October 30th, 2015

Mary D. Nichols
Chairman
Air Resources Board
California Environmental Protection Agency
1001 I Street, PO Box 2815
Sacramento, CA 95812

Dear Chairman Nichols,

The Environmental Investigation Agency (EIA) appreciates this opportunity to comment on the Draft Short-Lived Climate Pollution Reduction Strategy ("Draft Strategy") released to the public on September 30th, 2015. 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 HFCs and incentivizing transitions to climate-friendly technologies.

EIA applauds the State of California and the Air Resources Board (ARB) for its national and international leadership on reducing emissions of short-lived climate pollutants, and HFCs in particular. ARB's Refrigerant Management Plan has set the bar high for managing lifecycle emissions resulting from refrigerant leakage, elements of which the U.S. Environmental Protection Agency (EPA) is now poised to adopt across the rest of the country under new proposed federal regulations.

EIA supports the key elements and policy measures contained in the Draft Strategy that ARB has put forth, but notes that there is an opportunity to enhance California's leadership on HFCs under this strategy by implementing an HFC supply phase-down in California that at least matches the ambition of those HFC phase-downs proposed on a global scale. The supply, technically consumption, phase-down should be paired with complementary mechanisms, including bans on the use of any refrigerants with global warming potentials (GWPs) higher than 150 in certain end-uses by specific dates, and targeted incentives for scaling up the adoption, and widespread commercialization of the low-GWP technologies already available to replace HFCs in almost every industrial sector.

ARB has a strong mandate and clear regulatory authority under the California Global Warming Solutions Act of 2006 (AB 32), which directs ARB, as the lead agency for its implementation, to adopt regulations to achieve "*the maximum technologically feasible and cost-effective GHG emission reductions*"[1] and

[1] Assembly Bill No. 32, Chapter 488, available at http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf

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Senate Bill No. 65 (SB 65), which requires ARB to adopt a comprehensive strategy to reduce short-lived climate pollutants by January 1, 2016.[2]

Climate-friendly alternatives to HFCs are already widely commercially available today for most end-uses due to the demand created by market signals from the proposed Montreal Protocol amendments, regulations already adopted, such as those under the U.S. EPA's Significant New Alternatives Policy (SNAP) program and in the European Union, and the significant energy efficiency gains of alternatives. A strong sub-national HFC phase-down in California, the 8th largest economy in the world, would create substantial additional demand and stimulus needed to scale up low-GWP technologies in the U.S. that are already widely adopted in other markets around the globe. Additionally, while broad and robust support exists for an amendment to the Montreal Protocol to phase-down HFCs globally, California's leadership on phase-down strategy can provide further impetus and serve as a model for achieving an ambitious reduction schedule, showing that an accelerated transition to the very low-GWP alternatives is already underway in the United States.

For your convenience, our detailed comments are divided into the following sections:

- **I. Phase-down in the Consumption of HFCs**
  - i. Suggested Phase-down Schedule (Table 1)
  - ii. Lessons from the Phase-down under the EU F-Gas Regulation
  - iii. Mid-GWP HFCs and Blends
- **II. Recommended Refrigerant and Equipment Bans**
  - i. Refrigerant Bans (Table 2)
  - **ii.** Equipment Bans (Table 3)
- **III. Incentives to Achieve Broader Adoption of Low-GWP Technologies**
- **IV. Analysis of Available Low-GWP Technologies by Sub-Sector - Supporting Technical Feasibility of Recommended Equipment Bans**
- **V. Extension of Phase-down to Sectors beyond Refrigeration and Air Conditioning**
- **VI. Technician Training**
- **VII. Research Needs**
  - i. Research to support development of safety standards for A2 and A3 refrigerants.
- **VIII. Cost-Effectiveness**

I. Phase-down in Consumption[3] of HFCs

i. Suggested HFC Phase-down Reduction Schedule

ARB should move forward with implementing an ambitious, but feasible, statewide phase-down in the consumption of HFCs in line with, or exceeding, statewide CO_2 equivalent emission reduction targets.

[2] Senate Bill No. 65, Chapter 523, available at http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB605

[3] As per definition in the Montreal Protocol, consumption = production plus imports minus exports.

The Draft Strategy outlines a supply phase down strategy designed to mitigate 23MMTCO_2e annually by 2030 or approximately a 35% reduction[4] in annual emissions below business as usual (BAU). However, when considered in light of current levels, this strategy allows for continued growth in absolute emissions of HFCs from current levels to 42MMTCO_2e[5], assuming no other measures are implemented that achieve reductions additional to those guaranteed by the consumption phase-down. In order to take a leadership role in the phase-down of HFCs, ARB should pursue a consumption phase-down that would put California on track to achieve reductions approximately equivalent to those under amendment proposals currently on the table internationally, including the North American proposal, which proposes a 70% reduction in CO_2 equivalent consumption below 2013 levels in 2030[6] and the Micronesia proposal which targets 75% reductions by 2029 and 90% reductions by 2033.[7]

It is already feasible for ARB to implement an ambitious HFC supply phase-down that freezes growth in consumption of HFCs in bulk and pre-charged equipment. With a baseline of the average consumption of 2015-2016, ARB can avoid having companies scale up their consumption in anticipation of the proposed phase-down. Additionally, setting the phase-down based on a CO_2 equivalent basis will encourage the phase-out of the highest global warming potential (GWP) HFCs first. The progressive phase-down should implement phase-down steps to achieve a reduction of at minimum 70% below set baseline levels by 2030. It should be noted that while the Draft Strategy does contain detailed information on emissions, it does not contain data on HFC consumption in California. An inventory of current and recent levels of HFC consumption will need to be assembled in order to set an appropriate baseline for the phase-down schedule.

Table 1: Suggested HFC Phase-down Reduction Schedule

Years	Phase-Down Schedule
2020-22	100% MMTCO_2e
2022-24	90% MMTCO_2e
2024-26	70% MMTCO_2e
2026-28	50% MMTCO_2e
2028-30	30% MMTCO_2e

4 Calculations based on Table 7 in ARB Draft Strategy: 1 – (65-23)/65)* 100 = 35%

5 Calculations based on Table 7 in ARB Draft Strategy: 65-23=42MMCO_2e

6 Summary of the North American 2015 HFC Submission to the Montreal Protocol, available at http://www3.epa.gov/ozone/intpol/HFC_Amendment_2015_Summary.pdf

7 Micronesia Amendment Proposal available at: http://conf.montreal-protocol.org/meeting/oewg/oewg-33/presession/PreSession%20Documents/OEWG-33-4E.pdf

Key elements of the phase-down:

- Based on reductions in CO_2 equivalent of all HFC consumption.
- Allocated annual quotas that are progressively reduced according to the reduction schedule given to producers, distributors, and importers of HFCs and/or HFC containing equipment.. 15% of the baseline should be set aside for quotas for new market entrants.
- Accompanied by Refrigerant Bans and Equipment Bans as complementary mechanisms to provide direction to the market concerning the sectors where transitions can most feasibly be accomplished. The effective dates of any bans serve as 'goal posts' for achieving the supply phase-down and must be sufficiently ambitious to achieve the necessary market transitions to low-GWP technologies needed to meet the phase-down schedule.

ii. Lessons from EU F-Gas Phase-down: Equipment Bans and Market Penetration of Very Low-GWP Equipment

The EU HFC phase-down assumed near perfect penetration of available low-GWP technologies in new equipment; meaning that whenever a low-GWP technology could technically be installed instead of an HFC technology, it was assumed that the market would adopt such equipment, and no HFC quota was deemed to be needed for first fill or servicing of that piece of equipment.[8] For many refrigeration sectors, including commercial refrigeration, the market has not transitioned as quickly as it could have due to issues unrelated to technical feasibility. However, as a result of the original expectations that guided the regulation, bans on many types of equipment containing high-GWP refrigerants are not set to take effect until 2020 or 2022, one to three years after the 2019 date when experts had assumed there would be 100% market penetration of low-GWP technologies in these sectors.[9]

In order to avoid similar unnecessary delays, ARB's predictive modeling of consumption reductions and resulting emission reductions should carefully consider the timing of Refrigerant and Equipment Bans to ensure that bans are scheduled to take effect as soon as suitable equipment is technically available to meet the needs of the sector. Effective dates should be established solely based on scientific and technical analysis of when transitions of new equipment in sectors with proven technologies can occur. Once this analysis is conducted, effective dates for bans are set at the timing of expected transitions needed to achieve the phase-down. This calculation can be carried out by estimating the number of new pieces of equipment expected to be installed, the corresponding rates of uptake of replacement technologies and the resulting reduction in HFC use with the force of regulation and incentives behind these transitions. With this in mind, EIA has suggested early, ambitious, and achievable Equipment Bans in the end-uses where the highest emission reductions can be realized.

[8] EIA, 2015. EU F-Gas Handbook, See Page4. https://eia-international.org/wp-content/uploads/F-Gas-Handbook-1-The-HFC-Phase-Down.pdf

[9] For illustration of this point in more detail, See EIA, 2015. EU F-Gas handbook, Chapter 1, Page 4, See Table 3 and compare with Placing on the Market Prohibitions 12 and 13 as outlined in Annex III of the EU F-Gas Regulation.

For a more detailed analysis on implementation challenges of the supply phase-down under the EU F-Gas Regulation, please see EIA's recent report: *EU F-Gas Regulation Handbook: Keeping ahead of the curve as Europe phases down HFCs*, available at: https://eia-international.org/report/eu-f-gas-regulation-handbook-keeping-ahead-of-the-curve-as-europe-phases-down-hfcs

iii. Mid-Range GWP HFCs and Blends

ARB should take note of and publicize at the outset the impact that a planned HFC phase-down reduction schedule will have on the market ceilings for mid- and high-GWP HFCs and HFC/HFO blends with GWPs ranging up to 2,000+, in order to avoid a phase-in of mid- to high-GWP HFCs and HFCs blends as alternatives which will need to be phased out to meet subsequent steps in the phase-down. In some cases, these new refrigerants can achieve significant ounce-for-ounce CO_2e reductions when being used to retrofit existing equipment and directly replacing the highest-GWP HFCs still on the market. However, these chemicals are not appropriate for use in new equipment in sectors where low-GWP alternatives have been proven, as they will result in high-levels of emissions for decades to come due to the long life of many of the refrigeration and air conditioning equipment. In the EU, where an ambitious phase-down is underway, the introduction of mid-GWP refrigerants is expected to encounter a market ceiling in new products and equipment beginning in 2020.[10] Furthermore, their introduction to the market is expected to exacerbate the quota shortage and HFC price premium beyond what would otherwise be expected.[11] By the end of the EU phase-down it is estimated that no refrigerant with a GWP above 200 to 400 will be allowable if the 79% reduction is to be achieved.[12]

ARB's emission reduction targets are based on additional reductions below BAU emissions that include the EPA's recent SNAP rulemaking, which has already established deadlines by which the use of HFC-404A and HFC-507A for many new refrigeration applications and HFC-134a in new mobile air conditioning must be discontinued. These transitions will deliver substantial reductions in the consumption of high-GWP HFCs and make it feasible for California to meet some of the early phase-down steps. In order to achieve sufficient emission reductions, in addition to those already achieved under the SNAP Program, ARB will need to ensure that a California phase-down provides incentivizes that aim to drive a near complete market transition to refrigerants with GWPs <150, particularly in the stationary refrigeration end-uses contributing the majority of f-gas emissions. According to ARB's inventory, together, commercial refrigeration, industrial refrigeration and residential refrigeration make up 56% of 2013 emissions and 66% of forecast 2030 BAU emissions.[13] By targeting a transition in these three sub-sectors to the lowest-GWP technically feasible alternatives, ARB will achieve the vast majority of the necessary reductions to realize an ambitious phase-down. However, ARB should also push for transitions in domestic, commercial and industrial air conditioning as there are proven alternatives in most end uses

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[10] EIA, 2015. EU F-Gas handbook, Chapter 1, Page 11.

[11] Ibid.

[12] Annex 3, 15 of E.U. F-Gas Regulation. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.150.01.0195.01.ENG.

[13] ARB Draft Strategy, Appendix A, Figure 4: http://www.arb.ca.gov/cc/shortlived/2015appendixa.pdf

and California can expect demand for air conditioning of all types to continue to increase as the effects of climate change impact the state.

II. Recommended Refrigerant Bans and Equipment Bans

The Draft Strategy suggests that ARB will pursue two types of bans: 1) the sale of all virgin high-GWP refrigerants ('Refrigerant Bans') and 2) bans on the sale of new stationary refrigeration or air conditioning equipment containing HFCs above specific 100-yr GWP thresholds ('Equipment Bans') in certain sectors. EIA supports the use of bans as complementary mechanisms to a consumption phase-down and urges ARB to implement Refrigerant and Equipment Bans with effective dates designed to help achieve the desired phase-down schedule, and GWP thresholds for Equipment Bans based on the availability and cost-effectiveness of low-GWP alternatives for a given sub-sector where such equipment is used. It will be important to set GWP thresholds for Equipment Bans that are low enough to achieve desired consumption and emission reductions and encourage end users to transition directly to the lowest-GWP alternatives available. As in the EU, although the bans are important to achieving a phase-down, it will be the overall rate of the comprehensive HFC phase-down that will have the greatest impact on overall reduction in the use of HFCs and resulting emission reductions. If bans are set earlier than needed to achieve a phase-down such that additional consumption and emissions reductions are achieved ahead of schedule, as is suggested in Table 7 of ARB's Draft Strategy, then ARB should clarify this from the outset in order to provide transparency for equipment manufacturers and end-users on the required timing of transitions.

i. Refrigerant Bans:

Refrigerant Bans are the most effective mechanism for controlling the overall supply of virgin high-GWP HFCs, and particularly effective for controlling their use in the servicing sector to refill existing equipment. Refrigerant Bans should initially allow exemption for certified reclaimed and recycled HFCs. They should, however, over time, restrict the supply of reclaimed and recycled HFCs and ozone depleting substances (CFCs and HCFCs) as they do in the EU, by banning recycled HFCs, ten years after an initial ban goes into effect. As a result, all high-GWP equipment will be transitioned to proven and commercially available low-GWP equipment within ten years of the bans going into effect and hence expediting the elimination of the emission of these super greenhouse gases. Once a Refrigerant Ban goes into effect, end users of equipment operating using HCFC-22 or high-GWP HFCs will have the three options of a) using recycled HFCs to service the equipment for up to ten years, b) retrofitting equipment with available, lower GWP technologies that limit HFC emissions, and c) installing new, future-proof equipment using the lowest-GWP refrigerants that will survive any existing and new regulations.

As summarized below in Table 2, Refrigerant Bans should include a ban on the highest-GWP (>2,500) refrigerants that goes into effect in 2019, prior to the 2020 HCFC-22 phase out date to ensure leapfrogging of high-GWP HFCs during the final step in the phase-out of HCFCs. These bans should be followed by an additional ban on all HFCs with GWPs above 1,000 ("Tier 2 GWP HFCs") effective in January 1, 2025. Setting a date of 2025 for banning Tier 2 GWP HFCs, coupled with incentives, will provide the maximum impetus for end users of obsolete CFC and HCFC equipment to transition to new equipment using the lowest–GWP alternatives available with GWPs < 20 including carbon dioxide (R-744), hydrocarbons (R-290, R-600, and R-441A), ammonia (R-717), air, water (R-718), and other not-in-kind solutions such as ammonia absorption, adsorption, evaporative cooling, desiccant cooling, and non-mechanical heat transfer. It will also incentivize more rapid investment in market research and development for new and cutting edge technologies such as electrochemical compression[14] and magnetocaloric refrigeration.[15] For a more thorough analysis of the available low-GWP alternatives to meet these bans, across each end-use please see Section IV of these comments.

Table 2: Recommended Prohibitions on the Sale of High-GWP Refrigerants for use in New Stationary Refrigeration and Air Conditioning

100-yr GWP Threshold	Effective Date	Key High-GWP Refrigerants Prohibited
2,500 ("Tier I GWP")	January 1, 2019	R-404A, R-507A and all other HFCs and HFC blends approved by the EPA SNAP program with GWPs about 2,500
1, 000 ("Tier II GWP")	January 1, 2025	R-407A, R-410A, R-134a and all other HFCs and HFC blends approved by the EPA SNAP program with GWPs about 2,500

ii. Equipment Bans:

Equipment Bans will be important mechanisms to aid in the implementation of the phase-down, serving as signals to market actors for meeting the supply phase-down. They are also the most targeted policy mechanisms available and can be applied at different effective dates to specific sub-sectors and equipment types where low-GWP alternatives are the most readily available to achieve maximum emission reductions. Equipment Bans should align with the end-use categories defined under EPA's SNAP Program[16] in order to simplify compliance and availability of alternatives.

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[14] Department of Energy, Low-cost electrochemical compressor utilizing green refrigerants for HVAC applications http://energy.gov/eere/buildings/downloads/low-cost-electrochemical-compressor-utilizing-green-refrigerants-hvac

[15] Department of Energy, Magnetocaloric Refrigeration, http://energy.gov/eere/buildings/downloads/magnetocaloric-refrigeration

[16] SNAP End-Uses for Refrigeration and Air Conditioning available here http://www2.epa.gov/snap/refrigeration-and-air-conditioning

Table 3: Suggested Equipment Bans

Prohibitions on Sale of New Equipment Using HFCs above a 100-yr GWP Threshold			
Refrigeration End-Use	**100-yr GWP Threshold**	**Effective Date**	**SNAP Approved Alternatives**
Household refrigerators and freezers	150	January 1, 2020	Propane (R-290), Isobutene (R-600a), R-441A
Stand-alone commercial refrigeration equipment (hermetically sealed)	150	January 1, 2020	Propane (R-290), Isobutene (R-600a), R-441A
Vending Machines	150	January 1, 2020	CO_2 (R-744), Propane (R-290), Isobutene (R-600a), R-441A
Remote Condensing units	150	January 1, 2020	CO_2 (R-744), Ammonia (R-717) with a secondary loop
Direct Supermarket Systems	150	January 1, 2020	CO_2 (R-744)
Indirect Supermarket Systems	150*	January 1, 2020	CO_2 (R-744) with secondary loop, Ammonia with a secondary loop
Industrial Process Refrigeration and Cold Storage Warehouses	150	January 1, 2020	Ammonia (R-717), CO_2 (R-744), Evaporative Cooling, HFO-1233zd, HFO-1234ze
Industrial Process Air Conditioning	150	January 1, 2020	Ammonia Absorption, Ammonia with a secondary loop, HFO-1234ze
Chillers	150	January 1, 2020	Ammonia (R-717) with a secondary loop, Ammonia Absorption, HFO-1233zd, HFO-1234ze
Packaged Room Air Conditioners	700	January 1, 2018	HFC-32**
	150	January 1, 2023	Propane (R-290), Isobutene (R-600a), R-441A

* ARB may consider allowing an exemption for the warmest climate zones that allows HFCs with a GWP<1,500 when used as the primary refrigerant in an indirect system, provided systems achieve at least a 70% reduction in charge size.

** EIA does not endorse the use of HFC-32 or other mid-range GWP HFCs and HFC-HFO Blends except as a temporary transitional refrigerant, and end-users making this choice should be aware when they make it that they will have to incur the cost of a second transition so that they can fairly weigh the economic costs of going to these refrigerants.

III. Incentives to Achieve Broader Adoption of Low-GWP Technologies

ARB should design incentives that can be targeted at specific end-uses where they will have maximum impact scaling up the widespread adoption of the lowest-GWP technologies. Whether done in partnership with a non-profit, through local air districts or in some combination, ARB should ensure that it retains a high level of oversight and approval over awarding incentives and should develop clear criteria for prioritizing projects based on their scalability and impact. For example, grants should not in any case be awarded for projects installing mid- and high-GWP HFC blends, or any equipment containing an HFC (even as a primary refrigerant in a secondary loop system), as this will serve to create a market for an unnecessary interim step that would delay transition to a truly low-GWP system.

The experience of using small grants in Quebec as incentives for installing transcritical CO_2 supermarket refrigeration systems suggests that targeted incentives in commercial refrigeration, the largest emitting f-gas sector, will be likely to yield the greatest return on investment in terms of impact on emissions reductions. Quebec's Ministry of Natural Resources and Wildlife offered an incentive in the form of an investment grant scheme called the Refrigeration Optimization Program (OPTER) that encouraged refrigeration system owners to transition to more environmentally friendly systems in commercial refrigeration.[17] The program offered up to CAD$125,000 to owners of refrigeration systems to make the shift to more climate friendly refrigerants, reducing the refrigerant charge by installing secondary loops, and integrating refrigeration, heating and ventilation systems. Largely as a result of this program, Sobeys, the second largest supermarket chain in Canada, has installed 40 transcritical CO_2 stores to date and pledged to install them in all new stores going forward.[18] As of 2013, the program now supports exclusively CO_2 as a refrigerant in projects involving refrigeration systems.

ARB should also coordinate with CPUC to offer incentives to commercial and industrial refrigeration end-users installing low-GWP energy efficiency systems. According to the DOE, the average U.S. supermarket consumes nearly 2 million kilowatt hours per year, while new R-744 systems reduce energy consumption by 25%.[19] R-744 systems using heat reclaim can achieve high energy efficiency[20] and recent reports indicate R-744 systems can have payback periods of less than three years.[21]

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[17] SADC, Directory of Sustainability Programs, 2011. See Page 32. http://www.caebl.ca/upload/documents/SADC-BottinDD-final-interactif-ANG.20130828.101741.0.pdf

[18] Cooling Post, Quebec aids switch to CO2 refrigeration, Feb 2015. http://www.coolingpost.com/world-news/quebec-aids-switch-to-co2-refrigeration/

[19] Department of Energy, New Advanced Refrigeration Technology Provides Clean Energy, Low Utility Bills for Supermarkets, http://energy.gov/eere/success-stories/articles/new-advanced-refrigeration-technology-provides-clean-energy-low

[20] More information available at: http://www.danfoss.com/NR/rdonlyres/5D7EB1FA-E49A-4DB9-97E5-655D3C13E910/0/Principletranscritheatreclaim_header.pdf.

[21] More information available at: http://www.marketwatch.com/story/transcritical-co2-market-worth-3070-billion-by-2020-2015-09-14-52033053.

There is certainly ample evidence to demonstrate the energy efficiency gains of many other additional applications of low-GWP equipment and ARB should work closely with CPUC to encourage incentives for other major energy consumers such as major convenience store and fast food chains, where energy efficient stand-alone refrigeration equipment using hydrocarbons can be scaled-up considerably.

IV. Analysis of Available Low-GWP Equipment by Sub-Sector Supporting Technical Feasibility of Recommended Equipment Bans

Household refrigerators and freezers

EIA urges ARB to implement an Equipment Ban on the sale of new domestic refrigerators and freezers containing refrigerants with a GWP above 150, effective January 1, 2020 or earlier.

Most household refrigerators currently sold in the U.S. use HFC-134a with a 100-yr GWP of 1,430 and a 20-yr GWP of 3,830.[22] Conversely, 100% of new household refrigerators sold in Europe and 75% of those sold in China, use isobutene (R-600a) with a GWP of 3.[23] The only remaining barrier to wide-scale adoption of hydrocarbon refrigerators in the U.S. lies in U.S. safety standards for equipment design, which fail to align with the international standards that allow for the safe, energy efficient, and near universal adoption of hydrocarbon refrigerators in households around the world.

The EPA added R-600a and hydrocarbon blend R-441A to the list of acceptable substitutes under the SNAP Program in December 2011[24] and subsequently added propane (R-290) in April 2015.[25] Due to their flammability, the use of hydrocarbons as refrigerants, both in the U.S. and abroad is subject to use conditions in accordance with the safety standards set by various national and international standards setting bodies. These standards place limits on the amount of flammable A3 refrigerants (i.e. hydrocarbons) that can be used in a single vapor compression loop, called the 'charge size limit'. The U.S market primarily follows the standards set by Underwriters Laboratories Inc. (UL), particularly UL250[26] for household refrigerators, which limits the charge size to 57 grams. The majority of the rest of the world follows the International Electrotechnical Commission (IEC), which under IEC 60335-2-24 allows 150 grams, or almost three times as much the allowable charge size. The 57 gram charge size limitation in the U.S. has inhibited the full market penetration of hydrocarbon refrigerators on the U.S. market, by limiting the cooling capacity that can be achieved efficiently with a single vapor compression loop using a hydrocarbon refrigerant. As a result, hydrocarbon equipment that has entered the U.S. market has consisted mainly of small equipment such as mini-fridges and wine coolers.[27] It should be noted that the IEC has established a working group to review the 150 gram charge size limit given recent developments

[22] IPCC AR4, https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html
[23] EPA Fact Sheet, http://www3.epa.gov/ozone/downloads/EPA_HFC_DomRef.pdf
[24] http://www.gpo.gov/fdsys/pkg/FR-2011-12-20/pdf/2011-32175.pdf
[25] http://www.gpo.gov/fdsys/pkg/FR-2015-04-10/pdf/2015-07895.pdf
[26] http://ulstandards.ul.com/standard/?id=250_10
[27] Avanti 600a mini-refrigerator available here.

in refrigeration equipment, safety equipment and warnings that make even larger, more energy efficient charges safe for use in domestic and small commercial applications.

Domestic refrigerators are hermetically sealed equipment, not requiring any on-site assembly or frequent servicing. For these reasons, domestic refrigerators have remarkably low refrigerant leak rates, estimated from <0.5% to 2.5% annually[28], making them an optimal equipment type for use of hydrocarbons. A 150 gram hydrocarbon charge size limitation means that a typical refrigerator with the maximum average leak rate of 2.5% would leak less than 5 grams of isobutene over the course of a year. There are also many other mechanisms, other than charge size limits, of mitigating the risks of a rare and highly abnormal large or quick leak, which include equipment safety design features and manufacturing controls such as automatic shut-off valves and leak tightness test requirements that are available to standards technical experts as mechanisms to ensure safe manufacturing of hydrocarbon refrigerators. UL 250 can and should be reviewed and amended to allow for a reasonable increase in charge sizes allowing greater market penetration of hydrocarbon refrigerators in California and the rest of the United States.

A January 1, 2020 or earlier date for the ban on equipment with GWP above 150 will provide ample time and the necessary impetus for industry experts and other stakeholders with membership on the standards technical panel for UL 250 to submit a proposal in accordance with UL policies and guidelines[29] to amend the standard, taking into account available research and data on leak rates, and other technology and safety mechanisms available for safe design of domestic refrigerators using hydrocarbon refrigerants.

A transition to hydrocarbons in domestic refrigeration will also carry significant energy efficiency co-benefits. A recent Department of Energy (DOE) Energy Star Scoping Report lists isobutene refrigerators as a design option for achieving up to 10% higher energy efficiency in residential refrigerators.[30]

<u>Stand-alone commercial refrigeration equipment and vending machines (hermetically sealed)</u>

EPA's SNAP Program will prohibit HFC-134a, R-410A and many other high-GWP HFCs in stand-alone medium temperature equipment beginning January 1, 2019, or January 1, 2020, depending on the size of compressor capacity.[31] However the EPA still allows HFC-134a in stand-alone low-temperature applications and allows other HFCs and HFC-HFO blends with GWPs above 600 for this end-use including HFC-HFO blends R-513A and R-450A. These mid-to-high GWP HFC blends are not needed when there are a number of alternatives on the market with a GWP of <4 that are achieving exponential growth in market penetration.

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[28] UNEP quotes typical leak rates at <0.5%, while GIZ cites leak rates at between 0.5% and 2.5%
See UNEP Fact Sheet, October 2015, available here. See also GIZ 2010. Guidelines on safe use of hydrocarbons, available here.

[29] See Underwriters Laboratories, UL standards Accredited Procedures, Amended February 24, 2014
http://ulstandards.ul.com/wp-content/themes/standards/pdf/ApprovedRevisionstoULsAccreditedProcedures.pdf

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

[31] EPA Fact Sheet on Rule 20, 2016, available at
http://www3.epa.gov/ozone/snap/download/SNAP_Regulatory_Factsheet_July20_2015_revised_508.pdf

ARB has the opportunity to go further than EPA's SNAP Program in this end-use, by banning the sale of all stand-alone retail refrigeration equipment and vending machines containing HFCs with a GWP >150 as of January 1, 2020 or earlier, concurrently with the changes in listing status that will go into effect for stand-alone equipment under SNAP Rule 20.

Like domestic refrigeration, stand-alone equipment used in retail food refrigeration such as reach-in food and beverage display cases and coolers, is an optimal equipment type for hydrocarbons as low-GWP alternatives. Unlike domestic refrigeration however, the safety standards for commercial refrigeration under UL471 allows for 150 gram maximum charge size consistent with the charge size limit used under IEC and European standards, and thus pose no significant market barrier to the market penetration of hydrocarbons in most stand-alone equipment types. This equipment is already available and in use in the U.S. market and abroad.

In EPA's July, 2014 proposed rulemaking for SNAP Rule 20, it is stated that:

> "We understand that R-290 is already in use globally, including in the United States, and that R-600a is in use outside of the United States as well as in test market trials in the United States. We believe that these two refrigerants can satisfy the vast majority of the current market for use in stand-alone equipment. We note that there may be a need to modify the equipment design in order to meet the use conditions for R-290 and the proposed use conditions for R-600a and R-441A (July, 9, 2014; 79 FR 38811)."[32]

Indeed, not only are hydrocarbons widely used throughout Europe in these types of equipment, but are quickly being quickly adopted here in the U.S. with natural refrigerants (R-744, R-290, R-600a) seeing ten-fold growth in light commercial refrigeration since 2013 from approximately 5,000 units installed, to 94,493 in 2015, 77,000 of which are hydrocarbons.[33] True Manufacturing is a company headquartered in the U.S. that has been a pioneer in introducing hydrocarbons in its line of retail refrigeration equipment on the U.S. market, citing its 15% higher energy efficiency performance than HFC-134a as a reason for the choice, along with a low-GWP.[34] Red Bull has a 100% HFC-free procurement policy already in place for its point of sale beverage coolers, with over a million units rolled out globally and almost 60,000 in the United States.[35]

Some claims have been made about the limitations of hydrocarbons in stand-alone freezer applications, but these claims seem contradictory to the large range of stand-alone equipment using hydrocarbons that has been introduced to the market in low temperature applications within the 150 gram charge limit. For

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[32] http://www.epa.gov/ozone/downloads/SAN_5750_SNAP_Status_Change_Rule_NPRM_signature_version-signed_7-9-2014.pdf, p142.

[33] Shecco Guide to North America, September 2015, See Page 82. http://publication.shecco.com/upload/file/org/1442485610258468_36393.pdf

[34] True Manufacturing, Why Hydrocarbons? Accessed 10/25/15. https://www.truemfg.com/NaturalRefrigerant.aspx#

[35] Shecco Guide to North America, September 2015.

example, Unilever has rolled out more than 2 million units[36], with its Ben & Jerry's ice cream freezers that use hydrocarbons being 10% more energy efficient than HFC models. 4,588 of these freezers had been used within the U.S. as of the end of 2013.[37] AHT Cooling offers integrated commercial display refrigerator/freezers with cooling down to -23°C.[38] Liebherr-International offers a laboratory freezer using R-600a that cools down to -30°C.[39] In Europe, McDonalds has rolled out R-290 equipment widely, including 3,811 meat freezers and 2,802 frozen dry dispensers, and 1,614 blended ice machines.[40]

Vending machines, as a subset of the stand-alone retail refrigeration market are also not lacking examples of widespread roll out of low-GWP equipment by many of the major beverage retail companies. Based on the following examples of wide use of these low-GWP refrigerants in vending machines in the U.S. and around the world, there is ample availability of low-GWP substitutes to supply the market once a ban takes effect in 2020.

Coca-Cola has also surpassed 1.5 million HFC-free vending machines using R-744, with 13,000 in the U.S. market.[41] Royal Vendors, a supplier of R-744 vending machines to Coca-Cola, has four different models available using R-744 refrigerant, including the RVCV-550-6, 660-8,804-8, and 500-64.[42] SandenVendo has supplied at least 1,200 R-744 vending machines in the U.S. to date.[43] Pepsi has more than 1 million HFC-free vending machines around the world, which use 20% less energy than Energy Star requirements, and it plans to phase out HFCs in all vending machines, coolers, and fountain soda dispensers by 2020.[44]

Industrial Process Refrigeration and Cold Storage Warehouses

Ammonia (R-717), with a GWP of 0, is the single most commonly used refrigerant for industrial refrigeration, which includes both cold storage and process cooling.[45] Low-GWP equipment using ammonia and other low-emission technology is more than sufficiently available for a range of equipment types used for cold storage warehouses, including packaged systems, chillers, and remote condensing

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36 Shecco Guide to North America, September 2015.

37 http://www.hydrocarbons21.com/articles/6243/atmosphere_europe_2015_end_users_ask_technology_providers_to_close_gap_in_the_natural_refrigerant_market

38 http://www.hydrocarbons21.com/web/assets/companybrochure/file/652_paris_hc_cabinet.pdf

39 http://www.hydrocarbons21.com/products/view/liebherr_lab_refrigerators_and_freezers

40 http://www.hydrocarbons21.com/articles/6243/atmosphere_europe_2015_end_users_ask_technology_providers_to_close_gap_in_the_natural_refrigerant_market

41 Shecco Guide to North America, September 2015.

42 EIA correspondence with Royal Vendors, 8/28/14

43 Schecco, Accelerate America, Edition 7, http://publication.shecco.com/upload/file/org/55bfa2b198da31438622385WjhMs.pdf

44 White House Fact Sheet: https://www.whitehouse.gov/the-press-office/2014/09/16/fact-sheet-obama-administration-partners-private-sector-new-commitments- .Vending Times, PepsiCo to Phase Out HFC in Vending Machines, Coolers and Fountains by 2020, 9/19/2014, http://www.vendingtimes.com/ME2/dirmod.asp?nm=Vending+Features&type=Publishing&mod=Publications%3A%3AArticle&tier=4&id=09D204A3CBE14022AE4E167E7F2634B7

45 http://www.scribd.com/doc/122993371/Industrial-Refrigeration-Best-Practices-Guide#scribd

units. The other low-GWP substitutes include R-744, evaporative cooling, and desiccant cooling, all currently available with GWPs of zero or one.

For more detailed analysis of the chiller equipment available, for these refrigeration end-uses as well as others such as commercial and industrial air conditioning, please see the below section on chillers which provides more detail on the various manufacturers of low-GWP chiller equipment in the U.S. and around the world.

While equipment using ammonia (R-717) is already widely available and in use, systems also utilizing R-744 as a secondary refrigerant with ammonia as the primary refrigerant are becoming more common in order to reduce ammonia charge sizes and associated toxicity risks. For example, US Cold Storage, the third largest refrigerated warehouse provider in the country has installed 11 systems since 2011 using a combination of R-717 and R-744 in either a cascade system or in critical brine systems using R-744 as a secondary coolant.[46] The use of R-744 to lower the charge size of R-717 systems makes these systems safer from both the human health and environmental risk perspectives, with the added bonus of remaining cost-competitive with pure ammonia systems at less than a 5% margin.[47] The use of evaporative cooling in evaporative condensers or in closed circuit towers using water or a solution of either ethylene or propylene glycol is another low-GWP alternative available.[48] In cases where there may not be a machinery room in which to store an ammonia charged unit, low-charge ammonia condensing units and chillers, which are now available in charge sizes of 3-5 lbs can be installed on rooftops or outside of occupied spaces.

Chillers

The low-GWP substitutes available on the U.S. market include R-717, water, water/lithium bromide absorption, evaporative/desiccant cooling, HFO-1233zd, and HFO-1234ze. Manufacturers of chillers using R-717, water and other natural low-GWP substitutes, including for uses in light and large industrial refrigeration and air conditioning applications, include Star Refrigeration[49], Power Partners[50], Mayekawa[51], GEA Refrigeration,[52] Refteco[53], and Beijer Ref[54].

The already deep market penetration of R-717 in chillers, including industrial refrigeration and air conditioning, end-uses should be considered, particularly in light of ongoing technological capacities to improve A2 safety through lower charge sizes, automated control systems, and R-717/R-744 brine

46 http://www.uscold.com/wp-content/uploads/2015/06/Publication_Accelerate-America_Mike_Lynch_sm.pdf
47 Ibid.
48 http://www.baltimoreaircoil.com/english/about-us/who-we-serve
49 http://www.azane-inc.com/products/Azanechiller.aspx
50 http://www.ppiway.com/brands-solutions/eco-max
51 http://www.mayekawa.eu/en/media/brochure-downloads/download/23
52 http://www.gea.com/global/en/productgroups/chillers_heat-pumps/chillers/index.jsp
53 http://www.refteco.com/chillers/ammonia-chiller-cha/
54 http://www.beijerref.ro/en/produse/nh3-brine-chillers-swa/107/

systems.[55] In IPCC Assessment Report 3, it was stated that R-717 systems were estimated to have a 90% market share in systems of 100kW cooling capacity and above in the USA.[56] 90% of chillers produced for the European market use R-717.[57]

The uptake of HFO-1234ze (GWP=1), another low-GWP alternative, in both air and water centrifugal and screw chillers has also been coming online rapidly over the past year. Trane[58], Carrier[59], Geoclima[60], and Airedale[61] have all introduced HFO-1234ze chiller equipment to the commercial market. HFO-1233zd (GWP <7) is also available as an alternative in centrifugal chillers and requires no standards changes to be adopted. Trane has already transitioned an entire line of centrifugal chillers for the European market to HFO-1233zd with capacities ranging from 20kW to 14,000kW.[62]

Finally, the EPA has yet to consider listing R-290 or R-744 as acceptable, or acceptable subject to use conditions, as low-GWP substitutes for chillers under SNAP, yet they have been widely proven by multiple manufacturers outside of the U.S. market. Geoclima, for instance, has introduced models using R-290 in their Greenmiser line of reciprocating chillers.[63] Similarly Johnson Controls has a line of air-cooled R-290 screw chillers with capacities ranging from 95 to 400 kW.[64] Another possibility is double combination R-290/R-744 chillers, which Geoclima piloted successfully in 2013.[65] R-290 chillers manufactured by FT Refrigeration used in an industrial refrigeration setting offered a 24% reduction in energy consumption compared to an aging ammonia system it replaced.[66] Other companies offering commercially available chillers using R-290 include Mayekawa screw compressor J series[67], HeronHill, Hitema/StastveldBV[68], and Bundgaard Koleteknik A/S.[69] Mayekawa's AdRef-Noa adsorption chiller using water as a refrigerant is ideal for industrial uses with an available heat recovery source.[70]

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55 http://www.shecco.com/files/news/guide_nh3-final.pdf
http://www.ammonia21.com/articles/6433/guide_china_nh_sub_3_sub_technology_has_significant_growth_potential_in_industrial_refrigeration

56 http://www.ipcc.ch/ipccreports/tar/wg3/index.php?idp=148

57 http://ec.europa.eu/clima/events/docs/0007/johnson_controls_ammonia_slides_en.pdf

58 http://www.coolingpost.com/world-news/trane-first-with-1233zd-chiller/

59 http://www.coolingpost.com/world-news/carrier-latest-to-install-r1234ze-chiller/

60 http://www.welcomegroup.com.hk/products_subcat.php?id=23

61 http://www.achrnews.com/articles/126828-airedale-chiller-with-low-gwp-hfo-refrigerant-to-cool-new-john-lewis-store

62 http://www.racplus.com/news/trane-launches-european-focused-chiller-range-including-a-centrifugal-version-using-hfo-refrigerant/8664781.article

63 http://www.geoclima.com/v-range/

64 http://www.johnsoncontrols.nl/content/dam/WWW/jci/be/eu_library/refrigeration/netherlands/SABlight_SB3306_Feb_2013Prt.pdf

65 http://www.geoclima.com/double-combination-cycle-r290-co2/

66 http://www.hydrocarbons21.com/articles/5287/span_style_color_rgb_255_0_0_update_span_r290_water-cooled_chillers_replace_existing_dairy_refrigeration_plant

67 http://www.mayekawa.ca/brochures/pdf/J_series_propane_brochure.pdf

68 http://www.hitema.it/marketing/realizations

69 http://www.hitechcr.com.au/wp-content/uploads/2013/07/OzChillNewsletter-June-2013-Web.pdf

70 Mayekawa, Ad-Ref Noa Brochure. http://www.mayekawa.com.au/wordpress/wp-content/uploads/2013/07/AdRef-Noa-Brochure-170713.pdf

Remote Condensing Units used in Retail Food Refrigeration

As HCFC-22 condensing units are taken out of commission, there are various low-GWP alternatives that are coming online to supply the market in 2020. With the newest developments in low-charge ammonia systems, there will be no need for mid-range GWP blends in these equipment types. Condensing units are packaged equipment often used in smaller scale commercial refrigeration that are installed on a rooftop or outside the sales area. The EPA SNAP approved low-GWP alternatives for remote condensing units include ammonia (R-717) and R-744. Low-charge ammonia condensing unit systems are available on the market for many uses, including light commercial refrigeration. Azane, based in San Francisco, manufactures azanefreezers, which typically carry a charge of less than 5lbs of ammonia.[71] Azane's systems have been installed in over 300 retail locations.[72] Bassett Mechanical[73] and Evapco manufacture low-charge systems here in the U.S. as well, with some of Evapco's systems having an ammonia charge size of less than 3lbs.[74]

There are also many small store solutions for condensing units using R-744, though the demand for these products thus far seems to be mainly outside the U.S. market. Panasonic manufactures an outdoor CO_2 condensing unit available on the European market[75] as do Zanotti[76] and SCM Frigo.[77]

ARB should implement a ban on condensing units with GWPs >150 effective January 1, 2020 at the latest in order to ensure that old HCFC-22 equipment is transitioned directly to the lowest-GWP solutions.

Direct and Indirect Supermarket Systems

Thousands of supermarkets around the world have transitioned to R-744 (GWP of 1) and hydrocarbons (GWP of <10), both demonstrating substantial energy savings over traditional HFC systems even in high ambient climates.[78]

It will be important as ARB considers Equipment Bans to consider the market penetration of low-GWP technologies in both direct and indirect supermarket systems and set appropriate Equipment Bans for both, as end-users operating in the various climate zones will likely need to consider both options when selecting new equipment. Central supermarket systems are broadly defined under EPA's SNAP Program as including multiplex or centralized systems, which operate with racks of compressors installed in a machinery room. 70% of the systems used in the United States are direct systems, while 30% are indirect

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71 http://www.azane-inc.com/products/Azanefreezer.aspx

72 http://www.azane-inc.com/case-studies/low-charge-ammonia-solution-for-frozen-food-specialist.aspx

73 http://www.bassettmechanical.com/wp-content/uploads/2015/04/Low-Charge-Ammonia-Sell-Sheet-0215.pdf

74 http://www.ammonia21.com/articles/6254/low-charge_ammonia_all_the_rage_at_iiar_gathering

75 http://www.r744.com/products/view/_outdoor_condensing_unit_panasonic

76 http://www.zanotti.com/en/18-stationary-refrigeration/condensing-units/156-co2-transcritical-condensing-unit

77 http://www.scmfrigo.com/Default.asp?lingua=eng&

78 EIA, 2015. Chilling Facts https://eia-international.org/wp-content/uploads/Chilling-Facts-VI.pdf See also, Schecco's 2015 Guide to North America.

systems, which are gaining in market share.[79] In direct systems, the refrigerant circulates from the machinery room to the sales area, where it evaporates in display-case heat exchangers, and then returns to the compressor racks. Another direct supermarket design, often referred to as a distributed refrigeration system, uses an array of separate compressor racks located near the display cases rather than having a central compressor rack system. Indirect supermarket designs include secondary loop systems and cascade refrigeration. Indirect systems use a "chiller" or other refrigeration system to cool a secondary fluid that is then circulated throughout the store to the cases. This allows the use of ammonia (and possibly in the future, hydrocarbons) as a primary refrigerant maintained separately from the occupied space of the supermarket.

In the category of direct systems, there is unparalleled growth of transcritical CO_2 systems in the United States taking place right now. The market has progressed voluntarily from two transcritical CO_2 stores in 2013, to 14 in 2014, to now 52 stores installed or planned by early 2016.[80] In the recent private sector-led voluntary commitments released this October at the White House, Roundy's Supermarkets announced it will use transcritical CO_2 in six new stores opening next year in Illinois and Wisconsin.[81] With over 6,500 transcritical CO_2 stores worldwide, this technology is no longer new, and scaling it up in California and the rest of the U.S. to catch up with other regions of the world with thousands of systems installed, including Europe and Japan, will be critical to U.S. leadership on HFC emission reductions in direct supermarket systems.

Using adiabatic condensers manufactured in the United States by Baltimore Air Coil Company, transcritical CO_2 booster systems have also been employed in warm climates where ambient temperatures frequently rise above the critical point for maintaining energy efficiency. This approach has been successful in the July 2014 installation of such a system in Atlanta, GA by Sprouts Farmers Market.[82]

While transcritical CO_2 for all supermarket systems in all climate zones of California may not be feasible, ARB should consider an Equipment Ban that guides a transition in direct supermarket systems in 2020 to transcritical CO_2, while allowing end-users operating in warmer climate zones to consider other options for new equipment installations including distributed and indirect systems.

A separate Equipment Ban on indirect systems and distributed systems achieving significant charge size reductions of at least 70% (up to 80% reductions are achievable[83]) would be an effective mechanism for ensuring significant emission reductions in warmer climate zones. End-users installing new equipment in hotter ambient climate zones are presented with an increasing number of options using cascade and secondary loop systems that offer significant refrigerant charge reductions, paired with low-GWPs (<150) options. R-717, with a GWP of 0, when used as a primary refrigerant in a secondary loop system is also

[79] EPA SNAP Rule 20, July 2015.

[80] Shecco Guide to North America, September 2015. See p 98-99.

[81] https://www.whitehouse.gov/the-press-office/2015/10/15/fact-sheet-obama-administration-and-private-sector-leaders-announce

[82] http://contractingbusiness.com/refrigeration/refrigeration-transitions

[83] EPA Fact Sheet, http://www3.epa.gov/ozone/downloads/EPA_HFC_ComRef.pdf

available as an alternative. R-717/R-744 cascade systems have been successfully piloted by supermarket chains, including Supervalu[84] and Whole Foods.[85] Carnot and others recommend the R-717/R-744 cascade systems as being particularly appropriate for larger stores such as those found throughout the United States.[86] The use of R-744 and R-717/R-744 cascade has even been employed by the U.S. government when it was recently announced that the US Defense Commissary Agency (DeCA), which operates 245 commissaries worldwide, would use R-717/R-744 cascade systems as their standard in warm climates and is considering transcritical CO_2 for other uses.[87] The DeCA's announcement came after a successful retrofitting of a R-404A system with a R-717/R-744 cascade system at Lackland Air Force Base in San Antonio, TX.[88] At an Albertsons in Carpinteria, California, a cascade system is being used and has been stated to have energy efficiency gains of up to 30% compared to a Freon based system.[89] An additional solution for high ambient climates is a propane micro-distributed system, which is installed at an HEB in Austin, Texas and is projected to achieve 50% greater energy efficiency compared to a synthetic based system.[90]

Ideally, the market should be guided toward using low-GWP, HFC-free refrigerants as the primary refrigerant in indirect systems, however, ARB may follow a similar path to the EU in allowing HFCs as the primary refrigerant, provided that new equipment is state-of-the-art in achieving maximum achievable reductions in charge size. As suggested in Table 3, ARB should implement Equipment Bans on supermarket systems effective in January 1, 2020 or earlier in both direct and indirect systems that guide the market to the lowest-GWP solutions in both types of equipment.

Packaged Room Air Conditioners

Most new self-contained window and wall mounted room air conditioners being sold in the United States currently use R-410A, an HFC blend with a GWP of 2,090. The replacements approved by SNAP that are being introduced to transition away from HCFC-22 and R-410A, include HFC-32 (GWP=675) and hydrocarbons R-290 and R-441A, both with GWPs less than 5. As both HFC-32 and hydrocarbons have flammable properties, both alternatives are subject to use conditions under the safety standards of UL 484, which restrict their charge sizes in accordance with their respective ASHRAE A2L and A3 flammability ratings.

The EPA SNAP decisions were based upon UL 484, Edition 8, but this standard was revised shortly after the EPA approved the use of hydrocarbons as refrigerants in air conditioners, rendering the SNAP

84 http://supermarketnews.com/technology/supervalu-pleased-ammonia-refrigerant
85 http://www.atmo.org/presentations/files/416_1_EILINGER_WHOLEFOODS.pdf
86 http://www.ammonia21.com/articles/6275/nh_sub_3_sub_heat_pumps_and_nh_sub_3_sub_-co_sub_2_sub_systems_grow_in_popularity_at_iiar_show-part_1
87 http://www.coolingpost.com/features/us-defence-agency-adopts-co2-refrigeration/.
88 http://www.coolingpost.com/features/us-defence-agency-adopts-co2-refrigeration/.
89 More information available at: http://www.ammonia21.com/web/assets/link/4091_GUIDE_NA_Case%20Study_MYCOM_1.pdf.
90 More information available at: http://www.hussmann.com/en/Press%20Releases/Hussmann_H-E-B_Propane_072513.pdf.

decision moot as a practical matter. The UL 484 standard was revised using assumptions that effectively reduced the allowable charge size so that as with domestic refrigerators, hydrocarbon air conditioners cannot be economically manufactured under the revised standard. Importantly, UL has acknowledged that the revisions were made with the working group not having access to, nor the mandate to evaluate, recent improvements in hydrocarbon air conditioner technology, safety devices or safety warnings. A review of the revised standard is necessary and a working group to evaluate charge sizes needs to be established in the immediate future. ARB should support and encourage such a review and evaluation. IEC is already undertaking such a review under IEC TC61D.

Hydrocarbon air conditioners have been used in Europe without incident for 15 years, nearly 200,000 units have been sold in India in the last two years without incident[91], Chinese companies are starting to sell hydrocarbon air conditioners[92] and likely Brazil is transitioning all of its manufacturing capacity to hydrocarbon air conditioners in the next few years. As with domestic refrigerators, hydrocarbons are the refrigerant of the future for many air conditioning end uses and the U.S. and ARB should take action to ensure that unnecessarily conservative industrial standards not based in scientific data, are not preventing safe and viable low-GWP alternatives from being used.

ARB should implement equipment bans in packaged room air conditioners that incentivize a near-term transition away from HFC-410A to lower-GWP HFCs, such as HFC-32, and a longer term transition in 2023 to low-GWP refrigerants <150 allowing time for UL standards to be reviewed and updated to allow for additional alternatives to be safely used and cost-effectively designed.

V. Extension of Phase-down to Sectors beyond Refrigeration and Air Conditioning

HFCs are used in foam blowing, aerosols, fire suppression and solvents and a few other end uses. EIA recommends that the phase-out cover all uses of HFCs to give the industries using HFCs the most feasibility to phase-out/down use of HFCs. There are sufficient low-GWP foam blowing alternatives including hydrocarbons, methyl formate, CO_2 and HFO-1234ze. The EPA's SNAP rulemaking 20 includes bans on the use in foam blowing, aerosol and solvent uses. Additionally, EIA has filed a new petition[93] to the EPA to change the SNAP status of many additional high-GWP HFCs, including the use of HFC-23 and the use of both HFCs and PFCs in fire suppression. EIA encourages ARB to consider appropriate bans in these sectors as well.

VI. Technician Training and Servicing Ecosystem

ARB should consider measures to address the need for additional training and certification of technicians in servicing the next generation of equipment using low-GWP refrigerants, including CO_2, hydrocarbons, new kinds of ammonia systems and other new alternatives to HFCs. This may include requiring that a

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[91] https://www.giz.de/en/worldwide/16863.html.
[92] http://www.unido.org/news/press/unido-asi.html. http://www.unep.fr/ozonaction/information/mmcfiles/6309-e-China_case_study.pdf.
[93] http://eia-global.org/images/uploads/EIA_SNAP_Petiton_10-6-15.pdf

certain proportion of technicians within servicing companies based in California receive additional training and certification on these refrigerants by January 1, 2020 when many bans on high-GWP equipment would go into effect. Incentives could be developed to encourage and/or assist servicing companies in initiating training of technicians to service new low-GWP refrigerants.

Technician training programs focused on hydrocarbons are already available in the U.S. from the Refrigerant Servicing Engineers Society (RSES)[94] with an online training manual available from the ESCO Institute.[95] Hillphoenix offers training on their CO_2 supermarket systems in California and trained over 300 technicians in the first half of 2015.[96] As new regulations are announced and go into effect, including a potential requirement for low-GWP technician certification, new training programs will be introduced and scale up to meet the anticipated demand.

VII. Research Needs

1) More research is needed to advance the work of standards technical panels re-examining the safety mechanisms and assumptions about the risks of flammable and mildly flammable refrigerants, particularly in household and light commercial air conditioning applications. For instance, current standards for calculating lower flammability limits assume that the full refrigerant charge leaks from a unit in under 4 minutes, which may be a significantly overly-conservative assumption both in terms of the rate of the leak as well as the assumption that the full charge is immediately released. Working Group 16 was established in June 2015 under IEC TC61D on appliances for air conditioning for household and similar purposes, and is charged with addressing safety of A2 and A3 refrigerants and examining requirements including safety mechanisms and charge size limits. The Working Group will evaluate rigorous data and evidence on the frequency, leak rates, duration, and extent of leaks in equipment, and the efficacy of additional safety mechanisms such as shut-off valves, to mitigate flammability risks. This process of updating safety standards and warnings for A2 and A3 refrigerants may take several years to be completed under both IEC and UL. A solid body of literature is needed on these and other safety aspects of refrigerant leaks so that a rigorous and evidence based approach may be taken by experts on standards panels under both IEC and UL. ARB should commission necessary research and assist in the process in order to expedite these reviews.

2) New low-GWP technologies have been developed for most end uses to replace HFCs and ozone depleting chemicals. However, sufficient alternatives have not been proven or commercialized in several sectors, including unitary air conditioning. ARB should use incentives to encourage the highly innovative industry and educational institutions in California to conduct research and pioneer solutions for these sectors so that as many of these end uses as possible can be transitioned to low-GWP alternatives.

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[94] http://www.rses.org/news/article.aspx?ArticleId=240
[95] http://www.escoinst.com/Training/HydrocarbonRefrigerants.aspx
[96] http://www.hillphoenix.com/2015/07/co2-training-eliminates-the-fear-factor-for-refrigeration-technicians/

VIII. Cost-Effectiveness

The cost-effectiveness of an HFC phase-down should be examined, taking into account the co-benefits of energy efficiency gains that will accompany it. Additionally, when the cost-effectiveness of certain sector bans is considered, the evaluation should take into account the costs of future transitions that will be required if end users are allowed to use mid-range and high-GWP HFCs and HFC blends which will be required to transition again if climate change is going to be effectively averted. A phase-down schedule in California that encourages, wherever possible, a direct transition to the lowest-GWP equipment, will be more cost-effective in the long term than a transition that encourages transitioning to mid- or high-range GWP HFCs and HFC blends, only to be followed in short order by another transition to the lowest-GWP technologies.

Conclusion

Thank you for this opportunity to comment on the ARB Draft Strategy with regard to the additional measures to reduce emissions from HFCs and other fluorinated gases.

Please do not hesitate to contact us with any questions of clarification on our comments. We look forward to continuing our constructive engagement with ARB in the months ahead as the process continues.

Respectfully submitted,

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