Carbon Neutral Schools' Strategy in Mediterranean Sea Area - Jordan

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1. Introduction: ESMES Project and Output Definition and Objectives

The "Energy Smart Mediterranean School Network" (ESMES) project is one of the 41 projects funded by the European Neighbourhood Instrument (ENI), the largest multilateral initiative for cross-border cooperation (CBC) in the Mediterranean area - ENI CBC MED Program. The Program has a budget of €209 million, and is managed by the Autonomous Region of Sardinia (Italy). Creation of innovative start-ups, development of Mediterranean-wide economic value chains, diversification of tourism, technological transfer, inclusion of women and NEETS in the labour market, better management of waste, water and coastal areas, and improvement of energy efficiency in public buildings are the main challenges addressed by the 41 projects selected for funding in the framework of the first call for standard projects out of 439 project proposals submitted. The value of the 41 projects is €110 million, of which €100 million are of EU contribution.

ESMES addresses the issues of growing energy demand, fossil fuel dependence and increasing CO_2 emissions in the Mediterranean area. ESMES tackles the common challenge of fostering renewable energies and reducing energy use, with the common perspective of: adapting to Mediterranean climate conditions, finding innovative, effective ways of optimizing renovation investments and reducing the effects on the electricity network.

ESMES is implemented in five Mediterranean countries, involving five partner organizations, in addition to the beneficiary Institute for University Cooperation (ICU): the German Jordanian University (GJU), the Lebanese Center for Energy Conservation (LCEC), the National Agency for Energy Management of Tunisia (ANME), the Ribera Consortium of Valencia (CRIB), and the Alcamo Municipality in Italy (Alcamo).

The goal of this document is to provide school decision-makers with a strategy to achieve a suitable energy mix through renewable energy and energy efficiency rehabilitations in public schools.

2. Executive Summary

This document will provide executive decision makers with a strategy on how to ensure that public schools achieve a sustainable energy mix, paving the way for sustainable school development that fosters sustainable growth and education. Various energy efficiency and renewable energy practices and technologies are presented, with key recommendations and conclusions based on the local context.

3. Strategy Objectives/Specific Objectives

The Jordan Energy Strategy 2020 - 2030 sets out the objectives to:

- Increase the proportion of electricity generated from local sources from 15% in 2019 to 48.5% in 2030;
- Increase the share of renewable energy share of the entire energy mix from 11% in 2020 to 14% by 2030;
- Improve the use of energy efficiency in various sectors to 9% by 2030 compared to the average energy consumption in 2018;
- Reduce carbon emissions by 10%.

Additionally, Jordan's Nationally Determined Contributions (NDC) report commits to:

- Reducing GHG emissions by 31% by 2030.

In light of the objectives of the Jordan Energy Strategy, the present strategy aims to promote the:

- Increase of the renewable energy share in public schools buildings;

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- Utilization of energy efficient practices and equipment;
- Reduction of the cooling/heating load in public school buildings;

- Improvement of the infrastructure and environment (that fosters sustainable development) of public school buildings to accept renewable energy systems;
- Limitation of barriers that impact the uptake of renewable energy systems.

4. Country Strategy (Action Lines)

As mentioned in the section above, the suggested strategy will focus on promoting renewable energy and energy efficient systems within the context of Jordanian public schools with the ultimate goal of increasing their sustainability.

a. Setting the Baseline: Energy Diagnosis/Audit

As a first step to assessing the kinds of practices, equipment, and rehabilitations that need to be introduced to a building, conducting an energy audit is essential. An energy audit assesses the energy efficiency of a building and identifies areas where energy consumption can be reduced. The audit typically includes a detailed analysis of energy use, equipment performance, and building systems to identify opportunities for cost-effective improvements to energy efficiency and overall sustainability. The end goal of an energy audit is to reduce energy waste, lower energy costs, and improve the overall energy performance of the building.

An energy audit is typically performed by an energy auditor, who is a professional trained to assess the energy efficiency of buildings and industrial facilities. Energy auditors use various techniques, such as analyzing energy bills, conducting equipment inspections, and using specialized tools, to identify energy-saving opportunities.

An energy audit study will typically begin with a site inspection to observe energy use, identify potential areas for improvement, and gather data. In addition to reviewing relevant documentation, data may be collected through interviews with relevant building occupants to determine energy usage durations, behavior, and habits to achieve the best estimation of unrecorded parameters. Following this, an energy usage analysis is conducted using energy bills and other usage data to identify areas of high energy consumption and cost. The equipment at the site is then inspected to examine heating and cooling systems, lighting, appliances, and other equipment to assess their energy efficiency, followed by a building envelope assessment to evaluate the insulation, air sealing, and other elements that determine the energy efficiency of the building envelope. Depending on the required depth and breadth of the energy audit study, a computer simulation of the building's energy performance may be performed to predict the effects of proposed changes. Based on all findings, recommendations for improving energy efficiency, reducing energy costs, and improving comfort are made. The aforementioned analyses and findings are then all consolidated into what is called an "energy audit report" and may include a financial analysis and estimated savings for each proposed improvement. The report should provide clear and actionable recommendations to improve the building's energy efficiency and achieve measurable energy savings.

The responsible body then analyzes the various suggested improvements and selects the solutions that best match their budget, scope, and current goals.

b. Administrative Aspects; Organisational structure (3.1.4); Written policy; Target setting. Operational Procedures; Commitments; Procurement policy

One of the essential steps to successfully roll out a sustainable energy strategy at public schools is assigning a responsible committee that would explore, drive, and monitor decisions (i.e. steering and monitoring committee) related to the strategy. It is essential that the committee includes the various key stakeholders within the public school and beyond. This committee should ideally include members from the schools' executive body, finance and procurement teams, and any members from other relevant government institutions that have influence on the schools' existing systems and decisions (i.e. Procurement Department, Ministry of Education, etc.).

This team would be responsible for setting objectives and commitments related to energy sustainability, as well as monitor their implementation.

National regulations that must be kept in mind as a way to facilitate the integration of new practices within the school include:

- Procurement should follow Government Procurement Bylaw No. 8 of 2022 in all its proceedings.

It is noteworthy to mention that the Project has set up a National Hub in Jordan to provide room for knowledge exchange and cooperation within the renewable energy and energy efficiency sector. The main objectives of this National Hub is to exchange knowledge and good practices, elaborate and approve of procedures. One of the main themes discussed during a National Hub meeting was on the issues associated with photovoltaic system output variations and their impact on the electricity grid (mainly power factor compensation and load shifting using automatic voltage regulators). To that end, a questionnaire was administered to collect feedback on these issues and to ensure that the Project's research outcomes are relevant to the local context, available resources, and expertise, prior to the Hub meeting. Based on the questionnaire results:

- It was evident that some stakeholders had previously utilized the power factor setting available in PV inverters. However, it seemed that the majority had experiences with fixing the power factor at a certain level and did not dynamically control it to suit real-time grid parameters.
- In terms of observing the impact of utilizing the inverter power factor compensation option to minimize voltage drop/rise issues on the grid, almost none of the survey respondents who had previously implemented the function were able to see the impact on the grid.
- Further investigation needs to be conducted to obtain feedback from electricity distribution companies on this aspect.
- There is great potential to invest time and resources to research and pilot implementing battery storage and AVR technologies.
- It is important to further investigate battery storage technologies for grid stabilization in Jordan.

With this information, various regulatory requirements were highlighted.

c. Creation of a RES & RUE Action Plan

Expansive whole-school involvement in the creation of sustainability action plans is essential. This includes not only executive decision makers, but also maintenance staff, faculty members, and even students. Such populations are those who first hand experience any sustainability shortcomings and whose needs, especially the faculty and students, should be met as they are the core of any educational system. Maintenance staff shall also be involved as they are aware of the building infrastructure, energy distribution, and energy-saving opportunities.

Such broad, vertical involvement would achieve whole-school buy-in and ownership to motivate and drive progress on any intended efforts. This also controls any potential resistance to change and facilitates the seamless integration of sustainable practices.

After an energy audit, the first step in prioritizing energy actions is to evaluate and prioritize opportunities for energy savings based on factors such as cost-effectiveness, feasibility, and impact on the organization's energy consumption and cost. The following steps can help prioritize energy actions:

1. Identify the most significant energy consumption areas: focus on the areas that consume the most energy and have the greatest potential for energy savings.
2. Evaluate cost-effectiveness: consider the cost of implementing each energy-saving measure and compare it to the potential energy savings and payback period.
3. Consider feasibility: evaluate the feasibility of each measure in terms of technical, operational, and financial aspects, as well as any constraints such as time and resources.
4. Consider impact on the organization: consider the impact of each measure on the organization's operations, including the potential for disruption, process changes, and any necessary investments.
5. Prioritize actions: based on the above factors, prioritize energy actions and develop an implementation plan that takes into account the resources and time required for each measure.

The prioritized energy actions should be reviewed and updated regularly to reflect changes in the organization's energy consumption and cost, as well as any new energy-saving opportunities.

It is noteworthy to mention that the contest organized by the Project for various public schools allowed participating schools to implement the above steps (please refer to the section titled "Engaging the Community: Awareness and Capacity Building (WP2)").

Additionally, the challenges and outcomes of the Hub Meeting discussed in the previous section shall be considered.

d. Energy Systems Design. Technical Considerations / Technology Solutions

i. Renewable Energy Systems

Solar thermal systems are systems that use solar energy to generate heat, typically for heating water. They consist of a collector, which absorbs solar radiation and converts it into heat, and a storage system, which stores the heat for later use. The collector can be a flat-plate or evacuated tube collector, and it is usually mounted on a roof or a sunny wall. The storage system can be a tank or a series of tanks, and it is typically insulated to prevent heat loss. Solar thermal systems can be a cost-effective and environmentally-friendly solution for providing hot water at school buildings. Some benefits of installing solar thermal systems at school buildings:

1. Cost savings: solar thermal systems can reduce a school's energy costs by utilizing free and renewable energy from the sun to heat water.
2. Environmental benefits: solar thermal systems produce hot water without generating greenhouse gas emissions or consuming non-renewable energy sources, making them a cleaner and more sustainable option.

3. Improved comfort: solar thermal systems can provide a reliable and consistent supply of hot water for showers, hand washing, and other applications, improving comfort for students and staff.
4. Educational opportunities: solar thermal systems can provide educational opportunities for students to learn about renewable energy, sustainable technology, and the benefits of reducing energy consumption.

Solar thermal systems have several advantages, but they also have some disadvantages that need to be considered when deciding whether to install one. Some disadvantages of solar thermal systems include:

1. Maintenance requirements: solar thermal systems require periodic maintenance and cleaning to ensure they continue to operate effectively and efficiently.
2. Limited hot water production: solar thermal systems may not be able to produce enough hot water to meet peak demand, especially during periods of extended cloudy weather or high demand.
3. System degradation: over time, the performance of solar thermal systems can decline due to weathering and other factors, reducing their efficiency and effectiveness.
4. Climate considerations: The performance of solar thermal systems can be affected by climate conditions, with areas that experience frequent cloudy or shady weather having reduced hot water production.
5. Space requirements: Solar thermal systems require adequate roof or wall space for installation, which may be a limiting factor for some buildings or homes.

Jordan has a high solar resource potential, and thus, such technologies are widespread in the country. When considering a solar thermal system for a school building, it is important to assess the building's hot water demand and existing hot water system. The size and cost of the solar thermal system will depend on these factors, as well as the budget and available funding for the project. It is essential to work with a qualified and experienced installer to ensure that the system is installed properly and operates effectively.

Photovoltaic (PV) systems are systems that convert sunlight into electricity. They consist of a set of solar panels, an inverter, and other electrical components. PV systems can be installed on the roof of a building, on the ground, or on a standalone structure. They can be used to generate electricity for a single building or a group of buildings, and they can be connected to the electrical grid or used in off-grid applications to save on electricity bill costs. PV systems provide a clean and renewable energy source, helping to reduce dependence on non-renewable energy sources such as coal, oil, and natural gas. They also reduce greenhouse gas emissions and other pollutants associated with electricity generation. Installing PV systems in school buildings can bring several benefits, including:

1. Energy cost savings: schools can reduce their energy costs by generating their own electricity using solar energy, which can also help to reduce their carbon footprint.
2. Educational opportunities: schools can use PV systems as a teaching tool, offering students hands-on experience with renewable energy technology and the benefits of reducing energy consumption.
3. Improved sustainability: PV systems can contribute to a more sustainable energy mix and help schools meet their sustainability goals.

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While PV systems offer many benefits, they also have some potential drawbacks that should be considered when deciding whether to install one in a school building. Some of the drawbacks of PV systems in school buildings include:

1. Maintenance requirements: PV systems require periodic maintenance, such as cleaning and inspection, to ensure they continue to operate effectively and efficiently.
2. Limited electricity production: PV systems may not be able to produce enough electricity to meet the school's peak demand, especially during periods of low sunlight.
3. System degradation: over time, the performance of PV systems can decline due to weathering and other factors, reducing their efficiency and effectiveness.
4. Climate considerations: The performance of PV systems can be affected by climate conditions, with areas that experience frequent cloudy or shady weather having reduced electricity production.
5. Space requirements: PV systems require adequate roof or ground space for installation, which may be a limiting factor for some school buildings.

In Jordan, geographical, environmental, economic conditions and regulations favor installation of on-grid PV systems. It is important to assess the building's electrical demand and existing electrical system. Additionally, the school building infrastructure should also be carefully examined to ensure that it can withstand the weight of the PV system on its rooftops.

Furthermore, the location of the nearest utility interconnection transformer should be evaluated, as distant transformers would significantly increase the cost of the PV system. The size and cost of the PV system will depend on these factors, as well as the budget and available funding for the project. It is important to work with a qualified and experienced installer to ensure that the PV system is designed and installed properly and meets the school's energy needs.

ii. Site Design; Outdoor Space and Surroundings (Space Management)

Location and orientation play an important role in the energy gains and losses of a building during the design phase. For example:

1. Solar exposure: the orientation of the building, particularly with regards to the sun, will affect the amount of solar energy that is gained or lost. A building that faces south, for example, will receive more solar energy.
2. Wind patterns: the location and orientation of the building with regards to wind patterns can also affect energy efficiency. For example, a building that is positioned to take advantage of natural ventilation from prevailing winds can reduce the need for air conditioning.
3. Building envelope: the design of the building envelope, including the size and orientation of windows, walls, and roof, will determine how much energy is lost or gained. For example, large south-facing windows can provide significant amounts of natural light, but also increase the risk of overheating.
4. Shading: the orientation and design of the building can affect the amount of shading that is received, which can impact the energy requirements for heating and cooling.
5. Vegetation around the building will provide shadows, wind flows, and dominant breezes.

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Considering the location and orientation of a building during the design phase is important for maximizing energy efficiency and reducing energy costs. An energy simulation and analysis can be used to predict the energy performance of a building based on its location, orientation, and design, and to inform decisions about design and construction to optimize energy efficiency.

iii. Energy-Efficient Building Shell/Building Envelope

The building envelope refers to the physical separator between the interior and exterior environments of a building. Its purpose is to control heat transfer, by preventing heat loss in winter and heat gain in summer. This can be achieved through various methods such as insulation, air sealing, shading, and glazing. A well-designed building envelope can improve the thermal performance of a building, leading to increased comfort and energy efficiency.

Here are some of the common technologies used for building envelopes to control heat transfer:

1. Insulation: a layer of material added to walls, roofs, and floors to reduce heat flow and provide thermal resistance.
2. Air Sealing: the process of sealing all cracks and gaps in the envelope to prevent air infiltration and exfiltration, which can lead to thermal losses and gains.
3. Double Glazing: the use of two layers of glass in windows to reduce heat transfer and improve energy efficiency.
4. Low-Emissivity (Low-E) Coatings: a microscopically thin coating applied to the surface of windows to reduce the amount of heat that can pass through the glass.
5. Passive Solar Design: the use of building orientation, shading, and thermal mass to passively regulate indoor temperatures by taking advantage of solar radiation.
6. Radiant Barriers: reflective materials installed in attics or on roof decking to reduce heat transfer by radiative heat flow.
7. Smart Glass: glass that can switch from transparent to opaque, or control the amount of light and heat passing through, using electrical or thermal energy.

These technologies can be combined to create a multi-layered building envelope that provides optimal thermal performance.

Advanced building envelopes are designed to not only control heat transfer but also to maximize energy efficiency and indoor comfort. Here are some of the advanced building envelope technologies:

1. Dynamic Insulation: a type of insulation that adjusts its thermal resistance based on temperature changes, providing enhanced thermal performance and energy efficiency.
2. Vacuum Insulation Panels (VIPs): thin, high-performance insulation panels made of a vacuum-sealed core material, which provide excellent thermal performance in a compact form.
3. Phase Change Materials (PCMs): materials that can store and release heat as they change phase, helping to regulate indoor temperatures and improve energy efficiency.
4. Solar Shading Devices: devices installed on windows or on the building exterior that control the amount of solar radiation entering the building, reducing heat gain and improving indoor comfort.
5. Building-Integrated Photovoltaics (BIPVs): photovoltaic panels that are integrated into the building envelope, generating electricity and improving energy efficiency.
6. Smart Windows: windows with advanced glazing and shading systems that can be controlled to regulate indoor temperatures and improve energy efficiency.

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These advanced technologies offer improved thermal performance and energy efficiency, helping to create a more sustainable and comfortable built environment.

It was found that in many schools, both the external walls and windows have insulation lower than recommended for Jordan and fixing these issues would result in better thermal comfort levels. However, this will not have a considerable effect on the energy consumption since the current heating system is capped by available kerosene, not actual demand. It will, however, be of great significance to the energy efficiency in case of installing an adequate heating system. Retrofitting should target the recommended insulation specifications indicated in the Jordanian energy efficient building code.

iv. Lighting and Appliances

Lighting can account for a significant portion of a building's energy consumption, depending on the type of lighting systems used and the occupancy patterns. To reduce energy use for lighting, energy-efficient technologies such as LED lights, occupancy sensors, and daylight harvesting systems can be used. Additionally, reducing the number of hours that lights are in use, and ensuring that lighting levels are appropriate for the task at hand, can also help to reduce energy consumption.

Efficient lighting technologies are designed to reduce energy consumption and lower costs, while providing adequate and comfortable lighting. Some of the most common efficient lighting technologies include:

1. Light-Emitting Diodes (LEDs): energy-efficient lights that last longer, use less energy, and produce less heat than traditional incandescent lights.
2. Occupancy Sensors: devices that turn lights on and off automatically based on the presence of people in a room.
3. Daylight Harvesting Systems: systems that use sensors and dimming controls to adjust lighting levels based on the amount of natural light available, reducing energy use.
4. Tunable White LED lighting: LED lights that can change color temperature to improve indoor comfort and reduce energy use.
5. Smart Lighting Systems: lighting systems that can be controlled and monitored remotely, providing greater flexibility and energy efficiency.

These efficient lighting technologies can provide significant energy savings, lower costs, and improved indoor comfort.

One key finding from the Project's work in public schools is that inefficient lighting technologies are widely spread. Also, poor lighting intensity and distribution was observed, which is not conducive to an appropriate learning environment. Therefore, a great potential to save energy is through the incorporation of efficient lighting technologies, starting with retrofitting all lighting to LED technology, followed by installing occupancy sensors and then exploring other efficient lighting technologies as listed above.

Daylighting is the use of natural light to illuminate a building or space, reducing the need for artificial lighting and electricity. Windows and shades play an important role in daylighting by allowing or controlling the amount of natural light that enters a space.

1. Windows: the design and placement of windows can significantly affect the amount of natural light that enters a space. Windows can be designed to maximize the amount of light that enters a space, and can be placed in strategic locations to minimize the need for artificial lighting.

2. Shades: shades can be used to control the amount of natural light that enters a space. Shades can be adjusted to allow or block light as needed, helping to regulate the temperature and brightness of a space.

Using daylighting and windows effectively can result in energy savings and improved indoor comfort. By taking advantage of natural light, building owners can reduce the amount of energy required for artificial lighting, which can result in lower energy bills and a more sustainable building. Additionally, exposure to natural light has been shown to improve the health and well-being of building occupants, making it an important aspect of sustainable building design.

In purchasing electrical appliances, it is essential that the appliance has an efficiency label and a rating as close to A+++ as possible. An appliance efficiency label is a label or rating system used to indicate the energy efficiency of household appliances. The most common appliance efficiency label is the Energy Star label, which is a program run by the U.S. Environmental Protection Agency (EPA).

High energy consuming appliances are household appliances that consume a significant amount of energy. Some common examples of high energy consuming appliances include:

1. Refrigerators and Freezers: these appliances run 24/7 and use a significant amount of energy to maintain proper temperature and keep food fresh.
2. Computers: can be high energy consumers, especially when in use for extended periods of time. To reduce energy consumption by computers, individuals can take steps such as reducing screen brightness, using power-saving modes, turning off Wi-Fi and other network connections when not in use, and using energy-efficient software and peripherals. Additionally, individuals can also consider using laptops instead of desktop computers, as laptops tend to consume less energy.
3. Dishwashers: dishwashers consume a significant amount of energy during each cycle, especially when using hot water and high-heat settings.
4. Air Conditioners: air conditioners consume a significant amount of energy during use, especially during hot summer months; there are however more efficient technologies that are available in the market. It was found through the Project's work that air conditioners consume the biggest share of electrical consumption in schools; therefore, investing resources to upgrade air conditioning technologies to more efficient ones shall be prioritized.
5. Televisions: televisions can consume a significant amount of energy, especially if left on for long periods of time.

By reducing usage of these high energy consuming appliances or replacing them with more energy-efficient models, households can reduce energy consumption and lower energy bills.

It is worth noting that all electrical appliances sold in Jordan must have an energy label and must adhere to the standards and regulations of the Jordan Standards and Metrology Organization (JSMO) and the Customs Department.

v. Heating and Cooling Systems; Ventilation

Space heating and cooling, as well as water heating account for nearly 55% of global buildings energy use.

In Jordan, the most common technologies used for space heating include:

1. Electric Heating: electric heating is a common type of space heating in Jordan, especially for small and medium-sized spaces. Electric heaters come in a variety of sizes and types, including convection heaters, radiant heaters, and fan heaters.
2. Gas Heating: gas heating is another popular type of space heating in Jordan. Gas heaters can be powered by natural gas or propane, and are typically more efficient and cost-effective than electric heating.
3. Heat Pumps: heat pumps are a type of space heating technology that use electricity to transfer heat from one location to another. Heat pumps can be used for both heating and cooling, making them a versatile and energy-efficient option for space heating in Jordan.
4. Boilers: Boilers are a type of space heating technology that use natural gas, propane, or other fuels to heat a building. Boilers are commonly used for large spaces, such as schools and office buildings, and can be more energy-efficient than electric heating.

The most common technologies used for space cooling include:

1. Air Conditioning: air conditioning is the most common type of space cooling technology in Jordan. Air conditioning units come in a variety of sizes and types, including split systems, window units, and central air systems. One very popular technology is inverter split units and VRF central air conditioning systems.
2. Evaporative Coolers: evaporative coolers are a type of space cooling technology that use water evaporation to cool air. Evaporative coolers are more energy-efficient than air conditioning units, and can be a good choice for households looking to reduce energy costs.
3. Chillers: chillers are a type of space cooling technology that use refrigerant to cool air. Chillers are commonly used for large commercial and industrial spaces, and can be more energy-efficient than air conditioning units.
4. Passive Cooling: passive cooling is a type of space cooling technology that takes advantage of natural ventilation, shading, insulation, and positive occupancy patterns to reduce the need for air conditioning. Passive cooling is a sustainable and cost-effective alternative to traditional cooling technologies. Utilizing passive cooling technologies reduced the cooling demand, which would directly reflect on energy bills.

   Other ways to reduce the cooling demand include using window/door sensors and performing window maintenance.

Choosing the right space heating/cooling technology will depend on several factors, including the size of the space, the heating/cooling needs of the building, and the available energy sources. Building owners and occupants are encouraged to consider the long-term energy efficiency and sustainability of their heating/cooling systems to minimize energy costs and improve indoor comfort.

Considering the building construction and activity type, it is recommended to install split air conditioning units in the heated zones of a building. Split unit AC systems are the simplest to install in a building without ducting or piping infrastructure, and they are suitable for efficiently heating and cooling small areas for intermittent time intervals. Operating air conditioning systems will increase energy requirements; however, installing a renewable energy system at the site will offset that increase in energy usage.

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The most common technologies used for water heating in Jordan include:

1. Electric Water Heaters: Electric water heaters are the most common type of water heater in Jordan. They are relatively cheap and easy to install, making them a popular choice for many households.
2. Gas Water Heaters: Gas water heaters are another popular type of water heater in Jordan. Gas water heaters use natural gas or propane to heat water, and are typically more efficient and cost-effective than electric water heaters.
3. Solar Water Heaters: Solar water heaters are becoming more popular in Jordan, especially as the cost of solar technology continues to decrease. Solar water heaters use the sun's energy to heat water, reducing the need for traditional heating sources and helping to reduce energy costs.
4. Heat Pump Water Heaters: Heat pump water heaters are a type of water heating technology that use electricity to transfer heat from one location to another. Heat pump water heaters are more energy-efficient than electric or gas water heaters, making them an attractive option for households looking to reduce energy costs.

Some governing national regulations/codes include:

1. Natural Ventilation Code
2. Central Heating Code
3. Mechanical Ventilation and Air Conditioning Code

vi. Resource-Efficient Building Products

In order for a school to establish high efficiency performance practices, appropriate materials and components should be chosen and combined effectively through good design and construction practices.

Resource-efficient building products are products used in the construction or renovation of buildings that are designed to be highly energy-efficient and environmentally sustainable. These products can help to reduce energy consumption and lower operating costs, while also improving indoor comfort and air quality. The aforementioned technologies serve as possibilities for resource-efficient building product types.

In determining which products (i.e. energy efficient systems) to use, it is essential to first conduct an energy audit to determine the energy consumption profiles and determine opportunities for energy saving. Following this assessment, it is essential to establish an energy performance target for the school building. This could be based on a set of performance standards, such as ASHRAE, ENERGY STAR, or LEED, or a local energy code.

Depending on the set targets, available resources (financial, products, infrastructure), and viable opportunities, possible products are determined. It is best practice to then execute a life-cycle assessment (LCA) to determine the environmental impact of a product or system over its entire life cycle. Once this assessment offers positive returns, then the adoption of products is confirmed.

The LCA can be used to evaluate the environmental impact of energy-efficient systems in buildings, including heating, cooling, lighting, and other building systems. When conducting LCA for energy-efficient systems, the following steps are typically followed:

1. Define the system boundaries: identify the scope of the system being evaluated, including all relevant components and stages of the life cycle.
2. Data collection: gather data on the energy and resource consumption, emissions, and other environmental impacts associated with each stage of the life cycle.
3. Life-cycle inventory: compile the data collected in a life-cycle inventory, including information on energy consumption, emissions, and other environmental impacts.
4. Life-cycle impact assessment: analyze the life-cycle inventory data to determine the environmental impact of the system, using methods such as environmental impact categories, such as global warming potential, acidification, and eutrophication.
5. Interpretation and reporting: interpret the results of the LCA and prepare a report summarizing the findings and recommendations.

The results of the LCA can be used to support decision-making about the selection and design of energy-efficient systems, and to evaluate the overall sustainability of the building. By conducting LCA for energy-efficient systems, designers and building owners can make informed decisions about the most environmentally responsible and sustainable systems for their buildings.

vii. Energy supply

Improving energy tariffs and "green" energy procurement is not applicable in Jordan. Jordan has a centralized electrical distribution system; therefore, diversifying energy supply is restricted.

e. Engaging the Community: Awareness and Capacity Building (WP2)

Educating communities and building capacity among students on renewable energy and energy efficiency is important for promoting energy conservation and achieving energy savings goals. By raising awareness and empowering school employees and students with the knowledge and skills to adopt sustainable energy practices, the benefits of renewable energy and energy efficient practices can be maximized.

The project has successfully engaged school communities in awareness and capacity building activities for renewable energy and energy efficiency technologies. Training sessions were held in nine schools on various energy efficiency and renewable energy technologies, the use of electrical appliances, and energy-saving behavior patterns. The schools were then asked to spread awareness to other schools and community members and ultimately prepare a report outlining the various kinds of energy efficient and renewable energy technologies that best fit the school needs including an elaboration of how and why those technologies would meet their respective school's needs. The schools entered a contest, whereby the prepared reports were evaluated by the Project based on the quality and applicability of their individually chosen technologies. The winning school received energy efficient and renewable energy equipment worth up to 60,000 Euros.

In another contest, the schools competed for the least energy consumption following their training on rationalizing energy consumption. According to data collected from data acquisition (DAQ) systems installed at the various schools, it was observed that all schools managed to lower their energy consumption.

The schools' achievements were recognized in a culminating event, where prizes and awareness materials were distributed. The goal of this contest was to encourage schools to adopt sustainable energy practices and to lower their energy consumption.

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Through this engagement, the Project witnessed the power of community engagement in adopting sustainable practices. Not only did schools' management bodies consider innovative solutions, but the awareness activities reflected positively on staff and student education, which would ultimately also reflect on their families.

f. Monitoring Measures & Impact

The effectiveness and impact of energy efficient and renewable energy interventions can be monitored through various measures, including:

1. Energy consumption: monitoring the energy consumption of a school building can give an accurate picture of the energy savings achieved through the implementation of energy-efficient technologies and the adoption of sustainable energy practices.
2. Economic impact: the economic impact of energy efficient and renewable energy interventions can be measured by evaluating the cost savings achieved through lower energy bills and the return on investment in sustainable energy technologies.
3. Environmental impact: the environmental impact of energy efficient and renewable energy interventions can be measured by monitoring the reduction of greenhouse gas emissions and other pollutants.
4. Behavioural change: the impact of energy efficiency and renewable energy interventions can also be measured by evaluating the changes in behavior and attitudes among school members towards energy conservation and sustainability.
5. Surveying school community members on their perceived benefits of the various installed interventions.

By monitoring these measures, it is possible to determine the impact and effectiveness of energy efficient and renewable energy interventions and make necessary adjustments to further improve their impact.

In schools, the monitoring of the effectiveness and impact of energy efficient and renewable energy interventions can be carried out by a combination of stakeholders, including:

1. School administrators: School administrators can be in charge of overseeing the implementation of energy-efficient technologies and sustainable energy practices, as well as monitoring their impact.
2. Energy teams: Schools can form energy teams composed of teachers, students, and other stakeholders, who can be responsible for monitoring the energy consumption and implementing energy-saving measures.
3. External experts: External experts such as energy consultants and engineers can be engaged to provide technical assistance and carry out the monitoring of the impact of energy-efficient technologies and sustainable energy practices.
4. Government agencies: Government agencies can provide support and resources for the monitoring and evaluation of energy efficient and renewable energy interventions in schools.

The key to successful monitoring is collaboration and cooperation among all stakeholders to ensure that the impact of energy efficient and renewable energy interventions is accurately measured and continuously improved.

g. Multi-Level Governance: LA, Regional, National, Management Board

Engaging and facilitating the collaboration of political stakeholders can be done in the following ways:

1. Building partnerships: form partnerships with political stakeholders who govern the energy efficiency and renewable energy sector and set goals and visions for the growth of the sector (e.g. Ministry of Energy and Mineral Resources, JREEEF).
2. Communication: develop effective communication strategies that allow reaching out to political stakeholders and engaging them in planning processes.
3. Stakeholder engagement: encourage political stakeholders to actively participate in the planning process by providing them with information and insights, and by creating opportunities for them to contribute their ideas and feedback.
4. Data-driven decision-making: use data and analysis to inform decision-making and demonstrate the benefits of energy efficiency and renewable energy technologies. This can help to offer transparency and foster support from political stakeholders.
5. Monitoring and evaluation: establish a system for monitoring and evaluating progress in implementing the interventions. This again can help offer transparency and thus increase the engagement of political stakeholders.

By engaging stakeholders and working together, developing and implementing effective action plans for adopting energy efficient and renewable energy technologies will be a success.

In Jordan, ministries are typically the decision-making, policy-making, and tendering bodies, whereas municipality offices are those that implement the decisions in the various municipalities. All service ministries follow this structure, including the Ministry of Education. Therefore, all decisions related to schools must be made/approved by the Ministry of Education.

5. Current legal & supporting framework (3.1.2). Opportunities identification.

Document	Description/Significance
Jordan 2025: A National Vision and Strategy	Documents Jordan's long-term national vision, strategies and policies that correspond to the basic principles of sustainability, institutionalization, excellence, competitiveness, and meritocracy.
National Energy Sector Strategy 2020 - 2030	Plan that sets the roadmap to increase self-sufficiency through utilization of domestic natural and renewable sources, to reduce the energy consumption by improving the energy efficiency measures in different sectors, and to reduce the carbon dioxide emissions.
The Executive Action Plan of Jordan Energy Strategy 2020-2030	Action plan to accomplish the objectives of the National Energy Sector Strategy.
Jordan's NDC Report to UNFCC 2021	Enhances Jordan's commitment to the international climate change governance system.
National Green Growth Plan 2017	Highlights the growth of the Energy, Waste, Agriculture, Water, Transport and Tourism sectors, and contains action plans for a green economy in these sectors.

Energy Sector Green Growth National Action Plan 2021-2025	Outlines a green growth framework and actions for the energy sector aligned with the National Green Growth Plan, Jordan Vision 2025, and Nationally Determined Contributions (NDCs) under the Paris agreement.
Jordan Economic Growth Plan 2018 - 2022	Comprises economic, fiscal and sectoral strategies that outline the vision and policies pertaining to each sector. It further identifies the required policy interventions, public projects and private investments that must be undertaken to realize these sectoral visions.
Renewable Energy and Energy Efficiency Law (Law. No. 13 for the year 2012) and Bylaw No. 73 for the year 2012 on regulating energy conservation and efficiency procedures	As a result of passing the Renewable Energy and Energy Efficiency Law No. 13 for the year 2012, a directive on regulating the procedures pertaining to energy efficiency and conservation practices was passed. This directive stresses adherence of consumers (which use more than 50 thousand tons of oil equivalent of energy annually) to energy efficiency building codes (detailed below), as well as energy efficient/conservation practices. It also dictates that these consumers conduct energy audits on an ongoing basis to ensure that highest energy efficiency practices are being utilized.
Jordan Green Building Guide	The Green Building Guide develops local green building assessment tools that suit the context of Jordan environmentally, socially, and economically with the aim to provide a basis for designing sustainable buildings. It contains parameters and credits that are suitable for Jordan's climate, resources, legislation, policies & policies instrument, building techniques and strategies. This Guideline is attached to a voluntary rating system that is connected to an incentive scheme given by the government.
Thermal Insulation Code and Thermal Insulation Manual	Define building thermal design principles and the methods for calculating the thermal characteristics of different structural elements. Additionally, it sets the minimum thermal requirements for these elements.
Energy Efficient Buildings Code and Energy Efficient Buildings Manual	The Energy Efficient Buildings Code code provides minimum requirements for energy efficiency in buildings in the design, construction, operation and maintenance phase of the building. It also includes a mechanism to verify the application of the code requirements. The Code includes requirements for new systems and devices in all existing buildings too.
Natural Lighting Code	This Code provides data for specialists, engineers, and designers on the importance of daylight in design, methods for calculations, methods for control, and energy saving potential from using natural light instead of artificial electric lighting. This Code includes requirements that apply to existing buildings (modification and extension)
Natural Ventilation Code	The Code provides requirements and design methodology to incorporate natural ventilation mechanisms when designing and retrofitting buildings. This Code requires that existing buildings are adjusted to fit the requirements (without energy consumption increase).
Central Heating Code	The Code includes everything related to the design, implementation, and operation of central heating systems that use hot water, and the use of devices and equipment such as section radiators and underfloor heating systems. It aims to provide ways to reduce energy consumption by organizing design, construction, installation, quality of materials, location, operation, maintenance and control in central heating systems. Retrofitting existing buildings can be based on this code.

Mechanical Ventilation and Air Conditioning Code	This Code includes information needed to carry out the work of designing mechanical ventilation and air conditioning systems for buildings and facilities, implementing, installing, testing and operating them. Retrofitting existing buildings can be based on this code.
Building Envelope Retrofits for Optimising Energy Efficiency & Thermal Comfort in Jordan	Includes guidelines/strategies for retrofitting the main components of building envelopes to be used by building stakeholders, including professionals working in the construction sector and the government, which develops policies on this issue.

6. School Buildings Assessment Tools (3.4)

A tool has been designed to determine the photovoltaic system needs for a building. The Photovoltaic (PV) System Design and Monitoring Tool has been developed to support users in estimating their PV system capacity requirements as well as monitoring and evaluating the system's performance over time. The design approach adopted in this tool is based on a data-driven design approach, which utilizes location-specific, environmental, and energy consumption data. This allows for the design of specifically tailored PV systems in accordance to the unique needs and conditions of the sites where the PV system is to be installed. In order to ensure that the tool generates results that are data-driven, solar irradiance data for all 12 governorates in Jordan was extracted based on the average solar irradiance over the past five years to account for any environmental variations. Additionally, the site-specific energy consumption was taken into account.

7. Conclusions/Recommendations

Adopting energy-efficient practices and renewable energy systems in school buildings is important for several reasons:

1. Cost savings: implementing energy-efficient/renewable energy measures can lower energy bills, freeing up budget for other important needs.
2. Environmental benefits: energy-efficient practices and incorporating renewable energy systems can reduce greenhouse gas emissions and contribute to a more sustainable future.
3. Improved indoor air quality: energy-efficient practices can also improve indoor air quality by reducing the need for air conditioning and heating, which can help reduce the spread of airborne pathogens.
4. Health and comfort: energy-efficient lighting and heating and cooling systems can improve indoor comfort and health by reducing exposure to excessive heat, cold, and bright light.
5. Educational opportunities: incorporating energy-efficient practices and renewable energy systems into the school curriculum can help educate students about the importance of energy conservation and sustainability, and equip them with the skills they need to make environmentally responsible choices in the future.

Such actions are an important step towards creating a more sustainable future, improving the health and well-being of students and teachers, and reducing costs for schools and communities.

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