DECISION XXIX/10 TEAP TASK FORCE REPORT ON ISSUES RELATED TO ENERGY EFFICIENCY WHILE PHASING DOWN HFCS

Suely Carvalho, Bella Maranion, and Fabio Polonara
TEAP Decision XXIX/10 Task Force Co-chairs

UNEP

TEAP

40th OEWG
Vienna, 11-14 July 2018

Decision XXIX/10

- Requests the TEAP "in relation to maintaining and/or enhancing energy efficiency in the refrigeration and air-conditioning and heat-pump (RACHP) sectors, including in high-ambient temperature conditions, while phasing down hydrofluorocarbons under the Kigali Amendment to the Montreal Protocol in parties operating under paragraph 1 of Article 5" **to assess the following:**
  - **Technology options and requirements including:**
    - **Challenges for their uptake;**
    - **Their long-term sustainable performance and viability; and**
    - **Their environmental benefits in terms of CO_2eq;**
    - **Capacity-building and servicing sector requirements in the refrigeration and air-conditioning and heat-pump sectors;**
  - **Related costs including capital and operating costs;**

UNEP

Decision XXIX/10 (cont.)

- Requests the TEAP **to provide an overview of the activities and funding provided by other relevant institutions**, as well as definitions, criteria and methodologies used in addressing energy efficiency in the RACHP sectors in relation to maintaining and/or enhancing energy efficiency in the RACHP sectors while phasing down hydrofluorocarbons under the Kigali Amendment to the Montreal Protocol, as well as those related to low- and zero-GWP HFC alternatives including on different financing modalities;

- Requests the TEAP **to prepare a final report for consideration at OEWG-40, and thereafter an updated final report** to be submitted to MOP-30 taking into consideration the outcome of the workshop organized by the Secretariat

UNEP

Decision XXIX/10 Task Force

CO-CHAIRS

- Suely Carvalho (Brazil, Senior Expert TEAP)
- Bella Maranion (USA, Co-chair TEAP)
- Fabio Polonara (Italy, Co-chair RTOC)

MEMBERS

- Omar Abdelaziz (Egypt, Outside expert)
- Jitendra M Bhambure (India, Outside expert)
- Sukumar Devotta (India, Member RTOC)
- Gabrielle Dreyfus (USA, Outside expert)
- Bassam Elassaad (Lebanon, Member RTOC)
- Ray Gluckman (UK, Member RTOC)
- Marco Gonzalez (Costa Rica, Senior Expert TEAP)
- Tingxun Li (PRC, Member RTOC)
- Maher Mousa (Saudi Arabia, Member RTOC)
- Tetsuji Okada (Japan, Member RTOC)
- Roberto Peixoto (Brazil, Co-chair RTOC)
- Per Henrik-Pedersen (Denmark, Member RTOC)
- Alessandro Giuliano Peru (Italy, Outside expert)
- Rajan Rajendran (USA, Member RTOC)
- Hélène Rochat (Switzerland, Outside expert)
- Nihar Shah (India, Outside expert)
- Dan Verdonik (USA, Co-chair HTOC)
- Ashley Woodcock (UK, Co-chair TEAP)

UNEP

Technology Options and Requirements: Opportunities

- Technologies resulting in EE improvement opportunities available for high global warming potential (GWP) refrigerants are applicable to low-GWP refrigerants as well
- The largest potential for EE improvement comes from improvements in total system design and components
  - These efficiency improvements can range from 10% to 70% (for “best in class” unit)
  - The impact of refrigerant choice on the EE of the units is usually relatively small – typically ranging from ±5 to 10%

UNEP

Technology Options and Requirements: Opportunities (cont.)

- By using a rigorous integrated approach to RACHP equipment design and selection, the opportunities to improve EE or reduce energy use can be maximised by:
  1. Ensuring minimisation of cooling/heating loads
  2. Selection of appropriate refrigerant based on application
  3. Use of high efficiency components and system design
  4. Ensuring proper installation, optimised control and operation, under all common operating conditions
  5. Designing features that will support servicing and maintenance

UNEP

Design Features

Efficiency improvement options and corresponding energy savings based on European conditions

Options	Description	Improvement	
		Min	Max
Efficient Heat Exchanger	High efficiency microchannel heat exchangers, larger sized heat exchangers	9%	29%
Efficient Compressors	Two-stage rotary compressors, high efficiency scroll compressors with DC motors	6%	19%
Inverter/Variable Speed	AC, AC/DC or DC inverter driven compressors	20%	>25%
Expansion Valve	Thermostatic and electronic expansion valves	5%	9%
Standby load	Reduced standby loads	2%	2%

UNEP

These options might not be additive

[Shah et al., 2014]

Technology Options and Requirements: Challenges for Uptake

- *Financial*: Higher efficiency equipment generally cost more to produce than less efficient ones. Therefore, prices for higher efficiency equipment tend to be higher
- *Market*: Split incentive problem: home/building owner for rental properties is not paying for utility bills; as such might not worry too much about EE and tenants don't have a long-term contract to justify the EE investment
- *Information*: Info about availability or benefits of higher EE equipment may not be available to end user. Labelling schemes and awareness campaigns can improve understanding of EE performance and benefits

UNEP

Technology Options and Requirements: Challenges for Uptake (cont.)

- *Institutional and regul*atory: Lack of legislation for EE, weak or non-existent regulatory framework, weak or unenforceable standards, lack of technical capacity to enforce standards and labels
- *Technical*: Testing facilities non-existent or cannot respond to demand
- *Service competency and others*: New technician skills required for latest technology; address misperceptions on quality and other performance criteria

UNEP

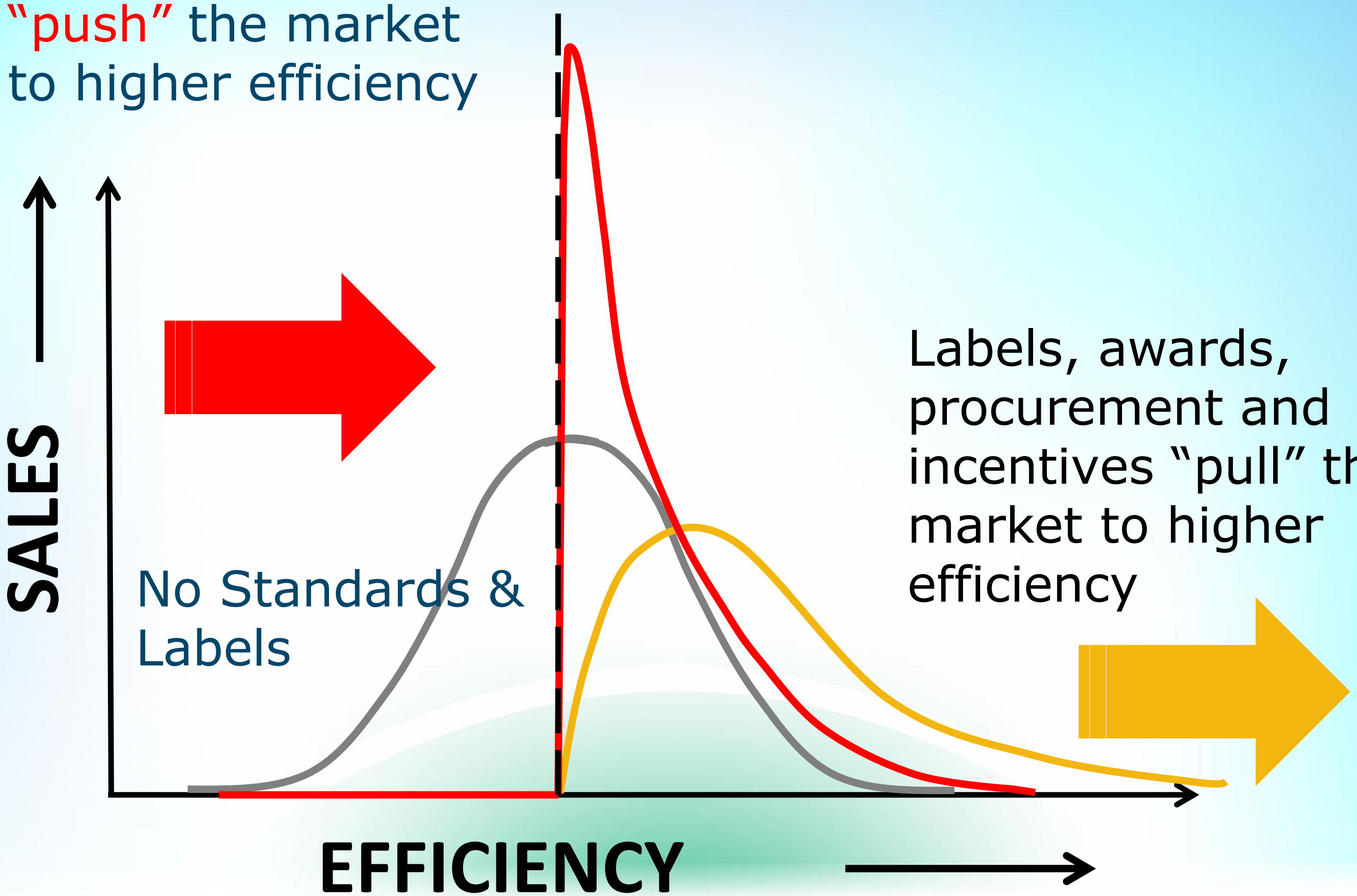
Long-term Sustainable Performance and Viability

- "**Long-term**" for RACHP technologies = 15 years; consistent with previous TEAP assessments
- **"Sustainable performance and viability"**
  – Evaluated if solutions meet EE objectives (i.e., viable)
  – Assessed whether or not they would remain viable over the next 15 years, including considerations for servicing
- Relevant aspects:
  – Technological environment (e.g. nearZeroEnergyBuilding, IoT, big data)
  – Codes and standards including Minimum Energy Performance Standards (MEPS)
  – Consider the whole supply chain, including the end user and industry engagement

UNEP

Strengthening MEPS

Minimum standards "push" the market to higher efficiency



Labels, awards, procurement and incentives "pull" the market to higher efficiency

UNEP

High Ambient Temperature (HAT) Considerations

- Additional set of challenges on the selection of refrigerants, system design, and potential EE enhancement opportunities
- Additional requirements such as ensuring the refrigerant can continue to deliver and sustain acceptable efficiency at HAT, and that the refrigerant doesn't breakdown or react with system components at high temperatures
- Can improve EE by increasing condenser size, however this results in increased refrigerant charge and system cost

UNEP

Environmental Benefits in Terms of CO_2eq

- Global warming impact of RACHP may be divided into:
  - *Direct emissions*: release of refrigerant to atmosphere
  - *Indirect emissions*: energy required to operate the equipment
- Indirect emissions contribute to over 80% of the RACHP global warming impact
- The impact of improving system efficiency on total global warming is dependent on:
  - Type of equipment
  - Hours of operation and time of use (influenced by ambient temperature and relative humidity)
  - Emissions associated with generating power (vary by country)

UNEP

Calculating Environmental Benefits of EE in RACHP equipment

- For a given equipment, identify the baseline model unit energy consumption
- Calculate the energy savings for higher efficiency models as a function of baseline unit energy consumption and hours of use (which vary significantly by country, climate, and application)
- Convert energy savings to CO_2eq by multiplying by the end-use emission factor for electricity generation

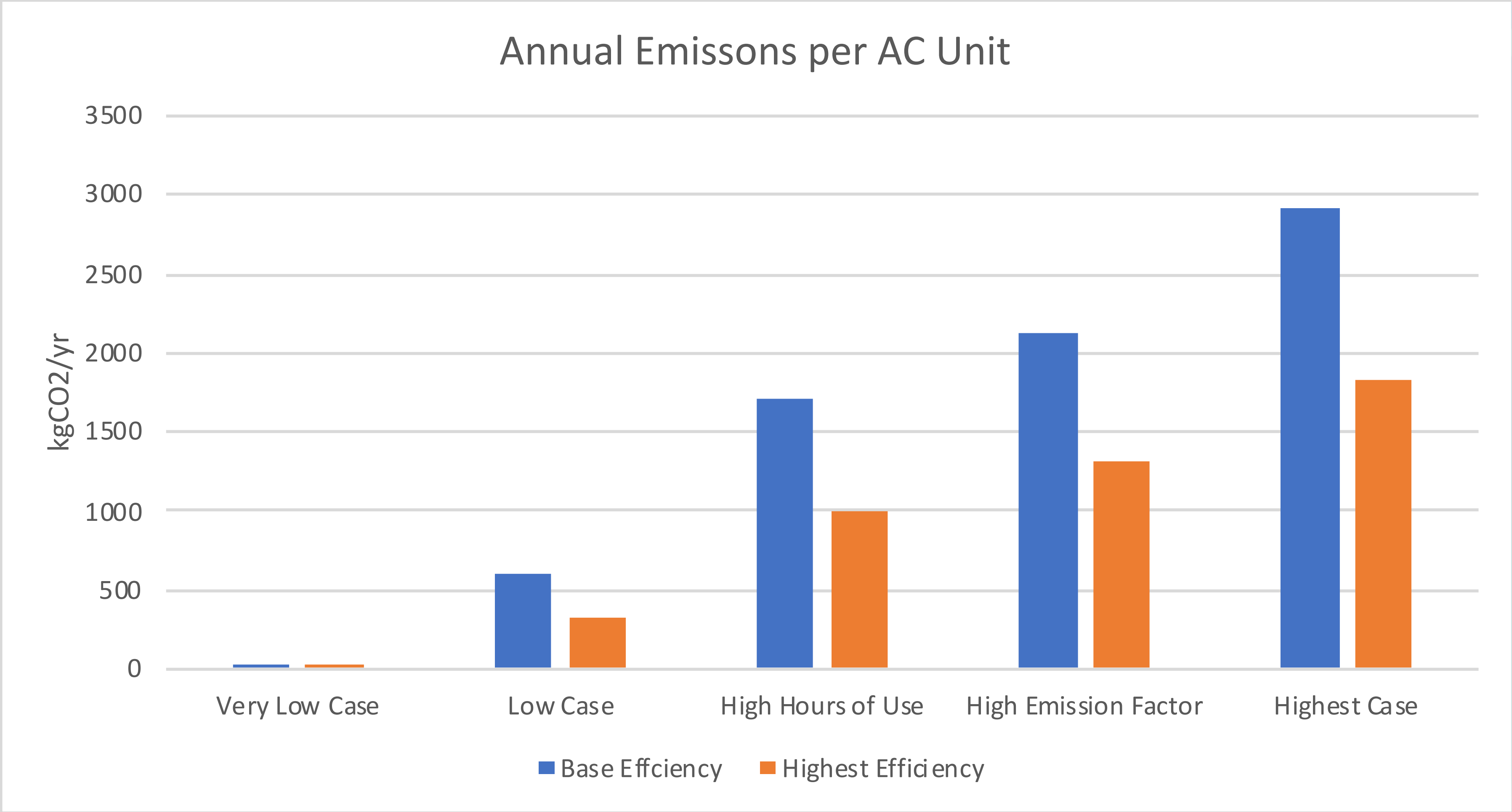
UNEP

Examples for Environmental Benefits in Terms of CO_2eq

- Equipment types considered: room AC, domestic refrigeration, heat pumps, commercial refrigeration, and mobile AC
- Three to five scenarios covered a range of hours of use (highest hours of use generally associated with HAT conditions) and electricity emissions factors, and considered three levels of efficiency:
  - Baseline
  - Higher EE (generally market average or better), and
  - Highest EE (best available on a representative market)
- EE improvement is characterized in terms of percent improvement in unit energy consumption

UNEP

Annual Emissions for a Room AC Unit under Five Scenarios



Servicing Sector Requirements

- Most A5 parties are concerned with proper training of technicians to support the HCFC phase-out; EE will require additional training and further awareness
- Performance degradation over equipment lifetime can be limited by improved design and servicing
- Proper installation, maintenance, and servicing of RACHP equipment has considerable impact on the lifetime EE at minimal additional cost
- Appropriate maintenance and servicing practices can avoid up to 50% loss of performance and maintain the rated performance over the lifetime

UNEP

Maintaining/Increasing EE of Equipment through Better Servicing Practices

- Improved training and education of service technicians, system operators, and refrigerant handlers
  - New courses and curricula
- Certification of technicians and other entities on handling refrigerants
- Policies to encourage regular maintenance and servicing
  - Maintenance contracts or warranties could be included as part of procurement practices

UNEP

Effects of Improper Maintenance

Improvement	Measures to be taken	Effect on Rated EE	Maintenance Cost Level
Correct levels of refrigerant and oil	Check levels periodically and refill	Up to 50%	Low
Air recirculation into condenser	Reduce recirculation by cleaning filters and removing obstacles	Up to 25%	Low
Thermostatic expansion valve (TEV) settings	Check and make set point adjustments	Up to 10%	Moderate
Condenser pressure control	Check and make set point adjustment	Up to 10%	Moderate

The effect on rated EE is not additive

[Usinger, 2016]

UNEP

Enabling Activities

- Capacity building, institutional strengthening, demonstration projects, and national strategies and plans help to bridge Montreal Protocol activities under the Kigali Amendment and EE
- A number of enabling activities supported by the other funds, such as the Kigali Cooling Efficiency Programme and the Global Environment Facility, have advanced both ozone depletion and EE goals
- Additional enabling activities under the Kigali Amendment can bridge the current Montreal Protocol activities with those destined towards EE and serve as examples of potential synergy between HFC phasedown and EE opportunities

UNEP

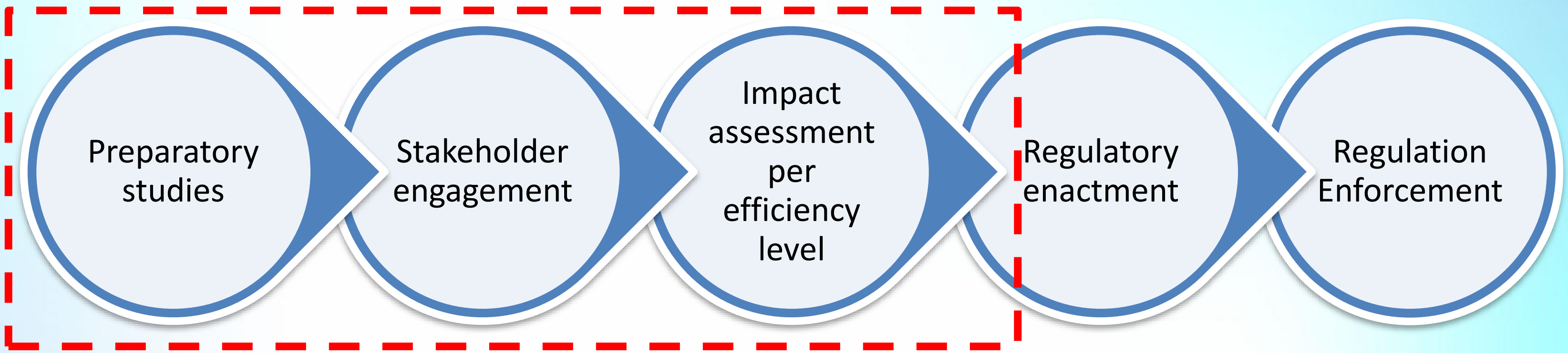
Activities and Associated Cost Examples

Bridging Enabling Activities	Number countries	Fund	Cost Example – US$/country
Capacity Building	14	K-CEP	44,000-430,000
Institutional Strengthening	147	K-CEP	12,000
Consumer Awareness	2	GEF	150,000 and 446,341
Demonstration Projects	14	K-CEP and GEF	208,000-400,000
Development of National Strategies	27	K-CEP	139,000
Design Procurement, market transformation	12	K-CEP	226,750
Design of Certification, monitoring, enforcement mechanism	6	K-CEP and GEF	100,000-319,000

UNEP

Overview of Typical Analytical Approach to Evaluate Capital and Operating Costs

Advocacy and expert groups: Industry, Consumer, Environment



- Consumer lifecycle costs and payback
- Manufacturer costs
- Other: GHG, Utility, etc.

12–24 months **9–12 months** **6-12 months** **9–12 months**

9–12 months

UNEP

Costs Related to Technology Options for Energy Efficiency

- Example for two established market transformation programs for promoting EE through MEPS and labelling programs: US Dept. of Energy's Appliance and Equipment Standards; EU Ecodesign Directive
  - Both use "bottom-up" engineering analysis based on detailed data collection, testing and modelling of more efficient equipment to identify manufacturing cost of EE
  - Similar processes have been used with limited extent to support EE standards in countries such as India and China
- Methodology can be used to estimate costs of the manufacturers of maintaining and/or enhancing EE for both A5 and non-A5 parties with manufacturing capacity

UNEP

Efficiency improvement options, corresponding energy savings and manufacturing costs in India

Options	Improvement	Additional Manufacturing Cost (US$)
Improved compressors	5.5% – 15%	<5 - 15
Variable speed compressors	21% – 23%	30 – 120
Variable speed drives for both fans and compressors	~ 26%	50 – 140
Heat Exchanger improvement	7.5% – 24%	10 – 165
Expansion valve	3.5% – 6.5%	<5 – 35

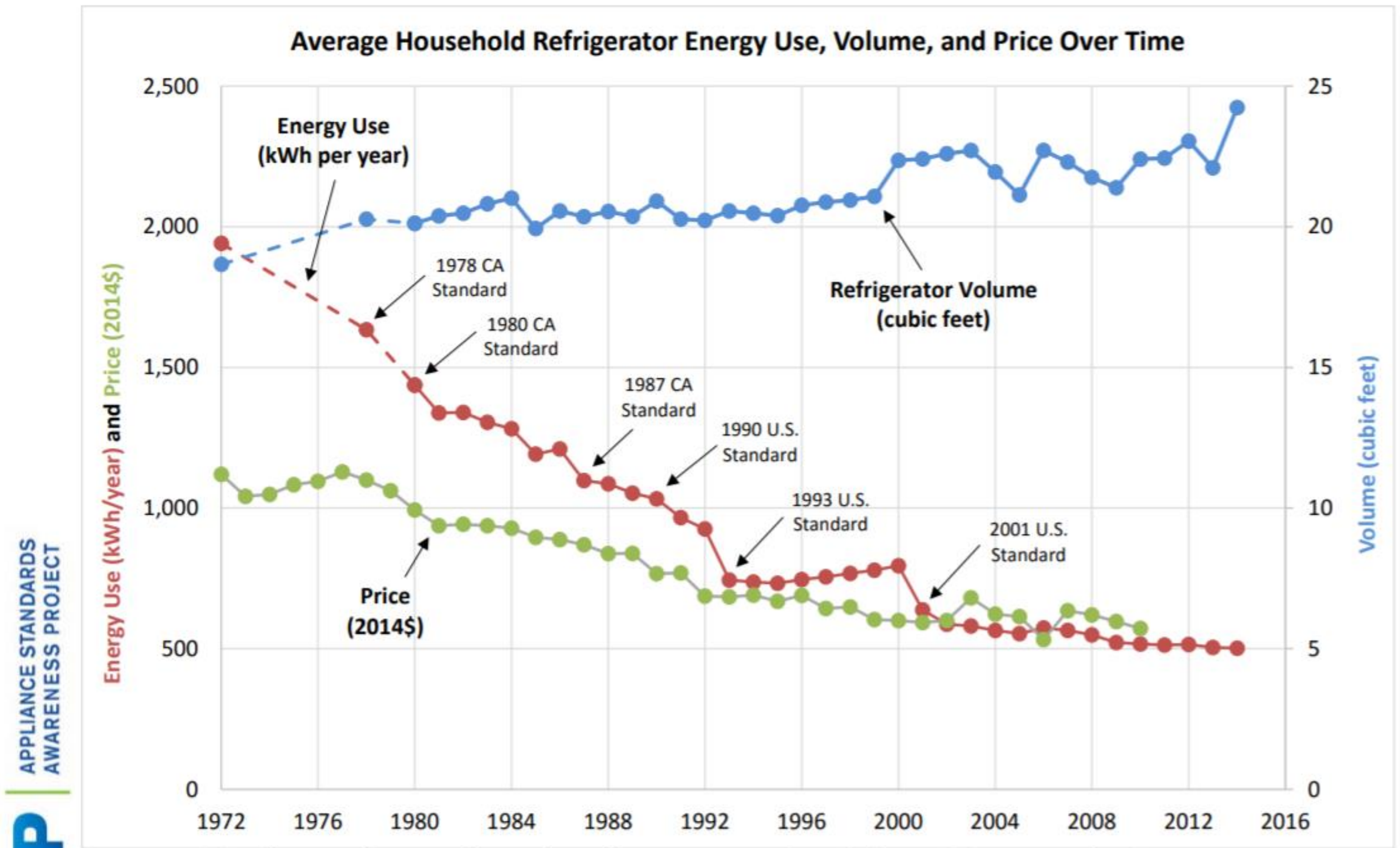
Country: India; System capacity = 5.27 kW

System type: Mini Split

[Shah et al, 2016]

UNEP

Average Household Refrigerator Energy Use, Volume and Price Over Time in the USA



Sources: Association of Home Appliance Manufacturers (AHAM) for energy consumption and volume; U.S. Census Bureau for price.

Notes: a. Data includes standard-size and compact refrigerators.
b. Energy consumption and volume data reflect the current DOE test procedure.
c. Volume is adjusted volume, which is equal to fresh food volume + 1.76 * freezer volume.
d. Prices represent the manufacturer selling price (e.g. excluding retailer markups) and reflect products manufactured in the U.S.

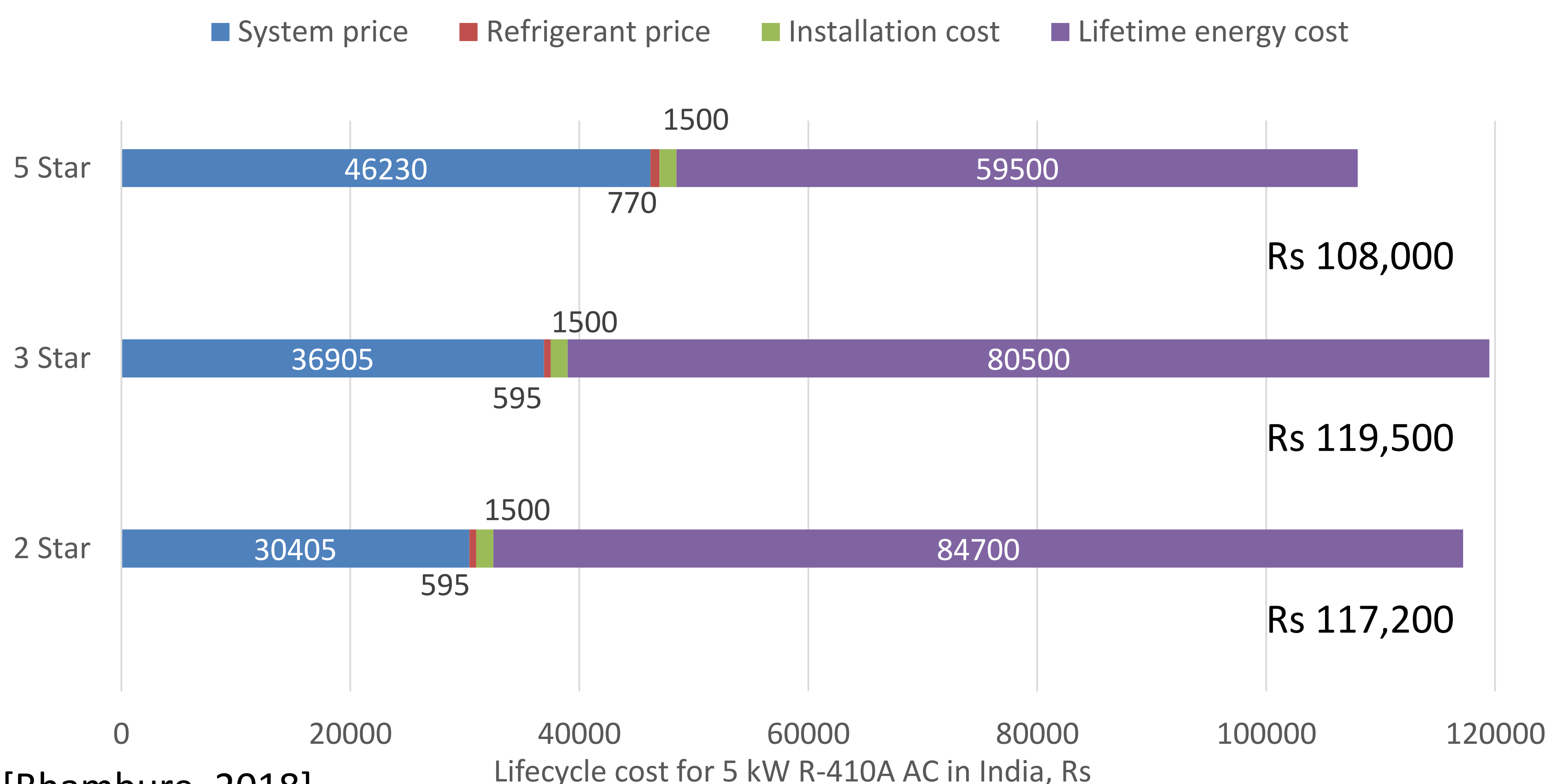
UNEP

Costs Related to Technology Options for Energy Efficiency: Challenges

- Limited publicly available data on capital and operating costs due to proprietary nature of business operations
- Retail prices on the global market show a wide variation in the prices of similar equipment; hence retail prices alone are not a good indicator for the costs of maintaining or enhancing EE in new equipment

UNEP

Lifecycle Cost Including Refrigerant for Different Efficiency Levels (India)



[Bhambure, 2018]

Breakdown of the lifecycle cost for a 5 kW R-410A AC in India at different efficiency levels

Funding Institutions

- Task Force approach to evaluate other funding institutions:
  - Focus on institutions other than the MLF
  - Distinguish between funding (those providing direct monetary support) and financing institutions (those providing project loans under typical application requirements and terms)
  - Consider where these financing and funding institutions specifically intersect with the objective of providing support for, among other things in the decision, “addressing EE in the RACHP sectors while phasing down HFCs”

UNEP

Funding Institutions (cont.)

- There are numerous financial resources for projects implementation in the field of EE:
  - Funding institutions that provide direct grants
  - Financing institutions that provide project funding support through loans, green bonds or other instruments
  - Private capital as an additional source through companies who might be interested to finance project implementation against investment payback
- Mapping finance for climate initiatives is a large exercise. This TF Report tackled activities and information on the GEF, K-CEP, Green Climate Fund, the World Bank Group, the GEEREF and GIZ.

UNEP

THANK YOU

UNEP