Clean Coalition
Making Clean Local Energy Accessible Now

Community Microgrid planning and design

A resilient clean energy solution

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Clean Coalition (nonprofit) mission

Clean Coalition

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

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.

Community Microgrid planning and design presentation outline

Clean Coalition

- Current situation
  - Lack of resilience.
- Traditional grid and microgrids
  - Microgrid vs. Community Microgrid;
  - Benefits and components.
- Community Microgrid planning and design methodology.

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).

- 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: Lack of resilience

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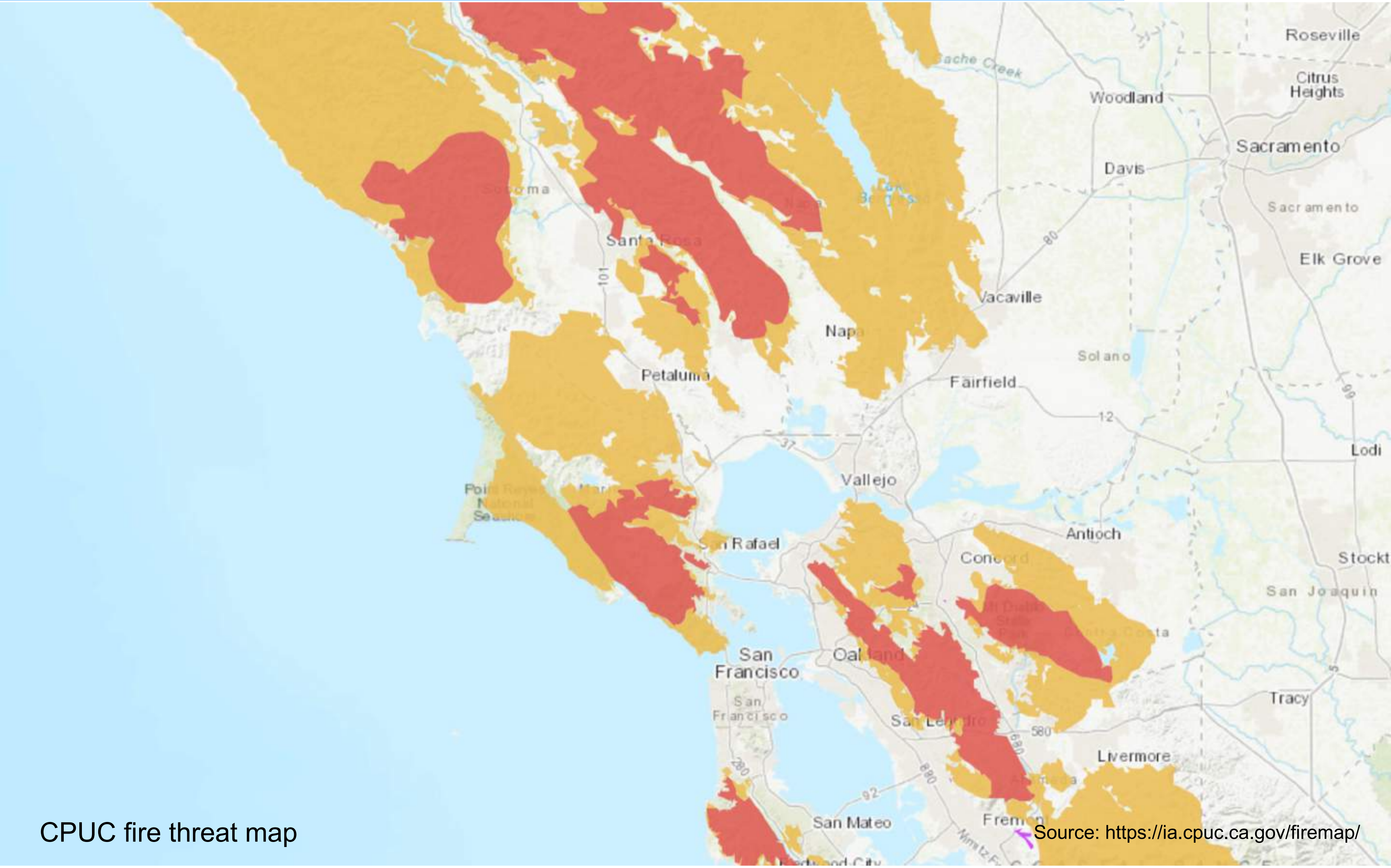

CPUC fire threat map

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

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

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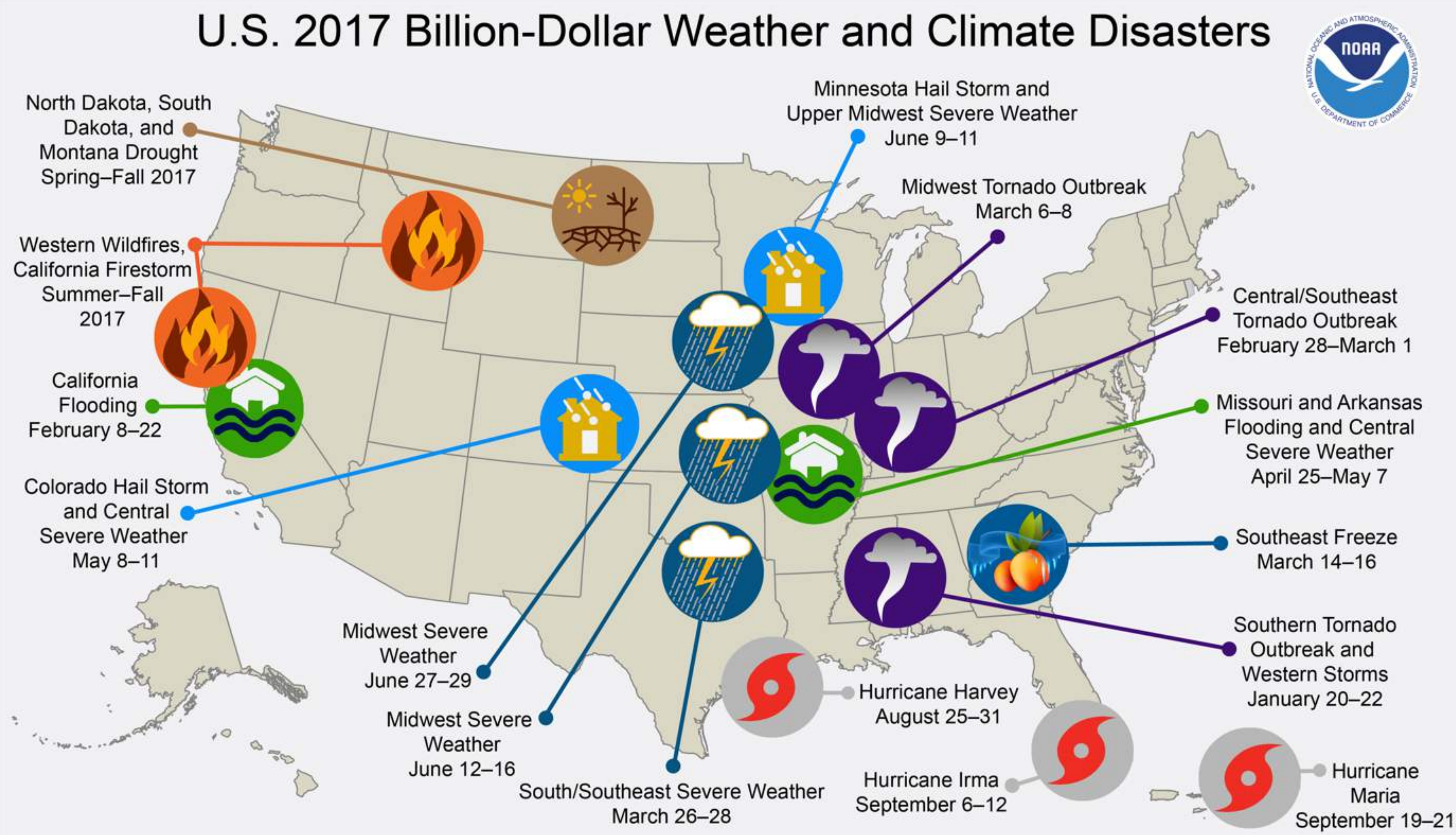

Source: National Oceanic and Atmospheric Administration

What is power system resilience?

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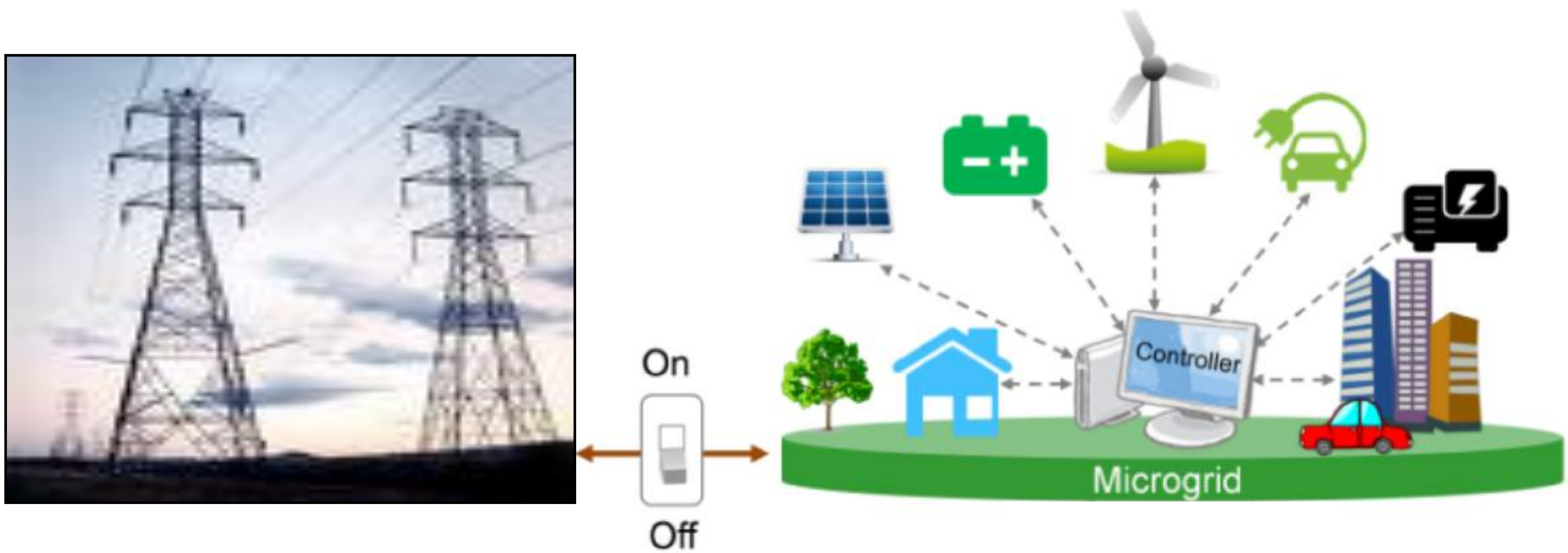
- **Resilience: The ability to keep critical loads online indefinitely** in the face of extreme or damaging conditions
  - This is Clean Coalition's definition of resilience;
  - Focused on reducing outage duration, cost, and impact on critical services;
  - Timescale: hours or days.
- **Power quality:** 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.

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

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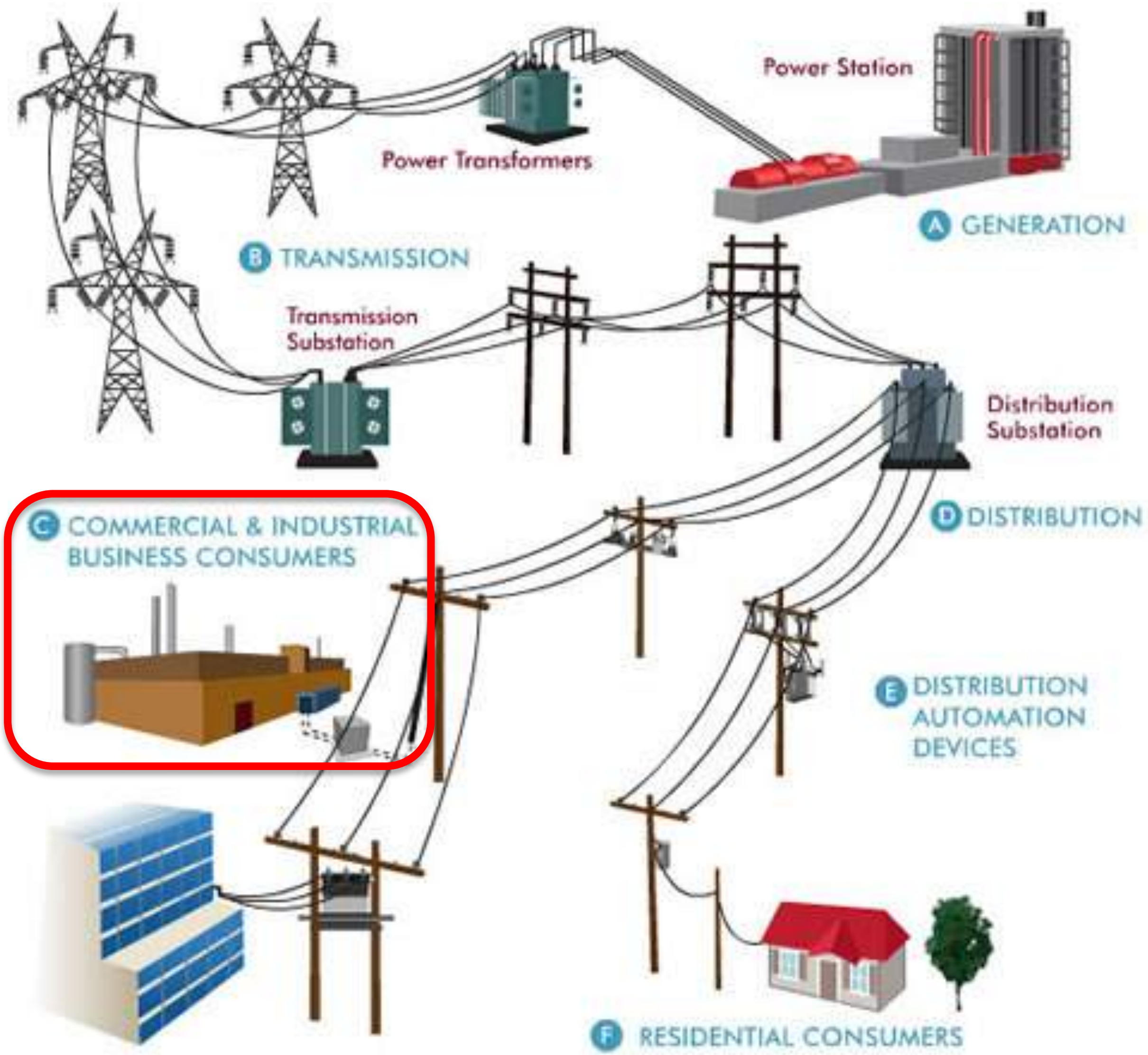

Source: Oncor Electric Delivery Company

Community Microgrids can serve up to thousands of customers

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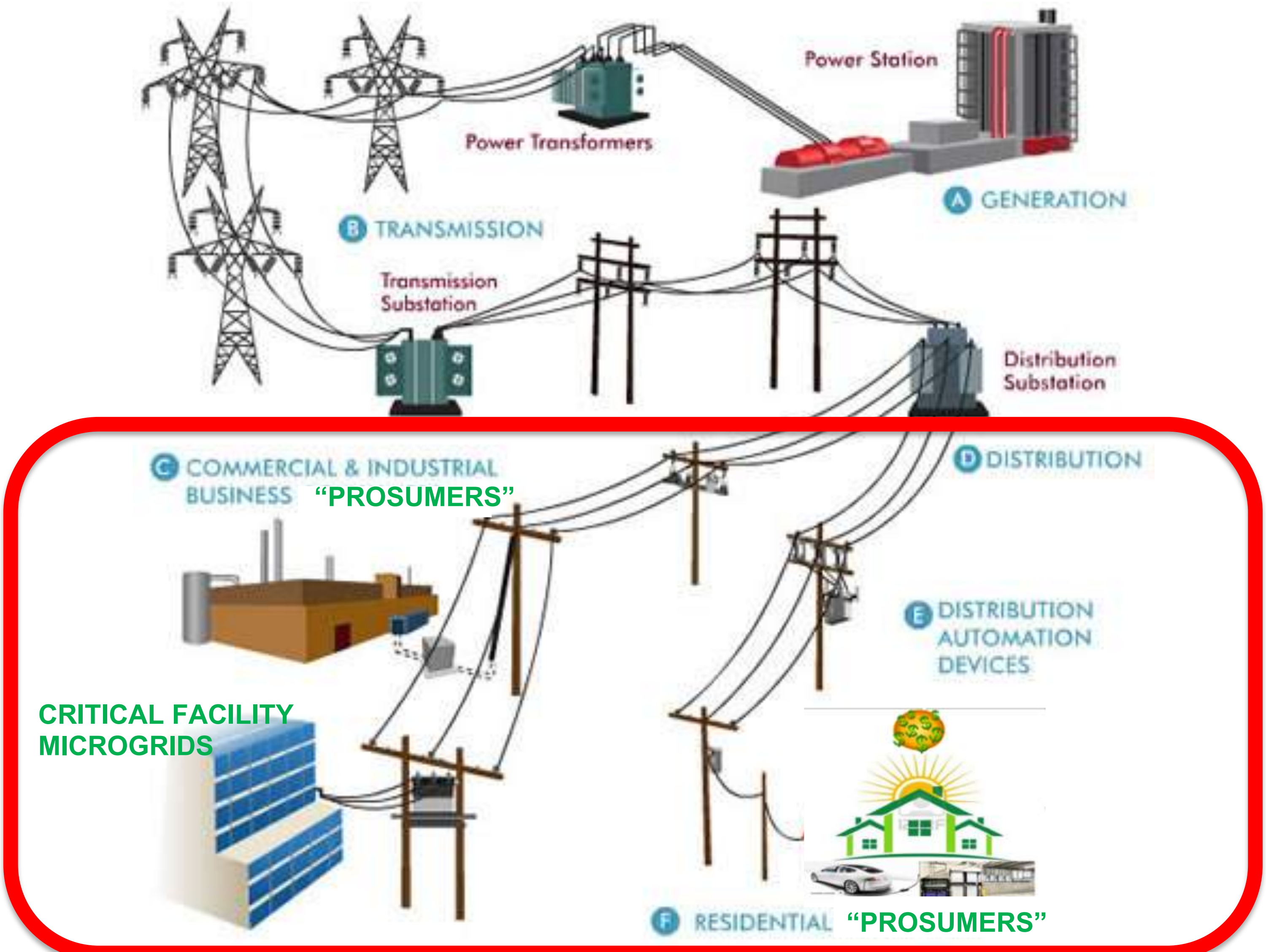
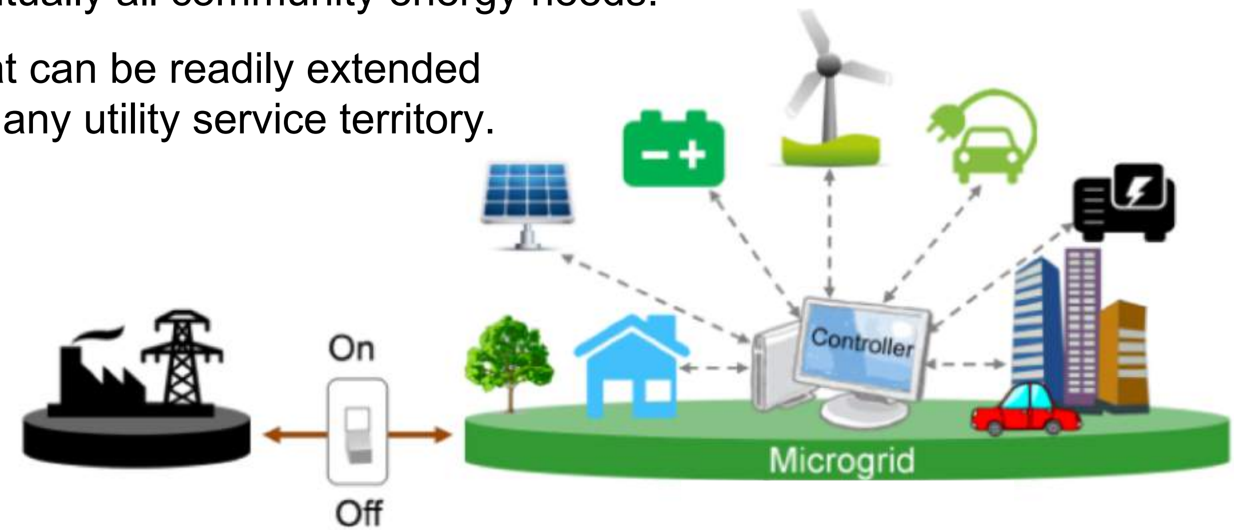


Source: Oncor Electric Delivery Company

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

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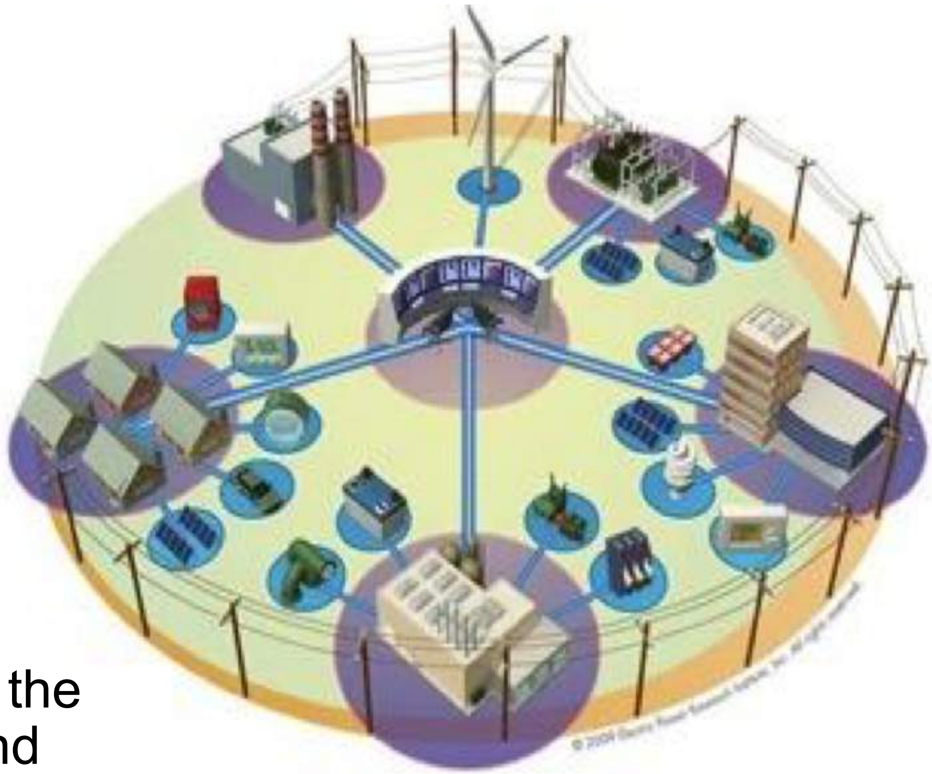
- Reliability and power continuity.
- Resilience and safety.
- Local, renewable energy
  - Greenhouse gas reductions;
  - Local control of energy;
  - For electric vehicles and charging infrastructure;
  - Reduced transmission losses.
- Local jobs in engineering, construction, and maintenance.
- More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



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 stakeholder alignment

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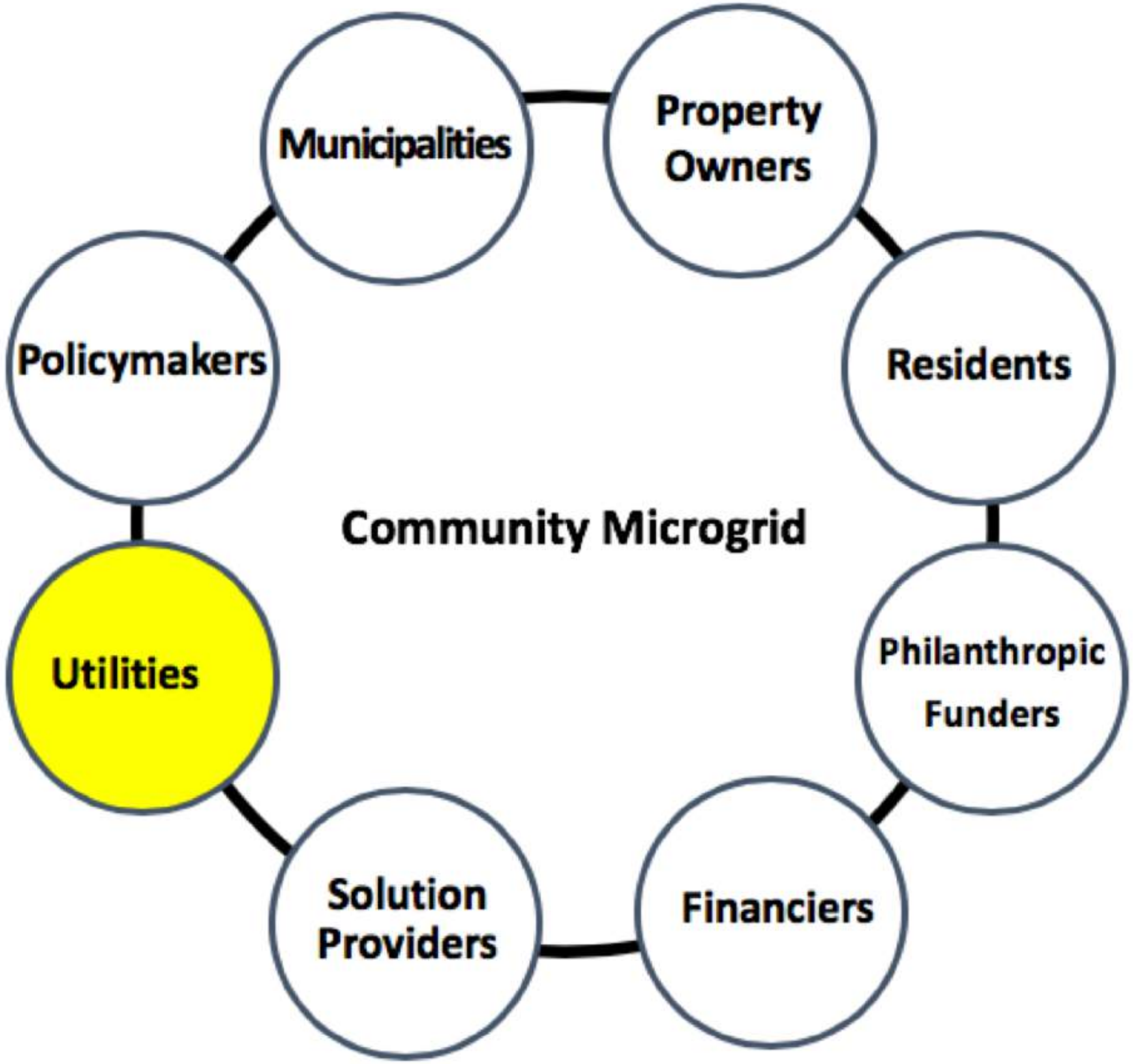

Phase 1:
Set goals, requirements and constraints

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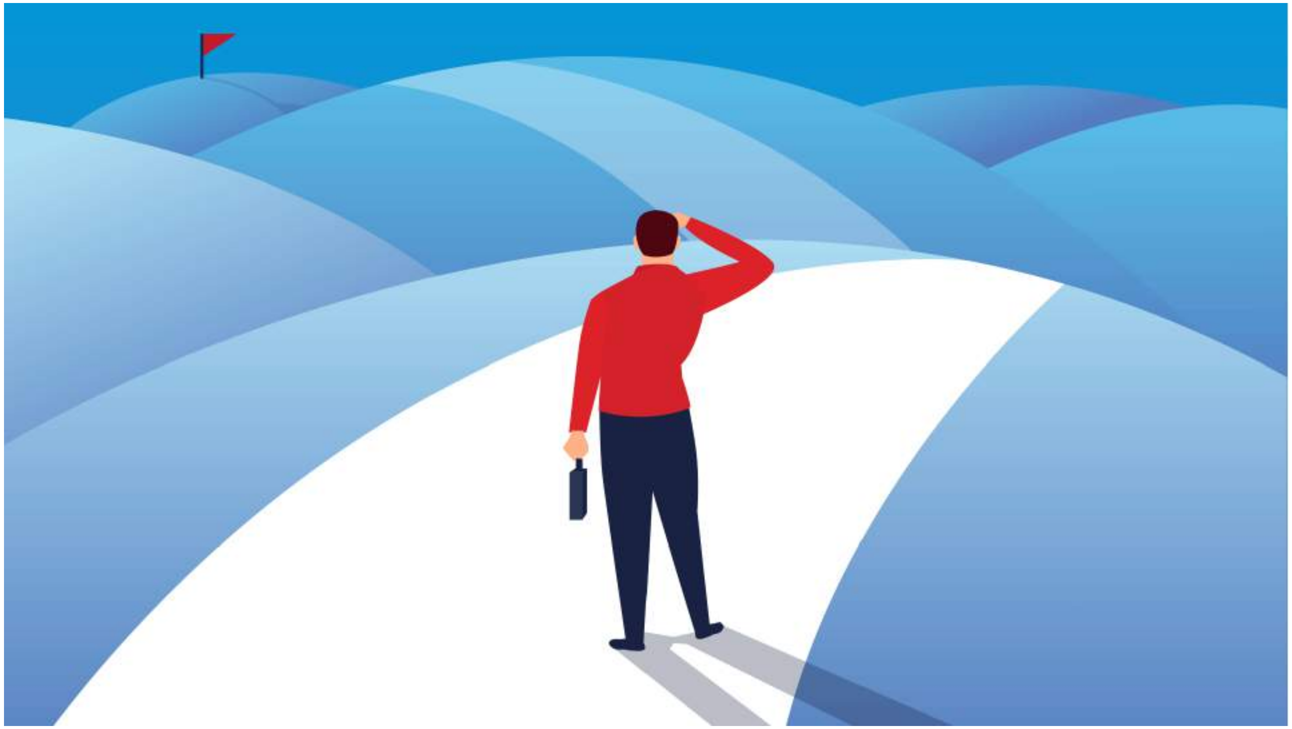
- Goal setting: develop SMART goals.
- What are the local requirements and constraints for the design?



Phase 1: Solar Siting Survey (SSS) for Montecito

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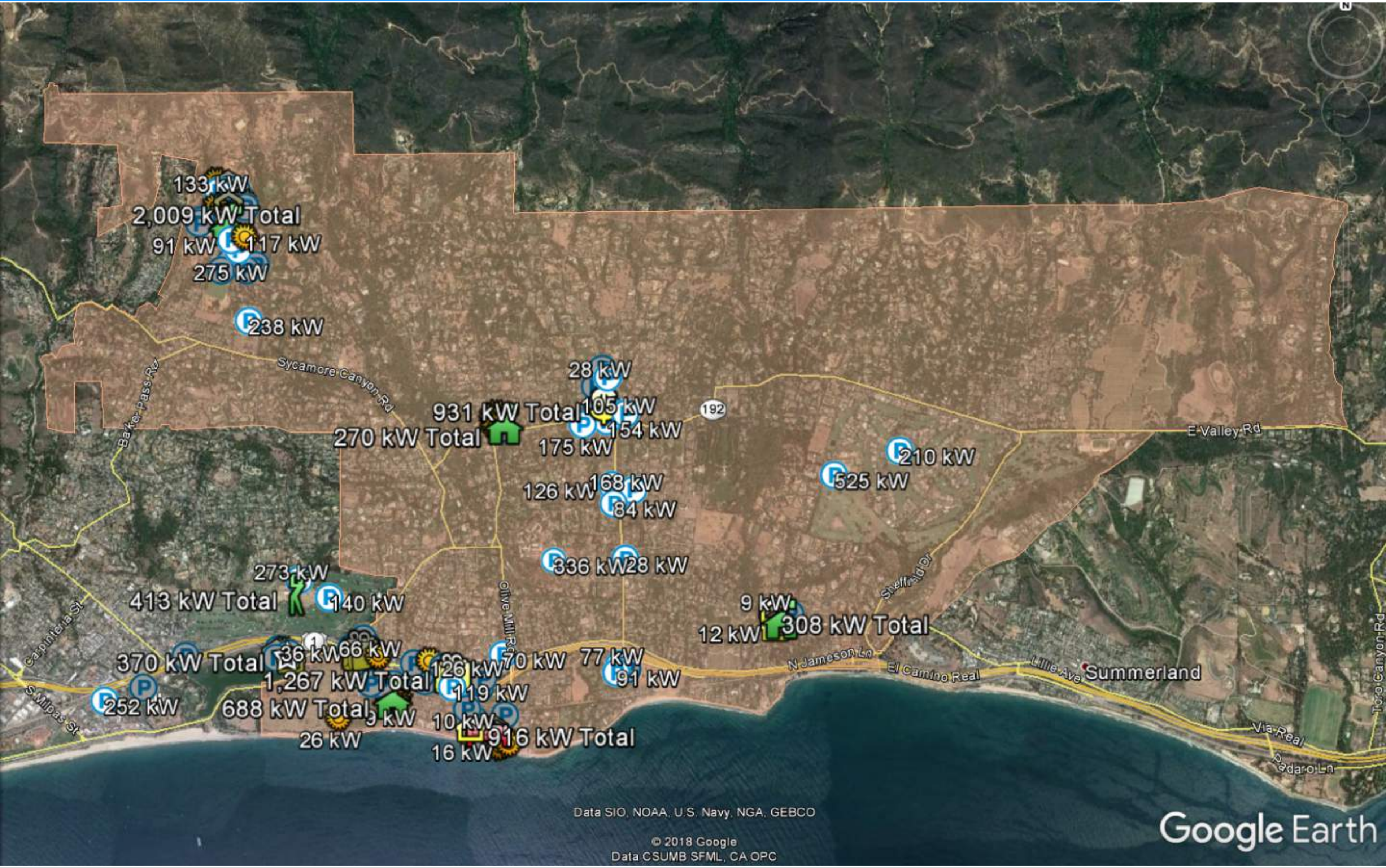
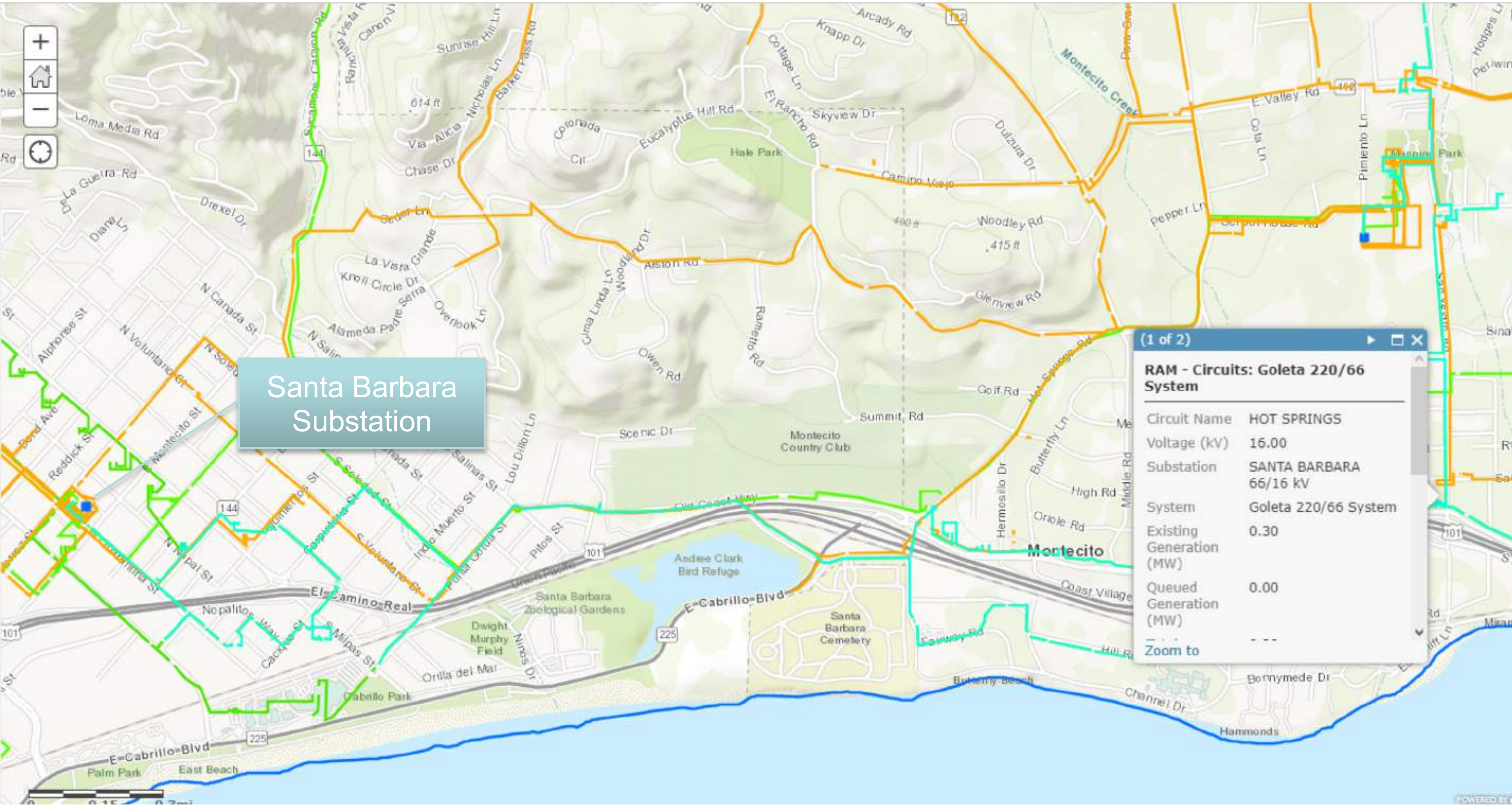
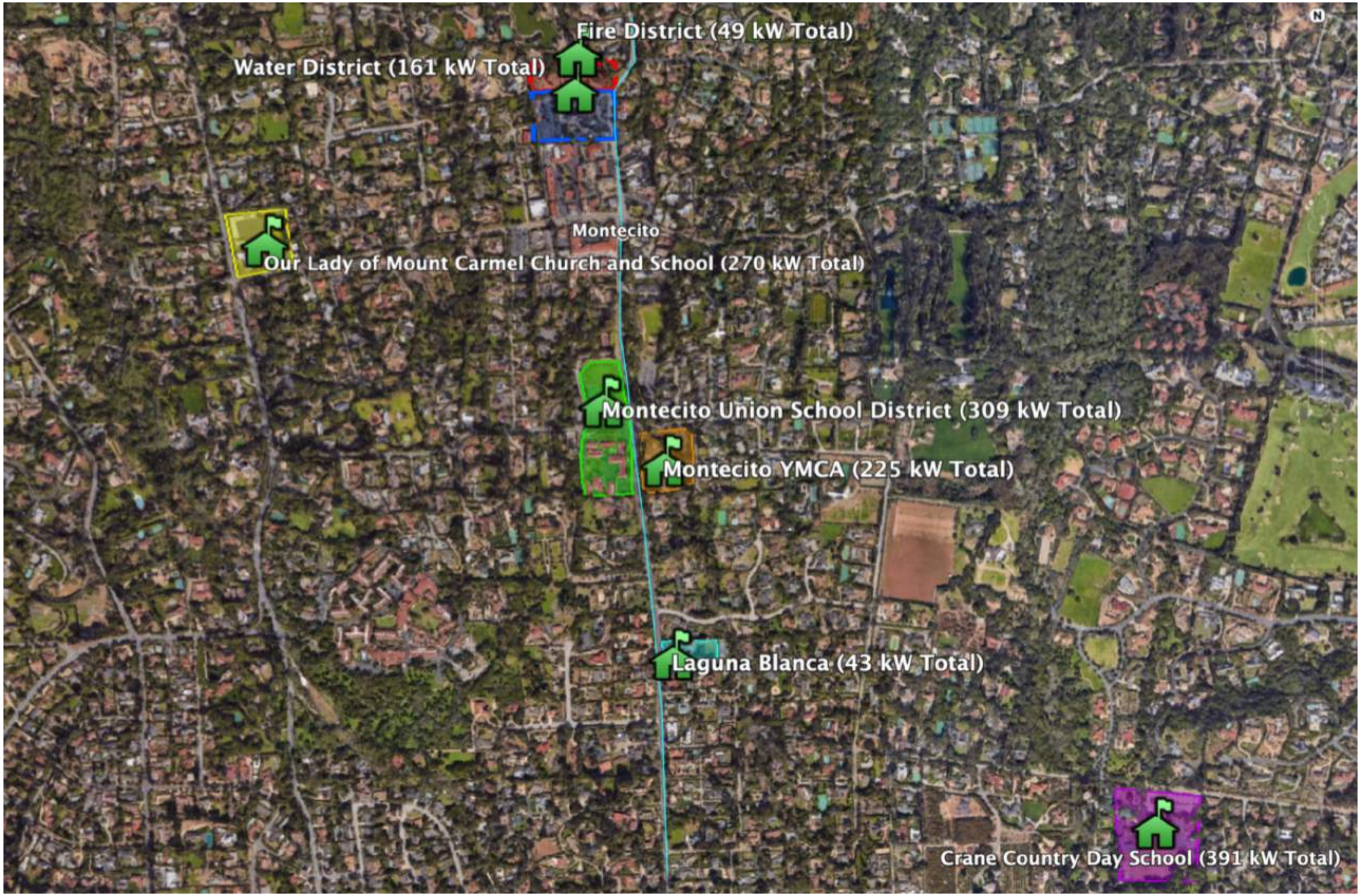


Phase 1: Hot Springs Feeder via Santa Barbara Substation



Phase 1:
Critical facilities along Hot Springs Feeder



Phase 1:
Montecito Upper Village block diagram

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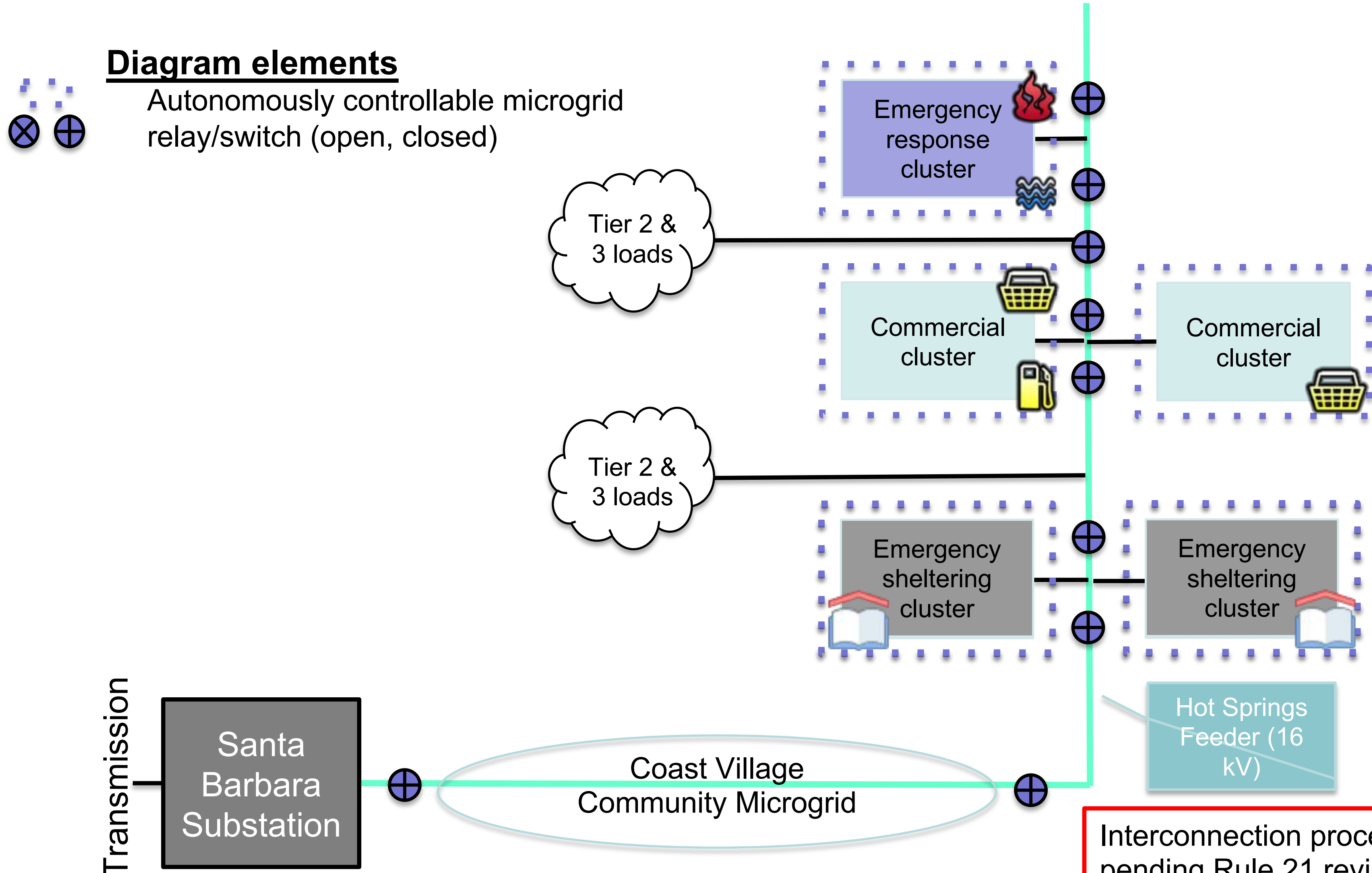

Interconnection process is pending Rule 21 review. Diagrams may change.

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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R8 | 7.68

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
[redacted]				HA10SX	1/1/16	1/1/16 0:30	WOP	KWH	6.88
[redacted]				HA10SX	1/1/16	1/1/16 0:45	WOP	KWH	6.4
[redacted]				HA10SX	1/1/16	1/1/16 1:00	WOP	KWH	6.72
[redacted]				HA10SX	1/1/16	1/1/16 1:15	WOP	KWH	6.24
[redacted]				HA10SX	1/1/16	1/1/16 1:30	WOP	KWH	7.52
[redacted]				HA10SX	1/1/16	1/1/16 1:45	WOP	KWH	7.68
[redacted]				HA10SX	1/1/16	1/1/16 2:00	WOP	KWH	6.24
[redacted]				HA10SX	1/1/16	1/1/16 2:15	WOP	KWH	7.2
[redacted]				HA10SX	1/1/16	1/1/16 2:30	WOP	KWH	6.56
[redacted]				HA10SX	1/1/16	1/1/16 2:45	WOP	KWH	6.24
[redacted]				HA10SX	1/1/16	1/1/16 3:00	WOP	KWH	7.2
[redacted]				HA10SX	1/1/16	1/1/16 3:15	WOP	KWH	7.36
[redacted]				HA10SX	1/1/16	1/1/16 3:30	WOP	KWH	6.56
[redacted]				HA10SX	1/1/16	1/1/16 3:45	WOP	KWH	7.68
[redacted]				HA10SX	1/1/16	1/1/16 4:00	WOP	KWH	7.84
[redacted]				HA10SX	1/1/16	1/1/16 4:15	WOP	KWH	7.52
[redacted]				HA10SX	1/1/16	1/1/16 4:30	WOP	KWH	6.72
[redacted]				HA10SX	1/1/16	1/1/16 4:45	WOP	KWH	7.04

Phase 1:
Basic technical and economic analysis

- 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

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

- Phase 1: Feasibility assessment
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  - Detailed technical and economic analysis;
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- Phase 3: Develop request for proposals (RFP).

Redwood City Community Microgrid conceptual diagram

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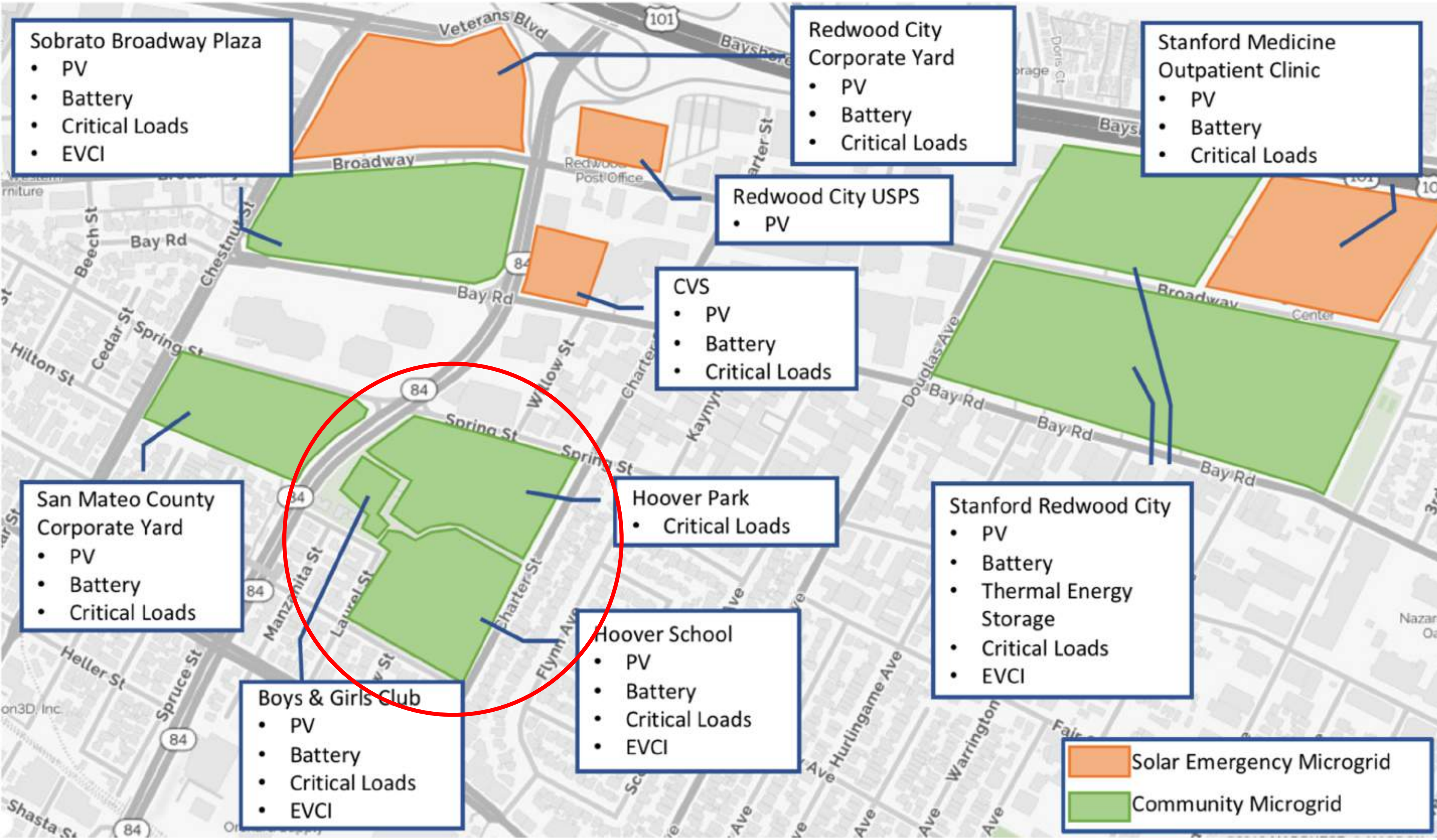

Deployment summary

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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. 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

- Step 1: Detailed site info and site walk.
- Step 2: Load shedding and operational design.
- Step 3: PV system sizing.
- Step 4: Grid-parallel optimization.
- Step 5: Grid-island optimization.
- 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

Clean Coalition

- 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

- 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?

Phase 2: Planning and engineering
Step 2: Operational design

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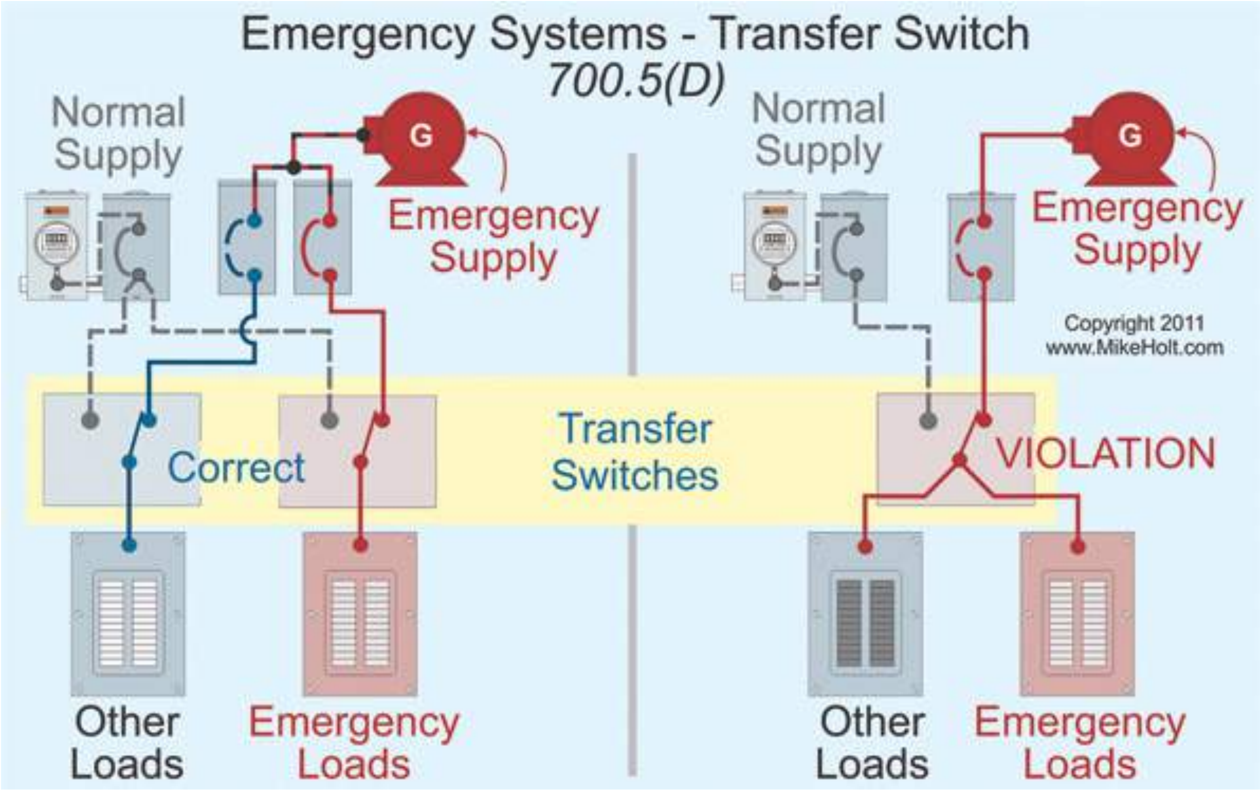
- Automatic transfer switches enable load shedding with an emergency load panel.
- Other switch types can provide more functionality.



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

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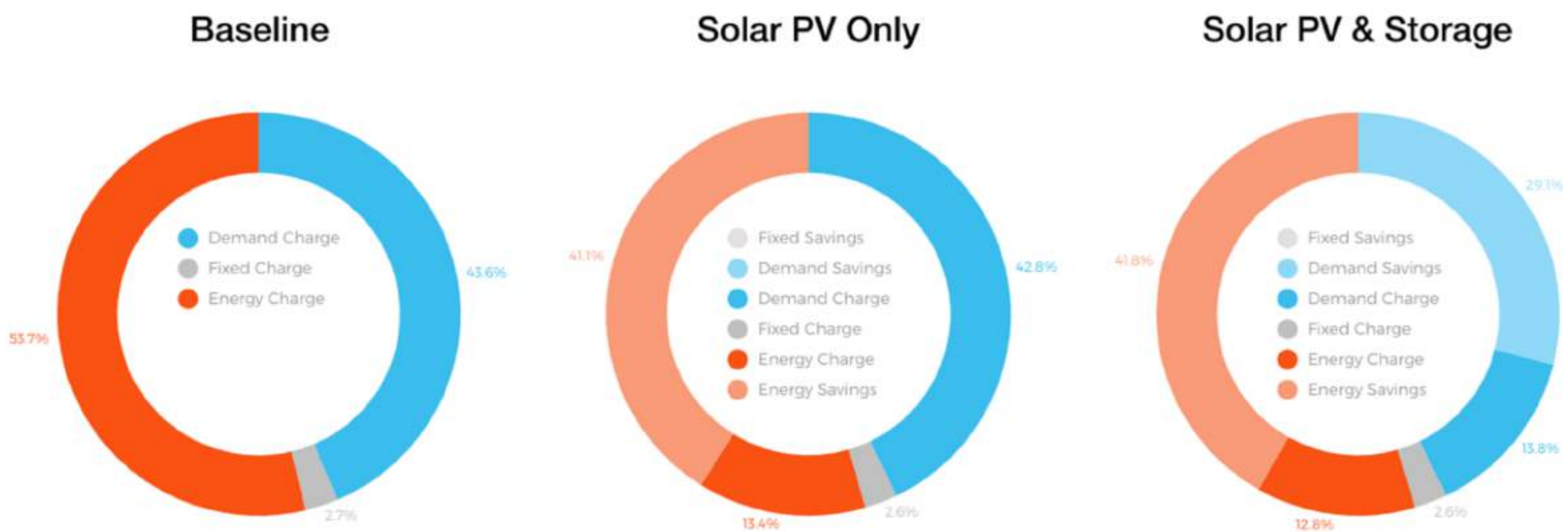
- Size and model multiple PV systems using PVWatts from NREL:
  - 1st system: **Full-scale PV deployment**. Use all feasible on-site rooftops, parking lots, and open spaces as defined in the Solar Siting Survey and site walk;
  - 2nd system: **Net-metered PV system**. Determine system size based on annual 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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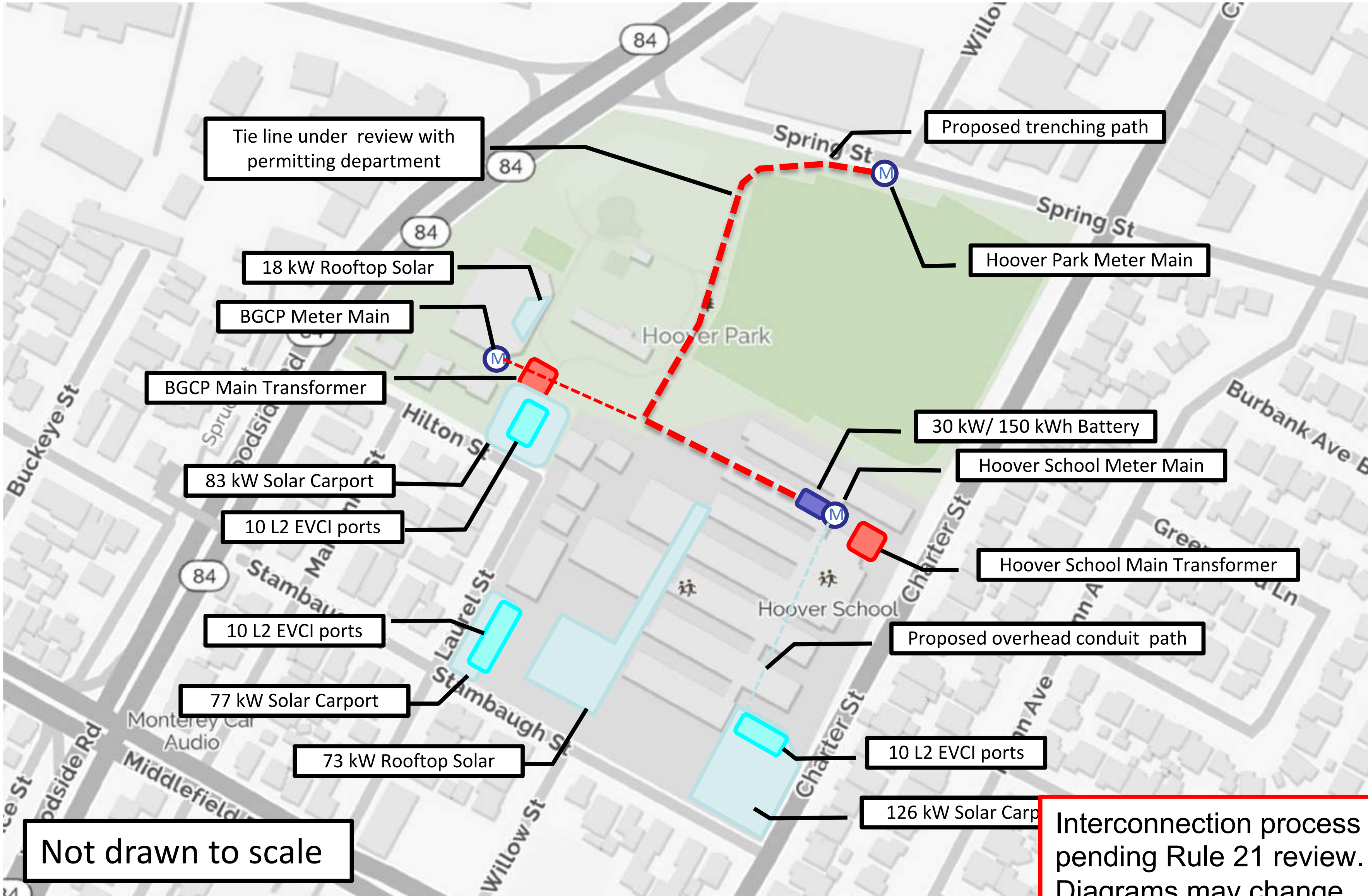

Interconnection process is pending Rule 21 review. Diagrams may change.

Phase 2: Planning and engineering Hoover Cluster detailed map

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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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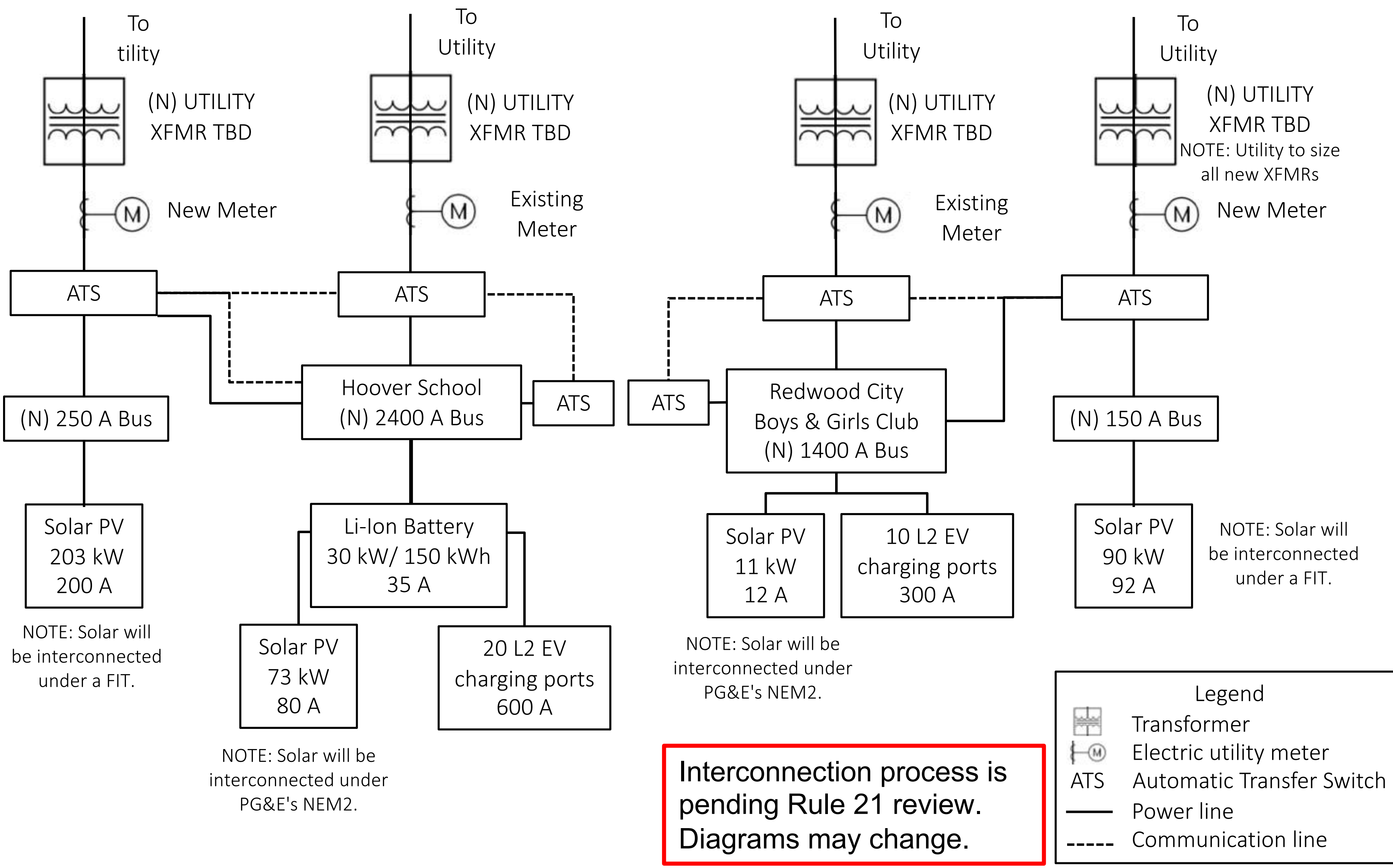

Interconnection process is pending Rule 21 review. Diagrams may change.

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

Clean Coalition

- Phase 1: Feasibility assessment
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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

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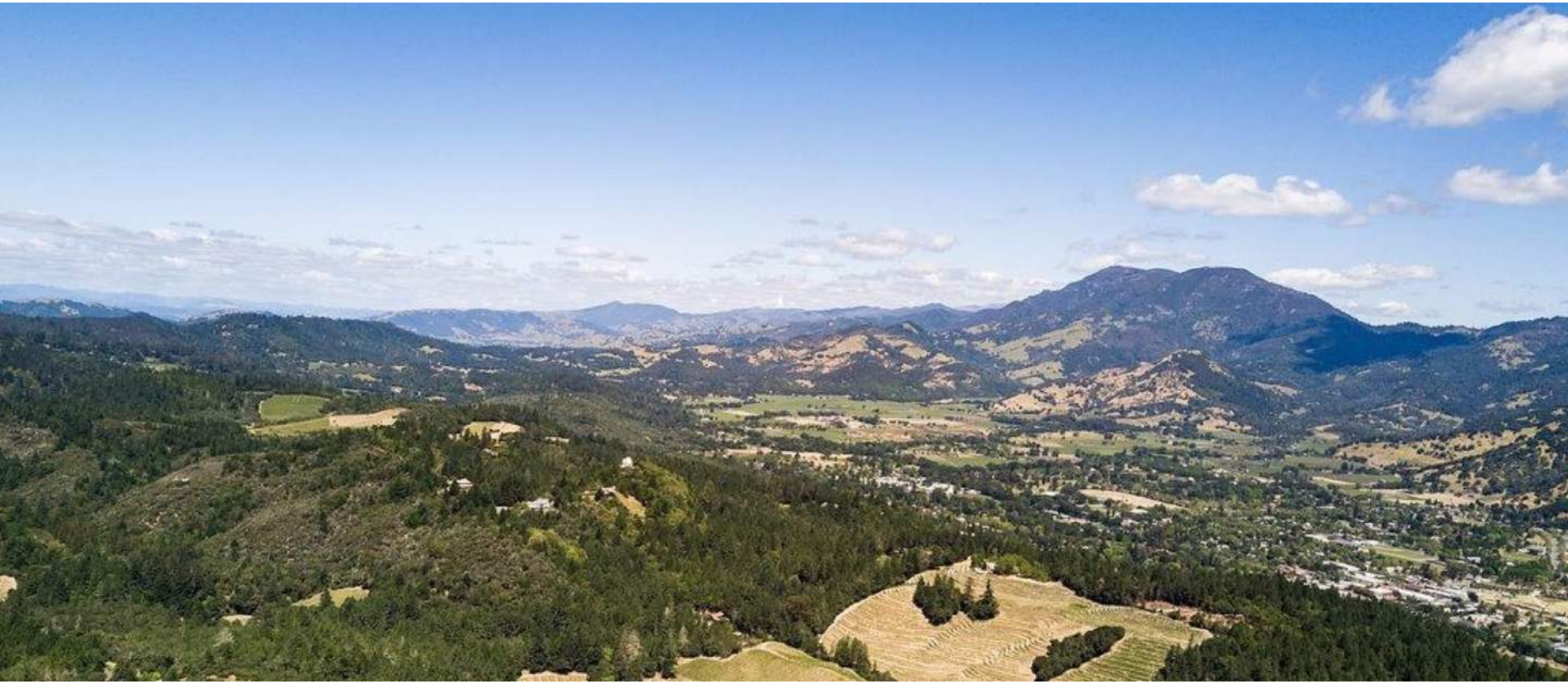
- Permitting: Redwood City Planning and Permitting Departments do not anticipate any roadblocks with permitting photovoltaics, lithium battery energy storage, or electric vehicle chargers.
- Interconnection: Proposed generating assets (solar and energy storage) can be interconnected within PG&E service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

Thank you! Any questions?



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