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Mary D. Nichols
Chairman
Air Resources Board
California Environmental Protection Agency
1001 I Street, PO Box 2815
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EIA Comments on the Proposed Short-Lived Climate Pollutant Reduction Strategy

Dear Ms. Nichols:

The Environmental Investigation Agency (EIA) appreciates this opportunity to comment on the Proposed Short-Lived Climate Pollutant Reduction Strategy (the "Proposed SLCP Strategy") released by the Air Resources Board (ARB) on April 11, 2016. For more than two decades EIA has been closely involved in international ozone and climate negotiations. In addition to supporting efforts to phase down hydrofluorocarbons (HFCs) under the Montreal Protocol, EIA has worked domestically in the U.S., EU, Canada, China and India to promote the promulgation of regulations focused on phasing down domestic consumption of HFCs and incentivizing transitions to low-global warming potential (GWP) technologies.

The Proposed SLCP Strategy has progressed well from earlier iterations in proposing tangible measures to curb the rapid growth of HFC emissions and achieving reductions of 40 percent below current levels in 2030. In particular, we applaud ARB for proposing ambitious but feasible GWP thresholds for the refrigerant ban (>2500 GWP) and the refrigeration equipment bans (>150 GWP) to take effect in 2020 and 2021. The GWP threshold for air conditioning equipment could be further re-evaluated and lowered as technologies continue to evolve rapidly, particularly for certain sectors and equipment as elaborated on below.

California's leadership with these planned HFC measures is a much needed signal of U.S readiness and continued commitment to an ambitious phase-down as negotiations progress toward reaching a global agreement at the Montreal Protocol. While a global agreement on HFCs in 2016 appears increasingly attainable, these measures in California are important steps that can be taken now to achieve the state's 2030 and 2050 emission reduction targets whether or not a sufficiently ambitious global agreement is reached this year. As the economic analysis outlines, these measures will also carry substantial co-benefits in the form of reducing energy consumption due to the improved energy efficiency of many of the low-GWP alternatives to HFCs.

Finally, it is important that ARB move forward with the proposed measures in line with the timing of the planned 2020 phase-out of ozone depleting refrigerant HCFC-22. More than half of refrigeration and air conditioning equipment, and at least 2,400 large commercial refrigeration systems in California, still use HCFC-22[1], which is scheduled to be fully phased out of

[1] ARB Proposed SLCP Strategy, page 86.

production and imports in 2020. It is critical that the measures take effect as soon as possible in in order to maximize transitions away from HCFC-22 that bypasses HFCs directly to low-GWP alternatives. The fact that so many systems using old ozone depleting refrigerants are still in operation further highlights the importance of early measures, and in particular a refrigerant ban to curb the availability of virgin supply of high-GWP refrigerants.

ARB's Mandate to Maintain and Continue Emission Reductions Post-2020

ARB has a strong mandate and clear statutory authority under the California Global Warming Solutions Act of 2006 (AB 32), which directs ARB as the lead agency for implementation to "*adopt rules and regulations …to achieve the maximum technologically feasible and cost-effective greenhouse gas emission reductions, as specified.*"[2] Additionally, with regard to authority to implement post-2020 measures, AB32 includes a clear statement of intent that statewide 2020 greenhouse gas limits "*be used to maintain and continue reductions in emissions of GHGs beyond 2020*" and directs ARB to "*make recommendations to the Governor and the Legislature on how to continue reductions of greenhouse gas emissions beyond 2020.*" [3] Finally, HFCs are one of the six greenhouse gases named under AB 32[4], and are thereby statutorily incorporated into California's greenhouse gas emission reduction targets.

Within the scope of this broader mandate to continue and strengthen emissions reduction post-2020, ARB has been directed under Senate Bill No. 605 (SB 605), to "*complete a comprehensive strategy to reduce emissions of short-lived climate pollutants in the state*" no later than January 1, 2016.[5]

Finally, Governor Brown's Executive Order B-30-15 set additional greenhouse gas reduction targets to be met in 2030 and 2050 for the state of California stating that a "*new interim statewide greenhouse gas emission reduction target to reduce greenhouse gas emissions to 40 percent below 1990 levels by 2030 is established…to ensure that California meets its target of reducing greenhouse gas emissions to 80 percent below 1990 levels by 2050.*"[6] Executive Order B-30-15 further stated that "*all state agencies with jurisdiction over sources of greenhouse gas emissions shall implement measures, pursuant to statutory authority, to achieve reductions… to meet the 2030 and 2050 greenhouse gas emissions reductions targets*."[7]

The measures included in the Proposed SLCP Strategy are consistent with these legal mandates and authority granted under AB 32, SB 605, and Executive Order B-30-15 and outlined under the First Update to the AB32 Scoping Plan approved by ARB on May 22, 2014.[8]They are also

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[2] Assembly Bill No. 32, Legislative Counsel's Digest, and Section 38561(a). Available at http://www.leginfo.ca.gov/pub/05--- 06/bill/asm/ab_0001---0050/ab_32_bill_20060927_chaptered.pdf

[3] AB 32, Sections 38551(b) and (c).

[4] AB 32, Section 38505(g).

[5] Senate Bill No. 605, Chapter 523, available at http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB605

[6] Text of Executive Order B-30-15, available at https://www.gov.ca.gov/news.php?id=18938

[7] Ibid.

[8] First Update to the AB 32 Scoping Plan, available at http://www.arb.ca.gov/cc/scopingplan/document/updatedscopingplan2013.htm

essential to reduce emissions of HFCs and other short-lived climate pollutants sufficiently to ensure that the 2030 greenhouse gas reduction targets are met.

Discussion of Proposed Measures

EIA strongly supports the proposed use of refrigerant and equipment bans to set clear goal posts for phasing out high-GWP HFCs in sectors and equipment where low-GWP alternatives are proven and commercially available. As the Proposed SLCP Strategy notes, new technologies are developing rapidly and the GWP thresholds and timing of the proposed bans are not only feasible with current technologies, but could be strengthened even further in some areas, particularly as new products enter the market and others that are widely used in other countries become more widely available on the U.S. market.

Refrigerant ban: The proposed refrigerant ban on the sale or distribution of refrigerants with a 100-year GWP value of 2,500 or greater beginning January 1, 2020 is both feasible and effectively timed. This ban specifically eliminates the use of HFC-507A and HFC-404A, both of which are widely used in industrial and commercial refrigeration alongside older systems still using HCFC-22.

Since the ban exempts certified recycled and reclaimed refrigerants, the installed base of systems using these high-GWP HFC refrigerants that are still in operation after the ban goes into effect will still be able to be serviced using recycled refrigerants. According to some estimates, only approximately 10-15 percent of HCFC-22 refrigerant is currently recovered, reclaimed and recycled.[9] The refrigerant ban in California, alongside finalization of proposed federal regulations under Section 608 of the Clean Air Act to require recovery of HFCs when servicing equipment will serve to significantly scale up the market for recycled HFC refrigerants. As seen with the low reclamation rates of HCFCs, actions in addition to the EPA's 608 regulation is critically necessary to increase and enhance reclamation of refrigerants to allow for a quicker phase-down in virgin production.

EIA urges ARB to also consider a subsequent ban by 2025 on sale of virgin HFC refrigerants above a 100-year GWP value of 1,000, which would include other widely used high-GWP HFCs such as HFC-407A, HFC-410A, and HFC-134a.

Stationary Refrigeration Equipment: EIA applauds ARB for selecting a 150 GWP threshold for both residential and non-residential stationary refrigeration equipment. This sends a strong signal and will encourage manufacturers and end users to bypass mid-range GWP refrigerants that still carry significant climate impacts, with GWPs ranging from around 500 to almost 1,500. Both the non-residential refrigeration and residential refrigerator-freezer sectors are well positioned with multiple commercially available alternatives to meet the 150 GWP threshold beginning in 2020 and 2021 respectively.

EIA has discussed the feasibility of transitioning to hydrocarbons in residential refrigerator-freezers with several member companies of the Association of Home Appliances Manufacturers

[9] EOS Climate White Paper, *Recycling HFC Refrigerant Delivers Immediate, Cost-Effective Climate Protection*, 2015.

(AHAM), who support expanding charge sizes for flammable refrigerants above the currently allowed 57 gram limit and are participating in a newly formed AHAM focus group to update U.S. standards. This group should move swiftly and efficiency to harmonize with the internationally recognized international IEC standard, which allows for up to 150 grams of flammable refrigerant and as a result has enabled over 800 million low-GWP hydrocarbon refrigerators to enter the global market. Many of these manufacturers are already manufacturing hydrocarbon refrigerators for other markets and it is quite feasible for technical experts participating in this process to change the standard for the U.S. years ahead of the 2021 deadline.

EIA provided very detailed comments on the previous Draft Strategy outlining the wide range of available low-GWP technologies in non-residential refrigeration sectors that use low-GWP refrigerants including carbon dioxide (R-744), hydrocarbons, ammonia, water, air, and certain low-GWP HFOs. EIA urges that any exemptions to these equipment bans be very limited, and that ARB consider the full range of options available, particularly for non-residential refrigeration in hot climates, where ammonia and hydrocarbons both demonstrate excellent energy efficiency[10], and can serve as primary refrigerants located on the roof or in a machine room used with CO_2 secondary loop or cascade system.

***Air conditioning Equipment*:** For the residential and non-residential air conditioning sectors, a 750 GWP threshold represents a significant reduction from current >2,000 GWP HFCs used. However setting this threshold across the board for all air conditioning systems could also encourage a greater transition to medium-GWP HFCs and HFC-HFO blends in some areas where it is possible, and both more cost-effective and energy efficient, to encourage a direct transition to <150 GWP solutions. As EIA outlined in its previous comments on the earlier Draft Strategy, setting bans that achieve a sufficient percentage of reductions by needed dates under a supply phase-down has been identified as an implementation challenge under the EU F-gas Regulation. Whether under a global or California-wide supply phase-down, meeting an 85 to 90 percent reduction in CO_2 equivalent consumption as proposed by most phase-down schedules will require reductions significantly below a 750 GWP level for the majority of the residential and commercial air conditioning sector.

The U.S. EPA Significant New Alternatives Policy program has approved self-contained hydrocarbon air conditioners with charge sizes up to 1 kg based upon Underwriting Laboratories (UL) then existing standards.[11] However, UL then changed industrial standards shortly after the EPA approval, radically reducing what UL deems to be safe charge sizes. While the EPA approval is still valid, no manufacturers will market hydrocarbon air conditioners due to legal liability issues created by the new UL standards. EIA is working with others in the industry and it is foreseeable that with additional research and work to harmonize the UL484 standards with internationally recognized IEC standard that hydrocarbon air conditioners will be safely placed on the American market in the near future.

EIA urges ARB to consider the air conditioning sub-sectors and equipment types that can go well below the 750 GWP threshold and revise this number downward for these systems prior to

[10] EIA, *Putting the Freeze on HFCs: 2016 Update*, *Low-GWP Solutions for High-Ambient Conditions*, 2016.
[11] See EPA SNAP Rule 19, Climate-friendly Refrigerant Alternatives, https://www.gpo.gov/fdsys/pkg/FR-2015-04-10/pdf/2015-07895.pdf

implementation. For many types of chillers used for commercial and industrial building air conditioning for instance, there are already multiple very low-GWP alternatives proven and commercially available (GWP <5). In other residential and light-commercial air conditioning equipment such as self-contained and single-split room air conditioners, technologies proven and available in Europe, India, China, and other parts of the world only require work be done to update U.S. safety standards. More work is needed to harmonize with internationally recognized safety standards for these types of equipment, which allow for A3 refrigerants including hydrocarbons to be safely used in charge size amounts up to 1kg or larger when designed and installed with the appropriate safety mechanisms and precautions.

Comments on Appendix B: Research Related to Mitigation Measures

More Research Needed to Advance Standards for Safe Use of Natural Low-GWP Refrigerants

As ARB notes in Appendix B, the European F-Gas regulation has catalyzed rapid research and development of low-GWP alternatives. While substantial resources have been directed toward advancing research and testing on A2L refrigerants with lower flammability (most of which are synthetic patented alternatives with varying levels of performance and climate impacts), resources are particularly lacking in the U.S. for research and testing to further advance standards related to natural refrigerants including hydrocarbons, CO_2, and ammonia.

The research agenda for the next five years outlined in the 2015 Climate Change Research Plan for California includes a priority item for studying the technical feasibility and cost-effectiveness of using low-GWP substitutes to HFCs where studies have not been conducted. As part of this agenda, California should strongly consider funding research to advance safety standards for equipment using hydrocarbons, particularly in the sectors such as residential and light commercial refrigeration where ARB's plan assumes 100% market penetration of these alternatives and relies on the associated efficiency benefits in its Appendix D economic analysis. Studies are needed on the safety of using up to 150 grams of flammable refrigerant in residential refrigerator-freezers, and additional studies are also needed for room air conditioning on the safety of hydrocarbons with respect to leak rates, leak detectors, and shut-off valves. Finally, for commercial refrigeration, the current 150 gram limit for standalone equipment also requires further research.

Comments on Appendix C: Draft Environmental Analysis

Peking University Study Suggests Growing Concentrations of Trifluoracetic Acid (TFA)

ARB's Draft Environmental Analysis includes mention of the potential risk of TFA, a bio-accumulative and potentially toxic breakdown product of some HFC, HFC/HFO blends and HFO refrigerants (e.g., HFC-134a and HFO-1234yf). HFO-1234yf has a low-GWP and is under consideration to be widely adopted in mobile air conditioning and other air conditioning sectors as replacement for HFCs. ARB's finding that this risk is less than significant is based largely on studies cited in the determination made by the U.S. EPA under its Significant New Alternatives Policy (SNAP) program in March, 2011 when HFO-1234yf was listed as an acceptable alternative in light duty passenger vehicles.

The studies cited by ARB from EPA's SNAP program determination, including the 2009 and 2010 ICF analysis, project maximum rainwater concentrations of TFA from certain emission assumptions, but do not model the concentrated accumulation of TFA buildup in various bodies of water.[12] These studies of projected rainwater concentrations fail to take into account the much higher potential for the high level of accumulation of TFA in urban surface and landscape waters, particularly those bodies where inflows of water accumulate but have little or no outlet other than evaporation.

The findings of a more recent study (Zhai et al., 2015, Peking University) shows a 17-fold increase between 2002 and 2012 in TFA concentrations in urban landscape waters, as well as exponential increases in other water bodies and snow samples in the region in and around Beijing.[13] The concentrations measured in urban landscape waters were found to be above 800 ng/L. The study cites that these increases are most likely to be attributed to the exponential growth in automobiles in China during this time, and in particular the use of HFC-134a in car air conditioners.

These findings should be put in the context that while HFC-134a has between a 7-20% molecular yield of TFA[14], the TFA yield of HFO-1234yf is 100%.[15] More research is needed to understand whether continued growth in automobile and HFC consumption and the transition of this sector and others to HFO-1234yf, would lead to concentrations of TFA that could pose a significant risk to aquatic ecosystems. According to the authors of this study, no other study currently models actual increases in TFA accumulation in bodies of water over a full decade. Nor have other studies been performed to date (that we are aware of) modelling predicted accumulation of TFA in bodies of water from HFO-1234yf, based on assumptions from actual data such as this one on the increased concentration of TFA due primarily to HFC-134a. EIA urges ARB to conduct similar studies to the Peking University study on concentrations in waters in California and to be in contact with the authors of the Peking University study who are now conducting a country-wide analysis of TFA in China.

Comments on Appendix D: Economic Assessment

With respect to the refrigeration equipment sectors, the estimated energy efficiency benefits and levels of market penetration of low-GWP refrigerants in Table 26 appear to be in the correct range if not conservative. For example, residential refrigerator-freezers using hydrocarbons have been found by the Energy Star program to be 10% more efficient[16] rather than the 3% efficiency gains cited in the analysis.

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[12] See ICF 2010, Sensitivity Analysis CMAQ Results on Projected Maximum TFA Rainwater Concentrations and Maximum 8-hr Ozone Concentrations 5/21/2010, Available at https://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2008-0664-0216

[13] Zhai, Zihan, et al. "A 17-fold increase of trifluoroacetic acid in landscape waters of Beijing, China during the last decade." Chemosphere 129 (2015): 110-117.

[14] Wallington, T.J., Hurley, M.D., Fracheboud, J.M., Orlando, J.J., Tyndall, G.S., Sehested,J., Mogelberg, T.E., Nielsen, O.J., 1996. Role of excited CF3CFHO radicals in the atmospheric chemistry of HFC-134a. J. Phys. Chem. 100, 18116‑18122.

[15] Hurley, M.D., Wallington, T.J., Javadi, M.S., Nielsen, O.J., 2008. Atmospheric chemistry of CF3CF@CH2: products and mechanisms of Cl atom and OH radical initiated oxidation. Chem. Phys. Lett. 450, 63‑267.

[16] Energy Star Market & Industry Scoping Report, April 2014. Available at: http://www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Misc_Residential_Refrigerators.pdf

Additionally, most if not all positive displacement and centrifugal chillers should be able to transition to low-GWP alternatives and not require HFC-32 as an interim solution, as suggested by the 50% market penetration assumed in the ARB analysis. Trane recently became the last of the big chiller manufacturers to introduce an HFO-1234ze air-cooled chiller[17], and it is believed that the sector can and should directly transition to low-GWP alternatives. While not currently allowed under the SNAP program in the chillers end use, EIA also notes that hydrocarbons (HC-290 and HC-1270) have been introduced in a number of small and medium capacity positive displacement chiller models that are widely available on the European market.[18]

Under Section 3 of the economic analysis on the proposed financial incentives, EIA strongly disagrees with the assumptions and conclusions derived from Table 32 that providing incentives to retrofit existing equipment to high-GWP refrigerants such as R-448A and R-449B, which both have 100-year GWP values of above 1200, is a cost-effective strategy. While these retrofits would achieve climate benefits of lowering the GWP of the refrigerant used from a baseline of HFC-404A (GWP=3922), the reductions will not be sufficient to achieve long-term CO_2e emission reductions of 85% that would be required under a phase-down. Considering the long lifetime of commercial refrigeration equipment, it will be necessary for much of this equipment to undergo a second transition to refrigerants with a GWP <150 by 2030. Therefore, ARB's economic analysis does not account for the costs of a second retrofit or replacement of equipment using R-448A and R-449A. Therefore the estimated costs of retrofits under the incentive program compared to those of new equipment would be approximately double assuming a second retrofit would be required in many cases.

EIA urges that the incentives be directed to encouraging conversions in refrigeration and air conditioning sectors to new equipment where true low-GWP alternatives are available.

Comments Regarding Emissions of Sulfuryl Fluoride

EIA notes that as a potent short-lived fluorinated greenhouse gas with a 100-year GWP of 6,840, sulfuryl fluoride (SO_2F_2) should be included in the GHG inventory. AB 32 clearly authorizes and directs ARB to periodically review and update the greenhouse gas inventory and EIA encourages the board to fulfill this mandate to: "*Ensure rigorous and consistent accounting of emissions, and provide reporting tools and formats to ensure collection of necessary data."*[19] and to *"(1) Periodically review and update its emission reporting requirements, as necessary*."[20] If included in the AB 32 greenhouse gas inventory, sulfuryl fluoride would contribute 20% of all F-gas emissions in the state or approximately 10 $MMTCO_2e$ annually[21] and if left unaddressed this percentage would increase to 30% of 2030 levels to be achieved under the current Proposed SLCP Strategy.

It is critical that a known greenhouse gas contributing this magnitude of emissions be added to the greenhouse gas inventory. Once included in the inventory, ARB may be required to take even

[17] Cooling Post, Trane adds R1234ze chiller, May 9, 2016. http://www.coolingpost.com/world-news/trane-adds-r1234ze-chiller/

[18] See EIA's comments on the earlier Draft Strategy. See also UNEP Fact Sheet 10: Water chillers for air-conditioning, October 2015.

[19] AB 32, Part 2 Mandatory GHG Emissions Reporting, Section 38530 (5) (b)

[20] Ibid, Section 38530 (5) (c)

[21] Proposed SLCP Strategy, page 57.

more ambitious steps to meet 2030 and 2050 emission reduction targets. If of alternatives to sulfuryl fluoride are identified, ARB would have to increase mitigation of other F-gases, in the amount of an additional 4 $MMTCO_2e$ annually in order to meet the 40% reduction target below current (2013) levels.[22]

Conclusions

Overall, EIA commends CARB for outlining a strong and achievable plan to significantly curb use and emissions of HFCs. We look forward to continued dialogue with ARB on the areas we mentioned for further enhancing the strategy and to seeing this plan move towards implementation.

Respectfully submitted,

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[22] Assumes constant consumption of sulfuryl fluoride at 10 MMT CO2e annually through 2030. 40% reduction from a 2013 baseline of 50 MMTCO2e is equal to 30 MMTCO2e. Assuming no alternatives to sulfuryl fluoride, current Proposed Strategy only achieves a reduction in total F-gases to 34 MMTCO2e.