Community Benefits of Local Spending of Money Saved with Super-Efficient Air Conditioning Including New Local Employment[1]

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Abstract

This paper presents a pioneering benefit assessment framework and indicative quantification of the community and national benefits of operating cost savings from super-efficient room air conditioning (RAC) that are spent locally and not for imported fuel, electricity, and power plants. It also estimates the benefits of expanded employment to replace and service the new RACs and to recover and destroy obsolete and contaminated ozone-depleting and greenhouse gas (GHG) refrigerants.

Shifting spending from foreign to local purchase improves balance of trade, strengthens domestic currency, and creates jobs and prosperity as funds circulate in the local economy. Added to that are the community benefits of mass replacement of RACs and their service to maintain energy efficiency over the life of the appliance. This community impact grows over time as savings accumulate on avoided fuel and energy infrastructure and as the income from the new jobs circulates in the local economy.

Based on this comprehensive assessment framework, we recommend fast action on replacing older RACs in Morocco that were inefficient when purchased, improperly installed, and badly maintained for maximum energy efficiency. The recommended comprehensive approach will use bulk purchase for affordable cost and will recover and recycle the ozone-depleting GHGs in local cement kilns. The savings on electricity will be spent locally and recirculated through the Moroccan economy.

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The calculations are based on a new carbon metric called Enhanced and Localized Life Cycle Climate Performance (EL-LCCP) that determines the avoided hour-by-hour electric generation when RACs are super-efficient. Bank of Africa BMCE Group economists translated the specific information on fuel, electricity, and power plant investment avoided by energy efficiency into community impacts based on how RAC owners spend marginal income and savings, confirming substantial previously unaccounted-for economic advantages of energy efficiency. Future work by Bank of Africa BMCE Group can fine-tune the quantification through surveys of how different RAC owners choose to spend or invest savings.

This paper is timely because Earth is in peril from climate change, and the Montreal Protocol on Substances that Deplete the Stratospheric Ozone Layer (Montreal Protocol) will phase out hydrochlorofluorocarbons (HCFC) and phase down hydrofluorocarbon (HFC) GHG refrigerants that are used in RACs sold in Africa and worldwide. Responsible manufacturers are shifting to next-generation refrigerants that are safer for the climate and are simultaneously designing and manufacturing the new RACs to be super-efficient. This paper is also timely because investment to recover from the COVID-19 recession will provide immediate jobs in manufacturing, distributing, and installing the RACs, as well as sustained jobs from spending of energy savings locally.

1. Introduction

The Montreal Protocol *phases out* *production and consumption* of HCFC refrigerants. The Kigali Amendment to the Montreal Protocol *phases down production and consumption of HFC refrigerants*, and the United Nations Framework Convention on Climate Change (UNFCCC), with its Kyoto Protocol and Paris Agreement, *reports and controls* HFC refrigerant *emissions* (Andersen and Sarma, 2002; Andersen, Sarma, and Taddonio, 2007; EPA, 2018). The UNFCCC Paris Agreement adopted by 195 nations in December 2015 sets a target limit of a global warming increase of 2°C (3.6°F) and seeks to achieve no more than 1.5°C (2.7°F) above pre-industrial levels (UNFCCC, 2018).

The phasedown of HFC GHGs under the Kigali Amendment will avoid consumption of 80 billion tons of carbon dioxide equivalent ($CO_{2\text{-eq}}$) by 2050 and avert up to 0.5°C (0.8°F) of warming by 2100 (Xu et al., 2013; EPA, 2018). Significantly improving the energy efficiency of refrigeration and air conditioning equipment together with the refrigerant transitions could more than double the benefit by avoiding on the order of 160 billion tons of $CO_{2\text{-eq}}$ fossil fuel emissions by 2050 (Shaw et al., 2019).

Morocco's Nationally Determined Contribution (NDC) to the UNFCCC is to reduce GHG emissions by 42% below business-as-usual (BAU) levels by 2030, providing that Morocco gains access to new additional sources of finance (UNFCCC, 2015). This commitment leads to a total reduction of 527 million tonnes (Mt) CO_2-eq between 2020 and 2030.

Recovery from economic recession caused by the COVID-19 virus will include massive financial efforts such as debt relief and productive new investment that is labour intensive and sustainable. This paper puts forward an ambitious program of investment in super-efficient RACs using next-generation climate-friendly refrigerants that take advantage of the environmental leadership of the government of Morocco, the power of national banks to lead by example and manage large investments, and the capability of the local RRAC businesses and their suppliers to hire and train installers and expand operations.

2. The Business Case for Sustainable Investment in Room ACs

This paper makes clear that replacement of old RACs using obsolete greenhouse gas refrigerants is conventionally cost-effective, nationally desirable, and globally essential. Benefits go far beyond lifecycle RAC ownership savings:

- Investment in replacing older RACs made available to recover from the COVID-19 recession can have immediate benefits of year-round jobs with good pay and working conditions. Jobs are sustained with service contracts to maintain RAC energy efficiency and reliability. Local sustainable jobs will also be created from local spending of savings in energy efficiency.
- Through enhanced efficiency, RAC owners rapidly recoup any additional up-front costs relative to low-efficiency units, and then enjoy a decade or more of substantial savings in electricity costs while also benefiting from value-added features such as automatic controls and quieter operation. Regular service is cost-effective at maintaining energy efficiency and extending the expected useful life of the AC. Savings on imported energy are available for local spending to improve quality of life or for investment for economic growth and future prosperity.
- RAC manufacturers, distributors, and installers grow their businesses with more affordable and reliable products and more satisfied customers, which increases sales and profits and builds competitive advantage.
- Stockholders and investors in super-efficient lower-global warming potential (GWP) appliances enjoy reduced financial risk and improved relationships with government authorities as a result of alignment on improved air quality and climate protection.
- Electric utilities see reduction in expensive "peak power" demand as a result of more efficient RAC units, and their suppliers choose to shed the least efficient and most polluting fossil fuel peak power plants and concentrate on clean energy from low-cost sources such as solar and wind that is located closer to demand, which reduces transmission and distribution losses and increases grid reliability.
- Citizens enjoy cleaner air, improved health, and reduced risk of the local and global consequences of climate change.
- The government of Morocco achieves GHG reductions that help satisfy its commitment to NDCs to the goals of the Paris Climate Agreement. Furthermore, investment in efficiency that avoids greater spending on energy supply improves the national credit rating, which provides greater access to finance at lower interest rates.
- Participating suppliers working beyond compliance with the Kyoto and Montreal Protocols are motivated to improve efficiency, innovation, reliability, and other business-critical outcomes.

The strategy of a Buyers Club to aggregate RAC demand to lower prices and improve product quality can be applied to an increasing number of procurement activities in both public and private sectors. As sustainability gains traction—citizens, investors, employees, and communities all gain. Quintuple Win.

3. Next Generation Refrigerant Technology for Super-Efficient AC

Before the global phaseout of ozone-depleting substances (ODSs) under the Montreal Protocol, the refrigerant used in room air conditioning was HCFC-22. Developed countries, acting on a phaseout schedule beginning in 1996, mostly switched from HCFC-22 to ozone-safe HFC-410A. Just as the HCFC phaseout schedule was beginning in 2013 for developing countries, RACs were commercialized with superior new refrigerants hydrocarbon (HC)-290 and HFC-32, which have far less lifecycle impact on climate. These refrigerants have lower GWPs, which lowers direct emissions, and RAC products that use lower GWP refrigerants have the potential to be much more energy efficient, lowering indirect energy use emissions as well. In response to the new technology, developed countries began a second transition away from HFC-410A. After 2016, when the Kigali HFC Amendment to the Montreal Protocol was agreed upon, companies in developing countries started to "leapfrog" obsolete HFC-410A and transition directly from HCFC-22 to either HC-290 or HFC-32. At the same time, RAC manufacturers realized that during the redesign for new refrigerants, they could dramatically increase RAC efficiency with the latest engineering, materials, and controls. Indeed, as of December 2019, lower-GWP R-32 is the refrigerant used by two-thirds of the highly efficient RACs listed by TopTen.eu,[2] a website that helps consumers and businesses find the most efficient appliances and equipment sold in the EU.

Table 1: List of Highly Efficient Room Air Conditioners

REFRIGERANT	ODP	GWP* (IPCC AR5)	EFFICIENCY AT HIGH AMBIENT	TOXICITY / FLAMMABALITY
HCFC-22	0.055	1760	High	ASHRAE A1 (Low/Not)
HFC-410A	0.0	1924	Low	ASHRAE A1 (Low/Not)
HFC-32	0.0	677	High	ASHRAE A2L (Low/Mild)
HC-290 (propane)	0.0	~3	Medium to High	ASHRAE A3 (Low/High)

* GWP from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5)

In 2017, Energy Efficiency Services Limited (EESL), with the support of The Energy and Resources Institute (TERI) and Institute for Governance & Sustainable Development (IGSD) issued the world's first bulk tender asking for: "Design, manufacture, supply, installation, and provision for after-sales warranty and customer support for 5.28 kW (1.5 RT) RACs with India Seasonal Energy Efficiency Ratio (ISEER) of 5.2 (or higher) including three-year comprehensive warranty." Daikin, Godrej, and Panasonic bid, with Panasonic and Godrej awarded the tender to supply RACs at higher efficiency than previously offered in India and at a price reduction of about 30%. The bulk purchase was for 100,000 RACs for total cost of US $68 million. On 22 February 2019, EESL announced the second RAC procurement for 5.4 ISEER super-efficient RACs using next-generation lower-GWP refrigerants, representing a 40% improvement in efficiency over current 3-star units and aiming for a 30% cut in price (GOI, 2019).

2 https://www.topten.eu/private/products/air_conditioners

3.1 HC-290 (propane) Room ACs

Indian manufacturer Godrej & Boyce Manufacturing Company (Godrej) in the 1990s was the first Indian company to manufacture refrigerators with HC-600a (isobutane) refrigerant and was the first worldwide in 2012 to mass produce and market split RACs using the hydrocarbon refrigerant HFC-290 (propane). This pioneering innovation was accomplished between 2008 and 2013 through cooperation with Gesellschaft für Internationale Zusamenarbeit (GIZ) Proklima on behalf of the German Environmental Ministry and the India Ministry of Environment, Forest and Climate Change. As of July 2018, Godrej had sold more than 100,000 HC-290 RACs, with 2018 sales expected to top 50,000 units and including the highest efficiency RACs sold in India. Godrej reports that its air conditioner manufacturing facility near Pune, India, can produce 180,000 HC-290-based RACs per year. Godrej also is first to achieve 6.15 ISEER (Godrej & Boyce, 2018) and was the only company to successfully compete for the EESL bulk procurement using a low-GWP refrigerant alternative (IGSD and OzonAction, 2018). Midea in China also manufactures HC-290 split RACs. The Midea's All Easy Series HC-290 residential split system RAC was awarded the federal government of Germany's Blue Angel certification (Cooling Post, 2018).

3.2 HFC-32 Room ACs

In August 2011, the Government of Indonesia Ministry of Environment, the Japan Ministry of International Trade and Industry (MITI), the United Nations Development Programme (UNDP) and IGSD with Daikin, Panasonic and other Japanese companies broke away from HFC-410A with the announcement of a comprehensive strategy to take advantage of the inherently higher energy efficiency and lower GWP of HFC-32 and make its use in RACs safe as manufactured, installed, and serviced. The partnership estimated that HFC-32 RACs could reduce life-cycle GHGs by more than fifty percent in hot and humid climates. Within weeks of the announcement, Fujitsu General, Hitachi, and Toshiba joined the new partnership (Sadatani, 2011).

Since first introduced in November 2012, over 55 million RACs (window and split) using HFC-32 have been sold in more than 50 countries (Australia, Canada, Indonesia, India, Japan, Malaysia, Mexico, New Zealand, Oman, Philippines, Russia, Saudi Arabia, Singapore, Thailand, Turkey, United Arab Emirates, United States, Vietnam, and the European Union) by all major brands in the residential RAC market (Chinese, European Union, Japanese, Korean, Indonesian, Philippine, and Thai brands) including Daikin, Fujitsu, Gree, Haier, Hisense, Midea, LG, Mitsubishi, Panasonic, Toshiba, Samsung, and others. In 2013, the Daikin HFC-32 RAC earned the prestigious "Top Runner" designation in Japan as the most energy efficient RAC of the year. By 2016, all Japanese manufacturers adopted HFC-32 for their RAC products up to 16 kW in capacity in the domestic market (JARN, 2016), and the top ten highest-efficiency RAC models all used HFC-32. By 2017 nearly all RACs sold in Japan were HFC-32 refrigerant (Park et al., 2017).

4. Enhanced and Localized Life-Cycle Climate Performance (EL-LCCP)

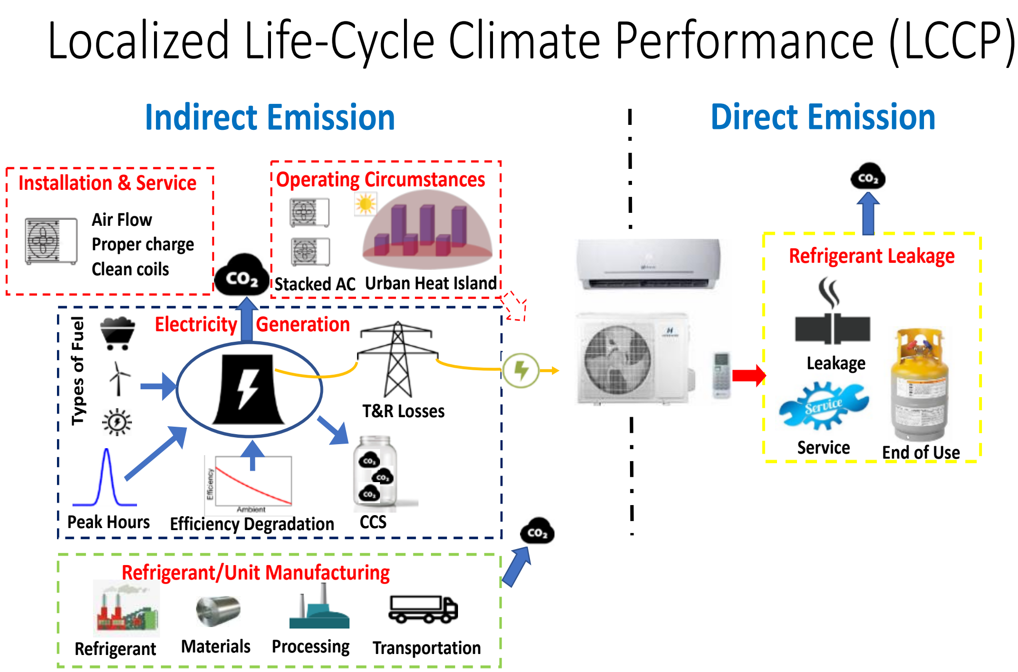
For the last several decades, energy experts have continuously improved the metrics for measuring AC system performance, include cooling capacity, energy efficiency (ratio of cooling output to electrical power input), and seasonal energy efficiency in regionalized weather conditions, expressed as Seasonal Energy Efficiency Ratio (SEER) (Tanaka, 2014). Life-Cycle Climate

Performance (LCCP) adds to the fossil fuel GHG emissions the carbon-equivalent direct refrigerant emissions and the embodied emissions of materials, manufacture, transport, installation, service, and recycle at the end of a product's life (Hwang et al., 2016; Troch et al., 2016; Andersen et al., 1999).

If refrigerants have near-zero GWP and/or are fully contained with near-zero emissions, then direct refrigerant emissions are relatively unimportant to LCCP calculations. If electricity is supplied by near-zero carbon electricity from nuclear, hydro, solar, and wind, then indirect emissions are relatively unimportant to LCCP calculations. If the refrigerant is contained in leak-tight designs and recovered and reused or destroyed, and all materials are recycled into future uses, then the embodied emissions are relatively unimportant to LCCP calculations.

The translation of direct refrigerant GHG emissions, indirect fossil fuel GHG emissions, as well as the emissions embodied in equipment to carbon footprint requires accounting of the carbon intensity of electricity as delivered to the RAC under circumstances of real-world operation. This new method was developed by an international team of experts organized by IGSD and supported analytically by researchers at the University of Maryland Center for Environmental Energy Engineering (Andersen et al., 2018). The method is outlined in Figure 1:

Figure 1: Concept Diagram of Localized Life Cycle Climate Performance Analysis



Enhanced and Localized LCCP (EL-LCCP) is designed to account for: 1) local climate conditions, including high temperature and humidity; 2) local seasonal and time-of-day carbon intensity of electricity sources, including backup electricity generation; 3) electricity transmission and distribution losses, including through the application of any voltage stabilizers; 4) energy embodied in water used for power plant cooling; 5) black and brown carbon power plant emissions; 6) more realistic assumptions about the actual air temperature entering RAC condensers (many open, located in urban heat islands, often stacked and clustered, arranged with poor ventilation, and placed in direct sunlight); 7) realistic assumptions about matching RAC capacity to cooling load; and 8) servicing to maintain efficiency over the lifetime of the installation.

EL-LCCP analysis avoids the common mistake of presuming that energy efficiency results in a reduction of CO_2 emissions at the average carbon-intensity of the generation mix. Instead, EL-LCCP takes into account that the reduction in electricity production will be accomplished by reducing output from the most expensive electricity source, which is typically the older fossil fuel power plants.

5. Morocco Plan to Replace Older RACs with Super-Efficient Lower-GWP Technology

Most other energy efficiency strategies have concentrated on transforming new markets to higher efficiency and lower-GWP by educating consumers to act in their own self-interest and to purchase equipment with least cost life-cycle costs through a combination of minimum energy performance standards (MEPS), appliance labelling according to energy performance and GWP, and financial incentives such as tax credits, rebates, and low interest loans.

The Morocco strategy considers all that, but has additional concentration and integrated approaches: 1) stopping dumping; 2) removing older incredibly inefficient equipment sold into unsuspecting markets before MEPS and replacing that older equipment with next-generation lower-GWP, super-efficient RACs; 3) engaging a buyers club to purchase in bulk; 4) properly installing in mass by trained technicians for efficiency, safety and to reduce total replacement costs; and 5) recovering the obsolete HCFC-22 and HFC-410A refrigerants from the old equipment and destroying them in local cement kilns.

Experts working on the Morocco Banker's AC Buyers Club project determined that the existing stock of RACs was relatively inefficient when purchased; often improperly installed, which compromised potential efficiency; and poorly maintained to achieve life cycle efficiency.

- Older RACs were inefficient when purchased because buyers looked for low first cost, because regulations at the time did not require an adequate MEPS, and because foreign companies supplying Morocco and Africa often dump low quality and obsolete models there.
- Older RACs were often improperly installed with: 1) too little clearance from building walls, overhangs and obstructions, causing inadequate air circulation at condensers; 2) stacked and clustered condensers pushing rejected heat from one condenser into the intake of another; and 3) placement of condensers far from evaporators, causing a decrease in system efficiency, particularly if refrigerant lines were sized too small.
- Older RACs are often poorly maintained, with heat exchangers corroded and clogged with dirt, which reduces system efficiency, and with refrigerant charge not maintained at the level required for highest efficiency.

The implication is that the replacement of older RACs with super-efficient models using lower-GWP refrigerants can be incredibly cost effective, particularly when undertaken under by a buyers club that can negotiate a lower price based on aggregated demand and economy of scale, simplified logistics, and coordinated installation. Furthermore, the buyers club project, in cooperation with dealers and installers, can organize training and inspection to assure safe and efficient installation and to offer maintenance contracts that maintain life cycle efficiency at affordable cost.

Consider also that if all older HCFC-22 and HFC-410A RACs are rapidly replaced, there will be far less demand for high-GWP and ozone-depleting refrigerants for servicing. A coordinated replacement effort also has the logistical advantage that obsolete refrigerants can be collected in bulk without concern for purity or cross-contamination and economically destroyed in local cement kilns.[3]

5.1 ***Investment and Energy Efficiency Benefits*** from Replacing Older Room ACs

Morocco can achieve significant savings by replacing approximately 1,432,000 RACs more than five years old with average energy efficiency ratio (EER) of 2.69 or lower when they were new[4] with energy efficient RACs with ISEER of 5.8.[5] The replacement RACs will use approximately half of the electricity of those replaced. Even greater savings may be obtained through proper installation practices and by eliminating older units that were improperly installed and poorly maintained (RAC units can lose 30% of their rated efficiency from improper installation and 5% to 20% loss of energy efficiency from heat exchanger physical deterioration and non-optimal refrigerant charge). Other benefits of RAC maintenance are improved reliability and safety (Holuj et al., 2019; Firdaus et al., 2019; Sullivan et al., 2010).[6] Morocco can also significantly reduce its peak power demand by replacing inefficient RACs with more efficient units, with potential for significant savings in the government and utility sector, as peak power is typically the most costly to provide. In 2013, the installed stock of RAC totalled 1,732 megawatts, accounting for about 31% of Morocco's maximum power demand of 5,580 megawatts in 2013 (Khalfallah et al., 2016).

5.2 Reduced Energy Demand and Fuel Savings

Fast recovery from the COVID-19 recession and protection of the climate through reduced GHG emissions require that this project get underway before all the benefits are precisely calculated. Replacement will focus first on the oldest and poorly installed RACs, which will deliver fast payback of investment and sustained energy savings spent locally over the life of the next-generation equipment.

[3] Unlike motor vehicle air conditioning (MACs), where recovered refrigerants are purified to pragmatic standards, stationary AC authorities require that used refrigerants be cleaned to the level of purity of newly-manufactured refrigerants. See: AHRI, 2016.

[4] Actual efficiency is lower due to equipment degradation over time. The World Bank reported that 2.69 EER was the average efficiency of AC units in 2013. Units installed in 2006 averaged 2.46 EER. Units installed earlier than 2006 are likely achieving very low efficiency levels (<2 EER) with high operating costs.

[5] 120,000 room ACs were sold in Morocco in 2014 (>5 years ago), plus 118,000 sold in 2013 (>6 years ago), plus 1,200,000 room ACs installed in 2012 or earlier (>7 years ago) and still in operation.

[6] Proper maintenance and operations reduce AC energy use by 10 to 20 percent across all climate zones, while poor maintenance practices can increase energy use by 30 to 60 percent. Other benefits of HVAC maintenance are improved reliability and safety.

The project will watch carefully for lessons learned, and adjust the investment pace and focus to achieve maximum jobs, economic, and environmental benefit.

The detailed Morocco RAC study by the World Bank estimated that the installed base of RACs were about half commercial and half residential.

- Businesses ran RAC more frequently. The typical RAC owned by a commercial business was operated 72 days per year for 5.8 hours per day. The implication is that businesses running RACs should be able to realize greater savings by switching to high efficiency RACs. (Government buildings were an exception; the typical government office ran their RAC 44 days per year for 3.7 hours per day.)
- Typical residential run-times were not as long as the typical US or European household. Moroccans, according to the World Bank, appear to be more judicious about their AC use: they used RAC 63 days per year on average, for 4.8 hours per day.
- Avoided peak power demand (in megawatts & MWh) would be very useful to calculate, as this would likely generate the most savings in the utility sector and account for most avoided construction of additional peak power plants.

New economic multipliers from energy efficiency and clean energy projects are being developed for the World Bank, with results to be applied as soon as available.

Tables 2 and 3 in the next page show fast payback analysis and avoided GHG emission analysis for home and office in India, respectively. As can be seen, EESL First Procurement case has 16.5 months and 13.6 months payback period over 3-Star 2016 BEE Table case in home and office cases, respectively. EESL First Procurement case can avoid 981 kg CO_2 and 899 kg CO_2 over 3-Star 2016 BEE Table case in home and office cases, respectively.

Table 2: Indicative Payback Analysis for Home Case Study in India

Home Case Study

Fast Payback if daily running of about 8 hours for 7 months, Avg. tariff: $0.095 per kWh.

	3-Star 2016 BEE table	5-Star 2016 BEE table	EESL Tender
ISEER	3.1	3.5	5.2
Estimated AC purchase price	$441	$552	$699
Annual energy use (kWh)	2857	2530	1703
Annual operating cost (US$)	$270	$239	$161
Additional energy expense (US$)	$109 per cooling season $15.57 per month for 7 months	$78 per cooling season $11.14 per month for 7 months	US$0
Simple payback if you purchased ESEAP instead	16.5 months of operation ~ 2.3 cooling seasons	13.2 months of operation < 2 cooling seasons	Saves $78 to 109 per cooling season compared to 3 or 5-Star, respectively
Avoided GHG emission reductions (kg CO_2)	981	833	0

Room ACs using HC-290 have additional climate benefits compared to equally efficient room ACs using HFC-410A

Table 3: Indicative Payback Analysis for Office Case Study in India

Office Case Study

Fast Payback if 5-day running of about 10 hours for 7 months, Avg. tariff: US$ 0.126 per kWh.

	3-Star 2016 BEE table	5-Star 2016 BEE table	EESL First Procurement
ISEER	3.1	3.5	5.2
Estimated AC purchase price (US$)	$441	$552	$699
Annual energy use (kWh)	2618	2319	1561
Annual operating cost	$330	$292	$196
Additional energy expense incurred by you if non-ESEAP used	$133 per cooling season $19 per month for 7 months	$96 per cooling season $13.71 per month for 7 months	$0
Simple payback if you purchased ESEAP instead:	13.6 months of operation < 2 cooling seasons	10.7 months of operation < 2 cooling seasons	Saves $96 to $133 per cooling season compared to or 5-Star, respectively
Avoided GHG emission reductions (kg CO_2)	899	644	0

Room ACs using HC-290 have additional climate benefits compared to equally efficient room ACs using HFC-410A

Next-generation super-efficient RACs are premium appliances with some added features that increase energy savings, and other added features that increase comfort and reliability. For example, the Daikin RAC used in the Bank of Africa Pilot included: 1) inverter technology with temperature adjusted by changing the motor speed, which ensures highest energy efficiency and quiet operation; 2) streamer plasma discharge technology to clean indoor air; 3) “Coanda Effect” air circulation for comfort throughout the room; and 4) intelligent sensor that detects occupancy and directs airflow for draft-free comfort (Daikin, 2019a).

Inverter technology also has the advantage of being less vulnerable to low and variable voltage, which often occurs in Morocco during peak hours of air conditioning operation, when power plants cannot maintain standard voltage. Non-inverter RAC motors lose energy efficiency, can overheat, and frequently fail (Bonnett and Boteler, 2001; Daikin, 2019b).

5.2 ***Economic Development and Prosperity Benefits*** of Replacing Older Room ACs

At the most basic level, when you buy local, more money stays in the community. A "multiplier" or "local premium" results from shifting the wealth now spent on imported fuel and power plants to local products and services. In other words, going local creates more neighbourhood wealth and jobs.

The Keynesian Multiplier (Keynes, 1939) is a calculation of how much an increase in private domestic consumption expenditure raises the total gross domestic product (GDP) compared to the GDP of the same expenditure on imported energy. For our calculation, we can assume that the cost of the new RAC is financed by banks, to be paid back from energy savings within three or four years and subsequently with all savings accruing to the owner of the RAC and spent locally. Shifting expenditure from imports to domestic products and services has a multiplier effect on the entire Moroccan economy (Laitner, 2020; Laitner et al., 2018).

The Morocco Banker's AC Buyers Club team includes John A. "Skip" Laitner, who in the early 1990s began to evaluate using progressively sophisticated analysis of the jobs and economic benefits for a wide variety of energy-efficiency, clean energy, and climate policy scenarios. The current, more comprehensive version of the "DEEPER Model" can also assess the lost opportunity cost of investments that increase energy consumption without enhancing productive use of energy. The recommended job-creating and fast climate mitigation strategy of replacing older RACs in Morocco will be analysed to fully include the many job, economic, and environmental drivers and multiplier effects of direct RAC capital investment, indirect benefits of more jobs and wages, and tertiary benefits of savings in electricity purchase spent locally.

The economic impact results from reduced spending on imported fossil fuel and new thermal powerplants, which has a positive ripple effect on balance of trade and access to finance for clean energy and energy efficiency.

Investments in super-efficient RACs reduce the demand for traditional energy sources, which puts downward pressure on the price of electricity, with benefits to all Moroccan electricity customers (Laitner, 2019). This is often referenced by economists as "demand reduction induced price effects" (DRIPE) (Taylor et al., 2015) resulting from the avoidance of higher marginal cost electricity from the least efficient fossil fuel power plants and taking into account transmission and distribution losses using the EL-LCCP framework.

Buyers Club project implementation includes all those activities required to procure, distribute, install, and service the new RACs, and all activities required to recover and destroy ozone-depleting GHG refrigerant and to disassemble old RACs for useful components and recycle the various scrap metal (steal, copper, aluminium, etc.).

- The replacement of older RACs injects millions of dollars into the Moroccan economy.
- Thousands of jobs are created to undertake the work and the service contracts.
- The project is managed to create permanent year-round jobs by scheduling replacement of older RACs and preventive maintenance service of all RACs outside the cooling seasons, when RAC technicians are traditionally unemployed.
- Many businesses benefit directly, including in the RAC sector and in the sectors supplying new construction (training, tools, electrical and plumbing supplies, etc.).
- Installing new RACs creates a new flow of factor incomes—including wage and profits that are taxed with revenue increasing spending by governments on public services.
- In these circumstances, the additional expenditures stay within the circular flow of the Moroccan income and spending, with a strong multiplier effect and a larger impact on GDP.

Money spent locally has a multiplier effect when re-spent locally, raising the community level of economic activity, paying more salaries, and building the local tax base. This recirculating of money leads to an increase of economic activity, with the economic benefit entirely dependent on the percentage of money spent locally. Local spending increases wages and benefits paid to local residents, profits earned by local owners, purchases of local goods and services, and contributions to non-profit organizations serving the local community.

The multiplier is comprised of direct, indirect, and induced benefits. Direct impact is spending of savings on electricity on local goods and services. The indirect benefits refer to the so-called “supply chain” activities necessary to provide local goods and services purchased because of the electricity savings. The induced impact happens as jobs created through the direct and indirect spending creates wages which are also then spent on local goods and services, which recirculate to other area businesses that also invest locally (Laitner et al., 2012). As an example of the induced effect, electricity bill savings from higher energy efficiency could pay for music lessons, the music teacher may spend that extra income at a farmer’s market, and the farmer may spend that extra money for organic compost from a neighbouring farm. On and on the money and wealth circulate.

Buying locally enhances the "velocity" of money, or circulation speed, in the area. When currency circulates more quickly, the money passes through more hands—and more people benefit. More goes into input activities that put that money right back in the community.

5.3 ***Local Employment Benefits*** of Replacing Older Room ACs

The effort required to replace all older RACs will increase Morocco’s local production capacity for goods and services, which will increase both the resilience and vitality of the regional economy. Reducing imports of traditional fossil fuel and thermal power plants while fostering local markets for efficiency and coordinated clean energy supply will further enhance local economic development (Laitner, 2019). This takes advantage of the fact that Morocco has a surprisingly well-developed industry dedicated to value-added production of intermediate goods and services (OECD, 2018).

Employment in the RAC sector is substantially increased by the combination of increased economic activity of the RAC replacement:

- Labour for removal of older RACs with refrigerant recovered. Components and materials recycled for profit, resource conservation, and reduced waste, and to avoid the re-installation of inefficient RACs in other locations.
- Labour to transport, manage, and destroy obsolete ozone-depleting and GHG refrigerants in local cement kilns.
- Labour to install replacement super-efficient RACs using lower-GWP refrigerants.
- Labour to annually maintain the energy efficiency of new RACs, including refrigerant leak checking and heat exchanger cleaning.
- Wages associated with all of these new jobs will, in turn, induce even more local purchases within the economy, which further increases new labour opportunities.

Employment can be further increased by expanding local assembly and manufacture of RACs to serve the new combined market for replacement RACs and new installations, and from the expansion of training of skilled technicians with substantially expanded tools, such as refrigerant recovery machines, refrigerant identifiers, and advanced leak detectors. This expanded investment effort can be accomplished under the Montreal Protocol Multilateral Fund (MLF), while the expanded non-investment can be accomplished with new work of the United Nations Environment (UNE) OzonAction office, national ozone unit (NOU), and regional network.

5.4 ***Avoided Power Plant Benefits*** of Replacing Older Room ACs

The replacement of obsolete and inefficient RACs will result in extraordinary savings in power plant investment and electricity subsidies, with savings available for investment in clean energy, energy efficiency, or social programs.

Without transition to super-efficient RACs, governments and electricity consumers will have to pay to add new generation capacity to accommodate increasing numbers of RACs. In countries where electricity is subsidized, governments will also pay a penalty for inefficiency. With energy efficiency, Morocco can avoid new fossil fuel power plant construction and fuel and electricity imports, easing the burden on public finances.

The World Bank has calculated that governments in the Maghreb region will save $100-$234 in avoided power plant construction costs per efficient RAC installed (Khalfallah et al., 2016). In the scenario presented by the World Bank that considered RACs in new applications (and not the full replacement planned by the buyers club), the savings started at $100 per efficient RAC and grew to $234 in 2030 (Khalfallah et al., 2016, 56-57).

The Morocco World Bank scenario calculated a savings of $1.8 billion on unnecessary power plant construction in Morocco, with the avoided investment in electricity-generating capacity averaging $170 per RAC unit across the region (Khalfallah et al., 2016, xxi).

5.5 Community Benefits of Recovering and Destroying HCFCs and HFCs in Local Cement Kilns

The Montreal Protocol controls the *production and consumption* of ODSs and HFCs but allows use of those substances as long as a Party chooses. The Montreal Protocol endeavours to phase out ODSs and phase down HFCs fast enough to avoid surplus production, but has not always been successful at the delicate balance of 'enough' without 'too much.' Mindful that it costs nothing to destructively release unwanted ODSs and HFCs to the atmosphere, Parties have encouraged destruction by defining Production as "…the amount of controlled substances produced, minus the amount destroyed by technologies to be approved by the Parties and minus the amount entirely used as feedstock in the manufacture of other chemicals."[7]

Unfortunately, this definition has not materially protected ozone or climate because allowed production was typically far greater than demand. Mostly, destruction was only undertaken in response to government policy or corporate responsibility (not economics).

Parties not seeking to offset new production of ODSs or HFCs can choose destruction technology *approved or not approved* by the Montreal Protocol. The Technology and Economic Assessment Panel (TEAP) assessment of destruction technology focused on Destruction & Removal Efficiency (DRE) as a measure of the effectiveness of destruction but failed to appreciate that the stringent DRE (typically 99.99% destruction) is only achieved by technology so expensive to operate that little or no ODS or HFC destruction would be undertaken unless compelled by stringent and enforced regulations.

The pragmatic view of Morocco Buyers Club Project is that it is better to destroy >95% of HCFC and HFC in cement kilns, where the low cost can be offset by carbon credits and ozone benefits, than to release the substances to the atmosphere because more complete destruction is simply prohibitively expensive. Furthermore, the envisioned program to replace all older RACs has an economy of scale, because the automated machines can recover refrigerant while technicians undertake other tasks. Recovered refrigerants can be accumulated in leak-tight storage until operating circumstances at the cement kiln allow least cost destruction.

Portland cement is produced by heating calcium (usually limestone), silica and alumina (typically clay or shale), and iron (steel mill scale or iron ore) in cement kilns to temperatures of up to 1500°C. Under this intense heat, the raw materials blend to form a pebble-like substance called "clinker," which is later cooled and ground with a small amount of gypsum to produce cement (Tope and Walter-Terrinoni, 2018).

[7] Article 1, paragraph 5, of the Montreal Protocol. Parties also implemented the incentives of not granting Essential Use Exemptions when used ODS is available if "The controlled substance is not available in sufficient quantity and quality from existing stocks of banked or recycled controlled substances" (Paragraph 1 (a) and (b), Decision IV/25, 4th Meeting of the Parties, 1992).

When ODSs and HFCs are destroyed in properly managed cement kilns, hydrogen fluoride and hydrogen chloride generated by decomposition are absorbed by cement materials[8] (Ueno et al., 1997).

Chlorine (Cl) concentration in typical Portland cement is usually about 60–70 ppm (parts-per-million), with chlorine adversely effecting quantity at levels of above 200 ppm. Therefore, feed rates must be selected to keep the chlorine increase in the cement to acceptable levels even in the case of total absorption (Ueno et al., 1997).

GIZ, based on MLF proposals, estimated the 2016 cost of cement kiln destruction at US $3.50 to US $6.00/kg in contrast to export and destruction in a rotary kiln at US $7.00 to US $20.00/kg (GIZ Proklima, 2016, slide 49). The MLF (2008) estimated the average cost to destroy concentrated ODS in the United States at $1.50 to $12.50 per kg. For a comprehensive discussion of destruction worldwide see ICF (2018).

Ueno et al. (1997) estimated each kiln could efficiently destroy about 25 tons of CFCs per year when operated for lowest incremental cost of destruction, which should be similar for HCFC-22 and HFC-410A destruction.

The replacement of approximately 1,432,000 RACs more than five years old is expected to recover about 1,018 to 1,221 tones of HCFC-22 and 54 to 64 tones of HFC-410A (depending on the cooling capacity, portion of refrigerant charge remaining at time of replacement, and efficiency of recovery).

	HCFC-22		HFC-410A		Total	
Total unit	1,360,400		71,600		Min	Max
Charge [kg/kW]	0.25	0.3	0.25	0.3	0.25	0.3
Capacity [kW]	3.5	3.5	3.5	3.5	3.5	3.5
Recovery efficiency	0.9	0.9	0.9	0.9	0.9	0.9
Total recovered refrigerant [Ton]	1,071	1,286	56	68	1,128	1,353
Destruction efficiency	0.95	0.95	0.95	0.95	0.95	0.95
Total destroyed refrigerant [Ton]	1,018	1,221	54	64	1,071	1,286

Our estimates are based on the conservative expectations that:

- >95% of older RACs used HCFC-22 and <5% HFC-410A (which is 50% HFC-32 and 50% R-125) (Khalfallah, 2016),
- The average charge at time of removal is 250 to 300 grams per kW capacity (UNEP, 2014).

[8] In some circumstances toxic halogenated organic compounds, such as polychlorinated dibenzo-p-dioxins or dibenzofurans (PCDDs/PCDFs) may be emitted.

- Single mini-split air conditioners as typical residential cooling system, with cooling capacity of 3.5 kW[9]
- Recovery equipment removes 90% of the refrigerant from RACs when the compressor is functional (USEPA, 2020)
- Destruction in cement kilns is >95% efficient (Tope and Walter-Terrinoni, 2018).
- Total recovered refrigerants = number of RACs at EOL x average unit charge x recovery efficiency
- Total destroyed refrigerants = Total recovered refrigerants x destruction efficiency

Table 7-1: Typical configurations of air conditioner type

Type		Primary configuration	System layout	Capacity range (kW)	HCFC-22 charge range (kg)
Small self-contained	Window	Small self-contained	Self-contained	1 – 10	0.3 – 3
	Portable	Small self-contained	Self-contained	1 – 10	0.3 – 3
	Through-the-wall	Small self-contained	Self-contained	1 – 10	0.3 – 3
	Packaged terminal	Small self-contained	Self-contained	1 – 10	0.3 – 3
Split (non-ducted)		Non-ducted split	Remote	2 – 15	0.5 – 5
Multi-split		Non-ducted and ducted split	Remote	4 – 300	2 – 240
Split (ducted)		Ducted split	Remote	4 – 17.5	1 – 7
Packaged rooftop		Ducted commercial	Self-contained	7 – 750	5 – 200
Ducted commercial split		Ducted commercial	Remote	10 – 750	5 – 250

Cement kilns are approved by the Parties to the Montreal Protocol for destruction of HCFCs and recommended by TEAP as "high potential" for destruction of HFCs, pending better data on NDC.

The $CO_{2\text{-eq}}$ of the HCFC and HFC refrigerants destroyed can be part of the Morocco NDC to the Paris Climate Agreement and can be traded in carbon markets, with revenue depending on carbon prices at the time.

The cost of destruction of HCFC-22 and HFC-410A will be minimized by leak-tight storage at the cement kiln property and destruction whenever the kiln has excess thermal capacity, such as at the end of a batch of cement production, when the kiln is still hot enough for efficient chemical destruction.

[9] The vast majority of mini-split residential and commercial air conditioners manufactured prior to 2000 used HCFC-22 refrigerant. Mini-split air conditioners have average HCFC-22 charge levels of approximately 0.25 to 0.30 kg per kW of cooling capacity. The majority of non-ODP refrigerants applied to these products are HFC blends such as R-410A.

5.6 ***Avoided Energy Subsidies*** **of Replacing Older Room ACs**

Energy subsidies are a result of many factors, including under-pricing, collection losses, transmission and distribution losses, and tax policy.

The original purpose of price subsidies was to:

- Protect vulnerable population groups from unaffordable prices,
- Shield consumers from excessive volatility of international energy markets,
- Share resource rents from domestic fossil fuel, hydroelectric, and other natural resources, and
- Foster industrial growth and promote domestic industries.

The Buyers Club project has determined that energy efficiency and local clean power production from solar and wind sources can satisfy the same social goals at lower cost than subsidies, particularly in circumstances where a substantial portion of subsidy benefits are captured by wealthy citizens and not the intended low income beneficiaries.

Morocco's energy and food price subsidies date back to the 1930s and had reached 6.5% of GDP by 2012, with 70% going to energy products. Up to 75% of energy subsidies were going to the richest 20% of the population (Dewitt et al., 2018).

Price subsidies have been phased down and energy prices deregulated since 2012, with price subsidies only remaining for liquified petroleum gas (LPG).

Thus, a side benefit of the replacement of older RACs is to avoid future expensive and counterproductive subsidies.

6. Summary and Conclusions

The comprehensive Moroccan strategy to replace older, obsolete, and inefficient RACs with super-efficient RACs using lower-GWP refrigerants will have direct, indirect, and induced economic value, including reduced import of fossil fuel and fossil fuel powerplants; increased household wealth and local spending; new jobs in RAC removal and installation, refrigerant recovery, destruction, recycle and reuse; and annual preventative maintenance to maintain reliability, energy efficiency, and affordability over the life of the equipment.

The reduced cost of super-efficiency will justify rapid upgrades of MEPS, which can guarantee that technology in the interest of Morocco is offered for sale rather than obsolete and inefficient RACs that have been dumped into Morocco's markets, as has occurred in the past.

The head start on compliance with the Kigali Amendment to the Montreal Protocol will contribute toward satisfaction of the Moroccan NDC toward the Paris Climate Agreement and will reduce pollution in Morocco, as fossil fuel power plants are more rapidly eliminated and replaced with clean energy.

The large RAC sales in Morocco and proximity to European markets and supply sources will make Morocco an attractive base for expanding RAC manufacture and for training managers and technicians to implement similar investment throughout Africa.

Moroccan Banks like Bank of Africa, with branches in many African nations, will open new investment opportunities for others seeking the citizen, business, environmental and sustainability benefits of buyers clubs implementing comprehensive RAC replacement.

The Morocco Strategy of replacing older RAC equipment with next-generation super-efficient and low-GWP equipment can be adapted to developed countries tailored to achieve jobs and profits during economic recovery and to secure lasting reductions in GHG emissions from lower-GWP refrigerants and higher efficiency.

APPENDIX:
Inventory of RACs in Morocco by Age, Assumptions Necessary for Benefits Estimation

Single split-RAC age	# of units in Morocco	Data Source(s)
<1 year old	113,000 (estimate)	https://www.jraia.or.jp/english/World_AC_Demand.pdf
1 year old	131,000	JRAIA. Based on 2018 sales.
2 years old	119,000	JRAIA. Based on 2017 sales.
3 years old	114,000	JRAIA. Based on 2016 sales.
4 years old	120,000	JRAIA. Based on 2015 sales.
5 years old	120,000	JRAIA. Based on 2014 sales.
6 years old	118,000	JRAIA. Based on 2013 sales.
>7 years old	1.2 million	World Bank. Khalfallah, Ezzedine; Missaoui, Rafik; El Khamlichi, Samira; Ben Hassine, Hassen. 2016. Energy-Efficient Air Conditioning : A Case Study of the Maghreb. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/25090 The World Bank estimated an installed stock 1.4 million AC units as of 2013 based on sales in Morocco between 2000—2013. The 1.2 million figure assumes that 90% of AC units were RAC (split type) and that 5% of that inventory has been retired since the World Bank estimate was published.
Total:	2,035,000	Installed split-type RAC units in Morocco as of the end of 2019. IGSD estimate based on JRAIA and World Bank data.

Average size: 12,000 British thermal unit (BTU)/hr

Residential/Commercial: In 2015, the World Bank estimated 60% of the installed stock of AC was non-residential and only 40% residential use. By 2030, they expect 56% of installed AC to be residential and 44% non-residential.

Run time: 63 days per year, 4.8 hours per day for residential
72 days per year, 5.8 hours per day for commercial

Recent sales:
- Inverter-type: 30% inverter, 70% non-inverter.
- Average efficiency: 2.69 EER for new models sold as of 2013 according to World Bank Report. Actual efficiency is lower due to equipment degradation over time. Improper installation drastically increases energy use. The World Bank "Baseline" scenario assumed that efficiency would improve to just 3.1 EER (installed base average efficiency) by 2030.

Sales before 2010:

Inverter-type: 0% inverter; 100% non-inverter

Average efficiency <2 EER, slowly improving to 2.46 EER in 2006; more degradation in efficiency than newer units

T&D losses: 13.6% (World Bank)

Efficiency potential: The World Bank modelled improved RAC efficiency to an installed fleet-wide average of 3.9 EER by 2030 and found it would save over 5,000 gigawatt-hours and save Morocco nearly $2 billion USD in avoided power plant construction costs. The Morocco Banker's AC Buyers Club and government partnership will move first to ISEER 5.2 and then to >ISEER 5.6 or better on an accelerated timeline,

Subsidies: Morocco spent USD $5.6 billion (48.2 billion Moroccan dirhams, DH) on energy subsidies in 2012, over 40% went to electricity subsidies. Efficient RAC could save the government billions per year. (World Bank).

Typical price: US$ 380 to US$ 490

Typical refrigerants: R-22 (all older units) and R-410A (some recent units). World bank estimated 95% of installed stock used R22 as of 2015. World Bank authors also noted that "following the prohibition of HCFC-22 in a number of developed countries, the Maghreb region (Algeria, Morocco, Tunisia, Libya and Mauritania) markets were flooded with air conditioning equipment using R-22 at rock-bottom prices, creating serious problems for the renewal and maintenance of equipment stock, and ultimately jeopardizing the commitments made in the context of the Montreal Protocol."

Popular brands: LG, Carrier, and Midea. More brands are offered as manufacturers
come to appreciate the marking opportunities. Many are manufactured by the
same company and labelled for retail distribution by the various brands.
All RAC units are imported.
Most originate from China, Thailand, and the United Kingdom.
Some from Egypt and the European Union.

Average refrigerant charge and portion recovered at removal depending on age: Almost all HCFC-22 used in Morocco is for the RAC sector. Reported consumption quantities by year are indicated in the table below, as well as ODP-tonnes and CO_2-eq tonnes of emissions that could be avoided if 95% were collected and destroyed in cement kilns. In short: Morocco could avoid 20-35 ODP tonnes per year and 500,000 to 1,000,000 tonnes CO_2-eq per year by destroying the HCFC-22; assuming it could be collected.

Table 1: HCFC consumption in Morocco

HCFC	2009	2010	Baseline (Avg. of '09 and '10)	2011-2013	2014	2015	2016	2017	2018
HCFC-22 (metric tonnes)	834.1	576.52	705.45	?	695.67	306.89	488.66	593.46	425.45
HCFC-22 (ODP tonnes)	45.88	31.71	38.80	?	38.26	16.88	26.88	32.64	23.40
ODP tonnes that could be avoided if 95% of this consumption was destroyed in cement kilns:	43.586	30.1245	36.86		36.347	16.036	25.536	31.008	22.23
HCFC-22 (GWP tonnes, AR5 GWP_{100} =1760)	1,468,016	1,014,675	1,241,592	?	1,224,379	540,126	860,042	1,044,490	748,792
CO2-eq emissions that could be avoided if 95% of this consumption was destroyed in cement kilns:	1,394,615	963,941	1,179,512		1,163,160	513,120	817,040	992,266	711,352

Source: UNEP/OzL_Pro/ExCom/83/82, 6 May 2019. Project Evaluation Sheet: HCFC phase out plan for Morocco

According to UNEP, "The total consumption of HCFC-22 [in Morocco] is used in the refrigeration and air-conditioning (RAC) sector, and mostly for servicing equipment. The overall consumption has been decreasing due to the enforcement of the licensing and quotas systems, activities in the refrigeration servicing sector included in stage I [of the HCFC Phaseout Management Plan -- HPMP] and the import of non-HCFC-based RAC (refrigeration and air conditioning) equipment into the country. Yearly fluctuations of HCFC-22 consumption are due to market demands, the availability of use of stocks from previous years, and the local economic situation."

Sources:

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- UNEP, 6 May 2019. Project Evaluation Sheet: HCFC phase out plan for Morocco. UNEP/OzL_Pro/ExCom/83/82

Other AC Sales:

Window Type AC	# of units in Morocco	Data Source
<1 year old	3,000 (estimate)	https://www.jraia.or.jp/english/World_AC_Demand.pdf
1 year old	3,000	JRAIA. Based on 2018 sales.
2 years old	2,000	JRAIA. Based on 2017 sales.
3 years old	2,000	JRAIA. Based on 2016 sales.
4 years old	No data	
5 years old	No data	
6 years old	No data	.
>7 years old	No data	
Total:	Unknown	Window-type AC units are uncommon in Morocco. JRAIA data on window-type units extends back only to 2016.

Commercial Air Conditioners	# of units in Morocco (PAC type)	Data Source
<1 year old	13,000 (estimate)	https://www.jraia.or.jp/english/World_AC_Demand.pdf
1 year old	15,000	JRAIA. Based on 2018 sales.
2 years old	13,000	JRAIA. Based on 2017 sales.
3 years old	13,000	JRAIA. Based on 2016 sales.
4 years old	13,000	JRAIA. Based on 2015 sales.
5 years old	13,000	JRAIA. Based on 2014 sales.
6 years old	12,000	JRAIA. Based on 2013 sales.
>7 years old	100,000	ESTIMATE by IGSD; assumes that installed stock as of 2013 is approximately equal to total sales from 2013-present, similar to RAC.
Total:	192,000	ESTIMATE. See explanation above.

Selected Acronyms and Abbreviations

AC	air conditioner, air conditioning
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
AR5	Assessment Report 5 of the IPCC
BAU	business-as-usual
BTU	British thermal units
CEEE	Center for Environmental Energy Engineering, University of Maryland
CFC	chlorofluorocarbon
Cl	chlorine
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalent
DRE	destruction and removal efficiency (of ODSs and HFCs)
DRIPE	demand reduction induced price effects
EER	energy efficiency ratio
EESL	Energy Efficiency Services Limited
EL-LCCP	Enhanced and Localized Life Cycle Climate Performance
ESMAP	Energy Sector Management Assistance Program (World Bank)
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GIZ	Gesellschaft für Internationale Zusamenarbeit
GOI	Government of India
GWP	global warming potential
HC	hydrocarbon
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HPMP	HCFC Phaseout Management Plan
IGSD	Institute for Governance & Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
ISEER	India Seasonal Energy Efficiency Ratio
JARN	Japan Air Conditioning, Heating & Refrigeration News
JRAIA	Japan Refrigeration and Air Conditioning Industry Association
LCCP	life-cycle climate performance
LPG	liquified petroleum gas
MAC	motor vehicle or mobile air conditioning
MAGHREB	Predominately the Muslim north African region of Algeria, Morocco, Tunisia, Libya and Mauritania
MEPS	minimum energy performance standard
MITI	Ministry of Trade and Industry (Japan)
MLF	Multilateral Fund of the Montreal Protocol
NDC	nationally-determined contribution (to the Paris Climate Accord)
NOU	National Ozone Unit
ODP	ozone-depletion potential
ODS	ozone-depleting substance
OECD	Organisation for Economic Cooperation and Development

RAC	room air conditioner
SEER	Seasonal Energy Efficacy Ratio
TEAP	Technology and Economic Assessment Panel
TERI	The Energy and Resources Institute
U4E	United for Efficiency (UN Environment)
UNDP	United Nations Development Programme
UNE	United Nations Environment
UNFCCC	United Nations Framework Convention on Climate Change

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