Lifecycle Cost (LCC) comparison of heating and cooling a single-family detached home of size 2,100 sf in California climate zone 3.

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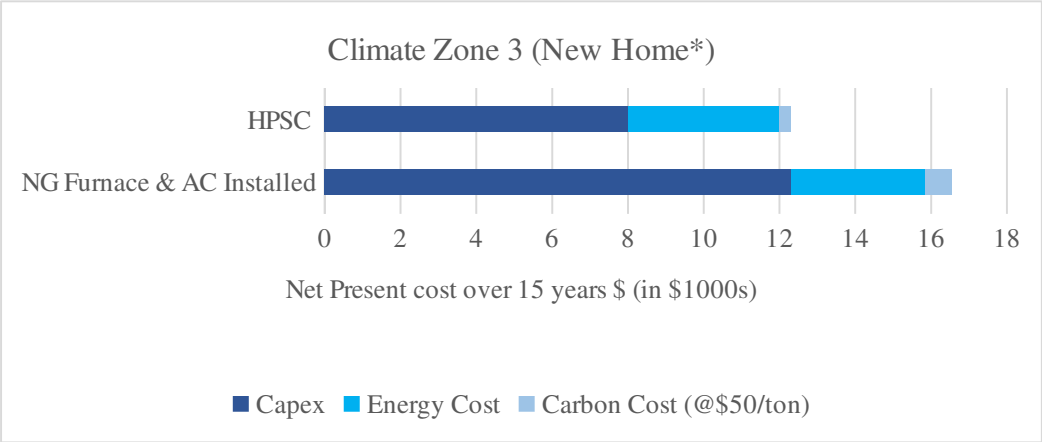
A new home can either be all-electric using (i) heat pump space conditioner (HPSC) for heating and cooling or (ii) dual-fuel using natural gas (NG) furnace for heating and a central AC for cooling. Figure 1 below shows the LCC comparison over 15 years for these two appliance combinations. A dual-fuel new home will incur an additional cost of an NG Infrastructure of $1500/per home. Cost of NG + AC = $3.6k + $7.2k[1]. Cost of HPSC = $8k. Other assumptions on fuel costs, appliance efficiencies, etc., can be found at the end of the document.

Figure 1: Comparison of lifecycle costs of heating & cooling over 15 years for a new home in Climate zone 3



* Thermal efficiency of shells as per 2019 Title 24

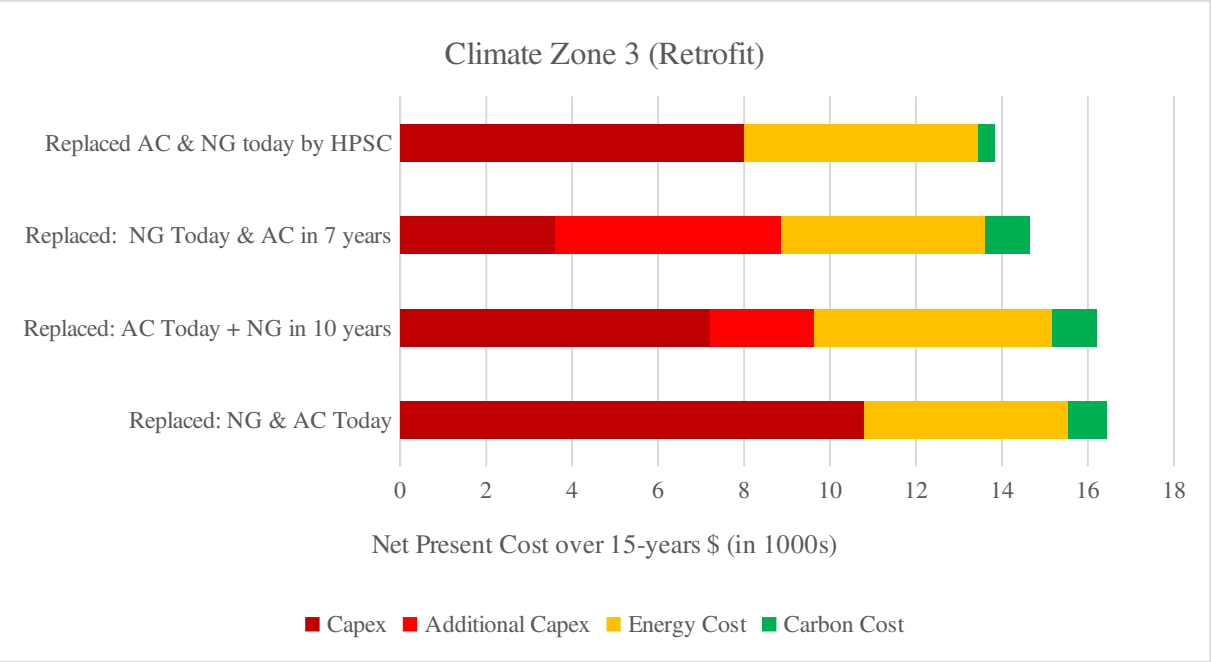
Five possible situations and solutions for a single-family existing home are presented below:

Situation	Solution
(i) NG retires first and AC is working and might have another 8 years of life	Household replaces NG and replaces AC in 8 years
(ii) AC retires and NG furnace is working and might have another 10 years of life	Household replaces AC and replaces NG in 10 years
(iii) AC retires and NG end of life is nearby or NG retires and NG end of life is nearby	Household replaces NG with NG and AC with AC
(iv) For any of the situations above	Household replaces both appliances by a HPSC
(v) Household has only a NG furnace and no cooler, but acquires one in the near future	This situation is equivalent to one of the above

1 Installed Capital Costs from RMI, report: https://rmi.org/wp-content/uploads/2018/06/RMI_Economics_of_Electrifying_Buildings_2018.pdf

Figure 2 below compares the lifecycle cost over 15 years for the situations (i) – (iv). As one can see, replacing NG furnace and AC with an HPSC is more economical in all the 4 scenarios. However, if the household uses NG furnace for heating and has no plans to adopt central AC in the next 10 years, the prevailing low fuel cost of NG and the lower capex of NG furnace will make the HPSC option expensive. In climate zones like CZ10 – CZ15, with higher cooling requirement, the case for HPSC is more compelling. However, with increased warming cooling is becoming more of a necessity.

Figure 2: Comparison of lifecycle costs of heating & cooling over 15 years for an existing home in climate zone 3

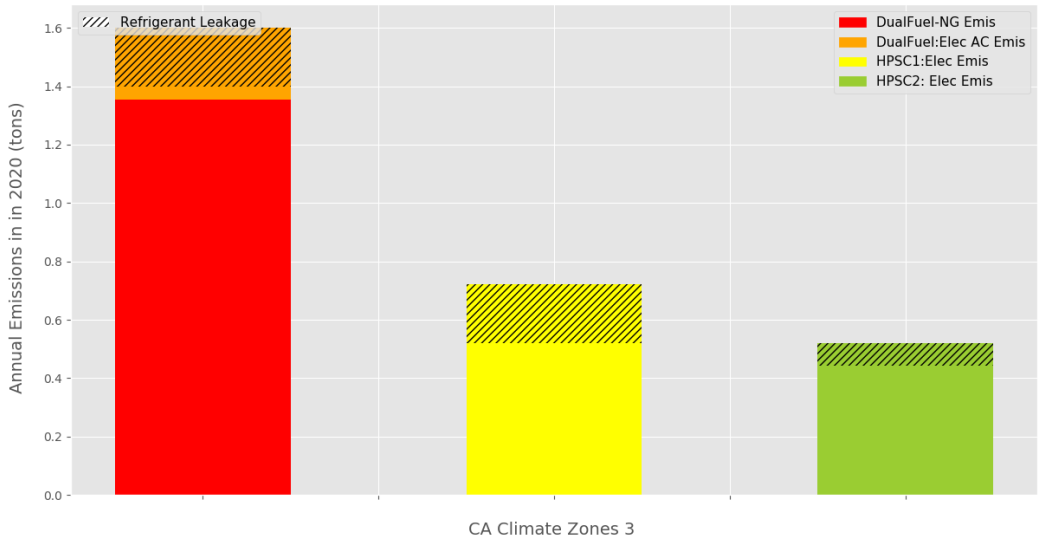


Additional Capex in bar 2 is the NPV of AC Replacement in 7 years
And in bar 3 is the NPV of NG Replacement in 10 years

Efficiency assumptions for the above graphs	
Existing NG Furnace COP = 0.8	*HPSC Heating HPSF = 10*
Replacement/New NG Furnace COP = 0.95	*HPSC/AC Cooling SEERP = 13*
Lifetime of NG Furnace is assumed to be 22 years and that of AC and HPSC is 15 years	

Figure 3 below compares total annual emissions for identical existing single-family home for three possible appliance combinations in climate zone 3. The 1st is the total annual emissions of operating an NG furnace for heating (red) and electric AC (orange). The hatch ('///') shows the emissions from direct leakage of refrigerant from AC. The 2nd and 3rd bars give the emissions from operating an HPSC for heating and cooling. HPS2 the 3nd bar has higher heating and cooling efficiency than HPSC1 and lower GWP refrigerant.

Figure 3: Comparison of GHG Emissions of 3 appliance combination for a single-family home in Climate zone 3



NG Furnace COP = 0.95
Elec AC SEER = 13

HPSC1: heating efficiency (HPSF) = 10
HPSC1: cooling efficiency (SEER) = 13
GWP of refrigerant (R-410a) = 1750

HPSC2 heating efficiency (HPSF) = 12
HPSC3 cooling efficiency (SEER) = 15
GWP of refrigerant (R-32) = 650

Heating degree days (current) = 2921
Cooling degree days (current) = 146

NG carbon intensity assumed = 6.1 kg/therm
Electricity carbon intensity assumed = 0.25 kg/kWh

NG fuel cost = $1.387/ therm
Electricity fuel cost = $0.1832/kWh
Annual escalation rate for both = 2%
Social discount rate = 4%

Conclusion

For new homes, an all-electric home is much more economical than adopting a dual-fuel home with two space conditioning appliances. In addition, taking into account the avoided cost of an NG infrastructure cost, the economics of an all-electric home gets even better. For existing homes, the current capital costs of HPSC are only

around 10-15% higher than air-conditioners (AC). So already replacing retiring NG furnace or AC with an HPSC makes economic sense.

Mandating new homes to be all-electric and incentivizing homes with AC and NG furnace to switch to HPSC will help bring down the cost the installation cost of HPSC, by learning by doing. Greater customer adoption will require larger outreach and education to consumers, building contractors, plumbers and technicians and developing regional partnerships that set market adoption targets, standards-setting, or performance goals in heat pumps.