The key role of propane in a sustainable cooling sector

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Split air conditioners (ACs) are the most used appliance for space cooling worldwide. The phase-down of refrigerants with high global warming potential (GWP) prescribed by the Kigali Amendment to the Montreal Protocol has triggered a major effort to find less harmful alternative refrigerants. HFC-32 is currently the most common refrigerant to replace HFC-410A in split ACs. The GWP of HFC-32 is about one-third that of HFC-410A but still considerably higher than that of a growing number of nonfluorinated alternatives like propane with a GWP of <1, which have recently become commercially available for split ACs. Here, we show that a switch to propane as an energy-efficient and commercially available low-GWP alternative in split ACs could avoid 0.09 (0.06 to 0.12) °C increase in global temperature by the end of the century. This is significantly more than the 0.03 (0.02 to 0.05) °C avoided warming from a complete switch to HFC-32 in split ACs.

Results

With the continued use of HFC-410A refrigerant in split ACs, our estimates show that global annual HFC emissions from split ACs would increase from 0.4 Gt CO₂eq in

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2017 to 1.7 Gt CO$_2$eq in 2050 and 2.6 Gt CO$_2$eq in 2100 (Fig. 1B). Transitioning to HFC-32 in split ACs would reduce these emissions on an annual basis by 38% in 2050 and 51% in 2100, whereas switching to propane would reduce them by nearly 100% in 2060. Transitioning from HFC-410A to HFC-32 can reduce the global cumulative HFC emissions from split ACs by 44% between 2017 and 2100, whereas adoption of propane could instead achieve a cumulative reduction by 88% over the same period. Fig. 2 presents the climate impact of the adoption of propane or HFC-32 as alternative refrigerants relative to the “baseline” HFC-410A scenario. A full switch toward propane in split ACs will avoid 0.09 (0.06 to 0.12) °C increase in global temperature by the end of the century, whereas the replacement of HFC-410A with HFC-32 would avoid 0.03 (0.02 to 0.05) °C warming.

**Discussion**

Market assessments (13) show that accelerating the transition to more energy-efficient split ACs, propane as a refrigerant can play a key role in creating a more sustainable split AC sector. Propane exhibits significant environmental advantages through good energy performance and a GWP close to zero. A recent study by the European Commission (7) concluded that propane in split ACs up to 7 kW can be classified as a technically valid alternative to HFC-driven split ACs; however, some national regulations prohibit their use, primarily due to regulations restricting the use of refrigerants with higher flammability. Leapfrogging from HCFC-22 or HFC-410A units to high-efficiency appliances using propane reduces energy consumption and GHG emissions (10) and thus provides a significant opportunity to contribute to national climate action plans. For example, to achieve the European Union’s ambitious 2050 climate neutrality targets, early and aggressive action is needed. In the short-term, converting new air-conditioning systems to more environment-friendly refrigerants can reduce their climate impact significantly. As time is running out to avoid climate tipping points (3), propane could be deployed in small AC units (<7 kW) faster than it will become available for larger-capacity systems ensuring proper safety, standards, and training.
Materials and Methods

For this study, baseline HFC emissions in the split-AC sector have been developed using the GAINS methodology (14). To analyze the impact of low-GWP alternatives two additional scenarios considering a transition toward HFC-32 and propane have been developed. Further details are provided in SI Appendix. The pathways derived from the HFC-410A baseline, and the replacement of split-AC refrigerants with HFC-32 and propane, are run in the emissions-driven FaIR climate model emulator (15, 16). Emissions of other species (e.g., CO₂) follow the SSP2-4.5 pathway (17). For the scenario of transition toward propane, we have added the propane emissions to the global total of emitted volatile organic compounds. This affects ozone formation and contributes a small positive forcing, but this increase is an order of magnitude smaller than the reduction in HFC forcing by elimination of HFC-410A.


7. European Commission, “The availability of refrigerants for new split air conditioning systems that can replace fluorinated greenhouse gases or result in a lower climate impact” (European Commission, Brussels, 2020).