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Buyers Club Handbook [1]

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The Institute for Governance & Sustainable Development (IGSD) and
OzonAction/United Nations Environment (UN Environment) [2]

This handbook presents the best available guidance on how to easily start a **Buyers Club for Affordable Super-Efficient Air Conditioners (ACs) using Lower-Global Warming Potential (GWP) Refrigerants.** It was developed through collaboration with The Energy and Resources Institute (TERI), Energy Efficiency Services Limited (EESL), and the Technology, Education, Research and Rehabilitation for the Environment Policy Centre (TERRE), and with advice from the Natural Resources Defense Council (NRDC).

The intended audience includes policy makers considering starting a buyers club and the managers who will put new buyers clubs in place. Please help make The Buyers Club Handbook as useful as possible by contributing case studies and advice, including updated information and edits. The plan is to frequently update the handbook with the latest technical information and case studies.

Abstract and Easy Buyers Club Recipe

The buyers club strategy includes public bulk procurement such as the approach pioneered for room ACs (RACs) by Energy Efficiency Services Limited (EESL) in India. Private buyers clubs are now being organized by private banks for air conditioning of the rooms housing automatic teller machines (ATMs). Buyers clubs are most easily organized for standardized products sold in large quantities, such as RACs, but can also be initiated for any product where a large enough number of customers can combine their buying power to obtain a significant discount. This could include purchase of refrigerators by consortiums of builders and housing authorities or purchase of appliance components like inverter/motor/compressor assemblies by consortiums of refrigerator and AC manufacturers.

This buyers club handbook is focused on how public and private buyers clubs can organize for the first and learn from that experience to organize subsequent

[1] We use the plural "buyers" rather than the possessive "buyer's" in harmony with the existing literature.
[2] The Buyers Club Handbook team includes Dr. Stephen O. Andersen (IGSD), Dr. Suely Carvalho (United Nations Development Programme—UNDP, retired), Ezra Clark (OzonAction), Mr. James Curlin (OzonAction), Dr. Gabrielle Dreyfus (IGSD), Mr. Richard (Tad) Ferris (IGSD), Saurabh Kumar (EESL), Mr. Manu Maudgal (ESSL) Mr. Marco Gonzalez (Montreal Protocol Ozone Secretariat, retired), Mr. Alex Hillbrand (Natural Resources Defense Council – NRDC), Mr. Karan Mangotra (TERI); Dr. Ajay Mathur TERI), Shamila Nair-Bedouelle (OzonAction), Mr. Rajendra Shende (TERRE Policy Centre), and Dr. Nancy J. Sherman (IGSD).

procurement, learn by doing, and continuously strengthen each subsequent tender to achieve superior affordability, energy efficiency and climate performance.

OzonAction and the other organizations contributing to this handbook are available to answer your questions and assist in jump-starting buyers clubs.

The Basic Recipe for a RAC Buyers Club

Put one ambitious "cook" in charge and give them your full support:
- Perhaps the National Ozone Unit or Regional Network Officer

Brainstorm on how to organize the most likely buyers, for example in regional network meetings:
- If for government procurement, which organizations buy RACs?
- If private, which organizations can cooperate in a large purchase?
- Perhaps banks for ATM rooms, or colleges for student housing
- Ask government and energy NGO experts for suggestions

Meet with the potential buyers with the strongest likelihood of leadership:
- Perhaps organizations pledged to climate protection

Hold a Buyers Club Open House:
- Brief presentation by the cook in charge
- Brief presentations by one or two supporting organizations
- Questions and Answers and work toward consensus

Put the best ideas down on paper and meet with stakeholders:
- Meet with RAC manufacturers, distributers and dealer stakeholders
- Share your plan and ask how it can be better
- Ask how many RACs you need to buy to get a substantial discount
- Ask if installation by trained technicians can be included in the price
- Ask if it is feasible to agree on a discount price and have the RACs delivered and installed where and when as needed over a specified period of time.

Consult the Energy Standard Agency of your country or region:
- Understand how the buyers club can complement the energy efficiency policies in your region.

Explore financing mechanisms that will allow energy savings to be monetized:
- Ask whether energy service companies operate in your region and sector

Consult with OzonAction:
- Once you are ready to move forward, contact OzonAction
  - Tell OzonAction what you want to do;
  - Work together to solve any problems;
  - Ask OzonAction to help arrange up-front finance;
  - Once finance is assured, work on the paperwork;

Communicate the plans and promote the benefits;
OzonAction will involve other experts as needed.

Issue the Tender and get ready for implementation

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1. Introduction

The Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) was amended in October 2016 at the Meeting of the Parties in Kigali Rwanda to phase down the production and consumption of hydrofluorocarbons (HFCs). HFCs are ozone-safe greenhouse gases (GHGs) that are alternatives to chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants as well as halons.

HFCs were once necessary to protect the stratospheric ozone layer, but are no longer needed because environmentally superior technology is available and emerging. The Parties to the Montreal Protocol at Kigali also agreed by Decision to encourage increases in energy efficiency, to be implemented at the same time as refrigerant transition away from HCFCs and HFCs

One of the important ambitions of the coordinated phaseout of HCFCs and the phasedown of HFCs is to leapfrog climate damaging and energy inefficient technologies such as those using HFC-410A that damage climate with large direct refrigerant emissions and indirect energy use emissions.

About 100 developing countries classified as Article 5 Parties (A5) under the Montreal Protocol do not manufacture room ACs and most of these probably do not have RAC efficiency standards. In contrast, most non-A5 Parties who do not manufacture have energy efficiency standards.

Business-as-usual in most developing countries classified as A5 under the Montreal Protocol is that RACs are over-priced with lower energy efficiency and durability than those sold in the countries where RACs are engineered and manufactured. The economic and environmental consequences for A5 Parties are that RACs are less affordable to own and do more damage than necessary to local air quality and climate.

Affordability of a RAC is determined by the lifecycle ownership costs, not just the purchase price. The lifecycle cost includes purchase price, installation, service, and energy consumption, which depend on energy efficiency and hours of usage. In most hot and humid locations, the energy cost over the life of the RAC is larger than all other costs combined (Fig. Goeztler et al., 2016). While a more energy efficient RAC may have a higher purchase price, the improvement in energy efficiency can pay for itself in electric bill savings in as little as one year[1]. The rate-of-return on upgrades in energy efficiency is far higher than on savings accounts.

This handbook begins with an explanation of how affordable super-efficient RACs can be made available in A5 Parties through complementary strategies under the Montreal Protocol, national governments and regional government coalitions, and private partnerships. After setting the stage with this comprehensive overview, the handbook concentrates on the newest proven strategy of government procurement and buyers clubs, which achieve affordability by bulk purchase discounts from manufacturers and by simplifying marketing, distribution and installation.

2. Air Conditioning Sector Impact on Ozone Depletion and Climate Change

Air conditioning contributes to ozone depletion when the refrigerant contains chlorine. Air conditioning also contributes to climate change 1) from the <u>*direct*</u> emissions of refrigerants that are GHGs, 2) from the <u>*indirect*</u> carbon dioxide emissions from the power plants that generate the electricity to power the air conditioner, and 3) from the *embodied* emissions in the manufacture, distribution, installation, service and recycle at the end of product life.

Ozone depletion potential (ODP) is the metric for comparing the damage to the stratospheric ozone layer of different chemicals. CFC-11 is the reference chemical with ODP set equal to one (1). All other ODSs are ranked relative to CFC-11. Global warming potential (GWP) is the metric for comparing the damage of chemical emissions to climate. Carbon dioxide (CO_2) is the reference chemical with GWP set equal to 1. All other GHGs are ranked relative to CO_2. Life-cycle climate performance (LCCP) is the metric for the total RAC carbon footprint i.e. equivalent of CO_2 emitted throughout the life cycle of the RAC and is most accurate when calculated for local climate conditions, specific patterns of use, time-of-day carbon intensity of electricity, and distribution (i.e. transmission) losses.

Thirty years ago, when the Montreal Protocol was signed, air conditioners were inefficient and leaked refrigerants that depleted stratospheric ozone and contributed to climate change. To protect the ozone layer, governments came together under the Montreal Protocol to phase out the production and consumption of ozone-depleting substances (ODSs).[2] Today 99% of ODSs are phased out including the full phaseout of CFC refrigerants, with the phaseout of remaining HCFC refrigerants well under way, except for equipment servicing, which will be allowed for about a decade after the phaseout of HCFCs in new products.

In the transition away from ODSs, industry worldwide drastically reduced damage to the ozone layer, improved energy efficiency, and often selected ozone-safe refrigerants that are less damaging to the climate.

3. Status of RAC Refrigerant Choices Under the Montreal Protocol

In many applications industries were able to move directly to sustainable refrigerants that are ozone-safe, low or zero GWP, and more energy efficient. About 85% of the products that were once dependent on ODSs shifted to not-in-kind (NIK) solutions, and about 15% shifted to fluorocarbons such as HFCs and hydrofluoroethers (HFEs). HCFCs were used as substitutes for CFCs in cases where ozone-safe natural refrigerants and HFCs were not safe or energy efficient. In some cases, where other alternatives were not available, industry had no choice but to move to ozone-safe HFCs, many of which have high GWP and hence global warming.

A-5 Parties are currently in the process of phasing out HCFCs and now, according to the October 2016 Kigali Amendment, HFCs will need to be phased down according to agreed control schedules. The HFC phasedown is already well underway with many non-A5 Parties (including the European Union (EU), Japan, and the United States (US) beginning under domestic regulations long before the Kigali Amendment was agreed. Environmentally superior alternatives to high-GWP HFCs are already commercially available for thermal insulating foam; stand-alone refrigerators and display cases; and motor vehicle, room, and building air conditioners. Additional technology will soon to be commercialized for most other sectors.

The next transition under the Kigali HFC phasedown amendment is expected to replace at least one half of the high-GWP HFCs with natural refrigerants (ammonia, hydrocarbons, and CO_2; GWP<6), one-third with hydrofluoroolefins (HFOs; GWP<1), and the remainder with HFO/HFC blends and lower-GWP HFCs (GWP<700).

Table 1. Commercially Available Refrigerants

Refrigerant	**For Sale?**	**ODP[1]**	**GWP**	**Flammable? (ASHRAE)**	**Energy Efficiency**
HCFC-22	Phasing out	0.034	1760[2]	No (A1)	Baseline
HFC-410A[4]	Yes	0	1924[2]	No (A1)	Lower
HFC-32	Yes	0	675[2]	Yes (A2L)	Higher
HC-290	Yes	0	3[3]	Yes (A3)	Higher
R-452B	Not Yet	0	676[2]	Yes (A2L)	Equal

[1]Source: Montreal Protocol 2014 Report of the Scientific Assessment Panel (SAP); For HCFC-22 allocation purposes, the Montreal Protocol uses ODP=0.055
[2]Source: Intergovernmental Panel on Climate Change (IPPC) Assessment Report 5 (AR5)
[3]IPCC AR4.

For motor vehicle ACs, CFC-12 (GWP=10,200) was replaced globally with ozone-safe and energy efficient HFC-134a (GWP equal to 1300). Now, HFC-134a is being replaced with ozone-safe but less energy efficient HFO-1234yf (GWP<1), while other options such as more energy efficient HFC-152a (GWP=138) are still under consideration.

For RACs, HCFC-22 was the status quo refrigerant prior to the Montreal Protocol. Non-A5 Parties, with early control schedules on HCFCs, choose HFC-410A because it was non-flammable and affordable, but they compromised on energy efficiency (~5% lower) and GWP (~10% higher).

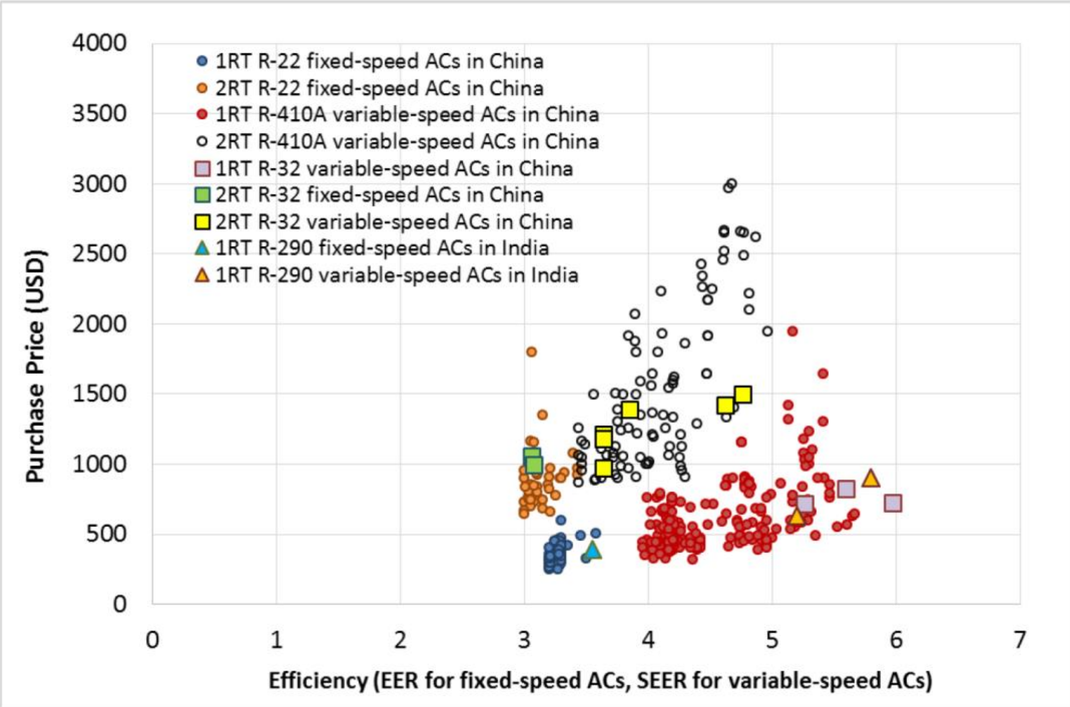
At the 20th anniversary of the Montreal Protocol in 2007, Parties agreed to accelerate the phaseout schedule of all HCFCs. Decision XIX/6 of the Meeting of Parties in 2007 promotes the use of alternatives that minimize environmental impacts, in particular impacts on climate, taking into account GWP, energy use and other relevant factors.

Until 2011, the only alternative to HCFC-22 for RACs was HFC-410A (GWP=1924), which is a 50%/50% blend of HFC-32 (GWP=675) and HFC-125 (GWP= 3175).

Then, in the late 2000s, the German Technical Cooperation Agency (GTZ) financed HC-290 (propane) demonstration projects at two RAC manufacturing companies, Godrej in India and Gree in China. Godrej commercialized HC-290 and now produces the highest efficiency 1.5-ton RAC sold in India, which uses HC-290, plus a dozen smaller RACs with up to 5-STAR RATING.

In 2012, Japan's Ministry of International Trade and Industry (MITI) and the government of Indonesia -- with support of Japanese industry, the United Nations Development Programme (UNDP) and IGSD – introduced HFC-32 for applications where HC-290 is considered too flammable or has a higher life-cycle carbon footprint.

Figure 1. Energy efficiency versus purchase price in China and India.



Now, as required by the 2016 Kigali Amendment, plans to phase down HFCs will be soon under way. HFC-410A replacements that are ozone-safe, have lower GWP, and are more energy efficient are HC-290 (GWP=3)[3] and HFC-32 (GWP=675)[4]. Several other refrigerants are being tested. HFC-32, with flammability class 2L is used where HC-290, flammability class A3, is not prudent.

Table 2. Safety Classification of Refrigerants in ASHRAE Standard 34

	Lower Toxicity Class A	**Higher Toxicity Class B**
Higher Flammability Class 3*	***A3*** HC-290 (Propane) HC-600a (Isobutane)	***B3***
Lower Flammability Class 2**	***A2*** HFC-152a	***B2***
Lower Flammability Lower Burning Velocity Class 2l***	***A2L*** HFC-32 R-452b (HFO/HFC blend)	***B2L*** R-717 (ammonia)

[3] Source: Intergovernmental Panel on Climate Change (IPPC) Assessment Report 4 (AR4)
[4] Source: Intergovernmental Panel on Climate Change (IPPC) Assessment Report 5 (AR5)

	HFO-1234yf HFO-1234ze(E)	
No Flame Propagation** Class 1******	***A1*** HCFC-22 HFC-134a R-410A HFO-1233zd(E) R-404A R-407C R-507A R-744 (carbon dioxide)	***B1*** HCFC-123

* Class 3 if the refrigerant meets both of the following conditions:
1. Flame propagation when tested at 60 ℃ (140 ℉) and 101.3 kPa (14.7 psia) and
2. LFL ≤ 0.10 kg/m3 (0.0062 lb/ft3)

** Class 2 if the refrigerant meets all three conditions:
1. Flame propagation when tested at 60 ℃ (140 ℉) and 101.3 kPa (14.7 psia)
2. LFL > 0.10 kg/m3 (0.0062 lb/ft3)
3. Heat of combustion <19,000 kJ/kg (8,169 Btu/ lb)

*** Class 2L criteria above, but with burning velocities less than or equal to 10 cm/s (3.9 in./s)

**** No flame propagation when tested in air at 60 ℃ (140 ℉) and 101.3 kPa (14.7 psia)

4. The Importance of Super-Efficiency with Lower-GWP Refrigerants

Air conditioning is one of the fastest growing uses of electricity in developing countries. Most electricity in developing countries is generated with fossil fuels, which makes the carbon intensity (carbon per kilowatt hour) very high, particularly during the cooling season when the least efficient and most polluting power plants are used. Furthermore, many developing countries have inefficient electricity distribution systems with high levels of power losses during transmission, which means that the carbon intensity of delivered electricity is far higher than that of the electricity at the point of generation.

HFCs are also the fastest growing non-CO_2 GHGs in much of the world, increasing at a rate of 10–15% per year, principally because of their use as air conditioning refrigerants.[3] HFCs are factory-made gases that were once necessary to replace ozone-depleting substances, but today are no longer needed in most applications, including air conditioning, refrigeration, and thermal insulating foam, with new technology being rapidly commercialized for remaining uses.

The HFC phasedown under the control schedules agreed in the 2016 Kigali Amendment will avoid up to 80 billion metric tonnes or more of carbon dioxide equivalent emissions by mid-century, and avoid up to 0.5°C of global warming by the end of the century.[4] Parallel efforts to increase the energy efficiency of appliances and thermal insulating foam as HFCs are replaced has the potential to double the above indicated climate benefits of HFC phasedown. The HFC amendment has four control schedules, rather than the traditional two control schedules, for delineated groups of A5 and non-A5 Parties, as outlined in the table 3 below. Russia and four former Soviet States, for reasons of regulatory complexity, and a group of other countries, for reasons of high ambient temperature, are offered slightly more lenient control schedules. As usual, non-A5 Parties are required to act first, and to provide financial assistance to A5 Parties. In addition, the HFC phasedown will catalyse significant energy efficiency gains in air conditioning and refrigeration systems, as was accomplished during the CFC refrigerant phaseout.[5]

Table 3. Timeline for HFC Freeze and Phasedown in Non-A5 and A5 Parties

	Non-A5 Parties Group A*	**Non-A5 Parties Group B****	**A5 Parties Group 1*****	**A5 Parties Group 2******
Baseline Formula	Average HFC consumption levels for 2011-2013 + 25% of HCFC baseline	Average HFC consumption levels for 2011-2013 + 15% of HCFC baseline	Average HFC consumption levels for 2020-2022 + 65% of HCFC baseline	Average HFC consumption levels for 2024-2026 + 65% of HCFC baseline
Freeze			2024	2028
1st Step	2020 – 5%	2019 – 10%	2029 – 10%	2032 –10%
2nd Step	2025 – 35%	2024 – 40%	2035 – 30%	2037 – 20%
3rd Step	2029 – 70%	2029 – 70%	2040 – 50%	2042 – 30%
4th Step	2034 – 80%	2034 – 80%		
Plateau	2036 – 88%	2036 – 85%	2045 – 80%	2045 – 85%

* Non-A5 Group A: Belarus, Kazakhstan, Russian Federation, Tajikistan, and Uzbekistan

** Non-A5 Group B: All non-A5 Parties not part of Group A

*** A5 Group 1: All A5 Parties not part of Group 2

**** A5 Group 2: Bahrain, India, the Islamic Republic of Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia and the United Arab Emirates

The energy efficiency of a RAC depends on more than just the choice of the refrigerant, which can affect performance on the order of 5-10%. The energy efficiency of a RAC depends primarily on the design and quality of the components, which can yield 50% or more improvement in energy performance. Achieving and maintaining that performance will depend on the quality assurance in manufacture, installation and service.

It is less expensive to manufacture and distribute super-efficient RACs in large quantities than in the small quantities sold today, and it costs less to buy a large quantity of RACs in a single purchase than to buy the same equipment one at a time.[5] The consumer purchase price of a RAC depends on the manufacturing cost, the marketing and distribution expense, the cost of installation, and the levels of profit at all stages in the supply chain.

[5] Shah N., et al. (2016) COST-BENEFIT OF IMPROVING THE EFFICIENCY OF ROOM AIR CONDITIONERS (INVERTER AND FIXED SPEED) IN INDIA, Ernest Orlando Lawrence Berkeley National Laboratory, 15 ("However, several studies tracking efficiency and price trends over time have shown that efficiency of appliances and their components improves over time while the prices continue to decline. For example, in Japan, between 1995 and 2008, efficiency improved by 180% while prices dropped by over 50 % in real terms (See Appendix [A] for details). While several factors such as economies of scale and changes in mark-ups have been identified as potential drivers for this overall trend, the primary driver is likely technological learning. Hence the revision of the stringency of the minimum energy performance standard (one star level) may not result in increase in prices in real terms compared to the levels before the revision. For example, a more stringent standard could speed up technological change or increase economies of scale in production of the new minimum efficiency level products, thereby reducing the prices of those products further than this bottom-up engineering analysis reflects.").

During the market transition that will occur as HFCs are phased down, manufacturers may be tempted to "dump" HFC-410A air conditioners at lower prices in markets where regulations on energy efficiency are not in place and/or not enforced, where consumer awareness is lower, and where governments are less able to protect consumer interests.

5. Opportunities to Introduce Affordable and Efficient RACs

Energy efficient HFC phasedown, with the introduction of affordable and efficient air conditioners, can be accomplished by a single strategy or by a combination of strategies. The Montreal Protocol establishes the global control schedule that is strengthened as new technology enters markets, and the MP's Multilateral Fund finances the agreed incremental cost of ODS phaseout and HFC phasedown. If integrated, national regulations and incentives to implement the Montreal Protocol obligations and Paris agreement commitments provide an opportunity to go faster and further. Private companies and partnerships are often key partners by sponsoring research, development, commercialization, and deployment.

In the RAC sector alone, improving the energy efficiency of equipment by 30% while simultaneously transitioning to lower-GWP alternatives could save an amount of electricity equivalent to up to 2,500 medium-sized power plants globally by 2050[6], while providing climate mitigation of nearly 100 Gt CO_2-equivalent (eq) by 2050 from this sector.[7] Further incentives would help to ensure that all of the energy efficiency gains are captured as quickly as possible.

As most of the present power plants are based on fossil fuel, avoiding them would also mean less air pollution, another major challenge for the A5 countries apart from energy losses. Additional health costs arising out of air pollution are a burden on many A5 countries. Hence nations have unique opportunity to reduce costs as well as become more efficient in their energy production.

6. Traditional Regulatory and Supporting Approaches for Energy Efficiency Increase

The Montreal Protocol is considered the most successful multilateral environmental agreement. All United Nations Member States—with the single exception of the new State of Palestine--are Parties, and 99% of production and consumption of manufactured ozone-depleting substances (ODSs) has already been phased out. The Montreal Protocol has always had the side-benefit of protecting climate because most ODSs are powerful greenhouse gases (GHGs); because about 85% of alternatives and substitutes to ODSs are not-in-kind (NIK) technology[8] with small carbon footprint; and because the global warming potential (GWP) of the fluorocarbons that replaced 15% of uses typically have far lower GWP than the ODSs they replaced.[9]

In 2016, Parties to the Montreal Protocol agreed with the Kigali Amendment to phase down HFC greenhouse gases, which were once necessary to rapidly phase out CFCs and HCFCs but are no longer needed in most uses. Developed countries (non-A5 Parties) have the most aggressive phasedown schedules, with developing countries (A5 Parties) allowed to start the phase down later and have more time. Non-A5 Parties contribute voluntarily and according to the UN scale of assessment to the Multilateral Fund, that pays the agreed eligible incremental costs of phasedown by A5 Parties, including in the manufacturing conversion, product safety, and while securing, as a minimum, the product's energy efficiency.

Emissions of HFCs are counted in the nationally determined obligations of climate protection agreed at the Paris climate Conference of Parties (COP21) in December 2015 by 195 countries. The universal, legally binding Paris climate agreement sets out a global action plan to avoid dangerous climate change by limiting global warming to well below 2° Celsius (C) above pre-industrial levels. Additionally, the Paris Agreement aims to strengthen the ability of countries to deal with the impacts of climate change.[6] Other obligations from the Kyoto agreement are also binding.

Together with labelling, Minimum Energy Performance Standards (MEPS) establish a framework for identifying high-efficiency products. This framework includes defining performance metrics and testing protocols.

6.1 Minimum Energy Performance Standards (MEPS)

MEPS are a highly cost-effective policy option to establish an "efficiency floor" for products sold within a country.[10] Models not meeting the minimum efficiency requirements may no longer be imported or sold after the effective date of implementation.

When setting MEPS, policymakers need to consider a full range of potential environmental and financial impacts to ensure that the policy is ambitious enough to achieve maximum energy savings and remain cost-effective. Performance levels and overall program requirements need stakeholders' input to gain their support and participation. A transparent stakeholder consultation process should include the government, private sector and civil society, with representatives from: government standards and test agencies, customs, standardization institutes, certification and accreditation bodies, test laboratories, manufacturers, suppliers and distributors of air conditioners and refrigerators, technology research institutes, and environmental and consumer organizations.

MEPS programs should be monitored, evaluated, updated, and revised regularly. Governments should establish a system to regularly monitor the market when MEPS are implemented in order to identify when policy revisions are required. A schedule indicating upcoming revisions to efficiency levels can be a useful tool to give ample notice to manufacturers and importers of expected increases in MEPS. A functioning system of monitoring, control, and testing facilities capable of ensuring product compliance are also important factors to program success.

For RACs, MEPS can be designed to be technology specific or technology neutral. A technology neutral approach has some advantages: a combined MEPS for non-inverter split air conditioners and inverter split air conditioners rewards designs that achieve higher efficiency levels independent of the technology used. MEPS can also vary depending on the air conditioner cooling capacity. From an engineering perspective, lower capacities can achieve higher efficiencies compared to the higher capacity units, thus more stringent requirements for smaller units would yield higher energy savings.

[6] Further information on key aspects of the Paris Agreement can be found at: http://bigpicture.unfccc.int/#content-the-paris-agreemen

A recommended approach is to align efficiency policies with programs that promote lower-GWP equipment and other policies that restrict usage of high-GWP gases in air conditioners.

A "MEPS" is usually made mandatory by a government energy efficiency body. It may include requirements not directly related to energy; this is to ensure that general performance and user satisfaction are not adversely affected by increasing energy efficiency.

Less efficient appliances may be less costly up front and may be apparently 'affordable' for the lower income group in the A5 country. But considering the higher electricity bill costs associate with energy inefficiency and the health impacts due to air pollution, such appliances are very costly to the lower income group section.

6.2 Labelling

Appliance product labelling makes it possible to compare the expected electricity consumption in order for consumers to make an informed purchase. The labels show the annual kWh of electricity use in specified locations and the cost of that annual electricity use. Labels also make it possible to differentiate more energy efficient products with an endorsement label, or a higher score on a categorical label. These distinctions can also be used to inform specifications for procurement or incentive programs.

Table 4. Energy Efficiency Labelling Definitions

Energy Efficiency Ratio (EER)	EER is the ratio of the cooling capacity to the power consumed when measured at full load (i.e. measures efficiency at a single point—the maximum cooling capacity or the design point). EER is measured in W/W or Btu/W.	ISO 5151[11]
Seasonal Energy Efficiency Ratio (SEER) or Cooling Seasonal Performance Factor (CSPF) or Heating Seasonal Performance Factor (HSPF) (for heating mode)	SEER is similar to EER, but takes into account part-load performance enabled by variable speed compressors, also known as inverters, that allow the cooling capacity to vary as a function of cooling load. SEERs are designed to be representative of local climates, building types, and user behaviour, and thus variations in the calculation of the metric used in the various countries and regions exist. An alternative name to SEER is the cooling seasonal performance factor (CSPF). Heating seasonal performance factor (HSPF) is used for heating mode.[12] SEER is measured in W/W or Btu/W.	ISO 16358-1[13]
Annual Performance Factor (APF)	APF is a metric used for reversible heat-pump room air conditioners that are used for both heating and cooling.	JIS C - 9612 JIS B 8616: 2006

6.3 Financial and Fiscal Incentives

Governments can design these incentives based on the national and societal benefits due to greater efficiency, reduced costs from lower imports of fossil fuels, reduced health costs due to prevention of air pollution, cost savings at the consumer level due to energy efficiency, and improved profits for the manufacturing industry due to enhanced manufacturing of affordable RACs.

The Kigali Amendment mandates the phasedown of high GWP HFCs. This historic decision of the parties to the Montreal Protocol transformed the Montreal Protocol into a combination ozone and climate protection treaty. Parties are now considering the replacement of ozone-safe high-GWP HFCs with new refrigerants that have lower GWP and are more energy efficient.

This phasedown of HFC refrigerants with funding for agreed incremental costs of A5 Parties can also lead the Parties into the path of materializing potential gains of reducing GHGs emissions through energy efficiency, which also opens the door to the climate finance landscape.

Several reports have documented that the phaseout of ODSs, using the Montreal Protocol approach, resulted in parallel energy efficiency improvements due to new regulations, new designs, new components, new factories, retooling of production lines, and new equipment. Those energy efficiency gains resulted in emissions reductions that were funded by the MLF and were not accounted for by the climate treaties.

One of the main barriers in the adoption of energy efficiency is the higher manufacturing cost and purchase price of equipment. Buyers clubs can play an important role in addressing this seemingly insurmountable barrier. As described in the Montreal Protocol Technology and Economic Assessment Panel (TEAP) Energy Efficiency Report, the basic types of financial incentives include rebates/credits, taxes (both increases and decreases), and loans.

1. Rebates/credits on equipment are intended to mitigate the higher initial price of new and more efficient appliances. This can be in the form of a direct subsidy at purchase, a refund after purchase, or some form of long-term credit (e.g. until the lower electricity bill has offset the higher price, typically after 2-3 years). These financial incentives can be part of a successful policy to drive the replacement of older, less efficient systems with new energy efficiency systems organized by Energy Service Companies (ESCOs).

2. Tax penalties can increase the purchase price of less energy efficient designs, closing the gap with the higher cost, higher efficiency systems. Taxes can be applied to individual consumers at the time of purchase, to manufacturers and to importers.

3. Tax incentives can be given to equipment designers, where lower tax rates or tax refunds can be offered for research and development (R&D) to develop energy efficiency designs.

4. Loans make the purchase affordable over time. Loan programmes can extend the repayment period, include a reduced interest rate, or provide guarantees of re-payment.

The above basic types of incentives can play an important complementary role in the operation of a buyers club.

The following sections describe in detail the concept and operation of a buyers club, including examples of buyers clubs organized to conduct bulk procurement to leverage purchasing power and reduce the initial cost of energy efficient air conditioners.

6.4 Market based mechanisms

6.4.1 Bulk Public and Private Procurement

An important lesson from CFL bulk procurements –

> "*The experience in Vietnam demonstrates that bulk purchase programs, while attractive in theory, have several limitations. In particular, while bulk procurement can help the utility get a very good price, it actually works against development and strengthening of CFL market channels, since it involves only a single manufacturer, and thus makes it hard for others to compete in the marke*t."[14]

7. The Buyers Club for Affordable Super-Efficient RACs using Lower-GWP Refrigerants

This handbook presents the best available guidance on how to easily start a buyers club for the air conditioning sector, learn by doing, and continuously strengthen each subsequent tender to achieve superior affordability, energy efficiency, and climate performance.

7.1 What is a Buyers Club?

A "buyers club" is any organization or team working to enhance the benefits to the buyer through, *inter alia*, lowering the price and increasing the quality of a standardized product by buying in bulk and managing distribution and installation. A buyers club aggregates demand to achieve large enough scale for prices to be affordable. Demand aggregation is a well-established concept that has been used by many countries for various consumer products for various reasons in the past.

The buyers club could be a government agency or a private organization. Government agencies refer to their buyers clubs as a "government procurement[15]." The non-government buyers club pools the collective power of private companies and citizens for bulk purchases or for lower prices for members through normal supply chains.

The buyers club can make the purchase, take delivery, and distribute the product to subscribers, or it can avoid the necessity of purchase financing by negotiating a price for members who pay when they place the order from dealers who deliver and install according to a standard contract.

7.2 How to Start a Buyers Club

Any organization seeking to lower the price and increase the quality of a standardized product can work to pool the collective purchasing power of its members by buying in bulk and streamlining distribution and installation.

The non-government buyers club pools the collective power of private companies and citizens for bulk purchases or for lower prices through normal supply chains.[16]

Familiar examples of buyers clubs are 1) membership organizations that negotiate discounts on rental cars and hotels for their members, 2) universities that negotiate discounts on computers for their students, 3) health authorities that negotiate discounts on drugs for their patients, and 4) military organizations that coordinate weapons purchases in order to each get a more favourable price.

The challenge in seeking affordable prices for super-efficient RACs with lower-GWP refrigerants is to identify and organize a large number of buyers who together can get a lower price than if they act alone. Governments accomplish this through a procurement process that typically seeks bids for a large minimum purchase, while allowing additional purchase at agreed prices.

7.3 Planning Process

The following steps can be used as part of the planning process:

a) Consult with buyers club experts on country experiences.
b) Plan to have one or more meetings with the likely suppliers of the super-efficient RACs to explain why super efficiency and lower-GWP is required, how energy efficiency and refrigerant GWP will be integrated in carbon footprint metrics, and other explanations that may seem appropriate.
c) A meeting with stakeholders is desirable to identify barriers, mindful of potential domestic content, local suppliers' issues, and the local labour situation
d) Assemble a business plan with details on the size of the market, the age of the existing equipment in the buildings owned by the organization(s) that will be in the buyers club, an estimate of energy use and carbon emissions, the key stakeholders to involve, and the criteria for the first tender. For instance, a banking association might be the buyers club convenor for all local or regional banks.
e) Consult the energy efficiency bureau in the government.
f) With the help of OzonAction networks, identify and consult other buyers' clubs and their experiences.
g) Monitor the existing energy use in locations selected as good candidates for old equipment replacement with new super-efficient RACs using lower-GWP refrigerants, for instance, at one or more ATM rooms.
h) Compare the energy use with the super-efficient equipment that will be sought in the purchase for replacement
i) Calculate financial savings and qualitatively describe local air quality improvement and climate protection in as much detail as possible. All that is needed is before and after equipment replacement for comparison.
j) With the results of comparison showing that savings in most cases will be overwhelming and persuasive, sign up the first tranche of candidates, for instance, the first group of selected banks.

k) Prepare carefully the specifications for procurement, put out the tender, choose the most favourable offer, and proceed with installation.

7.4 Key Provisions of a Basic Buyers Club Tender

The tender will have to be tailored to satisfy local circumstances, including a significant number of details such as electricity voltage and cycles; wire size and circuit protection; refrigerant tubing size, materials and joints; terms of warranty; delivery and installation schedule; and more. [7]

Examples of items to include are:

Quantity requested
Minimum efficiency
Global Warming Potential (GWP)
Minimum warranty
Delivery date

7.5 General Considerations for Specifications of First Tender

For example, Table 5 presents the specifications for a basic tender for application of buyers club to private banks' ATM rooms, with suggested values for some of the specifications.

Table 5. Suggested Basic Specifications of First ATM Room Tender

Quantity requested:	TBD based on the number agreed by banks
Included	RAC system and hardware necessary for basic installation (e.g. up to 5 meters separation of inside and outside units), basic installation by trained technicians
Available at specified additional cost	Additional time and materials if an installation is not basic (e.g. a specified additional cost at X$/linear foot (if needed))
Cooling capacity	As determined by local climate, frequency of entry and exit, and ATM room size and construction (solar orientation, windows, and insulation)
Minimum efficiency	TBD after consultations with likely local and global sources
Maximum Global Warming Potential (GWP)	<700
Allowed refrigerants	Available: HC-290 (GWP=3), HFC-32 (GWP=675) Soon to be available: R-452B (GWP=676)

[7] Over time, and with data from countries' experience, these details will be incorporated and updated in the handbook.

Safety	Maximum charge and safety according to relevant safety standards specified in the tender (ISO, UL, ASHRAE, etc.)
Minimum warranty	3 years all inclusive, non-transferable
Minimum Bids	Two are recommended. If superior technology is only available from one source, it may be possible to negotiate a bulk purchase at a favourable price even without competition.

8. Examples of Buyers Club

8.1 Starting Simple: Private Bank ATM Room Buyers Club

Banks worldwide have attached small ATM rooms that are typically accessible only by banking customers who insert a bankcard in a code reader. Once safely in the bank ATM room, the customer can withdraw cash, make deposits, pay bills, and do other banking business. In hot climates, these enclosed spaces can overheat on sunny days, so air conditioners are already installed. Most ATM ACs were inefficient when they were installed more than a decade ago, and have deteriorated in performance with age. New air conditioners use half the energy, with cost savings to the banks, air quality benefits to the community through avoided power plants and fossil fuel use, and protection for the climate, with less harmful refrigerants and fewer carbon dioxide emissions from electricity generation.

The banks that own the ATM rooms can finance their own RAC replacement, but motivation and trusted technical advice is lacking. In addition, banks may not appreciate how large the energy savings will be to the bank itself, and the importance of the introduction of next-generation RACs to the communities that local banks serve and the global environment. Banks do appreciate that any money they save on energy can be reinvested in the community and that energy savings of their customers improves the prosperity of the community and the level of banking activity.

Consider also that ATM RAC replacement is the easiest installation imaginable when the electricity, wall penetration for refrigerant pipes, and brackets are already in place. Furthermore, appreciate that, in many countries, a small number of service companies manage ATM cleaning, security and maintenance of AC appliances. This overall simplicity also provides the advantage of advance knowledge of the cost of replacing old equipment with new models and simplicity in collecting old equipment to properly recover the refrigerant and recycle the materials.

The idea of starting simple by selecting, for instance, private banks, has the advantage that the start-up plan of a buyers club can be privately organized without the potential complications of government-related processes, which may be long. In addition, the tender can be crafted to allow public banks to participate too, but only once the performance and price is determined by the initial bidding. In fact, the tender might be crafted to allow bank customers or other institutions to participate in the purchase at the same or similar favourable prices.

Imagine also that the banks themselves will be the preferable partner in later stages of the buyers club when they can validate the savings, persuade the government to become part of the solution, and possibly offer financing.

ATMs are also effective places to raise awareness of the EE RAC and even the buyers' club by putting on walls crisp and innovative advertisements.

9. Lessons of Learning-by-Doing

One category of the lessons of learning-by-doing will be to determine which of the added costs are justified by the additional benefits.

- The substantial performance bond and withholding of 10% of the purchase price during the warranty period has interest costs to the manufacturer that are passed onto the customer;

- The requirement of immediate delivery increases the cost of manufacturing if new designs must be implemented, if factories must work overtime, or if parts and components must be fabricated overseas and shipped with express delivery;

- The requirement to install the RACs at any location in India required manufacturers to consider worst-case scenarios of remoteness and number likely to be installed in each one location at any one time; and

- The warranty is an added cost that may have been priced above cost by companies inexperienced in the high reliability of the inverter AC technology necessary to satisfy the 5.2 ISEER;

Another category of lessons learned is that it will be economically superior to specify a minimum carbon footprint and allow manufacturers to choose the combination of refrigerant GWP and energy efficiency that satisfies the minimum carbon footprint rather than to specify just the SEER energy efficiency. In the first tender, EESL did not reward the lower GWP of HC-290 and HFC-32 relative to HCF-410A and did not reward higher 5.4 ISEER offered by Daikin relative to Panasonic and Godrej.

Consider also that it is more expensive to install RACs with flammable HC-290 and HFC-32 refrigerants than RACs with non-flammable HFC-410A refrigerant because greater care must be taken with flammable refrigerants. In addition, in the case of highly flammable HC-290, the separation of the inside and outside equipment cannot be greater than about five meters or the refrigerant charge will exceed the amount considered safe. The extra cost of making RACs with flammable refrigerants more leak-tight is offset for the manufacturer by fewer warranty repairs and for the customer by greater reliability and lower frequency of repair after the warranty has expired.

Furthermore, flammable HC-290 and HFC-32 are safely used by limiting refrigerant charge size to levels that would be safe if leaked into a room, and by enclosing electrical components of the AC so as to never create open sparks. After all, flammable gases are used safely throughout society, including in residential applications such as cooking, heating and aerosol products.

Because smaller rooms require smaller RACs – like in many housing societies in India – and hence lower charge RACs are possible there.

Affordable RACs rapidly pay back the added cost of efficiency through savings in electricity purchase. They also have co-benefits in cleaner air and life-cycle ownership savings that can be spent locally in support of jobs and prosperity rather than for power plants and fuel that are often imported. Affordable prices of super-efficient RACs economically justify very strong minimum energy efficiency standards.

The economics presented above as food-for-thought are intended to portray the complexity of technology choices, and also to reassure readers that EESL and its supporters appreciate the challenges and will continuously improve the strategy in subsequent tenders.

This pioneering demonstration of the power of procurement is taking a learning-by-doing approach, where the answers are not all known in advance and where the outcomes depend on the good faith efforts of companies to respond to market forces and environmental imperatives.

The EESL kick-start procurement test-drives procurement guidelines, builds the trust and confidence of RAC manufacturers that the program incentivizes the manufacturing scale necessary for affordable prices, and sorts out issues of inventory, installation, and warranty.

This tender shows a stepwise approach to enhancing efficiency, taking into consideration India's current market situation, while at the same time looking forward to changing the market to absorb higher efficiency products.

9.1 Case Study of the EESL 2017 Bulk Procurement

EESL is a joint venture company of the Government of India's Ministry of Power and Public Service Undertakings (PSUs), which is famous for leapfrogging less-efficient compact fluorescent light bulbs (CFLs) to more-efficient light-emitting diode (LED) bulbs by bulk purchase, which stimulated price competition and increased economy-of-scale in domestic manufacturing, with millions of dollars of savings and significant climate and clean air benefits.

EESL repeated its LED success story with a February 2017 tender for:

> "Design, manufacture, supply, installation, and provision for after-sales warranty and customer support for 5.28 kW (1.5 TR) RACs with ISEER[17] of 5.2 (or higher) including three-year comprehensive warranty." [18]

The EESL leadership had the support of three environmental non-governmental organizations (ENGOs) -- TERI, IGSD and TERRE, and with the advice of a fourth -- the Natural Resources Defense Council in setting the stage, aligning policy, and communicating the outcome to Parties to the Montreal Protocol concerned about the affordability of alternatives to high-GWP HFCs.[19]

Panasonic and Godrej & Boyce (Godrej) submitted low and affordable final bids of Indian Rupee (INR) 44320 (US$687.16; €614.023) per unit inclusive of design, manufacture, supply, installation, 3-year comprehensive warranty, and specified customer support. The tender was for a total of 100,000 super-efficient RACs that achieve an Indian Seasonal Energy Efficiency Ratio (ISEER) of 5.2. The approximate value of the tender was about INR 443 Crores million (~US$68 million; ~€61 million).[20]

Panasonic will supply 60,000 units ISEER 5.2 RACs using hydrofluorocarbon (HFC)-410A[21]refrigerant, and Godrej will supply 40,000 units ISEER 5.2 using hydrocarbon (HC)-290 refrigerant. The ISEER 5.2 RACs qualify for India's highest 5-Star energy efficiency rating and use up to one third less energy than the average RAC sold in India (3-Star).[22]

EESL plans to purchase up to 400,000 more RACs in the near future under government tender, with anticipated lower prices, lower GWP, and higher energy efficiency over time.

The 2017 ISEER bulk procurement is a transformational market strategy that has widespread benefits within India, for its export markets, and worldwide. Low and affordable prices of super-efficient RACs will pull the entire Indian market toward better efficiency and justify higher minimum energy efficiency standards, implemented faster than previous schedules.

Policy makers worldwide are impressed with the price reduction and will set their sights on local procurement at comparable or lower prices and comparable or higher energy efficiency. The most efficient manufacturers will compete in all markets to profit from large sales under certain conditions and to satisfy their own corporate pledges to do their part to protect the climate.

The India government EESL strategy can be immediately adapted to markets worldwide. Adoption of the strategy has already started in Bangladesh and Nepal, with the price in India indicative of the highest price anyone should pay for RACs with comparable efficiency and warranty. Lower prices in India and its export markets (already in Bangladesh and Nepal, and probably next in Sri Lanka) will likely be driven by subsequent bulk procurements, making the super-efficient RACs available to ever-growing markets and achieving global economy of scale in manufacture.

9.2 Questions and Answers from EESL Learning by Doing

Is it necessary to prohibit HFC-410A and/or HCFC-22 systems?

Answer: Yes, regrettably, because otherwise companies might dump obsolete high-GWP technology with unnecessarily large carbon footprints

Elaboration: HC-290 and HFC-32 systems can be manufactured over a broad range of cooling capacity at the same cost as HCFC-22 and HFC-410A systems.

Is it necessary for bid prices to be as low as economically possible?

Answer: No, over time prices will be expected to be lower as economy of scale in manufacturing is achieved.

Elaboration: Be cautious to not burden the purchase with discretionary requirements such as: immediate delivery, installation anywhere, bid deposit, warranty bonding, and extended warranty, all of which may or may not have been worth the added cost.[23]

How can the bid selection criteria incentivize higher energy efficiency or lower GWP?

Answer: LCCP analysis using local climate and electricity carbon intensity is the metric to achieve the lowest carbon footprint.

Elaboration: IGSD and a team of global experts are developing this metric. Soon that metric will be available and buyers clubs will be able to determine the value of higher efficiency and/or lower-GWP.

Appendices

Appendix A.

The Economics of Super-Efficient RACs with lower-GWP refrigerants

For specified climate conditions and cooling set points, each refrigerant has energy efficiency that can be ranked relative to other refrigerants, presuming that the refrigerant charge necessary to achieve the necessary cooling capacity is safe to use if the refrigerant is flammable and/or toxic. The actual energy efficiency of the product in operation depends on the design, controls, performance of the equipment components, installation and service. The discussion below focuses on refrigerant choice. Components and designs that improve equipment energy efficiency, such as inverters and electronic expansion valves, can be optimized for any refrigerant, with some additional cost considerations described below.

The safe use of flammable refrigerants is currently achieved by limiting the refrigerant charge to the amount that could safely be leaked into a room and not exceed the lower flammability limit (LFL), defined as the mixture with air required for combustion. Higher cooling capacity requires larger refrigerant charge or more investment in heat exchangers and other components. For example, HC-290 systems can achieve high energy efficiency at relatively low cost for up to about 1-ton capacity, but the price of manufacture increases significantly for 1.5-ton or larger RACs, which use advanced technology such as micro-tube heat exchangers and expensive metals. Because HFC-32 is about 5 to 7 times less flammable than HC-290, the safe maximum refrigerant charge for HFC-32 allows high efficiency for RACs up to 3.5 tons or larger at generally lower cost of manufacture.

Another devil-in-the-detail is that each refrigerant has unique energy efficiency at each ambient temperature, which means that the refrigerant must be selected to provide the highest seasonal efficiency (kWh/year) for particular climate circumstances. In climates with short, cool and dry air conditioning seasons, any of the commercial refrigerants can achieve high energy efficiency with proper design and components. However, in climates with long air conditioning seasons, with high ambient temperatures and humidity, the refrigerant choice becomes more important, and it is cost effective to spend more money on energy efficiency because more electricity will be saved each season.

HFC-410A is the least efficient and worst choice in all climates and particularly expensive to own and operate in hot and humid climates. Beware of environmental dumping of HFC-410A systems that are obsolete, that will be unsupported in parts and service by manufacturers, and that may be expensive to maintain as the HFC-410A refrigerant becomes scarce from the HFC phasedown.

For RACs, HC-290 and HFC-32 have the highest cooling capacity and coefficient of performance (COP -- ratio of cooling provided to the energy consumed; the higher the COP, the more efficient the system), followed by HFC-410A, which is the least energy efficient at the full range of ambient temperatures[24].

> The refrigerant charge for a 1-ton RAC is small enough that either HC-290 or HFC-32 refrigerant options can be used without energy efficiency compromise.

> The refrigerant charge for an energy-efficient 1.5-ton RAC is too large to be safe with highly flammable HC-290 (propane) unless more expensive components like micro-channel heat exchangers are used. Less flammable HFC-32 achieves the same energy efficiency without microchannel heat exchangers and other expensive components.

In most markets, HFC-32 and HC-290 are the least cost refrigerants for RACs, and HFC-410A is the most expensive refrigerant.[25] For example, the current indicative costs of bulk refrigerants in India are:

HC-290: $3-$4/kg
HFC-32: $2-$3/kg
HFC-125: $4-$5/kg

R-410A (50%/50% blend of HFC-32 /HFC-125) has refrigerant ingredient costs of $3.00 to $4.00 plus blending costs. HFC-290 (propane) is expensive when produced in small quantities as a refrigerant because it is difficult to separate out various unwanted hydrocarbons that have similar boiling points. Purity of the refrigerant is important to avoid corrosion, to facilitate lubricant compatibility, to ensure low toxicity of inhaled refrigerant, and to minimize the toxicity of atmospheric by-products of refrigerant decomposition.

With a typical refrigerant charge of <400 grams, the cost of the refrigerant is an insignificant portion of the room air conditioner’s cost. The bottom line is that the cost to manufacture a 5.2 ISEER RAC in India is lowest using high-efficiency, low cost HC-290 and HFC-32 and highest using inefficient and more expensive HFC-410A.

However, manufacturers may choose to dump obsolete HFC-410A RACs in developing countries at lower prices than next-generation HC-290 and HFC-32 RACs. A5 Parties that allow the dumping of HFC-410A equipment in their markets will waste money on service infrastructure, and owners of the obsolete equipment may experience higher service costs once surplus repair parts are used up and the very high GWP HFC-125 (GWP= 3175) ingredient (50% of R410A) is in short supply because chemical manufacturers cannot recover the cost of new investment.

Fortunately, new metrics are being developed that take the guesswork out of technology selection and provide an accurate estimate of carbon footprint for specific locations, taking into account local climate, the local carbon intensity of electricity, and distribution losses in electricity transmission and distribution. With the new metric, the lifecycle price and performance of available choices will be simple to compare.

Learned by Doing Procurement Lessons from India’s EESL Experience

Table 6 (below) lists the basic specifications of the first tender and Table 7 elaborates the details. Table 8 explains the delivery schedule.

A preliminary review of the tender from the perspective of bidding companies finds that some of the provisions may have increased the bid price without compensating environmental or ownership benefits. Consider this framework and comments:

1. A more simple bidding process may encourage more companies to participate.
2. In some cases, the provisions splitting the purchase with companies who match the winning price after bidding higher in the tender may prevent the winning company with the lowest bid price from achieving the economy-of-scale necessary to recover the cost of providing the RACs. Alternatively, uncertainty over whether a company with the lowest bid will be awarded the full procurement may perversely cause each company to bid higher in order guard against not achieving full economy of scale.
3. Flexible delivery after selection of the winning bid may allow more competition in bidding and may allow manufactures to improve the energy efficiency of the products offered.
4. Specified location of the installations may allow lower bids that account for f delivery from the point of manufacture or distribution.
5. Certainty over the specifications of future tenders may encourage wide and competitive participation. For example, if tenders progressively increase the minimum ISEER, companies will need time to achieve economy of scale.
6. The requirement of a large deposit increases the bid price to recover the cost of borrowing or the alternative yield on investment.
7. Withholding 10% of the winning bid (contract value) until the warranty expires also increases the bid price.
8. Requiring a premium 3-year comprehensive warranty (compared to standard warranties of as little as one year) substantially increases the bid price and may discourage purchase by customers not wanting or appreciating the value of the warranty. Furthermore, an original equipment manufacturer (OEM) warranty is more expensive than an aftermarket warranty, and both may cost far more than the expected cost of repair. A premium warranty tailored to permanent installation in government buildings will be more economic than temporary installations in locations such as rental properties, where the warranty expires when the equipment is re-installed in a second or subsequent location.

EESL March 2017 First Tender Elaboration

Table 6. EESL First Tender Basic Specifications

Quantity requested	100,000
Minimum efficiency:	5.2 ISEER (India Seasonally Adjusted Energy Efficiency)
Global Warming Potential (GWP):	No maximum specified
Minimum warranty:	3 years all inclusive, non-transferable
Prompt delivery:	Within ~30 to 150 days of awarding (see detailed schedule below)
Bonded performance:	INR 20,800,000 (~US$320,000)
Bonded warranty:	10% of purchase price withheld until warranty expiration

Table 7. Elaborated Specifications EESL First Tender

Bidding Document Cost	INR 25,000 (~US$400) (*non-refundable & non-*

	adjustable).
Earnest Money Refundable Deposit (EMD)/ Bid Security	INR 20,800,000 (~US$320,000)
Security Deposit/ Contract Performance Guarantee/Security	10% of the contract value, to be held up to three months beyond the warranty-expiry date.
Online Bid Submission Period	From 23-02-2017 to 16-03-2017 (up to 1430 hours IST).
Techno-commercial E-bid Opening Date & Time	16-03-2017, at 1500 hrs. IST
Bid Validity Duration	180 days from the date of opening of techno-commercial bid.
Accountability and Responsibility of EESL for Non-Performance	"EESL reserves the right to cancel / withdraw the IFB without assigning any reason whatsoever and in such a case, no bidder / intending bidder shall have any claim arising out of such action."
Bidders "single responsibility" basis such that the total bid price covers all the contractor's obligations	"…including procurement and subcontracting (if any), delivery, construction, installation, survey cost, monitoring and verification cost and completion of the facilities including supply of mandatory spares or spares to be supplied during warranty (if any). This includes…testing, pre-commissioning and commissioning of the facilities and…the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services…all in accordance with the requirements of the General Conditions of Contract and Technical Specification."
Delivery cost	"Price basis of the price quoted shall be on F.O.R (Free on Road) destination basis for site." "…in general, prices shall be inclusive of sales tax, transportation, insurance, levies, service tax and any other duties payable including entry tax/octroy etc., (wherever applicable) on FOR destination/site basis.

Table 8. EESL First Tender: Delivery and Installation Schedule and Timelines

S. No.	**Duration**	**Cumulative Quantity**	**Delivery Location(s)**
1	Within 30 days from date of LOA (letter of award).	20 %	Locations spread across India - shall be intimated later.
2	Within 60 days from date of LOA.	40 %	

3	Within 90 days from date of LOA.	60 %	
4	Within 120 days from date of LOA.	80 %	
5	Within 150 days from date of LOA.	100 %	

Appendix B

SEER and Price of RACs in Selected Countries

Appendix C

Typical Cost of RAC Manufacture and Marketing

Selected Acronyms and Abbreviations

A2L	ASHRAE rating for substances with low flammability and low toxicity
A5 Parties	developing countries qualifying for MLF financing
AC	air conditioner, air conditioning
AC Challenge	Advanced Cooling Challenge (of the Clean Energy Ministerial-CEM)
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
AR5	Assessment Report 5 of the IPCC
CCAC	Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants
CEM	Clean Energy Ministerial – a global forum to promote policies and share best practices to accelerate the transition to clean energy (http://www.cleanenergyministerial.org)
CFC	chlorofluorocarbon
CFL	compact fluorescent light
CO_2	carbon dioxide
CO2-eq	carbon dioxide equivalent
COP	coefficient of performance
EESL	Energy Efficiency Services Limited
EC	European Commission
EMD	earnest money deposit
ENGO	environmental non-governmental organization
ESCO	energy service companies
FOR	Free-on-Road
GHG	greenhouse gas
GWP	global warming potential
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HFO	hydrofluoroolefin
HPMP	HCFC Phaseout Management Plan
HVAC	heating, ventilating and air conditioning
IGSD	Institute for Governance & Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
ISEER	India Seasonal Energy Efficiency Ratio
IST	India standard time
K-CEP	Kigali Cooling Efficiency Programme
kW	kilowatt
kWhrs	kilowatt hours
LCCP	life-cycle climate performance
LED	light-emitting diode
LFL	lower flammability limit
LOA	lowest offer accepted
MEA	multilateral environmental agreement
MLF	Multilateral Fund of the Montreal Protocol
MoEF	Ministry of Environment and Forests (India)
MoEFCC	Ministry of Environment, Forest, and Climate Change (India; formerly the MoEF)
MOP	Meeting of the Parties (to the Montreal Protocol)
NGO	non-governmental organization

Non-A5	Parties not qualified for MLF financing
NRDC	Natural Resources Defense Council
ODP	ozone-depletion potential
ODS	ozone-depleting substance
OEM	original equipment manufacturer
PSE	public sector enterprise
PSU	public service undertakings
RAC	room air conditioner
SERAC	super-efficient room air conditioner
SLCP	short-lived climate pollutant
SNAP	Significant New Alternative Policy Program (US EPA)
TEAP	Technology and Economic Assessment Panel (of the Montreal Protocol)
TERI	The Energy and Resources Institute
TERRE	Technology, Education, Research and Rehabilitation for the Environment Policy Centre (India)
TR	refrigeration ton (heat to melt 1 ton - 2000 lbs. - of ice in 24 hours
UJALA	Unnat Jyoti by Affordable Lighting for All
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WSDS	World Sustainable Development Summit (TERI)

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[1] Abhyankar et al. (2017) *Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies* ("We find that consumers benefit from accelerated AC efficiency even with aggressive ratcheting of MEPS in 2018 and under the most conservative assumptions about price changes. The incremental price of an efficient AC (ISEER 3.9) is estimated at Rs 900 (maximum value) over the conventional AC (ISEER 3.5), and the electricity bill savings would be about Rs 1,400 per year; in other words, consumers can recover the incremental price in less than one year.")

[2] The Montreal Protocol on Substances that Deplete the Stratospheric Ozone Layer was agreed on 16 September 1987 by 24 nations and the European Commission and was eventually signed by every United Nations state. Today, 99% of ODS are phased out worldwide.

[3] Velders Guus JM, AR Ravishankara, Melanie K. Miller, Mario J. Molina, Joseph Alcamo, John S. Daniel, David W. Fahey, Stephen A. Montzka, and Stefan Reimann. (2012) Preserving Montreal Protocol Climate Benefits by Limiting HFCs, SCI. 335(6071): 922-923. The high growth rates have been confirmed by atmospheric measurements. See: Stephen A. Montzka, Mack McFarland, Stephen O. Andersen, Benjamin R. Miller, David W. Fahey, Bradley D. Hall, Lei Hu, Siso Carolina, & James W. Elkins (2014) Recent Trends in Global Emissions of Hydrochlorofluorocarbons and Hydrofluorocarbons—Reflecting on the 2007 Adjustment to the Montreal Protocol, J. Phys. Chem.

[4] United States Environmental Protection Agency (US EPA). 2017. Recent International Developments under the Montreal Protocol: Amendment to Address HFCs under the Montreal Protocol. https://www.epa.gov/ozone-layer-protection/recent-international-developments-under-montreal-protocol. See also: Guus JM Velders, Susan Solomon, and John S. Daniel3 (2014) Growth of climate change commitments from HFC banks and emissions, Atmos. Chem. Phys. Discuss. 14:4563, 4568 ("If, for example, HFC production were to be phased out in 2020 instead of 2050, not only could about 91–146 GtCO2-eq of cumulative emission be avoided from 2020 to 2050, but an additional bank of about 39–64 GtCO2-eq could also be avoided in 2050.") The totals range from 130 to 210 GtCO2-eq. by 2050. See also: Xu Y., Durwood Zaelke, Guus J.M. Velders, and Veerabhadran Ramanathan. (2013) The role of HFCs in mitigating 21st century climate change, ATMOS. CHEM. PHYS., 13:6083-6089.

[5] Speech, Shende Rajendra 2009 US EPA's Stratospheric Ozone Protection and Climate Protection Awards (21 April 2009) ("Humanity has already benefited by about 60% improvement in energy efficiency in domestic refrigerators since the industry started looking at their design in order to change from CFC-12."); and U.S. EPA (2002) Building Owners Save Money, Save the Earth: Replace your CFC Air-Conditioning Chiller, 6-7 ("The most energy-efficient new chillers will reduce electric generation

and associated greenhouse gas emissions by up to 50% or more compared to the CFC chillers they replace.").

[6] Shah Nihar, Max Wei, Virginie Letschert & Amol Phadke. 2015. Benefits of Leapfrogging to Super efficiency and Low Global Warming Potential Refrigerants in Air Conditioning, Ernest Orlando Lawrence Berkeley National Laboratory, ES-10. ("[Results for the policies enacted in parallel are lower than simple addition of the results for the policies in isolation simply because the results are multiplicative and not additive (i.e. the results from efficiency improvement are multiplied to the results from refrigerant transition). For example, an efficiency improvement of 30% along with a 5% improvement in efficiency from refrigerant transition will result in a 33.5% reduction in energy consumption...").

[7] Papasavva, Stella, and Stephen O. Andersen. 2011. GREEN-MAC-LCCP©: Life-Cycle Climate Performance Metric for Mobile Air Conditioning Technology Choice. Environ. Prog. Sustain. Energy 30(2): 234–47. doi:10.1002/ep.10465; Papasavva, Stella, William R. Hill, and Stephen O. Andersen. 2010. GREEN-MAC-LCCP©: A tool for assessing the life cycle climate performance of MAC systems. Environ. Sci. Technol. 44(19): 7666–72. doi:10.1021/es100849g.

[8] In-kind replacement technology is fluorocarbons, while not-in-kind (NIK) replacement technology is from other chemical groups or non-chemical technology. See: Seidel, Steve, Jason Ye, and Stephen O. Andersen and Alex Hillbrand. 2016. Not-in-Kind Alternatives to High Global Warming HFCs Center for Climate and Energy Solutions (CCES), Washington DC. https://www.c2es.org/site/assets/uploads/2016/10/not-in-kind-alternatives-high-global-warming-hfcs.pdf

[9] For example, about half of motor vehicle CFC air conditioning emissions were eliminated by NIK better containment, lower leak rates, and recovery and recycle at service; while the replacement of CFC-12 (GWP=10,200) by HFC-134a (GWP=1300) reduced the lowered emission impact by a factor of eight.

[10] Information on existing standards and labels is available via the CLASP online database and Energy Efficient Strategies and Maia Consulting (2014) Energy Standards and Labeling Programs Throughout the World in 2013, commissioned by the Government of Australia.

[11] The International Organization for Standardization (ISO) standard, ISO 5151, has been adopted by most countries as a reference test standard for measuring air conditioners' cooling capacity and efficiency. Not all economies are aligned with ISO 5151, and some differences remain between test methods. For instance, North American countries (Canada, Mexico, and the United States) follow standards set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). The ISO 5151 testing standard specifies how to measure the cooling capacity and efficiency of air conditioners using stipulated test conditions. Condition T1, which specifies indoor (27°C) and outdoor temperatures (35°C) at moderate climates, is used by most countries. Some countries with hotter climates, such as Egypt, require additional testing at the T3 condition, which specifies higher indoor (29°C) and outdoor (46°C) temperatures.

[12] Park W. Y., Shah N., & Gerke B. (2017) Assessment Of Commercially Available Energy-Efficient Room Air Conditioners Including Models With Low Global Warming Potential (GWP) Refrigerants, 55 ("The seasonal efficiency metrics used in China, India, Japan, and South Korea are highly consistent with ISO 16358 defined metrics (i.e., CSPF, HSPF, and APF), except they use region-specific climatic conditions and some adjustments. SEERs used in the United States and Europe (EU SEER uses the regional climatic conditions and includes the impact of standby and other low-power modes) require more data points in outside temperature and part-load conditions than those used in the Asian countries or the ISO 16358 standard. All [five countries and the EU] base their test procedures for ACs on adaptations of the ISO 5151 standard (Econoler et al., 2011). The ASEAN countries—including Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam—have agreed to use a test method based on ISO 5151: 2010 and CSPF defined in ISO 16358-1: 2013 (ASEAN SHINE, 2017). Therefore, the difference in seasonal efficiency metrics is primarily due to the outside temperature profiles used to aggregate steady-state and cyclic ratings into a seasonal efficiency value, as well as the ways of evaluating (measuring or calculating) performance at part-load operation into the metric.")

[13] The ISO 16358 is a newer standard based on the ISO 5151 test points. It allows for fixed speed and inverter air conditioners to be rated under the same metric and product category, capturing part-load savings from inverters, and provides flexibility in adoption of a country specific temperature bin (i.e. a representation of the country's year-round cooling demands). The test points required by ISO 16358 for fixed-speed, two-stage, multistage and variable speed air conditioners are based on the ISO 5151 T1 climate condition, facilitating its adoption because additional testing is not required. Only two test points are required for a fixed speed capacity or variable speed capacity air conditioner.

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https://www.eceee.org/library/conference_proceedings/ACEEE_buildings/2006/Panel_6/p6_6/
. http://www.esmap.org/sites/default/files/esmap-files/14.%20Vietnam_CFL_Case_Study.pdf.

15 Buyers clubs have historic origins in rural agricultural cooperatives that succeeded in purchasing farm inputs at reduced prices and in marketing farm products at increased prices. More recently, buyers clubs have succeeded in providing medicine to treat hepatitis C, human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS), and other medical conditions.

16 Buyers clubs have historic origins in rural agricultural cooperatives that succeeded in purchasing farm inputs at reduced prices and in marketing farm products at increased prices. More recently, buyers clubs have succeeded in providing medicine to treat hepatitis C, human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS), and other medical conditions.

17 ISEER methodology factors in the variance in higher temperature in India and rates air conditioners accordingly. As per Indian Weather Data Handbook, 2014, the weather profile of 54 major cities shows that 65% of the total number of hours in a year have a temperature above 24 degrees Celsius (5778 hours out of 8760).

18 http://www.igsd.org/wp-content/uploads/2017/08/Updated-EESL-AC-Bulk-Procurement-4-Aug.pdf

19 These NGOs helped set the stage by encouraging the 2016 Clean Energy Ministerial (CEM7) to ask private companies to offer high efficiency appliances at affordable cost, by encouraging Indian manufacturers to respond to the CEM7 Challenge with offers of high efficiency RACs using lower-GWP refrigerants, and by working with Parties to the Montreal Protocol on an Amendment requiring the phasedown of HFCs and simultaneous increase in energy efficiency at affordable cost. EESL had planned the bulk procurement of 500,000 units of RACs before Kigali. CEM7 did issue the 'Advanced Cooling Challenge' (http://www.cleanenergyministerial.org/Our-Work/CEM-Campaigns/AC-Challenge), Daikin India did respond with an ISEER 5.2 RAC offered at a lower price if purchased in bulk, Parties to the Montreal Protocol did agree an Amendment phasing down HFCs and a decision on higher energy efficiency, but for practical reasons EESL was not able to insist on lower GWP in the tender.

20 All conversion from INR to US dollars and EU Euros is based on web exchange rates on 24 June 2017.

21 LOA No.: EESL/06/RfP- 1617053/ Supply-AC-1.5T- 1L/LOA-1718050
dated: 26.05.2017 and LOA No.: EESL/06/RfP- 1617053/ Supply-AC-1.5T- 1 /LOA-1718051 dated: 26.05.2017

22 The highest available ISEER is 5.8; offered by Daikin, Godrej, and LG.

23 Some of the tender requirements no doubt increased the bid price above what would have been offered for a more basic tender specifying only 5.2 ISEER energy efficiency. The first EESL tender was for RACs to be almost immediately installed anywhere in India, included a premium warranty, and included a performance bond and withholding of 10% of payment until the warranty expired, which entails payment of interest by the manufacturers, which must be required in the bid price. Lower cost in any aspect would have allowed a lower bid while maintaining normal profit. Furthermore, bidders may have been subsidized internally or by promotional partners in order to win the bid in hopes of later increased profits, or as voluntary contribution to climate protection.

24 Abdelaziz, xv – xix.

25 HC-290 is a low cost raw gas, but requires expensive purification to use as a refrigerant. HFC-32 is a simple fluorocarbon with low cost feedstocks. HFC-125 (50% of HFC-410A) is a more expensive refrigerant due to its chemical complexity. HFC-410A is expected to increase in price as the HFC phasedown proceeds and manufacturing capacity of the HFC-125 ingredient is in short supply because manufacturers will not be able to recover the capital costs of new facilities.