October 30, 2015

VIA Electronic Filing at arb.ca.gov

California Air Resources Board
1001 "I" Street
Sacramento, CA 95814

P.O. Box 2815
Sacramento, CA 95812

Subject: NRDC and IGSD Comments on the HFC portions of ARB's Draft SLCP Reduction Strategy

The Natural Resources Defense Council (NRDC) and the Institute for Governance & Sustainable Development (IGSD) appreciate the opportunity to comment on the California Environmental Protection Agency Air Resources Board's (CARB's) "Draft Short-Lived Climate Pollutant Reduction Strategy," published on September 30, 2015. As Governor Brown and the California Air Resources Board recognize, climate change is already causing harm to people in California and beyond. 2014 holds the record as our planet's warmest year ever. Scientists predict that 2015 will be even hotter. And California is in the grip of a devastating drought. Swift and dramatic action to reduce emissions of all greenhouse gases is critical. We thus applaud CARB for undertaking this initiative aimed at three classes of short-lived but extremely potent greenhouse gases. As CARB notes, California must achieve deep reductions in these short-lived climate pollutants (SLCPs) in order to reach its future climate goals.

We urge CARB to follow through on and expand its Draft Reduction Strategy by enacting the regulations needed to ensure rapid reduction in all three classes of pollutants. In this comment, we address in detail specific measures that may be taken to reduce hydrofluorocarbon (HFC) emissions in California.

Hydrofluorocarbons (HFCs)

HFCs are a class of chemicals used as replacements for other classes of chemicals, including chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) and to a small extent halons, which were phased out because of their ozone depleting potential. In addition to harming the ozone layer, CFCs, HCFCs, and halons have high global warming potentials (GWPs). HFCs represent an improvement over these chemicals because they do not harm the ozone layer, but HFCs are themselves highly potent agents of climate change, some with GWPs thousands of times greater than that of carbon dioxide. For example, HFC-134a, the most abundant HFC, has a global warming potential of 1,430. This means that, over a 100-year timeframe, each ton of HFC-134a emitted to the atmosphere results in 1,430 times more warming than a ton of carbon dioxide.

CARB notes that "F-gases, specifically HFCs, are the fastest growing source of [greenhouse gas] emissions in California."[1] Nationally, HFCs make up 1.5 percent of the United States' greenhouse gas emissions, and domestic emissions of HFCs are expected to triple by 2030.[2] Atmospheric concentrations of HFCs are increasing as well: HFC-134a increased by an average of ten percent per year from 2006 to 2012.[3] This projected rapid growth underscores the urgent need to replace these chemicals with lower-GWP alternatives. Without strong standards limiting their use, HFC emission increases would counteract the carbon pollution reductions CARB is striving to make in other sectors.

Strong action by CARB to reduce HFCs will be important in California and beyond. Currently the United States and other nations are working toward an agreement to reduce rapidly-growing global HFC use under the Montreal Protocol. CARB's actions can provide a significant boost to these international negotiations. By showing that it is feasible to replace high-GWP HFCs with low-GWP alternatives and by creating the market for the development of additional substitutes, California will give international actors support to move forward with an amendment to the Montreal Protocol. Similarly, California's actions can facilitate further domestic steps by EPA to set standards for high-GWP HFCs.

1 California Air Resources Board, *Short Lived Climate Pollutant Reduction Strategy*, Concept Paper, May 2015 *available at* http://www.arb.ca.gov/cc/shortlived/concept_paper.pdf [*hereinafter* "Concept Paper"].
2 The President's Climate Action Plan, Executive Office of the President, pg. 10 (June 2013) *available at* http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf (last accessed Oct. 1, 2014).
3 U.S. EPA, *Climate Benefits of the SNAP Program Status Change Rule*, pg. 1 (June, 2014)) *available at* Memorandum to Docket: References and Associated Documents, Docket No. EPA-HQ-OAR-2014-0198-0003.

NRDC and IGSD had hoped that CARB would propose action on HFCs in advance of the Meeting of Parties (MOP) to the Montreal Protocol in November 2015. NRDC and IGSD believe that California can, by acting in advance of international action, significantly contribute to the global transition to a low-GWP future. CARB should lead, not follow, the international efforts under the Montreal Protocol. It is thus imperative that CARB publish for comment a strong proposal for HFC reductions in their next release.

CARB's Concept Paper identifies many excellent targets for action. In order to achieve its 80 per cent HFC reduction goal by 2030, CARB must address a) the use of high-GWP HFCs in new products, b) high-GWP HFC leakage from distributed refrigeration systems, and c) end-of-life HFC venting from existing products. Proposals to limit HFC use and increase energy efficiency should be explored whenever possible, as the carbon dioxide emissions from the electricity used to run these systems contributes significantly to life cycle greenhouse gas emissions. NRDC and IGSD proposes several areas around which an HFC reduction strategy may be built and looks forward to collaborating with stakeholders as CARB moves forward in developing its HFC reduction strategy.

GWP Limits by End-Use

Limiting the GWP of refrigerants allowed for use in a particular application (e.g. industrial refrigeration, retail food refrigeration) is an effective way to prevent the use of high-GWP refrigerants while maintaining chemical and manufacturer neutrality. In addition, specifying end-use GWP limits and distinguishing between new and retrofit systems allows for tailoring of standards to specific applications while considering the efficiency implications of a given refrigerant switch. NRDC and IGSD recommend the following limitations in the following years based on availability of refrigerant options below the GWP thresholds, potential for equal or better energy efficiency, and the progress of updates to relevant American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) safety standards. In particular, NRDC and IGSD recommend:

1. Setting a GWP_{100} limit of 2500 for all new and retrofit stationary HVAC and refrigeration equipment, and for service and maintenance of all applications, effective January 1, 2018.

   Reclaimed and recycled gas could be used to service and maintain existing systems until they are retrofitted with compliant alternatives or replaced by new equipment. This regulation would put California ahead of European Union Regulation No 517/2014 Article 13, which bans refrigerants above a GWP_{100} of 2500 in 2020 but allows continued use in applications of less than 40-ton CO_2-equivalent refrigerant charges.

This measure would eliminate use of R-404A and R-507A, two similar refrigerants with GWP_{100} = 3950 and GWP_{100} = 3900, respectively. R-404A and R-507A are used in commercial and industrial refrigeration, including medium- and low-temperature refrigeration applications, retail food display cases, walk-in refrigerators, retail freezers, cold storage warehouses, supermarket condensing systems, and industrial process applications. Many of these systems represent the leakiest refrigerant applications currently in use, with annual leak rates of up to 30%.[4] In its July final rule, EPA disallowed the use of R-404A, R-507A, and other similar refrigerants in commercial refrigeration in stand-alone, condensing unit, and direct and indirect supermarket retail food refrigeration and vending machines. CARB can and should entirely ban additional end uses not covered by EPA's rulemaking by issuing a universal maximum GWP for stationary applications.

Beyond EPA's delisting of R-404A and R-507A from commercial applications, CARB would be restricting these refrigerants from industrial refrigeration. In industrial refrigeration, R-404A and R-507A are used over a wide range of applications for low- and medium-temperature refrigeration. These systems cool with direct-expansion coils and typically have site-installed refrigerant pipework that leak 5-10% per year.

There are several suitable lower-GWP alternatives for industrial applications, including the well-established R-407 series (in particular, R-407A and R-407F) and the recently developed R-448A, R-449A and R-452A blends. The R-448A and R-449A refrigerants, while not yet extensively deployed, offer GWP reductions of about 65% below R-404A, maintain A1 non-flammability, and can be retrofitted into existing systems without an oil change or used in new equipment. R-452A offers a non-flammable, lower discharge temperature alternative with a 45% reduction in GWP from R404A. R-452A's application for addition to the SNAP list is being considered by EPA and Chemours has committed to making R-452A generally available 12 months after approval. R-452A can be used to retrofit existing equipment or incorporated into new system designs and has demonstrated thermodynamic efficiency and capacity comparable to that of R-404A in most configurations. Thermodynamic efficiency often surpasses R-404A and R-507A levels with modest adjustments to the thermal expansion device.

Exemptions should be granted for certain end-uses or situations, including military applications, extreme low temperature refrigeration, or applications for which there are no available alternatives.

4 UNEP Ozone Secretariat. *Fact Sheet 4: Commercial Refrigeration*, Pg. 2. April 2015 *available at* http://conf.montreal-protocol.org/meeting/workshops/hfc_management-02/presession/English/FS%204%20Commercial%20Refrigeration%20final.pdf (last accessed June 11, 2015).

2. Setting a GWP_{100} limit of 150 for all low- and medium-pressure chillers and a GWP_{100} limit of 750 for all high-pressure chillers effective January 1, 2019.

   Many medium and large commercial buildings use water chillers to meet their cooling needs. Chillers require large quantities of refrigerant to cool water that is circulated through building spaces to remove heat. Their prevalence and use of high-GWP HFCs make chillers an important application in which to make reductions in HFC consumption. Moreover, because chillers qualify as commercial equipment and are managed by professional technicians, manufacturers will offer chillers with lower-GWP refrigerants before any other HVAC equipment class.

   Commercial buildings employ chillers based on low-, medium-, or high-pressure refrigerant circuits. Low-pressure systems use centrifugal compressors, medium-pressure systems use centrifugal or screw compressors, and high-pressure systems generally use small screw or scroll compressors. Large, low-pressure chiller systems are currently sold in the US using only ozone-depleting HCFC-123 as a refrigerant, which will be phased out by 2020 in accordance with the Montreal Protocol. Some of these chiller designs have been transitioned to HFC-134a with a GWP of 1430—nearly an eighteen-fold increase in GWP over HCFC-123 accompanied by an efficiency decrease. A new low-pressure hydrofluoroolefin, HFO-1233zd, has a GWP of 7, A1 non-flammability and nontoxicity, and a theoretical energy efficiency about 3% higher than HFC-134a. At least one manufacturer is developing an HFO-1233zd chiller already, suggesting that a GWP limitation of 150 is suitable for this subset of the market. Moreover, this GWP limitation will ensure that state-of-the-art HFO-1233zd chillers do not fail to gain traction because they employ a more costly refrigerant.

   Medium-pressure chillers are generally large or mid-sized and use centrifugal or screw compressors with HFC-134a as the refrigerant. For chillers with this design, SNAP-approved HFO-1234ze provides an alternative to HFC-134a with similar theoretical efficiency and a GWP of <1. HFO-1234ze chillers have already been sold in the US and Europe by various manufacturers, again suggesting that availability will be sufficient to comply with a limit of 150 by 2019.

   High-pressure chillers are generally compact systems using screw or scroll compressors with R-410A, with a GWP of 2088, as the refrigerant. These chillers are prevalent and carry the greatest risk of refrigerant climate impact. While several high-pressure alternatives are under development in chillers, HFC-32 and “DR-55” have emerged as likely leaders in this market. Daikin Industries and other Japanese manufacturers have championed HFC-32, as it offers a GWP of 675, higher energy efficiency, and better capacity compared to R-410A. “DR-55”— a blend of HFO-1234yf, HFC-32, and HFC-125—promises near-design-compatibility, very low burning velocity, a GWP of 675, higher energy efficiency, and comparable capacity to R-410A. While no chillers are

currently on the market using these blends, several manufacturers are heavily invested in releasing such chillers along the proposed timeline.

Safety Standards and Building Codes

HFO-1234ze, HFC-32, and "DR-55" are classified as having 2L flammability, meaning that certain standards updates will be necessary for chillers using these refrigerants to be widely commercially available. In particular, ASHRAE Standard 15 and Underwriters Laboratories (UL) Standard 60335-2-40 need to be updated to include 2Ls.

In order to allow the use of 2L-class refrigerants in 2019, California may take one of two pathways to building code modification. First, should ASHRAE 15 finish in time to submit its language to the Uniform Mechanical Code's (UMC's) 2018 cycle, California could simply adopt the updated version of the UMC. This would allow for 2L-class chillers during 2018 in advance of a 2019 GWP limitation. Alternatively, if ASHRAE 15 takes until the end of 2017 to finish their updated standard, California could independently absorb its language into the state's building codes in 2018 in preparation for GWP restrictions in 2019.

Availability

In the event that there is limited availability of HFO-1233zd and HFO-1234ze chillers or ASRHAE standards are not developed in time, CARB could either revise the threshold of low- and medium-pressure chillers to 750 or extend the compliance date of 2019. There are several market-ready, non-flammable, medium-pressure alternatives, including Honeywell's R-450A and Chemours' R-513A, that are compatible with existing HFC-134a chiller designs—requiring only changes to controls—and have GWPs just less than 750. These could provide interim GWP reductions while HFO-1233zd and HFO-1234ze redesigns are completed and building codes become fully compatible with 2L refrigerants. Otherwise, extending the compliance date beyond 2019 could ensure a direct path to very-low GWP chillers while sacrificing short term GWP improvements.

R-513A and R-450A offer roughly a 50% GWP reduction from HFC-134a and are nonflammable. In the case of R-513A, energy efficiency is nearly thermodynamically equal to that of the HFC-134a being replaced. R-450A suffers a more significant efficiency penalty and may not be ideal from a total climate impact standpoint. Trane already offers its Sintesis® line of chillers using R-513A and has committed to making its full chiller line available with alternative refrigerants in 2018. Johnson Controls has

also indicated that its new chiller designs will be compatible with alternative refrigerants, most likely pointing to a mid-GWP blend as well. As such, increasing the 2019 GWP limit to 750 appears to dovetail with the direction manufacturers are heading.

R-513A and R-450A are not suitable long-term solutions, however, because their GWPs remain high. California would do well to set limitations that force chiller sales below a GWP of 150 as soon as possible. Mid-GWP HFC-134a replacements such as these may be the necessary choice only in applications where it is not yet feasible to mitigate flammability of currently available lower-GWP refrigerants.

Significant New Alternatives Policy (SNAP)

SNAP has already included HFO-1234ze, a 2L-class refrigerant, in its approved list of alternatives for chillers. HFC-32 and "DR-55" have not yet been SNAP approved, but EPA will be working on approvals alongside any further changes of status to be proposed in early 2016.

NRDC and IGSD expect HFC-32 or "DR-55" chillers to be available to replace R-410A chillers in advance of the proposed 2019 compliance date. However, in the event that they are not, NRDC and IGSD suggest extending the compliance date rather than setting an interim GWP reduction level; manufacturers are not considering any GWP reduction steps between R-410A and the alternatives offered in this discussion.

3. Setting a GWP_{100} limit of 750 for new portable factory-sealed air conditioners and dehumidifiers effective January 1, 2018.

   Portable factory-sealed air conditioners, commonly referred to as window air conditioners, and dehumidifiers occupy a specific subclass of appliances for which R-410A alternatives may be rapidly deployed, as flammability is fairly easily mitigated given the modest refrigerant charge sizes.

   The UL484 safety standard was recently updated to include class 2- and class 3-flammability refrigerants for use in factory-sealed portable appliances like small air conditioners, dehumidifiers and other similar devices. EPA SNAP has also recently provided additional options for refrigerants in this area, listing certain climate-friendly hydrocarbons like ethane, isobutane, propane, and R-441A as acceptable in these applications and others[5]. EPA has also listed HFC-32, previously discussed in the

5 US EPA. *Protection of Stratospheric Ozone: Listing of Substitutes for Refrigeration and Air Conditioning and Revision of the Venting Prohibition for Certain Refrigerant Substitutes; Final Rule. Federal Register April 10, 2015.*

chiller section, as acceptable in room air conditioning units. EPA has also exempted ethane, isobutane, propane, and R-441A from the §608 venting prohibition for the specific applications listed above. As such, CARB could limit the GWP in these systems to 750. Setting a lower limit to ensure the use of hydrocarbons is likely premature, as the charge restrictions on hydrocarbons may not be sufficient to make economically priced units.

4. Setting a GWP_{100} limit of 750 for new and retrofit light commercial and residential split air conditioning effective January 1, 2023.

   Light commercial and residential air conditioning constitutes a major subset of the heating, ventilating, and air conditioning (HVAC) sector. Further, this subset of end uses has been dominated by R-410A since R-22's phase out. These systems differ from chillers in that they directly condition air intended for space cooling, whereas chillers are indirect systems that cool water that will eventually be circulated through coils in the space.

   Commercial products included in this sector include rooftop air conditioning units and air handlers, while residential products include split systems, packaged central air conditioners, ductless mini-splits, heat pumps, and packaged-terminal air conditioners. There is also overlap between these two categories, as certain classes of residential products may also be used in small businesses or other light commercial applications.

   The alternatives being developed for these applications are the same as for chillers, and also offer the dual benefit of lower GWP and greater energy efficiency. NRDC and IGSD urge California to place a date on the restriction of R-410A systems in these applications as soon as possible. Such action will set an example for EPA to put the US on a path towards major HFC emissions reductions.

   ASHRAE 15 has established a subcommittee—ASHRAE 15.2—to determine safety standards for flammable refrigerants in residential applications. ASHRAE 15.2 expects to complete its work by December 31, 2017, in order to be included in the 2021 International Residential Code published by the International Code Council for state and local government adoption. California would need to commit to adopting the updated IRC before 2023 to enable the GWP limitation to take effect.
   For light commercial systems, the language developed by ASHRAE 15.2 for residential products will likely be published into an updated ASHRAE 15, which has jurisdiction over all commercial refrigeration systems. This process will likely follow the same 2021 code cycle timeline as residential applications. A GWP limitation in 2023 reflects the U.S. Department of Energy's estimate for refrigerant changeover used in setting efficiency standards for commercial unitary air conditioners (rooftop light commercial units), a date that US manufacturers are now targeting as well.

5. Setting a GWP_{100} limit of 1500 for cold storage warehouses, industrial process refrigeration, and industrial process air conditioning effective January 1, 2022.

   As discussed in the previous section, the R-410 and R-407 refrigerants will be largely supplanted by available alternatives starting in 2021. As such, California should extend the applicability of its GWP restriction to include cold storage warehouses, industrial process refrigeration, and industrial process air conditioning. Currently-existing alternatives like R-717 and R-744 allow this transition to begin even sooner than for the residential and light commercial applications discussed in the previous section.

6. Setting a GWP_{100} limit of 15 for new household refrigerators and freezers effective January 1, 2021.

   Across the United States, at least 150 million domestic refrigerators, freezers, and combination units preserve food using HFC-134a. During their lifetimes, these units do not typically leak much HFC-134a, but improper disposal frequently results in the entire refrigerant charge being vented to the atmosphere. Because improper disposal is prevalent and hard to control, domestic refrigerators and freezers have a significant impact on US greenhouse gas emissions. As such, NRDC and IGSD believe it to be critical that California put a strict GWP limitation on these appliances.

   Several sub-GWP 15 alternatives to HFC-134a are being explored, including HFO-1234yf, HFO-1234ze, propane (R-290), and isobutane (R-600a). HFO-1234yf has the benefit of being thermodynamically similar to HFC-134a, although adjustments to desiccants, expansion valves, and heat exchangers may be necessary to match HFC-134a's efficiency. HFO-1234ze offers a more efficient, lower-capacity version of its cousin that will require more redesign but offers greater life cycle benefit.

   Propane and isobutane, two hydrocarbons widely used abroad, also provide excellent options. These chemicals offer potential efficiency gains over HFC-134a, low GWPs, and are abundant and low cost. Today, these options are restricted by UL's and EPA's charge limit of 57g in domestic refrigeration applications—a charge limit too small to build a typical refrigerator/freezer with just one refrigerant circuit. Given the widespread and apparently safe use of units with more than 57 grams abroad, with nearly half a billion units in use based on an international standard that allows for 150 grams, we believe CARB should issue a GWP limitation that encourages UL and EPA to revisit the use conditions they have placed on hydrocarbons. If UL or EPA were to do so, California and the US market could follow the major shift to hydrocarbon refrigerators that has already occurred internationally.

Impact of R-410A Alternatives on the Grid

The two major R-410A alternatives currently being incorporated into HVAC designs—HFC-32 and "DR-55"—offer dramatically better efficiency performance at elevated ambient temperatures compared to their predecessor. In particular, a recent study conducted by Oak Ridge National Laboratory shows a 4% efficiency increase using HFC-32 and a 3% efficiency increase using "DR-55" at 95F in R-410A units soft-optimized for the new refrigerants[6]. As such, natively designed hardware could achieve even more significant efficiency benefits (provided that manufacturers do not relax the efficiency of other components to compensate).

CARB should coordinate with other relevant state agencies to determine the impact of this additional efficiency potential, especially since the efficiency improvement will coincide with peak load power generation. It is possible that a roll-out of HFC-32 and "DR-55" equipment could avoid significant peak load energy consumption, avoiding the carbon intensity and additional cost of firing peaking plants along with it. Simulations over 8760 hours per year using weather data and grid load estimates could offer a picture of the carbon savings that may be achieved. CARB should facilitate utility rebate programs that encourage these alternative refrigerants accordingly.

Mitigation Fees

CARB should consider implementing a mitigation fee on the sale of high-GWP refrigerants that scales with GWP and increases over time, applicable to commercial and industrial distributed refrigerant systems. These systems are also the target of CARB's Refrigerant Management Program (RMP), which regulates stationary distributed refrigeration systems with over 50lb of refrigerant charge. In particular, the RMP requires leak testing, prompt leak repair, service records, and licensed refrigerant handling for large systems. Rigorous refrigerant management to prevent leaks and properly recover high-GWP refrigerants is vital and we applaud CARB's efforts on this front. A mitigation fee would complement this structure by providing a direct incentive for equipment owners to retrofit with a low-GWP alternative. Mitigation fees would of course also ensure that CARB has the resources necessary to implement the management program. The use of a GWP-weighted mitigation fee is also consistent with AB32's use of market based structures to require that those emitting greenhouse gases internalize the costs of those emissions and could provide a model as others consider ways to address HFC use.

There are several ways that a mitigation fee will encourage equipment owners to reduce emissions of HFCs. Equipment owners who successfully prevent leaks use less refrigerant in

6 Abdelaziz, Omar, et al. *Alternative Refrigerant Evaluation for High-Ambient-Temperature Environments*. Oak Ridge National Laboratory. October, 2015. Page 17.

their systems and thus will pay lower fees. An escalating mitigation fee will also encourage equipment owners to retrofit their systems with lower GWP refrigerants or to replace old equipment with equipment designed for low-GWP refrigerants. Funds collected from this fee could be used to provide grants for retrofits or the purchase of new high-efficiency, low-GWP equipment and innovative systems (such as cascade systems in supermarkets). We look forward to working with CARB to further discuss the policy and legal questions concerning a mitigation fee system.

Refrigerant Buyback Program

NRDC and IGSD also suggest that CARB consider implementing a refrigerant buy-back requirement for the manufacturers of high-GWP (e.g. above GWP_{100} = 1000) packaged and mini-split residential HVAC and refrigeration equipment (e.g. domestic refrigerators, room air conditioners, central air conditioners) sold in California. While the mitigation fee described above would apply primarily to systems with the highest risk of leakage, this program targets equipment that is hermetically sealed and most likely to leak at end-of-life when lines are cut or other improper disposal takes place. Although venting of refrigerants to the atmosphere is illegal, enforcement is difficult and technicians can save time and money by venting rather than properly evacuating and disposing of refrigerant. By creating a buy-back program, CARB could create the incentives needed to ensure proper disposal, avoiding significant end-of-life emissions.

There are various ways that CARB might structure a buy-back program. One way would be to require that manufacturers purchase back the refrigerant from their unit sales in California. Such a buy-back would provide a market for recovered gases, and an incentive for end users, municipal recycling facilities, and residential HVAC technicians to properly handle HFCs in old equipment. Manufacturers might participate in the program either by paying for the proper disposal of refrigerants or by buying back the refrigerant following processing and repackaging (with appropriate certification) at a U.S. reclaiming facility. A retroactive cut-in date for program eligibility would likely be necessary to make this program practical (e.g. equipment manufactured after January 1, 2005).

Recycled Refrigerant Standard

CARB should consider requiring that a minimum portion of high-GWP refrigerants sold by manufacturers or refrigerant distributors in California be recycled refrigerant. At present, estimates suggest that less than ten percent of refrigerants are recycled and reused.[7] As noted, refrigerants that are not recycled most often end up being vented to the atmosphere. By setting

7 See http://eosclimate.com/wp-content/uploads/2015/04/EOS-Climate-White-Paper.pdf

a minimum recycled product requirement, CARB could significantly increase rates of refrigerant recycling and improve refrigerant management in California and beyond. CARB could set the required percentage of recycled refrigerant based on the current availability of recycled refrigerant and the GWP of the refrigerant, with higher percentages of recycled refrigerant required for the highest GWP refrigerants. Further, CARB could consider setting the requirement only for refrigerants above a certain GWP. In this way, the standard would, either in combination with or in lieu of the mitigation fee requirement, provide an additional incentive for users to switch to low GWP alternatives.

Future Research & Further Commitments

CARB has indicated that they are the evaluating the climate impact of HFCs based on their GWPs as measured over 20 years. While this timescale may work for black carbon and certain other greenhouse gases, it is not a reliable indicator of the lifetime impact of HFCs. CARB should use the internationally agreed-upon 100-year GWP or, better yet, radiative forcing to evaluate the environmental impact of various HFC restriction measures. Otherwise, CARB's efforts to curb SLCP emissions may not be properly synchronized with California's larger efforts to curb carbon emissions, which affect the globe for a hundred years or more. In other words, the total climate benefit of carbon reduction policy and SLCP policy together is greater when HFCs are considered over 100 years rather than 20 years. However, CARB can consider shorter time intervals when appropriate for specific applications.

In addition to the specific recommendations above, NRDC and IGSD recommend that CARB coordinate research on several other areas relevant to reducing emissions of HFCs in California.

1. Building Codes

   Many local, state, and national building codes do not currently allow use of any flammable refrigerants. Efforts are underway to approve appropriate standards and to update building codes to reflect safe levels and use conditions for flammable refrigerants, but the process can be long and complex. This effort is important because updating building codes to reflect safe use conditions for flammable refrigerants will be key to achieving CARB's goal of an 80% HFC reduction by 2030. NRDC and IGSD believe that there are two ways that CARB can support building code efforts:

   a. CARB should consider providing grants to academic institutions to study flammable refrigerant safety in residential and commercial applications. In particular, NRDC and IGSD believes that it would be valuable for CARB to support further research on the relationship between refrigerant auto-ignition temperature and the field conditions necessary to cause actual

ignition. In addition, research on optimal refrigerant sensor location and maximum charge amounts should be conducted in a peer-reviewed context.

b. CARB should work to obtain a commitment for swift review and, if acceptable, adoption of proposed codes for safe use of flammable refrigerants into the state mechanical code or CA Title 24. As discussed, ASHRAE has begun evaluating residential and commercial refrigerant safety this year and is expected to set standards for safe use of low-flammability refrigerants by 2018. California should consider directly adopting these standards as soon as they become available.

By facilitating the process of adopting new standards for the safe use of alternative refrigerants, California could pave the way towards low-GWP HVAC and refrigeration systems across the country.

2. Heavy Duty Vehicle Refrigerants

CARB should consider facilitating grants to academic institutions in order to investigate the feasibility of low-GWP refrigerants in heavy duty vehicles, and to establish a timeline for such a transition. There are unique technical challenges for heavy duty vehicles that do not exist in light duty applications and additional research in this area would be valuable. In particular, it is important to evaluate the use of larger charge sizes of R-1234yf and the efficiency of R-744.

NRDC and IGSD look forward to working with other stakeholders and with CARB as it moves forward in developing its HFC reduction goals. The SLCP concept paper highlights that California is well-positioned to lead the nation in transitioning away from high-GWP chemicals. This leadership will allow California to both meet the state goal of an 80% reduction by 2030 and provide a valuable example to the rest of the nation and the international community that decisive action must be taken to eliminate these harmful chemicals.

Sincerely,

David Doniger
Benjamin Longstreth
Emily Davis
Alex Hillbrand

Climate and Clean Air Program
Natural Resources Defense Council
1152 15th St. NW
Washington, D.C. 20008
ddoniger@nrdc.org
blongstreth@nrdc.org
edavis@nrdc.org
ahillbrand@nrdc.org

Durwood Zaelke
Stephen O. Andersen
Nancy Sherman

Institute for Governance & Sustainable Development
2300 Wisconsin Ave. NW Suite 300B
Washington, D.C. 20007

zaelke@igsd.org
soliverandersen@aol.com
nsherman@igsd.org