

Incremental Costs of Gas Infrastructure

By SEAN ARMSTRONG of
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Sean Armstrong

Managing Principal
at Redwood Energy

- Began working at a demonstration house for renewable energy in 1995 at HSU's campus
- Science teacher ('02-05')
- Development Project Manager ('05-'11)
- Redwood Energy with Michael Winkler (2011-Present) and Staff
- International Leadership in Electrification + ZNE Scale Solar



SOLARIZED PROJECTS, UNIT COUNT	SOLARIZED PROJECTS	ZNE PROJECTS (80 %- 120 %), UNIT COUNT	ZNE PROJECTS (80 %- 120 %)
5,377	68	2,063	32

The Analogy of a Previous Methane Emitting Technology: Disease, pollution, housing, infrastructure, land use and operating costs.



THE NEW HORSE DISEASE.; Dropsy and Glanders Prevalent Several Deaths Reported in Up-Town Stables. Virulent Type of the Horse Disease at Baltimore Reports From Other Places. The Disease at



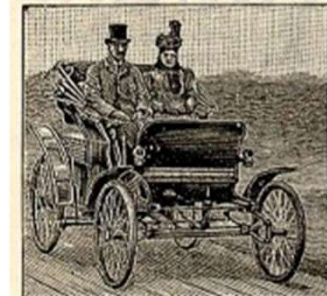
“The horse has become unprofitable. He is too costly to buy and too costly to keep.”—Munsay Magazine, late 1800s



MORTON STREET, CORNER OF BEDFORD, LOOKING TOWARD BLEECKER STREET, MARCH 17, 1893.



DISPENSE WITH A HORSE



and save the expense, care and anxiety of keeping it. To run a motor carriage costs about $\frac{1}{2}$ cent a mile.

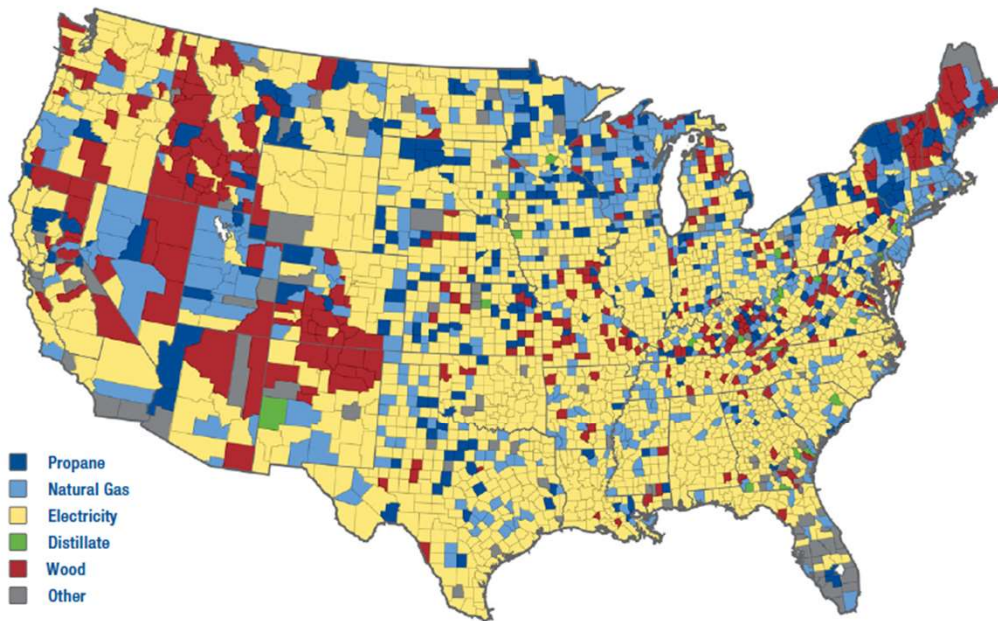
THE WINTON MOTOR CARRIAGE

is the best vehicle of its kind that is made. It is handsomely, strongly and yet lightly constructed and elegantly finished. Easily managed. Speed from 3 to 20 miles an hour. The hydrocarbon motor is simple and powerful. No odor, no vibration. Suspension Wire Wheels. Pneumatic Tires. Ball Bearings.  Send for Catalogue.

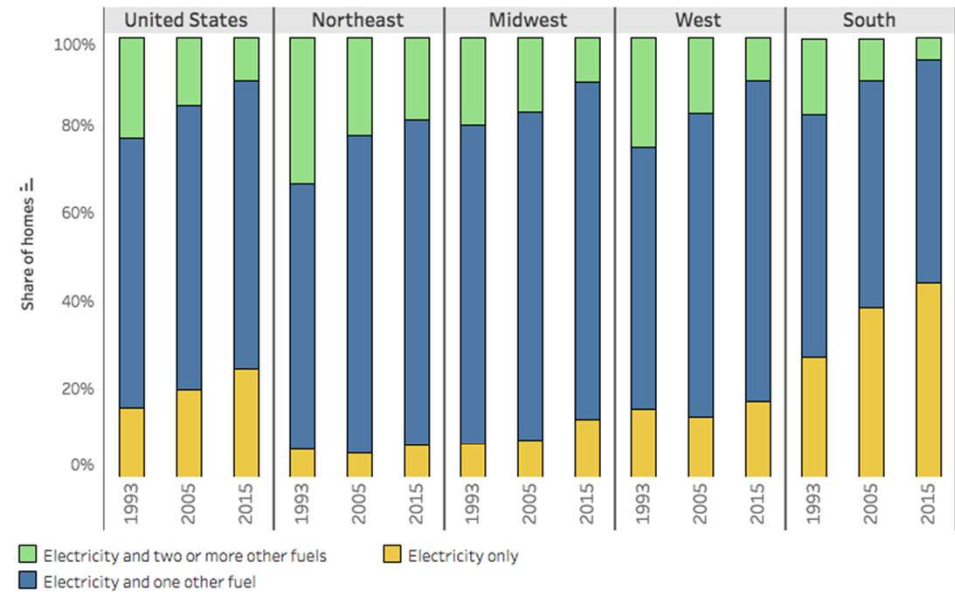
Price \$1,000. No Agents.
THE WINTON MOTOR CARRIAGE CO., Cleveland, Ohio.

Nation-wide Electrification Trend Dates from 1993, Accelerating Since 2010 with New “Cold Climate” Heat Pumps

Fig. 1
Fuel with Largest Market Share Gains between 2010 and 2014

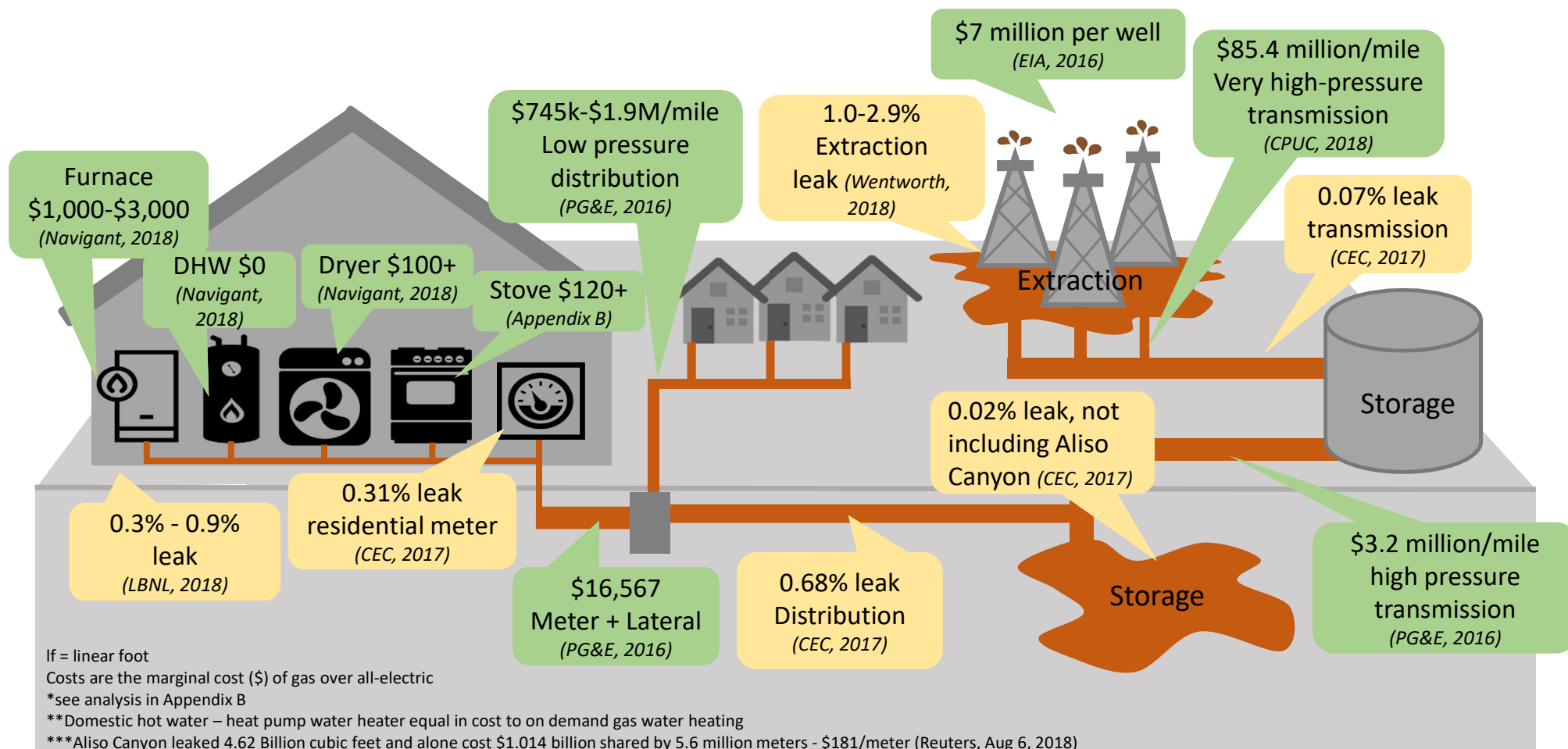


What Fuels American Homes



Source: U.S. Energy Information Administration, 2015 Residential Energy Consumption Survey | inewssource.org

California's Natural Gas Leaks at 2.4%-4.3% and Adds ~\$40,000/House in Construction Costs



California's CEC, CPUC, and CAISO Commissioners Agree: All-Electric construction and infrastructure is better for developers and tax payers



California rejects gas peaker plant, seeks clean energy alternatives

The California Public Utilities Commission rejected a refurbishment of the Southern California Edison's Ellwood Peaker Plant, paving the way for a solar+storage solution instead.

OCTOBER 4, 2017 **FRANK ANDORKA**

"At this time, absent very compelling circumstances, we should be directing all of our investments in infrastructure and energy to clean energy resources," said Clifford Rechtschaffen, one of the commissioners. "The proposed refurbishment is not a good use of ratepayer dollars."



California's Next Frontier: Clean Electricity for Everything

Posted: 24 May 2016 11:46 AM PDT

By David Hochschild and Mark Ferron

Electrification can also reduce costs. California home builders such as City Ventures and KB Homes have begun building homes without gas lines, where gas central heating, hot water and stoves are replaced by electric appliances. By avoiding the need to install gas pipelines under the streets and inside homes, these forward-thinking builders are able to reduce the price of the home by \$4,500.



Extra Gas Costs, Including Infrastructure, Can Be More than \$40,000 per residence

SoCalGas: Average of \$33,400 of Gas Main Cost Per Service						
City Name	Buttonwillow	Selma City	Rosamond	California City	Porterville City	Allensworth
Services Per City	23	44	619	1796	133	125
Price Per Service (\$1277+ \$1398)	2675	2675	2675	2675	2675	2675
Total for services	\$61,525	\$117,700	\$1,655,825	\$4,804,300	\$355,775	\$334,375
Main costs	\$1,520,000	\$3,675,000	\$7,260,000	\$7,400,000	\$3,360,000	\$670,000
Pressure up project				\$1,050,000	\$495,000	
Total	\$1,581,525	\$3,792,700	\$8,915,825	\$13,254,300	\$4,210,775	\$1,004,375
Total Main and Pressure Up Costs Per Service	\$66,087	\$83,523	\$11,729	\$4,705	\$28,985	\$5,360

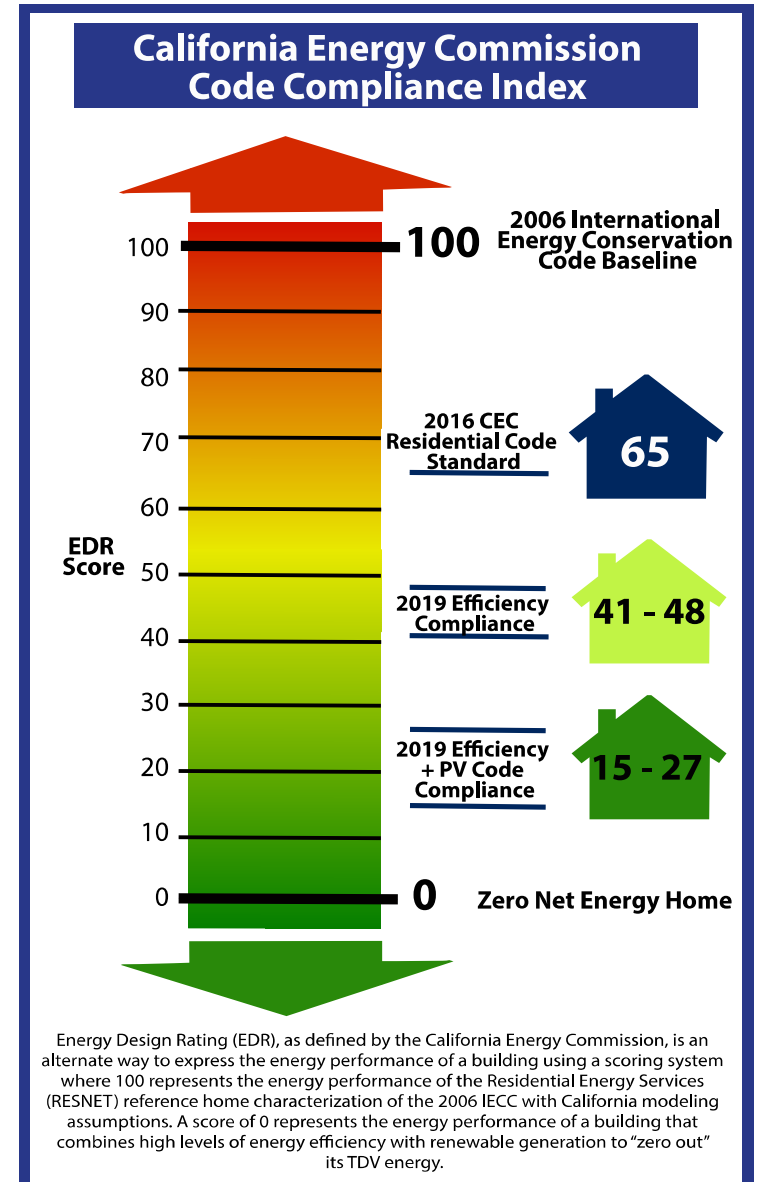


Price Quote	Source
\$8841 (single-family)	Palo Alto
\$17,634 (8-unit MF)	Palo Alto
\$1000 (single-family)	EPRI for SMUD
\$600 (per unit of MF)	Contractor quote, north coast
\$2000 (per bldg. of MF)	Contractor quote, north coast
\$14,768 (single-family)	PG&E, Richmond
\$10,000 (MF)	Pasadena



Price Quote/Estimate	Source
\$578 - \$718 (single family)	Homewyse Web Site
\$300 - \$1000 (single family)	Costhelper.com
\$259 - \$733 (single family)	homeadvisor.com
\$200 - \$500 (single family)	Fixr.com
\$550 (single family)	EPRI for SMUD
\$200/fixture (MF)	Contractor quote, north coast
\$200-\$300/fxtr. (MF)	Contractor quote, Pasadena

Getting Rid of the Last 15-27 EDRs of Gas in the Code



Do We Need Gas: COLD Climate Habitat Studio NetZero Energy Houses completed by 2015

- Started with CMHC's Equilibrium Initiative in 2007
- 5400° C (9700° F) Heating Degree Days
- -34° C (-29° F) Design Temperature



Belgravia NetZero



Parkland NetZero
LEED Platinum



Riverdale NetZero



Mill Creek NetZero

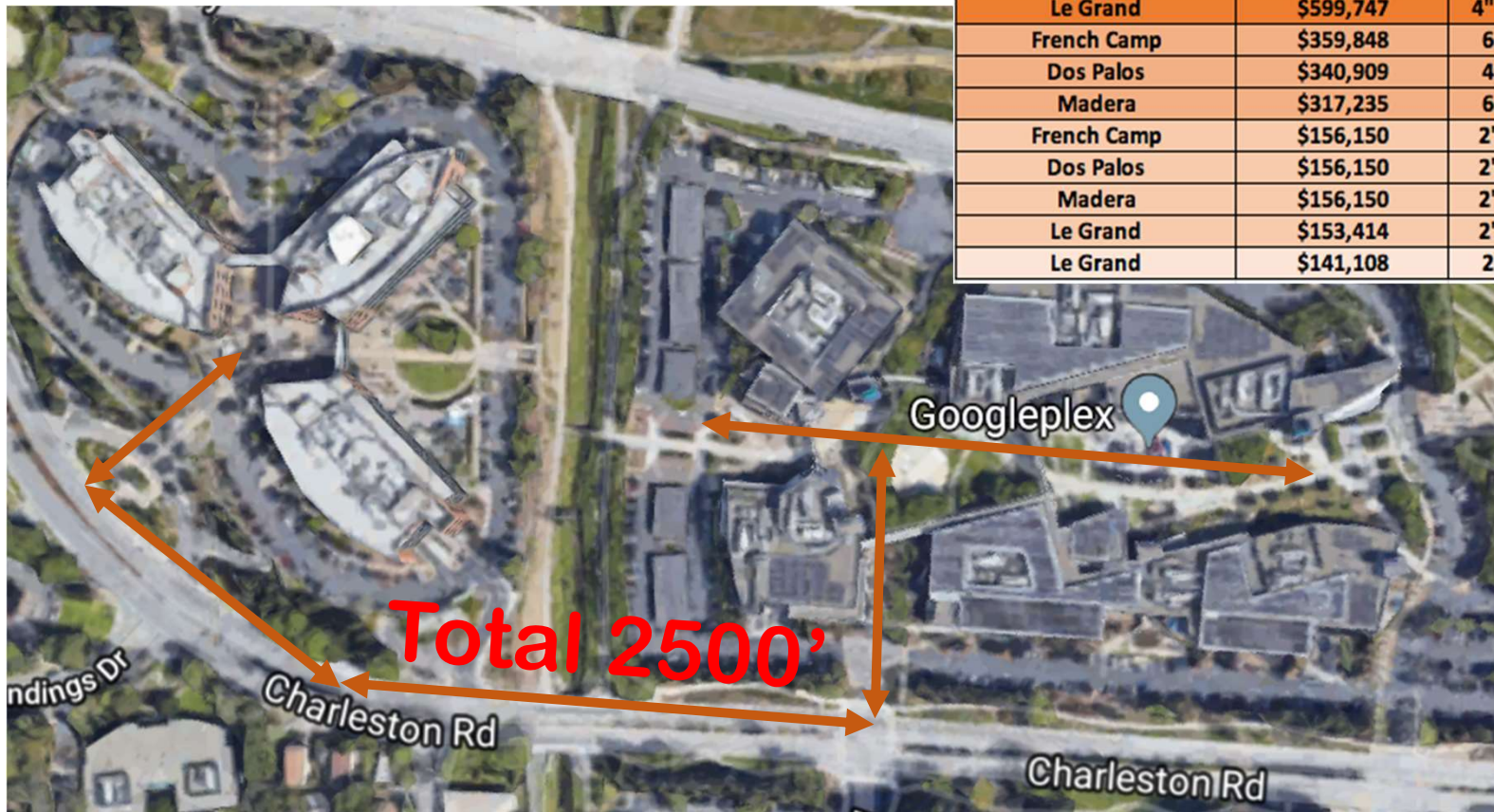


South Windsor Park
NetZero



Holyrood Near NetZero
Retrofit

Google Campus Methane Infrastructure Costs



A Range of PG&E Methane Pipeline Infrastructure Costs

(From Rulemaking No. 15-03-010, October 12, 2016, An Order Instituting Rulemaking to Identify Disadvantaged Communities in the San Joaquin Valley and Analyze Economically Feasible Options to Increase Access to Affordable Energy in Those Disadvantaged Communities)

Small Central Valley Town Currently Without Methane Service	Cost per 1000 Feet of Methane Piping	Type of Methane Piping	Cost of Connection: Lateral + Meter Set
Le Grand	\$599,747	4" Transmission Line	\$16,567
French Camp	\$359,848	6" Distribution Rib	\$16,567
Dos Palos	\$340,909	4" Distribution Rib	\$16,567
Madera	\$317,235	6" Distribution Rib	\$16,567
French Camp	\$156,150	2" Distribution Line	\$16,567
Dos Palos	\$156,150	2" Distribution Line	\$16,567
Madera	\$156,150	2" Distribution Line	\$16,567
Le Grand	\$153,414	2" Distribution Line	\$16,567
Le Grand	\$141,108	2" Distribution Rib	\$16,567

Facebook Campus Methane Infrastructure

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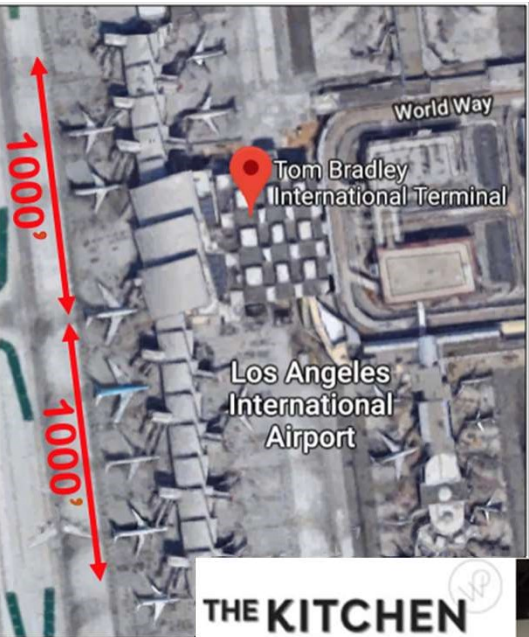


Avoided Methane Costs at LAX Bradley Terminal

A Range of PG&E Methane Pipeline Infrastructure Costs

(From Rulemaking No. 15-03-010, October 12, 2016, An Order Instituting Rulemaking to Identify Disadvantaged Communities in the San Joaquin Valley and Analyze Economically Feasible Options to Increase Access to Affordable Energy in Those Disadvantaged Communities)

Small Central Valley Town Currently Without Methane Service	Type of Infrastructure Methane Piping Used	Cost per 1000 Feet of Methane Piping	Cost per Mile of Methane Piping
French Camp	6" Distribution Rib	\$359,848	\$1,900,000
Dos Palos	4" Distribution Rib	\$340,909	\$1,800,000
Madera	6" Distribution Rib	\$317,235	\$1,675,000
French Camp	2" Distribution Line	\$156,150	\$824,472
Dos Palos	2" Distribution Line	\$156,150	\$824,472
Madera	2" Distribution Line	\$156,150	\$824,472
Le Grand	2" Distribution Line	\$153,414	\$810,028
Le Grand	2" Distribution Rib	\$141,108	\$745,050



All-Electric LAX International Terminal Saves Hundreds of Thousands of Dollars



High performance Electric DHW is similar in cost to modestly efficient Gas Water Heaters



Rheem Prestige Hybrid Electric Water Heater - 50 Gal

\$1,289.00 from GP Conservation

Rheem · Tank · Electric · 50 gallon

The **Rheem Prestige** Hybrid Water Heater is simply the most efficient water heater available. Its Efficiency Factor (EF) of 3.50 is unequaled by any ...

370% Efficient
Electric Tanks



AO Smith HPTU-50N 50 Gallon Voltex Residential Hybrid Electric Heat Pump Water Heater

\$1,379.95 from 4 stores

★★★★★ 12 product reviews #1 in Heat Pump Water Heaters

Efficient Electric Hot Water The **A.O. Smith Voltex** line heats water with a high efficiency electric heat pump rather than ...

A. O. Smith · Tank · Electric · 50 gallon · Energy Star · Heat Pump

Other size options: [66 Gallon](#) (\$1,560) [80 Gallon](#) (\$1,845)



Rheem Residential Gas Water Heater

\$1,223.73 from 5+ stores

Rheem · Tank · Natural Gas · 40 gallon

19-3/4 In., First Hour Recovery - Water Heaters 68 gph, Draft Hood Size 2 In. or 3 In., Recovery @ 90 F Rise 40.4 gph, Low N Yes, Max ...

Other size options: [50.0 Gal](#) (\$1,963)

67% and 90% Efficient
Gas tanks and tankless



Westinghouse 11
GPM High

★★★★☆ (3)

\$1338⁰⁰/each



Westinghouse 11
GPM Ultra Low

★★★★☆ (75)

\$988⁰⁰/each



Westinghouse 8.2
GPM High

★★★★☆ (5)

\$1215⁰⁰/each



Rheem
Performance

★★★★☆ (3)

\$1329⁰⁰/each



Rheem
Performance

★★★★☆ (2)

\$1399⁰⁰/each



Rheem
Performance

★★★★☆ (4)

\$1195⁴⁰/each



3 Ton 14 Seer Rheem / Ruud Air Conditioning System

from The AC Outlet

Rheem · 36,000 BTU · With Heater

Air Conditioning Systems are Split Systems which consist of the outdoor air conditioning unit (blower, fan coil). For added warmth during the coldest ...

[See more details at The AC Outlet »](#)

\$1,758.20

Free shipping. No tax

The AC Outlet

92% positive (396)



Rheem 3 Ton 14 SEER Heat Pump Split System R410A Refrigerant

from ACWholesalers.com

Rheem · Heat Pump · With Heater

Overview for Rheem RH1T3617STANJA RP1436AJ1NAThis Rheem 3 Ton 14 SEER Heat Pump Split System Bundle comes with a highly featured and reliable Rheem RP1436AJ1NA heat pump ...

[See more details at ACWholesalers.com »](#)

\$2,085.38

Free shipping. No tax

ACWholesalers.com

★★★★★ (3,949)

Rheem 3 Ton 14 SEER 80% AFUE 75K BTU R410A Complete Split System AC and Gas

from Ingrams Water And Air Equipment

Rheem

Condenser Model: RA1436AJ1NA Coil Model: RCF3617STAMCA Furnace Model: R801SA075417MSA Rheem 3 Ton 14 SEER 80% AFUE 75K BTU R410A Complete Split System AC and Gas Rheem RA14 3 ...

[See more details at Ingrams Water And Air Equipment »](#)

\$3,024.00

Free shipping. No tax

Ingrams Water And Air Equipment

★★★★★ (966)

Heat Pumps are Cheaper Compared to AC + Furnace, but More Expensive than Just a Furnace

Rheem 80% AFUE 75,000 BTU Upflow/Horizontal Gas Furnace

Model: W801SA075417MSA Item Number: 94024



Our Price: \$697.00

Only 5 In-Stock Ships Wednesday, February 14, 2018

- Free Shipping
- Free Lift Gate
- Low Price Guarantee

Gas Venting Costs Make Gas More Expensive



Rheem EcoSense 36 in. Vent
Length 3 x 5 in. Stainless Steel
Concentric Venting Straight Vent
for Rheem Indoor Tankless Gas
Water Heaters

Model# RTG20151D-1

NOT YET RATED

\$44²⁸



Rheem EcoSense 3 in. x 5 in.
Stainless Steel Vertical
Concentric Termination Vent Kit
for High Efficiency Tankless Gas
Water Heaters

Model# RTG20211

★★★★☆ (3)

\$239⁰⁰



Rheem EcoSense 3 in. x 5 in.
Horizontal Stainless Steel
Concentric Termination Vent Kit
for Mid Efficiency Tankless Gas
Water Heaters

Model# RTG20210

★★★★★ (6)

\$89⁰⁰

Cost of Venting Gas Exhaust: \$270-\$850 per Appliance

Electrification Provides Cost Effective Efficiency

Energy Upgrade Recommendations				ECON-2	
Project Name <i>St. Marks Hotel</i>		Documentation Author <i>Redwood Energy</i>			
Project Address <i>394 12th Street Oakland, CA 94607</i>		Author Address			
Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings	
				Site	TDV
<i>Domestic Hot Water Heater</i>	<i>Name = Sanden HPWH 3.40 Type = Heat Pump Volume = 200.0 gal Efficiency = 3.400 EF</i>	\$0	\$0	41.6 %	18.4 %
<i>Windows</i>	<i>Type = Upgraded Windows U-Factor = 0.250 SHGC = 0.3</i>	\$0	\$0	15.0 %	20.7 %
<i>Domestic Hot Water Heater</i>	<i>Name = copy of Laars HH0500EN04*BA Type = Gas Fired Volume = 0.0 gal Efficiency = 0.650 %</i>	\$0	\$0	-8.5 %	-3.5 %



HVAC Electrification Retrofit Saved Construction Costs at Ethan Terrace Apts, Sacramento

Retrofit Activity	Construction Cost	Incremental Cost Compared to PTAC	Incremental Cost per Unit (96 Units)
Cost of Intalling PTACs with Resistance Heat	\$ 202,400	\$ 14,400	\$ 150
Cost of Upgrading service to PTACs to 220V	\$ 34,960	\$ 34,960	\$ 364
Avoided Cost of Wall Furnaces	\$ 144,000	\$ (144,000)	\$ (1,500)
Cost of removing Wall Furnaces, Drywall Patching, Texture and Paint	\$ 19,320	\$ 19,320	\$ 201
Total		\$ (75,320)	\$ (785)

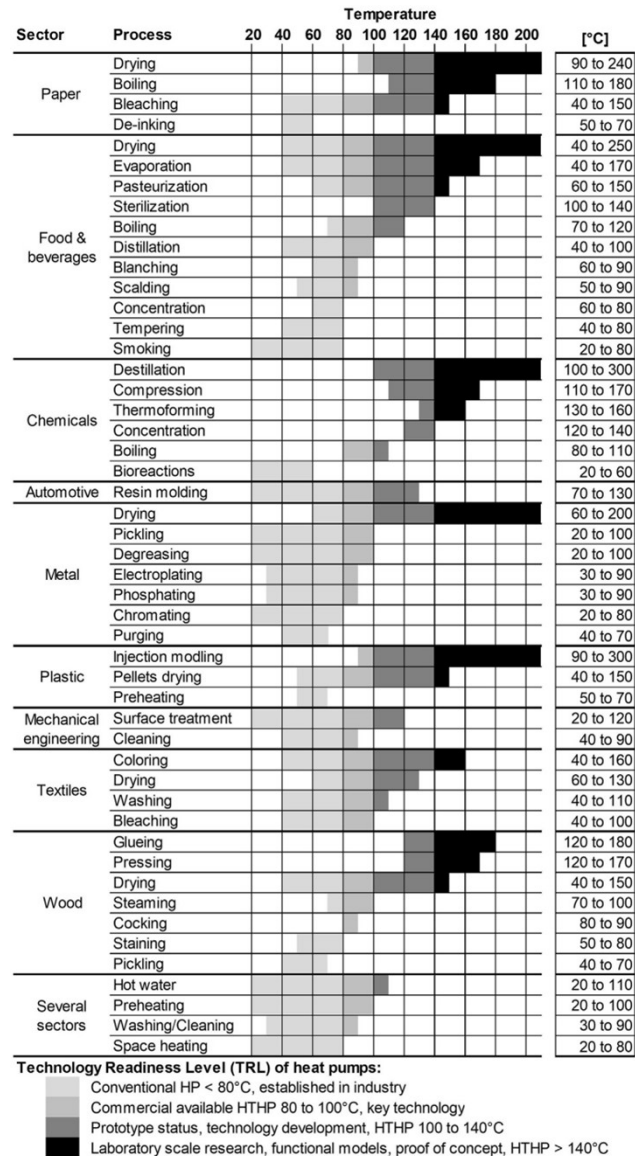


Transformative Technology: Retrofit Ready Cold Climate Packaged Terminal Heat Pumps (PTHPs)



Transformative Technology: Retrofit-ready hot water heat pumps










Heat Pumps are Ready for Most Industrial Processes

Higher End Cooking Solutions

Slide-in Induction Ranges with oven

Make/Model	Viking VISC5304BSS	Frigidaire Gallery 30"	Samsung NE58K9560WS/AA	KitchenAid KSIB900ESS	GE PHS930SLSS
					

Residential/Commercial 4 Burner Induction Stovetops

Make/Model	Summit SINC424	GE Profile	Frigidaire Gallery Series	Bosch Benchmark Series	Whirlpool W5CE3024XB
					

Heat Pumps for Hot Tubs and Swimming Pools

Sizing Tip: 4 BTU/Hr to 6 BTU/Hr per gallon of pool water



Hayward Heat Pro



Pentair



Aquacal Heatwave

