Clean Coalition
Making Clean Local Energy Accessible Now

Community Microgrid planning and design

A resilient clean energy solution

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About the Clean Coalition

- A wealth of experience in microgrid planning and engineering
    - Developing projects that provide unparalleled economic, environmental, and resilience benefits.
- Renewable energy modeling and design
    - 15+ Community Microgrid feasibility assessments completed to date with clients including Stanford University, various Fortune 500 companies, and multinational independent power producers (IPPs)
    - 2 California Energy Commission (CEC) grants
    - 1 Department of Energy (DoE) grant
    - 1 National Renewable Energy Lab (NREL) contract
- Experience working with utilities
    - Investor-owned utilities (IOUs): PG&E, SCE, SDG&E, PSEG Long Island.
    - Municipal utilities: CPAU, LADWP, SMUD.
    - Current active projects with PG&E, SDG&E, SCE, CPAU.

Clean Coalition (nonprofit) mission

To accelerate the transition to renewable energy and a modern grid through technical, policy, and project development expertise

Community Microgrid planning and design presentation outline

- Current situation
  - Lack of resilience
- Traditional grid and microgrids
  - Microgrid vs. Community Microgrid
  - Benefits and components
- Pathway to Community Microgrids
  - Phased approach
- Policy overview
- Community Microgrid planning and design methodology
- Design activity: electric load analysis and identifying critical loads

Current situation:

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- Who can benefit from a microgrid?
- What are some common use cases?
- What is the value proposition of a microgrid?

Current situation:
Public Safety Power Shutoffs (PSPS) outages

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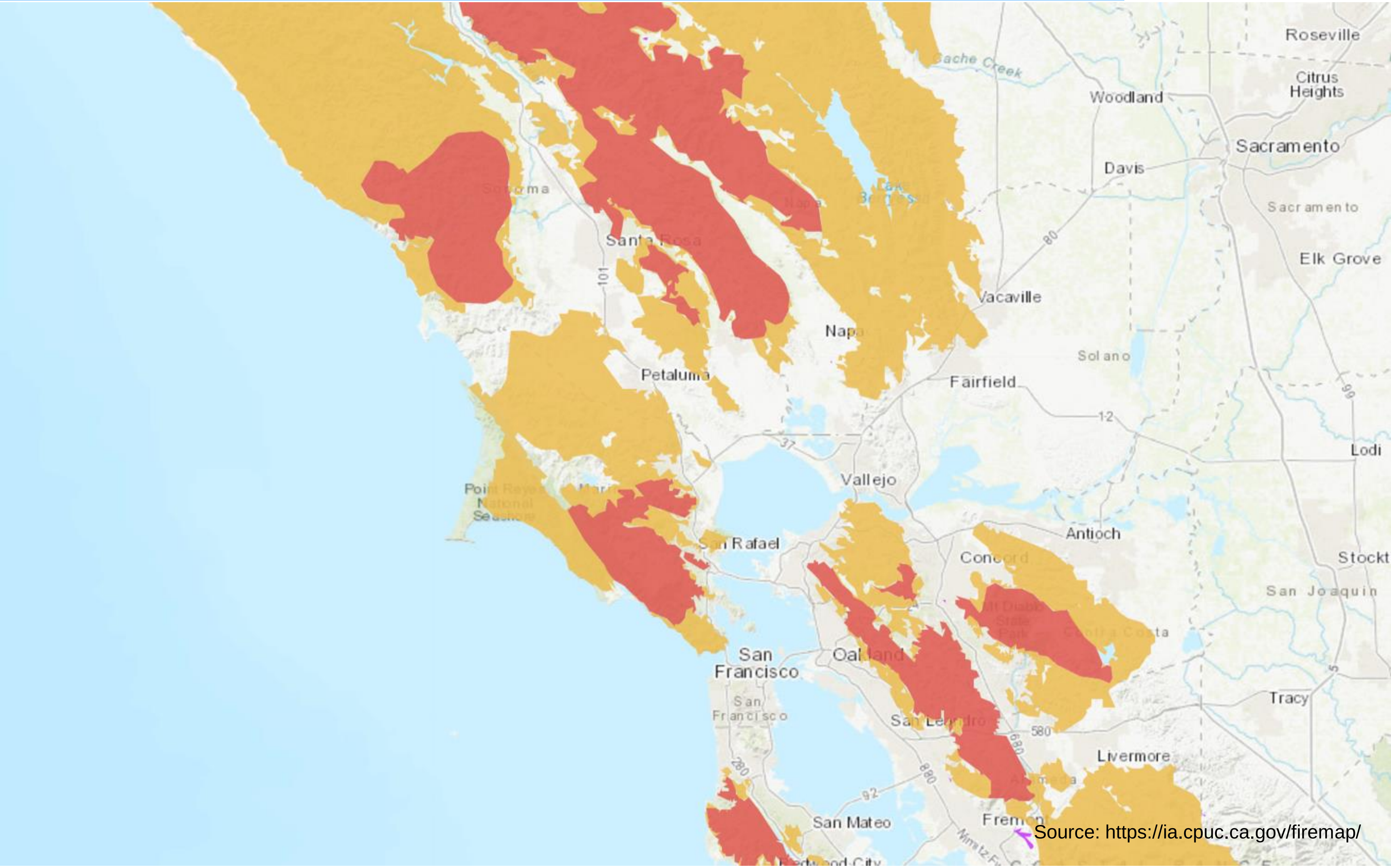
WHICH CUSTOMERS ARE MOST LIKELY TO HAVE THEIR POWER TURNED OFF?

If we need to turn off power for safety, it will be limited to neighborhoods or communities served by electric lines that run through areas experiencing extreme fire danger conditions. We will turn the power back on as soon as it is safe to do so. The most likely electric lines to be considered for shutting off for safety will be those in areas that have been designated by the California Public Utilities Commission (CPUC) as at extreme risk for wildfire (Tier 3 areas).

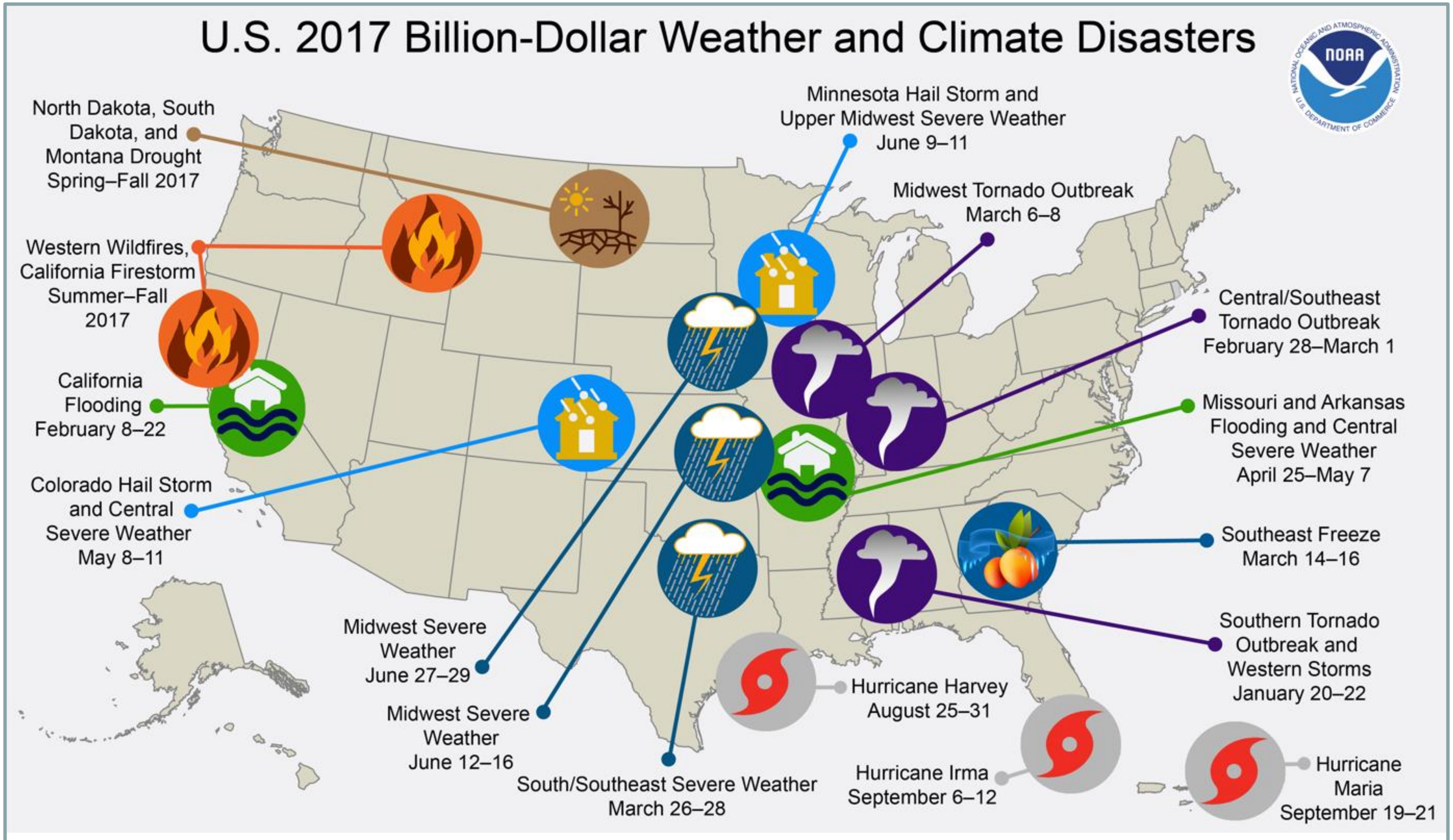
- Multiple PSPS events were planned in 2018, one event executed.
- Negative impact: Critical facilities, businesses, and residents lose power during planned shutdowns and cannot provide services.
- Microgrids can provide a solution to keep power on, however local hazards (e.g. local fire threats) need to be considered to be considered in the design process.

Current situation:
CPUC fire threat map



Source: https://ia.cpuc.ca.gov/firemap/

Current situation:
$1B+ weather events in U.S. Jan – Sept 2017



Source: National Oceanic and Atmospheric Administration

What is power system resilience?

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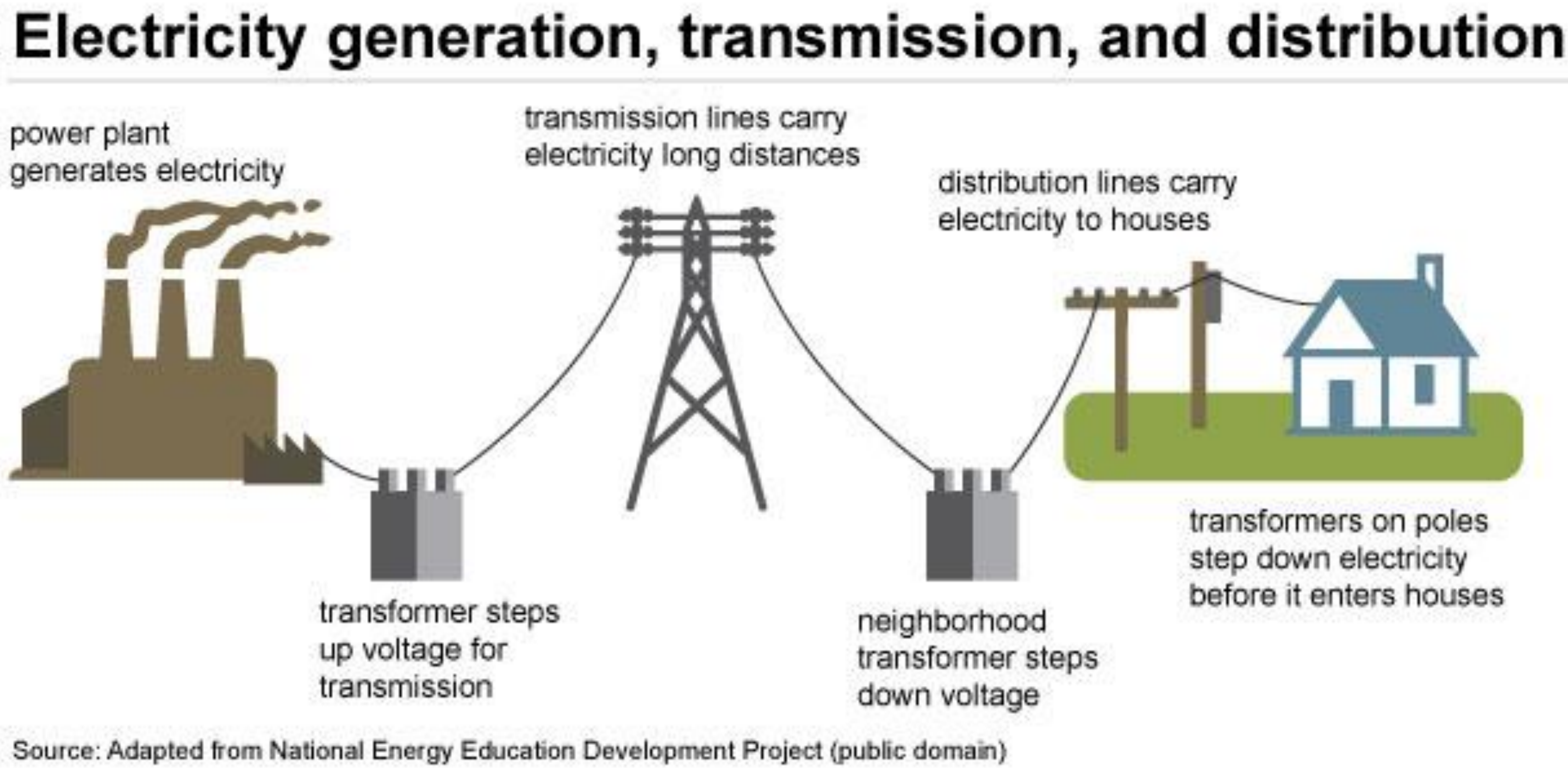
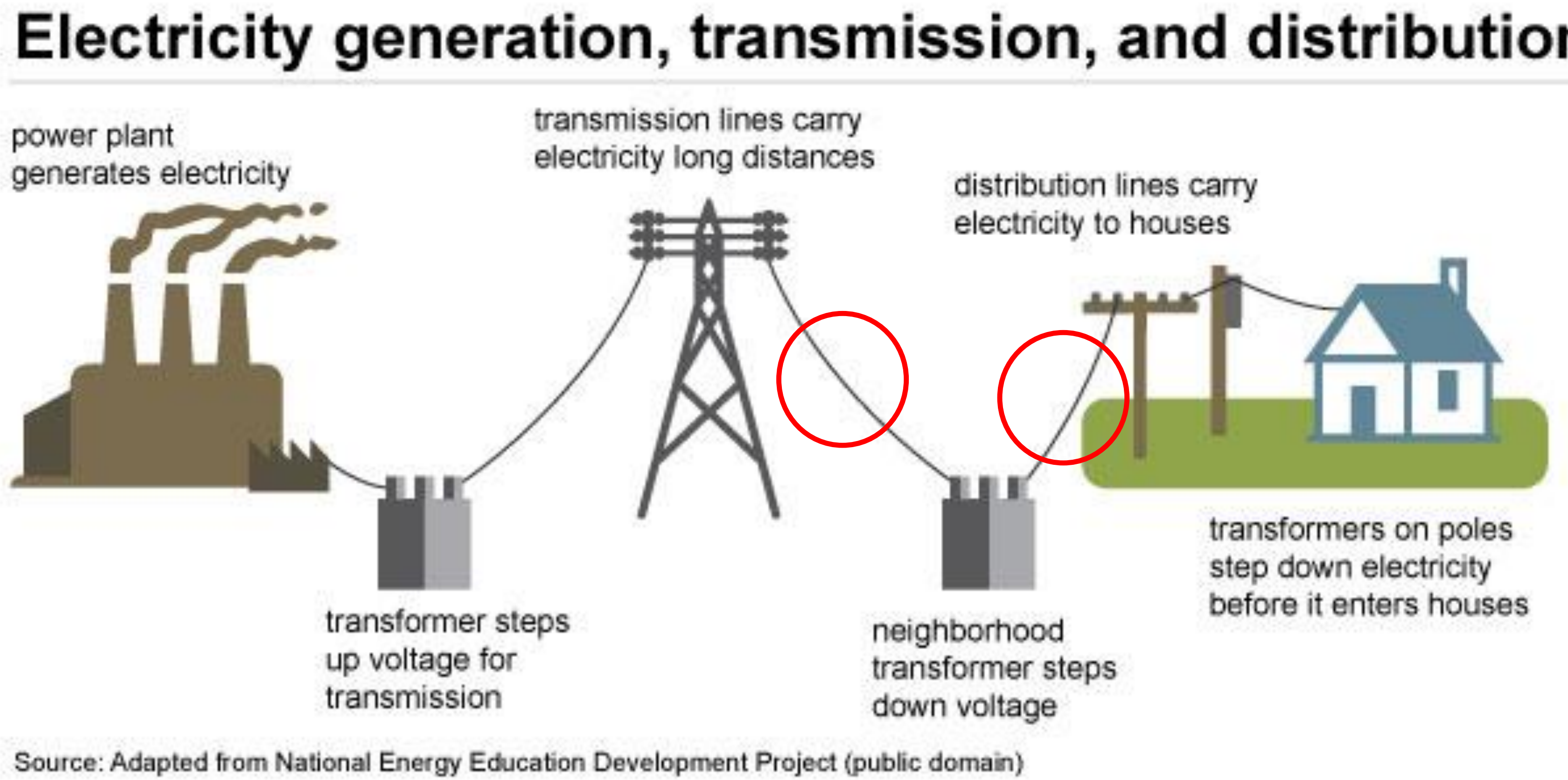
- **Power quality:** Issues with harmonics, power factor, etc. related to voltage, frequency, and waveform of electricity on the grid.
  - Timescale: micro-seconds
- **Reliability:** Measured after 5 minutes of grid outage
  - Timescale: minutes
- **Resilience: The ability to keep critical loads online indefinitely** in the face of extreme or damaging conditions
  - This is Clean Coalition’s definition of resilience
  - Focused on reducing outage duration, cost, and impact on critical services.
  - Timescale: hours or days

Traditional grid operations

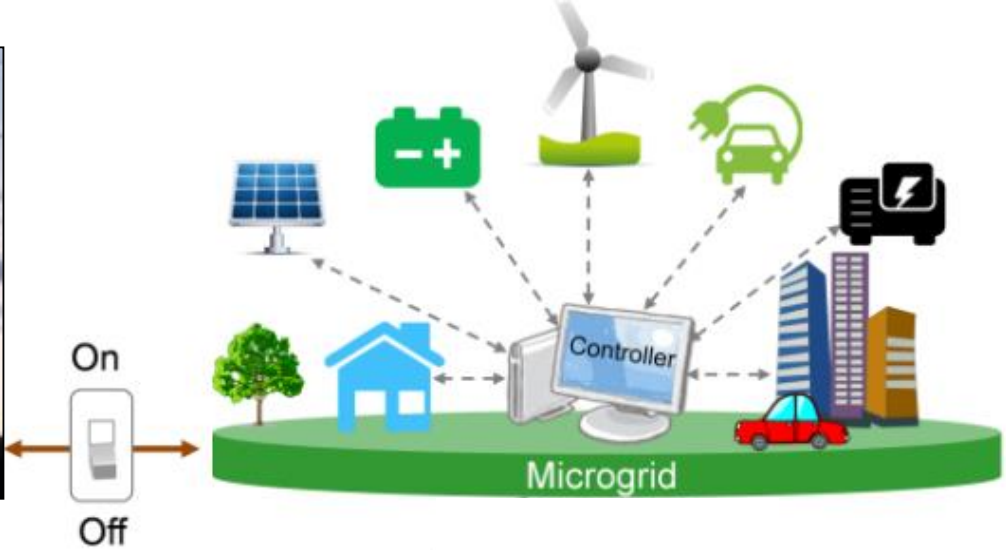


Traditional grid operations

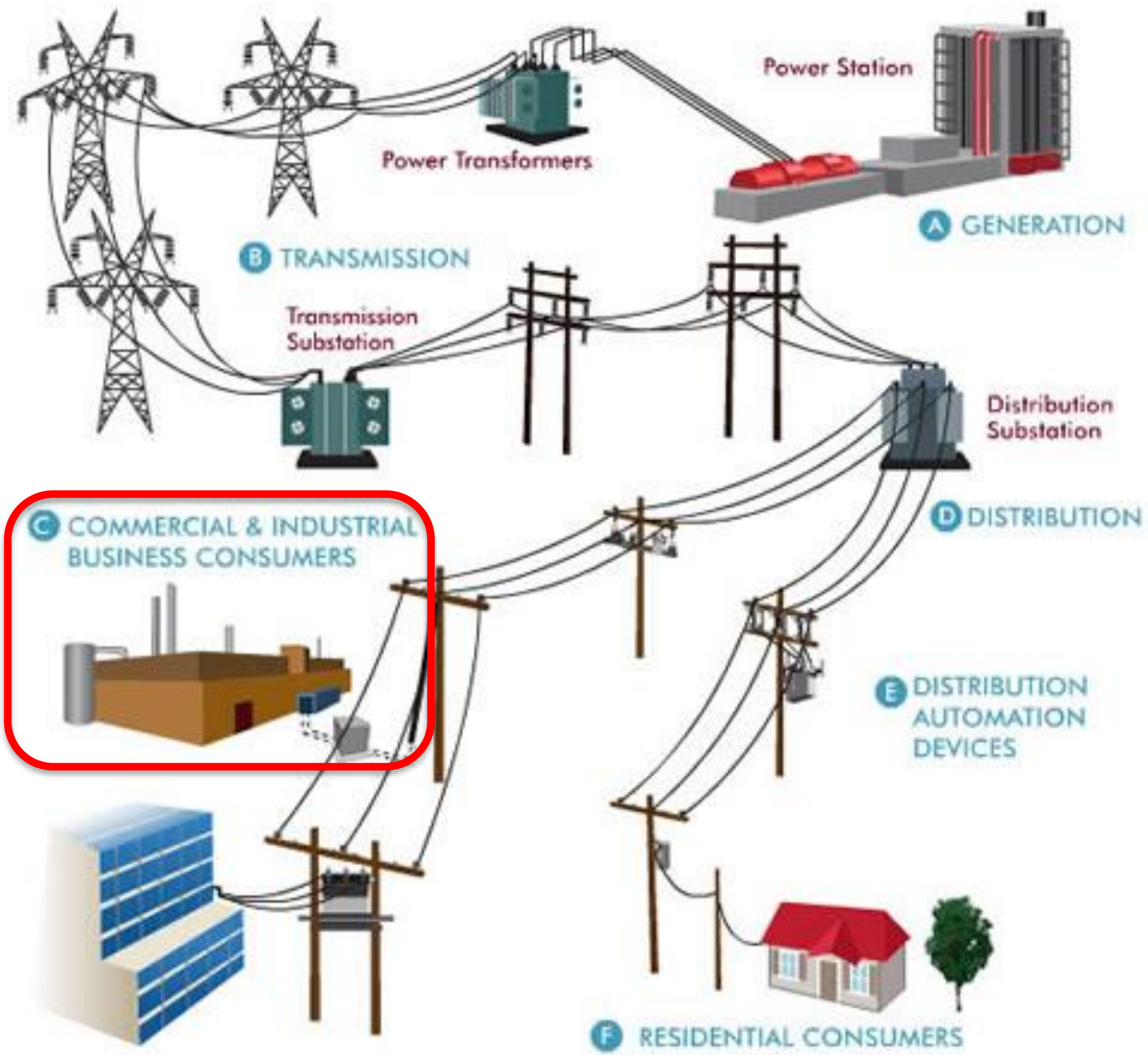


Long-term vision: Community Microgrids

- Long-term vision: Develop **Community Microgrids** to serve areas that currently lack reliable power, or that are at risk for frequent power shutoffs.

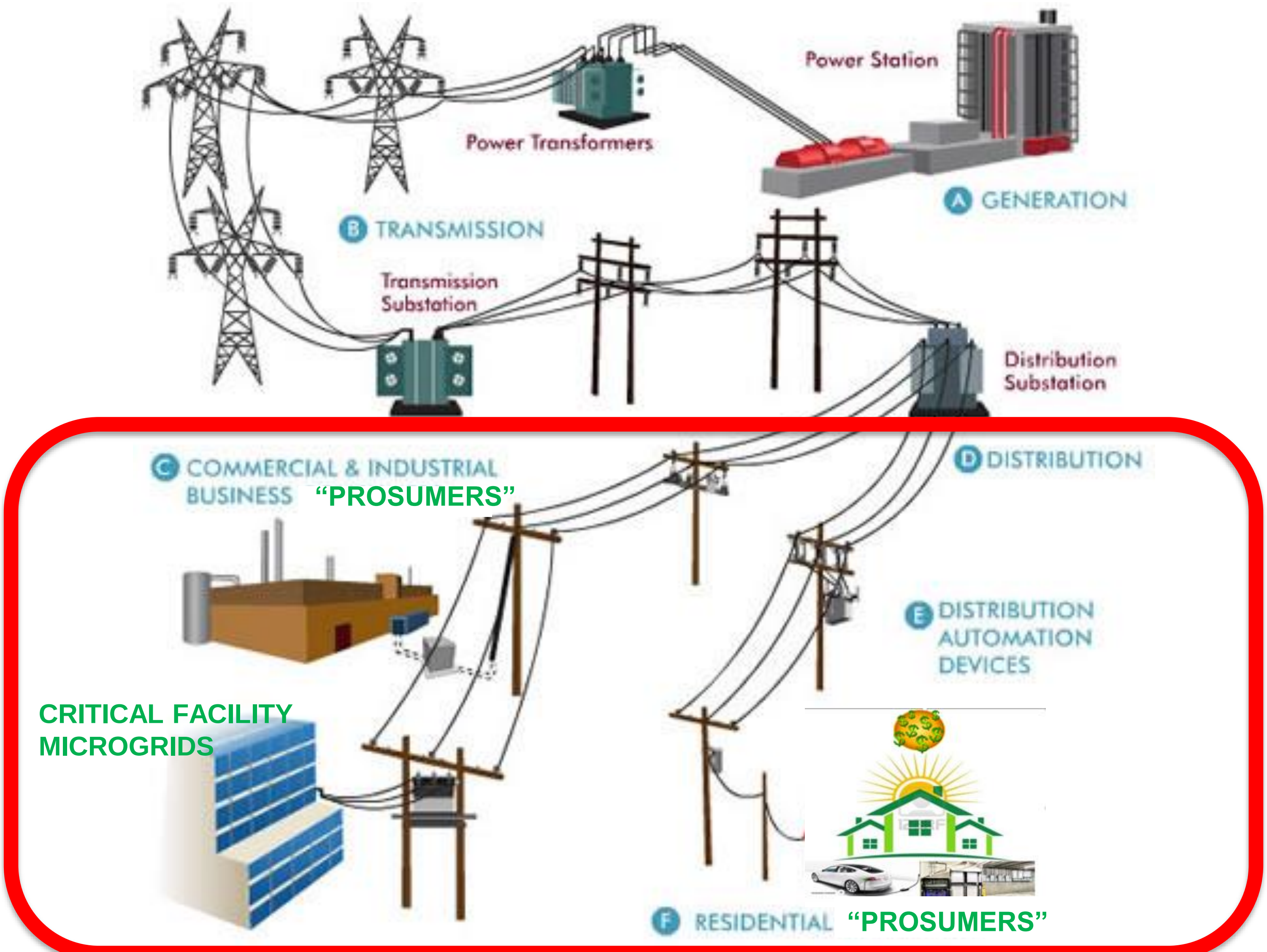


Facility microgrids focus on single customers



Source: Oncor Electric Delivery Company

Community Microgrids can serve up to thousands of customers

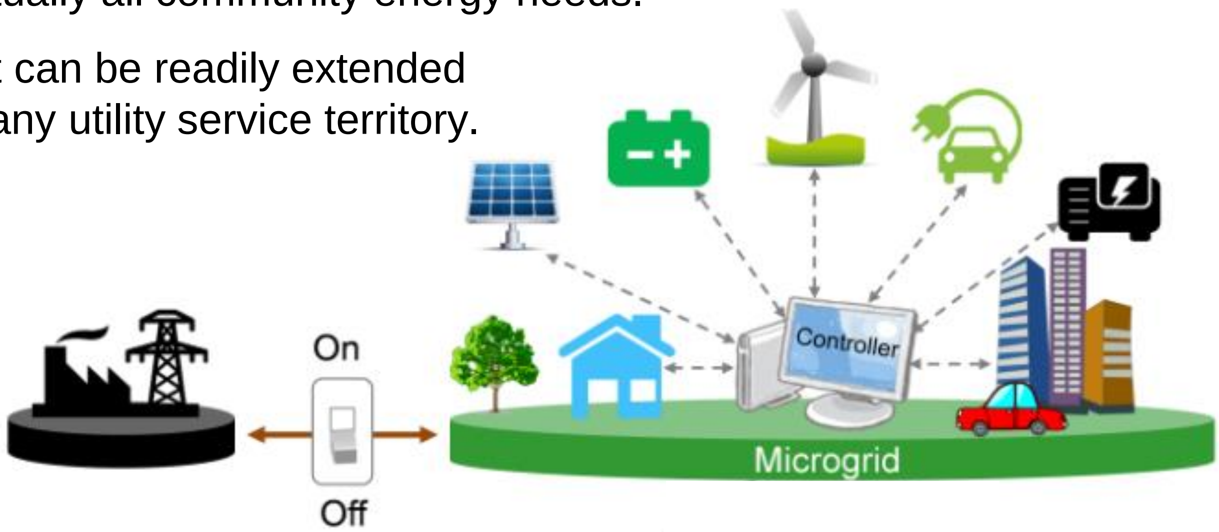


Source: Oncor Electric Delivery Company

Community Microgrid defined

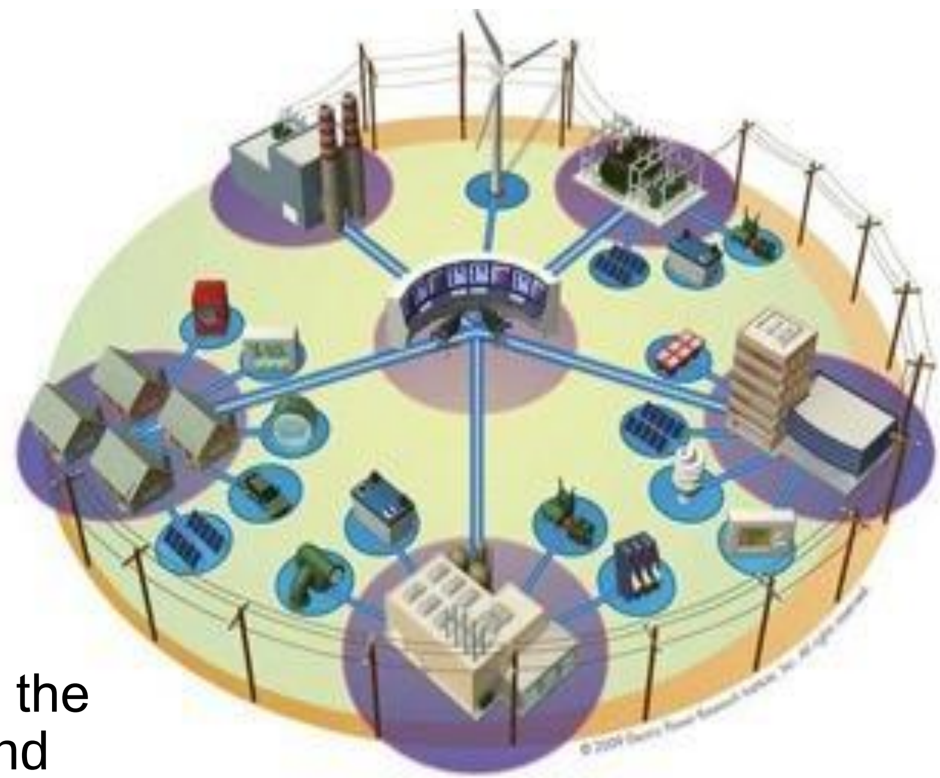
A modern approach for designing and operating the electric grid, stacked with local renewables and staged for resilience.

- **Can "island" from the grid:** A coordinated local grid area that can separate from the main grid and operate independently.
- **Components:** Solar PV and other renewable energy, energy storage, demand response, and monitoring, communications, & control.
- **Clean local energy:** Community Microgrids facilitate optimal deployment of distributed energy resources (DER).
- **Resilient:** Ongoing, renewables-driven backup power for critical and prioritized loads, and eventually all community energy needs.
- **Replicable:** A solution that can be readily extended and replicated throughout any utility service territory.



Community Microgrid benefits

- Reliability and power continuity
- Resilience and safety
- Local, renewable energy
  - Greenhouse gas reductions
  - Local control of energy
  - For electric vehicles and charging infrastructure
  - Reduced transmission losses
- Local jobs in engineering, construction, and maintenance
- More participation enables by a network of “prosumers” who share the use, generation, and revenue of and from energy
- Energy security and national security



Pathway to Community Microgrids

	Community Microgrid	Pre-installed interconnection hub (PIH) microgrid	Behind-the-meter microgrids at critical facilities
Timeline for deployment	Long-term 5-10 years	Mid-term 3-5 years	Near-term 1-3 years
Scope and scale	• Entire substation grid area • Municipal buildings, businesses, and residences	• Neighborhood • Priority sections of the distribution grid • Determined by stakeholders and PG&E	• Single building • Critical facilities are key target sites • Businesses and residences can also choose to deploy
Loads to be served	• All loads • Critical and priority loads	• All loads within the priority sections of the distribution grid	• Design can accommodate critical, priority, and noncritical loads
Renewable energy demand*	• All loads • Critical and priority loads	• TBD based on the loads of the PIH area	• TBD based on desired loads

*Renewable energy supply can be augmented with existing diesel generators

Microgrids: Policy overview

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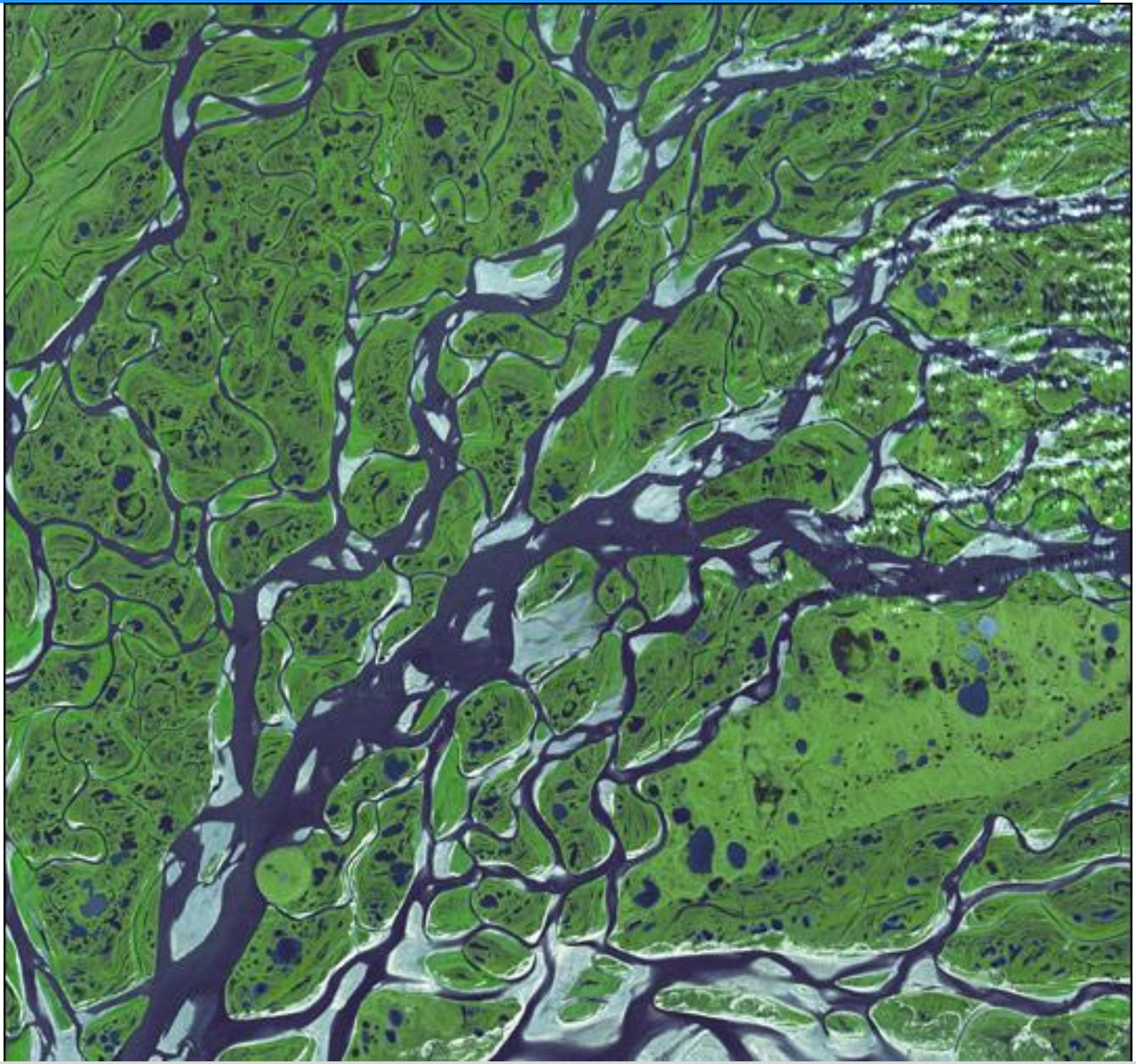
- Behind-the-meter (BTM) microgrids: Policies to enable islanding and operation behind the meter exist. These systems are being deployed now.
  - Applies to buildings and campuses with a single utility meter.
  - DER interconnection: Net energy metering (NEM) or non-exporting backup power
  - Key requirement: Automatic transfer switch (ATS)
  - Major constraint: Policies allow microgrids, but utility rate tariffs do not necessarily incent developing microgrids for all customers.
- Microgrids using the public grid (e.g., Community Microgrids) face the same policy barriers as DER:
  - How do DER get compensated for grid services?
  - How do we manage open access to utility wires?
  - PG&E will continue to operate utility lines that it owns.

Policy tributaries and interaction



Microgrid milestones and policy map

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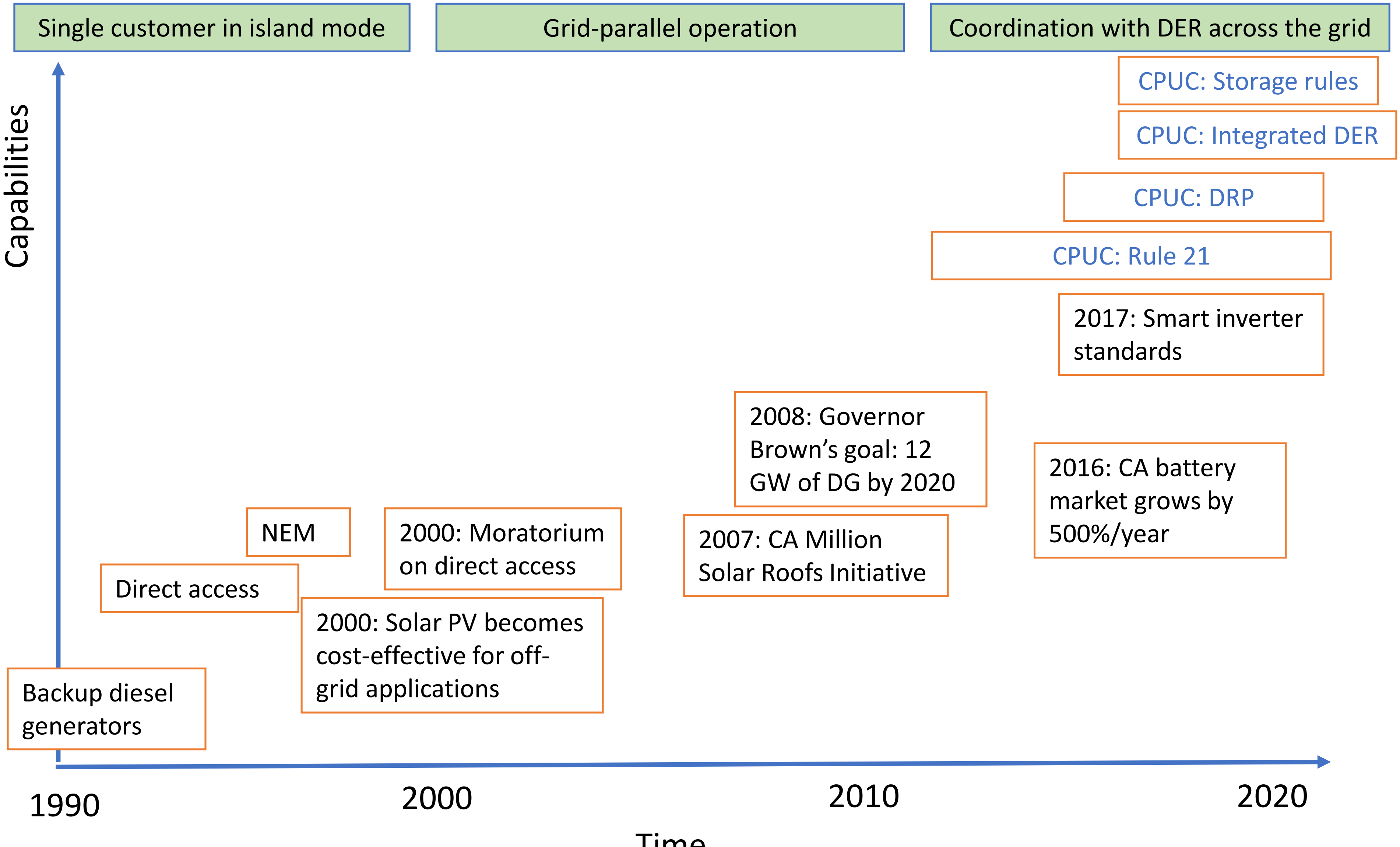

Solutions to regulatory challenges

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- Implement a phased approach, with technology that is future-compatible
  - Near-term: Implement behind-the-meter microgrids at critical facilities first, and stage them for the capability to participate in a future Community Microgrid.
    - Critical facilities include essential city services (fire departments, water treatment, public works), emergency shelters at schools and churches.
    - Automated load shedding can reduce system size and cost, but can be expensive to implement due to rewiring costs. However, there a low-cost devices that can be used to shed plug loads and individual circuits from the electrical panel. Manual load shedding is also a possibility.
    - Systems can be designed to power critical loads within facilities indefinitely with renewable energy and energy storage.
  - Mid-term: Work with CPUC and PG&E to incorporate renewable DER into PIH resilience zones.
    - All customers within the PIH resilience zone will continue to have power.
    - Load shedding can be a part of this strategy to reduce demand.
    - PG&E will continue to operate lines they own.

Community Microgrid planning and design methodology

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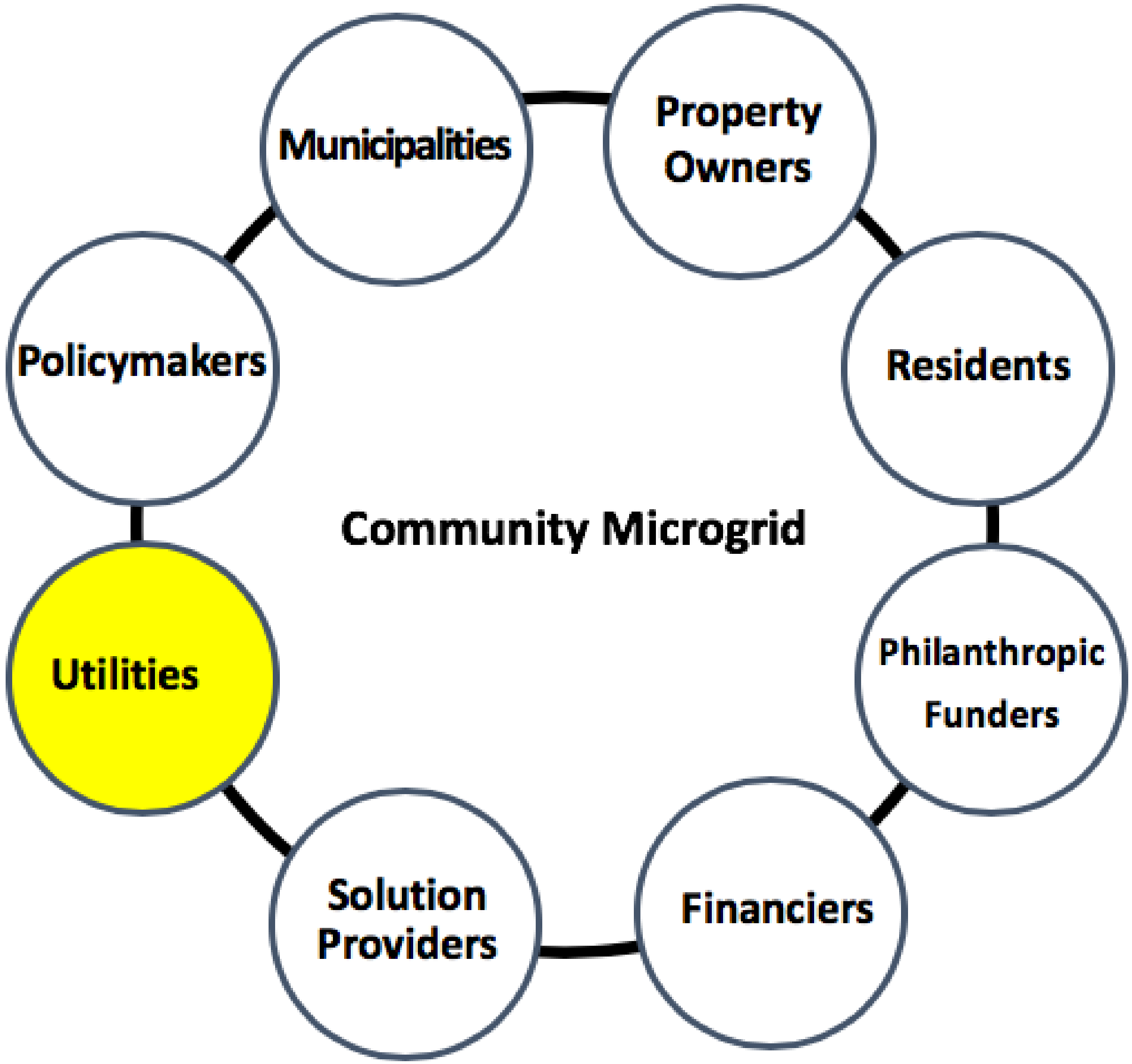
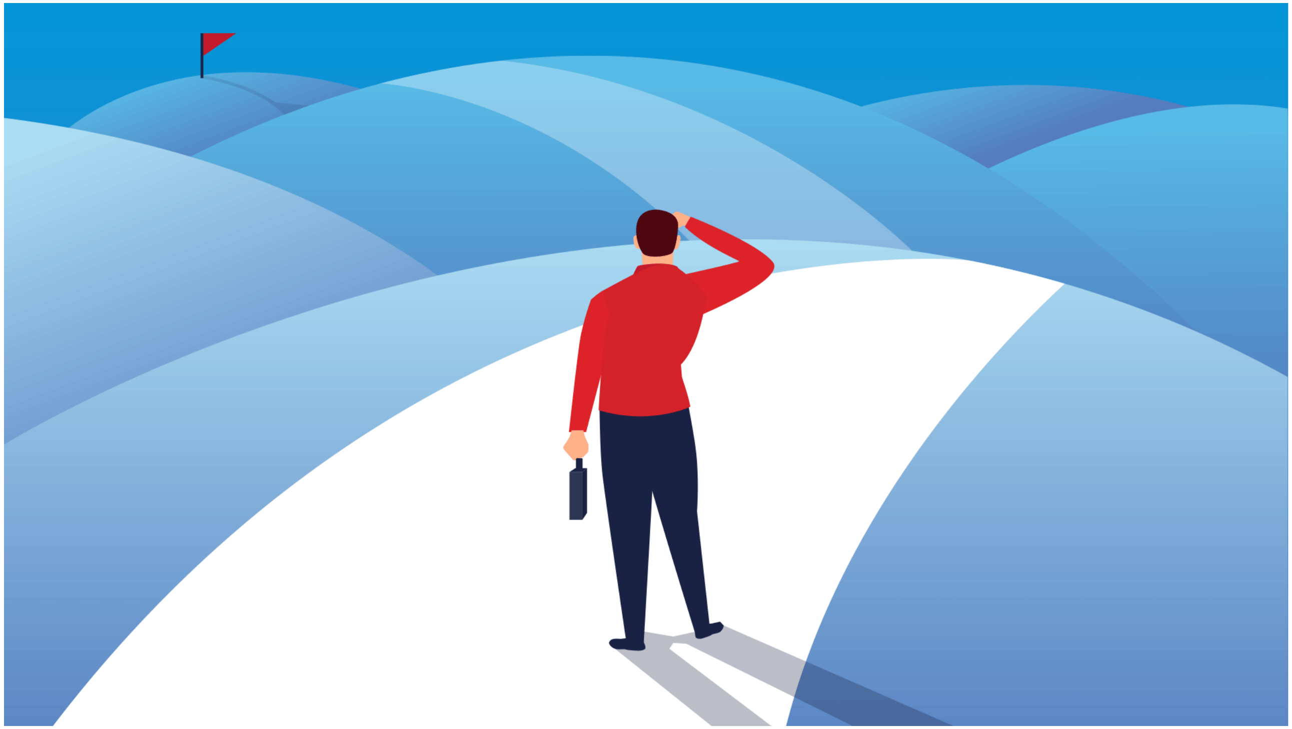
- Phase 1: Feasibility assessment
  - Stakeholder alignment and goal setting
    - Design requirements and constraints
  - Perform Solar Siting Survey (SSS)
  - Shortlist sites for basic technical and economic analysis.
  - Gather basic site details including load data, and perform a technical and economic analysis.
    - Aim for 70% accurate cost estimates
- Phase 2: Planning and engineering
  - Detailed technical and economic analysis.
  - Develop conceptual and functional design.
  - Engage engineering, procurement, and construction firm (EPC) to develop key engineering documents needed for utility buy-in (single-line diagram).
- Phase 3: Develop request for proposals (RFP)

Phase 1:
Community Microgrid key stakeholders



Phase 1:
Goal setting, requirements and constraints

- What are the local requirements and constraints for the design?
- Goal setting: develop SMART goals



Phase 1:
Solar Siting Survey (SSS) for Montecito

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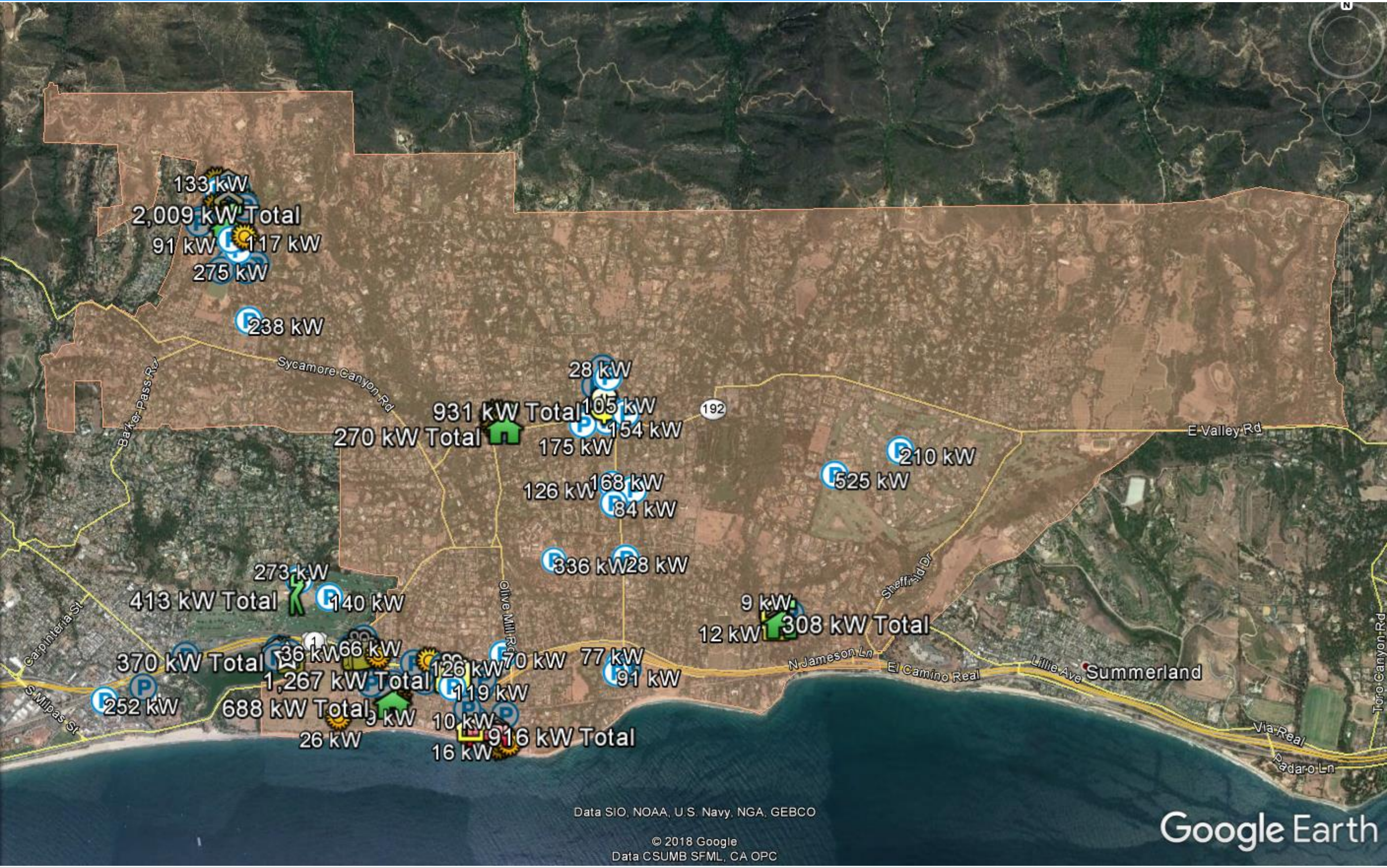

Phase 1:
Hot Springs Feeder via Santa Barbara Substation

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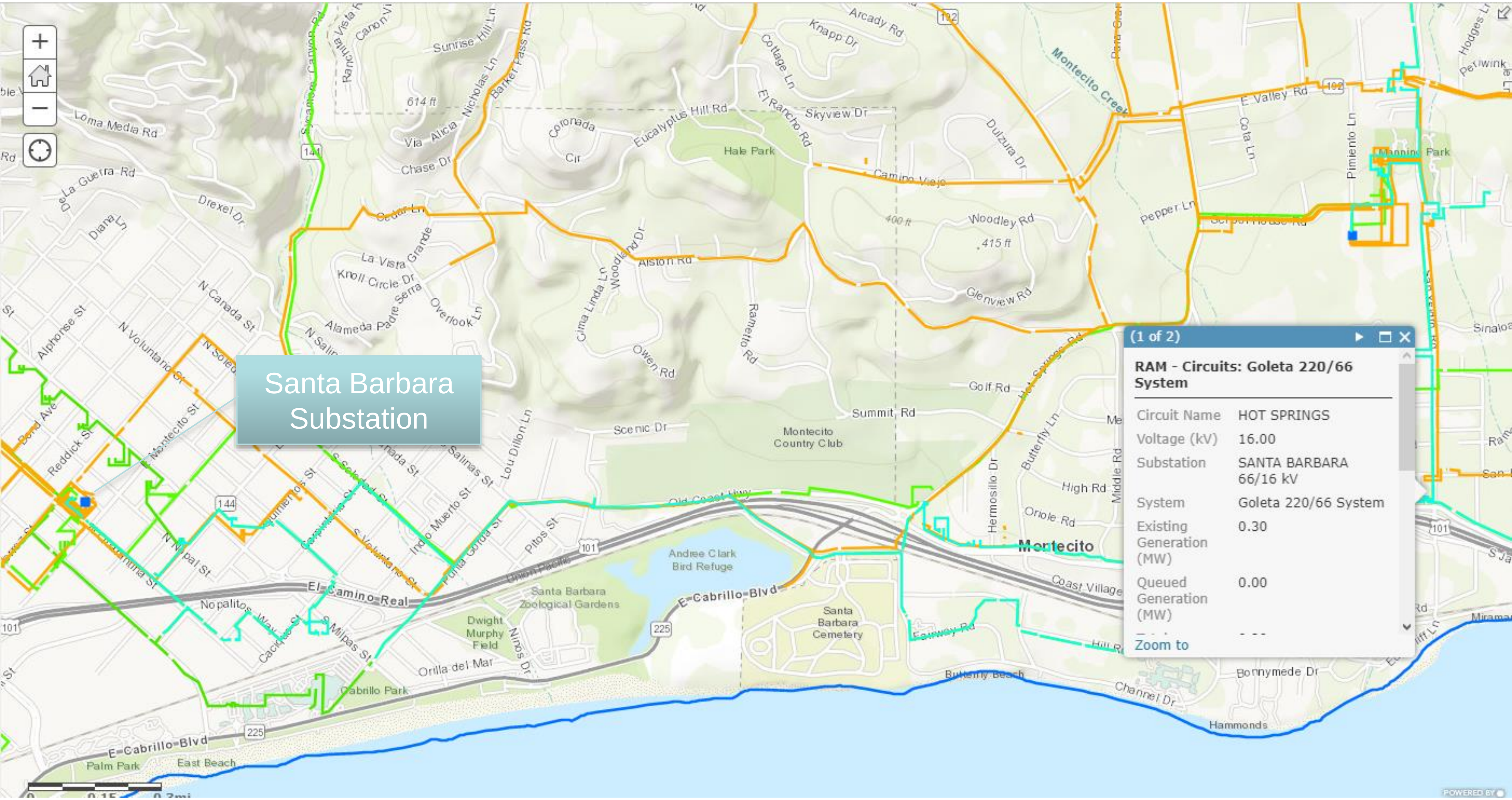

Phase 1:
Critical facilities along Hot Springs Feeder

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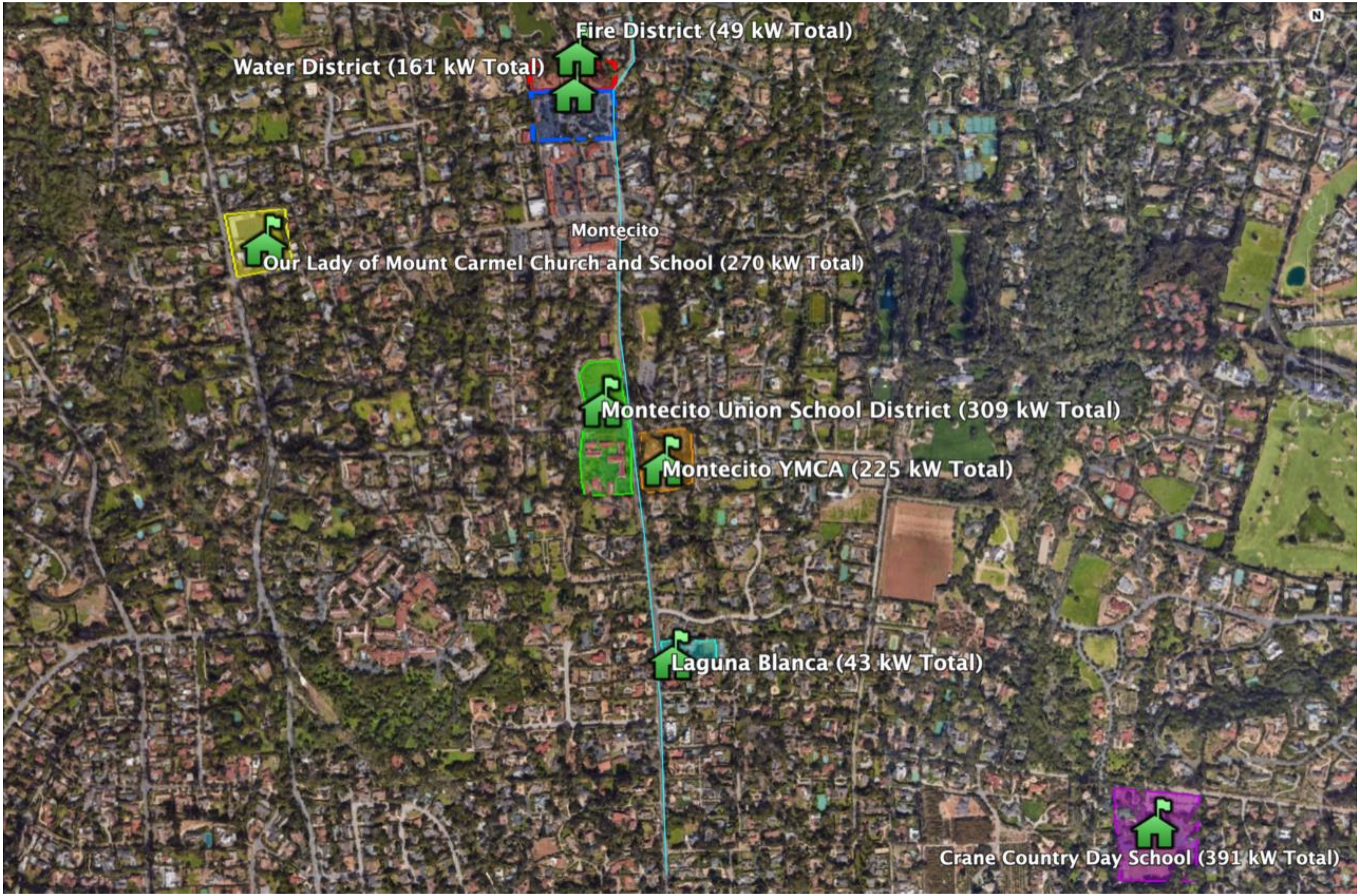

Phase 1:
Montecito Upper Village block diagram

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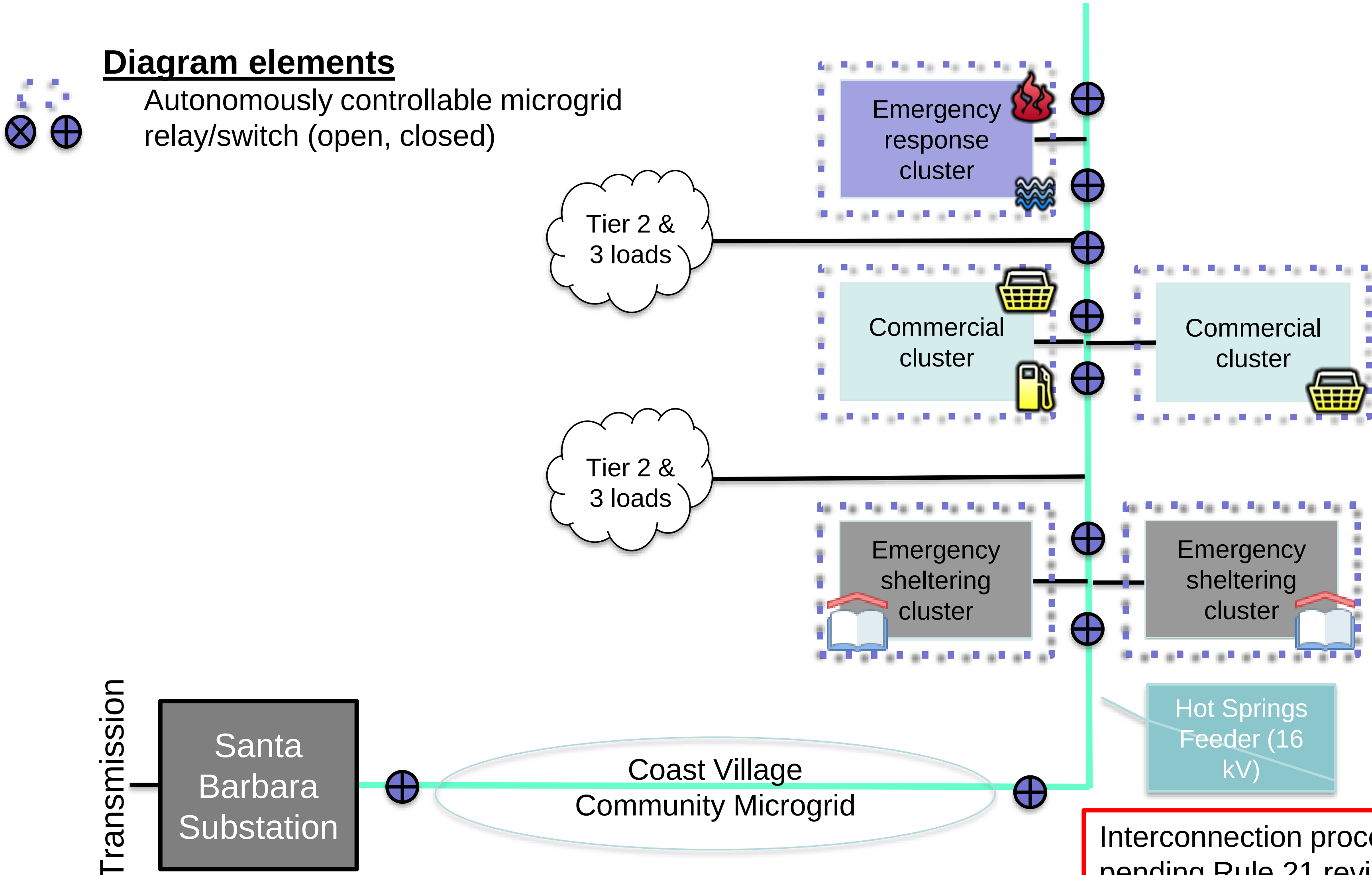

Interconnection process is pending Rule 21 review. Diagrams may change.

Phase 1:
Gather load data: Utility bills

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ENERGY STATEMENT
www.pge.com/MyEnergy

Account No: [redacted]
Statement Date: 08/28/2015
Due Date: 09/14/2015

Details of Electric Charges

07/29/2015 - 08/27/2015 (30 billing days)

Service For: [redacted]
Service Agreement ID: [redacted]
Rate Schedule: A10S Medium General Demand-Metered Service

07/29/2015 – 08/27/2015

Customer Charge	30	days	@ $4.59959	$137.99
Demand Charge	115.840000	kW	@ $16.23000	1,880.08
Energy Charges	22,803.920000	kWh	@ $0.16116	3,675.08
Energy Commission Tax				6.61
Redwood City Utility Users' Tax (5.000%)				284.66

Total Electric Charges $5,984.42

Average Daily Usage (kWh / day)

Last Year	Last Period	Current Period
602.46	736.06	760.13

Service Information

Meter #	[redacted]
Total Usage	22,803.920000 kWh
Serial	W
Rotating Outage Block	50

Phase 1:
Gather load data: 15-minute interval data

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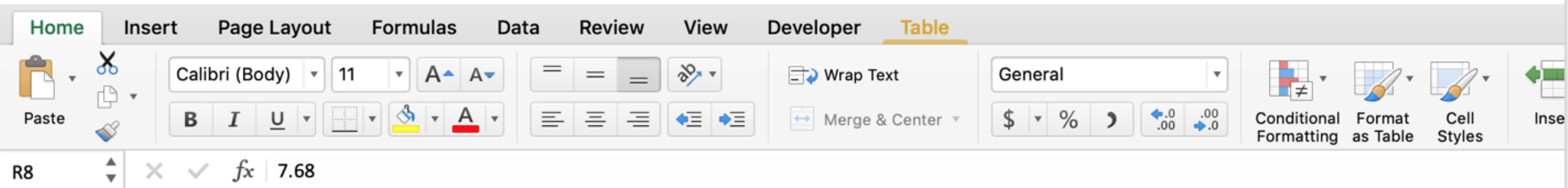

Account ID	Service Agreement ID	Meter Badge Number	Service Descriptor	Rate Code	Date	Time	TOU Code	Unit of Mea	Usage Value
[redacted]				HA10SX	1/1/16	1/1/16 0:15	WOP	KWH	6.56
				HA10SX	1/1/16	1/1/16 0:30	WOP	KWH	6.88
				HA10SX	1/1/16	1/1/16 0:45	WOP	KWH	6.4
				HA10SX	1/1/16	1/1/16 1:00	WOP	KWH	6.72
				HA10SX	1/1/16	1/1/16 1:15	WOP	KWH	6.24
				HA10SX	1/1/16	1/1/16 1:30	WOP	KWH	7.52
				HA10SX	1/1/16	1/1/16 1:45	WOP	KWH	7.68
				HA10SX	1/1/16	1/1/16 2:00	WOP	KWH	6.24
				HA10SX	1/1/16	1/1/16 2:15	WOP	KWH	7.2
				HA10SX	1/1/16	1/1/16 2:30	WOP	KWH	6.56
				HA10SX	1/1/16	1/1/16 2:45	WOP	KWH	6.24
				HA10SX	1/1/16	1/1/16 3:00	WOP	KWH	7.2
				HA10SX	1/1/16	1/1/16 3:15	WOP	KWH	7.36
				HA10SX	1/1/16	1/1/16 3:30	WOP	KWH	6.56
				HA10SX	1/1/16	1/1/16 3:45	WOP	KWH	7.68
				HA10SX	1/1/16	1/1/16 4:00	WOP	KWH	7.84
				HA10SX	1/1/16	1/1/16 4:15	WOP	KWH	7.52
				HA10SX	1/1/16	1/1/16 4:30	WOP	KWH	6.72
				HA10SX	1/1/16	1/1/16 4:45	WOP	KWH	7.04

Phase 1: Basic technical and economic analysis

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- Key inputs: normal load profile, critical load profile, and rate tariff
- Goal: Determine optimal system sizing of PV, energy storage, and other DER for both normal grid-parallel operations and emergency grid-island operations
- Estimating critical loads:
  - Tier 1 = Critical (10%) — crucial and life-sustaining loads. Tier 1 loads can be critical facilities like fire stations, water systems and communications infrastructure.
  - Tier 2 = Priority (15%) — important but not necessary.
  - Tier 3 = Discretionary (75%) — the remainder of the total load.
  - These estimates will not work for all facilities (e.g. hospitals)

Phase 1: Montecito Upper Village emergency response facilities

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Site	Annual Historic Use	Proposed Solar PV Capacity (DC)	Solar PV Annual Production
Fire District	103,623 kWh	70 kW	102,533 kWh
Pump House	21,415 kWh	14.5 kW	21,379 kWh
WD Office	28,716 kWh	19.5 kW	28,765 kWh
WD Mech Yard	14,933 kWh	10.2 kW	15,141 kWh
Sand Lot	NA	75.9 kW	112,069 kWh
Phase 1 Total	168,687 kWh	190.1 kW	279,887 kWh

Note that the 75.9 kW Solar PV system proposed for the Sand Lot would be used to offset electricity from other municipal electric accounts, such as the Water District accounts not located in this site, via the Renewable Energy Self-Generation Bill Credit Transfer (RES-BCT) program.

Interconnection process is pending Rule 21 review. Diagrams may change.

Community Microgrid planning and design methodology

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    - Design requirements and constraints
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  - Gather basic site details including load data, and perform a technical and economic analysis.
    - Aim for 70% accurate cost estimates
- Phase 2: Planning and engineering
  - Detailed technical and economic analysis.
  - Develop conceptual and functional design.
  - Engage engineering, procurement, and construction firm (EPC) to develop key engineering documents needed for utility buy-in (single-line diagram).
- Phase 3: Develop request for proposals (RFP)

Redwood City Community Microgrid conceptual diagram

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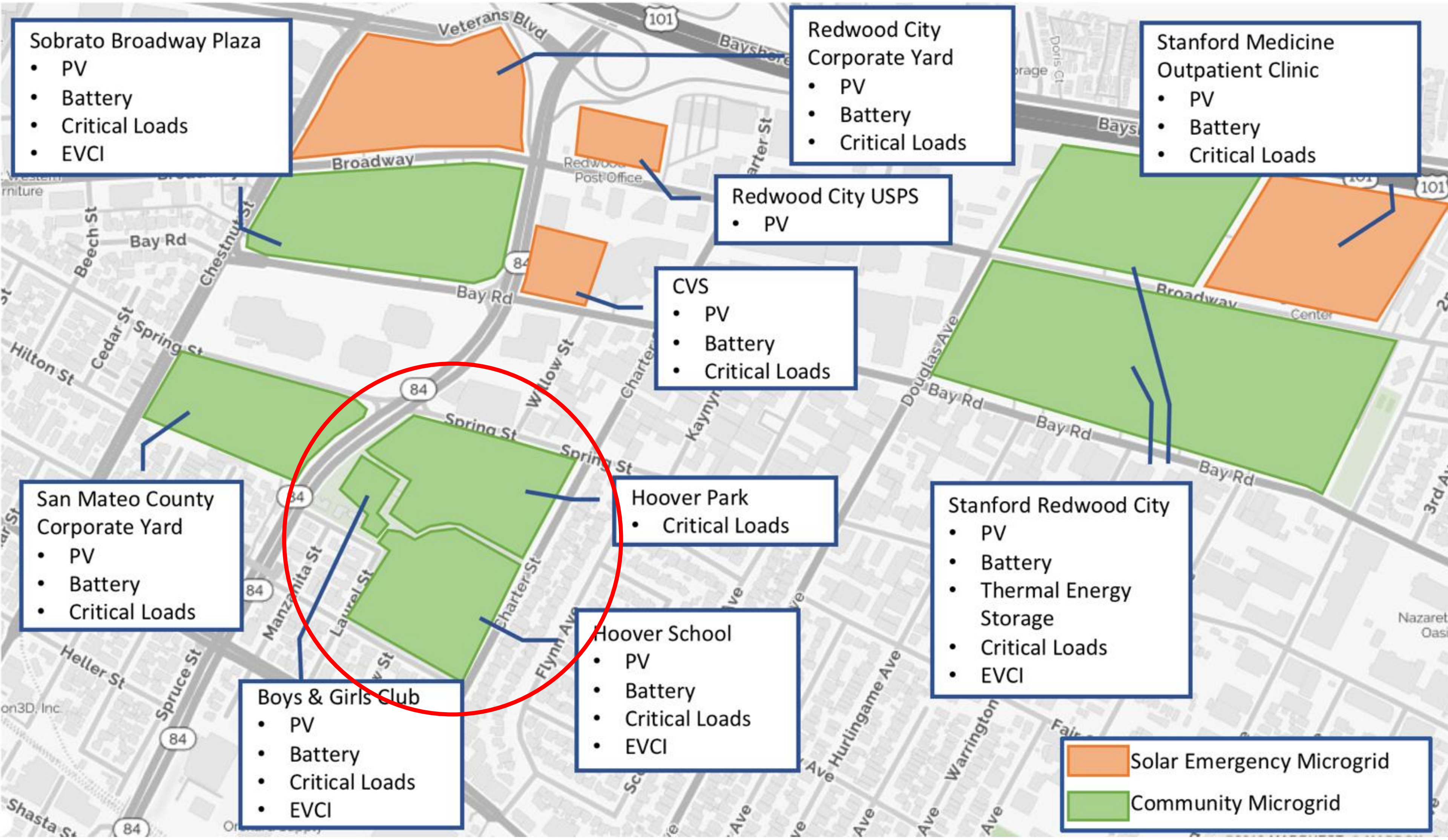

Deployment summary

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Site name	Meters or buildings	Critical Loads	NEM solar [kW AC]	FIT solar [kW AC]	Total solar [kW AC]	Battery [kW]	Battery [kWh]	EVCI (Level 2)
Stanford Redwood City Phase 1	P1, B1-B4	Campus emergency response	886	0	886	251	2,100	52
Hoover Cluster	Hoover School	Shelter & food service	73	203	276	29	150	20
	Boys & Girls Club	Shelter & food service	11	90	101	0	0	10
	Hoover Park	Equipment staging	0	0	0	0	0	0
Redwood City Corporate Yard	Redwood City Corporate Yard	Road and public facility maintenance and repair	136	352	488	58	360	*4
San Mateo County Corporate Yard (SMC Yard)	SMC Yard Meter 1	Road and public facility maintenance and repair	65	0	65	58	240	0
	SMC Yard Meter 2		33	121	154	0	0	*4
	SMC Yard Meter 3		0	79	79	0	0	0
Sobrato Broadway Plaza	Sobrato Broadway Plaza (multiple meters)	Low-income housing	0	1,197	1,197	TBD	TBD	TBD
	Sobrato CVS	Pharmacy & grocery	0	83	83	TBD	TBD	TBD
New Deployments TOTAL			**1,204**	**2,125**	**3,329**	**396**	**2,850**	**82**

- With net metering, only 1.2 MW can be deployed.
- With a new Feed-In Tariff (FIT) program, an **additional 2.1 MW** of local, renewable generation could be deployed in a disadvantaged community. We are working with the local community choice aggregator (CCA) to serve as an offtaker for the FIT solar.

Phase 2: Planning and engineering technical approach

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- Step 1: Detailed site info and site walk
- Step 2: Load shedding and operational design
- Step 3: PV system sizing
- Step 4: Grid-connected optimization with Geli ESyst
- Step 5: Off-grid optimization with HomerPRO
- Develop system sizing recommendation, cost estimates, conceptual diagram, and SLD block diagram
- Work with EPC to develop SLD and basic civil CAD drawing

Phase 2: Planning and engineering
Step 1: Detailed site info and site walk

- Obtain site as-built drawings
  - Architectural, electrical, structural
- Conduct site walk
  - Validate:
    - Solar siting potential and feasibility
    - Energy storage and electric vehicle (EV) charging locations
    - Details of existing electrical infrastructure (meters, AC bus sizing, etc.)
  - Assess critical load:
    - In Phase 1, Tier 1 critical load was estimated to be 10% of normal load.
    - In Phase 2, we develop a ground-up energy budget that accounts for site-specific and emergency operations. This is more accurate than a load percentage.
    - The activity following this presentation will explore this concept more.

Phase 2: Planning and engineering
Step 2: Load shedding

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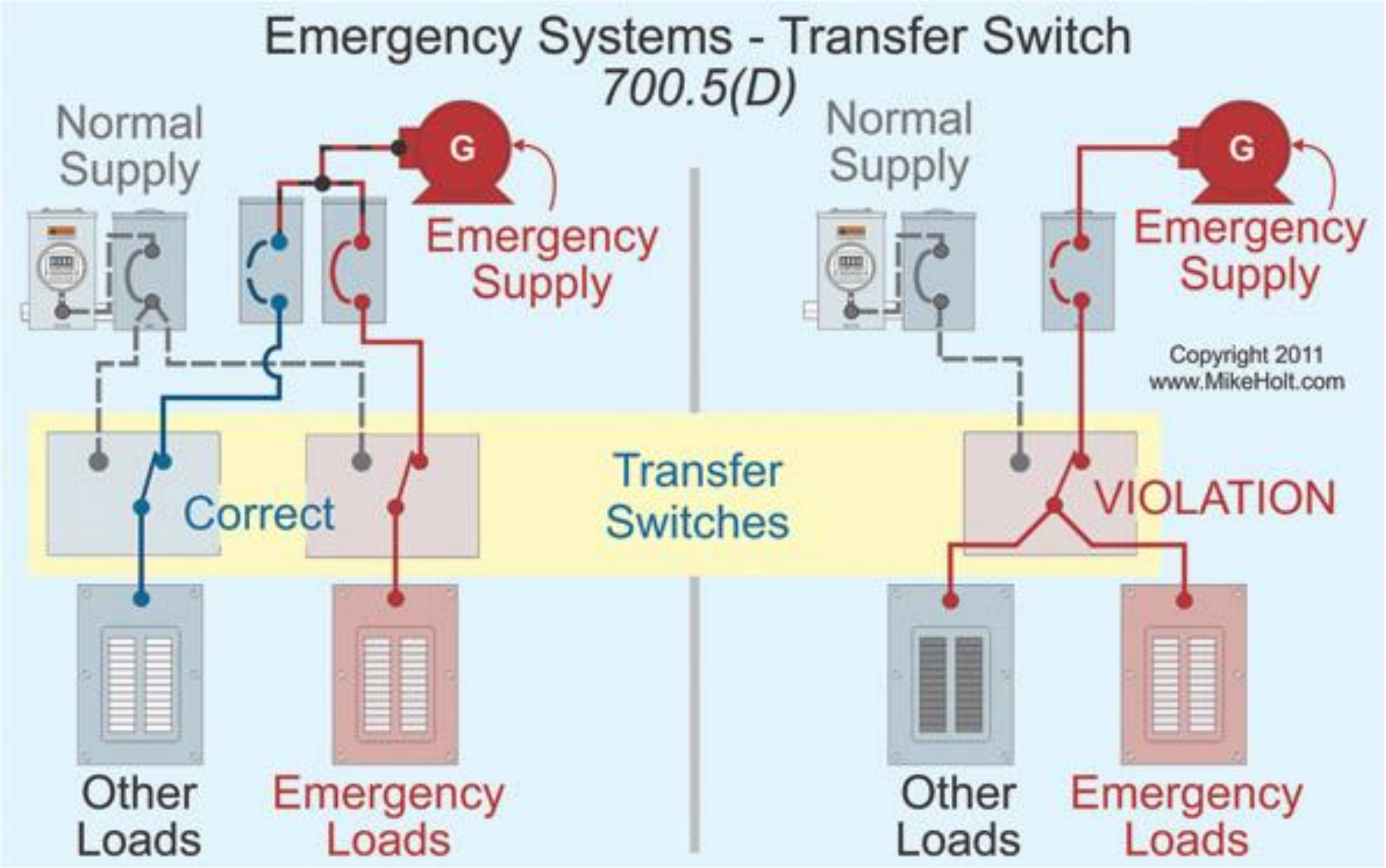
- Utility-scale definition: rolling blackouts
- Building or community-scale definition: shedding circuits so the load matches the available generation capacity.
- What loads are non-critical?

- Automatic transfer switches enable this load shedding by using an emergency load panel



Phase 2: Planning and engineering
Step 3: PV system sizing

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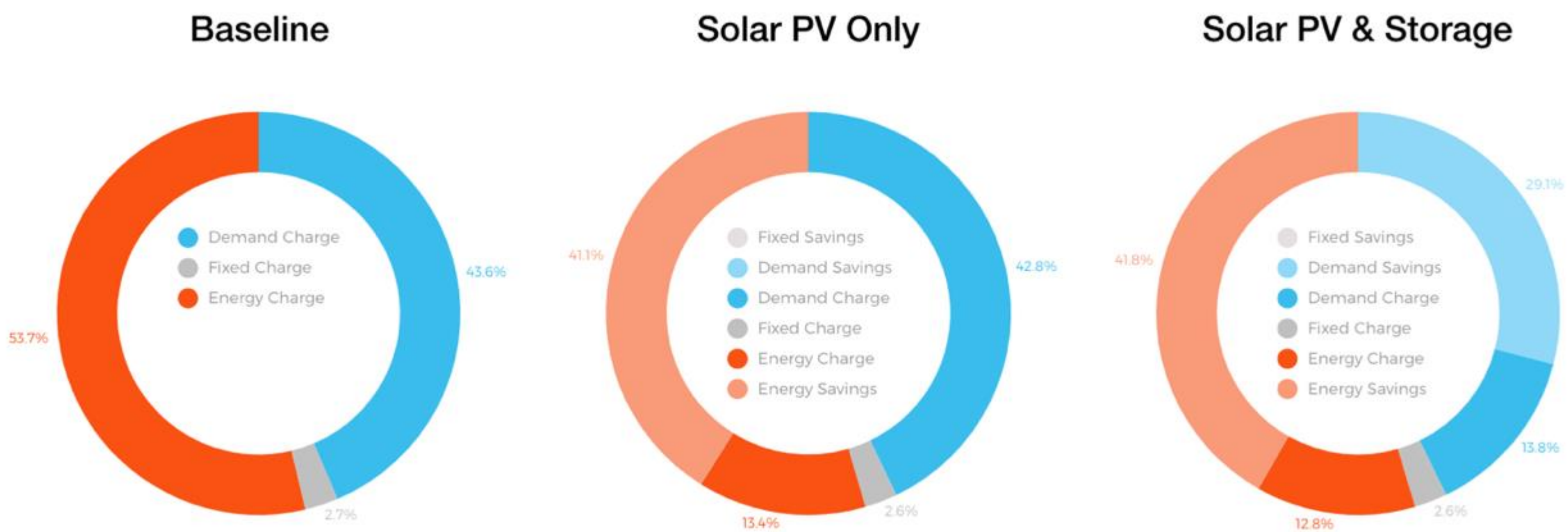
- Size and model multiple PV systems using PVWatts from NREL:
  - 1st system: **Full-scale PV deployment**. Use all feasible on-site rooftops, parking lots, and open spaces as defined in the Solar Siting Survey and site walk.
  - 2nd system: **Net-metered PV system**. Determine system size based on annual utility bills.
  - 3rd system: **Net-metered PV system with load growth**. If the site is a candidate for load growth (e.g., EV charging), combine the existing load profile with the project load profile of additional EV chargers.

Phase 2: Planning and engineering
Step 4: Grid-connected optimization with ESyst

- Used Geli's ESyst tool to determine the optimum energy storage size for a grid-connected system that takes advantage of peak shaving and demand charge management.
- Example: The figure below shows the projected savings for one of the solutions for RWC Yard: 150 kW of PV, and 58kW 240kWh of energy storage.



Phase 2: Planning and engineering
Step 5: Off-grid optimization with HomerPRO

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- To properly size the system for island mode and use of the Community Microgrid during emergency operations, the critical load profile was input into HomerPRO.
- HomerPRO is a microgrid optimization tool.
- Simulation inputs:
  - Critical load profile
  - Total on-site solar potential
  - Assumptions: uptime required: 100%
  - Cost assumptions and incentives
- Simulation outputs:
  - Optimal energy storage system sizing, based on optimization of net present cost of the system

Phase 2: Planning and engineering
Cost assumptions and incentives

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- **PV CapEx: $1,750/kW**
  - 30% Investment Tax Credit (ITC) is applied to EPC ground-mount price of $2.50/W
  - O&M costs: $10/kW/year
  - Replacement- $2,000/kWh (reflects end of ITC program and 20% reduction in module price)
- **Battery CapEx: $136.80/kWh**
  - 30% ITC is applied and SGIP Phase II applied
  - O&M costs: $5/kWh/year
  - Replacement- $205/kWh (replacement occurs when battery has degraded by 30%)
- **Converter CapEx: $569.30/kW**
  - DC-coupled system- PV and battery share a converter
  - 30% Federal ITC is applied
  - O&M costs: included in PV & battery O&M costs
  - Replacement- $850/kW (every 15-years)

Phase 2: Planning and engineering Hoover Cluster conceptual diagram

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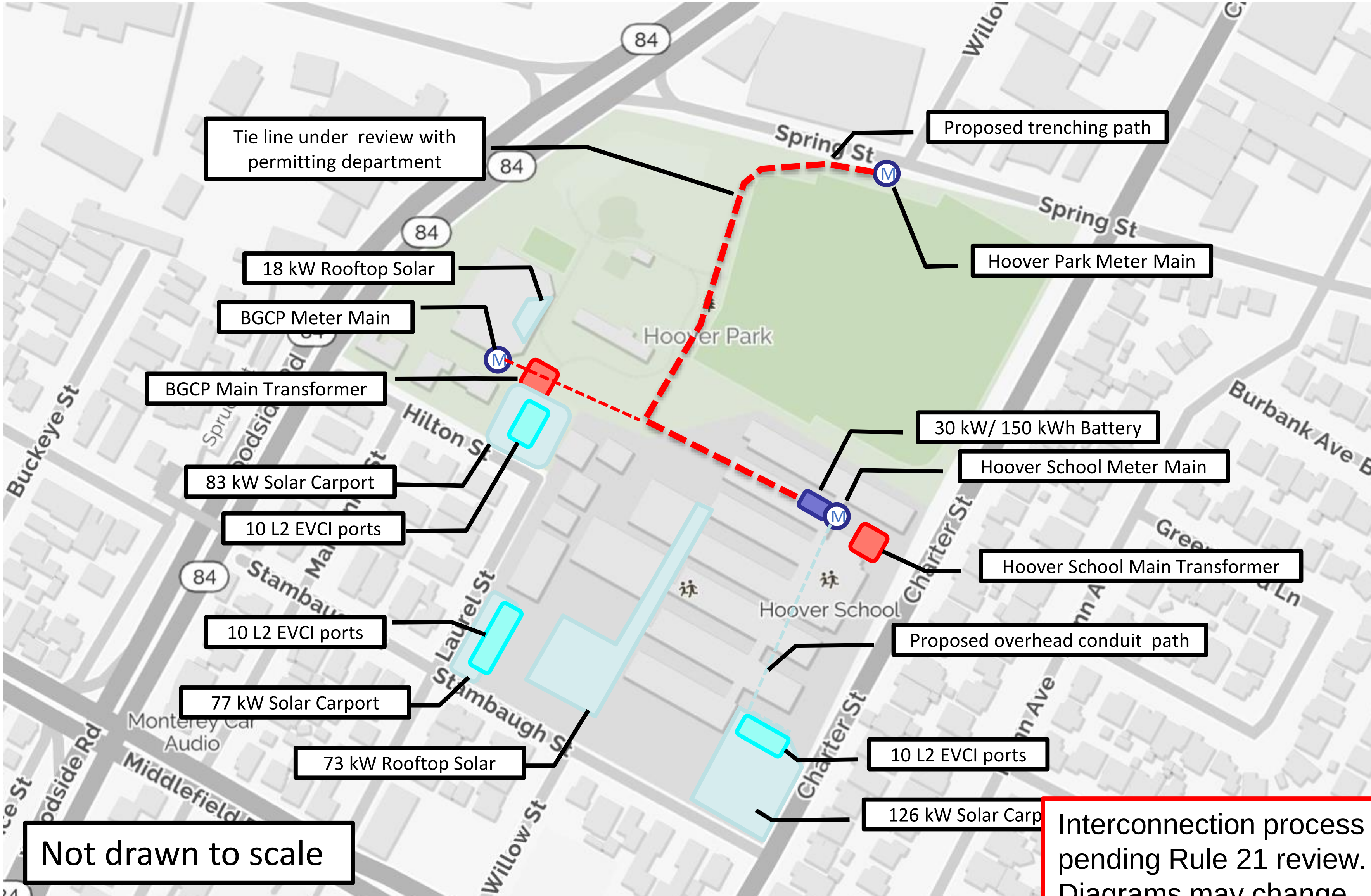

Interconnection process is pending Rule 21 review. Diagrams may change.

Phase 2: Planning and engineering
Hoover Cluster detailed map

Interconnection process is pending Rule 21 review. Diagrams may change.

Phase 2: Planning and engineering
Hoover Cluster conceptual single-line diagram

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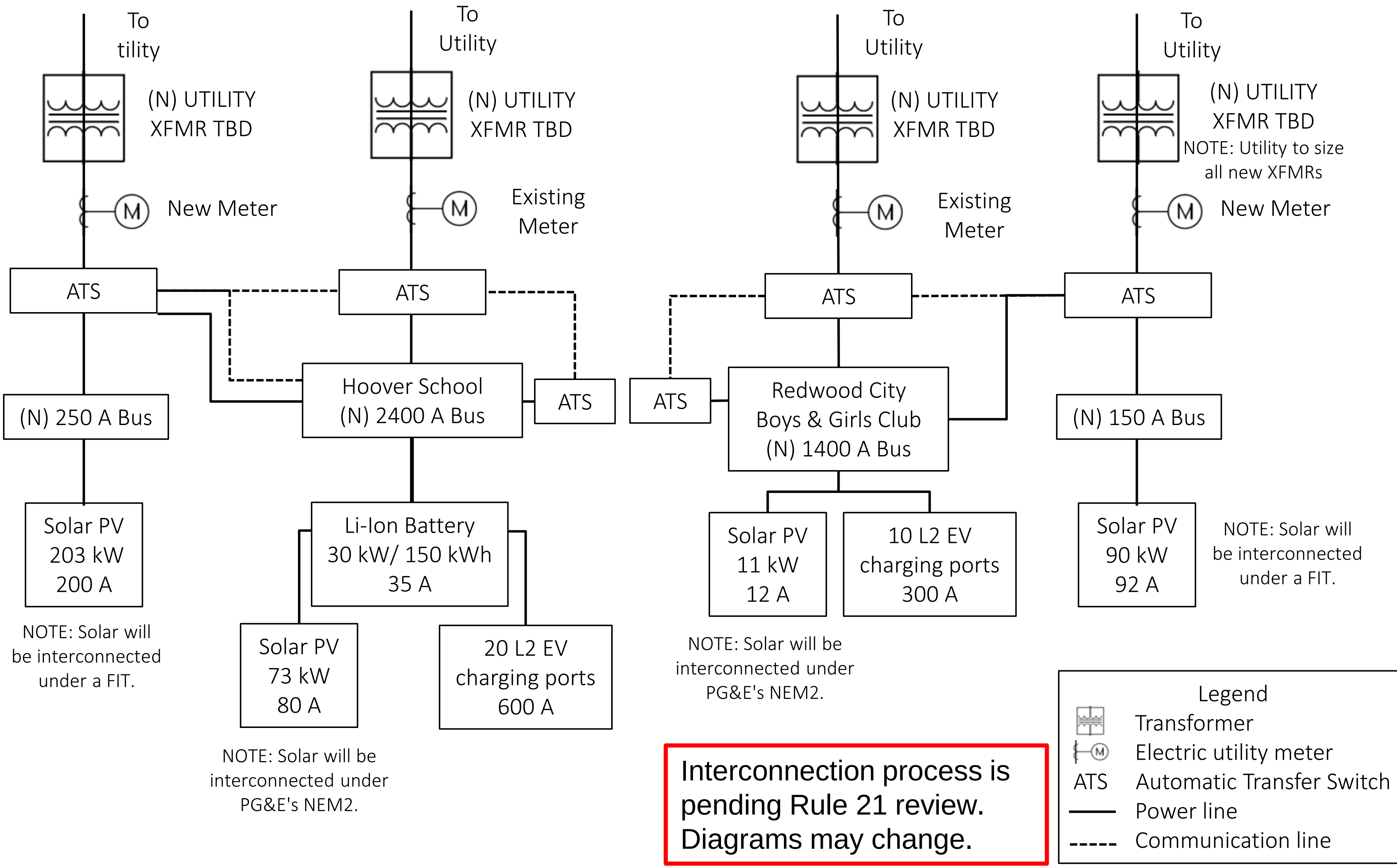

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Community Microgrid synergies

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- Bundling DER deployments can improve bankability.
- Focusing on critical facilities and critical loads only minimizes the cost of resilience.
- Designing Community Microgrids for sites that have already implemented energy efficiency measures can save money.
- Integrating a battery into a site with EV charging can reduce demand charges and reduce the impact of high-power charging on the grid

Community Microgrid planning and design methodology

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  - Stakeholder alignment and goal setting
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  - Detailed technical and economic analysis.
  - Develop conceptual and functional design.
  - Engage engineering, procurement, and construction firm (EPC) to develop key engineering documents needed for utility buy-in (single-line diagram).
- Phase 3: Develop request for proposals (RFP)

Phase 3: Develop request for proposals (RFP)

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- Develop an RFP, collect responses, and select winning proposal.

Steps to establish a microgrid

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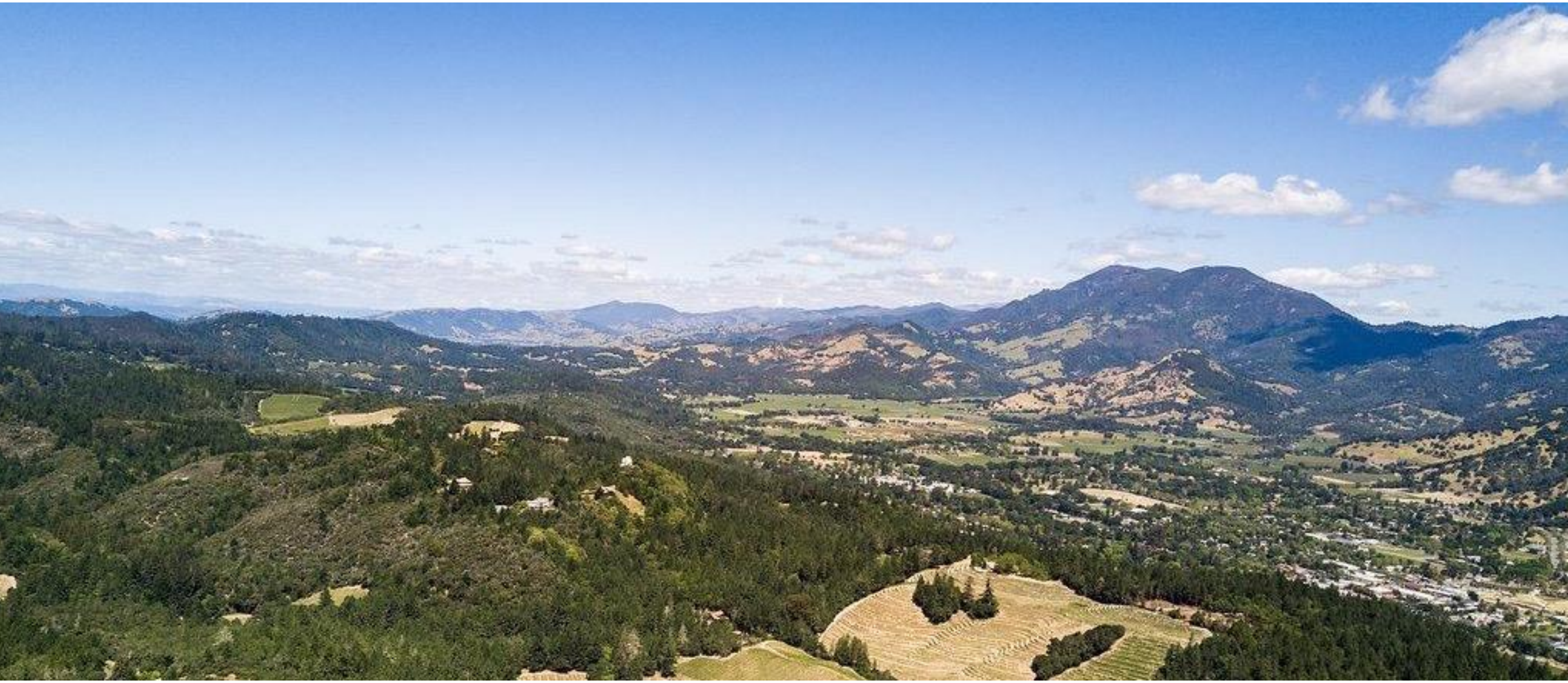
- Identify project team: EPC, financier, vendors, utility engineers, etc.
- Develop finance-ready collateral.
- Secure financing with a letter of intent (LOI), a signed power purchase agreement (PPA), or an energy services agreement (ESA).
- Submit interconnection application.
- Develop permit-ready drawings and secure permits.
- Procure equipment (solar, batteries, etc.).
- Construction and commissioning.
- Measurement and verification of system operation and cost savings.

Permitting and interconnection

- Permitting: Redwood City Planning and Permitting Departments do not anticipate any roadblocks with permitting photovoltaics, lithium battery energy storage, or electric vehicle chargers.
- Interconnection: Proposed generating assets (solar and energy storage) can be interconnected within PG&E service territory under the NEM2 or NEM Multiple tariffs.

Thank you! Any questions?



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Small group activity (groups of 3-5)
Identifying critical loads

- Choose one of the following project scopes:
  - Single family home
  - Office building/ other business
  - Research hospital (e.g. UC San Francisco)
  - Suburban or small town
- Brainstorm, discuss, and record loads:
  - Tier 1 = Critical (10%) — crucial and life-sustaining loads.
  - Tier 2 = Priority (15%) — important but not necessary.
  - Tier 3 = Discretionary (75%) — the remainder of the total load.
- 2:20pm: 2-3 groups will present their findings

Backup slides

Microgrids: Policy Future

- Transmission TAC credit
  - (recognizes and adds 3¢/kWh to value),
- Dispatchable Energy Capacity Service (DECS)
  - (FIT compensation for energy exports made dispatchable)
- Value of Resilience (VOR)
- Interconnection Pilot
  - (which aims to give WDG the same advantageous streamlined treatment as NEM, making it equally fast and predictable)
- Using the public grid as a CM
  - utilizing DER to meet prioritized loads, including DER behind a different customer's meter, islanding sections of the public grid for operation during grid outages, and the DERMS and MC2 required to make this work (which requires policy decisions to authorize and allocate costs)

Resilience provided by Community Microgrids has tremendous value

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- **Powers critical loads until utility services are restored**
  - Eliminates expensive startup costs and the need to relocate vulnerable populations.
- **Ensures continued critical services**
  - Water supply, medical and elder-care facilities, grocery stores, gas stations, shelters, communications centers.
  - Avoids the cost of emergency shipments.
- **Provides power for essential recovery operations**
  - Lighting for buildings, flood control, emergency shelters, food refrigeration.
  - Minimizes emergency response expenses.
- **Reduces dependence on diesel generators**
  - Diesel can be expensive and difficult to deliver in emergencies.
- **Keeps businesses open**
  - Serves the community and maintains revenue streams.

Example of PV canopy for parking

From: Zapotec Energy, commercial solar project in Wakefield, MA

How does energy storage provide value?

- Batteries for energy storage can help considerably in demand charge management for individual buildings or electric accounts, especial those with high peak usage compared to average usage, such as sites with daytime EV charging peaks.
- Energy storage also enables renewables-driven resilience.