Introduction to Transactive Energy

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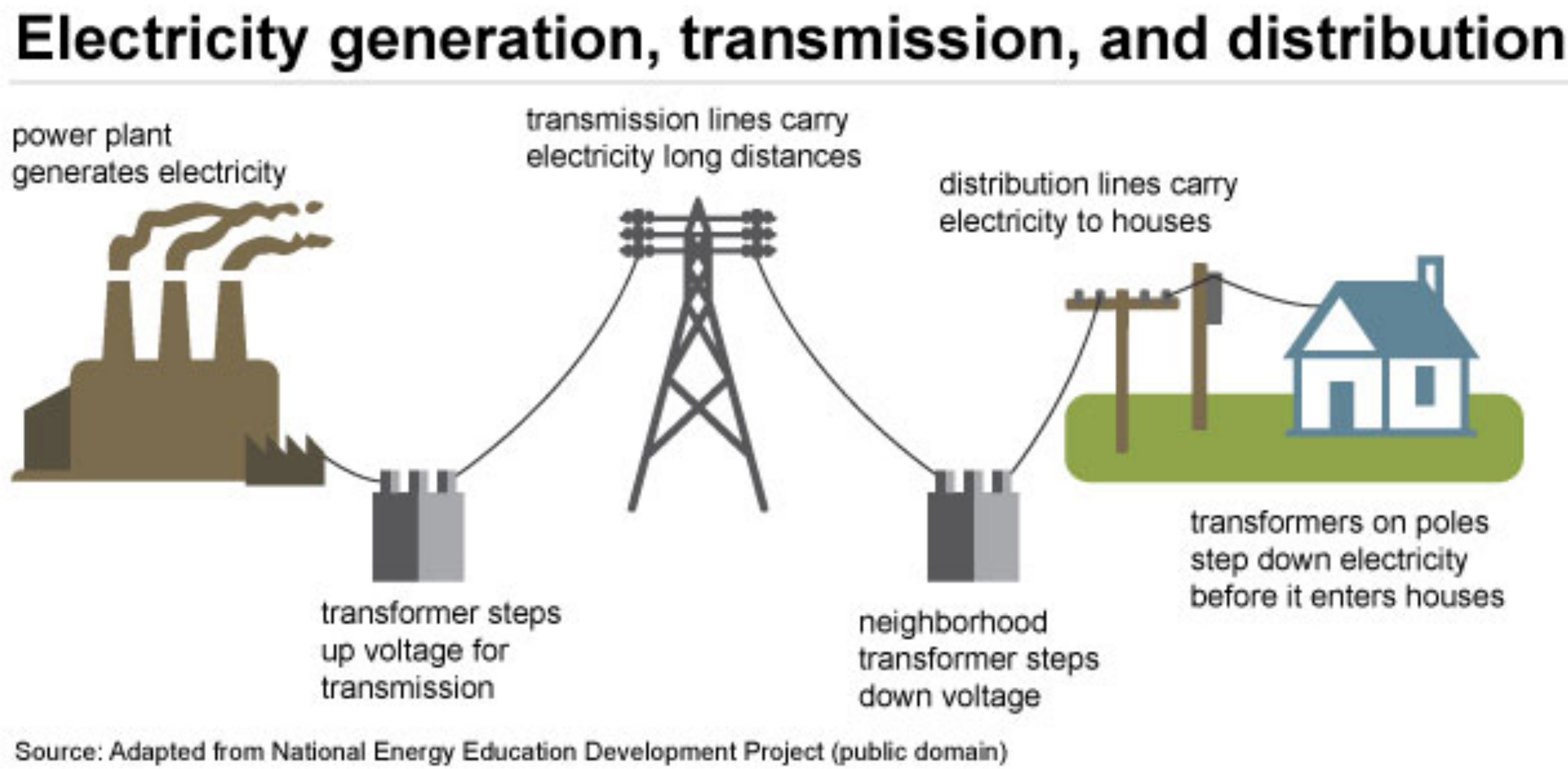
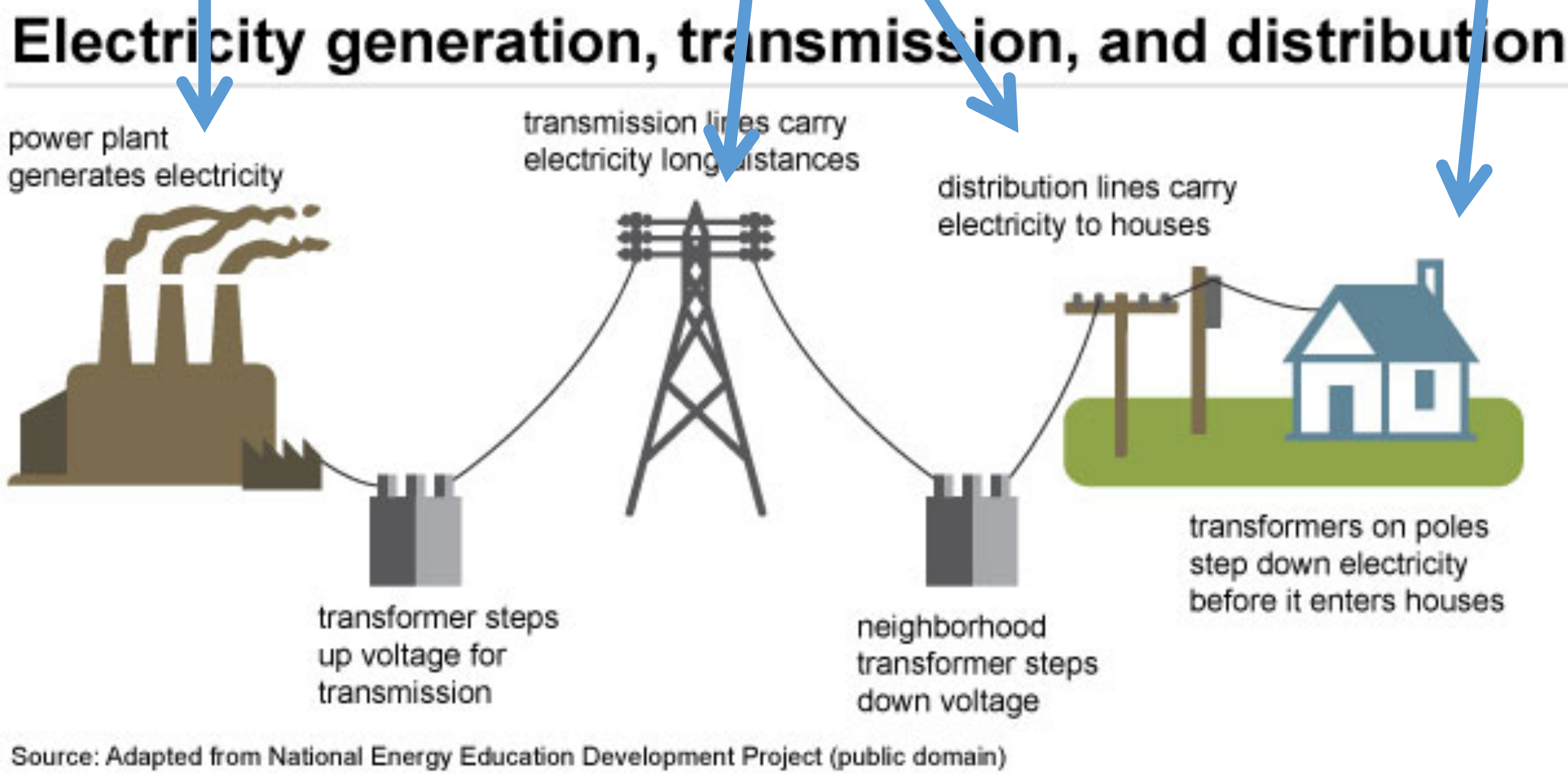
Historical Model:

Single Entity (Utility) Controlled all Aspects



https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery

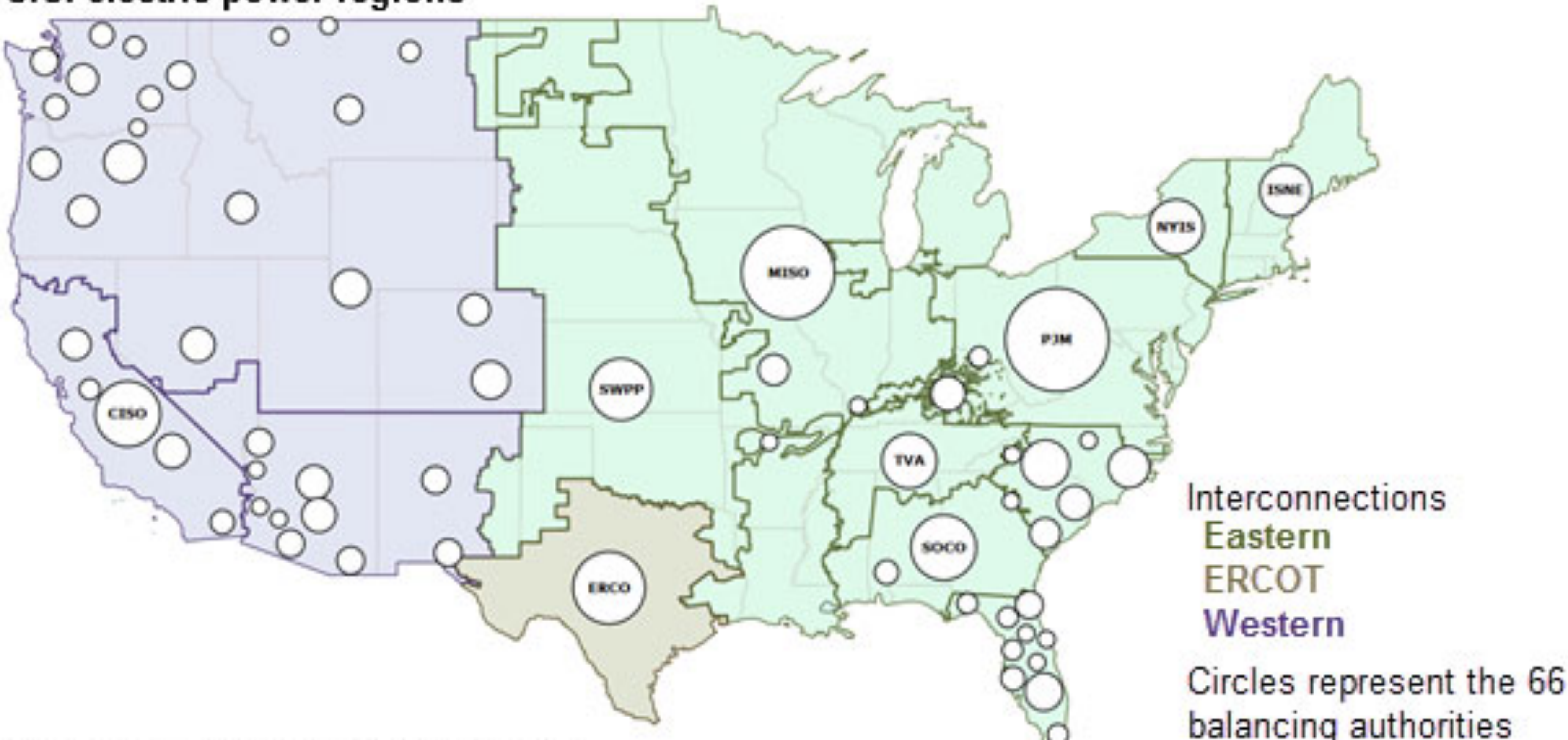
Competitive Wholesale Market	Regulated Utility: Transmission & Distribution	Competitive Retail Market



https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery

The U.S. Electricity Grid: Balancing Authorities

U.S. electric power regions



Source: U.S. Energy Information Administration

Note: The locations of the electric systems are illustrative and are not geographically accurate. The sizes of the circles roughly indicate the size of the electric system.

https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery

Changes in the Electricity System

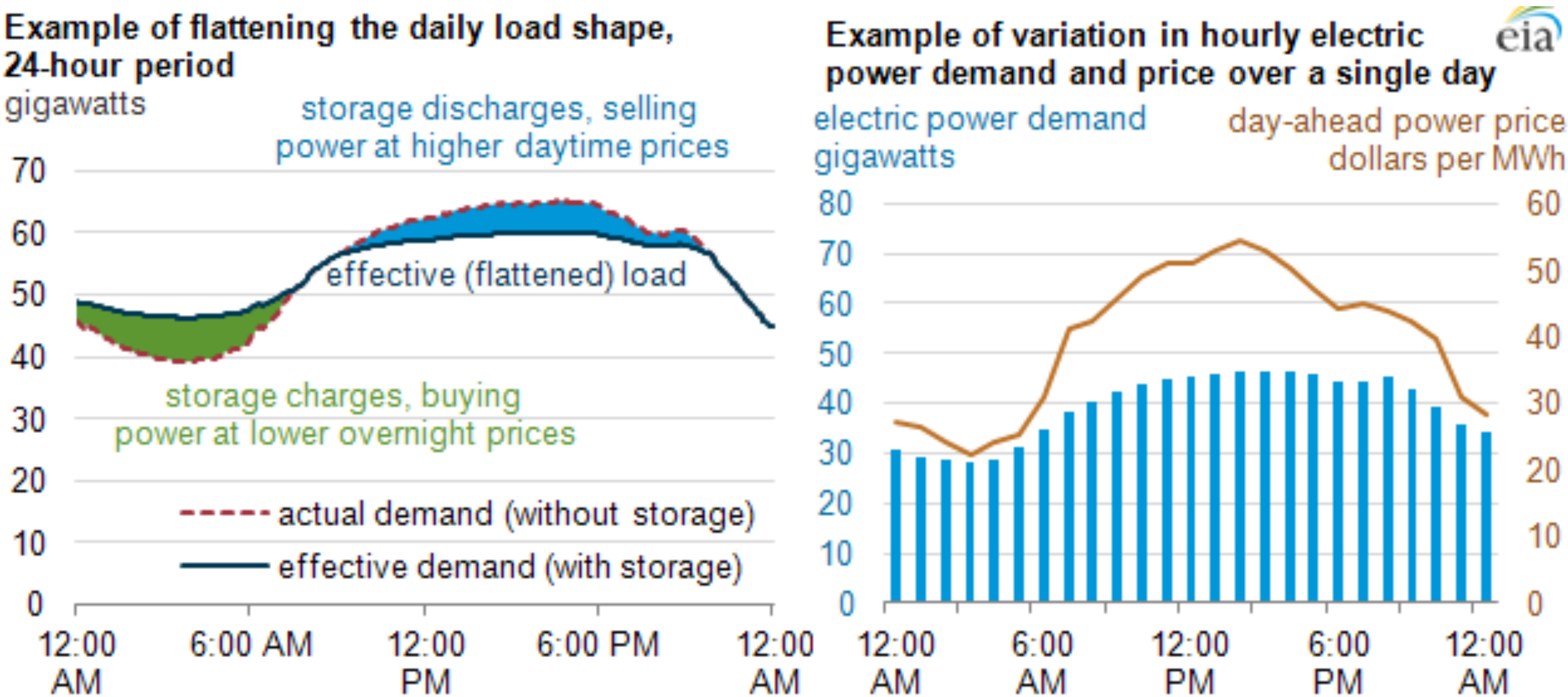
Historical Regime

- Regulated Utility Monopoly
- Centralized power generation (hydro, nuclear, fossil)
- One-way transmission
- Goal: provide stable, baseload power with some peaking ability

Emerging Regime

- Generation, utility, and retail companies
- Distributed energy resources
- Two-way transmission
- Management of intermittency, energy storage

Daily Peak Load



http://www.eia.gov/todayinenergy/images/2012.05.21/DailyLoadShape.png

Transactive Energy: Definitions

- Transactive energy allows the dynamic balance of supply and demand across the entire electrical infrastructure
  - Sale and purchase of electricity among generators, utilities, and retail electricity providers
  - Sale and purchase of distributed electricity (e.g., rooftop solar) from prosumers (producer-consumers) to utility (and to other prosumers)
  - Management of demand through incentives to consumers

Benefits: Transactive Energy

- Security
  - Better response to power outages and shortages
- Health-Environmental
  - Use of renewable energy and energy efficiency
  - Retiring of thermal generation → improved air quality
- Equity
  - Potential for price reductions for consumers

Two Examples Discussed Today

- Distributive Energy Resources & Microgrids
- Smart Meters

Distributed Energy Resources and Microgrids

Definitions

- Distributed energy resources: small-scale electricity generation that can be aggregated and used to supply electricity to the grid:
  - Small photovoltaics, wind, hydro, geothermal
  - Energy efficiency
  - Local energy storage
  - Local combined heat and power

- Microgrid: localized network of electricity generation that is connected to the grid but can operate in island mode (such as during power outages)

DER Compensation

- Net metering: prosumer paid at the retail rate (very good for prosumer)
- Feed-in tariff (more common in EU): prosumer paid at a set rate
- Value of solar: prosumer paid at a negotiated rate based on assessment of the value of solar to the utility

DER Growth

- Favorable and stable prices over long-term contracts
- Good loan programs from government
- Technology and finance sector investing heavily in “third-party ownership”

Concerns from Utilities

- Profitability. Cost of paying for DER, especially rooftop solar under net metering rules.
  - Stranded assets concern.
  - Off-grid concern

- Stability: Concerns with so much solar that the grid becomes unstable (Hawaii)

- Equity: Solar customers who produce more than they consume end up using grid services for free; should have a connect charge. Otherwise, nonsolar customers pay for it.

2016. Hess, David J. “The Politics of Niche-Regime Conflicts: Distributed Solar Energy in the United States.” *Environmental Innovation and Societal Transitions* 19: 42-50. 10.1016/j.eist.2015.09.002.

Utility-Solar Industry Conflicts

- Attempts to end net metering laws and block third-party ownership laws
- Social movement mobilizations to protect the "right to solar" in many states
- Often the coalitions have a "strange bedfellows" quality (solar industry, conservatives, environmentalists, consumer groups)

2017. David J. Hess and Kate Pride Brown. "Green Tea: Clean-Energy Conservatism as a Countermovement." *Environmental Sociology* 3(1): 64-75. DOI 10.1080/23251042.2016.1227417.

Equity and Environmental Values

- Equity
  - Utilities: rights of non-solar customers
  - Prosumers: property rights of building owners to have rooftop solar
- Environmental
  - Benefits of encouraging renewable DER

Microgrids

- Transactions between the microgrid and the utility

- BUT Can involve transactions **within** the microgrid
- Emerging model in Brooklyn, NY, and Landau, Germany
- Peer-to-peer sale of solar within a neighborhood using blockchain technology
- Security: can form island during outages
- Equity: can motivate more local ownership of electricity, power to the poor in LDCs
- Environmental: more renewable energy, load balancing

Smart Meters

Traditional Meter

Digital AMI Meter

http://www.michigan.gov/mpsc/0,4639,7-159-56137_58213---,00.html

Definitions

- Devices that allow the transmission of information to the utility and consumer
  - In the U.S. generally wireless
  - Information feedback can encourage efficiency
  - Time of day pricing possible
- Can allow communication with devices in the home or building
  - The utility can change the temperature to enable shaving of daily peak load (opt-in)

Privacy: Smart Meters

- Electronic signature of individual appliances
  - Capacity to track which appliances are being used
  - Capacity to know who is at home and what they are doing

- Depends partly on the frequency of transmission of information (e.g., hourly v. a few times per day)

Security: Transactive Energy

- Hackers can find out who is at home and when

- Government may use the information for some purposes (e.g., child custody cases—is the parent really at home?)

- Hackers may be able to turn on and off devices, causing fires (furnance, ovens), etc.

Health & Environment

- Health 1
  - Public opposition based on concern with microwave exposure
  - Standard smart meter vs. collector meters
  - Scientific research is weak, but public groups advocate the precautionary principle
- Health 2: Accidents
  - Some reports of overheating and fires
- Built Environment
  - Concern with “electrosmog”
  - Invisible—little public interest to date

Social Equity: Transactive Energy

- Time of day pricing
  - Privileges households that have flexible hours or programmable devices
  - Low-income households may need to use appliances during times when prices are higher

Public Opposition

Dimensions of Anti-Smart Meter Movements

- Background: spillover from opposition movements to cell-phone towers to smart-meter opposition
- Condition: anger at lack of opt-out provision and mandated installation, then anger at opt-out fees
- Outcome 1: Many local ordinances and resolutions against smart meters, especially in British Columbia and California
- Outcome 2: Opt-out provisions are included in some state laws or regulatory policies

Reasons Given in 53 Local Policy Actions in California

- Health (claimed headaches, etc.)
- Privacy (knowing who is at home)
- Accuracy (billing errors)
- Security (theft, knowing when people are home)
- Transmission (interference with ham radios, appliances)
- Environmental (vague language about increasing the carbon footprint, rebound effect)
- Safety (fire)

2014 David J. Hess and Jonathan Coley. “Wireless Smart Meters and Public Acceptance: The Environment, Limited Choices, and Precautionary Politics.” *Public Understanding of Science* 23(6): 688-702

Table 1. Local-level policy responses and rationales to WSMs in California.

	Petition	Moratorium	AB 37 support only
Health	22	13	3
Privacy	14	12	2
Accuracy	12	12	0
Security	8	7	2
Transmission	5	5	0
Environmental	2	5	0
Safety	7	1	0

2014 David J. Hess and Jonathan Coley. "Wireless Smart Meters and Public Acceptance: The Environment, Limited Choices, and Precautionary Politics." *Public Understanding of Science* 23(6): 688-702

Controversial Health Claims

- Utilities reject public understanding of health risks
- Public concern rests on claimed ill health following installation (no epidemiological studies)
- Some people claim to be electrosensitives
- Scientific research is summarized in the *BioInitiative Report*
- Applicability of most microwave research to humans and smart meters is unknown

2014 David J. Hess and Jonathan Coley. "Wireless Smart Meters and Public Acceptance: The Environment, Limited Choices, and Precautionary Politics." *Public Understanding of Science* 23(6): 688-702

Analysis of Media Reports in North America

Table 1. Reasons for public concern in news reports*.

Public concern	British Columbia	California	Other states
Number of articles	49	37	34
Cost (overruns, accuracy)	16 (33%)	15 (41%)	8 (24%)
Fire hazard	3 (6%)	1 (3%)	3 (9%)
Health	37 (76%)	31 (84%)	26 (76%)
Privacy	11 (22%)	11 (30%)	16 (47%)
Security (theft)	3 (6%)	3 (8%)	6 (18%)
Other	1 (2%)	0	3 (9%)

Note: *Percentages are the number of articles mentioning the concern divided by the total for the regional category (e.g., 16/49 for cost for British Columbia). Because some articles identify more than one issue, the percentages total to more than 100.

Hess, David J. "Smart Meters and Public Acceptance: Comparative Analysis and Governance Implications." *Health, Risk, and Society* 16(3): 243-258.

Variation in Degree of Concern

- Health concerns: higher if no opt out policy, if the opposition group is local and in North America
- US: State-level groups have a broader range of concerns; local groups often more health focused.
- US: right-wing groups highlight privacy.
- Australia and UK (early roll-out phase): cost was primary concern
- Netherlands (2006-2008): privacy
- Health concerns are negligible in areas with wired systems in the US and Europe

Some General Conclusions

- How to negotiate the relationship between expert knowledge and public concern?
- Transmission model: educate the great unwashed
  - Results in populist backlash
- Deliberative model:
  - Understand public concerns first
  - Develop opt-out & opt-in policies
  - Build flexibility into system design