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CASE STUDY – A NEAR-ZNE COMMERCIAL BUILDING USING CHP

The Resort, a LEED Platinum recreational facility has both CHP and solar PV for energy and environmental benefits

2019 ACEEE Hot Water Forum, Nashville, TN

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PROJECT OBJECTIVES

» A Case Study

- A "near-Zero Net Energy" demonstration
- 3-year real data results

» Questions to Address

- Can a LEED Platinum certified **building** be more efficient?
- Look outside-of-the-box; what-if we include ancillary systems process loads in the whole **campus**
- Better or worse if burning more natural gas? How much is too much?

» Purpose

- To integrate combined heat and power (CHP,) a clean natural gas technology to renewable solar PV in getting closer to ZNE
- To discover obstacles and explore potential solutions
- To find a pathway in the California ZNE policy-making

Disclaimer

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Acknowledgment and Partnership

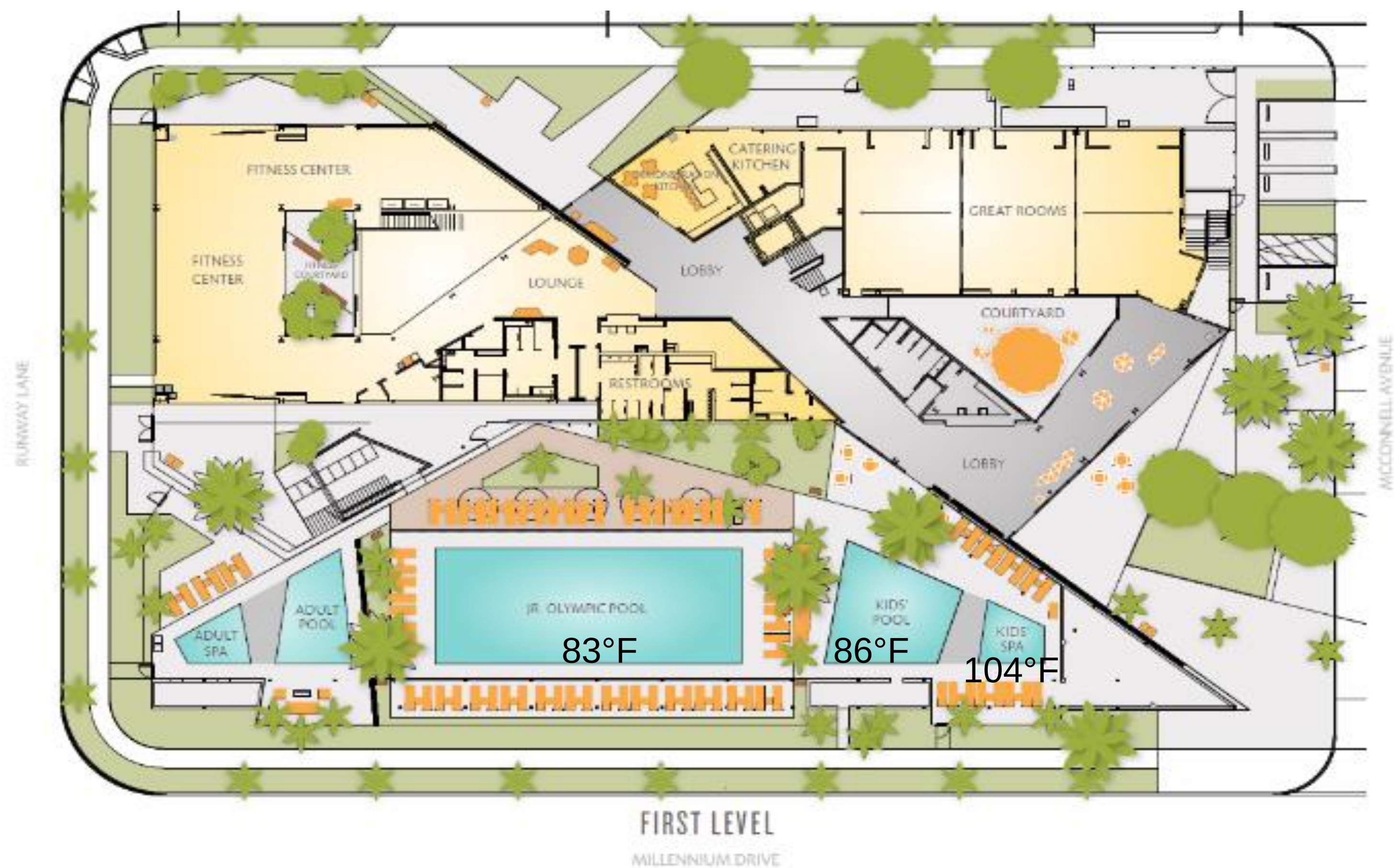
- Brookfield Residential
- Playa Vista Home Owners' Association
- SoCalGas
  - R&D
  - Emerging Technologies Program
  - Engineering Analysis Center
- Los Angeles Department of Water & Power
  - Emerging Technologies Program

Quiz: How many Therms a day do you use at home? Pool and spa use?

BACKGROUND

- » California Energy Efficiency code Title 24 uses Time Dependent Value (TDV) to measure compliance/permit
- » Zero Net Energy (ZNE) definitions – site vs. source
- » California Energy Efficiency Long Term Strategy Goals
  - Action Plans are being developed currently
- » California Public Utility Commission (CPUC), California Energy Commission (CEC), and Integrated Energy Policy Report (IEPR) call for demonstrations and advocate **community** or **campus** based solutions
- » Department of Energy (DOE) publications: ZNE at source for all loads on site

The Resort
AT PLAYA VISTA



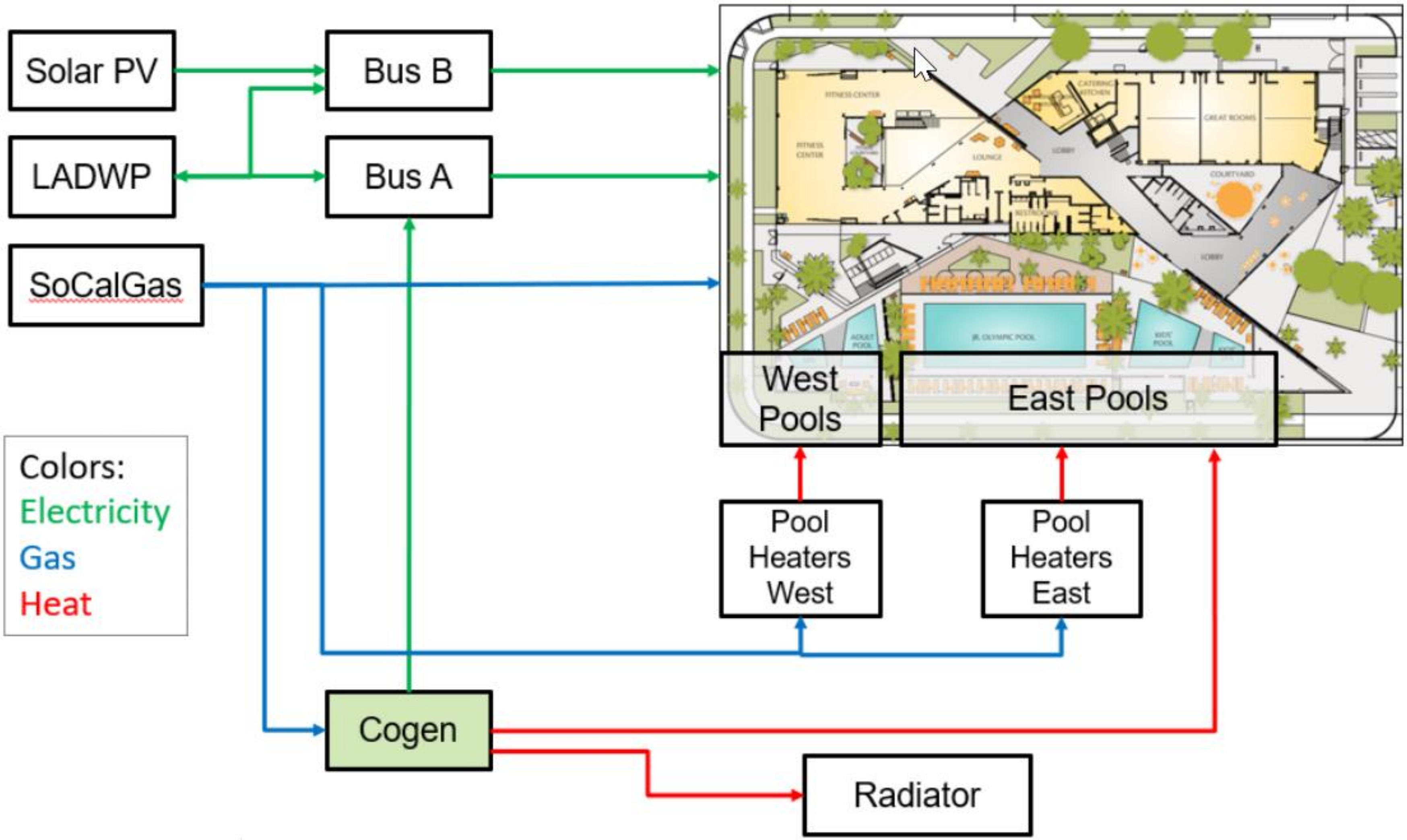
PLAYA VISTA

Illustration is artist's conception only, not to scale and subject to change. Space and room uses are subject to change.

Brookfield Residential

Source: http://blog.playavista.com/wp-content/uploads/2014/08/Playa-Vista-The-Resort-Floorplan.pdf

Energy Flow at The Resort



Project Obstacles

1. **Joined late, had to revise construction permits**
   - First recent civilian application in DWP service territory; permitting agencies were not familiar
   - Design team coordination priorities and experience
2. **Electric tariff requires dedicated meters & separated loads for PV/CHP**
   - Elec-load profile does not match easily with the CHP-heat profile
   - Occupancy is not 24 hours
3. **The original pool equipment has been replaced extensively in Year 1-3**
   - Water flows to harvest CHP-heat is passive
   - 208 versus 230V; pump motors changed out; pool heaters replaced

Despite all challenges, we still managed to produce energy savings and environmental benefits. Brookfield No. Cal. called, with interest to replicate.

Solutions

Current generation strategy is working:

» Run CHP at high and mid-peaks, following the electric rate schedule and load.

» CHP heat taking priority over pool heaters when available

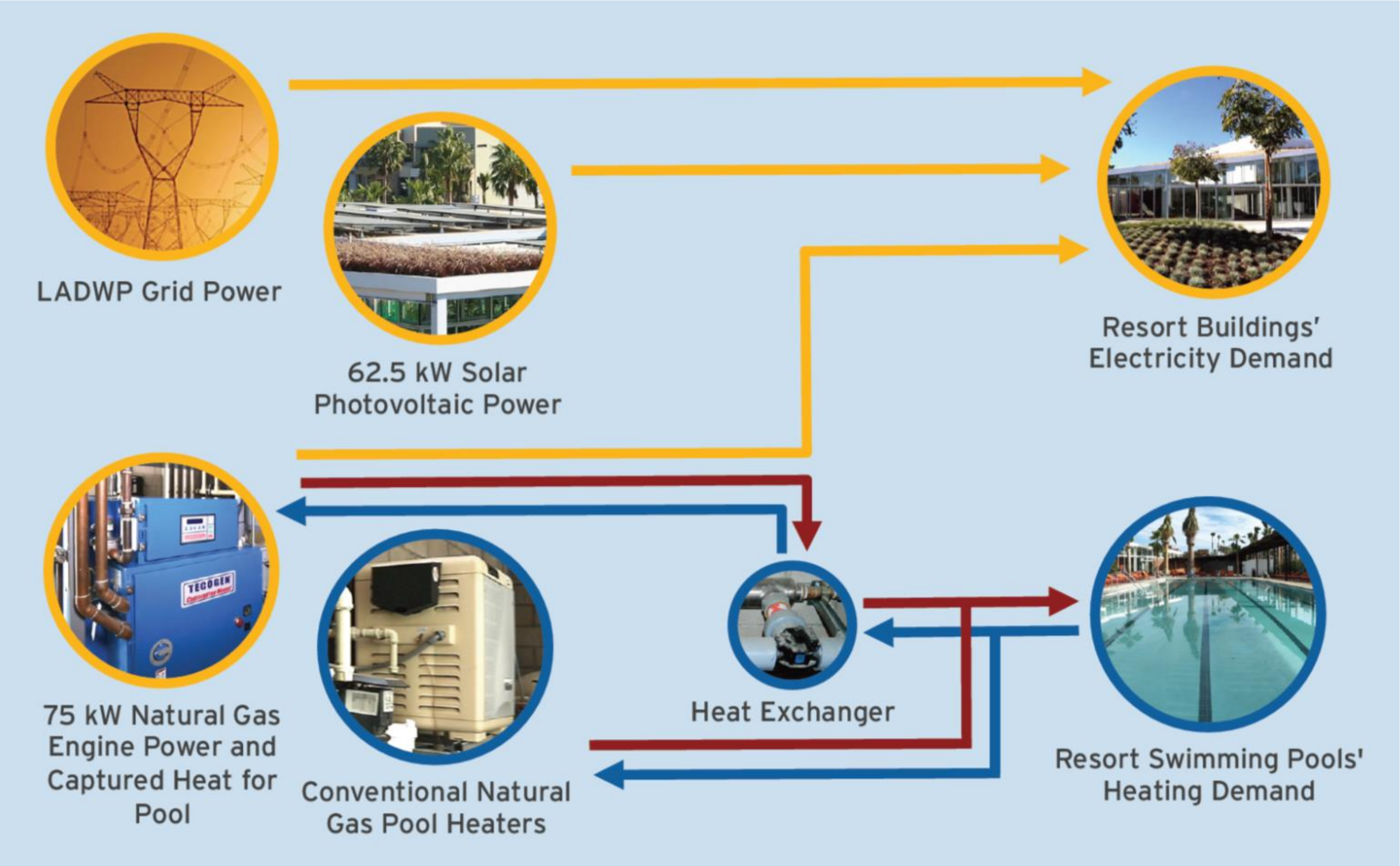
» Load and usage increasing yearly – to adjust controls accordingly

» Utility assisted operations troubleshooting using a dashboard big data

Green Roofs &
Solar Photovoltaic (PV) Panels


THE RESORT

Combined Heat and Power (CHP) System



CHP System

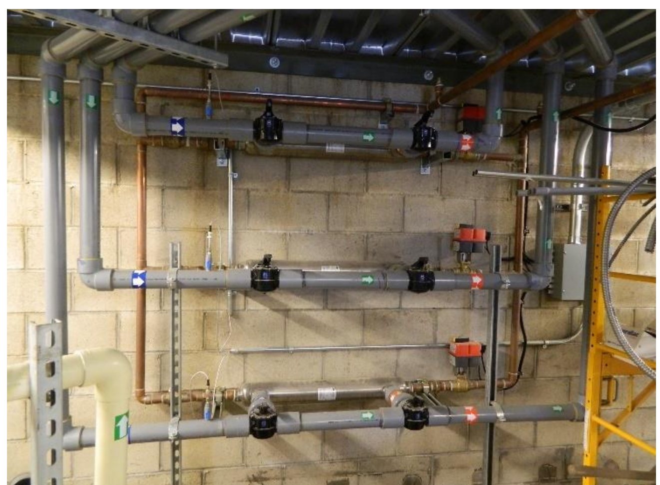
CHP enclosure

Control logic: Electric load following, net export not allowed

CHP console

CHP exhaust

Controller and Data communication center



CHP heat exchangers

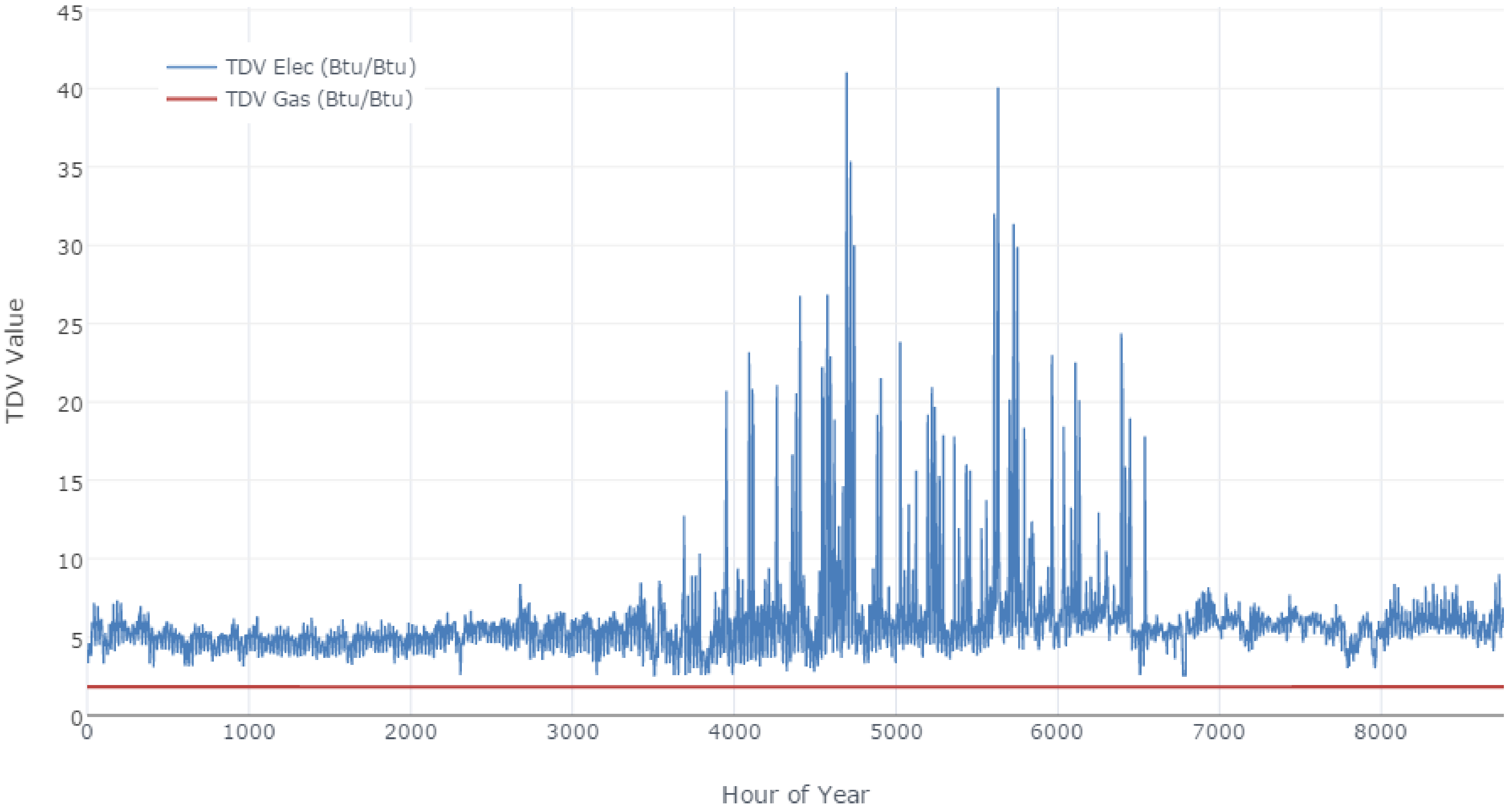
CHP Engine

The Dashboard

Dashboard Internet Link
http://buildingdashboard.com/clients/playavista/

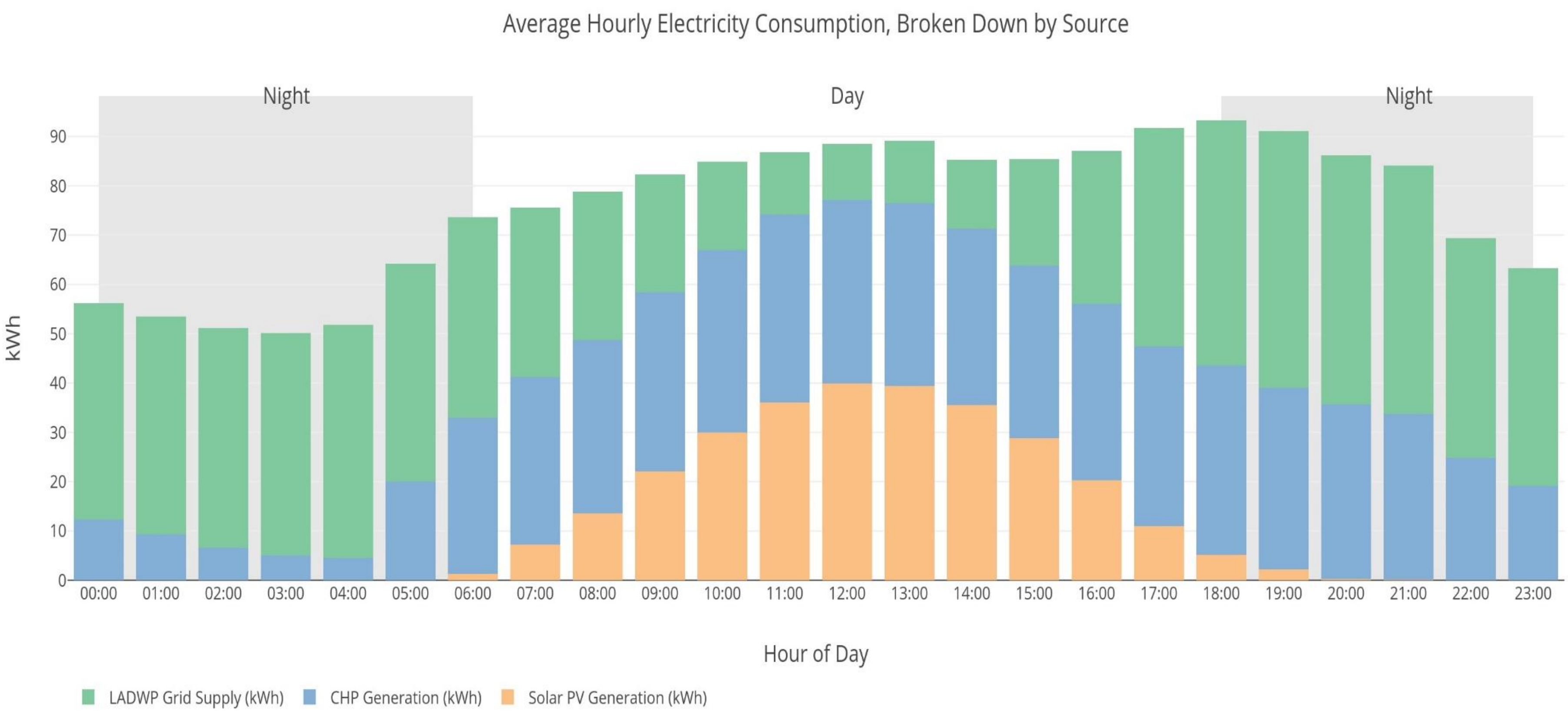
TDV 8760 Hours, Design Year 2010

Project Site Climate Zone 6



AVG. HOURLY ELECTRIC POWER MIX

Jan. 2017-Jan. 2018



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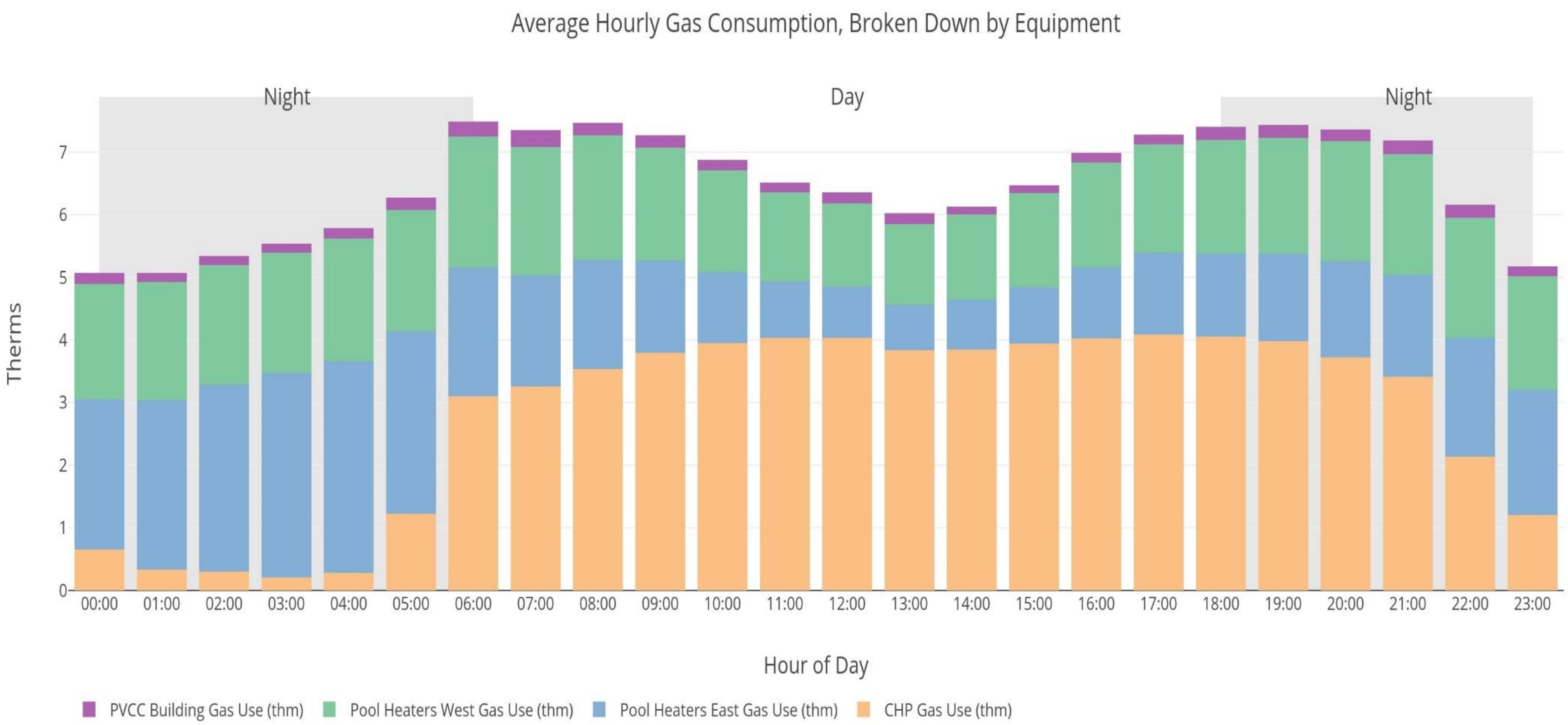
AVG. HOURLY NATURAL GAS USE MIX

Jan. 2017-Jan. 2018

Quiz: How many Therms a day do you use at home? Pool and spa use?



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Onsite Generation Results: PV increased, CHP stay steady

Measured Energy (including Process Loads)	Year 1	Year 2	Year 3	Unit	% Change Year 2 to Year 3
Electricity Used, Total	544,762	632,128	710,032	kWh	12%
From Grid	276,730	335,016	305,723	kWh	-9%
From Solar PV Generation	55,487	92,440	106,614	kWh	15%
From CHP Generation	212,546	204,673	297,695	kWh	45%
Natural Gas Input, Total	51,662	49,291	62,755	thm	27%
Used by CHP	26,768	24,515	38,110	thm	55%
Used by Building	1,164	1,047	915	thm	-13%
Used by Pool Heaters (estimated)	23,729	23,729	23,729	thm	0%

ZNE Results: CHP & PV Contribution

TDV for the main building w/o process is 11,858,162 kBtu/yr in the compliance certificate. It is 54% of the adjusted campus-wide total 21,822,091 including process loads, such as pool pumps and heating.

	Scenario	kBtu/yr	Difference from Baseline	Remarks
Year 1	Code Standard (2010)	21,822,091	Baseline	Main building as simulated* + Actual Year 1 process loads
Year 1	Proposed Design, 12 months	20,388,276	-6.60%	
Year 1	Total Onsite Generation	3,180,737	-14.60%	Sep. 2015-Aug.2016
Year 1	CHP	1,845,387	-8.50%	3/5 of total
Year 1	Solar PV	1,335,350	-6.10%	2/5 of total
Year 2	Scenario	kBtu/yr	Difference from Baseline	Remarks
Year 2	Code Standard (2010)	22,284,785	Baseline	Main building as simulated* + Actual Year 2 process loads
Year 2	Proposed Design, 12 months	20,832,711	-6.50%	
Year 2	Total Onsite Generation	4,064,020	-18.20%	Sep. 2016-Aug.2017
Year 2	CHP	1,809,542	-8.10%	2/5 of total
Year 2	Solar PV	2,254,478	-10.10%	3/5 of total
Year 3	Scenario	kBtu/yr	Difference from Baseline	Remarks
Year 3	Code Standard (2010)	21,964,013	Baseline	Main building as simulated* + Actual Year 3 process loads
Year 3	Proposed Design, 12 months	20,512,004	-6.60%	
Year 3	Total Onsite Generation	3,633,065	-16.50%	Sep. 2017-Aug.2018
Year 3	CHP	1,060,804	-4.80%	1/3 of total
Year 3	Solar PV	2,572,261	-11.70%	2/3 of total

Environmental Results
CHP & PV Contributions & Weights

Emissions Reduction from Onsite Generation	Year 1		Year 2		Year 3	
(lbs)	CHP	Solar PV	CHP	Solar PV	CHP	Solar PV
NOx	199	25	193	42	217	49
CO_2	55,547	60,532	69,686	100,844	-981	116,307
CH_4	17	5	17	9	23	10
N_2O	3	1	3	1	4	1
CO_2e	56,732	60,886	70,842	101,435	601	116,988
% of Total CO_2e	48%	52%	41%	59%	1%	99%

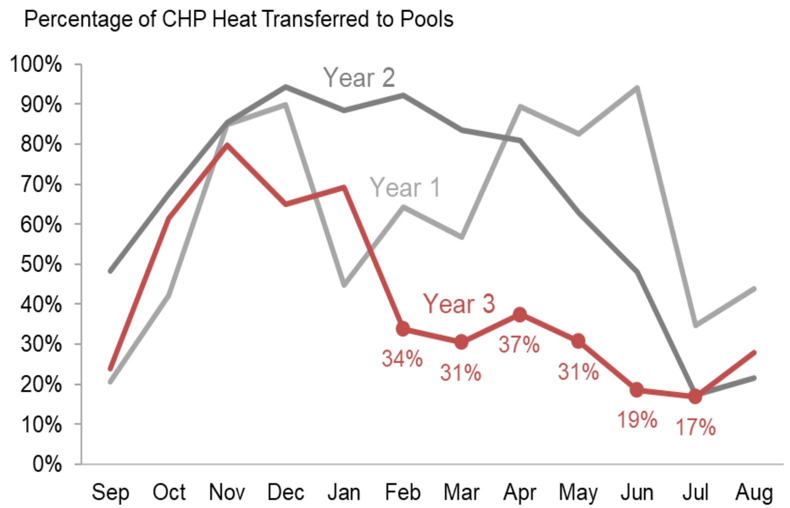
Note: Sensitivity analysis revealed if CHP-heat utilization increases by 1%,the CO_2 reduction credit in Year 3 will become positive.

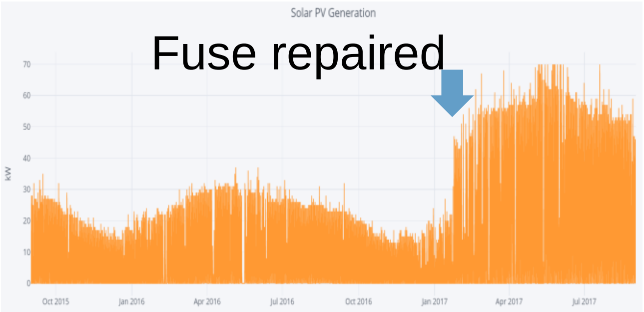
Variables in Onsite Generation

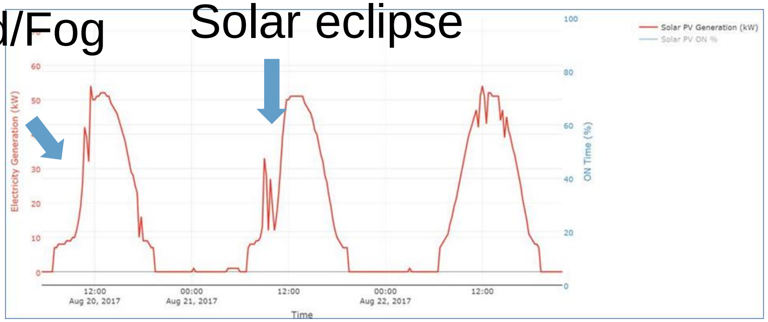
CHP follows electric load; PV follows the Sun

CHP	Useful Heat (thm)	Waste Heat (thm)	% Used
Year 1	9,581	5,346	64%
Year 2	9,328	4,569	67%
Year 3	8,401	12,094	41%

PV	Average Output (kW)	Rated Output (kW)	Load Factor
Year 1	6.32	62.5	10%
Year 2	10.54	62.5	17%
Year 3	12.10	62.5	19%







Operators are implementing changes

Owner's Perspective
CHP/PV Incremental Cost-Benefit

The cost and savings are approximately

CHP Savings Subtotal	Year 1	Year 2	
CHP fuel, commodity and transportation	($17,016)	($17,984)	
O&M, as an insurance and evergreen reserve	($10,071)	($10,733)	
Avoided pool heater fuel	$12,972	$11,564	
Avoided grid power, consumption component only	$22,724	$28,843	
Net Savings/Year	$8,609	$11,690	★

Solar PV Savings Subtotal	Year 1	Year 2	
Avoided grid power	$5,981	$12,901	★
O&M and evergreen insurance or overhauls	$? >0	$? >0	

- Demand savings not included

★ - Equally important

Other Costs not included are:

- Natural gas biannual emissions testing cost
- Staff training
- The initial one-time construction costs

Lessons Learned

1. Clean natural gas CHP can reduce TDV, carbon, and emissions; w/robust availability and resilience
2. Natural gas technologies can work with renewable and electric technologies harmoniously
3. Traditional pool E/M designs need to be industrial grade, instead of residential grade
4. Load and onsite generation need close match for the maximum benefit
5. Process loads are very significant and pivotal in ZNE initiatives and campus-based solutions
6. Codes & standards, rate design, and net metering solutions are needed for community based ZNE.

Q&A

» Dashboard Internet Link

http://buildingdashboard.com/clients/playavista/

» Contact

- Joe Shiau
- Emerging Technologies Program
- SoCalGas
- (213) 244-4130
- ysshiau@semprautilities.com

Appendix

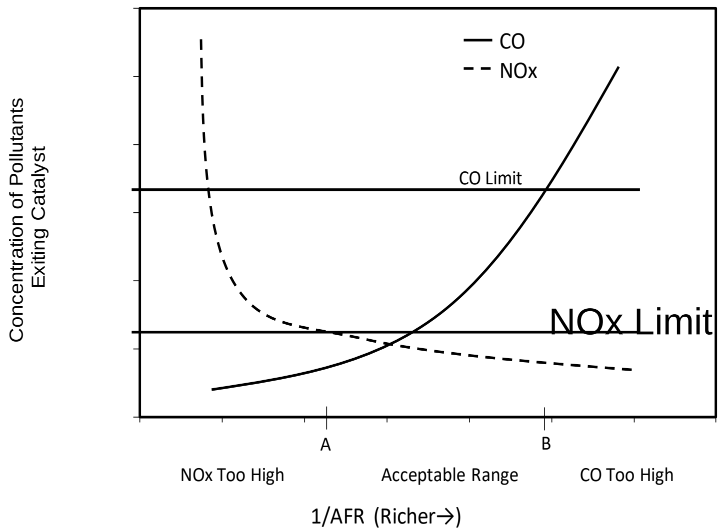
- CHP equipment performance data
- Catalytic converter was developed by the manufacturer with SoCalGas RD&D assistance and demonstrated in a CEC project

- Technology supply pipeline:
- R&D > Emerging Tech Program > EE Program

Ultra-clean Emission Control for the CHP

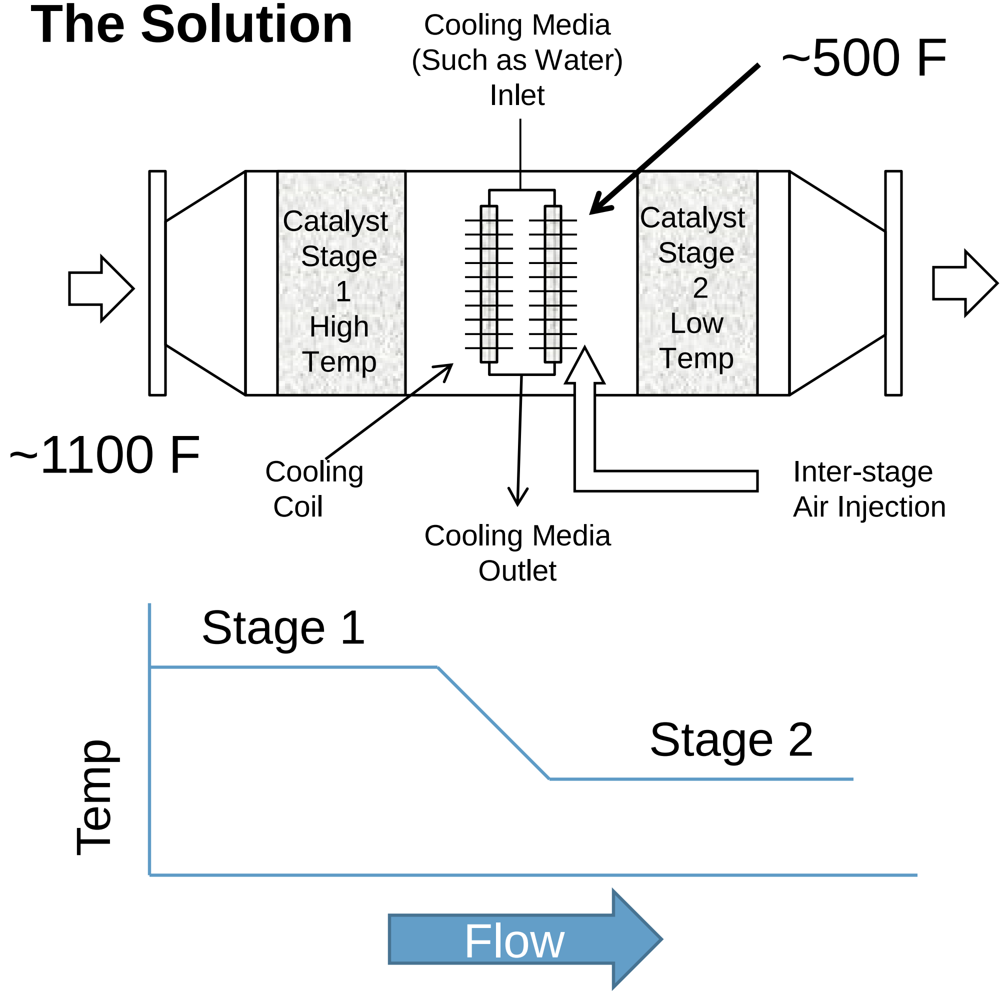
NOx < 1 ppm

The Challenge



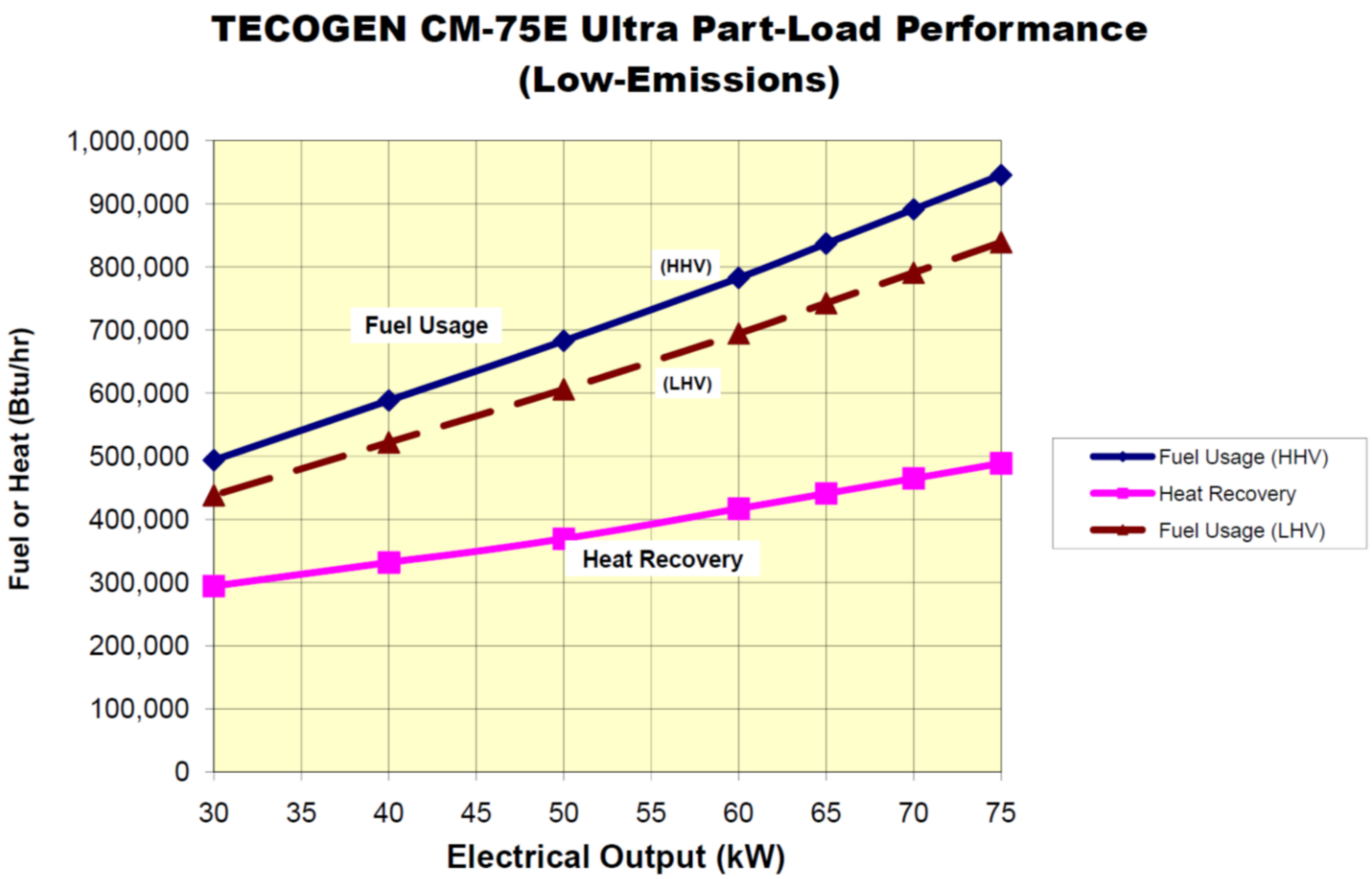
Source: SoCalGas RD&D/DE Solutions 2014

The Solution



The Engine Performance Spec

Source: Tecogen® Catalogue



Engine Jacket Water Max Entering 180°F, Leaving 230°F

Courtesy: Tecogen® Catalogue

CM-75E *Ultra* Modulation (with emissions controls)							
	Fuel Usage (Btu/hr)			Efficiency (%)			
				Electrical		Overall	
Electrical Output (kW)	Based on HHV	Based on LHV	Heat Recovery (Btu/hr)	Based on HHV	Based on LHV	Based on HHV	Based on LHV
75	**945,500**	**838,900**	**489,000**	**27.1%**	**30.5%**	**78.8%**	**88.8%**
70	891,221	790,740	465,049	26.8%	30.2%	79.0%	89.0%
65	836,943	742,581	441,098	26.5%	29.9%	79.2%	89.3%
60	782,664	694,422	417,147	26.2%	29.5%	79.5%	89.6%
50	682,861	605,872	369,245	25.0%	28.2%	79.1%	89.1%
40	588,311	521,982	331,821	23.2%	26.2%	79.6%	89.7%
30	493,761	438,092	294,398	20.7%	23.4%	80.4%	90.6%