The (Subversive) Layered Architecture of Energy Resilience

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Electric System Policy, Structure, Market Design

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Sustainability => Stop doing more damage Resilience => Prepare for impacts of damage done Resilience => The ability to maintain essential quality of life functions and services when a severe disruption occurs

- Concern rises after major weather events (New York opened "Reforming the Energy Vision" (REV) following Superstorm Sandy)
- A major concern of US DOE and FERC for the Bulk Electric System
- Microgrid initiatives in cities, military bases, campuses, communities

Response to Disruptive Events

- Impacts are always local
- Be prepared to provide for water supply, shelter, food, medical care, rescue, safety, wastewater, communications, mobility, ...
- All essential functions require energy

Preventive Measures

- Public Safety Power Shutoffs (PSPS) => de-energizing power lines in highfire-risk conditions cuts off all down-stream energy users
- Microgrids for critical facilities and back-up energy for vulnerable residents can allow safe, less disruptive PSPS

Layered Architecture of Resilience 1:



Nature's layered architecture of complex living systems



Layered Architecture of Resilience 2: "Resilient Community" policies and strategies

Household

- * Personal health
- * Energy efficiency
- * All electric
- * Smart charging
- * Minimal waste
- * Grey water
- * Low-water landscaping * Micro-habitats

Neighborhood

* Food production
* Car shares
* Tool libraries
* Places to meet, gather & celebrate
* Community
energy systems
* Rainwater capture
* Tree canopy & PV
in healthy balance



Santa Barbara, CA

State

* Policy, funding & <u>structure</u> for community resilience & local capacity building * No community is left behind

Bioregion

* Local food
* Waste mgmt
* Water mgmt
* Ecosystem
protection

Municipality

- * Whole-system integration of critical services
- * Public spaces
- * Local business
- * Vital, engaged neighborhoods

Some things to consider ...

- Today's electricity system hardware, operations & planning, business models, regulation — was made for central power plants & high-voltage transmission, central control, one-way power flow to exogenous end-use customers (participating only as consumers)
- Scalable, distributed technologies + resilience & sustainability goals challenge all the existing industry structures
 - Alternatives to big infrastructure (e.g., to meet peak loads)
 - The "BTM Market" (behind the customer meter) => grid defection
- Bottom-up driven change is a frightening possibility
 - Decentralization feels like loss of control ("fragmentation")
- Industry conversations are full of false dichotomies
 - Regional grid <u>versus</u> local power systems
 - Access to needed information <u>versus</u> privacy/security concerns
- Individual utility maximization does not maximize quality of life
 - Individual customer adoption is an insufficient basis for change
 - Policy needs larger units of analysis => neighborhoods, local governments
 - "Being human is a team sport." D. Rushkoff, Team Human