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NRDC et al. Comments on CEC Proposed Model Solar PV Ordinance and Proposal for a â€œRenewable Water Heatingâ€ Model Ordinance

Additional submitted attachment is included below.

NRDC et. al. Comments on CEC Proposed Model Solar PV Ordinance
and Proposal for a "Renewable Water Heating" Model Ordinance

May 5, 2017

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On April 20, 2017, the California Energy Commission (CEC) presented a proposal for a solar photovoltaic model ordinance to help California cities interested in clean energy and climate leadership adopt a local "reach" building energy code, helping pave the way toward zero-net energy (ZNE) homes.

We very much appreciate the presentation of this proposal and the opportunity to provide comments before the CEC finalizes and publishes this model ordinance. This letter submits comments on this draft model ordinance on behalf of the Natural Resources Defense Council (NRDC) and our more than 380,000 members and online activists in California, Acterra, the Association for Energy Affordability, the California Solar Energy Industries Association, the City of Berkeley, Carbon Free Palo Alto, Design

AVEnues LLC, Home Energy Analytics, MenloSpark, Sanden International, the Sierra Club, Stone Energy Associates, and the Union of Concerned Scientists.

We strongly support CEC's initiative to develop a model solar photovoltaic (PV) ordinance. It provides an opportunity for city leadership and a glide path toward ZNE homes in California. The proposed ordinance is cost-effective for home owners, and an opportunity to reduce greenhouse gas (GHG) emissions in a way that will save bill payers money, increase their disposable income and help the state's economy.

We propose that CEC also adopts an optional add-on "renewable water heating" model ordinance. This would allow cities to consider both options, and either adopt the solar PV ordinance alone or both options together depending on their situation and priorities.

CEC's proposal aims to offset most of the electricity use in a dual-fuel building, but it does not address the energy used for thermal end uses such as water heating and space heating. Direct use of fossil fuels, primarily natural gas, for thermal end uses in residential buildings is responsible for a roughly equivalent amount of GHG emissions in California as all electricity used in these buildings.[1]

This is an overlooked opportunity to save energy and reduce GHG emissions, as several technologies are available today that can provide significantly lower-carbon hot water in buildings than with current natural gas systems. These include electric heat pump water heaters (HPWH), and solar thermal water heating.

Renewable water heating model ordinance requirements: A renewable water heating local ordinance would require that newly constructed single-family and low-rise multifamily buildings use a renewable water heating solution which is either a heat pump water heater and associated PV, or a solar thermal water heater and its backup electric or gas water heater, or that the whole building achieves the CALGreen "**PV-Plus**" package as defined in the 2016 Energy Efficiency Ordinance Cost Effectiveness Study.

The heat pump option would consist of a high-efficiency electric HPWH instead of a gas tankless water heater, combined with enough additional PV panels to cover 80% of the annual energy use of the HPWH.

Benefits: The combination of HPWH and PV provides a unique opportunity to make the HPWH more cost-effective for home owners: by taking advantage of the fact that PV electricity is cheaper than grid electricity, our preliminary analysis indicates home owners can **save around 13 percent of lifecycle water heating costs**. HPWHs would also **reduce source energy use by over 30 percent** and **GHGs by nearly 50 percent**. In addition, HPWHs would help address the duck curve and the grid impacts of rooftop PV exports, through their capability to increase self-consumption of rooftop PV electricity, and absorb and store excess PV generation.

Our proposal is focused on water heating instead of all-electric buildings, because it provides a lower barrier to entry to heat pump technology than all-electric buildings, and it avoids potential customer

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[1] Jones C., Kammen D., "Bay Area Consumption-Based Greenhouse Gas Emissions Inventory", Jan. 2016, http://www.baaqmd.gov/research-and-data/emission-inventory/consumption-based-ghg-emissions-inventory

acceptance issues with all-electric buildings (especially with electric cooking) which do not exist with water heating. However, builders would be able to build all-electric if they choose to. Choosing an all-electric building would be even more cost-effective than electrifying water heating only, because of avoiding gas connection costs and using a single heat pump appliance for both space heating and cooling instead of a separate furnace and A/C.

Our detailed proposal in presented in Appendix A. We are working with the Statewide Codes and Standards team to refine our cost analysis and develop model ordinance language.

We ask CEC to consider this opportunity to cut GHG emissions from energy use in buildings through reach codes and local government leadership.

NRDC recommends that CEC adopt the renewable water heating ordinance as soon as possible - At the April 20 workshop, CEC asked stakeholders to comment on whether to hold off on the solar PV ordinance until this renewable water heating ordinance is ready and can be published at the same time. NRDC does not recommend delaying the PV ordinance in case the renewable water heating ordinance takes longer to finalize than anticipated, but we recommend that CEC adopt the renewable water heating ordinance as soon as possible, i.e. within a matter of weeks not months. This will help cities consider both options at the same time, and CEC and other parties to promote them together.

The renewable water heating ordinance is under development and close to completion: the language is being developed, and the cost-effectiveness analysis finalized. We expect to complete these two tasks by mid-May, allowing for stakeholder comments and any changes by mid-June.
We appreciate the opportunity to provide this input to the CEC, and thank CEC for its careful consideration of our comments.

Respectfully submitted,

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Appendix A - Proposal for Renewable Water Heating Model Ordinance

Background

CEC has proposed a model solar ordinance to help cities looking for climate leadership opportunities to adopt a local building code ordinance that would require rooftop photovoltaic (PV) and higher energy efficiency than the California 2016 building code for new construction. Specifically, the proposed model ordinance would require:

1. Rooftop PV covering at least 80% of projected electrical use (with exemptions)
2. Energy efficiency in line with 2016 code requirements without the PV credit.

Opportunity: Extend solar requirements from covering just electricity to including water heating energy (through electric heat pump or solar thermal)

Why include water heating in a solar PV ordinance? - Water heating already represents roughly half of all residential gas use in CA, and is responsible for approximately a quarter of residential emissions from energy use today. This share is set to increase as California's electricity becomes increasingly renewable, and heating energy use decreases thanks to higher building efficiency, while the potential for reduction of water heating loads is more limited.

High-efficiency electric heat pump water heaters (HPWH) offer an alternative solution to meet household hot water needs using less source energy and, when powered by increasingly clean electricity, with much lower GHG emissions than the most efficient gas water heaters on the market (even from a system perspective, including power plants emissions and distribution losses).

In addition, HPWH have the potential to help integrate solar electricity into the grid by leveraging their thermal storage capacity to pre-heat water off-peak and shed load on-peak. While grid-connectivity and utility and 3rd-party programs will be required to dispatch this capability, it is important to start by scaling the market share of HPWH to make these programs viable.

PV makes HPWH more cost-effective – The combination of HPWH with rooftop PV allows the use of lower PV electricity costs instead of grid electricity prices (as modeled by time dependent valuation or TDV) for HPWH operation. This significantly improves the cost-effectiveness of HPWH vs. gas water heating, and leverages the customer investment in solar PV to decarbonize both electricity and water heating energy use in a cost-effective manner.

Climate policy benefits - Beyond the immediate emissions and cost reduction benefits, including water heating in this solar ordinance also presents the following policy benefits:

1) It will drive demand for heat pumps and **build capacity in the HPWH market in CA in the short-term**, allowing heat pumps to become a significant pathway to help meet the state's ambitious energy efficiency and climate goals such as SB 350 Doubling Energy Efficiency goal, and SB 32 40% reduction in GHGs by 2030;
2) It will give leading cities an opportunity to pave the way for extending this approach to the statewide building code in the future.

Scope: Same as CEC's proposed ordinance: newly constructed single-family buildings and low-rise residential structures

Proposed solar hot water requirements - We propose adding the following requirements to the ordinance:

- **Compliance option 1, prescriptive method**: the domestic hot water shall be delivered by a **heat pump water heater** that is compliant with the Tier 3 requirements of the NEEA Advanced Water Heater Specification and listed on the NEEA Qualified Product List located at http://neea.org/advancedwaterheaterspec, and the rooftop PV system shall be sized to meet 80% of the annual heat pump water heating load in addition to the currently proposed sizing requirements.

- **Compliance option 2, prescriptive method**: the domestic hot water shall be delivered by a **solar thermal** water heating system with a solar fraction of 60%.

- **Compliance option 3, performance method**: The building shall meet the requirements of the CALGreen "PV-Plus" package as defined in the 2016 Energy Efficiency Ordinance Cost Effectiveness Study. Buildings that are not suitable for solar as determined by the Building Official shall meet the requirements of the CALGreen "Tier 1 Efficiency-only" package instead.

Table 14: Single Family Reach Code Package Recommendations

Packages	Climate Zones	T-24 Compliance Target	QII	PVCC Allowed	PV	Solar Ready
Tier 1 Efficiency Only Package	1-3, 11-16	15%	Yes	No	n/a	Yes
	5, 9-10	15%	Yes	No	n/a	No
	4	10%	Yes	No	n/a	No
PV-Plus Package	1,2,4, 8-16	30%	Yes	Yes	Yes	n/a
	3,5	20%	Yes	Yes	Yes	n/a
	6-7	10%	Yes	n/a	Yes	n/a

Table 15: Multifamily Reach Code Package Recommendations

Packages	Climate Zones	T-24 Compliance Target	QII	PVCC Allowed	PV
Tier 1 Efficiency Only Package	1, 11-16	15%	Yes	No	n/a
	10	10%	Yes	No	n/a
	2	QII	Yes	No	n/a
PV-Plus Package	4, 9-16	25%	Yes	Yes	Yes
	1-2, 8	20%	Yes	Yes	Yes
	3	15%	Yes	Yes	Yes
	5	10%	Yes	Yes	Yes
	6-7	10%	Yes	n/a	Yes

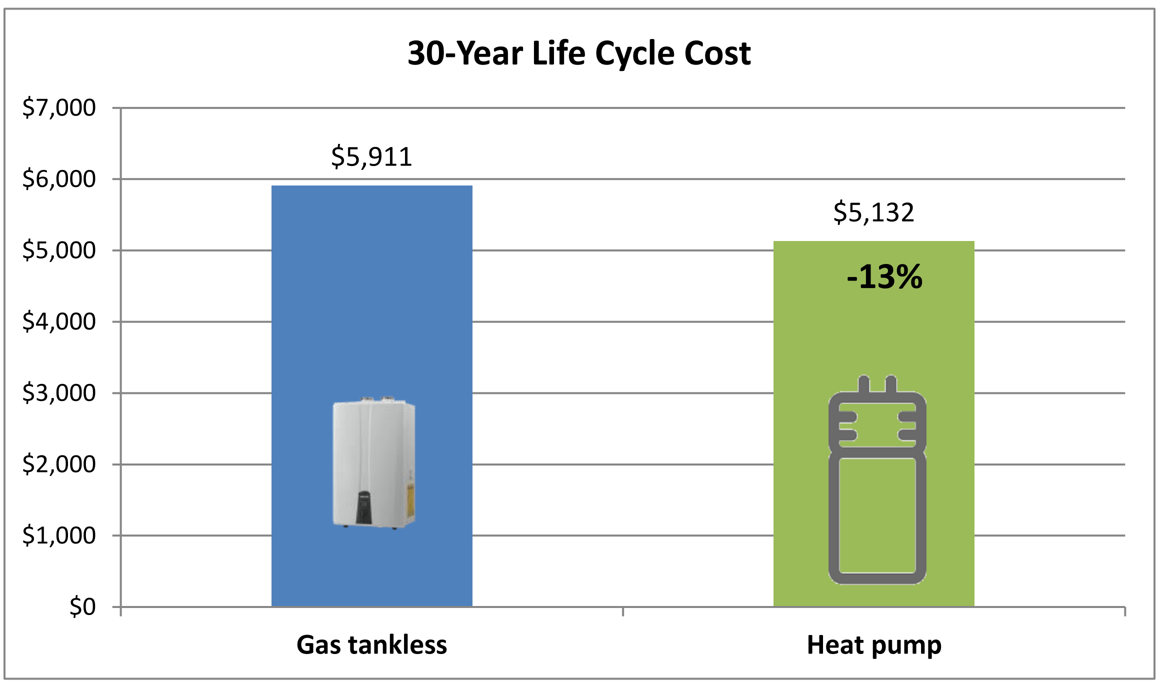
Avoiding pre-emption –The proposed approach allows an option with a gas water heater when combined with a solar thermal system, as well as an envelope efficiency option. Neither of those requires appliances that exceed federal efficiency standards. The solar thermal option may not be cost-effective today but could become cost-effective with increased adoption. Both the HPWH and efficiency options are cost-effective (see below for the HPWH+PV option. The cost-effectiveness of the CALGreen PV-Plus and tier 1 efficiency-only packages was already demonstrated in the 2016 Energy Efficiency Ordinance Cost Effectiveness Study).

Why not include space heating? – While it is tempting to include renewable space heating in the ordinance too because it can even be more cost-effective than HPWH in new construction (heat pump space heating and cooling requires only one heat pump system instead of a separate furnace and A/C, as well as saving on gas access and combustion venting costs), we don't propose to include it in this ordinance because this could raise the barrier to adoption. However, builders may choose to build all-electric as a cost-effective way to achieve this water heating requirement.

Cost-Effectiveness

A preliminary analysis of the cost difference of installing a HPWH and additional PV to cover 80% of the HPWH's annual load (on top of what the PV already required by the model solar ordinance), instead of a 0.82 EF instantaneous (tankless) gas water heater in a new construction single family home, indicates that a HPWH + PV would cost roughly 13% less than a 0.82 EF gas tankless equivalent, on a 30-year lifecycle basis.

This preliminary analysis uses average values for California (not by climate zone), a 50-gal, 66-gal, and 80-gal HPWH (3.5 EF) depending on the household size. A separate analysis by climate zone is being developed by the Statewide Codes and Standards team.



Data and assumptions uses in the analysis are detailed in the last section of this document. The analysis does not account for the lower marginal cost of PV: adding a few PV panels to those already required in the solar PV ordinance costs a lot less than the first PV panels, because the additional panels leverage the fixed costs such as getting a crew on-site.

GHG Emissions and Source Energy

The source energy and GHG emissions of a HPWH depend on the generation resources at the margin at the time of operation: when operating during peak time, the marginal resource is more likely to be a gas peaker plant, and when operating during PV generation, the marginal resource is the home's PV system (since the additional PV was installed specifically to serve the HPWH).

To estimate the GHG emissions and source energy use of a HPWH, three scenarios are considered:

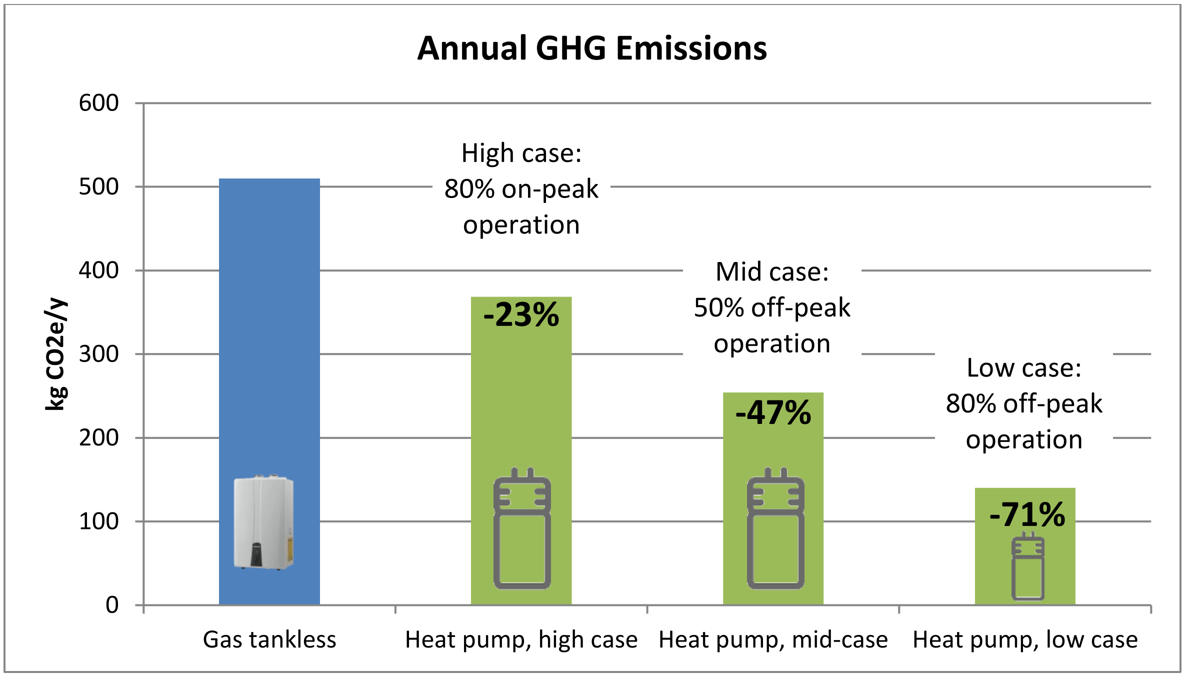
1. **High-emissions case**: HPWH operated 80% on-peak, 10% during solar hours, and 10% off-peak outside of solar hours (e.g. at night)
2. **Mid-emissions case**: HPWH operated 50% on-peak, 30% during solar hours, and 20% off-peak outside of solar hours
3. **Low-emissions case**: HPWH controlled to operate mostly off-peak: 20% on peak, 50% during solar hours, and 30% off-peak outside of solar hours.

The emissions and source energy factors of peak and off-peak grid electricity were then estimated (see last section of this document for detailed data and assumptions).

A "long-run marginal" or "build marginal" accounting methodology is used: this considers the generation resources which will be built/procured over the long-term to serve this new load, not the long-term operational margin which would be there anyway even without the new HPWH load. For renewables, the long-run margin includes mostly solar, wind and gas, since no new large hydro or nuclear is expected to be built in California.

The analysis indicates a GHG emissions reduction ranging from 23% in the high-emissions case, to 71% in the low-emissions case, with a mid-case of 47%. The magnitude of these numbers reflects a number of things:

1. Even with a gas peaker plant on the margin, recent heat pump water heaters outperform 0.82 EF gas tankless water heaters on GHG emissions
2. Even without being combined with PV, heat pump water heaters will operate partially off-peak where they benefit from an increasing share of renewables on the build margin, per California's renewable portfolio standard (RPS). This is increased when combining the HPWH with PV as the solar-coincident part of the load is emissions-free.
3. Controlling HPWH offers an opportunity to use their inherent thermal storage capacity to shift most of the HPWH operation off-peak, helping absorb renewables and reduce peak load.

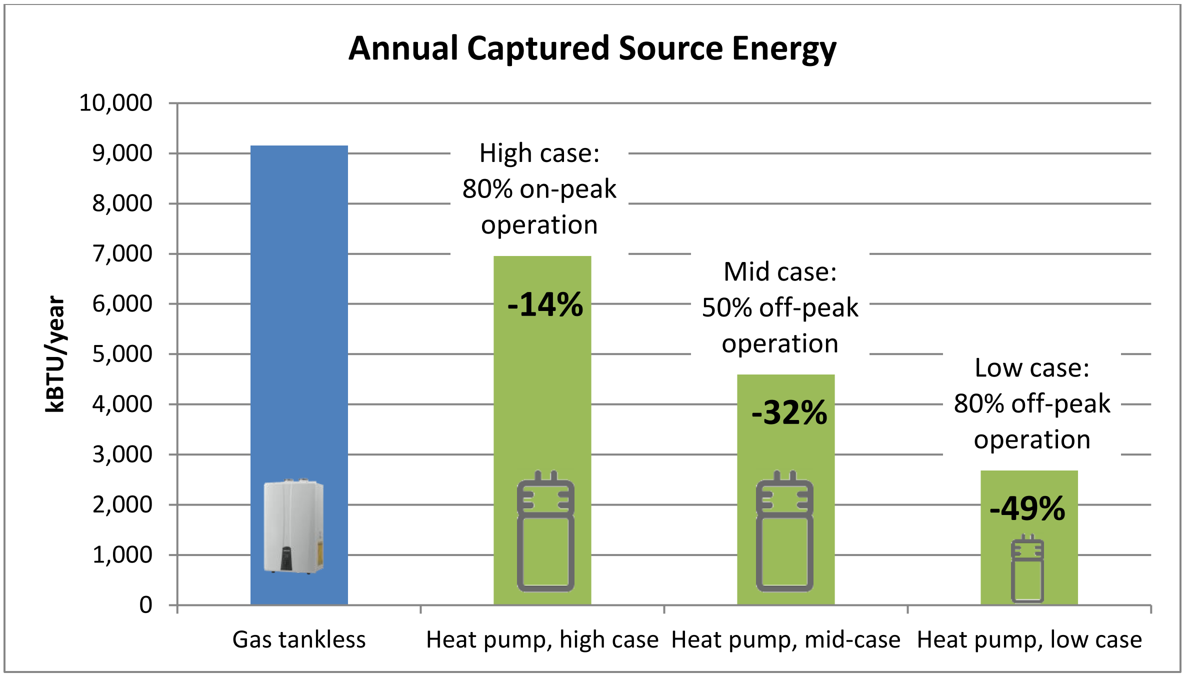


Source Energy (Captured)

Source energy considers the upstream losses in the production, transmission and distribution of electricity and natural gas to the site. In this analysis, DOE's "captured source energy" methodology[2] was used to estimate source energy for electricity. The difference with the conventional source energy methodology is that Captured Source accounts for renewables by attributing a thermal efficiency of 100% to renewable electricity generation, and only counting transmission and distribution (T&D) losses for these resources. Captured Source only counts the energy that is "captured" by solar and wind generators. Apart from T&D losses, renewable electricity is essentially considered site electricity. The traditional source energy methodology which considers all electricity to be generated from fossil power plants is no longer appropriate in California given the significance of state's renewable electricity policies.

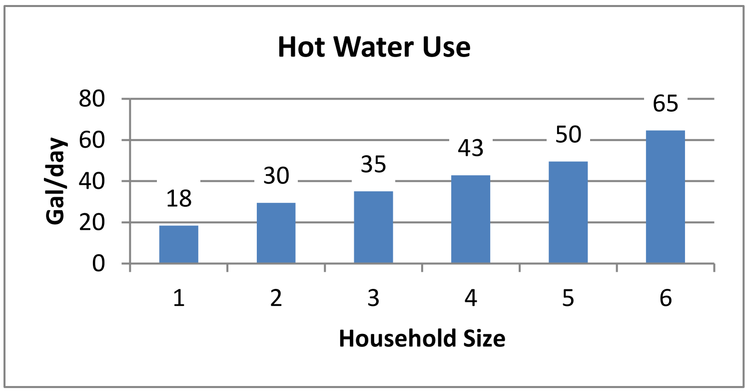
The Captured Source Energy analysis indicates that HPWH + PV uses on average one third less source energy than an 0.82 EF gas tankless water heater, with source energy savings ranging from 14% in the high case to 49% in the low case.

[2] U.S. DOE, "Accounting Methodology for Source Energy of Non-Combustible Renewable Electricity Generation," Oct. 2016, https://www.energy.gov/sites/prod/files/2016/10/f33/Source%20Energy%20Report%20-%20Final%20-%2010.21.16.pdf


Annual Captured Source Energy
kBTU/year
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
High case:
80% on-peak
operation
-14%
Mid case:
50% off-peak
operation
-32%
Low case:
80% off-peak
operation
-49%
Gas tankless
Heat pump, high case
Heat pump, mid-case
Heat pump, low case

Data and Assumptions for Cost Analysis

- Discount rate: 3%
- **Average CA residential gas rate**: $1.28/therm (EIA, Jan. 2017, https://www.eia.gov/dnav/ng/hist/n3010ca3m.htm)
- **30-year discounted cost of photovoltaic in single family**: $0.114/kWh ($3.02/watt installed), Davis Energy Group, Enercomp, Misti Bruceri and Ass., "Local PV Ordinance Cost Effectiveness Study", https://fremont.gov/DocumentCenter/View/33146, updated to focus on new construction costs, and to correct overhead and margin costs.
- **Hot water usage**: NRDC calculation based on Kruis et al., California Residential Domestic Hot Water Draw Profiles, May 2016 (Draft), http://www.bwilcox.com/BEES/docs/Kruis%20-%20Dhw%20Analysis%205.docx



- **Gas tankless equipment list price**: $1,042 for 8 GPM, $1,221 for 10 GPM, per www.homedepot.com on 4/14/2014. Energy factor: 0.82 EF
- **Gas tankless installation cost**: Gas supply line: $200, water heater installation: $346 (2014 Itron Measure Cost study adjusted for inflation). Combustion venting: $50 equipment and $178 equipment cost per 2011 DWH CASE report. Combustion testing costs not included.
- **Gas tankless lifetime and replacements:** 20 years (per DOE and 2016 DWH CASE report). The cost of one replacement is included in the calculation.
- **HPWH equipment list price**: $1,200 for 50-gal, $1,400 for 80-gal, per www.lowes.com on 4/14/2017. Energy factor 3. 5, COP per NRDC-Ecotope 2016 study, https://www.nrdc.org/experts/pierre-delforge/very-cool-heat-pump-water-heaters-save-energy-and-money, scaled by 7% to account for performance improvements since 2014 (ratio of 3.5 EF and 3.25 EF)
- **HPWH installation:** $497 (2014 Itron Measure Cost study adjusted for inflation) + $200 for 240V conduit cost per online search.
- **HPWH lifetime and replacements:** 13 years (per DOE and 2016 DWH CASE report for storage water heaters). The cost of two replacements is included in the calculation.

Data and Assumptions for GHG Emissions and Source Energy Analysis

- **Natural gas source to site ratio**: 1.05, Energy Star Portfolio Manager - Technical Reference, https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf
- **Electricity T&D losses**: 1.047, EIA, 2015, , http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3
- **Natural gas emissions factor**: 5.302, kg CO2/th, , http://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references
- **Emissions factors**: Table 10, "CEC Draft Staff Report: ESTIMATED COST OF NEW RENEWABLE AND FOSSIL GENERATION IN CALIFORNIA (May 2014)", http://www.energy.ca.gov/2014publications/CEC-200-2014-003/CEC-200-2014-003-SD.pdf

	lbs/MWH	kg CO2/kWh
Single cycle	1,239.3	0.5621
Combined cycle	823.1	0.3734

- **Source-to-site ratios and heat rates**: Table 39, "CEC Draft Staff Report: ESTIMATED COST OF NEW RENEWABLE AND FOSSIL GENERATION IN CALIFORNIA (May 2014)", http://www.energy.ca.gov/2014publications/CEC-200-2014-003/CEC-200-2014-003-SD.pdf

	Heat rate Btu/kWh	Thermal efficiency	Source-to-site
Single cycle	10,585	32%	3.10
Combined cycle	7,250	47%	2.12