Grid Harmonization & Building Decarbonization CANNOT be Separate Topics

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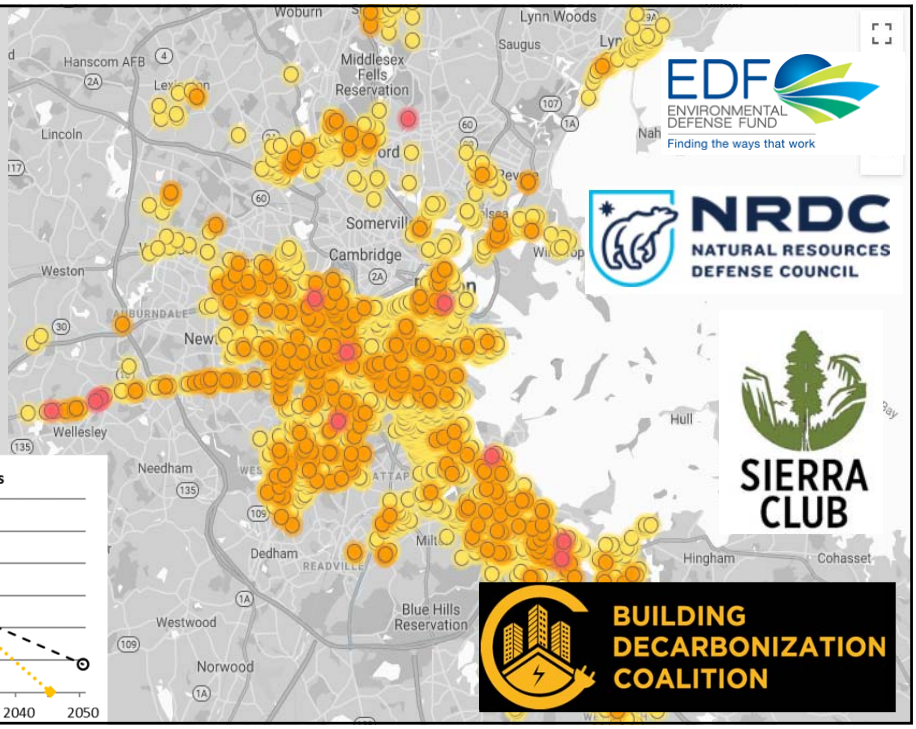
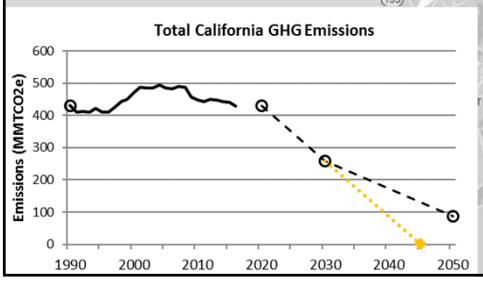
DECARBONIZATION POLICY PUSH

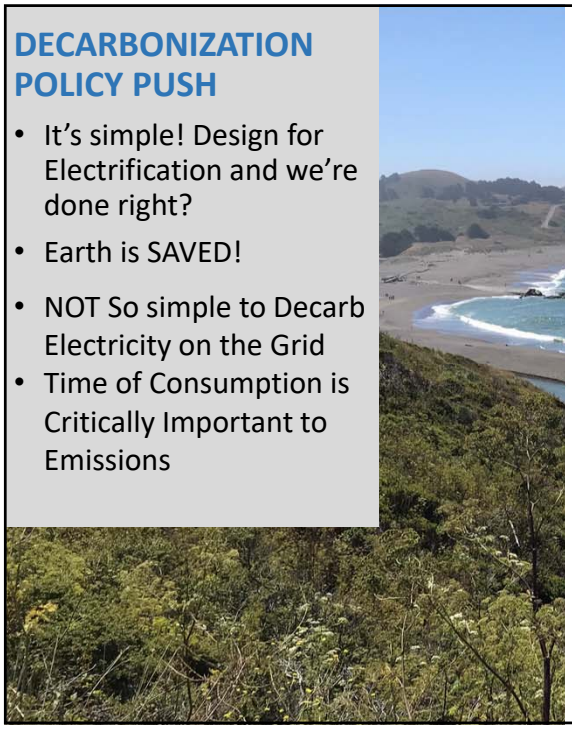
- By 2020: return GHGs to 1990 levels *(AB 32, 2006)*
- By 2030: 40% below 1990 levels *(SB 32, 2015)*
- By 2050: 80% below 1990 levels *(Executive Orders B-30-15 and S-3-05)*
- And now…By 2045: 100% zero-carbon electricity (SB 100) and *carbon neutral economy-wide* (*Executive Order B-55-18*)

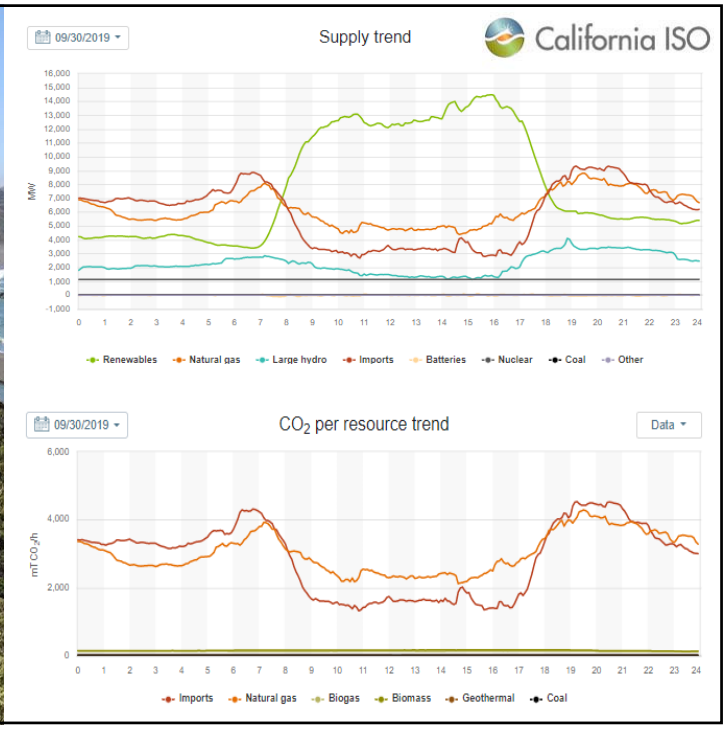




DECARBONIZATION POLICY PUSH

- It's simple! Design for Electrification and we're done right?
- Earth is SAVED!
- NOT So simple to Decarb Electricity on the Grid
- Time of Consumption is Critically Important to Emissions





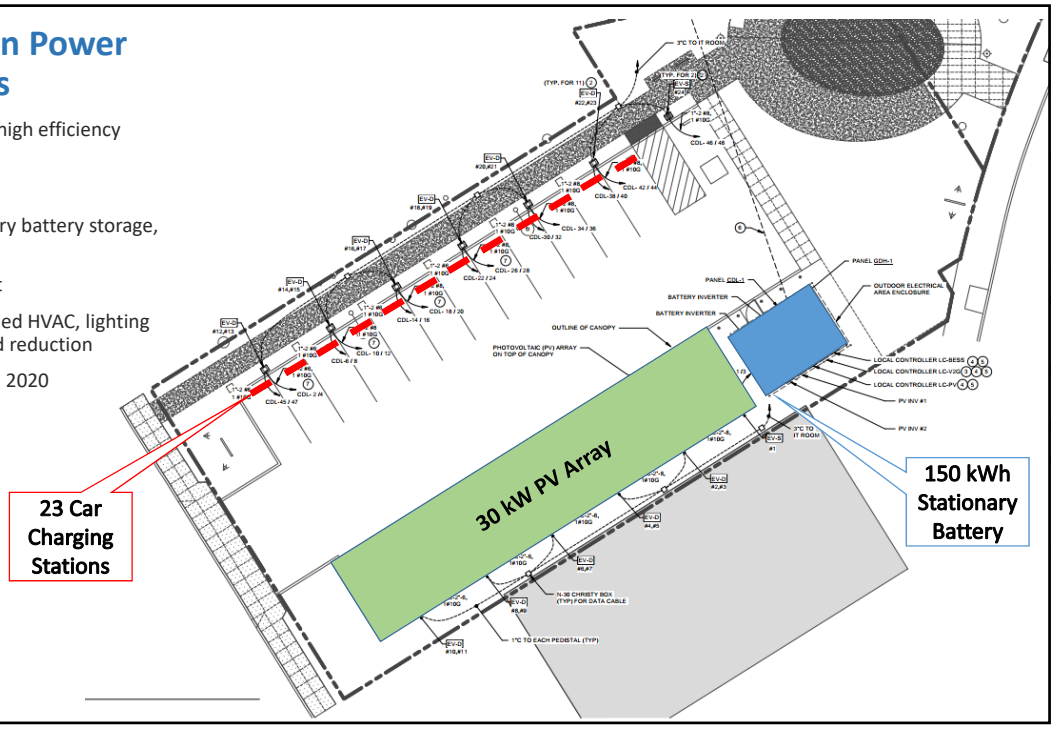
Sonoma Clean Power Headquarters

- Building Electrification Retrofit
- 15,000 SF Two Story Office
- Eliminated "Natural" Gas on site
- High Efficiency Variable Speed Rooftop Heat Pumps
- Smart VAV diffusers
- On-site Solar 30kW
- 150 kWh Stationary Battery storage
- 23 Electric Car Charging Stations
- Automatic, grid-signaled HVAC, lighting and plug load demand reduction
- NBI Grid Optimal Pilot
- Estimated completion 2020

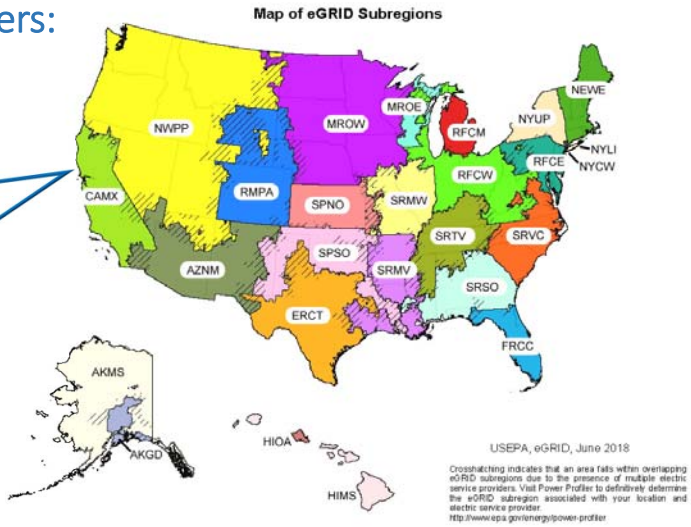
GRIDOPTIMAL™ BUILDINGS INITIATIVE

Sonoma Clean Power Headquarters

- Building retrofit with high efficiency rooftop heat pumps
- Smart VAV diffusers
- On-site solar, stationary battery storage, car charging
- NBI Grid Optimal Pilot
- Automatic, grid-signaled HVAC, lighting and plug load demand reduction
- Estimated completion 2020



Sonoma Clean Power Headquarters: Static Carbon Accounting



SCP's Power Sources

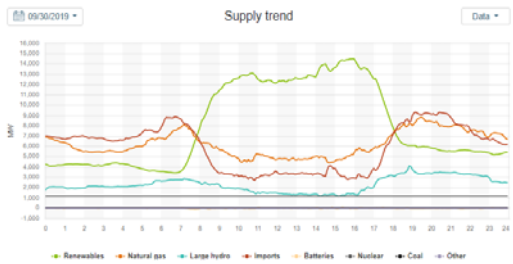
2017 Emission Factor:

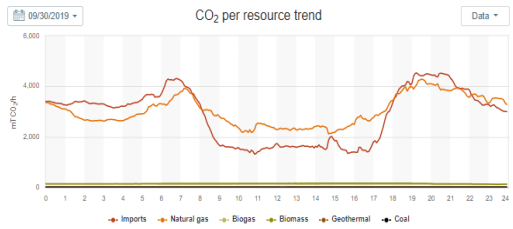
CleanStart -127.98 lb CO_2/MWh

EverGreen - 53.00 lb CO_2/MWh

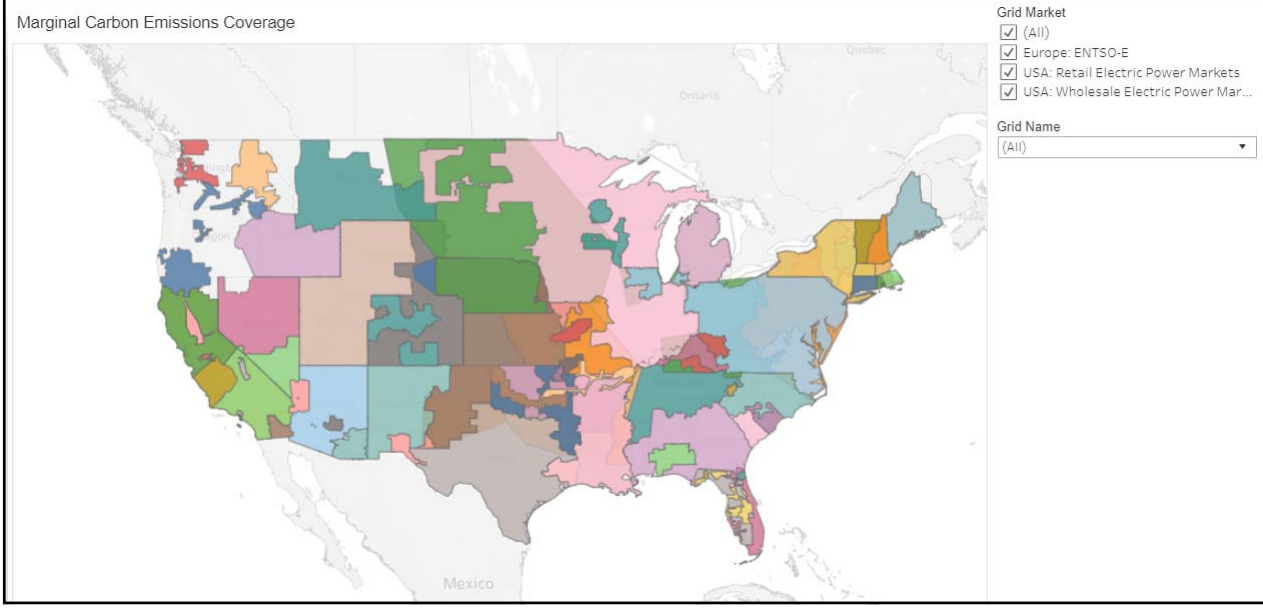
Static Carbon multipliers are easy & accessible BUT not useful for Time of Use or Grid Harmonization

Sonoma Clean Power Headquarters: Hourly Carbon Accounting Emission Sources

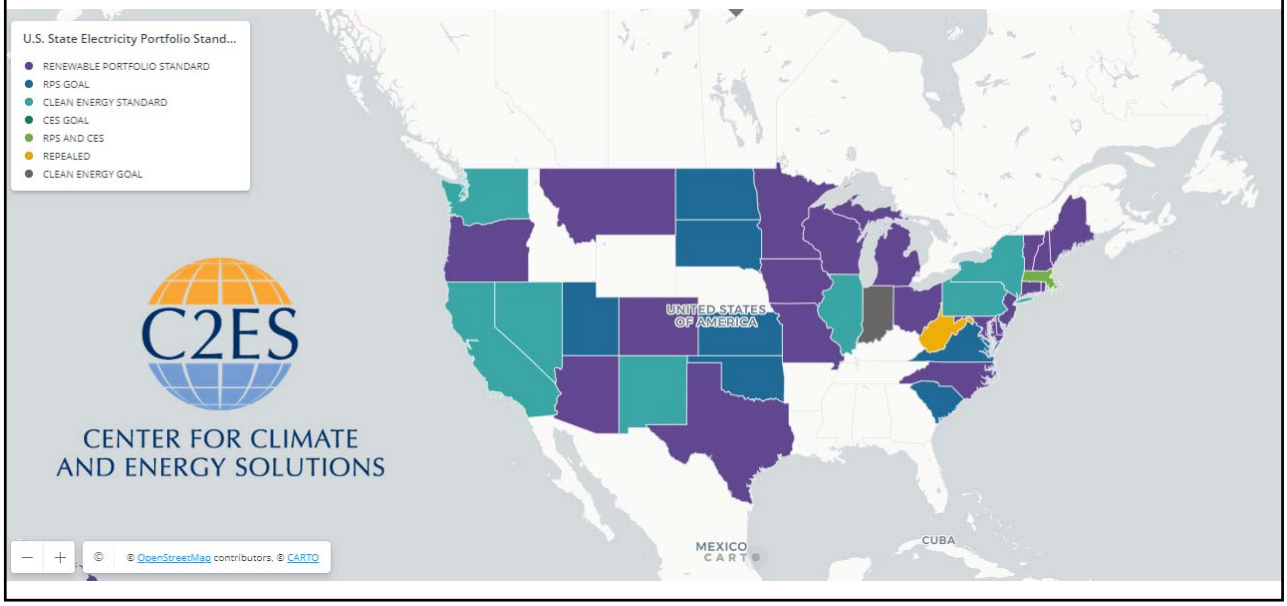




Sonoma Clean Power Headquarters: Hourly MARGINAL Carbon Accounting Emission Sources

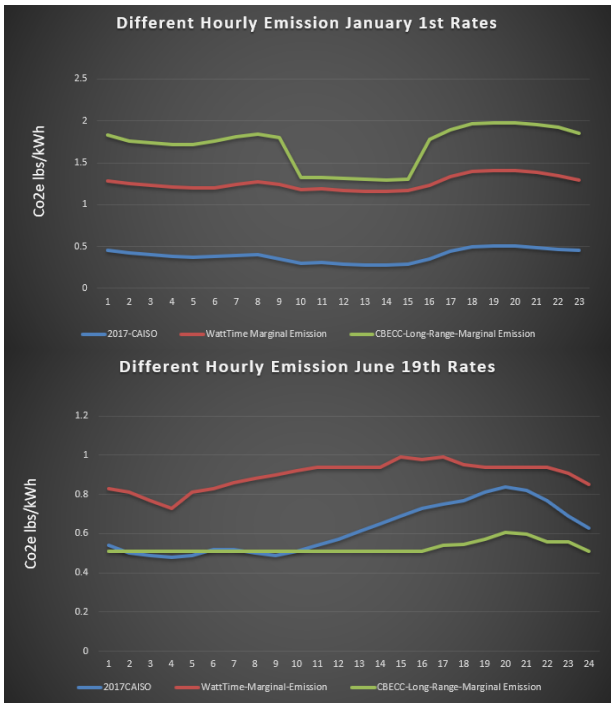


Sonoma Clean Power Headquarters: Hourly LONG RANGE MARGINAL Carbon Accounting Emission Sources



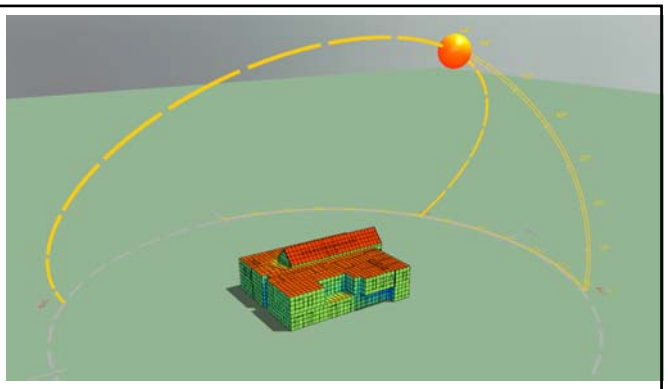
Sonoma Clean Power Headquarters: Which Hourly Emission Factor Is BEST?

- Marginal emission rates are best for project planning and carbon mitigation strategies
- LONG Range Marginal emission rates (30 Year Planning) good for life cycle carbon emissions of buildings or long range policy development



Sonoma Clean Power Headquarters: Design Modeling

- Traditional Modeling Tools Designed for optimizing energy and cost = NO Connection to Carbon
- Energy & Building Performance tools NOT Connected to Renewable and Storage tools automatically
- Charge Charging Stations NOT modeled in tools easily or modeling the dynamic nature



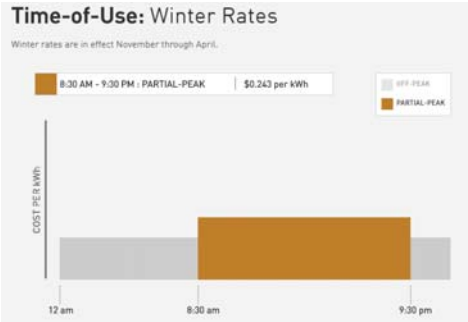
Energy Use, Cost, and Savings

Energy Conservation Measure No.	Annual Electricity Usage (kWh/yr)	Renewable Energy Production (kWh/yr)	Renewable Energy Offset (% of Elecricity)	Net Annual Energy CostWith PV ($)	Annual Energy Cost Savings of Measure ($)
Base Case	167,080	41,295	25%	$ 32,468	N/A
ECM-1 Temperature Setback	162,670	41,295	25%	$ 31,348	$ 1,120
ECM-2 Lighting Demand Response	165,470	41,295	25%	$ 32,048	$ 420
ECM-3 Interoperable Thermafusers	155,890	41,295	26%	$ 29,908	$ 2,560
ECM-4 ECM-1+ Easy winter warm up	162,350	41,295	25%	$ 31,278	$ 1,190
ECM-5 Bundle of ECM's from 1-4	150,620	41,295	27%	$ 28,558	$ 3,910
ECM-5 Plus 150 kWh Battery	150,620	41,295	27%	$ 26,244	$ 6,224
ECM-5 Plus 400 kWh Battery	150,620	41,295	27%	$ 26,234	$ 6,234
ECM-5 Plus 600 kWh Battery	150,620	41,295	27%	$ 26,251	$ 6,217

Sonoma Clean Power Headquarters:

PGE/SCP A6 TOU Rate

- Winter Peak rates fall outside of building warm up period, NOT aligned with carbon
- Maintaining building temperature and "gentle winter warm up" a key strategy
- Utilizing battery storage early morning a carbon savings advantage



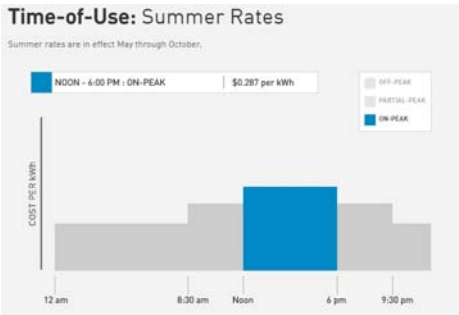
Winter Warm Up Carbon Peaking

	Base	ECM-1	ECM-2	ECM-3	ECM-4	ECM-5	150 kWh Battery	400kWh Battery	600 kWh Battery
1/1/2019 22:00	3.9	5.3	5.3	4.8	5.3	4.8	2.0	2.0	2.0
1/1/2019 23:00	16.5	12.3	12.3	10.5	12.3	10.5	13.2	2.3	2.3
1/2/2019 0:00	0.7	5.1	5.1	6.8	5.1	6.8	20.9	16.8	15.7
1/2/2019 1:00	17.5	17.7	17.7	16.1	17.7	16.1	19.3	15.4	14.4
1/2/2019 2:00	0.7	0.7	0.7	2.3	0.7	2.3	19.3	15.6	14.5
1/2/2019 3:00	17.3	17.3	17.3	15.5	17.3	15.5	18.8	15.1	14.1
1/2/2019 4:00	12.1	12.1	12.1	14.0	23.4	19.8	19.2	15.6	14.4
1/2/2019 5:00	18.7	18.7	18.7	16.6	30.8	24.6	20.3	16.6	15.2
1/2/2019 6:00	40.9	36.7	36.6	26.7	32.9	25.9	21.3	17.4	16.4
1/2/2019 7:00	40.4	36.4	36.4	27.4	33.6	26.5	21.9	17.9	16.8
1/2/2019 8:00	38.5	36.4	36.3	27.4	33.8	27.0	22.0	18.0	16.9
1/2/2019 9:00	35.9	36.3	36.2	27.4	33.6	26.6	22.0	21.1	16.8
1/2/2019 10:00	19.0	23.7	23.7	20.9	23.5	20.8	21.8	17.5	16.2
1/2/2019 11:00	13.2	17.8	17.8	15.5	17.7	15.4	21.5	17.3	16.1
1/2/2019 12:00	15.9	18.2	18.2	18.3	18.9	17.4	20.9	16.7	15.6
1/2/2019 13:00	16.1	16.1	16.1	14.3	16.0	14.1	20.9	16.7	15.6
1/2/2019 14:00	16.7	16.7	16.7	15.1	16.7	14.9	21.9	17.5	16.3
1/2/2019 15:00	14.4	14.4	14.4	12.8	14.4	12.8	23.0	18.4	17.2
1/2/2019 16:00	15.2	20.2	20.2	18.7	20.1	18.7	24.3	20.2	18.8
1/2/2019 17:00	12.7	18.3	18.3	16.3	18.3	16.2	16.2	23.2	21.6
1/2/2019 18:00	11.4	17.2	17.2	14.6	17.2	14.6	14.6	23.7	22.1
1/2/2019 19:00	35.6	37.2	37.2	33.9	36.9	33.8	28.7	23.4	21.9
1/2/2019 20:00	35.9	35.9	35.9	32.7	35.7	32.7	28.2	23.0	21.5

Sonoma Clean Power Headquarters:

PGE/SCP A6 TOU Rate

- Time of Use Rates NOT Aligned with Carbon on the Grid with this office occupancy, exacerbated by hotel/motel, restaurant occupancy types
- Solar and battery storage deployment shifts to later day "ramping period" outside CURRENT on peak rate time

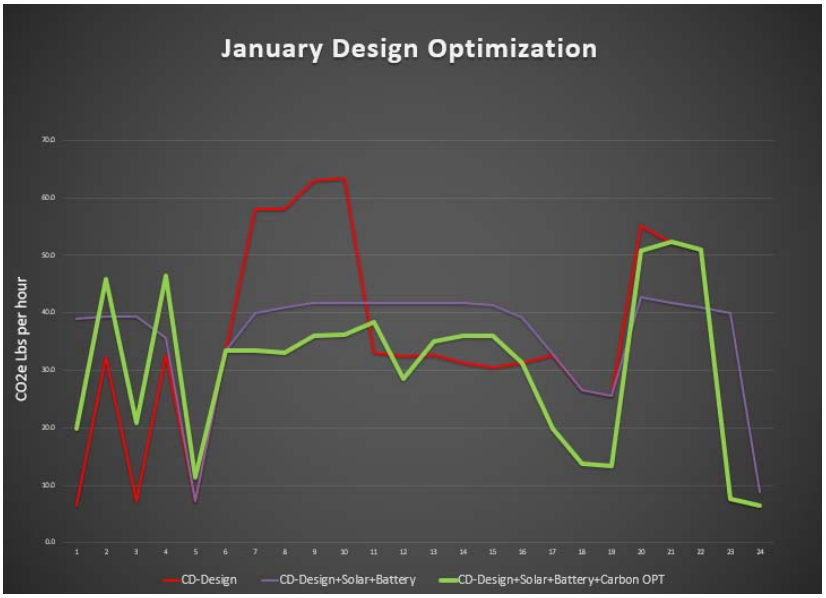


Summer Afternoon Carbon Peaking

	Base	ECM-1	ECM-2	ECM-3	ECM-4	ECM-5	150 kWh Battery	400kWh Battery	600 kWh Battery
8/7/2019 0:00	2.9	0.7	0.7	0.7	0.7	0.7	9.2	9.2	9.1
8/7/2019 1:00	0.7	0.7	0.7	0.7	0.7	0.7	8.6	8.6	8.6
8/7/2019 2:00	0.7	0.7	0.7	0.7	0.7	0.7	8.5	8.5	8.5
8/7/2019 3:00	0.7	0.7	0.7	0.7	0.7	0.7	8.6	8.6	8.6
8/7/2019 4:00	1.3	1.3	1.3	1.3	1.3	1.3	7.4	9.0	9.0
8/7/2019 5:00	8.7	8.6	8.7	7.8	8.6	7.3	7.3	9.3	9.3
8/7/2019 6:00	10.8	10.9	10.8	9.4	10.9	9.5	9.5	9.6	9.6
8/7/2019 7:00	14.5	15.4	14.5	14.6	15.4	15.4	9.7	9.7	9.7
8/7/2019 8:00	11.7	12.3	11.6	11.7	12.3	12.5	8.8	8.8	8.8
8/7/2019 9:00	13.9	14.8	13.9	13.0	14.8	13.7	8.5	8.5	8.5
8/7/2019 10:00	16.5	17.2	16.4	14.3	17.2	14.8	8.8	8.8	8.8
8/7/2019 11:00	16.0	16.6	15.9	13.6	16.6	14.2	8.9	8.9	8.9
8/7/2019 12:00	19.0	19.6	17.5	16.4	19.6	16.0	9.5	9.5	9.5
8/7/2019 13:00	22.1	9.9	20.5	19.7	9.9	11.2	9.8	9.8	9.8
8/7/2019 14:00	25.1	22.7	22.3	21.4	22.7	18.2	10.6	10.6	10.6
8/7/2019 15:00	29.5	24.5	24.0	23.0	24.5	21.0	11.5	11.5	11.5
8/7/2019 16:00	19.1	25.7	25.0	24.0	25.7	20.3	11.9	11.9	11.9
8/7/2019 17:00	19.3	25.1	26.2	25.2	25.1	19.5	12.9	12.4	12.4
8/7/2019 18:00	22.8	27.7	27.8	26.6	27.7	23.4	22.8	13.3	13.3
8/7/2019 19:00	25.1	22.8	29.1	26.0	22.8	19.2	18.6	13.6	13.6
8/7/2019 20:00	17.4	14.5	20.9	16.5	14.5	12.6	13.4	13.4	13.4
8/7/2019 21:00	9.1	1.9	1.9	1.9	1.9	1.9	12.9	12.9	12.9
8/7/2019 22:00	7.5	0.9	0.9	0.9	0.9	0.9	11.7	11.7	11.7

Design Optimization: Winter Weekday

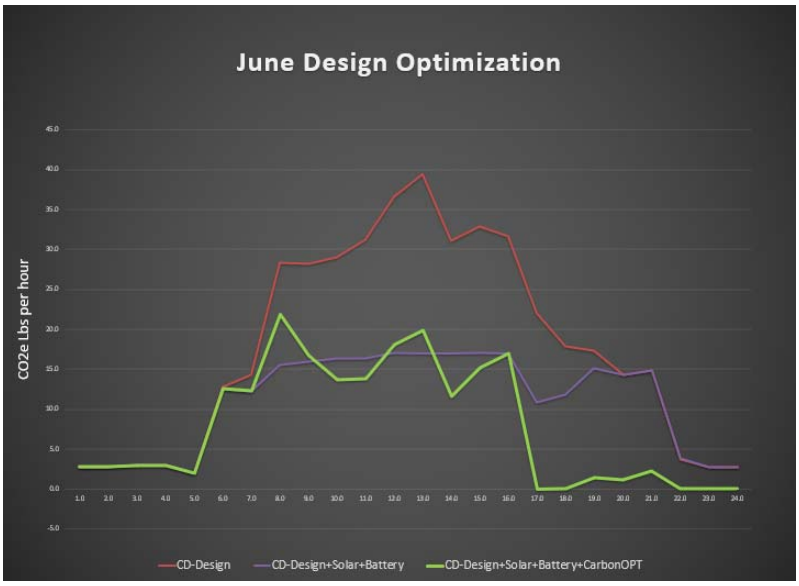
- Utilize Battery Storage for building warm up
- Prioritize building warm up and maintain building temps overnight
- Charge Batteries after winter ramping period



GRIDOPTIMAL™
BUILDINGS INITIATIVE

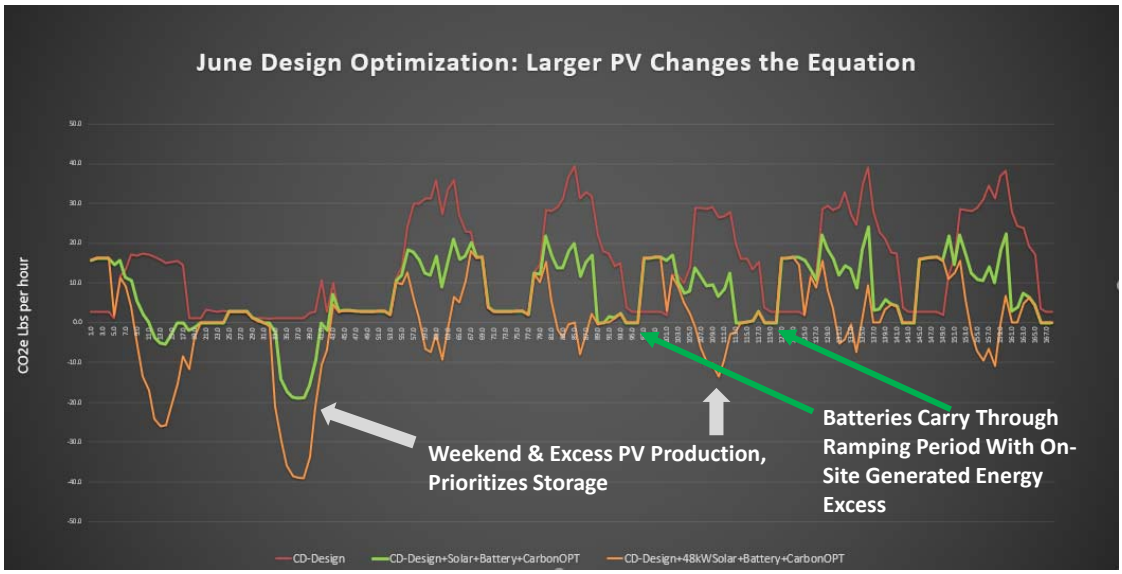
Design Optimization: Summer Weekday

- Utilize Battery Storage for afternoon ramping period
- Prioritize self utilization or storage of on-site generation
- Mitigate Building loads in ramping period, temp setback, lighting dimming, etc.



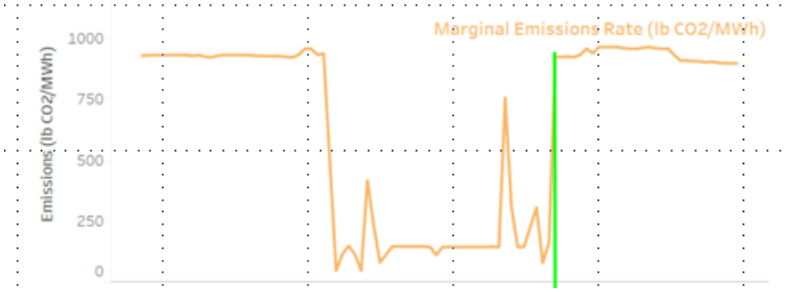
GRIDOPTIMAL™ BUILDINGS INITIATIVE

Design Optimization: Summer



GRIDOPTIMAL™ BUILDINGS INITIATIVE

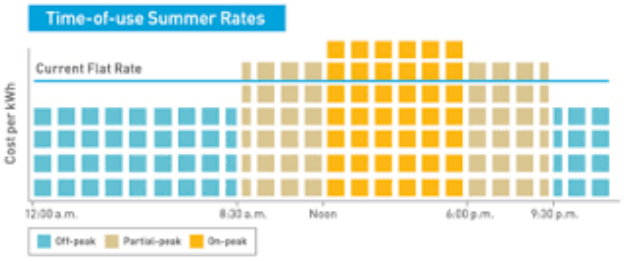
Optimization Challenge



ADR Automated Demand Response Program

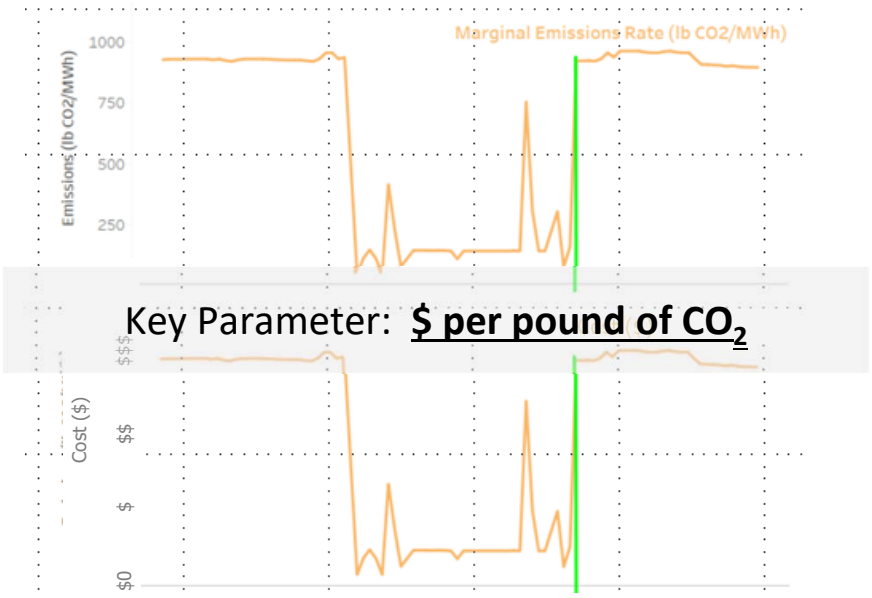
Pacific Gas and Electric Company

$$$$$$$



Basis of Design : System Control Architecture

Proposed Approach



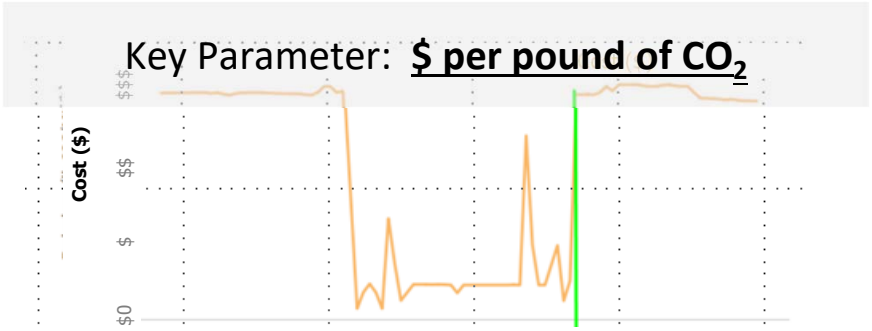
Key Parameter: **$ per pound of CO_2**

Proposed Approach

Carbon Value	Demand Charge Management Savings	Energy Arbitrage Savings	GHG Impact
$0/metric ton	$3,112/year	$158/year	15 metric tons INCREASE/year
$15/metric ton	$3,112/year	$158/year	10 metric tons INCREASE/year
$65/metric ton	$3,112/year	$47/year	8 metric tons INCREASE/year
$150/metric ton	$3,112/year	-$53/year	7 metric tons INCREASE/year
$1000/metric ton	$2,220/year	$63/year	1 metric ton DECREASE/year
$2000/metric ton	$904/year	$145/year	8 metric tons DECREASE/year

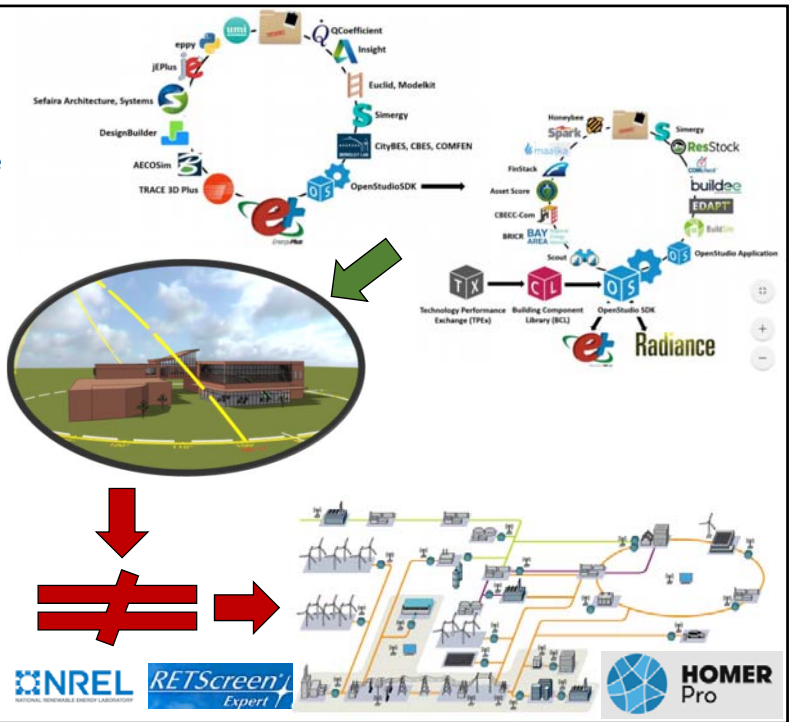
From a study by Enel X on impacts of adding cost of carbon assumptions to a microgrid financial model

Key Parameter: **$ per pound of CO_2**

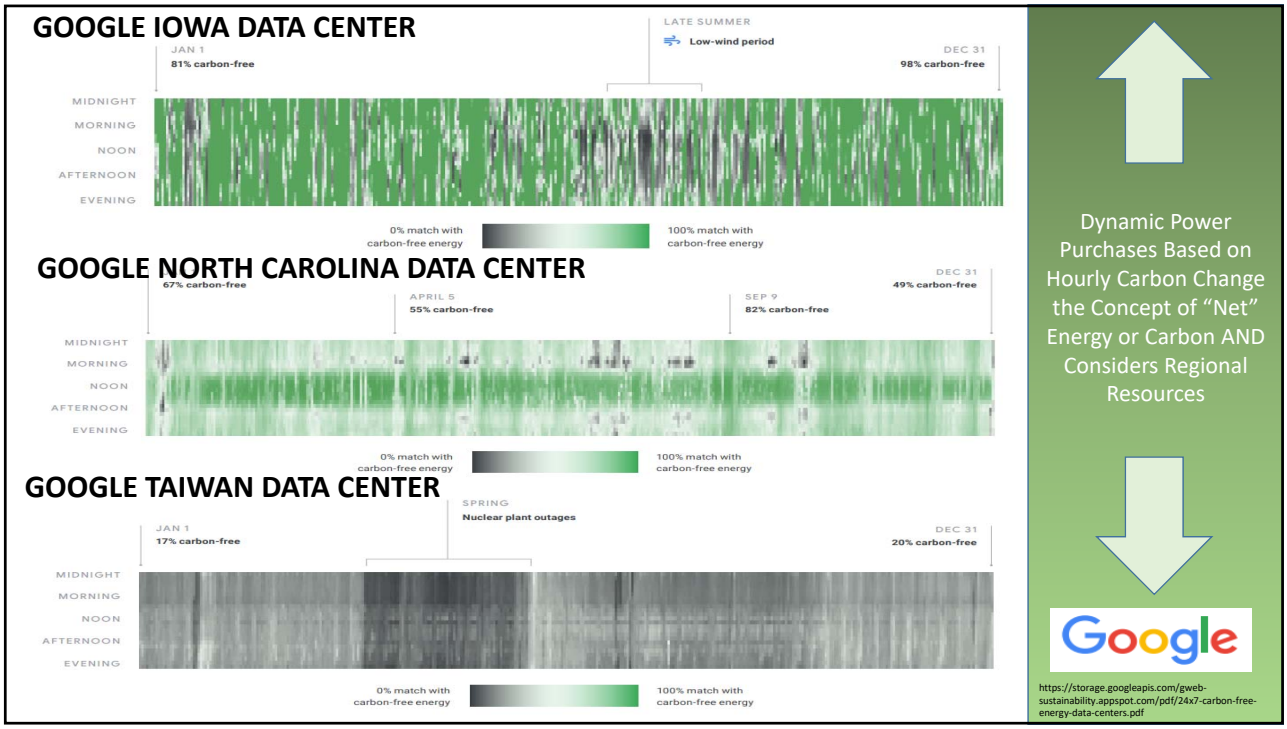


Lessons Learned:

- Key To Everything is COST of CARBON
  - Either align utility rates to Carbon on the grid (3-5yr process with CPUC/Utilities OR
  - Include the high cost of Carbon to the financial equations
  - Rates need to adapt to reward self utilization of on site renewable power first before seeking low carbon energy on the grid
- Design tools need to be enabled with:
  - PV and battery storage sizing tools
  - Marginal Emission rates need to be accessible like weather files for different grid regions
  - Utility rate adders for cost of Carbon should be easily added



NREL RETScreen Expert HOMER Pro



Dynamic Power Purchases Based on Hourly Carbon Change the Concept of "Net" Energy or Carbon AND Considers Regional Resources

https://storage.googleapis.com/gweb-sustainability.appspot.com/pdf/24x7-carbon-free-energy-data-centers.pdf


THANK YOU!
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ground-breaking
&
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