# California Building Electrification

IEEE Life Members October 23, 2020 Tom Graly tgraly@gmail.com



# AGENDA

- GHG and Methane
- Laws and Mandates
- Electrification Technologies
- New Buildings
- Retrofit of Older Buildings
- Electric Grid
- Q&A





#### Electricity is getting cleaner, moving toward 100% carbon-free by 2045



Source: CA Air Resources Board, Emission Inventory 2018. https://www.arb.ca.gov/cc/inventory/pubs/reports/2000\_2016/ ghg\_inventory\_trends\_00-16.pdf

### Outdoor Air Quality: Burning Fossil Fuels in Buildings is a Big Part of California's Smog Problem

Nitrous Oxide (NO<sub>x</sub>) in California



Source: California Air Resources Board

# Methane

A Cleaner Transitional Fuel CNG for Transportation Power Plants replacing Coal Hydrogen production – another possible transportation fuel



### Methane and Natural Gas



NATURAL GAS LIQUIDS | 2 to 7%
 CARBON DIOXIDE | 0 to 2%
 OXYGEN | 0%
 NITROGEN | 0.1 to 1%
 HYDROGEN SULFIDES | 0.000001%
 Varying amounts of water and sand



# **METHANE IS**

# **84X more potent** than $CO_2$ in the short run



# Average Atmospheric Methane Concentrations



Source: 2° Institute methanelevels.org

### We Import 84% of the Methane We Use



# California's Natural Gas Leaks at 2.4% - 4.3%



Appliance costs are the marginal cost (\$) of gas over all-electric

\*heat pump water heater equal in cost to on demand gas water heating

\*\*Aliso Canyon leaked 4.62 Billion cubic feet and alone cost \$1.014 billion shared by 5.6 million meters - \$181/meter cost (Reuters, Aug 6, 2018)

# Gas Flaring

- Texas Permian Basin
- Reported 55 Billion Cubic Feet
- NOAA Satellite Data 104 Billion Cubic Feet







# Safety Issues

- Fires and Explosions
- Leakage
  - Storage
  - Old pipes



San Bruno



Boston



Alviso Canyon

# Indoor Pollution Issues

- University and LBNL Studies
- High Concentrations
  - NOx
  - CO
  - Formaldehyde
- NO<sub>2</sub>
  - Causes respiratory disease
  - EPA has regulated NO<sub>2</sub> for 50 years
  - 12 million California homes with gas stoves are breathing levels of NO<sub>2</sub> that are illegal outdoors



# AGENDA

- GHG and Methane
- Laws and Mandates
- Electrification Technologies
- New Buildings
- Retrofit of Older Buildings
- Electric Grid
- Q&A





 Achieving CA's climate goals will require <u>at least</u> a 40% reduction in building sector GHGs by 2030, and an 80% reduction by 2050



Source: E3 report on "Deep Decarbonization in a High Renewables Future" June 2018, CEC-500-2018-012

### Environmental Laws and Mandates

- AB32, 2006 : Reduce GHG to 1990 levels by 2020
- SB32, 2016 : Reduce GHG to 40% of 1990 level by 2030
- SB100, 2018 : 100% zero-carbon electricity by 2045
- 2018 Mandate by Building Standards Comm. for solar panels on new homes
- 2018 Mandate by Gov. Brown for a carbon neutral economy by 2045
- SB1477, 2018 : \$50M/year fund to reduce emissions from homes
- AB3232, 2018 : Reduce GHG from buildings to 40% of 1990 level by 2030

# Primary California Agencies

- CEC Ca. Energy Commission The state's primary energy policy and planning agency.
  - Title 24 Building Energy Efficiency Standards
- CPUC Ca. Public Utilities Commission regulates privately owned public utilities.
- CARB Ca. Air Resources Board lead agency for climate change programs and oversees all air pollution control efforts
- CBSC Ca. Building Standards Commission manage the many processes relating to development, adoption, approval, publication, and implementation of California's building codes

# Supporting Companies and Organizations

- Community Choice Aggregators: East Bay Community Energy, Marin Clean Power, Sonoma Clean Power, CleanPowerSF, Peninsula Clean Power, Silicon Valley Clean Power, San Jose Clean Energy
- PG&E, SCE, SDG&E, SMUD, Alameda Municipal Power, Silcon Valley Power
- Rocky Mountain Institute
- National Resources Defense Council
- EPRI
- BayRen Bay Region Energy Network
- Building Decarbonization Coalition

### The Bay Area Regional Energy Network (BayREN)

BayREN is a highly effective and trusted group of local governments that deliver targeted, integrated, and regional-scale climate solutions focused on energy, water, and resilience.







### The Bay Area Region





### Program Overview: Home+

- Launched in January 2019
- Eligibility: Own 1-4 unit home built before 2001, located in 9county Bay Area
- Program offerings:
  - Up to \$5,000 in rebates for energy efficiency upgrades
    - Includes weatherization & building shell, heating and cooling systems, water heaters, and certain consumer appliances
    - Recently added electrification incentives
  - No-cost Home Energy Advisor service
  - Network of trained participating contractors
  - Free "Energy Efficiency" kit worth up to \$70





- Unites building industry stakeholders with energy providers, environmental organizations and local governments to power California's homes and workspaces with clean energy.
- buildingdecarb.org





Rep Darin Cline of @PGE4Me says the utility supports allelectric buildings, and invites city officials to visit its allinduction kitchen for a tour. #berkmtg



### Berkeley became first US city to ban natural gas. Here's what that may mean for the future

The California city on Tuesday voted to ban natural gas hook-ups in new buildings, in a historic move



▲ The view of the Bay from the Berkeley Hills. Photograph: Alamy Stock Photo

Berkeley this week became the first city in the United States to ban natural, fossil gas hook-ups in new buildings.

#### 60+ CA Local Governments Actively Exploring Zero-Emissions Reach Codes

Northern California	Southern California
Bay Area	Central Coast
• Alameda County: Albany, Berkeley, Dublin, Fremont,	City of San Luis Obispo
Hayward, Oakland	
Marin County	Santa Barbara
• Santa Clara County: Campbell, Cupertino, Gilroy, Los	Santa Barbara, Goleta
Altos, Los Altos Hills, Milpitas, Monte Sereno, Morgan	
Hill, Mountain View, Palo Alto, San Jose, Sunnyvale	Ventura
• San Mateo County: Brisbane, Burlingame, East Palo	• Ojal, mousand Oaks
Alto, Menlo Park, Millbrae, Portola Valley, Redwood	Los Angeles
City, San Mateo City and County	City and County of LA Santa Monica
San Francisco	West Hollywood. Malibu
• Sonoma County: Cloverdale, Petaluma, Santa Rosa,	······································
Sebastopol, Sonoma, Windsor, Healdsburg	San Diego
Central Valley	Carlsbad (adopted!), Chula Vista, Encinitas, Escondido
Sacramento, Davis	
Humboldt: Arcata	
Mendocino: Fort Bragg, Point Arena, Willits	

Santa Cruz: City of Santa Cruz

		A	ppr	oach		S	sten	ns	Building Types				Add-Ons							
Jurisdiction	Natural Gas	Infrastructure	Prohibition	All-Electric Reach	Electric-Preferred	Whole Building	Water Heating	Space Heating	Low Rise Residential	City-Owned Properties	High Rise Residential	Hotel	Retail	Office	Restaurant	Life Sciences	Additional Solar	Electric Vehicles	Low Carbon Concrete	Natural Gas In Lieu Fee
Alameda		Х				X				Х										
Berkeley		Х			X	Х			Х	Х	Х	Х	Х	Х	X	Х	Х	Х	X	
Brisbane*				Х		Х			Х	Х	X	Х	Х	X	X					
Carlsbad				Х			X		Х								Х			
Cupertino				Х		X			X	Х	Х	Х	X	Х	X			X		
Davis					Х	Х			Х											
Healdsburg				Х			Х	Х	Х	Х	Х	Х	Х	X	Х	Х				
Los Gatos*				Х		Х			Х									Х		
Marin County					Χ	X			X	Х	Х	Х	X	X	X	Х		Х		
Menlo Park*				X			Х	Х	X	X	Х	X	X	Х	Х		Х	Х		
Mill Valley					Х	Х			Х		Х							Х		
Milpitas					Х	X			Х	Х	Х	Х	X	Х	X	Х	Х	Х		
Morgan Hill		Х				X			Х	Х	Х	Х	X	Х	X	Х				
Mountain View*				X		X			Х	Х	X	Х	Х	Х	X		Х	Х		
Pacifica				X			X	X	Х	X	X	X	X	X	X		X	Х		
Palo Alto*				Α	В	X			Α	X	В	В	В	В	В	В		X		
Saratoga				Х			Х	Х	X	X	Х	Х	X	X	X	Х		Х		
San Jose*		Α			В	X			Α	Х	В	В	В	В	В	В	В	Х		
San Luis Obispo					Х	X			Х	Х	Х	X	X	Х	Х	Х	Х			X
San Mateo					X	X			Х					X			X	Х		
Santa Monica					X	X			Х	Х	X	X	X	X	X	X	X			
Santa Rosa				X		X			X											
Windsor				X		X			X											

\*City Council opted to go beyond staff recommendation

A and B indicate different approaches as applied to specific building types.

# AGENDA

- GHG and Methane
- Laws and Mandates
- Electrification Technologies -
- New Buildings
- Retrofit of Older Buildings
- Electric Grid
- Q&A



### Targeted Appliances for Electrification



# Electrification Technologies

- Heat Pumps
  - Water heating
  - HVAC
  - Clothes Drying
- Induction Heating
  - Cooking



Stove



**Clothes Dryer** 





Water Heater

## Heat Pump Water Heaters

- Efficiency
  - Gas
  - Electric
- Issues
  - Location
  - Electric Supply
  - Ducting
  - Noise
- (Solar Thermal)









## Heat Pump HVAC Heating/Cooling

- Efficiency
  - Seer 18-30+
  - HPSF 9.5-14+
  - EER 12.5-19
- Split System
  - Heat Pump
  - Air Handler
    - Whole house
    - Rooms
- Electric Supply





Image by Redwood Energy

# Heat Pump Clothes Dryer

- Efficiency
  - CEF 4.5-9+
- EPA Energy Star
  - Heat Pump only
  - No Gas or Electric resistive products
- Ventless closed system
- Electric Supply
- Issues
  - Time to dry
  - Small loads









# Condensing Clothes Washer/Dryer

- Efficiency
  - ~\$10/year
- Ventless closed system
- Electric Supply : 120V
- Issues
  - 2-3 hours per load



Summit





Haier



Whirlpool

## Stoves and Cooktops

- Types
  - Glass Top Radiant
  - Induction
- Efficiency
  - 70-95%
- Electric Supply : 240V /120V
- Induction Advantages
  - Faster
  - Immediate Response
  - Accurate Temperature Control
  - Even Cooking
  - Safer
  - Easy to Clean
  - Cooler Kitchen







#### KitchenAid Stovetop



#### **Frigidaire Induction**



#### **Countertop Induction**



# **Consumer Reports Prefers Induction**

Top 6 of 8 Ranges for 2020 were electric, top 2 were Induction

		Consumer Reports			
Fuel	Model	Rating	Cost		
Induction	GE Profile PHS930SLSS	86	5	\$2,432	44 <b>111111</b> 444
Induction	Kenmore Elite 95073	84		\$1,525	32 32
Gas	LG Signature LUTD4919SN	84		\$3,000	
Induction	LG LSE4617ST	82		\$2,500	
Induction	LG LSE4616ST	82	2	\$1,700	Sterrowwww.
Smoothtop	Whirlpool WGE745c0FS	82	2	\$1,000	
Gas	Samsung NY58J9850WS	81		\$2,725	
Induction	Frigidaire Gallery FGIF3036TF	81		\$1,035	-

### Operations & Maintenance and Building Shell Measures

#### Measure

#### 2020 Rebate Amount

#### **Operations and Maintenance Measures**

Smart Thermostat (must be listed on the ENERGY STAR qualified product list for Smart Communicating Thermostat)	\$150		
Duct sealing ≤ 10% total leakage (Ducts or Furnace/Air Handler/FAU located in garage disqualify this measure)	\$200		
Duct Replacement < 5% total leakage	\$800		
Building Shell Measures			
Building Shell Measures Attic insulation $\ge$ R-44 (includes attic air sealing)	\$0.75 / ft <sup>2</sup> (not to exceed \$1,000 per home)		

HVAC & Water Heating Measures

Measure	2020 Rebate Amount	
Heating and Cooling Measures		
High efficiency central gas furnace ≥ 95% AFUE (must replace existing central gas furnace)	\$300	
High efficiency central air conditioner≥ 17 SEER High efficiency packaged central air conditioner≥ 16 SEER (must replace entire load associated with existing central AC)	\$800	
High efficiency heat pump ≥ 17 SEER / 9.4 HSPF (must replace entire load associated with existing heating and cooling equipment with ducted direct exchange heat pump or ductless mini-split heat pump)	\$1,000	
Water Heating Measures		
High efficiency storage gas water heater $\ge 0.70$ EF or medium draw patter $\ge 0.64$ UEF, high draw $\ge 0.68$ UEF instantaneous water heater $\ge 0.82$ EF or $\ge 0.87$ UEF (must replace existing gas storage water heater)	n \$400 g	
Heat pump water heater ≥ 3.1 UEF (must replace existing gas, electric or heat pump water heater)	\$1,000	

Bonus Rebates & Electrification Appliance Measures

#### Measure

#### Bonus Rebates

Combine one or more Building Shell measures with a Heating or Cooling measure (measures must be completed simultaneously)	\$500
Downsize heating and/or cooling system compared to existing system (requires a minimum 12 kBTU or 1 ton input reduction)	\$100
Building air sealing $\geq$ 30% total leakage reduction (must be combined with another measure, otherwise requires blower door test-in and test-out to qualify as a standalone building shell measure)	\$150
Combustion Appliance Safety (CAS) test-out (CAS test-out required for all measures. Not available as a standalone rebate. Only one per service address)	\$150
Electrification Appliance Measures	
*Induction electric range (no hybrid) or cooktop (must replace existing natural gas range or cooktop)	\$300
*Heat pump clothes dryer ≥ 4.50 Combined Energy Factor (CEF) (must replace existing natural gas clothes dryer and listed as ENERGY STAR Efficient heat pump clothes dryer.	\$300

### The Other Appliances



# Electric Fireplaces

- Electric Supply : 120V
- Cost : \$500 \$5000



#### Touchstone



#### Modern Flames



Dimplex





#### Puraflame

Amantii

# Electric Grills

- Electric Supply : 120V (240V)
- Cost: \$200-\$3600



Char-Broil



Electri Chef



Weber



Americana

# Pool Heaters

- Electric Supply : 240V
- Cost: \$3000-\$4200



AquaCal HeatWave



Hayward



Pentair

# AGENDA

- GHG and Methane
- Laws and Mandates
- Electrification Technologies
- New Buildings



- Retrofit of Older Buildings
- Electric Grid
- Q&A



### New Single Family Homes



## Multi-Family Developments









### California Projects

Redwood Energy, Sean Armstrong



Heritage Square in Pasadena by BRIDGE Housing



Cloverdale, Corporation for Better Housing



Atascadero, Corporation for Better Housing



Castroville, Corporation for Better Housing



Quetzal Gardens in San Jose by RCD Housing

# AGENDA

- GHG and Methane
- Laws and Mandates
- Electrification Technologies
- New Buildings
- Retrofit of Older Buildings
- Electric Grid
- Q&A



# The Challenge of Retrofitting Older Homes

- The bigger the home, the bigger the electrical panel
- Most panels (newer, bigger homes) have enough space for all-electric end uses
- The biggest challenge is for small homes



Credit:Redwood Energy

# Fitting All the Appliances on Small Panels

Small Trailer Home or Apartment	Apartment	Single Family Home
30 Amps	50 Amps	100-200 Amps
		

# "Conventional" Efficient Appliances (240V)

Product Type	Electric Dryer-Energy Star	Heat Pump Water Heater	Split Heat Pump 2-4 Tons
Maximum Rating	30A, 7,200W	19A, 4,500W	18-29 Amps, 4,300W- 7,000W
Make and Model	Whirlpool WED5620HW	Rheem Prestige	York YZH060 Series

# Power Efficient Appliances (120V)

Product Type	4.5 cu ft Condensing Washer/Dryer Combo	Heat Pump Water Heater	Low-Amp Window Heat Pump	120V Mini-Split Heat Pump
Maximum Rating	10A, 1200W	8.3A, 1000W	6.3-15A, ~1400W	10.4A, 1090W
Make and Model	LG WM3998HBA	GE GeoSpring	Innova HPAC 2.0	LG LS-120HXV







# Smart Circuit Splitters, Sub Panels, Whole House Panels

<b>Circuit Splitter -</b> BSA Electronics Dryer Buddy	<b>Sub Panel</b> - Eaton Energy Management Circuit Breaker	<b>Whole House Panel -</b> Koben GENIUS Smart Panel
DryerBuddy 30amp		
<ul> <li>Plugs into a 30A circuit (common dryer plug) and allows for vehicle charging while dryer is not in use.</li> <li>It has a digital display that shows the draw of each load.</li> </ul>	<ul> <li>Programmable breakers to prioritize loads in power outage scenarios, control shedding of lighting and plug loads</li> <li>Remote cycling of HVAC, WH, to offset energy demands and save</li> </ul>	<ul> <li>Replaces old electrical panel and allows home to become "Smart Grid" ready</li> <li>Integrates EV Charging, Solar, Battery Storage, Generator and your utility whether you are planning for</li> </ul>

- offset energy demands and save money
- Can connect with solar monitoring, home networks and demand response

the new energy era or have already

installed your new energy technology.

# AGENDA

- GHG and Methane
- Laws and Mandates
- Electrification Technologies
- New Buildings
- Retrofit of Older Buildings
- Electric Grid
- Q&A



### Electrical Grid

# Can the grid handle this transition?

# Are electric vehicles going to take down the grid?

### **Recent Studies**

- Residential Building Electrification in California -Energy and Environmental Economics, Inc
- Electric Vehicles Are Driving Electric Rates Down -Synapse Energy Economics
- Will Electric Vehicles Drive Distribution Grid Upgrades?: The Case of California – IEEE Electrification Magazine



# Residential Building Electrification in California – E3 Study

- California grid is a summer peaking system
- Demand is driven by air conditioning
- Electrification will drive winter electricity demand
- Winter demand will be lower than summer demand
- Better utilization of grid assets will result
- May have localized impacts necessitating grid upgrades

# Electric Vehicles Are Driving Electric Rates Down - Synapse Energy Economics

- PG&E and SCE were examined for costs and revenues associated with EVs between 2012 and 2019
- EVs increase consumption by approximately 250 kilowatt hours (kWh) per month per car
- TOU rates and off-peak rates drive EV charging behavior
- EVs impose minimal costs on the grid and help to utilize resources more efficiently
- \$806 million more in revenues than associated costs, driving rates down for all customers
- CPUC mandated "revenue decoupling" means that revenues were returned to utility customers in the form of lower rates and bills



PG&E and SCE Revenues and Costs of EV Charging, 2012-2019

# What about the future?

- Bigger electric loads
- More end users
- Techniques to manage load
  - More efficient appliances and homes
  - Times of Use (TOU) Rates
  - Demand Response
  - Distributed Energy Resource (DER)
    - Solar + Battery
  - Vehicle to Grid (V2G)
  - IOT (Internet of Things) / Smart Devices

### Acknowledgements

- Building Decarbonization Coalition
- BayREN
- Redwood Energy
- Gridworks
- Energy + Environmental Economics
- Synapse Energy Economics
- National Resources Defense Council
- IEEE
- Lawrence Berkeley National Laboratory
- EPRI



# AGENDA

- GHG and Methane
- Laws and Mandates
- Electrification Technologies
- New Buildings
- Retrofit of Older Buildings
- Electric Grid
- Q&A



