KIGALI
COOLING EFFICIENCY PROGRAM

UNDP

GUIDANCE FOR INTEGRATING EFFICIENT COOLING IN NATIONAL POLICIES IN LEBANON

MAY 2021

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AC	Air Conditioner
AE	Annual Energy
BAU	Business as Usual
BDL	Banque Du Liban (Central Bank of Lebanon)
BOD	Board of Directors
BUR	Biennial Update Report
CAGR	Compound Annual Growth Rate
CDD	Cooling Degree Day
CDM	Clean Development Mechanism
CE	Coordinating Entity
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CER	Certified Emission Reduction
CIF	Climate Investment Funds
CO_2-eq	Carbon Dioxide Equivalent
COM	Council of Ministers
CSPF	Cooling Seasonal Performance Factor
CTF	Clean Technology Fund
DAC	Development Assistance Committee
DC	Direct Current
DEL2	Deliverable 2 of this assignment
DEL3	Deliverable 3 of this assignment
DOC	Declaration of Conformity
EDL	Electricité du Liban (Electricity of Lebanon)
EE	Energy Efficiency
EEI	Energy Efficiency Index
EER	Energy Efficiency Ratio
ER	Emission Reduction
EU	European Union
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gas
GSP	Global Support Programme
GWh	Gigawatt Hour
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HFC-134a	Tetrafluorethane
HFO	Hydro-fluoro-olefin
HPMP	HCFC Phase-out Management Plan
HSPF	Heating Seasonal Performance Factor
IE	Implementing Entity
IEC	International Electrotechnical Commission
IKI	International Climate Initiative
IPCC	Intergovernmental Panel on Climate Change
IRI	Industrial Research Institute
ISO	International Organization for Standardization
ITMO	Internationally Transferred Emission Reductions
JI	Joint Implementation
KA	Kigali Amendment
K-CEP	Kigali Cooling Efficiency Program
kW	Kilowatt
kWh	Kilo-watt Hour
LCC	Lifecycle Cost
LCEC	Lebanese Centre for Energy Conservation
LEEREFF	Lebanon Energy Efficiency and Renewable Energy Finance Facility
Libnor	Lebanese Standards Institution
MAC	Mobile Air Conditioner
MDB	Multilateral Development Bank
MEPS	Minimum Energy Performance Standards
MIT	Mitigation
MLF	Montreal Protocol's Multilateral Fund
MOE	Ministry of Environment
MOEW	Ministry of Energy and Water
MOP	Meeting of the Parties
MP	Montreal Protocol
MRV	Monitoring, Review, and Verification
$MTCO_2eq$	Metric Ton Carbon Dioxide Equivalent
NAMA	Nationally Appropriate Mitigation Action
NAP	National Adaptation Plan
NC	National Communication
NCP	National Cooling Plan
NDC	National Determined Contribution
NEEAP	National Energy Efficiency Action Plan
NEEREA	National Energy Efficiency and Renewable Energy Action
NGO	Non-Governmental Organization
NL	Norme Libanaise (Lebanese Norm)
NOU	National Ozone Unit
ODA	Official Development Assistance

ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substances
OECD	Organization for Economic Cooperation and Development
PA	Paris Agreement
R134a	Tetra-fluoro-ethane
R22	Chlorodifluoromethane
R290	Propane
R404A	Blended cooling agent from R134a (4%), R143a (52%), R125 (44%)
R410A	50 % R-32, 50 % R-125
R600a	Isobutane
R717	Ammonia
R744	Carbon Dioxide
RAC	Refrigeration and Air-Conditioning
RE	Renewable Energy
SAE	Standard Annual Energy
SEER	Seasonal Energy Efficiency Ratio
UAC	Unitary Air Conditioner
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
VCS	Verified Carbon Standard
WP	Work Program
WTP	Willingness to Pay

1 EXECUTIVE SUMMARY

1. EXECUTIVE SUMMARY

As a member party to the Paris Agreement and signatory of the Montreal Protocol's (MP) Kigali Amendment (KA), Lebanon also has an obligation to reach climate targets, i.e. net Greenhouse Gas (GHG) neutrality latest by the middle of this century. This goal can be reached through its increasing ambition and setting specific sector goals within Lebanon's Nationally Determined Contributions (NDC). This "National Cooling Plan" (NCP), outlines that cooling sector plays a critical element for Lebanon to achieve these targets under the Paris Agreement, the Montreal Protocol and the Kigali Amendment. The NCP includes the pathway for the transition to lower indirect and direct emissions through enforced Energy Efficiency (EE) requirements and the phasedown of high Global Warming Potential (GWP) refrigerants and foam blowing agents. The NCP also serves the purpose in providing affordable access to cooling to the population, in meeting Lebanon's Sustainable Development Goals (SDGs) and meeting Lebanon's economic development targets.

Two major Refrigeration and Air Conditioning (RAC) subsectors are low hanging fruits to reduce the country's emissions and improve energy efficiency, **Residential Air Conditioners (ACs) and Domestic Refrigerators**.

Globally, ACs, accounted in 2015 for approximately 20 percent of the residential electricity demand in 150 developing and emerging countries. In those countries, the number of room air conditioners in use is expected to increase to 1,5 billion in the next 15 years. Air conditioning makes up a significant portion of household energy demand particularly in regions with hot climates where periods of high use correlate with peak demand[1]. Residential refrigerators accounted for approximately 10 per cent of global electricity consumption in households. The number of refrigerators is expected to double to just under two billion in the next 15 years (U4E Policy Guide Series, Energy efficient and climate friendly air conditioners and refrigerators, 2017).

The NCP includes the five following main parts:

- the **market study**, performed in the second quarter of 2019, aimed to better understand the stock of appliances' and their technical and performance characteristics,
- a proposal for a **MEPS and Labels regulation** based on the survey results and the regional and international best practices,
- the **financing approach** to support the introduction of energy-efficient appliances through the enforcement of a MEPS and Labels system,
- a proposal for the integration of the **NCP into Lebanon's NDC,**
- a **roadmap** for the transition to carbon neutrality in the cooling sector by 2050.

The market study established Lebanon's first RAC GHG inventory for all major RAC subsectors including unitary air conditioning, chiller, mobile air conditioning, domestic-, commercial- and transport refrigeration and the in-depth assessment of the key appliance types, room air conditioners and domestic refrigerators, with a proposal for the future introduction of MEPS and labels for these appliances.

The market study combines refrigerants and energy use of RAC appliances. With its projection of business as usual emissions and mitigation scenarios, the RAC assessment is an important input for the development of mitigation options as serving the targets of both the Kigali Amendment (KA) under the Montreal Protocol (MP) and toward the National Determined Contributions (NDCs) under the Paris Agreement (PA).

The assessment of the RAC sector provided the following key findings:

- The RAC sector accounts currently for about 7.7 $MTCO_2$-eq in annual GHG emission and 6,000 GWh (2018) in electricity consumptions which is about 26%[2] of Lebanon's total electricity demand. Under the Business as Usual (BAU) scenario, the GHG emission will increase to 10 $MTCO_2$-eq and about 8,000 GWh in electricity consumption by 2030.
- With the transition to energy-efficient and low GWP RAC appliances, GHG emissions can be lowered, by 2050, to 4.5 $MTCO_2$-eq and electricity demand to below 5,000 GWh. This assumes a constant combined grid emission factor. With the combined transition to low GWP refrigerants, higher energy efficiency and the deployment of renewable energies a target of zero emissions by 2050 can be achieved as implied in the targets of the Paris Agreement (Paris Agreement, Article 2, 2015; IPCC, Special Report on Global Warming 1.5C, 2018). The Table 1 below summarizes the GWh savings, from the RAC sector, under the MIT scenario versus the BAU scenario for 2030 and 2050. Note this is only from compression cooling powered by electricity (MAC and transport refrigeration are not included).

1- It should be noted that in regions where both seasonal cooling and heating, such in Lebanon, are required, frequently dual mode units are installed which use both heating and cooling This report mainly focuses on the cooling aspects.

2- RAC sector electricity demand based on the analysis carried out through the project analysis of the NCP and the total electricity demand has been taken from.

Table 1: RAC sector: potential GWh savings in 2030 and 2050 for BAU and MIT scenarios.

RAC emissions scenario	Year 2030	Year 2050
BAU (GWh)	7,996	7,610
MIT (GWh)	6,578	4,634
Savings (GWh)	**1,418**	**2,976**

- Mitigation action is most important in the AC and refrigerator sector which account for about two-thirds of the GHG emissions of the RAC sector and about 5,000 GWh of electricity consumption.

Mobile Air Conditioning (MAC) is the third most important sector in terms of national emissions in Lebanon. This sector is controlled by the major car manufacturers, mainly located in developed economies, with limited intervention options through smaller countries to influence the choice of technology.

In order to achieve the emissions' reduction goal, the NCP recommends the implementation of a mandatory **MEPS and Labels regulation** and shows the required adoption steps. Based on surveyed data, recommendations are provided for the MEPS and labels for refrigerators and ACs. The adoption of advanced energy efficiency standards and a transition to low GWP refrigerants are required to realize GHG savings. The adoption of increasingly ambitious MEPS and labels will not lead to higher costs for the end-users. Instead, with current electricity prices life-cycle-costs (LCC) for end-users will stay about the same; and with the expected higher electricity prices in the future, that LCC will even be lower for end-users and the economy. This "National Cooling Plan" (NCP), recommends the following elements towards the introduction of the MEPS and Labels regulation:

- Establishment of the Minimum Energy Performance Standards,
- Establishment of the Labelling System,
- Development of Testing Procedures.

As a third element of this report, there is a proposal for a Funding and Financing Mechanism to support the intended market transformation towards energy efficient and low GWP appliances targeted at the AC and refrigeration focus sectors. The Funding and Financing Mechanism refers to a consistent set of measure to accelerate that transition.

The Funding and Financing Mechanism covers the following key elements:

- An import levy on imported appliances and refrigerants linked to the energy efficiency and label classes of, initially, ACs and refrigerators, and the carbon content of refrigerants,
- An incentive mechanism based on carbon credits on the purchase of climate-friendly and efficient appliances linked to the return of old, inefficient cooling appliances sent for environmentally sound disposal,
- Financial mechanisms, like soft loans, and a baseline and credit program are proposed, whereby soft loans are used to support the private sector investment, while the baseline and credit program to cover the cost for a recycling and disposal facility,
- Available funding source from national and international programs. These are analysed regarding the available level of funding and their applicability in Lebanon.

The NCP includes recommendation to **integrate the NCP into Lebanon's NDC,** whereas climate friendly and energy efficiency cooling can contribute with a mitigation effort by up to 4 MT CO_2-eq or about up to 20% of Lebanon's current GHG emissions. Chapter 7 and a recommended **NCP roadmap** include recommendation for the integration of the NCP into sectoral measures of the NDC covering the energy, building, transport, industry, waste and agricultural sectors.

2 INTRODUCTION & BACKGROUND

2. INTRODUCTION AND BACKGROUND

2.1 General introduction

Climate change is rapidly becoming one of the most important policy issues worldwide and it's no different for Lebanon. As a signatory to both, the Paris Agreement and the Montreal Protocol (including the Kigali Amendment) Lebanon is looking to deliver on its international commitments as well as reaping the multiple benefits from rational energy efficiency and environmental policies such as enabling the already stretched electricity system to meet a greater proportion of demand in the country, reduction of noxious emissions (i.e. particulates), and reducing Investment needs on the electricity grid.

In hot climate countries, cooling is a significant contributor to GHG emissions, usually contributing between 5 and 15 percent (IEA report, The Future of Cooling, 2018) of energy-related emissions. As outlined in the NCP, Lebanon has a high ownership of refrigerator and AC ownership and an above average share of cooling emissions with about 26% of total emissions.[3]

As such, a transition to low-emission cooling in Lebanon is an important aspect that should be integrated into Lebanon's development strategies.

In this context the NCP looks at the greenhouse gases (GHG) and ozone-depleting substances (ODS) from cooling demand in all its forms. The plan identifies potential energy demand reduction, energy efficiency interventions, the transition from high to low GWP refrigerants, and proposes a timeline for the implementation of these actions in an integrated national cooling plan. There is a focus on the appropriate framework to implement Minimum Energy Performance Standards (MEPS) and labelling system for the domestic refrigeration and air-conditioning sectors as the current main contributors to carbon emissions and energy consumption.

The NCP was developed by a consortium led by HEAT GmbH and included OTB Consulting and First Climate AG as partner companies. The work was carried out under the direct supervision of UNDP National Ozone Unit Project Manager and in coordination with the global UNDP team of the K-CEP Programme as well as the Ministry of Environment of Lebanon. The NCP is funded by the Kigali Cooling Efficiency Programme (K-CEP) through the United Nations Development Programme (UNDP).

2.2 Legal framework

Lebanon has committed to several national and international regulations and agreements relevant to the RAC sector. These are explained below based on their key focus:

- **Climate policies.** Lebanon has signed the Paris Agreement on 22 April 2016. The Lebanese parliament has ratified the Paris Agreement on March 6th, 2019. The instrument of ratification has being deposited with the UN on February 5th, 2020. In September 2015 Lebanon has submitted its first Nationally Determined Contribution (Ministry of Environment, 2015), which already explicitly mentions that its electricity infrastructure needs to cope with increased demand for cooling.
- **Energy policies.** Lebanon has issued several national policies to improve the energy efficiency of energy use sectors, including the RAC sector. These policies include the second National Energy Efficiency Action Plan (NEEAP) 2016-2020. The NEEAP addresses both primary and end-user-oriented energy savings. The decarbonization of the energy supply has been addressed through the National Renewable Energy Action Plan 2016-2020. The Ministry of Energy and Water (MOEW), has in 2019 issued the "The Updated Policy Paper for the Electricity Sector" (MOEW (2019)) to deal with the chronical power shortages faced in the country through introducing measures including the reducing losses, adding power generation capacity and increasing power tariffs.
- **Refrigerant related policies.** The XIXth Meeting of the Parties (MOP) to the Montreal Protocol in September 2007, through its Decision XIX/6, adopted an accelerated phase-out schedule for hydrochlorofluorocarbons (HCFC) as shown in Figure 1 below. With its ratification of the Kigali Amendment on February 5th, 2020, Lebanon needs to phase-down the use and consumption of hydrofluorocarbons (HFC) along with the phase-out of HCFCs. Importantly, the Kigali Amendment encourages parties to enhance the energy efficiency of appliances along with the transition to low GWP refrigerants.

3- Cooling emission according the analysis undertaken as part of the NCP and total emissions adopted from https://www.pik-potsdam.de/paris-reality-check/primap-hist/#scenario=histcr&id=lbn&entity=kyotoghgar4

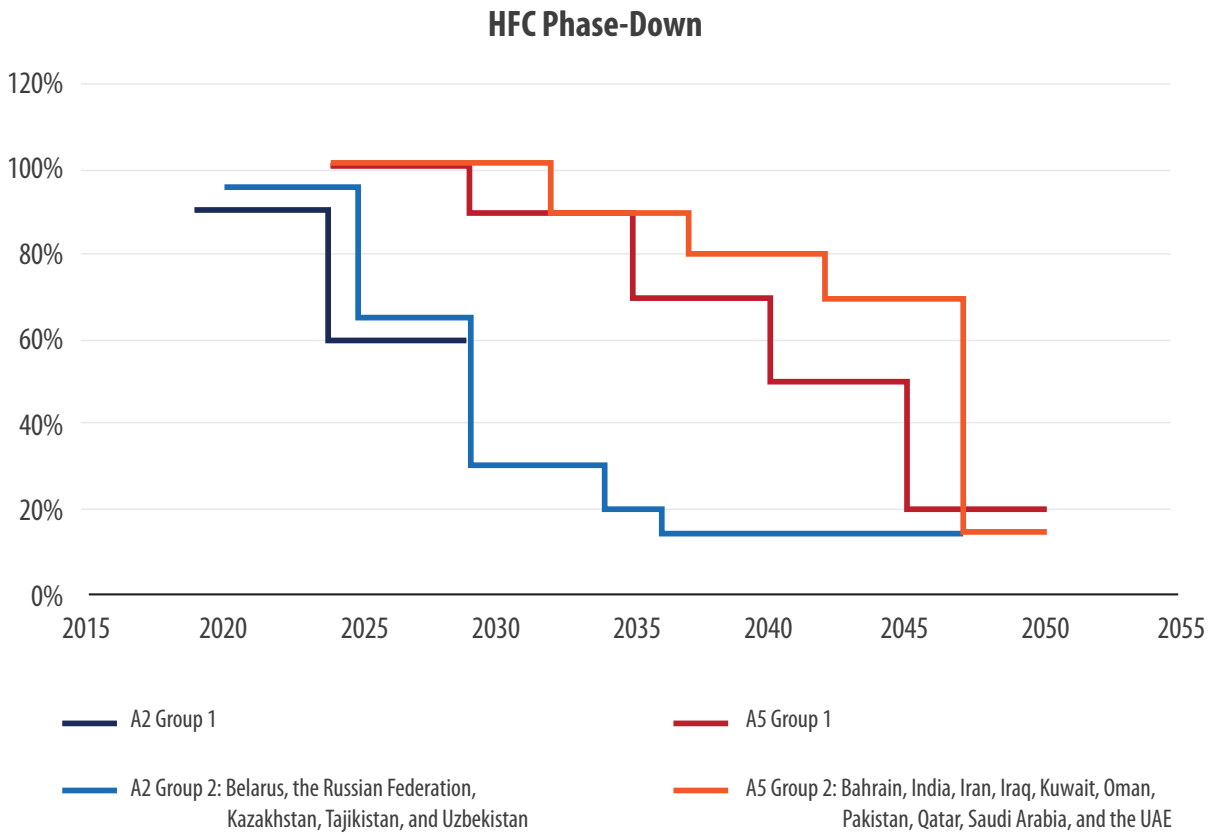

Figure 1: HFCs phase-down per Kigali Amendment to the Montreal Protocol.

2.3 NCP objectives and elements

The NCP aims at an effective action plan that tackles GHG and ODS emissions with coherent policies. To meet these objectives the development of the NCP covered discrete elements of work as shown in Table 2 below. The first three produce the foundational basis with information on the current state of cooling activities and appliance markets as well as the current state of cooling policies in Lebanon. The following three elements generate the necessary recommendations and tools to achieve the NCP's objectives. The final element is capacity building and awareness necessary to empower local officials and institutions to implement the tools effectively.

Table 2: Development steps of the NCP

Elements	Development steps description
1	General overview and analysis of the refrigeration and air conditioning (RAC) sector, including a market survey of cooling appliances.
2	Overview and projection of electricity consumption in the RAC sector and electricity demand in Lebanon.
3	Assessment of the RAC energy efficiency regulations and national policies.
4	Recommendations for the establishment of Minimum Energy Performance Standards (MEPS), a labelling programme and the development of test procedures.
5	Assessment and proposals of funding and financial mechanisms for market transformation
6	Development of a National Cooling Plan
7	Capacity Building and Awareness

This NCP report brings together all the information gathered during the stages of its development to formulate robust recommendations and guidance for the sustainable and low carbon development of cooling in Lebanon.

The objectives of the NCP include:

- Provide information on the current state of the market and projections of the potential future paths of energy demand and GHG emissions for the RAC sector,
- Identification of key subsectors with the highest GHG emissions as well as the highest emission reduction and energy-saving potential,
- Provide recommendations and the background support for the development and implementation of mitigation measures, especially a MEPS and Labelling scheme for the domestic refrigerators and Unitary Air Conditioners (UAC),
- Provide recommendations to support Lebanon's Monitoring, Reporting and Verification (MRV) activities,
- Support the development and achievement of Lebanon's National Determined Contribution (NDC) targets based on the GHG projected emissions and mitigation measures defined and implemented in the RAC sector,
- Provide recommendations to support the preparation for the implementation of the Montreal Protocol (MP), especially the Kigali Amendment.

This NCP report concentrates first on a summary of the current state of demand for cooling services and appliances in Lebanon as well as the status of energy efficiency and environmental policy in this sector. Then, the report proposes a series of interventions oriented towards achieving Lebanon's Paris and Montreal related commitments. The report will delve into the financial aspects of implementing the mentioned interventions, from revenue gathering through levies or penalty payments to providing direct subsidies to stimulate action. Finally, the report provides an action plan with suggested interventions and an optimum timeline for implementation.

3 METHODOLOGY

3. METHODOLOGY

3.1 Baseline information

The first step in the development of the NCP was to establish a comprehensive baseline understanding the status of the RAC sector in Lebanon beginning with a definition of the sector's boundaries. This was followed with a careful analysis of all the stakeholders, their role in the sector and their level of involvement in the project.

3.2 Sector and subsector definitions

A bottom-up approach was applied to gather the necessary data to build the RAC appliances inventory and enable historic inventory estimates and make future projections of the inventory, cooling energy use, and GHG emissions. The RAC sector is composed of a series of applications that spans several industries, consumer sectors, and appliances. For the purposes of this project the RAC sector has been broken down into six key subsectors covering multiple types of appliances as shown in Table 3 below.

Table 3: RAC subsectors and appliance types

Subsector	Appliance types
Unitary air conditioning (UAC)	Window-type air conditioners
	Split residential air conditioners
	Split commercial air conditioners
	Duct split residential air conditioners
	Commercial ducted splits
	Rooftop ducted
	Multi-splits
Chillers	Air conditioning chillers
Mobile air conditioning	Car air conditioning
	Large vehicle air conditioning
Domestic refrigeration	Domestic refrigerators
Commercial refrigeration	Stand-alone equipment
	Condensing units
	Centralized systems for supermarkets
Transport refrigeration	Transport refrigeration

This detailed data collection and breakdown enabled analysis that meets the Intergovernmental Panel on Climate Change (IPCC) 2006 Tier 2 (GIZ, RAC NAMA Technical Handbook, MODULE 1, 2013) requirements for direct and indirect emissions. In this context, direct emissions are related to refrigerant losses on each appliance and indirect emissions are those related to the generation of the electricity used for cooling.

3.3 Key stakeholders

A key element of the initial step of the project is the identification of all the players in the RAC sector, the role that they currently have in the sector, what influences them, and the potential impacts that the implementation of the recommended policies may have on them. These key players and their role are detailed in Table 4.

Table 4: Overview of involved stakeholders for the RAC assessment

Stakeholder	Roles and responsibility
LIBNOR	Lebanon's regulatory body issuing and adopting standards and potentially labels
Industrial Research Institute (IRI)	National authority for the testing of industrial equipment and appliances
Lebanese Customs Authority	The authority in charge of controlling the imports of RAC appliances. Providing data on imports and exports of RAC equipment and refrigerants
Car Registration Authority	Responsible for the registration of vehicles in use in Lebanon. Providing data on the registration of vehicles in Lebanon
K-CEP	Climate fund manager, funding UNDP and the NCP of Lebanon project
Manufacturers and assemblers	Local manufacturers and assemblers of RAC equipment; they will be directly affected by MEPS enforcement
Ministry of Environment (MOE) - National ozone unit (NOU)	The ministry is the host of Lebanon's UNFCCC climate focal point and overseeing the majority of climate change and environmental projects in Lebanon. The ministry is also the National Focal Point for the Montreal Protocol and activities carried out under the Montreal Protocol. The ministry is responsible for setting refrigerant quotas to local suppliers. The NOU is a UNDP project concerning Montreal protocol activities and initiatives.
Order of Engineers and Architects	The national organizations hosting engineers and architects in Lebanon. They regularly publish reports and studies on energy performance in appliances and buildings.
LCEC	Housed within the Ministry of Energy and Water, responsible for energy efficiency and renewable energy activities. Their role includes supporting the MoEW To set-up national strategies, implementing RE&EE initiatives, and supporting Libnor on standards and MEPS.
Ministry of Energy and Water	Ministry responsible for the national electricity utility (EDL) and overseeing Lebanon's energy sector
RAC Sellers	Retailers and sellers of RA equipment in both retail and wholesale
End users	Households and other users buying and using RAC equipment. MEPS will have a direct impact on their energy consumption and maybe the cost of equipment
Servicing companies	Companies performing aftersales service to RAC equipment

Of importance in the list above, are the key stakeholders involved in the implementation of MEPS and labelling policy as they need to ensure that the design of the policy generates the maximum benefit for all stakeholders yet have enough strength to effect change. RAC manufacturers have also been highlighted as a key stakeholder, as the government places high value in the survival and growth of local businesses.

3.4 Data collection

The data for this inventory was collected from primary and secondary sources. The following activities were carried out to obtain information for completing the RAC inventory assessment:

- A national kick-off workshop in Beirut on May 27, 2019. It took place at the MOE with relevant stakeholders, with main outcomes included in the inception report.

- Primary data was gathered through a detailed survey performed at local shops, sales points, and supermarkets (See section 3.5).
- More primary data was collected through a supplier-specific survey aimed at distributors and manufacturers. Twelve questionnaires were completed accounting for around 45% of the market share for each of the 7 subsectors. In addition, an online survey was used for additional data collection (links to these surveys are in Annex 1),
- Secondary data were obtained from statistical outputs of government departments, reviewing previous surveys data, custom offices for imported equipment and refrigerants, IPCC default values, expert opinions.

The following challenges were encountered during the data collection work from the primary data sources:

- Reluctance to provide information or provision of only partial information due to the confidentiality policy of the companies.
- Difficulties in filling out questionnaires on the part of the companies; questionnaires had to be explained during personal visits to get the needed information, although a simplified online version was provided.
- Despite multiple feedback loops, the attribution of collected equipment's data to the appliance groups defined in the inventory was difficult.
- Contradicting information was provided in some questionnaires, reducing the confidence level in some results.

3.5 Survey data collection

For two key subsectors, namely unitary air conditioners and domestic refrigerators, representing roughly two-thirds of total cooling demand, a survey of appliances currently sold in the Lebanese market was carried out to form the base of the recommendations for Minimum Energy Performance Standards (MEPS) and energy labels.

The largest supermarkets and sales point offering refrigerators and air-conditioners were surveyed to cover the biggest possible share of the market and understand what is offered to consumers. The survey was done through extensive field visits conducted by the project team, collecting information on the appliances' key data as described in Table 5. More than 25 shops across Lebanon were visited in the regions of Beirut, Mansourieh, Jbeil, Hazmieh, Saida, Jdeideh, Dora, Zahle, and Tripoli to provide a nationwide view on appliance sales.

Table 5: Survey data collected from RAC Sellers

Data collected for Air Conditioners	Data collected for refrigerators
Cooling capacity	Cooling Capacity
Energy demand	Refrigerator and Freezer volumes
Energy performance (EER)	Units energy capacity
Brand	Annual energy demand
Type	Unit price
Make	Brand
Labelling status	Appliance types
Country of origin	Refrigerant use
Refrigerant use	
Unit price	
Installation costs	

Currently, there are no MEPS and labels established in Lebanon. Accordingly, the appliances carry no uniform labelling of MEPS and labels. Some appliances carry labels from their country of origin however, these labels are not harmonized so the end-users in Lebanon have no consistent information on the energy performance of the appliances.

Given the lack of labels, the survey team manually checked the manufacturer specifications of each surveyed model, either in-store or on the manufacturers' websites to get the needed information.

3.6 Data analysis methodology

The analysis was based on the IPCC Tier 2 methodology[4] covering both the refrigerant and the energy-related emissions for the refrigeration and cooling appliances in use. The same approach is applied for estimating energy use.

IPCC Tier 2 methodology allows for the implementation of GHG mitigation actions (such as NAMAs) in relevant RAC subsectors and the integration of the RAC sector into the NDC development and the reporting of mitigation actions under the National Communications (NC) and Biennial Update Reports (BURs) as part of Lebanon's commitments to the UNFCCC.

For each of the subsectors and their respective appliance types, the methodology estimates an inventory of historic and future unit sales and stocks. From this, energy and refrigerant demand, as well as their respective emissions trends, were estimated. Finally, RAC appliances in use in Lebanon are compared with international best practice technologies to assess potential gains from the introduction of improved technologies. The approach considers the gradual replacement of the stock through the sale of new appliances.

A Business as Usual (BAU) and Emissions Mitigation scenarios were developed to highlight the potential size of the opportunities as well as providing insights on the possible costs and associated benefits. Both BAU and mitigation scenarios assume the development of appliances in use in line with the overall economic growth. The scenarios differ on the technical performance of the appliances and the use of alternative low-GWP refrigerants.

In order to estimate the direct (refrigerant related) emissions, it was necessary to account for refrigerant use and losses throughout the appliance's useful life:

- Refrigerants used to fill newly manufactured products,
- Refrigerants used to refill systems in operation to account for annual losses (average annual stocks),
- Refrigerants that remain in appliances at decommissioning,
- The modelling parameters for the analysis of this inventory in Table 6 were derived from primary and secondary data collections mentioned previously. Gaps were filled with default values from HEAT's expert judgement and similar RAC assessments in other countries such as Ghana, Indonesia, Thailand, Jordan, and many others, with special consideration to the case of Lebanon.

Table 6: Modelling parameters for the BAU scenario

Equipment type	Lifetime [years]	Main refrigerants	Initial charge (IC) [kg]	EER (2018)	Service emission factor[5] [% of IC]	Disposal[6] emission factor [% of IC]
Split residential AC	9	R22, R410A	0.9	3.2	10	95
Split commercial AC	9	R22, R410A	1.8	3.1	10	80
Rooftop ducted	9	R22, R407C, R410A, R134A	10	2.9	8	75

4- IPCC (Intergovernmental Panel on Climate Change) Tier 2 generally uses the same methodological approach as Tier 1 but applies emission factors and other parameters which are specific to the country.

5- Service emission factor is related to the direct emissions during servicing i.e. refrigerant leaks. It's a percentage of the initial charge emitted annually.

6- Related to the direct emissions at the appliances' disposal. It's a percentage of initial charge emitted at the end of life assuming the system was maintained till disposal.

Multi-splits	9	R22, R407C, R410A	15	3.6	10	80
Air conditioning chillers	20	R22, R134A, R410A	35	3.2	22	95
Car air conditioning	15	R134A	0.6	2.7	20	100
Large vehicle air conditioning	15	R134A	8	2.7	30	100
Domestic refrigeration	8	R134A, R600A	0.175	1.3	2	80
Stand-alone equipment	15	R134A, R404A, R290A, R744	0.4	2.8	3	80
Condensing units	20	R22, R134A, R404A, R744, R717	5	3.1	30	100
Centralized systems	30	R717	500	2.0	40	100

3.7 Cooling demand drivers

For the evaluation of future growth figures in the RAC appliance sectors, information is needed on the key drivers of cooling demand. These include:

- Population growth – influences the total number of households as well number of people per household, affecting cooling demand.
- Rates of urbanisation – Urban households usually have a higher probability of owning an AC or refrigeration unit, as well as making greater use of these appliances.
- Climate change – As climate change takes hold, it is likely to increase temperatures in the region causing increased demand for cooling.
- Economic growth – Increased economic growth will drive demand in the RAC sector as there is increased activity in the economy. Similarly, increasing wealthy households will make greater use of AC usually expressed in more or larger units working for a longer time.

Lebanon is a relatively small country with overran area of 10,452 km^2 with a population close to 5.5 million[7] resulting in a high population density of 527 people per square kilometre and ranks the 10th among the top 25 most densely populated country in the world. However, the UN projects a declining population in the 2020 – 2030 period, remaining roughly stable from 2030 until 2050. This is largely explained by the influence of the recent influx of refugees from neighbouring countries (mainly Syria). It is expected that a proportion of the refugees will return to their home countries in the 2020 – 2030 decade. The number of households follows population growth patterns[8].

Additionally, Lebanon hosts refugees from different origins, with around 224,901 Palestinian refugees in 2017[9], and additional refugees of 947,063 from Syria, 14,291 from Iraq, 1,941 from Sudan, and 1,996 from other nationalities as of January 2019[10]

As a result, it is expected that population growth, the number of households and the urbanisation will not be a major growth driver for RAC appliances.

Table 7 shows the current population and households in Lebanon. The number of population and households is estimated to remain stable over the coming years[11].

7- Population data: https://monthlymagazine.com/ar-article-desc_4858_

8- https://population.un.org/wpp/Graphs/DemographicProfiles/Line/422

9- Palestinian refugee's data: http://lpdc.gov.lb/DocumentFiles/8-10-2019-637068152405545447.pdf

10- Other refugees data: https://www.unhcr.org/lb/wp-content/uploads/sites/16/2019/03/UNHCR-Lebanon-Operational-Fact-sheet-February-2019.pdf

11- https://data.worldbank.org/indicator/SP.POP.GROW?locations=LB

Table 7: Population and household numbers

(Reference: Footnote 7)	2018
Population (number)	5,508,692
Households (number)	1,281,091[12]

Lebanon has a very high urbanisation rate which currently stands at 88.6% as shown in Table 8. The Urbanisation will remain at a very high level until 2050 and slightly increase towards 93.4%.

Table 8: Current and projected urbanization[13] growth

	Compound Annual Growth Rates (CAGR)				
	2018	2020	2030	2040	2050
Urbanisation	88.6%	88.9%	90.6%	92.1%	93.4%

At the end of 2019 and the beginning of 2020, Lebanon entered a difficult economic phase. During the course of the coming years it is expected that the economic activity in Lebanon will recover and to enter again on a growth path towards and annual growth rate of about of 3% until 2050 (Foure, Bénassy-Quéré and Fontagne, 2012).

Climate change is also expected to be a significant driver for cooling demand with increasing temperatures projected for Lebanon. An estimate from Climate Impact Lab (2019) indicates that the number of days with temperatures over 35°C will increase dramatically in the future as shown in Figure 2 below.

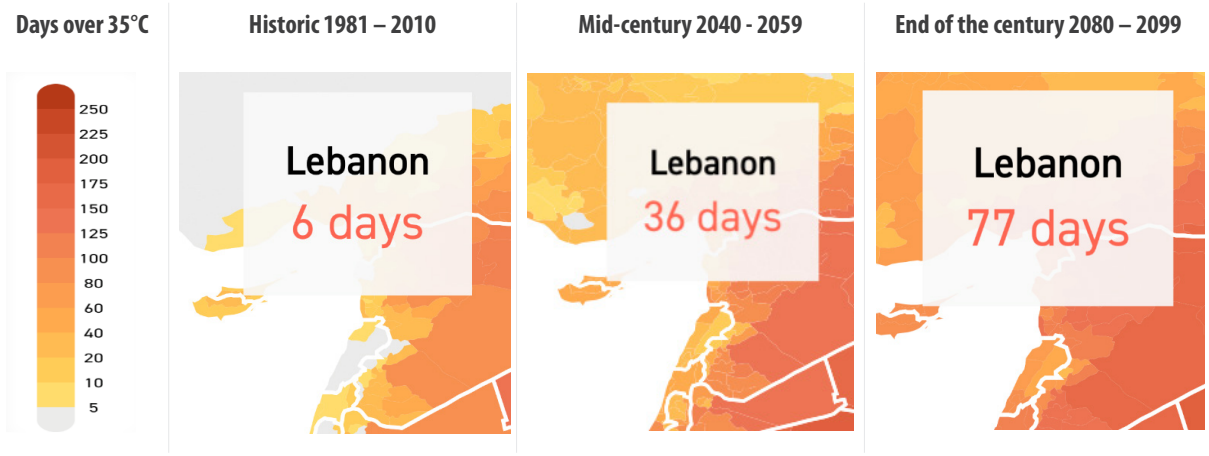

Figure 2: Expected temperature change from climate change (days >35°C) Source: Climate Impact Lab

12- https://www.un.org/en/development/desa/population/publications/pdf/ageing/household_size_and_composition_around_the_world_2017_data_booklet.pdf

13- See https://population.un.org/wup/Country-Profiles/

4 STATE OF THE COOLING SECTOR IN LEBANON

4. STATE OF THE COOLING SECTOR IN LEBANON

4.1 RAC appliances sales projections

In the year 2010 the sale of AC units (all types) was 277,000, with unitary AC making the bulk of sales with over 78%. However, from 2010 there is a significant drop in the market size of UAC, with many companies reporting a steep drop in their sales volume caused by an unstable economic situation. The numbers were also reflected in the annual import volumes as reported by the Lebanese customs, showing a drop of more than 33% in the imported appliances between 2010 and 2014 as indicated in Figure 3.

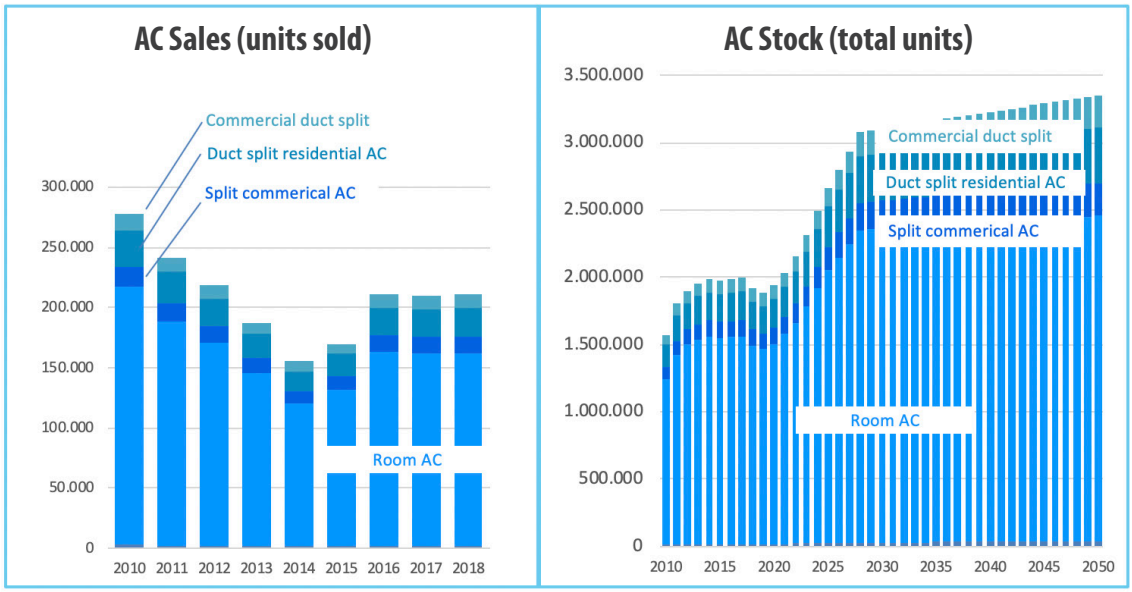

Figure 3: Development of Unitary AC sales and stock units

In the longer term, with an economy stabilizing, it is projected that the sales of air conditioners will recover, although not to the same levels of 2010. Other factors influencing the increase in sales and stocks are the increasing demand due to rising temperatures, the increasing affordability of AC with the predicted increase of the GDP per capita, and the still slightly increasing urbanization.

Figure 4 shows the progress of the market for air conditioning chillers and refrigeration chillers. During recent years, the market of process chillers was more dynamic than air conditioning chillers representing more than 75% of the market by 2018, compared to under 30% in 2010. The number of chillers is predicted to further increase over the coming years to exceed 3,000 chillers after the year 2025. The key drivers for the predicted future increase of the chiller stock are very similar as described above for room air conditioners.

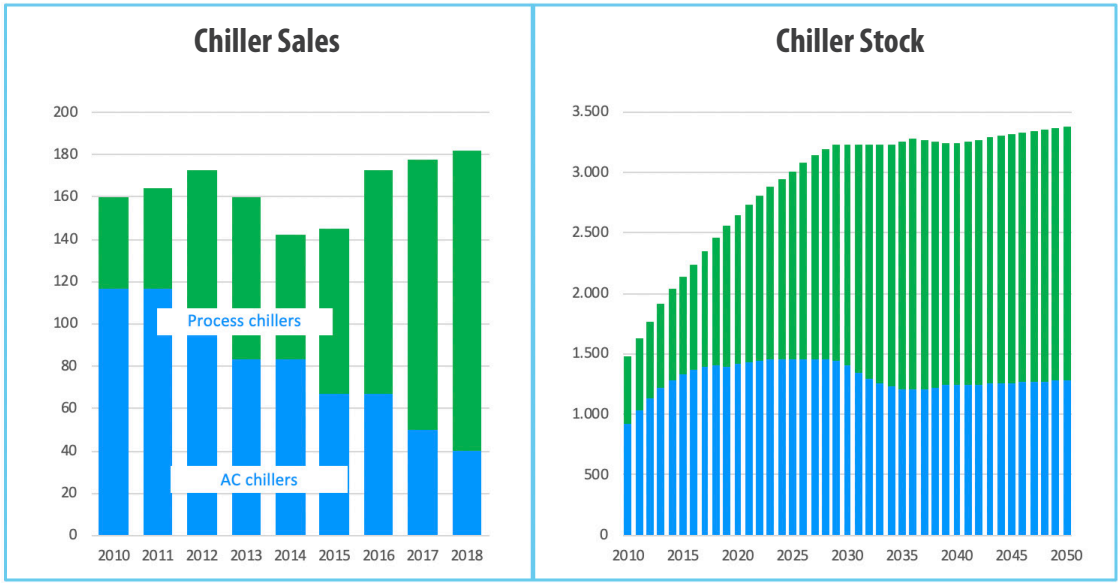

Figure 4: Development of chiller sales and stock units

Figure 5 shows the historic and estimated future market of domestic refrigerators. During recent years, sales of domestic refrigerators have been sluggish, mirroring the pattern for AC sales. It is estimated that in the longer term the stock of domestic refrigerators will remain at around 2.2 million units. The household ownership of refrigerators in Lebanon is already high, compared with other developing and developed countries, assumed to be close to saturation. With the predicted decline of the population over the coming years, through factors such as the aging of the population, the stock of refrigerators will decline and thereafter stabilize following the closely the trend of the total number of households.

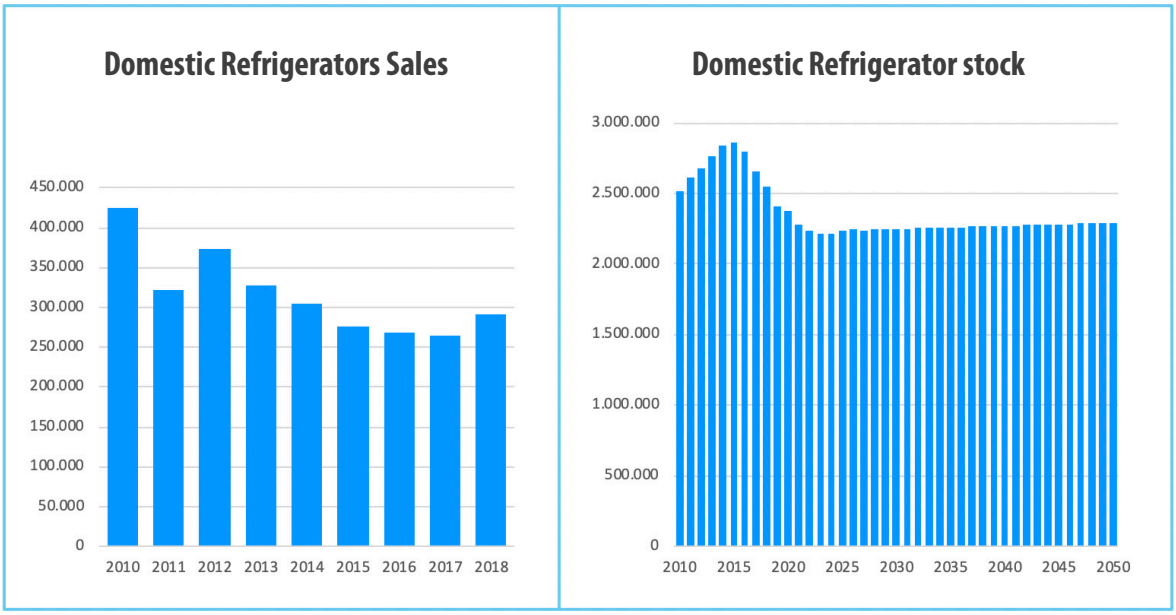

Figure 5: Development of domestic refrigerator sales and stock units

Figure 6 shows the sales numbers of commercial refrigerators. Over 95% of sold commercial refrigerators are standalone refrigerators and freezers, with the remainder condensing units for supermarkets mainly. While the sales of commercial refrigerators fluctuated during the 2010-2018 reference period, sales of stand-alone commercial refrigerators are expected to increase in the future following the strong economic growth assumed in the projections.

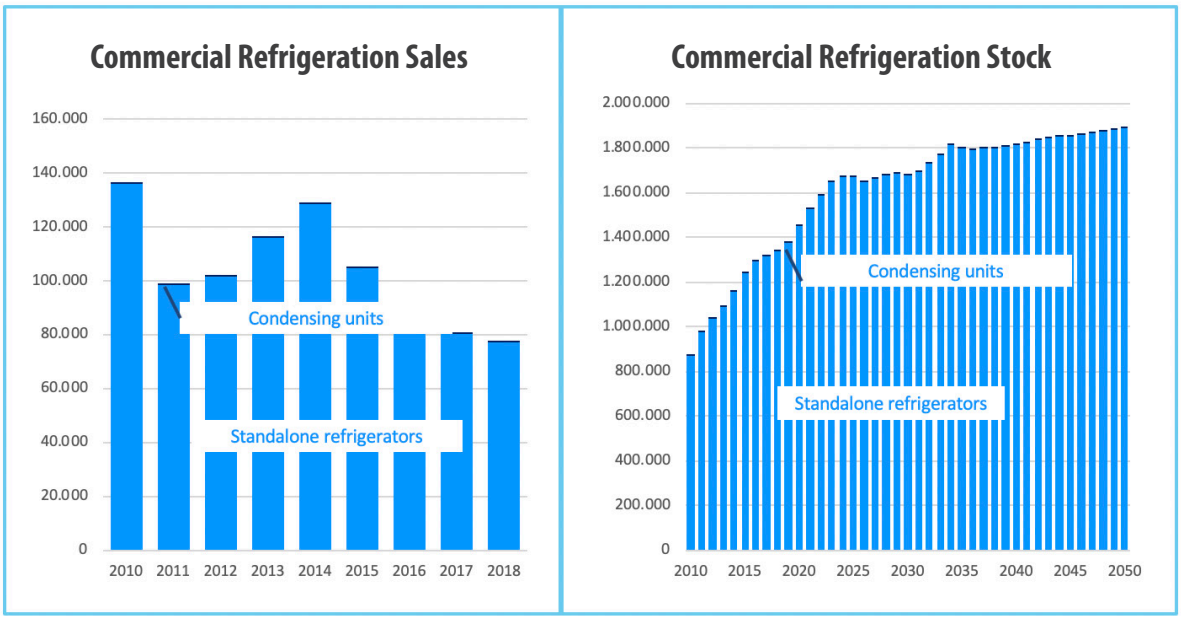

Figure 6: Development of commercial refrigeration sales and stock units

Figure 7 shows the sales and stock development of Mobile Air Conditioners (MAC). The sales numbers of MACs were picking up during recent years. The MAC appliance in use, i.e. the MAC stock, will increase over the next few years with reaching a plateau after 2025.

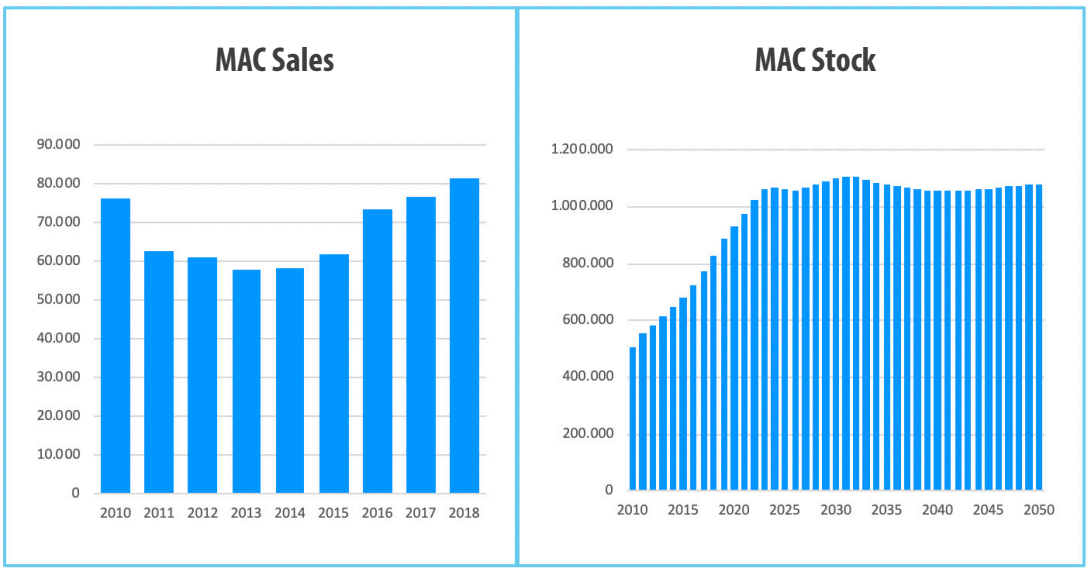

Figure 7: Sales and stock development of Mobile Air Conditioners (MAC).

4.2 RAC sector emissions: BAU Scenario

RAC emissions in the BAU Scenario rise from 5.8 $MTCO_2$-eq in 2010 (base year) to around 9.7 $MTCO_2$-eq in 2050, an increase of two-thirds over the base year. The most significant contribution comes from unitary air conditioners (UAC), especially room air conditioners as the main category. In the BAU scenario, emissions from UAC more than double during the period from around 2.9 $MTCO_2$eq to over 6 $MTCO_2$-eq in 2050 as shown in Figure 8.

The next significant subsector is MAC with about 2 $MTCO_2$-eq in 2018. MAC emissions are estimated to remain stable following the same pattern of the MAC stock. The two other major subsectors are domestic and commercial refrigerators both contributing 1 $MTCO_2$-eq in 2018. With a stable stock of domestic refrigerators, lower direct emissions from refrigerants and improved energy efficiencies, GHG emissions from refrigerators are expected to decrease in the BAU scenario by 25% compared to 2018[14]. The GHG emissions from standalone commercial refrigerators are estimated to stay at current levels. Chillers, transport and industrial refrigeration have only a minor contribution to the GHG emissions of the RAC sector in Lebanon.

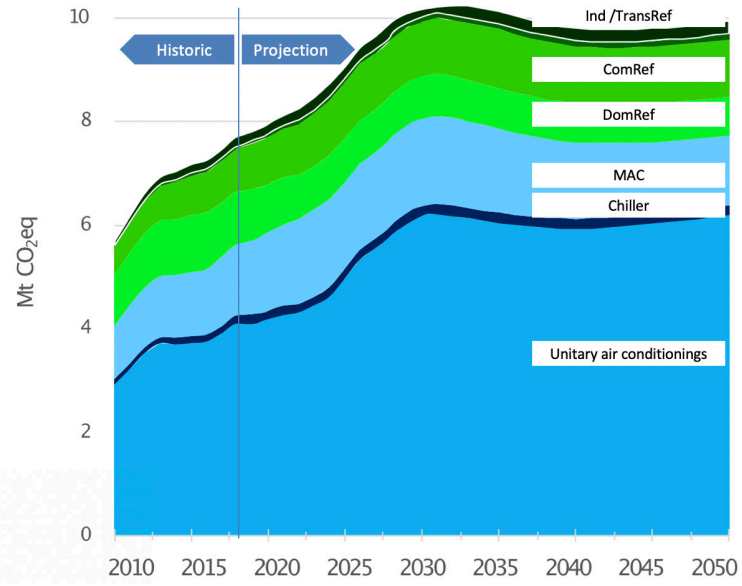

Figure 8: 2010 - 2050 GHG emissions of the RAC sector (BAU scenario)

14- Against the baseline 2010 emissions from domestic refrigerators will fall by 32% until 2050.

Figure 9 shows the 2018 GHG emissions split by subsectors. The subsector with the most significant contribution to the overall RAC emissions is the room air conditioning sector ("unitary air conditioning") with a share of 53% followed by Mobile Air Conditioning (MAC) with 18%, domestic refrigeration with 13% and commercial refrigeration with 11%, transport and industrial refrigeration with a combined 2% contribution.

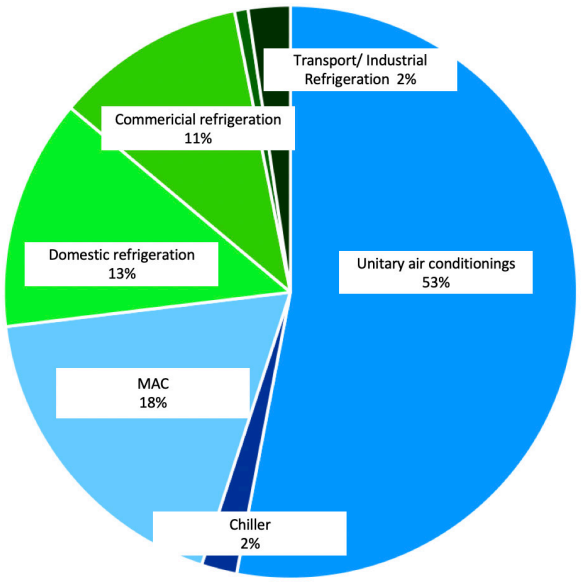

Figure 9: Split of GHG emissions by subsectors 2018

As shown in Figure 10, the emissions from the RAC sector are split in about 32% direct emissions (refrigerant related) and 73% indirect emissions (energy consumption related)[15].

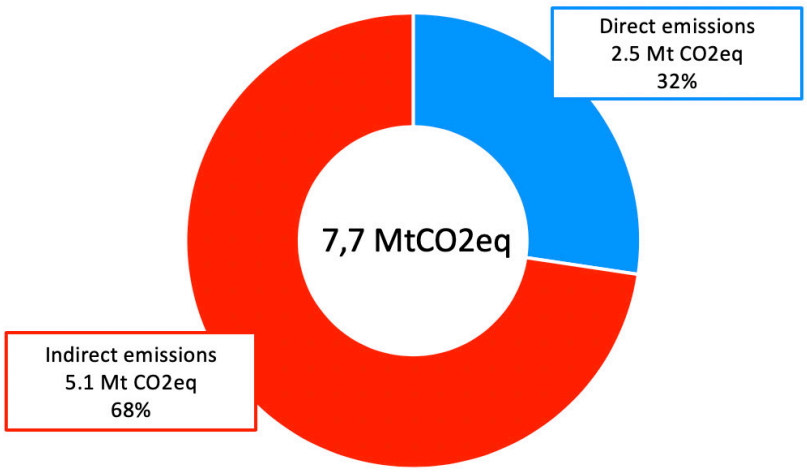

Figure 10: Split of current RAC GHG emissions in direct and indirect emissions

4.3 RAC sector emissions: Mitigation Scenario

With a transition to ozone-friendly, climate-friendly, and energy-efficient appliances, direct and indirect GHG emissions can be reduced while reducing pressure on the Lebanese electrical grid. These transitions can also achieve better alignment with neighbouring countries leading to lower pricing as a consequence of larger sales volumes.

15- The estimated split of direct/indirect emissions are for each of the subsectors are unitary air conditioning 40/60; chillers 25/75%; MAC 20/80%; domestic refrigerators 5/95%; commercial refrigeration 12/88%; industrial refrigeration 16/84%; transport refrigeration 44/56%;

Table 9 lists the refrigerant and assumed energy performance improvements for new appliances in the Mitigation Scenario. While all sub-sectors' efficiencies increase significantly, it is of note that UAC's nearly doubles, domestic refrigerator's nearly triples, and there is a general movement towards the use of natural refrigerants.

Table 9: Subsector assumptions for the GHG Mitigation Scenario

Subsector	Refrigerants			Energy efficiency ratios[16]		
Category	**Current**	**2030**	**2050**	**Current**	**2030 (MIT)**	**2050 (MIT)**
UAC	R22, R410A	R290	R290	3.2	4.3	6.1
Chiller	R22, R134a, R410A	R290, R744, HFO	R290, R744, HFO	3.5	4.3	5.2
MAC	R134a	HFO1234yf, R290, R744	HFO1234yf, R290, R744	2.6	3.2	4
Domestic refrigerators	R134a, R600a	R600a	R600a	1.3	2.1	3.1
Commercial refrigerators	R134a, R404A, R290, R744	R290, R600a, R744	R290, R600a, R744	2.1	2.4	3.3

The improved efficiencies from Table 8 result in an overall reduction of nearly 4 $MTCO_2$-eq, of which around 80% comes from indirect emissions (i.e. a reduction in electricity demand). The targeted energy efficiency for Lebanon by 2050 are achievable with the use of top energy efficient equipment currently available in the world market. Therefore, the target energy efficiencies are achievable with current technologies and should therefore be well into the implementable reach by 2050. The largest contribution comes from UAC accounting for about 70% of total reductions. This was followed by domestic refrigeration and MAC with approximately 10% of the reductions each. The remaining subsectors account for the remaining reductions.

Figure 11 shows the mitigation potential by 2030. The blue coloured bars show the mitigation potential for direct and indirect emissions. The grey bar to the left shows the baseline emissions. By 2030 most of the transition towards natural refrigerants (low GWP) for the AC subsector has been completed, realizing the majority of the direct emissions reduction potential for this subsector. The subsector with the second highest mitigation potential is the domestic refrigerators. This type of transition has been demonstrated by the European Union with their implementation of F-Gases Regulation banning high GWP refrigerants. The transition can take place reasonably fast as technical solutions are available for most appliances at low or, in some cases, even negative marginal abatement costs[17].

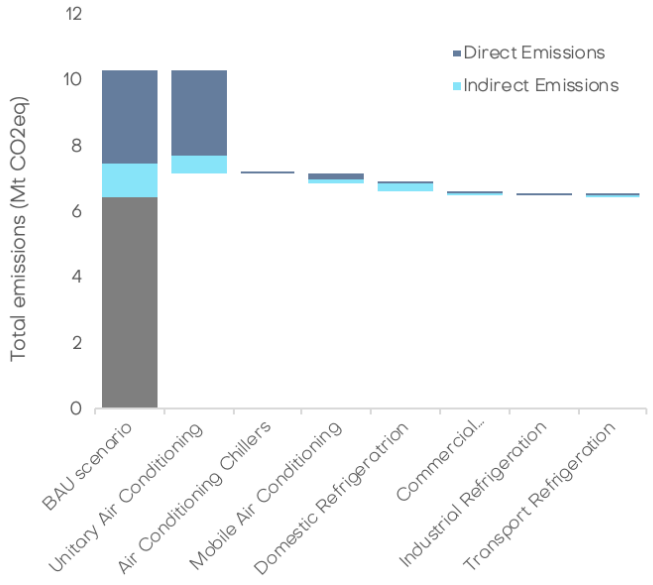

Figure 11: Direct and indirect GHG mitigation potential in 2030

16- EE ratios are comparing the cooling output to the electrical input (W/W)

17- The preparatory analysis for EU F-gas Regulation (EU) No. 517/2014 showed that the phase out of F-gases in the EU would be possible at marginal abatement costs below EUR 10/ tCO_2eq. For many subsectors, marginal abatement costs for F-gases are lower in developing countries compared to developed countries (Schwarz, 2019).

As the majority of direct emissions has already been achieved by 2030, the main reductions between 2030 and 2050 come from the introduction of increasingly efficient appliances to the RAC stock (Figure 12). Lebanon so far is lacking effective regulations, i.e. MEPS and labels, for key RAC appliances and the effective market introduction and its enforcement will require some time. After the introduction of such regulations, mandatory energy efficiency levels for MEPS and labels can be gradually increased.

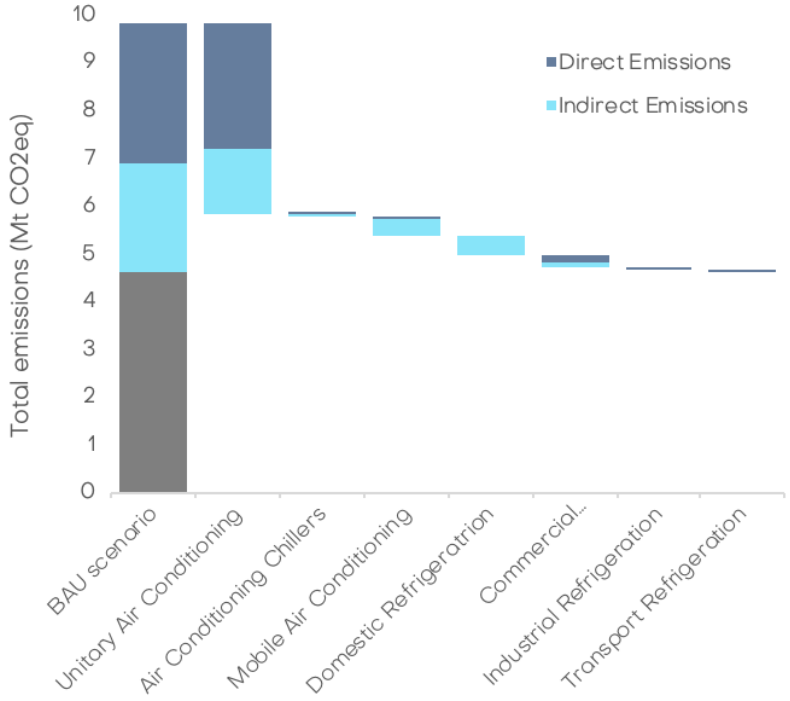

Figure 12: Direct and indirect GHG mitigation potential in 2050

Figure 13 shows the mitigation potential for key subsectors over time. The left side of the figure shows the BAU scenario and the right side shows the mitigation scenario (MIT). The transition to low GWP solutions has the potential to lower GHG emissions by 5.5 $MTCO_2$-eq in the year 2050 assuming a constant combined grid emissions factor. This assumes that by 2050 all appliance sectors have transited to low GWP refrigerants (GWP below 10). Total emissions can be further reduced with the further introduction of renewable energy generation to the electricity grid as the Government of Lebanon indicated in its National Renewable Energy Action Plan (NREAP) 2016–2020.

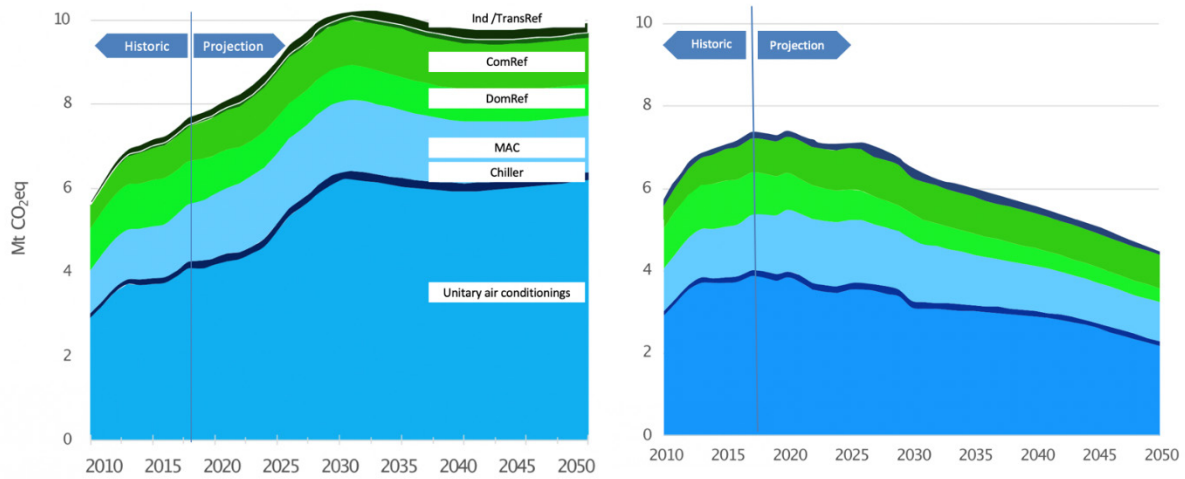

Figure 13: GHG emissions by subsectors by 2050 BAU and MIT

4.4 RAC sector energy demand

4.4.1 Lebanon electricity system

The Lebanese electricity sector has faced many challenges since the 1970s, with the year 2018 recording a deficit of more than 30% in EDL's (Electricité du Liban) power supply (MoE&W, 2019). EDL is a state-owned enterprise with a monopoly of the electricity sector under the control of the Ministry of Energy and Water (MoE&W). EDL controls over 90% of the Lebanese electricity sector with the remaining 10% being hydroelectric power plants owned by other public companies and concessions.

In 2019, EDL's installed capacity was 2,449 MW, making 66% of the country's increasing demand that is reported to be 3,669 MW[18] (MoE&W, 2019). More than 95% of electricity is generated from heavy fuel oil and diesel. The demand gap is partly made up with purchases from Syria and offshore electricity generation barges (MoE&W, 2019)[18]. Yet, this was not enough to provide 24/7 electricity, making room for privately-owned distributed generators to bridge the gap.

The grid emission factor (GEF), the intensity of CO_2 emissions per unit of generated electricity in the system, for this analysis is assumed constant at 0.673[19] tCO_2/MWh. This grid emissions factor is used throughout the period for both scenarios as no alternative projections have been made.

4.4.2 RAC sector electricity demand: BAU Scenario

Electricity demand in the RAC sector, shown in Figure 14, grows from 5,000 GWh in 2010 to around 7,500 GWh in 2050 in the BAU Scenario, a growth of 50%. It is of note that demand does peak in this scenario at 8,000 GWh in 2030, (in line with the population development and the predicted increase of appliances during the coming decade. After 2030, the assumed increasing energy efficiencies, also in the BAU scenario, as outlined in chapter 4.5 will gradually lower the projected electricity consumption), before decreasing to the 2050 levels as the UAC stocks remain stable while efficiency continues to grow. Transport refrigeration and mobile air conditioners are excluded as the systems are powered by the fuel from vehicles rather the electricity grid.

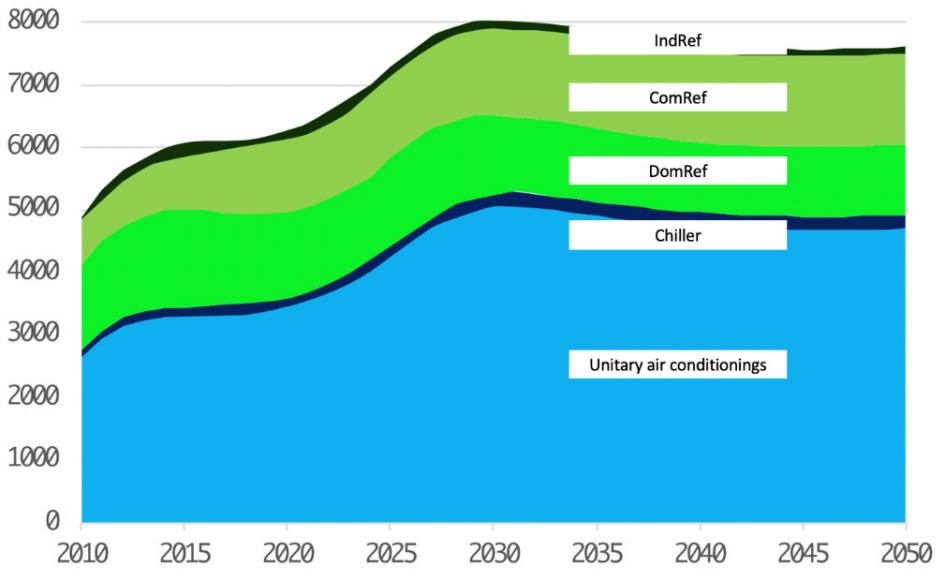

Figure 14: BAU scenario for the RAC electricity consumption in GWh.

In 2018, electricity consumption of the RAC sector was around 6,000 GWh of which about 53% or 3,195 GWh is from room air conditioners, 24% or 1,402 GWh from domestic refrigerators, and 1,164 GWh or 20% from commercial & industrial refrigeration.

The RAC sector accounts for about 26 %[20] of the total reported electricity demand of Lebanon of about 23,000 GWh in 2018 (Ibrahim, 2013) and the room air conditioning appliances account for about 25%, domestic refrigerators account for approximately 11%. This demand pattern is mainly driven by economic growth, population growth, and climate change.

18- MoE&W, (2019). Updated Policy Paper for the Electricity Sector. Beirut, Lebanon. https://www.energyandwater.gov.lb/mediafiles/articles/doc-100515-2019_05_21_04_27_25.pdf

19- Adopted from EDL data 2017 for the GEF including private power generation

20- Whereas the RAC electricity demand for 2018 had been taken from the NDC analysis and the total electricity demand projected by Ibrahim (2013).

The estimated additional electricity demand from the RAC sector will add to the peak electricity demand in Lebanon increasing the need for additional generation capacity. Efforts to increase energy efficiency in the RAC sector can lower the demand for additional generation capacity. Lowering the RAC related electricity demand could result in electricity savings of about 2,000 GWH per annum (e.g. 8760hrs*0.5 load factor*500MW/1000) which represents the equivalent of a 500 MW power plant running at 50% of the fulltime annual equivalent. Another way to reduce emissions would be to meet the RAC sector added demand with solar generation as peak cooling demand is during summer days coinciding with higher insolation levels.

4.4.3 Assessment of the energy consumption by climatic zone

Lebanon is divided into four distinct climatic zones as shown in Table 10, the coastal zone (Zone 1), the western mid-mountain zone (Zone 2), the inland plateau (Zone 3) and the high mountain zone (Zone 4).

Zone 1 has the highest cooling demand with about 120 to 1050 Cooling Degree Days (CDD) and also includes the most populated areas with Beirut, parts of Mount Lebanon, North Lebanon, South Lebanon and Nabatiyeh. This is followed by Zone 2 with 0 to 600 CDD covering parts of Mount Lebanon, North and south Lebanon and Nabatiyeh. Zone 3 has between 120 and 600 CDD covering the Bekaa plateau. The lowest cooling demand is in Zone 4 with 0 CDD covering parts of Mount Lebanon North Lebanon and Bekaa.

Table 10: Four climatic zones (Source: Mortada, 2018)

Climatic zone	Approximate altitude range	Approximate HDD (18) and CDD (21) thresholds
Zone 1 (coastal)	0 – 700 m	300 < HDD < 1,200 120 <CDD < 1,050
Zone 2 (western mid-mountain)	700 – 1,400 m	1,200 < HDD < 2,000 0 <CDD < 600
Zone 3 (inland plateau)	700 – 1,150 m	1,200 < HDD < 1,800 120 <CDD < 600
Zone 4 (high mountain)	Littoral side +1,400 m	HDD > 200 CDD = 0
	Inland side +1,150 m	HDD > 1,800 0 <CDD < 120

Based on the above, Zone 1 accounted for around 57% of RAC demand in 2018, followed by Zone 2 with 23%. Table 11 shows the estimated cooling demand for each of the climatic zones based on the Cooling Degree Days (CDD) from Mortada (2018), and the RAC estimated electricity demand as detailed in section 4.4.2 above.

Table 11: Cooling electricity demand by zones in 2018 (GWh)

Zone	Share	Cooling electricity demand in 2018 (GWh)
Zone1 - Beirut, Mount Lebanon, North Lebanon, South, Nabatiyeh	57%	3,386
Zone2 - Mount Lebanon, North Lebanon, South, Nabatiyeh	23%	1,306
Zone3 - Bekaa	13%	772
Zone4 - Mount Lebanon, North Lebanon, Bekaa	7%	356

4.4.4 RAC sector electricity demand: Mitigation Scenario

In the Mitigation Scenario, RAC electricity demand peaks around 2030 at just over 6,500 GWh, a 19% reduction on the BAU RAC peak demand of 8,000 GWh. By 2050, RAC electricity demand in the Mitigation Scenario is 44% lower than BAU at 4,500 GWh, this is 10% below 2010 demand and 25% below the 2018 levels observed at the beginning of this study. The largest gains come from UAC and domestic refrigeration as observed with emissions reductions in Figure 13.

The observed reductions are largely the result of the technical improvement on the operating energy efficiency of RAC appliances with a contribution from the increased efficiency that natural refrigerants to provide to the market. However, it should be noted that other measures can be taken to further reduce the RAC demand including:

- The introduction of mandatory building codes with increasingly ambitions energy performance standards. This includes also improving the insulation and design of buildings to better retain cooling while minimizing solar heat gains (e. g. passive cooling designs and reflective rooftops).
- Improving the management of space conditioning to minimize waste.
- Increase the awareness of consumers to ensure they purchase the right appliance for their needs (i.e. size, capacity, functionality) and used optimally (i.e. installation and operation, optimal set point selection in order to avoid the over-cooling of rooms). China e.g. mandates public buildings not to be cooled below 26°C; Some companies in Japan restrict wearing ties during hot summer days.

4.5 EE targets in the RAC sector

The key measures to realize the energy saving in these two subsectors will be the introduction and enforcement of mandatory policies aimed at bringing higher efficiency appliances to the market. A mandatory MEPS and labelling scheme will prohibit the importation and sale of underperforming appliances while providing information on the energy performance of the appliances that are allowed in the market. The introduction of such mandatory requirements will have an impact on how manufacturers design their appliances including the use of more efficient components (e.g. DC compressors, LED lighting, DC fan motors, electronic controls, etc.) and lowering the appliances' thermal load (e.g. for refrigerators, by improving the cabinet's insulation).

Table 12 shows the targeted improved MIT energy efficiency of the two main subsectors between 2018 and 2030. Table 13 shows the assumed energy efficiency for all appliances under the BAU and MIT scenario.

Table 12: EER values in sold units in the BAU and MIT scenarios

Scenario	Application	Current level 2018	Target levels 2030
MIT	Split residential air conditioners	3.39	4.51
MIT	Domestic refrigeration	1.39	2.13

Table13: EER values in sold units in the BAU and MIT scenarios.

Scenario	Application	2018	2020	2025	2030	2040	2050
BAU	Self-contained air conditioners	3.23	3.23	3.44	3.64	4.16	4.27
BAU	Split residential air conditioners	3.20	3.32	3.32	3.64	4.16	4.51
BAU	Split commercial air conditioners	3.10	3.16	3.16	3.31	4.16	4.04
BAU	Duct split residential air conditioners	3.61	3.61	3.61	3.81	4.01	4.01
BAU	Commercial ducted splits	3.10	3.29	3.29	3.77	4.19	4.66

Scenario	Application	2018	2020	2025	2030	2040	2050
BAU	Rooftop ducted	2.89	2.95	2.95	3.09	4.15	4.27
BAU	Multi-splits	3.59	3.59	3.59	3.87	4.15	4.15
BAU	Air conditioning chillers	3.18	3.18	3.18	3.50	3.82	3.82
BAU	Process chillers	3.42	3.42	3.42	3.53	3.64	3.64
BAU	Car air conditioning	2.65	2.65	2.65	2.76	2.88	2.88
BAU	Large vehicle air conditioning	2.65	2.65	2.65	2.76	2.88	2.88
BAU	Domestic refrigeration	1.30	1.30	1.30	1.38	1.46	1.46
BAU	Stand-alone equipment	2.80	2.80	2.80	2.91	3.02	3.02
BAU	Condensing units	3.07	3.07	3.07	3.37	3.67	3.67
BAU	Centralised systems for supermarkets	2.04	2.04	2.04	2.12	2.21	2.21
BAU	Integral	1.93	1.93	1.93	1.98	2.02	2.02
BAU	Condensing units	2.11	2.11	2.11	2.17	2.22	2.22
BAU	Centralised systems	3.62	3.62	3.62	3.73	3.85	3.85
BAU	Refrigerated trucks/trailers	2.30	2.30	2.30	2.42	2.53	2.53
MIT	Self-contained air conditioners	3.48	3.64	4.16	4.27	4.73	5.00
MIT	Split residential air conditioners	3.39	3.64	4.16	4.51	5.20	6.35
MIT	Split commercial air conditioners	3.19	3.31	4.16	4.04	4.99	5.00
MIT	Duct split residential air conditioners	3.85	4.01	4.15	4.27	6.11	6.11
MIT	Commercial ducted splits	3.39	3.77	4.19	4.66	5.75	6.00
MIT	Rooftop ducted	2.97	3.09	4.15	4.27	4.73	5.00
MIT	Multi-splits	3.93	4.15	4.27	4.49	5.19	5.19
MIT	Air conditioning chillers	3.56	3.82	4.04	4.27	5.20	5.20
MIT	Process chillers	3.55	3.64	3.82	4.16	4.62	4.62
MIT	Car air conditioning	2.79	2.88	3.00	3.23	4.04	4.04
MIT	Large vehicle air conditioning	2.79	2.88	3.00	3.23	4.04	4.04
MIT	Domestic refrigeration	1.39	1.46	1.79	2.13	3.14	3.14
MIT	Stand-alone equipment	2.93	3.02	3.13	3.24	3.64	3.64
MIT	Condensing units	3.43	3.67	3.78	4.03	4.38	4.38
MIT	Centralised systems for supermarkets	2.14	2.21	2.32	2.69	3.50	3.50
MIT	Integral	1.99	2.02	2.11	2.32	2.84	2.84
MIT	Condensing units	2.18	2.22	2.32	2.39	3.50	3.50
MIT	Centralised systems	3.75	3.85	4.03	4.40	4.89	4.89
MIT	Refrigerated trucks/trailers	2.44	2.53	2.59	2.65	2.77	2.77

5 ENABLING POLICIES

5. ENABLING POLICIES

5.1 Minimum Energy Performance Standards and appliance labelling

Minimum Energy Performance Standard (MEPS) is a regulatory policy specifying the energy performance requirements of equipment or appliances limiting the maximum amount of energy that may be consumed per unit of output. Under a MEPS policy, the appliances that do not meet the specified minimum performance required are banned from import and/or sell in the market. MEPS are a key tool to remove inefficient equipment from the market and the stock of energy-consuming units.

Appliance labelling schemes, on the other hand, are about providing information to consumers on the appliance's energy performance. This is important as the appliances' energy consumption is a cost that is hidden from consumers and often turns out to be several times larger, over the operating life of the appliance, than the purchase cost.

The introduction of mandatory regulations with Minimum Energy Performance Standards (MEPS) and labels has proven its effectiveness for RAC appliances internationally. They are a universally applicable instrument to drive the energy efficiency, and have been especially effective for room ACs and domestic refrigerators, taking over 70% of the market share as shown in Figure 15 (Gloël *et al.*, 2014).

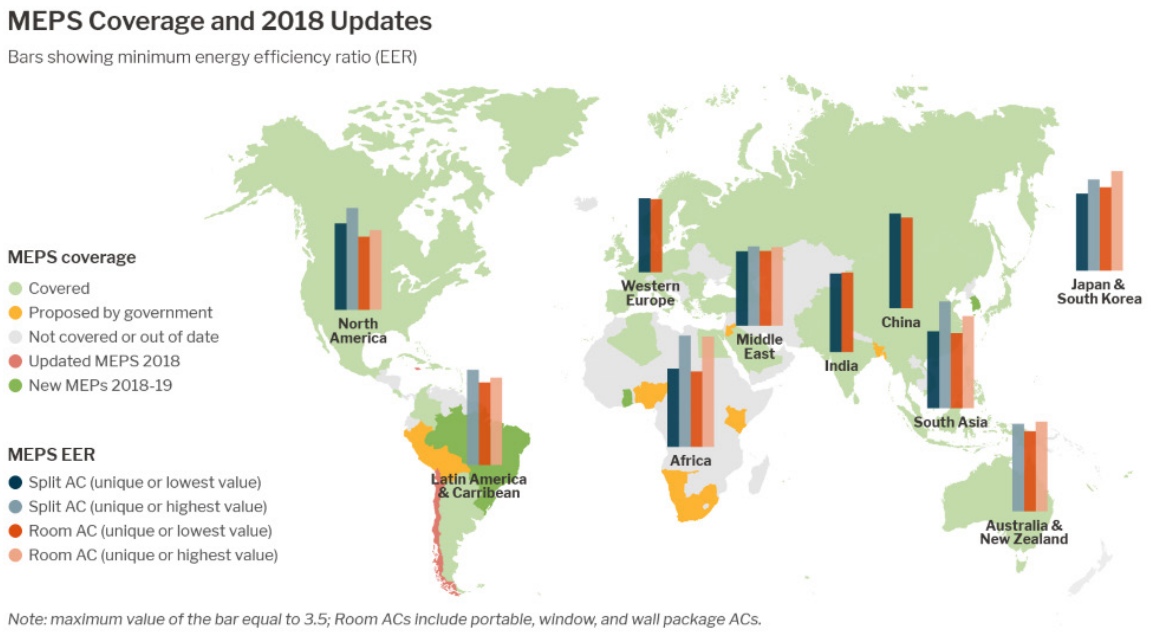

Figure 15: Cooling MEPS and labelling global coverage Source: K-CEP (2018).

Countries that fail to implement MEPS and label systems face the risk of becoming dumping grounds for energy inefficient and low-quality equipment. In many countries, energy-inefficient appliances are not sold at lower upfront costs, with the effect that inefficient appliances with higher operating costs, due to their higher electricity consumption, end up having higher Life Cycle Costs (LCC).

The energy label provides information on the energy performance of the RAC appliances expressed as a ratio of the cooling output compared to the energy input required. This is called energy efficiency ratio (EER) in its most basic form, and seasonally adjusted energy efficiency ratio (SEER) when the measure accounts for differences in the performance due to seasonal climate variation.

Most labelling schemes also include a rating system that enables easy comparison between models in the same market, like the examples shown in Figure 16:

- The European system grades appliances with a letter and colour ranking with the best performers earning an A+ mark with a green colour, while the worst performers are grade G with a red colour. The Australia/New Zealand uses a star system, awarding more stars to higher performing appliances.

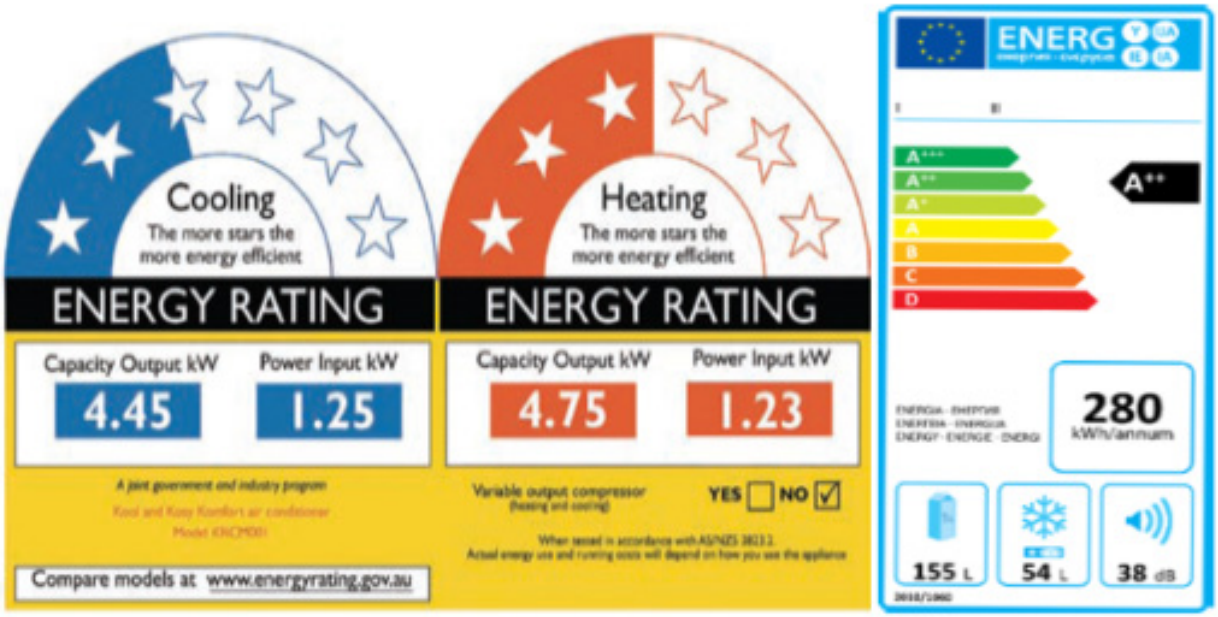

Figure 16: Australia/New Zealand AC label (left), European fridge label (right)

There are different types of labelling systems in place for RAC appliances, globally, e.g. endorsement or comparative labels. The most common labelling systems, for indicating the energy efficiency performance of appliances, are comparative labels such as the star labels (e.g. 1-5 stars systems applied in countries including India, Thailand, Indonesia, the Philippines and Viet Nam) or the color-coded A-G scheme which has been established in the European Union and subsequently adopted in other locations such as most parts of Latin America and Eurasia including Turkey.

It is recommended that a MEPS and labels programme be implemented in Lebanon based on the following general principles:

- **Introduce MEPS and labels targeted at household refrigerators and ACs,** the two largest energy-consuming RAC appliances, but also with the highest energy-saving potential.
- **The initial introduction of MEPS using a model cut-off level in 2021** with an announcement of a step-up after three years. It is recommended to implement the initial MEPS at a lower level than leading markets to gain the acceptance of key stakeholders, local manufacturers in particular.
- **Continuous review and upgrading of MEPS and labels** to reflect the energy efficiency advances in the market with a recommended updating period of two to five years. Ideally MEPS are revised in line with the ambition raising mechanism under the NDCs of the Paris Agreement which will be updated every five years. In the first period, the top label classes are left empty or nearly empty in order to allow the market to grow over time into these classes. When the MEPS level increases, products in the lowest class will disappear and the next class up products will become the lowest class. The increase from G to F in 2024 should be announced with the MEPS introduction in 2021. With the early announcement, the industry has time to adapt. A rescaling of label classes would be required once a significant proportion of the market (e.g. over 20%) is represented in the top labelling classes. This is only expected to be the case after 2025.
- **Proposed MEPS and label levels** oriented at **life-cycle costs assessment** and **international benchmarking.**
- **Provide technical, and potentially financial, support to the local manufacturing industry** to catch-up with international energy efficiency standards.
- **Continuous market surveillance and enforcement** are recommended to ensure that appliances are displaying the labels and that the labels reflect the actual performance.
- Establish a **product registry system** for market control and as a database to support and inform MEPS upgrade review process as well as track the progress of the market.

5.2 Rationale for the implementation of EE regulations for ACs and refrigerators in Lebanon

As a member party to the Paris Agreement and signatory of the Montreal Protocol's Kigali Amendment, Lebanon is committed to meeting its climate targets, i.e. net GHG neutrality latest by 2050 as an implicit target of the Paris Agreement. This goal can be reached through its increasing ambition and setting specific sector goals. The 2030 Nationally Determined Contributions (NDCs) unconditional target for energy efficiency is a 3% reduction in power demand through energy efficiency measures compared to the demand under the BAU scenario (this target increases to 10% with international support). These targets aim to reduce the country's direct emissions through the phasedown of high Global Warming Potential (GWP) refrigerants and foam blowing agents and indirect emissions through enforced energy efficiency requirements.

An effective energy efficiency regulation will help to unlock economies of scale for products that save consumers money on energy bills, reduce air pollution, and cut GHG emissions from power generation.

5.3 The process for setting up RAC EE regulation

The process for setting up a mandatory MEPS and labelling scheme in Lebanon is identical for both air conditioners and refrigerators, although Lebanon has little experience in the process as it currently has no voluntary or mandatory scheme on this area. Figure 17 illustrates the process.

A precondition for the realization of MEPS for ACs and refrigerators is the adoption of *safety standards*. The relevant international standards are the IEC 60335-2-24 for refrigerators and IEC 60335-2-40 for ACs. The IEC standard for AC is currently under revision and an update is expected by the middle of 2020. Lebanon should adopt the most current version of the safety standards.

The expected update for AC is likely to include higher charge sizes for low GWP refrigerants, supporting the transition to more climate-friendly and energy-efficient air conditioners. It should be noted that the adoption of flammable low GWP refrigerants, such as R600a and R290, require supporting training for all market participants: manufacturers, service companies, and operators for the safe handling of flammable gases specific to the design, maintenance, servicing, and end-of-life disposal of these appliances.

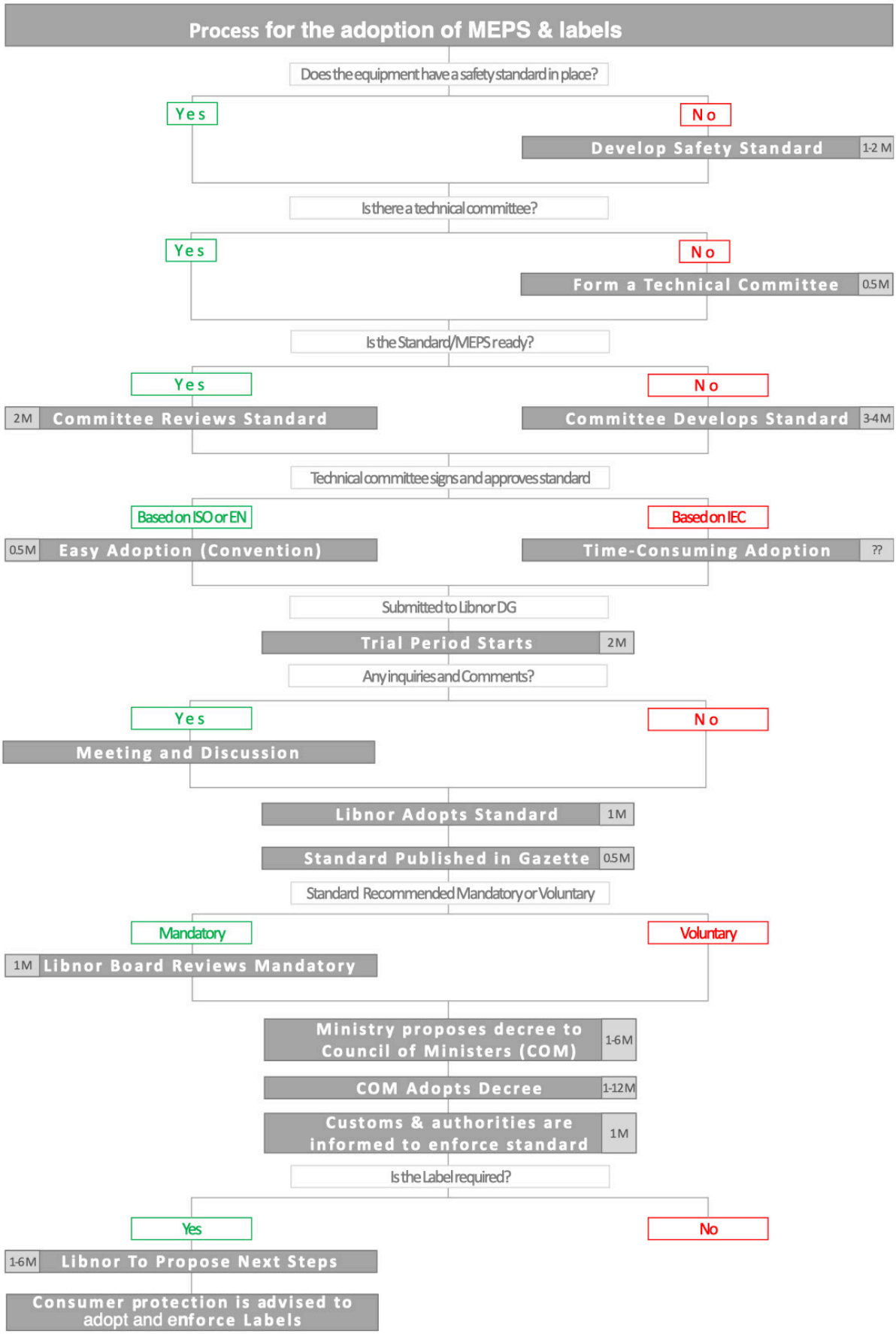

Figure 17: Process showing the adoption of MEPS and labels in Lebanon

5.3.1 The process for setting national standards

Standardization, labelling, and granting the Lebanese NL (Norme Libanaise) conformity mark are managed by The Lebanese Standards Institution (LIBNOR), a public institution attached to the Ministry of Industry with its main responsibilities being to prepare, publish, and amend national standards, as well as to grant the Lebanese Conformity Mark NL and represent Lebanon at international and regional standardization meetings.

When setting standards, LIBNOR can either adopt a standard from an international reference such as ISO, CEN, IEC, etc. or may develop its own national standards. It is important to highlight that LIBNOR is a member of the International Standardization Organization (ISO), and an Affiliate Member of the European Committee for Standardization (CEN - Comité Européen de Normalisation), this gives LIBNOR direct access to both organizations standards, however, Lebanon is not yet a member of the IEC (International Electrotechnical Commission), which may require a long process to acquire these standards.

The first step in setting new standards is to develop a Work Program (WP) that includes all the standards requested by the industry (public authorities, NGOs, private sector, etc.). This Work Program must be approved by LIBNOR's Board of Directors (BOD) in order to proceed with the process.

After receiving the BOD approval, it is required to establish a Technical Committee (TC) if the field of the requested standard is not covered by an existing TC at LIBNOR (for the development of MEPS/labels there is already a TC in place, see below). This is done by regrouping experts representing all involved sectors and stakeholders such as the public sector, private sector, universities, testing labs, engineering organizations, NGOs, the Consumer Protection Office, international organizations, etc.

Once the list of the TC members is finalized and approved by the BOD, the relevant TC is established and its members will be invited to a TC meeting to discuss the standard's many facets including setting the calculation methods, scales, conventions, symbols, and the definition of products quality, testing methods and analysis. The TC meetings continue to reconvene until a consensus is reached and signing it as a Draft National Standard (DNS). This process may take several months as experiences in other countries have shown.

The standard is then sent to a trial period of two (2) months to allow for public consultation. If some comments arise, they will be sent to the TC to be addressed. When the trial period is over and comments are addressed, the Final Draft of National Standard (FDNS) is sent to the BOD for approval. Once approved, the standard is finally published and announced in the official gazette as a Lebanese standard.

The Lebanese standards are voluntary in principle. However, for reasons of public health, public safety or national interest, a standard can be rendered mandatory by a decree from the Council of Ministers (COM).

To render a standard mandatory, once issued as an FDNS in the official gazette, the concerned ministry (ذات صفة ومصلحة) may ask LIBNOR to make it mandatory. For MEPS and labels; and the appliances' testing methods the, Ministry of Environment (MOE) can raise[21] the request to LIBNOR to render relevant standards mandatory.

A Technical Regulation Committee (TRC) will be developed by LIBNOR including representatives from concerned ministries and involved stakeholders headed by the delegate of the concerned ministry (MOE in this case) to discuss the importance of rendering the standard mandatory. TRC meetings continue to reconvene until the discussions are completed reaching a consensus to render the standard mandatory. Once agreed it will be sent by the concerned minister to the council of ministers in order to be issued in a decree.

It is obligatory that the COM transfers the draft decree to the state council for their opinion (which is a non-binding opinion) and makes sure that the relevant draft decree does not contradict with any existing regulation (law or decree).

Once all comments are addressed, the COM gives the final approval and the decree makes its way to be signed by the President of the Republic of Lebanon, the prime minister, and the minister of the concerned ministry (in this case the Ministry of Energy and Water), and for promulgation and publication in the official gazette. The COM will inform customs and other relevant authorities to enforce the MEPS and labels. Finally, the Consumer Protection Office will enforce and adopt the MEPS and labels.

Note: Once a standard or a set of standards are sent to a trial period, and in order to gain time, the TC may continue to hold meetings working on other standards (for example after finalizing safety and Energy Efficiency (EE) draft national standards, the TC can directly start working on label standards).

Lebanon has already established a TC for the development of MEPS and labels. Its Heating Ventilation & Air Condition (HVAC) TC includes different members such as the Lebanese Centre for Energy Conservation (LCEC), the Ministry of Environment, private sector representatives, etc. This committee, that is currently working under LIBNOR on safety standards, is most likely to be working on further developing

21- As per decree 2275 Article 25 point 10.

technical standards and MEPS. However, the Committee has not developed a detailed proposal for the issuances of MEPS and labels. The work carried out under the RAC NCP project will support the development of MEPS and labels as per this deliverable and the following ones. Once the MEPS and labels are ready, they can be forwarded to the TC for review and approval. It is advisable to have consensus, but the decision can be made by voting.

It is recommended that Lebanon adopts the international standards as a basis for MEPS and labels for ACs and refrigerators as shown in Table 14 see also UNEP (2019a and 2019b).

Table 14: International safety standards and EE testing standards

Equipment type	Refrigerant safety standards	EE testing standards
AC	IEC 60335-2-40	ISO 16358:2013
Refrigerators	IEC 60335-2-24	IEC 62552:2015

Figure 18 and Figure 19 show the process for the adoptions of international and non-international standards in Lebanon. The implementation of either standard needs to be in place and adopted before moving to mandatory standards as outlined above and illustrated in Figure 17.

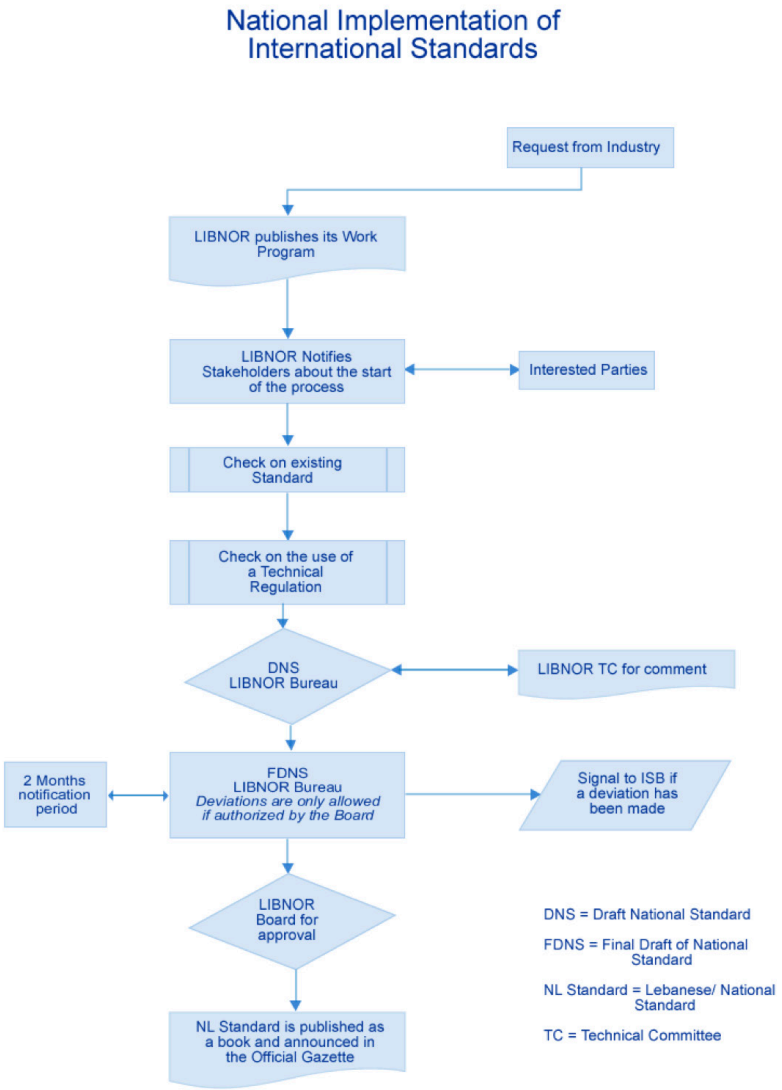

Figure 18: Process for the adoption of international standards in Lebanon

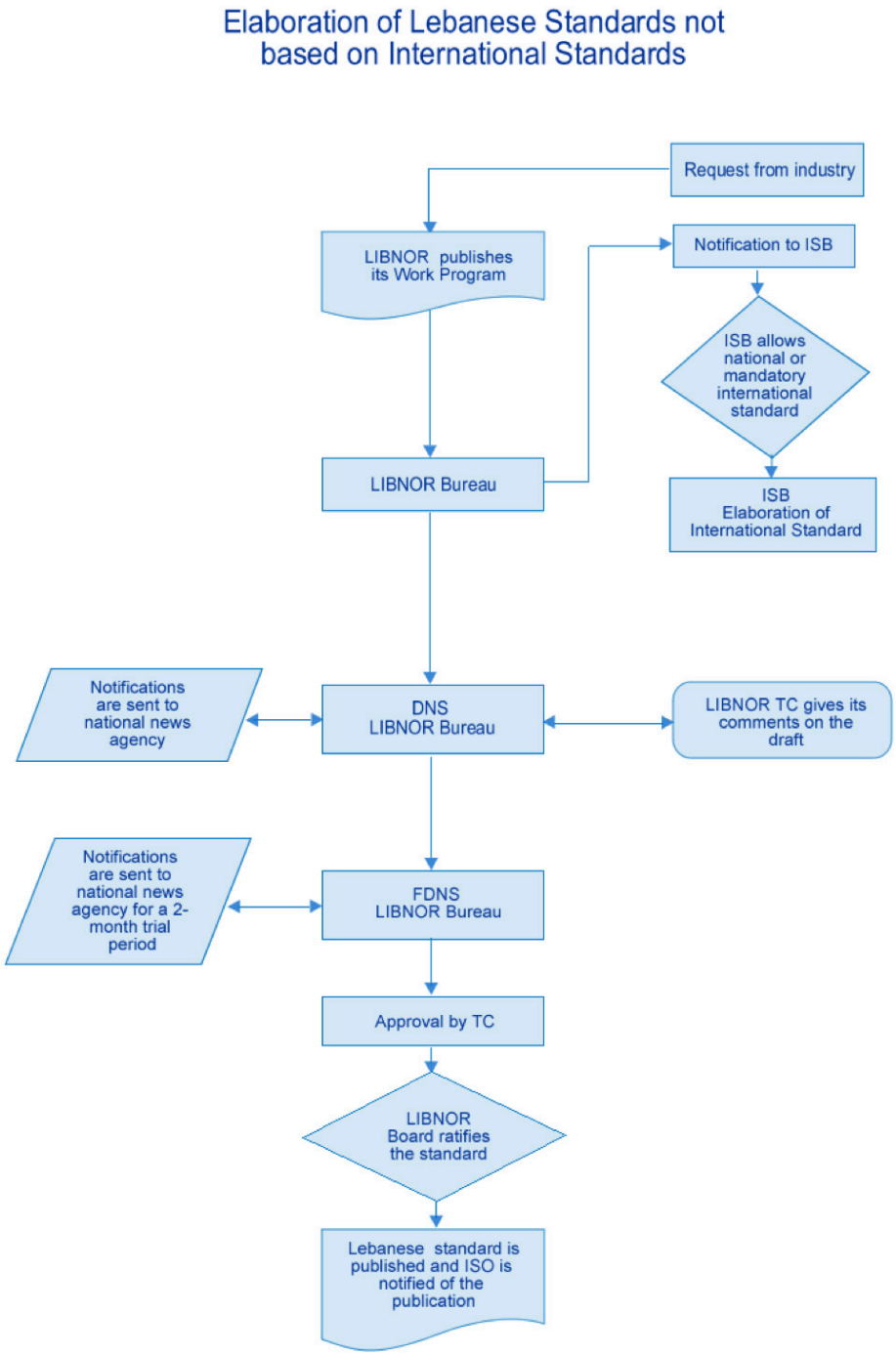

Figure 19: Process for the adoption of national standards

5.4 Status of standards implementation in Lebanon

IEC 60335-2-40 (AC Safety standard)

- Lebanon adopted the standard **NL EN 60335-2-40:2009** that is mandatory according to decree 9847 dated 4/2/2013.
  - Since it is a mandatory standard and issued through a decree, important to note that it cannot be updated or annulled except through the same way it was issued and given its mandatory effect that is through a decree. **Only a new decree may amend or annul a previous decree.**

- The reference of this standard is EN 60335-2-40:2003 *Safety of Household and Similar Electrical Appliances - Part 2-40: Particular requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers,* Including Amendments A11:2004, A12:2005, A1:2006 and Corrigendum AC: 2006.

  This reference is a modified version of IEC 60335-2-40:2002/A1:2005

- Internationally, a new version is currently available for both IEC and EN but not updated yet in the Lebanese context:

  EN 60335-2-40:2003/A13:2012/AC:2013: *Household and similar electrical appliances - Safety - Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers.*

  IEC 60335-2-40:2018: *Household and similar electrical appliances - Safety - Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers.*

IEC 60335-2-24: (Refrigerators Safety standard)

- Lebanon adopted the standard **NL IEC 60335-2-24:2009** as a **voluntary** standard
- The reference of this standard is IEC 60335:2007 *Safety of Household and Similar Electrical Appliances - Part 2-24: Particular Requirements for Refrigerating Appliances, Ice-Cream Appliances and Ice Makers.*
- Internationally, a new version of this standard is available but not yet updated in the Lebanese context:

  IEC 60335-2-24:2010+AMD1:2012+AMD2:2017 Household and similar electrical appliances - Safety - Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice makers

ISO 16358: (AC EE testing standards)

- This family of standards is not yet adopted in Lebanon.
- There are 3 parts of this standard currently available on ISO
  - ISO 16358-1:2013 + COR 1:2013+ AMD 1:2019: *Air-cooled air conditioners and air-to-air heat pumps -- Testing and calculating methods for seasonal performance factors -- Part 1: Cooling seasonal performance factor*
  - ISO 16358-2:2013+COR 1:2013: *Air-cooled air conditioners and air-to-air heat pumps -- Testing and calculating methods for seasonal performance factors -- Part 2: Heating seasonal performance factor*
  - ISO 16358-3:2013: *Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors — Part 3: Annual performance factor*

IEC 62552: (Refrigerators EE testing standards)

- This standard is not yet adopted in Lebanon.
- Internationally, there was an old version IEC 62552:2007: Household refrigerating appliances - Characteristics and test methods (from IEC) and EN 62552:2013: Household refrigerating appliances - Characteristics and test methods (From the European Committee on Electrotechnical Standardization, CENELEC) which is a modified version of the IEC 62552:2007
- However, the IEC standard IEC 62552:2007 was withdrawn in 2015 and replaced by 3 new standards as below, CENELEC is working on doing the same.
  - IEC 62552-1:2015 *Household refrigerating appliances - Characteristics and test methods - Part 1: General requirements*
  - IEC 62552-2:2015 *Household refrigerating appliances - Characteristics and test methods - Part 2: Performance requirements*
  - IEC 62552-3:2015 *Household refrigerating appliances - Characteristics and test methods - Part 3: Energy consumption and volume*

Note that there is also a Lebanese standard:

NL EN 153:2008: Methods of measuring the energy consumption of electric mains operated household refrigerators, frozen food storage

cabinets, food freezers and their combinations, together with associated characteristics. It is a **voluntary** standard with the reference EN 153:2006 that was **withdrawn** and replaced by EN 62552:2013 (mentioned above).

5.5 Product registration for market access

Once the MEPS and regulation have been approved, Original Equipment Manufacturers (OEMs) will be required to register their product **before** they can enter the market. It is recommended that Lebanon appoints its Industrial Research Institute (IRI) as a single central agency to authorise the product, confirming that it will meet the MEPS and label requirements as illustrated in Figure 20. The enforcement of MEPS shall happen together with the assignment of a body (here IRI) to verify the DOC and issue certification and authorization. IRI will review and approve product to be placed on the market based on DOCs submitted from manufacturers and distributors with the approved testing results from accredited international labs. In the initial interim phase, the market surveillance and verification of MEPS and labels can start even if the national laboratory is not yet in place with the verification of test results and labels issued by approved international laboratories.

Accordingly, importers and local manufacturers must submit a "Declaration of conformity - (DOC)" for each model they intend to sell proposing the relevant label class for the product. The DOC carries a certification confirming the energy efficiency of the appliances was tested according to the relevant standards i.e. recommended IEC 62552:2015 for refrigerators and ISO 16358:2013 for AC, with an accredited laboratory according to ISO 17025. Unless authorised, the products won't be allowed to enter or be sold in Lebanon. If a DOC is rejected, a written explanation will be provided to the submitter. The approved DOC is valid for the designated model for 24 months.

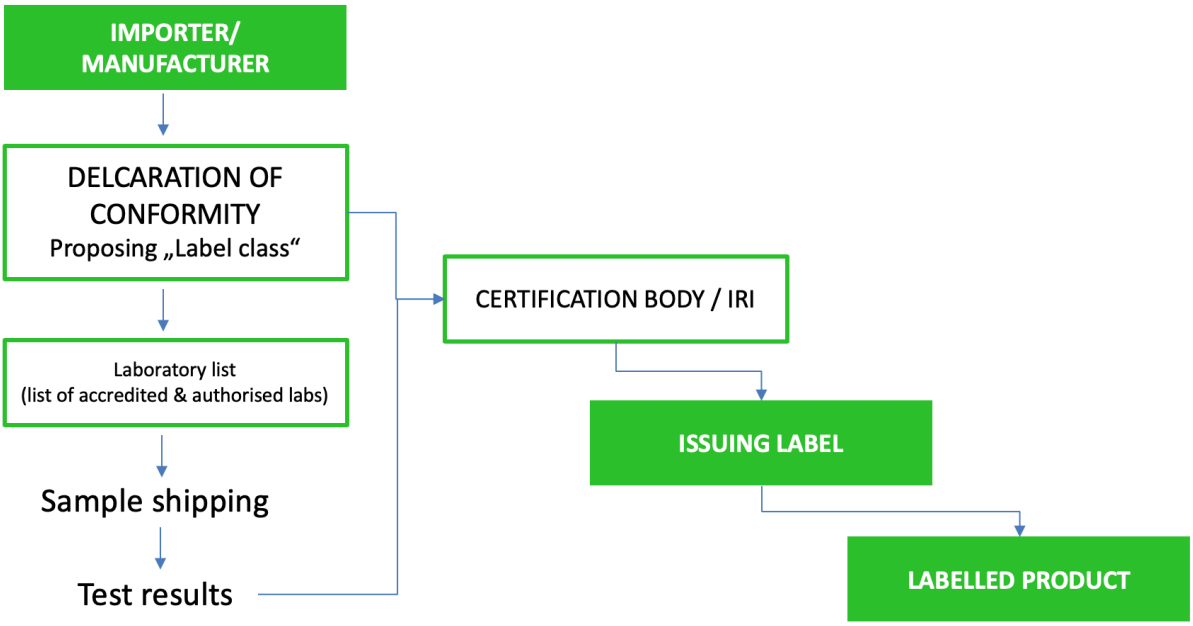

Figure 20: Product and labeling registration process.

It is recommended that all approved products be registered in a central database. As a good practice, it is recommended that the central register of products should be online and accessible to end-users and that all entities commissioned by the OEM to sell their products report their annual sales numbers to the central registry for each registered product type.

The label to be stated in the DOC should carry the following product information:

- Model name and number
- Type of unit
- The country where the product was manufactured
- For fridges: Volume of different compartments and whether they are frost-free
- Rated performance grade according to the recommended standard, i.e. IEC 62552:2015 for fridges and IEC ISO 16358:2013 for room ACs
- Rated maximum power consumption in kW

- Rated energy efficiency in Cooling Seasonal Performance Factor (CSPF), Annual Performance Factor (APF), Energy Efficiency Ratio (EER), or COP, and yearly electricity consumption in kWh at ambient temperature in degree Celsius
- Reference ambient temperature(s) used for performance testing
- Refrigerant and foam-blowing designation in accordance with ISO 817 including the Ozone Depletion Potential (ODP) and GWP.

All representations of the energy performance should indicate that the performance rating is an indicative value under standard test conditions rather than exact annual energy consumption. SEER or CSPF should be declared to three significant digits and indicate the reference outdoor temperature bin distribution used.

The label should be affixed on the product in a location that is readily visible for the consumer.

5.6 Market surveillance

The designated authority implementing the MEPS and label regulation should develop a program to check compliance with the relevant standards and monitor the market for noncompliance. The program should include details on sample size, lab accreditation requirements (ISO/IEC 17025 certified), and a process that manufacturers can use to challenge the results if the initial testing is found to be out of compliance.

It is recommended that IRI as the single central agency to be responsible for enforcement activities that include potential assessment of penalties for non-compliant products in the country. The assigned agency should establish written policies that clearly spell out its authority, procedures, and penalties. All testing done for compliance and market surveillance testing purposes should be done using the measurement and calculation methods set out in the MEPS & label regulation.

5.7 Importance of the servicing sector in the cooling plan

Servicing is an important element for the effective implementation of the national cooling plan. As appliances age, they lose performance and increase their energy consumption due to several reasons:

1. The normal deterioration that affects the operational efficiency and the system with ageing and operation.
2. Residential and commercial RAC equipment can lose significant performance and efficiency depending on how the components are sized, installed, and maintained.
3. Occasionally appliances suffer damage or corruption due to accidents or inadequate operation.
4. Improper charge can cause significant performance loses.

Deterioration can be minimized through proper preventive maintenance but cannot be totally avoided and this has been remarked by leading institutions:

- International Institute of Refrigeration (IIR) stated better optimization, monitoring, and maintenance of RAC equipment has the potential to save 30Gt of CO_2 emissions by 2050 (K-CEP, 2016),
- The International Energy Agency reported that the improvement in energy efficiency due to better maintenance and servicing practices can be up to 50% of the rated performance.

As such, it is recommended that the National Cooling Plan includes a strong component on training and certifying cooling service technicians and develop this capacity across all the relevant market participants such as services companies, repair technicians, AC installers, and more.

5.8 Analysis of future MEPS and label levels

5.8.1 Test standards and methodology

For many practitioners, good practice for RAC appliances energy performance testing means meeting the requirements of the relevant

ISO standard:

- Room ACs - ISO 16358:2013 standard, "Air-cooled air conditioners — Testing and calculating methods for seasonal performance factors".
- Non-ducted AC - ISO 5151, "Non-ducted air conditioners — Testing and rating for performance (ISO 5151)".
- Portable AC appliances - ISO 18326:2018, "Non-ducted portable air-cooled air conditioners having a single exhaust duct – Testing and rating for performance".

In terms of energy efficiency measures for ACs, the European SEER energy classification systematic was applied for the analysis of the energy efficiency of AC and as a basis for the development of a MEPS and Labelling system in Lebanon.

For domestic refrigerators, the energy efficiency analysis for refrigerators in Lebanon was based on the norm IEC 62552:2015 - "household refrigerating appliances – Characteristics and test methods (IEC 62552)". Currently, the Lebanese manufacturers (e.g. Lematic) are testing their products according to the IEC 62552:2007 standard which also forms the basis for the current label regulation applied in the EU. However, the EU is moving to IEC 62552:2015 from 2021.

The IEC 62552:2015 is also recommended for Lebanon as it is targeted to achieve international harmonization as is being adopted many key jurisdictions including the EU, Australia, Japan, China, Viet Nam, Pakistan, Indonesia, Thailand, Malaysia, Kenya, and North America. The new test standard aims to resemble closer to real-life conditions, to maintain or increase testing accuracy, reliability and reproducibility of the test results. The IEC 62552:2015 standard also aims to address some of the 2007 standards issues:

- Large uncertainties in energy consumption tests.
- Energy consumption measurement only at a single ambient temperature point of 25°C.
- Limited accounting for different product designs.
- The high target temperature for the fresh food compartment at 5°C.
- Volume measurements are sensitive to different interpretations.
- Long storage temperature tests.
- Limited suitability of test methods for refrigerators with variable automatic defrost.
- Complicated freezing capacity tests.

The advancements of the IEC 62552:2015 include:

- Simplified storage temperature tests with test packages only at 500g (50x100x100 mm) and new stability criteria,
- Shorter and simplified freezing tests focusing on the freezing time at a single ambient temperature of 25°C, with a freezing capacity of 3.5 kg for 100 L,
- Only one measurement method for the volume,
- The target temperature for the fresh food compartment at 4°C,
- Two ambient temperature at 16°C and 32°C with improved energy efficiency due to the required temperature optimization of fridges for both ambient temperatures but under some test period requirements as for the 2007 standard.

Harmonization is reached with the option left open for each country to weight these factors according to its individual requirements. With the new 2015 standard, there are separate measurements for defrost and stationary energy consumption. The test provides information on the actual consumption of defrosting technology, the energy stabilization time is flexible and not fixed to 24h anymore. Key differences with the 2007 test standard are described in Table 15 below.

The challenge with the new testing method is that manufacturers need time to adapt and optimize their products to the temperature range.

It is further recommended that Lebanon apply the European framework label classifications, e.g. the closed classification from A-G, and the Energy Efficiency Index (EEI) classification framework for refrigerators. The EU framework for the testing and the classification of appliances is already applied by major local manufacturers such as Lematic.

Table 15: Key differences between IEC 62552:2007 and IEC 62552:2015

Feature	IEC 62552:2007	IEC 62552:2015	Justification
Ambient temperature testing conditions	At a single ambient temperature point (25ºC)	At 16°C and 32°C, with interpolation between the two testing points (for energy consumption test)	IEC 62552:2015 with a single lab test universally applicable for several countries through interpolation, no-repeat tests are required for different countries. Furthermore, units are optimized at different ambient temperatures which reduce the use of circumvention devices
Stable running time	Comparison of two periods of minimum 24h each	Energy stabilization time is flexible and not fixed to 24h anymore (adaptative algorithm)	Ensures a stable and reproducible test
Temperature test for the fresh food department	5°C	4°C	Testing conditions better at real-life conditions (4°C allows better conservation of fresh food)
Volume measurement test	Two measurements: gross and net volumes	Only one measurement method for the volume	Simplified test method, fewer uncertainties in the measurement
Storage temperature test	Various sizes of test packages	Only test packages of 500g (50x100x100 mm), with new load procedures and stability criteria	Simplified test method with simpler load procedure. Shorter test and less uncertainty
Automatic defrost	Energy from automatic defrost is not measured separately, missing different procedures for different types of defrost	Separate measurements for defrost and stationary energy consumption. Considers different types of defrosting technologies	The test provides information on the actual consumption of the defrosting technology
Freezing capacity test	The load depends on the declared value from the manufacturer. If the declared value is not met, the test is repeated with different load	Same ambient temperature (25ºC), but the load is fixed depending on freezer volume, measuring the time needed to freeze the volume	Shorter and simplified freezing tests

5.8.2 Recommended MEPS and labels for refrigerators

5.8.2.1 Refrigerator energy efficiency metrics

The recommended energy efficiency metrics for refrigerators is the Energy Efficiency Index (EEI) for both, the labelling scale and the minimum efficiency requirements for refrigerators, as in the European Union. The current EEI is based on the Annual Energy Consumption (AEC) of a model relative to the consumption of a 'standard' model (SAEC) of the same category and with the same volume and temperature. The new regulation refers to the different refrigerator types by setting different default parameters per compartment type, which are then included in the calculation of the Standard Annual Energy Consumption (SAEC).

The EEI is defined as the quotient (in percentage) between the Annual Energy Consumption (AEC) measured in the laboratory under specified conditions (IEC 62552) and the Standard Annual Energy Consumption (SAEC)[22]:

$$EEI = \frac{AEC}{SAEC} * 100$$

In the EU 1060/2010 regulation, the SAEC is calculated using the equation below:

$$SAEC_{\alpha} = M_{\alpha} \times \sum_{Com} \left(V_C \times \frac{25 - T_C}{20} \times FF \times CC \times BI \right) + N_{\alpha} + CH$$

M and N are the modelling parameters specific to each refrigerating compartment type. These values depend on the type of refrigerator. α is specific to the appliance's range. V_C and T_C are the volume and target temperature of each compartment. FF is the coefficient for compartments with automatic defrost, it is only used in refrigerators containing compartments for frozen products as volume correction factors and has a value of 1.2

The CC coefficient depends on the climatic class of the appliance, being 1.1 is used for Lebanon (climate group 1, subgroup 2A). BI refers to the volume correction factor built-in appliance taken to be 1 for the assessment. CH has a fixed value of 50 kWh/year and is used in appliances with "Chill" compartment (0°C).

Those factors are given for 10 different refrigerator types[23] enabling the use of one uniform energy labelling system, as shown in Table 16 below.

Table 16: Energy efficiency classes for refrigerators as per 2014 (based on EU Regulation 1060/2010)

Energy efficiency class	Energy efficiency Index
A+++ (most efficient)	EEI < 22
A++	22<= EEI < 33
A+	33 <= EEI < 42
A	42 <= EEI < 55
B	55 <= EEI < 75
C	75 <= EEI < 96
D	96 <= EEI < 110
E	110 <= EEI < 125
F	125 <= EEI < 150
G	EEI >= 150

For the surveyed appliances in Lebanon, the respective EEIs from their specific AEC and SAEC values, are calculated as per the formulas above. Based on the calculated EEIs, the label classes are assigned according to the current EU label category distribution.

Similar to the development in the EU, where the open label category system (A+++, ….) will be abandoned in favour of a closed label category (Table 16) system from A to G for the upcoming revision of labels, it is suggested that Lebanon adopts closed label classes (A-G). Reviews in the EU have shown that closed label classes provide better orientation for consumers with less confusion (i.e. the top label class "A" will always be the best available label class). Closed label classes will have the consequence that future rescaling of labels will require a re-labelling of label classes at the retail level.

22- SAEC: Standard Annual Energy Consumption Is defined as the reference annual energy consumption of the refrigerating appliance, expressed in kWh/year. The calculations are based for variable temperature compartments, the compartment types with the lowest target temperature for which it is declared suitable to be chosen.

23- Details given in EU Reg. 1060/2010

5.8.2.2 Recommended MEPS and label classes for refrigerators in Lebanon

The market survey, mentioned in chapter 3 of this report, covered 184 combined refrigerators and freezer appliances (covering appliances with a refrigerator and freezer compartment), 20 models were refrigerator alone (covering refrigerators and bottle coolers with only one refrigeration compartment) and 17 models were freezers alone. The Energy Efficiency Index (EEI) was calculated for all appliances based on the latest international standard for refrigerators IEC 62552:2015.

The MEPS and labelling classes in Table 17 are recommended Based on the market analysis. The MEPS recommendation is an EEI of 140 starting from 2021 with appliances above 140 not be allowed to enter the market. This means that 40% of the surveyed models (79 models) must be taken out of the market. This level is 10% lower than the targeted level in the EU.

It is recommended to follow the same principle as in the EU, to have an equal relative percentage difference between the different labelling classes, with a difference of 18%. The EEI class, "A", is suggested to be set at an EEI of 50.

Table 17: Recommended MEPS and Labels for refrigerators.

	Label classes	Energy Efficiency index (EEI)	Number of surveyed models	% of models in each class
MEPS	**7G**		**79**	**40%**
	6F	140	91	46%
	5E	114	24	12%
	4D	93	2	1%
	3C	76	0	0%
	2B	62	1	1%
	1A	50	0	0%

As shown in Figure 21, currently no product in the Lebanese market meets category A and only one model meets the suggested "B" category. The recommended labelling categories leaves the two top labelling classes effectively empty to allow the market to grow into these classes. Also, in line with EU regulations, it's recommended to plan and announce a revision of the MEPS by 2024.

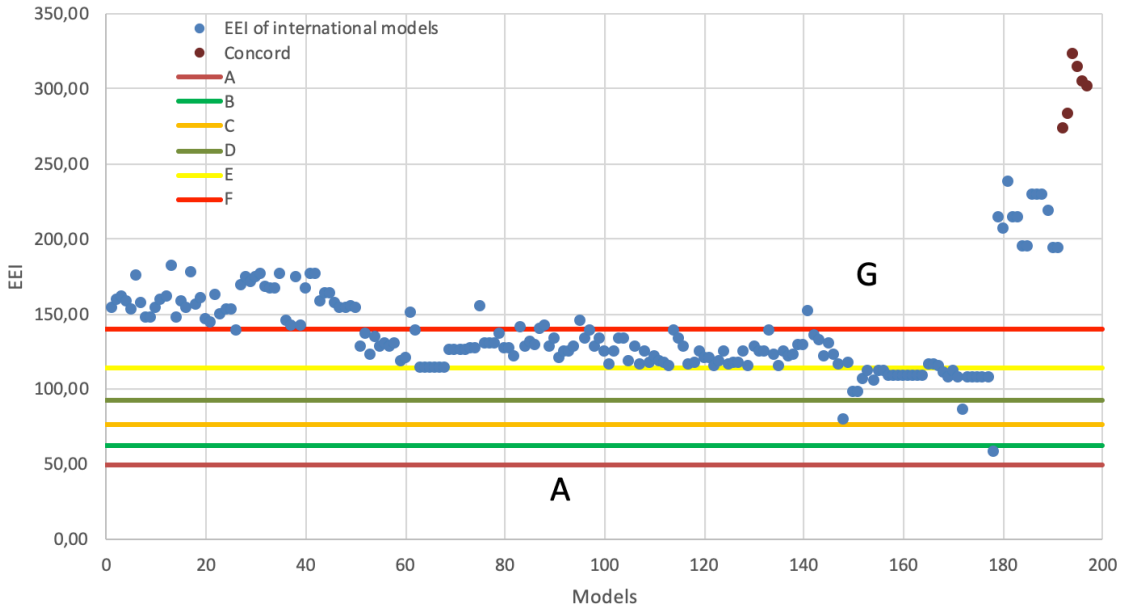

Figure 21: Appliance mapping within proposed labelling classes.

The models above the red line, in the above figure, would be denied market access.

Local brands support the transition to the suggested MEPS and labels but need support to upgrade to the newest international testing standard IEC 62552:2015 which they are not yet applying. It is suggested that the local brands will be supported in their efforts to adapt to the new standard and label classes.

5.8.2.3 Refrigerator life-cycle costs analysis

Figure 22 shows the relationship between the LCC of the most common type of the surveyed refrigerators, fridge freezers, and their Energy Efficiency Index (EEI). The red line in Figure 23 shows the proposed MEPS. Models to the right of the red line would be banned from the market.

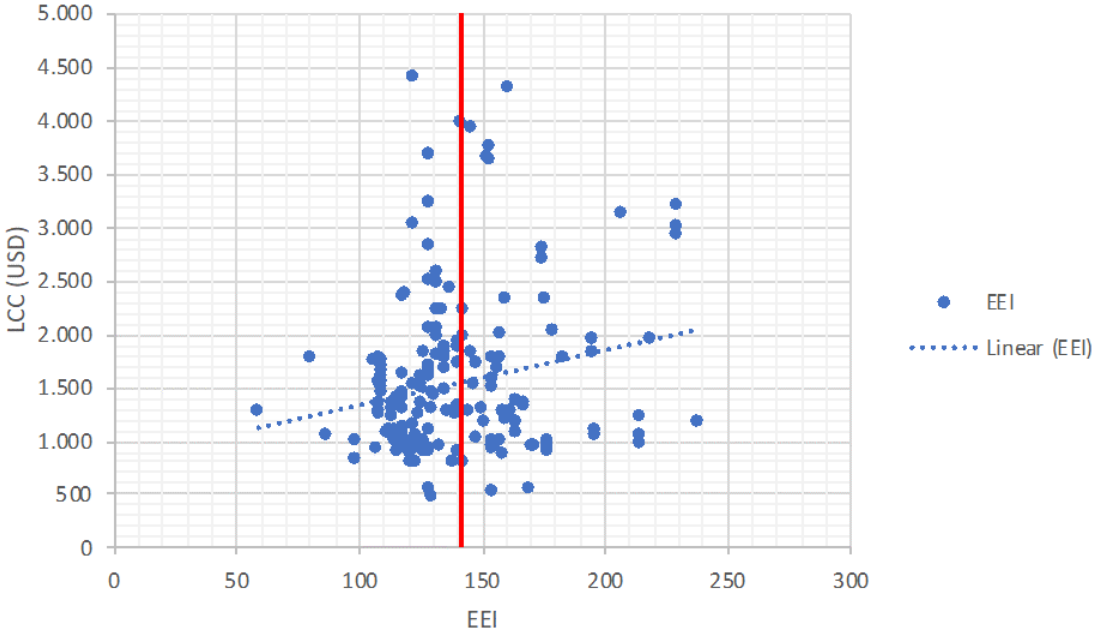

Figure 22: Relationship between Life Cycle Cost (LCC) and EEI.

The graph shows that on average with increasing energy efficiency the LCC tend to be lower. This is assuming the current electricity price. With the future possibility of higher energy prices, more energy-efficient appliances would show lower relative life-cycle-costs. This suggests that with the introduction of the MEPS, the life-cycle costs for the available appliances will not increase or could even decrease.

5.8.2.4 Benchmarking refrigerators' MEPS and labels internationally

Figure 23 below shows the proposed MEPS in comparison with the current (dashed blue line), the proposed new EU 2021 (blue line) and the EU 2024 update (green line) MEPS for different volume classes. The proposed Lebanese MEPS for 2021 is less ambitious than the current EU MEPS level and the recommend minimum global MEPS suggested in the model regulations of U4E (see UNEP 2019a and 2019b).

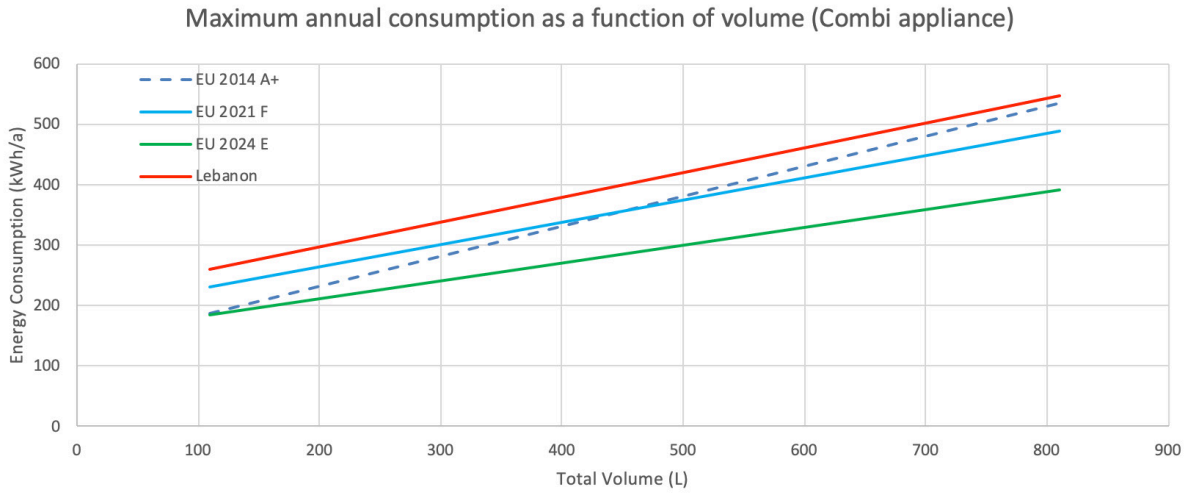

Figure 23: Comparison of proposed refrigeration MEPS in Lebanon versus EU MEPS

5.8.3 Recommended MEPS and labels for room ACs

The AC appliance survey includes an analysis of more than 140 room AC models in the Lebanese market. The models varied from capacity ranges of 2 kW to more than 10 kW. Most of the units were within 3-4 kW cooling capacity range.

5.8.3.1 AC Seasonal Energy Efficiency Ratio (SEER[24])

Adopting the EU MEPS and labelling scheme is recommended for Lebanon. The EU MEPS and labels are a long-established system and many of the current manufacturer and importers of ACs in Lebanon are familiar with the EU system. The current MEPS and label classes in the EU, as per Directive 2010/30/EU, are shown in Table 18 below.

Table 18: Energy efficiency class for air-conditioners (EU Regulation No 626/2011)

Energy efficiency class	Energy Efficiency
A+++ (most efficient)	SEER>= 8.5
A++	6.1 <= SEER < 8.5
A+	5.6 <= SEER < 6.1
A	5.1 <= SEER < 5.6
B	4.6 <= SEER < 5.1
C	4.1 <= SEER < 4.6
D	3.6 <= SEER < 4.1
E	3.1 <= SEER < 3.6
F	2.6 <= SEER < 3.1
G	SEER >= 2.6

Going forward, for classifying room ACs in Lebanon, it is recommended that Lebanon adopts a closed label system with classes from A to H, instead of the current EU system A+++ to G. The EU will also transit from the open system to a closed system A-G. When the top classes are filled with more than 20% of the appliances, a rescaling of the labelling is triggered, where retailers will need to change the labels. It is recommended that Lebanon, where currently no labelling of ACs exists, should directly start and remain with a closed labelling classification.

5.8.3.2 Refrigerant distribution for room ACs

The main refrigerants in use are R410A with a GWP of over 2,080 and R22 with a GWP of over 1,810 with only a few models having R32 as a refrigerant. While Lebanon is phasing-out ozone-depleting refrigerants, the market is saturated with high GWP refrigerants. Figure 24 shows the refrigerant distribution of the analysed models from the Lebanese market.

24- The Energy Efficiency Ratio (EER) is the ratio of the total cooling capacity to the effective power input to the device at given rating condition. This is the efficiency you can expect from the AC at peak cooling time (e.g. in the midst of the summer) because it is measured at only one, higher temperature.

The Seasonal Energy Efficiency Ratio (SEER) is an average. It takes into account the highs and lows of a typical outdoor ambient temperature over the whole cooling season.

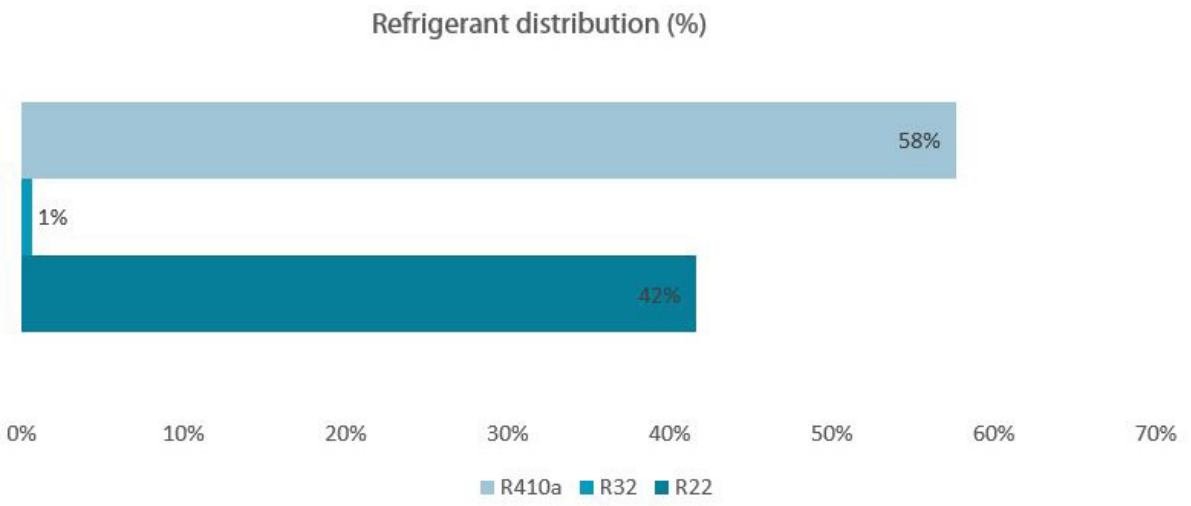

Figure 24: Current refrigerant distribution for ACs in Lebanon

5.8.3.3 Recommendation of MEPs and labelling classes for room ACs

With reference to the EU Reg. 626/2011 energy labelling of air conditioners, the different models are classified into 8 energy classes, from A to H as shown in Table 19. The most efficient energy class has a SEER>8.5. While none of the surveyed models falls into this category, the majority fall within the least energy-efficient classes of G and H.

We recommend adopting the label classification of Lebanon in-line with the current energy classes in the EU as illustrated in Table 17 above:

- **MEPS**: MEPS starting at class H in 2021, at a SEER of 3.6, with 44 models falling out of the market,
- The MEPS should increase, in 2024, to a SEER of 4.1,
- Top **label** class: The initial top label class with a SEER of 8.5 will be initially empty with the aim that over time the market will grow into the top energy efficiency class.

Based on the recommended energy classes, the most popular class is 3.6<=SEER<4.1 with 59 models, the majority belong to class G as shown in Table 19 below.

Table19: Recommended MEPS and labels for ACs in Lebanon

Energy class	EER ranges	Avg. EER	Avg. cooling capacity (kW)	Avg. Energy consumption (kWh)	Total models analysed
A	SEER>8.5	-	-	-	-
B	6.1 <= SEER < 8.5	6.29	4.86	792.76	26
C	5.6 <= SEER < 6.1	-	-	-	-
D	5.1 <= SEER < 5.6	-	-	-	-
E	4.6 <= SEER < 5.1	4.80	5.28	1,318.87	1
F	4.1 <= SEER < 4.6	4.14	3.52	1,019.42	6
G	3.6 <= SEER < 4.1	3.79	3.94	1,253.46	59
H (MEPS)	SEER < 3.6	3.23	4.22	1,568.77	44

5.8.3.4 Room AC life-cycle costs analysis

The LCC vs SEER analysis for split residential AC models are shown in Figure 25 below. Based on the previous subchapter the initially recommended MEPS for 2021 is at a SEER<3.6 (Energy class H). All the products below this SEER value of 3.6 should be taken out of the market.

Figure 25 also shows that even with current electricity prices more efficient appliances will on average not lead to higher life-cycle costs. With the expected increase in electricity prices, more energy-efficient appliances will have lower LCC assuming their upfront prices remain at a similar level.

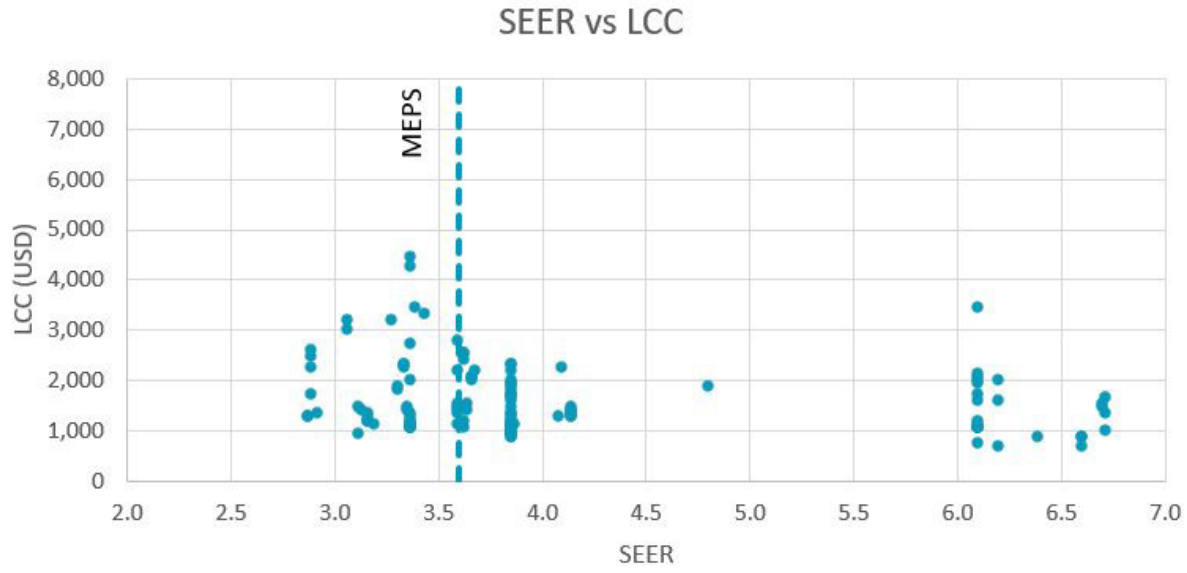

Figure 25: LCC vs SEER with recommended MEPS

Again, the analysis shows that higher efficiency appliance tends to have a lower LCC as shown in Table 20. The average unit price of more energy-efficient appliance increases from class G to B, however, the LCC for class be is the second lowest on average. Operating costs account for about 66% of the total LCC, therefore with increasing electricity prices and stable average unit prices, the relative competitiveness of higher energy-efficient appliances increases and the average LCC of more energy-efficient appliances decreases.

Table 20: Energy classes and LCC for room ACs in Lebanon

Energy class	Average Unit price (USD)	Average LCC (USD)
A	-	-
B	737.56	1,385.97
C	-	-
D	-	-
E	869.00	1,823.57
F	533.86	1,338.12
G	520.92	1,494.64
H	636.51	1,842.30

5.8.3.5 Benchmarking room AC MEPs and label internationally

The proposed MEPS of 3.6 SEER for Lebanon is in line with international MEPS programs with most developing countries adopting MEPS between 3 and 4 SEER. It also presents a top-class above 8.5 SEER to allow the market to grow over time, considering that units in this energy efficiency class are already available internationally[25].

25- Source: Shah 2016, S&L programs for efficiency improvement in room air conditioning, 2016.

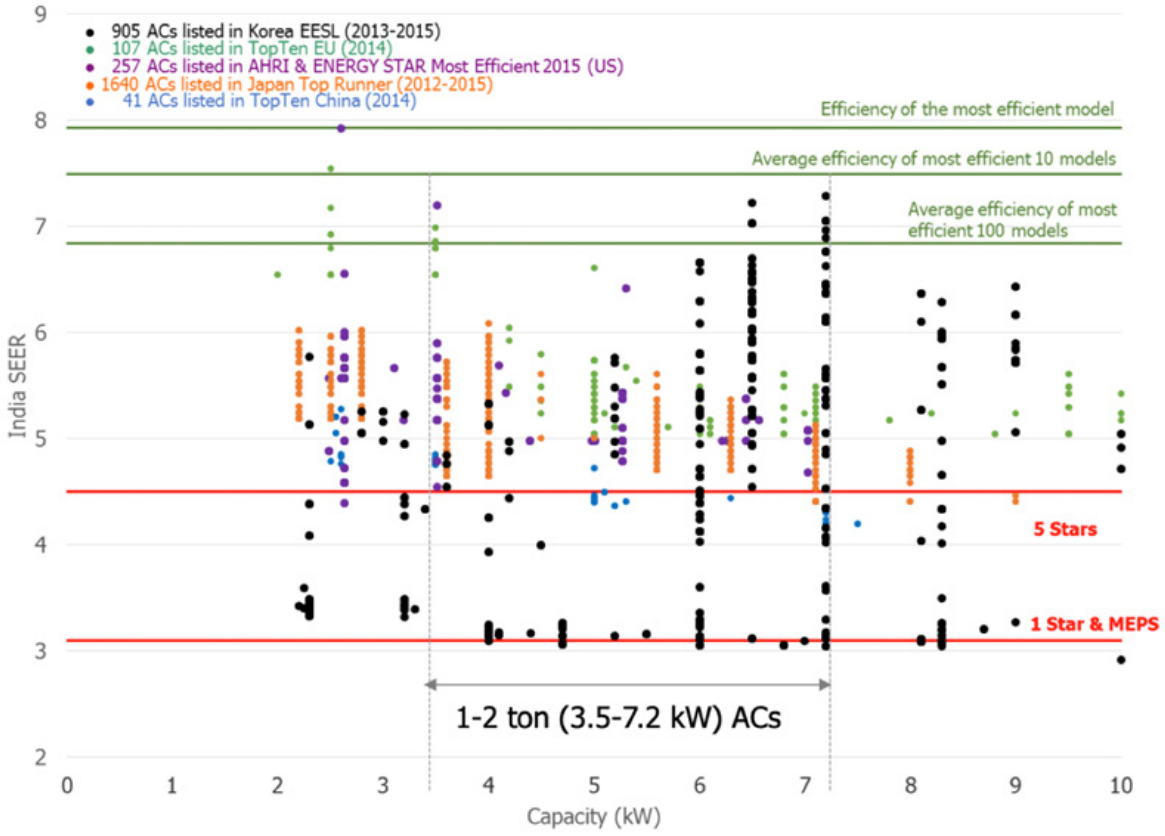

Figure 26: Room AC comparison with international MEPS and label levels.

The recommended SEER of 3.6 compares relatively low relative to international efficiencies of ACs as mentioned in the United for Energy (U4E) AC best practice reference guide (Error! Reference source not found.). However, it is believed that starting at this lower level will allow local manufacturers to adapt to these new requirements. The Lebanon market is expected to catch up to international best practice over time with the recommended MEPS revision in 2024 to 4.1 SEER will drive the market to transition to the more efficient variable speed drive (VSD) inverter AC appliances.

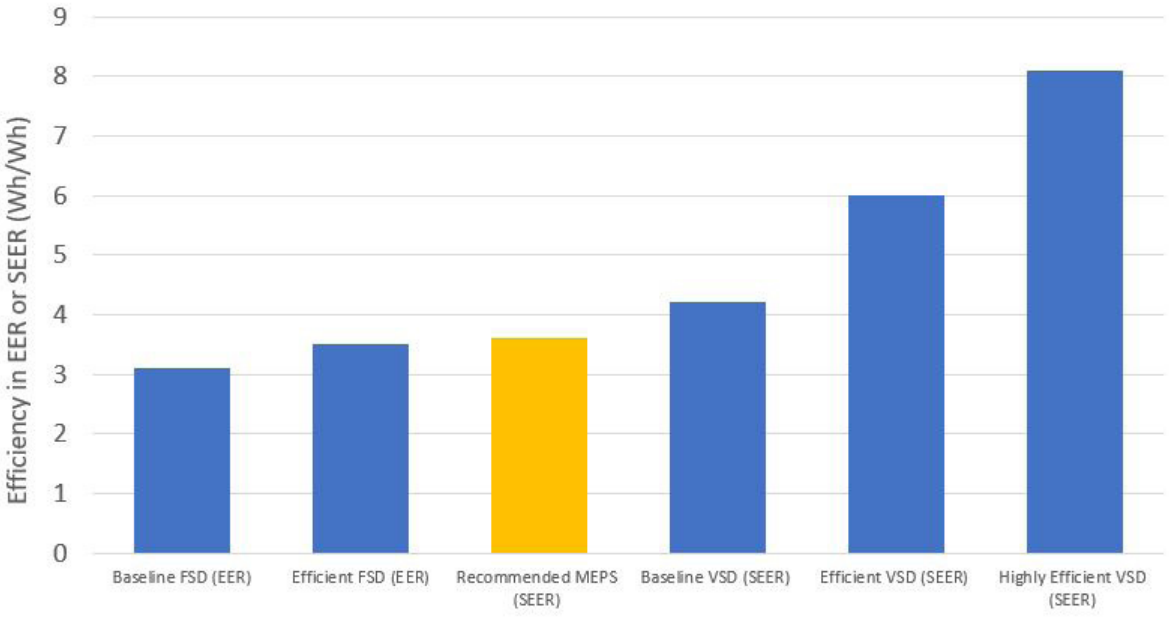

Figure 27: Recommended Lebanon SEER for AC relative to international AC efficiencies.

5.9 Market Surveillance

5.9.1 Introduction

This document summarizes the Energy Efficiency (EE) requirements and test procedures for UAC and domestic refrigerators according to the relevant international standards. It is intended as guidance when considering a regulatory or legislative framework[26] to require more energy-efficient appliances and using lower GWP refrigerants and to ban the import of second-hand units.

5.9.2 In-Scope appliances

Space cooling – ACs: It covers all electrical single-phase non-ducted single split (or mini-split), self-contained air-cooled air conditioners and portable air conditioners, used commonly in residential and light commercial applications, with a rated cooling output of at or below 16 Kilowatts (kW) placed on the market for any application.

Domestic refrigeration: It covers the types of refrigerators, refrigerator-freezers, and freezers used commonly in residential and light commercial applications. It applies to refrigerate appliances of the vapor compression type, with a rated volume at or above 10 litres (L) and at or below 1,500 L, powered by electric mains and offered for sale or installed in any application.

5.9.3 Lebanon's climate class

In terms of climate group[27], Lebanon is classified under the Primary Group 1[28] (thermal: hot) and Secondary Group 2A (Humid, hot-humid) under the relevant energy performance standard ISO6358:2013. Energy performance requirements of AC units in-scope are a determined function of this classification and must comply with the stipulations of the above regional climate group.

5.9.4 Refrigerants

Part of a transition to more climate and environmentally friendly appliances includes a transition to no ODS and low GWP refrigerants. Accordingly, refrigerants used in ACs should comply with requirements for Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) over a 100-year time horizon as suggested in Table 21 which is based on the U4E best practice guidelines and the GWP limits under the European F-gas Regulation (EU Regulation 517/2014).

Table 21: Requirement for ACs' refrigerants.

Refrigerating System	GWP	ODP
Self-Contained Systems	Below 150	0
Split Systems	Below 750	0

For refrigerating appliances, refrigerants and foam blowing agents should comply with requirements concerning their ODP and GWP values over a 100-year time horizon according to the limitations listed in Table 22.

Table 22: Requirement for refrigerators' refrigerant and foam-blowing agent characteristic.

Product Class	GWP	ODP
All types	Below 10	0

Domestic refrigerators using hydrocarbon (e.g. Isobutane R600a, propane R290) refrigerant, must comply with current IEC 60335-2-24:2010/AMD:2017, limiting the refrigerant charge, of each refrigerating circuit, to a maximum of 0.15kg (150gr). In Annex 2, depicts the ODP and GWP values of most commonly used refrigerants.

26- An effective legislation framework consists of regulatory requirements which can be verified and enforced. The regulation should include a collection of requirements which are based on testing protocols and requirements set by the International Standards Organization (ISO).

27- As defined by the UN's United for Efficiency (U4E) document: "*Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Air Conditioners.*"

28- Primary climate group 1 refer to ISO 16358-1: 2013.

5.9.5 Assessment of existing institutional capabilities for equipment testing

Currently, there is no RAC energy efficiency test lab in Lebanon, nor an official accreditation for foreign energy performance test labs. Only an electrical safety test lab exists at the Industrial Research Institute (IRI).

LCEC (under the ministry of energy and water) has received Italian funds for a heat pump energy performance test lab. Yet it hasn't been officially confirmed where the lab will be implemented, and which agency will manage and operate it.

5.9.6 Estimated laboratory cost and tests pricing[29]

This section provides indicative cost and price estimates for establishing and operating appliance testing laboratories for Unitary Air Conditioners (excluding whole-house central air conditioners) and Domestic Refrigerators. Test lab cost and testing fees for both appliances were desk researched and surveyed across five global regions: Sub-Saharan Africa, Asia, Middle East & North Africa, Latin America and the Caribbean, and other regions (including most of Europe and North America). Table 23 provide the resulting estimates of the lab set-up costs.

Table 23: Estimated laboratory capital and operational cost (USD).

Technology	Capital Cost (USD)		Operational Cost (USD)
	Low	High	
ACs	363,000	665,000	12,000 + Staff & Space
Refrigerators	265,000	617,000	4,000 + Staff & Space

Table 24 below contains indicative prices for a single product unit to be tested at an accredited laboratory in the Middle East and North Africa region. The reported ranges in USD reflect quoted prices provided by both national (i.e. those owned by public entities) and private laboratories and include relevant national and regional test methods and standards.

With an estimated 20-40 types of ACs and refrigerators per year, the test lab can at best break even. Their function would be mostly (1) to have a national test lab for an effective market surveillance and (2) to level the playing field for domestic manufacturers who do not need to send their equipment abroad for testing. Due to the latter reason, priority should be given to a domestic test lab for refrigerators.

Table 24: Estimated testing fees in the Middle East and North Africa (MENA) region (USD).

Technology	Testing Prices per unit (USD) - MENA Region	
	Low	High
ACs	1,040	8,057
Refrigerators	480	2,939

5.10 Test methods and energy efficiency performance calculation

5.10.1 Air conditioners[30]

Compliance with the energy performance requirements should be tested according to ISO 16358:2013, "*Air-cooled air conditioners — Testing and calculating methods for seasonal performance factors (ISO 16358)*[31]" which refers to ISO 5151, "*Non-ducted air conditioners*

29- SEAD: Global Appliances Testing Cost Catalogue – Edition June 2019

30- These requirements apply also to heat pump appliances.

31- The term ISO 16358 in this document includes ISO 16358-1:2013/Amendment 1:2019.

— *Testing and rating for performance (ISO 5151)*[32]". Rating conditions for cooling capacity and heating capacity (as a significant share of ACs in the market have dual-mode, cooling and heating. If they have dual-mode they need to be tested for both cooling and heating) can be found in *Table 25* and *Table 26* respectively. Ductless portable products or portable products with a single exhaust duct should be tested according to ISO 18326:2018, "*Non-ducted portable air-cooled air conditioners having a single exhaust duct – Testing and rating for performance*"[33].

Table 25: Cooling capacity rating conditions.

	Air temp. entering indoor side. dry-bulb / wet-bulb	**Air temp. entering outdoor side. dry-bulb / wet-bulb[34]**
ISO 16358-1:2013 (T1 moderate climate) Standard cooling capacity	27 °C / 19 °C (ISO 5151 T1)	35 °C / 24 °C (ISO 5151 T1)
ISO 16358-1:2013/Amd 1:2019 (T3 hot climate) Standard cooling capacity	29 °C / 19 °C (ISO 5151 T3)	46 °C / 24 °C (ISO 5151 T3)

Table 26: Heating capacity rating conditions.

	Air temp. entering indoor side dry-bulb / wet-bulb	**Air temp. entering outdoor side dry-bulb / wet-bulb**
ISO 16358-2:2013 Standard heating capacity	20°C / 15°C (maximum)	7°C / 6°C (ISO 5151 H1)

Products are to be represented according to the calculation of a seasonal performance factor as prescribed in ISO 16358. Determining the *Cooling Seasonal Performance Factor (CSPF)* and the *Annual Performance Factor (APF)* requires testing the appliances according to ISO 16358 and calculating the efficiency performance by using Lebanon's outdoor temperature bin data as shown in Table 27.

Table 27: Temperature bins for calculating CSPF for countries in Primary Group 1, Secondary Group 2A.

Outdoor temperature ℃	**Reference bin hours**	**Bin hours for Lebanon**
21	ISO 16358-1: 2013	49
22		92
23		128
24		161
25		191
26		210
27		219
28		212
29		188
30		149

32- ISO 5151 specifies how to measure the cooling capacity and efficiency of air conditioners using stipulated test conditions. While ISO 5151 and ISO 16358 are used as primary references, countries may consider other national or regional test methods according to their market or infrastructure that fulfil the same objective and maintain the energy efficiency requirements.

33- EN14511 and the U.S. standard (USA Federal Register, Vol 81, No. 105) can be alternative references of testing portable products.

34- The wet-bulb temperature condition is only required when testing air-cooled evaporative condensers.

31	ISO 16358-1: 2013	118
32		86
33		58
34		37
35		22
36		13
37		8
38		4
39		3
40		1
41		1
42		1
43 to 50		0
	TOTAL	**1,951**

Detailed reference test conditions and clauses of the test standard ISO 16358:2013 for cooling and heating of ACs or combined cooling and heating appliances are listed in Table 28 below.

Table 28: Reference standards for test methods and for energy efficiency calculations.

Temperature and humidity conditions and default values for cooling efficiency test at T1 for moderate climate[35]	ISO 16358-1:2013 Table 1
Test methods for cooling efficiency	ISO 16358-1:2013 Chapter 5
Cooling efficiency calculations	ISO 16358-1:2013 Chapter 6 Clause 6.4 (fixed capacity units) Clause 6.5 (two-stage capacity units) Clause 6.6 (multi-stage capacity units) Clause 6.7 (variable capacity units)
Temperature and humidity conditions and default values for heating efficiency test.	ISO 16358-2:2013 Table 1
Temperature and humidity conditions and default values for cooling efficiency test at T3 for hot climate	ISO 16358-1:2013/Amd 1:2019 Table F.1
Test methods for heating efficiency	ISO 16358-2:2013 Chapter 4
Heating efficiency calculations	ISO 16358-2:2013 Chapter 5 Clause 5.3 (fixed capacity units) Clause 5.4 (two-stage capacity units) Clause 5.5 (multi-stage capacity units) Clause 5.6 (variable capacity units)
Annual Performance Factor (APF) calculation	ISO 16358-3:2013 Chapter 5

35- This regulation allows use of the default value below by setting the low-temperature cooling capacity test for fixed speed units as an optional test.

Cooling full capacity at outdoor temperature 29°C = 1.077 × Cooling full capacity at outdoor temperature 35°C

Cooling full power input at outdoor temperature 29°C = 0.914 × Cooling full power input at outdoor temperature 35°C.

5.10.2 Domestic refrigerators and freezers

Domestic refrigerators compliance should be tested according to IEC 62552:2015, "*Household refrigerating appliances – Characteristics and test methods*". Energy performance should meet the MEPS set at an Energy Efficiency Index (EEI) equal or below 140, with the calculation as detailed in section 5.8.2.1 with the Energy Efficiency Index (*EEI*) defined as:

$$EEI = \frac{AEC}{SAEC} * 100$$

Where *SAEC* is the Standard Annual Energy Consumption in kWh/year. It represents the average AEC of commercialized appliances (similar types) in the country.

Equation 1. AEC = ECT × (365/1000) in kWh per year

Where ECT is energy consumption in Wh per 24 hours based on ambient temperature T, as calculated per Equation 2 and rounded to the nearest integer.

Equation 2. ECT = $\boldsymbol{a}$ × EC16 + $\boldsymbol{b}$ × EC32 in Wh per day

Where EC16 is energy consumption measured at ambient temperature 16°C and EC32 is energy consumption measured at ambient temperature 32°C, per IEC 62552-3:2015.

If the typical temperature where refrigerating appliances are used is not identified, the reference ambient temperature of 24°C and coefficients a and b from Table 29 can be used for Equation 2.

Table 29: Reference Ambient Temperature and Coefficients a and b for Equation 2

Reference Temperature (°C)	a	b
24	0.5	0.5

Optional reference temperatures and associated requirements are in Table 30 below.

Table 30: Optional Reference Ambient Temperatures and Coefficients a and b for Equation 2

Reference Temperature (°C)	a	b
20	0.75	0.25
32	0	1.0

To enable the direct comparison of energy consumption between label classes, the average adjusted volume (which refers to the average volume of the refrigerating appliance in each of the energy classes) is calculated as per equation 3 below:

Equation 3. $\boldsymbol{Adjusted\ Volume\ (AV) = \Sigma (Volume i \times K_i \times F_i)}$

where K_i is the volume adjustment factor, as calculated per Equation 4 and F_i is the frost adjustment factor.

Equation 4. $K = (T_1 - T_c)/(T_1 - T_2)$

for fresh food compartments, K=1

For other compartments, T_1 is reference ambient temperature selected by the country, T_2 is the temperature of the fresh-food compartment (4°C), and Tc is the temperature of the individual compartment concerned as shown in Table 31.

Table 31: Examples of Volume Adjustment Factor (K) calculations.

Reference Temperature	Fresh Food Compartment	Frozen Food Compartment	
T_1 = 24°C	K = 1 (T_2 = 4°C)	Tc = -6°C	K = 1.48
		Tc = -12°C	K = 1.76
		Tc = -18°C	K = 2.05

F=1.1 for frost-free (automatic defrost) is applied only to frozen food compartments. F=1.0 is applied to all other compartments and manual defrost frozen food compartments.

6 ENABLING FINANCING

6. ENABLING FINANCING

This section discusses the financing options to implement the NCP. It will explore financing tools to incentivize actions as well as raising the needed funds. The proposed funding mechanism under the NCP takes consideration of the current situation of Lebanon's limited available financial resources. The suggested funding sources therefore build on levies on imported, high GWP refrigerants and energy in-efficient appliances as national co-funding in combination with international climate finance. In turn, the raised funds will finance incentives for highly energy efficiency appliances in top label classes in line with the label system proposed in Chapter 5 of the NCP. The intended impact of the incentive system will be the accelerated market introduction of climate friendly and energy efficient appliances, the installation of the relevant labs, the costs of certification tests, the costs for the registration process and the market surveillance system including an effective fining system for non-compliance. The funding mechanism will also provide financial resources in support for the local manufacturer transiting to highly energy-efficient appliances, including the certification of their lab e.g. ISO certification. Such lab ISO certification establishment could be further co-financed with international climate financing.

In the medium term, it is also suggested to introduce a carbon credit system, where carbon credits earned through the destruction of high GWP refrigerants would finance a system for the take-back of old, energy-inefficient appliances with high GWP refrigerants and their replacement with appliances in the top-label classes and having low GWP refrigerants. The old appliances will be collected and sustainably recycled, their high GWP refrigerants and foam blowing agents will be recovered and destroyed.

In the following, the cost and financing possibilities of incentive systems have been analysed for refrigerators and air conditioners. There are an estimated 2.2 million domestic refrigerators and 2.5 million room ACs in operation in Lebanon today. As these appliances are used across the country in nearly all households, potential incentive and financing systems have a wide reach.

As such, the main target group for the proposed incentive are households buying refrigerators and ACs. Incentive schemes for the remaining parts of the RAC sector can be implemented later, benefiting from the experience of implementing incentives for ACs and refrigerators.

6.1 Transition towards energy-efficient appliances with low Life-Cycle Cost

Customers currently consider the appliance's upfront cost, look and functionality as the primary criteria when buying any home appliance for domestic use. Currently, no or very limited information on the Life Cycle Costs (LCC) of appliances is available, and customers cannot compare upfront costs against operations to LLC costs (Renew, 2016). The assumption is that a better-informed customer, with the proper labelling of appliances and available information on the LCC will choose highly efficient appliances more often (see also Peter K. Smith et al. (2010)). Most existing studies report a positive effect of LCC information, through labels, on the purchase likelihood of eco-innovations. Disclosing LCC information provides an important base for long-term thinking on the individual, corporate, and policy levels.

The Investment Development Authority of Lebanon analysed the willingness of customers to pay for energy-efficient home appliances in Lebanon. Approximately 33% of respondents expressed a willingness to pay a premium for more energy-efficient appliances. 39% of the respondents, claimed to be determining their decisions looking at specific features of the appliances including their prices. 28% of buyers were not willing to pay higher upfront prices. The willingness to pay for low emission appliances with higher upfront costs is higher in the higher socio-economic segment of society. Incentive systems have an important function in bridging the gap between the potentially higher upfront of more energy-efficient appliances and their lower running costs (Investment Development Authority of Lebanon, 2018).

Even though efficient RAC appliances tend to have lower LLC costs, Lebanese consumers prefer to buy lower efficiency appliances which are perceived to be cheaper due to possibly lower upfront costs. This may be due to a combination of factors including lack of information regarding the LCC, lack of access to funds or finance for the premium, or an unwillingness to pay for an upfront premium.

To overcome these barriers, a 2-step bonus and malus or reward is suggested, also known as a feebate system or incentive and tax system:

1. **Taxation system**[36], which increases the price of inefficient appliances and high GWP refrigerants.

   Tax on the import of inefficient appliances: This tax aims to increase the upfront cost of inefficient appliances to bring them on par, or make them more expensive, than the efficient appliances.

   Tax on the import of the GHG potential of refrigerant: an import tax based on the GWP weighting of HFC refrigerants is

36- In the context of this study custom duties or tax are to be understood as inter-exchangeable terms for "surcharges" on relatively inefficient appliances with high GWP refrigerants.

proposed to trigger the transition to low GWP refrigerants. The levy will be only for HFC as the HCFCs phase-out is already comprehensively addressed as part of the HCFC phase-out management plan. Initially, an entry carbon tax of 30 EUR/t CO_2-eq is proposed. The levy can be increased over time. The HFC import levy will be introduced on bulk imported refrigerants and it is proposed not to differentiate the levy according to different appliance types as the refrigerants are usually used across different appliances. The main refrigerant types affected will be the imports of HFC-134a, HFC-410A.

2. **Incentive on purchase of efficient appliances with the exchange of inefficient old appliances.**

   The second part is the introduction of a discount on the purchase price or direct cash subsidy on energy-efficient appliances in exchange for handing back an inefficient appliance for disposal. This would only be provided for appliances in classes A and B with low GWP refrigerants and only be paid once the old device is handed back to the retailer or service provider for proper disposal. The retailer or service provider will ensure that the replaced devices will be handed over to the recycling and disposal facility, which will scrap the devices and dispose of or recycle the refrigerants. To ensure that the collected devices do not re-enter the market, the retailer/ service provider will receive reimbursement for the incentives paid to the customer, only when the devices are handed over to the recycling and disposal facility. Cost for disposal of the systems and the cost for the recycling and disposal facility are considered in chapter 6.5.3.

6.2 Implementation and management of the enabling financing system

Drawing on the stakeholder list, tasks and roles for the implementation and management of the incentive system are allocated. Two core roles are defined for the management, that are a coordinating entity and an implementing entity. An approximate role description is provided in Table 32 below.

Table 32: Stakeholders and their roles in the incentive system.

Stakeholder	General roles and responsibilities	Tasks to implement system
Libnor	Lebanon's regulatory body issuing and adopting standards and potentially labels	Develops energy efficiency standards and analyse test results to derive energy labels.
Industrial Research Institute (IRI)	National authority for the testing of industrial equipment and appliances	Implementing entity: Proposed issuing authority for MEPS and label certificates to manufacturers and importers. Testing centre for RAC appliances. It is assumed that they will need to test 50 devices per year for market surveillance. IRI is also suggested to carry out market surveillance with shops and refrigerant distributors for illegal imports of appliances and refrigerants. IRI is suggested to establish and manage a central online database for market surveillance and the Monitoring, the Review and Verification of measures.
Lebanese Customs Authority	The authority in charge of controlling the imports of RAC appliances. Providing data on imports and exports of RAC equipment and refrigerants	Introduce and collect new import tax for cooling equipment and refrigerants based on their energy efficiency and the GWP of refrigerants. The customs authority will closely collaborate with IRI. IRI will be responsible for defining the criteria according to which the custom import duties will be raised.
K-CEP	Philanthropic program targeting the transition to efficient, climate-friendly cooling	

Ministry of Environment (MOE) - National Ozone Unit (NOU)	The ministry is the host of Lebanon's UNFCCC climate focal point and overseeing most of the climate change and environmental projects in Lebanon. The ministry is also the National Focal Point for the Montreal Protocol and activities carried out under it. The ministry is responsible for setting refrigerant quotas to local suppliers. The NOU is a UNDP project concerning Montreal protocol activities and initiatives.	Responsible for the implementation of the National Cooling Plan and its integration into Lebanon's NDC Compiles monitoring reports on refrigerants Overseeing the market surveillance
Order of Engineers and Architects	The national organizations hosting engineers and architects in Lebanon. They regularly publish reports and studies on energy performance in appliances and buildings.	n.a.
LCEC	A centre within the Ministry of Energy and Water responsible for energy efficiency and renewable energy activities. Their role includes setting up national strategies, implementing RE&EE initiatives, and supporting Libnor on standards and MEPS.	Member of the national committee for setting up energy efficiency standards in Lebanon.
Ministry of Energy and Water	Ministry responsible for the national electricity utility (EDL) and overseeing Lebanon's energy sector	Support in Legal framework for the incentive system, support implementation of taxes, arrange for soft loans jointly with MOF and the Central Bank of Lebanon (BDL).
Manufacturers, Assemblers and Distributors	Local manufacturers and assemblers of RAC equipment; they will be directly affected by MEPS enforcement	Manufacturers, assemblers and distributors, are bringing the appliances on the market and will be responsible for the registration of the energy efficiency classification of the appliances, which they bring into the market. They will be also responsible for the take-back of old appliances and bringing them to environmentally sound recycling centres. Local manufacturers (e.g. Lematic as the major local manufacturer) will benefit from import tax on foreign devices.
End Users	Households and other users buying and using RAC equipment. MEPS will have a direct impact on their energy consumption and maybe the cost of equipment	Purchase devise, cover investment and operating cost, decommissions old device in case of refrigerators and ACs

Servicing Companies (Installers and Maintenance)	Companies performing aftersales service to RAC equipment	Installers are responsible for the appropriate and safe installation, environmentally-sound disposal, and proper and energy-efficient installation and maintenance of the new appliances. Knowledge of replacement program - marketing and advertisement
Recycling and disposal facility (e.g. Lematic Group)		Recycling centres are responsible for the environmentally sound recycling of old appliances, the recovery and destruction of HFCs. The recycling and disposal facility receive equipment from retailers or assemblers or services companies The recycling and disposal facility will undertake the scrappage, potentially the recycling and the disposal of refrigerants from old appliances in Lebanon. Otherwise, export and disposal abroad would be required.

Marketing will be an essential element for the successful implementation of this incentive system. End-users need to be aware of the advantages of climate-friendly and energy-efficient appliances, understand the LCC of appliances, and be aware of ancillary benefits.

6.3 Cost of an incentive system

Assumptions for the cost assessment include the management cost for the incentive system and the amounts required for the financing of the incentives as such. The cost components were assessed in consultation with local Lebanese authorities, based on other projects like the Lebanese Fuel-Efficient Transport NAMA (UNDP LECB, 2017), or in discussion with local partners.

For the operation of the incentive and replacement program over 9 years, the following funds in Table 33 have been analysed.

Table 33: Cost for the operation of an incentive and disposal system for refrigerators and room ACs.

Activities		Cost for 9 years
Output A.1	A Coordinating Entity (CE) and an Implementing Entity (IE) are established and operating (including the costs of a testing facility and the costs for market surveillance)	3,572,000
Output A.2	Finance Facility is established and operating	135,000
Output B.1	Eligibility criteria are assessed, and defined & emission standards assessed and given legal force	108,000
Output B.2	Replacement fees, HFC tax and import tax are legally established and operating	338,000
Output B.6	The installation of a recycling and disposal facility is financed	5,279,000
Output C.1	Awareness creation for the refrigerator replacement program	536,000
Output C.2	Awareness creation for the room AC replacement program	536,000
Output D.1	Incentive program is implemented for refrigerators	77,000,000
Output D.2	Incentive program is implemented for room ACs	100,000,000
	Total cost	**187,504,000**

For the refrigerator replacement, it had been assumed an average lifetime of 8 years per equipment, which results in a replacement of 12.5% of all equipment per year. Assuming a starting stock of 2.2 million units, 275,000 will be replaced every year. 80% of all devices are assumed to be correctly disposed and hence will benefit from the replacement fee, which results in costs of 11,000,000 USD per year, required to be paid to customers.

For the room AC replacement, an average lifetime of 9 years per unit was assumed, which results in a replacement of 11.1% of all units per year. At a stock of 2.5 million units, 277,778 units will be replaced every year. 90% of all units are assumed to be correctly disposed of. A higher disposal rate is assumed, as ACs often require a service company for the installation of new units and the removal of old ones, which will result in higher collection rates for old units. The replacement fee results in a cost of 12,500,000 USD per year. Further detailed cost assumptions are presented in the Annex 10.3 of this report.

The costs for the implementation of the incentive system are intended to be covered by the proceeds from the levies on refrigerants and inefficient appliances will be used. The final goal is that all costs are covered by the levies and that no additional government funding is needed. The outline of the funding program is explained in the following chapter.

6.4 Fund raising programme

For the raising of funds to finance the costs of the programme, it is proposed that first, a levy in the form of customs duties for imported appliances based on their energy efficiency and on HFC refrigerants will be established. As this system will drive the market towards low GWP refrigerants and more efficient appliances, it can be expected that there will be only a transitory impact on higher appliance prices. The market for appliances is international and very competitive, more energy-efficient appliances do not have significantly higher upfront costs. The longer effect for the economy and end-users will be deflationary with lower life cycle costs, i.e. savings, for the end-users and the economy. If HFC refrigerants are replaced by natural refrigerants the costs of refrigerants will decrease as these refrigerants are not patented, have lower purchasing costs, are less environmentally damaging, and have superior thermodynamic properties.

The proposed import tax and the HFC tax can cover the cost of the incentive system even under the conservative assumption that only energy label A appliances will be imported as outlined below in Table 34. Expected total revenues are higher than the total cost of the incentive scheme shown in Table 33 above.

Table 34: Total expected revenue from import taxes on refrigerators and room AC and from the HFC tax.

Total revenues from taxes		Revenue for 9 years
Output B.3	Import taxes are collected for refrigerators	89,012,000
Output B.4	Import taxes are collected for room ACs	66,666,667
Output B.5	A tax on HFC imports is legally established and operating	250,656,960
	Total Revenue	**406,335,627**

6.4.1 Import tax on energy in-efficient appliances

The first part of the proposed levy system is import duties on energy in-efficient appliances. The import duty is suggested to be progressive to greater penalize inefficient cooling appliances. The proposed additional import duty would start with a 5% tax of the cost of devices in class A and rising to 150% for the lowest class, G for refrigerators and H for room AC. Energy-efficient devices with low GWP refrigerants will therefore only face a low-price increase. Appliances with high GWP refrigerant will be burdened twice, at the import as well as through the HFC tax, which will be introduced on top of the import tax. The tax will impose a strong market push to energy-efficient appliances.

The following tables outline the levels of import tax suggested for refrigerators (Table 35) and room ACs (Table 36). The suggested taxation levels are based on the equipment's price. Inefficient devices should not be available at a significantly cheaper price than highly efficient equipment. The customer will benefit from the lower LCC of highly efficient equipment, which should be used as the selling argument.

Table 35: Proposed import tax levels for refrigerators.

Import tax for refrigerators						
Energy labels	**Current mean unit price [USD]**	**Import-tax (theoretical)**	**Import-tax (practical)**	**Import tax revenue per unit**	**Mean prices for domestic units**	**Tax revenue from imported units per year**
G	528	118.94%	150.00%	792	1,320	
F	469	146.48%	150.00%	704	1,173	
E	839	37.78%	50.00%	420	1,259	Assumption: 100% class A units imported – hence left blank.
D	1,215	-4.86%	10.00%	122	1,337	
C	1,201	-3.75%	10.00%	120	1,321	
B	1,139	1.49%	5.00%	57	1,196	
A	1,156	0.00%	5.00%	58	1,214	12,716,000

Table 36: Proposed import tax levels for room ACs.

Import tax for room ACs						
Energy labels	**Current mean unit price [USD]**	**Import-tax (theoretical)**	**Import-tax (practical)**	**Import tax revenue per unit**	**Mean customer prices for domestic units**	**Tax revenue from imported devices per year**
H	637	17.83%	150.00%	955	1,591	
G	521	43.98%	150.00%	781	1,302	
F	534	40.49%	150.00%	801	1,335	
E	869	-13.69%	50.00%	435	1,304	Assumption: 100% class A units imported – hence left blank.
D	800	-6.25%	10.00%	80	880	
C	800	-6.25%	10.00%	80	880	
B	738	1.69%	5.00%	37	774	
A	750	0.00%	5.00%	38	788	8,333,340

There remains a positive risk that the proposed tax level will impact the market so strongly, that only top labelled products will be imported. In this case, revenue from the import tax on appliances will decrease, although the proposed HFC import duties will still generate ample returns. It will be unlikely that, that the refrigerant market will immediately shift to low GWP refrigerants. Therefore, the combination of the two levies could be important to future-proof the funding for the scheme. Alternatively, further funding mechanisms as described in chapters 6.4.2 to 6.4.4 and 6.5 could be accessed.

The intended shift towards energy efficient appliances will also have the shadow benefit of overall energy savings, the use of more energy efficient appliances. This will also result in macro-economic savings through lower subsidies, as currently electricity remains subsidized in Lebanon.

6.4.2 HFC tax

The second part of the proposed levy system is an HFC tax levied on imported HFCs based on their GWP. The proposed HFC tax is recommended to range between 30 and 70 USD per ton CO_2-eq. For the most common refrigerants, the tax per kg would be in the range as indicated in Table 37.

Table 37: HFC and HCFC tax per kg.

HFC tax per kg			
Refrigerant	**GWP**	HFC tax: 30 USD/ t CO_2-e: **Tax [USD/kg]**	HFC tax: 70 USD/ t CO_2-e: **Tax [USD/kg]**
HCFC-22	1,810	54.30	126.70
HFC-134a	1,300	39.00	91.00
HFC-404A	3,922	117.66	274.54
HFC-407C	1,774	53.22	124.18
HFC-410A	2,088	62.64	146.16

In total, the collected tax for room ACs and refrigerators, where HFC-134a and HFC-410A are mainly used, would range between 31 and 73 million USD per year, based on the import numbers from 2015. This contribution would cover the cost of an incentive system. The contribution from imports of refrigerant in refrigerators is marginal, as the HFC amounts per unit are small. HFC tax will mainly be paid for HFCs which are imported to fill and refill AC appliances (Table 38).

Table 38: Expected HFC and HCFC tax for room ACs and refrigerators.

Total HFC tax revenue			
Refrigerant	**Import 2015 [t]**	**Tax @ 30 USD/t CO_2-eq**	**Tax @ 70 USD/t CO_2-eq**
HCFC-22	566	22,074,000	51,506,000
HFC-134a	650	25,350,000	59,150,000
HFC-404A	133.7	15,731,142	36,705,998
HFC-407C	37.35	1,987,767	4,638,123
HFC-410A	95.5	5,982,120	13,958,280
Sum of HFC-134a and HFC-410A tax		**31,332,120**	**73,108,280**

6.4.3 Soft loans

For the replacement of cooling devices in Lebanon, and as shown in Table 39, considerable amounts of private sector funding are required. This holds true for large cooling appliances as well as for small units like refrigerators and room ACs. In any case, the investment cost for low emission cooling appliances is perceived as a significant hurdle, which can potentially be overcome through soft loans for purchasing new highly energy-efficient appliances. In this chapter, we discuss the possibility for subsidized consumer loans, which should help them to acquire refrigerators or room ACs with energy label A.

Table 39: Required private sector funding per year.

Private sector funding - USD per year	
Private sector funding for the replacement of refrigerators	302,500,000
Private sector funding for the replacement of room AC	208,333,333
Total funding	**510,833,333**

Due to the political and economic circumstances in Lebanon, lending costs are high and currently range at above 11% per year (Lebanon Bank lending rate) for short- and long-term tenors.

Specific loan schemes for individuals and small enterprises do already exist in Lebanon (Investment Development Authority of Lebanon, 2019). To push the implementation of low emission equipment, soft loans with low interest rates would be an appropriate measure, which could make the switching more attractive to bridge the higher investment cost and repay the loan through energy savings.

Already existent soft loan schemes are operated by the Central Bank of Lebanon (BDL), which initiated the National Energy Efficiency and Renewable Energy Action (NEEREA), an incentive scheme that provides subsidized green loans. A similar scheme, the Lebanon Energy Efficiency and Renewable Energy Finance Facility (LEEREFF) is being implemented by the BDL and MoE&W/LCEC with the support of the European Investment Bank and the Agence Française de Développement.

6.4.4 Carbon credit program

This subchapter outlines a carbon credit programs over a predefined project period, e.g. 7 years. The basic concept of the carbon credit program builds on the collection and destruction of high GWP refrigerants against receiving carbon credits from international buyers which use carbon credit certificates to offset their own emissions. Such projects are also referred to as offset projects and the tradable emission reductions (ER) to as offsets or credits. In principle, baseline and credit systems are a subsidy that is measured by both the number of emission reductions achieved and the market price of corresponding certificates.

A credit program would in principle be applicable for any situation, in which the emission reduction measure is not imposed by law. For the cooling appliances discussed in this report, we suggest considering the emission reductions which accrue through the switch to low GWP refrigerants and energy-efficient appliances.

The baseline would already include Lebanon's Kigali commitment to reduce HFCs, which means that only actions to switch to low GWP refrigerants faster than the Kigali baseline would be eligible for such a program.

Project-based emission reduction certificates are issued domestically or internationally by an independent regulator, according to defined standards. The resulting certificates are sold to parties, who only pay upon receipt of the certificates. This contrasts with climate finance, where climate investments are made in advance via loans or grants.

There are three principal options to consider for a potential scheme involving international carbon markets (i.e. the issuing of carbon credits, to finance the measures under the NCP):

1. Mandatory reductions objectives of industrialized countries under the Kyoto Protocol coordinated by the United Nations Framework Convention on Climate Change (UNFCCC).
2. Voluntary projects, where a variety of registries lay down the rules for participation and private clients purchase emission reduction certificates to reduce their own emissions.
3. Trading of emission reduction units between governments under the Paris Agreement.

Historically, item 1 is the most important international system, the Clean Development Mechanism (CDM) and Joint Implementation (JI), both of which are anchored to the Kyoto Protocol and are supervised by the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC). CDM and JI certificates were credited against the reduction obligations of the Parties to the Kyoto Protocol. In Europe, installations subject to emission trading obligations can continue to use CDM certificates instead of European emission rights with restrictions until the end of 2020.

Figure 28 shows the development of project-based greenhouse gas reduction certificates under the UNFCCC and illustrates both the decline in the importance of project-based Kyoto certificates in recent years and the resulting price erosion.

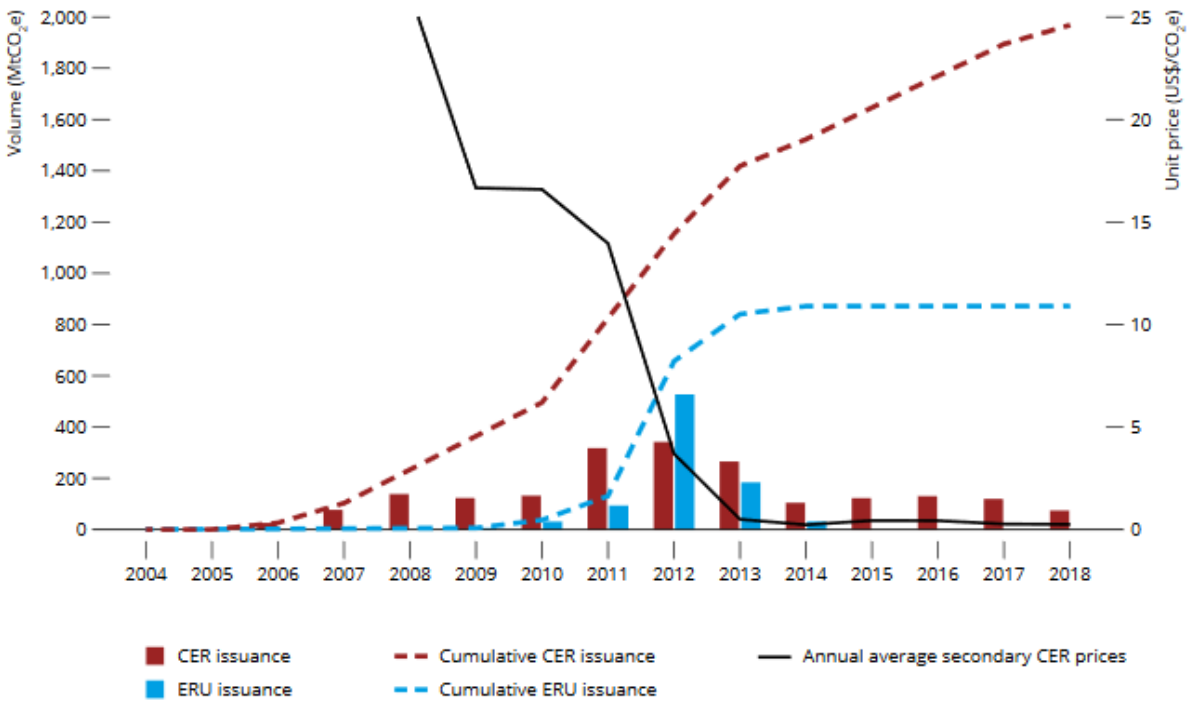

Figure 28: Issued project-based certificates and prices under the Kyoto Protocol (CER&ERU)(World Bank, 2019)

Due to the recent developments and the Paris Agreement, these mechanisms lost relevance. Nevertheless, they are a good showcase for the functioning principle of baseline and credit systems.

Item 2. Refers to the voluntary carbon market. There are various non-governmental standards for the certification of project-based emission reductions, including mainly Verra[37] (formerly Verified Carbon Standard, VCS) and the Gold Standard. Most of their certificates flow into the market for voluntary CO_2 offsetting, but some are also recognised with restrictions in national or sub-national emissions trading systems (e.g. California).

Pricing in this market varies considerably. The World Bank Group's *State and Trends of Carbon Pricing 2019* reports prices ranging from of 0.1 USD to 70 USD per CO_2-eq for credits transacted in the first half of 2018, with approximately half of those transactions taking place at under 1 USD per tCO_2e (World Bank, 2019). Many observers expect these prices to increase after 2020, given a noticeable increase in voluntary demand and the potential supply restrictions associated with host countries NDCs. The voluntary market has been comparatively stable, albeit at a much lower level.

Our assessment is that this market will be of less relevance. Reason for this is inter alia that buyers of voluntary carbon credits will not prefer credits from governmental programs like the replacement program described above, that the investment to replace the refrigerator will need to be covered by numerous private individuals and the contribution through baseline and credit programs per replacement is for all cases rather marginal. Hence, voluntary emission reduction projects will not be a relevant option to subsidize the early implementation of Kigali in Lebanon.

Item 3 refers to article 6 of the Paris Climate Agreement, which provides two new market mechanisms for the international transfer of emission reductions. The precise rules of these mechanisms are still being negotiated; however, it is becoming apparent that they will function according to the baseline and credit principle and could effectively replace the CDM and JI mechanisms. The key difference is that the transfer of emission reductions will be directly between governments, which are able to purchase emission reductions achieved in other countries.

However, the future of the CDM post-2020 is uncertain and its role within Art. 6 mechanisms is subject to much debate by negotiating parties. Whether CERs in vintages post-2020 will at all be issued under the Paris Agreement regime and what their price levels would be compared to Internationally Transferred Emission Reductions (ITMOs, Offset Credits under Articles 6.2 and 6.4 of the Paris Agreement) cannot be judged at present.

37- https://verra.org/project/vcs-program/

Based on the description above, only feasible option to use carbon credits substantially under the NCP implementation in Lebanon are *carbon credits under Article 6.2 of the Paris Agreement,* e.g. within the framework of bilateral agreements between a country like Switzerland and Lebanon as the host country. Switzerland's newly revised CO_2 act enters into force in 2021 and is currently debated in parliament. The proposed version of this new law obliges private companies that import fossil fuels into Switzerland, to compensate for up to 90% of fuel-related CO_2 emissions. This is to be done by financing carbon offset projects that meet strict requirements. Within this offsetting scheme, it may be possible to develop a replacement program that is financed by the Swiss Foundation for Climate Protection and multi KliK to incentivize the usage of low emission appliances in Lebanon. This could happen within the framework of a bilateral agreement under Article 6.2 of the Paris Agreement and is already piloted in programs which have been launched this year.

6.4.4.1 Carbon credit program for refrigerators

To estimate for the order of magnitude of possible financial contributions regarding a baseline and carbon credit program for refrigerators, an ex-ante estimation has been conducted. For this estimation, we assumed that the baseline emissions occur at commissioning, during operation and once appliances are replaced after reaching their technical lifetime and are disposed of without collection of the remaining refrigerants for disposal, which causes the release of their full remaining charge into the atmosphere. In the project scenario (ex-post), refrigerators are correctly collected, recycled, refrigerants captured and destroyed.

The parameters to calculate related emissions for refrigerators are given in Table 40. To calculate the end-of-lifetime emission, it was assumed, for reasons of simplification, that the remaining amount of refrigerant consists of the initial charge multiplied by the end-of-lifetime percentage. All the calculations are done using maximum and minimum values in order to get an idea of the range of financial contributions from a baseline and credit program. Importantly, it should be noted that under the proposed scheme, only the remaining end of life (EOL) refrigerant emissions are claimed eligible to earn carbon credits. The underlying assumption is that end of life refrigerants emissions is currently not addressed by appropriate policies in Lebanon, that appliances are not collected and treated at their end of their useful life and that all remaining refrigerants are effectively released into the atmosphere.

The operation of refrigerators in the residential/public sector does not require special know-how. They are easy to be started or decommissioned since they come as closed systems and just are plugged in to start operation. Since refrigerators contain low amounts of refrigerants and are easier to handle, the potential to reduce GHG emissions from a refrigerator in the residential/public sector is low.

Domestic refrigerators mainly contain the refrigerant R134a in the baseline, which has a GWP of 1,430, whereas in low emission devices mainly R600a is used, which has a GWP of 3. Assumptions to calculate a range of possible financial support and the results are presented in Table 40.

Table 40: Range of contribution from baseline and credit schemes for domestic refrigerators (IPCC, 2000).

Domestic refrigerators		
	Refrigerant old	Refrigerant new
	R134A	R290
GWP	1,430	3
	Minimum scenario	Maximum scenario
Initial Charge [kg]	0.05	0.30
End-of-life emission min (% of initial charge)	70%	70%
End-of-life emission [kg]	0.035	0.210
R134a [tCO_2-eq]	0.050	0.300
R600a [tCO_2-eq]	0.0001	0.001
ER [tCO_2-eq]	**0.05**	**0.30**
Financial contribution for GHG emission reduction		
Price per ER [USD/tCO_2-eq]	10	50
Contribution per refrigerator [USD]	**0.5**	**15.0**

Using the parameters given in Table 39, carbon finance contributions per refrigerator range between 0.5 USD and 24.8 USD. Under the assumption of a yearly replacement rate of 100,000 refrigerators, based on 10 years lifetime and around 1,000,000 units, an overall contribution between 100,000 USD per annum and approximately 1.5 million USD per annum from the residential/public sector refrigerator replacement can be achieved in total.

In the following paragraphs the potential funds raised from different RAC sub-sectors are estimated, followed by a brief outline of the costs for a recycling centre.

6.4.4.2 Carbon credit program for commercial refrigeration

In the commercial sector, comparably bigger appliances are used containing larger amounts of refrigerants and greater complexity in commissioning and decommissioning requiring experts to undertake these operations.

Current refrigerators in the commercial sector mainly use the refrigerants R134a and R404A with GWPs 1,430 and 3,922, respectively. To be conservative, the baseline regarding commercial refrigerators is calculated using the refrigerant R134a. For low emission refrigerators in the commercial sector, refrigerants R290 and R744, with GWPs 3 and 1, respectively, are considered. Assumptions to calculate a range of possible financial support are presented in Table 41.

Table41: Range of contribution from baseline and credit schemes for commercial refrigerators (IPCC, 2000).

Commercial refrigeration		
	Refrigerant old	Refrigerant new
	R134A	R290
GWP	1,430	3
	Minimum scenario	Maximum scenario
Initial Charge [kg]	50	200
End-of-life emission min (% of initial charge)	80%	90%
End-of-life emission [kg]	40	180
R134a [tCO_2-eq]	57	257
R290 [tCO_2-eq]	0.120	0.540
ER [tCO2-eq]	**57**	**257**
Financial contribution for GHG emission reduction		
Price per ER [USD/tCO_2-eq]	10	50
Contribution per refrigerator [USD]	**571**	**12,843**

These devices bear a higher financial potential for baseline and credit schemes and are considered separately.

Using the parameters given in Table 41, funds from carbon pricing per commercial refrigerator range between 570 USD and 12,843 USD per device. Direct contributions through carbon finance may hence provide significant contributions for larger devices. Under the assumption of a yearly replacement rate of 15,000 units, an overall contribution of 8,750,000 USD per annum from the commercial sector may be achieved. To be noted, that this is an evaluation of the limits. Refrigerant quantities of 200 kg per equipment only exist in cold storage rooms and large chillers, which are comparatively low in numbers. Therefore, the actual annual contribution might not range much higher than the above number.

6.4.4.3 Carbon *credit* programme for unitary air conditioners

Unitary AC is a broad category consisting of several types of appliances such as Room AC, split commercial AC, duct split residential AC and commercial duct split. For the calculation of contributions coming from a baseline and credit program, the procedure described in chapter 6.4.4 is applied.

The UAC category consists of devices for the residential and for the commercial sector. Regarding appliances in the residential sector, we focus on room ACs, which account for more than 80% of the UAC category. Similar to refrigerators in the residential/public sector, also room ACs come as "plug-and-play"-devices, which are easy to handle but offer only a low potential to reduce GHG emissions.

Current UAC devices mainly use the refrigerants R22 and R410A with GWPs 1,810 and 2,088, respectively. To be conservative, the baseline regarding room ACs is calculated using the refrigerant R22. For low emission room ACs in the residential/public sector, refrigerant R290, with a GWP of 3 is considered. Assumptions to calculate a range of possible financial support are presented in Table 42.

Table 42: Range of contribution from baseline and credit schemes for Room AC (IPCC, 2000).

Room AC		
	Refrigerant old	Refrigerant new
	R22	R290
GWP	1,810	3
	Minimum scenario	Maximum scenario
Initial Charge [kg]	0.50	1.00
End-of-life emission min (% of initial charge)	70%	80%
End-of-life emission [kg]	0.35	0.80
R22 [tCO_2-eq]	0.63	1.45
R290 [tCO_2-eq]	0.0011	0.002
ER [tCO_2-eq]	**0.63**	**1.45**
Financial contribution for GHG emission reduction		
Price per ER [USD/tCO_2-eq]	10	50
Contribution per refrigerator [USD]	**6.3**	**72.3**

Using the parameters given in Table 41, the funds per room AC range between 6.3 and 72.3 USD. Assuming a yearly replacement rate of 150,000 units, an overall income will be between 630,000 USD per annum and 10,845,000 USD per annum from the residential and public sector can be expected.

6.4.4.4 Carbon credit programme for the commercial AC sector

The average commercial AC size ranges from 2 tons for small buildings to as much as 30 tons for very large buildings (SOBIESKI, 2019). Therefore, these devices are potentially bigger sources for HFC emissions and are more complicated to be maintained.

As for the use of refrigerants, the same assumptions apply as used for the UAC residential sector. Further assumptions to calculate a range of possible financial support are presented in Table 43.

Table 43: Range of contribution from baseline and credit schemes for Commercial AC (IPCC, 2000).

Commercial AC		
	Refrigerant old	Refrigerant new
	R410A	R290
GWP	2088	3
	Minimum scenario	Maximum scenario
Initial Charge [kg]	20	200
End-of-life emission min (% of initial charge)	70%	80%
End-of-life emission [kg]	14	160
R410A [tCO_2-eq]	29	334
R290 [tCO_2-eq]	0	0
ER [tCO_2-eq]	**29**	**334**
Financial contribution for GHG emission reduction		
Price per ER [USD/tCO_2-eq]	10	50
Contribution per refrigerator [USD]	**292**	**16,680**

Using the parameters given in Table 43, funds per one UAC device in the commercial sector range between 292 USD and 16,680 USD. Assuming a yearly replacement rate of 5,000 units, the overall income per year would be an amount of 1,460,000 USD per annum from the commercial sector can be expected, whereby very large devices with a load of 200 kg are rare.

6.4.4.5 Usage of revenues from a baseline and crediting system (recycling center)

As described in section 6.3, it is intended to erect a domestic recycling and disposal facility in Lebanon. The funds of a baseline and credit system would be an ideal source of funding to cover the investment for this facility. In case this facility can be established near to or on the premises of local manufacturers, personnel that has the necessary know-how regarding the decommissioning, scrappage and disposal of RAC appliances would be available.

6.5 International climate financing options

Besides the measures to cover the operating cost of an incentive system as outlined in section 6.3, funding options through international climate finance will be of relevance for the start-up financing and the implementation of a program incentivizing the market introduction of low emission cooling appliances.

Lebanon is part of the Group 1 of Article 5 countries of the Kigali amendment and hence obliged to set the start of its baseline-freeze in 2024. The first reduction step with 10% of HFC consumption against the baseline will be in 2029. Under the Montreal Protocol, the Article 5 countries are eligible to receive financial support to comply with the phase-out ODS consumption by deploying a series of technical assistance and industrial conversion projects, at country level, so that producing and consuming sectors can abandon the use of these substances. Lebanon is currently developing a national cooling plan (NCP) with the support of UNDP. Different sources of funding are available and can be used for the implementation of the cooling plan. This NCP could be financed using both upfront funding and appliance-based instruments like carbon pricing.

The goal of the analysis of the funding options is to find out, which funding sources are available for the implementation of the cooling plan. It needs to be determined, for which parts of the NCP grants would be a suitable funding source, and which parts would require other financial mechanisms to get implemented.

Funds, which are paid upfront, can be used to finance specific activities like managerial tasks and can help to kickstart the implementation of new regulations. Other financial mechanisms like the introduction of specific taxes or a baseline and credit system may be better applicable to finance appliance specific measures like a subsidy for equipment replacement. The analysis of different financial means provides insights to decision makers involved in the processes for switching from current high emission RAC appliances towards purchases of low emission appliances.

In this chapter, we firstly analyse different grant subsidy systems specifically dedicated to supporting the Kigali amendment or otherwise relevant for the implementation of the NCP. An analysis of the appliance-based approaches is based on a bottom-up analysis shown in Chapter 3.

To facilitate efforts under the Kigali Amendment of the Montreal Protocol, primarily one fund has been established: The Kigali Cooling Efficiency Program (K-CEP). Other relevant funding options are described subsequently to the K-CEP.

6.5.1 The Kigali Cooling Efficiency Program (K-CEP)

To enable energy-efficient and environment-friendly cooling in developing countries, K-CEP has been founded. As a philanthropic collaboration, K-CEP supports the refrigerant transition under the KA by promoting efficient and climate-friendly cooling.

K-CEP aims for increased access of efficient and clean cooling and strives to increase the climate and development benefits of the Montreal Protocol, i.e. a refrigerant transition and a simultaneous improvement in the energy efficiency of cooling (K-CEP, 2019).

6.5.1.1 Level of funding available

The financial means of K-CEP were provided by 17 foundations and philanthropists that have pledged 51 USD million. all of these phase 1 funds are planned to be used over the years 2017 - 2020. As K-CEP recognizes that some results may take longer to come to fruition, it aims to create a legacy of post–2020 emissions reductions impacts. Eligibility, focus and application

All 127 countries listed as A5 Group 1 countries in the Kigali Amendment to the Montreal Protocol are eligible. K-CEP prioritized support on the basis of emissions reduction potential, cooling market status (e.g., major producers, exporters), policy frameworks, political economy, geographical distribution, and existing initiatives (K-CEP, 2019).

K-CEP phase 1 focused on specific cooling solutions. Priority was given to those solutions with the greatest emissions reduction potential. Air-conditioning was a major focus, but refrigeration and district cooling were also be considered. The program aimed to identify the most accessible, sustainable cooling solutions.

Countries can apply for support through the bilateral and implementing agencies of the Multilateral Fund of the Montreal Protocol as described in the following Chapter 6.5.2.

6.5.1.2 Current activities in Lebanon

K-CEP supports Lebanon's National Ozone Units that are working with energy efficiency experts to build their capacity, support coordination with national energy efficiency policymakers, convene country-level dialogues, and develop national plans or roadmaps assessing approaches to improve energy efficiency. Such approaches include: bulk procurement, replacement programs for inefficient equipment, alternative cooling strategies, and analysis of national standards and labelling for AC and refrigeration (K-CEP, 2018). This project is part of the K-CEP funding.

Moreover, K-CEP delivers support in order to enhance and integrate existing knowledge resources such as training manuals, knowledge platforms and toolkits on energy-efficient cooling. In this respect, K-CEP is funding a training module on energy efficiency to complement Montreal Protocol funded activities in the refrigeration and AC servicing sector. A 'train the trainers' approach is supposed to promote further replication of the training benefits.

This is important because technicians regularly service cooling equipment for refrigerant performance but typically do not look at energy efficiency. Neglecting the optimization, monitoring, and maintenance of cooling equipment results in increased energy use, lower cooling performance, and shortened equipment life. Better education for technicians promotes best practice and associated energy savings.

K-CEP funded activities to do the preparatory work needed for the smooth operation of Lebanon's NCP are in place already and should be considered in the future.

6.5.2 The Montreal Protocol's Multi-Lateral Fund (MLF)

The MLF is a global fund supporting environmental objectives (Climate Finance Advisors, 2019). The institutional structure of the MLF was established at the 1990 Meeting of the Parties to the Montreal Protocol in London. The MLF operates under the authority of the Parties to the Montreal Protocol. The MLF has an Executive Committee comprising seven developed and seven developing countries, which oversee MLF operations. The Fund Secretariat assists the Executive Committee and carries out day-to-day operations. In delivering financial and technical assistance, the MLF works together with the following implementing agencies: UNDP, UNEP, UNIDO, the World Bank and a number of bilateral agencies. The Fund Treasurer is responsible for receiving and administering pledged contributions (cash, promissory notes or bilateral assistance), and disbursing funds to the Fund Secretariat and the implementing agencies, based on the decisions of the Executive Committee (Multilateral Fund, 2019).

The MLF finances activities that are carried out by four implementing agencies: The United Nations Environment Program (UNEP), the United Nations Development Program (UNDP), the United Nations Industrial Development Organization (UNIDO), the World Bank and bilateral agencies. These four UN agencies and the bilateral agencies have contractual agreements with the Executive Committee and are present as observers at Executive Committee meetings and at the Meetings of the Parties.

6.5.2.1 Level of funding available

The MLF has channelled several billion dollars to developing countries to facilitate compliance with the Montreal Protocol. The Executive Committee approved a total of 33.6 million USD for projects for immediate implementation of the HFC phase-down (Climate Finance Advisors, 2019; Multilateral Fund, 2019)

6.5.2.2 Eligibility, focus and application

Any Party that is a developing country and whose annual calculated level of consumption of the controlled substances in Annex A of the Montreal Protocol is less than 0.3 kilograms per capita is referred to as an Article 5 country to the Montreal Protocol. Article 5 countries may receive assistance under the Multilateral Fund. Currently, over 120 countries hold Article 5 status. Being an A5 Group 1 country, Lebanon is eligible for MLF funding.

Each of the four implementing agencies has roles that evolved over time in regard to practical implementation. The World Bank concentrates on large-scale phase-out and investment projects at plant and country levels. UNDP organizes demonstration and

investment projects, technical assistance and feasibility studies. UNIDO prepares and appraises investment project proposals and implements phase-out schedules at the plant level. UNEP carries out no investment projects, but rather helps to establish the infrastructure within which projects can proceed. This includes institutional strengthening activities (such as establishing national ozone units within each country), facilitating regional networks, and helping to prepare country programs, especially for low-volume-consuming countries. UNEP also provides clearinghouse functions and produces a range of training materials. Its Compliance Assistance Program is geared towards achieving total phase-out and decentralized most of its resources to the regional level, facilitating direct support to developing countries.

According to the consolidated business plan of the MLF for 2018 – 2020, the HFC phase-down and implementation of the Kigali Amendment are expected to expand the scope and complexity of work under the Multilateral Fund, including of its Executive Committee, the implementing agencies, Secretariat and Treasurer. Bilateral and implementing agencies have already witnessed an increase in the volume of work related to the preparation of project proposals and enabling activities to respond to challenges related to the HFC phase-down (UNEP, 2017).

Upon receipt of a project proposal submitted by an Article 5 country, the Secretariat of the Executive Committee will send it to the Implementing Agency, if so, designated by the applicant country (secretariat@unmfs.org). The Implementing Agency will then establish the necessary contacts with the Article 5 country concerned and elaborate the project documentation to meet all the necessary requirements. The Secretariat will evaluate the project documentation for submission to the Executive Committee (NDC Partnership, 2019).

6.5.2.3 Current activities in Lebanon

In 2018, UNIDO requested 1,053,848 USD for the conversion of domestic and commercial refrigerator manufacturing lines at Lematic to shift from HFC-134a and R-404A to R-600a and R-290 in domestic and commercial refrigeration (UNEP, 2018). Further, the Government of Lebanon has already issued HCFC import quotas for 2018 at 52.58 ODP tons, which is lower than the Montreal Protocol control targets and the maximum allowable consumption set in its Agreement with the Executive Committee. The submission was accompanied by a letter dated from the Government of Lebanon committing to the ratification of the Kigali Amendment and agreeing that no further funding would be available from the Multilateral Fund until the instrument of ratification had been received by the depositary at the Headquarters of the United Nations in New York; and that any amount of HFC reduced as a result of the project would be deducted from the starting point, in line with this decision.

In the same year, the Executive Committee approved a total level of funding for HFC investment activities of 15.11 million USD for Lebanon together with nine other countries (China, the Dominican Republic, Ecuador, Egypt, Lebanon, Mexico, Morocco, Thailand, Viet Nam and Zimbabwe) (UNEP, 2017).

6.5.3 Green Climate Fund (GCF)

The Green Climate Fund (GCF) was set up in 2010 by the countries who are parties to the UNFCCC. When the Paris Agreement was reached in 2015, the Green Climate Fund was given an important role in serving the agreement and supporting the goal of keeping climate change well below 2 degrees Celsius by 2050 (Green Climate Fund, 2018).

6.5.3.1 Level of funding available

GCF launched its initial resource mobilization in 2014, and rapidly gathered pledges worth 10.3 billion USD. These funds come mainly from developed countries, but also from some developing countries, regions, and one city (Paris). A total of 27 countries raised 9.8 billion USD at a pledging conference in Paris to fund green projects for the 2020-2023 period – including 4% in zero-interest loans, which could be of particular interest for this project in Lebanon (Climate Home News, 2019).

6.5.3.2 Eligibility, focus and application

All developing country Parties to the UNFCCC are eligible to receive resources from the GCF. The GCF gives recipient countries access to funding through accredited national, sub-national and regional implementing entities and intermediaries (including NGOs, government ministries, national development banks, and other domestic or regional organizations that can meet the Fund's standards). Countries can also access funding through accredited international and regional entities (such as multilateral and regional development banks and UN agencies) under international access. Private sector entities can also be accredited as implementing entities (Climate Funds Update, 2019a).

According to GCF (2019), one of the focus areas for GCF should be to support the development of environmentally sustainable technologies, technology transfer and collaborative research and development. Two of the areas where GCF sees an opportunity to contribute are working with other climate funds to scale and replicate successful investments and to accelerate the uptake of green investment by mainstream investors, keeping in view GCF's core value proposition of supporting country-driven transformation through catalytic investment. Further, in the GCF strategic programming document, promoting minimum energy appliances, among others in the cooling sector, are identified as interventions for creating an enabling environment for a paradigm shift in energy efficiency (GCF, 2019).

Contact information for inquiries regarding the application procedure and to submit requests for funding is available on the GCF-Homepage[38]. Since the GCF is a powerful source of financial means that is dedicated to supporting mitigation activities in developing country's cooling sectors, it may be recommended to employ the GCF for Lebanon's NCP Implementation. Under the GCF Readiness program, the technology needs assessment for the cooling sector and related financing schemes as suggested in this report could be further evaluated and detailed, with the aim of developing a GCF concept note and funding proposal.

6.5.3.3 Current activities in Lebanon

In Lebanon, the Ministry of Environment (MoE) is the nationally designated authority to the GCF. Lebanon has submitted one readiness proposal for "Strengthening and enhancing Lebanon's institutional arrangements and capacity to enable and optimize access to the Green Climate Fund" and is expected to launch the project by 2020. In addition, Lebanon is currently seeking support from the GCF to prepare its National Adaptation Plan (NAP) through the readiness program and is working with the UNDP-UNEP NAP-GSP program to prepare and submit this proposal (MoE, UNDP, 2019).

6.5.4 Global Environment Facility (GEF)

The Global Environment Facility (GEF) Trust Fund was established in 1992 at the Rio Earth Summit, to help tackle our planet's most pressing environmental problems. GEF funding to support projects is contributed by 39 GEF donor countries and is replenished every four years.

The World Bank serves as the GEF Trustee, administering the GEF Trust Fund. The Trustee disburses funds to GEF Agencies (World Bank, UNDP and UNEP) and prepares financial reports on investments and use of resources. Furthermore, it monitors the application of budgetary and project funds. The Trustee creates periodic reports that contain an array of fund-specific financial information (GEF, 2019).

6.5.4.1 Level of funding available

On April 25, 2018, around 30 countries pledged 4.1 billion USD to the GEF. Recognizing the worsening state of the global environment, the GEF has received strong support for its new four-year investment cycle (known as GEF-7), which lasts for the 2018 – 2022 period (GEF, 2019).

6.5.4.2 Eligibility, focus and application

GEF funds are available to develop countries and countries with economies in transition to meet the objectives of the international environmental conventions and agreements such as the Vienna Convention for the Protection of the Ozone Layer (Montreal Protocol) or the United Nations Framework Convention on Climate Change (UNFCCC) (Paris Agreement). Furthermore, GEF support is provided to government agencies, civil society organizations, private sector companies, research institutions, among the broad diversity of potential partners, to implement projects and programs in recipient countries (GEF, 2019).

Transfer to energy-efficient technologies is a stated priority in the GEF-7 programming strategy, adopted in 2018. In this regard, GEF aims to expand its support to more countries and across sub-sectors, including buildings, district heating and cooling (GEF, 2018).

GEF Agencies create project proposals and then manage these projects on the ground. In doing so, they help eligible governments to develop, implement and execute their projects (GEF Agencies, 2019). Since UNDP is both the focal point for the development and implementation of Lebanon's NCP and a GEF agency, it is most reasonable for Lebanon's MoE to apply through UNDP as the first contact for an application towards GEF financed activities.

6.5.4.3 Current activities in Lebanon

The operation of Lebanon's GHG inventory is funded through the GEF. As for agriculture and forestry, funding is extended to both mitigation and adaptation measures. Support received in these sectors was therefore reported for both types of climate action since the

38- https://www.greenclimate.fund/home

two are often interconnected. These funds were mainly provided by international bodies such as GEF, Adaptation Fund, the EU, and European Governments (MoE, UNDP, 2019)

There is a number of indicative allocations of GEF funds in Lebanon, among which 2 million USD are foreseen to be invested in the sector of climate change. This 2 million USD are yet to be programmed and could potentially be used to support NCP activities. Moreover, further funds could be asked for in order to strengthen GEF financed support for NCP implementation in Lebanon (GEF Agencies, 2019).

6.5.5 Other funds

Apart from the funds described above, other funds to provide financial means to support NCP implementation in Lebanon are potentially available or are in development. In this respect, the 27 million USD fast-start fund and the Clean Technology Fund (CTF) can be mentioned.

6.5.5.1 $27 million fast start fund

Unlike the Kigali Cooling Efficiency Program (K-CEP), which is funded by philanthropic foundations, the "$27 million USD fast-start fund" is funded by several donor governments and was announced together with K-CEP in September 2016 aiming to help developing countries to shift from HFCs to low emission appliances with increased energy efficiency. The 16 donor countries are Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. The fast-start fund is thought to kick-start the market transition away from HFCs, similar to the K-CEP program (K-CEP, 2019).

6.5.5.2 Clean Technology Fund (CTF)

The Clean Technology Fund (CTF) is part of the Climate Investment Funds (CIF) and has 5.4 billion USD at its disposal, which are donated by 14 developed countries. These public resources are held in trust by the World Bank, and they are disbursed as grants, highly concessional loans, and risk mitigation instruments to recipient countries through multilateral development banks (MDBs) (Climate Investment Funds, 2019).

The CTF is dedicated to empowering developing and middle-income countries by providing resources to scale up low carbon technologies with significant potential for long-term greenhouse gas emissions savings. Over 75% of these resources are approved for implementation in renewable energy, energy efficiency, and clean transport. The CTF seeks to promote financing for demonstration, deployment and transfer of low-carbon technologies with significant potential for long-term greenhouse gas emissions savings. It aims to Fund low carbon programs and projects that are embedded in national plans and strategies, scaling up development and accelerating the diffusion and transfer of clean technologies (Climate Investment Funds, 2019).

Country access to CTF funding requires ODA-eligibility (commensurate with OECD/DAC guidelines) and the existence of active MDB country programs. MDBs jointly assess whether interested eligible countries meet the following criteria: The country has to promote economic development and welfare; the grant element must be at least 25% and the country has to be in the DAC list of ODA eligible countries. Where there is a potential fit, MDBs conduct a joint exercise involving other relevant development partners to discuss with interested governments, private industries and other stakeholders how CTF may help finance scaled-up low carbon activities. Later on, an investment plan is produced under the leadership of the applicant country (Climate Funds Update, 2019b).

The CTF Trust Fund Committee reviews the investment plan with a view to authorizing designated MDBs to proceed with the development and preparation of individual investment operations for CTF co-financing (Climate Funds Update, 2019b).

7 INCLUSION OF THE NCP IN LEBANON'S NDC & ROADMAP

7. INCLUSION OF THE NCP IN LEBANON's NDC AND ROADMAP

In Lebanon, in line with many countries, particular in warmer climatic zones, the demand for cooling is a major driver for electricity consumption and GHG emissions. If these emissions are left unabated, they pose a massive threat to sustainable development and a stable climate. The electricity demand in Lebanon for cooling combined with insufficient power supply is a key reason for continuous power outages during hot days.

The NCP addresses the effort to ensure that Lebanon's need for cooling is met with energy efficient and climate-friendly technologies. The NCP provides a critical guidance to the sector on more sustainable, climate friendly technologies, cooling services, and innovative space cooling approaches that are less dependent on energy-intensive electrical cooling.

Under the Paris Agreement, countries are requested to submit updated Nationally Determined Contributions (NDCs) ahead of the 2020 round of NDC revisions. The NCP of Lebanon could be

used to enhance the overall mitigation ambition of Lebanon's NDCs, and to strengthen specific implementation strategies targeted under its NDC. With this Lebanon can contribute to the substance of its NDC and contribute to the required global effort of raising of ambitions for meeting the objectives of the Paris Agreement in meeting the global mitigation requirements and temperature targets. Every 5 years, the UNFCCC conducts a global stocktake to assess the collective progress towards achieving the purpose of the Paris agreement. The guiding principles for NDC revisions are progression and highest possible ambition.

It is recommended that the following key elements and principles are included into Lebanon's NDC and are considered for the NDC targets for 2025, 2030 and 2050 as further outlined in the NCP roadmap in Chapter 8. Chapter 4 outlines that against the business-as-usual emissions, the introduction of the measures suggested in the NCP will result in emission reduction of up to 4 Mt CO_2-eq or about 20% of Lebanon's current emissions.

7.1 Institutional setup

It is recommended that MOE with its NOU leads the cross-sectoral and inter-ministerial coordination for integrating the NCP into the NDC. As such MOE/NOU will have the mandate to update the NCP systematically and to conduct the outreach to relevant counterpart ministries (such as Energy, Finance or Industry) in order to coordinate the integration of the NCP and its recommended actions and measures into the NDC.

7.2 Integration of F-gas phase down

The 2016 Kigali Amendment to the Montreal Protocol mandates an F-gas phase-down, which entails a freeze from 2024 and phase-down schedule from 2029. Therefore, the climate benefit from the F-gas transition will accrue reasonably close to the 2030 timeframe of NDC targets. However, Lebanon did not include F-gas phasedown actions or Kigali Amendment commitments in its initial NDCs, and it is worthwhile for Lebanon to include their plans for compliance in their NDC revision, consistent with recommendations on cooling efficiency measures as suggested in this NCP. It is suggested in the NCP, particular, in the outline of the funding and incentive system in Chapter 6, that the HFC-phase down of the Montreal Protocol's Kigali Amendment, is linked to the targeted energy efficiency improvement programme. Specifically, that the proposed levy on HFC is raised to accelerate the phase down of HFC and to provide the funding of the proposed MEPS and label programme for ACs and refrigerators.

7.3 Roadmap and sectoral integration into the NCP

It is recommended that the NCP targets, as outlined in Table 44, are referenced in Lebanon's updated NDC. This includes sectoral targets relevant for cooling for energy, building, industry, waste, transport and agricultural sectors. The classification of these sectors follows the categorisation of sectors according to the IPCC methodology for the national reporting of GHG emissions.

Key measures in the **energy sector** are the introduction of mandatory MEPS and labels as outlined in the NCP, initially for household refrigerators and ACs, later extended to all cooling and refrigeration equipment. The introduction of energy efficiency labels for cooling/refrigeration appliances will allow end-users to identify higher-performing products and can be paired with procurement and incentive programs or inform the specifications of buyers' clubs. Such information is currently hardly available in Lebanon. It is recommended, that along the introduction of MEPS and labels, a compliance and testing programme will be established. The programme will safeguard that

energy inefficient appliances, that do not comply with national energy performance standards, from entering the market. These programs will require coordination between the MOE (ministry setting the MEPS) and LIBNOR (national standardization body). The NCP further recommends an import levy based on the energy efficiency label of imported appliances. For products being imported, this is a key factor to avoid sub-standard products entering the market. Environmental dumping of sub-standard appliances by manufacturing countries (which may have higher domestic standards) must be safeguarded against. Relevant regional trade alliances can be considered, i.e. in coordination with neighbouring countries such as Turkey, Syria, Jordan or Egypt.

In the **industrial/manufacturing** sector, the NCP recommends to the retooling of appliance manufacturing lines for local manufacturer to comply with the refrigerant transition and to redesign cooling appliances, mainly refrigerators, to reach or exceed the recommended MEPS. Further, the NCP recommends measures for the accelerated phase down of HFC, ahead of the targets under the Kigali Amendment. The proposed levies on imported HFCs will be used to finance the transition to climate friendly and energy-efficient systems using low GWP refrigerants. According to the methodology established under the IPCC, F-gas emissions are categorized under industrial or manufacturing sector. Technicians in the RAC sector should be qualified and certified dealing safely with low GWP and flammable hydrocarbon refrigerants or, alternatively, low GWP but high-pressure CO_2 or dealing with toxic Ammonia refrigerant.

In the **agriculture and food sector**, measures include the deployment of energy efficient refrigeration systems using low GWP refrigerants. Efficient clean cold chains are important for reducing food loss and waste, as well as losses in other products which are temperature sensitive. Every stage of the food cold chain which is mechanically cooled should be efficient and use low-GWP refrigerants, from cold warehouses storage to refrigerated transport, to warehouses and supermarket cooling. Where possible, cold storage should be renewably powered. Alternative cooling technologies and reducing the need for cooling.

In the **building sector**, the typical buildings in Lebanon uses about half of its energy consumption on cooling. Tighter and better insulated buildings will allow gradually to lower the cooling demand. Passive house standards, as an integral part of the NCP, should become the mandatory standard for new buildings and, also, increasingly with increased renovation rates for the existing building stock. Measures such as cool roofs and pavements, and greening of urban spaces, can reduce urban temperatures by up to 4˚C. This reduces the number of cooling appliances needed, as well as reducing the amount of time they need to be running, saving indirect emissions from electricity use. Mandatory, energy-efficient building codes and building retrofit plans are a key policy tool for minimizing cooling loads. Recommended buildings standards are included in the recommend roadmap in Table 44. Additional measures include the installation of smart thermostats reduce electricity demand and there are even battery storage technologies which can interact with the electric grid to shift load peaks from ACs.

Thermal energy storage is another way to shift load peaks, where cold is stored at low-demand times (e.g. at night) and used to offset AC needs during the heat of the day. These systems can be paired with renewables such as rooftop solar.

Table 44 summaries the above described measures in the form of a National Cooling Plan roadmap with sectoral milestones.

Table 44: Recommended roadmap milestones for the NCP implementation

Feature	Status (2020)	2025	2030	2050
Cross-sectoral financing	No or limited dedicated incentive programs for cooling appliance	• Import levies based on energy consumption of appliances and their labels • Import levies based on GWP content of refrigerants • Carbon credit programme to finance take-back system	Continued	Continued
Energy	No mandatory MEPS and labels for appliances	• Mandatory MEPS and labels for ACs and refrigerators according to the recommendations of the NCP • Compliance and spot testing of MEPS and labels • Ban on import of second-hand appliances	• Mandatory MEPS and labels for commercial refrigeration and AC systems (alignment with U4E model standards) • Updated MEPS and labels for domestic refrigerators and ACs	Increasingly ambitious MEPS and labels
Buildings	No-mandatory building standards	Target building standards (< 150 KWH/m2); Improved tightness and insulation standards; Cool rooftops for >50% of new buildings	Target building standards (< 100 KWH/m2); Cool rooftops and/ or solar for all new buildings and 50% of old buildings;	Target building standards (< 50 KWH/m2); Cool rooftops/ rooftop solar for all buildings;
Industry/ Manufacturing	F-gases: No/ limited restriction on F-gases;	• F-gases: Levies on F-gases based on NCP; • Ban for F-gas use on appliances with ready alternatives: refrigerators; < GWP 10 ACs; < 1000 commercial AC and refrigerator • Manufacturing: Incentives climate friendly and energy efficient design • Mandatory certification and registration for all cooling technicians	• F-gases: Increased levies • Ban for F-gas use on appliances with ready alternatives: refrigerators; < GWP 10 ACs; < 1000 commercial AC and refrigerator • Mandatory certification and registration for all cooling technicians	• F-gases: Phase out of HFC; HFC limits < GWP 10 • Mandatory certification and registration for all cooling technicians
Transport	No/ limited cooling standards	>25% of new vehicles with AC or refrigeration systems with refrigerants < GWP10	>55% of new vehicles with AC or refrigeration systems with refrigerants < GWP10	>75% of new vehicles with AC or refrigeration systems with refrigerants < GWP10
Waste	No or limited recycling of cooling appliances & recovery of refrigerants	Establishment of a central recycling facility, establishment of a take back programme	Achieving > 80% recycling quota for all mass cooling appliances; environmental sound destruction of refrigerants and foam blowing agents	Achieving > 90% recycling quota for all mass cooling appliances and destruction of refrigerants and foam blowing agents
Agriculture and food	No cold chain standards	25% of all cold stores with renewable power and integrated cooling appliances	50% of all cold stores with renewable power and integrated cooling appliances	>75% of all cold stores with renewable power and integrated cooling appliances

8 CONCLUSIONS & RECOMMENDATIONS

8. CONCLUSIONS AND RECOMMENDATIONS

The NCP is the overarching approach covering and integrated approach on regulatory, technical, environmental and operational matters. It's an important step for Lebanon to contribute towards the targets of the Paris Agreement and the Kigali Amendment of the Montreal Protocol. The underlying rationale for the NCP includes the following considerations

- Increased Energy Efficiency has been an important side benefit of the Montreal Protocol through two previous transitions of refrigerants over 30 years. There are many opportunities to achieve improvements in EE during the transition to low GWP refrigerants,
- Demand for RAC equipment is increasing rapidly,
- EE aspects require additional training and further awareness,
- Some EE degradation over the lifetime of equipment is inevitable; improved design and improved servicing (installation and maintenance) limits degradation,
- The impact of proper installation, maintenance, and servicing on the efficiency of equipment and systems is considerable over the lifetime of these systems while additional cost is minimal,
- Appropriate maintenance and servicing practices can reduce up to 50% reduction in performance and maintain the rated performance over the lifetime,
- MEPS and labels can be a powerful and cost-effective instrument for pushing the market towards higher-efficiency products by removing inefficient equipment from commerce,
- MEPS can work together with labels and other incentive programs, such as rebates, to "pull" the market towards more efficient technologies,
- MEPS will push manufacturers to improve the efficiency of their products.

8.1 The current situation in Lebanon

As Lebanon does not have a MEPS system in place, appliances in use have lower energy performance compared to international good practice and the more advanced developing countries. Similarly, there is no uniform labelling system established in Lebanon and end-users are lacking clear guidance to energy-efficient appliances. Importers, resellers and manufacturers have little incentive to place more energy-efficient appliances on the market, as un-informed end-users tend to purchase the appliances with the lowest up-front costs.

One of the key reasons for the lack of MEPS and labelling systems is the limited institutional capabilities for the introduction of effective such systems.

The government lab, IRI, so far has only a lab for the safety test of room ACs and refrigerators but not for the energy performance testing. The installation of a national lab within IRI for energy performance testing is recommended for effective market surveillance to ensure that the proposed MEPS and labels are correctly applied. Besides the labs, it will be important to establish the required institutions and personal capacities for the effective implementation of the system.

Currently, there is no central product database established with shared information among the relevant institutions and stakeholders on key data for approved appliance (including the relevant performance data, label, refrigerant, annual sales, etc.).

Local manufacturers in Lebanon, particularly Lematic, have not yet adopted the new EE testing standard for domestic refrigerators. The adaptation to the new standard will cause costs to Lematic, as their currently testing performance according to the old standard IEC62552:2007

8.2 Implementation of a MEPS and labelling system

The following points provide a list of activities for the timely implementation of MEPS and label system in Lebanon:

1. Adoption of mandatory safety and energy testing standards as per Table 14. These standards are greatly advanced compared to the previous standards and are adopted quickly by a growing number of countries and manufacturers.
2. Adoption of a mandatory MEPS level:

a. For domestic refrigerators: EEI (Energy Efficiency Index) < 140 as shown in Table 45,

b. For domestic room ACs: SEER (Seasonal EE Ratio) > 3.6 as shown in Table 46.

Table 45: MEPS and Labels for Domestic refrigerators.

	Label classes	Energy Efficiency Index (EEI)	Number of surveyed models	% of models in each class
MEPS	7G		79	40%
	6F	140	91	46%
	5E	114	24	12%
	4D	93	2	1%
	3C	76	0	0%
	2B	62	1	1%
	1A	50	0	0%

Table 46: MEPS and Labels for split ACs.

Energy class	EER ranges	Avg. SEER	Avg. cooling capacity (kW)	Avg. Energy consumption (KWh)	Total models analysed
A	SEER>8.5	-	-	-	-
B	6.1 <= SEER < 8.5	6.29	4.86	792.76	26
C	5.6 <= SEER < 6.1	-	-	-	-
D	5.1 <= SEER < 5.6	-	-	-	-
E	4.6 <= SEER < 5.1	4.80	5.28	1318.87	1
F	4.1 <= SEER < 4.6	4.14	3.52	1019.42	6
G	3.6 <= SEER < 4.1	3.79	3.94	1253.46	59
H (MEPS)	SEER < 3.6	3.23	4.22	1568.77	44

3. Adoption of a mandatory labelling system:
   a. For domestic refrigerators: closed-scale A to G labelling system, as suggested in Table 45.
   b. For the room ACs: closed-scale A to H labelling system, as suggested in Table 46.
4. Adoption of a timetable for introducing and updating MEPS and labels:
   a. First introduction of mandatory MEPS and labels for domestic refrigerators and ACs in 2021.
   b. Updating MEPS and labels in 2024 by cancelling the lowest label class (MEPS 2021) and stepping MEPS up one class.
5. Identify IRI as the national agency for RAC equipment's certification and market monitoring
6. It is recommended to establish a national certification scheme for service technicians. Such curriculum to include information on MEPS, labels, proper maintenance of appliances to keep up with high energy efficiency levels and the proper handling of low GWP, flammable refrigerants. The training could be integrated into the HPMP training developed under Stage II RAC

training carried out 2019-2021 under the HPMP. The inauguration (on September 16, 2019) of the first RAC training centre in Beirut is an encouraging sign towards setting a relevant national training program. Four other training centres are planned to be completed by 2021.

7. Establishing an effective product registration and market surveillance mechanism:
    a. Adopt a national product database for RAC appliances, whereby manufacturers and importers register their appliances and report their annual sales at IRI.
    b. Grant access to the database to the relevant government institutions for market monitoring and surveillance and internet-based access for end-users.
    c. Upgrade the capacity of customs controls (custom officers are under the ministry of finance and they monitor the execution of the MOE legal requirements) on the import of appliance below the future MEPS level and to ban and control the import of second-hand appliances. The training of customs officers could be linked to the running activities of MoE and the NOU for customs training under the HPMP.
    d. In cooperation with the Ministry of Economy and Trade, empower the "Consumer Protection Directorate" to perform market monitoring and control works and ensure labels are correctly presented on all RAC appliances.
    e. Establish a working group, within LIBNOR's relevant Technical Committee, that would meet bi-annually and discuss any amendments or improvements to standards.
    f. Develop financial support mechanisms, for manufacturers and end-users, supporting energy-efficient appliances as it will be further detailed in the Deliverable 4 report.
    g. Develop national awareness campaigns and Green Procurement schemes to accelerate the market penetration of EE appliances with low GWP refrigerants.
8. It is recommended to technically support local manufacturer to upgrade their testing capacity to comply with the new energy efficiency testing standards (e.g. IEC62552:2015 for refrigerators).
9. From the above-mentioned product database, relevant information should also be made available to the public, e. g. comparative information on the upfront prices and the LCC of appliances through a central internet portal or mobile apps.

8.3 Financing the market transformation

Financial mechanisms increase the market share of efficient, clean cooling technologies, displacing the purchase of inefficient and climate-polluting appliances and so helping to reduce emissions. By making efficient appliances more widely affordable, they also increase access to cooling and provide the associated development benefits.

The NCP proposes an incentive and financing scheme on transformational changes for a low carbon pathway for the RAC sector in Lebanon. These schemes incorporate national and international funding and financing sources to move towards affordable and highly energy-efficient appliances and systems as supported by the targeted introduction of a MEPS and labelling system, the transition to low GWP refrigerants, the exchange of old and inefficient appliance, their environmentally sound recycling, and the replacement to top labelled energy-efficient appliances.

The outlined incentive system has been proposed in a way to be financially viable and that the available cost of the program will be sustainable covered through the identified funding and financing options.

8.3.1 Incentivizing the market introduction of low emission appliances

The funding mechanism is based on (1) a proposed energy consumption related import levy for refrigerators and room AC as the most used cooling appliances in the country and (2) an import tax on the import of HFC refrigerants based on their GWP weight.

Both the energy consumption-based import levy and the HFC import tax will fund or co-fund the administration and the monitoring, verification and enforcement (MVE) of the energy efficiency incentive systems.

The effects, of increased energy efficiency, for the country, will result in further benefits such as shifting off-peak demand, reducing power outages, lowering subsidies and allowing Lebanon to meet its NDC targets or enhancing its NDC targets. The proposed HFC tax will provide an incentive to replace high GWP refrigerants even before the Kigali Amendment's reduction path kicks in.

The replacement program, which will increase the price of inefficient equipment and high GWP HFCs, as well as incentivize the proper disposal of decommissioned appliances will create regulatory, managerial and marketing efforts, which need to be covered. Further, the cost of the incentives provided during the course of the nine year program, will accrue as shown in the following Table 47.

Table 47: Cost overview.

Activity	Cost (USD)
Regulatory implementation and management of the replacement program	4,153,000
Awareness creation and marketing	1,072,000
Replacement program implementation (Payment of incentives)	5,279,000
Installation of a disposal and recycling facility	177,000,000
Total cost	**187,504,000**

Funds to cover the cost outlined in Table 46 will primarily come from the collected HFC tax and the import tax. These funds will sufficiently cover the cost, as shown in Table 48.

Table 48: Overview of annual revenues.

Annual revenues - USD	
Import taxes	155,678,667
HFC tax	250,656,960
Total annual revenue	**406,335,627**

For the recycling and disposal facility, a baseline and carbon credit program had been proposed as an additional measurement for the funding of a take-back, replacement and environmentally sound recycling. If the baseline and carbon credit program is designed in a way that the disposal of HFC's at the end of their useful life are targeted, the carbon credit program will be additional and strongly supporting the environmental integrity requested under the market mechanisms of the Paris Agreement. The carbon credit proceeds can be sufficient to finance or at-least co-finance the operational cost of a recycling and disposal facility.

The proposed funding scheme will support the NCP's objective of bringing the RAC sector on a low carbon pathway.

8.3.2 Funding NCP integration into the NDC

The NCP implementation could be financed through the GCF. At the 25th Conference of the Parties in Madrid, the GCF announced its updated funding budgets and that the introduction of low carbon cooling solutions is one of their goals. We hence recommend preparing a GCF proposal for the NCP implementation, which could cover the initial funding needs of the set-up of the proposed tax and incentive system. For the development of such a GCF proposal, the proposed tax and incentive scheme needs to be refined in close collaboration and agreement with local stakeholders. Funding for this intermediate step could be provided through the GEF, already very active in Lebanon[39] or the K-CEP NDC facility, where under a competitive process, Lebanon can apply for funding for the implementation of GHG mitigation measures under its NDC in the cooling sector.

8.3.3 Implementation options

The proposed funding scheme will strongly push the deliverable of the NCP, bringing the RAC sector on a low carbon pathway with multiple-co benefits. It is suggested to fully integrate the NCP into the NDC, with a comprehensive financing package including supporting sources from GEF, GCF, etc. complementing national co-funding with the proposed tax and incentive scheme with additional GEF; GCF funding for its proper implementation.

For the implementation of an incentive system and replacement program, we suggest following a 2-step approach. Direct rollout to the entire country would be challenging. Therefore, a pilot program tried first to obtain experience to fine-tune a full programme. This pilot phase could be operated in greater Beirut, be limited to refrigerators and UAC and financed as a project through the MLF and/ or GEF. If a GCF proposal is prepared to finance a full roll-out, the pilot phase would be a good start to demonstrate the case for a strong proposal.

39- GEF Operational Focal Point Lebanon: H.E. Mr. Fady Jreissati - Ministry of Environment - Lazarieh Building – Downtown – Beirut - Lebanon

Tel: +961 1 976 555 ext 501 / +961 1 976 510 - Email: n.khoury@moe.gov.lb; z.chaib@moe.gov.lb; manal.moussallem@undp.org

GCF focal point: Ministry of Environment - Ms. Samar Malek - UNFCCC National Focal Point, Acting Head of the Service of Environmental Technology

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10 ANNEXES

10. ANNEXES

10.1 Annex 1 - Market surveys in Lebanon

Due to the large size of the surveys' questionnaires, these will be attached to this report in separate pdf files. Here below are the links to the on-line surveys:

Air conditioners survey: https://s.surveyplanet.com/tU0t24aQy

Domestic refrigeration: https://s.surveyplanet.com/5S7laF_dZ

Commercial refrigeration: https://s.surveyplanet.com/enG6XBXx1

Industrial refrigeration: https://s.surveyplanet.com/joil-Vi2z

Transport refrigeration: https://s.surveyplanet.com/enG6XBXx1

10.2 Annex 2

Table 49: ODP and GWP of main refrigerants.

Refrigerant	Ozone Depletion Potential - ODP	Global Warming Potential - GWP
CFCs & HCFCs		
CFC-12 Dichlorodifluoromethane - 100% global production & consumption ban under the Montreal Protocol	1.0 (high)	10,900
HCFC-22 Chlorodifluoromethane - Subject to consumption phase down under the Montreal Protocol	0.05 (medium)	1,810
HFCs		
HFC-32 (Difluoromethane)	0	675
HFC-125 (Pentafluoroethane)	0	14,900
HFC-134a (Tetrafluoroethene)	0	1,430
HFC-152a (Difluoroethane)	0	120
HFC-410A (50% R32, 50% R125)	0	2,088
HFC-404A (44% R125, 52% R143a, 4% R134a)	0	3,922
HFC-407A (20% R32, 40% R125, 40% R134a)	0	2,107
HFC-407C (23% R32, 25% R125, 52% R134a)	0	1,774
HFC-407F (30% R32, 30% R125, 40% R134a)	0	2,088
HFC-407H (32% R32, 15% R125, 53% R134a)	0	1,495
HFC-448A (HFC-HFO blend)	0	1,387
HFOs and HCFOs		
HFO-1234yf	0	4
HFO-1234ze	0	6
HCFO-1233zd	0	4.5
Natural refrigerants		
Ammonia (R-717, NH_3)	0	0
HC-600a (Isobutane)	0	3
HC-290 (Propane)	0	3
Carbon dioxide (R-744, CO_2)	0	1*

10.3 Annex 3

Figure 29: Financial estimations for a replacement programme.

Refrigerator Replacement Assumptions			
Program assumption: 8yrs lifetime of equipment; replacement rate: 12.5%-> 100% exchange after 8 yrs.			
Total number of refrigerators replaced per year	pcs./yr	275'000	12.5% of 2200000 refrigeratorsas per Del2
Replacement subsidy (upon correct disposal) per refrigerator	USD	-50	assumption
Investement cost for refrigerator (average, after introduction of HFC tax)	USD	-1100	as per Del 2
Import tax per device collected	USD	58	import tax for class A devices, assumption that only such devices will be imported (conservative)
Import rate	%	80.0%	assumption
Total import tax collected	USD/yr	12'716'000	
Collection rate	%	80.0%	assumption
Total replacement subsidy per year	USD/yr	-11'000'000	
Total private sector investment per year	USD/yr	-302'500'000	

Room AC Replacement Assumptions			
Program assumption: 9yrs lifetime of equipment; replacement rate: 11.1%% ->100% exchange after 9 yrs.			
Total number of refrigerators replaced per year	pcs./yr	277'778	as per Del2, 2500000 room Acs
Replacement subsidy (upon correct disposal) per refrigerator	USD	-50	assumption
Average investement cost for refrigerator	USD	-750	as per Del 2
Import tax per device collected	USD	38	import tax for class A devices, assumption that only such devices will be imported (conservative)
Import rate	%	80.0%	assumption
Total tax collected	USD/yr	8'333'333	
Collection rate	%	90.0%	assumption: higer than refrigerators, as service companies collect old devices
Total replacement subsidy per year	USD/yr	-12'500'000	
Total private sector investment per year	USD/yr	-208'333'333	

HFC tax			
HFC tax collected, at 30 USD/t CO2eq	USD/yr	31'332'120	

Cost Assumptions (USD)			
Annual Salary - Admin Officer (Program Manager)			-75'000
Annual Salary - Associate Admin Officer			-50'000
Annual office, materials, transport costs for CE, IE			-30'000
Cost of 1 Capacity Building Workshop (hotel rental, per diem, travel etc. for Int'l Consultant)			-10'000
Cost of 1 Training Program (local)			-5'000
Cost of 1 Ad-Hoc working Group Meeting (hotel rental, per diem)			-3'000
Cost of 1 Ad-Hoc working Group Meeting (without hotel rental, per diem)			-1'000
Cost of 1 National Consultant + Exp (30 days of work)			-15'000
Cost of 1 National Consultant + Exp (60 days of work)			-30'000
Cost of 1 National Consultant + Exp (90 days of work)			-45'000
Cost of 1 International Consultant + Travel + Exp (30 days of work)			-35'000
Cost of 1 International Consultant + Travel + Exp (60 days of work)			-60'000
Cost of pamphlets, and other marketing material etc.			-10'000

Outcome A	Institutional framework for the replacement program is established	Type	Description	Source	2021	2022	2023	2024	2025	2026	2027	2028	2029	Total
Output A.1	A Coordinating Entity (CE) and an Implementing Entity (IE) are established and operating													372'000
Activities	A.1.1 The CE is defined, staffed and is operating	F	1) ED 1-2 Definition of CO 2 local consultants for 90 days	National Government Budget	70'000	210'000	210'000	210'000	210'000	210'000	210'000	210'000	210'000	1'710'000
	A.1.2 The CE is trained on relevant issues related to their role and responsibility	CB	1) ED 1-2 Initial 1) Java I & II International consultant for 10 days	International Support Partner - Grant	25'333	25'333	25'333							76'000
	A.1.3 The IE is defined, staffed and is operating	F	1) ED 1 Definition of CO 2 local consultants for 90 days	National Government Budget	70'000	210'000	210'000	210'000	210'000	210'000	210'000	210'000	210'000	1'710'000
	A.1.4 The IE is trained on relevant issues related to their role and responsibility under the program	CB	1) ED 1 - 20 Initial 1) Java I & II International consultant for 10 days	International Support Partner - Grant	19'000	19'000	19'000	19'000						76'000
Output A.2	Finance Facility is established and operating													135'000
Activities	A.2.1 An agreement with the Financial Trustee (FT) is established	CB	1) Java I and II International consultant for 10 days (Concurrently Do Internal Work in new T...	International Support Partner - Grant	70'000									70'000
	A.2.2 The Grant Subsidy Scheme is established and operational under the FT	F	1) ED 1 Initial Do be Matching Scheme 2) local consultants and 1) International consultant for 5 days on	National Government Budget	32'500	32'500								65'000
	TOTAL - Cash Flow, Outcome A				-285'833	-485'833	-464'333	-429'000	-410'000	-410'000	-410'000	-410'000	-410'000	-3'707'000

						2021	2022	2023	2024	2025	2026	2027	2028	2029	Total
Outcome B		**Refrigerator replacement program is prepared and incentive scheme defined**													
Output B.1		**Eligibility criteria are assessed and defined & emission standards assessed and given legal force**													-108'000
Activities	B.1.1	Energy Efficiency classes are analysed and a labelling system is defined	F	[illegible]	International Support Partner - Grant	-12'000	-12'000								-24'000
	B.1.2	Minimum Energy Performance Standards are defined	F	[illegible]	International Support Partner - Grant	-42'000	-42'000								-84'000
Output B.2		**Replacement fees, HFC tax and import tax are legally established and operating**													-338'000
Activities	B.2.1	The legal basis for replacement fees is established and financing of fees is provided	F	[illegible]	National Government Budget	-91'000									-91'000
			CB	[illegible]	International Support Partner - Grant	-56'000									-56'000
	B.2.2	The legal basis for the HFC tax is established and collected	F	[illegible]	National Government Budget	-120'000									-120'000
			CB	[illegible]	International Support Partner - Grant	-71'000									-71'000
Output B.3		**Import taxes are collected for refrigerators**													89'012'000
Activities	B.3.1	The import tax is collected for refrigerators	F		National Government Budget		12'716'000	12'716'000	12'716'000	12'716'000	12'716'000	12'716'000	12'716'000		89'012'000
Output B.4		**Import taxes are collected for room ACs**													66'666'667
Activities	B.4.1	The import tax is collected for room ACs	F		National Government Budget		8'333'333	8'333'333	8'333'333	8'333'333	8'333'333	8'333'333	8'333'333	8'333'333	66'666'667
Output B.5		**A tax on HFC imports is legally established and operating**													250'656'960
Activities	B.5.1	The import tax on HFCs is collected for all imported HFCs	F		National Government Budget		31'332'120	31'332'120	31'332'120	31'332'120	31'332'120	31'332'120	31'332'120	31'332'120	250'656'960
Output B.6		**The installation of a recycling and disposal facility is financed**													-5'279'000
Activities	B.6.1	The recycling and disposal facility is planned	CB	[illegible]	International Support Partner - Grant	-97'000									-97'000
	B.6.2	Recycling and appropriate disposal of HFC is legally binding	F	[illegible]	National Government Budget	-120'000									-120'000
	B.5.3	The recycling and disposal facility is implemented	F	[illegible]	International Support Partner - Grant		-3'000'000								-3'000'000
	B.5.4	The recycling and disposal facility is operated	F	[illegible]	International Support Partner - Grant			-300'000	-300'000	-300'000	-300'000	-300'000	-300'000	-300'000	-2'100'000
		TOTAL - Cash flow: Outcome B				-571'000	49'327'453	52'081'453	52'081'453	52'081'453	52'081'453	52'081'453	52'081'453	39'365'453	400'610'627

						2021	2022	2023	2024	2025	2026	2027	2028	2029	Total
Outcome C		**Promotion and awareness building**													
Output C.1		**Awareness creation for the refrigerator replacement program**													-536'000
Activities	C.1.1	The framework for advertisements is established and implemented for refrigerators	CB	[illegible]	International Support Partner - Grant	-36'000	-36'000	-36'000							-108'000
	C.1.3	Educational and awareness-building resources for RAC dealers will be developed and RAC dealers will be equipped to support the program	CB	[illegible]	International Support Partner - Grant		-60'000	-60'000							-120'000
	C.1.4	Marketing resources to promote the scrappage program will be developed and a marketing campaign launched	CB	[illegible]	International Support Partner - Grant		-36'000	-36'000	-36'000						-108'000
	C.1.5	Marketing resources to promote the scrappage program will be developed and a marketing campaign continued	CB	[illegible]	International Support Partner - Grant					-40'000	-40'000	-40'000	-40'000	-40'000	-200'000
Output C.2		**Awareness creation for the room AC replacement program**													-536'000
Activities	C.1.1	The framework for advertisements is established and implemented for refrigerators	CB	[illegible]	International Support Partner - Grant	-36'000	-36'000	-36'000							-108'000
	C.1.3	Educational and awareness-building resources for RAC dealers will be developed and RAC dealers will be equipped to support the program	CB	[illegible]	International Support Partner - Grant		-60'000	-60'000							-120'000
	C.1.4	Marketing resources to promote the scrappage program will be developed and a marketing campaign launched	CB	[illegible]	International Support Partner - Grant		-36'000	-36'000	-36'000						-108'000
	C.1.5	Marketing resources to promote the scrappage program will be developed and a marketing campaign continued	CB	[illegible]	International Support Partner - Grant					-40'000	-40'000	-40'000	-40'000	-40'000	-200'000
		TOTAL - Cash Flow: Outcome C				-72'000	-264'000	-264'000	-72'000	-80'000	-80'000	-80'000	-80'000	-80'000	-1'072'000

						2021	2022	2023	2024	2025	2026	2027	2028		Total
Outcome D		**Scrappage program Implementation**													
Output D.1		**Incentive program is implemented for refrigerators**													-77'000'000
Activities	D.1.1	Low efficiency and high GWP refrigerators are subsidized upon their collection	F	[illegible]	National Government Budget		-11'000'000	-11'000'000	-11'000'000	-11'000'000	-11'000'000	-11'000'000	-11'000'000		-77'000'000
	D.1.2	Low efficiency and high GWP refrigerators are purchased and replace old, inefficient, high GWP refrigerators	F	[illegible]	Private sector		-302'500'000	-302'500'000	-302'500'000	-302'500'000	-302'500'000	-302'500'000	-302'500'000		-2'117'500'000
Output D.2		**Incentive program is implemented for room ACs**													-100'000'000
Activities	D.2.1	Low efficiency and high GWP refrigerators are subsidized upon their collection	F	[illegible]	National Government Budget		-12'500'000	-12'500'000	-12'500'000	-12'500'000	-12'500'000	-12'500'000	-12'500'000	-12'500'000	-100'000'000
	D.2.2	Low efficiency and high GWP room ACs are purchased and replace old, inefficient, high GWP refrigerators	F	[illegible]	Private sector		-208'333'333	-208'333'333	-208'333'333	-208'333'333	-208'333'333	-208'333'333	-208'333'333	-208'333'333	-1'666'666'667
		TOTAL - Cash Flow: Outcome D					-534'833'333	-534'833'333	-534'833'333	-534'833'333	-534'833'333	-534'833'333	-534'833'333	-220'833'333	-3'961'166'667

			2021	2022	2023	2024	2025	2026	2027	2028	2029	Total
		TOTAL - Cash Flow: ALL	-929'833	-485'756'713	-482'970'213	-482'752'880	-482'741'880	-482'741'880	-482'741'880	-482'741'880	-181'957'880	-3'565'335'040

10.4 Annex 4

Table 50: Examples of regional MEPS and labelling systems.

Region	AC or HP	COOLING CAPACITY	METRIC	MEPS OR LEAST STRINGENT LABEL	MOST EFFICIENT LABEL	EFFICIENCY OF BEST AVAILABLE PRODUCT
		RT (NOMINAL)				
EU	HP	0.75	EU SEER	4.60	8.50	10.5
	HP	1.00		4.60	8.50	10.0
	HP	1.50		4.60	8.50	8.60
	HP	2.00		4.30	8.50	6.80
CHINA	HP	0.75	CHINA APF	3.50	4.50	5.45
	HP	1.00		3.50	4.50	5.05
	HP	1.50		3.30	4.00	4.50
	HP	2.00		3.10	3.70	4.40
INDIA	AC	1.00	ISEER	3.10	4.50	6.15
	AC	1.00		3.10	4.50	5.80
	AC	1.50		3.10	4.50	5.20
	AC	2.00		3.10	4.50	4.80

10.5 Annex 5

Table 51: Barriers and solutions.

Barriers	Solutions to overcome the barriers
Technology • International best practice technologies (e.g. advanced inverter technologies) have limited presence in the Lebanese market • Inefficient appliances are sold in the Lebanese market below international average efficiency levels, partly with high life cycle costs • Testing facilities to evaluate, measure and verify EE are not available	• Inefficient appliances, including second-hand appliances, need to be banned from entering the market through the introduction of Minimum Energy Performance Standards (MEPS) • Installation of an appropriate national testing facility for refrigerators and room air conditioners
Manufacturing • Local manufacturers of RAC appliances lack the know-how to design and operate appliances to compete with international best practice products • Local manufacturers: lack of know-how on the application of the latest EE standards	• Training and capacity building with local manufacturers to enhance their know-how and technical capabilities regarding the product design, the manufacturing processes, the use of highly energy-efficient appliances with low GWP refrigerants. • Application of the latest EE and safety product standards
Service competency • Local service technicians: lack of know-how to carry out regular EE services for appliances • Lack of know-how in convincing end-users that regular servicing will lower the life-cycle costs for operating the appliances over their useful life	• Strengthening the competencies of RAC technicians including energy efficiency as a mandatory component on their qualifications and certification.
Uptake of EE appliances by end-users • End-users focus on buying equipment with low upfront costs, i.e. purchasing prices, versus assessing life-cycle costs savings taking into consideration upfront and operational costs • End-users are not informed about the operational costs of appliances	• End-users need to be informed with clear labelling on energy efficiency and the operational costs of appliances through their electricity consumption • Labels need to be designed in a way which is intuitively understandable for end-users (e.g. adoption of the color-coding system as it will be applied in the future in the EU with an EE rating from A to G.
Regulatory and institutional barriers • International applicable energy efficiency standards (e.g. IEC 62552:2015 for refrigerators and ISO 16358:2013 for room air conditioners) and product standards (IEC 60335-2-40 for air conditioners and IEC 60335-24 for refrigerators) are not adopted in Lebanon • Lack of regulations on the mandatory applications of MEPS & labels for RAC appliances and their enforcement	• The rapid adoption of the latest international safety and energy efficiency standards for refrigerators and air conditioners • Adoption of MEPS & labels initially for refrigerators and room air conditioners and their enforcement • Establishment of processes to regularly update MEPS & labels at defined intervals, e.g. every two years • Establishment of regular market control to confirm the equipment's compliance with set standards and regulations.
Financial • Appliances with higher energy efficiency are marketed at a premium. End-users often lack access to adequate financing instruments at acceptable costs to finance the purchase of appliances with higher upfront costs but lower operating and often lower life-cycle costs.	• Market access to financial instruments at affordable costs and feasible guarantee arrangements to allow the financing of purchasing EE appliances with lower life-cycle costs.

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