What We've Learned Since 2007 - Efficiency, Load Management and De-Carbonization

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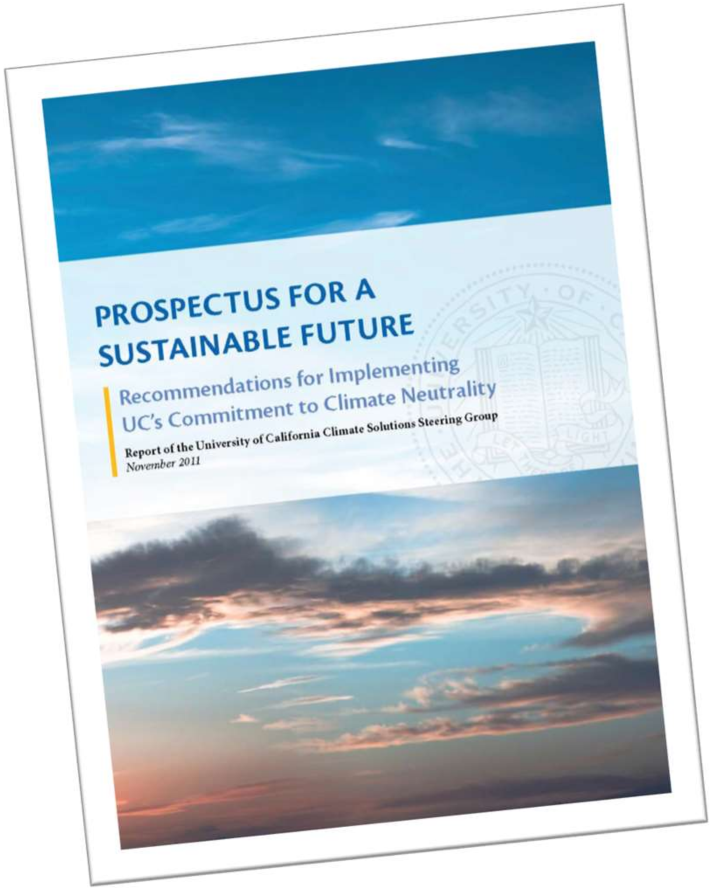


Three-Part Strategy

- Minimize demand through efficiency
- Procure biomethane to mitigate Scope 1 emissions
- Procure renewable energy to mitigate Scope 2 emissions

“Deep” Energy Efficiency

- Goal for efficiency retrofit projects = 50%
- Goal for new construction = outperform T24 by 50%
- How: “Smart” controls
- Why: 1. Efficiency = “First Principle”
  2. How can we afford decarbonized energy?

Key Components of a "Smart" Building

- Demand-controlled HVAC
- Many HVAC zones
- Right-sizing airchanges to minimize reheat, as well as cooling and ventilation energy
- Demand-controlled, high-CRI LED lighting and more efficient plug-loads

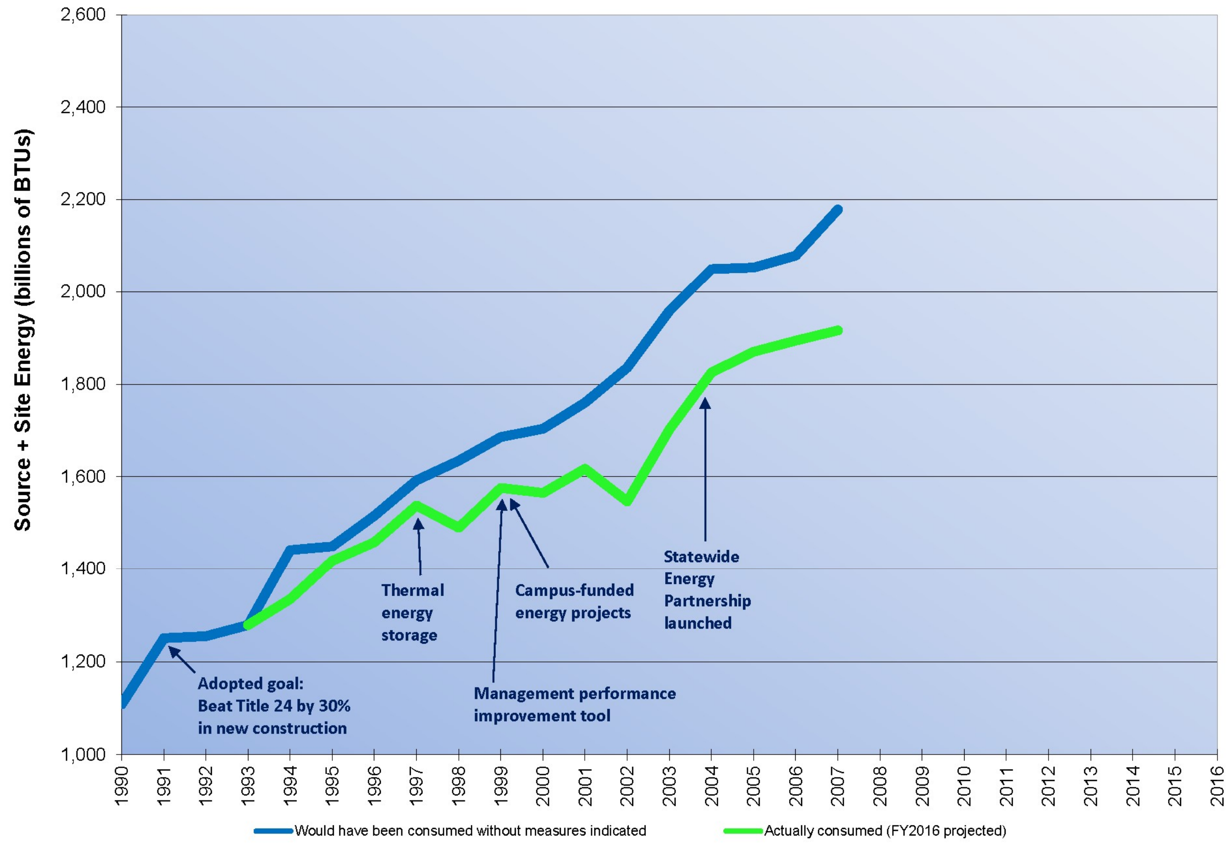
Energy Efficiency Impact Much Greater Than Expected

- Smart Labs > 60% energy reduction
- Lighting retrofits > 70% energy reduction
- Non-laboratory energy retrofits ≈ 40%
- Housing target 35% reduction

Mechanical System Energy Performance Requirements

Overall building energy performance	U.S. Green Building Council LEED Platinum
Air-handler face velocity / air-speed through filtration	300 ft. (91.4 m.)/minute maximum
Total HVAC pressure drop (supply+filtration+distribution +exhaust)	Labs: < 5 in. W.G. (1,250 pascals) Non-lab spaces: < 3.5 in. W.G. (875 pascals)
Static pressure setpoint reset (supply and exhaust)	Reduce static setpoints based on zone voting
Supply temperature setpoint reset	Raise supply setpoint based on zone voting
Air-handler and duct sound-attenuators	None
Minimum occupied lab air-changes per hour	4 air-changes/hour with contaminant sensing (Aircuity)
Minimum unoccupied lab air-changes per hour	2 air-changes/hour with contaminant sensing and reduced thermal conditioning during setback
"Purge" laboratory air-changes per hour	10-12 air-changes/hour when contaminants sensed
Laboratory exhaust stack discharge velocity	Requires wind study; design goal ~1,500 FPM; > 1,500 FPM when necessary during re-entrainment conditions
Exhaust stack height (labs)	As determined by wind study, minimum 10 ft.
Exhaust bypass damper (outside air into exhaust header)	Only activated by adverse wind conditions
Laboratory illumination power density	< 0.5 watt / sq. ft. including bench task lighting
Fume hoods	Occupancy controlled, low-flow/high performance
Heat-generating equipment exhaust	Exhaust grilles directly over equipment such as freezers, etc.
Non-laboratory (recirculating) HVAC delivery and outside air	HVAC delivery occupancy-based w/relief air CO_2-controlled

25 Years of Energy Efficiency



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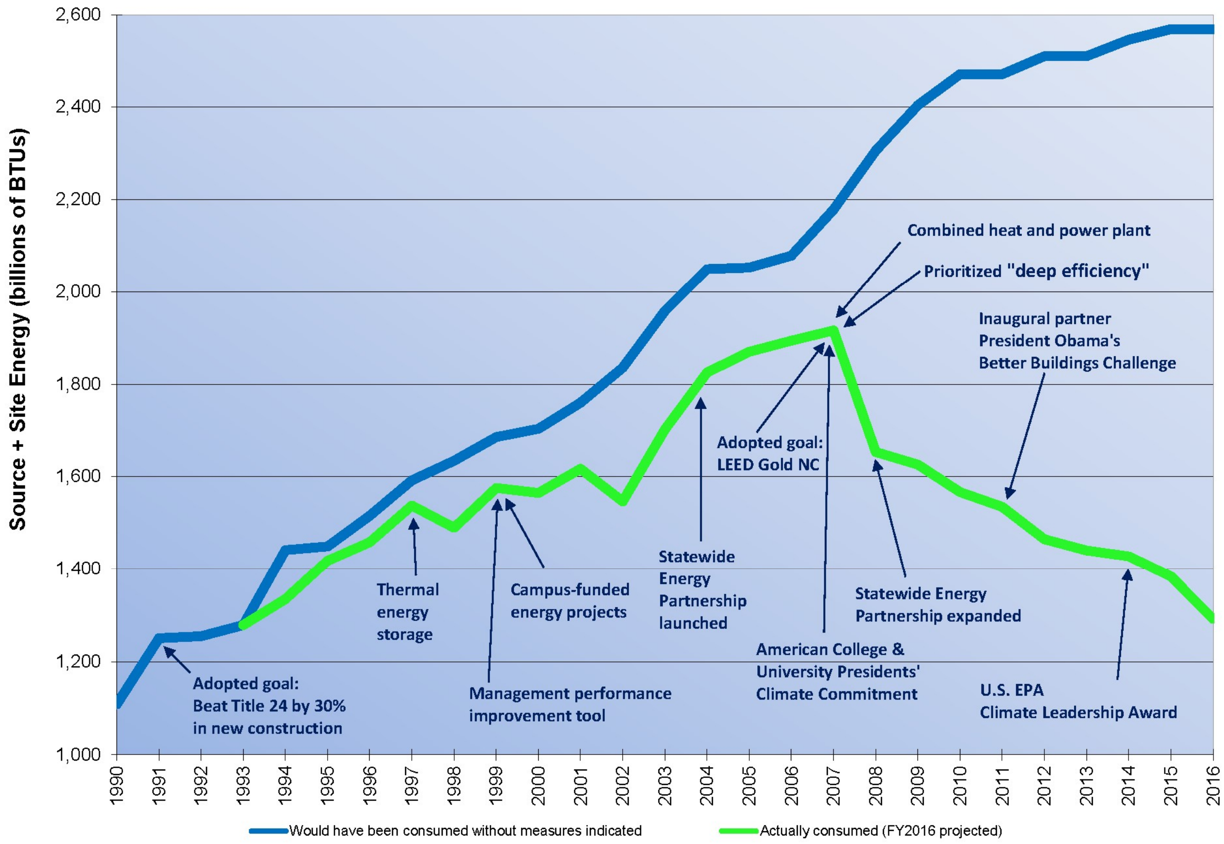
25 Years of Energy Efficiency



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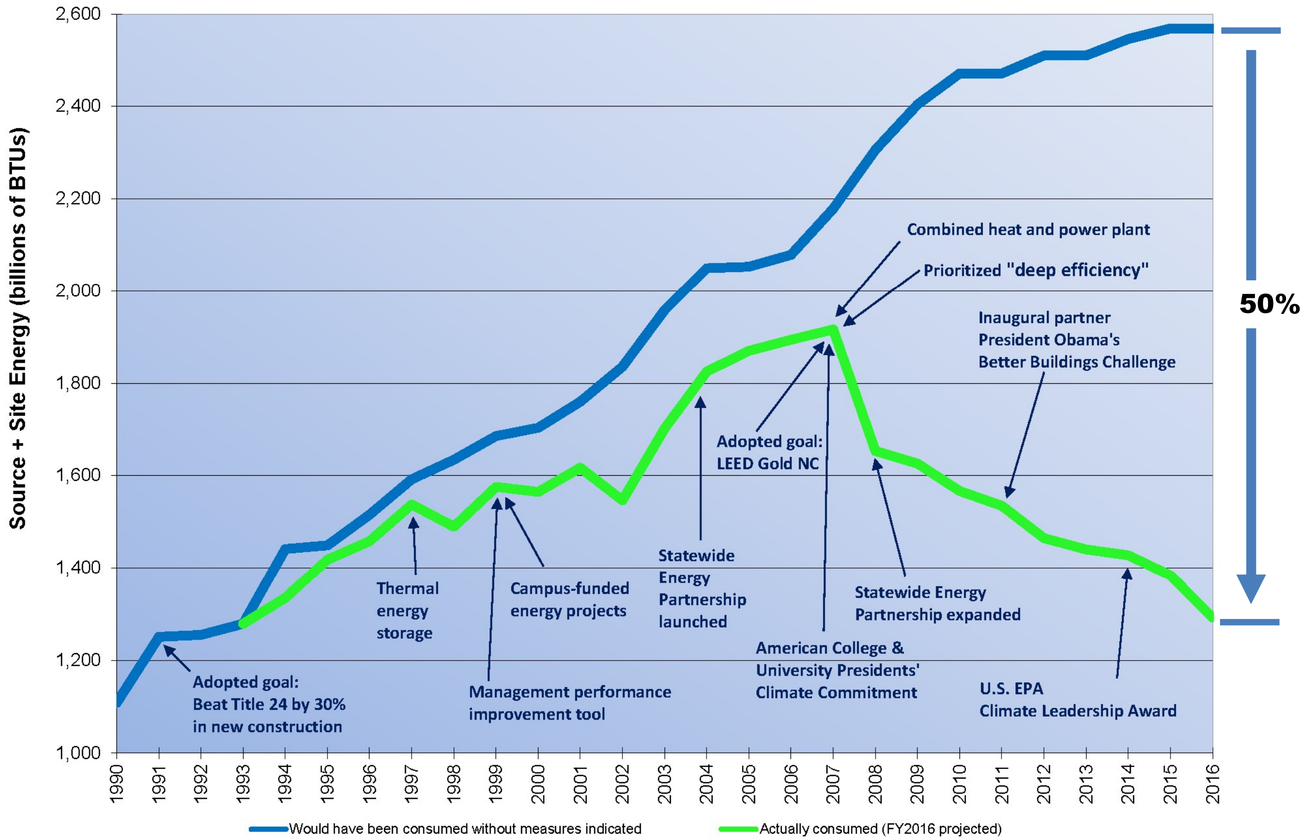
25 Years of Energy Efficiency



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Co-Benefits of Deep Energy Efficiency

- Many HVAC deferred maintenance problems fixed/funded through energy savings
- "Information layer" provides real-time commissioning and air quality track-record
- Lighting efficacy improved (especially labs, studio arts, clinical settings, streets)
- Quieter buildings inside and outside
- Cleaner indoor air
- Longer service life for heat-producing and friction-producing building system components
- Avoided capital investments for generation, central plant chillers, and infrastructure
- Deferred maintenance problems fixed/funded through energy savings
- Safer laboratories
- More reliable research infrastructure.

Lessons Learned

- Big goals change the culture, not just results at the margin
- Deep energy efficiency was attainable
- Waste had been designed-into mechanical systems
- Sensors and software enabled a new paradigm
- Some energy retrofits/redesigns yielded highly nonlinear savings
- Co-benefits ***much*** greater than expected

Do “Smart” Building Controls Provide a Demand-Response Opportunity?

Smart Buildings = Precision Control of Energy

Just enough energy, at just the right place, at just the right time!

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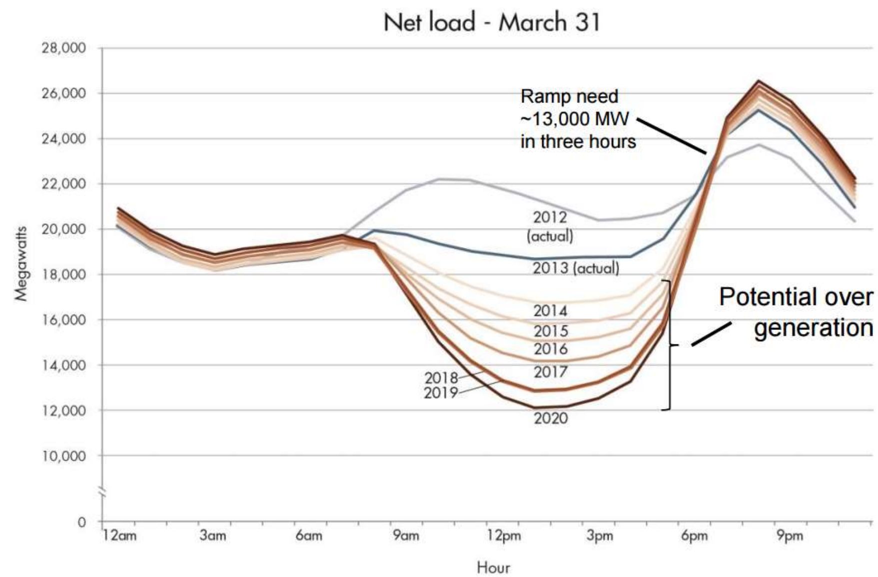
40 MWH of Storage

Managing demand as important as reducing

- Time-of-use pricing inevitable (and desirable)
- Efficient buildings provide limited demand-response
- Best form of energy storage may not be a battery!
- Demand management can radically reduce carbon footprint



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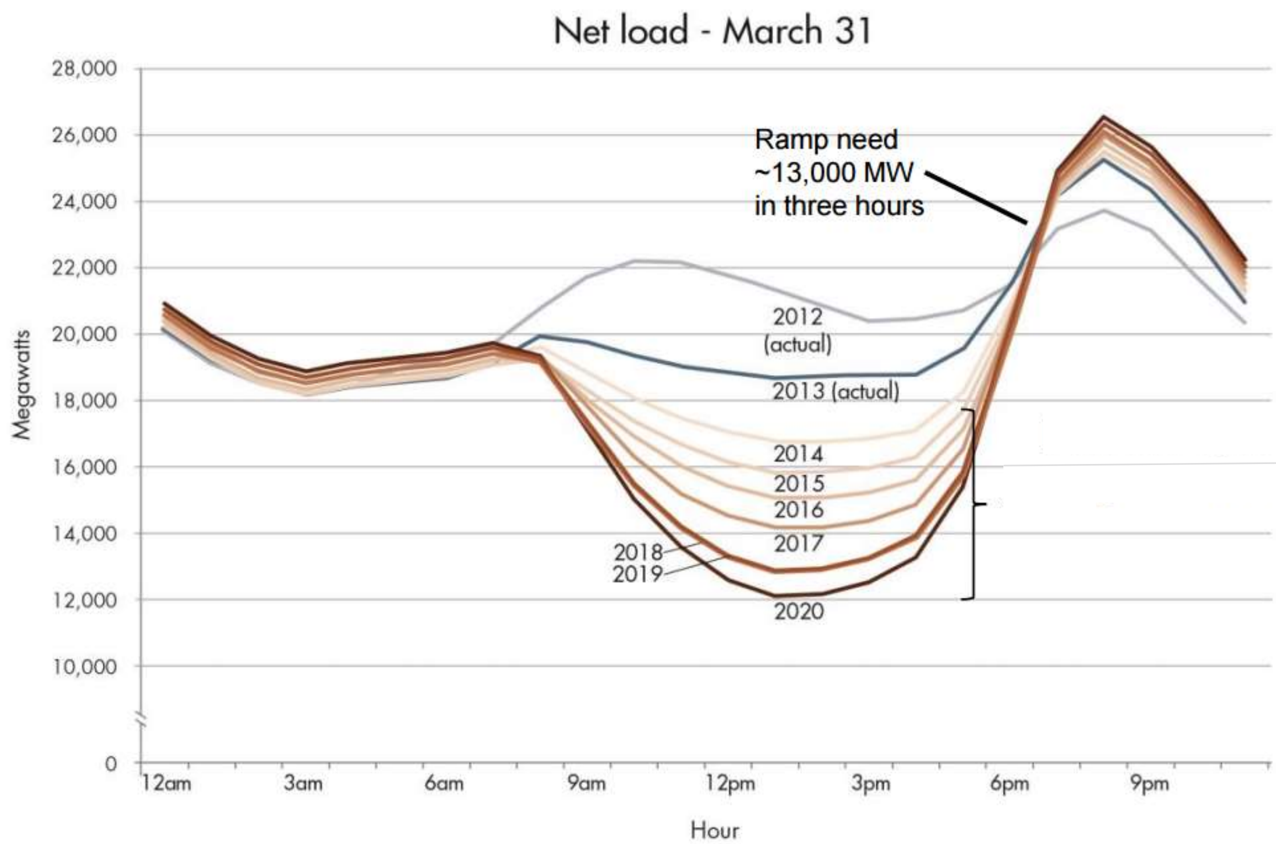
Exploiting the “Duck Curve” to Reduce Carbon Footprint



More Subtle Lessons Learned

- Attitude is as important as technology
- “Information layer” as important as control system technologies themselves
- Demand-response concept changed radically with “smart” buildings
- Demand management requires an ***enterprise*** solution
- Batteries not the best storage solution

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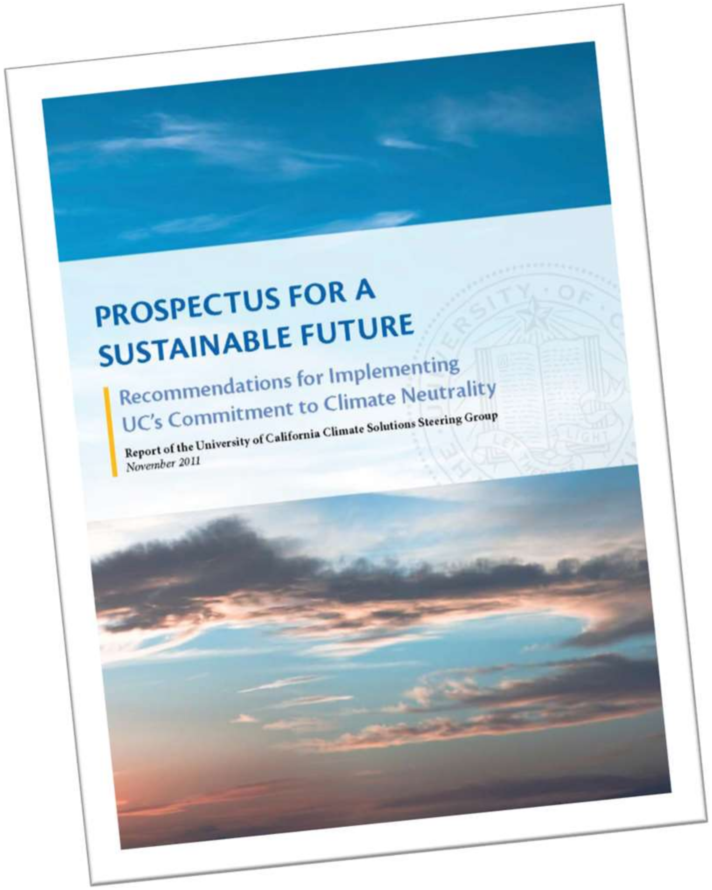

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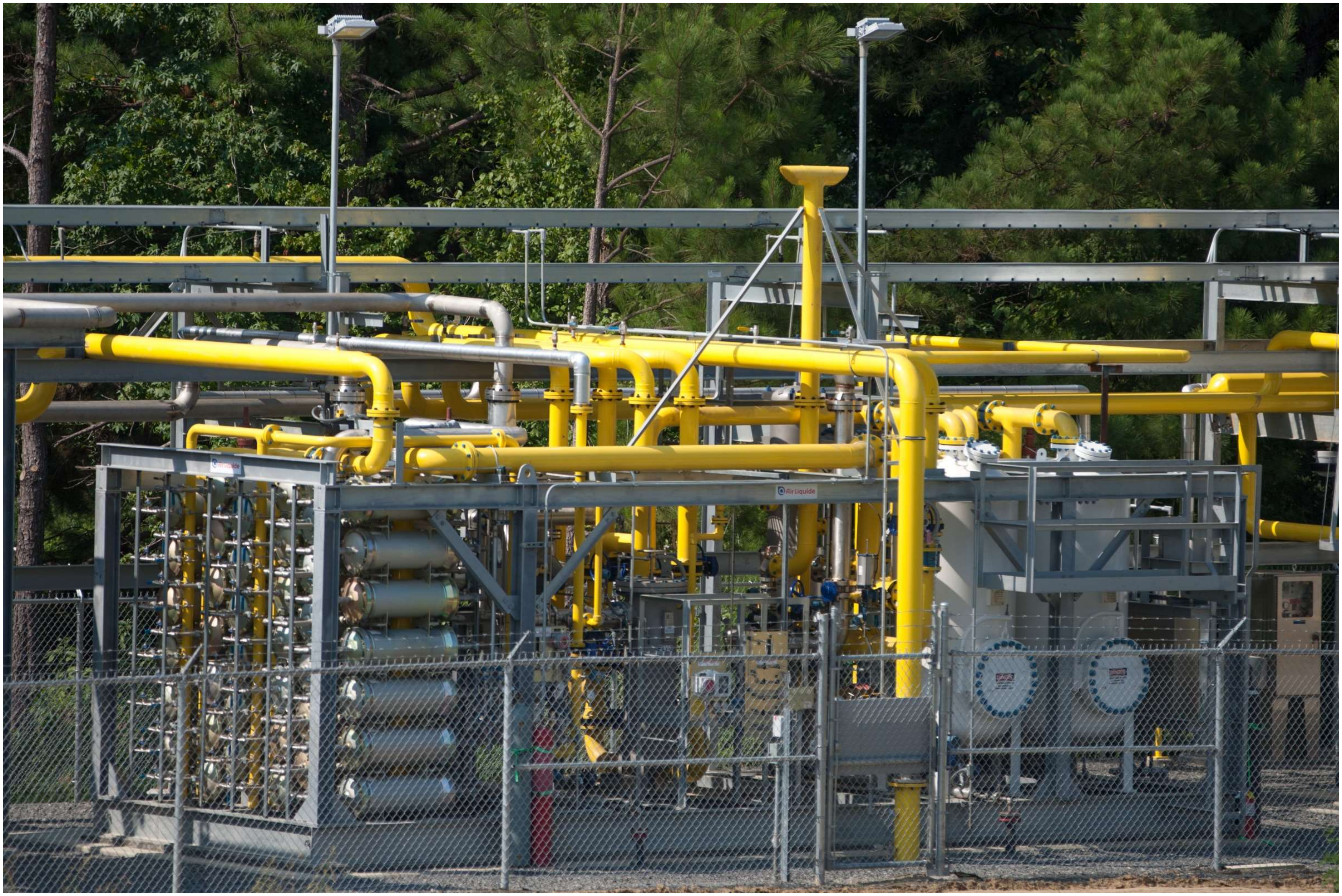
Biogas procurement not as easy as renewable electricity

- Not a mature market
- Natural gas real prices at prolonged low
- Delivery infrastructure costs


Air Liquide

Co-benefit: Methane Emissions Reduction

This Could Be a Game-Changer!

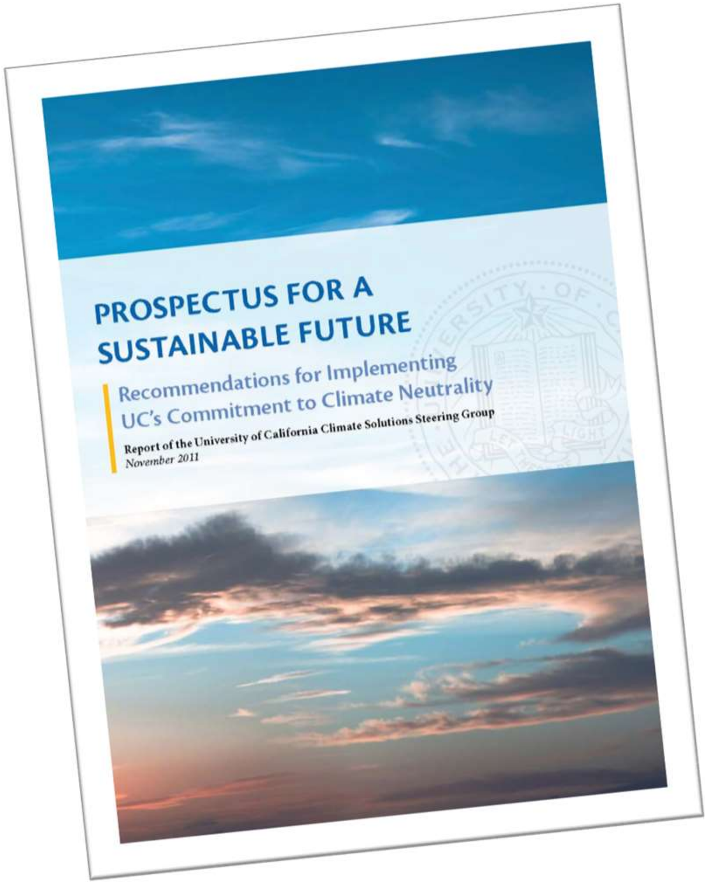
SoCalGas Announces Vision to Be Cleanest Natural Gas Utility in North America

Utility commits to delivering affordable and increasingly renewable energy to customers - Includes replacing 20 percent of traditional natural gas supply with renewable natural gas by 2030

Senate Bill 1383 requires 40 percent methane capture from California's waste streams -- from sewage treatment, and landfills, and agriculture, and dairies

UCI Carbon-Capture Symposium

- Bob Mroz, President of Bio-Tek, a Baltimore startup firm
- Jack Brouwer, Professor of Mechanical, Aerospace, and Environmental Engineering and Associate Director of the UC Irvine Advanced Power and Energy Program
- Professor Jenny Yang, UCI Chemistry
- Dr. Sahag Voskian, Chemistry Department, MIT
- Gaurav Sant, Professor of Engineering at UCLA
- Liang-Shih Fan, Distinguished University Professor of Chemical and Biomolecular Engineering, The Ohio State University



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Phase III
Puerta del Sol
Phase IV-A & IV-B
Plaza Verde
Phase II
Vista del
Campo
Norte
Phase III
Parking
Structure
Phase III
Camino del Sol
Phase I
Vista del
Campo
Potential
Additional
Phase

How Do We Pay for Exemplary Energy Efficiency in New Buildings?

Cost-Control & Savings Opportunities	Areas Into Which Savings are Redirected
Sensible ratios for floorplates & exterior “skin”	“Smart Labs” energy design standards
Cost-effective architectural detailing and articulation strategies	Small, demand-controlled HVAC zones for comfort as well as efficiency
Consolidate/separate non-laboratory functions into adjoined structure	LEED Platinum
Generic, modular approach to laboratory design	Outperform Title 24 by >> 20%
Moderate column-spacing in laboratory structures for cost-effective vibration control	Stretch goal to outperform Title 24 by 50%
Avoid unconventional structural, seismic, and foundation systems	Robust laboratory core infrastructure systems to support inexpensive future modifications
Unconditioned exterior stairways (weather-protected)	Durable materials and system quality to avoid major maintenance expenses
Avoid custom-fabricated, exotic, specialized materials	Long-life/low maintenance exterior finishes
Conventional interior finishes	High-quality teaching spaces
No floor coverings in laboratories	Stainless steel flashings
Generic acoustical materials	Durable hardware and interior finishes
No sound absorption in partial-height partitions or walls w/doors	Operable office windows (w/HVAC interlocks)
Downsize HVAC due to sun shading	Quality hardscape and landscape features
Essentially eliminate window coverings if electrochromic glass is used	Sound isolation where needed (e.g., offices)
Eliminate exterior wall insulation, furring, sheetrock, and paint	Weather-protection canopy to extend life of roof-mounted equipment
	Sun-shading 85% overall annual effectiveness
	Exterior walls ≥ 12 in. concrete integral color, exposed both sides

Feasibility Success Factors

1. Adopt a challenging goal and aggressive sub-goals
2. Technology
3. Questioned status-quo design practices
4. Targeted energy waste that was built-into building systems
5. Made intentional, explicit trade-offs to fund life-cycle performance
6. Assumed that de-carbonized energy might cost 2X status quo

Awards and Recognitions

SIERRA The national magazine of the Sierra Club

CLIMATE AND ENERGY | LANDS AND WATERS | ADVENTURE | GREEN LIFESTYLE | MAGAZINE | SUBSCRIBE

UCI Sustainability Recognitions & Awards

- ***Sierra* Magazine**'s top ten "Coolest Schools" ten consecutive years
- **Princeton Review**'s Green Honor Roll six consecutive years
- **CA Governor**'s Environmental & Economic Leadership Award – Climate Change (2008)
- **CA Governor**'s Environmental & Economic Leadership Award – Leadership (2013)
- **EPA** Climate Leadership Award (2014)
- **President Obama**'s Better Buildings Challenge: first to improve efficiency 20% (7 years early)
- **Clean Air Excellence Award** in Transportation Efficiency from the U.S. EPA (2016)
- Best Practice Award for Sustainability in Academics (2016) and New Construction (2017), **California Higher Education Sustainability Conference**
- **APPA**'s Sustainability Award in Facilities Management for sustainability excellence (2012)
- **Second Nature** Climate Leadership Award (2011)
- **Urban Land Institute**'s "Best of the Best" Award for campus wide sustainability (2011)
- **NACUBO** Innovation Award for Energy Efficiency (1996)
- Gold level Bicycle Friendly University designation from **League of American Bicyclists** (2016)
- **National Arbor Association** "Tree Campus" designation nine years

QUESTIONS?

   

Presented Wednesday, April 22, at CalPlug 2020 Virtual Workshop

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Formal Assessment at Financial Cross-roads when Co-generator is Amortized

- Progress toward gas de-carbonization
- Feasibility of procuring more biogas
- Feasibility of on-site carbon capture
- Electrification of carbon-emitting plant equipment
- Hydrogen co-generation
- Emergent technologies