REPUBLIC OF LEBANON
MINISTRY OF PUBLIC HEALTH

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Implemented by: KFW

World Health Organization

UNDP

SUSTAINABLE ENERGY STRATEGY

for the Health Care Sector in Lebanon

Edition 1: A Focus on Public Hospitals

Editorial

This document should be referenced as:

Sustainable Energy Strategy for the Health Care Sector in Lebanon.

For more information

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Reference project

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The Energy crisis in Lebanon is taking a heavy toll on all sectors of the country, with the healthcare sector being no exception. Amid the intertwined challenges facing the country due to a pandemic, socio-political unrest, and economic meltdown, the Lebanese healthcare facilities have been facing tremendous difficulties in having secured access to energy. Extreme shortage in electricity and the escalating cost of fuel, when available, have a rendered the advent of a sustainable source of green energy a life-saving intervention for the healthcare facilities.

Health care facilities have intensive energy requirements over the clock. Transforming these into energy conscious, energy efficienct, and environmentally responsible facilities have become a necessity. The launching of the 'Sustainable Energy Strategy for the Health Care Sector' reflects a commitment to a transformative roadmap towards efficient and green energy use and production.

The expected returns of this strategy are innumerable. Public hospitals can reduce their electricity demand by 15-30%, while supplying electricity through a combination of conventional and renewable energy sources. Thermal energy demand, mainly in the form of hot water and heating, can also be reduced by up to 50%, as projected by the strategy. Provided these targets are met, the healthcare sector will be able to reduce its operating and maintenance costs, enabling the reallocation of funds towards more urging needs. In addition, Lebanon has committed itself to reduce its greenhouse gas emissions by 30% by the year 2030. This target may be sought for by scaling up of renewable energy use.

The Ministry of Public Health appreciates the financial support offered by the German Government and KFW Bank and the technical support provided by UNDP, all of which were vital to launch the Solar for Health Program. The Ministry of Public Health also acknowledges the support and contribution of the World Health Organization to the Lebanese health sector in general and to the sustainable energy strategy in specific. Hoping that, in the near future, this program will be scaled up until the objective of greening the entire healthcare sector is met.

Dr. Firass Abiad
Minister of Public Health

Lebanon is going through a grave human-made economic and financial crisis that has wide-ranging social repercussions. The country has also been impacted by the COVID 19 pandemic, as well as the devastating explosion in the port of Beirut in 2020. In addition to this, Russia's war of aggression against Ukraine, which started on 24 February 2022, has caused an unprecedented increase of grain and energy prices all over the world, which does not leave Lebanon untouched.

Germany is one of the biggest and most committed bilateral partners of the Lebanese government. Since 2012, the Federal Republic of Germany has made available about 2.6 billion euros *[BMZ: Ministry of Development Cooperation]* 1.7 billion euros; for development policy measures and *[GFFO: Ministry of Foreign Affairs]* 0.9 billion euros for humanitarian aid in order to ease the impact of these multiple crises on Lebanon's infrastructure. Today Germany provides support in a variety of sectors, including health, energy and water.

As a response to the COVID-19 pandemic, the German Government has provided substantial support to the Lebanese health care sector through KfW Development Bank other international and local partners. Within this support, the UNDP's Solar for Health project has provided sustainable energy solutions to those Lebanese public hospitals that were the first to offer COVID-19 treatment units. Such energy interventions in 15 public hospitals across all of Lebanon have enabled these hospitals to make an estimated $2.3 million of savings per year, which can be used, inter alia, to directly support immediate health-related activities. Furthermore, this approach to energy efficiency is in line with Lebanon's national climate targets for greenhouse gas reduction as well as the global climate response.

Clearly, Lebanon harbors a considerable potential for a wider and more systematic use of renewable energies as a means of both overcoming the acute dire energy crisis in the country and transitioning towards the path of sustainable climate-friendly solutions for the future. Currently, most initiatives are private or donor-funded. They underline the numerous benefits for individual consumers and institutions alike. To make the gradual transition to renewables a reality in Lebanon's health-care sector, bold steps by the government will be needed.

We hope Sustainable Energy Strategy in the Health-Care Sector will set the stage for the transformation of all health-care institutions, public and private, in the way they use and procure energy. In doing this, Lebanon will be able to better balance its trade, safeguard hard currency, increase diversity and security of energy supply and build momentum to reach its climate change targets by 2030.

Germany will continue to support Lebanon and the Lebanese people through difficult times.

Mr. Andreas Kindl
German Ambassador to Lebanon

In response to the COVID crisis that has impacted all countries across the world, the German Government, through KfW Development Bank has supported among others the “Solar for Health” project for Lebanon in partnership with the UNDP. This is only one component of our support to Lebanon to mitigate the negative effects of the COVID pandemic, however, it is an extremely relevant one, especially with regards to the current energy crisis of the country.

15 public hospitals were supported to install sustainable energy system, most of which benefitted from multiple interventions such as solar hot water systems, solar photovoltaic systems, lighting retrofits, building management systems, energy audits and computerized maintenance management systems. These interventions will save the hospitals in total approximately $2.3 million per year - money that is urgently needed to be spent on the delivery for health-care services.

The Sustainable Energy Strategy for the health-care sector builds on the lessons learned through the energy analysis conducted on these 15 hospitals and the valuable support of the World Health Organization (WHO). It provides a baseline for all public hospitals in Lebanon and realistic targets that the entire sector should strive to achieve.

I hope that this Strategy and its recommendations will be picked up by both private and public sector hospitals. Transforming the way the health-care sector uses and produces energy is a key component to ensure energy access and to support Lebanon in managing the risks and consequences of high international oil prices, especially given the financial crisis facing the country. In addition, it substantially contributes to reducing air pollution, global greenhouse gas emissions and combat climate change, a mission we all strive for.

Dr Solveig Buhl
KfW Office Director, Beirut

Lebanon is faced today with unprecedented political, financial and economic collapse. Essential services have been suspended and the health critical situation is affecting the livelihoods of people especially the most marginalized. How can we transform this exceptionally difficult momentum into opportunities, transforming the way all institutions, private or public address the much needed and critical services? Unfortunately, the very fragile economic environment, the COVID-19 crisis and the recent cholera outbreak, coupled with the global inflation in energy, food and product prices, have had devastating effects impacting even further the health sector.

Today change is possible if every institution, private or public, transforms challenges into opportunities by investing in reform and moving towards greener and more sustainable approaches.

The Sustainable Energy Strategy for the Health-Care Sector is a roadmap for all Lebanese health institutions to ramp up Lebanon's commitment towards climate change, while securing energy access to the most vulnerable seeking health services.

With financial assistance from the German Government, through the KfW Development Bank, the United Nations Development Programme (UNDP) targeted 15 public hospitals across Lebanon that were leading in the corona-virus fight. Concrete measures to reduce the operational and maintenance costs of their facilities were identified using energy audits. This resulted in increasing their energy supply with renewable energy technologies.

The implementation of these programmes in hospitals shall serve as pilot projects to gather data for the design of the Sustainable Energy for the Healthcare Strategy. UNDP partnered with the World Health Organization (WHO) working closely with the technical teams at the Ministry of Public Health to analyse the data and assess the overall needs of the sector. Interesting findings reveal that across the Lebanese health-care sector, energy efficiency can lower electricity and thermal energy demand by at least 26% and 54%, respectively. On the other hand, energy sources can deliver substantial amounts of the remaining requirements. To illustrate this, we installed 1.86 MWp of solar photovoltaic systems spread across the 15 public hospitals. These systems will deliver a minimum of 2.9 million kWh per year. With the current diesel prices, the savings related to these solar systems in the 15 public hospitals can reach 1.17 million USD a year.

We hope that this strategy is implemented to promote health and environmental sustainability for hospitals and healthcare systems. We are confident this approach will lead to better healthcare provision and improved well-being for those most in need.

Ms. Melanie Hauenstein
UNDP Resident Representative

Energy is a critical input in every aspect and operation related to the health-care sector, on which quality and safety, as well as sustainability of care depends to a large extent.

The current energy crisis in Lebanon heavily impacted the hospital sector in the country, inciting WHO and UNDP to explore alternative a sustainable and environmentally friendly energy sources.

The technical support of WHO focused on providing evidence-based information to help shape the Sustainable Energy Strategy for the Lebanese Health Care Sector. Accordingly, WHO conducted in October 2021 an assessment of the hospital medical equipment to identify their energy needs, using a combination of desk review and field visit for a mix of private and public hospitals.

Based on this assessment, general recommendations for energy saving and key recommendations were set for each hospital department, such as focusing on the importance of selecting the devices that match the needed workflow of the hospital. A list of medical equipment consuming high level of energy with its level of energy consumption, and specific recommendations per equipment for energy saving was developed. These recommendations and criteria would be considered for any interventions necessitating the procurement of medical equipment to save energy, hence reducing negative environmental health impacts.

This important and timely strategy, funded by the KFW Development Bank, and coordinated through UNDP Solar for Health program, outlines key measures that can be implemented to lower the demand for energy, on the one hand, and to increase the share of renewable energy generation on the other.

Implementing these energy efficiency measures are vital for the transformation of the sector and for the sector's long-term sustainability.

As promoting health (SDG3) is at the heart of sustainable development, WHO strongly believes that promoting sustainable and eco-friendly energy (SDG 7) within the healthy cities concept (SDG 11) is an important determinant of health, that together with UN family and partners, will continue advocating for and supporting its progressive implementation, in line with the national Health sector strategy for Lebanon.

On behalf of my Colleague Dr. Iman Shankiti, who accompanied the support provided by WHO country team as Lebanon Country Office representative, I would like to thank all the Line Ministries Teams, UNDP and WHO team that worked hard and relentlessly to develop this strategy and finalize it despite the many challenges encountered.

Dr. Abdinasir Abubakar
Acting WHO Representative in Lebanon

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ACRONYMS

A	Amperage
AC	Air conditioning
AHU	Air handling units
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BMS	Building management system
CAPEX	Capital expenditure
CCT	Correlated colour temperature
CDD	Cooling degree days
CDR	Council for Development and Reconstruction
CHW	Chilled water system
CO_2	Carbon dioxide
COP	Coefficient of performance (KW cooling/KW electrical)
CRI	Colour rendering index
EDL	Électrecité Du Liban
EEM	Energy efficiency measures
EER	Energy efficiency ratio
ESCO	Energy services company
FCU	Fan coil unit
Fluo	Fluorescent
GHG	Greenhouse gases
Hal	Halogen
HDD	Heating degree days
HVAC	Heating ventilation air conditioning
IRR	Internal rate of return
KVA	kilo volt ampere

KW	Kilowatt
KWh	Kilowatt-hour
LED	Light-emitting diode
LPG	Liquefied petroleum gas
m	Meter
m^2	Square meter
m^3	Cubic meter
MDB	Main distribution board
MJ	Megajoules
MoE	Ministry of Energy
NPV	Net Present Value
°C	Degree Celsius
°K	Degree KelviN
°F	Degree Fahrenheit
PF	Power factor
TRV	Thermostatic radiator valve
V	Volt
VFD	Variable frequency drive
VRF	Variable refrigeration flow
W	Watt
W m^2/°K	Watt square meter per degree Kelvin
WWR	Window-to-wall ratio

01

EXECUTIVE SUMMARY

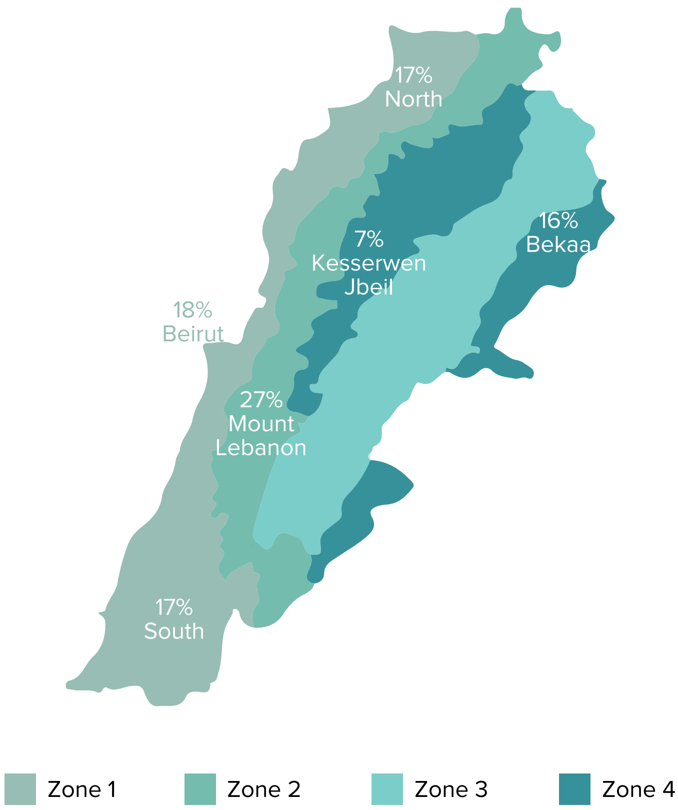
1. EXECUTIVE SUMMARY

Lebanon has committed to unconditionally generate 18% of its power demand and 11% of its heat demand or, conditionally, to generate 30% of its power demand and 16.5% of its heat demand from renewable energy sources by 2030. Amid the economic and political instabilities of the country, the health care system continues to face challenges from the shortage of supplies, the increase in the number of patients due to the pandemic, and the heart-wrenching energy crisis leading to an overwhelmed and exhausted medical system.

With this background, the UNDP implemented the 'Solar for Health' project, funded by Germany through KfW Bank, which included a number of actions from energy auditing public hospital facilities for the implementation of various energy efficiency and renewable energy projects as well as the development of a strategy to enhance the energy performance of Lebanese public hospitals, which is covered in the present report. Furthermore, and as part of the National Sustainable Energy Strategy for the Lebanese Health Care Sector, the World Health Organization (WHO) assessed hospital medical equipment to identify their energy characteristics and needs, using a combination of desk review and field visits for a mix of private and public hospitals. Based on this, WHO developed energy saving criteria for medical equipment per hospital department, the outcomes and results of which are included in this assessment.

The Lebanese health care sector is comprised of 158 short-term care hospitals and 14,210 beds, of which 30 percent are governmental facilities distributed over the four climatic zones.

Figure 1: Distribution of Lebanese hospitals over the four climatic zones



According to the report on energy consumption in the commercial and institutional sectors prepared in 2015[1], 67% of the electrical energy in health care facilities was provided by the utility company Électrecité Du Liban (EDL) and 33 percent by diesel generators; while thermal energy is covered by liquefied petroleum gas (LPG) primarily used in kitchens, in addition to diesel oil used in boilers for hot-water generation and space heating, and for use with an autoclave. However, given the country's current energy crisis (in 2021-2022), the largest share of electrical energy consumption today is done through diesel generators.

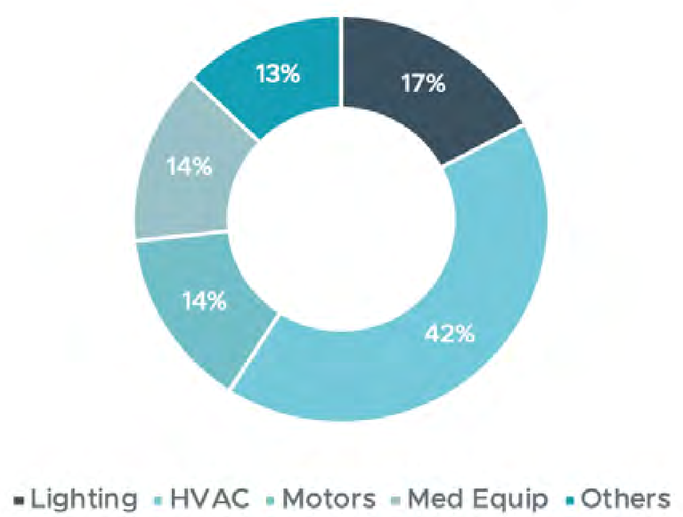
The energy use of health care facilities is also influenced by their climatic zone distribution due to the variation of cooling degree days and heating degree days (CDD and HDD). The results show that Lebanon has a centralized health care system, with 55 percent of its hospitals located in large cities in coastal areas corresponding to zone 1, consuming 40 percent of the total energy of the audited hospitals. In contrast, facilities in zone 3 constitute 30 percent of total energy consumption, and those in zone 4 constitute only 4 percent of total consumption.

Further analysis was completed to aggregate the energy balance (electricity usage per end use category) obtained from energy audits of 35 public and private hospitals. Results are seen in Figure 2, whereby the lighting category represented 17% of total electricity

[1] MoE/GEF/UNDP (2015), "Energy consumption in the commercial and institutional sector" (Beirut, Lebanon).

usage, 42% for heating, ventilation and air conditioning (HVAC), 14% for motors, 14% for medical equipment, and 13% for miscellaneous loads. These numbers were than extrapolated for the entire sector.

Figure 2: Energy balance of Lebanese hospitals



When analysing the current situation of Lebanese hospitals, results show that the health care system suffers from a great divergence between its private and public hospitals in terms of energy efficiency measures and sustainability initiatives, despite the efforts of multiple agencies to perform and fund energy efficiency and renewable energy projects in the public health care sector. The main issues are the shortage of funds and the lack of employee awareness and engagement, in addition to generally poor operation and maintenance of the technical infrastructure – all leading to obsolete installations, the reduction of energy efficiency, and the increase of energy consumption. Accordingly, a clear strategy to enhance the energy efficiency and reduce the energy and carbon footprints of public hospitals is necessary, including a road map of specific actions to be taken.

The electrical and thermal energy consumptions obtained from the commercial and institutional sector report prepared in 2015 were updated, and new key indicators of all public hospitals were found following the energy audits completed on 10 public hospitals under the KfW Bank-funded UNDP ‘Solar for Health’ project. Accordingly, a new energy baseline and energy balance per bed per climatic zone was prepared in terms of annual kWh electrical and kWh thermal average per bed.

Table 1: Annual kWh electrical & thermal averages per bed per climatic zone

	kWh Electrical	kWh Thermal
Zone 1	22,997	23,108
Zone 2	8,269	8,315
Zone 3	4,722	4,681
Zone 4	9,014	9,128

To mitigate all issues raised previously and to enhance the overall energy and carbon footprints of the public hospitals, a set of energy efficiency and renewable energy measures covering all the infrastructure and equipment were recommended (see Table 2). These opportunities include actions that require very little or no capital expenditure (referred to as Low Cost/No Cost – LC/NC), and others needing capital expenditure (CAPEX). They vary from 'staff awareness and engagement' to solutions provided to improve systems' efficiency and reduce their energy consumption, as well as to renewable energy projects, insulation improvements, and systems' retrofits.

Table 2: List of energy efficiency measures (EEMs)

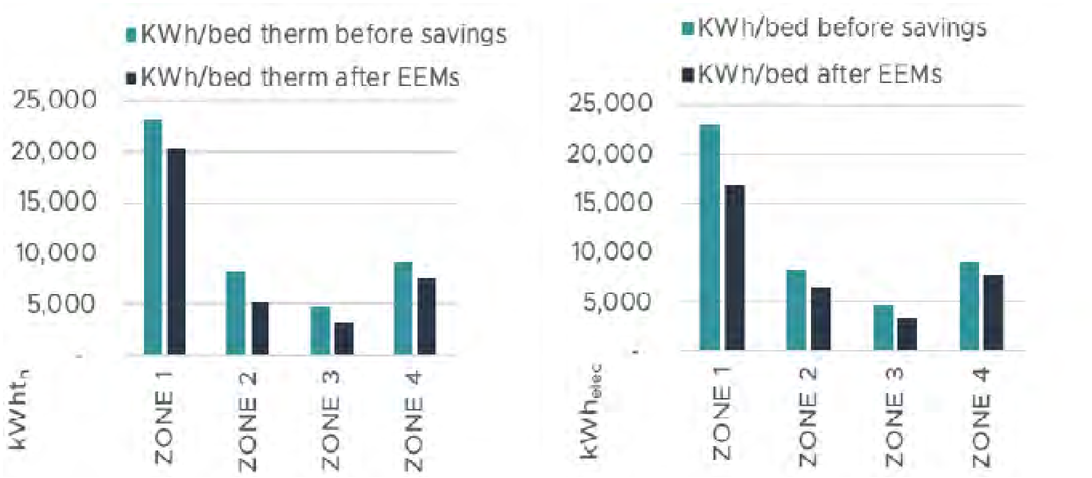
CODE	TYPE	TITLE
EEM – 01	LC/NC	Staff awareness and engagement
EEM – 02	LC/NC	Maintenance management
EEM – 03	LC/NC	Green Procurement
EEM – 04	LC/NC	Lighting load management
EEM – 05	LC/NC	Free cooling
EEM – 06	LC/NC	Chilled water pipes insulation
EEM – 07	LC/NC	Hot water network insulation and steam leakage mitigation
EEM – 08	CAPEX	Building envelope improvement
EEM – 09	CAPEX	Lighting retrofit
EEM – 10	CAPEX	Lighting control
EEM – 11	CAPEX	Chiller plant retrofit and air quality improvement

EEM – 12	CAPEX	Convert constant primary chilled water flow to variable primary flow
EEM – 13	CAPEX	Cooling system retrofit: Variable refrigeration flow rationale
EEM – 14	CAPEX	Installation of variable frequency drives
EEM – 15	CAPEX	Domestic water system control and management
EEM – 16	CAPEX	Solar water heaters
EEM – 17	CAPEX	Photovoltaic driven electricity generation
EEM – 18	CAPEX	Building management system installation
EEM – 19	CAPEX	Thermostatic valve installation on radiators
EEM – 20	LC / NC CAPEX	Energy management on biomedical equipment

It is to be noted that EEM 20 was prepared by the World Health Organization and focuses on the biomedical equipment in various hospital departments.

Implementing the various mix of actions listed in Table 2 across public hospitals in Lebanon would yield substantial energy and cost savings, which are summarized in Figure 3. It is seen that electricity consumption could drop by an average of 23%, and thermal energy consumption by 25%.

Figure 3: kWh electrical savings (left), and kWh thermal savings (right) per climatic zone



The economic performance of these measures show a total of $4 million in cost savings, with a related $17.6 million in implementation costs, a payback period of 4.5 years, and $13.3 million in Net Present Value.

On the governmental level, awareness-raising policies and actions are needed to organize and facilitate the implementation of the EEMs as well as moving the health care sector towards the appropriate energy and sustainability management paths. First, it would be crucial to appoint managing entities to ensure successful energy policies and actions implementation. This can be provided by an adequate delineation of roles and responsibilities with regard to energy management. The proposed managing entities constitute a step towards a working organizational structure manifested in the Ministry of Public Health and health services.

The second step is to develop good energy management practices that could be achieved from adopting a proactive and consistent approach across the Lebanese health care sector addressing three primary areas: energy supply, energy demand, and understanding energy use at both the local and system-wide levels.

Energy scores are another important step for assessing the current state of the health care sector in Lebanon and for benchmarking these facilities in terms of energy performance and use against similar facilities nationwide. The scoring can be then used by the government to set holistic energy targets for the sector. Furthermore, the government needs to set energy efficiency and renewable energy targets for the health care sector as a scheme to reduce the level of wasted energy and to increase energy efficiency. These targets would result in compelling actions that encourage the health care sector to achieve certain energy outcomes, track progress, and increase financing.

Lastly, guidelines need to be developed for minimum sustainability requirements covering all health care capital works. The guidelines should include sustainability initiatives on all projects to improve energy efficiency.

02

INTRODUCTION

2. INTRODUCTION

The health care sector in Lebanon is comprised of 158 hospitals, of which 30 are public with a total of 2,810 beds[2] and 128 are private with a total of 11,400 beds[3]. These hospitals are distributed in different climatic zones and governorates. Approximately half are in climatic zone 1 spread between Beirut and Mount Lebanon governates.

Hospitals are energy intensive facilities due to their long operating hours, occupancy, special equipment, and complexity. Therefore, considering the dysfunctional state of the Lebanese energy sector and the country's environmental and economic crises, it is important to rethink the energy performance of hospitals.

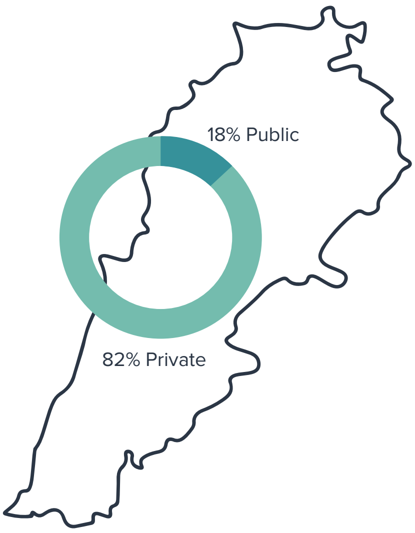
Generally, strategic planning is a process in which organizations determine their vision for the future as well as identify their goals and objectives, while establishing the sequence in which those goals need to be achieved to reach a stated vision. This is especially true in the practice of energy management. This report is part of the larger UNDP implemented 'Solar for Health' project, funded by KfW Bank, which aims at improving the energy performance of Lebanese public sector hospitals. Energy audits were completed for 10 public hospitals, and their data was compiled with other available data to perform the analysis. The report has been supported by the World Health Organization (WHO) through their survey and desk-review research into energy-use of medical equipment.

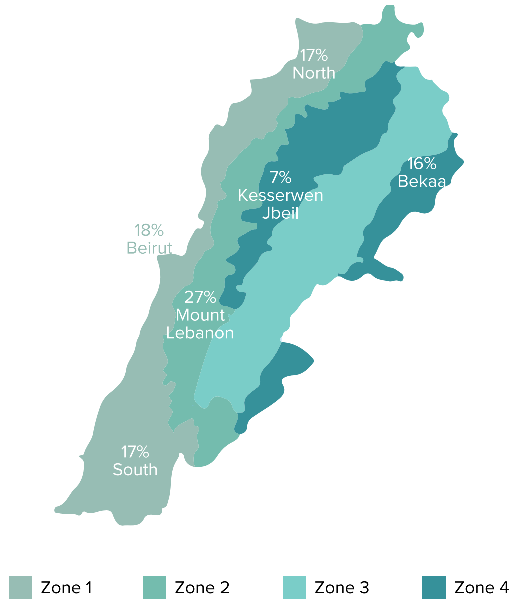
The sections below provide an overview of the energy consumption in the Lebanese health care sector, in addition to a description of the current status of energy efficiency in both public and private hospitals, recommended energy efficiency measures, potential savings for the Lebanese public hospitals, and finally a set of policies and actions that can be adopted as part of a government-level policy action plan.

[2] Ministry of Public Health, https://moph.gov.lb/en/HealthFacilities/index.

[3] Syndicate of Hospitals, www.syndicateofhospitals.org.lb.

Figure 4: Distribution of hospitals in Lebanon by type (left), and their geographical distribution (right)





03

ENERGY CONSUMPTION IN HOSPITALS

3. ENERGY CONSUMPTION IN HOSPITALS

3.1. General

On average, hospitals consume up to 1,467 GWh per year distributed among diesel, the Lebanese utility company Électrecité Du Liban (EDL), and LPG in 2012; and up to 15% of the commercial and institutional sectors' diesel oil for backup generators operation[4], which makes it among the most energy intensive market segment in the commercial and institutional sectors. A general overview of the energy consumption of hospitals in Lebanon was performed, accounting for all sources of energy used by this sector.

3.1.1 Electrical Energy

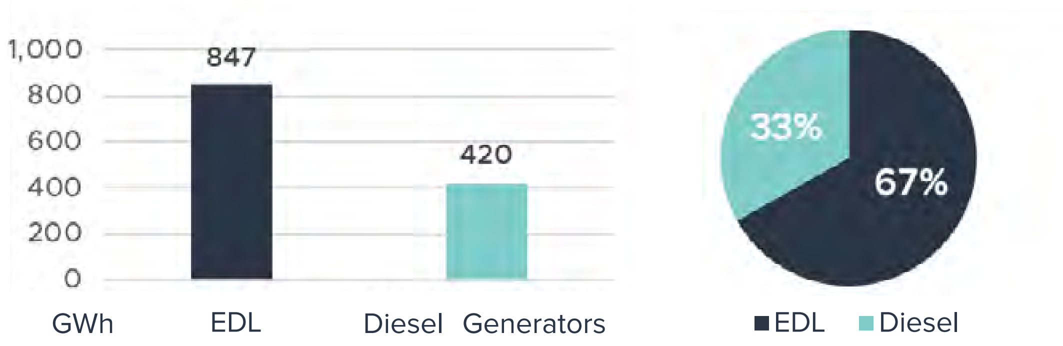
The health care sector represents 18% of the electricity consumed by the commercial and institutional sectors from EDL power, corresponding to 846.8 GWh[5]. In terms of CO_2 emissions, the commercial and institutional sectors accounted for 3.1 million tons of CO_2 emissions annually in 2012[5] Hence, it is estimated that CO_2 emissions by the health care sector is approximately 558,000 tons.

Private Generators

All sectors in Lebanon are currently facing an acute electricity shortage, and the health care sector is no different. Whether the facility is using its private generator or a public generator subscription, diesel is being consumed to provide electricity during the EDL's power during cut-off periods. Around 35% of the energy consumed in the health care sector comes from private generators, making this share among the highest in economic activities. In 2015 the sector consumed up to 15% of the diesel oil used for private electricity generation operations – some 97,804 tons, equivalent to 420 GWh[4]. Considering the increasing electricity shortage, however, the aforementioned numbers are today considerably higher.

[4] Yassin, A., PhD Candidate, Faculty of Business Administration (2018), "Rising Level of Hospital Consumption and the Environment: New Mazloum Hospital Initiatives," BAU Journal - Health and Wellbeing, vol. 1:3, article 71.
[5] MoE/GEF/UNDP (2015), "Energy consumption in the commercial and institutional sector."

Figure 5: Electricity breakdown



3.1.2 Thermal Energy

Boiler diesel consumption (thermal)

Hot water and steam boilers are generally used to generate thermal enegy. Hot water boilers are used in several large facilities to provide hot water and space heating, while steam is used for laundry and autoclave machines. Almost all boilers utilized in Lebanon are diesel powered, with only a few using other fuels such as LPG, biomass, solar energy, and others. The health care sector in Lebanon consumes 21,854 tons of diesel oil per year for thermal energy production, which is equal to 13% of the total annual diesel boiler consumption of the commercial and institutional sectors.

LPG consumption

LPG is mainly used in the kitchens of restaurants, hotels, and hospitals. Around 422 tons of LPG is consumed by the health care sector per year. The two figures below show the annual utilities energy consumption in mega joules (MJ), in addition to their CO_2 emissions.

Figure 6: Energy breakdown

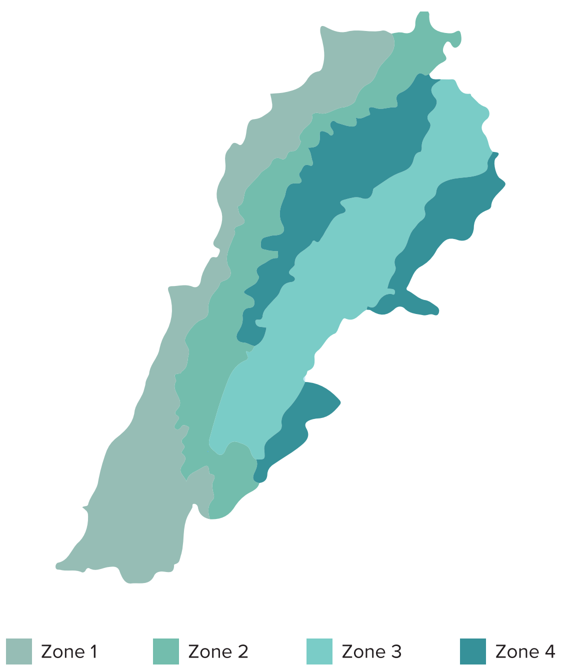
Figure 7: CO_2 emissions by utility

3.2. Lebanon's Climatic Zones

Lebanon has a Mediterranean-type climate characterized by hot and dry summers (June to September) and cool and rainy winters (December to mid-March), with an average annual temperature of 15˚C. Along the coast, summers are hot and humid with temperatures crossing 35°C in August.

Lebanon is divided into four climatic zones. Zone 1 comprises Beirut and coastal areas, zone 2 corresponds to the western Mid-Mountain range with an altitude higher than 700m, zone 3 groups together the eastern Anti-Mount Lebanon range and part of the western Mount Lebanon range, and finally Zone 4 encloses the Beqaa governate (Figure 8).

Figure 8: Lebanon's climatic zones



Each of these zones has different cooling and heating demands based on their heating degree days (HDD) and cooling degree days (CDD) as seen in the Table 3.

Table 3: Climatic zones in Lebanon with corresponding CDD and HDD

Zone	Description	Reference weather station	Characteristic HDD	Characteristic CDD
1	Coastal	Beirut	379	882
2	Western Mid-Mountain	Qartaba	1,514	105
3	Inland Plateau	Zahle	1,600	390
4	High Mountain	Cedars	3,330	-

(Source: MoE/GEF/UNDP (2015),
"Energy consumption in the commercial and institutional sector")

HDD & CDD are indicative measurements that reflect the demand for energy needed to heat & cool a building, respectively. These values are derived from measurements of outside air temperature. An analysis was conducted on 32 hospital facilities to investigate the relationship between the geographic climate zone & the energy consumption of hospitals (Table 4).

Table 4: Public and private hospitals distribution across climatic zones

	Number	Percentage
Climatic zone 1	91	58%
Climatic zone 2	48	30%
Climatic zone 3	16	10%
Climatic zone 4	3	2%
Total	158	100%

On a more aggregate level, Figure 9 represents the distribution of public hospitals across climatic zones.

Figure 9: Distribution of public hospitals across climatic zones

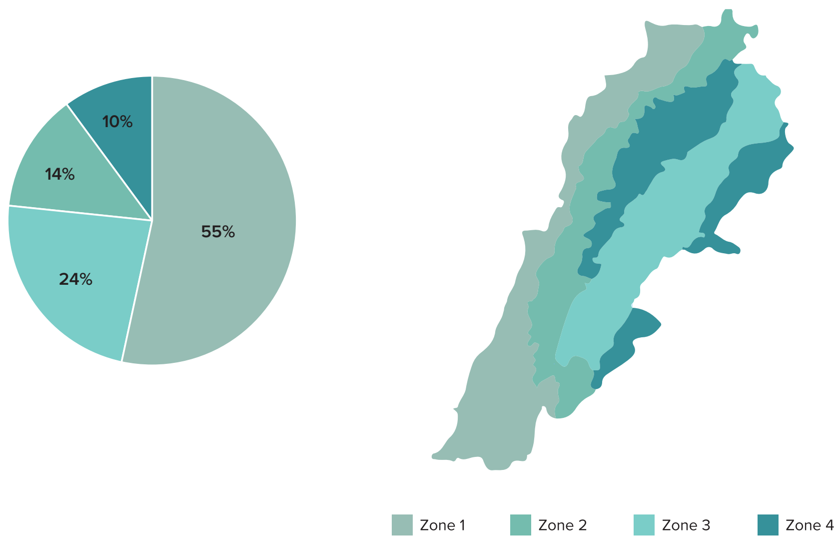
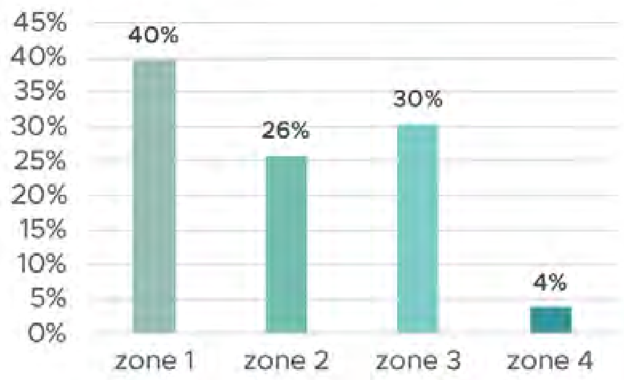


Figure 10: Average energy consumption in kWh as function of climate zones



The results show that Lebanon has a very centralized health care system, as most hospitals are found in large cities. Moreover, 40% of the total energy consumption of the audited hospitals are located in Zone 1, which corresponds to the coastal area and has the highest CDD. This percentage is explained by the need for higher cooling energy. Hospitals located in Zone 3, reflecting high HDD and CDD, consume 30% of the total; while facilities in Zone 4 consume only 4%.

3.3. Energy Audits

An energy audit is an analysis that identifies where and how facilities use energy. It aims at developing energy efficiency measures (EEMs) that could optimize the overall energy costs, ranging from small energy projects to major capital investments on operations and maintenance.

As part of the KfW Bank-funded UNDP CEDRO Solar for Health project, energy audits were completed for 10 public hospitals. In addition, data from previous energy audits of 25 public and private hospitals over the last seven years were also gathered to provide the full database of the present analysis. The main objective is to find various trends in energy consumption as well as the energy balance of hospitals.

From all the energy audits gathered, electrical loads were divided into the following categories:

1. Lighting

This category corresponds to all types of existing indoor and outdoor lighting fixtures.

2. HVAC

This category corresponds to all the split units, chillers, cooling towers, extraction fans, fan coil units, and air handling units responsible for the required circulation of air in the facility.

3. Motors

This category corresponds to water pumps (hot and domestic), circulation, pool pumps, and lifts.

4. Medical equipment

This category corresponds to all medical equipment installed in hospitals.

5. Miscellaneous

This category corresponds to all electrically driven equipment, such as laundry loads, IT loads, kitchen loads, closed-circuit television, and other miscellaneous equipment.

3.3.1. Lighting

The lighting category shows some divergences between public and private hospitals in Lebanon. Lighting in Lebanese health care facilities is mostly manually controlled, with some motion detectors installed in a few private hospitals. A very limited number of facilities have access to a building management system (BMS) to manage their electric loads.

In public hospitals, lighting mostly consists of linear fluorescent fixtures in addition to compact fluorescent fixtures (generally flush-mounted), halogen spots, 8W exit, and emergency fixtures. Incandescent lamps can be found on balconies, in toilets, and in technical areas. Halogen and high-intensity discharge (HID) fixtures are generally used for external lighting.

Figure 11: Linear Fluorescent Lighting

Private hospitals, on the other hand, have mostly moved to light-emitting diode (LED) lighting within the past six years.

Figure 12: LED square panels in Hotel Dieu de France Hospital

On average, lighting represents 17% of the total electricity consumption in Lebanese hospitals, while its energy share averages around 9%.

3.3.2. HVAC

The HVAC category comprises heating, ventilation, and air-conditioning equipment. HVAC fans combine exhaust fans with negative pressure fans and air handling units in technical rooms, toilets, and the kitchen to ensure proper indoor air quality and prevent the spread of infection and disease.

Most mid/large Lebanese hospitals rely mainly on chilled water systems for their space cooling in addition to split units in areas where the piping system is not connected. Smaller hospitals tend to rely on split and DX units.

Figure 13: Split units, chillers, and air handling units

The installed HVAC electric power consumption averaged around 40% of the total load in Lebanese hospitals, while it accounted for 42% of the total electricity consumption.

3.3.3. Motors

The end-use for motors includes all cold and hot water pumps responsible for water circulation, pressure, & distribution; elevators; vacuum machines; compressors; & water treatment plants for dialysis & domestic water feeders.

Figure 14: Pumps

Figure 15: Water treatment plant for dialysis

Figure 16: Compressors

Motors represent 13% of the total load in Lebanese hospitals, and their electricity consumption account for 14% of the total electricity consumption.

3.3.4. Medical Equipment

Medical equipment includes all devices intended for diagnostic, therapeutic, or monitoring care provided to a patient by the hospital. These equipments are spread over multiple departments, such as:

- Radiology department comprises CT scan, mammography, x-ray, echography, and others.
- Laboratory includes all equipment needed for testing, in addition to a blood bank section.
- Operation and delivery room.
- Dialysis department, where dialysis machines are operating.
- Sterilization with autoclave units.
- Others, which includes all the biomedical equipment in the other departments such as neonatal, emergency, nurse stations, pharmacy, as well as other equipment such as aspiration, vacuum, and morgue.

Figure 17: Echography (left), lab equipment (right)

Figure 18: Refrigerator pharmacy (left), autoclave unit (right)

Medical equipment's average installed power represents 22% of the total load in Lebanese hospitals, while its electricity consumption share is only around 14%. This is because the electrical consumption of medical equipment is important, but its usage is generally for short periods of time and for specific medical cases (e.g., during an examination or operation).

3.3.5. Miscellaneous Equipment

Miscellaneous equipment includes kitchen, office, and laundry equipment as well as low current and IT systems. Electrical water heaters, if installed in certain hospitals, are also included in this end-use category.

Figure 19: Kitchen equipment

Figure 20: Refrigerators and cold rooms

Figure 21: Telecommunication

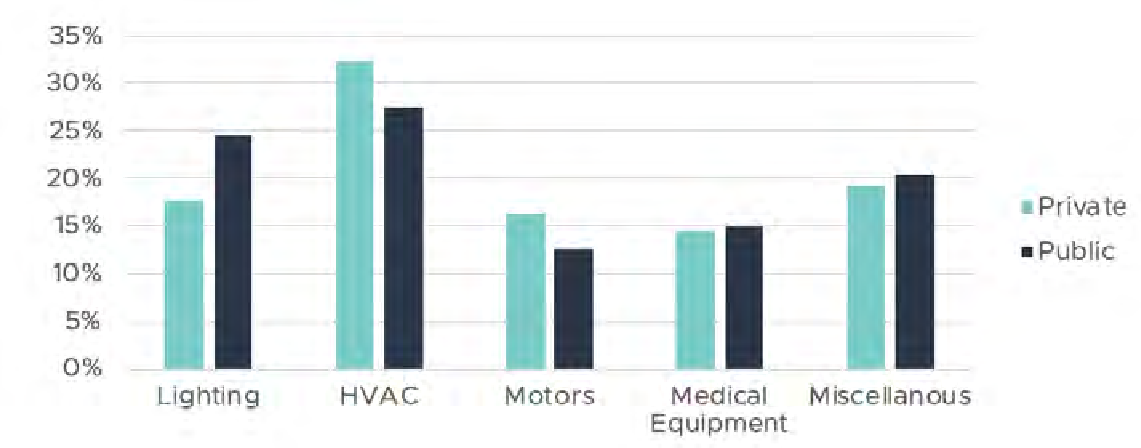
Miscellaneous equipment account for 16% of the total load in a Lebanese hospital and is responsible for 13% of the electricity consumption.

The energy audits performed led to the energy balance (i.e., energy breakdown per end-use category) as depicted in Table 5 and Figure 22, below. The analysis was based on the data of 32 energy audits, including 10 public hospitals audited under the UNDP 'Solar for Health' project, while the remaining 22 are from a mix of public and private hospitals audited in recent years.

Table 5: Electrical energy breakdown in audited Lebanese hospitals

Category	Total Electrical Load		Total Energy Consumption			
Unit	kW	%	kWh	$	Kg. CO_2	%
Lighting	4,340	9	14,144,000	1,939,000	9,485,000	18
HVAC	20,060	40	32,525,000	5,242,000	21,886,000	41
Motors	6,412	13	11,581,000	1,975,000	7,771,000	15
Medical Equipment	11,147	22	10,518,000	1,495,000	7,065,000	13
Miscellaneous	7,962	16	10,122,000	1,285,000	6,767,000	13
Total	**49,921**	**100**	**78,890,000**	**11,936,000**	**52,974,000**	**100**

Figure 22: Public vs private hospital shares in electrical end-user consumption



From the above analysis, we can indicate the following general remarks:

• On average, lighting consumption in public hospitals represents double the share of those in the private sector, which is mostly explained by the near complete transition to LED in the private sector.

• In many public sector hospitals, original chilled water systems were gradually replaced by split units for space cooling.

• In most public sector hospitals the HVAC system is manually controlled, whereas private sector hospitals have generally a better control either through a building management system or through timers, as well as more stringent manual control.

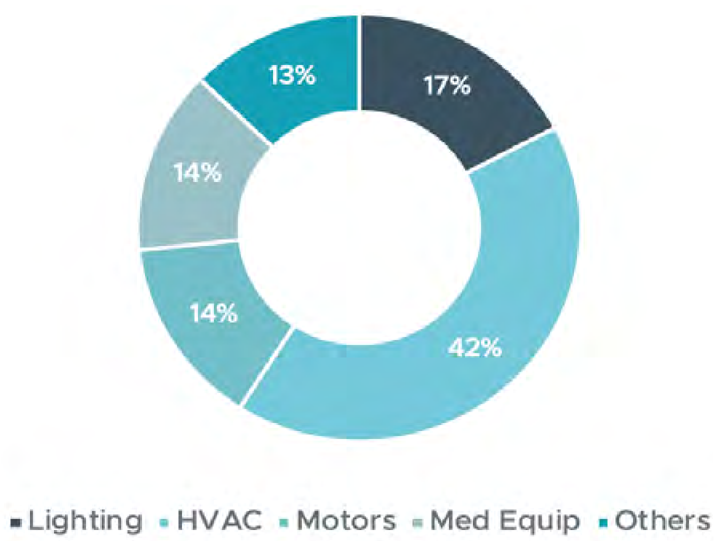
•The electricity tariff for the public sector is 140 LL/KWh, while private health care institutions are billed at the normal commercial tariffs, typically the triple tariff system (80 L.L/kWh, 112 L.L/kWh, and 320 L.L/kWh).

The energy balance was further extrapolated for the entire sector of all 158 hospitals (public and private), as shown in Table 6.

Table 6: Energy balance of the entire health care sector

	End Use Category Consumption in kWh					
Number of Hospitals	Lighting	HVAC	Motors	Med Equip	Miscellaneous	**TOTAL**
158	218,962,100	530,392,600	180,792,250	176,216,200	162,264,500	**1,268,627,650**
Percen-tage	17	42	14	14	13	**100**

Figure 23: Estimated energy balance per end-user category



04

CURRENT STATUS OF ENERGY EFFICIENCY IN HOSPITALS

4. CURRENT STATUS OF ENERGY EFFICIENCY IN HOSPITALS

Amid the current energy crisis in Lebanon, health care institutions are facing a heart-wrenching dilemma with regards to their energy consumption and efficiency status. Most of health care institutions are increasingly forced to rely on private generators due to the insufficient supply hours and the poor quality of electricity from the utility.

The health care sector suffers from great differences between its private and public hospitals in terms of energy efficiency and sustainability measures, except for Rafik Hariri University Hospital (RHUH), which is benefiting from interventions from the International Committee of the Red Cross. Multiple agencies, including the UNDP, perform and fund energy efficiency and renewable projects in the public health care sector.

Between 2009 and 2012 the UNDP CEDRO 1, 2, and 3 projects – funded by the Spanish Agency for International Development Cooperation through the Lebanon Recovery Fund – completed the installation of 13 solar hot water systems in 13 public hospitals (Ehden, Jezzine, Sir el Donnie, Hermel, Abdallah Rassi-Halba, Sebleen, Keserwen, Saida, Tripoli, Qartaba, Bcharre, Dahr El Beshiq, and Jbeil governmental hospitals – see Figure 24).

Figure 24: Solar hot water systems in Saint Charles Hospital, Saida Governmental Hospital, Ehden Governmental Hospital, and Baalbek Governmental Hospital, respectively.

Despite many agencies' efforts, energy audits performed in governmental hospitals show the deteriorated state of these public health care facilities in terms of the end-user components discussed in the earlier section. This poor state results from the lack of budget to upgrade systems and equipment, but more importantly from the absence of a suitable procurement processes driven by energy efficiency.

Moreover, the lack of staff and occupant awareness and engagement hinders energy efficiency and increases energy consumption. Finally, the lack of maintenance and operation management of systems and equipment presents an important obstacle. Hence, there is an urgent need to reduce the health care institutions' energy consumption through an appropriate and comprehensive energy and sustainability management programme.

The Lebanese health care system is dominated by the private sector. In fact, between 2010 and 2019 the private health care sector witnessed a significant growth through the expansion and upgrades of current hospitals as well as through the opening of new facilities. Notably, investments were made to improve energy efficiency. For example, while the shift to LED is considered very rare in public health care institutions, LED represents more than 90 percent of all lighting in the private hospitals in Lebanon.

Moreover, the private health care sector has seen large-scale solar photovoltaic projects installations, such as at Hotel Dieu de France, Mount Lebanon, Jadra, Jabal Aamel, and Alaa Eldine Hospitals, as well as solar thermal installations as in Ain Wa Zein and Hopital Libanais Geitaoui.

Figure 25: Solar photovoltaic systems in Mount Lebanon, Bsalim, Hotel Dieu de France, and Jadra hospitals, respectively

05

ENERGY EFFICIENCY MEASURES (EEMs)

5. Energy Efficiency Levels (EEMs)

5.1. EEMs On Mechanical, Electrical, and Plumbing Equipment

The main objective of this section is to provide a roadmap that includes a number of energy efficiency measures to reduce consumption. There are a considerable number of solutions that could yield substantial energy cost and carbon footprint reductions. These opportunities include those that require very little or no CAPEX (referred to as Low Cost/No Cost – LC/NC), and those needing capital expenditure (CAPEX). The EEM assessments combined both financial feasibility and technical viability.

The typically recommended EEMs are listed in Table 7 and described in the following subsections.

Table 7: Energy efficiency measures

CODE	TYPE	TITLE
EEM – 01	LC/NC	Staff awareness and engagement
EEM – 02	LC/NC	Maintenance management
EEM – 03	LC/NC	Green Procurement
EEM – 04	LC/NC	Lighting load management
EEM – 05	LC/NC	Free cooling
EEM – 06	LC/NC	Chilled water pipes insulation
EEM – 07	LC/NC	Hot water network insulation and steam leakage mitigation
EEM – 08	CAPEX	Building envelope improvement

EEM – 09	CAPEX	Lighting retrofit
EEM – 10	CAPEX	Lighting control
EEM – 11	CAPEX	Chiller plant retrofit and air quality improvement
EEM – 12	CAPEX	Convert constant primary chilled water flow to variable primary flow
EEM – 13	CAPEX	Cooling system retrofit: Variable refrigeration flow rationale
EEM – 14	CAPEX	Installation of variable frequency drives
EEM – 15	CAPEX	Domestic water system control and management
EEM – 16	CAPEX	Solar water heaters
EEM – 17	CAPEX	Photovoltaic driven electricity generation
EEM – 18	CAPEX	Building management system installation
EEM – 19	CAPEX	Thermostatic valve installation on radiators
EEM – 20	LC/NC CAPEX	Energy management on biomedical equipment

5.1.1. Low Cost/No Cost EEMs

LC/NC measures are simple steps that require little or no investment and can help health care facilities reduce their energy bills (see Appendix A for full list).

EEM 01: Staff awareness and engagement rationale

The most successful operations and maintenance (O&M) measures and power-saving automation solutions can be rendered ineffective by careless occupant behaviours. Therefore, increasing staff engagement and awareness is a pillar in the strategy of energy conservation in hospitals.

Energy efficiency strategy and savings

Energy efficiency strategy, in this case, can be done through:

• Spread the culture of energy conservation among the staff and employees and engage staff at different levels.

• Promote green purchasing of equipment and products that have a reduced effect on human health and the environment.

• Promote the basic ‘turn it off and unplug it’ behaviours through posters, label stickers, and banners to save energy in rooms as well as organize campaigns for certain types of medical equipment.

- Design periodical energy-saving programmes.
- Develop targeted energy reduction strategies for labs, medical imaging, and food services.
- Create energy efficiency survey feedback by the staff.
- Put stringent measures and accountability on staff members who do not comply with these measures.
- Leadership and management change. Ensure that the management and leaders in the organization have competencies and are aware of the importance of energy saving to spread the culture among employees at all levels.
- Appoint supervisors at each unit level to promote and supervise energy-saving behaviours of staff.
- Conduct training and awareness campaigns on the importance and practices of energy saving for doctors and nurses.
- Develop extrinsic motivators and recognition for employees by providing bonuses, awards, increased compensation levels, and career growth.
- Use data to empower the team by setting realistic goals in reducing energy consumption (a reduced energy bill for example) and by celebrating achievements and progress.
- Develop a new energy-responsible workforce. Ensure all new employees in the hospital receive a comprehensive orientation that helps them understand the importance of energy-saving and develop this culture.

EEM 02: Maintenance management rationale

The results of the energy audits clearly illustrate the degraded state of Lebanese hospitals' mechanical infrastructure resulting from non-operation, as well as from poor or no maintenance practices. The lack of maintenance is coupled with employee behaviour that leans towards a lack of accountability, likely exacerbated due to the current economic and social conditions in the country in general and of public sector employees in particular, in addition to a non-existent culture of energy efficiency and sustainability. Hence, it is important to integrate a maintenance management programme to rectify these problems and maintain a good state of hospitals and equipment, in addition to ensuring proper function and reducing the energy bill.

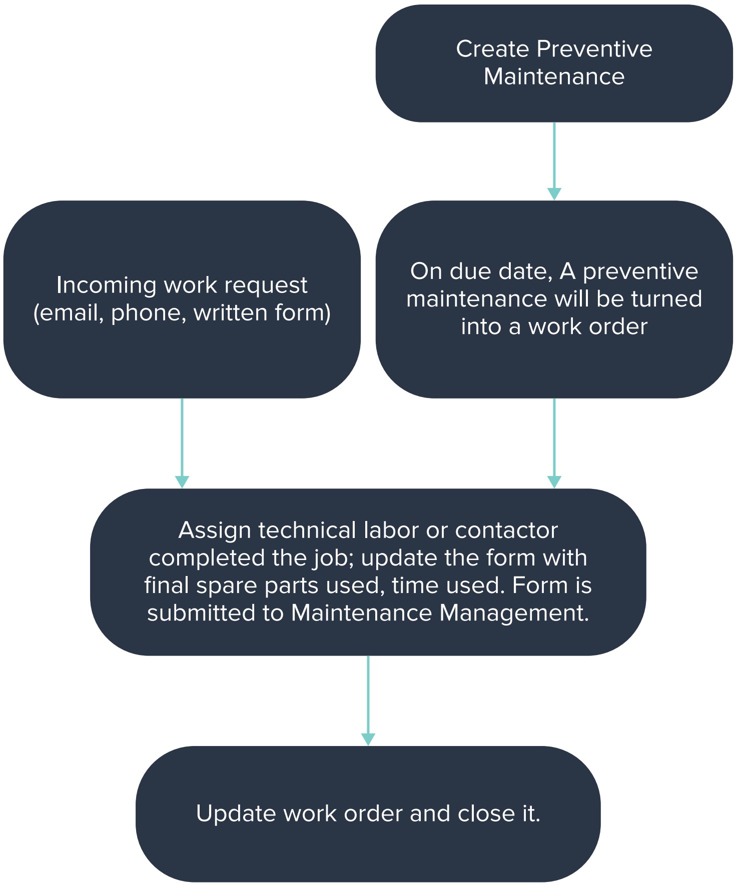
Energy efficiency strategy and savings

O&M is a process for managing the operation of systems and performing day-to-day operational activities. These are done to ensure a proper facility function and that the initial energy savings are not undermined over time through improper use or inadequate maintenance. Hence, O&M practices help to achieve 5-20 percent energy savings of a building's entire energy use, decrease comfort complaints, ensure the adequate operation of equipment until the end its planned or useful lifetimes, maintain acceptable indoor air quality, and provide safe working conditions for facility staff and occupants.

O&M activities are corrective, preventive, and predictive in nature. In most Lebanese public hospitals, the maintenance team is currently performing corrective maintenance and only acts on the spot when any equipment is damaged. There is no scheduled maintenance set as per the standard timeframe required for each item of equipment. Therefore, it is crucial to develop proper assets and maintenance management systems, which include mechanical, electrical, and plumbing equipment as well as biomedical equipment and furniture, to increase accountability and traceability.

This comprehensive maintenance management system can be done using Microsoft Excel sheets aiming to centralize maintenance information and to facilitate the processes of maintenance operations. This is done by organizing information on all assets, equipment, materials, and other resources and tagging each of them with a unique code that can be later processed using Excel-based tools or, ideally, using a computerized maintenance management system. Moreover, such an asset maintenance management system also organizes the opening and closing dynamic of work requests and work orders, which is currently non-existent in public health care facilities.

Figure 26: Workflow of maintenance management systems



The system can be used in Lebanese hospitals to solve numerous maintenance management problems, such as improving resource and labour management. In addition, it can help develop an asset and equipment registry to record manufacturers, models, serial numbers, equipment classes and types, location, performance, etc. Finally, the system traces work order management information, such as work order number, description, priority, type (repair, replace, schedule), cause and remedy codes, and personnel assigned.

Table 8: The advantages of implementing an asset maintenance management system

Description	Range of Savings (%)	Average %
Better scheduling: • Planning time per job decreases, resulting in more job plans produced, fewer backlogged jobs, and fewer breakdowns and emergency repairs. • Job scheduling is more efficient through the availability of reserve stores materials. Only jobs with materials available are scheduled, resulting in fewer schedule changes and reduced time spent by personnel waiting for materials. • Job planning is improved by the systems support data, which include planner backlog and status reports, quick recall of repetitious job plans, and computerized scheduling and historical job analysis.	5 to 12	8.5
Parts availibility: More productive time is assured through parts availability. When parts are not available, craft personnel not only idly await new assignments but also many times spend hours attempting to locate or even fabricate parts.	1 to 3	2
Machine availibility: Machine production time increases as the computer contributes to reduced emergency repair through the preventive maintenance programme. The ability of the system to automatically schedule preventive maintenance puts this valuable programme upfront and removes it from neglect.	0.5 to 2	1.25
Stores Inventory: The ability of the system to maintain moment-by-moment inventory levels, automatic ordering, and parts cross-referencing results in reduced inventory and fewer stockouts. The automatic cycle counts and updates inventory for efficient parts management.	10 to 20	15

EEM 03: Green procurement rationale

More than 70% of emissions from the health care sector are primarily derived from the health care supply chain[6] – the production, transport, use, and disposal of goods and services that the sector consumes. When deciding on products and services, health care organizations should consider not only cost effectiveness but also overall environmental footprint, staff and patient safety, and community impact.

[6] Health Care Without Harm & Arup (2019), "Health Care's Climate Footprint: How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action."

Hence, a **sustainable purchasing strategy** or **green procurement policy** is crucial in the Lebanon health care sector to guide hospitals in selecting and acquiring materials, technologies, equipment, and supplies based on their environmental and human health impacts.

Energy efficiency strategy and savings

In Lebanon the notion of green procurement is mostly absent in the health care sector. When equipment needs to upgrade, most public hospitals resort to the Council of Development and Reconstruction (CDR) or rely on donations. In such cases the procurement process is non-existent or is mostly based on specifications without regards to energy efficient standards.

Therefore, launching a systemic and regulated procurement process that meets sustainability and energy efficiency is a must, in addition to collaborating and partnering with donors to meet sustainability requirements.

Green procurement leverages the sector's purchasing power to drive demand for innovation and sustainable products. It also positions health care organizations as leaders and as responsive to community health and well-being. Sustainable procurement supports uninterrupted operations, as well as supporting design systems and supply chains to withstand health and environmental emergencies. Green purchasing maximizes budgets through streamlined processes and efficient resource and labour management and helps in cost savings. This policy minimizes environmental impacts, including the carbon footprint of products and services used to deliver health care, while prioritizing the use of safer products for the benefit of patients, health care workers, and communities. Finally, sustainable procurement encourages investment in diverse and local suppliers to reduce inequities across the supply chain.

The implementation strategy for a green procurement policy is based on the following principles:

- Integration of environmental performance considerations in existing procurement processes, policies, procedures, tools, and instruments using life-cycle analysis in the context of achieving value for money.
- Monitoring and reporting (e.g., through reports on plans and priorities and departmental performance reports) to support continuous improvement in the integration of environmental performance in procurement.
- A coordinated government-wide approach to optimize information-sharing, consistency, and performance measurement.

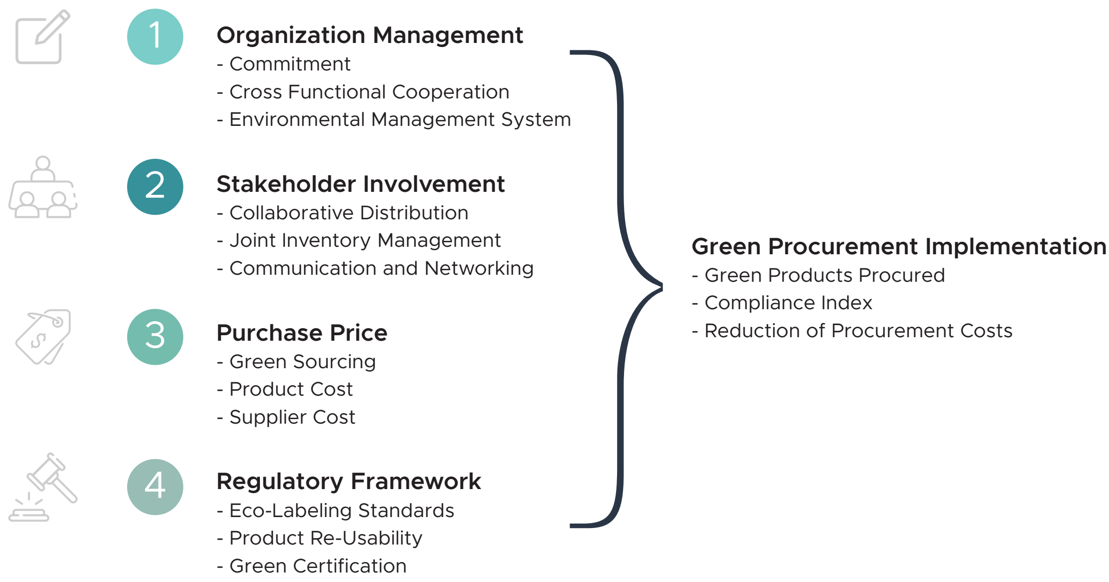
Implementation activities are focused on three key areas:

• Inclusion of environmental specifications and evaluation criteria in centrally managed procurement in the CDR and donating parties.

• Development and sharing of green procurement information and tools, such as guidelines and training.

• Systemic integration of environmental performance in the procurement decision-making processes in the health care sector.

Figure 27: Green procurement framework



EEM 04: Lighting load management rationale

During energy field audits several electrical loads were seen to be operating unnecessarily. Lighting loads represent an easy win in any operational savings strategy. In fact, in some areas enforcing lighting control would help save energy and reduce maintenance costs. This measure can only be implemented with the combined efforts of housekeeping and maintenance departments.

Substantial energy savings can be obtained from switching off the lighting in unused areas. These savings can reach more than 50 percent of the lighting energy consumption in the targeted areas.

Efficiency action and energy savings

a. In empty patient rooms

Patient rooms in Lebanese hospitals do not have key card controls or any other control method except a manual switch. When patients leave rooms, housekeeping should clean the room and turn off all lights when finished.

b. In storage areas and mechanical rooms

Most storage and technical rooms have their lighting operating all the time.
While a motion detector can solve this issue, an employee awareness programme can also help in immediately reducing energy waste.

c. In other departments

Some hospitals departments such as laboratories, medical imaging, dialysis, etc. have precise operating hours. Hence, it is important to turn off the lights in these zones when not occupied.

EEM 05: Free cooling rationale

Free cooling is the process of using the external ambient temperature to reject heat, rather than using the refrigeration process. If used within an optimised system, free cooling can provide significant energy savings.

Depending on the climatic conditions, free cooling can be used when outdoor temperature reaches a threshold of 15 to 17°C and hospitals can use the concept of free cooling across their premises, especially those located in mid and high altitudes.

Efficiency action and energy savings

When outdoor temperatures are relatively low in winter months or in night times, cooling demand drops across buildings; and if the buildings are equipped with the appropriate systems, they can benefit from free cooling.

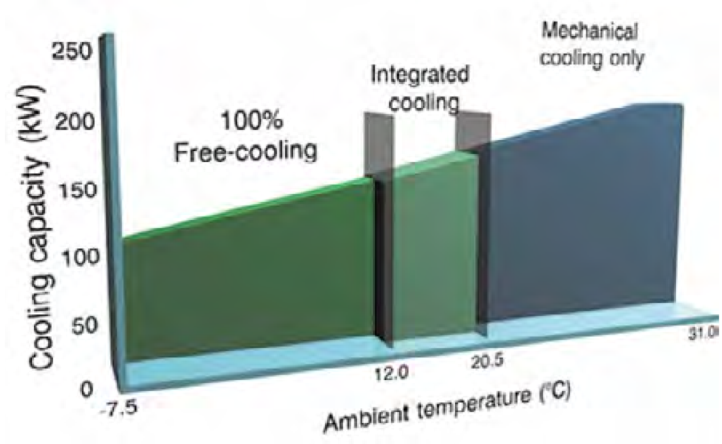
In actual practice, free cooling is not entirely free, because pumps, fans, and other air/water-handling equipment is needed, and that equipment also requires periodic repairs and maintenance.

As noted above, free cooling application depends on the existing HVAC equipment configuration. Potentially, the following scenarios can be applied:

- Whenever there is a chilled water system with air handling units, the latter can have the fresh air dampers open 100 percent with the cooling coils closed, and subsequently the chillers and their pumps will be shut off
- If a chiller has a free cooling mode, the compressors can be shut off and the water circuit will then run through the air heat exchanger mode.

In the case of Lebanese hospitals, free cooling can be used mainly in climatic zones 2, 3, and 4, during the period extending from October to April, and even in zone 1 during peak winter months. But most importantly, whenever the ambient temperature is below 15°C.

Figure 28: Free cooling vs mechanical cooling



Overall savings resulting from this measure are estimated at an average of 85 percent of total chillers electricity consumption in the winter season.

EEM 06: Chilled water pipes insulation rationale

To ensure efficient space cooling in a chilled water system, it is crucial to check both the chilled water production and its distribution. Accordingly, even when chillers in hospitals work properly, the chilled water network needs to be checked thoroughly – and specifically the status of the related pipes' insulations.

Efficiency action and energy savings

Chilled water systems play an important role in meeting the cooling needs of commercial and institutional facilities. Given that chilled water pipes operate below ambient temperatures, proper insulation can protect these pipes from moisture and condensation problems, such as corrosion and mold growth. Adequate insulation can also safeguard against heat gain, which would otherwise minimize the cooling system's efficiency.

Chilled water pipes are especially prone to moisture intrusion, that is, the condensation of vapor on the surface of the pipe. This happens because of the temperature difference between the chilled water pipes and the surrounding environment. Vapor condensation and formation of moisture on the surface of the piping network can result in a number of problems. First, moisture forms mold and mildew. This not only diminishes the efficiency of the cooling system but also poses significant health risks to facility workers. Second, moisture causes piping to corrode and deteriorate faster. A malfunctioning or inefficient chilled water system has serious implications, especially in facilities where round-the-clock cooling of spaces or processes is crucial.

The formation of a single spot of rust or mold can spread quickly to affect the entire piping system. Selection and installation of the right insulation material can mitigate such damage and prolong the service life of your facility's chilled water system.

Types of chilled water system insulation

Contractors use several materials to insulate chilled water pipes, the most common of which are fiberglass and polyurethane foam.

Fiberglass is among the most cost-effective insulators when compared with other materials that deliver the same degree of thermal resistance. Fiberglass is also fire and moisture resistant.

Commonly known as spray foam insulation, polyurethane foam has a comparably higher R-value or thermal resistance. This safeguards chilled water piping against heat gains that can minimize the efficiency of the cooling system.

Generally, contractors need to make crucial design considerations to ensure proper installation of chilled water system insulation. Some important considerations include:

- Minimum insulation thickness: The right thickness will prevent condensation.
- Insulation material: The choice of insulation material will depend on factors such as the ambient temperature and the design of the piping network.
- Environment: High traffic and high maintenance areas need a different type of insulation system than less exposed areas of a building.

Figure 29: Fiberglass (left) and polyurethane (right) insulations

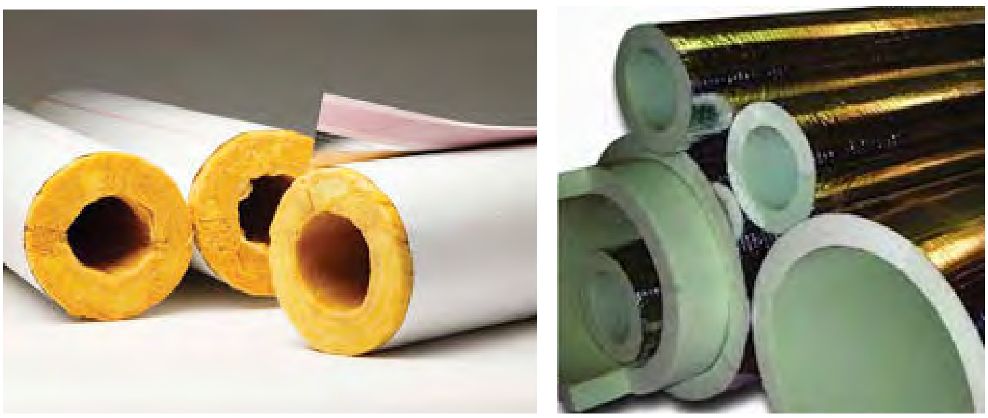


Table 9 provides guidance for chilled water pipe insulation thickness.

Table 9: Chilled water pipe insulation thickness

FLUID OPERATING TEMPERA-TURE RANGE (°F)	INSULATION CONDUCTIVITY			NOMINAL PIPE DIAMETER (in inches)						
				< 1		1 to < 1.5		1.5 to < 4	4 to < 8	8 and larger
	Conductivity (in Btu-in/h per ft² °F)	Mean Rating Temperature (°C)		INSULATION THICKNESS REQUIRED (in inches)						
Space cooling systems (chilled water refrigerant and brine)				Minimum pipe insulation required (Thickness in inches or R-value)[1]						
5-15	0.21-0.27	23	Inches	0.5	0.75	0.5	0.75	1	1	1
			R-value	R3	R6	R3	R5	R7	R6	R5
Below 5	0.20-0.26	10	Inches	1		1.5		1.5	1.5	1.5
			R-value	R8.5		R14		R12	R10	R9

[1] These thickness are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation

(Source: American Society of Heating, Refrigerating, and Air-Conditioning Engineers [ASHRAE] Standard 90.1)

EEM-07: Hot water network insulation and steam leakage mitigation rationale

Proper hot water and steam lines insulation is extremely important in preventing thermal losses and increasing the efficiency of systems, resulting in improved energy consumption. These thermal losses can be identified during routine maintenance practices performed on the hot water and steam networks through thermal imaging.

Efficiency action and energy savings

Pipe insulation

Hot water and steam pipes insulations in hospital facilities should be regularly checked and maintained. By repairing such insulation, heat loss can be reduced by more than half in the damaged areas, which would directly lead to an increase in the supplied temperature by 1°C to 2°C and the related reduction in energy consumed to produce hot water. Heat loss from un-insulated horizontal pipes with ambient temperatures between 10°C and 21°C are described in Table 10.

Table 10: Heat losses from horizontal pipes with ambient temperature

Temp Diff Steam to Air (°C)	15 mm	20 mm	25 mm	32 mm	40 mm	50 mm	65 mm	80 mm	100 mm	150 mm
	W/m									
56	54	65	79	103	108	132	155	188	233	324
67	68	82	100	122	136	168	198	236	296	410
78	83	100	122	149	166	203	241	298	360	500
89	99	120	146	179	205	246	289	346	434	601
100	116	140	169	208	234	285	337	400	501	696
111	134	164	198	241	271	334	392	469	598	816
125	159	191	233	285	321	394	464	555	698	969
139	184	224	272	333	373	458	540	622	815	1133
153	210	255	312	382	429	528	623	747	939	1305
167	241	292	357	437	489	602	713	838	1093	1492
180	274	329	408	494	556	676	808	959	1190	1660
194	309	372	461	566	634	758	909	1080	1303	1852

When comparing flanges and valves to un-insulated pipes, the results are:

1. Each un-insulated bare flange is equivalent to 0.3 metres of un-insulated same size pipe.
2. Each un-insulated valve is equivalent to 1.5 metres of un-insulated same size pipe.

From the length and number of flange and valve, the estimation of heat loss from different pipes can be made using the values of Table 9.

Fiberglass and cellular glass are common choices for steam pipe insulation as both can handle high temperatures and provide good insulation value. As for hot water pipes, polyethylene foam is usually used to reduce heat losses and provide good performance.

Table 11 provides general guidance on hot water and steam pipe insulation thickness.

Table 11: Hot water and steam pipe insulation thickness

FLUID OPERATING TEMPERA-TURE RANGE (°F)	INSULATION CONDUCTIVITY			NOMINAL PIPE DIAMETER (in inches)				
				< 1	1 to < 1.5	1.5 to < 4	4 to < 8	8 & larger
	Conductivity (in Btu-in/h per ft² °F)	Mean Rating Temperature (°F)		INSULATION THICKNESS REQUIRED (in inches)				
Space heating, service water heating systems steam, steam condensate refrigerant, space heating, service hot water)				Minimum pipe insulation required (Thickness in inches or R-value)				
Above 350	0.32-0.34	250	Inches	4.5	5	5	5	5
			R-value	R37	R41	R37	R27	R23
251-350	0.29-0.32	200	Inches	3	4	4.5	4.5	4.5
			R-value	R24	R34	R35	R26	R22
201-250	0.27-0.30	150	Inches	2.5	2.5	2.5	3	3
			R-value	R21	R20	R17.5	R17	R 14.5
141-200	0.25-0.29	125	Inches	1.5	1.5	2	2	2
			R-value	R11.5	R11	R14	R11	R10
105-140	0.22-0.28	100	Inches	1	1.5	1.5	1.5	1.5
			R-value	R7.1	R12.5	R11	R9	R8

(Source: ASHRAE Standard 90.1)

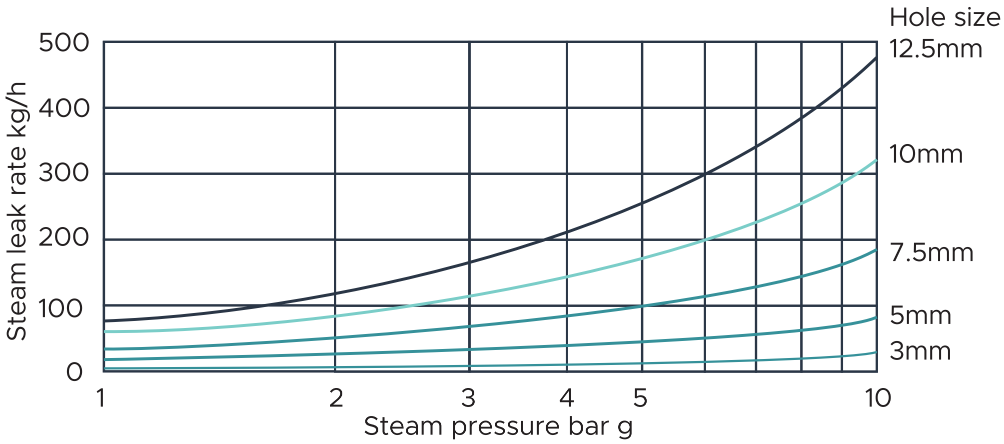
Steam leakage mitigation

Steam leaks have multiple negative effects on steam-based plant operations, including energy loss, increased emissions, decreased reliability, production issues, and safety. In fact, due to the high cost of these energy losses, the correction of steam leaks offers very lucrative paybacks.

Figure 31 shows the steam pipe leakage rate at different levels of steam pressure and hole sizes.

Figure 30: Steam leakage

Figure 31: Steam leakage rate



Steam traps testing

Steam traps are a type of automatic valve that filters out condensate steam and non-condensable gases such as air without letting steam escape. And like all mechanical devices, they are subject to wear that will eventually require maintenance to prevent steam leakage and blocked condensate discharge (i.e., cold traps).

Given thermal energy costs, it is highly important to have a proactive steam trap testing programme. A steam trap failure rate must be lower than 3 percent annually. Several methods are used to test the operating condition of a steam trap to determine if it is working properly, including visual observation, measuring temperature, measuring sound/vibrations or ultrasound, and some combination of these methods.

1. Testing traps through visual observation

Visual observation is an important first step in determining the proper trap operation in an open system. Certain visual signs such as the lack of any condensate discharge or extremely large quantities of steam leaking out of a trap may indicate the need for trap repair. However, when recovering condensate in a closed piping system, the piping will prevent performing visual diagnosis, and thus installing a sight glass at the trap's outlet may help provide a visual indication.

2. Testing traps using temperature

Temperature can be extremely useful when trying to determine if a trap is blocked and/or if its capacity is insufficient. Measuring the trap's inlet condensate temperature is the first step in the process of testing for steam trap failure. If the temperature is significantly lower and the application is 'in service', the low reading generally indicates an undersized trap, incorrect pressure orifice for the trap, a blocked trap/strainer discharge failure, or possibly a negative pressure differential condition in the case of equipment being supplied through a modulating control valve.

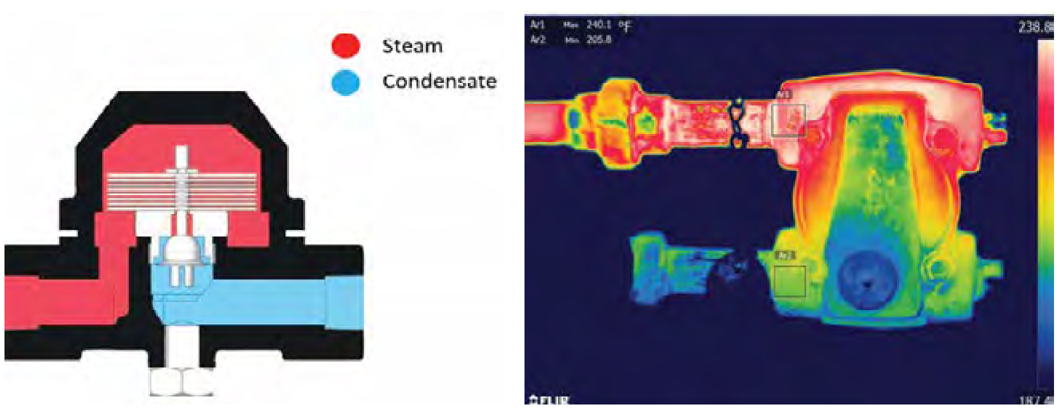
3. Testing traps using sound

Condensate flowing through a trap produces sound and vibration, and so does the opening and closing valve mechanism of most traps. When a trap is no longer operating as intended (from wear, blockage, or some other reason) these sounds will often change. Recognizing this difference can be one method of assessing a steam trap's condition.

A steam trap testing programme will accomplish:

- Reduce energy losses
- Increase system reliability
- Keep failure rates below 3 percent annually
- Decrease combustions emissions
- Improve steam quality.

Figure 32: Steam trap schematic (left) and infrared image (right)



An alternative for large systems could be the installation of sensors as part of the trap or as a separate chamber. These sensors are capable of distinguishing between steam and condensate and give indication about the operation of traps. As Figure 33 shows, If the steam trap is operating correctly, the sensor will be immersed in hot condensate; if the steam trap is leaking, it will be immersed in steam; and finally if the steam trap is blocked, the sensor will be immersed in cool condensate. As the sensor is permanently fitted in the heart of the trap, it is continually alert to any trap malfunction.

Figure 33: Sensor indications

The cost of ignoring leaking steam traps

Steam leaks are both financially and environmentally costly and thus need prompt attention to ensure that the steam system is working at its optimum efficiency with a minimum environmental impact. For each litre of heavy fuel oil burned unnecessarily to compensate for a steam leak, approximately 3 kg of CO_2 are emitted to the atmosphere. Steam traps can have different sized orifices to suit different conditions. If a trap leaks steam, the amount wasted will depend on the size of the trap and the steam pressure. The cost of waste will also depend on the number of traps and the operating time, as shown in Table 12.

Table 12: Typical steam wastage & annual costs due to leaking steam traps

Trap size	Average orifice size in steam traps (mm)	Steam loss (kg/h)			Typical annual cost £000s		
		6 bar g	14 bar g	32 bar g	6 bar g	14 bar g	32 bar g
DN 15	3	8	19	43	13	32	72
DN 20	5	24	53	119	40	89	200
DN 25	7.5	55	121	270	92	203	453
DN 40	10	98	214	478	164	359	802
DN 50	12.5	152	335	747	255	562	1254

The cost of ignoring blocked steam traps

Water will not be removed from the process, with the result that both safety and performance are compromised. In the case of the latter, the cost will depend on the process. In the case of the former the cost can prove incalculable.

5.1.2. CAPEX EEMs

CAPEX are energy efficient measures that require a certain level of capital investment for these solutions to be implemented.

EEM 08: Building envelope improvement rationale

The building envelope includes all elements of the outer shell and is a major component of a building's energy performance and the physical separator between conditioned and unconditioned environments. Its function is mainly to resist heat, cold, and noise transfer.

A building envelope is considered inefficient when it allows high rates of heat transfer between interior spaces and the outdoor environment. Completely eliminating heat gain and heat loss is not possible, but they can be minimized to improve efficiency.

If a building envelope has poor performance, there are two possible causes. Both issues may be found together in the same building, increasing energy waste:

• Deficient insulation
• Air leakage

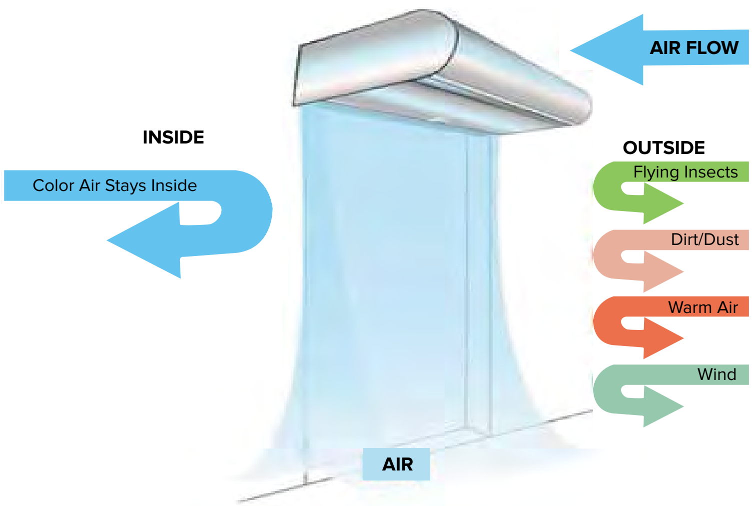
When a building is poorly insulated, much heat is conduction through the roof, walls, windows, and floor slabs, which translates into heat gains during the summer, and heat losses during the winter. The insulation level is normally measured with the R-Value, which describes heat flow resistance per unit of area. For example, a building with R-20 insulation loses 75 percent less heat than an identical building with R-5 insulation. Air leaks increase heat transfer differently, but the effect on energy consumption is the same. The loss of cool air increases air conditioning costs in summer, while the loss of warm air increases heating costs in winter.

Efficiency action and energy savings

Entrance insulation

Air curtains (Figure 34) are machines used for separating two spaces from each other, usually placed at doorways. The most common configuration for air curtains is a downward-facing fan mounted over entrances to prevent winter cold air, summer warm air, wind draughts, pollution, fumes, pest, and insects from coming inside the facility. The fan must be powerful enough to generate a jet that can reach the floor.

Figure 34: Example of air curtains application during summer



Glazed windows

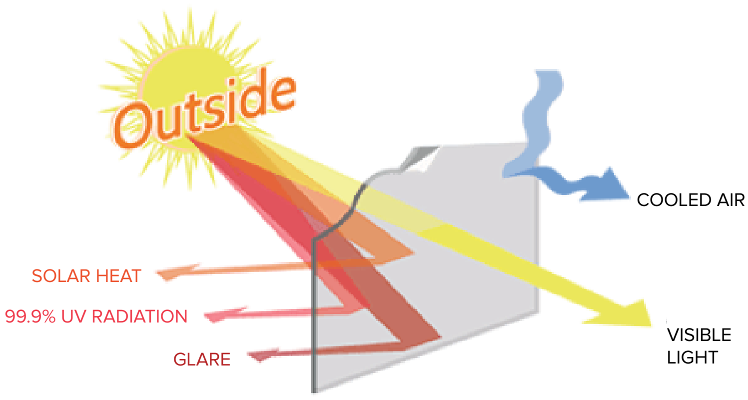
Glazing properties can highly affect the amount and quality of daylight as well as the amount of solar heat gain that is permitted into the building. It allows visible light into the room, air infiltration, and condensation, which highly influences the cooling and heating demands of the internal space. To improve the efficiency of the glazed windows two opportunities can be followed:

- Installing sun control windows film to reduce the heat gain from the glazed windows and doors.
- Retrofit all windows and doors with double glazed.

1. Sun control window film

As the window-to-wall ratio increases in a facility, it is advisable to install sun control window films (Figure 35) regardless of the climatic zone location. Accordingly, sun control films provide great energy efficiency opportunities and are a cheaper alternative than installing special glass.

Figure 35: Sun control window film



Great energy savings are possible by preventing heat gains and losses. Unlike drapes and blinds, specialized films reject up to 79% of the heat that would otherwise come through the window while allowing for the high transmission of natural light into the space. This is translated into savings of about one ton of air conditioning for every 100 square feet of glass exposed to sunlight. Sun control windows films block out 98–99 percent of UV light, thus protecting the occupants from the sun's harmful rays. In addition, they can reduce glare to improve indoor visibility and greater eye comfort while using computer monitors and televisions. Finally, sun control window films improve safety and security by making glass harder to penetrate and by holding shattered pieces in place.

2. Double-glazed windows

Installing double-glazed windows improves the performance of building envelope. The double glazing consists of two layers of glass with a layer of inert gas sealed between them (Figure 36), thus providing nearly twice the insulation as single-glazed units. Once sealed, the unit becomes airtight. Double-glazed windows present several advantages:

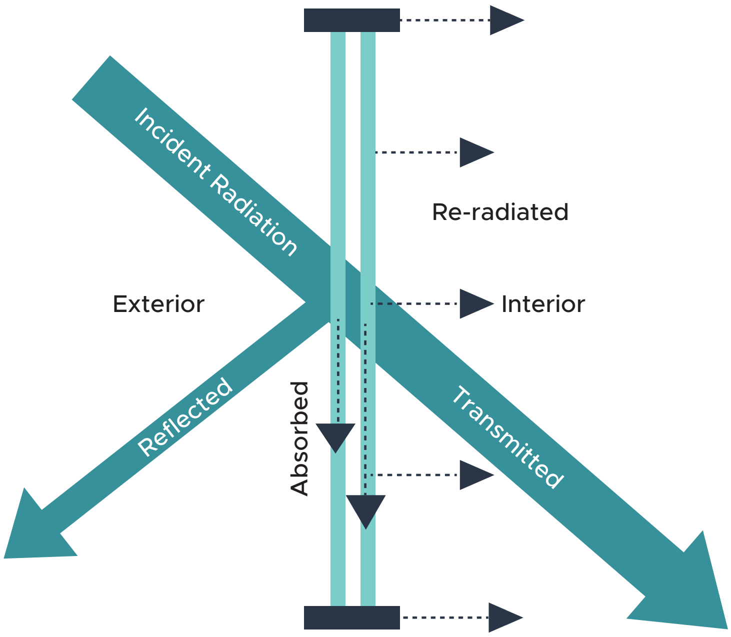
• **Energy cost savings:** The airtight construction of double-glazed windows provides thermal insulation by reducing the flow of incoming and outgoing heat. Therefore, less energy is used to heat up or cool down the space, resulting in lower energy bills.
Adding a third or fourth layer of glass increases the insulation value of windows, where each layer of glass traps a significant amount of heat that passes through and increases the windows protection against heat loss.

• **Limited condensation:** The improved thermal insulation helps to keep the glass and the surrounding air temperature at about the same level, therefore there is less of a chance for moisture to form on the glass surfaces and thus prevents condensation.

• **Sound insulation:** Double-glazed windows improve sound insulation by creating a barrier between the internal space and the environment outside.

• **Safety:** Double-glazed windows are harder to break than single-pane windows, so they increase the security of institutions.

Figure 36: Double-glazed windows solar radiation



In retrofitting windows glazing, it is important to check the thermal transmittance of the glazing to minimize heat gain.

Table 13 provides the maximum thermal transmittance allowable for vertical glazing components based on climatic zones.

Table 13: Maximum thermal transmittance allowable for glazing by climatic zone

Climatic Zone	Maximum U-value (W/m2.K)
Vertical Glazing	
Zone 1: Coastal	6.2
Zone 2: Western Mid-Mountain	4.3
Zone 3: Inland Plateau	4.3
Zone 4: High Mountain	2.8

(Source: Thermal standard for buildings in Lebanon, 2010)

EEM 09: Lighting retrofit rationale

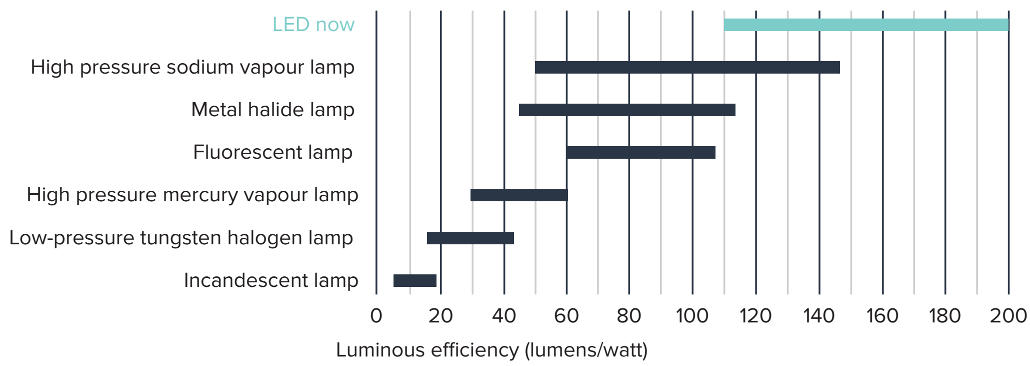
Lighting applications in hospitals are wide and varied given that different areas with their own specific purpose have different requirements. For example, ward areas, treatment areas, observation areas, examination rooms, waiting and circulation spaces, and operating theatres each have different lighting requirements and require specific design criteria. In addition to functionality, hospital lighting also aids in improving patient care and comfort. There are three main parameters to be considered in hospital lighting retrofits: lighting level, colour rendering index, and colour temperature.

Efficiency action and energy savings

Hospitals require lighting 24 hours per day, 365 days per year. Therefore, it is important for health care facilities to revert to LED lighting when planning a retrofit or replacement of existing lighting fixtures. LED is the only light source that satisfies all the criteria in terms of efficiency, colour rendering index (CRI), correlated colour temperature (CCT), and lamp life.

As Figure 37 shows, LED fixtures offer the best lighting technology available in terms of efficacy, with savings of 30 – 90 percent. Moreover, LEDs have a longer lamp life (40,000 to 60,000 hours).

Figure 37: Lighting technology efficacy (lumens/watt)



Adequate lighting levels are crucial in health care facilities, as they have a direct impact on patient health and mood and on limiting energy consumption. Table 14 presents the ASHRAE Standard 90.1–2004 of the recommended minimum illumination (Lux) levels in hospitals. The following values can be easily covered by LED fixtures.

Table 14: Illumination levels in hospitals

Area	Recommended min. illumination(Lux)
Bathroom	100 - 150
Entrance hall	200
Consultation room	100
Corridor, general	300
Ward	150 - 300
Delivery room	400
Diagnostic X ray, work place	300
Doctors' offices	300
Enquiry office	500
Nursing station (day)	300
Nursing station (night)	30 - 100
Kitchen	300
Laboratory, Pathology	300 - 500
Maternity department	400
Operating theatre	10,000 - 50,000
Store	100
Pharmacy	300
Scrub room, operating rooms	300
Mortuary	200

Source: ASHRAE/IESNA Standard 90.1.2004

Moreover, LED has an excellent CRI, reaching 70 to 100 CRI. Finally, it is important to include a good CCT to provide eye comfort, which is also addressed by LED technologies.

Table 15: Colour temperature ranges

Temperature (K)	Colour	Description
2000 - 3500	Orange/Yellow	Ultra Warm or Warm White
3500 - 5000	Paper White	Natural/Neutral White
5100 - 6500	Bluish White	Cool White

(Source: Montes de Oca, 2017)

EEM 10: Lighting control rationale

The concept of lighting control is based on managing lighting loads across various areas of a property through human manual control or the introduction of specific technologies. It provides a major opportunity for any facility to reduce its overall lighting energy consumption. Lighting control examples are time control, daylight control, and occupancy control.

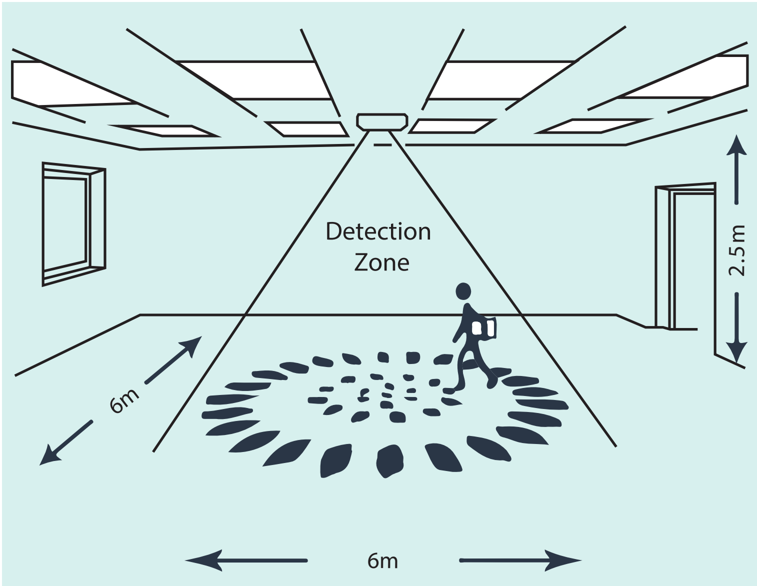
The recommended control strategies in health care facilities are the following:

- Motion detectors
- Daylight controller

Efficiency action and energy savings motion detectors

The installation of motion detectors is especially beneficial in bathrooms, stairwells, private offices, private examination rooms, supply closets, break areas, low-traffic corridors, and parking garages and lots. Motion detectors shut the controlled lights OFF when the space is vacant and will put them ON when they sense a human presence, which can typically provide more than a 20 percent energy savings in areas that are partly unoccupied during the day. Their installation is rather easy, and the average objective is to control 70 - 85 percent of the total lighting fixtures of the controlled area.

Figure 38: Motion detector coverage area



The occupancy sensor installed in the area can detect any human motion with an angle of 0° to 360° (Figure 38). The occupancy sensor used includes a feature that holds the lighting systems off when natural light levels are above a pre-set level.

Daylight controller

By installing a daylight controller (photocell) in common areas and patients' rooms, it is possible to continuously measure the ambient light levels. Daylight controllers shut down the light during the day and turn it ON during night time. This system can control all the external parking, pole, and peripheral lights.

EEM 11: Chiller plant retrofit and air quality improvement rationale

Many hospitals in Lebanon were originally designed to have a chilled water system through chillers and air handling units for space cooling and fresh air intake for adequate indoor air quality. Due to poor maintenance, however, this system stopped operation and facilities have reverted to the installation of split units as a cooling energy source. Although split units meet the cooling demand, they do not have the ability to provide the fresh air required for proper indoor air quality levels. The present situation is far from ideal from both an energy efficiency and indoor air quality perspective.

Generally, air conditioning in hospitals can play a role beyond the promotion of comfort. In many cases, proper air conditioning is a factor in improving patient therapy. Cooling recirculated air is not enough to remove higher airborne concentrations of infectious viruses and bacteria. It is therefore recommended to increase outside air intake to the maximum allowable level to enhance the mixing and elimination of recirculating air.

Corridors having natural ventilation present a free source of fresh air and help reduce indoor concentrations of indoor-generated air pollutants. However, natural ventilation is not always effective. Intentional openings cannot always guarantee adequate temperature and humidity control or indoor air quality. Ideally, hospitals should have a central chilled water system with the proper control. The present EEM covers the prospect of upgrading the chilled water plants present in the majority of public hospitals and removing existing split units.

Efficiency action and energy savings

The main target of upgrading the chilled water systems is to provide air conditioning to all the hospital spaces by supplying conditioned air that is free of dust, dirt, odor, and chemical and radioactive pollutants. Central chilled water systems provide a platform based on the temperature setting and predefined schedules that offer optimal energy consumption while maintaining thermal comfort. The process that should be followed to retrofit chiller plants is discussed next.

Cooling load calculation

It is crucial to readjust the cooling load calculation, especially during peak demand. This exercise will guide the consultants in making a better selection for the chiller plant in terms of capacity and features.

Testing, adjusting, balancing, and commissioning

Testing is a crucial step to be completed prior to remodelling. In fact, testing, adjusting, and balancing will provide the designer/consultant with information on the actual system performance and whether components are suitable for the intended modifications, as well as disclosing additional necessary modifications. Table 16 provides a guide to water testing and the balancing procedure to achieve it.

Table 16: Water balancing procedure

Preparation procedure	Test and balance procedure
1. Air balance should be completed before water balance begins.	1. Set chilled water pumps to proper flow.
2. Open all valves to full open position. Close coil bypass and stop valves. Set mixing valves to full coil flow.	2. Adjust chilled water flow through chillers.
3. Verify that the responsible parties have removed and cleaned all strainers.	3. Check leaving water and entering water temperatures through chillers. Reset to correct design temperatures.
4. Examine the water in the system and determine if water has been treated and cleaned.	4. Check water temperatures at the inlet side of cooling coils. Note any rise or drop of temperatures from the source.
5. Check chilled water pumps rotation.	5. Proceed to balance each cooling coil.
6. Check expansion tanks to determine they are not air bound and the system is completely full of water.	6. Upon completion of low readings and adjustments at coils, mark settings and record data.
7. Check all vents at high points of a chilled water system and determine all are operating freely.	7. After adjustments to the coil are made, recheck the settings at the chilled water pumps and chillers and readjust if required.
8. Set all temperature controls so all coils are calling for full cooling.	8. With full flow through the bypass, set the pressure drop across the bypass valve to match the coil flow pressure drop. This prevents unbalanced flow conditions when coils are on bypass. The same procedure must be applied on chillers to adjust chillers' bypass valves.
9. Check operation of automatic bypass valves.	9. Record and check pressure drop on each cooling coil and across bypass valves.
10. Check and set temperatures of chillers to design requirements.	10. Chilled water pumps operating suction and discharge pressures and final THD

Chillers retrofit

Following the calculation of the cooling demand, the sizing of the chillers could be finalized & the specifications for the new chillers can be completed.

The recommended key specifications are as follows:

• For resilience purposes, chillers should be installed in a N+1 topology, with 1 duty chiller and 1 standby chiller to allow for continuous operation of the system in case of any component failure.

• Chillers should have 2 to 3 compressors with variable frequency drives (VFD).

• Choose high-efficiency chillers with a minimum energy efficiency ratio (EER) of 3.3 with a minimum European Seasonal Energy Efficiency Ratio (ESEER) of 4.1.

By applying these key specifications, the cooling system efficiency increases and the related energy consumption will decrease by around 40%.

Air handling units (AHUs) rehabilitation

A functioning HVAC system is critical to proper ventilation. These systems work around the clock to clean the air & prevent mold & bacteria from forming. They help keep employees healthy & productive while working to prevent Sick Building Syndrome. It is important to keep the following in mind while upgrading air handling units:

• All new AHUs should be classified with A+ efficiency.

• All AHUs should have their fans equipped with inverters (VFDs).

• All AHUs should use type-4 pipe to provide both cooling and heating – if hot water for space heating is available.

• All AHUs should be equipped with a modulating pressure independent valve on each coil (chilled and heating).

• New sensors, dampers, and accessories should be installed on AHUs and chillers to allow proper control and operation of the systems.

All the above-mentioned points will lead to substantial energy savings across the whole chilled water system.

Pumps retrofit

Select and install an adequate number of chilled water pumps – primary only circuit-equipped with variable speed chilled water pumps.

Re-commissioning

When needed, execute full flushing of existing piping and retrofit the damaged piping sections with new insulation – mainly the pipes with direct exposure on the roof.

End-user control

Upgrade thermostats in rooms and connect them to the control platform.

Central control

Connect the chiller plant to a control platform: chiller plant manager or BMS platform. The platform should have many features, such as chilled water temperature setting, scheduling, and chilled water pumps automation.

EEM 12: Convert constant primary chilled water flow to variable primary flow rationale

Most of Lebanon's public hospitals with chilled water plants have a constant primary chilled water flow configuration. Converting constant primary chilled water flow to variable primary flow is crucial to achieve reductions in the absorbed pumping power that are realized when a heating or cooling system runs under 2-way control with variable speed pumps. This entails reductions in the total operating costs.

Efficiency action

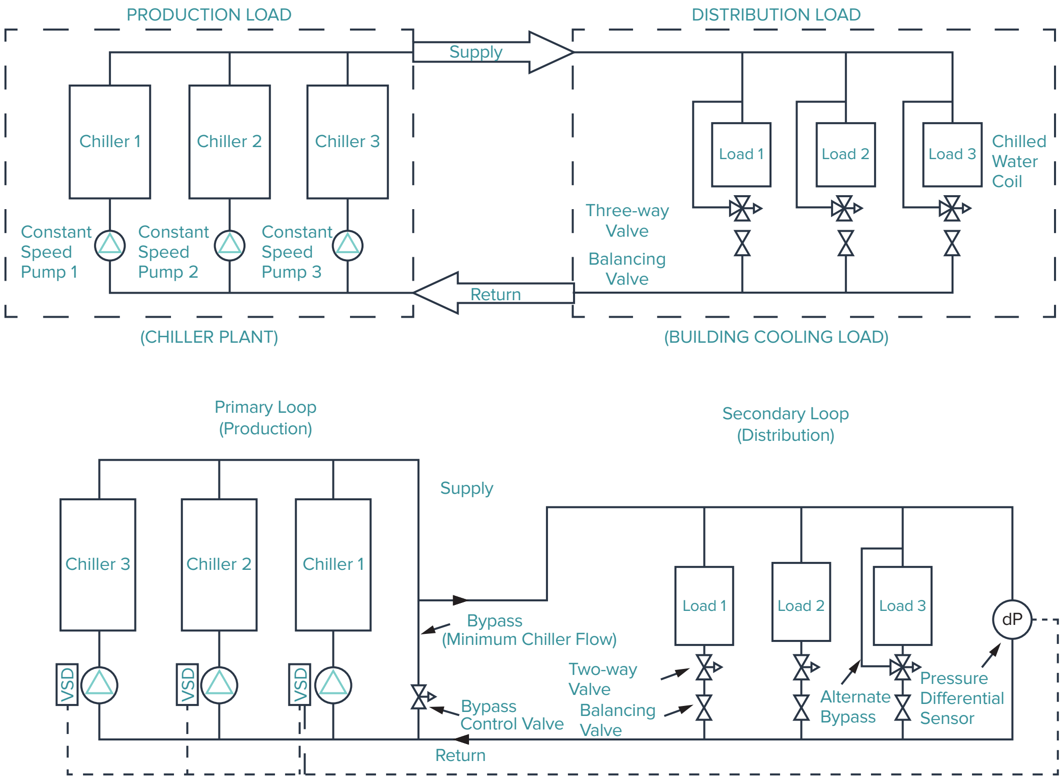
The hydronic system of the chiller plant should be reviewed according to the new requirements to include the following steps:

Turn the system from a Primary Constant Flow to a Primary Variable Flow by equipping the pumps by VFD and converting all the 3-way valves to 2-way valves.

- The current state of the art variable flow energy-saving pumping systems use 2-way motorized control valves and are installed without a bypass line. Existing valves shall be reviewed if they can be converted or if they need to be replaced.
- The conversion can be done by closing the regulating valve in the bypass line. When the 3-way valve modulates, it attempts to divert the flow around the load and through the bypass, but it will restrict the flow rate instead. If this is not possible, a new 2-way valve shall be installed.

Figure 39 shows the difference between the primary constant flow and the primary variable flow.

Figure 39: Conversion from constant (top) to variable flow (bottom)



EEM 13: Variable refrigeration flow (VRF) in replacement of split units rationale

As mentioned earlier, the majority of Lebanese public hospitals were designed to have a chilled water plant system. However, many hospitals have provided cooling by installing split units in their original design. In this case, it is more interesting for these facilities to replace the split units by a variable refrigeration flow system.

Efficiency action and energy savings

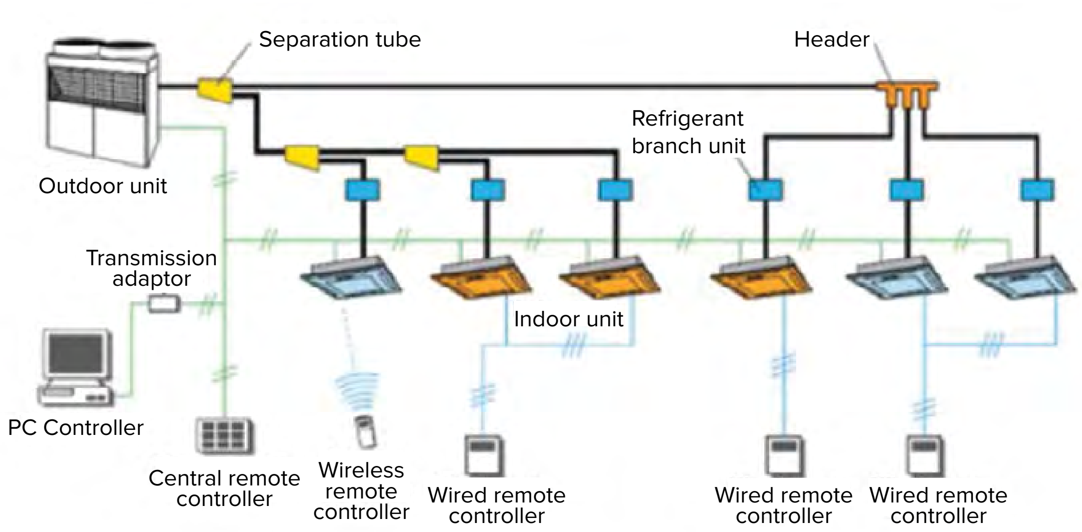
Hospitals opting for split units for cooling suffer from their degraded state, aging, and low coefficient of performance (COP). In addition, the split units are controlled manually within each space's occupancy instead of being automatically controlled by a central platform and based on the temperature setting and predefined schedules.

In this case, the VRF system is one of the best choices for air conditioning. It is equipped with an inverter technology and works based on a heat recovery system. The VRF continuously adjusts the flow of refrigerant to each indoor evaporator, allowing each one to have its own set of controls and permits it to simultaneously heat and cool a space, unlike AC split units' systems which can either cool or heat a space.

This application is especially beneficial for hospital facilities where different portions of the building need to be at consistently different temperatures. Each indoor unit will have its own programmable thermostat, which allows individuals to control temperature based on their comfort level critical for the facility operation.

The improved individual zone control permits the user to continuously adjust the temperature of the refrigerant to match the actual capacity and temperature required, which increases the seasonal efficiency and saves energy. Furthermore, VRF systems are space-saving, whereby one outdoor unit can be linked to several indoor units (Figure 40). VRF systems are also easy to install and can be adopted for any floor plan. They have a vast range of control systems with low operating sound design, and they also have auto-restart and auto swing functions. Finally, they are highly efficient and work with an average COP as high as 4.41.

Figure 40: Variable refrigeration flow system components



EEM 14: Installation of VFDs rationale

Cooling and HVAC fans represent the largest share of electrical consumption in Lebanon's hospitals. Implementing proactive speed control on fans and pumps can result in direct reductions in their corresponding electricity consumption as well as their chilled water demand. Therefore, expanding the variable frequency drive (Figure 41) installation in hospitals is crucial for increasing energy savings.

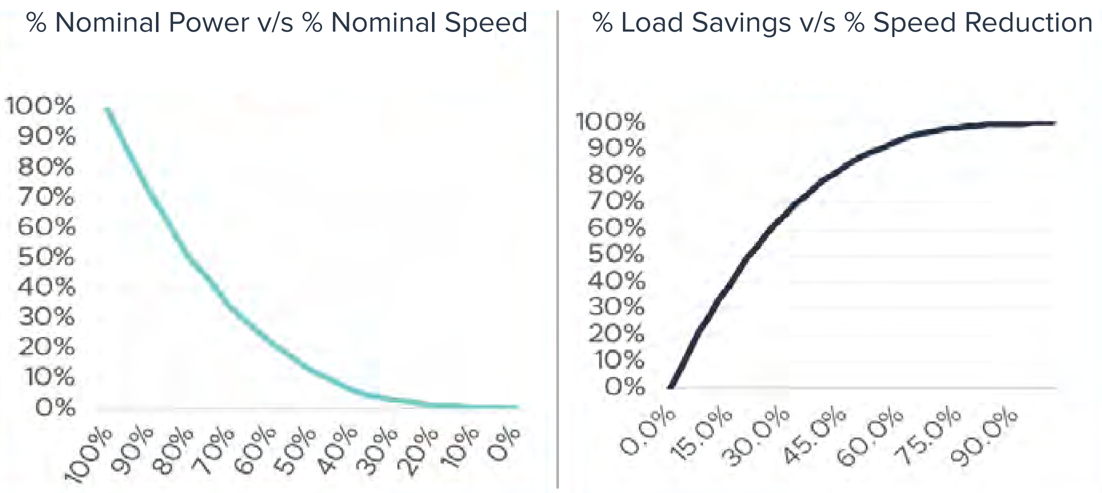
Figure 41: Variable frequency drives

Efficiency action and energy savings

The use of VFDs allows substantial energy savings when the speed reduction is well implemented in a proportional integral derivative/automatic loop or proactively changed manually or via a schedule time setting. As the graph in Figure 42 shows, a 10 percent speed reduction would lead to a 27 percent saving in the power used.

VFDs on HVAC fans can be installed on kitchen hoods, parking fans, fresh air and exhaust fans, in addition to the air handling units of constant air volume system or a proportional integral derivative loop.

Figure 42: Power and speed variations



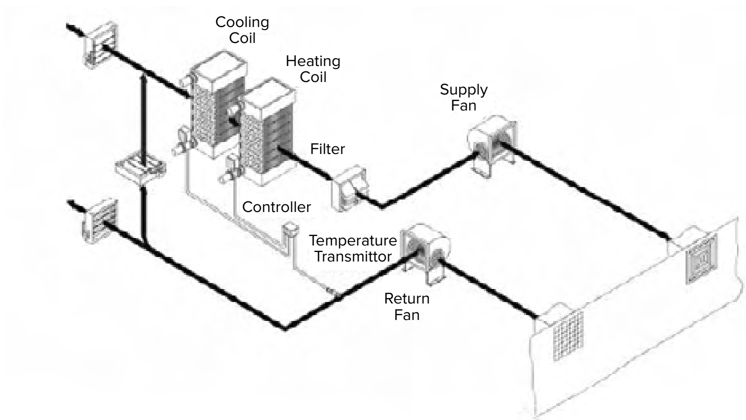
VFD application in constant air volume (CAV)

The majority of public hospitals with chilled water plants have traditional constant air volume systems, where air is conducted across cooling and heating coils and into the building ductwork. The return fan extracts air from the conditioned zone back to the air handling unit, where it is either re-circulated or exhausted outside. A temperature sensor in the return duct supplies signals to a controller for the heating and cooling coil valves. The valve controller regulates water flow to the coil to maintain the correct temperature in the conditioned space.

As per Figure 43, traditional single-zone CAV systems are designed to flood an area with conditioned air. As with most HVAC systems, CAV systems are designed for 'worst-case' demands. Consequently, they commonly waste energy relative to the needs of the building and do so for their entire operational life.

No airflow modulation method for system control is used other than the original balancing of the system, and control is limited to on/off.

Figure 43: Traditional CAV ventilation system



Installing VFDs on CAV systems can achieve the following:

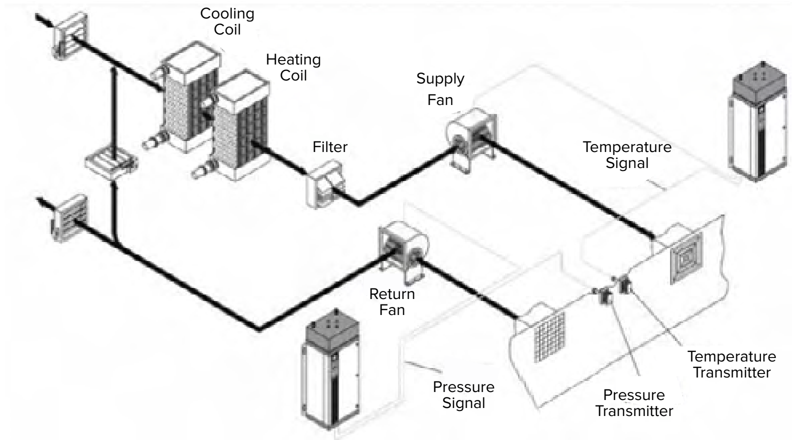
• CO_2 sensors can provide feedback signals to the drive, which allows efficient regulation of the building's HVAC system. When people leave a controlled area, the amount of fresh air needed is reduced. A sensor detects lower levels of CO_2 and, in response, the drive slows the supply fan's speed. A second drive, programmed to maintain either a room static pressure set-point (referenced to outdoors) or a fixed differential between the supply and return airflow, modulates the speed of the return fan to maintain system balance.

• In controlling for temperature, as the zone temperature satisfies the set-point, the drive reduces the supply fan speed to decrease the airflow. The energy used to run the fan is reduced.

Whether controlling for temperature or air quality, the drive regulates the CAV system (Figure 44) based upon the changing building conditions.

Therefore, it is recommended to install variable frequency drives to achieve significant energy savings. Motor wear and maintenance costs are also reduced, adding further savings.

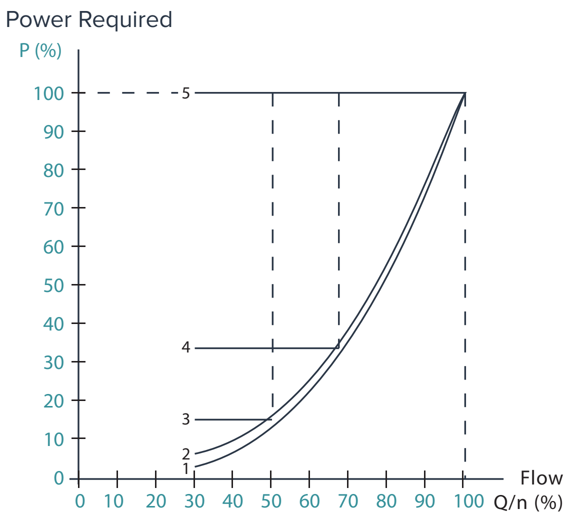
Figure 44: CAV ventilation system with adjusted VFD



Air quality is an important element in controlling a ventilation system. By programming a minimum output frequency in the drive, the desired amount of supply air is maintained independently of the feedback or reference signal. The drive can maintain a minimum speed to ensure fresh air intake or a minimum pressure at the diffusers. The return fan is frequently controlled to maintain a fixed differential in airflow between the supply and return.

Adjustable frequency drives with an internal proportional integral derivative controller eliminate the need for an additional external controller. Feedback from a sensor in either voltage (0 to 10 V) or current (0 or 4 to 20 mA) is used by the drive to control fan speed.

Figure 45: Variable speed curve



Many studies made on fans at different flows with and without VFD show a real energy savings of more than 68 percent with an adjustable frequency drive set for 30 percent minimum flow, compared to a constant speed fan. As for a flow of 70 percent for an AHU, it is assumed to have an energy saving of 35 percent.

VFD application in booster pumps

Similarly, VFDs should be applied on booster pumps. Booster pumps need to be sized to maintain the design pressure while experiencing the maximum expected flow at the lowest suction pressure to the pump. A pressure control valve is used to balance the system and maintain the desired pressure as the flow rate decreases or the suction pressure varies to avoid over pressurization and control problems. In instances where the flow requirements vary significantly, multiple pumps are placed in parallel. As water consumption changes, additional pumps are staged on or off to maintain the pressure.

VFDs can be added to pressure booster pumps as an alternative to using pressure control valves. This saves energy and eliminates maintenance costs. The VFD savings can amount to 20 percent or more, simply due to the safety factor used during the design of the system. If the suction pressure of the pump varies, the over-sizing of the pump required to handle the lowest suction pressure does not penalize the installation when the suction pressure increases.

EEM 15: Domestic water system control and management rationale

Water consumption in hospitals is totally dependent on such factors as services provided, equipment used, and age of the facility, among others. This large range indicates that some hospitals are using water more efficiently than others and that there is a lack of consensus on a specific benchmark per facility type. It is therefore crucial to review the maintenance procedures to maintain the water infrastructure in hospitals and proper water flow.

Efficiency action and energy savings

Water in hospitals is used in toilets, faucets, single-pass water-cooled equipment, boilers, kitchens, washers, and chillers. With an understanding of where and how a hospital is using water, the maintenance team is supposed to make improvements that will save water, energy, and money.

The first step towards water efficiency is to take advantage of low-cost opportunities by ensuring the following:

• **Automatic faucets:** Retrofit the faucets in most critical areas such as the operating room and kitchen with automatic faucets. This has the advantage of shutting off automatically after hand washing, thereby reducing water waste. The automatic shutoff mechanism also reduces the risk of sink overflow due to a faucet being left on either inadvertently or deliberately. Automatic faucets are water-saving devices that help save 70 percent of the water that would otherwise be unused. Other benefits include inhibiting the spread of germs, which are known to thrive on faucet handles, as well as helping to prevent or mitigate scalding incidents caused by hot water.

• **Installation of flow control:** Flow control is achieved by stopping the kinetic energy at the faucet's discharge point down to less than 4 feet per second (or 1.2 m/sec) and directing water through precisely engineered and spaced perforated plates within the flow control. The application of inline flow controls saves between 20 percent and 80 percent. This can be achieved by replacing faucet aerators with new flow controls and installing inline flow controls before the showerhead. With characteristics such as exclusive, patented, and soft-to-the-touch flow, there will be no splashing. Although it gives the impression of a higher water flow, in reality it is using 27 - 90 percent less water.

Figure 46: Water control aerators

Table 17: Expected water savings per application using flow controls

Plumbing Fixture	Water Used		
	With Aerator	With Flow Control	% Savings
Half Bath/Public Restroom	2.5 GPM	0.5 GPM	83 - 90
Lavatory Sink	2.5 GPM	1.5 GPM	45 - 70
Kitchen Bar Sink	2 - 3 GPM	2.0 GPM	27 - 60
Shower	3 - 4 GPM	2.5 GPM	27 - 60

Ordinary aerators do not compensate for pressure changes in inlet pressure, so the greater the pressure the more water you use. Flow controls, on the other hand, use a unique pressure compensation system that saves water and reduces the amount of energy needed to heat water by delivering the same flow rate, regardless of water pressure. The flow control for faucets and showers can be implemented in all toilets and WCs, which can lead to a reduction of more than 40 percent of the water consumed in these areas.

EEM 16: Solar water heaters rationale

The need for effective infection control drives much of how hospitals use water, particularly hot water. Hot water systems generally supply shower/bathing functions as well as process functions (such as dishwashing equipment) and are provided generally through diesel boilers. To reduce the hot water energy demand, it is recommended to install solar water heaters to meet the domestic hot water production.

Efficiency action and energy savings

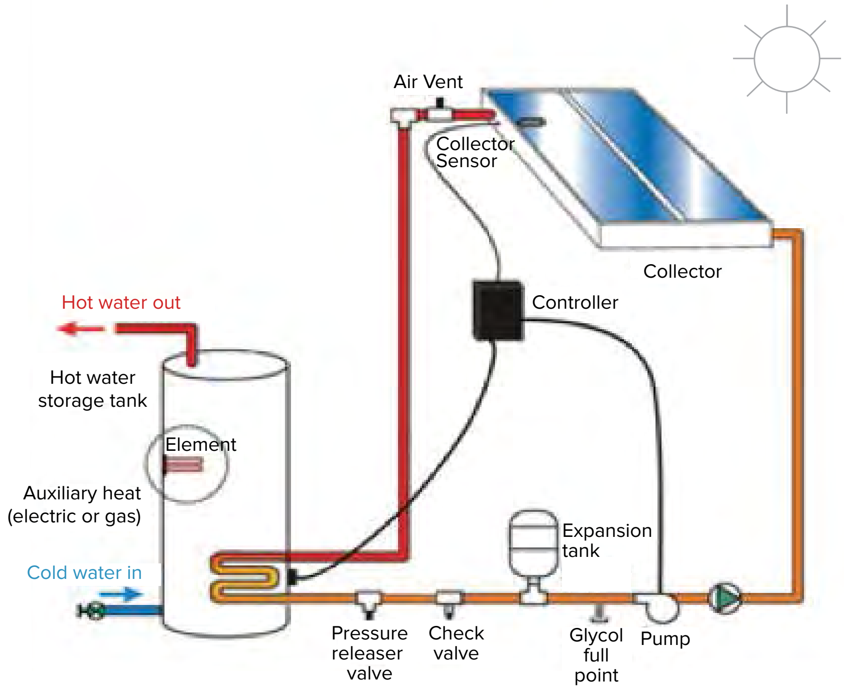
The main parameters for solar thermal installation are solar irradiance, surface availability, and energy prices. The solar irradiance in Lebanon is considered very convenient for solar-related energy production. The majority of health care facilities in Lebanon have sufficient space for the installation of solar thermal panels. In addition to solar water heaters (SWHs) being an environmentally friendly choice (such systems reduce the amount of greenhouse gas emissions for heating water compared to conventional methods), they can be quite cost-effective when compared to conventional systems.

Essentially, the SWH system uses the sun to heat water in collectors mounted on a roof or some raised south-facing façade. The heated water is then stored in a tank. A solar thermal system works by harnessing the sun's energy & converting it into heat, which is then transferred to the building's hot water system.

Solar thermal panels are used in conjunction with a boiler, collector, or immersion heater. The solar collector utilizes the sun's rays to heat a transfer fluid, which is a mixture of water and glycol (if temperatures may freeze). The heated water from the collectors is pumped to a heat exchanger inside a water cylinder. The heat from the exchanger will then heat the water inside the cylinder; and after the liquid releases its heat, the water flows back to the collectors for reheating. A controller ensures that the fluid circulates to the collector when there is sufficient heat available.

Solar thermal technology is proven to be reliable and has low maintenance needs. The key components of the systems are depicted in Figure 47.

Figure 47: Example of a solar hot water system



• Collectors: Solar thermal collectors capture the sun's energy by heating a fluid contained within reinforced glass pipes.

• Pump & controller: The pump ensures that the transfer fluid is circulated between the collectors and the water cylinder efficiently. A system control panel regulates the pump, providing information on the system's performance, and highlighting any issues, should they develop.

• Water cylinder: The heat captured by the solar thermal collectors is pumped to a coil in the water cylinder. A solar thermal water cylinder has a dedicated coil that allows the heat from the collectors to be transferred as efficiently as possible.

Table 18 describes the main activities required for the proper maintenance of the existing SWH installed in hospitals.

Table 18: Maintenance activities for solar water heater systems in hospitals

Description
Supply and installation of new circulating pumps
Supply and installation of new booster filling pump with pressure kit
Cleaning existing plate heat exchangers
Supply and installation of new temperature sensors
Supply and installation of new safety valves
Supply and installation of an uninterruptible power supply
Upgrade the firmware of the existing data logger to operate as an online monitoring device
Supply and installation of data cables, router, and all required accessories for the data logger
Electrical check-up for the existing panel boards
Supply of safety valves as spare parts
Supply of circulating pump as spare parts
Supply of temperature sensors as spare parts

EEM 17: Photovoltaic-driven electricity generation rationale

PV (photovoltaic)-driven electricity generation is a clean and renewable source of electricity crucial to increase the energy security of the Lebanese hospitals suffering from the current energy crisis. Savings from PV electricity generation will come from the avoided kWh to be purchased from the utility or obtained from the local diesel gensets.

The recommended solution is an on-grid solar PV power plant without batteries whereby produced energy is used instantaneously by the property by integrating it to the main electrical panels. However, if the current conditions of the power supply in Lebanon persist, battery storage can be included for critical functions of the hospitals and sized to provide the required number of hours of autonomy to such functions.

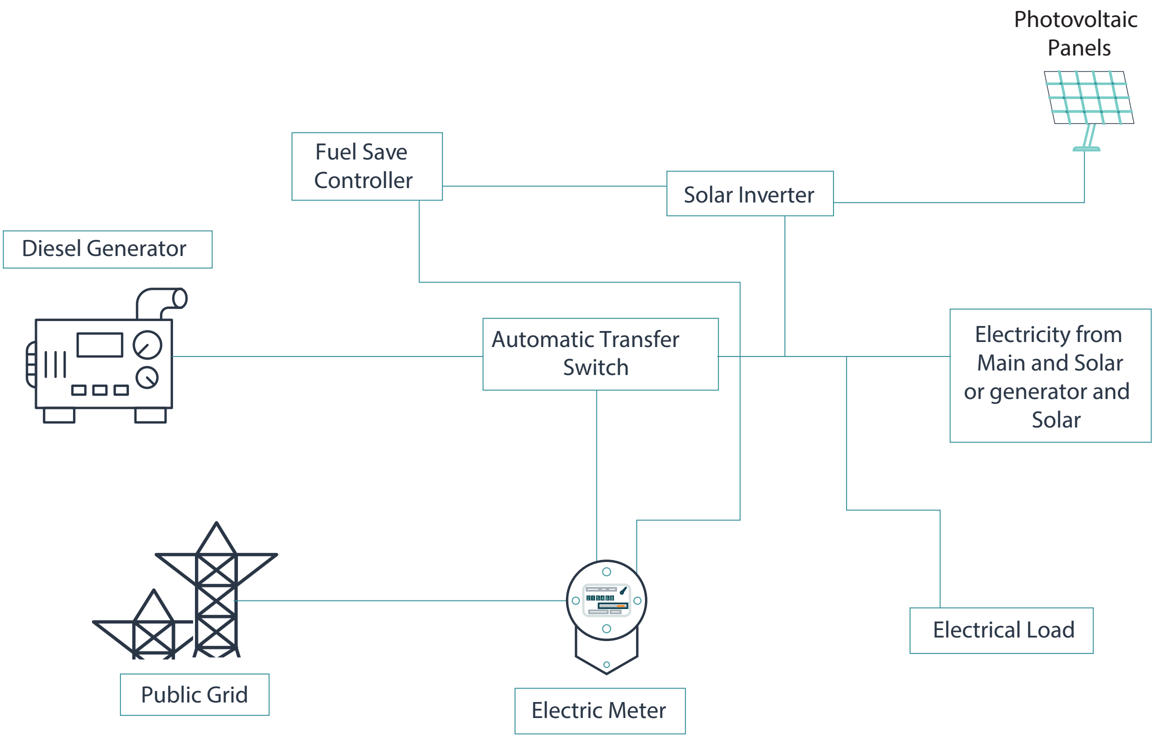
Efficiency action and energy savings functional configuration

The designed systems are 'Hybrid PV-diesel' with net metering.

• Hybrid systems (Figure 48) are those that have a functioning EDL, a diesel generator network, and an added renewable energy source (on-grid PV system with fuel save controller).

The modes of operation have been defined by looking at the type of power source that feeds it. There are two different grid-forming power sources: the utility grid and the diesel generator.

Figure 48: PV hybrid system



Hybrid systems feature the following:

• It will be coupled at the main distribution board of the facility or to the nearest MDB.

• It should feature a fuel save controller to manage the operation of the system in parallel with the diesel generator and the grid.

• The fuel save controller must be able to control the active and reactive energy from the PV inverters.

• PV inverters should have the capacity to supply reactive power depending on the power factor of the hospital without clipping active power production, i.e., oversizing the DC capacity per inverter is not accepted.

• The fuel save controller must monitor which power source (generator and mains) is connected to the load.

• Export extra energy produced into the grid after a net meter is installed.
• Before installing a net meter, there should be an option of zero feed-in into the grid where PV will have a set point to cover the whole load during grid operation.
• The fuel save controller must curtail extra PV produced to maintain at least 20–25 percent load on the generator when running in parallel with the PV.
• A weather station to monitor the performance of the system according to temperature and irradiance level.

The two distinctive operation modes are here detailed:
• Grid mode: When there is grid supply, the PV generator can reduce the consumption from the utility grid by parallel connection and offsetting the loads of the facility as well as potentially back-feeding surplus PV production into the grid. Net metering applications are to be submitted and followed up by the contractor for facilities with 'hybrid' systems.

The PV systems should be set on Zero Export Mode until net metering is installed in the facility, when it should be set to Grid Managed Mode with no back-feeding to the generator subscription grid using a PV fuel save controller.

• Fuel reduction mode: This mode is automatically triggered when there is a grid blackout and the genset is ON. The genset is started automatically when there is a shortage of grid supply for a transition from Grid Mode to Fuel Reduction. The fuel save controller is required to synchronize the PV penetration while respecting the generators' minimum load capacity. The system design prevents the following risks from utility networks or genset networks: fault current, voltage rise, reverse power flow, substation/transformer loading, and potentially neutral voltage displacement. The fuel save controller should have the option to disconnect the PV plant at any time the load drops immediately to zero through a contactor installed at the output of the PV system near the point of common coupling. If during the Fuel Reduction Mode the grid is available again, then the plant enters the Grid Mode automatically.

PV inverters must have fall-back settings for active and reactive power. Fall-back settings are to be set to zero in the fastest time possible in the absence of a communication signal from the fuel save controller. Also, in the absence of communication between the PV inverters and the fuel save controller, the main PV contactor must open to guarantee the safety of the system.

Table 19: PV system general specifications

Photovoltaic Generator	Type of module	Crystalline silicon, Min. 72 cells
	Orientation	Preferred south orientation
	Standards	IEC 61215 edition 2, IEC 61730-1 and -2, IEC 62716, IEC 61701, IEC TS 62804
	Performance	More than 80% of initial nominal power rating after 20 years
	Module efficiency STC	≥ 20%
	Warranty	≥ 10 years
Grid-Tied Inverter	Location	Outdoor
	Type	Three phase transformer less
	Rated power	DC/AC ratio = 1.1
	Number of MPP tracker	≥ 2
	Protection class	≥ IP65
	DC input voltage range	200 V - 1000 V
	MPP voltage range	300-800
	Maximum DC voltage	1000 V
	Output AC voltage	3 / N / PE 230, 400 V (adjustable)
	Output AC frequency	50 Hz (adjustable)
	Power factor	0 - 1 (inductive and capacitive)
	THD	≤ 3%
	Consumption at night	≤ 3 W
	Maximum efficiency	≥ 98%
	Euro efficiency	≥ 97%

Grid-Tied Inverter	Cooling	Active The temperature derating curves should be submitted, and the inverter should ensure continuous output power at a temperature of 25 degrees
	Standards	Harmonic Current (IEC 61000-3-2 and / or IEC61000-3-4), IEC 62109-1/2
	Anti-islanding protection	Yes/ VDE 0126-1-1 or similar
	Communication	RS485, Ethernet, RS232
	Additional requirements	Dynamic compensation of reactive power, inverter automatic reconnection conditions, linear output power control from a third device (read and write capabilities) and utility-interactive photovoltaic inverter system, reverse polarity protection, AC (AC surge protection could be inside the inverter, or installed outside the inverter) and DC surge voltage protection, AC operating under and over-voltage protection, frequency range protection
	Permissible grid characteristics (inverter not to be disconnected or damaged)	Vp-n = 230 V ±20%; Vp- p= 400 V ± 20%; Freq = 50 ± 5 Hz
Monitoring System	Type	Data logging (on local memory and online), local and remote monitoring at least and not limited to input and output DC and AC voltages and currents, frequency, active and reactive power, active and reactive energy, power factor, alarms, faults, warnings for all available sources, weather data (irradiance, ambient temperature, cell temperature), de-rating of the on-grid system (optional)

Monitoring System	Communication	RS485, Ethernet, and/or RS232 (compatible with Grid-connected inverter, battery inverters/charges, sensors, and electrical meters)
	Inputs	Meters, sensors, inverters, controllers, grid (consumption), weather sensors
	Local monitoring	Monitored parameters should be available to be viewed on the screen of the data logger locally on-site or downloaded locally to a laptop in case there is no Internet or remote monitoring is not functioning
	Outputs	Inverters, Grid (back-feeding)
	Data logger	Remote logging, 2 years' data logging capacity, monthly evaluation report, calculation of indicators
Mounting System	Material	Anodized aluminium/Hot-dip galvanized
	Wind speed	140 km/h Gust speed
		120 km/h continuous speed
	Installation	Concrete ballasts cast on/off-site with sample test or written confirmation on the quality of concrete batching
	Fixation	standards
	Verification	Wind load calculations
	Warranty	≥ 10 years

PV Plant Controller Unit	Type	Fuel save controller
	Communication	RS485, Ethernet and/or RS232 (compatible with Grid-connected inverter, existing genset control unit, environmental sensor, and electrical meters)
	Inputs	Meters, sensors, inverters, genset control units, grid (consumption)
	Outputs	Inverters, grid (back-feeding)
	Data logger	Remote logging, 2 years data logging capacity, monthly evaluation report, calculation of indicators
	Functions	Maintain minimum load on diesel generator; operation with at least 4 generators; control active and reactive power from inverters; Prevent back-feeding into the generator; zero-feed into the grid when not required; export extra energy produced into the grid when a net meter is installed; gradual ramp up and ramp down of PV power; emergency shutdown for the PV system; ability to monitor which source is on load; voltage and current measurements; trip the PV system at any time there is loss or interrupt of communication with the inverter

EEM 18: BMS installation rationale

Hospitals should have as a priority a well-tuned and appropriately scaled building management system that covers the entire mechanical and electrical systems to accurately track and control all the key loads on the premises for optimal energy usage.

Efficiency action and energy savings

The facilities should plan to install a BMS with an integrated web module for remote access along with trending and reporting modules.
Overall, the BMS design and implementation should monitor and control the following loads/systems:

• The electrical stations are to be connected to the BMS showing the Électrecité Du Liban metres along with the generators & their synchronization panel showing the generators' loading.

• Chiller plants, if present: the platform should provide several data, such as chillers' status (ON/OFF), pumps' VFD reading (%), chilled water temperatures (supply/return), differential pressure readings (ΔP), in addition to ambient air conditions (temperature/relative humidity).

• AHUs and fan coil units (FCUs): cooling coil and heating coil valves opening (%), supply temperature after the coil, return temperature, space temperature settings for occupied scenario and vacant scenario, filter status, alarm, damper opening.

• Exhaust fans and negative pressure fans: status of operation.

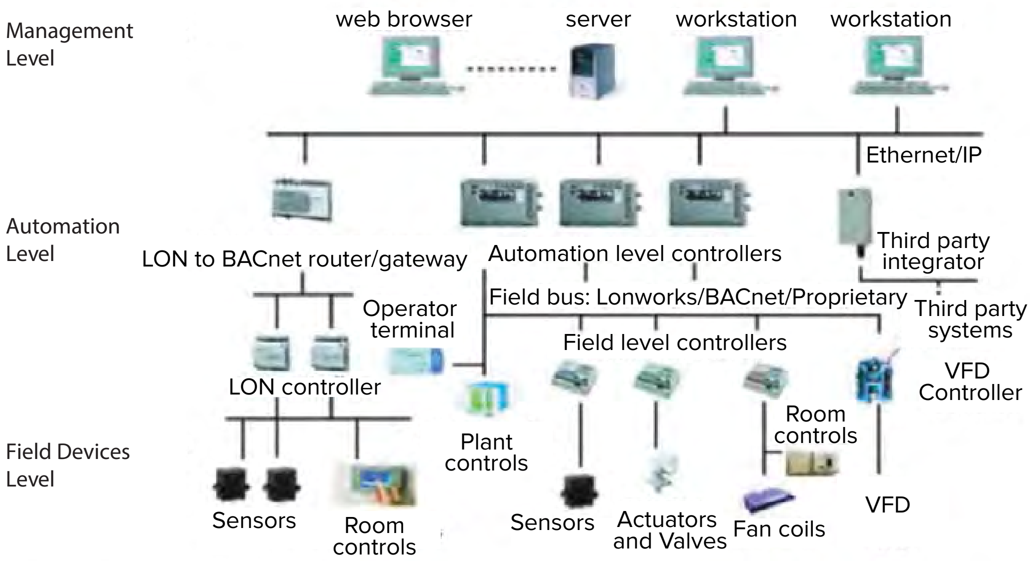
• Solar thermal plant: visualization of the system and hot water storage tanks along with the water temperatures in each of them.

• Boiler plant: boilers along with the heating pumps, hot water supply, and return temperature.

Once the list of targeted equipment is completed, the BMS infrastructure design can be done, including devising the direct digital controls installation strategy. The BMS platform should have remote access with complete trending functions and automation possibilities. A BMS will provide the visibility needed to manage every part and facet of the infrastructure of hospitals. Accordingly, proactive scheduling of all pumps and AHUs can be done along with continuous temperature reset strategies. In addition, it will reveal discrepancies in the operation, waste, and unnecessary heating or cooling. In the current situation of Lebanese hospitals, these features are not possible. Installing a BMS will provide the appropriate proactive energy management tool, leading to extensive savings at all levels of utilities: electricity, chilled water, and hot water.

Figure 49 is a general schematic of a BMS connection showing the key components of the system. It is to be noted that the main objective is to keep the installations as limited and simple as possible to ensure the budget is kept as low as possible.

Figure 49: Building management system applications



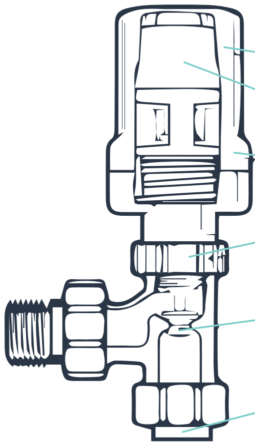
EEM 19: Thermostatic valve installation on radiators rationale

It is crucial to ensure heating demand is properly covered without wasting the primary energy in moderate climates or even in unoccupied spaces. Balancing the heating load without affecting human comfort is achieved by controlling the room temperature of each space and varying the heating flow in radiators through the room temperature settings. The simple and easy solution is the thermostatic radiator valve installation.

Efficiency action and energy savings

It is recommended to install one thermostatic valve (Figure 50v) on the supply heating pipe. A thermostatic radiator valve (TRV) adjusts automatically the amount of hot water coming to the radiator according to the temperature of the room and not according to the temperature of the radiator. A metal coil built in the thermostatic head of the TRV pushes the valve down or up to control the hot water flow according to the room temperature. The TRV has a pin on the top of it which can be set on several numbers (1, 2, 3, 4, and 5) based on the desired room temperature range.

Figure 50: Thermostatic radiator valve components



The use of TRVs contributes to a reduction in primary energy used for space heating. Overall, installing TRV should save around 5 percent of average diesel consumption of the boilers.

5.2. EEMs on Medical Equipment

The following section consists of observations and recommendations made by the World Health Organization (WHO) for medical equipment energy management based on site visits.

The site visits have covered selected private and public health care facilities to check running statuses, required electrical energy demand, and many other parameters that directly influence the energy management of medical equipment.

5.2.1. Laboratory, blood bank, pharmacy departments observation

All automated analysers, including haematology, biochemistry, immunology, and bacteriology devices, are ON at all-times or on Standby mode when not used as long as they need continuous calibration and quality control tests to ensure reliable patient exams results.

Medical refrigerators and freezers are kept ON at all times with temperature monitoring systems.

Devices for limited laboratory activities such as centrifuges, microscopes, water baths, mixers, and biosafety cabinets are shut off after finishing the specific manipulations.

These equipment are typically found in all hospitals regardless of the type and size.

Strategy

• Select the devices that match the needed workflow of the hospital. An example of this strategy would be buying a medical blood bank refrigerator with a capacity of 300 litres instead of one with a 700 litres capacity. The selection should be done by taking into consideration the hospital size, the maximum expected needed blood units to be collected, the number and types of surgical operations that are conducted in the health care facility, etc.

• Do not oversize equipment by more than 30 percent of the actual need as laboratory equipment is in continuous evolution. Equipment more than approximately 10 years old is not considered efficient and will need replacement.

• Perform preventive maintenance on a regular basis to ensure the smooth performance and low energy consumption of motors, pumps, and compressors that are integrated into medical devices.

• All devices that are not dependent on reagents or chemicals with a limited expiry lifetime should be turned off after finishing their use.

• Select laboratory, blood bank, and pharmacy refrigerators and freezers that are classified A+ or above for better energy consumption. As a point of reference, for example, ENERGY STAR® has a dedicated website that compares the energy performance of lab grade refrigerators and freezers.

5.2.2. Imaging department observation

MRI equipment and all its related components are kept ON at all times and should never be shut down for technical reasons.

CT scanner, X-ray machines, mobile X-ray, mammography, and panoramic dental, etc. all use spontaneous peak electrical energy during the few seconds of X-ray exposure. Newer versions of X-ray machines use less energy and emit fewer X-ray doses for patients while getting better imaging results through a smarter image reconstruction algorithm and ameliorated semi-conductor and detector technologies.

It was observed during site visits that ultrasounds are kept ON even after finishing the patient diagnostic appointments. It is recommended to activate the sleep or Standby mode in all similar devices.

Computed radiography systems are found ON to accelerate image conversion and the processing of X-ray films coming from analogue devices.

Strategy

• Select X-ray machines that are FDA and/or CE approved with recent improved X-ray technologies that consume less energy than older versions.

• Select the size of X-ray machines (generator and tube) by taking into consideration the type of applications needed and patients to diagnose. For example, it is not recommended to buy a 30 kW mobile X-ray machine if it will be used only for the paediatric department.

• Investing in a DR system (a detector that digitalizes an analogue X-ray machine) or buying a fully digital X-ray machine can eliminate the need to use a computed radiography system. Moreover, it can improve the image quality even when using lower energy during X-ray exposure.

• Injectors should be kept OFF until an angiographic application is needed.

5.2.3. Operating rooms and sterilization departments observation

Anaesthesia machines, surgical lights, electrosurgical units, laparoscopic towers, monitors, surgical microscopes, electric drills, operating tables, drug pumps, warmers, etc. are kept ON or on Standby mode during surgical operations and are to be used on spot when needed.

Steam sterilizers, sealers, and washers of the sterilization department usually consume a high and continuous level of energy due to integrated steam generators, pumps, and heaters, and are mostly ON during the day shift.

Strategy

• Invest in a central steam boiler and connect sterilizers without internal steam generators. This strategy helps to decrease the consumption of electrical energy.

• Each health care institution should elaborate its own financial comparative study between the selling price of single-use items and the running cost of reusable items in order to minimize the number of sterilizing cycles whenever possible.

• Connect the control of sterilizers and washers to an uninterruptible power supply to avoid aborting the complete sterilization cycle and prevent restarting it from zero.

• Avoid oversized and undersized sterilizers and washers. Selecting any of these can result in running cycles with only a few instruments inside or in an increasing number of cycles due to insufficient volume spacing. Close coordination with the operating rooms manager should be done at all times by taking into consideration the type and number of scheduled surgical operations.

• Perform end-user's trainings and raise awareness to turn off the sealers immediately after finishing all the packing tasks, as one sealer with high heating capacity consumes as much as a whole department lighting system. Trainings as well as written instructions with simplified schematics should be put on all the devices that consume high energy in each department. This strategy should be taken in close coordination with the hospital maintenance managers for better results.

• Replace all surgical halogen bulb lights with LED surgical lights. This will result in an important decrease in the electrical energy consumption; the elimination of maintenance interventions for not less than 15,000 running hours; and a reduction in heat gains resulting from halogen lamps, which can in turn decrease the cooling demand needed inside operating rooms. The same applies to endoscopic and laparoscopic towers by avoiding systems with halogen light sources and lamps.

5.2.4. Intensive care units, labour & delivery, emergency departments observation

Monitors, drug pumps, ventilators, ECG machines, defibrillators, High Flow Therapy (HFT) machines, nebulizers, capnography, exam lights, incubators, etc. are all connected to electrical outlets at all times. These devices are used on hospitalized patients case by case and kept on Standby mode or OFF in charging mode when not in use. Normally, electrical beds do not consume much energy as long as the needed positions are limited.

Strategy

• Create charging docking stations for drug pumps, ECG machines, and ventilators inside each department to centralize and optimize the power management of these devices when not in use. These devices are equipped with internal batteries that should be kept ready for safe immediate usage when required.

• Ensure routine preventive maintenance for all medical equipment and especially for life-saving ventilators and defibrillators. For example, the cleaning of air intake filters of turbine ventilators will decrease the pressure on its internal motor, which leads to better energy consumption.

• Adopt a procurement policy to select devices that are certified by international organizations and have been successfully accredited (FDA, CE, ISO, etc.) as these undergo multiple tests and are equipped with energy-saving technologies.

5.2.5. Dialysis department observation

Haemodialysis machines are ON during pre-sessions and post-sessions for a certain period of time to ensure safe functioning, disinfection, and calibration processes. The time needed depends on the level of training of the end-user in performing the aforementioned steps. However, the period does not extend for more than one hour. Machines presenting higher advanced technologies perform the processes automatically. These machines need special daily care by qualified technicians. Keeping backup machines ready on charge is a must as per the accreditations norms.

Strategy

• The water treatment station that supplies the dialysis centre is equipped with a reverse osmosis system. The membranes of this system should be replaced on time to prevent a lower water flow production leading to higher electrical water pumps running hours to ensure the same volume of treated water.

• A closed loop with an automated controlled intermittent water flushing system is recommended to manage the status of the treated water inside the piping network. Moreover, it can minimize the occurrence of an infected network, which would necessitate the complete re-production of pure sterile water, and thus waste additional energy.

5.2.6. General departments (medicine, post-surgeries, OB/GYN, maternity, ophthalmology, ENT, etc.) observation

Vital signs monitors, ECG machines, oximeters, defibrillators, physiotherapy automated motions machines, nebulizers, etc. are usually OFF or on Standby mode, or they are in charging mode if they contain internal batteries unless they are used during daily routine rounds and when needed. Electrical beds do not consume a considerable amount of energy as long as the needed positions are limited.

Strategy

• During the procurement process, select the medical devices that have a better type of internal battery with high performance. This is achieved by asking for a technical datasheet showing the charging and discharging curves, in addition to the estimated lifetime number of cycles. It is recommended to choose a defibrillator with a quicker battery charging cycle in order to minimize the charging duration and ameliorate the energy management process.

• Ensure appropriate training for the end-users nursing staff to properly manipulate the locking functions of the beds' movements, and thus prevent uncontrolled manipulations that could be done by curious visitors.

5.2.7. Clinics and specific diagnostic units observation

This section includes lithotripters, lasers, ophthalmic units, ENT units, urology exam units, examination lights, pulmonary function test machines, stress-test machines, holters stations (stations for ambulatory cardiac and blood pressure monitoring devices), audiometers, etc. The aforementioned devices are usually ON for defined hours, when doctors are present and patients are ready for diagnostic or basic treatment.

Strategy

- Select LED examination lights during the procurement process by taking into consideration many essential characteristics, such as the minimum required power, colour energy type, working distance, focus, maximum light diameter, etc. Other clinics may require less essential criteria depending on the medical application.
- Replace any old medical devices equipped with an apparent slow processor as soon as possible. For instance, an old laser or ultrasound machine may need more than 15 minutes to achieve the start-up phase and hence is wasting time and electrical energy.

06

THE POTENTIAL OF ENERGY SAVINGS IN PUBLIC HOSPITALS

6. The Potential of Energy Savings in Public Hospitals

In this chapter, the potential savings for Lebanese public hospitals were calculated based on energy audits completed on 10 public hospitals under the KfW Bank-funded UNDP Solar for Health project. To perform this analysis, the public hospitals were segregated based on the four Lebanese climatic zones as per Figure 9.

Sixteen of the country's 30 public hospitals are located in climatic zone 1, 7 are located in zone 2, 4 in climatic zone 3, and 3 in climatic zone 4.

6.1. Energy balance for zone 1

The yearly average energy balance/bed is obtained from the energy audits performed on hospitals corresponding to climatic zone 1. Table 20 shows these results.

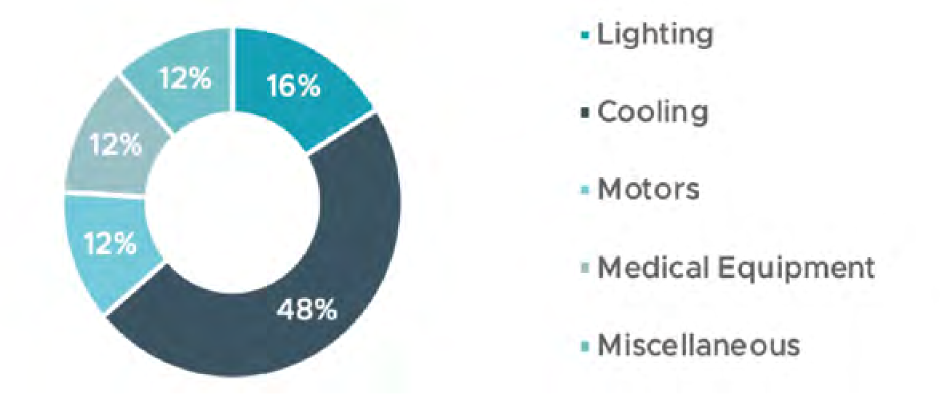
Table 20: Average energy balance/bed/ year for zone 1

Category	Load		Energy			
Unit	kW	%	kWh/year	Cost (USD/year)	Kg. CO_2 /year	%
Lighting	1962.65	5	7,033,979	1,050,252	5,007,826	16
Cooling and HVAC	14418.08	37	20,749,716	3,386,221	14,722,086	48
Motors	4107.83	11	5,301,062	1,011,045	3,736,243	12
Medical Equipment	12969.74	33	5,338,822	812,552	3,796,104	12
Others	5647.99	14	5,133,623	715,881	3,663,741	12
Total	39,106	100	43,557,202	6,975,951	30,926,000	100

[7] Costs assuming 0.13 $c/KWh in this section.

Figure 51 shows the energy balance/bed. As can be seen, the cooling category takes up the largest percentage of the energy consumption/ bed.

Figure 51: Distribution of energy consumption per bed in zone 1



The total energy balance extrapolated for all public hospitals corresponding to zone 1 appears in table 21, comprising 1,894 beds in total.

Table 21: Zone 1 total energy balance

Category	Load		Energy			
Unit	kW	%	kWh/year	Cost (USD/year)	Kg. CO_2 /year	%
Lighting	1962.65	5	7,033,979	1,050,252	5,007,826	16
Cooling and HVAC	14418.08	37	20,749,716	3,386,221	14,722,086	48
Motors	4107.83	11	5,301,062	1,011,045	3,736,243	12
Medical Equipment	12969.74	33	5,338,822	812,552	3,796,104	12
Others	5647.99	14	5,133,623	715,881	3,663,741	12
Total	39,106	100	43,557,202	$6,975,951	30,926,000	100

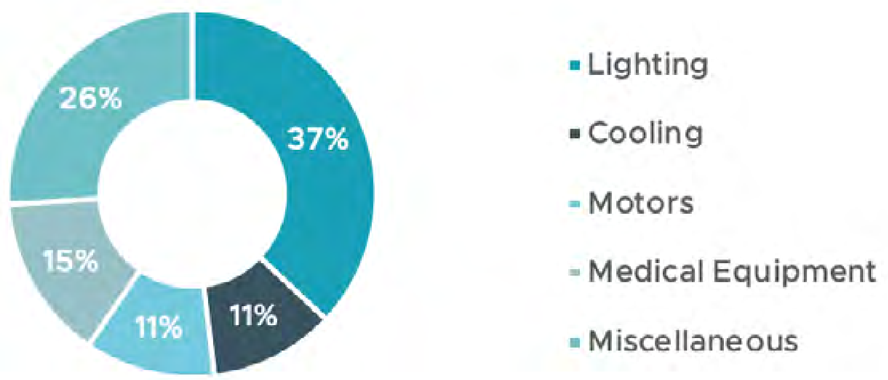
6.2. Energy balance for zone 2

The average energy balance/bed/year obtained from energy audited hospitals corresponding to climatic zone 2 appears in Table 22.

Table 22: Average energy balance/bed/year for zone

Category	Load		Energy			
Unit	kW	%	kWh/year	Cost (USD/year)	Kg. CO_2 /year	%
Lighting	0.772896	8	3,062	328	2,012	37
Cooling and HVAC	1.747575	18	912	98	599	11
Motors	1.186709	12	948	101	623	11
Medical Equipment	4.082361	42	1,207	129	793	15
Others	2.00712	20	2,141	229	1,406	26
Total	10	100	8,269	885	5,433	100

Figure 52: Distribution of energy consumption per bed in zone 2



The total energy balance extrapolated for the 10 public hospitals located in zone 2 is presented in Table 23, with 358 beds in total.

Table 23: Zone 2 total energy balance

Category	Load		Energy			
Unit	kW	%	kWh/year	Cost (USD/year)	Kg. CO_2 /year	%
Lighting	276.6966	8	1,096,092	117,282	720,132	37
Cooling and HVAC	625.632	18	326,403	34,925	214,447	11
Motors	424.8418	12	339,295	36,305	222,917	11
Medical Equipment	1461.485	42	432,027	46,227	283,841	15
Others	718.5489	20	766,387	82,003	503,516	26
Total	3,507	100	2,960,202	316,742	1,944,853	100

6.3. Energy balance for zone 3

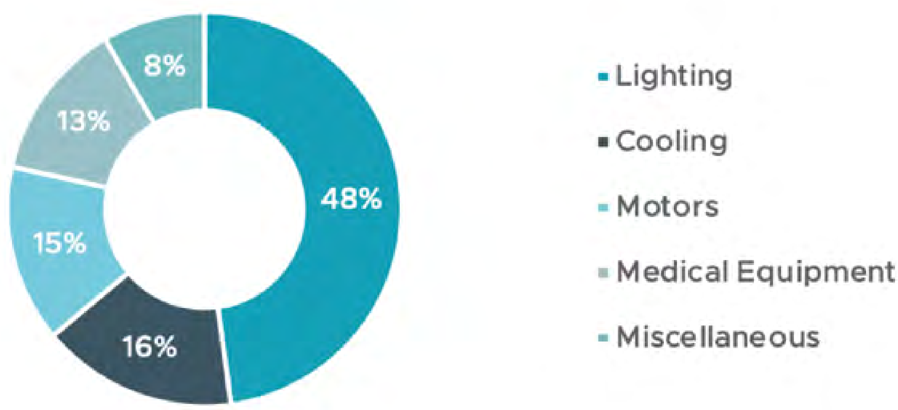
The average energy balance per bed for zone 3 public hospitals is presented in Table 24.

Table 24: Average energy balance/bed/year for zone 3

Category	Load		Energy			
Unit	kW	%	kWh/year	Cost (USD/year)	Kg. CO_2 /year	%
Lighting	0.721429	9	2,260	255	1,620	48
Cooling and HVAC	0.943233	12	759	85	544	16
Motors	1.155388	14	687	80	492	15
Medical Equipment	3.587594	45	619	69	444	13
Others	1.594612	20	398	44	285	8
Total	2,801	100	1,652,775	$186,782	1,184,502	100

The energy balance/bed end-use categories corresponding to zone 3 is shown in Figure 53.

Figure 53: Distribution of energy consumption per bed in zone 3



The total energy balance of zone 3 is indicated in Table 25, with 350 beds in total.

Table 25: Zone 3 total energy balance

Category	Load		Energy			
Unit	kW	%	kWh/year	Cost (USD/year)	Kg. CO_2 /year	%
Lighting	252.5	9	790,960	89,338	566,862	48
Cooling and HVAC	330.1316	12	265,532	29,827	190,300	16
Motors	404.386	14	240,331	28,115	172,238	15
Medical Equipment	1255.658	45	216,812	23,990	155,382	13
Others	558.114	20	139,141	15,512	99,720	8
Total	2,801	100	1,652,775	$186,782	1,184,502	100

6.4. Energy balance for zone 4

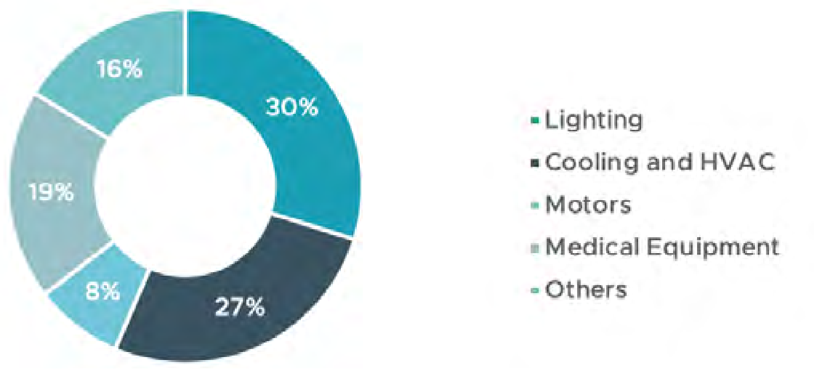
Three public hospitals located in zone 4 were subject to energy audits. Table 26 shows the results of the average energy balance/bed/year for zone 4.

Table 26: Average energy balance for zone 4

Category	Load		Energy			
Unit	kW	%	kWh/year	Cost (USD/year)	Kg. CO_2 /year	%
Lighting	0.887143	8	2,690.80	438.22	1,928.42	30
Cooling and HVAC	3.81	35	2,399.72	386.57	1,719.82	27
Motors	0.804286	7	729.06	124.58	522.49	8
Medical Equipment	3.355	31	1,736.72	286.44	1,244.66	19
Others	2	18	1,457.64	231.29	1,044.65	16
Total	11	100	9,014	$1,467	6,460	100

The energy balance/bed end-use categories corresponding to zone 4 is shown in Figure 54.

Figure 54: Distribution of energy consumption per bed in zone 4



The total energy balance of zone 4 is indicated in Table 27, with 185 beds in total.

Table 27: Zone 4 total energy balance

Category	Load		Energy			
Unit	kW	%	kWh/year	Cost (USD/year)	Kg. CO_2 /year	%
Lighting	164.1214	8	497,798	81,071	356,758	30
Cooling and HVAC	704.85	35	443,949	71,515	318,166	27
Motors	148.7929	7	134,875	23,048	96,661	8
Medical equipment	620.675	31	321,293	52,991	230,262	19
Others	370	18	269,664	42,788	193,261	16
Total	2,008	100	1,667,579	271,412	1,195,108	100

6.5. Potential energy efficiency measures and their impact

The following potential energy efficiency measures were obtained from the energy audits performed on 10 public hospitals located across the four climatic zones. These EEMs can be applied to each of the end-use categories based on the corresponding climatic zone needs. The energy efficiency measures cover potentials in lighting, HVAC system upgrade, thermal system, and the entire energy consumption of the health care facility. The potential EEMs for Zone 1, 2,3 and 4 are shown in Tables 28, 29,30 and 31, respectively.

Table 28: Potential energy efficiency measures for Zone 1

EEM Name	kWh $_{ELECTRICITY}$				
	% savings from total	Potential annual kWh savings	Potential annual $ savings	Average cost $/ kWh	Total implementa-tion cost $
LIGHTING					
Lighting retrofit	6	2,434,591	316,497	0.41	1,000,986
Lighting control	1	279,295	36,308	0.38	104,904
HVAC System Upgrade					
HVAC system upgrade	7.3	3,178,310	413,180	1.17	6,470,848
VFDs					
VFD on AHUS	1.66	721,544	93,801	0.54	389,900
TOTAL BASELINE					
PV power electricity generation	12.5	5,386,242	700,211	0.41	2,234,007
BMS installation	11	4,662,814	606,166	0.61	2,844,347
Total		16,662,796	2,166,163		13,044,993
Thermal	kWh $_{THERMAL}$				
Solar water heater	12	5,251,887	682,745	0.12	643,956

Table 29: Potential energy efficiency measures for Zone 2

EEM Name	kWh ELECTRICITY				
	% savings from total	Potential annual kWh savings	Potential annual $ savings	Average cost $/kWh	Total implementa-tion cost $
LIGHTING					
Lighting retrofit	16	460,181	59,824	0.28	128,851
Lighting control	2	63,429	8,246	0.40	25,371
HVAC System Upgrade					
HVAC system upgrade	20	588,795	76,543	0.44	259,070
VFDs					
VFD on AHUS	4.61	136,385	17,730	0.47	64,101
TOTAL BASELINE					
PV power electricity generation	33	962,675	125,148	0.29	279,176
BMS installation	32	947,561	123,183	0.39	369,549
Total		3,159,026	410,673		1,126,118
Thermal	**kWh THERMAL**				
Solar water heater	38	1,131,208	147,057	0.19	214,929

Table 30: Potential energy efficiency measures on Zone 3

EEM Name	kWh ELECTRICITY				
	% savings from total	Potential annual kWh savings	Potential annual $ savings	Average cost $/ kWh	Total implementa-tion cost $
LIGHTING					
Lighting retrofit	30	498,293	64,778	0.47	233,567
Lighting control	3	46,534	6,049	0.39	18,062
HVAC System Upgrade					
HVAC system upgrade	17	283,992	36,919	2.65	847,789
VFDs					
VFD on AHUS	4	58,720	7,634	1.01	59,307
TOTAL BASELINE					
PV power elec-tricity generation	53	870,798	113,204	0.60	522,479
BMS installation	16	256,204	33,307	0.89	227,081
Total		2,014,541	261,891		1,908,910
Thermal	**kWh THERMAL**				
Solar water heater	33	540,703	70,291	0.52	283,580

Table 31: Potential energy efficiency measures on Zone 4

EEM Name	kWh ELECTRICITY				
	% savings from total	Potential annual kWh savings	Potential annual $ savings	Average cost $/ kWh	Total implementa-tion cost $
LIGHTING					
Lighting retrofit	8	148,615	19,320	0.27	39,808
Lighting control	1	14,402	1,872	0.88	12,659
HVAC System Upgrade					
HVAC system upgrade	11	209,422	27,225	0.78	169,411
VFDs					
VFD on AHUS	4	58,720	7,634	1.01	59,307
TOTAL BASELINE					
PV power electricity generation	31	575,612	74,830	0.46	262,638
BMS installation	8	140,301	18,239	1.16	163,211
Total		1,088,352	141,486		425,849
Thermal	**kWh THERMAL**				
Solar water heater	18	336,827	43,788	0.02	5,379

Summary of EEMs

• The total savings from the interventions are approximately $4 million per year (Table 32).

• Similarly, the average cost/kWh saved was calculated for each of the four zones in addition to the total cost needed to achieve those savings, equal to approximately $17.6 million for the entire sector as CAPEX investments. The operation and maintenance costs required per year will be in the order of 5% of the total capex cost, corresponding to $880,000 per year.

• The Net Present Value (NPV) of implementing these measures on the entire sector is $13,400,000.

• Accordingly, a payback period of 4.5 years is obtained.

Table 32: Summary economic performance of EEMs

ECONOMIC PERFORMANCE	
Annual Cost Savings ($)	3,924,09
Implementation Cost ($)	17,653,714
Simple Payback (Years)	4.5
Net Present Value ($)	13,396,536
Internal Rate of Return (%)	22

Figure 55: Electrical energy consumption/bed before and after savings

Figure 55 depicts the average electrical energy consumption in kWh electrical per bed before and after savings implementation corresponding to each climatic zone. Similarly, calculations were performed to obtain the annual kWh thermal per bed before & after savings implementations for each climatic zone. Figure 56 shows the results.

Figure 56: Thermal energy consumption/bed before and after savings implementations

07

GOVERNMENTAL POLICIES AND ACTIONS

7. GOVERNMENTAL POLCIES AND ACTIONS

The purpose of energy policy and actions is to establish a roadmap andframework for acceptable protocols, practices, and operational standards administered by the government.

7.1. Need for managing entities

A successful energy policy and action cannot be done without a clear delineation of roles and responsibilities with respect to energy management. Therefore, it is crucial to develop a working organizational structure acting as a managing entity. This managing entity can be done through:

Ministry of Public Health

The Ministry of Public Health can form a department responsible for strategic energy management across the portfolio as a whole and act as a system manager. This revolves around monitoring energy demand, supply, and use across the health care system and putting in place programmes and initiatives to meet the stated goals of energy management at the system level.

The department can drive energy performance through systematically collecting, analysing, & reporting information related to energy performance, and using this information to inform the development of benchmarks and targets. The department should also undertake research into energy use within hospitals to better understand how energy is used.

The department would be responsible for investigating the potential for system-wide embedded energy opportunities, and should also include:

• Providing health services with technical advice & support on energy management.

• Communicating knowledge, relevant efficiency programmes, and best practice across the health system.

• Providing input energy policy and programmes that affect health services.

Health services

A special health services unit should be created in each public hospital, in collaboration with the Ministry of Public Health and the department responsible for strategic energy management to operate in public hospitals. These health service units should be responsible for energy management at the local level and therefore have an operational role.

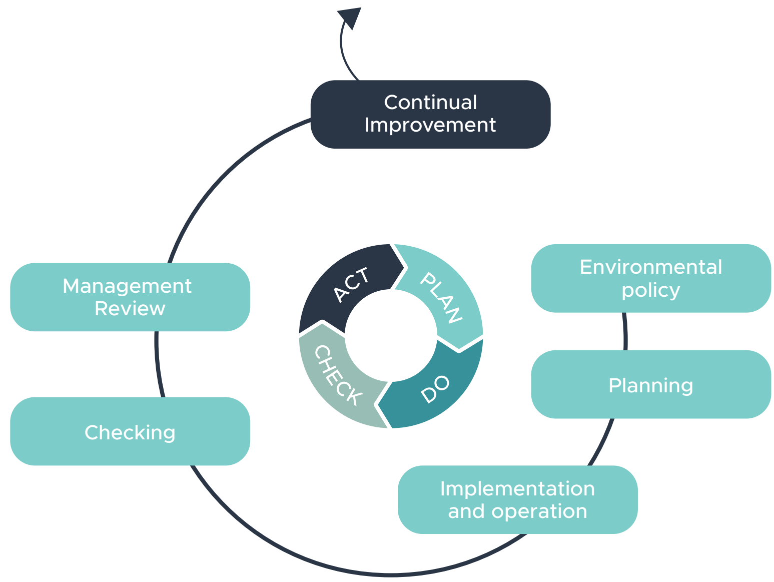
Health services must meet the energy requirements of any departmental policy, including preparing environmental management plans, reporting energy (and water) use to the department, and reporting publicly on their environmental performance. Given the importance of energy (and carbon) management, health services must also place a strong focus on energy in organization-wide environmental management systems and processes, including setting targets for improving energy efficiency. They must also ensure that any infrastructure and asset renewal projects achieve the best outcome on a whole-of-life basis, including the cost of energy over the life of the asset. Finally, they should be responsible for ensuring that their respective facilities have the required level of energy security and comply with the wider energy plan.

7.2. Energy management

The second step for adequate energy policy and actions is to take a proactive and consistent approach to energy management across the Lebanese health care sector. These should be guided by government policies that address the three primary areas of energy management: energy supply, energy demand, and understanding energy use.

Implementing a central environmental management plan can be of use to publicly report on the environmental performance of the health care sector. Adequate reporting includes specific measures that health services must progress on energy, including actions to manage energy use within their environmental energy plan (Figure 57) and reporting publicly on energy use and intensity.

Figure 57: Elements of environmental management plan



In order to effectively manage demand and understand energy supply, it is necessary to have energy data systems at both the local and system-wide levels. There are broadly two types of energy data: billing data (how much energy costs) and consumption data (how much energy is used). Thus, the importance of developing an energy dashboard for the entire health care sector in Lebanon. This energy dashboard is based on data and scoring obtained from all hospitals and then connected to an energy management platform. An example of an energy dashboard for energy management can be found in Figure 58.

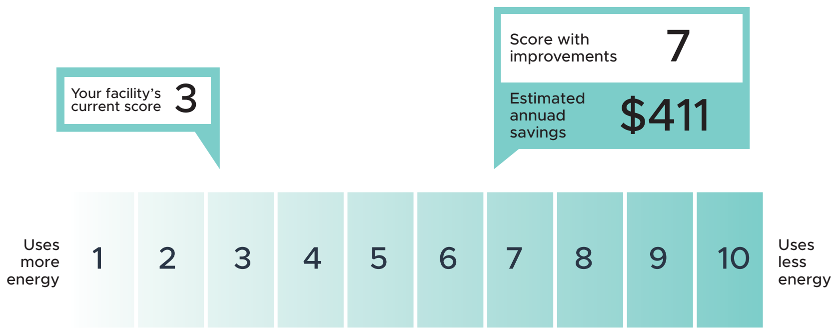
Figure 58: Energy dashboard for energy management

7.3. Energy Scores

An important step in energy policy is to understand the current state of health care facilities in Lebanon so as to set a benchmark in terms of energy performance and use against similar facilities nationwide. Therefore, the government can appoint inspectors to perform site visits to both public and private hospitals to score their energy performance based on a questionnaire/checklist. Results will then be entered into an online system serving as a portal to the managing entities so they know where these facilities stand in terms of energy consumption and savings.

The scoring acts as an external benchmark for assessing the performance of these health care facilities, to be then used by the government to set holistic energy targets for the sector. The energy scoring system allows everyone in health care facilities, from the maintenance technician to the management, to quickly understand how the hospital is performing. The scoring criteria are in the areas of energy management, lighting, building envelope, equipment/plug loads, kitchen/cafeteria and food service equipment, and HVAC (for a sample, see Appendix B). The scoring system's proposed interface is shown in Figure 59.

Figure 59: Interface for the scoring system



7.4. Energy efficiency target

After analysing the energy supply, demand, and use, and after setting a benchmark for energy consumption, the managing entity appointed by the government has a number of reasons for developing energy efficiency and renewable energy targets in hospitals as a scheme to reduce the level of wasted energy from the health care sector and increase its energy efficiency.

The renewable energy target should set guidelines to help health care facilities to generate 20 percent of their electricity and thermal energy from renewable sources by 2030. Moreover, milestones need to be set to achieve 10 percent energy efficiency, in line with the government's broader commitment to the Paris Climate Change Agreement, while providing the needed funding from the donor community, especially in the public sector.

Energy efficiency targets have the following benefits:

- Compel action: targets encourage the health care sector to achieve certain energy outcomes.
- Track progress: energy policies and measures can be tracked, monitored, and evaluated with the target in sight.
- Increase financing: a clear message is provided to investors that energy efficiency is a priority.

Below are some categories of energy efficiency targets with their advantages and disadvantages.

Table 33: Categories of energy efficiency targets

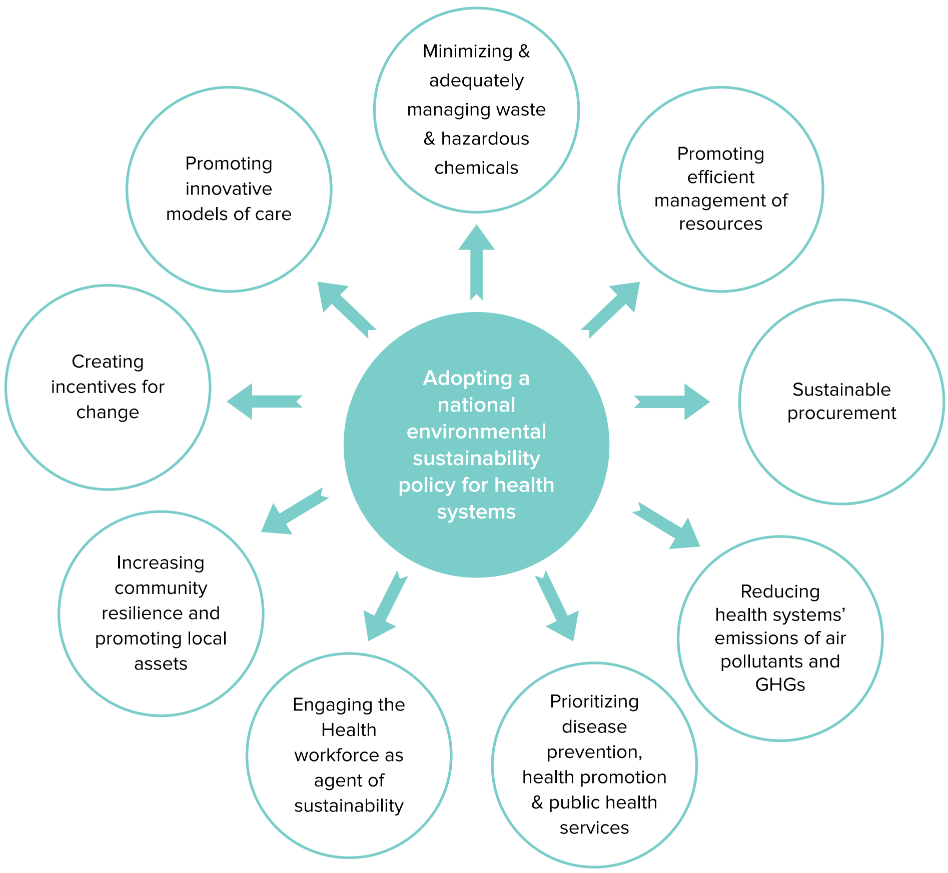
Category	Energy Intensity	Energy Productivity	Energy Consumption	Energy Elasticity	Policy Progress	Transactional
Description	A reduction in energy consumption per unit of activity	An increase in activity per unit of energy consumed	A reduction in energy consumption relative to a base year, projection or benchmark	A reduction in the ratio of energy consumption growth to activity growth	An increase in the impact of energy efficiency policies	An increase in the uptake of energy efficient goods of services
Advantages	A commonly used metric because data are usually available.	Resonates well with some stake-holders	Aligned with environmental benefitsof energy efficiency such as emissions reduction	Allows for target development in the absence of reliable, detailed data or forecasts	Encourages strong policy leadership	Encourages an increase in sales of energy efficiency products and services
Disdvantages	Achievements influenced by economic activity and structural change. Not always linked to energy use reduction	Achievements influenced by economic activity and structural change. Not always linked to energy use reduction	Achievements influenced by economic growth and structural change.	Not commonly used metric and can be difficult to understand	Difficult to measure	Achievements not always linked to energy use reduction

7.5. Develop guidelines for sustainability in health care

Set guidelines on minimum sustainability requirements for all health care capital works. The guidelines should contain sustainability initiatives on all projects to improve energy efficiency. Possible sustainability guidelines in the health care systems can include:

- Minimizing and adequately managing waste and hazardous chemicals generated.
- Promoting efficient management of resources.
- Adopting sustainable procurement.
- Reducing the emission of air pollutants and greenhouse gases.
- Prioritizing disease prevention, health promotion, and public health services.
- Engaging the health workforce as agents of sustainability.
- Increasing community resilience and promoting local assets.
- Creating incentives for change.
- Promoting innovative models of care.

Figure 60: Possible sustainability guidelines in health care systems



08

CONCLUSION

8. CONCLUSION

Based on studies, energy audits, and data gathered, the energy reality of Lebanese health care facilities proves to be very difficult and nonsustainable. The yearly electrical and thermal energies consumed per bed were calculated per climatic zone for the entire public hospitals sector.

The results obtained are:

Electricity (kWhe per bed)

- 22,997 kWh electrical for Zone 1
- 8,269 kWh electrical for Zone 2
- 4,722 kWh electrical for Zone 3
- 9,014 kWh electrical for Zone 4

Thermal (kWhth per bed)

- 23,108 kWh thermal for Zone 1
- 8,315 KWh thermal for Zone 2
- 4,681 KWh thermal for Zone 3
- 9,128 KWh thermal for Zone 4

Hence, there is a need to re-think the energy efficiency in hospitals, which is done by pointing the way for the Lebanese health care sector to achieve the energy-saving goals identified above.

This strategic plan represents a holistic energy efficiency policy for the health care sector in Lebanon. The Low-Cost/No-Cost and CAPEX measures discussed above can be performed internally in hospitals to conserve energy consumption and thus reduce energy bills. These measures have a total implementation cost of around $17.6 million and result in approximately $4 million of savings per year. The payback of such measures is 4.5 years, and the Net Present Value is approximately $13 million. Hence, after implementing the aforementioned measures, the expected yearly energy consumption per bed becomes:

Electricity (kWhe per bed)

- 16,949 kWh electrical for Zone 1
- 6,543 kWh electrical for Zone 2
- 3,314 kWh electrical for Zone 3
- 7,609 kWh electrical for Zone 4 Thermal (kWhth per bed)
- 10,586 kWh thermal for all zones

Additional actions can be identified as part of institutional strategic thinking, developed by the government as a holistic energy policy. These governmental policies and actions start by understanding where the sector currently stands in terms of energy use by benchmarking and scoring, and then by developing energy management plans and dashboards; appointing and identifying the roles of managing entities; setting energy targets, guidelines, and programmes; and finally setting environmental charges as a penalty mechanism. However, this strategy remains mere words on paper without the serious governmental will to implement much-needed sector reforms, especially by ensuring adequate levels of operation and maintenance of public hospitals and the Ministry of Public Health.

APPENDIX A – LOW COST/NO COST CHECKLIST

Checklist of low-cost operation and management practices to identify opportunities, assign responsibilities, and track progress towards goals at health care facilities.

	Opportunity exists	Target reduction	Responsible person	Target date to complete	Actual date completed	Notes
OPERATIONS & MAINTENANCE						
Ensure all equipment is functioning as designed						
Calibrate thermostats						
Adjust dampers						
Implement janitorial best practices						
Properly maintain existing equipment						
OCCUPANTS' BEHAVIOUR						
Turn off equipment						
Institute an energy awareness programme						
Adopt a procurement policy						
Maximize use of daylight						
Install task lighting						
Train staff						
LIGHTING						
Change incandescent to CFLs						

	Opportunity exists	Target reduction	Responsible person	Target date to complete	Actual date completed	Notes
Install occupancy sensors in back of the house, infrequently used areas						
Install high-efficiency LED exit signs						
Periodically clean the bulbs with a dry cloth						
De-lamp where illumination is excessive						
Only use lights that are needed						
KITCHEN						
Pre-heat ovens no more than 15 minutes prior to use						
Keep refrigerator coils clean and free of obstructions						
Bleach clean with warm water						
Use fan hood only when cooking						
Purchase ENERGY STAR® commercial cooking equipment						
COMPUTERS & OFFICE EQUIPMENT						
Utilize power down feature on computers						
Purchase ENERGY STAR® office equipment						
Install energy control devices on vending machines						
HVAC AND PLANT SYSTEMS						
Align and adjust belts						
Adjust thermostats for seasonal changes and occupancy						

	Opportunity exists	Target reduction	Responsible person	Target date to complete	Actual date completed	Notes
Balance air and water systems						
Replace boiler burners						
Unblock air flow from unit ventilators						
Clean centrifugal chiller water tubes						
Clean and repair chilled water plants or package units						
Repair leaking steam traps						
Repair pipe and vessel insulation from steam and hot water distribution lines						
Chemically treat feed water						
Annually test combustion efficiency						
Clean and lubricate moveable surfaces and check actuator movement and set-points in the damper and economizer						
Perform boiler tune-ups						
Clean filters and fans						
Clean air conditional evaporator and condenser coil fins						
Check for air leaks in equipment cabinets and ducts						
Ensure proper operation of air damper						
Clean condenser and evaporator coils						
Properly charge refrigerant						
Install VFDs and energy efficient motors						

	Opportunity exists	Target reduction	Responsible person	Target date to complete	Actual date completed	Notes
FANS						
Clean fan blades						
Inspect bearings						
Adjust/change belts						
Check fan current						
BUILDING ENVELOPE						
Regularly inspect doors and windows for air leaks						
Periodically inspect building for water leaks						
Check the caulking and weather stripping for leaks						
WATER HEATING						
Adjust water temperature to lower legal limit						
Periodically check the hot water systems for leaks						
Test the burners of gas or oil fired water heaters annually						
Periodically flush fixtures to prevent bacteria growth						
Annually flush storage-type hot water tanks						
Periodic maintenance on the hot water system						
Install or repair pipe insulation						

APPENDIX B – SCORING CHECKLIST SAMPLE

Facility management

☐ Make note of your energy use intensity and energy score.

☐ Ensure that facility energy management plan and operations and maintenance plan is up to date and that appropriate staff have reviewed the latest versions.

☐ Review building management system and/or building automation system code to ensure that specific commands to reduce unneeded energy consumption (e.g., on/off times) have not been overwritten.

Lighting

☐ Identify where lights have been left on in unoccupied spaces.

☐ Identify and assess opportunities to use automated lighting controls:

☐ Occupancy/motion sensors for low-traffic areas.

☐ Timers or daylight sensors to dim or turn off exterior and parking lot lights during the day.

☐ Dimming controls in locations where there is natural lighting (e.g., near windows, skylights, light tubes).

☐ Confirm that installed lighting controls are operating as intended.

☐ Assess need to institute a regular cleaning plan for lamps/fixtures for maximum light output.

☐ Identify where reflectors can be practically added to existing lighting.

☐ Assess whether any areas are over-lit, compared to requirements or design levels; consider opportunities for de-lamping.

☐ De-energize and/or remove ballasts that are not in use.

☐ Evaluate the opportunity to upgrade to more energy-efficient lighting options:

☐ Replace T12 fluorescents with T8s or T5s with electronic (rather than magnetic) ballasts; consider the use of tubular LEDs.

☐ Upgrade incandescent and CFL applications to LED (especially for task lighting or specialty/decorative applications).

☐ Use LED Exit signs in place of incandescent or CFL models.

☐ Consider making operating room lighting fully dimmable to provide flexibility in lighting levels required during preparation, procedures, & clean-up.

Building envelope

☐ Inspect doors and windows to identify gaps or cracks that can be repaired.

☐ Note damaged or missing weather stripping.

☐ Note air leaks that should be sealed with caulking or other sealant.

☐ Inspect insulation levels and identify inadequacies to be addressed.

☐ Close doors to the outside and to any unheated or uncooled areas.

☐ Assess the opportunity to install solar film or other window coverings on east, west, or south exposures to reduce solar heat gain and heat loss.

Equipment/Plug loads

☐ Identify any new equipment (e.g., TVs) in patient rooms & waiting rooms that will be needed soon, & make plan to ensure they are green when possible.

☐ Identify any new office equipment that will be needed soon; make plan to ensure they are certified as green where possible.

☐ Identify any equipment left on overnight (including those left in sleep/idle or screen saver mode).

☐ Ensure that power management settings are activated on office equipment such as computers, monitors, printers, and copiers.

☐ Identify where power strips can be used for easy disconnect from power source. Consider the use of advanced power strips.

Kitchen/Cafeteria and food service equipment

☐ Establish operating procedures for cooking/baking equipment (for instance, preheating only when necessary, turning down/off equipment when not in use).

☐ Verify oven thermostat accuracy and recalibrate, if necessary.

☐ Identify worn and/or leaky door seals/gaskets on refrigerators & freezers.

☐ Make plan to regularly clean refrigerator coils and keep free of obstructions.

☐ Identify where low-flow pre-rinse spray valves can be installed.

☐ Ensure that range hoods and exhaust fans are only running when the range is being used.

☐ Identify and assess opportunities for demand-controlled ventilation.

☐ Identify and assess opportunities to install variable frequency drives on kitchen hoods.

☐ Identify and assess opportunities to use green-certified commercial food service equipment.

☐ Check if vending machines get turned off or put in sleep mode at the end of the day. Consider installing motion/occupancy-based vending machine controls.

☐ Look for opportunities to replace older vending machines with new green-certified vending machines.

HVAC

☐ Identify & make plans to address instances of simultaneous heating & cooling.

☐ Ensure that thermostats and outside air temperature sensors are properly calibrated/maintained.

☐ Ensure that thermostats are set to appropriate temperatures based on season and local weather conditions.

☐ Confirm proper implementation of a temperature setback policy for heating/cooling unoccupied areas.

☐ Perform testing and balancing of air and water systems.

☐ Ensure free airflow to and from registers.

☐ Ensure window shades are available to block excess heat gain. Make plan to educate staff about when to use them

☐ Monitor make-up air ventilation; ensure the proper functioning of dampers to achieve outside air requirements.

☐ Assess the opportunity to use air-side economizers so outside air can be used for 'free cooling'.

☐ Ensure that HVAC system components are being maintained regularly, including:

☐ Replace filters on a regular schedule.

☐ Inspect and clean evaporator and condenser coils.

☐ Clean fan blades and adjust belts as needed.

☐ Inspect water/steam pipes and ducts for leaks and/or inadequate insulation; address as needed.

☐ Verify & calibrate operation of variable air volume boxes, where applicable.

☐ Evaluate furnace/boiler efficiency and clean/tune up as needed (including boiler water treatment and inspection of steam traps).

☐ Check chiller & cooling tower components for fouling or corrosion; ensure proper water treatment is in place.

☐ Check for unusual noise, vibration and/or decrease in performance of compressors/motors.

☐ Evaluate how chillers operate during the cold months and determine if chiller or pumps can be shut off.

☐ Identify and assess opportunities for installing variable frequency drives for fan and pump motors, and variable air volume boxes in the ductwork – especially where variable loads are being served.

☐ Consider expansion of building automation system to optimize performance of air handlers, boilers, chiller plant, fan/pump speed controls, hot water systems, humidity control, and variable frequency drives.

☐ Explore the possibility to establish separate HVAC zones for spaces with similar requirements (e.g., airflow, temperature and humidity control) to potentially allow reductions in air changes and more appropriate temperature/humidity setbacks.

☐ Identify and assess opportunities for heat recovery.

☐ Confirm total building is under positive pressure to avoid air infiltration.

☐ Evaluate part-load performance conditions to optimize operation for the staging and warm-up of boilers and chillers.

☐ Reduce the number of operating room air changes per hour (within applicable standards), depending on whether operating rooms are occupied or unoccupied.

☐ Assess the opportunity to install carbon monoxide monitoring/control for garage ventilation.

☐ Check underground parking garage ventilation systems for operation during unoccupied times.

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