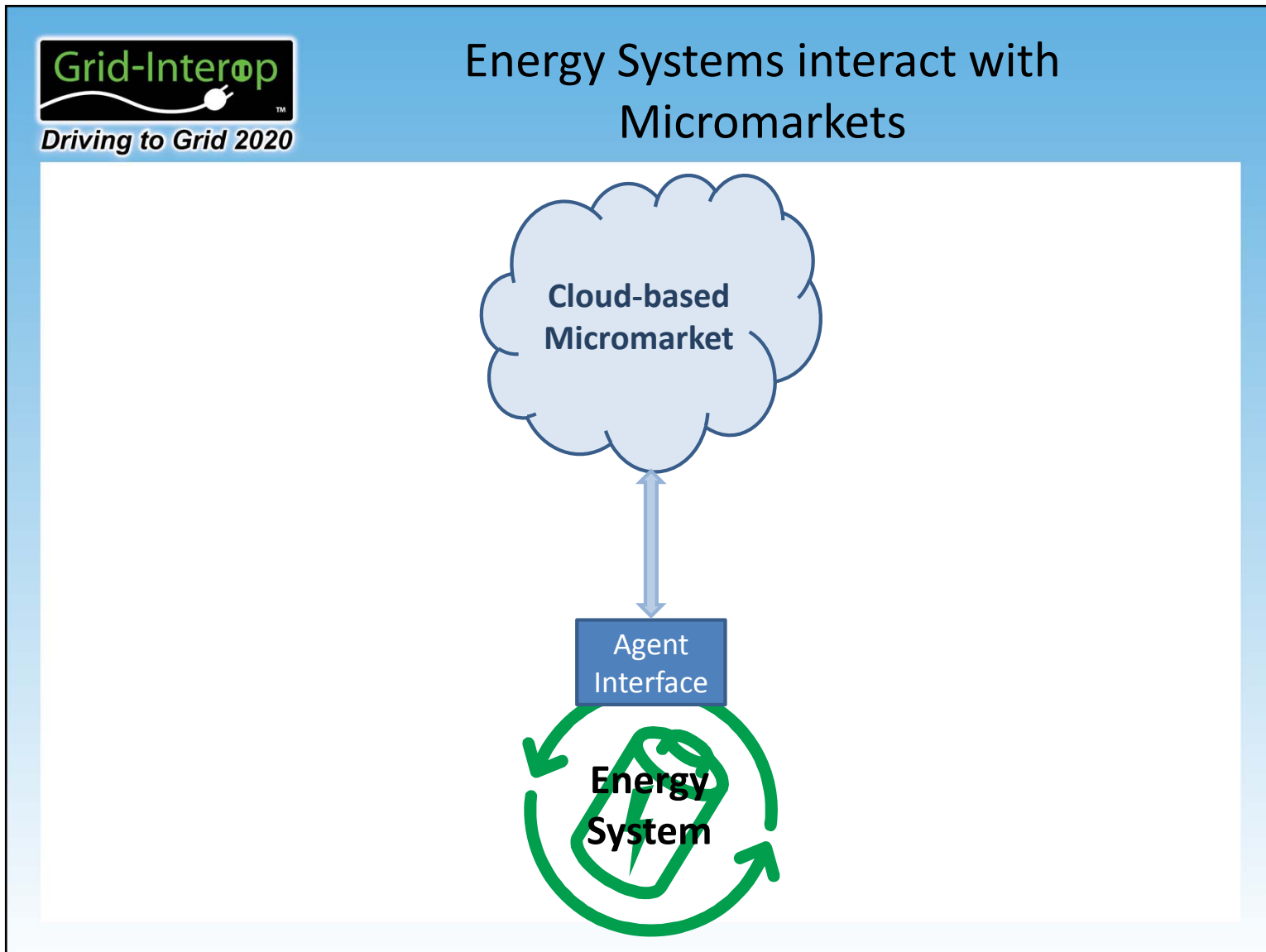
- Distributed Energy is local energy
- Priorities and purposes for each source and use of energy are ever changing
- Each microgrid presents a classic knowledge problem
- Markets are tested means to operate control systems
- OASIS Energy Operation defines market interface for any agent or system.

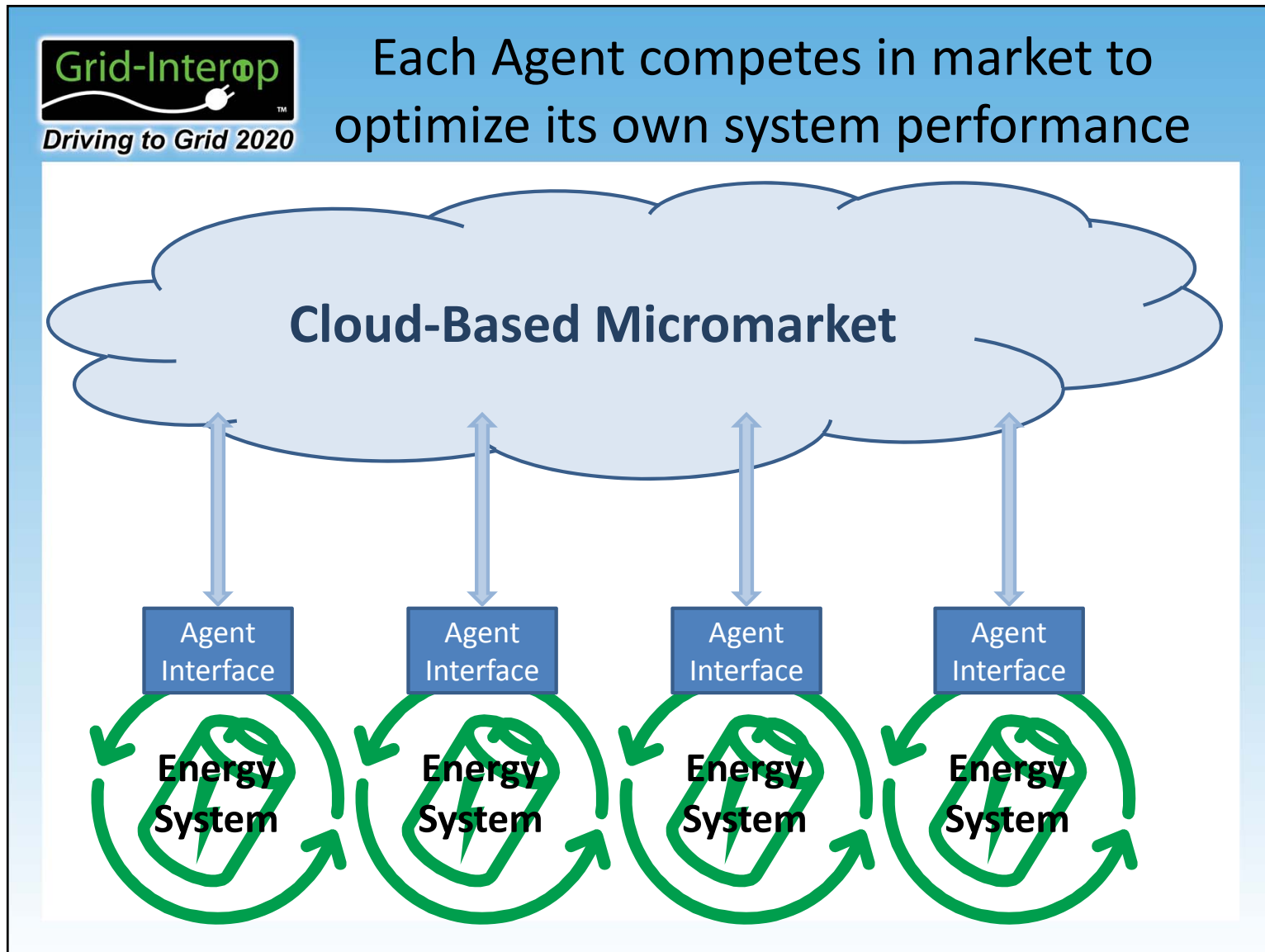


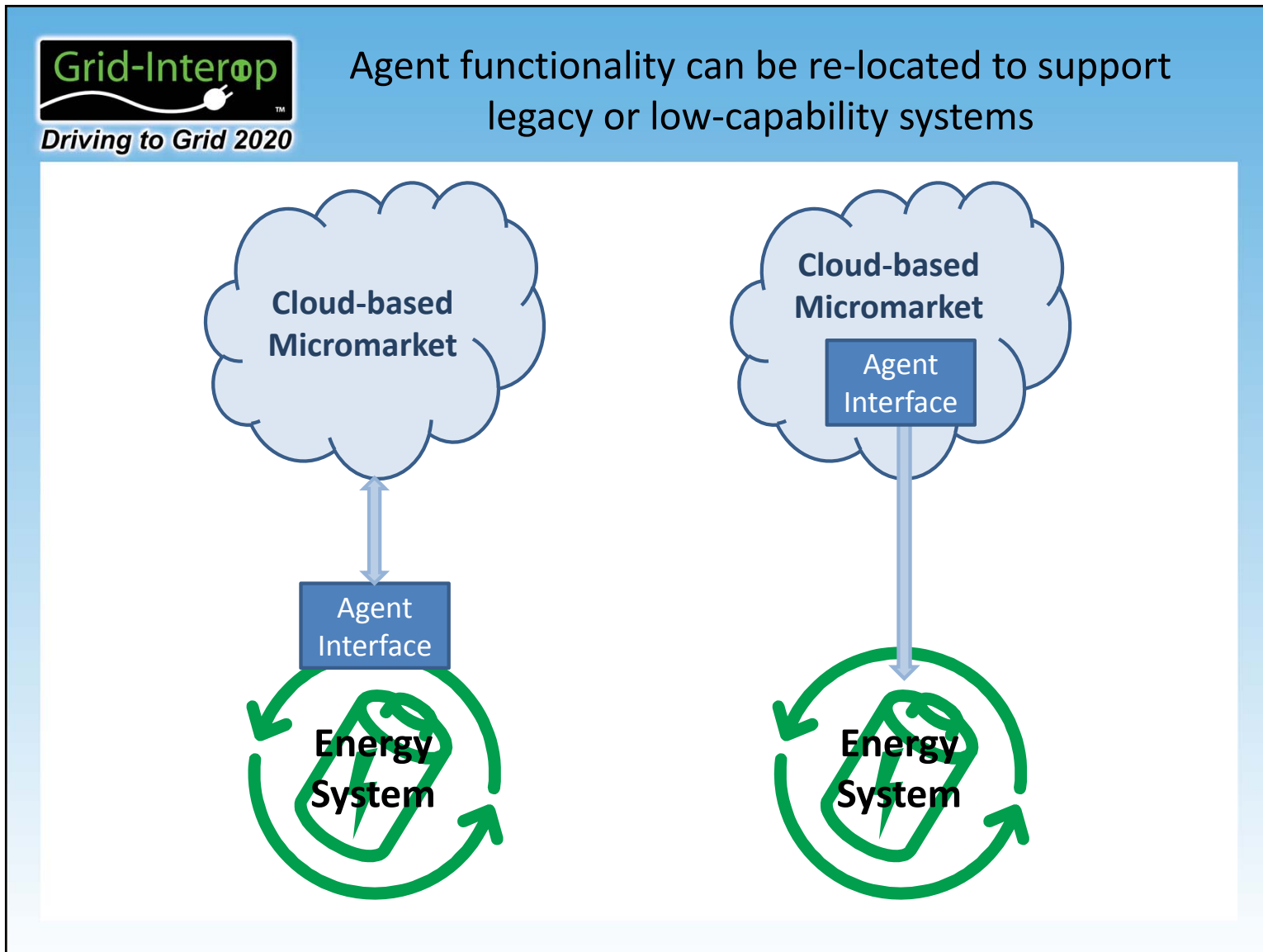
OASIS Energy Interoperation provides semantics and interaction patterns  
for energy market operation

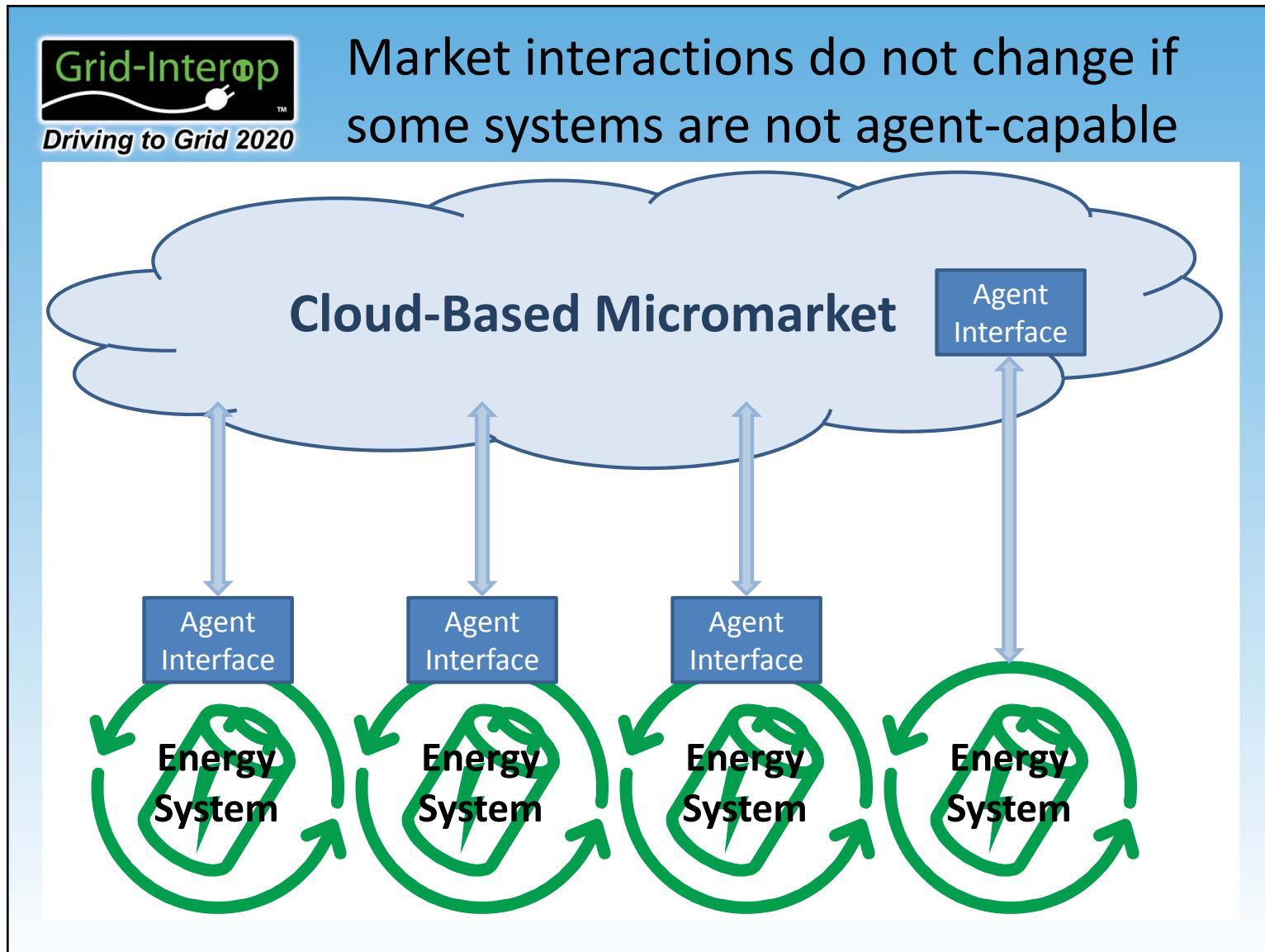
## **USE TRANSACTIVE MARKETS TO SOLVE KNOWLEDGE PROBLEM**







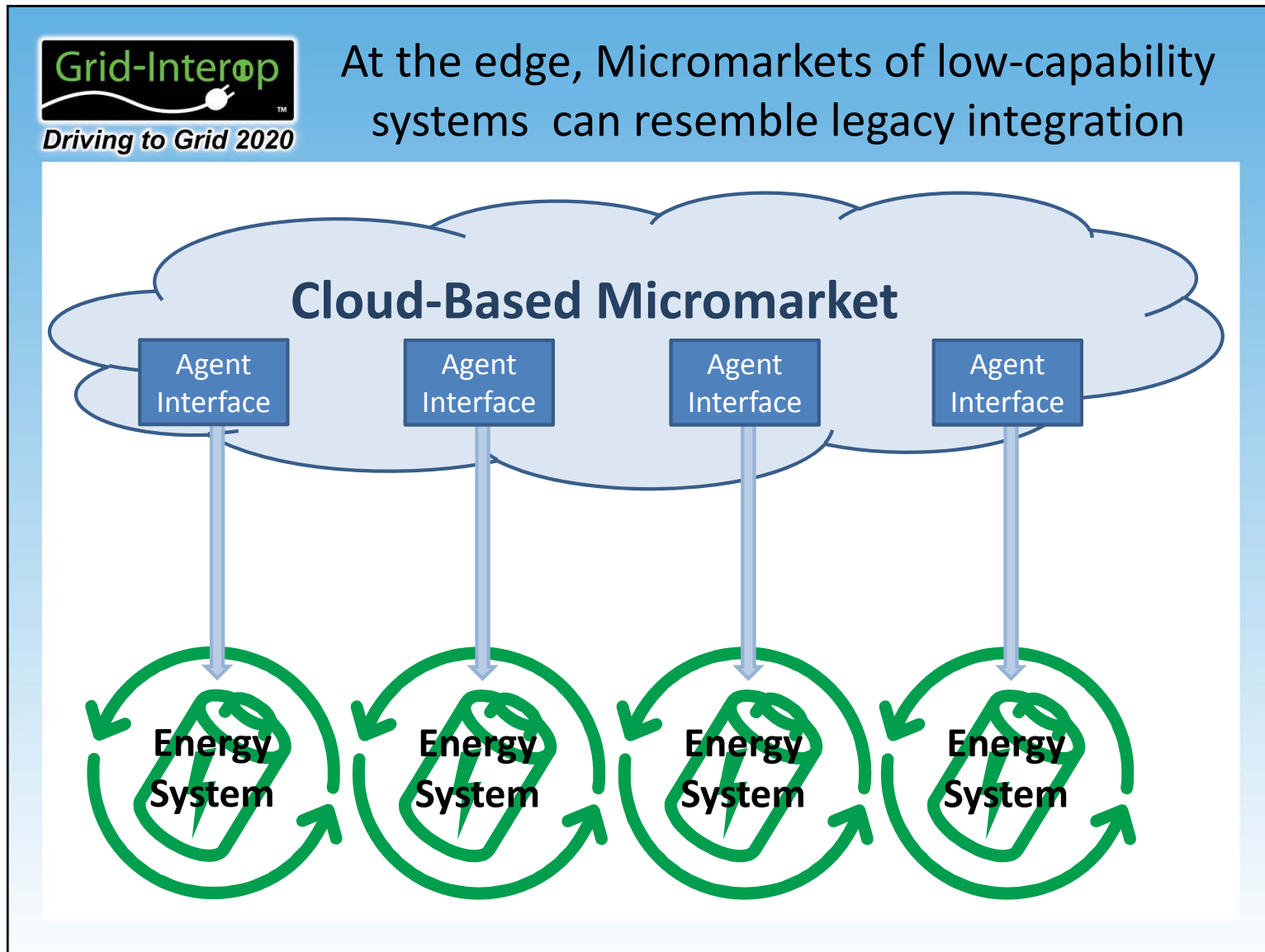


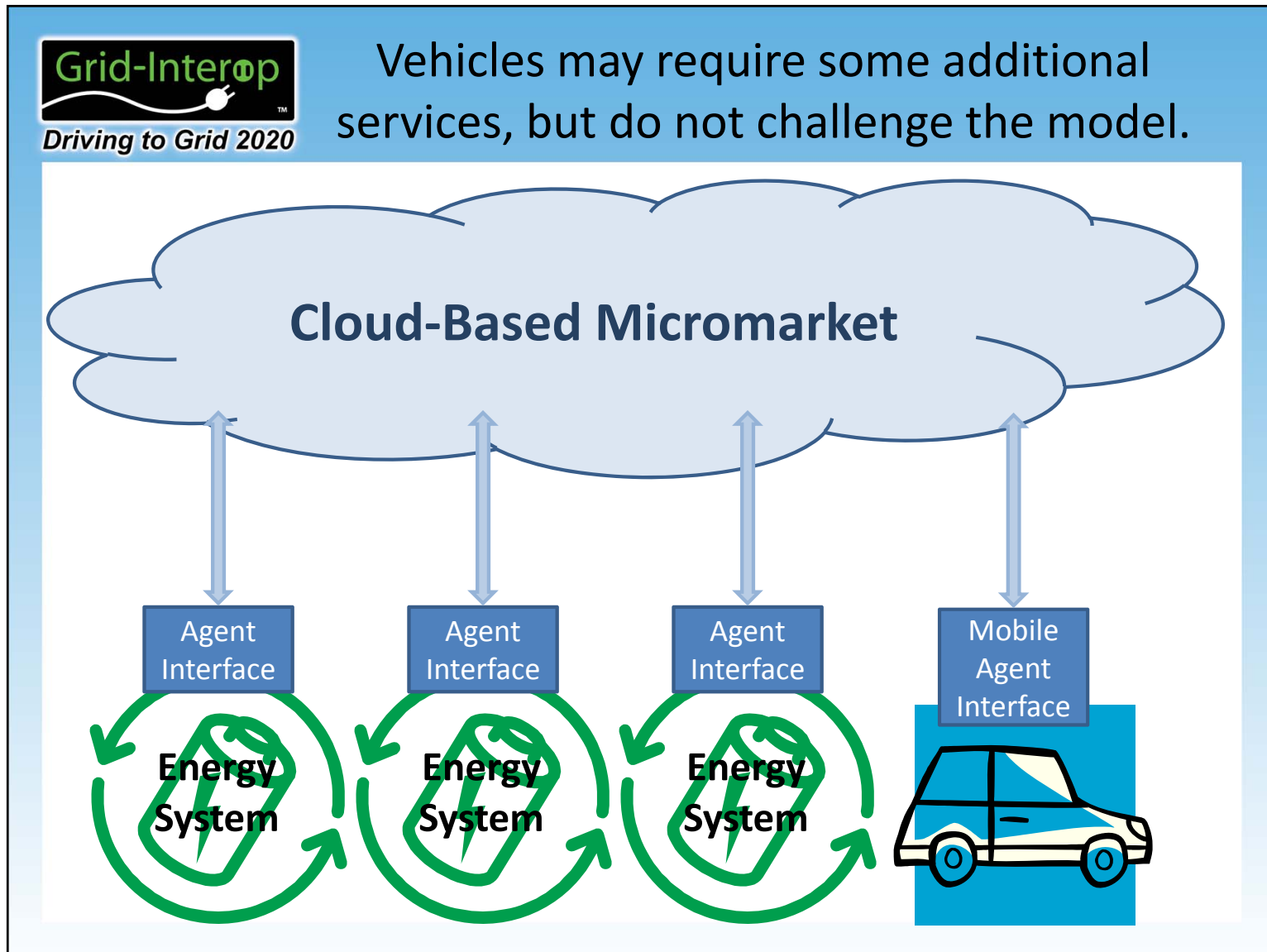


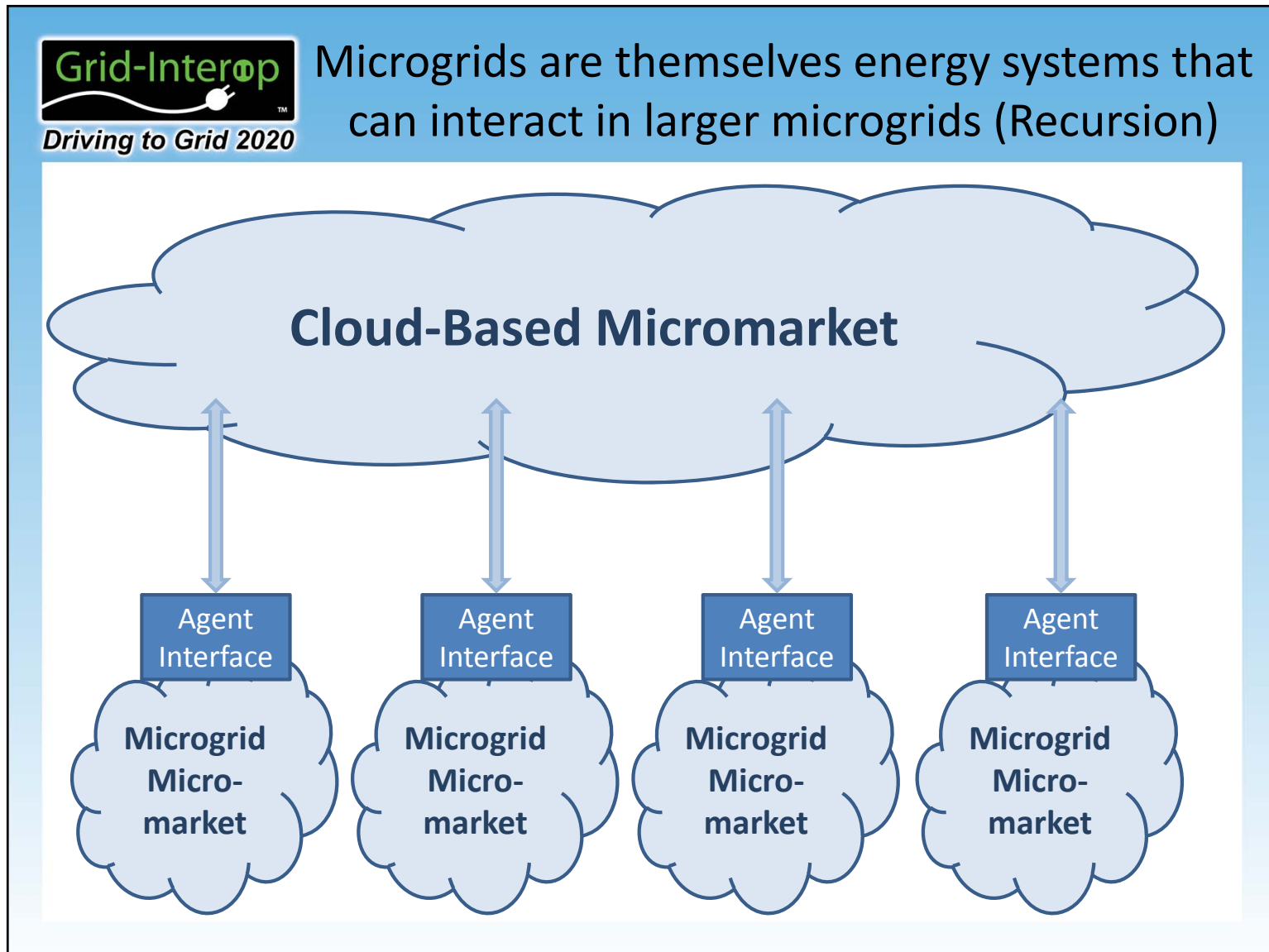


Many grids means diversity of purpose as well as of technology

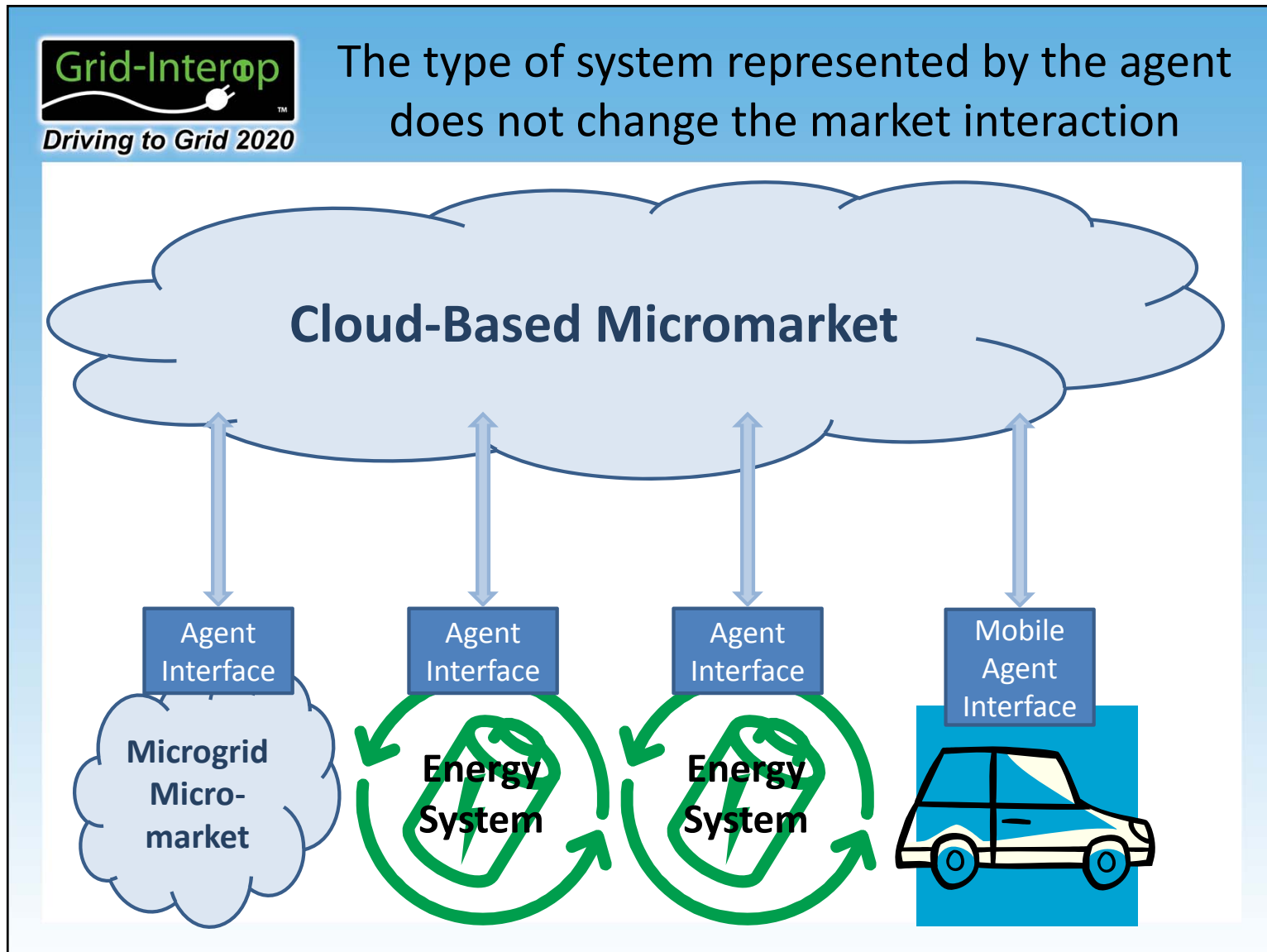
# **THE ARCHITECTURE OF MICROGRIDS**















# Questions





## 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.