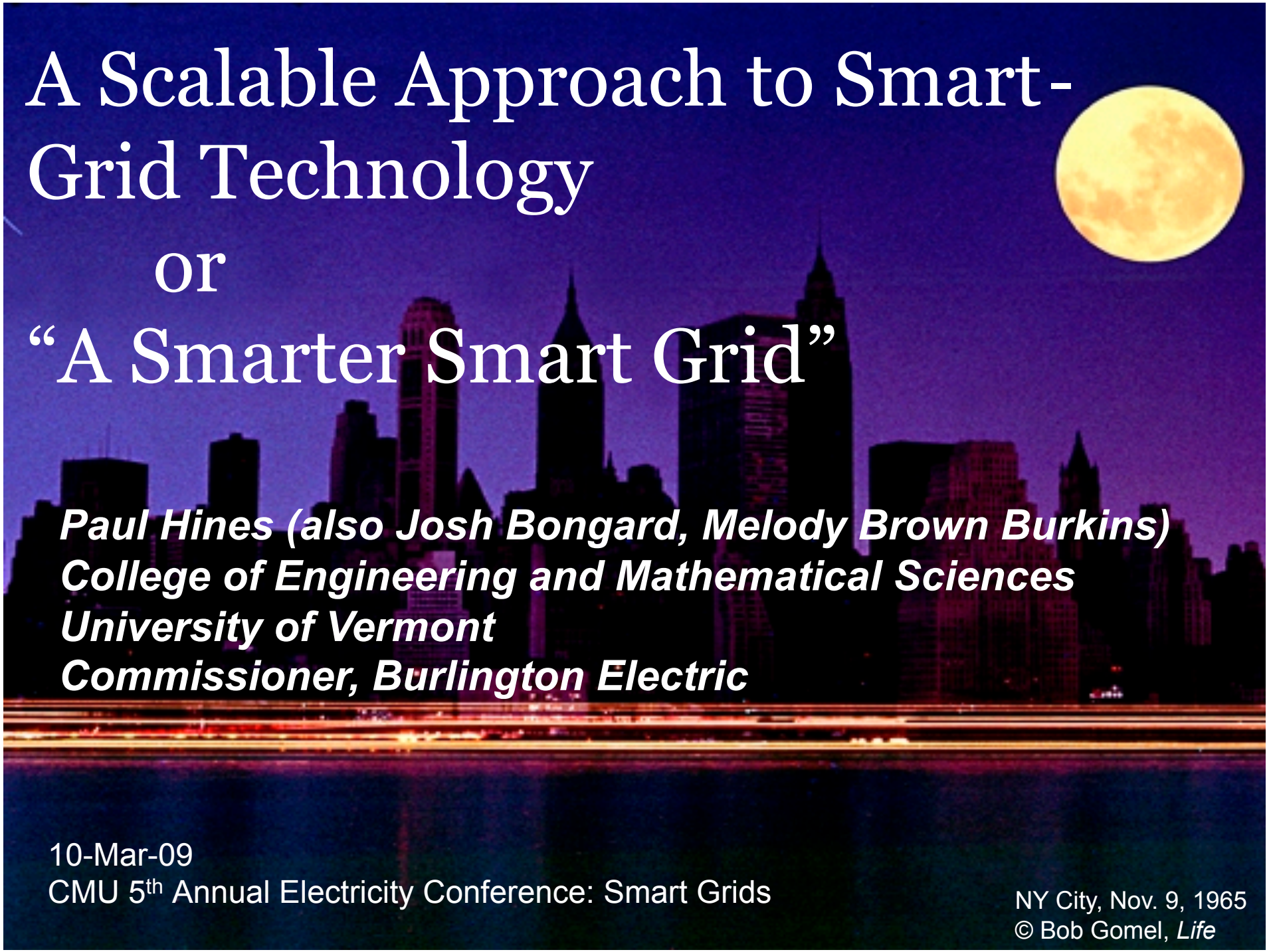
A Scalable Approach to Smart-Grid Technology
or
"A Smarter Smart Grid"



Paul Hines (also Josh Bongard, Melody Brown Burkins)
College of Engineering and Mathematical Sciences
University of Vermont
Commissioner, Burlington Electric

10-Mar-09
CMU 5th Annual Electricity Conference: Smart Grids

NY City, Nov. 9, 1965

Outline

- What is the smart grid?
- Privacy, Scalability and Security
- Top-down vs. bottom up smart grid
- AMI: What should a smart meter do?

Why are we talking about this?

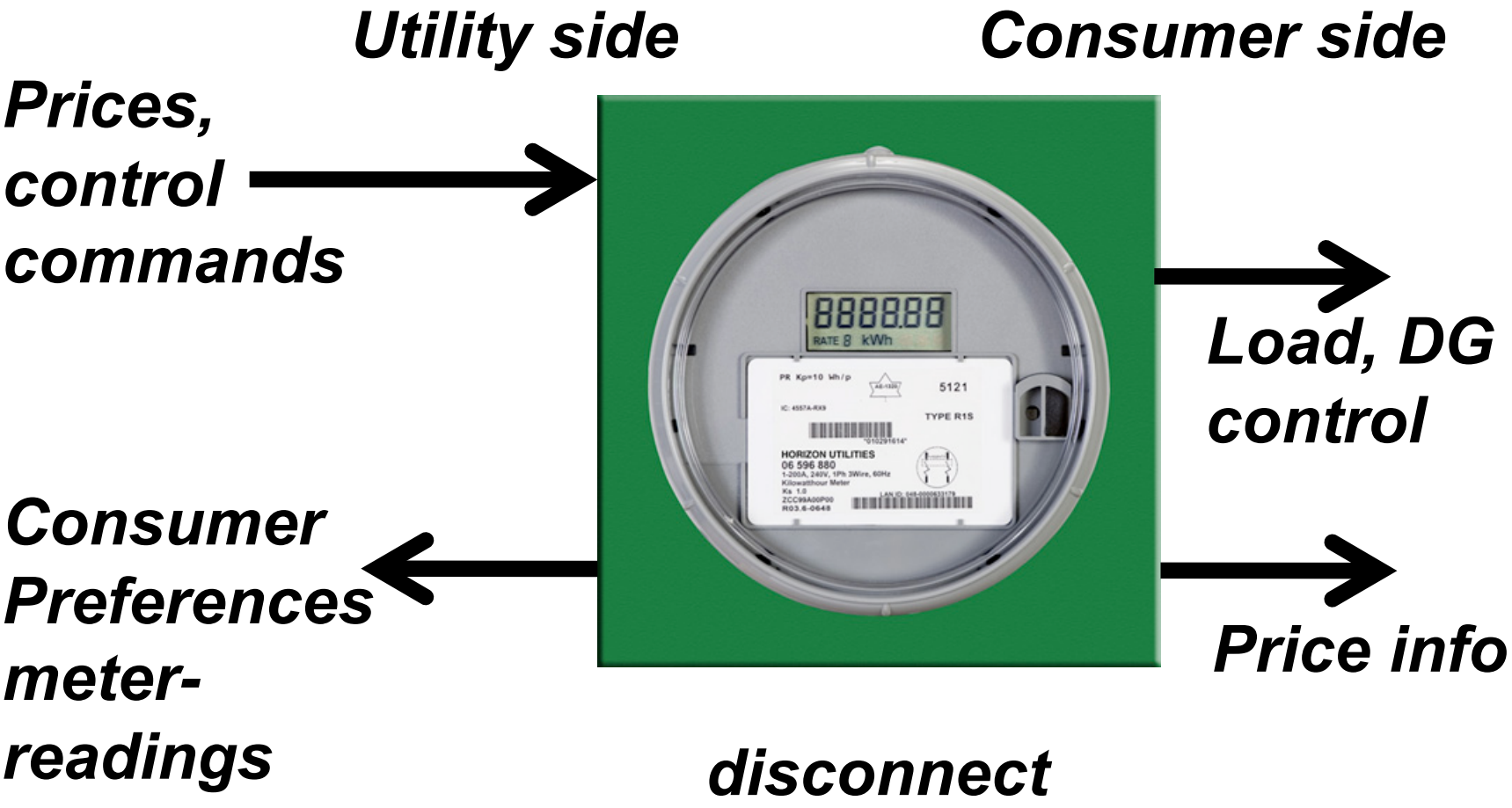
ELECTRICITY DELIVERY AND ENERGY RELIABILITY

For an additional amount for "Electricity Delivery and Energy Reliability," $4,500,000,000: *Provided*, That funds shall be available for expenses necessary for electricity delivery and energy reliability activities to modernize the electric grid, enhance security and reliability of the energy infrastructure, energy storage research, development, demonstration and deployment, and facilitate recovery from disruptions to the energy supply, and for implementation of programs authorized under title XIII of the Energy Independence and Security Act of 2007 (42

What is the Smart Grid?

- My definition:
  - Use IT to make the electricity more reliable, less costly, with reduced emissions
- In reality:
  - Technology from the distribution substation downward (+ storage)
  - “Advanced Metering Infrastructure”
    - aka Smart Meters

The Smart Meter



Benefits/costs of AMI

- Real time pricing
- Load ***control***
  - Regulation
  - Reserves
- Facilitate DG
- Remote meter reading
- $200+ each + installation

Privacy, Scalability, Security

- **Privacy**: To what extent will private information be transferred? How will people react?
  - Without privacy, public outcry, limited adoption
- **Scalability**: How will IT costs scale with the number of meters?
  - If it doesn't scale well, too costly for small customers
- **Security**: Can a bad guy get into the system and mess with the signals?

Information & control flows

- To understand privacy, security, scalability consider:

- **Information flows**
  - Who is telling what to whom?

- **Control flows**
  - Who makes the decisions? How are these decisions passed to the actuators?

Olympic peninsula smart-grid project

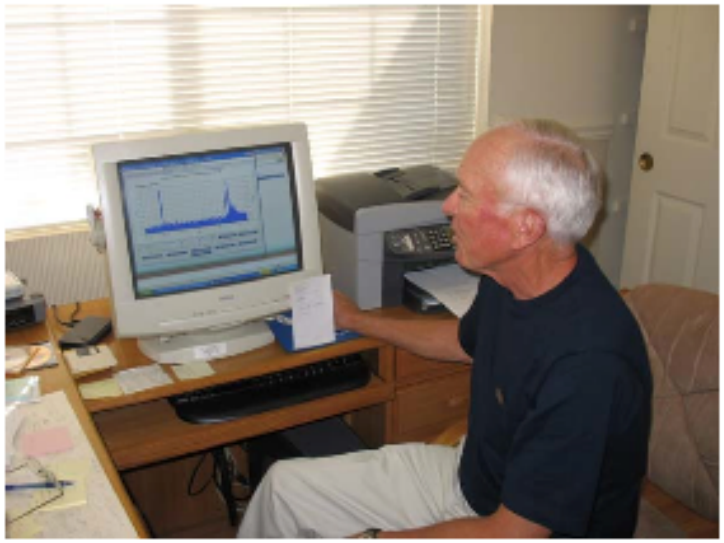


Figure 3.6. Residential Participant Using His GoodWatts™ Web Site

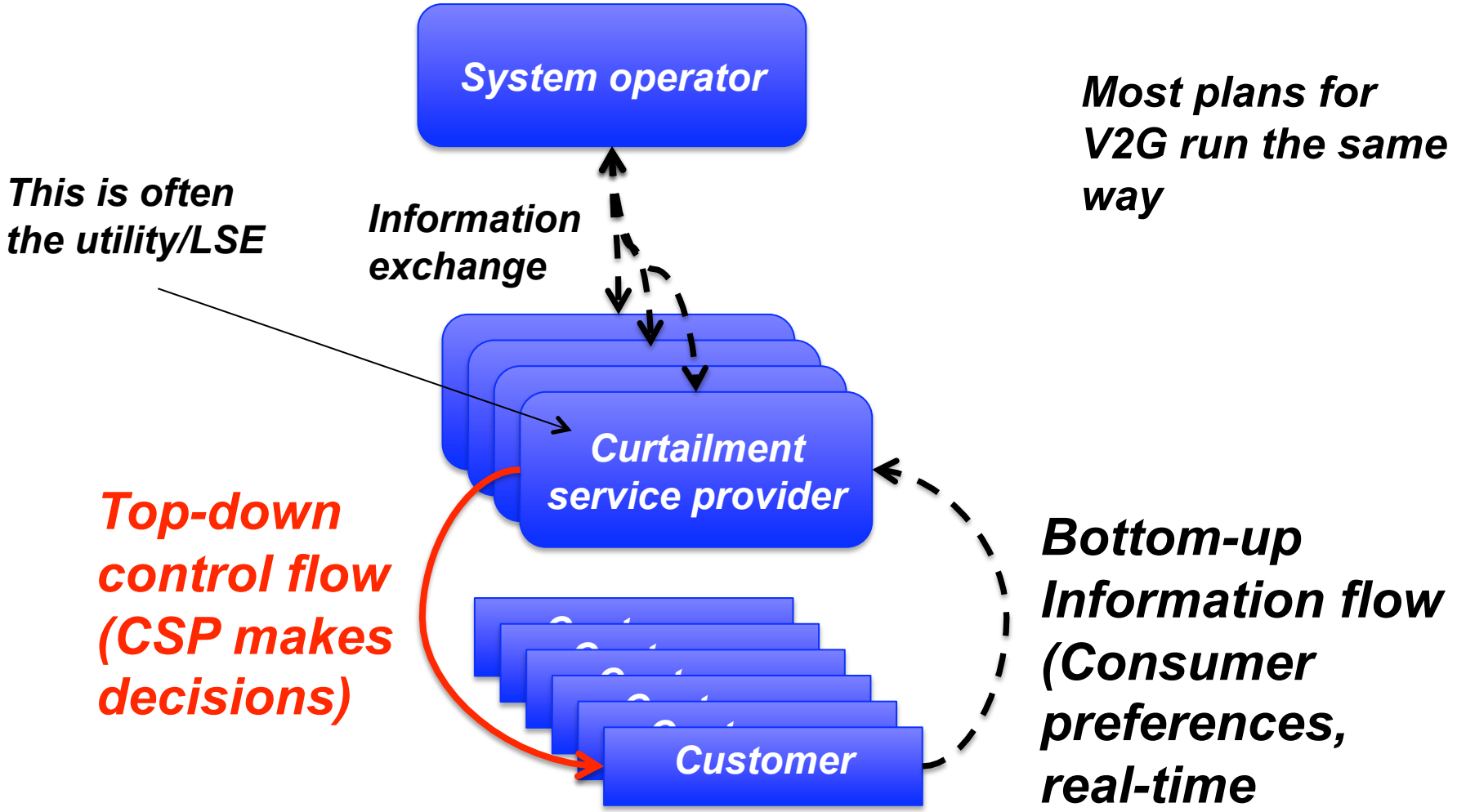
Information flow:
Customers upload preferences to web site
Bottom-up

Control flow:
Utility servers send control signals
Top-down

Results

Good. Consumption is shifted to off-peak.
Consumers respond to overloads on distribution cables.

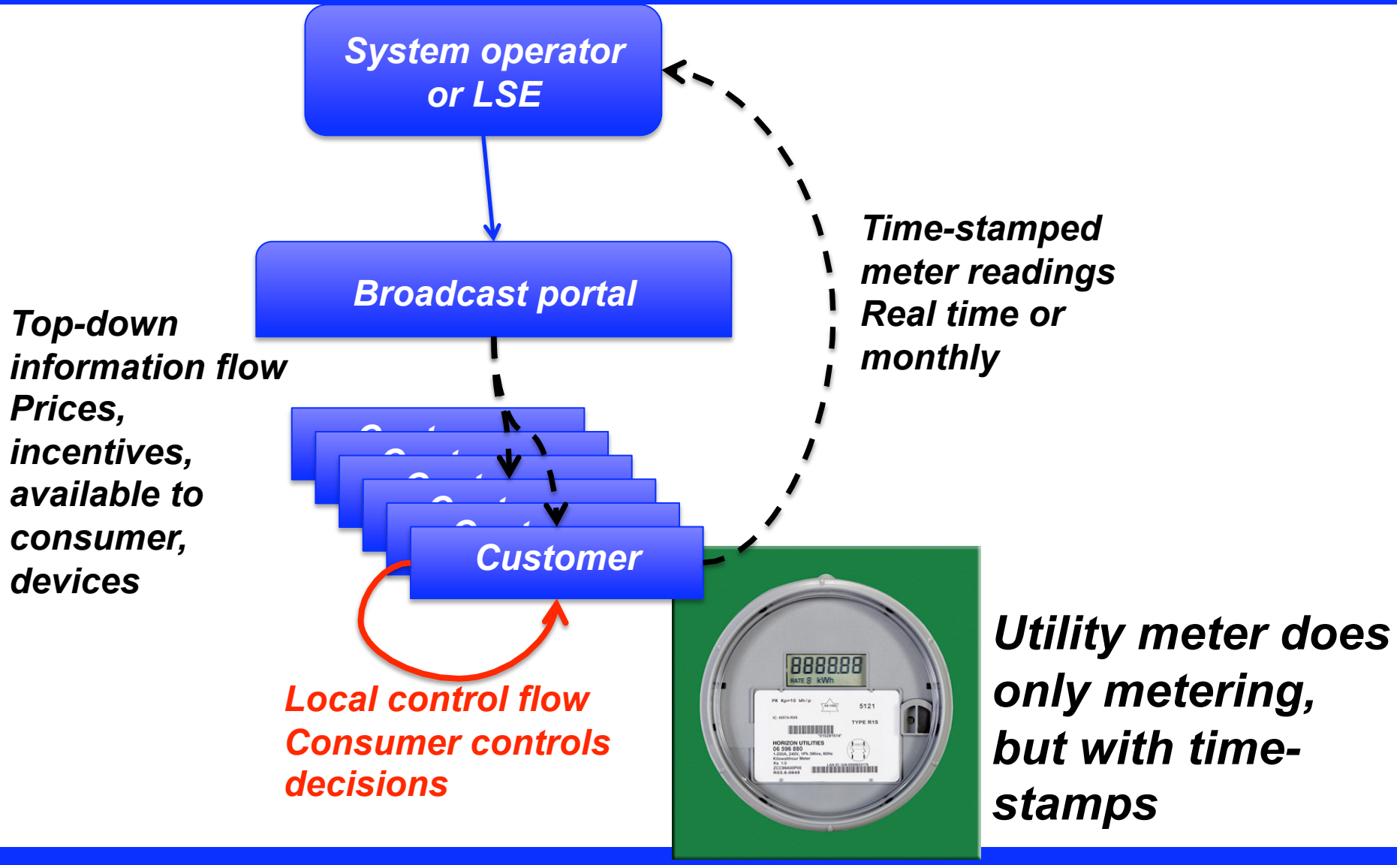
Many demand response programs



Analysis of top-down method

- **Privacy**: User preferences/data flows to a third party. Many will dis-prefer this
- **Scalability**: Each additional customer requires some additional cost to CSP
  - May limit to medium and large customers
- **Security**: If one can mimic the control signals, one might be able to control loads

Bottom-up "Smarter Smart Grid"



Analysis of top-down method

- **Privacy**: Only meter readings need to flow upward
- **Scalability**: The IT costs are only that of putting the signals on web sites
- **Security**: A diversity of relatively autonomous devices may be more difficult to control. Still need to secure the information portal.

Other advantages/disadvantages

- **Innovation**
  - With broadcast, uniform incentives, any response method works.
    - Different technology, programs, service providers for customers with different preferences
  - Energy efficiency clubs?
- **Ancillary services**
  - Cannot contract for unknown response
  - But, SO can learn response rate, and reduce reserve purchases
  - Can have aggregators for medium-large customers in addition to broadcast

Thoughts on smart-meters

- Let the meter keep its traditional role of measuring electricity consumption
  - Add time-stamps

- Don’t make the technology (ISO 61850?) so complicated that innovation is limited to the big players

Time-stamped meter readings