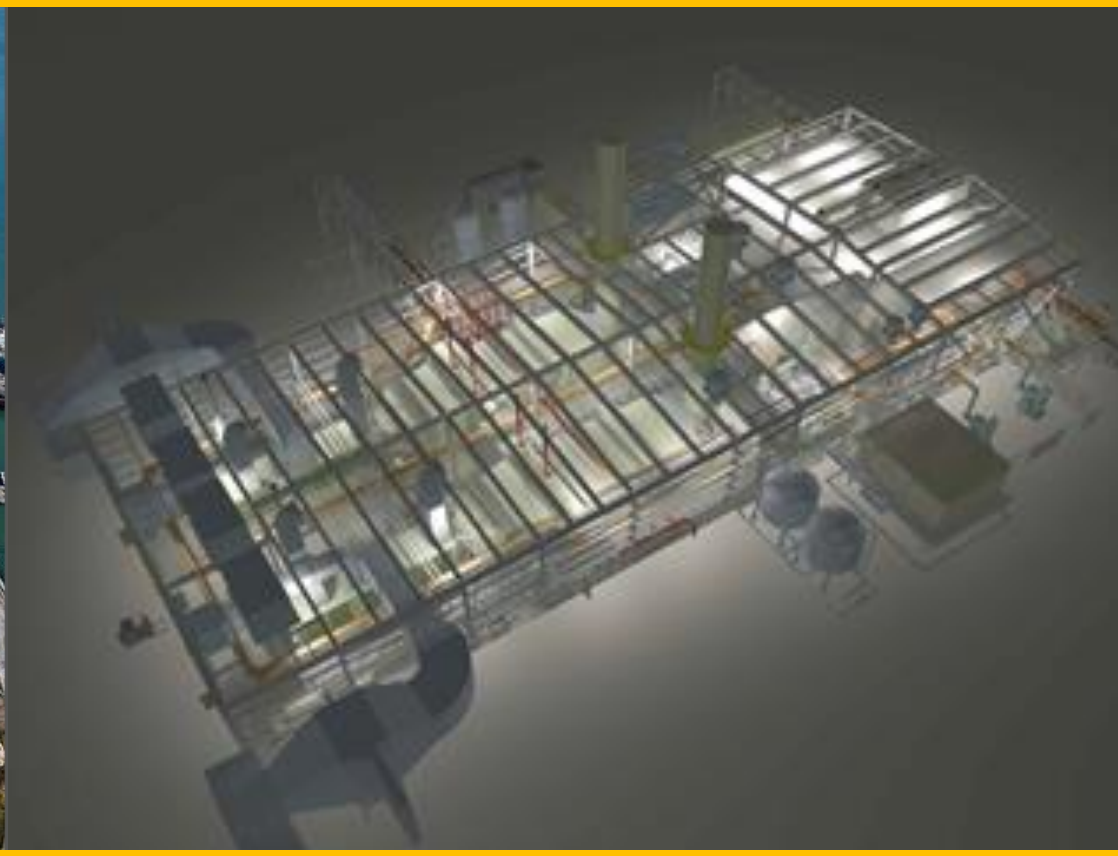
Mission Bay Campus, San Francisco, CA



CHP, Mountain Pass, CA

UCSF Mission Bay: Can CHP Be Used as a Tool to Tackle Carbon-Neutrality Goals?

Presented by:
Jeff Duncan & Bryce MacMartin
Vanderweil Power Group

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

February 2017

VANDERWEIL POWER GROUP

Agenda

Challenges:

- Carbon Neutrality: A View from the Left…Coast
- What is your “Real” Carbon Footprint?
- CHP in a Low-Carbon World

Solutions / Lessons Learned:

- Options and Perspectives
- Case Studies - California
- Lessons Learned & Recommendations

Carbon Neutrality - Leadership

- **State of California**
  - AB 32 - Requires Carbon Reduction to 80% of 1990 levels by 2050
  - Title 24 Building Efficiency Standard – 30% better than ASHRAE 90.1

- **California Utility Providers**
  - 33% renewable electricity by 2020
  - 50% renewable electricity by 2030
  - Generous incentives for PV, Wind, Emerging Technologies
  - 12% spare generating capacity

- **University of California**
  - 10 Campuses – All Carbon Neutral by 2025

- **California State University**
  - 23 Campuses
  - Each has own timeline for Carbon Neutrality (2030+)

- **Numerous Private Institutions w/ Aggressive Goals (Tech, Pharma…)**

Carbon Reduction Strategies

- **Renewable Power Generation**
  - Solar
  - Wind
  - Hydro



- **Renewable Fuel Sources – Biogas**

- **Acquisition of Renewables**
  - Contract OR Build Onsite
- **High-Efficiency Energy Generation**
  - CHP with 70%-80% system efficiencies w/ waste heat utilization
- **Purchase Carbon Offsets or Renewable Energy Credits**

Climate Progress

- **CA Grid Carbon**
  - 33% reduction goal achieved in 2017 (3 years early)
  - NEW 40% reduction by 2020

- **Self-Generation Incentive Program**
  - 10% Biogas beginning 2017

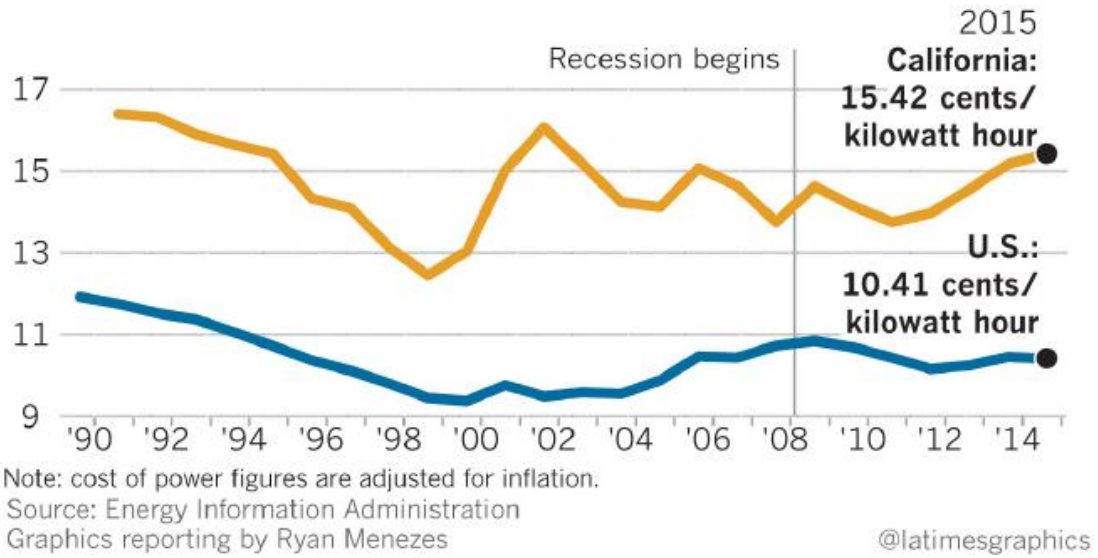
- **Fossil Generation & Emissions**
  - CHP 2-2-2 ppm for NOx, CO, and VOC
  - Boilers 5ppm NOx

- **Transportation**
  - California Emissions Standards become “THE” Standard

- **UC Campuses**
  - Large Scale Renewables / Biogas Development

Carbon Trends/Challenges

- **CA Grid Power Costs/Supply**
  - Demand costs increasing
  - Commodity costs decreasing
  - 12% rate increase since 2008
  - $0.154 per kWh
  - 21% excess capacity in 2020
    - Normal ~10% for resiliency



- **Renewables**
  - Federal ITCs expired in 2016
  - Oversupply for next few years?
  - Bargain contracting: 6-8 cent range

- **UC Campuses**
  - Aggressive Goals – “How to Pay for it”?

Carbon Accounting vs "Global Good"

- **What is your True Carbon Footprint?**
  - National E-Grid Emission Rate = 1,150 lb-CO_2 / MWh
  - CA E-Grid Emission Rate = 620 lb-CO_2 / MWh
  - Where and how are your kWhs generated? More later…
- **Accounting**
  - Know Your Site Metrics (reporting)
  - Creative Solutions (Berkeley CHP)
  - Buy Carbon Offsets and/or RECs
- **Fuel Sourcing (Dynamic Markets Today)**
  - Biogas for CHP, Transportation, and Gas Pipeline Injection
  - Dedicated pipeline or virtual pipeline
- **Best Global Strategy**
  - Energy Efficiency (Generation, Distribution, and Consumption)
  - Diversity of energy sources and tools to use them

A Tale of Two Rivals

Stanford University (Private)

- "Gold Standard" in Climate Action

- Decommission Existing Assets:
  - 30 year old CHP
  - Steam Distribution, Chillers and Boilers
  - 100,000 ton-hr Ice on Coil TES

- Build New Infrastructure:
  - Heat Recovery Chillers w/ Hot Water & Chilled Water TES
  - Microgrid + HW Distribution to 150 buildings
  - 68 MW Peak Capacity Solar Array

- $500 million Investment in Utility Infrastructure
- 65%+ Carbon Neutral Campus Electricity by 2020

A Tale of Two Rivals

University of California, Berkeley (Public)

- "Gold Standard" in Climate Conscious

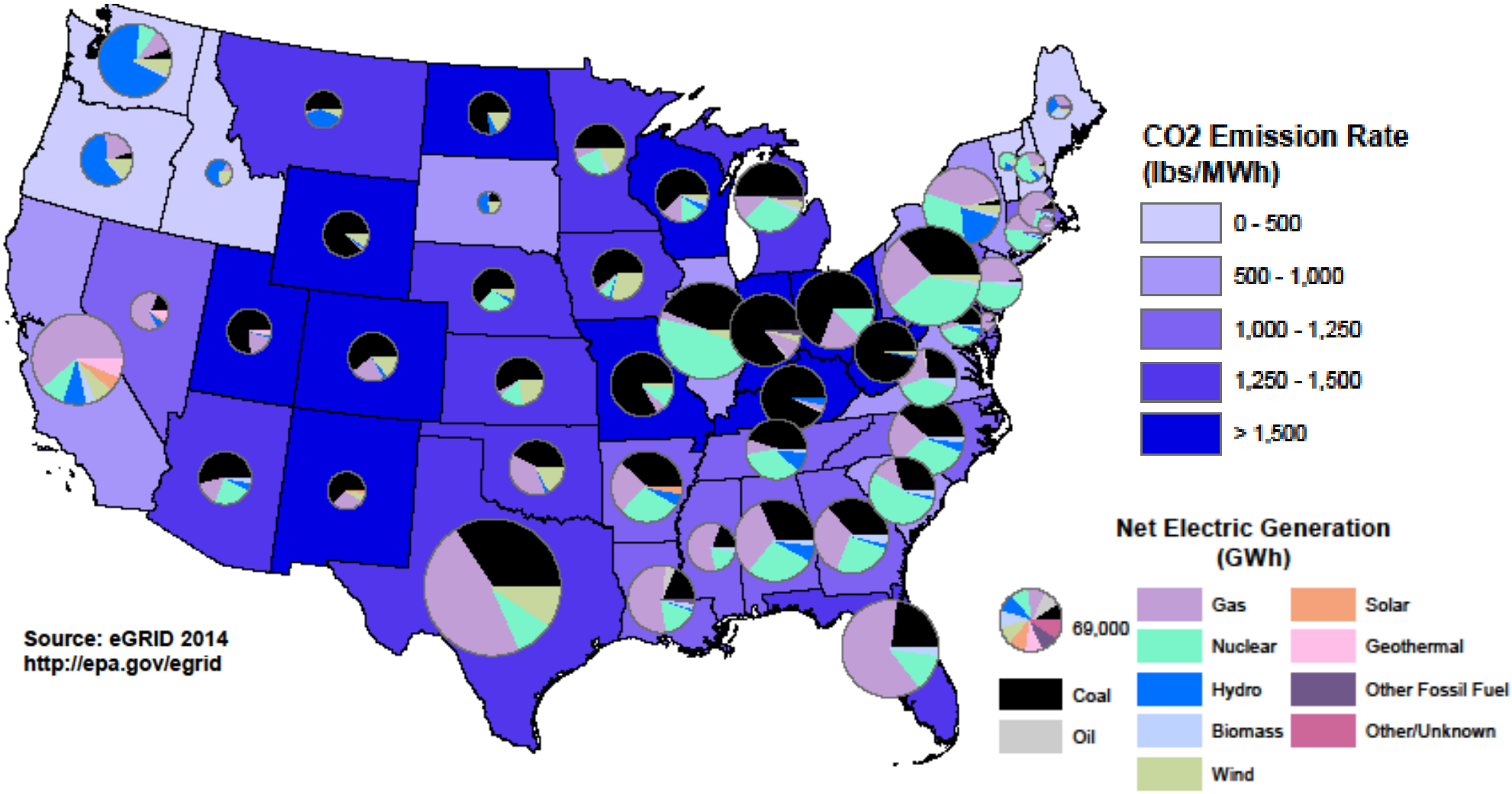
- Aging Existing Infrastructure:
  - 30 year old CHP, 50 year old steam plant
  - 100 year old steam distribution system
  - CHP Owned & Operated by 3rd Party Entity (on campus)

- Financial Challenges:
  - Inadequate PM budgets for repairs
  - Inadequate ECM budgets to reduce energy demand
  - Last Major Infrastructure Investment 1995
  - $150+ million in Debt (reported by LA Times)

- What to do?

Solutions

U.S. Utility Power Generation



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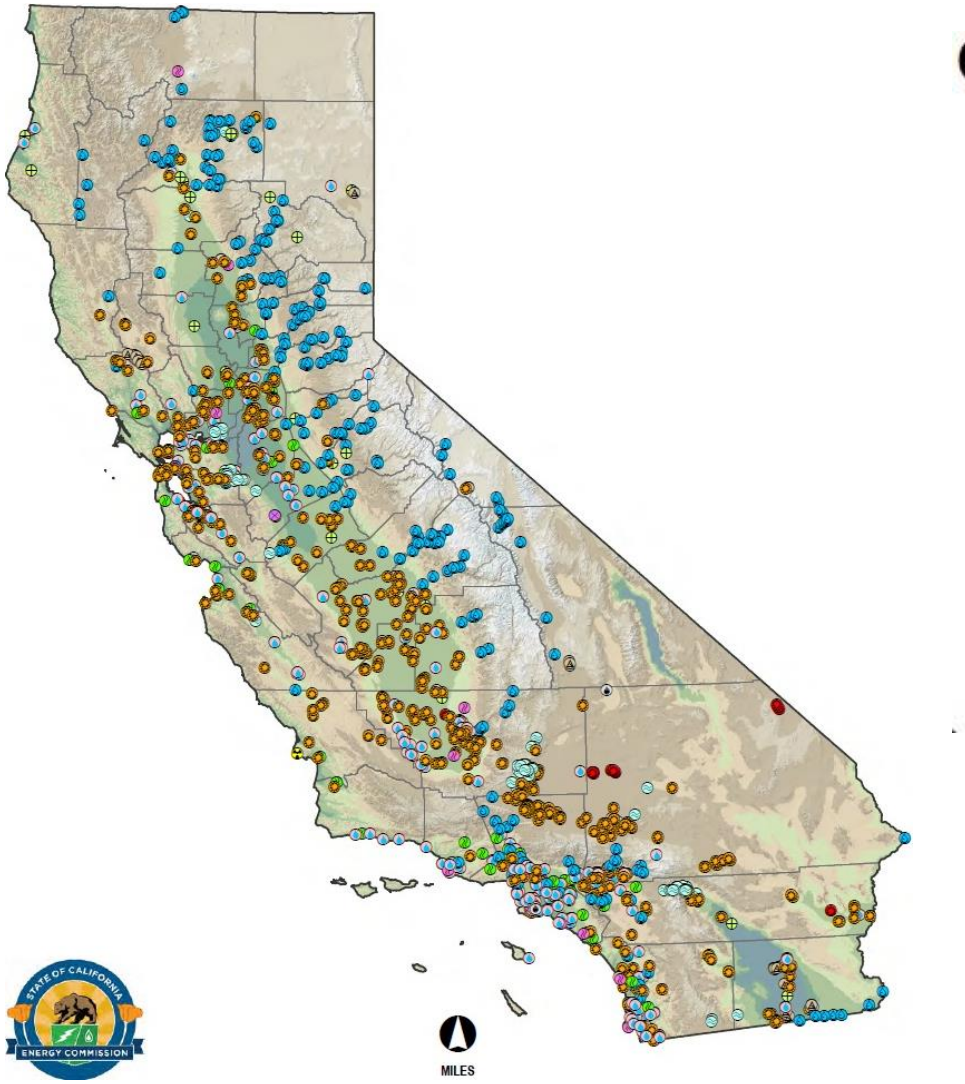
California Utility Power Generation



Operational Power Plants
January - 2017

- Biomass
- Coal
- Digester Gas
- Natural Gas
- Geothermal
- Hydro
- Landfill Gas
- MSW
- Nuclear
- Solar PV
- Solar Thermal
- Wind

Note: Power plants shown have a generation capacity greater than 1 MW
Source: California Energy Commission Cartography Unit

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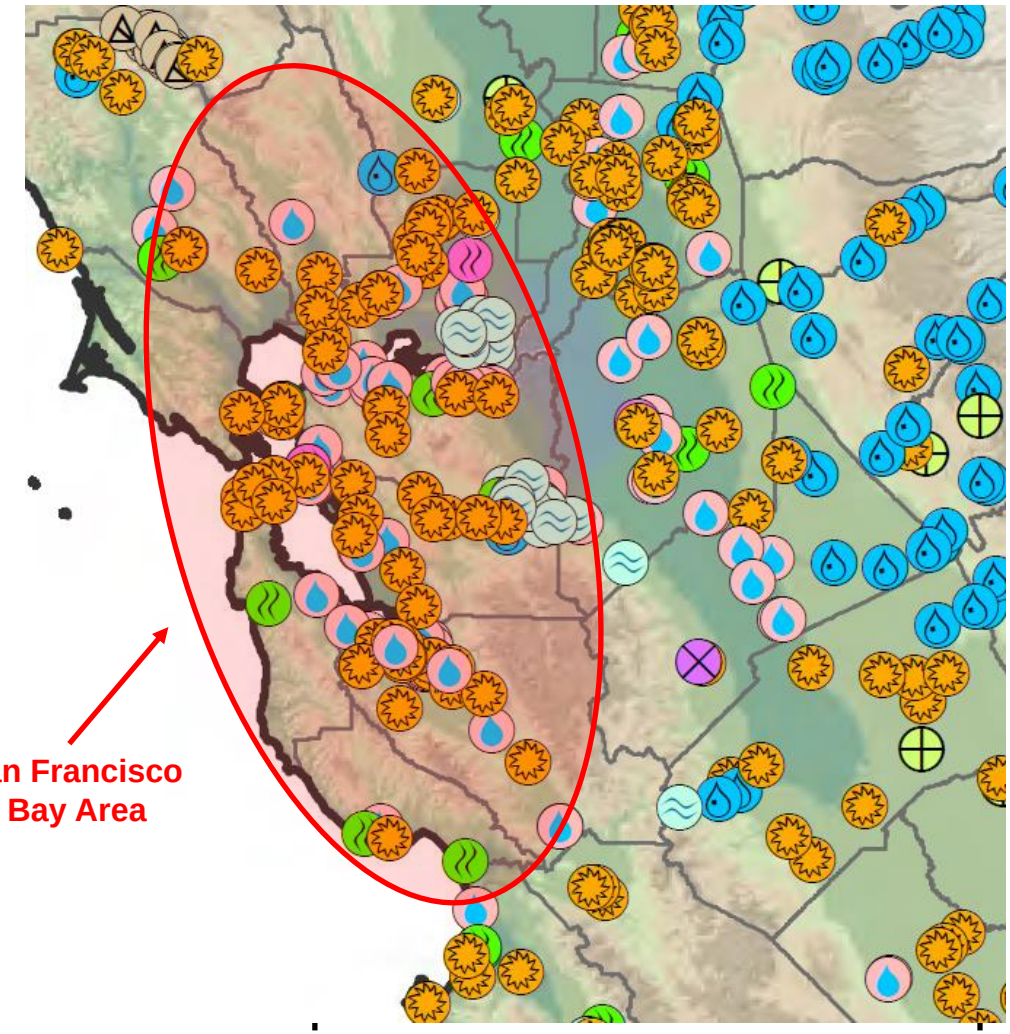
Northern California Power Generation



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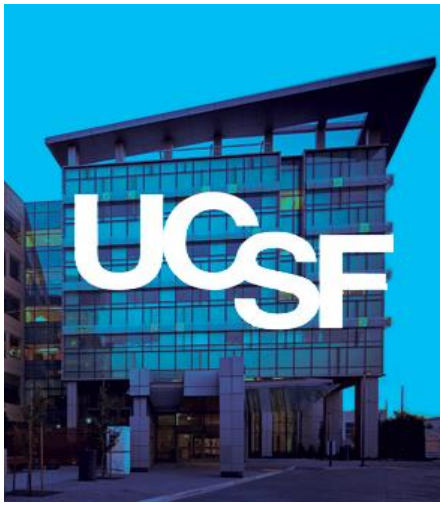
Case Study – UCSF Mission Bay

UC San Francisco, Mission Bay



- Utility Goals/Drivers:
  - Central Plant Replacement
  - Carbon Reduction (2025 Neutrality Goal)
  - Evaluate Various System Options

- Obstacles:
  - New Research bldg. needs expanded CW capacity
  - No funds available for utility upgrades
  - Existing assets in buildings, limited centralization/distribution

- Project Approach: BOOM Evaluation by 3rd Party Provider
  - Buy/Own/Operate/Maintain to relieve financial burden from UCSF

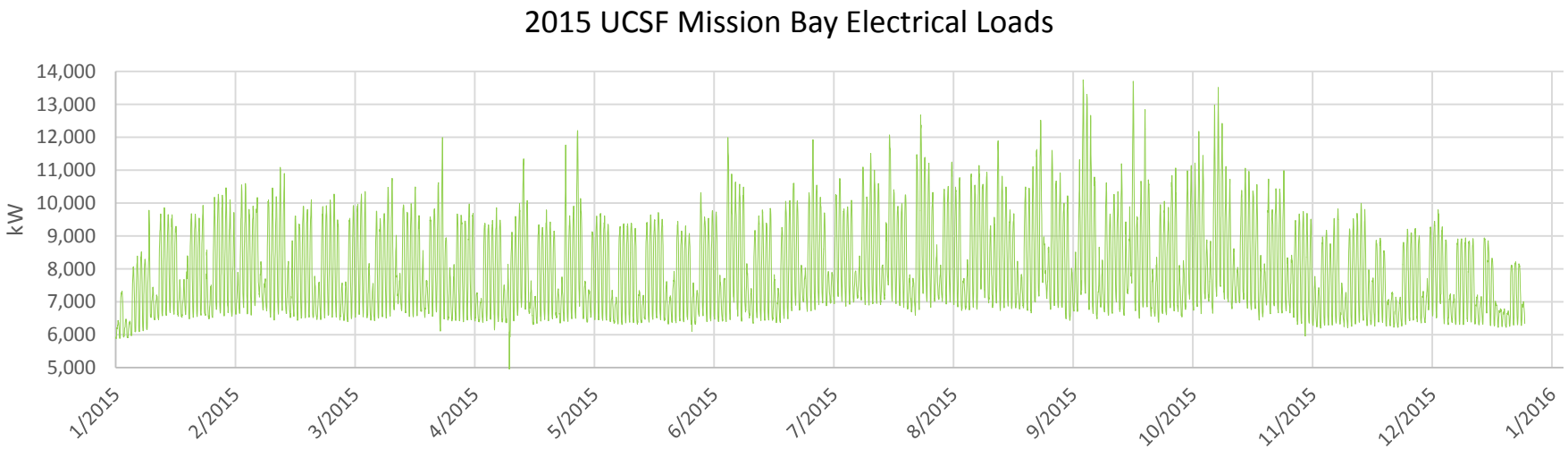
UCSF Mission Bay – Evaluation Approach

Grid Power vs. On-site Generation (CHP)

- PG&E w/ UC carbon accounting (~450 lb-CO_2/MWh lowest rate used)
- UCOP direct access program w/ 50% or 100% CO_2-free rates
- SFPUC w/ 100% carbon-free (hydro)

Financial Build-up of "all-in" cost per kWh must include:

- Rate tariff structure + carbon impact/offset costs (carbon-neutrality)
- UCOP DA @ 50% carbon-free = $0.126 / kWh ---- Others = $0.132+ / kWh



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UCSF Mission Bay – Solution

Energy Services Agreement (ESA) Basis

- Electricity, Hot Water, Chilled Water to UCSF
- High-efficiency Recip Engine = 49% elec. & ~75% CHP efficiency
- CUP replacement & distribution expansion w/ O&M
- CO_2 offsets to meet site Carbon Neutrality 2025 target

ESA rate MUST BEAT "all-in" grid cost of $0.126 / kWh

Optimization / Next Steps

- Battery Storage / Peak Shifting (GOOD) - $
- Eco-District Exploration w/ neighbors (BETTER) - $ + %
- Biogas Contracting Strategy (BEST) - %%%
  - Multi-year agreement for increasing carbon reduction

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Case Study – UCB Revisit

UC Berkeley – Preliminary Ideas

- Purchase of the Existing CHP
- No More “Grid Carbon Cleaning”
- Convert to “Behind the Meter” Power Production

Future Actions / Alternatives

- Contract for Renewable Electricity – GRID OPTION
- Contract for Biogas – CHP OPTION
- District Energy Infrastructure Replacement and Building ECM
  - Will need 3rd-Party ESA offering to accomplish

Case Study – UCB Option Evaluation

	BUSINESS AS USUAL (BAU)	CENTRALIZED CASES				NODAL CASES		
		NEW COGENERATION		NEW GAS FIRED BOILERS	NEW ELECTRIC BOILERS	HEAT RECOVERY CHILLERS AND GAS FIRED BOILERS	ELECTRIC CHILLERS AND GAS FIRED BOILERS	NEW COGENERATION TURBINE
CASE No.	0	2A	2B	6	8	1	3	4
DISTRIBUTION SYSTEM	STEAM EXISTING	HOT WATER NEW		HOT WATER NEW	HOT WATER NEW	HOT WATER CHILLED WATER NEW	HOT WATER CHILLED WATER NEW	HOT WATER NEW

Utility System Option		Purchased Electricity	Purchased Gas	System Efficiency	Total Carbon
0	Central CHP Retrofit (BAU)	3	7	4	7
2	New Central CHP	1	6	2	6
6	Central Gas Boilers	5	3	6	2
8	Central Electric Boilers	7	1	7	4
1	Nodal HR Chillers and Gas Boilers	6	2	1	1
3	Nodal Chillers and Gas Boilers	4	4	5	3
4	Nodal CHP	2	5	3	5

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Case Study – NorCal Biotech

SF Bay Area – Biotech Facility

- "True" Carbon Footprint in PG&E Utility Territory

PG&E Published Carbon Rates			
Full Asset Mix (Lowest)	Base-Loaded Marginal CHP	Must-Run Peaker Plants	CA E-Grid (reference)
450 lbs / MWh	810 lbs / MWh	940 lbs / MWh	623 lbs / MWh

Carbon Accounting Methodology

- Site assumes Marginal CHP rate for grid carbon rate
- On-site generation plays well…. *BUT*
- Pursuing Community Energy Programs for GREEN grid power
  - 50% carbon-free @ PG&E electrical rates
  - 100% carbon-free at a cost premium
  - Community programs in development, not executed yet

Biotech Case Study – Utility Approach

Utility Master Planning Drivers

- Increased Efficiency
- Energy Cost Reductions
- Resiliency
- Portfolio Flexibility (not all eggs in one basket)

All PROJECTS must meet min. financial requirements (TCO/NPV)

Multi-Use Campus

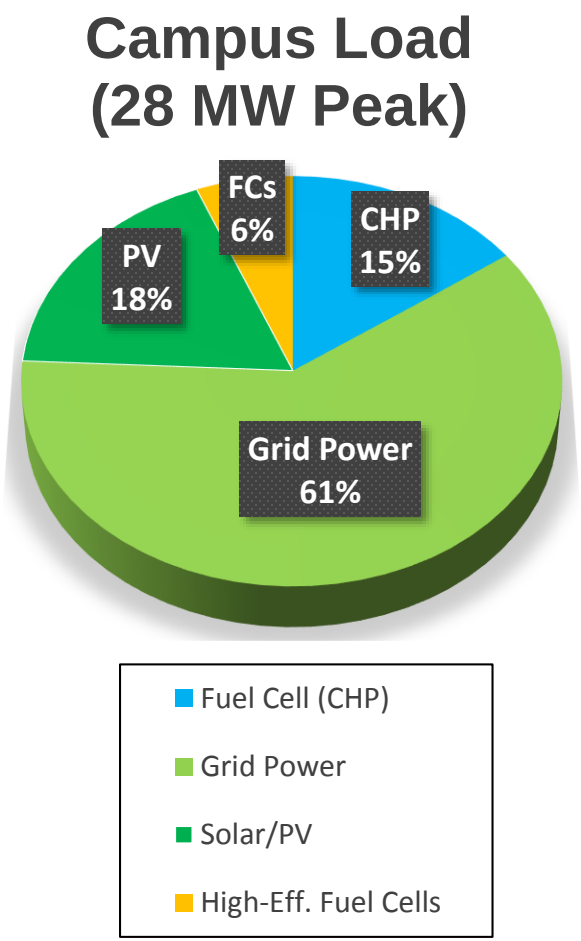
- Research Labs
- Production / Manufacturing
- Office Buildings

Biotech Case Study – Solution

Flexible Portfolio Approach

- 6 MW Distributed PV – Carbon-free
  - Office building areas (no thermal)
- 5 MW CHP via ESA – Natural Gas
  - Fuel Cell w/ 47% elec. & 71% CHP efficiency
  - Requires new 12 kV Microgrid & HW distribution
  - Manufacturing areas (large thermal loads)
- 2MW Small Fuel Cells – Natural Gas
  - 55%-60% electrical efficiency
  - Office / Lab areas
- Balance of Electricity via "Clean" Grid Power

Meet Carbon Goals + Utility Cost Assurance



Lessons Learned & Recommendations

- ✓ **Understand Carbon Metrics**
  - Accounting Methodology vs Global Impact
  - Push Efficiency ⬆⬆⬆

- ✓ **Understand Project Execution Options**
  - To Achieve Efficiency, Resiliency & Carbon Goals
  - Private Energy Companies & ESA offerings can be tools for overcoming financial hurdles

BE BOLD!

- Don't be Afraid to Push the Technological and Financial Envelope

BE CONNECTED!

- Use the IDEA Network of Owners, Operators, Service Providers

Questions & Answers

Thank you

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