SUSTAINABLE ENERGY STRATEGY OF THE LEBANESE ARMED FORCES (LAF)

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Acknowledgments
The United Nations Development Programme (UNDP) would like to thank the European Union for the grant that established and enabled the work of CEDRO 4. CEDRO would also like to thank all its partners including the Ministry of Energy and Water, the Council of Development and Reconstruction, the Lebanese Center for Energy Conservation (LCEC), and all other institutions that work closely with this project.
Foreword

It is a great privilege and honor for me to be entrusted with the task of serving as Lebanese Minister of Defense. I would like to take this opportunity to reiterate my pledge to fully devote myself to the service of Lebanon and of this great institution, the Lebanese Armed Forces (LAF), to the best of my abilities.

Throughout its history, the LAF has been the valiant defender of Lebanon’s sovereignty, thwarting countless attempts by armed groups and hostile armies to dismantle the Lebanese Republic and its institutions, while ceaselessly safeguarding Lebanon’s ethnic and religious diversity through the boundless sacrifices of all its servicemen and servicewomen.

In addition to its role in defending Lebanon, the LAF has always been a pioneer of innovative and groundbreaking ventures. The LAF, like modern armies worldwide, is increasingly conscious of the lasting effects that its carbon footprint will leave on the environment. This concern for the environment is reflected in the current initiative to provide energy to the LAF in a more environmentally friendly and cost effective manner. In implementing a project which utilizes sustainable energy sources, the LAF will be able to greatly reduce its operating costs, and thus be able to devote additional resources towards modernizing its equipment and weaponry, and more importantly, towards enhanced training for its troops, officers and personnel. The execution of this project will serve as an example for other Lebanese institutions to follow suit in committing to the use of green energy sources. The LAF’s position as a role model for all Lebanese citizens will also encourage the population to choose eco-friendly solutions in their daily lives.

I call upon all distinguished guests to contribute to the success of this undertaking. We are committed to the success of this project that represents a partnership between the public and private sectors, a goal that goes much beyond the Army and Lebanon to tackle global issues of equal importance to world peace.

I welcome this opportunity to underwrite the LAF ENERGY SUSTAINABILITY STRATEGY that our fellow servicemen have worked so diligently to develop. I would like to express my sincere gratitude towards the Our Central Bank, The European Union, the UNDP, and to all those who have so generously committed the time and resources to ensure the success of this endeavor.

Yaacoub Riad El Sarraf

Minister of National Defense
Foreword

Since the publication of the “Policy Paper for the Electricity Sector” in 2010, the Ministry of Energy and Water has been and is still dedicated to achieving Lebanon’s national target of 12% renewable energy by 2020. This has been concretized with the support offered to the distributed renewable energy generation market in Lebanon through the provision of soft loans, the tendering of 200 MW of wind power, the recent tender of 180 MW of solar photovoltaic power, and the many other initiatives undertaken in this sector.

Through the work of the Lebanese Center for Energy Conservation (LCEC), along with the cooperation of national and international partners such as the United Nations Development Programme (UNDP) and the European Union (EU), Lebanon is moving with firm steps towards prescribing and implementing the necessary and practical measures required to achieve our national objectives. Moreover, the recent publications of the National Energy Efficiency Action Plan (NEEAP) and the National Renewable Energy Action Plan (NREAP) has consolidated the targets for the years 2020 and 2030.

The Lebanese Army, through the publication of its “Energy Sustainability Strategy”, has once again demonstrated its vital role in protecting Lebanon and leading the way for others to follow. The Lebanese Army “Energy Sustainability Strategy” has aligned its goals with Lebanon’s national climate change targets, equating climate change and sustainability with national security. Reducing our greenhouse gases emissions through the implementation of renewable energy and energy efficiency measures, among other initiatives, is no longer a luxury, but an essential step in building our future. The consequences of climate change threatens our social and economic fabric and thus requires that we act together to strengthen our institutions and our united response.

The Ministry of Energy and Water remains fully ready to assist the Ministry of Defense and the Lebanese Army in achieving the goals set in this strategy, hoping that the strategy’s implementation will lead the way for many other public and private institutions to follow this path.

César Abi Khalil

Minister of Energy and Water
Foreword

The effects of climate change are wide ranging and often have complex interactions. In Lebanon, the impacts of climate change on water and forestry resources constitute a national security concern. In addition, changes in frequency of natural disasters in Lebanon are already being felt and likely to become more apparent over the next 50 years.

The last couple of years witnessed accelerated actions towards fighting climate change. Lebanon answered the call by putting forward its nationally determined contribution and committed to introduce renewable energy and increase its energy efficiency by as much as 20% and 10% respectively by the year 2030.

Throughout its rich history, the Lebanese Armed Forces has been the safeguarding institution of national defense, security, and development and humanitarian action. The Lebanese Armed Forces have relentlessly, since its establishment, played a major role in alleviating the suffering of the Lebanese citizens during crisis and natural disasters. The Lebanese Armed Forces have in fact been at the front lines in fighting the climate change related disasters, through their contribution in extinguishing forest fires and launching large reforestation campaigns, and managing natural disasters in coordination with the concerned agencies as well as forming specialized committees to evaluate the damages of such disasters.

Therefore, it is no surprise that the Lebanese Armed Forces have risen to the challenge of fighting climate change, through the development of its Energy Sustainability Strategy. In fact, the Energy Sustainability of the Lebanese Armed Forces establishes a vision that ensures effective delivery of defense capability that is robust to climate change and does not substantially contribute to its causes. This document constitutes the first national energy strategy that complies with Lebanon’s international commitments, under the climate change umbrella, by upholding the national renewable energy and energy efficiency targets of 20% and 10% respectively, by the year 2030, and will contribute towards increasing our national energy security. With the Energy Sustainability Strategy, we find, yet again, the Lebanese Armed Forces on the frontlines, this time in the fight against climate change. The Ministry of Environment is ready to put its entire resources in support of the implementation of the Energy Sustainability Strategy of the Lebanese Armed Forces.

Tarek El Khatib
Minister of Environment
Foreword

The defense and security missions performed by the army are not to be separated from the developmental missions, despite their difference in nature, size, style and occurring circumstances.

Therefore, the army command constantly thrives to improve its developmental missions, whether those related to the nation as a whole or those related to the military institution, in view of the fact that they are similar in goals, results and impact.

Moreover, considering that the army holds major human, material and organizational capabilities, the army command endeavors to invest in these resources and capabilities to the maximum extent with the cooperation of friend countries, organizations and local and international associations. Through this investment, the command aims to facilitate daily life issues facing soldiers on the one hand and to alleviate the burden that weighs on the state on the other hand.

The EU-funded UNDP - CEDRO project, based on the cooperation between the UNDP and the Directorate of Engineering in the Lebanese Armed Forces aiming to provide water and renewable energy to barracks and military posts, is one of the most outstanding viable projects that concern the army. Its importance is due to practical steps achieved by this project during the past years, mainly equipping the Training Academy and the Military academy with solar powered water heating systems. After an exemplary study was put forth in order to provide renewable energy to the army, we hope that it will be achieved in reality at the near and intermediate future.

Undoubtedly, the success of this project in accomplishing all its stages will be a qualitative leap in meeting the army’s daily needs and a motive to execute similar projects at the level of the nation in general.

I extend my appreciation and gratitude to the officials at the United Nations Development Programme (UNDP) for following up with this project with the ultimate seriousness, responsibility and motivation. Moreover, I extend my appreciation and gratitude to the funding part - the European Union that is always by the army’s side and is always supporting its efforts in different fields.

In the end, may this project be a symbol of mutual trust through which friendship between nations and peoples is built.

General Joseph Aoun

Armed Forces Commander
Foreword

“It is better to light a candle than to curse the darkness”. This is the motto that most describes the attitude of the people behind the CEDRO project. Those benevolent people that have committed themselves through the years to the firm cooperation with the military institution in the energy and water sectors, so that this creative cooperation produces, under the supervision of the army command, major accomplishments that were embodied in equipping the training academy and the military academy with solar-power water systems. This cooperation also resulted in issuing this promising study in cooperation with the Directorate of Engineering as a roadmap to provide sustainable energy to the Lebanese Armed Forces.

The suggested study that we hold in our hands sheds the light on a major part of life issues that face the Lebanese Armed Forces as well as means to solve them in modern ways and methods that keep up with the major development in the field of renewable energy, particularly in light of the difficult economic situation that faces Lebanon and the lack of credits dedicated for the Lebanese Armed Forces. Undoubtedly, the practical implementation of this study in the coming years will have a positive impact on the general situation of the institution and will be an example to follow in generalizing this project in the public and private sectors and will ultimately alleviate the financial burdens that weigh down the Lebanese state’s treasury and the lives of citizens.

In the end, I would like to express my utmost appreciation and gratitude to the officials of the United Nations Development Programme (UNDP) which manages this project, and through you to the funding European Union that continues to support the Lebanese Armed Forces on different levels. Furthermore, I am filled with hope that all the goals of this project will be achieved thanks to the will to give and create that lies in the people that are responsible for this project and to the solidarity of all sincere efforts.

General Jean Kahwagi
Former Armed Forces Commander
Foreword

The European Union and Lebanon have a strong history of cooperation which spans across different sectors, aiming at supporting national efforts to promote sustainable socio-economic development in a safe and secure environment. The EU-Lebanon Partnership Priorities, signed in November 2016, reconfirm the reciprocal engagement and commitment in working together for peace and stability in Lebanon and the region. The Lebanese Armed Forces (LAF) play a key role to this end. In recognition of such a role, the EU has been supporting LAF efforts with the aim to reinforce its organisational development.

Under the EU-funded CEDRO IV project, the LAF, with support from UNDP, has conceived an innovative “Energy Sustainability Strategy.” This is a unique and original document that greatly complements EU-Lebanon cooperation promoting a safer and greener Lebanon. The strategy stands as an important pillar for ensuring the army’s long term efficiency and increased LAF’s energy security will bring immediate economic and financial benefits and enhance the daily well-being of its troops, thus contributing to better energy efficiency for the benefit of all citizens.

While moving towards concrete renewable energy and energy efficiency measures, the army, as one of the biggest national institutions, would act as a leading example and show “the way forward” for numerous other public and private bodies as well as the general population. The LAF would also stand as one of the main actors in upholding Lebanon’s commitments towards fighting climate change.

We are confident that the strategy will add value to EU’s support for a more stable and prosperous Lebanon.

Christina Lassen
Head of the Delegation of the European Union to Lebanon
The partnership between the United Nations Development Programme (UNDP) and the Lebanese Armed Forces (LAF) in the field of renewable energy and energy efficiency started nearly a decade ago. We have worked on several initiatives for the installation of large solar water heaters in LAF facilities to improve the living standards of army personnel, while reducing energy consumption and related costs.

The LAF Directorate of Engineering has been a very active partner in planning and coordinating the technical trainings provided by various UNDP projects on sustainable practices for facilities. As a result, necessary retrofitting and improvements have been introduced into the existing LAF infrastructures to reduce energy losses.

This long collaboration has culminated in the formulation of an overall “Sustainable Energy Strategy” for the LAF. This strategy aims at “greening” all armed forces facilities, including barracks, offices, and stations. Recommendations include installing decentralized renewable energy equipment, adopting energy efficiency measures, and making technical changes to most installations and equipment.

It is the first time in the Arab region that a national armed force takes concrete step towards reducing its carbon footprint and ensuring more sustainable sources of energy. In committing to this strategy, the LAF is confirming that energy security, climate change, and sustainable development are important to Lebanon and to the world at large. The strategy is also aligned with Lebanon’s commitments to the UN Convention on Climate Change, particularly the Paris Agreement, and the pledge to achieve 20% renewable energy and a 10% energy efficiency target by 2030.

In partnership with the Ministry of Energy and Water, UNDP will continue to support the LAF and the Ministry of Defense in mobilizing the resources needed to implement this strategy, as a proud partner of these institutions in their pursuit to promote sustainable development in Lebanon.

Philippe Lazzarini
UNDP Resident Representative
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<table>
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<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AC</td>
<td>Air Conditioning</td>
</tr>
<tr>
<td>CFL</td>
<td>Compact Fluorescent Lamp</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>EP</td>
<td>Environmental Performance</td>
</tr>
<tr>
<td>IEQ</td>
<td>Indoor Environment quality</td>
</tr>
<tr>
<td>kVA</td>
<td>Kilo Volt Ampere</td>
</tr>
<tr>
<td>kW</td>
<td>Kilo watt</td>
</tr>
<tr>
<td>kWh</td>
<td>Kilo Watt- hour</td>
</tr>
<tr>
<td>LAEI</td>
<td>Lighting Areal Energy Intensity</td>
</tr>
<tr>
<td>LAF</td>
<td>Lebanese Armed Forces</td>
</tr>
<tr>
<td>LPD</td>
<td>Lighting Power Density</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquid Petroleum Gas</td>
</tr>
<tr>
<td>NCO</td>
<td>Non Commissioned Officer</td>
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</table>
Executive Summary

The Lebanese army considers that climate change affecting Lebanon is forecasted to continuously increase, potentially leading to the demise of both the Lebanese economic foundations and social fabric. Indisputably, climate change, if left unchecked, will have the following impact on the Nation:

- Temperatures projected to increase from around 1ºC on the coast to 2ºC in the mainland by 2040, and by 2090 are predicted to increase by 3.5ºC to 5ºC.
- Rainfall volume is set to decrease by 10-20% by 2040 and 25-40% by 2090,
- Changes in snowfall patterns (occurrence at increasing elevation due to temperature rise) – from currently recorded elevations of 1,500 m shifting to 1,700m by 2050 and to 1,900m by 2090, reducing the total snowfall expectancy by 40%.
- Stress on our agricultural produce, water availability, and various natural ecosystems.
- The frequency of heat waves are anticipated to occur, adding 50 days with recorded temperatures above 35ºC and 34 nights with temperatures exceeding 25ºC to the yearly calendar by end of century
- Increase in the intensity of winter storms, and the rise of sea level.

These in return will cause dramatic costs to our economy, and stir social unrest and instability.

Furthermore, energy security is yet another vital motive and objective to achieve. Energy security is beginning to be seen as more than the availability and accessibility of energy resources only, yet also the acceptability (i.e., environmental implications) and affordability of these resources. More and more energy security is falling within the definition and scope of sustainable development. For the Lebanese Army, energy security and sustainable development are now an integral part of National Security.

Being the most sizable public institution that has earned national status of being both trustworthy and an emblem of Lebanese pride, it is imperative for the Lebanese army to spearhead the mitigation of climate change through the reduction of greenhouse gas emission and the adoption of cleaner technology through embracing renewable energy and energy efficiency measures and conventions.

To this end, the Lebanese Ministry of Defense, the Lebanese army and the European Union (who has generously committed & mobilized material & human resources), have entrusted and appointed the United Nations Development Program CEDRO to undertake a full energy assessment that has culminated in this Army Strategy Publication.

As a first step, CEDRO undertook an energy survey initiative, assessing and appraising the entire built-up area portfolio of the Lebanese Army. This survey succeeded in establishing an accurate baseline of energy use. To set a point of reference, CEDRO used the data from the year 2015 during which the Lebanese Army consumed 52,106.89 MWh of utility electricity and 19,676 MWh of diesel genset electricity (total of 71783 MWh). An additional 28,600 MWh of thermal power consumption was documented in 2015.

As part of the UNFCCC framework, the Republic of Lebanon published the “Lebanon’s Intended Nationally Determined Contribution” in September 2015 in which the government pledged the following:

- An unconditional target of “15% of the power and heat demand in 2030 to be generated from renewable energy sources” coupled with a “3% reduction in power demand through energy - efficiency”. This would lead to a 15% reduction of greenhouse gas emission in relation to the business as usual (BAU).
- A conditional target of “20% of the power and heat demand in 2030 to be generated from renewable energy sources” coupled with a “10% reduction in power demand through energy - efficiency”. This would lead to a 30% reduction of greenhouse gas emission in relation to business as usual (UNFCCC, 2015).
In an effort to pioneer such enterprises and set benchmarks for private and public sector institutions challenging them to follow suit, the Lebanese Ministry of Defense and the Lebanese Army pledge the following:

1. 20% of its total electricity consumption is to be generated from renewable energy sources by the year 2030. This will be realized by steadily, gradually & continuously increasing dependency on renewable energy source implementations between the years 2017 and 2030.

2. 20% of its total thermal consumption is to be generated from renewable energy sources by the year 2030.

3. 10% reduction in energy use per sqm by the year 2030.

To achieve these targets, multiple streams need to be followed. The below table indicates these initiatives, directives and operational measures to be implemented to ensure success (with their respective indicative costs).
<table>
<thead>
<tr>
<th>Item</th>
<th>Measure</th>
<th>Cost Required</th>
<th>Calculation Notes</th>
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<tbody>
<tr>
<td>1</td>
<td>Awareness &amp; Capacity Building</td>
<td>$260,000.00</td>
<td>20,000$/year*13 years</td>
</tr>
<tr>
<td>2</td>
<td>Metering &amp; Monitoring</td>
<td>$378,830.00</td>
<td>431 water meters<em>120$/meter+ 588 Elec Meter</em>150$/meter+ 477 Fuel Meter<em>150$/meter+ 1417 Run hours meter</em>30$/meter+ 604 Diesel Meter*100$/meter+ 20,000$ software</td>
</tr>
<tr>
<td>3</td>
<td>Building Thermography Monitoring</td>
<td>$6,000.00</td>
<td>2 hand-held thermographs*3000$/Therm.</td>
</tr>
<tr>
<td>4</td>
<td>O&amp;M Software and training</td>
<td>$10,000.00</td>
<td>5900$ software fee and 4100$ training</td>
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<tr>
<td>5</td>
<td>Detectors &amp; Timers</td>
<td>$155,050.00</td>
<td>4,430 Detectors &amp; timers*35$/unit</td>
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<tr>
<td>6</td>
<td>Water Saving Devices</td>
<td>$250,000.00</td>
<td>(3500 Lavatories+2100 Shower)*44.64$/pc</td>
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<td>7</td>
<td>Solar Hot Water Systems</td>
<td>$6,000,000.00</td>
<td>300 SWH Systems*20000$/SWH</td>
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<tr>
<td>8</td>
<td>Solar PV Systems</td>
<td>$9,360,000.00</td>
<td>7800 kW*1200$/kW</td>
</tr>
<tr>
<td>9</td>
<td>Biogas Assessment</td>
<td>$60,000.00</td>
<td>Estimated</td>
</tr>
<tr>
<td>10</td>
<td>Roof Insulation</td>
<td>$1,100,000.00</td>
<td>92,000 m²*12$/m² Expected yearly energy saving is 2,002 MWh to 4,0004 MWh in the form of thermal energy Expected yearly energy saving is 1,377.3 MWh and 2,754.67 MWh in the form of Diesel Energy (electricity) and 3,647.48 MWh and 7,294.96 MWh in the form of utility energy (electricity)</td>
</tr>
<tr>
<td>11</td>
<td>Double Glazing</td>
<td>$4,500,000.00</td>
<td>25,000 m²*180 $/m² of Double Wall Glazing Expected yearly energy saving is 1,967.6 MWh in the form of Diesel Consumption Expected yearly energy saving is 5,210.69 MWh in the form of electricity (EDL) and 2,860 MWh in the form of thermal energy</td>
</tr>
<tr>
<td>12</td>
<td>Thermal Films (Zone 1a)</td>
<td>$50,000.00</td>
<td>15,000m² of Glazing to be applied with thermal film *3.33$/m²</td>
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<tr>
<td>13</td>
<td>Army Technical Support</td>
<td>$1,200,000.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>$23,329,880.00</strong></td>
<td></td>
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</table>
These measures above would allow an approximate and direct annual saving for the Lebanese Army of approximately $3 million in the current environment of low fuel prices. This leads to a payback period of 7.7 years. If oil prices were to reach the $100/barrel mark again, the saving will double and the payback period will halve. With respect to greenhouse gas emissions, these measures will reduce a total of 17,348 tons of CO$_2$ equivalent per annum (based on a 0.7 kg of CO$_2$ per kWh and 2.65kg of CO$_2$ per liter of diesel).

The LAF hopes to implement, as much as possible and hopefully within the next 5 years, the majority of the measures listed above through its available resources. The Lebanese Ministry of Defense and the Lebanese Army Command will guide, prioritize and oversee the implementation of this Strategy. The Strategy itself will be carried out by the Lebanese Army Directorate of Engineering, either through direct implementation or through coordination with national and international organizations that may hopefully assist, through grants or in-kind contributions, in fulfilling our objectives.

In parallel, a vibrant momentum will be formulated and deployed through several creative and wide reaching communication strategies and channels, awareness raising strategies and activities that would run in parallel with the implementation of the Strategy.

Our aspirations extend beyond the Lebanese Army’s endeavor at hand. We hope to inspire and lead by example so that a ripple effect will spread to other public and private institutions, so that the Lebanese people and economy will come together to face one of the greatest challenges of our time.

For any communication and/or cooperation on the implementation of the Lebanese Army Strategy, kindly contact lafses@mod.gov.lb
CHAPTER 1
LEBANESE ARMED FORCES (LAF) SUSTAINABILITY STRATEGY
1.1 Introduction

Throughout Lebanon’s modern history, since its independence in 1943, the country has been facing and is facing ongoing pressures, in the form of external wars waged on the country, internal political instability and civil strife that rise and ebb continuously.

The Lebanese Armed Forces (LAF) is the symbol of hope for Lebanese and it embodies Lebanon’s geographic unity, stability, and prosperity. Safeguarding and strengthening our combat and non-combat human resources, advancing our military and non-military capital assets and our ability to dynamically operate to safeguard internal security and safeguard Lebanon’s borders is of tantamount importance to the continuity of relative peace and stability in a currently turbulent region.

Energy use is a social and environmental burden on Lebanese citizens, impacting every Lebanese household and other commercial, agricultural and industrial entity, and it is a major drain on the national economy given the high reliance on imported primary energy (at least 97%) to satisfy energy demand for heating and hot water, electricity, and transportation.

The LAF is obliged, from both a civic responsibility and as the largest public institution in Lebanon, to lead the way in lowering its energy demand, increasing the utilization of local sources of energy, mainly low-carbon sources, enhancing its environmental performance, and assisting in securing affordable energy to the Lebanese. The LAF can directly reduce its energy needs through behavioral changes and energy efficiency measures, and by increasingly relying on renewable energy to align themselves with national targets set by:

- The Lebanese Council of Ministers (Decision 1, dated June 21st, 2010) and announced at the Copenhagen Summit on Climate Change in 2009;
- The Ministry of Energy and Water through the Ministry Policy Paper in 2010;
- The National Energy Efficiency Action Plan (2016 - 2020);
- The National Renewable Energy Action Plan (2017 – forthcoming), and;
- Lebanon’s Intended Nationally Determined Contributions (INDC) targets set by the Paris Agreement in 2016.
1.2 Purpose: Achieving Energy Security through sustainable development

Energy security is a fundamental objective of most nations around the world. Initially, energy security has focused more on availability and accessibility of energy supplies and has taken a rather political stance on energy security. From this perspective, energy security is regarded as an integral part of national security. However, with new challenges facing society, energy security has increasingly focused on economic, social and environmental dimensions. The European Commission, for example, describes Energy Security as “uninterrupted physical availability of energy products on the market at an affordable price for all consumers.” Therefore, an aspect of affordability is integrated. The International Energy Agency defines Energy Security as the “adequate, affordable, and reliable access to energy fuels and services, and includes availability of resources, decreasing dependence on imports, decreasing pressures on the environment, competition and market efficiency, reliance on indigenous resources that are environmentally sound, and energy services that are affordable and equitably shared (Sovacool, 2011).” These definitions of Energy Security translate to the Four A’s pillars of Energy Security: Availability, accessibility, acceptability, and affordability, as shown in Figure 1.

These views and definitions can further be related and linked to sustainable development, through its well-known Venn Diagram integrating economic (and technical), social and environmental concerns, as depicted in Figure 2.
To this end, the sustainable development path is one of energy security, and energy security is part of national security encompassing all the aspects of Lebanon’s economy.

The LAF cannot but play a pro-active role, within its modest means and available resources, to assist Lebanon’s economy, institutions and people to gear towards sustainable development. In the long run, the social and economic benefits of this initiative will only relieve the growing pressures and risks involved. This can be most significant when assessing the risks involved from climate change.

1.3 Climate change: A threat to national security

Climate change is a rising threat to Lebanon’s national economy. The Intergovernmental Panel on Climate Change (IPCC) and other scientific bodies have documented the effects of human-induced emissions of carbon dioxide and other greenhouse gases. These effects include changes in the climate system inducing an increase in average temperature, more extreme weather events, rising sea levels, and ocean acidification, as well as resultant changes in ecosystems, species, human systems, and other aspects of life on Earth.

Relative to Lebanon’s present climate, the consequences listed below are expected:

- Temperatures will increase from around 1ºC on the coast to 2ºC in the mainland by 2040, and by 2090 they will increase 3.5ºC to 5ºC.
- Rainfall quantity is set to decrease by 10-20% by 2040 and 25-40% by 2090.
- Changes in snowfall patterns and elevation – from current elevations of 1,500 m shifting to 1,700m by 2050 and to 1,900m by 2090, reducing the total expected snowfall by 40%.
- Pressure on Lebanon’s agricultural produce, water availability, and various natural ecosystems.
- The frequency of heat waves are expected with the addition of 50 days with temperatures above 35ºC and 34 nights with temperatures exceeding 25ºC by end of the 21st century.
- Increase in the intensity of winter storms and the rise of sea levels.
These future effects of climate change will stem from an unstable process, involving sudden, and possibly in some cases, catastrophic changes. It is possible that the effects will be felt more rapidly and widely than anticipated, leading to unexpected impacts, challenging our individual and collective capacity to respond.

There are certainly disruptive events that could occur potentially earlier. An extreme weather event, or multiple extreme weather events, could occur at any time. Lebanon’s lifestyle is built around a few sources of water. So any stress on rivers and aquifers can be a source of conflict. Water stress will increase, with the risk that disputes over water will contribute significantly to tensions in our already volatile region, possibly triggering military action and population movement.

The above, coupled with increasing local demand on food, is likely to place pressure on the food supply, with a succession of poor harvests resulting in major price hikes that could result in economic and political turbulence, as well as recurrent humanitarian crises of significant proportions.

The total economic cost of climate change can reach 1.9 billion USD in 2020. This implies that in 2020, every Lebanese household will have an additional cost estimated at USD 1,500, as a result of the cumulative effects of global greenhouse gas emissions in the period 2015-2020. But the more significant implications probably occur over the next few decades, and then of course far into the future. The costs incurred are estimated to be around 138.9 billion USD by 2080 and the cost per Lebanese household can reach up to USD 107,200 by 2080 (MOE/UNDP, 2015).

Unless Lebanon begins to reduce greenhouse gas emissions, defines and ramps up its adaptation strategy, and changes the way it uses energy, Lebanon is in for a challenging future. If humans succeed in maintaining global warming below the 2ºC target, these economic impacts will be reduced by 28% in 2020 and 91% in 2080.

Through this LAF Sustainable Energy Strategy and a commitment to strive in implementing its recommendations to lead by example, the LAF commits to protect Lebanon and its citizens and hopefully inspire other public and private institutions to follow suit.
1.4 LAF Sustainability Strategy report objectives and structure

This report is the first report to set out a non-combat related sustainability strategy of the LAF. The LAF acknowledges that sustainability encompasses various concepts and issues, which this report in its current first version cannot cover in its entirety. The main focus of this first report will be on energy use, particularly energy use in the LAF’s built environment; other vital topics will be briefly mentioned. The LAF hopes that future updates will include other vital aspects of environmental sustainability, including, yet not limited to, sustainable transportation, water use, solid waste management, wastewater management, and natural ecosystem protection and enhancement, among other diverse areas.

Through this report, the LAF hopes to set out its accurate baseline conditions in terms of energy use in the built environment (Chapter 2). From this baseline situation, the LAF aims to achieve energy saving and efficiency targets and renewable energy (outlined in Chapter 4) targets that are aligned to and are key to achieve national targets. However, the LAF is also pragmatic in its aspirations. Chapter 4 describes the targets for 2020 and 2030. The possible roadmap to reach the indicated targets is described in Chapter 5.

Achieving these objectives cannot happen without support from multiple institutions and organizations, local and international, public and private, from the Lebanese residents and diaspora. Consequently, under the guidance of the Ministry of Defense, and in collaboration with the Ministry of Energy and Water, the Ministry of Environment, the European Union, the United Nations Development Programme, and the Lebanese Center for Energy Conservation (LCEC), among other integral contributors, the LAF aims to reach out, through this publication and its dissemination, to secure the required resources, both material and intellectual, to achieve its disclosed targets.
2.1 Building stock

LAF non-combitative facilities have been classified into eleven categories based on the criteria of each building’s function and occupancy profile, major determinants of resource use, specifically energy and water. The seven categories are:

- **“Administration”** facilities that have administrative and training functions but could also be used as domestic quarters in emergency situations. This category includes some facilities that are operational round the clock albeit at reduced occupancy. The use profile for this category is not much different than its civilian counterpart, namely, office facilities.

- **“Storage”** represents storage areas for all kinds of materials and equipment including military hardware.

- **“Workshop”** facilities that have mixed use: Administrative, training as well as sleeping quarters, therefore operational round the clock albeit at somewhat reduced occupancy during nighttime.

- **“Medical”** includes hospitals, clinics and other facilities that have a health care purpose. This category is similar to its civilian counterpart in the health sector.

- **“Kitchen”** facilities that include cooking, dining halls or both.

- **“Leisure”** includes officers and non-commissioned officer (NCO) clubs, as well as hotels. This category is quite similar to its civilian counterpart, namely, the hospitality sector.

- **“Others”** includes facilities with specific functions, most being operated round the clock (e.g.: fuel stations, power houses, control towers, shooting ranges, etc.).

Figure 3 shows the distribution of LAF facilities in the various regions and distribution per category type.

![Figure 3: Distribution of LAF facilities per region (left) and per type (right)](image)

The figures above provide the percentage of:

- Left: The total built up area in the five different regions (area of each region in reference to the total area)
- Right: The total built up area for each of the seven different identified building types within LAF facilities (area of each building types in reference to the total area)
Another determinant of energy use and, to a lesser extent, water use is climate: climate zoning has a significant impact on energy use especially in a country like Lebanon where at least 80% of the territory consists of mountains and highlands. Table 2 indicates the breakdown of the LAF built-up area as a function of climatic zone.

Table 2: Breakdown of LAF facilities built-up area by function per climate zone (m²)

<table>
<thead>
<tr>
<th></th>
<th>Zone 1a (0 - 300)</th>
<th>Zone 1b (300 - 700)</th>
<th>Zone 2 (700 - 1,400)</th>
<th>Zone 3 (Bekaa)</th>
<th>Zone 4 (&gt; 1,400)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admin</td>
<td>291,140</td>
<td>21,533</td>
<td>16,850</td>
<td>62,306</td>
<td>3,622</td>
<td>395,451</td>
</tr>
<tr>
<td>Storage</td>
<td>36,743</td>
<td>3,359</td>
<td>2,495</td>
<td>2,656</td>
<td>60</td>
<td>45,313</td>
</tr>
<tr>
<td>Worksh</td>
<td>31,754</td>
<td>4,163</td>
<td>9,975</td>
<td>31,572</td>
<td>64</td>
<td>77,528</td>
</tr>
<tr>
<td>Medical</td>
<td>31,599</td>
<td>617</td>
<td>1,050</td>
<td>3,533</td>
<td>1,900</td>
<td>38,699</td>
</tr>
<tr>
<td>Kitchen</td>
<td>17,513</td>
<td>2,107</td>
<td>230</td>
<td>6,318</td>
<td>0</td>
<td>26,168</td>
</tr>
<tr>
<td>Leisure</td>
<td>52,670</td>
<td>6,718</td>
<td>3,930</td>
<td>8,963</td>
<td>5,000</td>
<td>77,281</td>
</tr>
<tr>
<td>Other</td>
<td>2,604</td>
<td>901</td>
<td>520</td>
<td>3,293</td>
<td>35</td>
<td>7,353</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>464,023</strong></td>
<td><strong>39,398</strong></td>
<td><strong>35,050</strong></td>
<td><strong>118,641</strong></td>
<td><strong>10,681</strong></td>
<td><strong>667,793</strong></td>
</tr>
</tbody>
</table>

Note: Climatic Zones altitude brackets are in meters

Most LAF facilities are located in the coastal zone totaling up to 69%, followed by the inland plateau (Bekaa) with almost 18%, while Zone 4 has a very low share (1.6%), except for leisure facilities which make up about 46% of all LAF built up areas in Zone 4. The lower zones, normally covering altitudes from zero to 700 meters of the western mountain range, have been further divided into two zones (1a: 0 - 300m and 1b: 300 - 700m). This is done in order to provide a refined sample for the segregation of the appropriate recommendations since most facilities are located in the coastal area (75% of the total LAF built up area evaluated/surveyed in the present document). Overall, it can be stated that the bulk of the facilities are located in a mild Mediterranean coastal climate that is potentially conducive to relatively lower energy expenditure in order to ensure acceptable indoor thermal conditions even during the summer.

Table 3 shows, in percentages, the share of each building function in each zone, while Table 4 shows the relative share (percentage) of each building function in each zone with respect to the total built up area. The category “Administration” is clearly dominant.

Table 3: Breakdown of LAF facilities built up area by function per climate zone (%)
Table 4 puts into perspective the absolute importance of each type of facility in each zone with respect to the total built-up area of LAF facilities over the nation’s territory. This Table also shows the importance of the “Administration” category in the coastal zone compared to other zones, as well as other identified building types in the different zones.

Table 4: Breakdown of LAF facilities built up area by function and climate zone relative to overall built – up area (%)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
<td>59.22%</td>
</tr>
<tr>
<td>Storage</td>
<td>6.79%</td>
</tr>
<tr>
<td>Workshops</td>
<td>11.61%</td>
</tr>
<tr>
<td>Medical</td>
<td>5.80%</td>
</tr>
<tr>
<td>Kitchen</td>
<td>3.92%</td>
</tr>
<tr>
<td>Leisure</td>
<td>11.57%</td>
</tr>
<tr>
<td>Other</td>
<td>1.10%</td>
</tr>
<tr>
<td>Total</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Most LAF facilities were established prior to the 1990s, many dating back to the first half of last century. Most of these facilities did not undergo any significant upgrade to enhance their weather resistance or the performance of their installed electro-mechanical systems. Moreover, buildings erected during the last 25 years have not adequately adapted to local climatic conditions. This impacts the environmental performance of these facilities, especially energy consumption, reinforcing and legitimizing the position of this document to focus on improving energy efficiency in LAF facilities. A list of the permanent army facilities (barracks and air forces) along with their respective built-up areas is provided in the table 5 here after.

Table 5: List of Fixed Military Facilities

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrack Soqour al Qomam - Akoura</td>
<td>92,000</td>
</tr>
<tr>
<td>Barrack Abdul Majid Chehab - Beiteddine</td>
<td>250,000</td>
</tr>
<tr>
<td>Barrack Said al Khatib - Hamana</td>
<td>385,000</td>
</tr>
<tr>
<td>Barrack Miled Naddaf - Amchit</td>
<td>66,013</td>
</tr>
<tr>
<td>Barrack Chikri Ghanem and Military School</td>
<td>98,000</td>
</tr>
<tr>
<td>Barrack Dory Irani - Loueizeh</td>
<td>134,000</td>
</tr>
<tr>
<td>Barrack Independent Works Regiment - Haret EL Sit</td>
<td>98,000</td>
</tr>
<tr>
<td>Barrack Youssef Al Qosta - Kfarchima</td>
<td>320,000</td>
</tr>
<tr>
<td>Barrack Raymond Hayek - Sarba</td>
<td>53,000</td>
</tr>
<tr>
<td>Barrack Rachad Abou Chakra - Bmariam</td>
<td>236,000</td>
</tr>
<tr>
<td>Barrack Henry Chehab - Ouzai</td>
<td>38,000</td>
</tr>
</tbody>
</table>
## Bekaa

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrack Iskandar Ghanem - Soghbine</td>
<td>132,000</td>
</tr>
<tr>
<td>Barrack Elias Abou Sleiman - Ablah</td>
<td>388,000</td>
</tr>
<tr>
<td>Air Force Base - Riyak</td>
<td>2,075,000</td>
</tr>
<tr>
<td>Barrack Mohamad Makki - Baalbeck and surroundings</td>
<td>1,250,000</td>
</tr>
</tbody>
</table>

## North

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force Base - Qlayaat</td>
<td>3,265,000</td>
</tr>
<tr>
<td>Barrack Bahjat Ghanem - Tripoli</td>
<td>105,000</td>
</tr>
<tr>
<td>Barrack Georges Al Naghawi</td>
<td>30,000</td>
</tr>
<tr>
<td>Barrack Hanna Ghostine - Arman and surroundings</td>
<td>836,000</td>
</tr>
<tr>
<td>Barrack Simon Chahin - Chadra</td>
<td>3,500</td>
</tr>
<tr>
<td>Hilan - Zgharta</td>
<td>155,000</td>
</tr>
<tr>
<td>Skiing School - Arz</td>
<td>7,000</td>
</tr>
<tr>
<td>Scouting City - Batroun</td>
<td>85,000</td>
</tr>
</tbody>
</table>

## South

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrack Mohamad Zoughaib</td>
<td>98,000</td>
</tr>
<tr>
<td>Barrack Jean Wehbi - Salhieh</td>
<td>114,000</td>
</tr>
<tr>
<td>Barrack Issam Chamoun - Nabatieh (and officer housing)</td>
<td>372,000</td>
</tr>
<tr>
<td>Barrack Francois El Hajj - Marjayoun (and officer housing)</td>
<td>25,000</td>
</tr>
<tr>
<td>Barrack Sary Adloun</td>
<td>84,000</td>
</tr>
<tr>
<td>Barrack Chamee - Tyr</td>
<td>15,000</td>
</tr>
<tr>
<td>Barrack Benoit Barakat - Tyr and surroundings</td>
<td>247,000</td>
</tr>
<tr>
<td>Barrak of Jezzine</td>
<td>21,000</td>
</tr>
</tbody>
</table>

## Military Region Command Beirut

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrack of the Central Military Hospital</td>
<td>29,000</td>
</tr>
<tr>
<td>Barrack Emir Fakhreddine</td>
<td>14,000</td>
</tr>
<tr>
<td>Barrack Emir Bachir</td>
<td>11,000</td>
</tr>
<tr>
<td>Barrack Traboulsi</td>
<td>11,000</td>
</tr>
<tr>
<td>Barrack of the Military Court and Beirut Area</td>
<td>4,000</td>
</tr>
</tbody>
</table>
2.2 Baseline Energy Use

The LAF's electricity requirements are provided through two main sources: the national grid through EDL, and diesel-run generators (gensets), mostly procured by the LAF's respective facilities. The Directorate of Engineering at the LAF has compiled data on energy use for the past three years (2013 - 2015), based on detailed bills for each of the sources. Furthermore, detailed monthly bills were gathered, documenting the total energy use of over 900 army facilities throughout Lebanon.

2.2.1 EDL Electric Energy and Cost Analysis

EDL is the main electricity provider in Lebanon with affiliated entities in Zahle (EDZ), Jbeil (EDJ), Kadisha (EDK), Aley (EDA) and Bhamdoun (EDB) that provide electricity to their respective regions based on EDL tariff schemes.

Two types of tariff schemes are available at EDL: the residential tariff (low voltage subscription) set at an average net cost (excluding VAT) of 140LL / kWh ($9.3/kWh) consumption and the industrial triple tariff (medium voltage subscription) based scheme (80 LL, 112 LL and 320 LL / kWh, equivalent to $5.3, $7.5, and $21.3 / kWh). When affiliated entities provide private generation along with utility generation (such as in the case of EDZ and EDJ under implementation), the customer is billed based on a unified compounded rate of 240LL per kWh (+10% VAT). The Lebanese Armed Forces (LAF) are billed based on a unified tariff regardless of the trench and area which is 140 LL/ kWh (+10% VAT) which totals to 154 LL / kWh.

Most LAF facilities have undergone some expansion or are currently used for other purposes than intended when they were constructed; for instance a facility could be a cluster of office buildings, a dormitory, a school and a workshop, or for instance, one facility that was intended for office use is currently utilized by the LAF's athletic team. Therefore, utility meters do not always reflect the nature of the facility (residential / commercial / industrial / etc).

Table 6 depicts a breakdown showing the subscription (as per the latest survey conducted in 2015) and the corresponding national electricity utility affiliate. About 40 to 50 subscriptions have been added mainly in the Bekaa and the South over the three year period.

<table>
<thead>
<tr>
<th>Name of the Utility</th>
<th>Low Voltage Subscriptions</th>
<th>Medium Voltage Subscriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Électricité Du Liban</td>
<td>362</td>
<td>82</td>
</tr>
<tr>
<td>Électricité de Kadisha</td>
<td>33</td>
<td>4</td>
</tr>
<tr>
<td>Électricité de Jbeil</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Électricité de Aley</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Électricité de Bhamdoun</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Électricité de Zahle</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Subscriptions</strong></td>
<td><strong>422</strong></td>
<td><strong>89</strong></td>
</tr>
</tbody>
</table>
Figure 4 shows the distribution of the total energy consumption in the various utility companies listed in Table 6 above. The majority of the consumption is affiliated with EDL followed by EDK (Électricité de Kadisha), and then both EDZ and EDJ (Électricité de Zahle and Jbeil respectively).

**Figure 4: Total Energy Consumption per utility (2013 - 2015) kWh**

EDL 87%
EDJ 2%
EDA 1%
EDB 1%
EDZ 2%
EDK 7%

Bills have been duly collected in all of the Army’s facilities in 2013 – 2015 inclusive. The total electricity consumption per year for the 2013 - 2015 period is 61,625,530.56 kWh, 54,932,428.89 kWh and 39,762,704.20 kWh, respectively, as shown in Figure 5 below. This has cost the army 8,627,292,459 LBP, 7,690,258,085 LBP and 5,566,496,488 LBP ($5.8 million in 2013, $5.17 million in 2014, and $3.74 million), respectively.

The depicted reduction in energy cost between the year 2013 and 2015 is mainly due to:

1. A re-structuring within the army personnel in the various areas and facilities, a re-shuffling aimed at reducing energy consumption and subsequently cost.
2. Longer power shortages
3. Irregular meter readings / billing from the provider

To this end, and in order to provide a reasonable baseline value for electricity consumption, 2013 – 2015 values have been averaged and selected as the baseline to be used throughout this publication (52,106,887.89 kWh and 7,294,682,344 LBP).
Figure 5: Yearly energy consumption KWh (2013 - 2015)

Energy Consumption (KWh)

Year

2013 2014 2015

EDL EDK EDJ EDZ

70,000,000.00 60,000,000.00 50,000,000.00 40,000,000.00 30,000,000.00 20,000,000.00 10,000,000.00 0.00

Figure 6: MV subscription yearly billings

Yearly Billings (LBP)

National Utility Entity

EDL EDK EDJ EDZ

Figures 6 and 7 show yearly billings, for both MV and LV subscriptions, of LAF facilities per utility company for the past three years (2013 – 2015 inclusive).

### 2.2.2 Private Electric energy and cost analysis

The Lebanese Armed Forces own 1,290 diesel run generators that operate during EDL blackouts, providing their facilities with their energy needs. Their generators have varied capacities ranging from 0.5 KVA up to 1,015 KVA. Approximately 63% of the generators produce below 20 KVA.

Generators are subject to two procurement conventions:

1. At design stage, the design department drafts the specifications of the required generator to cover the facility’s entire load during blackouts.
2. At retrofit / maintenance stage and following a request for procurement submitted by the facility’s operation and maintenance team to the Engineering Department. Following the request, an inspecting team visits the facility and evaluates its energy consumption that sets the basis to determine the generator capacity.

As a rule of thumb, every building / entity should be equipped with its own power generators, rarely do buildings rent out or share backup generators.

Backup generators operation is a facility management decision based on priority and needs; the generators are designed to cover the complete facility needs. However, in an effort to save on diesel consumption, generators might not be operated during all the blackouts, especially in remote locations.

As generators age, their efficiency decreases, hence requiring higher amounts of diesel per unit of electricity supply. In certain facilities and in an attempt to delay generator replacements / retrofit, facilities reduce their consumption load by strictly connecting priority loads to the generators. However in most common cases, selective load connectivity is due to generator overload and diesel shortages.

Diesel allocations are set at the beginning of the year by the Engineering Department per facility, and values are based on previous years’ needs. If facilities consume the allocated quantity before the end of the year, a request for “additional” quantity is then filed.
Bills or diesel allocations have been duly collected for the entirety of the army facilities for the year 2015. The total diesel consumption per year for 2015 is 6,558,720 liters; assuming a conversion factor of 10, this is equivalent to 65,587,200 kWh costing the army 6,132,403,200 LBP ($4.56 million). The 2015 values have been selected as a baseline to be used throughout this publication.

However, considering the available generators’ age and how they are being utilized throughout LAF facilities, their efficiency is assumed at 30%, hence rendering the actual electricity production from diesel powered generators at 19,676,160 kWh.

### 2.2.3 Electric Energy use baseline

Combining the total energy consumption (in kWh) from EDL and private diesel generators provides the total electrical energy baseline of LAF facilities. Considering that private consumption is only available for the baseline year 2015, the LAF energy baseline has been set at 71,783,047.9 kWh, costing a total of 13,427,085,544 LBP ($9.03 million USD) annually.

### 2.2.4 Thermal energy

Thermal energy consists of water and space heating, mainly through diesel-operated boilers. At Lebanese Armed Forces facilities, when diesel-operated boilers are inactive, distributed electric heaters are used in the facilities’ various rooms, or in the case of most offices, air conditioning split units are installed and operated when needed. However, in leisure type facilities, such as clubs and hotels, the boilers are additionally used for pool heating during the winters.

Facility management keeps logs of boilers’ diesel consumption for each facility; logs have been collected for the past three years (2013 – 2015, inclusive). Similarly with electricity use, the values from the year 2015 of the baseline for thermal energy use will be used as a baseline throughout this publication.

![Figure 8: Heating and hot water diesel consumption (Liters)]
Heating and hot water demand has been logged for the entirety of army facilities for the years 2013 - 2015 inclusive as shown in Figure 8 (consumption in liters).

Utilizing a conservative conversion factor (10) for heat generation from diesel, the total energy consumption per year for the 2013-2015 period would be 28,328,150 kWh, 28,500,650 kWh and 28,600,700 kWh, costing the army 3,427,706,150 LBP, 3,448,578,650 LBP and 2,674,165,450 LBP ($2.02M, $2.02M, and $1.56M), respectively and including VAT as broken down per area in Figure 10 (excluding VAT). The 2015 values have been selected as the baseline to be used throughout this publication (28,600,700 kWh and 2,674,165,450 LBP or $1.56M).

2.2.5 Summary

In terms of energy use at Lebanese Armed Forces facilities, the pie chart (Figure 10) below shows the share of energy: Utility constitutes 52% (52,106.89 MWh) and diesel (i.e. private on site generation from diesel-run generators) provides 20% share (19,676.2 MWh), while thermal energy use constitutes 28% of total energy use.
CHAPTER 3
ASSESSMENT AND DATA COLLECTION
A sample survey has been carried out to collect information regarding the existing building stock and the respective energy performance of the various facilities in the five zones identified above. Sixty-one LAF facilities all over the country have been selected, complemented by interviews with personnel from the LAF Engineering Directorate in order to compile the present baseline and outline the design and procurement processes in the LAF.

### 3.1 Assessment methodology

LAF technical personnel carried out facilities' assessments using a five section survey consisting of:

- Electrical loads (lighting, plug loads, air conditioning, etc).
- Thermal systems (Heating, air conditioning, etc)
- Water use (Plumbing systems, irrigation, liquid waste, etc)
- Building envelope (External walls, glazing, solar control)
- Building Operations and Maintenance

The survey covered a total built-up area of 90,000 m² equivalent to nearly 14% of the total LAF built-up facilities: facilities labeled “others” were not included in the survey (Table 7). However, area sub-divisions are not indicative since many LAF facility functions (administration, workshop, medical, etc) include storage space.

<table>
<thead>
<tr>
<th>Climate Zones</th>
<th>Total quantity</th>
<th>Qty surveyed</th>
<th>Area surveyed*</th>
<th>Climate Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number</td>
<td>%</td>
<td>m²</td>
<td>%</td>
</tr>
<tr>
<td>Administration</td>
<td>397</td>
<td>30</td>
<td>7.56%</td>
<td>51,301</td>
</tr>
<tr>
<td>Storage</td>
<td>101</td>
<td>6</td>
<td>5.94%</td>
<td>4,543</td>
</tr>
<tr>
<td>Workshops</td>
<td>88</td>
<td>7</td>
<td>7.95%</td>
<td>11,785</td>
</tr>
<tr>
<td>Medical</td>
<td>43</td>
<td>8</td>
<td>18.60%</td>
<td>12,761</td>
</tr>
<tr>
<td>Kitchen</td>
<td>33</td>
<td>3</td>
<td>9.09%</td>
<td>2,825</td>
</tr>
<tr>
<td>Leisure</td>
<td>50</td>
<td>7</td>
<td>14.00%</td>
<td>9,713</td>
</tr>
<tr>
<td>Other</td>
<td>34</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
</tr>
</tbody>
</table>

*This is the net area surveyed, however this may not represent the total surface area of the facilities that have been surveyed, because some parts of the buildings may not have been included in the survey.

“Leisure” and “Medical” facilities are the two types of facilities that rely heavily on energy (both utility and private generation). Therefore, a more extensive survey could be well justified to ensure statistical representativeness of the sample for these two particular categories.

### 3.2 Survey results

The survey results presented hereafter will be extrapolated to all LAF facilities and used for the compilation of the roadmap recommendation.
However, and due to the many unforeseen difficulties faced during the data collection and survey phases, it is highly recommended that a more detailed data collection exercise is to be performed prior to any implementation, coupled with a thorough data logging system on energy use for each building at the LAF.

### 3.2.1 Electrical loads

The electrical loads identified in the surveyed facilities have been classified into sixteen categories (Table 8) with the relative weight of each with respect to installed capacity and energy used.

<table>
<thead>
<tr>
<th>Electrical Load</th>
<th>Installed power</th>
<th>Energy use</th>
<th>Operating time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KWe</td>
<td>kWh/yr</td>
<td>Hrs/day</td>
</tr>
<tr>
<td>Internal lighting</td>
<td>638</td>
<td>2,326,460</td>
<td>10.0</td>
</tr>
<tr>
<td>Air conditioning</td>
<td>1,510</td>
<td>2,120,739</td>
<td>3.8</td>
</tr>
<tr>
<td>Appliances</td>
<td>425</td>
<td>589,495</td>
<td>3.8</td>
</tr>
<tr>
<td>Cold storage</td>
<td>168</td>
<td>493,850</td>
<td>8.1</td>
</tr>
<tr>
<td>External lighting</td>
<td>109</td>
<td>426,120</td>
<td>10.7</td>
</tr>
<tr>
<td>Water heaters</td>
<td>255</td>
<td>369,464</td>
<td>4.0</td>
</tr>
<tr>
<td>IT equipment</td>
<td>132</td>
<td>211,777</td>
<td>4.4</td>
</tr>
<tr>
<td>Kitchen equipment</td>
<td>111</td>
<td>203,631</td>
<td>5.0</td>
</tr>
<tr>
<td>Workshop equipment</td>
<td>121</td>
<td>190,586</td>
<td>4.3</td>
</tr>
<tr>
<td>Medical equipment</td>
<td>74</td>
<td>122,676</td>
<td>4.5</td>
</tr>
<tr>
<td>Pumps</td>
<td>34</td>
<td>96,064</td>
<td>7.7</td>
</tr>
<tr>
<td>Large fans</td>
<td>25</td>
<td>92,360</td>
<td>10.0</td>
</tr>
<tr>
<td>Water coolers</td>
<td>25</td>
<td>81,481</td>
<td>8.8</td>
</tr>
<tr>
<td>Office equipment</td>
<td>46</td>
<td>75,837</td>
<td>4.5</td>
</tr>
<tr>
<td>Elevators</td>
<td>7</td>
<td>23,240</td>
<td>9.4</td>
</tr>
<tr>
<td>Fitness equipment</td>
<td>9</td>
<td>14,935</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,689</strong></td>
<td><strong>7,438,715</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>
The highest electrical energy consumer is internal lighting representing 31%, followed closely by air conditioning with 28.5% despite the fact that installed AC electrical power (1,510 kW) is almost double the internal lighting (638 kW). This discrepancy is due to the fact that internal lighting is used for longer periods than air conditioning. The difference is shown in the last column of Table 8 where the average daily operating time of the lighting load is 10 hours (which is all year round) compared to 3.8 hours for ACs (seasonal use). AC operating time is its energization period, which is the time it takes the temperature to stabilize and allow the compressor to “de-energize” or shut down.

**Internal Lighting**

As shown in Table 8, internal lighting constitutes the highest energy-consuming load comprising 31.3% of total consumption. Performance parameters used in the internal lighting analysis are identified in Table 9 and data have been duly collected from the 61 surveyed facilities. For a more detailed analysis of the existing quality of internal lighting in the surveyed facilities, refer to Annex 1.
Table 10: Performance parameters of internal lighting in surveyed facilities

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built up surface area surveyed</td>
<td>m²</td>
<td>92,928</td>
</tr>
<tr>
<td>Installed internal lighting power in surveyed facilities</td>
<td>kW</td>
<td>638</td>
</tr>
<tr>
<td>Installed lighting power density in surveyed facilities (internal lighting)</td>
<td>Watt/m²</td>
<td>6.86</td>
</tr>
<tr>
<td>Estimated yearly electrical energy consumption in surveyed facilities</td>
<td>kWhr/yr</td>
<td>2,326,460</td>
</tr>
<tr>
<td>Estimated yearly electrical energy intensity in surveyed facilities</td>
<td>kWhr/m².yr</td>
<td>25.03</td>
</tr>
<tr>
<td>Estimated average daily operating hours of lighting in surveyed facilities</td>
<td>hr</td>
<td>10</td>
</tr>
<tr>
<td>Estimated incandescent lights share in lighting power</td>
<td></td>
<td>21.1%</td>
</tr>
<tr>
<td>Estimated incandescent lights yearly electrical energy consumption in surveyed facilities</td>
<td>kWhr</td>
<td>334,683</td>
</tr>
<tr>
<td>Estimated incandescent lights electrical energy consumption share in surveyed facilities</td>
<td></td>
<td>14.4%</td>
</tr>
<tr>
<td>Number of surveyed facilities with no incandescent lamps</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Percentage of surveyed facilities with no incandescent lamps</td>
<td></td>
<td>33%</td>
</tr>
<tr>
<td>Estimated average number of rooms surveyed having day-lighting potential</td>
<td></td>
<td>66%</td>
</tr>
<tr>
<td>Average internal space area serviced per lighting switch (zoning factor)</td>
<td>m²</td>
<td>37</td>
</tr>
<tr>
<td>Percentage of lighting power in surveyed facilities manually operated</td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

*Incandescent lights*

The army has adopted a policy to phase out incandescent lighting from its facilities. Therefore this type of lighting is absent from 33% of the facilities surveyed, but it still represents 21% of installed lighting power in all the other surveyed facilities and is responsible for 14% of consumed electrical energy (Table 8).
Daylighting, demand control and zoning

The three major factors when considering internal lighting systems are (1) natural lighting, (2) artificial lighting demand management and (3) zoning control. Based on results from the surveyed facilities, 66% of the occupied spaces have daylighting potential, however artificial lighting is in use throughout the day, and zoning distribution (the areas covered by artificial lighting connected to a single lighting switch) is high with an average of 37 m² served by one electrical switch (Table 10). One factor that contributes to the high lighting demand is the complete absence of task lighting in office spaces (desk lamps).

These factors are major determinants of lighting average daily operating time, which is close to ten hours in the case of the surveyed facilities (Tables 8 and 10). Although there are no established standards with regards to lighting operating hours, the surveyed figure is still considered rather high. However, considering that this parameter is building use related, this value is justified (due to the security considerations in military facilities).

The survey has shown that 60% of the buildings utilize their artificial lighting systems throughout the day in proportions varying from 5% to 100% (on average 19%) of the installed lighting power. This is mainly (70%) due to security measures, while the remaining 30% could be switched off through internal behavioral awareness campaigns.

External lighting

In the case of external lighting, the following performance parameters in Table 11 below were identified and their data duly collected.

<table>
<thead>
<tr>
<th>Table 11: Performance parameters of external lighting in surveyed facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of surveyed facilities with external lighting</td>
</tr>
<tr>
<td>Installed external lighting power in surveyed facilities</td>
</tr>
<tr>
<td>Estimated yearly electrical energy consumption of external lighting</td>
</tr>
<tr>
<td>Estimated average daily operating hours for external lighting in surveyed facilities</td>
</tr>
<tr>
<td>Estimated halogen lights share in lighting power</td>
</tr>
<tr>
<td>Estimated halogen lights yearly electrical energy consumption in surveyed facilities</td>
</tr>
<tr>
<td>Estimated halogen lights electrical energy consumption share in surveyed facilities</td>
</tr>
<tr>
<td>Percentage of surveyed facilities with external lighting and halogen lamps</td>
</tr>
<tr>
<td>Percentage of lighting power in surveyed facilities manually operated</td>
</tr>
</tbody>
</table>

Halogen lighting constitutes 75% of the lighting installations in external lighting with an equivalent energy consumption of 56% of the facility’s total consumption (Table 11). Like incandescent lighting, halogen should be phased out from external lighting, except in cases where electricity outages are frequent and this constitutes a backup source for security since its starting time is spontaneous unlike other sources. Demand management for external lighting is another major issue: currently, the majority of external lighting is manually operated over an average daily operating time of eleven hours in surveyed facilities (Table 11).
**Air conditioning (AC)**

Air conditioning is the second most important electrical load (as seen in Table 8). Split units (less than 2 tons) represent 91% of installed AC capacity in the surveyed facilities (equivalent to 390 tons of refrigeration) while the remaining 9% are centralized AC systems. The weighted average age of AC units installed in the surveyed facilities is around six years, 90% of which are in good condition. All split units are manually operated using R22 as refrigerant. It is worth noting that the buildings' envelope thermal performance is a crucial factor not only in the size but also the average operating time of the AC equipment. It is also worth noting that LAF has a total 6,118 AC units installed equivalent to 10,610 tons of refrigeration of which 68% are split systems type with capacities of 24,000 BTU or less.

<table>
<thead>
<tr>
<th>Table 12: Gross average cooling power coverage per category (m²/kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
</tr>
<tr>
<td>Calculated</td>
</tr>
<tr>
<td>Recommended</td>
</tr>
</tbody>
</table>

The values of gross average cooling power coverage (Table 12) are computed by dividing the occupied area of the facility by the cooling capacity installed. The values shown in Table 12 are considerably higher than recommended values, indicating that AC split units are installed in selected parts of the spaces for each category except for “Medical” facilities where the coverage is extensive and in line with the recommendations.

**Appliances**

Appliances, belonging to the various categories listed under Table 9, are responsible for nearly 8% of the facilities’ electrical load (Table 8). Most, if not all, of this equipment have no energy labels.

The most important class of this category features the various available types of refrigerators: front doors with capacities ranging from mini-bars to 40 CFT (cubic feet) capacity, beverage display cases and box freezers for ice cream. The electrical energy consumption associated with the listed equipment in the surveyed facilities is estimated at 4.3% of the facility’s total energy consumption (Tables 8 & 9).

White appliances consisting of dishwashers, washing machines, vacuum cleaners, etc are the second most energy-consuming category followed closely by coffee machines with an 11% of the total appliances energy demand (Table 9). Electrical space heaters consume 2.7% of the surveyed facilities’ electricity load. However, this value cannot be considered as indicative since these appliances are not sanctioned in LAF facilities, in addition to the fact that the survey was conducted in summer. Buildings with poor thermal performance may be substantially cold in winter even in climate zone 1. In case of lack of heating systems, personnel resort to individual space heaters for harsh winter days.

**Water heaters**

The electrical energy consumption of water heaters ranks in sixth place (Table 8). Out of the 61 facilities surveyed, 51 have domestic water heating out of these 45 rely solely on electric water heaters (90%), five on a combination of electric and fuel heating and only one relies on a boiler. All surveyed water heaters have no energy labels and some are of poor quality. Solar water heaters are installed in more than seven LAF facilities with around 1,000 m² of collector area.
**IT equipment**

This category mainly includes desktop computers with their associated printers and UPS; it absorbs nearly 2.8% of the electricity consumed in the surveyed facilities, occupying seventh place (Table 8). Of the surveyed facilities equipped with desktop computers, 20% are still equipped with CRT screens, while only 15% have energy labels. However, there is no evidence indicating that these labels reflect the true performance of the machines.

**3.2.2 On-site power generation**

Approximately 46% of the surveyed facilities are equipped with generators while others receive electricity either from the military compound where they are located or from area generators. Some facilities are equipped with several generators operating in parallel or on duty/standby. Generator output sizes range between 0.5 and 1,015 KVA with an average age of 10 years, and 50% of the generators are older than 15 years.

On site generation operating hours are region dependent, the highest being the South, Nabatieh and Baalbeck where many facilities are subject to 12-hour power rations, which has to be compensated by resorting to private generators. This is followed by Mount Lebanon, North and Akkar with blackouts varying between 4 and 12 hours per day, followed by Beirut with 4 hours and finally Bekaa where some regions such as Zahle do not experience power cuts (EDZ operating area).

The total generators’ diesel consumption for LAF facilities totaled to 6,558,720 liters of diesel fuel in 2015, which corresponds to an overall generation efficiency of 30%, an expected value considering the size and age of the generators. Approximately 70% of the facilities perform operation load management. Depending on the demand versus supply, they selectively operate certain equipment and their respective operating times. Their operating style brings into question the management of the wasted heat loss from the excessively operated generators.

**3.2.3 Thermal systems**

Thermal systems are practically restricted in LAF facilities to hot water central heating systems, domestic hot water central heating systems and piping of chiller systems. Only 14 facilities of the 61 that were surveyed were equipped with fuel fired heating systems, whether for space or water heating. Space heating applications are limited to Zones 3 (inland) and 4 (Mount Lebanon and North > 1400 m). Facilities in Zones 1a and 1b as well as the lower bounds of Zone 2 are not equipped with space heating systems, while facilities in Zone 3 like workshops and warehouses are not furnished with space heating systems.

The survey indicates that fuel-fired heating systems are relied upon in all leisure facilities and hospitals to accommodate indoor swimming pools and domestic hot water supply.

The diesel fuel consumed in boilers in 2015 in LAF facilities reached the equivalent of 28,600.7 MWh (Section 2.2.4). Roughly 50% of the hot water systems surveyed suffer damaged pipework or lack insulation, while heating boilers require tuning for optimal performance.

It has been recorded that only one site is equipped with a chilled water system; the piping system is properly insulated except at the interface with the pumps and the valves.

**3.2.4 Water use**

The LAF facilities that were surveyed rely on different sources of water supply. Approximately 46% of their demand is supplied from their respective municipality water source, while the balance may rely on one or more alternative sources such as local wells, water springs, water tankers, etc.
Water use in LAF facilities is mostly limited to domestic applications, namely housekeeping, personal hygiene and kitchen use. Table 13, below, details water use intensity in the various LAF facility types. The plumbing systems in most surveyed facilities are rudimentary and old, 97% of lavatory faucets are handle type; relatively modern installations are available and equipped with push button faucets only in leisure facilities. Similarly, 93% of WCs are single flush tank types that require upgrading. Flow limiters for showers, faucets and kitchen sinks are non-existent.

<table>
<thead>
<tr>
<th>Administration</th>
<th>Storage</th>
<th>Workshops</th>
<th>Medical</th>
<th>Kitchen</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.7</td>
<td>0.5</td>
<td>1.2</td>
<td>6.2</td>
<td>17.9</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Leakage was reported in 25% of the surveyed facilities, whereas only 10% were leakage free; furthermore, water flushing is used for floor cleaning in 84% of the facilities.

Adding the yearly water use in each category and averaging the total over the surface area of the category obtained the values in Table 13. The total estimated yearly water use in the surveyed facilities is 382,000 m³. Extrapolating to all LAF facilities based on total built up area, the total yearly use for the LAF totals up to 3,000,000 m³.

Approximately 23% of the surveyed facilities use some sort of water treatment, either filtration or disinfection or a combination of both. Rain water harvesting and grey water use are not practiced in any facility; however, AC condensate collected for reuse is practiced in three of the surveyed facilities. With respect to sewage water, 58 of the 61 surveyed LAF facilities discharge their sewage into the municipality network or into septic tanks without any kind of treatment. Water for landscaping is negligible in the surveyed facilities and is the case for all LAF facilities.

### 3.2.5 Building envelope

Building envelope of the surveyed facilities have the following features:

- Single walls varying between 25 and 40 cm thickness, none thermally insulated;
- No thermally insulated roofs;
- 47% of the facilities are furnished with simple aluminum glazing framework, 31% have metal frames and only one facility has wooden frames. The remaining 20% have a combination of aluminum/iron or aluminum/wood frames;
- 90% of the facilities are furnished with single glazing and 10% have double glazing;
- 90% of the glazing in surveyed facilities is clear glass;
- 47% of the buildings are furnished with some kind of overhang and/or fins for solar control;
- 55% of facilities are furnished with loose glazing frames with up to a 3 mm void;
- 67% of facilities are furnished with glazing frames that allow perceptible air infiltration;
- 60% of facilities display some kind of mold or fungi on internal walls.
3.2.6 Operation & Maintenance

Operation and Maintenance sound practices play a major role in determining the lifespan of equipment or a facility. This section evaluates the O&M management in LAF facilities based on the 61 surveyed facilities: it covers facilities, equipment, energy sources, monitoring and tracking.

Approximately 95% of the 61 facilities have an assigned maintenance team / person part of the permanent staff on site. However, only 28% reported to have clear and detailed Operation and Maintenance manuals available to refer to.

Only 5% of the facilities are equipped with energy meters, whether in their various buildings or in some sections within these buildings. It is up to the staff members, in particular the maintenance team, to keep track of fuel readings in 40% of the facilities, hence adding on to the databases. The same situation applies to water measurements, with 5% of the 61 surveyed facilities having separate water meters in different sections where 11.5% have registered consumption data.

Table 8 shows that lighting represents the highest consumption load due to long operating times and a high number of systems, therefore its O&M represents a considerable share of the tasks.

Operation and maintenance for lighting apparatus include:

- Cleaning reflectors / diffusers;
- Repairing and replacing damaged reflectors / diffusers;
- Replacing burnt out bulbs and / or electrical parts;

Based on the surveyed data, 27% of observed lighting fixtures suffered damaged reflectors / diffusers whereas 22% had at least one burnt out bulb. Furthermore, no de-lamping (the practice of removing light bulbs where natural lighting is deemed enough) was performed in any of the facilities, confirming that such a practice is not adopted in LAF facilities.

In terms of behavioral efficiency, which could lead to savings namely in lighting loads in addition to cooling / heating loads since both are subjective, no energy savings signs (signs reminding the user to shut down or switch off lights, air conditioning units and WC / lavatory units in the unused spaces) were noted in any of the facilities. But, 54% of the facilities have an appointed staff member to make sure they turn off equipment at the end of the work shifts.

Split units serving as cooling / heating apparatus are regularly serviced and filters (helping in enhancing their efficiencies) are cleaned out and / or replaced twice a year, depending on their conditions.

In terms of transportation, approximately 23% of the facilities have mass transit mode (buses) available. Armed forces buses run on schedule and follow certain routes, picking up LAF members along their way.

Finally, cooking oil, which constituted 1,181,866L for the year 2015 is sold / given in 54% of the facilities after use, while in approximately 46% of the facilities it is disposed of in gutters.

3.2.7 Engineering design practices

The last section of the survey focused on the engineering design practices that could favor environmental performance in LAF facilities. Table 14 reflects findings from a sample of nine architects and engineers (including the head of the design department) belonging to the design department at the Directorate of Engineering for the YES/NO questions while quantitative outputs are detailed below.
Table 14: Engineering design practices polling in surveyed facilities (9 responses)

<table>
<thead>
<tr>
<th>Activity description</th>
<th>YES</th>
<th>NO</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Are efficiency measures and environmental performance taken into account?</td>
<td>8</td>
<td>0</td>
<td>Sometimes: 1</td>
</tr>
<tr>
<td>2. Are environmental considerations listed within the requirements?</td>
<td>8</td>
<td>0</td>
<td>Sometimes: 1</td>
</tr>
<tr>
<td>3. Are building standards and certifications (such as: Arz, LEED, BREAM, HQE, etc)</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4. Is rainwater harvesting considered in any facility?</td>
<td>2</td>
<td>6</td>
<td>no answer: 1</td>
</tr>
<tr>
<td>5. Are there any plans to re-use waste water for some purpose?</td>
<td>2</td>
<td>4</td>
<td>no answer: 3</td>
</tr>
<tr>
<td>6. Are diesel generators monitored for delivered energy and fuel consumption?</td>
<td>2</td>
<td>3</td>
<td>no answer: 4</td>
</tr>
<tr>
<td>7. Are the records available and used for awareness or operational purposes?</td>
<td>0</td>
<td>5</td>
<td>no answer: 4</td>
</tr>
<tr>
<td>8. Are there plans to start energy and water use monitoring in the buildings?</td>
<td>3</td>
<td>2</td>
<td>no answer: 4</td>
</tr>
</tbody>
</table>

Regarding waste construction material disposal, answers varied between:
- recycling with no further explanations
- re-use of fill material in other sites
- disposal in dumpsites
- incineration or waste being handled by third party

The survey outcome responses above reflect design practices integrated during the design phase of new construction projects that are scheduled for implementation at a later stage. Some of the design features could be overlooked or reconsidered at the implementation phase due to budget constraints.

3.2.8 Procurement

The survey included the technical specifications department in order to identify the extent to which environmental performance is included in the drafting of technical specifications and the procedure required to include such future characteristics.

The feedback received showed that cost issues are a major factor in procurement: while other considerations relating to environmental performance could be taken into account as long as cost is not affected.
CHAPTER 4
LAF TARGETS / GOALS
This report constitutes the Lebanese Armed Forces’ commitment to adopt sustainable approaches in all its non-military operation and maintenance activities. In 2010 the Lebanese government adopted the Policy Paper for the electricity sector targeting the electricity sector as a nation-wide strategy, which was then succeeded by the first NEEAP that was adopted in 2011. The strategy was based on the 2009 national baseload and featured a list of recommendations for both energy efficiency and renewable energy measures (in total 3 out of 10) to achieve “12% of electric and thermal supply from renewable energy” along with energy saving of “a minimum of 5% of the total demand.” In 2009, the average energy demand was estimated at 15,000GWh while the production capacity was 11,522GWh.

As part of the UNFCCC framework, the Republic of Lebanon published “Lebanon’s Intended Nationally Determined Contribution” in September 2015 in which the government pledged the following:

An unconditional target of “15% of the power and heat demand in 2030 to be generated from renewable energy sources,” coupled with a “3% reduction in power demand through energy efficiency.” This would lead to a 15% reduction of greenhouse gas emissions in relation to the business as usual (BAU).

A conditional target of “20% of the power and heat demand in 2030 to be generated from renewable energy sources,” coupled with a “10% reduction in power demand through energy efficiency.” This would lead to a 30% reduction of greenhouse gas emissions in relation to business as usual (UNFCCC, 2015).


The NREAP adopts the unconditional 15% target, further separating electricity from heat, where approximately 85% of this 15% target comes from low-carbon electricity and approximately 15% comes from low-carbon heat sources.

The NEEAP (2016 - 2020) projects energy efficiency targets to lower demand from 2015 to 2020. The outcome will be a 5.81% growth in demand as opposed to 7%. The overall savings in 2020 is 6.5% less than what it would be if NEEAP action plans are not implemented. The energy efficiency targets for 2030 can be assumed to follow those of the INDC.

In light of the national energy efficiency and renewable energy targets, the Lebanese Armed Forces pledges the following:

1. In terms of renewable energy, the LAF pledges to derive 20% of its total electricity consumption from renewable energy sources by 2030. To reach this percentage, a steady increase in renewable energy resources from 2017 to 2030 is to be implemented. Figure 11 illustrates a pragmatic pathway to achieve this objective.

Figure 11: Pathway to 20% RE (electricity) by 2030
In this model we are assuming the current consumption level of electricity (both from utility and private generation) as used for the baseline, i.e., 71,783.05 MWh, then 14,356.61 MWh of that total power will be generated from renewable energy sources. To put this in perspective, one solar PV power plant with a 7.8 MWp capacity can achieve this target (assuming all of the 7.8 MW power output is consumed). The LAF believes this target is attainable, hopefully before 2030. In addition, it is important to note that if the army grows in manpower numbers and facilities, relatively more renewable energy power would be needed to maintain this objective.

2. With respect to heat generation, the army pledges to reach a similar 20% renewable energy target by 2030. Figure 12 illustrates a most likely pathway to achieve this objective.

![Figure 12: Pathway to 20% RE (heat) by 2030](image)

If we assumed that all this heat will be obtained from solar hot water systems, the total required volume would be approximately 246,000 liters of hot water, or 41 systems of 6,000 liters.

3. With respect to energy efficiency, the LAF pledge a 10% reduction in energy use by 2030 relative to 2015. For simplicity, the LAF will achieve these target reductions from electricity, in that the foreseen reduction in electricity use per m² will decrease from 107.49 kWh/m²/year to 96 kWh/m²/year by 2030.

Unlike the energy and thermal generation targets listed above, energy targets are not quantifiably achieved through one measure or one implementation but through a combination of several initiatives, mostly: Lighting system retrofit, lighting control and daylight, equipment upgrade (in particular, refrigerators and televisions) and finally thermal retrofit (especially in zones 2, 3 and 4).
CHAPTER 5
LEBANESE ARMED FORCES FEATURED MEASURES
The survey has provided the baseline for energy and water consumption in LAF facilities, which helped identify future improvements that need to be evaluated. The purpose of the roadmap developed here serves as a manual for LAF’s sustainable development goals (outlined above) and provides a framework to ensure a process of continuous evolution down the path of improved environmental performance. The roadmap will identify and group in order of magnitude of impact and priority energy efficiency measures that are listed into two main categories:

- **General Measures**: Measures to be implemented in all facilities that fall under the “managerial” aspect of the retrofit.
- **Specific Measures**: Measures to be implemented in specific types of facilities for a reasonable payback / net benefits.

The present roadmap details measures in both the short and long term that would contribute to LAF’s goals. The roadmap is designed to meet the set target in Chapter 4 and will require continuous amendment and updates; the present revision details the soft start approach where relatively no cost/low cost measurements, awareness and capacity building interventions are provided to lay the ground for future potentially more costly and demanding measures.

This study provides the qualitative and quantitative cost-benefit analysis for the suggested interventions, including “environmental aspects.” It is the aim of LAF through this study to gather support and secure a long term partnership with various vested parties aiming to help reduce the environmental aspects of the operations and thus contribute effectively to a worthwhile initiative.

### 5.1 General Measures

#### 5.1.1 Sustainability Unit

This report is a stepping stone for LAF’s roadmap to sustainability and an initial commitment towards the government. This report provides recommendations and targets for the 2017 - 2030 period, and the roadmap is an on-going process that requires constant follow-up and regular re-adaptation.

Therefore the LAF intends to commission personnel within the Engineering Department to form a sustainability unit that would be in charge of up keeping the report, i.e. following up on recommendations and their implementation, target reach, improvements and at a later stage updating the report in regular intervals.

In addition, the Unit’s main objectives is to nurture, develop and instill a culture of environmental awareness at the LAF institution that will also be instrumental in cutting down running expenses. The scope of responsibility of this unit includes, yet is not limited to, the following:

- Lay down the action plan for the implementation of the road map developed in this document;
- Supervise/monitor the design and implementation of awareness and capacity building programs for LAF personnel;
- Supervise all forms of communication issued by LAF regarding EP;
- Initiate/supervise/monitor EP projects in LAF facilities;
- Act as central repository and processing of all EP data and information received from monitoring and measurement stations located in LAF facilities;
- Act as advisors in EP matters to LAF command;
- Initiate/supervise EP events undertaken by LAF (seminars, workshops involving stakeholders, etc.).
5.1.2 LAF Awareness and Engagement

Shifting into sustainable operations through the adoption of sustainable standards, equipment and facilities requires internal awareness and engagement efforts mirroring external expectations. Internal engagement is a process with several stages as shown in Figure 13 below (source: BrownFLynn).

Figure 13: Stages of employee engagement (Source: BrownFLynn)
Reaching members’ engagement, which would in turn translate into on-ground actions, starts with raising awareness. The introduction of required certifications or degrees related to energy savings, efficiency and/or clean generation, would provide army personnel with the desired information to contribute to the army’s road to sustainability.

Capacity building scenarios and short courses ought to be introduced to the activities / curricula of LAF members. For more details, please refer to Annex 2.

Furthermore, member engagement can also be achieved through short training sessions or visuals (posters, stickers, etc.) and online tools.

This includes the design, execution, distribution and installation of placards and signs calling for rational use of water and energy and for waste reduction to be placed in all LAF facilities. The signs will:

- Encourage occupants to take advantage of day lighting instead of artificial lighting, as surveys showed that 66% of surveyed rooms have a day-lighting savings potential.
- Phase out incandescent lamps in both internal and external lighting from LAF facilities by the end of 2018. Recall that it was estimated that incandescent lighting still represents 21% of installed internal lighting power and is responsible for 14% of the respective consumed electrical energy. Similarly the share of halogen lighting in external lighting of buildings (excluding street lighting) still represents 56% of installed external lighting power and is responsible for 55% of the consumed electrical energy by external lighting.

Finally, the army is committed to the implementation of engagement programs such as the election of a team of Energy Champions per year, ideally a small group for each facility with more than five occupants. An Energy Champion team is a group of individuals that sets a “good example” to others through their actions, in particular in terms of energy conservation within workspaces, developing conservation strategies specific to their work areas and sharing innovative energy practices. In practice, the designated team should perform the following:

- Take measurement readings in facilities where measurement instruments are installed
- Relay and post all information received as feedback to the measurements monitoring process
- Turn off the lights and AC in unoccupied areas where lighting and AC is not necessary
- Report faulty equipment
- Suggest improvements to resource use
- Place water and energy saving placards and signs, advising occupants to take advantage of day lighting
- Responsible for improving the facility resources use profile

### 5.1.3 Metering and Monitoring

In order to be able to manage energy usage and identify possible opportunities and percentages for energy savings, energy use should be measured and monitored: it is considered one of the vital activities when shifting into a more sustainable path. With the large number of establishments distributed all over Lebanon, along with their decentralized management, installing smart meters would provide a centralized, reliable and accurate way of keeping track of energy consumption in the various facilities. The installation of smart meters provides the necessary tool to gather the data and update the baseline while keeping track of improvements.
Currently, most LAF facilities are not equipped with electricity meters except in the case of stand-alone buildings in a civilian environment. Buildings that are within a military compound do not have their own electricity or water meters.

**Water**

All LAF facilities having a total built-up area of 300 m² and above, excluding unoccupied warehouses, are to be equipped with water meters for each source of supply (municipality, water well, tanker, etc.) recording only cumulative throughput.

**Electricity**

All LAF facilities having a total built-up area of 150 m² and above, excluding unoccupied warehouses, are to be equipped with electricity meters for each source of supply (utility, and all types of private generation) recording cumulative demand. Each diesel generator exceeding 20 KVA rated power will be equipped with an electricity meter recording cumulative electricity supply.

**Diesel fuel**

All LAF facilities where boilers and/or diesel generators are installed with a generator capacity exceeding 20 KVA or a boiler capacity exceeding 50 KW are to be equipped with a monitoring device to screen daily diesel use separately for boilers and generators whether by using graduated sight glass on day tanks or diesel meters. It is worth noting that diesel sheds supplying a military compound are considered as one independent facility.

**Thermal energy output**

Every monitored boiler for diesel use is to be equipped with an energy meter on its water mains in order to monitor its cumulative thermal output.

**Run hour meters**

Every boiler and generator monitored for diesel use is to be equipped with a run hour meter recording its cumulative operating time. This measure is intended to monitor water, electricity and diesel use over a year on a daily basis in order to establish a measured and more accurate baseline.

Of the non-critical LAF facilities available, 558 have a built-up area greater than 150 m², which would qualify them for the installation of electricity meters; 431 have a built-up area greater than 300 m², which would qualify them for the installation of water meters; in addition to the 477 diesel generators with capacities greater than 20KVA, which would also be equipped with electricity meters and sight glass (many generators are already equipped with the electricity and run hour meters, which would help reduce the implementation cost); finally 127 diesel boilers with capacities greater than 50 KW, which would also be equipped with run hour meters.

Below is a breakdown of unit price per type of monitoring equipment (Table 15), no tangible direct savings can be computed in order to identify the payback period for this measure. This measure remains, however, an integral action for future accuracy in reporting energy use and recommending adequate energy saving measures.

Considering that LAF yearly energy and water bill is around USD 10,000,000 at current energy prices (USD 500/ton diesel and LL 140/kWh as stated in section 2.2.1), a 10% saving amounts to approximately one million dollars.
Table 15: Unit price breakdown

<table>
<thead>
<tr>
<th></th>
<th>Unit Price ($)</th>
<th>Units required</th>
<th>Total expected costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Meters</td>
<td>120</td>
<td>431</td>
<td>51,720</td>
</tr>
<tr>
<td>Utility Electricity Meters</td>
<td>150</td>
<td>588</td>
<td>88,200</td>
</tr>
<tr>
<td>Diesel Electricity Meters</td>
<td>150</td>
<td>477</td>
<td>71,550</td>
</tr>
<tr>
<td>Run hour Meters</td>
<td>30</td>
<td>1,417</td>
<td>42,510</td>
</tr>
<tr>
<td>Energy Meters</td>
<td>350</td>
<td>127</td>
<td>44,450</td>
</tr>
<tr>
<td>Diesel Metering</td>
<td>100</td>
<td>604</td>
<td>60,400</td>
</tr>
<tr>
<td>Software / Hardware</td>
<td>1</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td><strong>Total (including software and hardware)</strong></td>
<td></td>
<td></td>
<td><strong>$378,830</strong></td>
</tr>
</tbody>
</table>

Readings from the measuring instruments should be done on a daily basis for the first year. The frequency of the readings is case dependent for the following years; however, frequency of readings should not be more than once per week, except for diesel where daily readings may be required. Readings shall be conveyed on a weekly basis to the entity in charge of data logging and analysis. Excel formats could be devised to standardize the readings entry and data logging for all facilities.

For a more complete unmanned solution, LAF will strive to opt for the installation of smart meters that can perform the following tasks:

- Measure the total energy used in the facility (similar to their traditional counterpart)
- Identify the times at which the “bulk” of the energy was used and hence, identify the relevant cost. This would allow better management of tasks.
- Remotely communicate the data measured
- Provide real time information on energy consumption along with the relevant cost; this would enable the user to make informed decisions about the consumption behavior and potential savings.

The display also presents historical information on consumption so that the sustainability unit can compare current and past use.

For higher accuracy, sub-meters are installed on the facility side of the master meter to allow recording power consumption at that point. Through this retrofit, the information made available to the end user further details the information received from utility bills and from the above meters. Sub-meters provide the following benefits / information:

- Identification of energy flow per given space (building, floor, etc.)
- Identification of “energy waste” at given times
- Compiling a database of facilities per type

In the case of LAF’s facilities, some are independent from an operation and maintenance view point while being dependent from the energetic administrative view point: in other words, a compound with two buildings and more that are all connected to one utility meter (hence a grouped energy consumption reading) have different operation and maintenance teams, and most probably have different schedules and needs. In this case, sub-metering is recommended to provide a detailed overview of the energy usage profile, especially that the buildings are administratively independent.
5.1.4 Building Thermography

The other factor that contributes to energy consumption is building composition; therefore no complete database for the energy consumption pattern would be complete without the documentation of building thermography. Consequently, a detailed engineering analysis aiming for building thermal behavior improvement is to be compiled in parallel with energy logging, in order to provide insight on some unclear / unjustified fluctuations in demand. It involves thermal scanning of the buildings to locate and study thermal bridges and other hot spots for the purpose of setting long term corrective actions.

Building thermography is the use of special equipment to study heat distribution in the structure and hence heat flow and losses due to the various building material. For this, two handheld thermographs allowing the LAF team to gather the above mentioned characteristics and spot air infiltrations are to be purchased at a starting unit price of USD 3,000 per hand held camera.

5.1.5 Operation and Maintenance Upgrade

The data collected from the facility surveys have shown that there is room for improvement in Operation & Maintenance practices in LAF facilities especially when it comes to the building upkeep.

Many facilities show aging and lack of proper maintenance especially in what relates to civil and architectural works (peeling paint and plaster, burnt out lights, bent window frames, leaking faucets, etc.), recommendations under this measure include:

- Adoption of a structured approach to O&M that will allow a shorter response time to equipment failures and malfunction
- Adoption of state of the art preventive maintenance software; for instance: ManWinWin, Fixd and UpKeep referred to in Table 16 below
- Preparation of O&M procedures for different types of facilities
- Stock control software and streamlining purchase request procedures
- Capacity building for technicians
Table 16 provides a comparative of the three most commonly used maintenance software.

<table>
<thead>
<tr>
<th>Name</th>
<th>Features</th>
<th>Cost</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| ManWinWin    | • Organize equipment inventory  
• Manage daily preventive / corrective tasks  
• Alert / control maintenance costs & track history  
• Record & attend maintenance requests  
• Keep record of spare parts  
• Keep record of stock / purchased spare parts or services | 5,900$ | One type payment  
No renewal installments |
| Fixd         | • Maintenance management  
• Asset tracking / inventory / reporting  
• Preventive maintenance | 19$   | The payment is per user and per month |
| UpKeep       | • Asset tracking  
• Billing and invoicing  
• Inventory  
• Planning  
• Preventive maintenance  
• Scheduling  
• History tracking  
• Technical management | 25$   | The payment is per user and per month |

This measure calls for an update to the current O&M organizational structure as it entails speeding up the process and decentralizing some of the validation work.

The stock control and purchase request procedures determine, to a considerable extent, the response time to equipment failures and malfunction. Currently, light bulbs may take weeks to be replaced or AC units may operate for several days with a reduced refrigerant charge. This measure would ensure a three-day maximum response time to address any kind of failure, malfunction or underperformance. Although this measure provides no tangible direct environmental improvement, however it reduces equipment downtime hence optimizing resource consumption. Implementing this measure would require the acquisition of the software, depending on how advanced the required software is, and costs could vary from 19$ / month or a fixed fee starting at 5,900$. Additional costs could be expected for training on the software.

5.1.6 Lighting systems demand management

In terms of lighting demand management, LAF facilities are equipped with manual switches controlling the spaces or areas to be lit for both internal and external lighting which sums up to 37% (total share: internal and external lighting 31.3% - 5.7%) of the energy use and is thus a major source of wasted energy.

The installation of presence detectors in all internal spaces that are not permanently occupied, such as storage areas and toilets, and photocells or timers for all external lighting, provides substantial monetary savings.

Bellia et al. (2015) explains that savings due to control systems’ installation can range from 9% to 30% under dimming daylight - linked controls, whereas a 3% - 38% savings can be achieved under an occupancy based control.
In order to remedy the sensitivity of the sensors that often erroneously detect presence and/or absence in the rooms, a time delay is applied. The delay time ranges between 5 and 20 minutes, depending on the sensitivity of the installed system. This time delay has provided energy savings that “vary from 3% to 50% in private offices and from 73% to 86% in restrooms.”

In the case of the 61 surveyed army facilities, these savings can amount to (considering a conservative savings of 10% of the total yearly electrical consumption in the surveyed facilities - 2,326,460 kWh - in all spaces) 232,646 kWh per annum.

However, implementing these measures would require the installation of detectors and timers costing USD 35 per unit. Approximately 4,430 units are required (for the 886 facilities for outdoor, toilets and storage), totaling a cost of $155,050.

5.1.7 Retrofit of shower heads and faucets

From the data collected through the surveys, shower heads and faucets in all LAF facilities are not equipped with flow limiters, which are devices installed at the outlet of the fixture and whose purpose is to limit the outgoing flow of water. It is completely different than the actuation method that could be a push button, remote sensing or simply turning a handle or swinging a lever.

This measure replaces all turning handle faucets with pushbutton actuated type equipped with flow limiters and showerheads of a flow limiting type.

Lavatories and showers in all LAF facilities currently use an estimated 1,100,000 m³/year. The estimated savings through flow limiters and the installation of new faucets is at least 30%, using the most basic limiters. Consequently, the resulting estimated reduction in yearly water use through this action is approximately 300,000 m³. This is the equivalent yearly water use of 1,400 households (4 people households), equivalent to one small town in Lebanon.

The number of lavatories and showerheads to be replaced is estimated at 3,500 and 2,100 pieces, respectively. The total replacement cost is estimated to be between USD 200,000 and 250,000.

5.1.8 Greening Procurement

LAF procurement and tendering processes are largely based on cost considerations, and although upfront cost is a crucial determinant of the ability to purchase, the LAF will commit, to the extent possible, that it will take into account operational costs that also embed environmental consequences over the product’s or equipment’s lifetime.

For a more holistic approach to the adaptation of the sustainable roadmap an upgrade to the current procurement system is devised through the acquisition of products (and services) that feature the following characteristics:

• Increased efficiency (energy labels, water consumption labels);
• Better quality (known suppliers/contractors that comply with international standards);
• Contain recyclable components or made of easily recyclable material;
• Do not represent health hazards to people using them or exposed to them (paint, adhesive);
• Use renewable energy (solar water heaters, photovoltaic, biomass boilers, etc.);
• Use products made of renewable resources (Wood products that are FSC labeled);
• Positive after sales track record for supplier or contractor;
• Clear O&M manuals and easy maintenance;
• Environmental aspects over its life cycle are not damaging to the environment.

To this end, the procurement team will upgrade its material specifications used in procurement and tender documents to take the above characteristics into consideration. Notices will be included in procurement documentation aiming to inform suppliers and manufacturers that environmental performance criteria are taken into account when evaluating their products and services and not only prices. Therefore, and based on the above data, a minimum reduction in the use of energy in the range of 15-20% compared to a business as usual scenario are to be expected over the long term.
Table 17 provides an overview of the possible reductions in energy consumption and operation in the main electrical equipment found in typical offices in the LAF facilities (based on the conducted survey).

<table>
<thead>
<tr>
<th>Appliance Type</th>
<th>Total Capacity / size</th>
<th>Energy Label</th>
<th>Average energy consumption (kWh/yr)</th>
<th>Average operation cost / yr ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freestanding refrigerator with freezer</td>
<td>200 - 400 L</td>
<td>A-</td>
<td>356</td>
<td>43</td>
</tr>
<tr>
<td>Freestanding refrigerator with freezer</td>
<td>400 - 500L</td>
<td>A++</td>
<td>395</td>
<td>47</td>
</tr>
<tr>
<td>Freestanding refrigerator with freezer</td>
<td>&gt;500L</td>
<td>A+</td>
<td>457</td>
<td>55</td>
</tr>
<tr>
<td>Plasma Television</td>
<td>40 - 60 inch</td>
<td>A</td>
<td>135</td>
<td>16</td>
</tr>
<tr>
<td>Plasma Television</td>
<td>≥ 60 inch</td>
<td>B</td>
<td>243</td>
<td>29</td>
</tr>
<tr>
<td>LED Television</td>
<td>40 - 50 inch</td>
<td>A+</td>
<td>97</td>
<td>12</td>
</tr>
<tr>
<td>LED Television</td>
<td>50 - 60 inch</td>
<td>A+</td>
<td>105</td>
<td>13</td>
</tr>
<tr>
<td>LED Television</td>
<td>≥ 60 inch</td>
<td>A+</td>
<td>145</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>No label</td>
<td></td>
<td>393</td>
<td>47</td>
</tr>
</tbody>
</table>
5.2 Building Specific Measures

5.2.1 Current Situation

Over the past few years (3 - 4 years), sustainable reforms have been introduced to both procurement processes, facility design and implementation at the macro level aiming at reducing energy consumption and showcasing the army as a role model in matters of energy and environment.

5.2.1.1 Design and Construction

As of the beginning of 2016, all new facilities were designed using LED lighting along with technical specifications that were disseminated to the procurement department for all upcoming purchasing is. Furthermore, HVAC equipment technical specifications have been updated and approved starting with the minimum acceptable energy efficiency class of “A” and design and operation temperatures are recommended to be set at 23°C.

In terms of energy production all new facilities are designed with:

- Solar Power Street Lighting (complete with back-up batteries) to provide an additional sense of security for personnel during night shifts through an uninterrupted supply of power, in addition to reducing dependence on diesel-fueled generators and mitigating the existing poor infrastructure in particular in remote areas
- Solar Water Heating system to reduce energy cost (both EDL and diesel generators) and save on emissions
- Solar Photovoltaic power systems in locations where energy infrastructure is either lacking or in poor condition, hence justifying costs related to RE implementation

Currently there is no specific sustainable standards based on which facilities are designed and duly constructed, and therefore, there is no limitation on yearly consumption per square meter; however, this remains at the forefront of reforms to come.

In terms of energy efficiency / architectural features, all new facilities are designed with (where applicable):

- Double walls / insulation and double glazing to conform to the geography specific heat loss measure (u-value), and consequently the heating / cooling consumption
5.2.1.2 Procurement

In regards to equipment and parts, the procurement department is composed of eight main streams:

- Marine
- Air Force
- Military Healthcare
- Directorate of Engineering
- Logistics Brigade
- Directorate of Quartermaster
- Directorate of Geographic Affairs
- Directorate of Information Technology

One person is in charge of each stream and drafts the technical specifications for the equipment to be purchased depending on the field they fall under, i.e. everything related to construction (architecture, electrical, mechanical, civil, etc.) falls under the responsibility of the representative of the Directorate of Engineering.

The procurement process involves the following steps:

- Drafting specs: The procurement department then forwards the request to the assigned person (stream representative). The drafting process is based on a market study conducted for the equipment at hand; this study would gather both technical and financial information on available products in the market. The gathered information is then measured against the implementation budget by the procurement department (yearly budget).

- Revision and Approval: The technical specifications are then approved by the procurement department (mainly budgetary, since the technical specifications are the sole responsibility of the assigned person for the stream).

- Official Request: An official request is sent out to the purchasing (procurement) team.

- Call for bid: The technical specifications are then edited to facilitate a call for a bid depending on the process to be applied. Private companies (offering services and / or equipment) register in the army database for a fee to be considered when calls for bid are released; registration is grouped per sector and according to budget (of implementation) under the Ministry of Defense (MOD), i.e. medical, engineering, logistics, etc.

- Bidding process: Contacted companies that are registered based on the Lebanese Armed Forces process - based on the bidding budget - would submit their offers as per the required specifications.

- Revision of offers: From this stage onward, the Ministry of Defense takes over the file.

Once the bidder is known (based on the MOD’s evaluation results), the bidder and the army (procurement and beneficiary departments) are notified.

5.2.1.3 End of Life

In case of equipment malfunction, an LAF specialist inspects the reported apparatus and files his / her report. In case of the need for repairs, the logistics team checks for spare part availability in-house, otherwise and depending on the available budget, parts are purchased. In case the apparatus needs replacement, it is taken apart for parts and personnel file a report requesting the replacement of the inspected machine.

At the equipment’s end of life army personnel check the status of the equipment: if it is no longer viable / usable, it is sold for scrap. If the equipment has functioning parts, those parts are re-used where applicable.
5.2.2 Recommended Measures

5.2.2.1 Energy Related Measures

This following section identifies facility specific measures, measures that require an in-depth analysis of the facility load profile prior to implementation.

5.2.2.1.1 Solar Water Heater

Solar Water Heaters (SWH) present a cost effective method of heating water for facilities all year round; however, during winter months, further heating using other equipment such as boilers would be needed. In Lebanon, the SWH market has reached maturity and the technology is available at a stable affordable price.

This measure introduces the general specifications for the systems, the sizing and the pre-requisites: of the seven identified types of facilities only four would be considered for this measure: Administrative, leisure, medical and kitchen. In the analysis and due to the nature of the facilities and their respective need for water, two load factors (the measure of the actual use divided by the total that could be used) will be applied:

- Administrative and leisure: Load factor of 0.4: a low load factor reflects non-constant water usage, with occasional peaks
- Medical and kitchen: Load factor of 0.6: a high load factor reflects constant water usage

Space availability is a primary concern when installing any kind of renewable energy and in the case of solar water heaters, shading, distances and space are critical criteria to investigate prior to installation.

Considering solar radiation intensity available in Lebanon, vacuum tubes may damage hot water tanks in case of overheating unless the tank (thickness of 1.2 mm and above) and other accessories are pre-designed to handle this overheating: lesser thicknesses would not resist the water pressure.

In centralized installations, a 4,000-liter system enough to fulfill the hot water needs of 80 people requires 110 m² for the collectors and 30 - 40 m² for the tanks. Table 18 details the technical constraints and assumptions for these installations.

<table>
<thead>
<tr>
<th>Type</th>
<th>Application (%)</th>
<th>Displacement of Diesel</th>
<th>Displacement of EDL</th>
<th>Load Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
<td>40</td>
<td>20%</td>
<td>60%</td>
<td>0.4</td>
</tr>
<tr>
<td>Kitchen</td>
<td>80</td>
<td></td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>Leisure</td>
<td>80</td>
<td>60%</td>
<td>40%</td>
<td>0.4</td>
</tr>
<tr>
<td>Medical</td>
<td>80</td>
<td></td>
<td></td>
<td>0.6</td>
</tr>
</tbody>
</table>

N.B: Application (%) is dependent on several factors: please refer to the text below for more information.
It is assumed that SWHs will be installed in 40% of the facilities in the “Administrative” category and 80% for the other three categories, due to space constraints, because SWH systems are already installed or other factors such as low hot water demand, especially in the “Administration” category. Forced circulation SWH systems are preferred in facilities with high water consumption, such as facilities with a 0.6 load factor. Through the use of electric pumps, sensors and controllers this would provide more flexibility in installations, since water tanks can be installed far from the system, even at a lower level. The second recommended scheme is the thermosiphon. It provides a simpler design, hence not requiring any electric pumps or controllers: rather, it uses the existing water connection and gravity to operate effectively.

Dependent on space availability, below is a breakdown of SWH areas required per facility type:

- Administrative / Leisure (thermosiphon scheme): 468 of the total LAF facilities that fall under this category have an occupancy rate of less than 80 people, 96 facilities have an occupancy rate between 80 and 200 people and 15 facilities have an occupancy rate more than 200 people.
- Medical / Kitchen (forced circulation scheme): 48 facilities within this category have an occupancy rate less than 80 people, 16 facilities have an occupancy rate between 80 and 200 people and one facility has an occupancy rate more than 200 people.

It is worth noting that some facilities (126 out of 909 total facilities including workshops, stores and others) lacked information on occupancy rate while some (13 out of 909) had a fluctuating occupancy rate. Furthermore, 310 of the total 909 facilities have an occupancy rate less than 10 people, 185 administrative and 14 medical / leisure.

SWH capacity is calculated based on the 40-l/person assumption. However, a more thorough evaluation of the facilities, the available spaces, the hot water needs and the occupancy rates would be recommended for the proper identification of the required collectors’ area. It is recommended that any SWH implementation be done post water savings measures listed in 5.1.7.

Systems between 10 m² - 30 m² of collector plates will be provided with energy meters at the system’s output as well as electricity meters if there are any electric heaters located in SWH storage tanks. Systems larger than 30 m² will be provided in addition to the above with pyrheliometers and pyranometers equipped with data loggers having an instantaneous and integrative insulation readings function.

Table 19 provides a simple comparative for the cost of this implementation:

<table>
<thead>
<tr>
<th>Capacity / Area</th>
<th>Origin</th>
<th>Cost</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>200L</td>
<td>Chinese</td>
<td>1,000$</td>
<td></td>
</tr>
<tr>
<td>200L</td>
<td>European / Local*</td>
<td>1,000 – 2,000$</td>
<td></td>
</tr>
<tr>
<td>2 sqm</td>
<td>Chinese</td>
<td>250$</td>
<td></td>
</tr>
<tr>
<td>2 sqm</td>
<td>European / Local*</td>
<td>500$</td>
<td></td>
</tr>
</tbody>
</table>

N.B: The Solar Water Heater system’s accessories are locally manufactured and purchased.

This implementation entails the installation of 300 SWH in the various listed facility types: assuming a 2,000L system average in these facilities, the implementation would cost between: USD 3,000,000 – 6,000,000.
5.2.2.1.2 Photovoltaic

Photovoltaic systems are considered clean energy generators because they use freely available solar radiation to produce DC energy that is then converted to AC using inverters. In Beirut, the average available Global Horizontal Irradiation (GHI) per day is 5.1 kWh/m²/day.

This measure introduces the general specifications for the systems, the sizing and the pre-requisites: of the seven identified types of facilities only five would be considered for this measure: Administrative, leisure, medical, kitchen and workshops. Storage areas do not feature any energy intensive equipment or any intensive use of lighting systems.

Based on data collected from the survey and the analysis in Chapters 2 and 3, the 2015 total energy demand for LAF facilities amounted to 71,783.05 MWh. With the highest load being internal lighting (31%) and the 5th highest being external lighting (6%), both of which can be satisfied by solar photovoltaic energy.

Space availability is yet again a primary concern since every kWp requires up to 10 m². Both mono and poly crystalline panels are available in the market with the latter having a slightly lower efficiency coupled with a lower initial cost.

The UNDP CEDRO’s current EU funded phase has implemented a number of demonstration sites in various locations in Lebanon where an innovative tailor made solution for the region was utilized: PV - Diesel hybrid. These implementations are labeled as “interconnected microgrids” and can function either in grid–tied mode when the utility grid is available or coupled with the diesel generators in case of blackouts, hence providing the end user with savings on both EDL bills through on-site use and net-metering and private generation (diesel generators) through lower diesel consumption. Use of the proper electronic equipment would allow the system to constantly monitor demand and production on the one side, and regulate energy use making sure all “generating” components remain safe.

To achieve LAF renewable energy objectives, at least 7.8 MW of solar PV power would be required from 2017 to 2030. The total cost of this capacity is approximately $9.36 million (assuming 1 kW costs $1200). Divided over 13 years, this would necessitate a $720,000 per year investment.

The LAF will strive to install solar PV systems on the various buildings where the space permits, integrated through a smart energy management system with local diesel generators and with the utility grid, when the utility grid is present. The LAF will apply for net metering on all the PV sites it aims on installing.

Furthermore, the LAF will be investigating the possibility to consolidate its electricity bills with EDL to one or a few bills. This will pave the way for the LAF to install a larger solar PV farm and net meter this farm’s electricity output with consolidated electricity bills. This is known as wheeling in the “net metering” discourse.

5.2.2.1.3 Biogas / Biomass

By definition, biogas is a “gaseous fuel, especially methane, produced by the fermentation of organic matter.” It could be a mixture of different gases produced using different raw materials. One such raw material is food waste: the LAF has 23 central kitchens in several areas in Lebanon that provide cooked meals to neighboring facilities. Big amounts of vegetable and fruits are acquired regularly, 20% of which goes to waste. The LAF normally distributes the waste to farmers in the form of cooked food that would later on be utilized to feed their feedstock. Table 20 details the cooked material purchased per year and per type: 3,170 tons of organic waste is generated by the LAF per year.
The LAF will investigate biogas generation potential from its food wastes, without jeopardizing farmers that rely on this waste. For this first LAF Energy Sustainability Strategy, the action required will be devoted solely to the requirement of a full assessment of biogas for the Lebanese army.

5.2.2.2 Building Envelope Related Measures

5.2.2.2.1 Roof Slabs Thermal Insulation

Un-insulated roof slabs represent a large reason for the need for cooling and heating and hence increase their respective loads for the upper floor level in typical residential, commercial and public buildings applications which incidentally represent a high percentage of LAF facility occupancies. The survey conducted in LAF facilities reveals that none of the buildings inspected has a thermally insulated roof, which coincides with common practices in Lebanon.

Roof surface area in the case of LAF facilities represents roughly 70% (almost 480,000 m²) of the total built-up area (almost 665,000 m²). Considering that the average weighted number of floors per facility is a mere 1.4, roof slabs, and insulation is a major contributor to space cooling and heating demand.

The potential roof surface area candidate for insulation is approximately 350,000 m² if storage areas, workshops and other non-permanently occupied facilities are excluded from the inventory. Another estimated 50,000 m² could be excluded because of tiled gabled roofs and equipment crowded roofs, like for instance hospitals, which unfortunately could have otherwise been prime candidates because of their high cooling load. Thus the net roof area to be considered is estimated at 300,000 m², which is already a sizeable undertaking.

<table>
<thead>
<tr>
<th>Food ingredient</th>
<th>Amount (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken</td>
<td>1,312,893</td>
</tr>
<tr>
<td>Meat</td>
<td>570,458</td>
</tr>
<tr>
<td>Fish</td>
<td>1,070,161</td>
</tr>
<tr>
<td>Eggplant</td>
<td>376,625</td>
</tr>
<tr>
<td>Pear</td>
<td>384,467</td>
</tr>
<tr>
<td>Onion</td>
<td>18,010</td>
</tr>
<tr>
<td>Red onion</td>
<td>479,364</td>
</tr>
<tr>
<td>Potato</td>
<td>2,048,132</td>
</tr>
<tr>
<td>Watermelon</td>
<td>107,432</td>
</tr>
<tr>
<td>Melon</td>
<td>190,173</td>
</tr>
<tr>
<td>Tomato</td>
<td>1,318,371</td>
</tr>
<tr>
<td>Apple</td>
<td>2,813,128</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Food ingredient</th>
<th>Amount (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic</td>
<td>75,041</td>
</tr>
<tr>
<td>Carrot</td>
<td>26,139</td>
</tr>
<tr>
<td>Greengage</td>
<td>45,490</td>
</tr>
<tr>
<td>Lettuce</td>
<td>28,810</td>
</tr>
<tr>
<td>Plum</td>
<td>487,527</td>
</tr>
<tr>
<td>Cucumber</td>
<td>751,996</td>
</tr>
<tr>
<td>Peach</td>
<td>314,324</td>
</tr>
<tr>
<td>Chard</td>
<td>57,292</td>
</tr>
<tr>
<td>Beetroot</td>
<td>11,822</td>
</tr>
<tr>
<td>Grape</td>
<td>273,808</td>
</tr>
<tr>
<td>Radish</td>
<td>4,892</td>
</tr>
<tr>
<td>Fava beans</td>
<td>74,897</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Food ingredient</th>
<th>Amount (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cauliflower</td>
<td>133,577</td>
</tr>
<tr>
<td>Cherry</td>
<td>8,901</td>
</tr>
<tr>
<td>Zucchini</td>
<td>194,732</td>
</tr>
<tr>
<td>String beans</td>
<td>72,700</td>
</tr>
<tr>
<td>Orange</td>
<td>284,386</td>
</tr>
<tr>
<td>Lemon</td>
<td>567,560</td>
</tr>
<tr>
<td>Apricot</td>
<td>155,898</td>
</tr>
<tr>
<td>American cucumber</td>
<td>21,592</td>
</tr>
<tr>
<td>Cabbage</td>
<td>799,972</td>
</tr>
<tr>
<td>Banana</td>
<td>721,807</td>
</tr>
<tr>
<td>Chicory</td>
<td>43,124</td>
</tr>
<tr>
<td>Spearmint</td>
<td>4,161</td>
</tr>
</tbody>
</table>
Out of the expected 300,000 m² of roof area, it is estimated that not more than 90,000 m² and 22,000 m² enclose respectively air-conditioned and heated spaces. Approximately 70,000 m² of air-conditioned roof area is located in zones 1a & 1b and the remainder 20,000 m² (both air-conditioned and heated spaces) in zone 4, while the remainder 2,000 m² of heated space is in zone 5.

The aim of this measure is not only to reduce the cooling and heating loads in air-conditioned spaces and save on energy, but also to improve indoor comfort in non-air-conditioned and non-heated spaces as well as preserving building envelope / fabric.

It is recommended that priority be given to the above-mentioned 92,000 m² that include the air-conditioned and heated spaces (20,000 m² of heated space is also air-conditioned). For optimal results, it is recommended that a polyethylene vapor barrier membrane be applied to the roof slab, then use expanded polystyrene boards in layers to reach the zone specific U value and finally cover with a polyethylene sheet and apply a screed slab 5-7 cm thick on which the bitumen waterproofing membrane is applied followed by a 10 cm gravel layer.

The recommended thermal transmittance values (U- values) for roof insulation for different zones are selected in accordance with TSBL 2005, reproduced in Table 21 below. It is important to note that zones 1a & 1b as defined in this document constitute zone 1 of the TSBL 2005.

<table>
<thead>
<tr>
<th>Zone 1a (0 - 300 m)</th>
<th>Zone 1b (&gt;300 - 700 m)</th>
<th>Zone 3 (Bekaa)</th>
<th>Zone 4 (&gt; 1400 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.57</td>
<td>0.57</td>
<td>0.57</td>
<td>0.44</td>
</tr>
</tbody>
</table>

N.B.: The U-values do not include the effects of interior and exterior air films. These should be accounted for when performing heat loss/gain calculations.

Based on climatic zoning for buildings in Lebanon published in 2005, increments in heating cost when dividing the climatic zones into five distinctive ones are USD 646 based on the heating degree - day range. Based on a study compiled by the IEA, the saving potential in heating demand from ceiling insulation are proportional to the “increase in heating degree-days.”

The estimated cost for the treatment of the 92,000 m² roof area described above amounts to approximately USD 1,104,000. The yearly savings in energy use, based on a study compiled by the Energy Star (2016) and Center for Climate and Energy Solutions (2016) ranges between 7% and 14% of the heating and cooling load, which in LAF’s case is in the range of 2,002 MWh up to 4,004 MWh in the form of thermal energy, and 1,377.3 MWh and 2,754.67 MWh in the form of diesel energy (electricity) and 3,647.48 MWh and 7,294.96 MWh in the form of utility energy (electricity).

5.2.2.2.2 Double Glazing

Based on the surveyed data, few LAF facilities are equipped with double glazing, even in climate zones 2, 3 and 4 that experience relatively harsh winter weather in addition to the mediocre condition of the fenestration frames. This report measures the details of the double glazing fenestration installation in climate zones 1b, 2, 3 and 4 for the categories “Administration,” “Leisure” and “Medical”, using zone appropriate types of glazing and frames.

Therefore, all categories in climate zones 1b and 2, and the “administration” category (commonly used as day offices) in climate zones 3 and 4 standard glazing is used in the configuration 8-12-8 (glass, air space, glass) coupled with aluminum frames.
All remaining categories (including “administration” that have dual usage - office and sleeping quarters) in climate zones 3 and 4, low e glazing (low e film shall be located on the third face of the glazing assembly) is used in the configuration 8-12-8 with PVC frames or aluminum frames with a thermal break.

This retrofit will help decrease the heating load except in zone 4 where some impact on the cooling load is also achieved. The installation of double glazing is not only meant to save energy but also to improve the indoor environment quality of the facilities.

The glazing surface area involved is approximately 25,000 m². Depending on window dimensions and the technology selected, prices vary. Based on a study published by Banihashemi, et al (2015), the saved cooling loads from improved glazing can range from 10% to 17% depending on orientation with a slightly lesser reduction on heating for hot and arid regions. In LAF’s case, this totals up to 1,967.6 MWh in diesel consumption, 5,210.69 MWh from EDL and 2,860 MWh in the form of thermal energy.

The estimated cost of this measure varies depending on the exact window dimensions. However, 1.2 x0.8m glass windows cost 180$ / m² and LAF’s total would amount to almost USD 4,500,000.

5.2.2.2.3 Thermal Film for Western Facing Glazing in Zone 1

Zone 1a was not considered as part of the facilities to undergo a double glazing retrofit due to the minimal benefits gained out of these measures in this specific climate zone. However, it is necessary to cut the cooling load resulting from glazing with western exposure (South-West to North-West). Consequently, it is recommended to install thermal films on glazing with western exposure, on the one hand to reduce the cooling load and on the other to improve the indoor environment quality considering that not all spaces are air-conditioned. The film installed shall allow ample daylight (minimum 60% visible light transmittance) while blocking infrared solar energy (SHGC < 0.6).

The glazing surface area involved is approximately 15,000 m², similarly for glazing; the installation of the 3 mm clear thin film varies depending on the window size. Implementing this measure would cost approximately USD 50,000. The yearly savings in energy are savings due to enhancement in glazing, close to 10% as detailed in section 5.2.2.2.2.
CHAPTER 6
SUMMARY OF ACTIONS: A CALL TO ARMS
The LAF reiterates the urgency to combat climate change to ensure a more stable and more hopeful future for Lebanese citizens. The LAF regards sustainable development key to energy security, and energy security key to national security. The LAF hopes to lead by example.

It commits to the targets outlined in this strategy:

- In terms of renewable energy, the LAF pledges to reach 20% of its total electricity consumption from renewable energy sources by 2030.
- With respect to heat generation, the army pledges to reach a similar 20% renewable energy target by 2030.
- With respect to energy efficiency, the LAF pledge a 10% reduction in energy use by 2030 relative to 2015.

To achieve these targets, many measures and actions are required. These measures are summarized in Table 22 below, along with their indicative expected costs.
In total, the LAF requires a $23,329,880 budget. Over 13 years, this entails a $1,794,606.15 annual investment.

Table 22: Summary of targeted measures and costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Measure</th>
<th>Cost Required</th>
<th>Calculation Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Awareness &amp; Capacity Building</td>
<td>$260,000.00</td>
<td>20,000$/year *13 years</td>
</tr>
<tr>
<td>2</td>
<td>Metering &amp; Monitoring</td>
<td>$378,830.00</td>
<td>431 water meters * 120$/meter + 588 Elec Meter * 150$/meter + 477 Fuel Meter * 150$/meter + 1417 Run hours meter * 30$/meter + 127 Energy Meter * 350$/meter + 604 Diesel Meter * 100$/meter + 20,000$ software</td>
</tr>
<tr>
<td>3</td>
<td>Building Thermography Monitoring</td>
<td>$6,000.00</td>
<td>2 hand-held thermographs * 3000$/Therm.</td>
</tr>
<tr>
<td>4</td>
<td>O&amp;M Software and training</td>
<td>$10,000.00</td>
<td>5900$ software fee and 4100$ training</td>
</tr>
<tr>
<td>5</td>
<td>Detectors &amp; Timers</td>
<td>$155,050.00</td>
<td>4,430 Detectors &amp; timers * 35$/unit</td>
</tr>
<tr>
<td>6</td>
<td>Water Saving Devices</td>
<td>$250,000.00</td>
<td>(3500 Lavatories + 2100 Shower) * 44.64$/pc</td>
</tr>
<tr>
<td>7</td>
<td>Solar Hot Water Systems</td>
<td>$6,000,000.00</td>
<td>300 SWH Systems * 20000$/SWH</td>
</tr>
<tr>
<td>8</td>
<td>Solar PV Systems</td>
<td>$9,360,000.00</td>
<td>7800 kW * 1200$/kW</td>
</tr>
<tr>
<td>9</td>
<td>Biogas Assessment</td>
<td>$60,000.00</td>
<td>Estimated</td>
</tr>
<tr>
<td>10</td>
<td>Roof Insulation</td>
<td>$1,100,000.00</td>
<td>92,000 m² * 12$/m² Expected Yearly energy saving is 2,002 MWh to 4,0004 MWh in the form of thermal energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Expected yearly energy saving is 1,377.3 MWh and 2,754.67 MWh in the form of Diesel Energy (electricity)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and 3,647.48 MWh and 7,294.96 MWh in the form of utility energy (electricity)</td>
</tr>
<tr>
<td>11</td>
<td>Double Glazing</td>
<td>$4,500,000.00</td>
<td>25,000 m² * 180 $/m² of Double Wall Glazing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Expected Yearly energy saving is 1,967.6 MWh in the form of Diesel Consumption</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Expected yearly energy saving is 5,210.69 MWh in the form of electricity (EDL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and 2,860 MWh in the form of thermal energy</td>
</tr>
<tr>
<td>12</td>
<td>Thermal Films (Zone 1a)</td>
<td>$50,000.00</td>
<td>15,000m² of Glazing to be applied with thermal film * 3.33$/W</td>
</tr>
<tr>
<td>13</td>
<td>Army Technical Support</td>
<td>$1,200,000.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>$23,329,880.00</strong></td>
<td></td>
</tr>
</tbody>
</table>
These measures above would allow an approximate and direct annual saving for the Lebanese Army of approximately $3 million in the current environment of low fuel prices. This leads to a payback period of 7.7 years. If oil prices were to reach the $100/barrel mark again, the saving will double and the payback period will halve. With respect to greenhouse gas emissions, these measures will reduce a total of 17,348 tons of CO$_2$ equivalent per annum (based on a 0.7 kg of CO$_2$ per kWh and 2.65 kg of CO$_2$ per liter of diesel).

The LAF hopes to implement, as much as possible and hopefully within the next 5 years, the majority of the measures listed above through its available resources. The Lebanese Ministry of Defense and the Lebanese Army Command will guide, prioritize and oversee the implementation of this Strategy. The Strategy itself will be carried out by the Lebanese Army Directorate of Engineering, either through direct implementation or through coordination with national and international organizations that may hopefully assist, through grants or in-kind contributions, in fulfilling our objectives.

As a featured example, the Directorate of Engineering at the Lebanese Armed Forces has selected two facilities in the North of Lebanon:
- the Aandket Barracks Buildings
- the North Medical Facilities in the Qoubbe Barracks

A detailed energy audit has been conducted and retrofit measures have been identified in order to reduce both energy and environmental footprint.

Details and findings are listed in Annex 3.

In parallel, a vibrant momentum will be formulated and deployed through several creative and wide-reaching communication strategies and channels, awareness raising strategies and activities that would run in parallel with the implementation of the Strategy.

Our aspirations extend beyond the Lebanese Army’s endeavor at hand. We hope to inspire and lead by example so that a ripple effect will spread to other public and private institutions, so that the Lebanese people and economy will come together to face one of the greatest challenges of our time.

For any communication and/or cooperation on the implementation of the Lebanese Army Strategy, kindly contact lafses@mod.gov.lb.
References


- BrownFynn, 2016. Emloyee engagement. Available at: https://brownflynn.com/consulting/engage-your-stakeholders/employee-engagement/


- UNFCCCC. September 2015. Lebanon’s Intended Nationally Determined Contribution available at: http://www4.unfccc.int/submissions/INDC/Published%20Documents/Lebanon/1/Republic%20of%20Lebanon%20-%20INDC%20-%20September%202015.pdf

Annex 1: Lighting Analysis

In this Annex, more focus is given to the analysis of internal lighting for the sake of understanding the most important parameters and indicators that characterize this load in order to propose relevant interventions, while keeping in mind the functionality and nature of the facilities.

Two Key Performance Indicators (KPI) worthy of consideration for lighting systems are introduced in Tables 23 and 24, namely the Lighting Power Density (LPD) which represents the load of any lighting apparatus in any defined area expressed in \( \text{W/m}^2 \) and the Lighting Areal Energy Intensity (LAEI), which represents the light intensity in any defined area over a year expressed in \( \text{kWh/m}^2\cdot\text{yr} \).

The average load-weighted LPD for the surveyed facilities is estimated at 6.86 \( \text{W/m}^2 \) (Table 23), which is below recommendation, and is not sufficiently representative because approximately eight different occupancy categories are lumped into this indicator.

For better analysis of the lighting performance in the surveyed facilities, the LPD has been calculated for each type of building use (Table 24).

The LPD values differ from one facility to another within the same category as illustrated in Table 23 here. Based on ASHRAE standard 90.1 2010, the maximum and minimum LPD values found for each category are not acceptable, whether from an indoor environment quality viewpoint for the minimum value or from a resources efficiency viewpoint for the maximum value. The average values are acceptable except for the “Medical” category where the LPD is 20% higher than the recommended aggregate value.

| Table 23: Lighting Power Density per building category for surveyed facilities (W/m²) |
|----------------------------------|----------|----------|----------|----------|----------|----------|
| Max                              | 24.6     | 10.3     | 30       | 48.2     | 8.8      | 12       |
| Min                              | 3.1      | 3        | 1.2      | 6        | 5        | 4.5      |
| Avg                              | 9.62     | 5.5      | 11.7     | 18.8     | 7.2      | 7.8      |
| Recommended                      | 10       | 8        | 14       | 11       | 14       | 11       |

This discrepancy in LPD between the actual and the recommended values shown in Table 23 above is not due to different types of lighting fixtures used in different buildings, but is rather an indicator of building quality, use profile, surveying inaccuracies, etc.

Automatically, the LAEI will also show wide variations, which are sometimes amplified by the use profile factor. The maximum values are out of range, due to excessive periods of occupancy as well as high LPD.

| Table 24: Lighting Areal Energy Intensity per building category for surveyed facilities (kWh/m².yr) |
|----------------------------------|----------|----------|----------|----------|----------|----------|
| Max                              | 84       | 42.2     | 98.1     | 359.1    | 63.7     | 61       |
| Min                              | 7        | 0.6      | 6.6      | 11.2     | 3.3      | 41       |
| Avg                              | 31.7     | 9.9      | 46.6     | 92.2     | 47.4     | 45       |

Values for LAEI should not exceed 10-15 kWh/m².yr for most applications shown, however only the “Medical” and “Workshops” categories could reach 20-25 kWh/m².yr. Consequently, and based on the surveyed values listed in Table 24, there is much to do to bring internal lighting in LAF facilities to an acceptable operating performance.
**Electrical systems energy intensity**

The energy intensity of three main families of electrical loads, namely: Internal lighting, auxiliary loads and AC loads are exhibited below for the surveyed facilities (Table 25). Auxiliary loads include all loads shown in Table 9 in chapter 3 except lighting, AC, kitchen equipment, medical equipment and workshop equipment. The last three items are considered specialties and not included in the buildings’ electro-mechanical systems. The energy intensity of lighting systems was already reviewed above but is shown again for the sake of comprehensiveness.

<table>
<thead>
<tr>
<th></th>
<th>Administration</th>
<th>Storage</th>
<th>Workshops</th>
<th>Medical</th>
<th>Kitchen</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>31.7</td>
<td>9.9</td>
<td>46.6</td>
<td>92.2</td>
<td>47.4</td>
<td>45</td>
</tr>
<tr>
<td>Auxiliary Loads</td>
<td>32</td>
<td>1</td>
<td>9</td>
<td>36</td>
<td>115</td>
<td>49</td>
</tr>
<tr>
<td>AC</td>
<td>33</td>
<td>5</td>
<td>NA</td>
<td>87</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>96.7</td>
<td>15.9</td>
<td>55.6</td>
<td>215.2</td>
<td>172.4</td>
<td>124</td>
</tr>
</tbody>
</table>

NA: Not applicable because the buildings surveyed in the category “Workshops” did not have AC equipment

The values for the lighting systems in Table 25 are the average values of Table 24. The values for auxiliary loads and AC are the average for all the surveyed facilities in these two categories respectively. Compared to the ASHRAE 90.1 - 2010, the calculated auxiliary loads fall within the norm for all types, except “kitchens” which is due to the cold stores and their use profile since kitchens almost operate round the clock.
Annex 2: Awareness and Engagement

Several audience specific courses are to be designed and included in LAF staff member curricula. Listed below are the proposed tracks along with a short description pertaining to intended audience and frequency of track offerings.

Track 1: Officers’ school and NCO (Non-Commissioned Officers) school

These courses and topics, presented differently for each level of education attained by various soldiers, will include the following:

- Differentiating between renewable and non-renewable resources
- The cost of the energy bill in Lebanon and energy security
- Renewable energy and its applications in Lebanon
- Water resources in Lebanon and how to preserve them, water security
- Tips for rational use of energy and water at home and during service time in LAF facilities
- Climate change and implications on Lebanon
- Environmental damage from pollution in Lebanon and its cost
- Solid and liquid waste and their impact on the environment

Track 2: Directorate of Engineering engineers and architects

Based on individual surveys conducted with the Directorate of Engineering staff (Architects / Engineers), several Environmental Performance (EP) measures are included at the design stage. However, in order to keep up with the advancement in technology, regular capacity building workshops should be designed and delivered.

Workshops include the following topics (non-exhaustive):

- Passive design (heating, cooling, lighting, ventilation)
- Renewable energy and carbon footprint
- Building materials
- Eco-design and life cycle assessment
- Indoor Environment Quality
- Water technology, water footprint, water harvesting
- Building rating systems
- Environmental performance procurement
- Introducing environmental performance in product specifications and tender documents
- ISO management systems (ISO 9001, 14001, 50001)

Track 3: Procurement and Tendering LAF staff

These workshops will feature two important concepts namely Eco-design (and Eco-labeling) and Life Cycle Assessment, along with other topics related to green procurement. The outcome of this sort of capacity building is to inculcate environmental performance thinking into the decision making process, which would be based on the premise that price is not the only criteria to consider when buying materials and equipment or selecting a bidder.

Track 4: Community Involvement

Awareness presentations related to basic EP concepts shared amongst LAF officers and NCO through half-day workshops should be conducted as many times as necessary to cover all the officers’ corps. During these workshops, the LAF EP policy and the LAF command’s strategic intent will be explained and conveyed to the commissioned and non-commissioned officers, and consequently, individuals get rewarded through programs, which increases their sense of accomplishment and belonging.
Annex 3: Featured case study

Region: North of Lebanon

Sites and Facilities:
- Aandket Barracks Buildings: Built areas around 10,000 m² of medical, administration, stores, kitchen, workshops and other.
- Tripoli - North Medical Facilities in Qoubbe Barracks about 2,200 m², four buildings

The works include the following measures:

**Energy Efficiency Measures:**
- Wall insulation.
- Double glazing.
- Lighting: Replacing the old T8, CFL and incandescent lamps with LED lamps.
- Water: Installation of water saving heads for showers and faucets.

**Renewable Energy:**
- Hybrid On-Grid PV Systems.
- Solar Water Heating Systems.

**Installation of Electricity Sub-meters.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Total</th>
<th>Unit</th>
<th>Unit price USD</th>
<th>Total price USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Supply and installation of wall thermal insulation consisting of 25 mm of extruded polyesterene and gypsum boards.</td>
<td>980</td>
<td>810</td>
<td>1790</td>
<td>m²</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Supply and installation aluminum profile fenestration with double glazing.</td>
<td>600</td>
<td>365</td>
<td>235</td>
<td>m²</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>Supply and installation of LED lighting fixture, recessed type, 60 cm x 60 cm, total 40W LED, 100Lm/W.</td>
<td>377</td>
<td>16</td>
<td>361</td>
<td>No</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>Supply and installation of LED lighting fixture, exposed mounting type, 120 cm, total 20W LED, 100Lm/W.</td>
<td>11</td>
<td>0</td>
<td>11</td>
<td>No</td>
<td>23</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Quantity</td>
<td>Unit</td>
<td>Unit price USD</td>
<td>Total price USD</td>
<td></td>
</tr>
<tr>
<td>------</td>
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<td>------</td>
<td>----------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Supply and installation of LED lighting fixture, exposed mounting type, 2 x 120cm, total 40W LED, 100Lm/W.</td>
<td>6 4 10</td>
<td>No</td>
<td>32</td>
<td>320</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Supply and installation of LED lighting fixture, exposed mounting type, 3 x 120cm, total 60W LED, 100Lm/W.</td>
<td>8 0 8</td>
<td>No</td>
<td>42</td>
<td>336</td>
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<tr>
<td>7</td>
<td>Supply and installation of LED bulb, E27, 12W LED, 100Lm/W.</td>
<td>105 5 110</td>
<td>No</td>
<td>15</td>
<td>1,650</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Supply and installation of LED bulb, E27, 15W LED, 100Lm/W.</td>
<td>94 4 98</td>
<td>No</td>
<td>18</td>
<td>1,764</td>
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<tr>
<td>9</td>
<td>Supply and installation of LED bulb, E27, 30W LED, 100Lm/W.</td>
<td>72 5 77</td>
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<td>25</td>
<td>1,925</td>
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<tr>
<td>10</td>
<td>Supply and installation of ceiling LED lamp, E27, 15W LED, 100Lm/W.</td>
<td>40 8 48</td>
<td>No</td>
<td>20</td>
<td>960</td>
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</tr>
<tr>
<td>11</td>
<td>Supply and installation of ceiling LED lamp, E27, 17W LED, 100Lm/W.</td>
<td>30 0 30</td>
<td>No</td>
<td>23</td>
<td>690</td>
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<tr>
<td>12</td>
<td>Supply and installation of LED flood light, 200W LED, 100Lm/W.</td>
<td>24 0 24</td>
<td>No</td>
<td>180</td>
<td>4,320</td>
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<tr>
<td>13</td>
<td>Supply and installation of LED spot light, recessed type, 15W LED, 100Lm/W.</td>
<td>0 6 6</td>
<td>No</td>
<td>21</td>
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<tr>
<td>14</td>
<td>Supply and installation of LED spot light, exposed type, 18W LED, 100Lm/W.</td>
<td>0 25 25</td>
<td>No</td>
<td>27</td>
<td>675</td>
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<tr>
<td>15</td>
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<td>0 257 257</td>
<td>No</td>
<td>23</td>
<td>5,911</td>
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<tr>
<td>Item</td>
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<td>Unit price USD</td>
<td>Total price USD</td>
<td></td>
<td></td>
</tr>
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<td>----------</td>
<td>----------------</td>
<td>-----------------</td>
<td></td>
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<tr>
<td>16</td>
<td>Supply and installation of Decorative LED lighting fixture, exposed mounting type, 2 x 120 cm, total 40W LED, 100Lm/W.</td>
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<td>No 90</td>
<td>3,600</td>
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</tr>
<tr>
<td>17</td>
<td>Supply and installation of water saving shower head.</td>
<td>30 15 45</td>
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<td>405</td>
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<tr>
<td>18</td>
<td>Supply and installation of water saving faucet head.</td>
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<td>No 7</td>
<td>700</td>
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<td></td>
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<tr>
<td>19</td>
<td>Supply and installation of PV Hybrid On-grid system, 5kWp</td>
<td>1 0 1</td>
<td>No 9,000</td>
<td>9,000</td>
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<td></td>
</tr>
<tr>
<td>20</td>
<td>Supply and installation of PV Hybrid On-grid system, 15kWp</td>
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<td>No 25,000</td>
<td>25,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Supply and installation of PV Hybrid On-grid system, 40kWp</td>
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<td>68,000</td>
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<tr>
<td>22</td>
<td>Supply and installation of PV Hybrid On-grid system, 50kWp</td>
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<td>No 80,000</td>
<td>80,000</td>
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<tr>
<td>23</td>
<td>Supply and installation of Solar Water Heating unit, 200L tank capacity, 4sqm absorber.</td>
<td>7 3 10</td>
<td>No 2,000</td>
<td>20,000</td>
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<tr>
<td>24</td>
<td>Supply and installation of Solar Water Heating unit, 300L tank capacity, 4sqm absorber.</td>
<td>6 5 11</td>
<td>No 2,600</td>
<td>28,600</td>
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<tr>
<td>25</td>
<td>Supply and installation of Solar Water Heating system, 4,000L tank capacity, 60sqm absorber.</td>
<td>1 0 1</td>
<td>No 32,000</td>
<td>32,000</td>
<td></td>
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<tr>
<td>26</td>
<td>Supply and installation of Electric kWh submeter, 3ph, 380V</td>
<td>10 6 16</td>
<td>No 250</td>
<td>4,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>451,375</td>
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