Renewables-driven Microgrids deliver unparalleled resilience

Craig Lewis
Executive Director
650-796-2353 mobile
craig@clean-coalition.org

Mission

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

Renewable Energy End-Game

100% renewable energy; 25% local, interconnected within the distribution grid and ensuring resilience without dependence on the transmission grid; and 75% remote, fully dependent on the transmission grid for serving loads.

Renewables-driven Microgrids deliver a trifecta of benefits

Clean Coalition

1. Economic

   Savings via grid efficiency and lower costs

2. Environmental

   Sustainability via high renewable energy

3. Resilience

   Safety via enduring energy availability

Various types of Solar Microgrids

Clean Coalition

- A microgrid is a combination of energy resources, definitely including generation, that are coordinated to serve specified loads, including in an islanded fashion.
- A Solar Microgrid is a behind-the-meter (BTM) microgrid that solely relies on solar for energy generation when islanded.
- A Hybrid Solar Microgrid is a Solar Microgrid that includes additional sources of energy generation, beyond just solar.
- A Community Microgrid a microgrid that covers a target grid area and relies on existing distribution feeders (ie, power lines) to operate when islanded. Community Microgrids typically include both front-of-meter (FOM) and BTM resources, including Solar Microgrids, and require effective participation from utilities, which have mostly erected barriers to date.

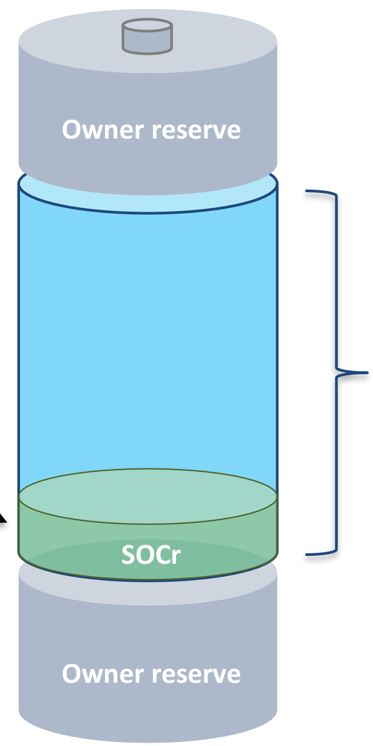
Storage, Resilience, Value-of-Resilience (VOR), and Load Management

Storage is optimized for economics & resilience

Clean Coalition

Top owner reserve is often in place to absorb battery energy storage system (BESS) degradation over time, while still delivering the contracted daily cycling energy capacity.

SOCr = the minimum state-of-charge (SOC) that is reserved for provisioning resilience. The SOCr can be dynamic and/or resized to between 0% and 100% of the contracted BESS energy capacity. A lower SOCr facilitates BESS operations that optimize daily economic performance, while a higher SOCr facilitates the provisioning of greater resilience.

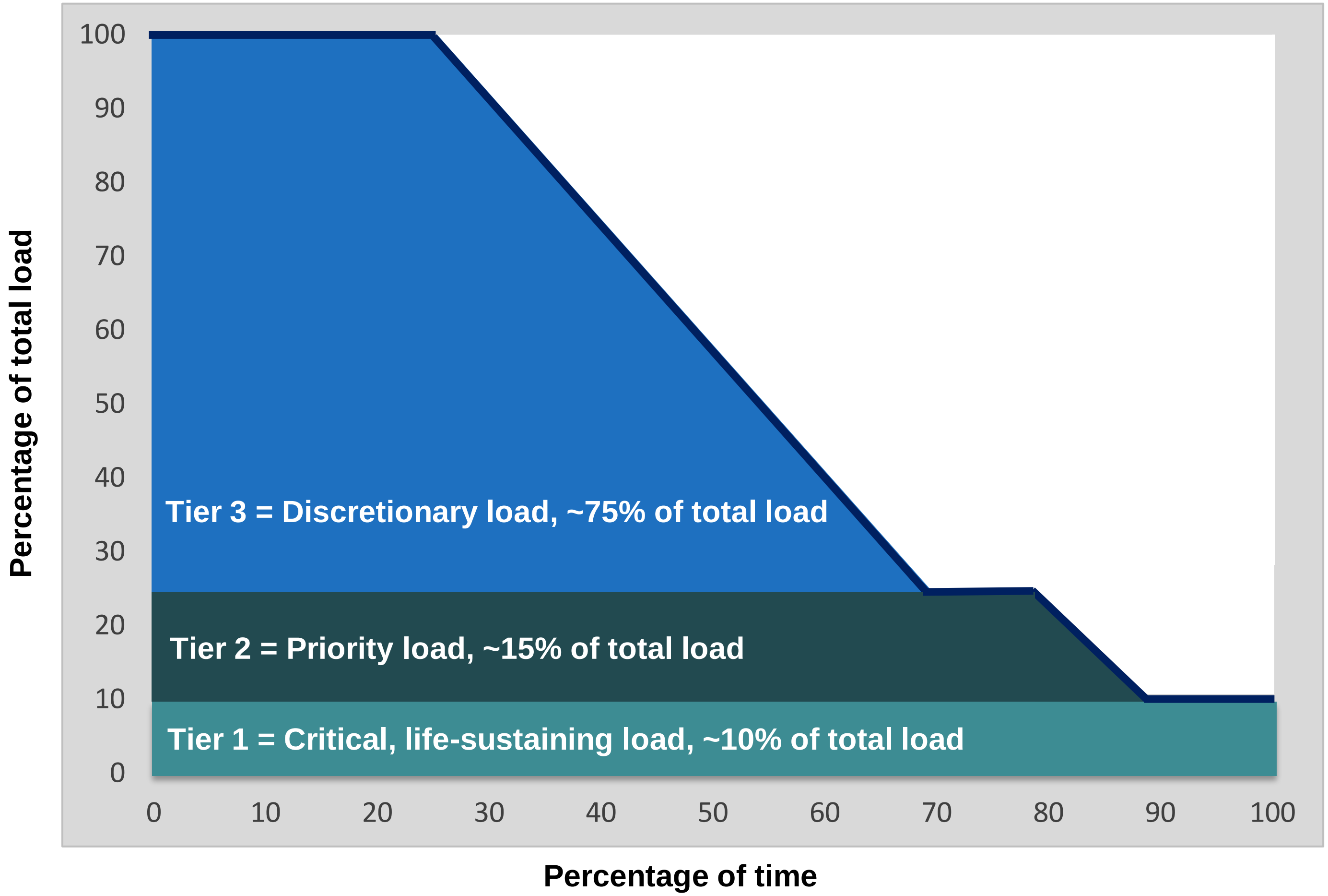


Contracted BESS energy capacity (kWh) that must be available for daily cycling over the contract duration for achieving specified economic & resilience performance.

Bottom owner reserve is often required to meet BESS warranty requirements that are imposed by BESS vendors.

Typical load tier resilience from Solar Microgrids

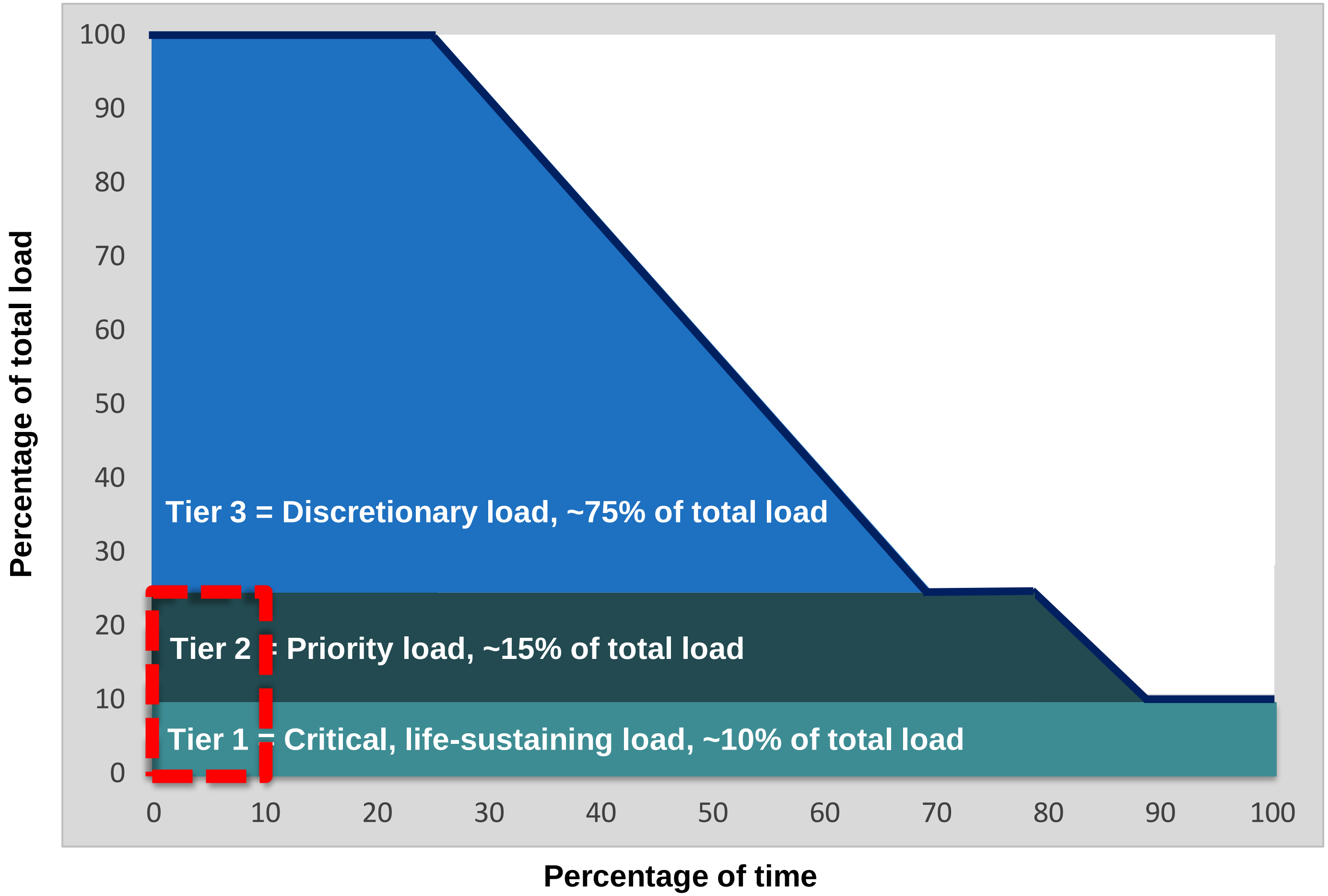
Clean Coalition



Percentage of time online for Tier 1, 2, and 3 loads for a Solar Microgrid designed for the University of California Santa Barbara (UCSB) with enough solar to achieve net zero and 200 kWh of energy storage per 100 kW solar.

Diesel generators are designed for limited resilience

Clean Coalition



A typical diesel generator is configured to maintain 25% of the normal load for two days. If diesel fuel cannot be resupplied within two days, goodbye. This is hardly a solution for increasingly necessary long-term resilience. In California, Solar Microgrids provide a vastly superior trifecta of economic, environmental, and resilience benefits.

Value-of-Resilience (VOR) depends on tier of load

- Everyone understands there is significant value to resilience provided by indefinite renewables-driven backup power, especially for the most critical loads
  - But, this value-of-resilience (VOR) has yet to be quantified in a straightforward methodology.
  - Hence, VOR is often given no value, leaving a dangerously short-sighted economic gap.
- The Clean Coalition aims to establish a standardized value-of-resilience (VOR) for critical, priority, and discretionary loads that will help everyone understand that premiums are appropriate for indefinite renewables-driven backup power to critical loads and almost constant backup power to priority loads, which yields a configuration that delivers backup power to all loads a lot of the time
- The Clean Coalition's VOR approach standardizes resilience values for three tiers of loads:
  - Tier 1 are mission-critical & life-sustaining loads and warrant 100% resilience. Tier 1 loads usually represent about 10% of the total load with a 3x energy value.
  - Tier 2 are priority loads that should be maintained as long as doing so does not threaten the ability to maintain Tier 1 loads. Tier 2 loads usually represent about 15% of the total load and get a 1.5x energy value.
  - Tier 3 are discretionary loads comprising the remaining loads, usually about 75%. Tier 3 loads possess no extra value and are only maintained when Tier 1 & 2 are secure.

Value-of-Resilience (VOR) details

Clean Coalition

VOR123

VOR123 is the value-of-resilience (VOR) from Solar Microgrids methodology that the Clean Coalition has developed to normalize VOR across all types of facilities & geographies. The VOR normalization is founded in tiering loads into three categories: Tier 1 (critical), Tier 2 (priority), and Tier 3 (discretionary). Since each Tier has its own resilience requirement and VOR, this methodology is called VOR123.

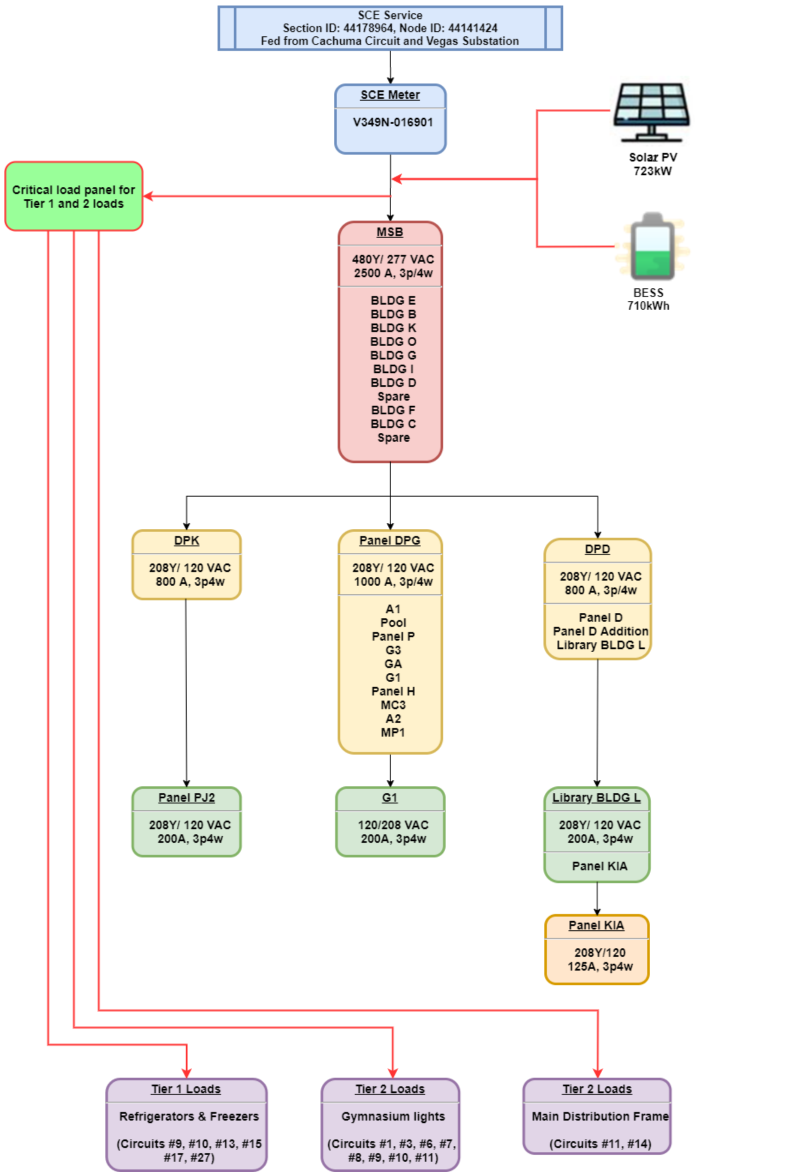
VOR123 webinar

https://clean-coalition.org/news/webinar-valuing-resilience-solar-microgrids-thursday-5-nov-2020/

Clean Coalition

Although there are multiple potential Load Management configurations, the minimal functionality anticipated to be cost-effectively implemented is referred to as **the Critical Load Panel (CLP) approach**.

The CLP name reflects the requirement for a smart critical load panel that maintains Tier 1 loads indefinitely and toggles Tier 2 loads. In the CLP approach, Tier 3 loads will be toggled as a group by toggling power to the Main Service Board (MSB). Figure 9 illustrates the CLP approach for SMHS, with Tier 1 and Tier 2 loads being served by new dedicated wire runs that connect to a new smart critical load panel.



Think Vertical for maximizing winter solar

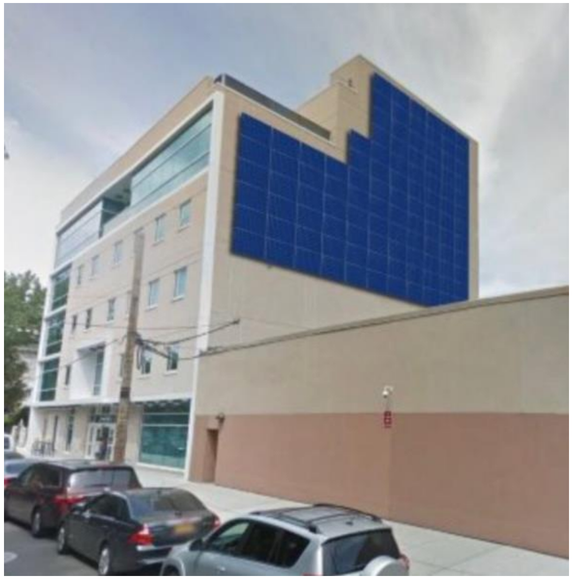
Clean Coalition

Think Vertical for maximizing winter solar

Solar sizing and generation per 1,000 sf by orientation type

Clean Coalition

Example Façade (Not as shown in table)



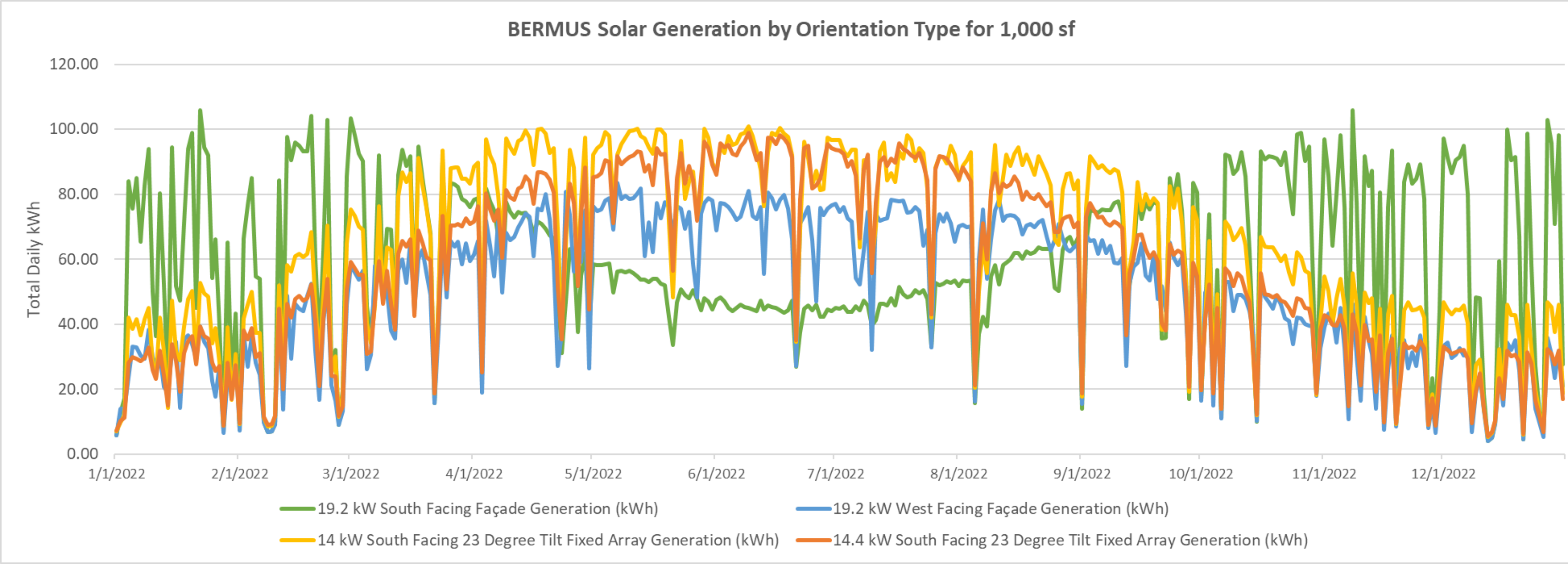
Fixed Tilt South Facing

Fixed Tilt West Facing

BERMUS Solar Generation by Orientation Type for 1,000 SQFT														
	System Size and Annual Generation			Summer and Winter Generation				System Layout Details						
Orientation Type	PV System Size (kWdc)	Annual Generation (kWh)	Annual kWh/kWp	21 June Generation (kWh)	21 June kWh/kWp	21 December Generation (kWh)	21 December (kWh/kWp)	Module Type	Number of Modules	Azumith (Degrees)	Tilt (Degrees)	Row Spacing (Feet)	Panel Orientation	Field Segment Size in Feet (Length x Width)
Façade South Facing	19.20	21,701	1,130	26.89	1.40	4.47	0.23	Q Cells (400W)	48	180	89	0	Portrait	-
Façade West Facing	19.20	18,221	949	27.09	1.41	4.61	0.24	Q Cells (400W)	48	270	89	0	Portrait	-
Fixed Tilt (Rooftop Canopy) South Facing	14.00	23,323	1,666	34.54	2.47	5.92	0.42	Q Cells (400W)	35	180	23	2.4	Portrait	25 x 40
Fixed Tilt (Rooftop Canopy) West Facing	14.40	20,789	1,444	35.04	2.43	6.17	0.43	Q Cells (400W)	36	270	23	1	Portrait	25 x 40

Daily generation by orientation type

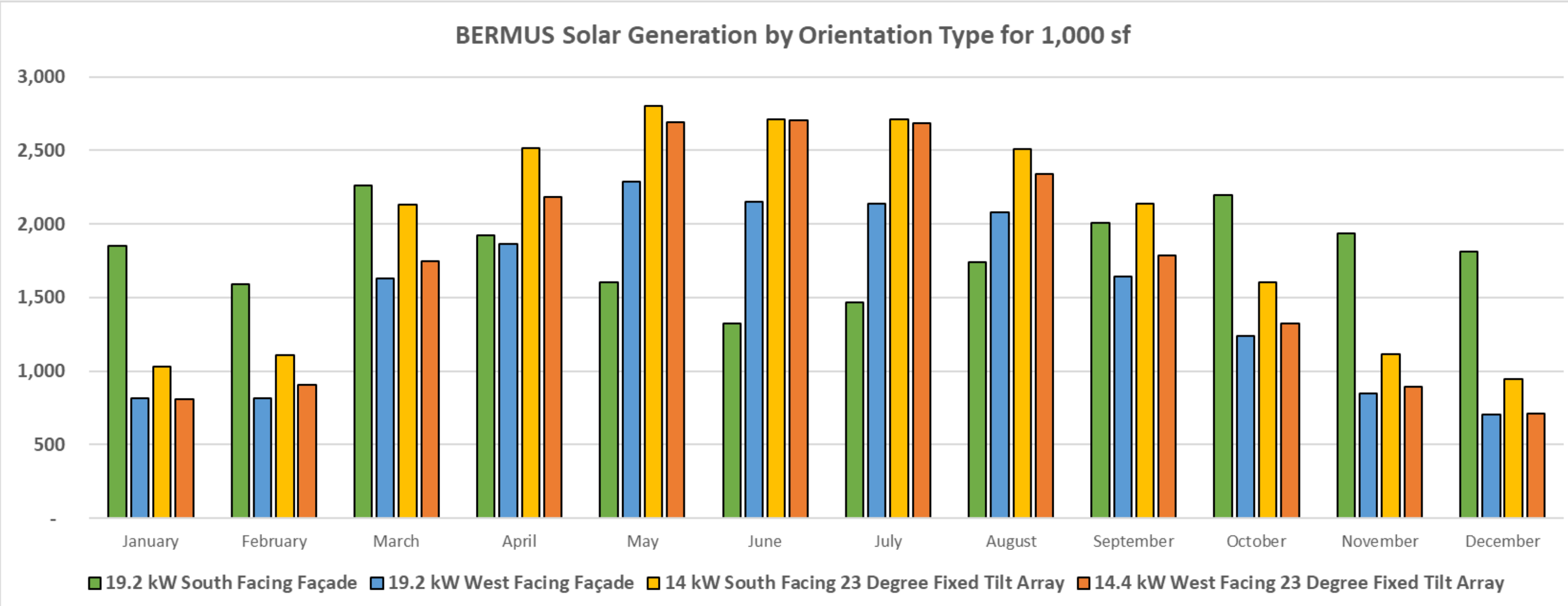
Clean Coalition



BERMUS - Max and Min Daily Solar Generation by Orientation Type and Date for 1,000 sf					
Time Period		19.2 kW South Facing Façade	19.2 kW West Facing Façade	14 kW South Facing 23 Degree Fixed Tilt Array	14.4 kW West Facing 23 Degree Fixed Tilt Array
Max Daily (kWh)	Annual	106	83	101	99
Max Day		11/8/2022	5/7/2022	6/9/2022	6/9/2022
Min Daily (kWh)		4	4	5	6
Min Day		12/12/2022	12/12/2022	12/12/2022	12/12/2022
Max Daily (kWh)	November - March	105.93	67.41	93.43	73.21
Max Day		11/8/2022	3/24/2022	3/24/2022	3/24/2022
Min Daily (kWh)		4	4	44	6
Min Day		12/12/2022	12/12/2022	12/12/2022	12/12/2022

Monthly generation by orientation type

Clean Coalition



BERMUS - Total, Max, Average, and Min Daily Solar Generation by Orientation Type and Month for 1,000 sf

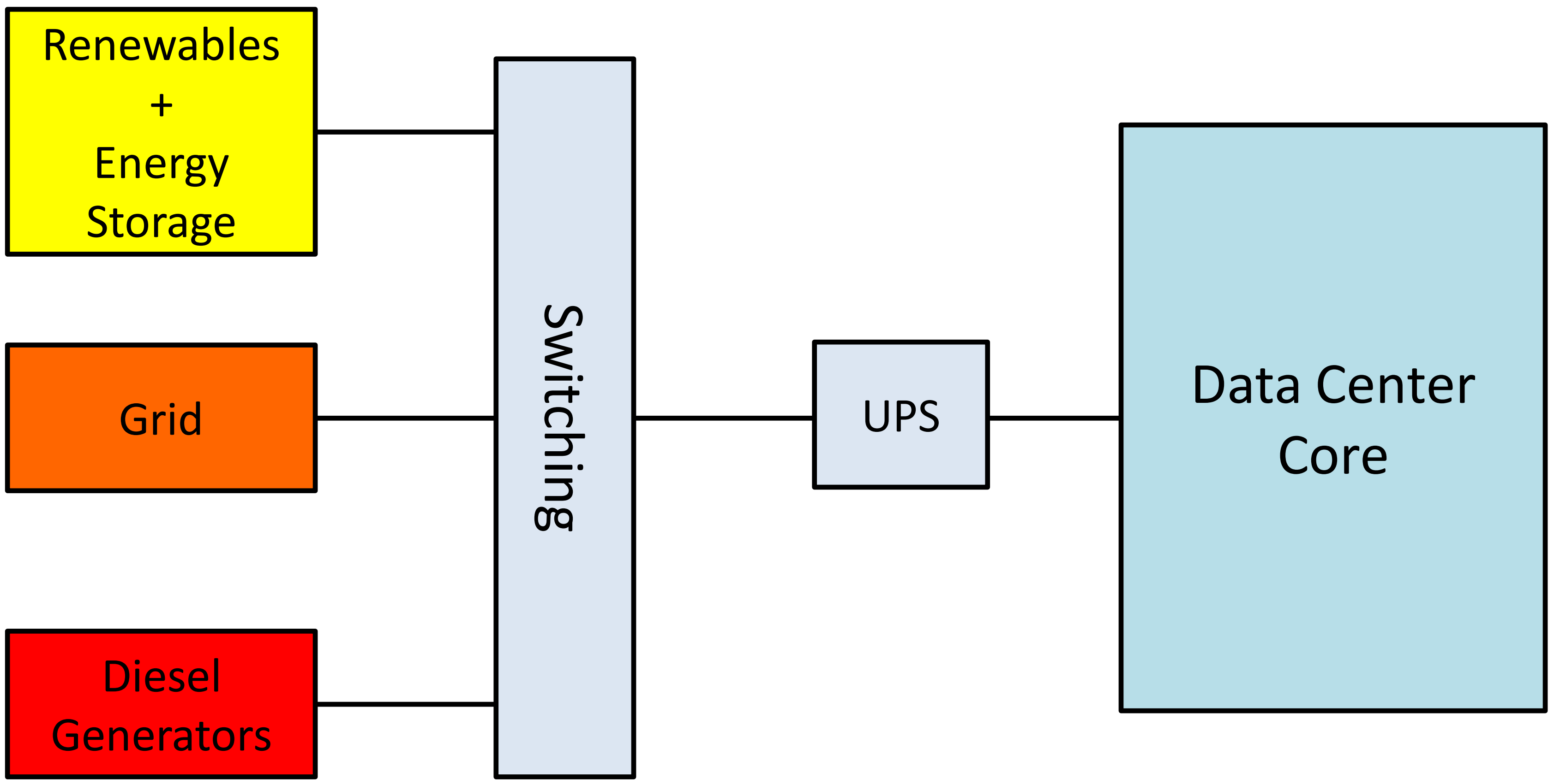
Month	19.2 kW South Facing Façade				19.2 kW West Facing Façade				14 kW South Facing 23 Degree Fixed Tilt Array				14.4 kW West Facing 23 Degree Fixed Tilt Array			
	Total Generation (kWh)	Max Daily Generation (kWh)	Average Daily Generation (kWh)	Min Daily Generation (kWh)	Total Generation (kWh)	Max Daily Generation (kWh)	Average Daily Generation (kWh)	Min Daily Generation (kWh)	Total Generation (kWh)	Max Daily Generation (kWh)	Average Daily Generation (kWh)	Min Daily Generation (kWh)	Total Generation (kWh)	Max Daily Generation (kWh)	Average Daily Generation (kWh)	Min Daily Generation (kWh)
January	1,853	106	60	6	816	39	26	6	1,033	53	33	7	812	39	26	7
February	1,594	104	56	7	816	53	28	7	1,112	70	39	9	904	54	32	9
March	2,261	103	73	16	1,632	67	52	16	2,131	93	68	19	1,747	73	56	19
April	1,920	82	65	25	1,867	81	63	19	2,514	100	85	30	2,185	88	74	25
May	1,603	59	52	34	2,290	83	74	48	2,801	100	90	48	2,693	96	87	56
June	1,325	48	44	27	2,150	81	71	27	2,713	101	90	35	2,704	99	90	35
July	1,464	53	47	33	2,141	78	69	32	2,710	98	87	42	2,688	96	87	43
August	1,738	67	56	16	2,078	78	67	16	2,508	95	81	20	2,341	88	76	21
September	2,006	86	66	14	1,642	67	55	15	2,135	92	71	18	1,789	77	60	19
October	2,194	99	71	10	1,238	54	40	10	1,601	71	52	12	1,323	57	43	12
November	1,934	106	65	8	850	46	29	7	1,117	56	38	9	892	43	30	9
December	1,814	103	59	4	706	36	23	4	948	47	31	5	712	33	23	6
Total	21,706	85	60	17	18,226	64	50	17	23,323	81	64	21	20,790	70	57	22

Clean Coalition

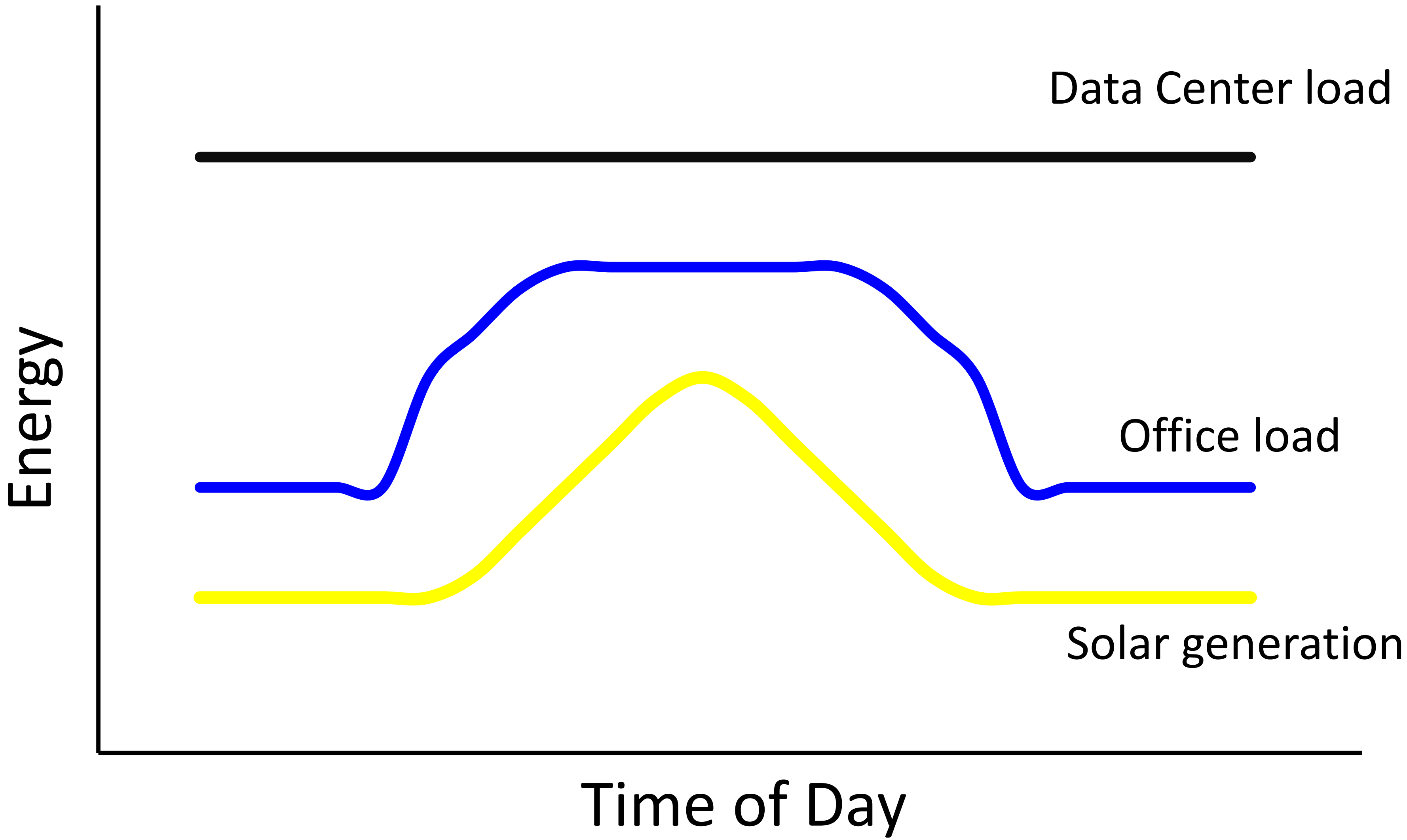
Solar Microgrid considerations for a Data Center

Renewables for Data Center Energy & Resilience

Clean Coalition

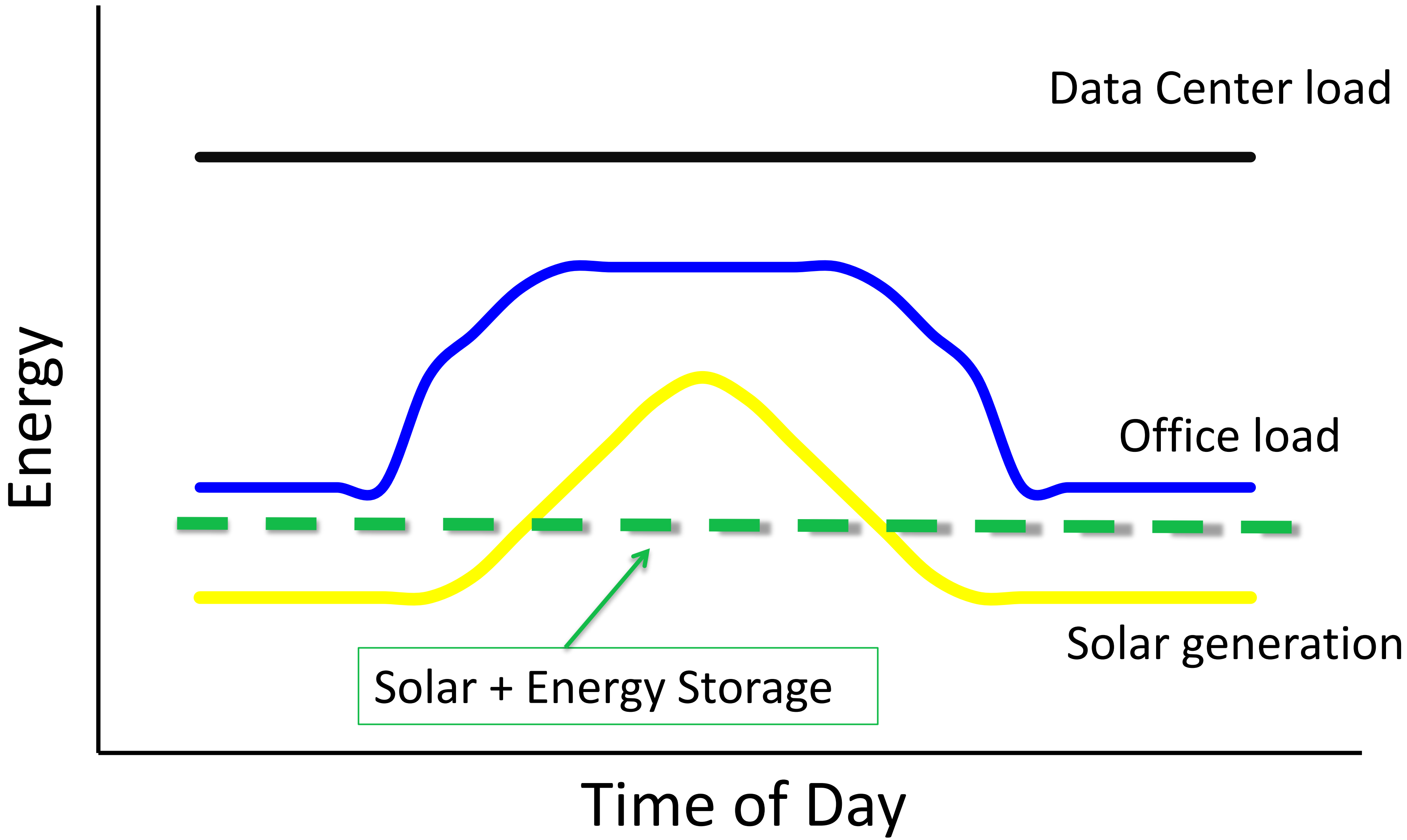


Solar and Load Profiles – Data Center Challenge



Local Solar + Energy Storage = Indefinite Energy

Clean Coalition



Local Solar + Energy Storage to Replace 1MW of Diesel

Clean Coalition

- Assumptions
  - 20% solar capacity factor (typical for MW-scale solar in California)
  - Worst solar day is 10% of average (ie, 2% capacity factor)
  - 2 acres of siting required per 1 MW of solar
  - Requires 24x7x365 performance
- Calculations
  - 24 MWh of replenishment solar required daily (1 MW x 24 hr)
  - 50 MW of solar required (50 MW x .02 capacity factor x 24 hr)
  - 24 MWh of energy storage required

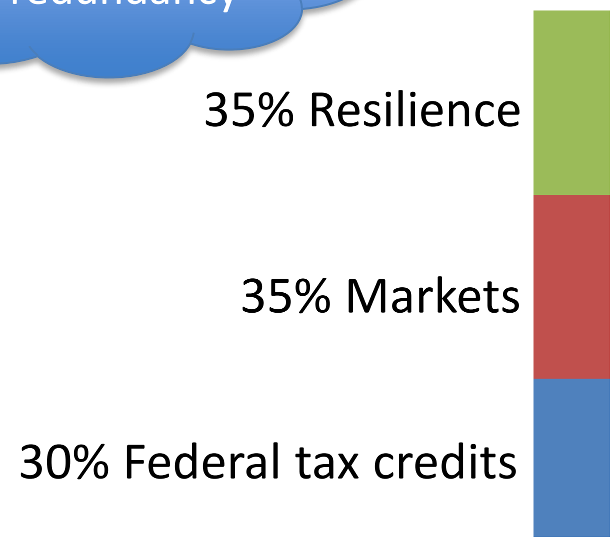
Opportunity: Local renewables + energy storage can provide indefinite backup power.

Challenge: Data centers have large flat loads; 100% solar is tough.

Other Plays for Local Renewables + Energy Storage

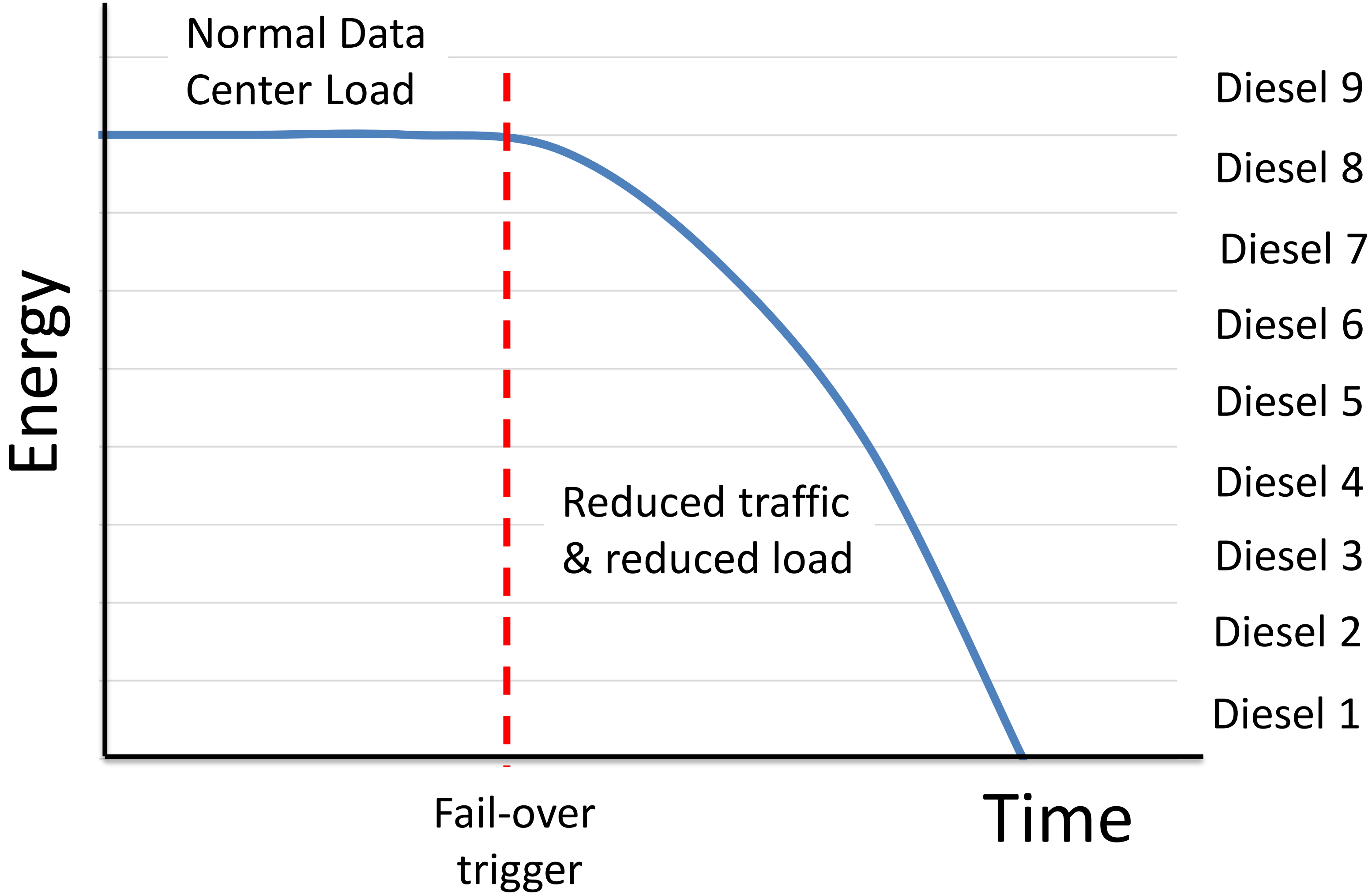
- Diversify renewables
  - Wind & solar generation profiles are highly complementary
  - One 3MW wind turbine averages 24 MWh/day
- Diversify geography
  - Demand Response (DR) combined with renewables + energy storage = big UPS
  - Fail-over strategies can allow significant reduction in energy usage
- Monetize energy storage in markets like DR and frequency regulation
  - Markets typically cover 35% of energy storage costs while tax credits cover another 30%

Cloud offers geo redundancy



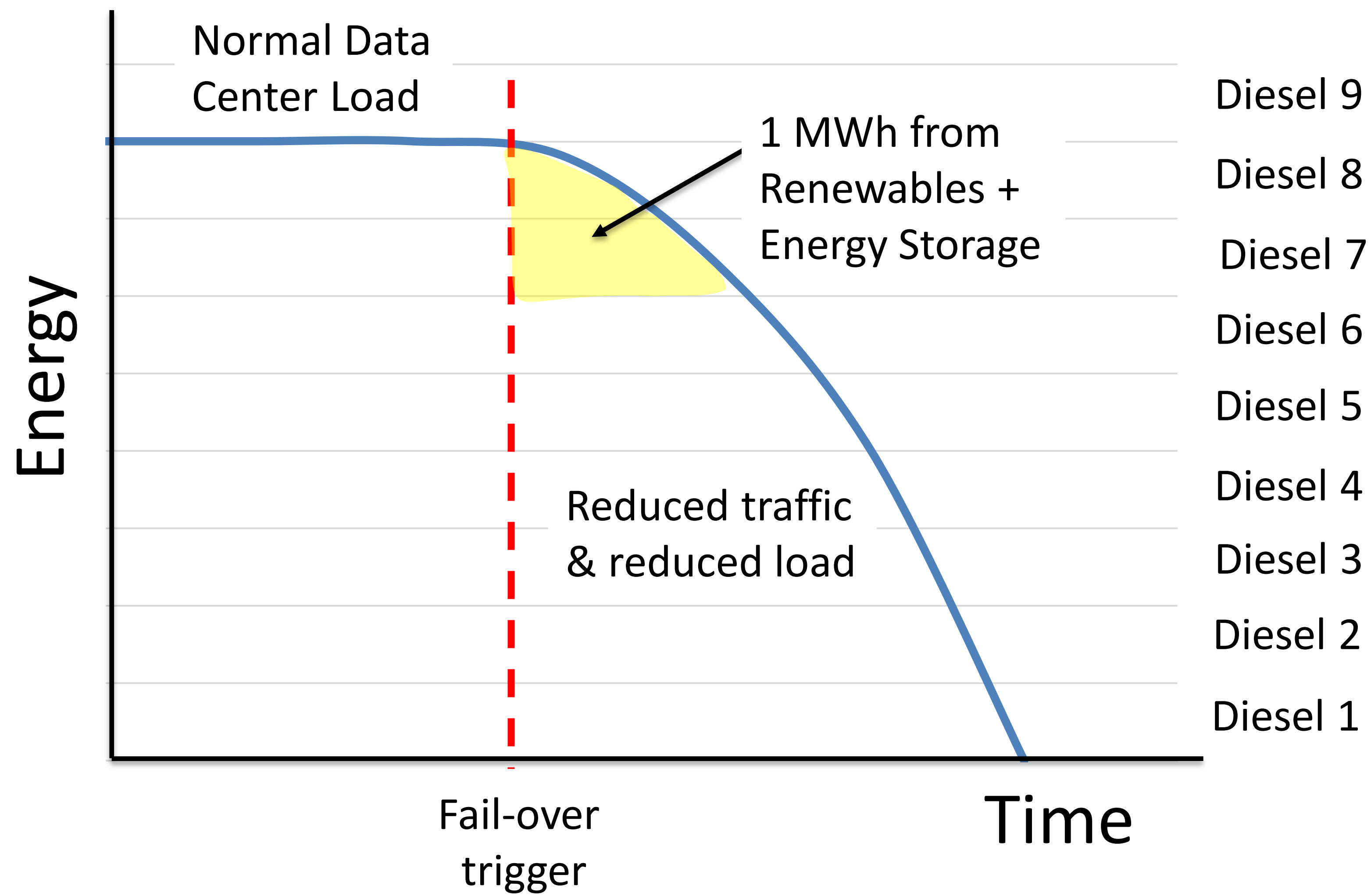
Demand Response (DR) Opportunity

Clean Coalition



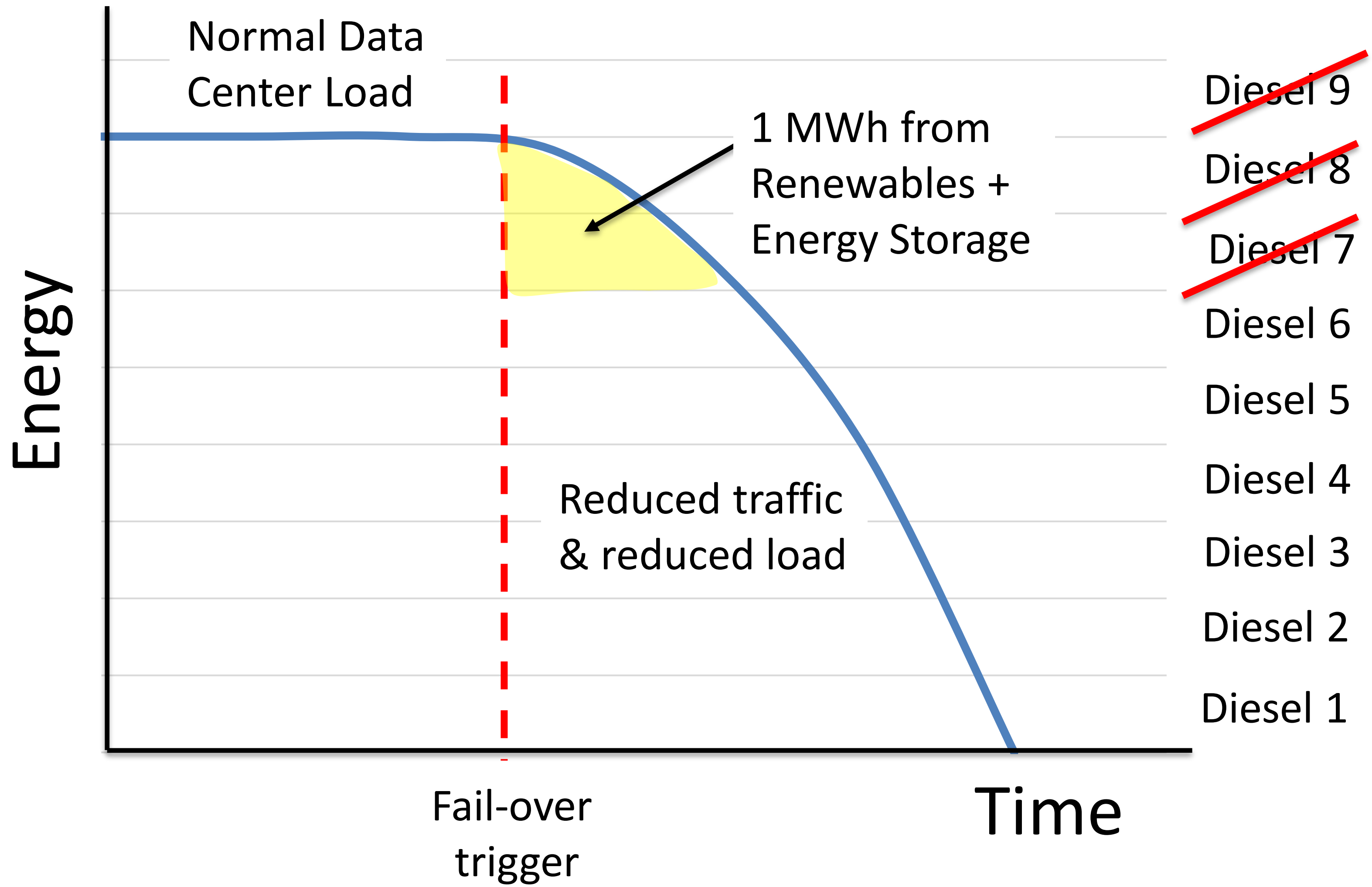
DR + Renewables + Energy Storage = Big UPS

Clean Coalition



DR + Renewables + Energy Storage = Success

Clean Coalition



Multiple Pathways to Replacing 1MWh of Diesel

Clean Coalition

- 1 MWh of energy storage with small solar or other renewables
- 2 MW of solar supplies 1 MWh of energy on worst weather day in California

Replacing 1 MWh of Diesel with
local renewables + energy storage is easy

Seeking Data Center Pioneers

Clean Coalition

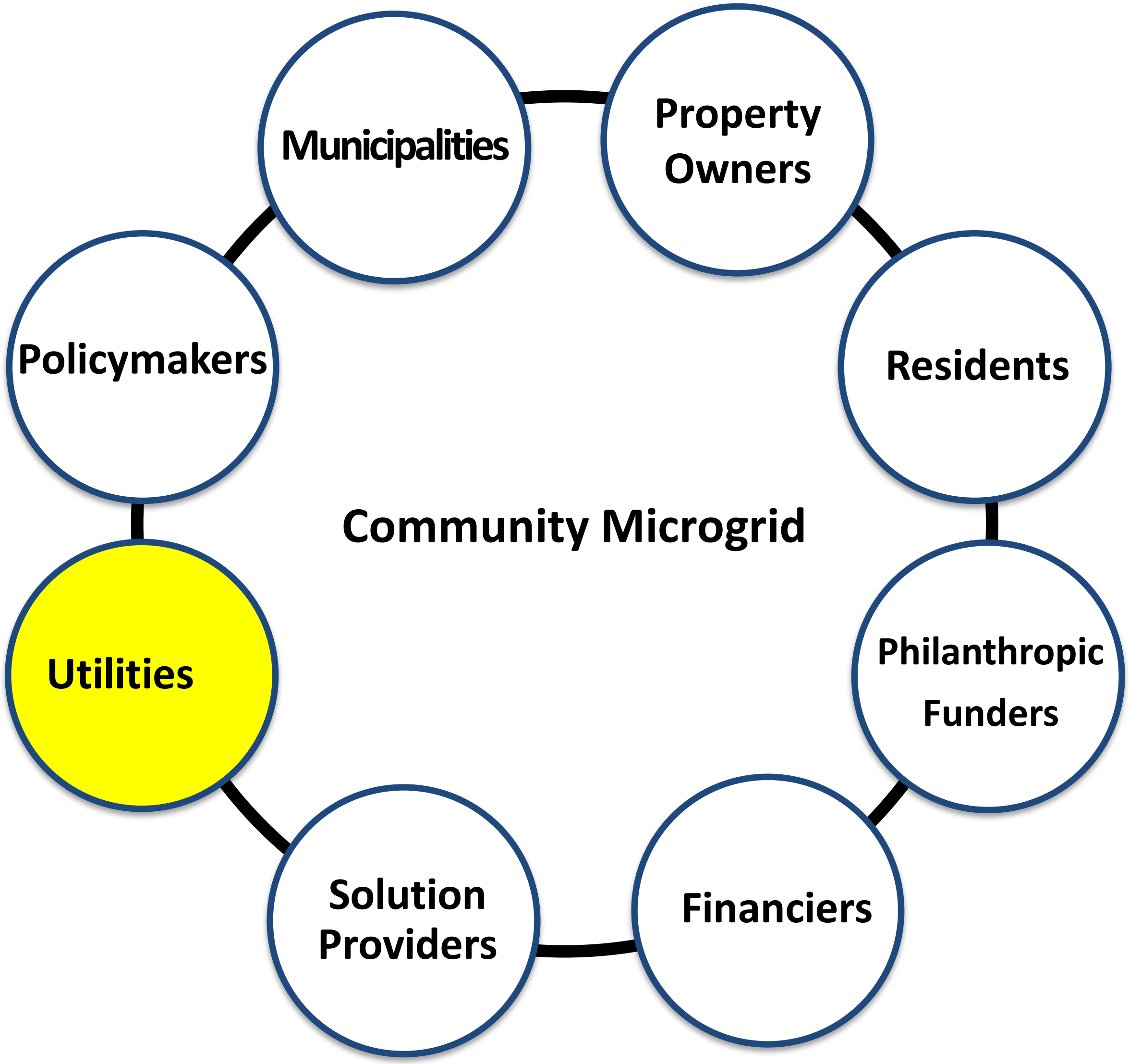
- Local renewables + energy storage is increasingly viable, including for a portion of data center requirements
- Challenges exist for data center pioneers to help overcome

The Clean Coalition is seeking data center pioneers to conquer the next renewables frontier!

Getting things done = aligning stakeholders

Getting things done = aligning stakeholders

Community Microgrid stakeholders



Remember that all stakeholders are human

Clean Coalition

1. Humans like things to be simple
    - Make sure that objectives & analyses are effectively presented.
2. Most humans are capitalists
    - Economics are fundamental to all stakeholder decisions.
    - With utilities, follow the money.
    - With policymakers, hold them accountable.
3. Success requires multi-pronged action combined with courageous & relentless pursuit
    - Perform comprehensive analyses.
    - Tell the story effectively – which usually means colorfully.
    - Repeat the messaging courageously and ad nauseum.