An Electricity System Structure for the 21st Century

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Electric System Policy, Structure, Market Design

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Preface

"The best way to ensure nothing gets done is to convince people they're on one side or the other of a false dichotomy."

attrib. to J. M. Greer

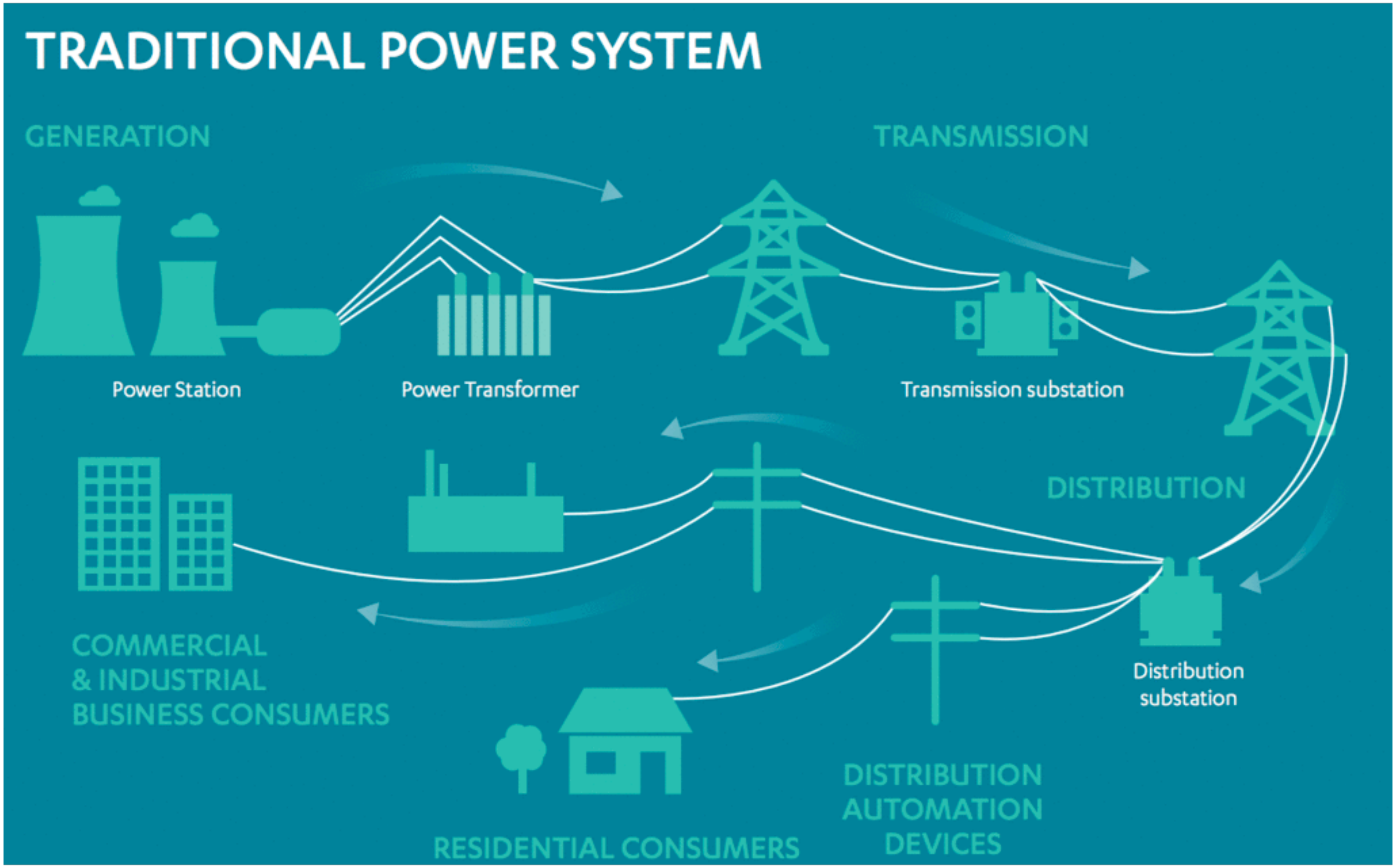
Bulk power system and wholesale markets are NOT going away yet …

- Distributed Energy Resources (DER) and the Bulk Power System are complements, not mutually exclusive

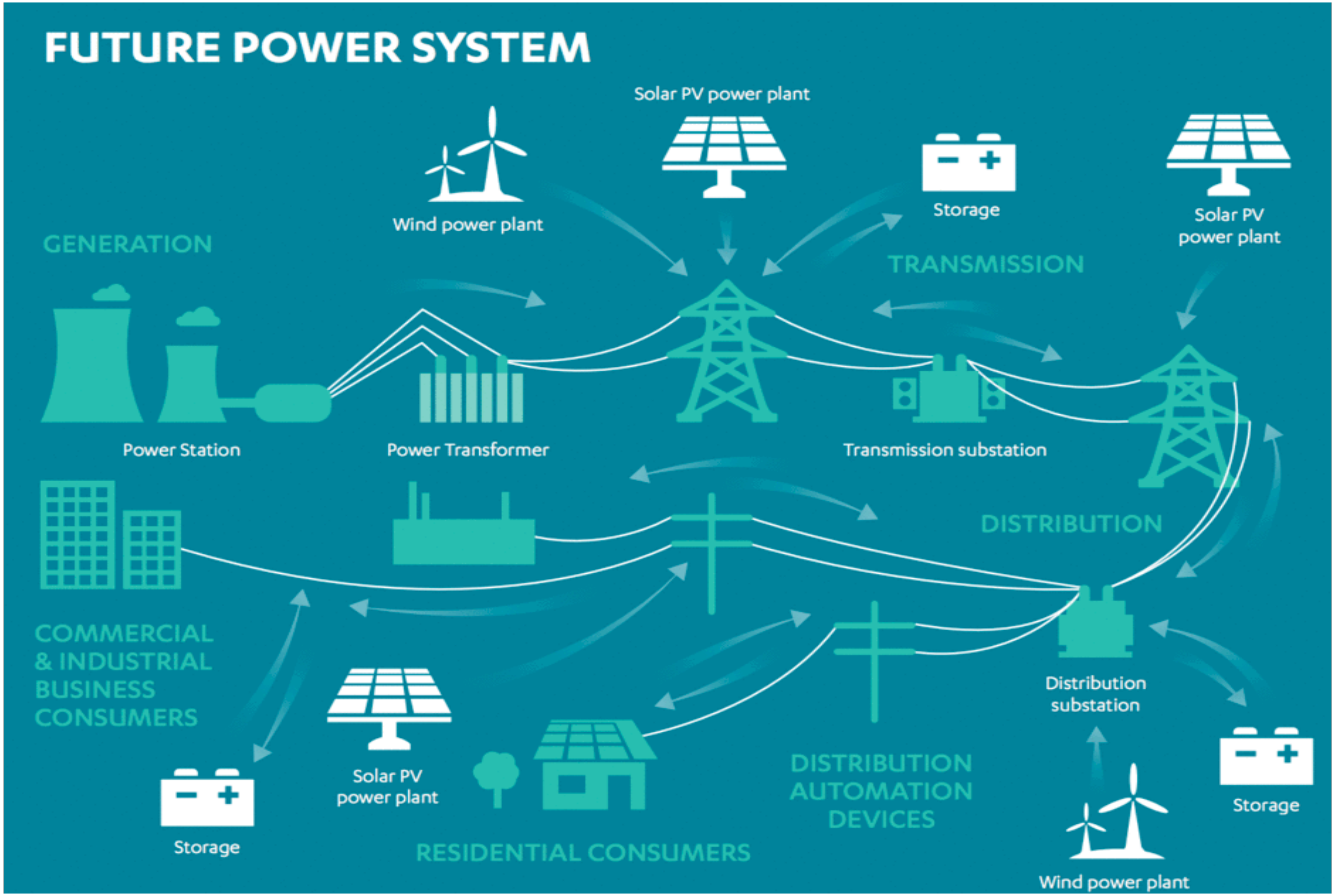
… but the grid is only part of the electric system, not the whole story.

"It's about a mental shift from prediction to intention." W. Blake

Electric power systems and institutions were all designed for centralized, top-down control and one-way power flows.



Renewable generators and powerful, low-cost, customer- and community-scale resources are driving energy transition.



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Distribution-connected energy resources (DER) effect the transition to a more decentralized power system.

- DERs = broad category, everything connected at distribution
  - Both sides of the end-use customer meter
  - Energy Efficiency, Demand Response, Distributed Generation, Energy Storage, EV Charging, Microgrids, Smart Cities …
  - Digital communication and control systems
- Growth of DERs is largely autonomous and decentralized
  - Electrification of transport, buildings, etc. – tied to local government planning – will add demand and impact distribution operations
  - Resilience for critical facilities, campuses, communities
  - The “behind the meter (BTM) market”
    - Energy users can customize energy uses and sources with on-site assets and control technologies …
    - … and use the grid for residual needs and trading surpluses
    - Grid defection becomes economically feasible — why stay connected?

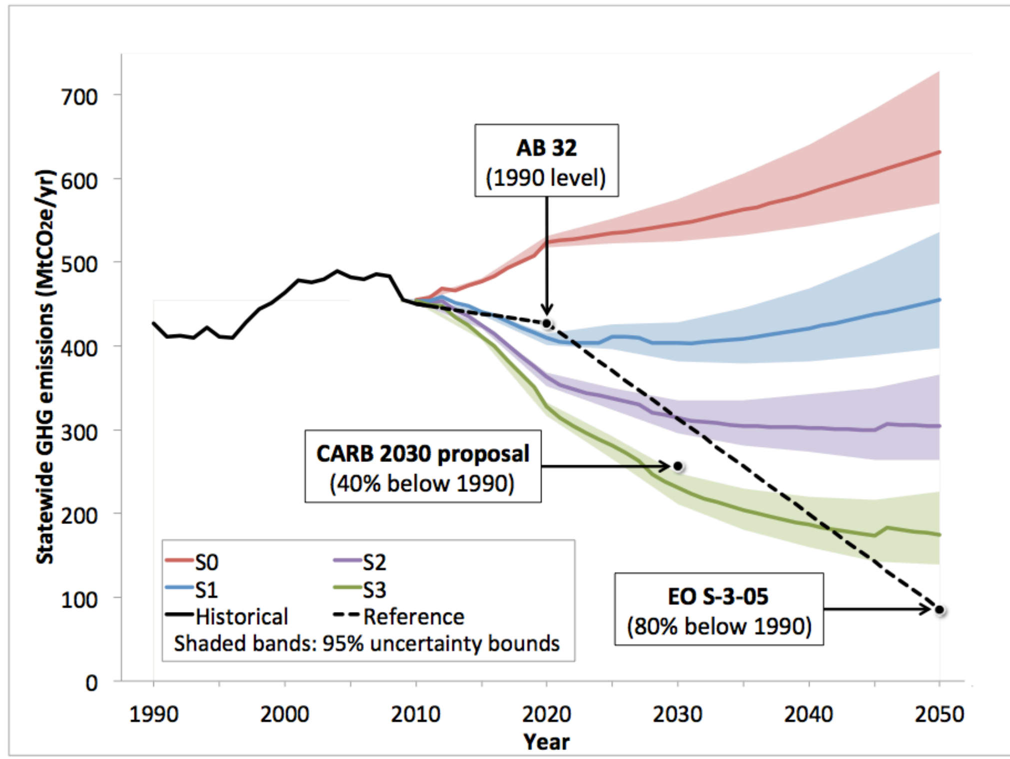
Decarbonization means electrifying major fossil-fuel uses: transportation, buildings, industry, agriculture.

– California's electric system accounts for less than 20% of GHG emissions
– Transportation about 42%, buildings about 35%

Electrification plays out locally

- *Most system impacts on distribution*
- *Resilience rises in policy priority*
- *Electrification strategies can play out through urban planning*

=> Electrification reshapes demand and drives change from the bottom up



=> Individual customer adoption (rooftop solar, storage, EVs) is only part of the story: <u>community-level actions</u> may be a big game changer.

See C. Figueres et al, 2017, "Three years to safeguard our climate," https://www.nature.com/news/three-years-to-safeguard-our-climate-1.22201

Resilience has entered the conversation.

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) proceeding following Superstorm Sandy)
- A major concern of US DOE and FERC for the Bulk Electric System
- Microgrid initiatives in cities, military bases, campuses, communities

Disruptive Events

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

Preventive Measures

- Public Safety Power Shutoffs (PSPS) => de-energizing power lines in high-fire-risk conditions cuts off all down-stream energy users
- Microgrids for critical facilities and energy provisions for vulnerable residents can enable safe PSPS

Managing the cost of decarbonization and resilience will depend on adopting smart energy transition policies.

Considerations

- DER growth will likely accelerate, though could be mostly through uncoordinated adoption by energy users (the BTM market)
- Uncoordinated autonomous adoption challenges grid operation and drives grid infrastructure needs and costs
- Focus on individual customers ignores community-level needs and misses possible highly effective and efficient strategies

What should smart energy transition policies include?

- Adopt **Resilient Communities** as an explicit state policy goal, on par with clean energy, equity/justice, decarbonization
- Create and fund a state-level program to plan and implement local decarbonization and resilience projects in all communities

  => **Advanced Community Energy (ACE)** proposal
- Update the investor-owned distribution utilities' roles, responsibilities and compensation to support 21st century state goals

  => **Open Access DSO** proposal

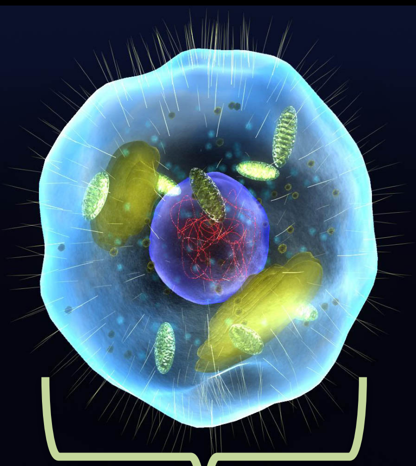
Charting a societally optimal path for energy transition starts with stating clear objectives.

1. Specify high-level policy **objectives** for the power system
   - Safety, Robustness (Reliability & Resilience), Security, Affordability, Minimal Environmental Footprint, Flexibility (extensibility & optionality), Financeability (utility & non-utility assets) [From DOE/PNNL 2015 “Grid Architecture” report]
2. Identify **system qualities** needed to achieve objectives
   - Should be discrete, specific, quantifiable, and translate into specific functions the system must perform [From Paul De Martini 2014, “More Than Smart”]

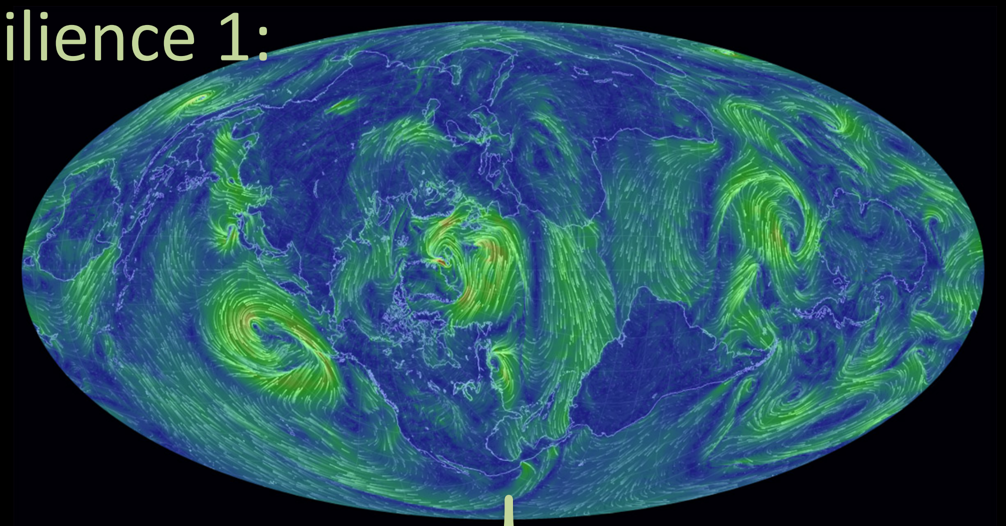
Reliability	Safety	Cyber-physical Security	Affordability	Environment	Finance-ability	Flexibility
Impact Resistance	Public Safety	Threat Detection & Mitigation	System Performance	GHG Reduction	Utility Credit Rating	Accommodate Tech Innovation
Minimal Recovery	Workforce Safety	Access Control & Data Protection	OpEx Management	Criteria Pollutants	DER Asset Finance	Accommodate New Busn Models
Operational Risk Management	Fail Safe Modes	Physical Security	Asset Optimization	Nexus w/Gas, Water & Transp.	Venture Capital Funding	Open & Interoperable

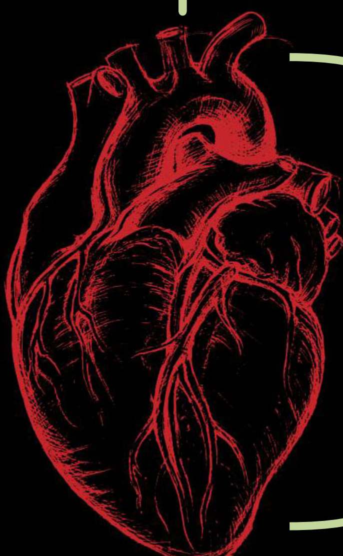
Objectives => System Qualities => Roles & Responsibilities of Key Actors

Layered Architecture of Resilience 1:

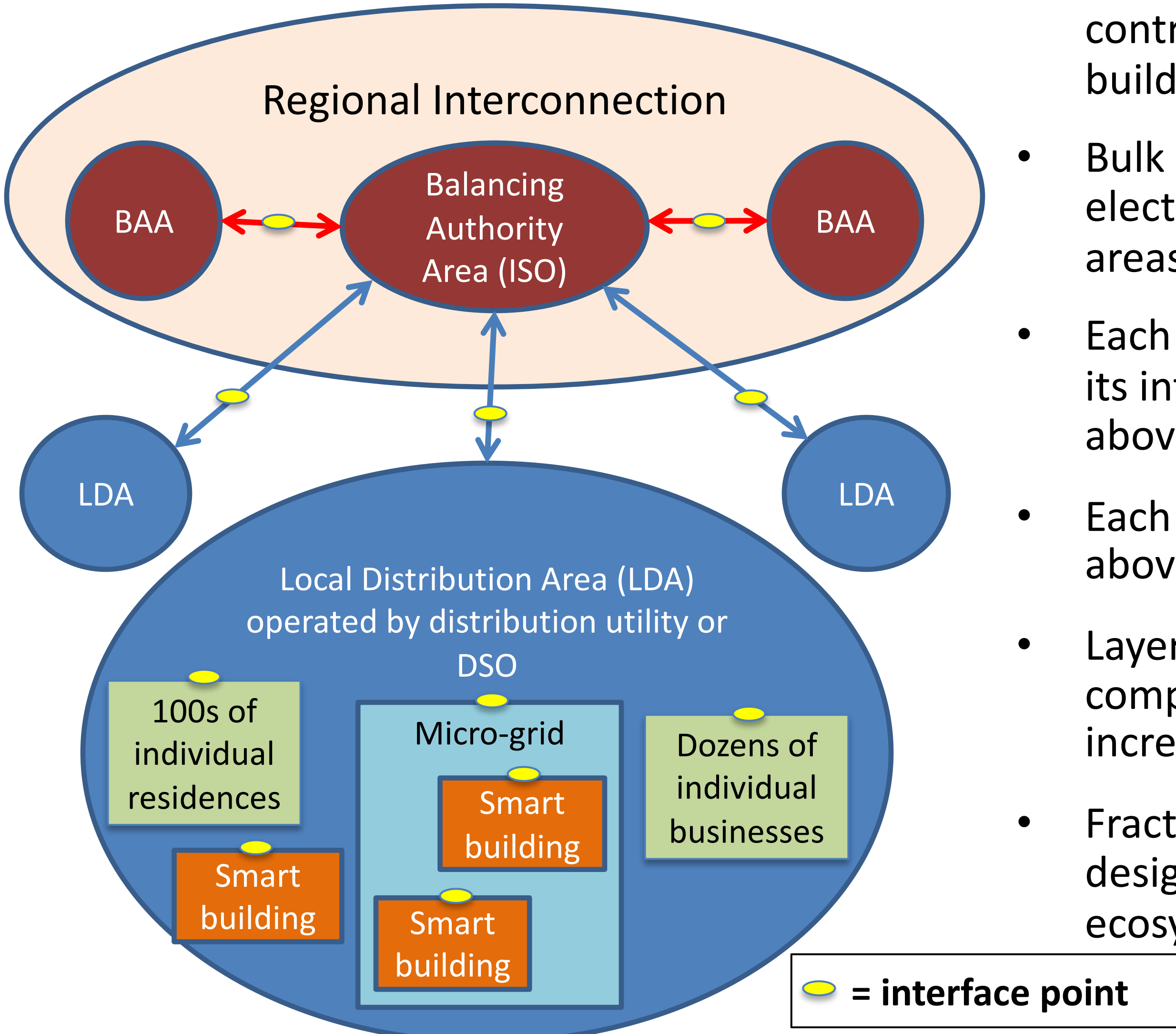


Nature's layered architecture of complex living systems





Layered Architecture of Resilience 2: Define power system roles & responsibilities at interfaces



- Rooftop solar, storage, and controls on premises form a building microgrid
- Bulk power system moves electricity from solar/wind-rich areas to load centers
- Each layer only needs to manage its interfaces with next layer above & below
- Each layer can "island" from layer above at the interface point
- Layered architecture reduces complexity, allows scalability, increases resilience & security
- Fractal structure mimics nature's design of complex organisms & ecosystems.

Transitioning today's electric utility to a "wires-only" company: What is required of a 21st century DSO?

Policy objective: Facilitate growth of local energy resources of various scales (DER) and diverse new actors with local focus (community choice agencies; NGOs; 3rd party DER providers)

- Objectives and guiding principles for an IOU-DSO
  - Reliable and safe electric distribution service
  - Resilience for more volatile "new normal abnormal"
  - Open access, non-discriminatory service (analogous to ISO function as transmission system and wholesale market operator)
  - Transparency of planning, interconnection, grid and market operations
  - Enable DER to provide and be paid for grid services (NWS)
  - Arena for beneficial innovation; limit scope of regulated monopoly DSO to "natural" monopoly functions and investments
  - Tie DSO financial incentives to performance of distribution services

Regulatory framework for an Open Access DSO:

1. Unbundle utility distribution service (DSO, delivery) from retail load-serving function (LSE, procurement)
   – Update Provider-of-Last-Resort function
2. Create an open, participatory distribution planning process where 3rd parties can provide DER or non-wires solutions
   – Base DSO profits on performance, not return on assets
   – Adopt DER solutions to meet local needs as well as grid needs
3. DSO uses market mechanisms to procure grid services from and fairly compensate flexible customers and DER providers
4. DSO partners with local governments and CCAs to implement community energy resources for decarbonization and resilience
5. DSO follows transparent real-time operating procedures to curtail or modify DER activity to meet distribution system needs
6. Adopt a data access framework that protects privacy while enabling all the above activities.
7. DSO coordinates planning, operations, markets with ISO/TSO

Advanced Community Energy is for all communities.

<u>Definition</u>: Advanced Community Energy (ACE):

1. ACE is a <u>physical system</u> of local electricity resources within a city or county, designed for the goals described below
2. ACE is a statewide <u>program</u> to plan and implement local ACE systems in all cities and counties in the state

<u>Objective</u>: Create a state <u>program</u> to empower, work with and assist all cities and counties to plan and implement <u>ACE systems</u> to achieve three goals:

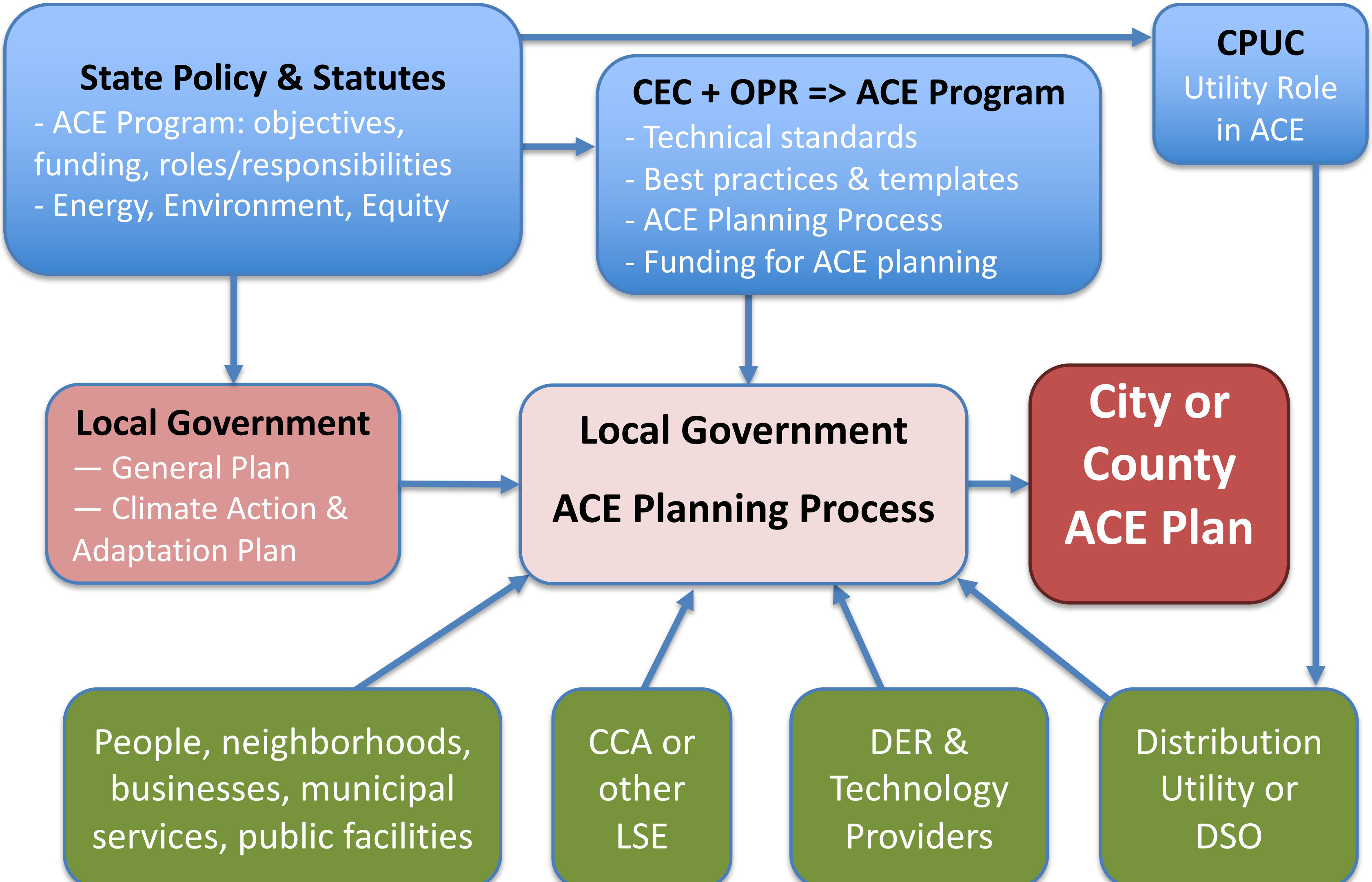
A. Address high-priority local benefits and local needs (such as jobs, resilience, disadvantaged communities)

B. Contribute to state policy goals for clean energy, decarbonization, resilience, equity and …

C. Have beneficial effects on the existing electric power system, by supporting grid operation and reducing infrastructure costs

How do we plan local ACE systems, in concept and in detail?

ACE planning is a structured collaborative process, set in motion by legislation.



Layered Architecture of Resilience 3: “Resilient Community” policies and strategies

Household
* Energy efficient
* All electric (zero net carbon)
* 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

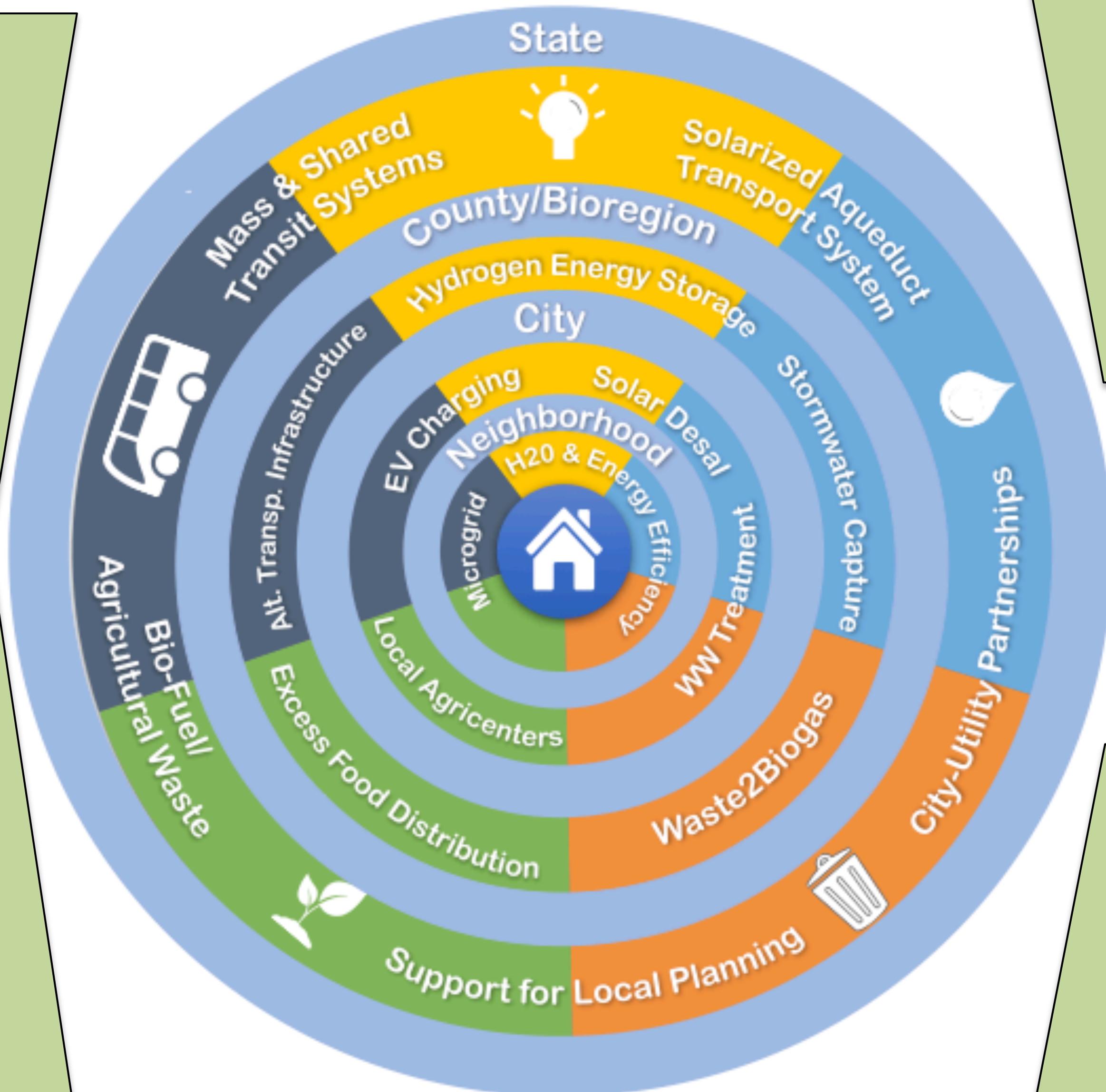


Image courtesy of World Business Academy
Santa Barbara, CA

State
* Policy, funding & structure 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

A sustainable, resilient 21st century electric system

The building blocks: "resilient communities" & "smart cities"

- Local power systems, based on renewable energy and storage, designed to meet community needs and enhance local economy
- Integrated municipal systems with electricity at the core: water, wastewater, solid waste, mobility, broadband, emergency services
- Decarbonize by electrifying and closing the loops (e.g., building efficiency; fuel from waste stream)
- Create electric "islanding" capability (micro-grid) for resilience

The whole electric system: "decentralized and integrated"

- Layered architecture of self-optimizing buildings within microgrids within local distribution areas (T-D interfaces)
- Able to island at each level if needed, but connected 99.9% of the time for transacting energy and services with the power network
- DSO platforms link local power systems to the bulk network
- Renewable-rich regions can deliver energy to load centers with modest transmission upgrades

Thank you.

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