Progress Report: 4 August 2017 (updated)

"Leap Frogging to Super Efficiency"

This is a progress report by The Energy and Resources Institute (TERI), the Institute for Governance & Sustainable Development (IGSD) and the Technology, Education, Research and Rehabilitation for the Environment for the Environment Policy Centre (TERRE) in support of the Energy Efficiency Services Limited (EESL) campaign to make super-efficient room air conditioners (ACs) available in India and export markets at affordable prices through bulk procurement.

The EESL support team includes Dr. Ajay Mathur, TERI Director General[1], Dr. Stephen O. Andersen (IGSD)[2]; Dr. Suely Carvalho (United Nations Development Programme—UNDP, retired)[3]; Mr. Marco Gonzalez (Montreal Protocol Ozone

[1] Ajay Mathur is Director General of TERI – The Energy & Resources Institute, and a member of the Prime Minister's Council on Climate Change. He was Director General of the Bureau of Energy Efficiency in the Government of India from 2006 until February, 2016, and responsible for bringing energy efficiency into homes, offices, and factories through initiatives such as the star labelling programme for appliances, the Energy Conservation Building Code, and the Perform, Achieve and Trade programme for energy-intensive industries. Dr. Mathur was earlier with TERI from 1986 to 2000, and then headed the Climate Change Team of World Bank in Washington DC. He was President of Suzlon Energy Limited and also headed the interim Secretariat of the Green Climate Fund. He has been a key Indian climate-change negotiator and was also the Indian spokesperson at the 2015 climate negotiations at Paris. He is a global leader on technological approaches to address climate change; recently, he joined the global group of industrial, financial and think-tank leaders to co-chair of the Energy Transitions Commission, which will suggest ways for companies and countries to move towards climate-friendly energy futures. He was Author for Intergovernmental Panel on Climate Change (IPCC) that shared the Nobel Peace Prize in 2007.

[2] Dr. Stephen O. Andersen is Director of Research at the Institute for Governance & Sustainable Development (IGSD), where he works to rapidly reduce ozone depleting and hydrofluorocarbon (HFC) greenhouse gases and other climate forcers. From 1986 to 2009 he worked for the US Environmental Protection Agency (EPA) including as Director of Strategic Climate Projects and Deputy Director of the Stratospheric Protection Division. He created the first EPA voluntary partnerships and Stratospheric Ozone and Climate Protection Awards. He was Co-Chair of the Montreal Protocol's Technology and Economic Assessment Panel from 1988 to 2012, and has been a senior editor and author of the Intergovernmental Panel on Climate Change (IPPC). He earned awards from Brazil, Iraq, Japan, Thailand, the United Nations, United States, Vietnam and Russia. He was Editor and Author for Intergovernmental Panel on Climate Change (IPCC) that shared the Nobel Peace Prize in 2007. His PhD is from the University of California, Berkeley.

[3] Dr. Suely Machado Carvalho, is Brazilian and a physicist with a PhD from Purdue University, USA; senior expert for the Technology and Economic Assessment Panel of the Montreal Protocol; co-chair of the International Expert Panel for Energy Efficiency Testing Air Conditioners High Temperature Environment, US Department of Energy (DOE) and Oak Ridge National Laboratory (ORNL), USA; former director of Montreal Protocol United Nations Development Programme (UNDP) in New York (retired), responsible for UNDP programme in 118 countries, which eliminated 68,000 tonnes of substances that deplete the ozone layer, in industrial sectors of great socio-economic importance. In searching for alternatives with low carbon footprint in the air conditioner sector, led successful market transformation initiatives in UNDP-assisted countries former director of the São Paulo State

Secretariat, retired)[4]; Mr. Karan Mangotra (TERI)[5]; and Mr. Rajendra Shende (TERRE Policy Centre).[6].Mr. Alex Hillbrand (Natural Resources Defense Council – NRDC) is a technical advisor.

Headline Climate Protection News:

IGSD, TERI and TERRE congratulate EESL for taking the first step in driving the market in India to more affordable super-efficient room air conditioners (ACs) and congratulate Panasonic and Godrej & Boyce (Godrej) for submitting low and affordable final bids of Indian Rupee (INR) 44320 (US$687.16; €614.023) each for a total of 100,000 super-efficient room ACs that will have achieve an Indian Seasonal Energy Efficiency Ratio (ISEER) of 5.2.[7] The ISEER 5.2 room ACs qualify for the highest 5-

environment protection agency, CETESB and author of the first CFC-free procurement programme for the government of Sao Paulo, which led to nation-wide legislation that helped to transform the market for CFC-free products and pave the way to an accelerated phaseout of HCFCs with significant climate impact. She was Author for Intergovernmental Panel on Climate Change (IPCC) that shared the Nobel Peace Prize in 2007.

[4] Marco Gonzalez is currently Senior Member of TEAP, former Executive Secretary of the Ozone Treaties from 2002 to 2013. He was the architect of Universal Ratification of the Ozone treaties, and assisted and supported the Parties in their discussions and negotiations in 14 Meetings of the Parties and related Open-Ended Working Groups. He has worked over 40 years in the fields of Policy, Power Systems Analysis and Global Environmental Protection. He graduated in Electrical Engineering in the University of Costa Rica and holds a Diploma in Electrical Engineering from the Imperial College Of Science and Technology and a MSc in Power System Analysis from the University of London.

[5] Karan Mangotra currently works as a Fellow at The Energy & Resources Institute in New Delhi, where his key responsibilities include Climate Policy, the Montreal Protocol, and Finance. Currently he is working on ensuring effective implementation of the NDCs for various developing countries through innovative implementation models. Prior to this, he was working as an energy efficiency specialist at UNDP, India. He was also a part of the Indian delegation to the Paris COP 21 and was involved in the preparation of the INDC submissions by India along with being a part of the team of authors for the Indian NATCOM & BUR. He holds an engineering degree from Bangalore, India, and an MBA in climate finance from the University of East Anglia, UK.

[6] Mr. Rajendra Shende is founder and Chairman of TERRE Policy Centre and is senior expert in Technology and Economic Assessment Panel of UNEP and is former Director in the United Nations Environment Programme (UNEP). An alumnus of IIT-Bombay Mr. Shende is member of the Advisory council of Indian Institute of Management's (IIM) Start-up incubator. In UNEP he coordinated successful implementation of global enabling activities for compliance of 146 Article 5 Parties to the Montreal Protocol. Through innovative mechanisms like Regional Networking of National Ozone Officers, he created practical implementation of global environmental accords. He was Author for Intergovernmental Panel on Climate Change (IPCC) that shared the Nobel Peace Prize in 2007. Recipient of number of global and national awards that include Climate Protection award from US EPA. His OzonAction Programme earned the Stratospheric Ozone Layer Protection award from US EPA. The global partnership of Refrigerants,Naturally! earned Harvard University's John F. Kennedy School of Government award. Development of SolarChill-vaccine cooler that he coordinated with diverse organizations, earned the UK-Industry award.

[7] ISEER methodology factors in variance in higher temperature in India and rates air conditioners accordingly. As per Indian Weather Data Handbook, 2014, 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).

Star energy efficiency rating and use up to one third less energy than the average room AC sold in India (3-Star).[8]

IGSD, TERI and TERRE are proud to be supporting partners in the EESL leadership and look forward to learning-by-doing and improving with lower-global warming potential (GWP) refrigerants the environmental performance of subsequent tenders already in the planning and finance pipeline.

Credit goes to Daikin India for extraordinary leadership in the promotion of super-efficient air conditioning using lower global warming potential (GWP) refrigerants, including donation of patented HFC-32 technology for free global use, and for publically offering a 5.2 ISEER room AC in India at such an affordable price that EESL was confident in putting forward their first tender.

The ultimate goal of government procurement is to lower the price and increase the quality of super-efficient room ACs using lower-GWP refrigerants 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.[9]

Bulk procurement is a transformational market strategy that will have widespread benefits within India, for its export markets, and worldwide. Low and affordable prices of super-efficient ACs will pull the entire Indian market toward better efficiency and justify higher minimum energy efficiency standards implemented ahead of previous schedules. Policy makers worldwide will be 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 is immediately transferable to markets worldwide, with the price in India indicative of the highest price anyone should pay for room ACs with comparable efficiency and warranty. Lower prices in India and its export markets (particularly Bangladesh, Nepal, and Sri Lanka) will likely be driven by subsequent bulk procurements, making the super-efficient ACs available to ever-growing markets and achieving global economy of scale in manufacture.

In February 2017, EESL issued a tender for:

> *"Design, manufacture, supply, installation, and provision for after-sales warranty and customer support for 5.28 kW (1.5 TR) room air- conditioners with ISEER of 5.2 (or higher) including three-year comprehensive warranty."*

[8] The highest available ISEER is 5.8; offered by Daikin, Godrej, and LG.

[9] 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.

> Note that the tender had strict specification for energy efficiency norms while allowing all refrigerants in order to ensure that there are adequate players in the market to bid as the government of India requires a minimum of three qualifying bids.[10]

As announced on 26 May 2017,

> Panasonic will supply 60,000 units ISEER 5.2 room ACs using hydrofluorocarbon (HFC)-410A[11] refrigerant and Godrej will supply 40,000 units ISEER 5.2 using hydrocarbon (HC)-290 refrigerant. The total cost per unit inclusive of design, manufacture, supply, installation, 3-year comprehensive warranty, and specified customer support is INR 44,320 (US$687.16; €614.023) for both the suppliers. The approximate value of the tender is about INR 443 Crores million (~US$68 million; ~€61 million).[12]

EESL plans to purchase up to 500,000 more room ACs in the near future under government tender, with anticipated lower prices, lower GWP, and higher energy efficiency over time.

Abstract and Findings

This paper describes how government organizations, and environmental non-governmental organizations in India are finding synergy and innovative market transformation mechanisms in the pursuit of affordable super-efficient room air conditioners using refrigerants that are less damaging to climate. The synergy is at an early stage of success, but with much more work needed, including communication of lessons learned and advice for implementation in India's export markets and replication worldwide.

IGSD, TERI and TERRE recommend that the government of India consider either allowing the next tender to go forward with two or more bids, or temporarily postponing future tenders until more AC manufacturers transition to HC-290, HFC-32, or other lower-GWP refrigerants. Environmental dumping of HFC-410A room ACs unnecessarily damages climate and jeopardizes the prosperity of future generations, particularly in the most vulnerable developing countries. Poor citizens are least able to afford the consequences of the purchase of an inefficient room AC at a low price but with high operating costs.

The challenges taken on by the Montreal Protocol in phasing down HFCs are to invest in new AC manufacturing factories using next-generation refrigerants and to achieve sustained super-efficiency at lower costs of production, distribution, marketing and installation to create savings that are passed onto consumers through buyers clubs, government procurement, and new market conditions. The Montreal Protocol has a

[10] The first tender specified only that: "Refrigerants used shall be consistent with the regulatory requirements of Ministry of Environment, and Forests (MoEF), Govt. of India."

[11] 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

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

proud heritage of eliminating dangerous chemicals while actually reducing the ownership costs of the new technology.

Institutional Background and How Government and Non-Government Organizations (GOs & NGOs) are Transforming Markets for Climate Protection

EESL is a joint venture company of the Government of India 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 manufacture, with millions of dollars of savings and significant climate and clean air benefits.

With the support of three environmental NGOs (ENGOs) -- TERI, IGSD and TERRE, and with the advice of a fourth -- the Natural Resources Defense Council -- EESL repeated its LED success story with a February 2017 tender for 100,000 super-efficient room air conditioners achieving 5.2 or greater ISEER and including a comprehensive warranty.

In order to satisfy the government of India procurement requirement of three bids, the tender allowed use of:

> Ozone-depleting greenhouse gas hydrochlorofluorocarbon (HCFC)-22 (non-flammable, ozone-depletion potential -- ODP=0.055; global warming potential -- GWP=1760), which is being phased out under the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol),
>
> Ozone-safe greenhouse gas HFC-410A (non-flammable, ozone safe; GWP=1924) and ozone-safe HFC-32 (slightly flammable, ozone safe; GWP=677, reduced charge), which will be phased down under October 2017 Kigali Amendment to the Montreal Protocol and with emissions controlled under the Kyoto Protocol of the Framework Convention on Climate Change (FCCC),
>
> Ozone-safe greenhouse gas HC-290, commonly known as propane, (highly flammable, ozone safe; GWP=~3, reduced charge), which is not controlled under the Montreal or Kyoto Protocols.

In the first-round of the February Tender, Panasonic submitted the low bid for 60,000 5.2 ISEER ACs using HFC-410A; Daikin offered at a higher price for 30,000 5.4 ISEER ACs using HFC-32 and Godrej offered at an even higher price for 10,000 ACs using HC-290.[13]

Once first-round bids are received, the tender has a second round, where bidders can match the lowest bid to qualify for a portion of the bulk purchase. In the second round, Godrej matched the Panasonic price, with an offer for 40,000 ACs, while Daikin did not match the price.

The Panasonic bid price using high-GWP HFC-410A is impressively low and demonstrates the power of bulk purchase in making super-efficient ACs affordable. The Godrej bid that matched the Panasonic price is evidence that super-efficient HC-290 room ACs using environmentally superior HC-290 refrigerant can be no more expensive to manufacture than the HC-410 ACs and is justification for disqualifying HFC-410A and HCFC-22 from future tenders.

Food for Thought on the Cost of Room AC Manufacture, Distribution, Marketing and Installation

It is reasonable to assume that companies were thoughtful in responding (or not responding) to the first EESL tender, and were mindful of avoiding the risk of setting prices too low to be sustainable and appreciated that it is EESL's ambition to continuously increase energy efficiency, favour low-GWP, and reduce price over time.

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 room ACs 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.

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 ACs 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 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 ISEER 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 ACs with flammable HC-290 and HFC-32 refrigerants than ACs with non-flammable HFC-410A refrigerant because greater care must be taken with flammable refrigerants and because in the case of highly flammable HC-290 the separation of the inside and outside equipment cannot be greater than about 5 meters or the refrigerant charge will exceed the amount considered safe. The extra cost of making ACs 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.

More subtly, consider that HFC-410A is an inferior technology in refrigerant cost and refrigerant energy efficiency that can only be made as efficient as HC-290 and HFC-32 by application of more expensive mechanical and electrical components. HFC-410A is a 50/50 percent blend of low-cost HFC-32 and high-cost HFC-225 (GWP=3170). HFC-125 is added to HFC-32 only to make the blend qualify under status quo safety standards as "non-flammable," but actually reduces the energy efficiency in the process. Manufacturers achieve high energy efficiency with inferior refrigerants like HFC-410A by manufacturing in fully amortized factories using existing components that have no use in countries like Japan, where HFC-410A is completely abandoned in favour of HFC-32 for domestic sales and for export to countries that protect climate and embrace new technology.

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.

Affordable room ACs 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 ACs economically justify very strong minimum energy efficiency standards.

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

A Dozen Extraordinary Steps Toward the Kigali Amendment to the Montreal Protocol and Affordable and Energy-Efficient Room ACs

This section of the report describes how the EESL tender was made possible by a small team of global experts motivated by the ambition to protect climate and provide the co-benefits of clean air and sustainable development. These experts proceeded independently and with orchestration through a dozen steps over a period of about one decade.

1) In 2008, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ--German Corporation for International Cooperation) with the support of the governments of India and China demonstrated HC-290 room ACs with Godrej India and Gree (China). Godrej started commercial production around 2010, but Gree is still waiting for product safety authorities to approve use in their German export market. Since 2010, Godrej has sold over 100,000 HC-290 room ACs, which exceeds sales by all other companies in all other global regions combined.

2) In 2011, the Indonesia Ministry of Environment and Ministry of Industry; Japan Ministry of Economy, Trade and Industry (METI) and Japan Refrigeration and Air Conditioning Industry Association (JRAIA); UNDP; IGSD; and the private companies Daikin, Panasonic, Fujitsu General, Toshiba and Hitachi agreed to cooperate in the commercialization of high-efficiency HFC-32 air-conditioners. In 2012, the Government of Japan approved the necessary measures for safe use of slightly flammable HFC-32 in room ACs. Daikin was first to market, with Panasonic, Fujitsu General, Toshiba and Hitachi quickly following. In 2012, the World Bank, under the auspices of METI, reached agreement with Daikin, JRAIA, Panasonic, Fujitsu General, Hitachi, and Toshiba-Carrier to transfer HFC-32 AC technology to AC manufacturers in Thailand. In 2013, Daikin offered companies worldwide free access to 93 patents, and Daihatsu Japan announced free access to its 14 patents related to the production and sale of HFC-32 air conditioners. In 2013, Daikin began manufacturing high-efficiency HFC-32 room ACs in India. In 2014, Daikin earned 'Top Runner' for the most efficient room AC sold in Japan. Since 2010, two dozen companies in a dozen countries have manufactured 30 million HFC-32 room ACs for markets in about 50 countries. HFC-32 completely dominates room AC sales in Japan.

3) In June 2016, the Clean Energy Ministerial Advanced Cooling (AC) Challenge inspired "…governments, companies, and other stakeholders to develop and deploy at scale super-efficient, smart, climate-friendly, and affordable cooling technologies that are critical for prosperous and healthy societies."

4) On 28 September 2016, Daikin India responded to the AC Challenge and offered a 5.2 ISEER room AC at an affordable price, conditioned on alignment of government policy.[14]

5) On 22 September 2016, a group of 16 non-A5 Parties[1] adopted the "New York Donor Declaration on an HFC Amendment to the Montreal Protocol", announcing their intent "to provide an additional US$27 million in 2017 to the [Montreal Protocol] Multilateral Fund if an ambitious HFC amendment is

[14] On 28 September 2016, Daikin Air-Conditioning India (Daikin India) offered to market in India and export markets (Bangladesh, Nepal, and Sri Lanka) affordable super-efficient room AC using lower-GWP refrigerant as soon as public and private energy efficiency programs could be aligned in India. Specifically, Daikin India offered a 5.2 ISEER (Indian Seasonal Energy Efficiency Ratio) inverter room AC with HFC-32 refrigerant at a price that is 12% to 15% lower than the current retail price of premium 4.5 ISEER variable speed ACs.

adopted at the October 2016 Meeting of the Parties with a sufficiently early freeze date for Article 5 parties to warrant fast-start support for implementation."

6) On 22 September 2016, (the same day as the New York Donor Declaration), a group of 19 philanthropic donors announced their intent to provide US $53 million to support the A5 Parties in improving energy efficiency in parallel with an HFC phasedown, contingent on a suitably ambitious HFC amendment.

7) On 5 October 2016, TERI, IGSD and TERRE formed a committee to satisfy the alignment required for Daikin to commercialize the super-efficient room air conditioner (SERAC).[15]

8) On 15 October 2017, Parties to the Montreal Protocol passed the Kigali Amendment to phase down the production and consumption of HFCs.[16]

9) On 23 February, Energy Efficiency Services Limited (EESL) issued a tender for up to 100,000 1.5 ton ISEER 5.2 or better room ACs.

10) In March 2017, three companies in India (Daikin, Godrej, and Panasonic) responded to the EESL tender to supply super-efficient 5.2 ISEER room ACs.[17]

11) Panasonic offered high-GWP HFC-410A room ACs for the lowest price. Godrej matched the Panasonic bid with environmentally superior, low-GWP HC-290 room ACs, and Daikin chose not to match the Panasonic bid and will therefore not participate in supplying ACs under the first tender.

12) EESL announced plans to purchase several hundred thousand additional room ACs at progressively higher ISEER and lower prices in response to increasing competition and high economy-of-scale in production, marketing, distribution and installation, presumably after disqualifying HFC-410A and HCFC-22 room ACs from tenders. TERI, IGSD and TERRE plan to work with EESL in taking the lessons forward to government procurement and private buyers clubs worldwide.

---

[15] On 5 October 2016, at the World Sustainable Development Summit (WSDS) in Delhi, The Energy and Resources Institute (TERI), The Institute for Governance & Sustainable Development (IGSD) and the Technology, Energy, Research, and Rehabilitation for the Environment Policy Centre (TERRE) announced a partnership to accomplish the policy alignment that was a condition of the Daikin offer of affordable super-efficient lower-GWP room ACs. The Natural Resources Defense Council (NRDC) joined as technical advisors. Dr. Ajay Mathur, Director General of TERI and Dr. Stephen O. Andersen, IGSD Director of Research co-chair a "Tiger Team" of experts including Dr. Suely Carvalho (former Director of United Nations Development Programme (UNDP) Multilateral Fund Implementing Agency); Marco Gonzalez (former head of the Ozone Secretariat); TERI Senior Fellow Karan Mangotra; and Rajendra Shende (former director of UNEP OzonAction). NRDC's Alex Hillbrand is a technical advisor.

[16] On 15 October 2016 India and all other Parties to the Montreal Protocol agreed by Amendment to phase down the production and consumption of HFCs that were once needed to rapidly replace ozone-depleting substances (ODSs), but are no longer necessary or sustainable because alternatives are available or soon will be available.

[17] Godrej offered to supply up to 10,000 using HC-290, Daikin offered to supply up to 30,000 using HFC-32, and Panasonic offered to supply up to 60,000 using HFC-410A.

This pioneering demonstration of the power of procurement is taking a learning-by-doing approach, where all the answers are not 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 room AC 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.

India Room AC Background, Challenges and Opportunities

1. The growing demand for air-conditioners (4.5 Mn unit sales in 2015, growing to expected sales of 19 Mn in 2030) in an unsaturated market (only 2-3% of Indian households have AC) directly leads to increased electricity demand.

2. While low GWP refrigerants are an essential element of the strategy to mitigate global warming, enhancing the energy efficiency of air conditioners is a far larger component of the strategy, particularly in countries with long, hot cooling seasons and carbon-intense electricity.[18] The comprehensive metric for carbon footprint is Life-Cycle Climate Performance (LCCP), calculated using local climate conditions and the carbon intensity of electricity[19].

3. The climate benefits of AC energy efficiency are unequivocal. Last year (2015 – 16), the avoided capacity addition due to already enhanced energy efficiency requirements for air conditioners was 2803.64 MW, and resulted in 2758.8 tons of avoided CO_2 emissions[20].

4. The current room AC refrigerant is hydrochlorofluorocarbon (HCFC)-22, which is being phased out under the Montreal Protocol as an ozone-depleting substance (ODS). [21]The replacement for HCFC-22 in developed countries was HFC-410A (50% HFC-32/50% HFC-125), and the next-generation already-commercialized replacements are HC-290 and HFC-32. Potential replacement refrigerant R-452b (a blend of R-32, R-125 and R-1234yf) is not yet commercialized. HC-290 is the clear environmental choice in applications

[18] Shah N., Wei M., Letschert V., & Phadke A., (2015) Benefits of Leapfrogging to Superefficiency and Low Global Warming Potential Refrigerants in Air Conditioning, Ernest Orlando Lawrence Berkeley National Laboratory, 26 (Table 9 "Relative contribution to overall GHG benefits from efficiency versus refrigerant transition").

[19] Papasavva, Stella, William R. Hill, Stephen O. Andersen, GREEN-MAC-LCCP ©: A Tool for Assessing the Life Cycle Climate Performance of MAC Systems

[20] Shah N., 28

[21] 2007 Montreal Adjustment on Production and Consumption of HCFCs http://ozone.unep.org/Meeting_Documents/mop/19mop/Adjustments_on_HCFCs.pdf

where the amount of refrigerant charge that can be safely leaked into an occupied room is large enough to cool the space on the hottest days; super-efficiency is demonstrated at 1.0 ton with existing technology[22] and up to 1.5 tones with advanced technology, such as micro-tube heat exchangers. For applications 1.5 to 5.0 tons, HFC-32 is the clear choice. In the future, active safety systems, designs with inherently slow leak rates, or increased allowable charge size without additional safety mitigation may allow safe use of super-efficient HC-290 room ACs above 1.0 tons and super-efficient HFC-32 room ACs above 5.0 tons.

5. Assuming 1600 hours/year, a super-efficient 5.2 ISEER room AC consumes 1462 kilowatt hours (kWhs)/year compared to a 3.5 ISEER room AC, which consumes 2172 kilowatt hours/year. The net 710 kWh/year saves about INR 5500 (US$83) at the current Delhi electric rate of 7.75INR (0.12/KWh. At 0.8kg/CO_2/kWh, the carbon savings is 615 [0.8 * 710 = 568 tons/yr.] tons/year.

Table 1: Comparison of Room AC Refrigerants[23]

	ODP	**GWP**	**Flammable?**	**Refrigerant Efficiency*** **	
				Lower Ambient T	Higher Ambient T
HCFC-22	0.055	1760	No	High	High
HFC-410A	0.0	1924	No	Low	Low
HC-290	0.0	~3	Very High ASHRAE "3"	High	High
HFC-32	0.0	677*	Lower ASHRAE "2L"	High	High

*HFC-32 requires ~20% to 30% lower charge for equivalent cooling capacity
**HCFC-22, HFC-410A, HC-290, and HFC-32 are all classified as low toxicity (ASHRAE "A")
***The refrigerant efficiency is a relative measure of the potential for efficiency, but actual efficiency of the appliance depends on the design, controls, and components in addition to the refrigerant. More effort and financial investment can usually increase the efficiency.

The Economics of Super-Efficient Room ACs

For specified climate conditions and cooling set points, each refrigerant has a relative energy efficiency, presuming that the refrigerant charge necessary to achieve the necessary cooling capacity is safe to use if the refrigerant is flammable and/or toxic.

[22] Abdelaziz, xv – xix.
[23] Ibid; Zaelke, Durwood, Nathan Borgford-Parnell, Stephen O. Andersen, 2016. Primer on Hydrofluorocarbons, Institute for Governance & Sustainable Development, on line at: www.igsd.org; Carvalho, Suely, Andersen, Stephen O., Brack, Duncan, Sherman, Nancy J. (2014) Alternatives to High-GWP Hydrofluorocarbons. Institute for Governance & Sustainable Development.

The actual energy efficiency of the product depends on the design, controls, and performance of the equipment components.

The safe use of flammable refrigerants is assured by limiting the refrigerant charge to the amount that could safely be leaked into a room and not exceed the lower flammable 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 increases significantly for 1.5 ton or larger room ACs, 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 allows high efficiency for room ACs up to 3.5 tons or larger.

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.

For room air conditioners, 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 room AC is small enough that any of the refrigerant options can be used without energy efficiency compromise.

- The refrigerant charge for an energy-efficient 1.5-ton room AC 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, or higher energy efficiency using this equipment.

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

[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

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 air conditioner's cost. The bottom line is that the cost to manufacture a 5.2 ISEER room AC 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 room ACs in developing countries at lower prices than next-generation HC-290 and HFC-32 room ACs. 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 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, 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.

Lessons Being Learned by Doing

Table 1 lists the basic specifications of the first tender and Table 2 elaborates the details. Appendix A explains the delivery schedule.

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

1. The overall complexity of the bidding process may discourage some companies from participating.
2. The provisions splitting the purchase with companies who match the winning price after bidding higher in the tender may prevent the winning company from achieving the economy-of-scale necessary to profit from the sale.

ingredient is in short supply because manufacturers will not be able to recover the capital costs of new facilities.

3. The rapid delivery after selection of the winning bid (first delivery as soon as 30 days; 100% delivery as soon as 150 days) may limit the bidding to the few products already in the market.
4. Unspecified location of the installations may increase the bid because of unknown and highly variable costs of delivery from the point of manufacture and possible delivery requirements in quantities too small to allow recovery of the costs of training and parts supply.
5. Uncertainty over the specifications of future tenders may discourage wide and competitive participation. For example, if tenders progressively increase the minimum ISEER, companies may not achieve economy of scale or may find themselves with surplus equipment and parts unsuitable for the new bid.
6. The requirement of a US$320,000 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.

Appended Information

Appendix A

Table 1: Basic Specifications of First Tender

Minimum efficiency:	5.2 ISEER (India Seasonally Adjusted Energy Efficiency)
Global Warming Potential (GWP):	No maximum specified
Minimum warranty:	3 years all inclusive
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 2: Elaborated Specifications of First Tender

Bidding Document Cost	INR 25,000 (~US$400) (*non-refundable & non-adjustable*).
Earnest Money Deposit (EMD)/ Bid Security	INR 20,800,000 (~US$320,000) (*refundable*)
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	"…including procurement and subcontracting (if any), delivery,

contractor's obligations	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 3: 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: Selected Acronyms and Abbreviations

A2L	ASHRAE rating for substances with low flammability and low toxicity
A5 Parties	developing countries qualified 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
FOR	Free-on-Road
GHG	greenhouse gas
GO	governmental organization
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
SERAC	super-efficient room air conditioner
SLCP	short-lived climate pollutant
SNAP	Significant New Alternative Policy Program (US EPA)
TEAP	Technology and Economics 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 LEDs for All
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WSDS	World Sustainable Development Summit (TERI)

Appendix C: Selected Timeline of Room AC Market Transformation

1987

24 nations and the European Commission (EC) sign the Montreal Protocol on Substances that Deplete the Ozone Layer as a "Start and Strengthen" treaty initially freezing halon production and consumption and reducing chlorofluorocarbon (CFC) production and consumption. The Montreal Protocol envisions adding new substances by Amendment (requiring ratification) and accelerating control schedules by Adjustments (not requiring ratification).

1991

Allied Signal (now Honeywell) invented and patented HFC-410A (50% HFC-125/50% HFC-32).

1992

The Copenhagen Amendment, among several provisions, added hydrochlorofluorocarbons (HCFC) to substances controlled by the Montreal Protocol and scheduled HCFC phaseout for developed countries (non-Article 5 Parties), beginning in 2004.

1996

Carrier Corporation was first to introduce an R-410A residential air conditioner

1997

The Montreal Amendment, among several provisions, included the phaseout of HCFCs in developing countries (Article 5 Parties) by 2005 and non-A5 Parties in 2015, respectively, with some continued use for servicing.

November 2011

The Indonesia Ministry of Environment and Ministry of Industry and the Japan Ministry of Economy Trade and Industry (METI), plus Daikin, Fujitsu, Hitachi, Panasonic, and Toshiba – with the support of the United Nations Development Programme (UNDP) and the Institute for Governance & Sustainable Development (IGSD) agreed to cooperate in the introduction of HFC- 32 air conditioners that are safe for the ozone layer and will reduce life-cycle greenhouse gas emissions under typical conditions in hot and humid climates. The strategy is for Indonesia and other developing countries to leapfrog high GWP HFC-410A technology, which most developed countries selected for their earlier transition away from ozone-depleting substances.

2011

Daikin releases HFC-32 patents to original countries qualifying under Article 5 of the Montreal Protocol.

April 2012

Godrej introduces HC-290 room ACs in India with the assistance of GIZ Proklima under the International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, in cooperation with the Government of India.

September 2013

Daikin Industries offered all companies worldwide free access to 93 patents to encourage companies to use HFC-32 refrigerant.

Daihatsu Motor Co. Japan announced free access to its 14 patents related to the production and sale of HFC-32 air conditioners. There is no patent that restricts the manufacture of HFC-32 itself and it is readily available from suppliers other than Daikin.

Daikin introduces HFC-32 room ACs in India.

5 January 2015

Prime Minister of India Sh. Narendra Modi and Shri Piyush Goyal, Union Minister of State (IC) for Power, Coal and New & Renewable Energy launch the Unnat Jyoti by Affordable LEDs for All (UJALA) scheme to leapfrog compact fluorescent light (CFL) bulbs with climate-superior light-emitting diode (LED) bulbs.

20 March 2016

India Power Minister Piyush Goyal announced in a press conference that EESL would orchestrate a program allowing buyers of air conditioners to pay for the added cost of high efficiency as they save money.

2 June 2016

The Clean Energy Ministerial (CEM)[2] Advanced Cooling Challenge (AC Challenge) Inspires: "…governments, companies, and other stakeholders to develop and deploy at scale super-efficient, smart, climate-friendly, and affordable cooling technologies that are critical for prosperous and healthy societies."

22 September 2016

A group of 16 donor countries – Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Switzerland, Sweden, United Kingdom, and the United States – announced that $27 million in additional funding would be available to the Montreal Protocol Multilateral Fund (MLF) in 2017 for fast-start implementation if an ambitious amendment with an early freeze date is adopted at the Montreal Protocol Meeting of the Parties in Kigali in October 2016.

A group of 19 philanthropists announced $53 million in fast-start funding (Kigali Cooling Efficiency Programme, K-CEP) to Article 5 Parties to maximize energy efficiency in parallel with an ambitious HFC amendment under the Montreal Protocol. The philanthropists are: Barr Foundation, Bill Gates, Children's Investment Fund Foundation, ClimateWorks Foundation, David and Lucile Packard Foundation, Heising-Simons Foundation, Hewlett Foundation, John D. and Catherine T. MacArthur Foundation, Josh and Anita Bekenstein, John and Ann Doerr, Laura and John Arnold, Oak Foundation, Open Philanthropy Project, Pirojsha Godrej Foundation, Pisces Foundation, Sandler Foundation, Sea Change Foundation, Tom Steyer, and Wyss Foundation.

28 September 2016

Daikin Air-Conditioning India (Daikin India) responded to the AC Challenge with an offer to market affordable super-efficient room ACs using lower-GWP refrigerant as soon as public and private energy efficiency programs are aligned in India. The Daikin India ambition is to market a 5.2 ISEER (Indian Seasonal Energy Efficiency Ratio)[3] inverter room AC with HFC-32 refrigerant at a price that is 12% to 15% lower than the current retail price of premium 4.5 ISEER variable speed ACs.

The Energy and Resources Institute (TERI) announced that Dr. Ajay Mathur (Director General TERI) and Dr. Stephen O. Andersen (Director of Research, IGSD) would co-chair a small committee of Indian and global experts and partner organizations to align public and private energy efficiency programs, support projects, and kick-start commercialization of super-efficient room ACs. Suely Carvalho, Marco Gonzalez, and Rajendra Shende are members of the committee, with an expert from the Natural Resources Defense Council (NRDC) serving as an advisor. The announced ambition is to complete the alignment within six months to make super-efficient room ACs both cost-effective for owners and profitable to companies who respond to the CEM AC Challenge.

15 October 2016

Parties to the Montreal Protocol agree the Kigali Amendment to phase down production and consumption of HFCs and to study opportunities to increase the energy efficiency of refrigeration, air conditioning, and heat pump equipment using lower-GWP substances. Parties also pledge to implement higher energy efficiency for thermal insulating foam, refrigeration, and air conditioning.

1 December 2016

Andrea Voigt, Executive Director of the European Partnership for Energy and the Environment (EPEE), announces that the first stage of the phasedown of HFCs under the Kigali Amendment and EU F-Gas rules will replace HFC-410A with higher efficiency and lower-GWP HFC-32 and HFC/HFO blends in room ACs.[4]

13 January 2017

Dr. Ajay Mathur, Director General, TERI and Mr. Saurabh Kumar, Managing Director, Energy Efficiency Services Limited (EESL), co-chair a workshop on super-efficient cooling systems attended by leading manufacturers. Blue Star, Daikin, Godrej, Panasonic, Voltas and Whirlpool pledged their support to develop and deploy super-efficient cooling systems in their own complexes and facilities, and endorsed the AC Challenge.[5]

23 February 2017

EESL issued a tender for "…design, manufacture, supply, installation, and provision for after-sales warranty and customer support for 100,000 5.28 kW

(1.5 TR) room air-conditioners with /ISEER of 5.2 (or higher) including three-year comprehensive warranty."[6]

The expectation is that other companies in India will soon respond to the AC Challenge with affordable super-efficient room ACs using lower GWP refrigerants, particularly because on 15 October, Parties to the Montreal Protocol agreed to an amendment that phases down high-GWP HFC refrigerants, with costs to companies in developing countries paid by developed countries and with additional financial commitment by philanthropists to help achieve high energy efficiency.

6 March 2017

India Ministry of Environment, Forest, and Climate Change (MoEFCC) and India National Ozone Unit (Ozone Cell) Launch Stage II of India's HCFC Phase-Out Management Plan (HPMP).

26 May 2017

EESL announces results of first tender.

11-14 July 2017

Montreal Protocol Open-Ended Working Group (OEWG), Bangkok

Appendix D: Elaborating Start-Up of EESL

EESL Started with Affordable LED Bulbs Leap-Frogging Obsolete Compact Fluorescent Builds to Next-Generation Low-Carbon Footprint LED Bulbs.

EESL is a Joint Venture Company of the Government of India, Ministry of Power and a state-owned enterprise, which in India is called a public-sector undertaking (PSU) or public sector enterprise (PSE). These companies are owned by the union government of India or owned by one of the many state or territorial governments, or both.

The signature EESL achievement to date is the Unnat Jyoti by Affordable LEDs for All (UJALA) scheme, which was launched on 5 January 2015 by Prime Minister of India Sh. Narendra Modi and Shri Piyush Goyal, Union Minister of State (IC) for Power, Coal and New & Renewable Energy. UJALA is currently running successfully in over 120 cities across India.

In this initiative, EESL procured massive quantities of LED bulbs from domestic manufacturers. In the first year, the bulk LED bulb procurement by EESL brought down the prices paid to manufacturers from about INR 300 - 400 to INR 75 - 95 per LED bulb, with a latest price of about INR 55 paid to manufacturers.

EESL then sold the LED bulbs to the public through an extensive chain of distribution kiosks, after adding taxes and overhead expenses.

Indicative Price Reduction by Bulk Procurement

Starting LED Bulb Price		End of First Year Price		End of Second Year Price	
Indian Rupees (IR)	US $	Indian Rupees	US $	Indian Rupees	US $
₹300-400	$4.61-6.15	₹75-95	$1.15-1.46	₹55	$0.85

Assuming 28 March 2017 exchange rate of ₹1 = US $ 0.0154

As of August 2016, over 140 million (14 crore) LEDs have been distributed to the public under the UJALA operating across 12 states[7], resulting in more than 52 million (5.2 crore) kWh energy savings per day, which avoided a peak demand of about 3,851 MW, and a reduction in carbon footprint of about 42,681 tonnes carbon per day. By 2019, EESL targets to sell about 770 million (77 crore) LED bulbs. The Domestic Efficient Lighting Programme last year provided over 70 million (7 crore) LED bulbs to families through power distribution companies at an instalment of INR 10 per month per bulb.

[1] Article V (A5) Parties under the Montreal Protocol typically are developing countries; non-A5 Parties typically are developed countries.

[2] The CEM includes Australia, Brazil, Canada, China, Chile, Denmark, European Community, Finland, France, Germany, India, Indonesia, Italy, Japan, Korea, Mexico, Norway, Russia, Saudi Arabia, South Africa, Spain, Sweden, United Arab Emirates, United Kingdom, and United States.

[3] The ISEER calculation method is based on ISO16358, adjusted for higher typical ambient temperatures in India.

[4] The International Symposium on new Refrigerants and Environmental Technology2016: Latest Technology of Energy Conservation, New Refrigerants and Environment issue on Air conditioning and Refrigeration Equipment for lead up to the 21st Century. The Japan Refrigeration and Air Conditioning Industry Association (JRAIA) 1-2 December, Kobe Japan.

[5] http://www.energetica-india.net/news/industry-commits-to-development-of-super-efficient-cooling-systems#comments

[6] Tender No: EESL/06/ESEAP-Supply-AC-1.5T-1L/1617053 dated 23-Feb-2017.

[7] Rajasthan, Maharashtra, Karnataka, Kerala, Uttar Pradesh, Himachal Pradesh, Delhi, Andhra Pradesh, Puducherry, Jharkhand, Bihar and Uttarakhand with more states expected to join soon.