المجلس الفلسطيني للأبنية الخضراء
Palestine Green Building Council

Green Building Feasibility Study Palestinian Green Building Council

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List of abbreviations

Solutions	Solutions for Development Consulting Co.
PalGBC	Palestinian Green Building Council
LEED	Leadership in Energy & Environmental Design
JSC	Joint Service Council for Solid Waste Management
VOC	Volatile Organic Compounds
WorldGBC	World Green Building Council
PCBS	Palestinian Central Bureau of Statistics
FSC	Forest Stewardship Council
PEFC	Programme for the Endorsement of Forestry Certification
PV Cells	Photovoltaic Cells
PERC	Palestinian Electricity Regulatory Council
PENRA	Palestinian Energy & Natural Resources Authority
HH	Households

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Executive Summary

Solutions was contracted by the Palestinian Green Building Council to conduct a study on the feasibility of Green Building in the West Bank and Gaza Strip. Taking into account different green building aspects, the research covered carbon impact of buildings, green and sustainable building material, waste, water, and energy management, and individual health and wellbeing. In order to ensure a comprehensive study, each aspect was studied on a national, municipal, and individual level in terms of buildings, offering recommendations for municipalities, developers, and end-consumers, as well as potential business opportunities to increase the availability of green solutions.

Green buildings are buildings and structures which taken into consideration the negative environmental impact of buildings and building material in their design, construction, operation, and end of life. The negative impact can be measures on two levels. The first, the embodied energy within a building, which is the amount of energy consumers to produce, transport, and construct the different building components and final product. Second is the operational energy, which is the total amount of energy needed to operate the buildings, including but not limited to, heating and cooling, lighting, shared utilities, and others.

There are many country level international agreements that Palestine is a signatory off, however, all benefits from these environmental agreements fall within the scope of the Kyoto Protocols, which limits the financing potential too all recognised states, which Palestine is not. However, a variety of smaller funds exist for municipalities, non- governmental organizations, civil society organizations, private investors, and individuals.

Looking at the different components of green buildings, the available options and used sources are studied on a national level, taking into consideration municipal case studies to scope the level of awareness and use of different green practises, as well as a general scan of retailers who provide different solutions for green buildings. As such, green building materials, waste, water, and energy management, and individual health and wellbeing in Palestine are all studied in order to provide comprehensive baseline information for the most feasible and available options to increase the use of green building measures.

Generally speaking, international selections of green building materials are available on demand in the West Bank, as the majority of building material suppliers are able to access and import many different types of material. In Gaza Strip, even though there are many restrictions on material, certain types of material can also be provided. However, two of the main constraints in using sustainable building material are the financial constraints and budget limitations due to poor economic situation, and the lack of awareness of end consumers and users of the benefits of using certain building materials.

The research in Palestine on the carbon footprint of main materials used in Palestinian buildings, as well as the availability of sustainable option took into consideration cement, pre-cast blocks (gypsum & cement), glass, paints, aluminium, wood, metal, insultation material, and windows & doors. The main results indicated not only the availability of sustainably sourced construction material, but also the availability of three local material waste collection, recycling, and recusing facilitates for metal, aluminium, and cardboard. Furthermore, effective insulation material, glass windows, and other components were found readily available for better energy management in the building. Even though different solutions are available, price differences and consumer awareness are the most crucial factors in using these materials. As the majority of direct

consumers are contractors or construction workers, these types of consumers prioritise lower prices and are generally less aware of environmental issues and hazards.

Waste management in Palestine is an issue growing in size, as the increasing Palestinian population, increase in waste production, and the saturation of Palestinian landfill is only going to cause more issues with already limited available space. As such, waste management across different municipalities is becoming more difficult, especially that there the municipal waste collection fee is barley collected, if even applied. As such, municipalities are very forthcoming to investors who are able to benefit from certain methods of waste disposal. In Hebron, the municipality was able to provide separate waste collection stream for commercial cardboard and paper waste, sending it to a pressing facility and selling it to a private company that recycles it for profit. In Ramallah, even though all waste water is treated, and stormwater is separated from municipal sewage water, both types of water are dumped back into the mountain after treatment or collection, indicating an ineffective use of a needed water source.

Even though municipalities are willing to implement waste management policies, as well as participate in ensuring different waste streams are available, they are still in dire need of businesses that are able to cover their cost and profit from the recycled or reused waste. Furthermore, this reflects on the municipal ability to enforce better waste management within their own municipalities for buildings and other structures. As even the majority of segregated waste will end up in landfill or the same wastewater stream, there are no effective waste management methods in place.

Lastly, looking at construction, deconstruction, and car skeleton waste. For the majority of materials that can be easily recycled and profited from such as metal, aluminium, and wood, the majority of contractors and developers ensure that these are separated and resold for profit. As for other construction waste, it generally sent to landfills. In Gaza Strip, the cement and concrete shortages has led to the development of concrete aggregate recycling methods, producing concrete blocks with 80% efficiency from their normal counterpart. This method was able to divert a large proportion of waste from landfills, creating new businesses specialised in collecting and profiting from construction and deconstruction waste.

Water shortages are felt across all Palestinian regions. In the West Bank, lack of water supply impact almost every Palestinian household. In Gaza Strip, the high salination of aquifers has meant that municipalities are only able to provide water for household use, where residents buy drinking water from other sources. Given the lack in water supply, municipalities face a number of issues in water distribution. In Hebron, the water shortages and difficult landscape of the municipality lead them to develop an advanced hydraulic metering system which distributed water on an 18-day cycle to consumers [1]. In Khan Younis, energy shortages greatly impact the municipal ability in treating salinated water and distributing it to households, where only solar energy is only recently being utilised to mitigate impact. In Ramallah municipality, there is sufficient water given the small population. However, the disposal of treated wastewater and collected stormwater still leads to the ineffective management of water sources, as it can alleviate water demand issues in other regions.

In buildings, even though there are available products and construction methods that are able to effectively manage water consumption, the lack of awareness amongst consumers and the lack of effective utilisation and reuse of water, leads to ineffective implementation of water management. Water management solutions such

[1] All buildings have wells to ensure collection of needed water supply.

as water efficient fixtures, rainwater and stormwater collection products, and buildings wells are all readily available across the region. However, the lack of consumer awareness in benefits leads to a lack of usage, and the lack of technical capacity means that there is no effective reuse of water in terms of diverting it flushing stream, smart agricultural systems, and cooling towers.

The energy context in Palestine is similar, where a shortage in energy supply across all regions leads more effective energy management methods in the whole region. On a national level, the Palestinian Electricity Regulatory Council (PERC) has only recently unified all policies for all distributors, however given the no response from electrical companies, information on the impact on distribution was not available. Furthermore, municipal effect on electrical policies is limited to the mayor's strategic involvement as the head of board for electrical distributors. Even though it is more complicated to ensure effective policies and distribution of electricity, there are many methods that can be used to decrease the Palestinian electrical demand. A key research result showed that the majority of buildings do not use thermal insulation, which causes a significant increase in the needed energy and costs for heating and cooling. Furthermore, even though efficient electrical fixtures (e.g., lights) are abundantly found and sold, there is lack of consumer knowledge regarding the impact of quality on the whole life cycle of the product, and the number of replacements needed. These two key components into effective building energy management are key for implementation of many key components in green building measures such as thermal comfort and individual wellbeing in general.

The use of renewable energy amongst Palestinian households is slowly increasing and decreasing at the same time. First, regarding solar energy and photovoltaic cells, there is an increase in municipal use of solar energy to provide electricity for their own facilitates, as well as an increase in use amongst high end households. Even though the payback period for household solar energy is around 4 years, the high initial investment makes it unfeasible for many residents. As for solar farms, the long payback period and disincentivising policies makes the investment less financially feasible. Second, as regard to solar water heaters, even though they were more abundantly used in Palestine, the increase in commercial residential buildings has led to a decrease in using and designing for solar water heaters in buildings.

As relation to the health and wellbeing of end users and construction workers in direct contact with construction material, there is a direct relationship between many construction materials and methods used in Palestine and its relation to certain diseases. Taking into account some of the top 10 causes of death in Palestine, ischemic heart disease, lung cancer, and lower respiratory infection (IHME, 2019), there is a clear relationship between these diseases and construction dust, bitumen, and other materials (Burstyn, et al., 2005).
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The comprehensive study above of the different building aspects of green buildings was able to provide valuable information regarding the feasibility of green buildings and challenges in their implementation. Taking in consideration all the available material and products in the region, developers and contractors will be able to tackle multiple aspects in green building designs, and potentially acquire certification for their buildings such as the Leadership in Energy and Environmental Design (LEED) certification. However, there are still many opportunities for municipalities, private investors, and end-consumers and developers to increase their use of green building measures.

Municipal work can focus on two aspects of green buildings, first, looking into municipal construction methods and design requirements, municipalities can enforce the use of thermal insulation, decorative water-based

paint, water efficient fixtures, and electrical efficient fixtures. These types of initiatives should be at least mandatory for all municipal and public buildings such as schools, hospitals, park facilities and other institutes. As for direct implementation, there are many opportunities for municipal partnerships with different stakeholders for better waste management and targeting key value chain actors, use of municipal space for solar energy production, and others.

As for business opportunities, the key gaps in consumer awareness of benefits of many green building aspects such as energy reduction due to thermal insulation, water reduction due to efficient water fixtures, and the impact of oil- based paint on users, means that there are still marketing opportunities for these products. Furthermore, the potential of municipal partnerships for waste treatment may be crucial into mitigating some of the investor risks.

As for end consumers, developers, contractors, and others, there is a need for focused awareness campaigns, targeting a variety of stakeholders and groups, in order to increase their awareness on harms of certain building materials and practises, methods for risk mitigation, as well as available options in the Palestinian market. These types of awareness campaigns will be crucial for increasing use of green building measures, and improving the general health and wellbeing of end- consumers.

Even with high potential of increasing the use of green building measures, there are still many limitations and challenged in implementation that will be faced by different parties. For municipalities, the lack of a clear and unified relationship with water and energy distributors, the large scope of work needed, and the budget constraints all lead to the possibility of overwhelming municipalities given their current capacity. As such, there needs to be a structures long term strategic plan with short term yearly outcomes that ەs able to include multiple stakeholder such as the PERC, JSC, and others.

As for investors, there high potential risk and initial financial cost may deter may investors from entering these markets. As such, incentive programs and risk share initiatives need to be implemented to incentivise investors. Lastly, the financial ability of end consumer, developer and contractors to uptake higher initial costs, as well as their lack of awareness in many green building benefits and measures all lead to bad practises in green building design and use. As such, awareness campaigns need to be able to reach a large network of stakeholders from different target groups.

1.0 Introduction

Green buildings can be defined as buildings and structures which reduce or eliminate negative environmental impacts within their design, construction, operation, and end of life. By taking into consideration different aspects within the building, such as use of green building material, waste, water, and energy management, and the individuals health and wellbeing, green buildings can be designed, constructed, and certified as buildings with less environmental impacts.

In order to assess the feasibility of green buildings, different aspects of green buildings were investigated in the Palestinian context, highlighting potential opportunities in increasing green building practises. The study took into account the three most important stakeholder in a green economy, municipalities (policy makers), investors (service providers), and end- consumers and developers (benefactors), providing recommendations on all three levels in order to enable effective implementation of green building strategies.

In order to understand green buildings and the different impact levels of green buildings, the research defines green buildings and international green building regulation. Taking a more in-depth look, the carbon footprint of buildings, including embodied and operational carbon, is defined in terms of source and impact on users and the environment. Furthermore, to ensure the availability of financing options, many of the different international agreements and funds offered to countries, municipalities, individuals and others are presented, noting the minimum requirements needed for these funds.

Embodied energy is the energy needed to produce, transport, and use building materials. As such, reducing the embodied energy and carbon footprint of the building by choosing better sources and more sustainable material is crucial into reducing the overall energy of a building. Looking into the different available options in the West Bank for Green Building Materials, the study takes into consideration cement, pre-cast blocks (gypsum & cement), glass, paints, aluminium, wood, metal, insultation material, and other building components are taken in consideration as key building material. For each material, the availability of green material or production methods, as well as recycling options is studied. Taking into consideration different incentive programs used to increase the use of green building materials.

Waste, water, and energy are studied on three different levels, on a national level, practises and available options in Palestine are presented. On a municipal level, data collected through municipal case studies on most important issues and available solutions provides a local view of aspects. And lastly, on a building level, current practises and available options are both presented.

Last but not least, the individual health and wellbeing, and the impact of building materials and practises have on it are brought onto perspective. Taking into consideration the top diseases and its relation to different building materials and practises, the benefits of green building practises can be become clearer for end consumers and users of green building materials.

Taking into consideration all the aspects above, the study presents a series of recommendations to increase awareness and practises of green building measures. Looking at the three levels of stakeholders within a green economy, recommendation and limitations of the study are presented on three levels, municipalities, business opportunities, and end consumers, developers, contractors, and others.

2.0 What are green buildings?

The World Green Building Council (WorldGBC) defines green buildings as those that "in design, construction, or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. [In effect], green buildings preserve precious natural resources and improve our quality of life" (WorldGBC, 2022). Some of the main features which can be a part of green buildings are:

- Efficient use of energy, water, and other resources
- Use of renewable energy, such as solar energy
- Pollution and waste reduction measures, and the enabling of re-use and recycling
- Good indoor environmental air quality
- Use of materials that are non-toxic, ethical, and sustainable
- Consideration of the environment in design, construction, and operation
- Consideration of the quality of life of occupants in design, construction, and operation
- A design that enables adaptation to a changing environment

In the US, the green building council set LEED (Leadership in Energy and Environmental Design) framework for green building certification. Taking into consideration all the features above, type of building, and developer financial capabilities, LEED certification offers different certificate levels for green buildings depending on the number of requirements implemented in any specific project/ building. The LEED certification uses pointing system for prerequisites and credits that address ***carbon, energy, water, waste, transportation, materials, health, and indoor environmental quality***.

As a baseline for green buildings, LEED scoring system is comprehensive in terms of covering different aspects of green buildings. Some of the current construction methods and material used already qualify as green building measures, however, many others were found to be available or can be potentially implemented in Palestine. Table (1) represents the basis of the LEED scoring system, covering many prerequisite and credit variables within the scorecard which are applicable to most buildings in Palestine. The different aspects and feasibility of green buildings are then discussed throughout the report, presenting the results for the feasibility of green buildings within the discussion and recommendations.

Table 1LEED Scorecard & current implementation in Palestine[2]

	Requirement	Implementation
Credit	Integrative Process	Partially applied
Location and Transportation		
Credit	LEED for Neighborhood Development Location	Not applied
Credit	Sensitive Land Protection	Applied in big projects
Credit	High Priority Site and Equitable Development	Applied in big projects
Credit	Surrounding Density and Diverse Uses	Applied in big projects
Credit	Access to Quality Transit	Partially applied
Credit	Bicycle Facilities	Not applied
Credit	Reduced Parking Footprint	Not applied

[2] Assessment of level of implementation in Palestine is based on information from the three municipalities interviewed, LEED consultant in the West Bank, and the consulting teams own experience working in the field. However, a national survey is required across all municipalities for more accurate results on percentage of implementation.

Credit	Electric Vehicles	Not Applied
Sustainable Sites		
Prereq	Construction Activity Pollution Prevention	Not applied
Credit	Site Assessment	Applied in big projects
Credit	Protect or Restore Habitat	Not applied
Credit	Open Space	Partially applied
Credit	Rainwater Management	Not applied
Credit	Heat Island Reduction	Not applied
Credit	Light Pollution Reduction	Not applied
Water Efficiency		
Prereq	Outdoor Water Use Reduction	Not applied
Prereq	Indoor Water Use Reduction	Not applied
Prereq	Building-Level Water Metering	Applied
Credit	Outdoor Water Use Reduction	Not applied
Credit	Indoor Water Use Reduction	Not applied
Credit	Optimize Process Water Use	Not applied
Credit	Water Metering	Not applied
Energy and Atmosphere		
Prereq	Fundamental Commissioning and Verification	Not applied
Prereq	Minimum Energy Performance	Not applied
Prereq	Building-Level Energy Metering	Not applied
Prereq	Fundamental Refrigerant Management	Not applied
Credit	Enhanced Commissioning	Not applied
Credit	Optimize Energy Performance	Applied in big projects
Credit	Advanced Energy Metering	Not applied
Credit	Grid Harmonization	Not applied
Credit	Renewable Energy	Applied for water heating
Credit	Enhanced Refrigerant Management	Not applied
Materials and Resources		
Prereq	Storage and Collection of Recyclables	Applied
Credit	Building Life-Cycle Impact Reduction	Not applied
	Environmental Product Declarations	Not applied
Credit	Sourcing of Raw Materials	Not applied
Credit	Material Ingredients	Not applied
Credit	Construction and Demolition Waste Management	Partially applied
Indoor Environmental Quality		
Prereq	Minimum Indoor Air Quality Performance	Partially applied
Prereq	Environmental Tobacco Smoke Control	Not applied
Credit	Enhanced Indoor Air Quality Strategies	Not applied
Credit	Low-Emitting Materials	Not applied
Credit	Construction Indoor Air Quality Management Plan	Not applied

Credit	Indoor Air Quality Assessment	Not applied
Credit	Thermal Comfort	Partially applied
Credit	Interior Lighting	Not applied
Credit	Daylight	Applied
Credit	Quality Views	Not applied
Credit	Acoustic Performance	Not applied

3.0 Carbon & Carbon Emissions in Buildings

3.1 Operational & Embodied Carbon

Buildings and the built environment have a significant impact on the environment, as it involves a large quantity of extracted material, big and intensive manufacturing processes, transportation of materials over long distances, as well as many other processes that can be found throughout the life cycle of the building. In terms of carbon and carbon emission, there are two main types of carbon within any structure:

- **Embodied Carbon:** Is the sum of all other carbon emission from the construction life cycle, which includes raw material extraction, transportation, construction, refurbishment, and demolition and disposal of materials. Embodied carbon in this sector accounts for 11% of global carbon emissions (Jones, 2020).
- **Operational Carbon:** Which describes carbon emission throughout the actual operation time of the building, accounting for 28% of global carbon emission (Jones, 2020). Operational carbon includes the total carbon emission from all energy sources used to keep the building warm, cool, ventilated, lighted, and powered (Hutton, 2020).

3.2 Carbon Reduction Solutions:

Reducing the amount of carbon that is produced through a building can be done in different ways. Taking into consideration the two main types of carbon emissions from buildings, embodied carbon and operational carbon, the main methods of reducing carbon will be discussed below:

3.2.1 Reducing Embodied Carbon

As explained above, embodied carbon is the carbon that is produced in the construction and deconstruction phases of the building, which takes into consideration the environmental impact and carbon emissions from sourcing the material, transporting them, on site of construction, and generally other non-operation emissions throughout the life cycle of the building.

In order to reduce embodied carbon, the majority of the effort is put through the design phase, by taking into consideration the different processes that involve embodied carbon and planning the project in a way to reduce them. Some of the main aspects to take into consideration when reducing embodied carbon include:

- Building Reuse: “Renovation projects usually save between 50% - 75% of embodied carbon emissions compared to constructing new buildings” (RPS Group, 2022). Renovating and reusing unused buildings, which are structurally sound, help reduce the amount of new carbon emissions, as many of the building material and construction processes have already been conducted.
- Materials: Choosing less carbon intensive material will reduce the amount of embodied carbon within the building. Two main aspects to focus on, first, using low- carbon concrete mixes by substituting it with fly ash, slag, and calcined clays, or using lower strength concrete. Second, replacing or reducing the use of carbon intensive material such as aluminium, plastic, and foam insulation (RPS Group, 2022).

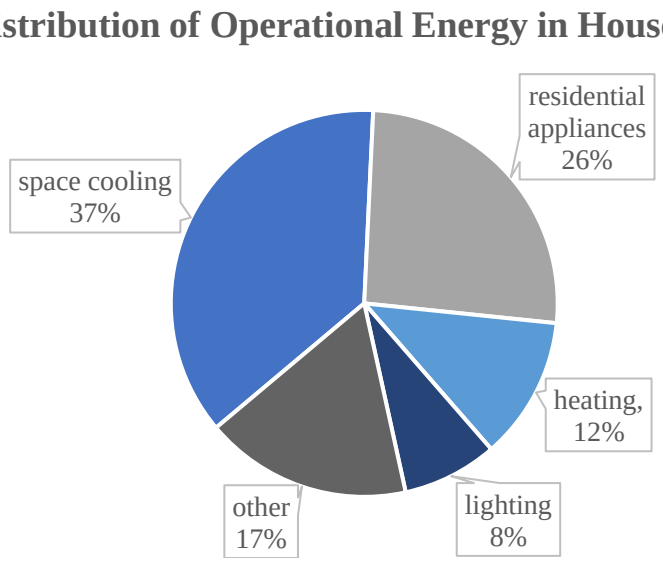
- Material Reuse and Reduce: The reuse of some materials such as bricks, metal, wood, and broken concrete can also reduce the overall embodied carbon within the building. Furthermore, reducing outside finishing within the building will reduce the embodied carbon (RPS Group, 2022)

3.2.2 Reducing Operational Carbon

Accounting for (28%) of global carbon emissions, operational carbon in buildings is important to tackle to reduce the overall carbon produced from the construction sector, especially amongst households, as regulated operational emissions can reduce the operational carbon from a single unit three time less than unregulated operational emissions (Wood for Good, 2022).

The main concept used for operation carbon reduction is net-zero carbon, which "is defined as a reduction in the demand for energy and material to level that can be met solely by sources that do not emit greenhouse gases" (Hill, Dalzell, & Allwood, 2020)

Figure 1 Distribution of Operational Energy in Households



Most of operational carbon throughout the life cycle of the building is from heating and cooling the building. For example, according to the international energy agency, household energy usage is distributed as seen in Figure 1, with total carbon from heating and cooling activities reaching 49.4% from total carbon emissions from the house (Nesler, Lam, & Lasternas, 2021). And as such, different methods can be used to reduce the need for heating and cooling, as well as other processes that cause carbon emissions.

- Effective designs: In the first stages of designing the building, crucial steps can be taken into consideration to help reduce operational carbon. For example, designers can maximize use of natural lighting through effective positioning of the building and openings to reduce direct and illumination cost.
- Material & Components: Choosing the right material and components within the building also leads to reduction of operation carbon. For example, using glass on window opening that reflects heat or UV rays (e.g., Low e-glass) helps in reducing the heat absorbed by the building and thus reduces costs for cooling. Similarly, using effective thermal insulation within the building structure (walls, roof, floor.) reduces the heat exchange with the building surrounding, retaining its cool temperature in the summer, and warmer temperatures in the winter, which also in effect reduces cooling and heating costs.

- Energy Efficient Appliances: Another method of reducing operational carbon is to ensure that appliances within the buildings (including cooling and heating methods) have energy efficient specifications to ensure that less carbon is emitted through normal day to day functions. Furthermore, integrating energy efficient schemes and systems within the buildings (e.g., HVAC cooling and heating or energy monitoring and management systems) will reduce the overall carbon emissions from the buildings, as energy is controlled and used more effectively throughout.

3.3 International Agreements for Carbon Reduction

The Palestinian Authority has signed and ratified a number of international treaties and has been a member of numerous conventions on environmental protection and biological diversity. These are the following (University of Oregon, 2019):

- The Paris Agreement under the UN framework convention on Climate change
- Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides International Trade (Rotterdam)
- Stockholm Convention on Persistent Organic Pollutants (Stockholm Convention)
- United Nations Convention to Combat Desertification
- The Convention on Biological Diversity
- Cartagena Protocol on Biosafety to the Convention on Biological Diversity
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
- Montreal Protocol on Substances that Deplete the Ozone Layer
- Minamata Convention on Mercury
- Vienna Convention for the Protection of the Ozone Layer
- Basel Protocol on Liability and Compensation for Damage Resulting from Transboundary Movements of Hazardous Wastes and their Disposal

The agreements above place certain restriction on economic behaviour in favour of sustained environmental progress. The Palestinian Authority has taken significant steps towards integrating Palestine into the global environmental framework; however, these protocols and treaties do not offer significant material help for transition, especially for developing countries such as Palestine.

An option for funding integration of carbon reduction solutions for the above agreements is the Adaptation Fund. The purpose of the Adaptation fund is to help countries in need to transition into better climate resilience, and to adopt more environmentally friendly measures. However, the fund was initially established through the Kyoto Protocol, which Palestine was not a signatory to as it is an observer state only.

However, different international funds and financing options do still exist for civil society organization, non-governmental organizations, municipalities, individuals, and others. Some of the main parties which provide a variety of funding programs globally include but not limited to:

- Green Climate Fund
- United Nation Environmental Program (UNEP)
- European Commission
- International Climate Initiative (IKI)
- EIT Climate- Knowledge & Innovation Community
- Climate Program Office
- Special Climate Change Fund
- European Bank for Reconstruction & Development (EBRD)
- Nordic Development Fund
- Trust Fund for Environmentally & Socially Sustainable Development (TFESSD) - World Bank Group
- Global Environment Facility (GEF)
- Climate Funds Update (Source for fund publications)

4.0 Green Building Material & Components

4.1 Green Building Materials & Availability in Palestine

A large part of any buildings embodied carbon comes from building materials themselves, where the amount of carbon produced in the material extraction, production, and transportation are usually taken into consideration when measuring the total embodied carbon from any given material. In any building, there are a variety of different building materials that are used to construct it, some of which are cement, pre-cast blocks (gypsum & cement), glass, paints, aluminium, wood, metal, and insultation material. Each material has its own different production method, as well as its own environmental impact. However, to mitigate many of the environmental impacts, new materials are being developed which are classified as green building material, or materials with reduced carbon emissions through using different raw materials, including recycled content, or changing production methods.

In order to have a better understanding of the amount of carbon produced for different products and building material, the European ECO2 research project developed a list for the carbon footprint to produce different material in Europe, as seen below (Ruuska, 2013)[3]. For each type of material, the table presents two values. the first, carbon dioxide equivalent, CO2e g/ kg, which describes the amount of carbon dioxide emissions, or their equivalent, emitted in producing 1 kg of the material. The second, carbon dioxide uptake CO2 uptake g/kg , describes the amount of carbon dioxide removed from the environment within the life time of the building material. Carbon dioxide uptake is only applicable to materials based on biological organisms such as tree, as trees absorb carbon dioxide within their lifespan before being transformed into building materials. For example, in Finland, given their reforestation regulations, for every 1 kg of fireboard (porous) manufactured, it will produce 425 g of CO2, however, every 1 kg of fireboard would have also absorbed 1531 g of CO2 within its lifespan.

Table 2 Carbon footprint for building products (2013) [Material available in Palestine highlighted in lighted grey]

Products & Materials		
Building board	CO2e g/kg	CO2 uptake g/kg
Fibreboard (porous) – Finland	425	1531
Chipboard (Raw) – Europe	409	1564
Chipboard (Melamine faced) – Europe	467	1527
Gypsum plasterboard – Europe	*1967*	-
High Density Fibreboard (Raw)	661	1437
Medium Density Fibreboard (Raw) – Germany	652	1418
Medium Density Fibreboard (Raw) – Sweden	340	1466
Medium Density Fibreboard (Melamine Faced) – Germany	788	1458
Oriented Strand Board (Raw) – Germany	208	1692
Plywood (Standard Birch) – Finland	718	1188
Plywood (Standard Conifer) – Finland	605	1708

[3] processing and production methods for construction material and products have not greatly developed the past 10 years, and as such, the data sheet presented is still applicable in terms of processing and production impact carbon production only.

Plywood – Sweden	229	1731
Wood Product	CO2e g/kg	CO2 uptake g/kg
Shipping Dry Timber – Finland	*87*	*1505*
Shipping Dry Timber – Sweden	*13*	*1502*
CLT – Germany	362	1611
CLT – Italy	408	1610
Dried Timber (Coniferous) – Germany	119	1637
Dried Timber (Deciduous) – Germany	167	1636
Special Dry Timber – Finland	108	1639
Timber, Fresh – Germany	49	1182
Timber, Fresh – Finland	44	1184
Glued laminated timber – Sweden	*109*	*1730*
Planed Timber – Germany	152	1638
Insulation Material	CO2e g/kg	CO2 uptake g/kg
Glass Wool – Europe	*3148*	-
Polystyrene (EPS) – Europe	*3300*	-
Polyurethane (Rigid Foam) – Europe	*4200*	-
Wood fiber insulation – Finland	*243*	*1240*
Other building products	CO2e g/kg	CO2 uptake g/kg
Aerated Concrete Block, Europe	*442*	-
Reinforced Aerated Concrete Block, Europe	*511*	-
Aluminum extrusion profile, Europe	*2264*	-
Aluminum sheet, Europe	2980	-
Ceramic Tile, Finland	613	-
Stainless Steel, Cold Rolled	*3778*	-
Copper Sheet, Europe	973	-
Copper tube, Europe	981	-
Copper wire, Europe	788	-
Crushed stone, Europe	14	-
Float Glass, Europe	*1230*	-
Gravel 2/32, Europe	3	-
Gypsum plaster, Germany	243	-
Gypsum stone, Germany	*3*	-
Lightweight Concrete Block, Europe	*240*	-
Polyethene (LDPE), Europe	2130	-
Pre-cast Concrete 20/25 (Europe)	*121*	-
Sand 0/2 (Europe	2	-
Finished Building Components	CO2e g/kg	CO2 uptake g/kg
Internal Door – Sweden	*18450*	*82500*
Wooden window – Sweden	42175	27200
Flooring Material	CO2e g/kg	CO2 uptake g/kg
Laminate Flooring – Europe	750	1476
Massive Parquet – Germany	2942	1696

Multi-layer Parquet – Germany	7292	1638

In Palestine, the political situation prohibits the production of many materials, as certain machines and processes are prohibited by Israel. As such, almost all raw material and products are imported for processing or resale as is. However, looking at the main building materials mentioned in the study, the availability of sustainable building material is assessed in Palestine.

1) Cement & Concrete

Cement & concrete production is one of the most carbon emitting construction material used given the sheer amount needed for any building that is structurally dependent on concrete. Furthermore, given the intense process for producing clinker (the main component in cement, and subsequently concrete), concrete itself cannot be considered as a green building material. However, initiatives for reducing the impact of concrete are mainly aimed towards reducing emissions in production, carbon sequestration, using greener additives, and other solutions that reduce the overall footprint of concrete (Further details in Annex I).

There is no cement production in the West Bank and Gaza Strip, but it is only imported from different sources, mainly Israel and Jordan. Given that the production of cement is not here, there is no control regarding using efficient production techniques or more sustainable material sourcing.

However, one of the biggest cement importers, SANAD, did note that many of the production factories imported from are starting to use more energy efficient techniques to reduce their energy consumption. As such, all the factories have a waste heat recovery system, and almost all of them have vertical mills to reduce energy use, as well as a clinker cyclone preheater to induce an earlier chemical reaction, reducing overall CO2 emissions in clinker production. Many of these methods used have proven a reduction of 650 – 100 kW of energy used per ton produced.

As for lightweight concrete blocks and pre-cast concrete, even though the CO2 emissions per kg is less than reinforced aerated concrete, the transportation distance of these pre- prepared components is crucial in determining if the overall carbon emissions are less than on-site installation. As one study showed, the environmental impact of pre-cast concrete components is higher if the transportation distance is more than 80 km (Seo, 2020). However, the transportation distance is not an issue in Palestine as lightweight concrete block and pre-cast concrete manufacturers are found across the West Bank.

2) Aluminium

Aluminium, mainly used in window profiles, produces a large amount of carbon on production. However, the low density of the material and specific usage of it leads to a lower carbon emission than other materials and products used in a building. Furthermore, one of the biggest advantages of aluminium is that it is 100% recyclable, where more than 70% of current aluminium circulating the world economy is recycled aluminium (Roush, n.d.).

In the West Bank, Aluminium is imported as raw material, and manufactured into different components. Even though production of components is from raw materials, the biggest manufacturers in the West Bank, NAPCO, does also recycle aluminium frames (windows, doors, and others). From total production, 20%-30% of aluminium products from NAPCO are from recycled material. As NAPCO buys used frames from sellers and contractors and recycles them for production. According to 2016 articles (Morgan, 2016),

NAPCO is estimated to currently have a production capacity of 38,000 tonnes per year, estimating a total of 9,500 tonnes of aluminium recycled yearly (at 25% recycled content).

3) Pre- Cast Blocks Gypsum Blocks

Gypsum is more environmentally friendly as a material than cement and concrete, as the amount of carbon emitted from its production is less than that of concrete. Furthermore, it has many valuable properties in its production and installation. In Palestine, pre-cast gypsum blocks have become recently available in the West Bank only, with one established manufacturer who has been providing this material for the past two years. (Refer to annex 06)

Generally speaking, gypsum blocks are easier and faster to assemble than concrete blocks, where contractors may finish larger areas within shorter time periods. Furthermore, some of its properties including thermal and sound insulation, less need for structural steel, reusable & recyclable, and the availability of waterproof blocks makes the product more beneficial for the consumers in terms of reduced energy costs and loss, and no need for other material such as plaster, structural metal bars, and others.

However, assembling pre-cast gypsum blocks requires specialised training for installation. As such, the manufacturer has been providing free training for vocational workers to increase contractors' capacity in installing pre-cast gypsum blocks instead of concrete. However, even though building styles in Israel have been shifting towards gypsum dry walls, in the West Bank consumers and developers still select harder structural components, e.g., concrete and pre-cast concrete blocks.

As for price, the average price for 1 meter square of gypsum blocks is USD19, not including transportation or any other costs. Noting that using pre-cast gypsum blocks removes the need for plaster or other finishings before painting. On the other hand, the average price for a pre-cast hollow concrete block was around USD 0.7 in 2020 (Wafa, 2020), which would be around USD6 per meter square. Even though this also excludes transportation and installation costs, costs for plaster, metal bars, and other components need to be taken into account for final price.

4) Paints

There are generally two types of paints, oil-based paint and water-based paint. The former type has environmental effects impacting the environment as well as individuals' health & wellbeing, as there is a certain amount of Volatile Organic Compounds (VOCs) which are used for the production of oil-based paints but are harmful for humans and the environment. On the other hand, water-based paints have a much lower amount of VOC making it safer for use.

In Palestine, both type of paints is produced or imported, oil- based paints and water-based paint. Water based paint is used more often for decorative finishing within building units, whilst oil-based paint is used for the former, as well as painting wood and metal components as it is better in term of surface adhesion. The price difference between both types of paints is around 15%, where water-based paint is 15% more expensive than oil-based paint. (Refer to annex 05, for paint data sheets)

One of the main issues in shifting consumer behaviour towards water- based paint, is that firstly, the majority of consumers from paint companies are developers, contractors, and painters, which means that end- consumers are rarely involved in choosing the type of paint. Second, the general awareness amongst consumers (developers/ contractors/ painters) of the harms of oil- based paint is lower, where the majority chose cost saving and old buying habits than to shift or try other types of paints.

Furthermore, paint suppliers also noted that governmental bids still require oil-based paint for their units, especially schools, as all outgoing bids still use outdates specifications that have never been reviewed in terms of their impact on children and other end- consumers.

5) Wood

Even though wood in itself is a sustainable material, the source of wood as a material may be not, as the sustainability of wood depends on the methods used to gather wood and reforestation initiatives taken by the country or source. To ensure that the wood is sustainable wood, two certifications are used international, the Forest Stewardship Council - FCS, and the Programme for the Endorsement of Forestry Certification – PEFC, which ensures that the used wood is replaces after harvesting and does not harm the surrounding eco-system and environment.

Sustainably sourced wood, with a certification of FCS or PEFC, is not the most widely available product in the West Bank. However, one importer who provides wood from Europe provides wood with PEFC certification, noting that all the wood is sourced from Germany, Sweden, and other European countries comes with this certification.

One of the main reasons for using this type of wood is the quality of it, as the product is treated more effectively and is delivered at higher quality than other wood that is imported from China and other regions.

6) Metal/ Steel

Metal and steel are crucial components in the majority of buildings, as it is used as a load boarding structural component as well as other ways. The high impact of steel can be mostly attributed to the energy needed to melt it into molten state and change its form for different uses. On the other hand, if in good condition, it can be reused and recycled multiple times.

In the West Bank and Gaza Strip, steel and metal are imported, as there is no local manufacturing or production of steel, mainly due to Israeli restrictions. In the West Bank, one of the biggest metal importers, Hassouneh, also collects steel and metal from construction sites and ships it to Jordan for recycling, returning it back to the Palestinian market for sale. Noting that there is no price difference between recycled and new steel products, as sales depend on product availability.

7) Glass

In glass production, heat and energy are used to melt sand and silicates to form glass sheets. This process is the most energy consuming in its production. Furthermore, recycling glass products does not greatly reduce the embodied carbon within the material, as almost the same amount of energy is needed to reshape it, and the availability of different types of glass (coloured, tampered, or other) means that many of it needs to be sorted before recycling.

In Palestine, window glass is imported and not produced. Furthermore, even though there are a few recycling options for glass, such as using it instead of aggregates in roads and artistic uses, none of these recycling initiatives are found in Palestine.

8) Insulation Material

Thermal Insulation

There are three types of thermal insulation, Mineral Fibre, Cellular Plastic, Plant/ animal derived. Even though both mineral fibre and cellular plastic thermal insulation material are found in the West Bank and Gaza Strip, the mostly widely used is cellular plastic insulation material, polyurethane, as spray foam. In applying spray foam thermal insulation, no calculation is used by contractors, but rather a general rule of thumb of 1.25 kg of foam for 1 m^2, at a cost of USD 7 per m^2.

Even though thermal insulation is available, the Palestinian demand for it is still low, as developers and contractors are usually more interested in reducing the apartment cost, given that the end-consumer is the one that will bear the extra costs for cooling and heating. However, awareness amongst end-consumers is increasing, and developers are starting to offer thermal insulation as an added value to their apartments and buildings. (Refer to annex 04 for material data sheet)

Other published studies found confirm the effectiveness of thermal insulation to Palestinian houses, in one study which looked at the optimal thickness of insulation in different Palestinian cities, the author noted that by using the optimum thickness of insulation, the payback period for installing thermal insulation was up to 1.5 years. Taking into consideration the most two abundant insulation material in the market, polystyrene and polyurethane, the study found the optimum insulation thickness to vary between 0.4 – 9 cm depending on the material and governorate, where polyurethane as an insulation material needed half of the amount as polystyrene for the same result, but cost more than double than its counterpart (Alsayed & Tayeh, 2019). This was also confirmed in their study "Energy Savings and Optimum Insulation Thickness in External Walls in Palestinian Buildings", where the optimum thickness for buildings in Palestine was the same, and the payback period up to three years, depending on the region and type of insulation found (Alsurak, Abdallah, Assad, & El-Qann, 2021).

9) Other Building Components

Windows

There are two main components within a window which may induce heat loss or gain into the building, the window frame and glass.

Regarding the window frame, even though it is a very small percentage of the total building components, there are different types available. Several manufacturers of aluminium window frames, as well as importers provide frame. The most effective type of aluminium frame imported are thermal break frames, however, there was no demand for these frame as it doubles the cost on consumers. Even though a more economical option was imported, it was still 30% more expensive than normal aluminium frame, and was limited to a 2m window span.

As for window glass, as it is all imported, all types of glass are generally available, as its usage solely depends on price difference and availability. This includes but not limited to Single glazed, double glazed, and triple glazed as well as untampered and tempered, low e- glass, and thermally insulated glass. Currently, all buildings use double-glazed glass, where the majority of developers use window glass thickness of 4 6 4 (glass thickness – air gap – glass thickness), but higher end buildings and houses use a thicker glass, 6 12 6.

Commercial buildings (which constitute of 80 – 85% of demand) use low standard double glazed windows (thick, tempered, and with air gap). However, for commercial buildings with glass curtain walls, the majority use higher grades (thick, tempered, with air gap) e-glass for the curtain walls. Thick double glazed

glass windows and low e- glass are also used by high end consumers and large corporations / establishments (1% of total market share).

The main reason for the use of thinner double-glazed glass is high price difference, where the thick tempered glass, 4 6 4, is priced around USD 35 per m^2, whilst thicker glass and low e- glass are USD 74 per m^2 and above[4].

Doors

As wood is an imported product, wooden doors are produced in the West Bank and Gaza Strip. However, other types of doors such as multi – lock doors are also readily available as they are imported from other countries.

4.2 Measures & Incentives to Increase Usage of Green Building Measures

Introducing incentive schemes to increase the usage of green building measures worldwide is being done on both the governmental and organizational level to reduce the general carbon footprint of the economy. Interestingly, one study which compared different incentive schemes available found that it is not necessary to focus on large measures that may significantly change the carbon footprint of a sector or activity. On the contrary, the study found that the most successful incentive schemes can be designed to challenge the minimum requirements towards the short term and long-term shift towards environmentally friendly measures (ECORYS, 2012).

There are generally two types of incentives programs:

- Command & Control: Based on explicit legislations that place hard limits on factors such as energy efficiency and utilization, emissions, etc… This category of policies is challenging as they require oversight, and an efficient governance and legislative system. (Ranaa, Sadiqa, Shahria Alama, Karunathilakeab, & Hewagea, 2020)
- Market Based Instruments: Creating financial incentives that shift the consumption behaviour and preferences of associated agents. Market Based Instruments can be divided into three categories:

    1) Market- Friction Based: These measures focus on raising the awareness of consumers and users for them to make more environmentally friendly purchasing decisions. Examples of measures include eco- labelling, and Energy Star Ratings of Appliances.
    2) Rights Based/ Quantity Based: Focusing on the amount of carbon produced, these policies and incentive schemes specify the amount of emission permitted under a specified condition, but also provide guidelines and schemes such as cap and trade, and carbon offset schemes.
    3) Price Based: These instruments explicitly change price structures in existing markets, either by increasing the effective price of unfavourable activities (e.g. by pacing a carbon tax on fossil fuels), or by lowering the effective price of favourable activities such as providing subsidies on high efficiency appliances or the implementation of other green measures such as green roofs. These incentives can come in many different forms, some of which include Subsidies, Loans, Grants, Tax Benefits, Rebates, and Disincentives.

[4] Price list in Appendix II

However, there are still barriers and gaps in implementation of incentive programs for green building measures (Ranaa, Sadiqa, Shahria Alama, Karunathilakeab, & Hewagea, 2020). Some of which include:

- Economic & Financial Barriers: The higher upfront costs associated with using more sustainable building material, measures, and energy efficient technologies is one of the main barriers to increasing the use of green measures. This is especially true for developers and contractors, as these stakeholders will not reap the long- term benefit of a green building but are more incentivised with short term goals such as lower construction costs (e.g. reduced administrative costs or taxes) and fast sales of apartments.
- Political & Structural Barriers: Due to gaps between governmental bodies (national, municipal, and local), insufficient enforcement of incentives, and lack of political/ leader interest. These barriers highly impact the implementation of the incentive program or measure, as the lack of leadership interest will lead to unalignment in governmental priorities across the different levels, which will lead to improper or ineffective implementation of incentive programs.
- Behavioural & Cultural Barriers: Lack of affinity of modern construction techniques and the affinity to use traditional techniques, informal construction, and unplanned urbanization all factor as barriers to incentive programs. In other words, the construction culture available within the society impacts the effectiveness of green building incentives. For example, contractors and construction workers who have been designing and building the same way for over 10 years., will find it more difficult to learn new building techniques, and less likely to understand the long-term impact of their behaviour.
- Information Barriers: The implementation of any incentive program may be highly ineffective if there is a lack of awareness of consumers, industry, and politicians of the benefits of a specific incentive. Furthermore, lack of evaluation data (baseline, monitoring, and evaluation, and endline) also reduces the trust and effectiveness in these programs and its ability to reach a wider community.
- Skills Barriers: The lack of needed skills also effects both the design and the implementation of incentive programs. For example, building with gypsum blocks, precisely calculating needed amount of insulation, and others.

A study performed by Shazmin Shareena Ab. Azis et al (20212) examined the use of tax exemptions as a form of green building incentive tools, utilizing US States as a case study, tax exemptions studied were:

- Property tax exemption
- Property tax reduction
- Property tax credit

This study showed that financial incentives work effectively to push for green measures relating to energy, atmosphere, water efficiency and materials, less so to incentivize indoor environment quality and sustainable sites (Azis, Sipan, & Sapri, 2012).

Malaysia introduced a Green Technology Financing Scheme (GTFS), whereby the government provided soft loans to incentive green building innovations. This experiment proved to be very successful as it increased certified green buildings from 1 to 137 in four years (Olubunmi, BoXia, & Skitmore, 2013).

In terms of non-financial incentives, the most effective ones are the ones that relate to the permitting a higher floor to area density, whereby the permitted floor area for a project is higher as a percentage of the gross floor area of the project if it is certified green. This initiative worked successfully in Singapore as a 2% increase in total gross floor area of the project was granted in case of the developers meeting high environmental ratings (Olubunmi, BoXia, & Skitmore, 2013).

5.0 Solid Management in Palestine

5.1 Solid Waste

In terms of municipal solid waste, the West Bank and Gaza generate 1.58 million tons a year, where the West Bank is responsible for 0.9 kg/capita/day, and the Gaza Strip is responsible for 0.7 kg/capita/day. In terms of the composition of the aforementioned waste, organic waste amounts to 50% of total waste, followed by plastics at 14.6%, paper/ cardboard at 12/5%, metal at 2.4%, glass at 1.9% and other at 18/6%. A very marginal percentage of municipal solid waste is reused or recycled, at most reaching a combined level of 3%, with 65% of total municipal solid waste being disposed of in landfills, and 32% being disposed of in illegal dumping sites. (Atallah, 2020). It is worth mentioning that the waste production per capita/day of the Palestinian Territories exceeds the global average of 0.74 kg/per capita/day. (Kaza, Yao, Bhada-Tata, & Van Woerden, 2018)

The growth of Municipal Waste has been outstripping population growth and GDP growth, which indicates that there is a higher reliance on disposable materials and might also signify a higher degree of consumerism likely related to the slowly rising standards of living.

The vast majority of waste in the Palestinian Territories is disposed of rather than treated or recycled, with only 3% of waste being recycled/ recovered, 65% heading into controlled landfills, and 32% being illegally dumped.

The West Bank & Gaza strip have the following sanitary landfills:

- Zahrat al Finjan (ZAF), Al Minya, Beit Anan, and an Israeli landfill in Jericho.
- The Gaza Strip has Al Fukhary, Johr al Diek, and Deir Al Balah (Closed in mid-2019)

ZAF, established in 2007 in Jineen covers 240,00m2 with a capacity of 2.25M tons of waste. ZAF landfill services the solid waste of Jenin and Tubas and was intended to serve the area for 30-35 years. Despite being designed to serve the north of the West Bank, the landfill is quickly approaching capacity as it receives MSW from other governorates such as Tulkarem, Qalqilya and Nablus, as well as Ramallah and Al Bireh.

Located in the South of the West Bank, Al Minya sanitary landfill was opened in 2014, designed originally for 630 tons/day but actually it receives 1,100 tons/day in November 2018: all the waste from the southern governorates, Bethlehem (220t/day) and Hebron (700 t/day) as well as from East-Jerusalem (115 t/day) and settlements (65t/day)ؚ It is operated by the Higher Council for Solid Waste Management – Bethlehem and Hebron. All the waste collected from these districts go either directly or through the transfer stations of the South governorate. The total landfill area is 250,000 $\mathbf{m^2}$, with a design capacity of 4.9M $\mathbf{m^3}$ and an expected lifespan of about 20 years.

5.2 Construction & Deconstruction Waste, and Car Skeletons

Construction & deconstruction waste is generally managed by contractors and developers themselves, as municipalities only offer polices and guidance regarding illegal and improper dumping of construction waste around the city and municipality. However, there is no form of involvement (either by means of counting or disposal guidance) done through the municipality, where their role is limited only to ensuring that the waste is not illegally dumped within their premises.

Nevertheless, as contractors and developers are bound to dispose of waste, waste is sorted in terms what can be resold and what cannot. In the West Bank, metal is the most recycled material, followed by aluminium (in the centre) and cardboard (in the south), as well as wood, which can be readily resold as fire wood. Other types of waste such as concrete and aggregates, rubber, glass, and others, are not generally recycled. In Gaza Strip, given the material restrictions and economical restrictions, there are specialised companies which take in construction and deconstruction waste, as well as rubble and building leftover after shelling, and recycles them into other products.

These are private businesses which completely manage all type of construction and deconstruction waste. Metal is hammered back into shape for reuse, and aggregates are sent to a crushing facility where it is recycled into recycled concrete blocks that are used in construction as part of non-structural components[5].

As for car skeletons, there are no national databases for the amount of car skeletons across the West Bank or Gaza Strip, nor where there any studies which tried to obtain quantitative data on the matter. As such, the current research aimed to identify potential disposal sites, as well as its feasibility for owners of car skeletons. One facility in Jericho was identified which collects car skeletons, crushes them, and exports them to Jordan for recycling and reselling the metal. In an interview with the facility owners, they noted that many car skeletons are generally kept for spare parts, however, for those who do wish to dispose of the car skeletons, they are able to directly contact the car crushing facility in Jericho. The crushing facility will be responsible to pick up the skeletons and dispose of them, as well as reimburse owners for the metal collected. However, the owners did not disclose any financial data, noting that the amount paid to owners for the car skeletons depends on the total amount of metal retrieved.

5.3 Waste Management in Buildings

In order to have effective waste solutions, waste needs to be sorted into different stream for it be effectively disposed of depending on its type. For this, different sorting methods are available. Off- site sorting refers to sorting waste on disposal site, e.g., by consumers. On-site sorting refers to the process of sorting through waste on site before disposing it in its selective streams.

For building and commercial units (e.g., restaurants) to be more aware of recycling needs and incentivised of doing so, there needs to be an appropriate final disposal site for sorted waste. This is the biggest issue amongst municipalities, as they are not able to invest in waste recycling facilitates, nor are there potential investors interested in potential waste disposal business opportunities. In Hebron, for commercial units, the municipality offers separate cardboard waste collection for it to be pressed and resold to a cardboard manufacturer who recycles it.

[5] https://www.youtube.com/watch?v=H8WNknnITxY (إعادة تدوير مواد بناء المباني المدمرة. مهنة جديدة في قطاع غزة بفعل الحصار الإسرائيلي)

5.4 Waste Management in Municipalities

5.4.1 Waste Management at Hebron Municipality

Solid Waste

In terms of solid waste, Hebron municipality is only responsible for collection solid waste from households and establishments, excluding bio waste and construction waste. On average, 300 tons of waste are collected per day in the municipality, of which, organic waste is 46%, plastic and rubber 18%, papers and cardboard 10%, textile 6%, glass 2%, metal 1%, and others.

Both primary and secondary waste collection is used in the municipality, where there are around 300 employees conducting daily primary waste collection around the city, and a total of 21 trucks used for secondary waste collection.

- Secondary waste collection is a joint effort between Hebron municipality and the Joint Service Council for Solid Waste Management (JSC), where 11 trucks are owned by JSC and 10 by Hebron municipality. Solid waste collected is all sent to the main landfill, Al-Menya landfill, either directly or collected at a collection point which is eventually sent to the same landfill.
- For paper and cardboard waste, Hebron municipality has designated 1 truck to collect papers and cardboard waste only. The waste is then sent to local presses (2 available within the city) for them to be pressed and then recycled. One main factor in the success of the paper and cardboard recycling project is that the municipality was able to find a business that was able to buy the pressed paper and cardboard waste for them to recycle and resell on their own. This meant that first the municipality has a channel to dispose of the collected paper waste, and second, it can cover any additional costs by selling the waste.
- As for plastic and rubber waste, it is mostly composed of car tyres which are an issue for the municipality. Given the manufacturing nature of Hebron, waste car & truck tyres are in abundance, which causes two main issues. First, the size and weight of tyres make it difficult for normal waste collection, as the trucks are quickly filled. Second, there are no specific disposal methods available for the waste, which means they are sent to landfill or burnt, causing other type issues. Currently, Hebron municipality is only able to provide a line for collecting tyres, separating it from other type of waste. However, as there are no establishments or businesses that are able to recycle of reuse the waste, it is still being sent to the landfill.
- As a municipality, Hebron municipality is prepared to sort waste (on site or post collection). But they are in need of stakeholders who will buy and reuse the waste. For example, a large part of the bio waste produced is through businesses (restaurants, café, markets), which the municipality is willing to collect separately, if they are any parties that are interested in.
- Regarding construction waste, Hebron municipality is only responsible for ensuring that the waste is collected and disposed of by the contractor or site manager. Generally speaking, all construction metal waste produced is recycled as contractors can sell it to other parties. Other waste collected, e.g., concrete, aggregates, is not recycled.

5.4.2 Waste Management in Ramallah Municipality

Solid Waste

In Ramallah, 100 tons of solid waste is collected daily from households and establishments, excluding bio-hazardous waste, which are collected separately by the ministry of health, adding up to 3 -4 tons per day Waste collected from households and establishments constitutes of 50% is organic waste, 9% papers and cardboard, 7% plastic, 4% metal, 3% wood, 2% glass, and others.

- There are a total of 12 municipal waste collection trucks that are owned by Ramallah municipality which is in charge of collecting all household and establishment waste from the city. Both primary and secondary waste collection methods are used, with a number of municipal employees conducting primary waste collection from throughout the city. And secondary waste collection is conducted using trucks that roam the city collecting waste from large municipal bins distributed around.
- There is no landfill around Ramallah municipality, where all waste collection trucks transfer solid waste to a central collection unit, which is then transferred to Zahret Al Finjan Landfill in Jenin. In total, the cost for waste collection, transportation, and disposal of in the landfill is USD 32per ton.
- On a policy level, Ramallah municipality has been implementing more strict policies to ensure that construction waste is controlled, the environment is restored or preserved, or that there are green areas within the building.
- Supermarket, hotels, and other big producers of waste have their own policies in terms of cost of waste collection, and where it is dumped. For example, carton and cardboard waste from large waste producers have their own baskets for waste collection.
- There is no sorting or recycling initiatives for waste in Ramallah municipality, as it is not feasible for the municipality to invest in large projects with a small population, around 63,000 residents' total. Furthermore, Ramallah as a municipality is limited in terms of space, and thus they are not able to provide the space for new projects (renewable energy, bio digesters, …. etc).
- The municipality is currently looking into installing a large digestor in a neighbouring area that will take in the biological waste, but some of the issues that they need to mitigate included cost of collection and transportation, as well as the financial feasibility of the project given the small amount of waste produced by the municipality. Another project is looking into separating and collecting paper and cardboard waste, but the small amount of cardboard waste produced through the municipality is a mean issue in its feasibility.
- Construction waste is not collected by the municipality, but they only manage it in terms ensuring that all construction waste is collected and dumped by the contractor. However, they do not conduct any type of management in terms of calculating amount of waste, recycling of waste, or others.

5.4.3 Waste Management at Khan Yonis Municipality

Solid Waste

In terms of solid waste, Khan Yunis municipality is only responsible for collecting solid waste from households. On average, 150 tons of waste are collected per day in the municipality, of which, organic waste is 55%-60%, plastic 20%, papers and cardboard 15%, glass 15%, aluminium cans 7%-10%, and others.

There are three methods of waste collection in the municipality, there are 36 waste carts that roam the city for primary waste collection, these carts collect around six cubic meter of waste in each run, transferring it to bigger bins. Secondary waste collection is conducted in two methods, where households either place their waste in large municipal bins placed around the municipality or through house to house waste collection, where households place their waste in front of the residence between the hours of 10 PM – 5 AM for truck to collect. The collection method used depends on the area, as the municipality is not able to place large bins in these areas.

There are a total of 12 waste collection trucks working in the municipality, 8 of which are owned by Khan Yunis Municipality, and 4 owned by the joint service council.

- Some of the main issues faced by the municipality include the lack of social awareness of need for these services, as some residents burn waste or rip bags in the street; bins and supporting infrastructure is old and wearing.
- A new landfill has been developed through funding of the World Bank, AFD, and the Islamic bank to receive up till 600 tons of waste daily, serving the central and northern governorates in Gaza Strip. The first phase of the landfill should serve for the following 10 years, whereas the second phase is still not funded.
- A pre- paid waste collection system is being implemented in the municipality aiming to increase awareness of waste produced by households as well as increase municipal income from the service provided. Households will have to buy specific bags that will only be collected, 1 bag for each day of the month, at a cost of USD 3 per month.
- Construction waste is managed entirely by the private sector, where all construction and construction waste are sold for recycling. This also includes concrete and aggregates, which is recycled to new pre-cast blocks.
- The cost of collection and disposal of solid waste is around USD 39per ton. Whereas the cost on residents is USD 3 per month.

6.0 Water and Wastewater Management in Palestine

6.1 Water Availability and Distribution in Palestine

Given the extreme political situation of the Palestinian Territories, the services of water provision suffer as well, as Palestine and Israel share the same groundwater resources and aquifers, with the parameters of water governance being set in place in the Oslo Accords between the Palestine Liberation Organization and the Government of Israel, particularly in article 40 of Oslo II.

The main water resources in Palestine are the mountain aquifer in the West Bank, and the Coastal Aquifer in Gaza, the coastal aquifer specifically is in a challenging situation, as the groundwater being abstracted from it is three times the sustainable rate, causing seawater intrusion. This seawater intrusion has jeopardized Gaza's only potable water source, as currently only 4% of water abstracted from the coastal aquifer meets drinking quality standards.

The lack of potable water has been met with residents drilling unregulated wells, which has further exacerbated the problem. Currently, 97% of drinking water is supplied through informal and unregulated water wells, and small desalination plants.

The Oslo Agreement led to severe water shortages for the Palestinian Authority, forcing it to purchase bulk water from the Israeli Water Company Mekorot, which has placed the PA in significant debt.

Desalination in the Gaza Strip has never been fully utilized to the largest extent possible, there are small scale private aquifers as stated earlier. the EU has funded a short-term low volume (SVTL) seawater desalination plant. The project has a capacity of 6,000 cubic meters/ day.

In order to organize Water Provision in Palestine, many initiatives have taken place such as the 2014 Water Law. The 2014 Water Law has established the following:

- Clarifying accountabilities
- Establishing Autonomous Utilities

The implementation of the law has been lacklustre and slow as the legal structure is considered incomplete, and financing and clarity requires more work.

Currently Bulk water provision is governed by the West Bank Water Department (WBWD). The WBWD is a governing body established by the Israeli Civil Administration. Currently the WBWD purchases bulk water from Mekorot and sells it to water service providers. To replace this the aforementioned law sets the base for the creation of the Palestinian National Water Company, which is yet to take effect.

There are many Service Providers in the West Bank and Gaza, making governance slightly fragmented.

- 17% of the population is served by two autonomous entities: the first being the Jerusalem Water Undertaking (JWU) active in parts of East Jerusalem, Ramallah & AlBireh. The second being the Water Supply and Sanitation Authority (WSSA) in the Bethlehem region.
- The rest of the West Bank and Gaza receive their water from providers mainly under the Ministry of Local Government such as municipalities and local councils, these are 76 in the WB and 25 in the Gaza Strip. Some villages and local councils in the West Bank have united to provide water services jointly through "Joint Service Councils" (JCSs) amounting to 13.
- The Coastal Municipalities Water Utility (CMWU) is the main service provider in Gaza, where it provides support to municipalities in Gaza but without oversight on operations.

- In order to cover the shortages in Gaza, an unregulated free market of reverse osmosis plants has popped up, serving mostly private companies, public bodies, NGOs, educational institutions and aid agencies. In 2015, these plants amounted to 154. A study conducted concluded that 59% of these plants produce contaminated water with respect to coliform. 68% of the aforementioned plants are not licenses, and 40% use water from unlicensed wells. They produce an equivalent of 4 m cubic on daily basis.

6.2 Wastewater

The treatment of Wastewater places the resource of water on a new trajectory and enables the Palestinians to reduce the costs of sending wastewater to Israel for treatment or dumping the wastewater.

The Palestinian Authority has built wastewater treatment plants in Ramallah, AlBireh, Nablus, Jenin, Tulkarem, , Gaza and Jericho, mostly financed by foreign donors.

The Palestinian Law on Agriculture has placed some significantly high standards on the treatment level of wastewater used for irrigation. So far, good experiences of using wastewater treatment plant outflow have been reported in Jenin, where crop yields have significantly increased in areas that use nutrient rich treated water. And in villages outside of Jenin, the reuse of waste has had a benevolent unintended consequence, which is the replenishment of water wells in the area, which are now used as agricultural well.The Jericho wastewater treatment plant has an outflow that is solely used for the growing of dates and has shown significant success due to the nutrient rich contents of the water.

In Gaza, the NGEST wastewater plant became operational during 2018, treating 34,000 cubic meters a day, with the treated wastewater being infiltrated into the soil. The Palestinian Water Authority then drilled 14 wells and planned for another 13 to channel more water into a planned irrigation system.

Another proposed project to reuse wastewater is to be in Nablus, with the USAID funding a 12 hectare irrigation scheme, with the KfW funding another 2922 hectares. Most of the targeted area is full of rain fed olives, and the plot planning was seen as insufficient, with the plots being too small for irrigated agriculture.

It should be noted that the National Water and Wastewater Strategy for Palestine aims to utilize 40% of treated wastewater to recharge the aquifer, however this is meant to be a long-term goal, and so far, the aforementioned strategy has been lacklustre at meeting its shorter-term goals. (Trotier, 2019)

Taken from the Palestinian Central Bureau of Statistics (PCBS) report on wastewater disposal (2015), the data below shows that broadly, there are decent connections to Waste Water Networks in households across the West Bank and Gaza Strip. Noting that even though a higher % of households in Gaza Strip are connected to the network in comparison to the West Bank, (77%) and (69%) respectively, there is a higher percentage of household who are not connected to any networks (8%) in Gaza Strip compared to (2%) in the West Bank.

Table 3 Wastewater Disposal Method PCBS 2015

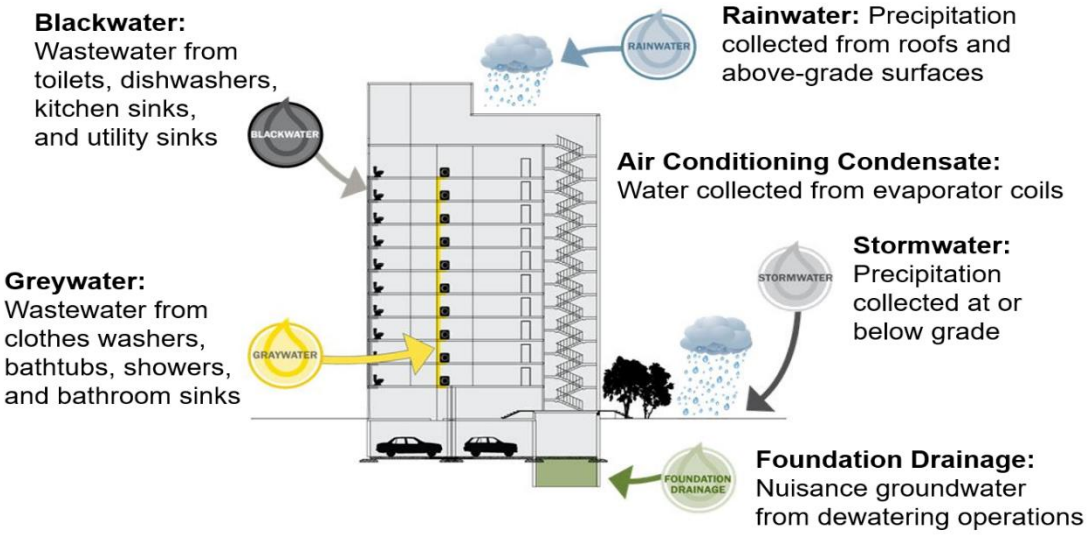
Region	Wastewater Network	Tight Cesspit	Porous Cesspit	Others	None	Total

Palestine	71.3%	5.5%	15.2%	3.9%	4.1%	100%
West Bank	68.8%	7.0%	20.7%	1.6%	1.9%	100%
Northern WB	62.8%	8.4%	21.0%	3.8%	4.0%	100%
Middle WB	75.5%	6.4%	17.0%	0.1%	1.0%	100%
South WB	70.8%	5.6%	23.5%	0.0%	0.1%	100%
Gaza Strip	76.8%	2.3%	3.4%	8.8%	8.7%	100%

6.3 Water Management in Buildings

In any building, there are multiple water sources and waste channels that can be found. Referring to the figure below, it can be seen that there are different types of water available, black water, grain water, rainwater, stormwater, air conditioning condensate, and foundation drainage. Separating and collecting the different water stream depending on composition enables water reuse in buildings.

Figure 2 Water Sources in Buildings, San Francisco Public Utilities Commission (EPA U. S., 2022)



In Palestine, there are no policies or procedures in place for effective water use and management. Although many residential and commercial buildings build water wells, especially in Hebron where it is mandatory to have a well to receive your monthly water supply, there is no effective collection and management of water from the different sources available. E.g., rainwater is stormwater, and air-conditioning condensate are not collected, nor is there separation of greywater and blackwater.

Ramallah municipality is the only area which has complete separation of stormwater and sewage water collection networks. However, both the treated wastewater and collected stormwater are pumped back into the mountains.

The implementation of more effective water management solutions is feasible in Palestine, for example, installing water fixtures for water saving is easy for each household, as well as use of design concepts such as smart landscaping. As for water recovery systems, even though the methods and systems for applying them are readily available, engineers and designers need to take make sure to take into consideration networks for water reuse, such as toilet flushing, irrigation, and cooling tower for effective management.

Efficient water fixtures

Efficient water fixtures are generally available in Palestine, however, the lack of consumer awareness of the benefits of using these fixtures is one of the main reasons for lack of use. There are a variety of different types and shapes of water fixtures at different prices, many of them competitive to average price of water fixtures available. Looking at the table below for efficient water fixtures, the majority of fixtures are found to be readily available:

Table 4 Efficient water fixtures for green building available in the West Bank

Fixture or Fitting	Maximum installed flush per rate (Imperial Units)	Maximum installed flush per rate (Standard Unit)	Threshold below code baseline	Availability in Palestine
Toilet (water closet)	1.28 gpf*	4.8 lpf**	20%	Yes
Urinal	0.5 gpf	1.9 lpf	50%	Yes
Public lavatory (restroom) faucet	0.4 gpf	1.5 lpf	20%	Yes
Private lavatory (restroom) faucet	1.5 gpf	5.7 lpf	32%	Yes
Kitchen faucet	1.75 gpf	6.7 lpf	20%	Yes
Showerhead	2.0 gpf	7.6 lpf	20%	Yes
*Gallon per flush **Litre per flush				

Currently, there are no national policies or procedures nationally implemented for commercial or households solid and wastewater collection and management. There is no separation of solid waste, nor are there separate wastewater networks for grey water and black water. Although municipalities are prone towards implementing waste collection policies and obtaining different streams for waste disposal, there is a need for a party at the end of the value chain to profit from waste recycling/ reusing.

6.4 Water Management in Municipalities

A public shareholding company is responsible for water distribution in Ramallah municipality, similar to other areas, however there was no response. As such, water in Hebron and Khan Younis are only presented as part of the case studies.

6.4.1 Water Management at Hebron Municipality

In Hebron Municipality, water is a scarce resource, as they are limited with a supply up to 5,200 cubic meter per day, whilst their actual demand in the municipality reaches 10,000 cubic meter per day. As such, Hebron municipality supplies water in cycles, to households and businesses, and requires all those connected to the network to have a well that can take up the amount of water needed for each cycle (around 18 days).

- In order to enable the water cycle across the municipality, the municipality built three collection points for the water supplied from different sources. From these collection points, the municipality distributes water to the different areas according to the cycle schedule.
- Due to the lack in water supply, the municipality is in an ongoing campaign to increase consumer awareness of water issues, and knowledge in methods of reducing water consumption. By limiting the supply of water for each household, the municipality was able to create a culture that is more conscious of their water consumption and waste.
- For establishments and manufacturers who require a higher supply of water, water distribution trucks are used.
- Hebron municipality recently launched a hydraulic monitoring system, which is connected to the whole network of Hebron. Through this, they were able to ensure better flow and water pressure for all connected points, as well as ensuring that water is distributed effectively to all areas.
- Given the geographic nature of the municipality, the hydraulic monitoring system was also able to provide crucial information regarding where issues in pressure arise, which areas need better lines, as well as network losses and other relative information.
- Currently, water has a set price for all uses. However, the municipality will implement new water prices based on amount consumed, where those with higher consumption will have higher rates for pricing. This initiative is mainly there to make consumers more conscious of the amount of water used, aiming to be a part of lower pricing brackets.

Wastewater

Wastewater is an issue for Hebron municipality, as the wastewater line (collected from households and businesses) runs through the area where the majority of stone cutting businesses are, who in turn dump their waste into the stream, making the wastewater much more difficult to treat or reuse. There are 153 stone cutting facilitates in Hebron, making it the 12th largest in the world, processing around 50 Tons of stone daily. Stone waste (الروبة) is comprised of 30% fine stone particles, and 70% water.

Hebron municipality is currently in the process of establishing a wastewater treatment facility outside of the city. However, given that the collected wastewater is illegally combined with stone wastewater, it will make the treatment process more difficult. An earlier initiative in 2009, funded through AJIN and the EU, established a central treatment facility for stone wastewater. However, improper planning and testing of the stone wastewater and its composition resulted in ending the project, as many of the equipment (more specifically

the filters) were not suitable for the high-density stone wastewater produced. The central treatment facility is still available but will need a large investment for it to work again.

6.4.2 Water Management at Ramallah Municipality

Wastewater in Ramallah municipality, 83% of residents are connected to the wastewater network, of which, they produce around 1,200 cubic meter of wastewater per month. All of the wastewater produced is sent to wastewater treatment plants, where most of the treated wastewater is reused by the municipality for construction or irrigation, and the rest dumped in the surrounding area.

- Ramallah municipality is one of the few, if not only, municipalities which have almost complete separation of wastewater and rainwater networks. All wastewater is treated in Ramallah, but both it and the collected rainwater are both dumped into the mountains and not effectively used.
- One of the issues faced by Ramallah municipality is the lack of control over the area and development potential, as opposed to the privileges that municipalities in the occupied territories have.

6.4.3 Water Management at Khan Yonis Municipality

Water is an issue in Gaza Strip in general, as the coastal aquifer is saline. In Khan Younis, the municipality does not provide drinking water as a municipal service, but only water to be used for household use. Municipal water services provide saline water (up to a minimum use standard) that is able to serve household usage. Of which, the daily demand is almost 6,000 cubic meters.

- Drinking water is mostly bought through private initiatives with small desalination plants for water from private wells. However, there is a central desalination plant operated by Khan Yunis and Rafah municipalities, providing drinking water to both municipalities and Deir Al- Balah. The plant produces around 1,500 cubic meter of drinking water per day, of which, Khan Yunis has 40% of it. The collection point in Khan Yunis only connects to the western side of the city, providing them with drinking water. Last, as part of capacity building, the desalination plant is being developed to increase the capacity to 4,700 cubic meter per day. On the long run, the central desalination unit is phased to increase its capacity up to 13,000,000 cubic meters, providing water to the whole of Gaza Strip.
- In the summer, as electricity becomes scarcer due to increase in cooling needs and restricted hours of electrical availability, as well as high price of gas prices, it becomes more difficult for the municipality to pump water to all residents. However, they are currently in phasing the installation of electro voltaic solar panels which are covering the electrical needs in the summer.
- There are around 24,000 subscribers in Khan Yunis municipality, many of which are connected to multiple households but have the same meter for the residential unit. Of all subscribers, the payment rate is still at 30%. To increase subscription rate, Khan Yunis municipality initiated a program to increase subscription by asking households to initiate the process, and they will cover the meter costs.
- All manufactures, as well as some schools, hospitals, and other private investors, many of them have invested in building their own wells and desalination units to provide themselves with the water needed. This is also becoming as part of emergency planning in UNRWA schools and some governmental schools

Wastewater

Total wastewater produced in Khan Yunis municipality is 4,000 cubic meters, of which, this only covers 65% of all households in the municipality, with 35% still using cesspits, and produce an extra 1,200 cubic meter per day. In terms of geographical coverage, 43% of the total area of the municipality is still not connected to any waste network at all.

- There are two wastewater treatment facilities in Khan Yunis municipality, one of which has the capacity to treat 3,700 cubic meter per day, the second, a temporary treatment facility, currently has the capacity of 470 cubic meter per day. The temporary wastewater treatment facility is not able to treat wastewater to standard levels, where the BOD[6] level is still high, but the water is still pumped back into the sea, causing a number of other issues.
- The main treatment facility used in Khan Yunis is being developed to increase its capacity to 6,000 cubic meter per day. Treatment level at this facility is up to 95%, one of the highest in the West Bank and Gaza Strip, reducing BOD level from 500 to 5 mg per litre[7].
- There are still 12,000 cesspits in Khan Yunis municipality, and a relatively low network coverage. This means that the municipality has large investments to make to be able to provide these services for all households across.
- Between 10% - 25% of all households who receive wastewater services are paying subscribers, which put more financial pressure on the municipality, especially with the high costs of wastewater treatment.
- The cost of collection and disposal of wastewater is around USD 2.6 per cubic meter. Whereas the cost on residents is 3.3 USD per month.

[6] Biochemical Oxygen Demand (BOD) is a measure used by wastewater treatment plants to ascertain the overall degree of organis pollution in a water source (AOST, 2018)

[7] The acceptable levels of BOD by the World Health Organization are 20 mg per Litre

7.0 Energy Efficiency & Renewable Energy in Palestine

7.1 Energy in Palestine

Primary Energy consumption in the Palestinian Territories can be broken down into its primary energy consumption classes in the following manner:

- Fuel and Gas account for 58%
- Renewables accounts for 13%
- Electricity accounts for 29%

In terms of final energy consumption, Households account for 45%, Transport accounts for 38%, Industry 6%, Public Services 10%, and Agriculture 1%.

99.9% of Palestinian Households are connected to the electrical grid, and about 56.5% of households have solar water heaters.

Collections are a substantial issue given that about 14% of electricity produced was lost to lack of payment, improper billing, or illegal connections, an issue that is slowly being mitigated with prepaid electricity meters which are now at about a 40% level.

A significant amount of household energy consumption in the Palestinian Territories goes to water heating, on a positive note however, 65% of water heating is done through flat plate solar units, which decreases reliance on both fuels and imported electricity, as only 19% of water heating is done through electricity, 14% through gasoline, and the rest through other means.

In terms of the overall energy balance in the OPTs and the use of Solar Energy, there is a significant lack of use, as out of a total energy supply of 75175 Terajoule, Solar Energy accounts for only 5,777 TJ, or 7.7% of the total energy balance. The Palestinian Government attempted to mitigate this issue by encouraging the installation of household solar units, in 2012 a target of 130 MW for domestic generation was set through PV units, this has led to lacklustre results, as 5 years into the initiative only 18MW were produced (meetMED, 2020).

The government attempted to incentivize the process by enabling HHs to purchase and install the domestic PV cells, financed through green loans, with any surpluses being sold to the grid with the provision of a feed in tariff from the government, however deteriorating fiscal conditions lead to such tariffs decreasing, and the lead to HHs finding it to be a continually less attractive option.

Solar energy use is an attractive option for the Palestinian Territories, as the utilization of PV cells at a large scale could potentially provide the Palestinians with a sovereign energy source, reducing thus the need to rely on imported energy sources, especially from Israel. Given the structure of the grid in the West Bank, and the restrictions of connecting the grids together through area C, large electricity generation plants and initiatives are unlikely to receive Israeli approval, this leaves the only proper power plant in Gaza, with a total output capacity of 140MW, but it is plagued by frequent cuts due to lack of fuel.

Palestine is an attractive place geographically for Solar Energy, with 3000 hours of yearly sunshine, and an average global horizontal irradiance of 5.4 kWh/m^2/ day. This is already being pushed with the private sector initiatives, with the AFD providing 25 million USD of green financing through its “Sustainable Use of Natural Resources and Energy Finance (SUNREF)” Program. The second phase of this program was launched in 2022, targeting 350 SMEs and adding 55GWh of renewable energy and 40GWh of energy efficiency (Proparco, 2022)

The Palestine Investment fund is mobilizing 2 billion USD to invest in Solar Energy, with Noor Palestine Solar Program being the leading project. Noor Palestine has a renewable energy investment portfolio of 200 million with a capacity of 200MW. The current phase 1 has a capacity of 60 MW that include power parks and the rooftops of 500 schools. (MeetMED, 2020). Furthermore, other parties such as UNIDO, the EU, PENRA, and others are implementing different projects working on policy level, capacity, infrastructure, and others, in order to increase the use of renewable energy in Palestine.

7.2 Energy Distribution & Electrical Demand Response Program

Strains on Energy Demand

According to the Palestinian Electricity Regulatory Council energy in demand in Palestine depends both on the region and the season. For example, in West Bank Centre and South, the highest consumption is in the winter for heating purposes. In West Bank North, such as Jenin & Tubas, in the summer, their demand is the highest as their energy demand for both agriculture usage and household cooling is higher. The lack of energy and high electrical demand has an impact on the electrical grid and amount of energy distributed, as seen in the table below provided the Palestinian Electricity Regulatory Council (PERC), all areas around the West Bank suffer from electrical outages (PERC, 2020):

Table 5 Service continuity Indicator: programmed and non-programmed Electrical Service Interruptions (2020)

Indicator	Type	Jerusalem	North	Hebron	Tubas	South	Distribution companies
Total minutes with no electricity per consumer per year	Programmed	82	525	94	118	508	210
	Non - Programmed	353	248	164	459	1008	357
Average number of times for electrical cut off per consumer per year	Programmed	0.35	6.49	1.25	2.43	1.63	1.96
	Non - Programmed	6.72	6.97	4.94	18.66	17.28	7.72

There are no electrical response programs currently being implemented in Palestine. As there is generally an electrical deficit, and there is no unified body which combines regulations across the West Bank and Gaza Strip.

7.3 Energy Efficiency in Buildings

Operational energy use can be reduced through the use of insulation, lighting, design, and energy efficient lighting and electrical appliances, this is true for both new and existing buildings. In one case study, Building Information Modelling tools were used to develop the baseline energy model for the building, including the annual energy consumption, solar access analysis, and building gains analysis. The study found that by replacing single glazed window with double glazed window, modifying window to wall ration, applying thermal insulation with optimum thickness, and application of energy efficient lighting, the operational energy use of the building was reduced by a total of 35% (Ahsan, et al., 2019). Furthermore, the most significant retrofitting technique used in the model was “application of insulation”, which includes choosing the right insulation material and thickness through testing using Building Information Modelling tools.

In a case study in Palestine, researchers conducted an energy simulation in order to estimate the amount of operation energy reduced by applying different measures through retrofitting existing buildings (Monna, et al.,

2021). Taking two unit and four-unit residential buildings in Jerusalem, Jericho, and Gaza, the study took into account the following three levels of retrofitting[8]:

Table 6 Retrofitting levels in sample residential buildings in Palestine

Level 1	• Reducing Infiltration • Set point temperatures for heating and cooling at 18ºC and 25ºC respectively.
Level 2	• Adding thermal insulation for external walls and roof (6 cm extruded polystyrene from inside) • Use of double low e- glass • Replacing standard fluorescent with CFL and LED lights • Blinds on the inside • External overhang shading for the windows • Enhances natural ventilation from 1 – 3 ACH.
Level 3	• Adding best practise for heating and cooling system using mixed-mode ventilation by enhancing natural ventilation to vie ACH for summer and mechanical ventilation for winter. • Triple glazed windows with overhand and blinds • Renovated solar water heating system.

Table 7 Results from the simulation for energy consumption for lighting, heating, cooling, and domestic hot water, comparing the base case scenario with the three-level retrofit plans for buildings with two units per floor area (Monna, et al., 2021).

Climate Zone/City	Retrofit Plan	Lighting kWh/m²	Heating kWh/m²	Cooling kWh/m²	Domestic Hot Water kWh/m²	Total Energy kWh/m²	% Energy Reduced from Base Case
Zone 4 (Jerusalem)	**Base Case**	12	61	38	28	139	
	Level 1	12	40	30	28	110	***21%***
	Level 2	9	8	15	28	59	***58%***
	Level 3	9	9	11	8	37	***73%***
Zone 6 (Gaza)	**Base Case**	13	28	68	28	136	
	Level 1	13	14	54	28	108	***21%***
	Level 2	9	1	28	28	66	***51%***
	Level 3	9	2	23	6	39	***71%***
Zone 1 (Jericho)	**Base Case**	12	30	80	28	150	

[8] For the simulation, each level was added after the other. E.g., reduction for level 2 are combined reductions for level 1 and level 2.

	Level 1	12	15	65	28	121	***19%***
	Level 2	9	2	33	28	71	***53%***
	Level 3	9	2	27	6	43	***71%***

Table 8 Results from the simulation for energy consumption for lighting, heating, cooling, and domestic hot water, comparing the base case scenario with the three-level retrofit plans for buildings with four units per floor area (Monna, et al., 2021).

Climate Zone/City	**Retrofit Plan**	**Lighting kWh/m²**	**Heating kWh/m²**	**Cooling kWh/m²**	**Domestic Hot Water kWh/m²**	**Total Energy kWh/m²**	**% Energy Reduced from Base Case**
Zone 4 (Jerusalem)	**Base Case**	14	54	37	23	127	
	Level 1	*14*	*32*	*28*	*23*	*97*	***24%***
	Level 2	*9*	*6*	*18*	*23*	*56*	***56%***
	Level 3	*9*	*7*	*8*	*1*	*25*	***80%***
Zone 6 (Gaza)	*Base Case*	*14*	*24*	*65*	*23*	*126*	
	Level 1	*14*	*10*	*50*	*23*	*97*	***23%***
	Level 2	*9*	*1*	*30*	*23*	*63*	***50%***
	Level 3	*9*	*1*	*19*	*5*	*34*	***73%***
Zone 1 (Jericho)	*Base Case*	*14*	*26*	*75*	*23*	*138*	
	Level 1	*14*	*12*	*59*	*23*	*108*	***22%***
	Level 2	*9*	*1*	*35*	*23*	*68*	***51%***
	Level 3	*9*	*2*	*23*	*5*	*38*	***73%***

Currently, the Palestinian Energy & Natural Resources Authority (PENRA) is working on increasing awareness amongst developer and engineer of the need of use of thermal insulation, as they believe it will be crucial in reducing the total energy consumption of building for cooling and heating. One of the main issues in including thermal insulation in buildings is the lack of practical and theoretical skills amongst engineers and contractors in calculating the amount of insulation needed and the techniques to apply optimum thickness.

Efficient Electrical Fixtures

Efficient electrical fixtures (internal and external lightening) are widely available in the West Bank and Gaza Strip and used by households, developers, and electricians regularly. However, even though efficient electrical fixtures are available, over 70% of the market is supplied and consumes low quality fixtures which have a short life cycle and are replaced frequently. One of the biggest reasons for this is the price sensitivity of consumers (end-consumers, electricians, and developers) who will opt for cheaper products rather than products that are guaranteed for longer periods.

The price difference between low end and high-end products is great, for example, a low- end bulb can be sold for USD 1.2per bulb with a lifetime of 6,000 hours (250 days). Whilst a high- end bulb is sold for around USD 620 NIS with 25,000 working hours (1041) days, four times the former. Another type of bulb has three grades,

the first up till 30,000 hours (1250 days), the second 70,000 hours (2917 days) , and the last 120,000 hours (5000 days). However, as Al Takamol supplier notes, all products must be tested before using it as some producers may provide ineffective products or those with a shorter life cycle.

Regarding the type of consumers who purchase efficient fixtures, for Al Takamol, which is one of the largest wholesaler and retailer in Palestine, the majority of their clients (60%) are electricians, (20%) are end-consumers, and (20%) are consultants and developers. However, they note that other electrical suppliers who supply home fixtures may have more than (60%) of their customer base as end-users, whilst those who supply electrical accessories may have more than (90%) of consumers electricians.

Even though there are no type of incentives that make it easier for importing efficient electrical fixtures and appliances, the initial need for multiple certifications of supplier of the product effectiveness make it easier for supplier to provide Israeli boarder agency with the required papers for testing.

According to Al Takamol supplier for electrical fixtures, Ramallah municipality has been replacing the majority of their street lightening to electrical efficient lightening, taking into consideration sunrise and sunset hours, time of the night and congestion, and other factors. The replacement of streetlights has results in a 68% reduction in bills relating to. Furthermore, as Al Takamol noted, almost every other large municipality is slowly starting to replace their lights, putting up small yearly bids to replace area by area as it is limited to their financial abilities.

However, one main issue when it comes to governmental use of efficient electrical fixtures is that the majority of governmental units still use outdated high consuming electrical fixtures for their buildings, including school, ministries, and other governmental offices. In public schools specifically, the specification of outdated lightening fixtures in outgoing bids makes it impossible for some companies to apply, as most manufacturers have stopped producing these types of fixtures.

Heating, Ventilation, and Air Conditioning systems

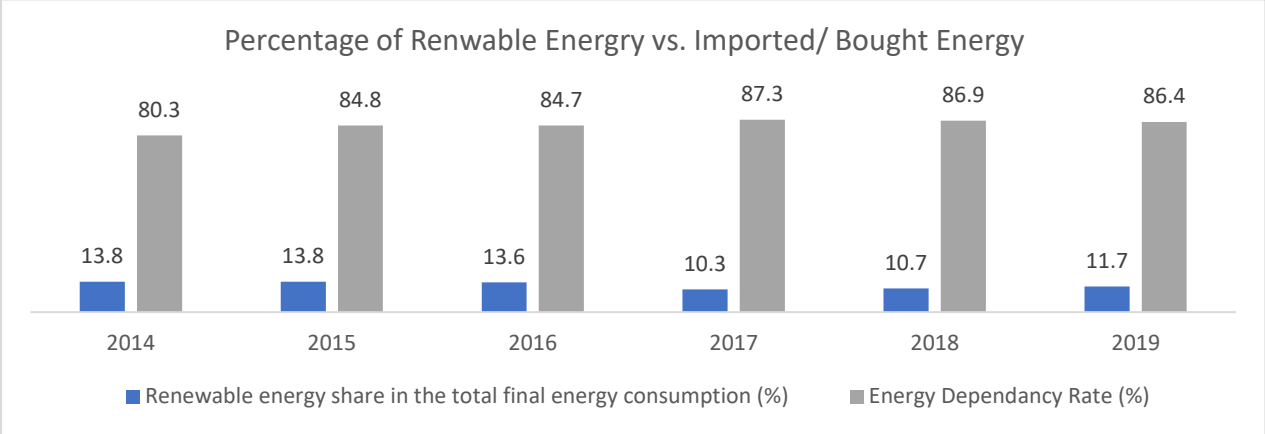
In Palestine, heating and cooling is generally done using different methods, where heating is done through use of electrical heater or fuel burners, whilst split Air Conditioning (AC) units are used for cooling purposes, as well as heating in some cases. The use of such appliances for heating and cooling within residential and commercial units leads to high strains on the electrical grid, especially at peak times.
One available option in Palestine are central Heating, Ventilation, and Air Conditioning (HVAC) units, which are central units for heating and cooling entire buildings, floors, or residential houses. When used correctly, HVAC systems are able to lower or minimise the heat load for any building. However, for effective use of HVAC systems, there needs to be a thermal requirement assessment, effective thermal insulation and management in place, and proper calculation the heating and cooling load. As such, these three requirements are currently the biggest issues in applying HVAC systems, as contractors use a general rule of thumb, which overestimates heating and cooling load by 35% - 40% and incurs extra initial costs for installation as well as less efficiency on the long run.
One of the current local providers of HVAC systems, Climatech, notes that all systems available in the West Bank and Gaza Strip are certified up to European standards, ensuring that systems available are effective and internationally used. Furthermore, Freon 32, the used refrigerant in these systems is considered Ozone friendly

contrary to other types of refrigerants Lastly, Climatech and other importers are also able to provide heat recovery systems and heat exchangers as part of the HVAC systems to ensure more efficient energy use.
The main type of consumers for HVAC systems are large institutes and institutional buildings such as private sector establishments, hospitals, and others, and high-end consumers such private villa owners. The rest of consumers use split AC units mainly for cooling purposes. One of the main reasons for consumers using split units is that it is more difficult to instal unified systems for large residential units, where different building members and household members may be comfortable with different temperatures.

7.4 Renewable Energy

According to the PCBS 2019 reports, renewable energy in Palestine account for almost 12% of the energy consumed in Palestine (PCBS P. C., 2019), however the PERC notes that only 2% of Palestinian electricity is produced through Photovoltaic cells, while the rest can be attributed to solar water heaters.

Figure 3 Final Energy Consumption by Sector and Type of energy and Year, 2014-2019



Photovoltaic Cells (PV)

As for Photovoltaic cells (PV), Al Takamol is one of the main suppliers for establishments which install solar panels. It does not however do any installation as they would compete with their consumers. Based on their studies and consumers, the payback period for households installing PV cells for electrical generation is around 3 – 4 years, given that the PV cells are installed on a 2-floor villa or single household. It is more difficult to install PV cells on residential buildings, as the space on the roof may be separately owned, and the space may be used to provide electricity for only a few apartments. However, some residents are finding a way around it, where 3 apartments within the building have taken up the roof space for PV cells to cover their electrical consumption, as well as supplying the building with electricity for shared utilities such as the elevator, lightening, and other electrical costs.

As for the payment mechanism between electrical companies, households, and those generating electricity for commercial use is different depending on the benefactor, and whether they were part of a subsidy program or not.
For households, given that batteries are too expensive as a way to store electricity, PV cells are usually connected to the electrical grid. The electricity generated by households is pushed back into the grid, where

the electricity company takes a total of (15%) from total production, providing the rest back to the household as needed. However, households are limited by the amount of electricity they are able to produce by their actual consumption (any surplus is taken by the company free of charge), and the amount of electricity provided by each household is zeroed at the end of each year, meaning that households disincentivised in covering part of the Palestinian electrical deficit, as they are not able to benefit from electrical production or saving on the long run.

As for manufacturers, the Palestinian Electricity Regulatory Council (PERC) has set policies to incentivise solar power production to cover their own electrical demand. For manufacturers who use renewable energy to cover their own electrical demand, the government will exempt them from annual tax for the extra profits gained through savings on electrical costs. The tax exemption is applied for 10 years, where they recover full exemption for the first 5 years, reducing every couple of year thereafter, until all profit is taxed equally.

For private investors and those interested in generating electricity through solar farms, electrical companies buy electricity from private PV farms at USD 0.06 per kWh[9][10], which is very low for it to have a lucrative payback period for investors, more than 8 years. However, one policy established by the PERC to incentivise solar farm development is tax a tax exemption program for 5 years for small farms (1 kWh or less), and 7 years for medium farms (more than 1 kWh). Another ongoing program that was initiated in 2018 subsidized price for electricity produced for solar farmers with a maximum production of 5 kWh, the first phase bought electricity at a price of USD 0.34 per kWh for 100 solar farms, the second phase of solar farms sold electricity at a price of USD 0.24 per kWh, and the last phase has electricity priced at USD 0.16 per kWh. There are around 100 – 200 solar farms funds still available for application. However, this program will end after the set fun is used.

Solar Water Heaters

Solar water heaters are used by more than half of Palestinian households, (57%), which is a decrease from 2011 (Monna, Juaidi, Ramez, & Itma, 2020). This indicates that many new residential houses are choosing electrical water heater rather than solar. The shift to electrical sources is due to the fact that electrical boilers can be used all year around, especially in high areas where there are colder winters and more clouds.

Furthermore, given that the majority of residential units are apartments in buildings, the infrastructure for solar water heaters is most likely being disregarded by the majority of developers, making it the end-consumers full responsibility to ensure available infrastructure. These factors lead to easier accessibility to electrical boiler for end- consumers and increase in usage amongst the populations.

Electrical Cars

In the West Bank, gas, diesel, electric hybrid, plug in electric hybrid, and full electrical cars are now available through different providers such as Hyundai and Kia Motors. The difference between the latter three cars are that hybrid cars are those which use fuel and a rechargeable battery, a hybrid plug in is similar to the hybrid but also includes a fast charging plug in for the battery, and lastly, a full electric cars is that which only used a rechargeable battery. In an interview with Kia Motors manager, information on the different types of Kia Sportage model was obtained, table (9) below provides a summary of the information.

[9] One of Israeli regulations states that electricity produced through renewable energy by Palestinians must be sold at a price 15% less than that of Israel. Where price of electricity bought from Israel is at USD 0.1 per KWh, and as an estimate price bought from Palestinian farms should be at USD 0.08 per month.

[10] Electricity prices in Palestine are the highest in the world, reaching to more than USD 0.18 per KWh

Table 9 Kia Motors Sportage Models Price, Milage, and Monthly Costs

	Sportage Gas	Sportage Diesel	Sportage Hybrid	Sportage Plug in Hybrid
Price ($)	43,860	46,784	54,094	61,404
milage /liter	11	13	18	21
Monthly Gas Cost ($)	439	351	205	117
Extra electrical cost ($)			88	88

Table (9) above shows the economic benefits of obtaining a Sportage hybrid car, where even though there is a higher upfront cost for the car, it cuts the monthly expenditure by half on gas. Furthermore, by estimating the total expenditure on gas and electricity for Sportage gas, Sportage Hybrid, and Sportage plug in, it was calculated that purchasing either Sportage Hybrid and Sportage Plug in Hybrid will lead to a pay- back period of 6 years to cover the larger initial investment.

7.5 Energy Management in Municipalities

Given that there is a different company for energy distribution in Ramallah and Hebron municipalities, however no official response was obtained from either. As such, energy in and Khan Younis is only presented as part of the case studies, as well as some solutions implemented by Ramallah municipality itself.

7.5.1 Energy Management in Khan Yonis Municipality

The total demand in Khan Yunis municipality is around 100 MW per day, of which they receive a total of 36 - 40 MW per day, 24 MW supplied through two lines from Israel, and the third line provided through the central electrical station in Gaza, providing 12 – 15 MW per day. Electricity in Gaza Strip is not provided by the municipality, but through Gaza Electrical Distribution Company.

- The central electrical station in Gaza Strip produces electricity through fuel burning. Given the situation in Gaza Strip and the ongoing siege, shortages in gas and fuel means that the station is not able to provide the amount of electricity needed.
- Given that the Electrical Distribution Company is in charge of providing electricity, ،Khan Yunis municipality only receives electricity from them, but have no formal relationship with them. That said, the demand for municipal facilities is prioritized to ensure that wastewater treatment facilities and other important units have their needed supply.
- In terms of renewable energy, there are 20 municipal units that are benefitting from solar panels. This includes wastewater treatment facilitating, salination facilities, pumping stations, market, and others. Some of these units have both solar panels and a battery in case of low energy production from the former.

7.5.2 Electric Car Fleet in Ramallah Municipality

There are 12 electrical cars owned by the municipality, of which, each car decreases its running cost by almost USD 3,800 in fuel prices. For each car, the municipality has its own charging point within the municipality, and two other charging points across the city, one in Ramallah, and one in Al Bireh.

Even though the use of electric cars did save up on energy through fuel, a non- renewable source, it did however put a large strain and more dependency on the already volatile electric grid and did not actually revert from using fossil fuels as our primary electric source from Israel is fossil fuel dependent.

8.0 Health and Wellbeing

8.1 Health & Well Being in Palestine

According to 2017 data, the Palestinian population, estimated at 4.9 million individuals, had an average life expectancy at birth of 78 for females, and 76 for males. According to 2019 data, lung cancer and lower respiratory infection are the 7th and 8th top causes of death for Palestinian, which can be a secondary effect of long exposure to different chemicals including VOCs, noting that lung cancer has had an increase of (71%) over the last 10 years, and is becoming more abundant amongst Palestinians (IHME, 2019). The impact of increase in long- term diseases will be felt amongst different stakeholders, the individual will suffer from long health effects as well as economical loss due medical payments and loss of work opportunity given time in treatment. Health service providers will also have an increase in needed capacity for long- term disease treatment. And the governmental units and budget will have to support both service providers and individuals in treatments and treatment requirements.

Mitigating diseases and factors which instigate and are attributed to different diseases is crucial into the sustainability and wellbeing of an economy and country. As seen in figure (3) below, the cost of health services for private individuals and the government will only increase in the next 40 years, straining both individual and governmental budget in this already volatile economy.

Figure 4 Top Causes of Death in Palestine (IHME, 2019)

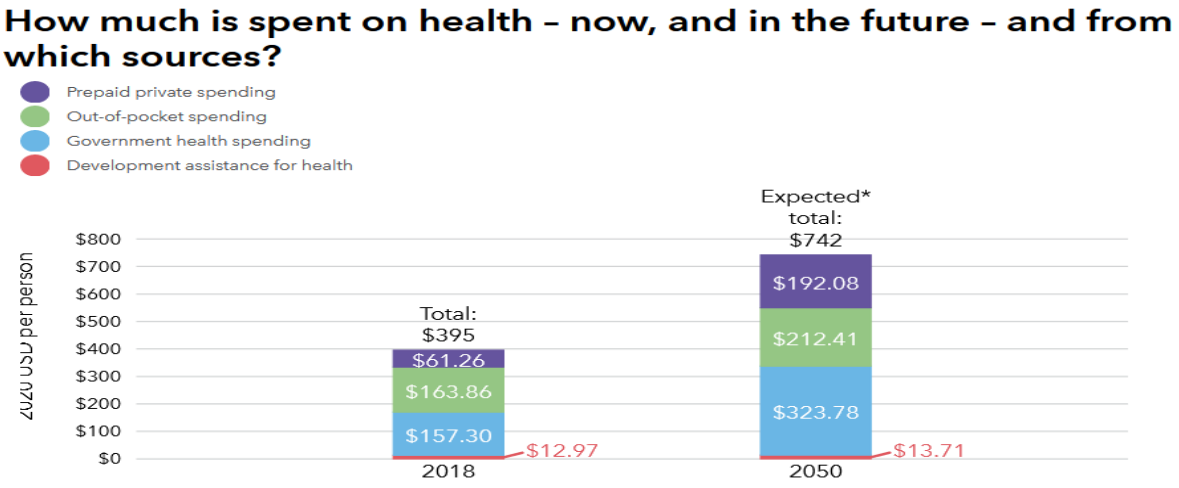
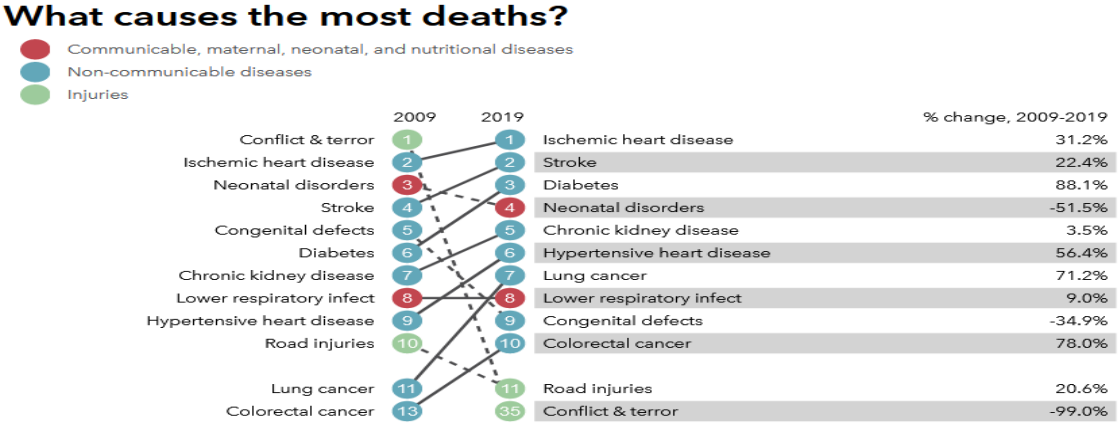


Figure 5 Health Data Distribution in Palestine (IHME, 2019)



8.2 Impact of Buildings on Individual Health & Wellbeing

The impact of buildings on individual health and wellbeing comes throughout the different life cycle phases of the project, including construction, operation, and end of life. Green buildings aim to minimize environmental risk to wider society throughout the different life cycle phases. Furthermore, in construction, the use of different building material and products may be harmful to those who use the material in construction, as well as the those on- site, or within a certain distance of the construction site.

During Construction and Deconstruction

In construction, the use of the different building material has its own harm (Annex I). However, exposure is not always limited to construction and on-site worker, but also to other individuals surrounding them. For example, although aggregates, sand, and other material are centrally stationed on the construction site, strong wind will carry dust particles across the entire area, entering homes, and reaching other residents.

Furthermore, the impact of a construction and deconstruction sites are not limited to the material but can be also attributed to the whole process. Material transportation and need for large vehicles cause more traffic disruption and closures, and loud ongoing sounds throughout the day from processes is considered as noise pollution.

In Design and Building Operations

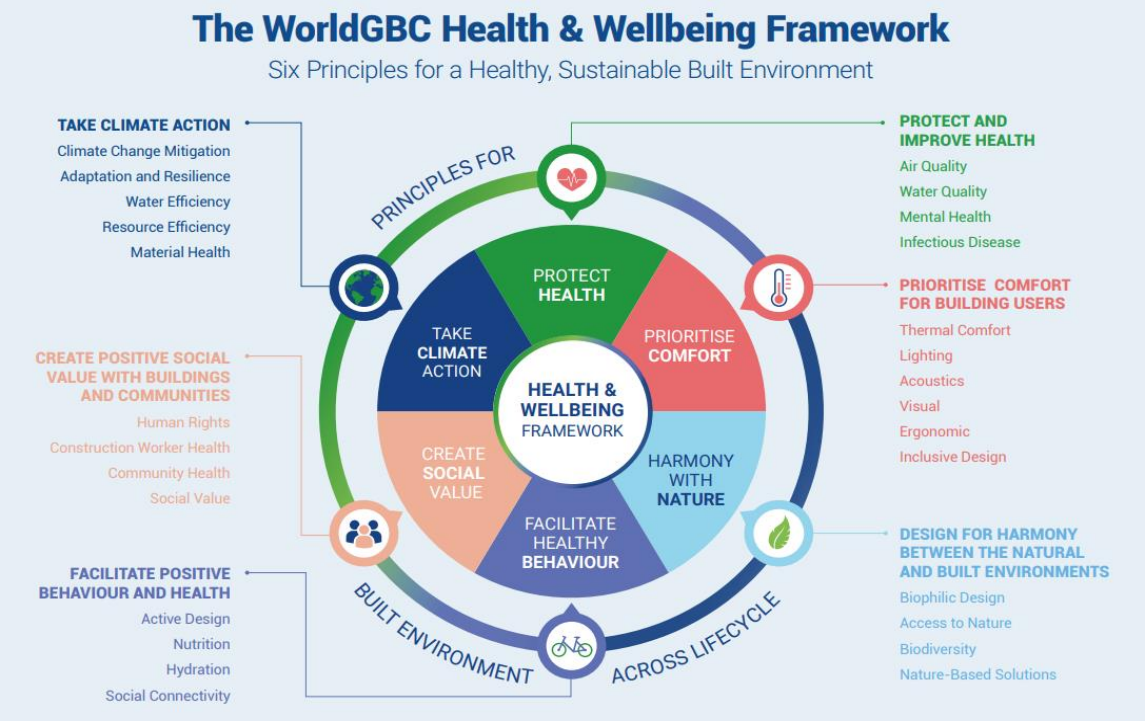
Improper and ineffective design and use of natural resources may greatly impact the users' health and wellbeing. Influenced by environmental factors such as comfort, daylight, and nature, a properly designed green building can significantly alleviate issues relating to respiratory health, mental illness, and others.

In a systematic review of literature titles "The relationship between buildings and health: a systematic review", the author investigates 39 research papers looking at the different factors within the building operation which impact the user's wellbeing. The study found that there is a clear relationship between the residential temperature (warmth) and respiratory health. Furthermore, improving housing quality through maximizing energy efficiency, removing home hazards, and adapting (retrofitting) existing buildings is found to have positive health effects, including but not limited to improve quality of life, mental health, and clinical health related outcomes (Ige, et al., 2018)

8.3 Improving Individual Health & Wellbeing

The World Green Building Council has put in place a comprehensive framework regarding health and wellbeing requirements of green building.

Figure 6 WorldGBC Health & Wellbeing Framework



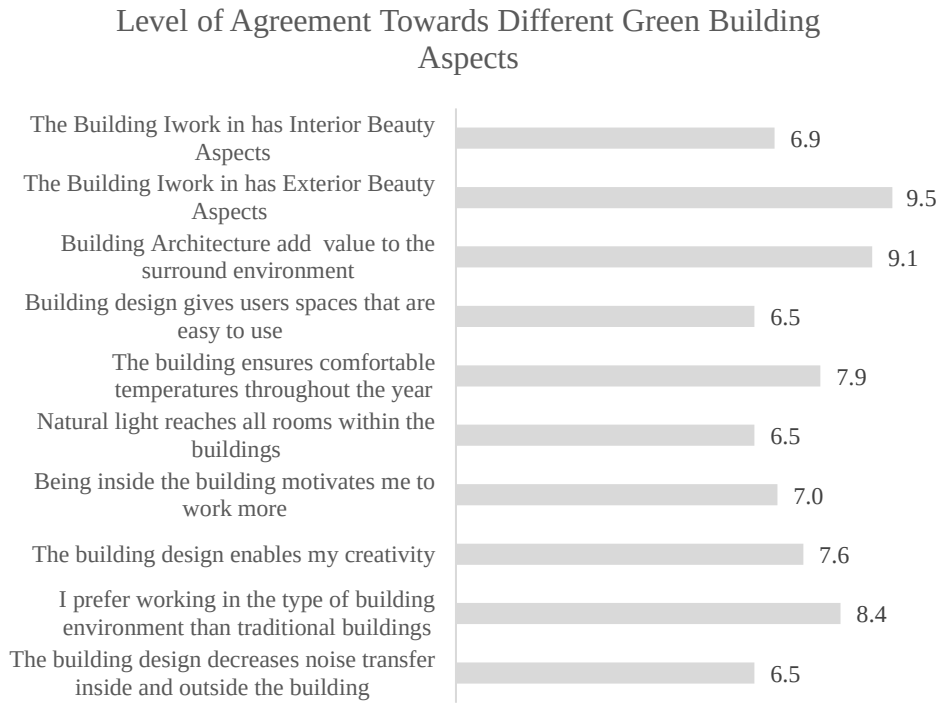
In terms of protecting an improving health, green buildings are important as currently people spend a substantial portion of their time indoors, thus indoor air quality is important:

- Green buildings must provide high indoor air quality including temperature and ventilation, as 3.8 million premature deaths occur prematurely due to exposure to polluted air, mostly resulting from the burning of fossil fuels.
- Volatile organic compounds also can trigger nausea, headaches, and repository issues.
- Biological contaminants such as mold can cause significant health risks, this is a significant issue as up to 40% of households contain mold to a degree.
- Outdoor air: adequate measures should be taken to prevent contaminated outdoor air from penetrating green buildings.
- Prioritizing thermal comfort, and lighting, with energy efficient solutions.

8.4 Health & Wellbeing in Palestine

In order to evaluate the impact of switching to a Green Building, Solutions developed and distributed a short survey to be self-administered by employees working in green buildings, The Palestinian Museum (TPM) and Al Qattan Foundation. Given that only one response was obtained from Al Qattan employees, responses from The Palestinian Museum will only be presented below.

Figure 7 The Palestinian Museum Survey results Perception on Green Building Aspects



Employees were asked about their level of agreement and comfort in different aspects of TPM. In general, there is more satisfaction in the exterior environment of the building and the value it provides. On the other hand, there is least satisfaction with the interior design of the building in terms of effective use of space, reach of natural light, and sound insulation abilities. However, green building users prefer working and using green buildings rather than traditional buildings.

This is further confirmed with results regarding the best feature of the building, where all respondents noted at least one external factor which they believe is a great factor for the work environment, the most being the availability of an accessible garden. Other factors which were mentioned by multiple respondents include the exterior architecture and design of the space, energy efficient management within the building, and thermal comfort throughout the year.

On the other hand, when looking at negative aspects of the building, all respondents also noted at least one internal design feature that they would change. The majority of responses were regarding issues in office space design, effective use of building design for the different types of exhibitions and activities conducted by TPM, and lastly, issues in echo throughout the building interior, where the effect of noise was not properly taken into consideration, which is causing a lot of issues for employees working in open spaces.

9.0 Discussion & Recommendations

9.1 Discussion

9.1.1 Green Buildings

This study looked into the feasibility of green building through multiple aspects, taking into consideration water efficiency, energy and atmosphere, material and resources, and indoor environmental quality. Given that a variety of materials and products are available, and many different green buildings process can be implemented, it can be said that green buildings could be feasible in Palestine given the currently available material

However, in order to make national shift towards more sustainable building, a comprehensive long term strategic plan needs to be developed, using yearly goals and budgets to accomplish small, focused outcomes on yearly basis, and working towards broader more national outcomes on the long run. Furthermore, strategic planning needs to ensure the use of effective partnerships in each sector, ensuring that many challenges in implementation are mitigated.

To classify a green building or a LEED accredited building, the construction and operation of the building need to consider multiple aspects of the building. This includes building design, type and source of material, construction techniques and processes, the use of renewable energy sources, recycling and reusing material…etc. Simply put, green buildings consider reducing the total embodied and operation carbon produced throughout the life cycle of the building, in order to reach closest to a net- zero state.

Looking back at the LEED scorecard, developers and contractors in Palestine are able to implement many green building measures to qualify as green buildings or even acquire LEED certification. As such, the table below provides research-based results for the measures applicable in Palestine that coincide with LEED building certification with green buildings.

Table 10 LEED Scorecard required implementation factors

Easy to apply	Feasible to apply	Challenges in application
	Requirement	**Applicability**
Credit	Integrative Process	Use of integrative process is bound in green building design.
Location and Transportation		
Credit	LEED for Neighborhood Development Location	Not applicable
Credit	Sensitive Land Protection	Experts needed for assessment.
Credit	High Priority Site and Equitable Development	Experts needed for assessment.
Credit	Surrounding Density and Diverse Uses	Experts needed for assessment.
Credit	Access to Quality Transit	Depends on area and stage of neighborhood development
Credit	Bicycle Facilities	Facilities can be easily fit into buildings
Credit	Reduced Parking Footprint	Reducing areas for parking lots & increasing the availability and ease of accessibility to public transportation
Credit	Electric Vehicles	Provide premium parking spots for charging stations to Incentivize household usage

Easy to apply	Feasible to apply	Challenges in application

	Requirement	Applicability
Sustainable Sites		
Prereq	Construction Activity Pollution Prevention	Need to develop mitigation plan for polluting activities. e.g., dust.
Credit	Site Assessment	Experts needed for assessment.
Credit	Protect or Restore Habitat	Not applicable in many areas
Credit	Open Space	Awareness amongst developers, architects, and engineers regarding the importance of open space in households.
Credit	Rainwater Management	Rainwater collection fixtures can be easily added to buildings.
Credit	Heat Island Reduction	Through the use of different material for parking lots and adding shading such as trees.
Credit	Light Pollution Reduction	Available smart lighting systems and efficient lighting.
Water Efficiency		
Prereq	Outdoor Water Use Reduction	Availability of water efficient fixtures
Prereq	Indoor Water Use Reduction	Availability of water efficient fixtures
Prereq	Building-Level Water Metering	Applied
Credit	Outdoor Water Use Reduction	Availability of water wells for gardening purposes and water efficient fixtures
Credit	Indoor Water Use Reduction	Availability of water efficient fixtures
Credit	Optimize Process Water Use	Integrate different methods such as rainwater and stormwater harvesting, separate grey water, and black water collection systems when possible.
Credit	Water Metering	Increasing awareness of smart metering across large enterprises and buildings
Energy and Atmosphere		
Prereq	Fundamental Commissioning and Verification	Experts needed for assessment.
Prereq	Minimum Energy Performance	Experts needed for assessment.
Prereq	Building-Level Energy Metering	Experts needed for assessment.
Prereq	Fundamental Refrigerant Management	Experts needed for assessment.
Credit	Enhanced Commissioning	Experts needed for assessment.
Credit	Optimize Energy Performance	Different measures available such as insulation, efficient electrical fixtures and appliances and others for energy optimizations.
Credit	Advanced Energy Metering	Smart systems available for advanced energy metering
Credit	Grid Harmonization	Experts needed for assessment.
Credit	Renewable Energy	Solar water heater already applied by many. PV cells are becoming more affordable and used by others.
Credit	Enhanced Refrigerant Management	Experts needed for assessment.

Easy to apply	Feasible to apply	Challenges in application

	Requirement	Applicability
Materials and Resources		
Prereq	Storage and Collection of Recyclables	There is a need for an end point for recycled material for municipalities to be able to provide separate waste storage and collection facilities.
Credit	Building Life-Cycle Impact Reduction	There is a need to provide a small number of materials with these specifications, which are available in Palestine.
Credit	Environmental Product Declarations	There is a need to provide specific number of materials with these specs. which are available in Palestine.
Credit	Sourcing of Raw Materials	There is a need to provide specific number of materials with these specs. which are available in Palestine.
Credit	Material Ingredients	There is a need to provide specific number of materials with these specs. which are available in Palestine.
Credit	Construction and Demolition Waste Management	There is still high potential for waste management in the West Bank. However, in Gaza, they have reached high efficiency in this regard.
Indoor Environmental Quality		
Prereq	Minimum Indoor Air Quality Performance	Incorporate methods to increase indoor air quality
Prereq	Environmental Tobacco Smoke Control	Prohibit smoking in certain buildings or floors
Credit	Enhanced Indoor Air Quality Strategies	Available methods for improved indoor air quality measures
Credit	Low-Emitting Materials	Different material is readily available in the West Bank on demand
Credit	Construction Indoor Air Quality Management Plan	Include plan within construction management plan
Credit	Indoor Air Quality Assessment	Experts needed for assessment.
Credit	Thermal Comfort	Through use of set temperature points, insulation material, and other measures.
Credit	Interior Lighting	Through effective use of windows, blinds, and natural lightening, effective indoors lights.
Credit	Daylight	Depends on the design.
Credit	Quality Views	Applicable & based on the design phase.
Credit	Acoustic Performance	Needs to be taken into consideration in design phase.

In order to implement many of these green building components, there needs to be different governmental, and individual led initiatives that are aimed to tackle key aspects in green buildings. As such, many of the feasible solutions presented above will have their own type of challenges and impacts. For example, even though there are many assessments that can be conducted to ensure the building is not harming the surrounding environment or to ensure effective mapping and designing energy facilities, these assessments come at any extra cost with experts which deter owners from using them.

Options that are more feasible for application (highlighted in yellow) are feasible options that also come at a price. However, the extra cost initially incurred for implementing these green measures may be paid back within a short period, or lead to immediate increase in user comfort within the building.

As for easily applicable green building measures, the inclusion of certain green building aspects in the design phase and incurring small extra costs could easily become a standardized building method amongst contractors and developers.

9.1.2 Building Materials

In terms of green building materials in the West Bank, sustainable sources for aluminium, wood, pre-cast gypsum, metal, and paints were available, as well as double glazed glass, Low-E glass, thermal glass, and thermal insulation material. The availability of all these materials indicates that sustainable sourcing of building material is feasible in the West Bank:

- Metal: Recycled metal is available through a local source. Metal across the West Bank is collected and exported to Jordan for recycling, where new bars are produced for construction and imported back into the West Bank. There is no price difference on the contractor.
- Aluminium: Aluminium is imported to Palestine and is mostly used for window and frame production. There is at least one recycling facility in the West Bank, where 30% of the aluminium it produces is from recycled content.
- Wood: Sustainably sourced wood from Europe, PEFC certified, is available from a local source. There is a price mark- up from non- sustainable sourced wood.
- Pre- cast gypsum: Pre-cast gypsum blocks are available. However, the lack of technical capacity for workers who are able to use it, as well as household preferences in terms of rigidity and sound insulation are barriers for increasing the utilization of pre- cast gypsum blocks.
- Paints: Even though water-based paints are readily available from local producers and importers, one of the main issues in market share penetration is the lack of awareness and poor practises of contractors and builders, choosing oil- based paints more often than others.
- Glass: All glass is imported in Palestine, and thus different types of glass is readily available in the region.
- Insulation material: Thermal insulation is available but still not readily used, as the developers still find it as an extra cost to the building development. Furthermore, in terms of effectively using insulation material to reduce heat gain and loss, there is no type of building energy design or specific calculation used, but a general rule of thumb.
- Doors & Windows: Even though doors only constitute a very small percentage of the building envelope, different types of doors thermally insulated and not are available upon demand. As for glass, low tier (thin, tempered, air vacuum), middle tier (thick, tempered, air vacuum), and high tier (thick, tempered, thermal insulator, air vacuum) Low-E glass, and thermal glass are all available. Low-grade double-glazed glass is the most used amongst residential buildings, as higher grades double in price, and e- glass almost triples. Similarly, for thermal aluminium profiles, even though they were provided through different importers, the price different and area limitations made it unattractive for developers and contractors.

In Gaza Strip, given the financial difficulties and importing restrictions, many materials are not readily available in the market, as the price difference, even as little as 15% for example, makes it not viable to import

or produce. However, 100% of construction material is generally recycled or reused, where there are specialised businesses that sort construction and deconstruction waste and sell it to other businesses for recycling or reuse. This also includes concrete aggregates and rubble, as some businesses manufacture pre-cast blocks using concrete aggregates from construction. Other material that is reused includes metal, aluminium, and wood. However, water-based paints and double-glazed glass are not generally available as the price difference make the market that can afford it very small. As for thermal insulation material, even though the material is available, usage is still relatively low. (Refer to annex 03 for building material prices data)

Generally speaking, for almost all building materials, many developers, contractors, or vocational workers will use cheaper building material to cut cost, this is specifically applicable to paints, glass, electrical efficient fixtures and water fixtures. Insulation material is still not readily used as the developer avoids higher construction costs, leaving the end- user to cover the costs of increased energy consumption. As for aluminium frames and metal, both of which can be recycled multiple times without losing the majority of their properties, there are available recycling and reusing options available in both the Wiest Bank and Gaza Strip. (Refer to annex 02 for contacts of green building material suppliers)

In relation to green buildings, many of the components for use of green building material are clearly feasible in both the West Bank and Gaza Strip. The availability of different importing options, as well as creative methods for recycling or reusing material means that many buildings can be classified as green buildings in terms of material resourcing.

9.1.3 Waste, Water, and Energy

There are a number of challenges when it comes to waste, water, and energy efficiency measures in Palestine, on national as well as municipal levels.

On a national level, the increase in total waste produced and lack disposal options is bound to result in many impacts in the next 20 years. The ongoing water deficit in the territory and increase in salination of Gaza Strip main aquifer will only result in more water shortages as the population increases. Similarly, the limited energy supply from Israel and other states, as well as the increase in Palestinian demand as the country develops means that other sources are in dire need to fill in the already existing gap in meeting consumer demands.

The challenges above are all reflected on a municipal level, as municipalities have to find solutions to mitigate these issues. Regarding solid waste, cardboard waste is the only type of waste that is recycled in Hebron municipality. In Ramallah, all wastewater is treated and there is separate stormwater collection network in use, however. Looking at water and water management amongst the different municipalities; In Hebron, all buildings and structures must have a water well to store the water supplied for each cycle, 18 days. In Khan Younis, the municipality is only able to supply water for household use, where drinking water is bought from private distributors. As for energy, Khan Younis municipality, similar to many other municipalities, has a deficit in energy supply. As the electrical strain increases in the summer, outages are induced more frequently. Lastly, many municipalities have been using renewable energy, powering up municipal units through PV cells.

Although both water and energy efficient fixtures are available, consumers generally choose cheaper products or those with lower quality. The level of governmental, municipal and consumer awareness in the impact of effective water fixtures and electrical fixtures is low, as even though it may greatly help in mitigating some of the water and electrical deficit, there are no policies or incentive programs aimed to increase the use of these type of fixtures.

9.1.4 Health & Well- Being

The impact of buildings on individual health and wellbeing can be discussed on two levels:

- Impact during construction and deconstruction, and
- Impact due to design and in operation.

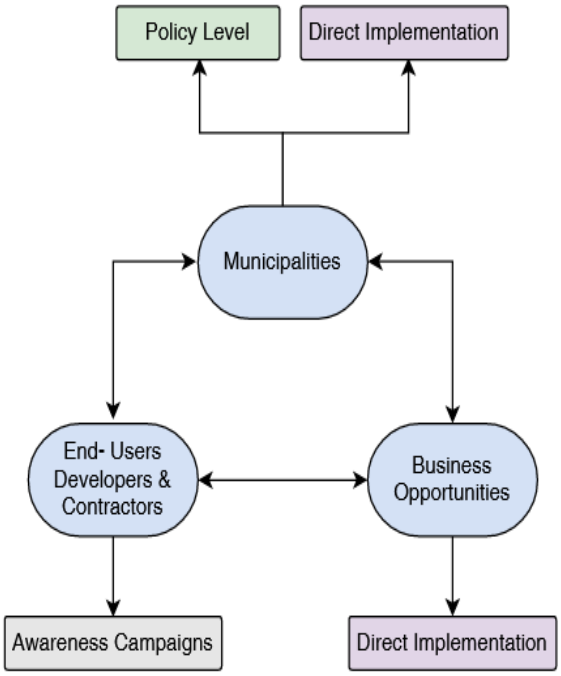


Figure 8 Relations between municipalities, businesses, and end users

First, in construction and deconstruction, the exposure to different material by construction worker, on- site employees, as well as users all have its own impact. The health impacts of many constructions material as seen in Annex I can itself be related to some of the top 10 diseases causing death in Palestine, such as ischemic heart disease, lung cancer, and lower respiratory infection. The health and economic impact on the individual as well as the financial impact on the governmental budget are both direct impacts of these increasing diseases. Even though construction workers such as painters and those working with asphalt and bitumen are the most prone to exposure, long period exposure by other residents and construction workers may also impact their health. Lastly, the increase in Palestinian population working in both the Israeli construction sector means that even though the Palestinian government may not reap the economic benefit of employment, it will have to still deal with the impact of using harmful construction material and methods.

Second level of health and wellbeing is in design of the building and its effect on the occupants during its operation. Improper ventilation, lack of natural light, and ineffective use of energy and space all leads to decreased quality of life, and clinical and mental issues.

9.2 Recommendations

The objective of this study was to assess the feasibility of green buildings in Palestine, as well as to look into recommendations for municipalities, investors, as well as end- consumers that are aimed at increasing both awareness and practise of green building measures and procedures.

Looking at the figure to the right, the direct economical relation between municipalities, businesses, and end-users and consumers can be easily noted. Municipalities are able to offer end users different services and benefit from residential taxes and other benefits. Business opportunities that are able to ease pressure on municipalities will be able to firstly provide municipalities support in providing waste treatment, clean water, or energy source, the investor will be able to financially benefit from the business opportunity. As for the investor and the end-user, the end user will also be a potential market for the investor, whilst the end-user will be able to benefit from the investor through the different services provided.

Currently, there are limited municipal or national incentive programs or policies for green buildings or any other factor within them (green building material, efficient water management, renewable energy…etc). As

such, the lack of incentive programs and policies reduce the likelihood of using green building measures in Palestine.

As previous studied have shown, green building incentives, programs, and initiatives do not need to tackle all issues at the same time, nor do they need to aim for large reductions in greenhouse gas emission. On the contrary, small steady initiatives that all include the most possible number of different stakeholders are the most to be successful. Taking into consideration all green building components studied above, the following are recommendations for municipalities, businesses, and individuals for key aspects to focus on in green buildings:

9.2.1 Building Materials

Municipalities

Policy

Municipal building and construction regulations and policies need to be reviewed and updated to ensure that more effective building methods are properly used and possibly mandating the use of certain material. Focusing on specific construction materials, municipal efforts can help dilute the impact of certain material on construction workers, end-consumers, health service capacity, and others, as follows:

- Paints: The availability of the local and international sources for water-based paint is a great indicator for the sustainable availability of this products. Municipalities are able to make it mandatory for residential and commercial units to use decorative water-based paint, and fine the distribution of oil based decorative paint.
- Thermal Insulation: There are both economical and individual wellbeing benefits of adding thermal insulation as household users save on cost of cooling and heating, as well as enjoy the benefits of thermal comfort. Furthermore, the decrease in energy strains in winter and summer seasons on the electrical grid will enable better distribution of electricity during peak seasons. As such, thermal insulation is recommended to become mandatory as part of building regulations in different municipalities. Noting that there needs to be a unified code and training efforts to ensure effective application of thermal insulation, given that current methods are highly outdated.
- Locally sourced recycled metal and aluminium: To increase both the use and reuse of metal and aluminium, sources local distributors and recycling facilities or facilitators should be marketed and used more often. The availability of a local establishment that stores and exports metal for recycling then reselling it in the Palestinian market as well as an aluminium producer that recycles and resells waste aluminium are good indicators for the ability to effectively reuse these two materials. As such, policies, incentive programs, and subsidies can be used to channel more metal and aluminium waste for recycling as well as reselling and reusing these products at lower costs.
- Governmental schools and other similar buildings: The use of water-based paint and insulation material should become mandatory policy for all large governmental units, especially school and other similar publicly used facilities.

Given that potential of municipalities to become leaders in supporting green buildings, municipalities need to ensure that they are using green measures and green building materials within their building units. As noted by paint providers, governmental bids for public schools specifically mandate the use of oil- based paint. Municipalities should attempt to make it mandatory for all schools (and other facilities where children are involved) to use decorative water–based paint in their building structures to reduce the amount of VOC exposure and ensure effective drying period to reduce inhalation of fresh paint. Municipal efforts can be in coordination with PalGBC, Palestinian Standards Institute, Ministry of Education and Higher Education, and

others. As the research shows, the majority of long-term effect of volatile organic compounds on humans are neurological based and may have long term effects. Children's exposure to such ingredients may induce early symptoms of such diseases.

The mandating of water-based paints should not only be to schools within a municipal district, but also to all other municipal units and public facilities. Also, municipalities should have initiatives to cooperate with other stakeholders, such as the government and the private sector to promote such trends and good practices related to green buildings

Business Opportunities

Given that the majority of building material and components are readily available in the Palestinian market, there are not many direct investments for importing different material, as the availability of products depends on demand rather than source.

However, of the missing components in the usage of sustainable and clean building material is advertising and marketing their benefits. A suggestion could be to provide a unified platform for building material retailers and distributors to advertise their products and highlight the available green building material. Private businesses in the UK and other regions run similar platforms by taking a small, fixed amount from retailer sales.

End Consumers, Developers, Contractors, and others

Raising awareness amongst consumer, developers, contractors, construction workers, and others is crucial into increasing the demand and usage of green building material. As many of the benefits impact all stakeholders, awareness campaigns need to target a variety of stakeholders.

- Paint: The impact of volatile organic compounds in oil-based paints effects construction painters as well as end- consumers and users. Awareness campaigns needs to target both types of stakeholders to increase awareness in the health risks of using oil- based paint. Joint efforts between stakeholders, including water-paint producers and importers, can be utilised to offer risk awareness and safer paint options simultaneously.
- Insulation material: Given the benefits for end-users to use or install thermal insulation through retrofitting, campaigns need to focus on the cost saving benefits and the low pay back period of insulation material. Increasing consumer demand for thermally insulated units and retrofitting will in force developers to include thermal insulation into design.
- Benefits for contractors and developers: As global awareness of green buildings and benefits of green design are increasing; developers and contractors need to become more aware of these added marketing value for the building. Ensuring that they are able to obtain the same profit margins as other buildings, as consumers will be willing to pay higher upfront costs for lower operational costs.

Parallel to awareness campaigns, training in methods for effective use and application of certain building material is still needed to ensure effective application. Some of which include:

- Insulation material: Even with the abundant amount of research onto the thickness of thermal insulation needed in the different region across Palestine, construction workers still use a general rule of thumb of application. There needs to be training for civil engineer, on-site engineer, and construction workers in proper methods of estimating needed insulation.

- Gypsum blocks: given that this material has only been recently introduced to the Palestinian market, there needs to be a general increase in the number of construction workers who are able to install gypsum blocks across the different regions.

9.2.2 Waste

Municipalities

Policy

Even though municipalities are prone towards introducing waste related policies for commercial units and residential areas, their main issues in waste remain is finding a cost-effective disposal method for waste disposal. However, as municipalities are responsible for ensuring the disposal of waste, they may be able to introduce policies which mandate or incentivise the recycling certain types of waste:

- Metal, Aluminium, and cardboard: Given that there are local facilities which recycle metal and aluminium, municipalities can make it mandatory contractors dealing with construction and deconstruction waste to recycle this material. However, given that contractors may be disincentivised in taking up the extra cost of transporting the material designated locations, different options need to be assessed before implementation.

Direct Implementation

Although there are municipal led initiatives for waste disposal, such as Hebron cardboard collection stream for recycling, and Ramallah ongoing feasibility study for bio waste recycling and reuse, there is still an issue in the small amount of waste that is produced by individual municipalities, in relation to any profitable solutions and ventures. In order to mitigate this, solutions for total waste produced by several municipalities and village councils need to be assessed, as such, the amount of certain type of solid or wastewater reused or recycled can be feasible for profit and investment recovery.

Business Opportunities

In relation to business opportunities from waste recovery and reuse, there is a clear need for further feasibility studies to assess the financial feasibility of different business opportunities. However, several different type of waste stream already available may be enough in volume to guarantee a feasible investment.

- Rubber Waste: Car tyres are one of the biggest municipal waste issues, as their large volume and heavy weight take up space and induce extra waste transportation costs, and the environmental impact of landfill treatment (the only available option) is very negative. As such there is both a need and a business's opportunity for a rubber recycling facility. The high abundance of rubber waste makes it feasible for any business to use it as a resource. Some of the methods for reuse of tyres include

    1) Shredding it and separating tyres into rubber granulates which can used for roads, paving, and children parks. Steel shreds, also a product of shredding tyres, may also be sold for recycling.
    2) Producing home and garden items (like recycled floors).
    3) Given that Palestinians have developed different types of concrete blocks from recycled concrete, using rubber tyres and shreds could be a potential solution to assess increasing durability and resistance.

- Concrete and aggregate waste: The recycling of concrete waste in Gaza Strip has greatly alleviated waste issues in the region. As such, this method should be further researched for structural durability, developed to obtain certifications, and branded and sold as products in different region across the West Bank and Gaza Strip. The certification and verification of such product will alleviate strains from the general waste stream of all regions in Palestine, municipal and contractor cost, as well as changing economic and political factors.
- Car Skeletons: There is a large quantity of car skeleton disaggregated around the West Bank and Gaza Strip. In the West Bank there is also the availability of a car crushing establishment that exports the metal for recycling. Car skeleton metal itself is profitable, however, the transportation of each car on its own is expensive. As such, there is a business opportunity in collecting car skeleton from the same region to transport together, cutting down on transportation cost per car, and selling the metal for a profit. However, the financial feasibility of this still needs further assessment.
- Metal & Aluminium: The availability local options that recycle metal and aluminium is a great indicator for sustainable waste disposal. Even though many contractors and developers already sell these types of waste, there is still potential for collection from many buildings and structures for recycling.
- Cardboard: The cardboard recycling model implemented in Hebron municipality through a partnership with a private business should be replicated across multiple municipalities. The ease of cardboard recycling, and its abundance amongst commercial units in city centres means that the same opportunity as in Hebron would exist in other areas such as Jenin, Nablus, Ramallah, and others.
- Bio waste and biofuels: The individual amount of municipal bio waste produced by the majority of municipalities is not sufficient for potential bio waste investment opportunities. However, there is a need to assess potential opportunities for multiple municipalities, especially those with high number of restaurants, cafes, and other food facilities.
- Stormwater reuse systems: Although the methods for stormwater recovery are available in Palestine, they are not used in buildings, and are not abundantly found. There is an opportunity for a stormwater recovery system specialist, who is able to design reuse networks within the same structure. E.g., stormwater and rainwater collected is directly used for flushing, agriculture, and other uses.

End Consumers, Developers, Contractors, and others

As there are still no effective streams for disposal of waste, awareness campaigns cannot tackle specific issues to increase consumer practises of sustainable waste disposal methods. However, if any of the above is applied on a municipal and national level, awareness campaigns need to coincide with each specific topic, aiming to increase consumer awareness of ongoing projects and how to participate with such initiatives.

However, developers, contractors, and commercial units are still able to benefit the sustainable green environment in Palestine. Given that there are already recycling options for metal, aluminium, and cardboard, awareness campaigns should provide information for the financial and environmental benefits of using these waste disposal streams, as well as provide information for how to access these facilities and easiest way of transporting waste. E.g., Waste from different governorates can be compiled within one area for easier transportation to the recycling facility to cut on overall transportation cost

9.2.3 Fresh water and Waste Water

Municipalities

Policy

Municipalities across the West Bank and Gaza Strip are structured differently, in Ramallah, the municipality provides only waste collection services, whereas water and electricity providers are separate entities (with municipalities themselves as the biggest shareholders), and the mayor is the head of board. In Hebron municipality, water service providers and waste collection services are managed by the municipality, leaving the electrical company as a separate entity, with the municipality as its biggest shareholder. Similarly, in Khan Yunis, water and waste management services are provided by the municipality, however, electricity is distributed through a privately owned company, which the municipality has not control over.

As such, the municipal influence and ability to implement is limited to the degree of involvement of the head of board, the mayor of the municipality. This makes it challenging for setting and implementing new policies, as water and electrical companies are for- profit enterprises and are generally more interested in making revenue to cover financial deficits.

However, given that municipalities are in control of their own building codes and regulation, there is still room for better effective water management in buildings. Some of key issues that could be tackles through policies include:

- Use of efficient water fixtures: Given the ongoing water deficit across Palestine, there is a need for effective use and management of water in all activities. As such, municipalities can make it mandatory for the use of efficient water fixtures in all structures, prohibiting the sale and distribution of certain products, and reducing the overall consumption of the municipality. These types of policies could be tested in municipalities such as Hebron, which is directly in control of water distribution, and heavily involved in optimizing their water distribution network. Furthermore, such policies should become mandatory for all municipal and governmental buildings within the municipality, especially schools, hospitals, and any other large institutes.
- Use of water wells: Although many municipalities such as Hebron mandate the design and construction of a water in any new structure, many still do not. The need and benefits of water wells across every region in Palestine will reduce water loads as well as increase water availability amongst households. Clear policies for well design and connections to the residential water network are needed. This could also include stormwater and rainwater collection and storage methods.

For more effective water management across the West Bank and Gaza Strip, municipalities and mayors need to be more involved in the monitoring of water and electrical services and ensuring effective water management. As seen in Hebron, the municipal involvement in water management meant that effective water distribution and management are in place on a citywide level.

<u>Direct Implementation</u>

Municipal involvement in effective water management is needed to ensure that residents are both aware of methods in water management and are able to access resources to do so. For this, municipalities should be leaders in implementing effective water management methods.

- Water Monitoring: Leaning from Hebron municipality, the hydraulic monitoring system was able to tackle key issues in water distribution and water shortages across the municipality. Municipalities should learn from each other and cross transfer certain skills and know how to enable more effective water management across the West Bank and Gaza Strip.
- Use of effective water management methods: In their own structures and facilities, municipalities can be the first to apply multiple water management methods. E.g., efficient water fixtures, stormwater and rainwater collection and reuse systems, and water wells. Not only that, but municipalities should

also ensure the community is aware of all the methods in order to spread awareness amongst residents and provide an example of their effectiveness.

As for wastewater, the separation of sewage wastewater from stormwater in Ramallah municipality is a great example of good water management practises. However, the inability of the municipality to effective reuse or sell the treated and collected water for reuse indicates that they are not able to profit from the full value chain of green economy and green cycle. As such:

- Joint Municipal initiatives: To investigate more feasible solutions for waste disposal, municipalities need to develop partnerships to combine their waste for recycling and reuse. As such, issues regarding making profitable options for investors may be mitigated, by ensuring enough waste is provided for daily processing and production.
- In Ramallah, there needs to be an in-depth investigation for possible benefactors of treated wastewater and stormwater (those with large establishments or parks, surrounding areas etc).
- A feasibility study for implementing the same solution of separating stormwater collection system and treating sewage water, needs to be conducted in other municipalities. Ensuring that the green economy value chain is taken into consideration, and end consumers for treated wastewater and stormwater are initially contacted.

Business Opportunities

- Marketing of water efficient fixtures: The water deficit across the West Bank means that many consumers are already aware of water issues. As such, the market for consumer buying efficient water fixtures should be bigger than the current one. However, retailers are still not effectively marketing these product attributes, even though there is a variety of water efficient fixtures.
- Effective water use: Learning from establishments in Gaza Strip, small well water treatment facilities can be used by establishment to process water for their own use. As such, large establishments in the West Bank may use the same method to process stormwater and well water up to human use standards, shifting their entire water consumption in certain cases onto their own stored and treated water supply.
- Exploiting unused wells: There are many wells across the West Bank that are unused for their full potential, a thorough assessment of the number of wells and status needs to be conducted to calculate the potential of untapped water across the different municipalities. As such, collection, treatment, and distribution of this water source may be profitable for small businesses across municipalities.

End Consumers, Developers, Contractors, and others

Consumers are generally aware that there is a water deficit in the region, even though it may not directly impact all residential units, such as Ramallah, municipalities with large populations suffer more from water shortages. As such, there needs to be effective awareness campaigns offering easy solutions for consumers for better water management. For example,

- Advertise the benefits of efficient water fixtures for indoor and outdoor use and local distributors,
- Easy methods for collecting rainwater and stormwater and redirecting it to storage or ground locations to prevent run off.
- Easy residential water treatment facilities for complete reuse of stormwater and rainwater

Pushing consumer awareness towards water efficient fixtures and methods will eventually push suppliers to increase supply of more fixtures, as well as shift developer and contracts perception onto these methods, and potentially shifting their behaviour as well into including these in their designs.

9.2.5 Energy

Municipalities

Policy

Similar to water issues, there is a general deficit in electrical and energy supply in the region. The increasing population and its dependency on transportation and technology will only result in an increase in the energy demand in the next years. Furthermore, the municipal segregation from the electrical company and grid also challenges the implementation of many effective policies for energy demand programs, and regional shift in consumer behaviour. However, some of the type of policies which can be implemented by them:

- Use of thermal insulation: As noted in the building material recommendation section, it is crucial for buildings across the West Bank and Gaza Strip to install thermal insulation to decrease their heating and cooling costs in the summer and winter. This should be pushed to become as part of municipal building policies.
- Use of efficient electrical fixtures: Similar to efficient water fixtures, municipalities may prohibit the distribution of certain types of low-quality electrical fixtures, offering options for better more efficient lighting. This should be mandatory in all municipal buildings as well as public buildings within any municipality, including schools, universities, hospitals, parks and facilities, and others.

Direct Implementation

As for direct implementation, municipalities can lead multiple initiatives to ensure better use of solar energy, and more effective use of electricity within its facilities:

- Use of Efficient Fixtures: adding on to the above policies of mandating efficient electrical fixtures in municipal facilities and governmental establishments such as school and ministries. Municipalities should work on joint initiatives with different establishments to replace current supply requirements as well as inefficient fixtures used to reduce overall municipal load.
- Solar Panels: Municipalities are already starting to use solar panels to power their own facilities. However, given that the majority of residential and commercial buildings are limited in their capacity for electrical production, municipalities may be able to overcome this obstacle and to develop small solar farms to feed entire neighbourhoods. Using residential rooftops, open parking lots, and other feasible areas, municipalities can invest in developing solar farms for neighbourhoods.
- Incentives and Subsidies for electrical fixtures: Although the price difference between low quality and high quality efficient electrical lights is four times, the longer life cycle of high-quality light bulbs provide multiple benefits. A long-life cycle for electrical lighting means that there is less yearly electrical waste, less maintenance cost for changing lightbulbs (yearly for low end bulbs, every four years for high end), and generally better and more effective energy management. To instigate changes in residential and commercial behaviours, municipalities could work on two fronts, first awareness campaigns, which will be discussed later on, and second incentive programs for replacing electrical fixtures. Municipalities may offer companies selling high quality efficient electrical lights tax exemptions or subsidies for lowering the price of these units or depending on the number of units sold, instigating these companies to better market and sell these products. On the other hand, tackling consumers, municipalities may offer a light replacement outpost, offering consumers more effective and long-lasting light fixtures in exchange for their outdated fixtures.
- Demand Response Programs: Although there are currently no demand response programs implemented, municipalities should assess potential electrical response programs with their electricity providers. By studying electrical usage across the different consumer segments, municipalities may

be able to develop policies or incentive programs targeting the different consumers. For example, in the UK, the use of electrical appliances by commercial units after certain hours is more expensive; and Households that prove to have efficient electrical fixtures and appliances may be able to benefit from reduced cost for energy.

Business Opportunities

- Even though there are great benefits for thermal insulation, it is still not effectively used in the Palestinian market, The gap can be traced back to multiple factors. As such, there is still room for establishments offering effective application of thermal insulation. Taking into consideration house dimension, energy transfer, optimum insulation thickness, and other factors, these businesses need to be able to offer quality implementation, and effective marketing. Focusing on the short payback period, the ability to conduct retrofitting, and overall benefits of thermal comfort within the household.
- Given that the energy price bought from solar farms is too low for investors to profit from on short periods, the feasibility of shared investments should be studied. For example, using parking lot spaces and empty spaces for small solar farm investments might be feasible depending on renting options with parking lot owners.
- There are still available incentive programs for investors to benefit from solar farms. Feasible options for solar energy production and investment in still a potential.

End Consumers, Developers, Contractors, and others

The awareness of end consumers of the benefits of thermal insulation, its application, and payback period is still low. Given that end consumers are the most to suffer from the high electrical prices, different awareness campaigns need to tackle main issues and methods for consumer participations:

- Thermal Insulation: The benefits of thermal insulation are not just decrease in cost of cooling and heating the residential or commercial unit, but also to improve thermal comfort, and decrease the potential of asthma. These benefits all need to be highlighted in different awareness campaigns targeting consumers. Options for including in building design as well as retrofitting need to be included to assure users of the availability of qualified contractors who are able to provide these services.
- Efficient electrical fixtures: The use of quality fixtures saves consumers energy and its cost, as well as time taken to change each fixture. Consumer awareness onto quality and determinants of quality products needs to increase to ensure that they are able to select the most effective fixtures.
- Awareness campaigns: targeting investors, developers, and engineers, focusing on the use of solar energy to, cover building expenses for joint facilities such as the elevators, staircase, parking lot lights, and other expenses. As well as setting up infrastructure for PV and solar water heaters to instigate residents to invest installing solar units for their apartments if the space allows for it.

9.2.6 Health & Well Being

Municipalities

Policy

Health and wellbeing of municipal residents should be prioritised in municipalities and in its regulations. The health impact of many different materials, as well as the lack of safe housing options that reduce the list on its residents allows for more productive municipality. As the health impact of certain building material and design components can greatly impact the health and wellbeing of individuals, municipalities should make certain

policies mandatory to ensure the wellbeing of its residents. Some of the most important topics that need to be tackled include:

- Use of water- based paint: There is a clear need to ban oil-based paint and high VOC content material as the neurological impact on painters and users is proven through multiple studies. This should be especially enforced on schools and other public facilities with children access, as current supply specifications require oil- based paint for all publics schools.
- Use of thermal insulation: The use of thermal insulation in building is crucial for better energy management in buildings, as well as to improve thermal comfort and reduce potential of asthma as a disease.
- Dust, bitumen, and other health hazardous in construction: Given that lung cancer and lower respiratory disease are within the top 10 most death causes in Palestine, there needs to have more enforce action towards construction methods that are harmful for humans. The inhalation of dust and bitumen gases are both proven to increase the potential of catching the two former diseases mentioned, that thus there needs to be municipal policies regarding the safe usage of these building materials.
- Air circulation and ventilation: The need to have sufficient air circulation and internal air quality in the new and old buildings.

<u>Direct Implementation</u>

- Municipalities need to take into consideration the health and wellbeing impacts of their facilities on all their users. Taking into consideration topics such as effective use of natural light, good ventilation, thermal comfort, and other topics, facilitates should be designed accordingly.
- Working with health service providers, municipalities can conduct awareness campaigns regarding the potential impact of different practises in Palestinian buildings, including but not limited to, low ventilation and its impact on air quality, thermal insulation and its relation to thermal comfort and reduction of asthma, the use of certain construction material such as oil based paint, bitumen, and others and the potential increase in developing ischemic heart disease, lung cancer, and lower respiratory infection. Working with health providers will ensure that awareness campaigns are able to reach those most affected by these practises, and currently suffering from the impact. It should be noted, awareness campaigns need to offer risk information, as well information for substitute materials or safe practises, ensuring that benefactors are able to start implementing safe practises.

Business Opportunities

- There is a potential for businesses that are able to offer design service, construction services, or materials that take into consideration the health and wellbeing of residents. Marketing this type of services and benefits will attract a variety of different consumers that are interested in improving their residential unit. As an example, there is no one company specialised in retrofitting houses and apartments to ensure better energy usage, effective ventilation and natural lights use. These services combined with effective marketing and an affordable price will be feasible for many consumers who suffer the impact of bad design but are not able to afford new housing units.

End Consumers, Developers, Contractors, and others

The lack of awareness amongst different stakeholders of the negative impact of certain design features, building methods, and material, and its negative effect on construction workers and users, is an issue for increasing green building measure. Some of the main topics that need to be tackled include:

- Indoor Air Quality: Improving air quality within any residential unit can greatly increase the users' comfort. As such, adapting small measures such as air filters and smoke fans, house plants, using paints and products with low or no VOCs, ensure air circulations, and other simple measures.
- Use of Natural Light: Even though all buildings are generally designed with windows, due to the proximity of buildings, users install electrical window shades for full coverage and rely on electrical lights. As such, awareness campaigns need to increase awareness of the benefits of natural light for human health and the ability to reduce use of electricity. Furthermore, awareness campaigns need to ensure to offer replacement options for privacy, such as the use of thick white blinds and other similar products that allow for natural light but ensure privacy.
- Thermal comfort: Through the use of effective thermal insulation and ventilation methods, thermal comfort within a residential unit can be greatly increased, which will directly impact the health and wellbeing of residents. Not only will these measures increase the wellbeing of individuals, but it will also reduce energy costs, as well as potential medical costs for issues such as asthma.

9.3 Challenges in Implementations

The study was able to offer a number of recommendations targeting municipalities, businesses investors, and consumer awareness. However, there are still challenges and limitations that all stakeholders will face in implementing any of these recommendations.

Municipalities

Lack of Unified Municipal Structures and Need for Effective Municipal Strategies

The segregation of different services across different entities leads to a lack of a holistic strategic plan to decrease the general carbon emissions from buildings, and the municipality as a whole. For example, in Hebron municipality, there is a potential of introducing policies to incentivise the use of efficient water fixtures, as the municipality is directly involved in supplying water and mitigating issues in water shortages. On the other hand, the lack of involvement of Ramallah municipality with Jerusalem water authority means that both entities are not necessarily working towards the same goals, which includes general preservation of water due to lack of water in the West Bank and Gaza Strip

Municipal strategic involvement in water and energy reduction solutions is crucial for the strategic shift in energy and water usage. As for- profit entities, water and electrical companies will prioritize profit and cost reduction rather than investing in reducing the general carbon footprint. However, given that there is already a lack in supply of water and electricity, it is unlikely that these entities will lose profit, but may also be able to capitalise on other opportunities if they are able to decrease networks strains.

Unified strategy for all entities. High involvement of mayor high involvement of mayors and similar entities such as the PERC, waste collection, and others.

Budget Constraints and Need for Collaborations

The general situation in Palestine is challenging in terms of increasing practises of green building measures, mainly because there are a number of issues that need to be tackled in every component, green building material, waste, water, energy, and individual health and wellbeing. The large scope of work that needs to be done will be difficult to implement simultaneously given budget constraints faced by governments, municipalities, non-governmental organizations, and every other entity. As such, certain factors need to be taken into consideration when planning and implementing green building policies and initiatives:

- Small changes make large impacts: To ensure that initiatives are feasible and have a long reach in impact, green building policies and initiatives need to be specific in context but applicable to or benefits a variety of stakeholders such as end-consumers, retailers and distributors, contractors, and developers. In other words, focusing on easy to implement policies and procedures that have even the smallest impact may be more beneficial on the long run than to try to tackle the biggest issues at one.
- Ensuring stakeholder involvement: To ensure that bigger budgets are accessible and that the work is effectively done, partnerships with different stakeholder for different components need to be implemented. Stakeholders involved in each sector are most useful in terms of accessing targeted consumers and retailers, ensuring effective solutions are presented tackling most important needs, and distributing project and initiatives cost amongst different the different parties. For example, some of the most important partnerships include

    1) Building Materials: Partnerships with unions and commerce of trade is beneficial to access retailers and provide targeted awareness campaigns for marketing green products.
    2) Waste: The Joint Service Council for Solid Waste Management (JSC) are crucial components of waste collection across the West Bank and Gaza Strip. Waste disposal options should take into consideration the amount transported by JSC as they may be the best consistent source of large amounts of waste.
    3) Water: There is a need in effective partnerships with water distribution companies and other similar stakeholders to ensure that effective water management across the municipality. Cross-municipal partnerships are also needed to ensure effective transfer of knowledge and project implementation. The Palestinian Water Authority and other governmental institutes can also be part in pressuring water companies to comply with effective water management methods.
    4) Energy: Similar to water partnerships, effective partnerships between municipalities and electrical distribution companies needs to be established to ensure better management and incentive programs for more efficient consumer consumption. Furthermore, partnerships with key governmental stakeholder such as Palestinian Electricity Regulatory Council (PERC) and the Palestinian Energy and Natural Resource Authority (PENRA) are key into enforcing national policies for better energy management, production, and incentive programs.
    5) Health & Well- Being: To ensure that consumers are more aware of the health risk of certain building components, there needs to be effective targeting for awareness campaigns for different stakeholders and at different levels. Partnerships with schools and vocational training centres, will allow for future construction workers and others to obtain early awareness training and options for solutions and mitigation methods for risks. Partnerships with health service to provide awareness campaigns across multiple facilities will enable the reach of those most impacted by harmful construction material and methods and spreading awareness on how to decrease current risk.

Strategic Goals and Long-Term Planning

Given that there are a number of issues to be tackled, a strategic long-term plan needs to be developed, including yearly goals and budgets, to ensure different issues are tackled within the plan. A strategic approach needs to be taken into consideration when defining the most general goals, as well as the sub- goals and achievements needed yearly to reach the end goal of green buildings. This plan needs to be accompanied by a financial plan to enable effective fundraising, use of stakeholder resources, and future financial planning.

Business Opportunities

Investment Risks

Even though there are many business opportunities highlighted above, many of them still require feasibility assessments and plans. Furthermore, the risk in finding a reliable source or consistent consumers to enable a lucrative payback period, may disincentivise potential investors. As such, business opportunities presented need to either be highly feasible and profitable, or there needs to assurances, policies, incentives, or subsides available to ensure that the business is able to sustain itself for the first few years. A few potential options for this include

- Green funding aimed at businesses and non-governmental establishments
- Governmental and/ or municipal subsidies and incentive programs
- Partnerships with different entities such as large private establishments, semi-governmental establishments, and others.
- Banks and other financial institutes that are able to provide easier financing and incentive

End Consumers, Developers, Contractors, and others

Impact of Israeli Building Practises

One of the main factors in the harmful building practises and material used in the West Bank are that they are using the same methods learnt in Israel. Until there are more sustainable green building methods in Israel, it will be difficult to enforce changing harmful building practises. In many cases where construction workers are employed in Israel even though these workers are exposed to harmful practises and material in Israel, the health impact is reflected on the Palestinian economy. In these cases, it might be more difficult to change user behaviour. To mitigate this, awareness campaigns can focus on risk reducing practises such as wearing facial masks on sites and others practises to reduce the risk of inhaling harmful compounds and dusk particles.

Financial Constraints

Another limitation for both end users and develops are the financial constrains in applying green building solutions. As even though there are short pay back periods for solutions such as insulation material, water efficient fixtures, and electrical efficient fixtures, the higher initial investment needed end- consumers and developers will deter many potential users of these solutions. As such, solutions need to ensure to be able to offer incentives or grants and funding for those most in need for these solutions. For example, residents in areas that are suffering most from electrical costs but are also unable to cover extra costs can be granted retrofitting at reduced costs or for free.

Large Target Group for Awareness Campaigns and Other Activities

Given the different type of awareness campaigns needed and the large number of targeted populations, there needs to be multiple partnerships for implementing awareness campaigns. For example, partnerships with universities can result in the establishment of local university clubs that lead awareness activities within and outside of the university. Furthermore, students interested in these topics may also be able to further investigate the feasibility of many of the options above, as well potentially provide one of the recommended services. Trade unions and other similar organizations are also a gateway to investors, developers, and others. Awareness campaigns through these types of partnerships will much more effective in reaching the designated group and ensure national coverage of most crucial issues.

References

Achintha, M. (2016). Sustainability of glass in construction. In *Sustainability of Construction Materials.* doi:10.1016/B978-0-08-100370-1.00005-6

Ahsan, M. M., Zulqernain, M., Ahmad, H., Wajid, B. A., SaqibShahzad, & Hussain, M. (2019). Reducing the Operational Energy Consumption inBuildings by Passive Cooling Techniques UsingBuilding Information Modelling Tools. *International Journal of Renewable Energy Research, 9*(1). Retrieved from https://www.researchgate.net/publication/331952182_Reducing_the_Operational_Energy_Consumption_in_Buildings_by_Passive_Cooling_Techniques_Using_Building_Information_Modelling_Tools

AISwebapp. (2018, 01 19). *Glass: The Most Eco-friendly Glass Material For Buildings*. Retrieved from AIS: https://www.aisglass.com/glass-eco-friendly-glass-material-buildings/

Alsayed, M. F., & Tayeh, R. A. (2019). Life cycle cost analysis for determining optimal insulation thickness in Palestinian buildings. *Journal of Building Engineering*, 101 -112.

Alsurak, I., Abdallah, R., Assad, M., & El-Qann, A. (2021). Energy Savings and Optimum Insulation Thickness in External Walls in Palestinian Buildings. *12th International Renewable Engineering Conference (IREC).* University of Sharjah. doi:10.1109/IREC51415.2021.9427847

AOST. (2018, 10 30). *Biochemical Oxygen Demand (BOD) in Wastewater Treatment*. Retrieved from AOS Treatment Solutions: https://aosts.com/biochemical-oxygen-demand-bod-in-wastewater-treatment/

Atallah, N. (2020, October 7). *Palestine: Solid waste management under occupation*. Retrieved from Heinrich Boll Stiftung Palestine and Jordan: https://ps.boell.org/en/2020/10/07/palestine-solid-waste-management-under-occupation#

Azis, S. S., Sipan, I., & Sapri, M. (2012). The Potential of Implementing Property Tax Incentives on Green Building in Malaysia. *American Journal of Economics*. Retrieved from http://article.sapub.org/10.5923.j.economics.20130302.01.html

Brewers Decorative Centres. (2020, 06 30). *What are VOCs and what are they used for?* . Retrieved from Brewers Decorative Centres: https://www.brewers.co.uk/know-how/article/What+are+VOCs+and+what+are+they+used+for

CTCN. (2022). *Building envelope thermal insulation*. Retrieved from UN Climate Technology Centre & Natwork: https://www.ctc-n.org/technologies/building-envelope-thermal-insulation

Cudby, S. (2014, 11 21). *Everything You Should Know About Sustainable Wood*. Retrieved from The Daily Bark: https://www.wood-finishes-direct.com/blog/everything-you-should-know-about-sustainable-wood/

ECORYS. (2012). *Study on Incentives Driving Improvement of Environmental Performance of Companies.* Rotterdam: European Commission - DG Environment.

EIA. (2021, 05 07). *What is energy? Sources of energy*. Retrieved from U.S. Energy Information Administration: https://www.eia.gov/energyexplained/what-is-energy/sources-of-energy.php

EPA. (2021). *Water Management Plans and Best Practices at EPA*. Retrieved from United States Environmental Protection Agency: https://www.epa.gov/greeningepa/water-management-plans-and-best-practices-epa

EPA, U. S. (2022). *Onsite Non-Potable Water Reuse Research* . Retrieved from United States Environmental Protection Agency: https://www.epa.gov/water-research/onsite-non-potable-water-reuse-research

Garg, A. (2017, 06 08). *Aluminium – A Green Building Material*. Retrieved from IQUBX: https://iqubx.com/aluminium-a-green-building-material/

Handler, B., Bazilian, M., & Hayes, M. (2022). *5 ways to boost renewable energy investment in developing economies*. Retrieved from World Economic Forum: https://www.weforum.org/agenda/2021/06/boost-renewable-energy-investment-in-developing-economies/

Handler, B., Bazilian, M., & Hayes, M. (2022). *5 ways to boost renewable energy investment in developing economies*. Retrieved from World Economic Forum: https://www.weforum.org/agenda/2021/06/boost-renewable-energy-investment-in-developing-economies/

HERCenter. (2015). *Paints*. Retrieved from Healthcare Environmental Resource Center: https://www.hercenter.org/facilitiesandgrounds/paints.php

Hill, S., Dalzell, A., & Allwood, M. (2020). *Net Zero Carbon Buildings: Three Steps to Take Now.* ARUP. Retrieved from https://www.arup.com/-/media/arup/files/publications/n/net-zero-carbon-buildings-three-steps-to-take-now.pdf

Hutton, P. C. (2020, 11 18). *Operating vs Embodied Carbon in the Built Environment: Operating vs Embodied Carbon in the Built Environment:*. Retrieved from Sustainable Brands: https://sustainablebrands.com/read/product-service-design-innovation/operating-vs-embodied-carbon-in-the-built-environment-the-difference-and-why-it-matters

Ige, J., Pilkington, P., Orme, g. O., Williams, B., Prestwood, E., Black, D., . . . Scally, G. (2018). The relationship between buildings and health: A systematic review. *Journal of Public Health , 3*(4). doi:10.1093/pubmed/fdy138

IHME, I. f. (2019). *Health Data- Palestine.* Institute for Health Metrics and Evaluation. Retrieved from https://www.healthdata.org/palestine

Jones, E. (2020, 8 28). *5 Ways to Reduce Embodied Carbon on Your Next Building Project*. Retrieved from Project Sight: https://projectsight.trimble.com/reduce-embodied-carbon-on-your-next-building-project/

Kaza, S., & Bhada-Tata, P. (2018). *Decision Maker's Guides for Solid Waste Management Technologies.* 2018: World Bank Group.

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a Waste 2.0 A Global Snapshot of Solid Waste Management to 2050.* Washington DC: The World Bank Group.

Kozicki, C., & Carlson, C. (2022). *Gypsum Recycling*. Retrieved from Feeco International: https://feeco.com/gypsum-recycling/

Lushnikova, N., & Dvorkin, L. (2016). Sustainability of gypsum products as a construction material. *Sustainability of Construction Materials*. doi:10.1016/B978-0-08-100370-1.00025-1

meetMED. (2020). *Country Report on Energy Efficiency and Renewable Energy Investment Climate.* Retrieved from https://www.rcreee.org/sites/default/files/a31_palestineclimate_final.pdf

Metsa Wood. (2022). *Sustainable building and resource efficiency with wood*. Retrieved from Metsawood: https://www.metsawood.com/global/news-media/articles/Pages/Resource-efficiency.aspx

MN, M. P. (2022). *Volatile organic compounds (VOCs)*. Retrieved from Minnesota Pollution Control Agency,: https://www.pca.state.mn.us/air/volatile-organic-compounds-vocs

Monna, S., Juaidi, A., Abdallah, R., Albatayneh, A., Dutournie, P., & Jeguirim, M. (2021). Towards Sustainable Energy Retrofitting, a Simulation for Potential Energy Use Reduction in Residential Buildings in Palestine. *Energies, 14*(13). Retrieved from https://doi.org/10.3390/en14133876

Monna, S., Juaidi, A., R. A., & Itma, a. M. (2020). A Comparative Assessment for the Potential Energy Production from PV Installation on Residential Buildings. *MDPI*. Retrieved from https://staff-beta.najah.edu/media/published_research/2020/12/15/sustainability-12-10344.pdf

Morgan, J. (2016, 04 07). *Oman: NAPCO to double production by end of 2017* . Retrieved from Construction Week: https://www.constructionweekonline.com/products-services/article-38430-oman-napco-to-double-production-by-end-of-2017

Muresan, F. (2019, 07 19). *How Steel Can Improve Sustainability in Construction*. Retrieved from NearBy Engineers: https://www.ny-engineers.com/blog/how-steel-can-improve-sustainability-in-construction

Nesler, C., Lam, K. P., & Lasternas, B. (2021, 09 08). *How to build smart, zero carbon buildings - and why it matters*. Retrieved from World Economic Forum: https://www.weforum.org/agenda/2021/09/how-to-build-zero-carbon-buildings/

Olubunmi, O. A., BoXia, P., & Skitmore, M. (2013). Green building incentives: A review. *Renewable and Sustainable Energy Reviews, 59*, 1611-1621. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S1364032116000587?via%3Dihub

PCBS. (2021). *Energy Balance of Palestine in Terajoul, 2019*. Retrieved from PCBS: https://www.pcbs.gov.ps/statisticsIndicatorsTables.aspx?lang=en&table_id=527

PCBS, P. C. (2019). *Fianl Energy Consumption by Sector and Type of energy and Year, 2010-2019.* Palestinian Central Bureau of Statistics. Retrieved from https://www.pcbs.gov.ps/statisticsIndicatorsTables.aspx?lang=en&table_id=530

PERC, P. E. (2020). *Annual Report 2019 - 2020.* Palestinian Electricity Regulatory Council. Retrieved from https://perc.ps/perc/wp-content/uploads/2022/02/PERC-AR-5s.pdf

Ramsden, K. (2020, 11 03). *Cement and Concrete: The Environmental Impact*. Retrieved from PSCI: https://psci.princeton.edu/tips/2020/11/3/cement-and-concrete-the-environmental-impact

Ranaa, A., Sadiqa, R., Shahria Alama, M., Karunathilakeab, H., & Hewagea, K. (2020). Evaluation of financial incentives for green buildings in Canadian landscape. *Renewable and Sustainable Energy Reviews, 135*, 1–18. doi:https://doi.org/10.1016/j.rser.2020.110199

Regen Power. (2021, 05 21). *What are the problems faced by renewable energy?* Retrieved from Regen Power: https://regenpower.com/articles/what-are-the-problems-faced-by-renewable-energy/

Roush, R. (n.d.). *How Aluminum is Essential to Green Building* . Retrieved from Green Building MAg: https://greenhomebuildermag.com/how-aluminum-is-essential-to-green-building/

RPS Group. (2022). *Embodied carbon: What it is and how to tackle it*. Retrieved from RPS Group: https://www.rpsgroup.com/services/environment/sustainability-and-climate-resilience/expertise/what-is-embodied-carbon/

Ruuska, A. (2013). *Carbon footprint for building products: ECO2 data for materials and products with the focus on wooden building products.* Finland: VTT Technical Research Centre of Finland. Retrieved from https://www.vttresearch.com/sites/default/files/pdf/technology/2013/T115.pdf

Sante Builders. (2017, 10 23). *Choosing Wood for Building Construction Projects*. Retrieved from Sante Builders: https://www.santereconstruction.com/choosing-wood-for-building-construction-projects/

Seo, M. (2020). *Environmental Impacts of Prefabricated Construction: Co2 Emissions Comparison Of Precast And Cast-In-Place Concrete.* Washington: University of Washington. Retrieved from https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/45407/Seo_washington_0250O_21227.pdf?sequence=1&isAllowed=y

Sperling, D. (2021, 10 25). *Why steel is such an environmentally sustainable building material*. Retrieved from Summit Steel Buildings: https://www.summitsteelbuildings.com/why-steel-is-such-an-environmentally-sustainable-building-material

The European Cement Association, E. (2013). *The Role of Cement in the 2050 Low Carbon Economy.* Retrieved from https://cembureau.eu/media/cpvoin5t/cembureau_2050roadmap_lowcarboneconomy_2013-09-01.pdf

TheWorldCounts. (2022). *Environmental Impact of Steel*. Retrieved from The World Counts: https://www.theworldcounts.com/challenges/planet-earth/mining/environmental-impact-of-steel-production/story

Thienen, G. v., & Spee, T. (2008). Health Effects of construction materials and construction products. *Tijdschrift voor toegepaste Arbowetenschap (2*. Retrieved from https://www.arbeidshygiene.nl/-uploads/files/insite/2008-01-thienen-en-spee-trf.pdf

University of Oregon. (2019). *MEAs to which Palestine, Occupied Territories has taken membership actions*. Retrieved from University of Oregon: https://iea.uoregon.edu/country-members/Palestine%2C%20Occupied%20Territories

USGBC. (2022). *Innovation*. Retrieved from LEED USGBC: https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-healthca-33

Wafa. (2020). *Issues in the Palestinian Housing Market*. Retrieved from Wafa: Palestinian News & Info Agency: https://info.wafa.ps/ar_page.aspx?id=9354

Wood for Good. (2022). *Embodied carbon and operational carbon: working together*. Retrieved from Wood for Good: https://woodforgood.com/news-and-views/2020/09/29/embodied-carbon-and-operational-carbon-working-together/

WorldGBC. (2022). *What is green building?* Retrieved from World Green Building Council: https://www.worldgbc.org/what-green-building

Yüksek, İ., & Karadağ, İ. (2021). Use of Renewable Energy in Buildings. In T. Taner, A. Tiwari, & T. S. Ustun, *Renewable Energy - Technologies and Applications.* doi:10.5772/intechopen.84929

Annex I: Literature Review

Defining Green Building Material

In any building, there are a variety of different building materials that are used to construct it, some of which are cement, pre-cast blocks (gypsum & cement), glass, paints, aluminium, wood, metal, and insultation material. Each material has its own different production method, as well as its own environmental impact. However, to mitigate many of the environmental impacts, new materials are being developed which account as green building material, or materials with reduced carbon emissions through using different raw materials, including recycled content, or changing production methods.

1) Cement

Cement is a crucial construction material in buildings, as it is used to construct most of, if not all, building components. However, the environmental impact of it is huge, as it can be seen at different stages from extraction to production. Some of the main environmental impacts of cement include resource depletion throughout quarrying for raw material; greenhouse gas emission, noise, and dust, throughout the processing of the raw material; emission from transportation; and others.

Cement as a building material is produced by mixing aggregates, limestone cement, and water. Through a chemical reaction between limestone and water, clinker, which is the binding material, is formed. The high carbon emissions that are attributed to cement come from two sources, first, the chemical reaction between limestone and water produces a significant amount of CO2, and second, carbon emissions from use of fossil fuels to heat up the drying and production furnaces (Kilns) (Ramsden, 2020).

Given that the majority of carbon emissions from concrete are due to the chemical reaction, there are no direct solution to produce “Green Cement”. However, because the material is so important in construction, but still harmful, other solutions are being developed to reduce the carbon emission for cement. Some of which include (The European Cement Association, 2013):

1- Resource Efficiency
   - 1.1 Alternative Fuels: By using alternative fuels such as sludge, sawdust, tyres, another to heat up the kiln, carbon emissions from fossil fuels are mitigated. One interesting fuel alternative used is wastewater sludge, where sludge from water treatment plants is dried and used in the kiln. Another is using methane emissions from waste biomass as an energy source.
   - 1.2 Raw Material Substitution: In clinker production, decarbonized products such as Ash can be used to reduce the amount of CO2 emissions from the process.
   - 1.3 Clinker Substitution: To reduce the percentage ratio of clinker to cement, some alternative materials can be added to the clinker mix, without treatment, to reduce the amount of clinker used, and thus the overall embodied carbon emission of the material. Some of which include natural pozzolans (clays/ shale), finely ground limestone, silica fume, granulated blast-furnace slag, and fly ash.
   - 1.4 Novel Cements: Through the use of different material or more advanced production methods, novel cement is being produced to mitigate the carbon emissions from the use of cement. Some of which include Magnesium silicate cement (substituting limestone), calcium sulfo-aluminate belite binders, geopolymer cements, new production techniques which replace the kiln and reduce process emissions, and the use of scrubbing systems to capture emissions.

1.5 Transport Efficiency: The emission from transporting heavy volumes of cement is significant on their own. As such, sourcing cement from closer suppliers, or using transportation methods with less emissions will reduce the embodied emissions for the product.

2- Energy Efficiency

2.1 Electrical Energy Efficiency: Improving the electrical efficiency of the plant and all machines within will generally reduce CO2 emissions. However, it should be noted that the deployment of carbon capture technology within a plant may increase electrical consumption by 50% – 120%.

2.2 Thermal Energy Efficiency: Similar to above, the continuous improvement to the production facility will result in more efficient use of electricity and heat. In kiln more specifically, using advanced technology will ensure a more efficient process.

3- Carbon Sequestration and Reuse

3.1 Carbon Sequestration and Reuse: One of the main research topics worldwide is the capturing and storage of CO2 to reduce carbon emissions from different manufacturing processes. However, there are still no effective or cost-efficient systems, as the process adds up 25% - 100% of the operational cost and needs the availability of a full Carbon Capture & Storage unit for it to be used.

3.2 Biological Carbon Capture: Research is also looking into using biological means, such as algae, to capture carbon and reuse the algae itself as fuel.

4- Product Efficiency

4.1 Low Carbon Concrete: Some concrete used is manufactured using less concrete but keeping it structural and performance integrity. Even though carbon is still being used to manufacture cement, less is used as a means to reduce overall need in manufacturing concrete.

5- Downstream

5.1 Smart Building and Infrastructure Development: Even though more building is being built in way to reduce energy use CO2 emissions over the life cycle, the mind set can still be developed. New buildings can be built with deconstruction in mind rather than demolition for certain parts to be reused entirely as modular element.

5.2 Recycling Concrete: Crushed concrete can be used as aggregates in concrete, as well as backfilling for many applications. The hardened cement fraction in concrete can also be used as raw material for cement production.

5.3 Re-carbonation: Concrete structures, and more specifically crushed concrete, is able to absorb part of the CO2 emitted during production back in. As such, during construction, and for construction waste, exposing the crushed concrete to the air for a few months may reduce CO2 levels generally produced through production.

5.4 Sustainable Construction: Concrete has many great advantages in construction, from its high durability to thermal qualities. And thus, it needs to be more effectively used where it’s needed most but replaced when possible.

2) Aluminium

Aluminium currently being used in the world is generally environmentally friendly, as (75%) of all aluminium manufactured is still being used today. Recycling and reuse of aluminium saves around (90%) of carbon emissions compared to manufacturing from raw material. (Roush, n.d.). However, this does not mitigate all emissions, as aluminium production form raw material is very intensive in carbon emissions.

Some of the main properties of aluminium include lightweight, strong, flexible; reflective; safe, durable, corrosion resistant, and long lasting; low maintenance; fire safety; and prefabricated (Garg, 2017).

Currently, aluminium is being highly regarded as a green building solution. As it has many important properties that can be used in construction, and it fits many LEED and green building requirements, especially that it is 100% recyclable.

3) Pre- Cast Blocks & Building Components

3.1 Precast Concrete Blocks & Components

Concrete blocks pose similar environmental threats as concrete and cement, as the most carbon emissions come from clinker production in the manufacturing of cement. However, there are certain advantages and disadvantages of using precast blocks and components (Seo, 2020):

- Pre- cast concrete blocks are sturdy and can be used for main components within the building. At the same time, the amount of concrete used within the blocks is less than what is used when making more load bearing elements.
- Less waste and material loss in production as the factory is a controlled production environment and there is less waste in transportation.
- Transportation is both advantageous and disadvantageous, as one study showed, if the transportation distance is 80 km or less, the carbon emission from transporting precast blocks and components is lower than transporting concrete mix. However, if the distance is longer, the carbon emissions are higher.
- On site installation of precast structural components (which includes large machinery) has more carbon emissions than on site construction.

3.2 Precast Gypsum Blocks & Components

Gypsum in generally is a more sustainable material than concrete, as it has half of the embodied carbon and carbon footprint than clay and concrete (Lushnikova & Dvorkin, 2016). Gypsum is used in a variety of building components, including gypsum as a binding material, concrete- gypsum, and other products including wall blocks, boards and panels, decorative elements, fireboards, and others. Some of the main properties of gypsum include:

- Fire resistant / non combustible
- Acoustic insulation
- Thermal insulation
- Recyclable

These properties, as well as its malleability to be formed in any shape make gypsum a sustainable material for construction. Furthermore, even though it does not have the same structural properties as cement and concrete, lightweight concrete- gypsum blocks can be used to reduce the amount of cement used but retain strong structural properties.

Gypsum is also a recyclable material, where gypsum waste from installation and deconstruction has many uses such as agricultural products, production of new drywalls, cement, composting, and paper products (Kozicki & Carlson, 2022).

4) Paints

There are two types of paints manufactured, solvent-based paint and water-based paint, each with its own properties and materials. Solvent based paint or oil-based paint contains Volatile Organic Compounds (VOCs), which is a main component that "act as the medium to transfer the paint from the can to the surface and aid the paint's flow…. some VOCs preserve the paint in the can, preventing it from spoiling…… [and others] required when the coating requires specialist properties such as rust prevention" (Brewers Decorative Centres, 2020). The health impact of VOC is high, as the released VOC from paints during the drying process react with the atmosphere and produce ground level ozone, which causes irritation in the eyes, nose, and throat, and can aggravate asthma and lung diseases (MN, 2022), as well as contributing to the formation of smog (HERCenter, 2015). On the other hand, water-based paints, the alternative to solvent-based paints, has much lower content VOC, if not any, and thus has a much less impact on health and the environment.

Furthermore, there are two types of recycled paint available, re- blended/ consolidated paint, and reprocessed paint, both of which are from post- consumer water-based paint. Re- blended/ consolidated paint is produced by collecting paint with similar characteristics and consolidating it at point of collection. This paint is usually used for exterior applications or as an undercoating. Reprocessed paint is paint that has been sorted by a variety of characteristics (interior/ exterior, light/ dark, high gloss/flat…). These paints are available for interior and exterior use (HERCenter, 2015). However, recycled paints are usually initiated through environmental and or governmental programs, collecting and combining the paints, then selling them at lower prices than non-recycled paint.

5) Wood

"Wood is currently the only renewable building material that we can create load boarding structures from…. [it is] the only full range building material that has the potential to become truly sustainable and probably the best answer for solving emission problems in the construction sector" (Metsa Wood, 2022). Wood is a natural building material that can be found across the globe and is used in different elements in construction. Where hardwood is usually used as a structural component (walls, ceilings, floors), and softwood is used for doors, windows, furniture, and others (Sante Builders, 2017).

Sustainable wood is wood that is sourced from sustainable managed forests, which are forests that are managed in a way to prevent damage to the eco-systems, watersheds, wildlife, and the trees themselves (Cudby, 2014). Sustainable managed forests ensure that the tree supply is always replenished, where only mature trees are cut and others planted in place, without effecting the eco-system and biodiversity around it. On the other hand, wood that is sourced from unsustainable resources leaves bare areas that are difficult to recover or reforest, which causes many loses including loss of biodiversity, loss of natural carbon capturing areas (trees and forests themselves), and other impacts.

Currently in the world, there are two certificates which identify wood from a sustainable source, the Forest Stewardship Council - FCS, and the Programme for the Endorsement of Forestry Certification – PEFC. These certifications guarantee that the wood is sourced sustainably, "replaced after harvesting, and is taken without harming the environment and neighbouring eco- systems" (Cudby, 2014).

6) Metal/ Steel

"Steel production is one of the most energy- consuming and CO2 emitting industrial activities in the world" (TheWorldCounts, 2022). Steel is manufactured using Iron ore mainly, as well as recycled steel and iron. The environmental impact of its manufacturing can be found across many phases, first, mining of iron ores is a highly energy intensive process which also produces a variety of greenhouse gases. Second, in mining of iron ore as well as production of steel, large amount of wastewater is produced with many chemicals which needs to be processed in its own stream. Lastly, the steel production process also takes in coke (a type of coal) which is extremely damaging to the environment, emitting both air pollutants, and dissolving in wastewater making it highly toxic and includes carcinogenic organic compounds (TheWorldCounts, 2022).

Steel is one of the most used materials in the world, as its production has increased 10 times in the past 70 years, reaching around 1808 million tons per year in 2018. However, steel is still a highly recyclable material, as all steel components can be endlessly recycled and used to produce new components, without jeopardizing its structural properties. Furthermore, with the increase in production and environmental regulation, the steel industry is still developing to reduce the environmental impact of the material. As such, within the past 40 years, the energy consumption in steel production has been reduced by 67%, water consumption was also reduced by (95%), and wastewater treatment facilities and reuse were introduced to reduce the amount of water used (Muresan, 2019) (Sperling, 2021).

7) Glass

Glass, generally speaking, is used in almost all buildings and structures, in window openings and others. It is a great source for natural lighting and can provide ventilation to the building. In green buildings, glass is a crucial component for many aspects of the green building. First, glass that reflects heat or UV rays helps in maintaining optimum temperature within the building. Second, glass that is installed with thermal insulation in mind also reduces the heat loss in both hot and cold seasons. All of which reduce the amount of energy used to heat or cool the building, and the energy used to light up the interior of the building (AISwebapp, 2018).

The most widely used production process of glass includes the melting of silica, lime, soda, and others material into a molten form, and producing glass sheets through a floating process. To produce tempered/ toughened glass or laminated glass, the glass sheets are processed further to increase its toughness or enhance its post-breakage performance (Achintha, 2016). Furthermore, to produce different types of glass (UV reflective, thermally insulating, or noise cancelling), additional material and processing is needed. Some of the main types of glass developed for different uses include:

- Solar Control Glass: Which regulates the solar radiation entering the building though managing the reflection, transmission, and absorption properties of the glass. The glass uses tinted/ translucent/ opaque/ patterned coating or interlayers to regulate the passage of solar radiation.
- Low Emissivity Glass/ Low E Glass: A product which allows only solar light to pass through, whilst reflecting the heat (AISwebapp, 2018). Low E glass is produced by covering glass sheets with an invisible coating that regulated wavelengths of energy coming through, reducing the heat transfer, and reflecting it back to the interior or exterior of the building. "Manufacturers of low e-glass products claim savings of up to (75%) compared to conventional single glazing (Achintha, 2016).
- Thermally- insulated glazing and low e – glass: "[used to] stabilise the internal temperature, and consequently be able to reduce the energy need for heating and cooling" (Achintha, 2016). Thermally insulated glazing technology includes the use of e-glass and insulating glass units (IGUs). Low e-glass units, as explained above, are used to reflect heat, and reduce thermal exchange between the building and

the surrounding. IGUs are manufactured by enclosing air sealed space between two or more glass panes and assembling it using a secondary edge seal (Achintha, 2016).

- Noise Control Glass & Vibration Control Glass: Both of which are similar in concept, Reisen- based interlayers formed between the sheets to reduce the damping effect of noise and vibration.
- Self- Cleaning Glass: To mitigate the costs and risk of cleaning glass on high rise building, these glass sheets are laminated with a coating which breaks down organic compounds and other material on the glass, and is easily washed off with rain (Achintha, 2016).
- Fire Resistance Glass: Produced by using laminated glass and intumescent interlayers which helps increase fire resistance and reduce thermal shock and breakage (Achintha, 2016).

Interestingly, the embodied carbon and embodied energy of glass and toughened is higher than of reinforced concrete, and somewhat close to that of steel. The reason for this being that the heating process of glass in manufacturing and processing consumers a lot of energy. Nevertheless, the environmental impact of concrete is still higher due to the sheet amount produced pre year (Achintha, 2016).

To reduce the embodied carbon and energy in glass components, glass can be reused or recycled. Glass can be reused in different ways, it can be used as aggregates in concrete or bituminous material in road construction, it can be used as ashtrays, filter medium, sand traps, aquarium sand and other. The availability of different options of reuse will increase the potential of recycling more glass (Achintha, 2016).

Glass recycling is not common for glass sheets used in buildings as firstly, it is difficult to remove coatings and lamination from glass sheets, and second, the energy saving of using recycled glass material is very small compared to manufacturing glass from raw material. As such, the payback for recycling glass may not be enough to incentivise recycling it (Achintha, 2016).

8) Insulation Material

Thermal Insulation

There are three classifications for thermal insulation (CTCN, 2022):

- Mineral Fibre: which includes rock, wool, slag wool, and glass wool. All type of mineral fibre thermal insulation may be sources from recycled waste and may be also reused and recycled at the end of the life cycle. Due to the nature of mineral fibre, the products are air and vapour permeable, which can reduce their thermal insulation performance or cause condensation and humidity. For this, installation techniques are important to ensure the needed impact is given.
- Cellular Plastic: These are oil derived products, available as fill, rigid sheets, and foam. There are two methods of production of cellular plastic insulation material, one which involves many Ozone depletion agents, the other, which has less of an environmental impact, uses a production process using neutral hydrocarbons. One of the benefits of this material is its long- lasting as it is not susceptible to decay or vermin infestation.
- Plant/ animal derived: Including cellulose fibre, sheep wool, cotton, and flax. Produced using renewable raw material and having a low embodied energy, these products are sold in form of fibre, batts, or compressed boards. However, given the type of chemical treatments for producing the products, it is difficult to re-use at the end of the life cycle. Plant/ animal derived products are the most susceptible for vermin infestation and may be easily damaged if exposed to moisture or humidity. Thus, similar to other

types of insulation, installation techniques and good craftsmanship are crucial to ensure the products performs as needed.

Waste, Waster and Energy

Waste & Waste Management Systems

Solid Waste Management

Waste Management Systems can be divided globally into the following major categories (Kaza & Bhada-Tata, Decision Maker's Guides for Solid Waste Management Technologies, 2018)

Sanitary Landfills:

Sanitary landfills are considered to be a rather popular solution to municipal waste management, as they can be a relatively more cost efficient and environmentally friendly option compared to unregulated scattered dumpsites. A sanitary landfill should be planned to last approximately 30 years, in a location that is isolated from residential areas, with care taken to recover recyclable and reusable materials. Sanitary landfills are constructed in a manner in which a polyethylene liner is placed at the bottom to mitigate fluids contaminating ground water, and methane is collected/used/disposed off appropriately. A properly used sanitary landfill plot can be utilized after it is exhausted if it is maintained properly, enabling a degree of recovery of land.

Sanitary landfills do have some significant redeeming qualities, as well as some factors that are lacking in appropriateness, broadly, they have the following drawbacks:

- Require significant amounts of land, furthermore, the land plot chosen to be a sanitary landfill must be adequate prepared and should be placed in an area that is logistically accessible, but at the same time at a sufficient distance as to not cause disturbances to nearby residents. This makes is a difficult method to use in areas where land is limited or highly regulated.
- Sanitary landfills must be maintained even after closure, and the utilization of the post closure lot can be relatively limited.
- Carries the risk of leachate passing through barriers and contaminating water resources.

On the other hand, sanitary landfills have significant benefits:

- It can handle varied types of waste such as “Municipal solid waste, construction and demolition waste, wastewater sludge, and non- hazardous industrial wastes” (Kaza & Bhata-Tata, 2018)
- It can provide energy through the extraction of emitted methane gasses; however, this requires significant technological knowhow, and a considerable upfront investment. Extracted gas can provide 65 kWj/tonne of MSW).
- It is less costly than other, more technologically advanced methods of waste elimination.
- Pre-processing of waste is not necessary, i.e., there is little benefit to sorting discarded waste, however, medical, and hazardous waste should be avoided.

Composting & Anaerobic Digestion

Composting is a method of waste treatment that has significant potential, especially in developing countries. Composting is limited to food, garden, and agricultural waste, and converts the organic portions of these waste into compost. 44% of municipal waste globally and 56% of waste in low-income countries can be composted.

Composting is underutilized as only an estimated 6% of total waste globally is currently composted. In addition, the method is space efficient as it can degrease the volume of organic waste by 60-90% and can be relatively passive as it relies heavily on naturally occurring microorganisms.

Two primary methods of composting are usually used, in vessel composting, or windrow/ static piles. In vessel composting requires the use of metallic vessels to create the compost in an encapsulated environment, while static piles are uncovered (in a less controlled environment), static piles can be more cost effective, but require more land. Special care has to be taken in order to ensure that the area of composting does not leak any waste or has no interference from adverse weather conditions.

Another method is Anaerobic digestion, which is a method of treating food and green waste into semi solid fertilizer and biogas. The semi solid fertilizer can be used for agricultural purposes while the biogas (primarily methane) can be used to generate electricity.

Anaerobic digestion follows a method similar to composting, but occurs in the absence of oxygen, this process decreases the solid contents of waste by 50-60% and eliminates up to 95% of disease-causing organisms.

The two products of this waste treatment method, (biogas and fertilizer), the fertilizer is stable and high with nutritional value, and every tonne of municipal solid waste treated by this method can produce between 100-200m3 of total gas.

Composting and Anaerobic Digestion utilize similar mechanisms of treatment, as both are considered biological treatment methods. They have certain benefits such as:

- They process biodegradable waste, examples include food waste, fats, oils, grease, paper, cardboard, garden waste, etc…
- Composting and Anaerobic digestion produce primary outputs of Compost, Methane, and Digestate, which have a broad extent of secondary uses such as agricultural fertilizer biofuel.
- Relatively space efficient, at least compared to landfills.

In terms of negativities, they are numerous:

- Solid waste has to be sorted into organic and non-organic waste
- Expensive to operate/ton
- Difficult to scale up

Incineration

Incineration with energy recovery is a relatively advanced method of MSW treatment, where the waste is combusted under a controlled environment in order to produce heat and energy. This method has the added benefit of significantly reducing the volume of MSW, leaving a by-product of ash that can be disposed of in

an easier manner. This method is usually more successful in areas that have high economic development, high technical capacities, strict environmental regulations, and limited land availability. Approximately 11% of MSW globally is combusted.

Pyrolysis and Gasification

Advanced Thermal Treatment (ATT) Technologies have Pyrolysis and Gasification as their two main categories. ATT technologies work by burning waste in a zero- or low oxygen environment. This provides significant reductions in mass and volume of waste, thus reducing the utilization of landfills, destruction of toxic substances, and energy production.

Incineration has multiple benefits compared to other Waste Management Systems they are the following:

- The ability to process a diverse selection of waste products such as: "mixed municipal solid waste, medical waste, demolition wood, auto shredder residue, dried sewage sludge, and some industrial solid wastes." It is however recommended to avoid food waste, and organic waste should ideally be separated prior to incineration.
- Incineration has the highest rate of energy conversion efficiency compared to alternative Waste Management Solutions, as a tonne of MSW yields 500-600 kWh of energy.
- Incineration reduces the volume of waste by 80-85%, yielding ash, which is less dense, and can be disposed of relatively easily. This makes land requirements relatively low, and thus is appropriate for geographically constricted regions.

The global utilization of incineration has been stifled due to the multiple shortcomings that come with them, they are the following:

- Incineration is a relatively costly method of waste management. especially in terms of upfront costs, the initial capital cost can be almost 20 times that of a similarly sized landfill, however, the operational and upkeep costs are not significantly different relative to other WM solutions.
- Incineration is very technically complex, both in terms of establishment and upkeep, as it requires highly skilled training, and maintenance.
- A good experience with incineration has been Japan, as they have a relatively advanced national economy, thus affordability is not much of an issue, furthermore, the high technical advancement of the country coupled with high population density makes incineration a fitting method for them, **as such, 80% of MSW in Japan is combusted compared to the global average of 11%.**

Wastewater Treatment

Wastewater can be treated in a variety of ways; the following are 4 recognized methods to do so:

1. Physical water treatment\

   This method relies on screening, sedimentation and skimming to remove solids in the wastewater, since it's a physical process, no chemicals are involved. With sedimentation, heavy particles are suspended in and after being enabled to settle, separate into a level that is lower than water, enabling for physical separation.

Aeration is another method in which air is circulated through the enabling for oxygen to penetrate wastewater and encourage microbial growth, these microbes thus feed on organic compounds in the wastewater, eliminating portions of the embedded waste, common aeration methods are fine bubble diffusers, coarse bubble diffusers and surface aeration. Filtration is another method of physical separation in which the wastewater is passed through filters such as sand in order to separate contaminated and insoluble particles.

2. Biological water treatment

   This process relies heavily on using microorganisms to metabolize organic matter in wastewater, it is divided into three categories.

   Aerobic Processes: Bacteria decomposes organic material and converts it inro carbon dioxide, complimentary to the physical process of aeration.

   Anaerobic Processes: A process without oxygen, leading to fermentation of waste.

   Composting: The mixing of waste with carbon sources such as saw dust.

3. Chemical Water Treatment

   In this process, chemicals are added to the water, commonly chlorine, where microbes responsible for decomposing waste are eliminated. Ozone can also be used as an oxidizing agent; Neutralization is another method where the alkalinity or acidity of wastewater is neutralized.

4. Sludge Treatment

   Is a process that minimizes moisture content in wastewater, enabling it to have a lower volume, and thus making disposal more environmentally efficient. (Environmental Protection, 2018)

Water & Water Management Systems

Water Management & Water Efficiency Systems

There are different water management techniques are available for individuals and organizations. Water management plans are developed to facilitate short- term and long- term conservation of water. Some of the top methods for water management techniques include (EPA, 2021):

- Meter/ Measure/ Manage: Metering and measuring water usage across different facilitates/ departments within the organization will allow analysis of water use efficiency across the organization. Where levels of increased or decreased usage are monitored, and water management plans can be developed to reduce overall consumption.
- Optimize Cooling Towers: For maximum water efficiency, the cycle of concentration within the cooling tower, used for large air conditioning systems, may be optimized to conserve water usage.
- Replacing Restroom Fixtures: Installing water efficient fixtures is mandatory in some countries. Some of the fixtures which have earned water efficiency certification, EPA WaterSense, include toilets with a flow rate of 6litre per flush, urinals with flow rate of less than 1.8 liters per flush, showerheads with

a flow of 9 liters per minute. All these types of fixtures reduce the water used up to half from normal fixtures.

- Eliminate Single Pass Cooling: Single pass cooling systems use the water just once as it passes through the system. Replacing the system with recirculated chilled water loop will save water needs.
- Smart Landscaping & Irrigation: This includes planting plants that need less water overall, which will reduce water irrigation needs. As well as installing soil moisture sensors to water plants only when in need.
- Rainwater Recovery: Rainwater recovery units can be installed on roofs to collect water and redirect it into a storage tank. This water can be then used for flushing toilets, supplying cooling towers, and irrigation.
- Recover Air Handler Condensate: Condensed water on air conditioning units can be captured for re-use in cooling towers, or others.

Renewable Energy & Use in Buildings

Renewable Energy

Renewable energy is important for the sustainability of the planet and environment, and it is becoming one of the most important topics in environmental sustainability. There are more around 10 sources of energy currently being used across the world, some renewable, other non-renewable. Non-renewable sources of energy include petroleum, hydrocarbon gas liquids, natural gas, coal, and nuclear energy. All these sources of energy are non-renewable because they are sourced from finite resources. As for renewable energy sources, these include solar energy, geothermal energy, wind energy, biomass, and hydropower (EIA, 2021).

Renewable energy sources and technology are becoming more readily available around the world. However, there are still barriers that deter increasing renewable energy production, some of which include (Regen Power, 2021):

- High initial cost of installation
- Lack of infrastructure
- Power storage
- Non-renewable energy monopoly
- Lack of knowledge and awareness
- Lack of policies, subsidies, …etc

However, many of these barriers are slowly being mitigated, with the cost of wind and solar PV becoming much lower and affordable for developers to invest in. In a 2021 report, the IEA categorized renewable energy projects as

1) Those already contracted and/ or finances and under construction (31%)
2) Those driven by government action (e.g., auction, FITs, other incentives) (46%)
3) Those mainly driven by market forces (e.g., corporate power purchase agreements, merchant projects) (23%).

In developing countries, to shift from non-renewable sources to renewable energy sources will take billions if not trillions of dollars (Handler, Bazilian, & Hayes, 5 ways to boost renewable energy investment in

developing economies, 2022). Many of developing countries are not able to up-take these initial costs, which means that there needs to be strategic cooperation between the public and private sectors. Some of the best practises found to increase the investment in renewable energy in developing countries include:

- Regulated and transparent power arrangements: Regulated and transparent policies and processes for independent power producers will increase investor confidence in their ability to recover their investments in power generation. This also includes standardized power purchase agreement (PPA) templates; holding transparent auctions; and having transparent and fair rate adjustments and public participation.
- Specific clean energy/ climate incentives: "Having an integrated, multi-year energy strategy with short-term targets for retiring fossil fuel plants, if applicable, and building renewable energy helps lay the foundation for conducive policies. Establishing a carbon market or other carbon-pricing mechanism, as well as governance/legislation around carbon removal, is also of value" (Handler, Bazilian, & Hayes, 5 ways to boost renewable energy investment in developing economies, 2022).
- General business- friendly measures: Developing policies and incentive programs that facilitate renewable energy investment. E.g., tax policy, allowing foreign direct investment, improving permitting process, and foreign currency/ ability to repatriate profits.
- Innovative financing mechanisms: Some innovative financing mechanism offer risk mitigation, additional return on profit potential, or create better investment opportunities. Some of the financial innovation include synthetic corporate power purchase agreements and energy transition mechanisms.
- Early risk assumption: In some successful projects, early sponsors take on a part of the risk, which makes it easier to attract financers at later stages.

Renewable Energy in Buildings

In buildings specifically, there are many renewable energy sources that may be included in the design to obtain net-zero operational carbon, meaning that the amount of energy consumed by the buildings operations is either produced through other means, or mitigated. Some of the methods of using renewable energy in buildings include (Yüksek & Karadağ, 2021).

1) Solar Energy
   - Passive Solar System
     - Passive heating: Using passive solar architecture, solar heat gains can be increased in the winter.
     - Natural lighting: The use of windows and opening to maximise natural light without heat absorption.
   - Active Solar Systems
     - Solar heating systems: Solar heating systems are used to heat up water, air, or other using a fluid or mechanical and/ or electronic system.
     - Solar water heating systems: Converting radiation into heat energy to heat water.
     - Photovoltaic systems (PV system): Use to generate electivity from solar radiation.
2) Wind Energy
   - Passive Wind System
     - Passive cooling: Use of passive systems to cool down the building without the use of energy, this includes preventing the building from heat gain. For example, one way of using wind is to include wind catchers in the design for natural ventilation, which were very common in middle eastern countries.

- Active Wind Systems
  - Energy from wind can be captured through turbines. In some building turbined were placed in suitable spots in the garden or roof and integrated into the buildings energy system.

3) Geothermal Energy
   - Geothermal energy is used to heat and cool down houses and building. Three types of systems are available, heat pumps, in-well heat exchangers, and heat pipes, which are the most commonly used in buildings.

4) Hydrogen Energy
   - Hydrogen, which is generated through many renewable energy sources (solar panels, wind, hydroelectric, and geothermal), can be also used as an energy sources. One of the most efficient systems is solar-hydrogen hybrid system. The process is as follows
     - PV Panels generate electricity through solar energy
     - H_2 & O_2 is produced by electrolyser
     - Gases are taken to storage tank for ground and water heating
     - Heating air in ventilation by burning hydrogen in winter
     - Fuel cell is activated if additional electricity is needed
     - Heat is released into fuel cell to heat water
5) Biomass Energy
   - In residence, biomass can be used to in electricity generation by using biogas, ethanol obtained from pyrolysis is used for heating, as well as hydrogen obtained by direct burning.

Health & Well- Being

Impact of Building Material on Individual Health

Some of the main harmful material used within construction (Thienen & Spee, 2008).

- Cement
  One of the main causes of skin diseases, as well as other effects during transportation and mixing that are included within dust.
- Concrete Release Agents
  Mineral oil based and vegetable-based release agents are used in the process of concrete production, both of which are harmful upon inhalation or skin exposure.
- Wood Preservative
  Many types of wood preservatives are based on very harmful compounds such as copper preservatives and compounds, Chromium compounds, Arsenic compounds, Boron compounds, and Fluorides. Each with its own different type of harms and impacts on the individual.
- Polyurethane products
  Polyurethane products have been extensively studied in their relation to asthma and long term occupational hazardous of asthma, where the research clearly shows a relation between the two.
- Asphalt/ Bitumen

Used in both asphalt and as water sealing material, some of the health hazards of the material includes lower respiratory tract symptoms, “lung diseases (Burstyn, et al.,2003a) and ischemic heart disease (Burstyn, et al., 2005)”Asphalt/ Bitumen

- Dust
  - Dust is defined as solid particles ranging from 1 µm to 100 µm in size, which may become airborne. The health hazards of dust depend on the dust composition, concentration, particle size and shape, and exposure time. Some of the main effects of dust include
  - Pneumoconiosis; disease due to accumulation of dust in lung. Mainly caused by asbestos and silica
  - Cancer: Examples of carcinomic dusts include asbestos, silica, certain wood dusts, and fly ash.
  - Systemic poisoning; Toxic metal dusts such as Lead and Cadmium may enter the blood stream over a period of time and poison the user.
  - Allergies; Wood dusts and metals may cause allergic reactions
  - Effects on skin; Cement and some metal and wood dust may cause skin irritation.
- Paints, Plaster, and varnishes

  The use of paint, plaster, and varnish material by construction workers increases the risk of dermatitis and skin irritation.
- Organic Solvents

  Construction painters are the most exposed to organic solvents at it is found in oil- passed paints. Some of the impacts of these solvents include impact on the central nervous system, inducing headache and dizziness. The long-term effect of exposure was tied to Chronic toxic encephalopathy (CTE): a neurological disease-causing personality change, memory loss, and neurological deficits; Ototoxicity: a hearing disorder; and other neurotoxic effects.

Annex II Contact Sheet for Green Building Material Providers

Name of Establishment	Location	Contacts Information		Comments
Paints companies:				
APC	WB North	Iman Attari/ Wael Qadoomi	599672173/ 0599200209	Has water- based paints
Duluxe	WB Centre	Khalil	595696956	Has water- based paints
Aluminum:				
Napco		Shadi Jallad	569400171	30% of Aluminum sold is recycled
Nassar		Tawfeeq Nassar	569840000	Provides thermal break aluminum profiles
Glass Factories:				
Nassar		Tawfeeq Nassar	569840000	
Steel:				
Hassouneh	Centre	Tareq Hassouneh	598603020	
Hassoneh		Fares Hassoneh/ Mohammad Hassoneh	0599275685/ 0599752461	Recycles metal, steel, and cars
Insulation Material:				
Brilliant Insulation	Hebron	Mr. Alaa Said	0599150990	Thermal Insulation
Wood:				
Almimi	Centre	Abdulhamid Mimi	599888013	
Dalbah	North		042438266	Provides sustainable wood
Block:				
DKG Gypsum Blocks	Centre	moath	598807082	Manufacturers gypsum blocks
Cement				
SANAD		Mahmoud Amer	0562500571	
HVAC Systems				
Climatech	Centre	George Mogannam	02-2981167	
Water Efficient Fixtures				
Maher Ceramics	Centre	Omar Abd Al Jawad	0599240552	Water Efficient Fixtures
Electrical Efficient Fixtures				

Al Takamol	Centre	Eng. Rasheed	02-2981181	Electrical Efficient Fixtures Supplier for PV cells Smart energy systems

Annex III Building Material Price Data

Building Material	Price	Notes
Gypsum Blocks	USD 19per m^2	Estimate of 20 NIS per m^2 for pre-cast concrete blocks
Double Glazed Glass (4 6 4)	USD 35 per m^2	Used in commercial residential buildings
Double Glazed Glass (6 12 6)	USD 74 per m^2	Used by high- end households and consumers
Thermally Treated Double Glazed Glass	USD 88 per m^2	
E- Glass	USD 82 – 88 per m^2	Used for large construction projects with curtain walls
Decorative Water Based Paint	15% more expensive than oil-based paint	
Thermal Insulation Polyurethane	USD 7 per m^2	Rule of thumb used: 1.25 kg per m^2
Low End 60% Efficient Light Bulb Type 1	USD 1.2 per bulb	6,000 hours
High End 60% Efficient Light Bulb Type 1	USD 6 per bulb	25,000 hours
Low End 60% Efficient Light Bulb Type 2		30,000 hours
Medium End 60% Efficient Light Bulb Type 2		70,000
High End 60% Efficient Light Bulb Type 2		120,000 hours

Annex IV: Insulation Material Data Sheet

Polybit

PU FOAM SS-45A

Two-component, spray-applied polyurethane foam system

PUFOAM SS-45 A is an HCFCblown & CFC free, polymeric M.D.I based system to produce rigid polyurethane foam.

CHARACTERISTICS

- Spray applied
- CFC free & HCFC blown
- 45kg density

thermal insulation | CFC free

DESCRIPTION

PUFOAM SS-45A is a two-component, spray-applied polyurethane foam that creates a seamless, monolithic barrier against water vapor and air. PUFOAM SS-45A is an HCFCblown & CFC free, polymeric M.D.I based system for producing rigid urethane foam witha nominal core density of 45 kg/m³ by spray process. The system may be applied to substrates where the surface temperature is of the order of 25 - 30°C. Grades, adjusted in reactivity, are available for both cold and hot condition.

FIELDS OF APPLICATION

- roof spraying applications.
- flooring and wall insulation.
- storage tank insulation

COMPONENT PROPERTIES

MDI component is a dark brown colored, undistilled grade of polymeric diphenyl methane di-isocyanate (crude M.D.I).

- viscosity @ 20°C. : 150 - 200 cps
- specific gravity @ 20°C 1.24
- NCO content, % wt. 30-31

Polyol Component is a low viscosity blend of polyols, hydro fluorocarbon blowing agent, catalysts and surfactant

- viscosity @ 20°C approx.450 cps.
- specific gravity @ 20°C : 1.16

STORAGE AND HANDLING

Store at room temperature in sealed drums. Moisture will react with this component to produce a surface skin of polymerized material. Protect from moisture and moisture vapour. Close all drums after use. Maximum permissible storage time is 6 months. The ideal storage temperature is between +20°C and +25°C. MDI may undergo partial crystallization at temperature below 0°C. The product can, however, be brought back into the liquid state by placing the container in a heating cabinet and carefully warming the entire contents for a short time to a maximum of 70°C. Safety goggles, impermeable protective gloves and coveralls should always be worn when handling this product. Contaminated clothing should be removed immediately to prevent further skin contact. Store at room temperature (below 25°C.) in sealed drums. Close all drums after use to prevent loss of blowing agent and absorption of moisture.

TDS_PU Foam SS45A_GCC_0118

1

MIX RATIO

1:1 by volume.

Typical reaction rate and density (laboratory, cup mix) (both components at 20°C)

- cream time: 6 - 8 sec.
- tack free time: 15 - 25 sec.
- free rise density : 32 - 36kg/m³

Reactivity and density may vary depend on ambient temperature and grade.

SUPPLY

PU Foam SS45A

Part A	220kg drum
Part B (MDI)	250kg drum

COVERAGE

Average consumption of 1.7kg/m² with 3cm thickness

Quality for Professionals

TECHNICAL SPECIFICATION

PROPERTIES	VALUES	STANDARDS
Mix ratio, [volume:volume]	1:1	-
Final density, [kg/m]	43 to 48	ASTM D 1622
Application thickness, [cm]		
Min	3	
Max	10	
Compressive strength, [kpa]		
With rise	220 to 320	ASTM D 1621
Against rise	172 to 207	
Thermal conductivity @ 25°C, W/(mk)		
Initial value	0.023	ASTM C 518/19
Aged value	0.026	
Closed cell content, apparent vol, %	92 to 93	ASTM D 2856
Water vapor transmission, perm-inch		
All cut surfaces	2	ASTM C 518/91
With skin retained	1	
Water absorption, per cm³ (gm/cc)		
Without protective coating	0.0087	ASTM C 272
With protective coating	0.0019	
Dimensional stability, % linear change		
7 days @ - 15°C	<1.0	ASTM D 2126
7 days @ 100°C	2	
7 days @ 70°C [100% RH]	2.5	
Fire resistance	Class B3	DIN 4102

All values given are subject to 5-10% tolerance

TDS_PU Foam SS45A_GCC_0118

2

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henkelpolybit@henkel.com; www.henkelpolybit.com

Quality for Professionals

POLEXchem
POLYURETHANE SYSTEMS

TECHNICAL DATA SHEET

System Description

This system is used for isolation, pipe, tank, terrace, ship and similar places. It is applied with spray machines because of its fast curing.

Polyol component	Isocyanate Component
S 625	S 600

Component properties

	Polyol component	Isocyanate Component
Storage temp. (°C)	15 - 25	15 - 25
Shelf life (month)	6	6
Viscosity (cP) at 25 °C	250 ± 50	210 ± 30
Specific gravity (g/cm^3)	1,11	1,23
NCO Content (%)	------	31 ± 1
OH Value (mg KOH/gr)	370	-------

Mechanical properties

Pushing value (psi)	36
Closed cell ratio (%)	> 90
Termal conductivity coefficient(W /m.K)	0,021

Mixture and Process Conditions

Polyol Temp (°C)	20 - 25
Isocyanate Temp (°C)	20 - 25

Reaction Profile

Mixing Ratio (pol/iso)	100 : 110
Cream time (sec)	2
Rise Time (sec)	3 - 4
Tack Free Time (sec)	5 - 6
Free rise density (kg /m^3)	25

The values given in the reaction profile are the values obtained in the laboratory conditions. However; external conditions and application factors that may affect the application and process of our product are beyond our control. Therefore, our company cannot be held responsible for any errors or damages that may occur in the product to be produced during or after the application. We recommend that practitioners use our products by performing their own checks and tests. The data written here does not imply any property of the material or the guarantee of conformity to the intended use.

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Annex V: Paint Data Sheet (Provided as Attachments)

DUAFLEX

**EXTERIOR FINISH
REQUIRES
NO PRIMER**

www.oikos-group.it/it/p/duaflex

Technical Qualities

DUAFLEX by OIKOS is a special, flexible finish coat, good for covering uneven surfaces, giving a matt rough effect suitable for both exterior and interior surfaces. The fillers used, with a selected grain size (0,3 or 0,7 mm), enable the product to cover uneven surfaces making it possible to even out small imperfections and irregularities.
DUAFLEX is composed of acryl-siloxanic resins, silanised, acrylic and elastomeric resins in water dispersion that make it extremely flexible with excellent adhesion even on difficult surfaces (tiles, stone, smooth cement).
For surfaces in good conditions there is no need to apply base coats: with two coats of DUAFLEX it is possible to decorate the entire façade thus saving time and money.
DUAFLEX is water repellent, light resistant, resistant to the elements and pollutants as well as preventing the formation of mould and algae.
The flexibility of the product remains stable over time, even if exposed to U.V light, or to frost-thaw cycles.
DUAFLEX has been EC labelled for Systems for the protection of concrete surfaces as per EN 1504-2:2005 as much as it ensures protection against carbonation to surfaces made of reinforced concrete.
It is recommended for use in the renovation of historical centres, villas, residential developments and industrial premises and in general for the protection and restoration of all wall surfaces and thermal insulation systems when it is necessary to even the surface or renovated plaster work, thus guaranteeing very good adhesion and protection against carbonation.
The product has low odour, is non inflammable and is friendly to humans and the environment.

Ideal Use

Exterior and Interior walls.

Surface Preparation

Remove any deposits of dust, smog or other similar elements by brushing or washing. Remove any loose or flaking materials. Only in case of powdering, badly adhering, detaching surfaces apply a coat of the special sealer NEOKRYLL by Oikos. Wait 4 ÷ 6 hours until dry.
On walls in good conditions there is no need for primers or sealers. For shades belonging to the Design colour collection or with reduced covering capability it is necessary to follow the instructions given in the Exterior colour fan.

Application Method

DUAFLEX 03: apply 2 coats of product diluted 10% with drinkable water waiting 4-6 hours between coats.
The product can be applied by brush, crossing the brush strokes, or by roller for exterior use, paying attention to evenly distribute the product over the surface. Avoid leaving roller marks.
DUAFLEX 07: apply 2 coats of product with an interval of 4-6 hours.
The recommended application is by brush diluting the product 10% with drinkable water, crossing the brush strokes.
The application by roller for exterior use is possible but attention shall be paid to evenly distribute the product over the surface avoiding to leave roller marks on it. Dilute the product 10% with drinkable water for the first coat, and 20% for the second one. We do recommend that you make a preliminary test before proceeding with this method of application.
CLOUD EFFECT: it is possible to accomplish a cloudy decorative effect by applying a first coat of DUAFLEX 07 diluted 20% with drinkable water and then, 4-6 hours later, a second coat of DUAFLEX 03 diluted 10% with drinkable water. The application of both coats shall be made by brush, crossing the brush strokes.

Finishes and Protection

In order to give the surface a wash effect, once the surface is dry, it is possible to apply a coat of VELDECOR by Oikos finishing it using a brush, sponge or glove by Oikos.

Safety information

The product is free of heavy metals such as lead or chrome. It does not contain toxic solvents, aromatics or chlorides. There is no risk of any dangerous polymerisation. The product is considered to be a nondangerous substance if used in the technically correct manner. Normal cautionary measures for the handling of water based paints are advised. No special arrangements are required for the storage, movement and transportation of the product; the containers, residue, eventual spilt material should be cleaned up using absorbent inert material such as sand, soil etc. and then disposed of in accordance with the regional and national regulations in force at that time. Transportation must be carried out in accordance with international agreements.

Specifications

Clean the surface to be painted by removing any loose or flaking material. New surfaces should be thoroughly dry and mature. In case of very crumbly, absorbing or powdering surfaces apply a coat of a sealer such as NEOKRYLL by OIKOS.
Once the surface is ready, apply two coats of a flexible finish coat, good for covering uneven surfaces such as DUAFLEX by OIKOS. All should be carried in accordance with the norms of application, with a cost of ..... per m² including material and labour.

The product

Composition	Acryl-siloxanic resins, silanised acrylic resins and acrylic elastomers in water dispersion, titanium dioxide based fillers and additives to facilitate application and the formation of the surface film
Specific weight	1,50-1,60 kg/l (white)
Grain size	0,3 Max = 0,3 mm 07 Max=0,7 mm
pH	8÷9
Viscosity	17.000-22.000 CPS Brookfield (RVT 20 revs/min. at 25°C)
Storage temperature	+2°C ÷ +36°C. Keep from freezing
Water absorption	W3 (low permeability to liquid water) (UNI EN 1062-3:2008)
Permeability to water vapour	V2 (medium permeability) (UNI EN ISO 7783-2:2012)
Crack Bridging Ability (CBA)	Class A2 (UNI EN 1062-7:2005)
Emission limits of Volatile Organic Compounds (VOC), according to Directive 2004/42/CE	Classification: A/c (classification limit A/c: 40 g/l); VOC: 8 g/l (ISO 11890-2)
Colours	White + shades from the ECS colour collection
Packaging	4-14 l
EC labelling for systems for the protection of concrete surfaces EN 1504-2:2005, as per EN 1504-2:2005 requirements	
Permeability to carbon dioxide	SdCO2>50 m, complies (UNI EN ISO 1062-6:2003)
Measurement of bond strength by pull off	fh > 0,8 MPa complies (UNI EN 1542:2000)
Water absorption	w<0,1 kg/m2 h 0,5 complies
Permeability to water vapour	Sd<5 m, class I

Applicatoin

Dilution	03: by brush, by roller, max 10% with drinkable water 07: by brush max 10%, by roller 1st coat 10%, 2nd coat 20% Cloudy effect: 07 max 20%, 2nd coat 03 max 10%
Yield	03: 1,8 ÷ 2,2 mq/l according to the absorption of the surface 07: 1,5 ÷ 2 mq/l according to the absorption of the surface Cloudy effect: 07 2,5-3,5 mq/l, 03 3-4 mq/l
Application tools	Brush, Roller or Spray gun (by suitable equipment)
Sealer	NEOKRYLL by OIKOS
Application temperature	+5°C ÷ +36°C (with relative humidity not exceeding 80%)
Drying time until touch dry	2÷3 h (temperature = 20°C with relative humidity at 75%)
Drying time until fully dry	24 h (temperature = 20°C with relative humidity at 75%)
Tools cleaning	Water

Issued 02/14

VINYL MATT

Dulux Trade Vinyl Matt is a top quality high opacity emulsion based on unique **AkzoNobel** technology which gives excellent coverage and application. Where condensation is a problem e.g. some kitchens and bathrooms, use **Dulux Trade** Diamond Eggshell. Suitable for all normal interior wall and ceiling surfaces.

KEY BENEFITS

- Excellent Application and Finish
- High Opacity
- Coverage up to 15m² Per Litre

PRODUCT INFORMATION

Typical Use

Suitable for interior use on all normal interior wall and ceiling surfaces. For interior areas that are likely to suffer from mould growth, use **Mouldshield** Fungicidal Eggshell* from **Dulux Trade.**

Pack Size

3.4L, 18L / 25Kg.

Colour Range

See appropriate **Dulux Trade** colour literature or visit ***duluxtrade.co.uk.***

Film Properties

Chemical Resistance: Not suitable.
Heat Resistance: Not suitable for use on heated surfaces, such as radiators.
Water Resistance: Where frequent heavy condensation is likely, as in some kitchens and bathrooms, **Dulux Trade** Diamond Eggshell is more suitable.

Composition (nominal)

Pigment: Lightfast Pigments.
Binder: Acrylic Copolymer Emulsion.
Solvent: Water.

Volume Solids

White – 33%, PBW – 31% (nominal). Other colours will vary.

SURFACE PREPARATION

To get the best results with **Dulux Trade** Vinyl Matt, make sure surfaces to be painted are sound, clean, dry (new surfaces particularly must be fully dry).

Remove all loose and defective paint. Special precautions should be taken during surface preparation of pre-1960s paint surfaces over wood and metal as they may contain harmful lead.

Where necessary, wash the surface to remove dirt, grease and powdery or dusty residues. Rinse with clean water and allow to dry. Seal surfaces that remain powdery after thorough preparation with an appropriate plaster sealer.

Where necessary, rub down and then wipe off with a damp, lint free cloth to avoid dust.

Any surface defects should be filled with the appropriate **Polycell** Trade **Polyfilla.**

SYSTEMS INFORMATION

STIR THOROUGHLY BEFORE USE. Seal new or bare surfaces with a thinned first coat of **Dulux Trade** Vinyl Matt (up to 1 part clean water to 5 parts paint). The normal finishing process is 2 full coats of **Dulux Trade** Vinyl Matt, but on previously painted surfaces in good condition where similar colours are used, 1 coat may be sufficient.

For best colour consistency, purchase sufficient tinted paint for each job including touch-in at one time from the same source.

APPLICATION METHOD

Brush, roller, conventional spray or airless spray.

As with other water-based paints, do not apply at temperatures below 8°C (as recommended by British Standard BS 6150).

Practical Coverage

A guide to the practical coverage which can be achieved under normal conditions is up to 17m² per litre.

VINYL MATT

Thinning

Sealing new or bare surfaces: Add up to 1 part clean water to 5 parts paint.
Normal use (not to be exceeded): Add up to 1 part clean water to 10 parts paint.
Conventional spray application: Add up to 1 part clean water to 2.5 parts paint.
Airless spray application: Add up to 1 part clean water to 5 parts paint.

Spray Recommendations

Conventional Spray: Satisfactory through most equipment.
Airless Spray: A typical set up for airless spray would be a minimum working pressure on paint of 133 bars (2000lb/sq in) with a spray tip size of 0.38mm (15 thou) and a spray tip angle of 65°.

Drying Times

Single coat at standard thickness:
Touch Dry: Dependent on temperature and humidity.
Recoat: 2-4 hours.

Cleaning Up

After use, remove as much product as possible from equipment before cleaning with water.

When this paint container is empty please ask your stockist about recycling. If you have leftover paint, please dispose of it responsibly and consider donating it to **Community RePaint**. Find out more at ***duluxtrade.co.uk/pp.***

Transportation & Storage

Do not use or store in extremes of temperature and protect from frost. To prevent spillage, please store and transport upright.

VOC

EU limit value for this product (cat.: A/a): 30g/l (2010).
Ready Mixed: This product contains max. 1g/l VOC. VOC content: Minimal (0-0.29%).
Tinted: This product contains max. 10g/l VOC. VOC content: Low (0.30-7.99%).

FURTHER SUPPORT

If you need further support, please contact the **AkzoNobel** Technical Advice Centre on 08444 817 818.

* **Mouldshield** Fungicidal Eggshell from **Dulux Trade** contains: 3-iodo-2-propynyl-n-butyl carbamate.
Use biocides safely. Always read the label and product information before use.

Always read full Health, Safety & Environmental Information on can before use.

Safety datasheet (SDS 411) is available free on request by telephoning the **AkzoNobel** Technical Advice Centre or by visiting ***duluxtrade.co.uk.***

Issued 02/14

VINYL EGGSHELL

Dulux Trade Vinyl Eggshell is a top quality, washable emulsion based on unique **AkzoNobel** technology with a fashionable mid-sheen finish. Where condensation is a problem, for example some kitchens and bathrooms, use **Dulux Trade** Diamond Eggshell. Suitable for all normal interior wall and ceiling surfaces.

KEY BENEFITS

- Tough Washable Finish
- Fashionable Mid-Sheen Finish
- Coverage up to 16m² Per Litre

PRODUCT INFORMATION

Typical Use

Suitable for interior use on all normal interior wall and ceiling surfaces. For interior areas that are likely to suffer from mould growth, use **Mouldshield** Fungicidal Eggshell* from **Dulux Trade.**

Pack Size

0.85 L, 3.4 L and 20 Kg.

Colour Range

See appropriate **Dulux Trade** colour literature or visit ***duluxtrade.co.uk.***

Film Properties

Chemical Resistance: Not suitable.

Heat Resistance: Not suitable for use on heated surfaces, such as radiators.

Water Resistance: Will tolerate the levels of atmospheric humidity present in normal interior environments and will withstand moderately vigorous washing. Where frequent heavy condensation is likely, as in some kitchens and bathrooms, **Dulux Trade** Diamond Eggshell is more suitable.

Composition (nominal)

Pigment: Lightfast Pigments.

Binder: Water-Based Emulsion.

Solvent: Water.

Volume Solids

Pure Brilliant White – 33% (nominal). Other colours will vary.

SURFACE PREPARATION

To get the best results with **Dulux Trade** Vinyl Eggshell, make sure surfaces to be painted are sound, clean, dry (new surfaces particularly must be fully dry).

Remove all loose and defective paint. Special precautions should be taken during surface preparation of pre-1960s paint surfaces over wood and metal as they may contain harmful lead.

Where necessary, wash the surface to remove dirt, grease and powdery or dusty residues. Rinse with clean water and allow to dry. Seal surfaces that remain powdery after thorough preparation with an appropriate plaster sealer.

Where necessary, rub down and then wipe off with a damp, lint free cloth to avoid dust.

VINYL EGGSHELL

Any surface defects should be filled with the appropriate **Polycell** Trade **Polyfilla.**

SYSTEMS INFORMATION

STIR THOROUGHLY BEFORE USE. Seal new or bare surfaces with a thinned first coat of **Dulux Trade** Vinyl Eggshell (up to 1 part clean water to 5 parts paint). The normal finishing process is 2 full coats of **Dulux Trade** Vinyl Eggshell, but on previously painted surfaces in good condition where similar colours are used, 1 coat may be sufficient.

For best colour consistency, purchase sufficient tinted paint for each job including touch-in at one time from the same source.

APPLICATION METHOD

Brush, roller, conventional spray or airless spray.

As with other water-based paints, do not apply at temperatures below 8ºC (as recommended by British Standard BS 6150).

Practical Coverage

A guide to the practical coverage which can be achieved under normal conditions is up to 16m² per litre.

Thinning

Sealing new or bare surfaces: Add up to 1 part clean water to 5 parts paint.
Normal use (not to be exceeded): Add up to 1 part clean water to 10 parts paint.
Conventional spray application: Add up to 1 part clean water to 5 parts paint.
Airless spray application: Thinning is not required.

Spray Recommendations

Conventional Spray: Satisfactory through most equipment.
Airless Spray: A typical set up for airless spray would be a minimum working pressure on paint of 133 bars (2000lb/sq in) with a spray tip size of 0.38mm (15 thou) and a spray tip angle of 65º.

Drying Times

Single coat at standard thickness:
Touch Dry: Dependent on temperature and humidity.
Recoat: 2-4 hours.

Cleaning Up

After use, remove as much product as possible from equipment before cleaning with water.

When this paint container is empty please ask your stockist about recycling. If you have leftover paint, please dispose of it responsibly and consider donating it to **Community RePaint**. Find out more at ***duluxtrade.co.uk/pp.***

Transportation & Storage

Do not use or store in extremes of temperature and protect from frost. To prevent spillage, please store and transport upright.

VOC

EU limit value for this product (cat.: A/a): 30g/l (2010).
Ready Mixed: This product contains max. 1g/l VOC. VOC content: Minimal (0-0.29%).
Tinted: This product contains max. 8g/l VOC. VOC content: Low (0.30-7.99%).

FURTHER SUPPORT

If you need further support, please contact the **AkzoNobel** Technical Advice Centre on 0333 222 70 70.

* **Mouldshield** Fungicidal Eggshell from **Dulux Trade** contains: 3-iodo-2-propynyl-n-butyl carbamate.
Use biocides safely. Always read the label and product information before use.

Always read full Health, Safety & Environmental Information on can before use.

Safety datasheet (SDS 413) is available free on request by telephoning the **AkzoNobel** Technical Advice Centre or by visiting ***duluxtrade.co.uk.***

WEATHERSHIELD SMOOTH MASONRY PAINT

Weathershield Smooth Masonry Paint from **Dulux Trade** is an exterior quality emulsion paint based on all acrylic resin. It contains a fungicide to inhibit mould growth on the paint film and help it stay cleaner for longer. It is particularly suitable for use in changeable weather and is shower resistant within 30 minutes after application.

KEY BENEFITS

- 15 Years All Weather Protection
- Shower Resistant within 30 Minutes
- Anti Carbonation Paint

PRODUCT INFORMATION

Typical Use

Ideal for use on most exterior masonry and rendering (including concrete, roughcast, pebble-dash and brickwork which is normally suitable for painting, such as rustic or sand faced bricks). Common or fletton bricks should not be painted. Painting of parapet, free standing and retaining walls below ground level damp-proof course is inadvisable, as it may be difficult to prevent moisture penetration and consequent failure of the paint coating. Painting this type of wall may also increase the risk of frost damage and spalling of the brickwork or stonework.

Pack Size

2.5L, 5L and 10L.

Colour Range

See appropriate **Dulux Trade** colour literature or visit ***duluxtrade.co.uk.***

Film Properties

Chemical Resistance: Resistant to mild atmospheric fume attack and to the salts in new mortar, rendering and similar surfaces.

Heat Resistance: Not suitable for use on heated surfaces.

Water Resistance: Resistant to the levels of atmospheric humidity normally experienced in exterior environments.

Composition (nominal)

Pigment: Lightfast Pigments.

Binder: Acrylic Emulsion with Fungicide/algicide.

Solvent: Water.

Volume Solids

White: 38% (nominal). Other colours will vary.

SURFACE PREPARATION

To get the best results, ensure surfaces to be painted are sound, clean and dry (new surfaces particularly must be fully dry). Wash down previously painted surfaces with a detergent solution to remove all dirt, grease or chalking paint where practicable. Rinse off with clean water and allow to dry. Carefully scrape back to a firm edge all areas of poorly adhering or defective coatings and rub down thoroughly to 'key and

feather' broken edges of existing coatings. Special precautions should be taken during surface preparation of pre-1960s paint surfaces over wood and metal as they may contain harmful lead.

Treat any areas affected by mould, lichens, algae and moss with **Weathershield** Multi-Surface Fungicidal Wash*. Make good minor defects with an appropriate **Polycell** filler. Use a sand and cement mix for larger holes and cracks. Allow to dry.

New or sound bare surfaces should be sealed with a thinned first coat of **Weathershield** Smooth Masonry Paint (add up to 1 part clean water to 5 parts paint).

Surfaces that remain powdery, friable or chalky after thorough preparation should be sealed with a coat of **Weathershield** Stabilising Primer. ***Note:*** do not seal sound new or bare surfaces with stabilising primer.

SYSTEMS INFORMATION

STIR THOROUGHLY BEFORE USE. Seal all new or bare surfaces with a thinned coat of **Weathershield** Smooth Masonry Paint (up to 1 part clean water to 5 parts paint). The normal finishing process is 2 full coats of **Weathershield** Smooth Masonry Paint, but on previously painted surfaces in good condition, where similar colours are used, 1 coat may be sufficient. In normal conditions two coats of **Weathershield** Smooth Masonry Paint properly applied to the substrate in accordance with the instructions will perform satisfactorily for up to 15 years giving good colour stability (as part of BBA certificate 97/3383). See current colour collateral for choice of colours.

For best colour consistency, purchase sufficient tinted paint for each job including touch-in at one time from the same source.

APPLICATION METHOD

Brush, roller, conventional spray or airless spray.

Do not use in extremes of temperatures (below 7ºC) or during rain, fog or relative humidity above 80%.

Practical Coverage

The spreading rate of this product will vary considerably according to the roughness and porosity of the surface.
On smooth surfaces of low porosity, such as rendering: up to 16m² per litre.
On textured surfaces of low porosity, such as pebbledash: 4-6m² per litre.
These figures are only an approximate guide due to the variation of different building surfaces and may be reduced. If in doubt, apply a small trial area.

Thinning

Sealing new or bare surfaces: Add up to 1 part clean water to 5 parts paint.
Normal use (not to be exceeded): Add up to 1 part clean water to 10 parts paint.
Conventional spray application: Add up to 1 part clean water to 2.5 parts paint.
Airless spray application: Add up to 1 part clean water to 5 parts paint.

WEATHERSHIELD SMOOTH MASONRY PAINT

Spray Recommendations

Conventional Spray: Satisfactory through most equipment.
Airless Spray: A typical set up for airless spray application would be a minimum working pressure on paint of 133 bars (2000lb/sq in) with a spray tip size of 0.38mm (15 thou) and a spray tip angle of 65º. Suggested pump capacity is 5 litres/minute minimum.

Drying Times

Single coat at standard thickness:
Touch Dry: Normally touch dry after 30 minutes.
Recoat: 2-4 hours. Drying time will vary according to temperature and humidity, and will be significantly longer in cold, damp conditions.

Cleaning Up

After use, remove as much product as possible from equipment before cleaning with water.

When this paint container is empty please ask your stockist about recycling. If you have leftover paint, please dispose of it responsibly and consider donating it to **Community RePaint.** Find out more at ***duluxtrade.co.uk/pp.***

Transportation & Storage

Do not use or store in extremes of temperature and protect from frost. To prevent spillage, please store and transport upright.

VOC

EU limit value for this product (cat.: A/c): 40g/l (2010). This product contains max. 10g/l VOC. VOC content: Low (0.30-7.99%).

FURTHER SUPPORT

If you need further support, please contact the **AkzoNobel** Technical Advice Centre on 0333 222 70 70.

*** Weathershield** Multi-Surface Fungicidal Wash contains: Benzalkonium Chloride.
Use biocides safely. Always read the label and product information before use.

Always read full Health, Safety & Environmental Information on can before use.

Safety datasheet (SDS 418) is available free on request by telephoning the **AkzoNobel** Technical Advice Centre or by visiting ***duluxtrade.co.uk.***

Issued 06/17

REALIFE

Dulux Trade Realife is a tough, water based matt emulsion paint that uses **Diamond Technology** from **Dulux Trade**, making it 10 times tougher than **Dulux Trade** Vinyl Silk and **Dulux Trade** Vinyl Matt. Ideal for high traffic areas such as stairwells and hallways, it is resistant to typical household stains and will repeatedly wipe clean without polishing up.

KEY BENEFITS

- Superior Durability
- Repeatably Wipeable Matt Finish
- Stain Resistant

PRODUCT INFORMATION

Typical Use

Suitable for interior use on all normal interior wall and ceiling surfaces, especially those subject to high traffic. When overcoating areas previously painted with solvent-based paints, a first coat of **Dulux Trade** Diamond Eggshell should be used.

Pack Size

3.4 L.

Colour Range

See appropriate **Dulux Trade** colour literature or visit ***duluxtrade.co.uk.***

Film Properties

Chemical Resistance: Not suitable.

Heat Resistance: Not suitable for use on heated surfaces, such as radiators.

Water Resistance: Resistant to the levels of atmospheric humidity present in normal interior environments and will withstand repeated washing. Suitable for use in kitchens and bathrooms. Not suitable for use on immersed surfaces or where there is heavy and prolonged condensation.

Composition (nominal)

Pigment: Lightfast Pigments.

Binder: Acrylic Copolymer Emulsion.

Solvent: Water.

Volume Solids

White – 41% (nominal). Other colours will vary.

SURFACE PREPARATION

To get the best results with **Dulux Trade** Realife, make sure surfaces to be painted are sound, clean, dry (new surfaces particularly must be fully dry).

REALIFE

Remove all loose and defective paint. Special precautions should be taken during surface preparation of pre-1960s paint surfaces over wood and metal as they may contain harmful lead.

Where necessary, wash the surface to remove dirt, grease and powdery or dusty residues. Rinse with clean water and allow to dry. Seal surfaces that remain powdery after thorough preparation with an appropriate plaster sealer such as **Dulux Trade** Stain Block Primer.

Where necessary, rub down and then wipe off with a damp, lint free cloth to avoid dust.
Any surface defects should be filled with the appropriate **Polycell** Trade **Polyfilla.**

SYSTEMS INFORMATION

STIR THOROUGHLY BEFORE USE. Seal new or bare surfaces with a thinned first coat of **Dulux Trade** Realife (up to 1 part clean water to 10 parts paint). The normal finishing process is 2 coats of **Dulux Trade** Realife, but on previously painted surfaces in good condition where similar colours are used, 1 coat may be sufficient.

For best colour consistency, purchase sufficient tinted paint for each job including touch-in at one time from the same source.

APPLICATION METHOD

Brush, roller, conventional spray or airless spray.

As with other water-based paints, do not apply in temperatures below 8ºC (as recommended by British Standard BS 6150).

Practical Coverage

A guide to the practical coverage which can be achieved under normal conditions is up to 16m² per litre.

Thinning

Sealing new or bare surfaces: Add up to 1 part clean water to 10 parts paint.
Normal use (not to be exceeded): Thinning is not usually required.
Conventional spray application: Add up to 1 part clean water to 5 parts paint.
Airless spray application: Thinning is not usually required.

Spray Recommendations

Conventional Spray: Satisfactory through most equipment.
Airless Spray: A typical set up for airless spray would be a minimum working pressure on paint of 133 bars (2000lb/sq in) with a spray tip size 0.38mm (15 thou) and a spray tip angle of 65º.

Drying Times

Single coat at standard thickness:
Touch Dry: Dependent on temperature and humidity.
Recoat: 4-6 hours.

Issued 06/17

REALIFE

Cleaning Up

After use, remove as much product as possible from equipment before cleaning with water.

When this paint container is empty please ask your stockist about recycling. If you have leftover paint, please dispose of it responsibly and consider donating it to **Community RePaint**. Find out more at ***duluxtrade.co.uk/pp.***

Cleaning Recommendations for Painted Surface: Common stains can be removed by cleaning promptly with a soft cloth and clean soapy water. Allow to dry. Vigorous scrubbing and the use of abrasive cleaners or scourers may impair the matt finish. Only apply enough pressure to remove marks. Oil based stains and marks from some pens/felt tips/permanent markers may not be completely removed. Full durability develops 7 days after initial application.

For information about removing specific stains, please phone the **AkzoNobel** Technical Advice Centre on 0333 222 70 70.

Transportation & Storage

Do not use or store in extremes of temperature and protect from frost. To prevent spillage, please store and transport upright.

VOC

EU limit value for this product (cat.: A/a): 30g/l (2010).

Ready Mixed: This product contains max. 7g/l VOC. VOC content: Low (0.30-7.99%).

Tinted Colour: This product contains max. 15g/l VOC. VOC content: Low (0.30-7.99%).

FURTHER SUPPORT

If you need further support, please contact the **AkzoNobel** Technical Advice Centre on 0333 222 70 70.

Always read full Health, Safety & Environmental Information on can before use.

Safety datasheet (SDS 447) is available free on request by telephoning the **AkzoNobel** Technical Advice Centre or by visiting ***duluxtrade.co.uk.***

Annex VI: Gypsum Block Brochure and Product Information (Provided as Attachment)

DALEEL
KEY GYPSUM
دليل كي جبس

يقدم نظام DKG لجدران الطوب الجبسي حلاً لبناء حديث ومبتكر، مستدام وأخضر من أجل فلسطين " أكثر خضرة ".

تقدم شــركة دليل كي كابيتــال لتطوير الأعمــال م.خ.م. منتجاتها المعروفــة بإســم DKG Gypsum Blocks التي توفــر فرصة رائعة لتركيب الجدران الجافة الداخلية غير الحاملة التي تتمتع بتكلفة أقل، جودة أداء عالية، وخصائص ســرعة وسهولة ومرونة البناء في وقت بناء أسرع بكثير عند مقارنتها مع الطوب الإسمنتي.

• طوبــة الجبس عبارة عن مــادة بناء ضخمة الكتلةوخفيفة الوزن تســتخدم لبنــاء جدران داخلية مقاومة للحريق وغير حاملة وخفيفة الوزن مقارنة بأنظمة الجدران التقليدية الأخرى.

• نظام تقطيع الجدران الذي يتم تشكيله بواسطة DKG Gypsum Blocks هو نظام جدران مستمر ويمكنه بناء لوحة حائط كاملة متجانسة.

• طــوب DKG عبارة عن كتل جبســية مجوفة، والتي تتضمن تجويفًا مُشــكلًا مســبقًا مما يجعل التعامل مع الأنظمة الميكانيكية والكهربائية وأنظمة الســباكة أســهل وأسرع. في حين أن كلا السطحين من طوب DKG موحد اللون وسلس، فإن جوانب الطوبة لها ألسنة وأخاديد الأمر الذي يمنح الطوبة طابع الترابط العالي.

• علاوة على ذلك، فإن طوب DKG عبارة عن كتل ضخمة بســبب سمكها (60 ملم و 100 ملم و 150 ملم) وتجمع بين أفضل بنية صلبة قوية وبنية خفيفة الوزن للجدران الجافة تتميز بقوة إنحناء مثالية. بمجرد النظر إليها من هذا المنظور، فإن طوب DKG يعتبر حل بناء اقتصادي فريد من نوعه.

• على الصعيد العالمي، يتم استخدام طوب الجبس كبديل للجدران الخرسانية والقصارة التقليدية، مــا يوفر أداءً عاليًا من حيث الخصائص الصحية والعزل الحــراري والحماية من الحرائق، والتي تعد الأفضل لرفاهية الموطن والبيئة.

• فــي عملية إنتــاج المنتجات المحددة من طوب DKG الجبســي يتــم اتباع المعايير الدولــية الهندسية المهنية BS EN 12859: 2011 و BS EN 12860 والمعايير المحلية المكافئة لهما.

لماذا طوب DKG الجبسي؟

توفير التكلفة

• نظرًا للسطح الأملس والموحد للطوب الجبسي ودقة الأبعاد العالية، لا يلزم القيام بأعمال التجصيص قبل تطبيق الطلاء أو مواد التشطيب الأخرى. وبالتالي، فإن استخدام طوب DKG الجبسي يعتبر طريقة بناء جافة.

• كل ما هو مطلوب بعد الانتهاء من بناء الجدار الجاف هو طبقة رقيقة من المعجون على سطح الجدار بالكامل لجعله جاهزًا للطلاء أو لتثبيت ورق الجدران أو بلاط السيراميك، بينما يتطلب بناء الجدران بواسطة الطوب التقليدي أو الخرسانة التجصيص والتمليس الذي يزيد من تكاليف البناء.

• بالإضافة إلى ذلك، فإن مستوى صيانة طوب DKG منخفض بسبب التخلص من الحاجة لإستخدام أي بنية هيكلية تحتية مثل الشبكة المعدنية أو الخشب أو تقوية الحديد.

ومن ثم فإن استخدام طوب DKG الجبسي
يسمح بتوفير كبير في التكاليف من حيث المواد والعمالة مما يؤدي إلى الانتهاء المبكر من المباني وشغلها.

توفير الوقت

• تركيب طوب DKG سهل ومرن وسريع (كل ثلاث طوبات سماكة 60 ملم أو 100 ملم تساوي 1م2 ؛ وكل أربع طوبات سماكة 150 مم تساوي 1م2).

• نظرًا للسطح الأملس لطوب DKG، لا يلزم التجصيص، وبالتالي لا توجد حاجة لأعمال حرفية رطبة على عكس أنظمة جدار الطوب البديلة الأخرى التي قد تستغرق وقتًا طويلاً للتجفيف.

• الجدران الفاصلة المصنوعة من طوب DKG ليس لها متطلبات على البناء الحامل.

• لا تتطلب الجدران المتجانسة والمستقرة جدًا المصنوعة من طوب DKG بنية أساسية معدنية كدعامة.

• تستخدم الأسكفيات (العتبات) في فتحات النوافذ والأبواب. أثناء البناء، لا يلزم سوى دعم أسكفية مجلفنة للطوب فوق الفتحة. يجب أن تستقر الأسكفية الموضوعة فوق الفتحة 20 سم على الأقل على كتل الطوب الموجودة على جانبي الفتحة.

• يمكن كذلك عمل الفتحات بسهولة باستخدام منشار يدوي أو آلي بأي شكل أيضًا بعد بناء طوب DKG.

الـــوزن الخفيف

• نظرًا للخصائص الخفيفة لمادة الجبس، يوفر طوب DKG الجبســي نظامًا يقلل من الوقت وتكلفة النقل.

• كما أنه يمنح المهندس فرصة لتقليل الحمل الإنشائي عند تصميم المبنى.

• مقارنــةً بالطوب الإســمنتي، فإن طوب DKG الجبســي أخف بنســبة 60٪ تقريبًا دون المساومة على ثباتها وقوتها، مما يؤدي إلى توفير تكاليف الحديد الإنشائي والأساسات الخرسانية.

الـــعزل الحراري /فعالية الطاقة

• يعــد العزل الحراري من أهم العوامل عند اتخاذ قرار اختيار مواد البناء لتقليل اســتهلاك الطاقة وتكاليفها.

• يتمتع الجبس، بسبب هيكله المســامي، بالقدرة على امتصاص الرطوبة، وبالتالي فإن طوب DKG الجبسي يعتبر مادة بناء موفرة للطاقة عند مقارنتها بالمواد الأخرى.

• الموصليــة الحرارية للطوب الجبســي هي فقط ثلث تلك الخاصــة بالطوب الأحمر أو الطوب الإسمنتي.

• البيئة الرطبة التي عادة تكون على الأســطح المبنية من الطوب الإســمنتي والجدران الخرســانية، والتي تســمح بتطــور الفطريات، قد تنتــج بكتيريا وتطلــق مركبات عضوية متطايرة. عندما لا يكون العزل الحراري جيدًا بما فيه الكفاية، فإن الرطوبة الممتصة في الجدران الإسمنتية قد تسبب الفطريات وتعرض الناس لخطر متزايد من المشاكل الصحية. إلــى جانب المشــكلات الصحية، في الحالات الشــديدة، يجب اســتبدال أجــزاء الجدار الإســمنتي التي نما عليها الفطر، مما يتطلب تكاليف إضافية. طوب DKG الجبسي يوفر حلاً آمناً وفعالاً لمثل هذه المخاطر.

• بفضل ميزات التوصيل الحراري الممتازة، يعمل طوب DKG الجبسي على تقليل تكاليف الطاقة من خلال تمكين تقليل اســتهلاك الطاقة ســواء في تدفئــة الأماكن أو تكييف الهــواء من خلال قدرته على تقليل فقد الطاقة في الشــتاء وارتفــاع درجة الحرارة في الصيف وبالتالي تقليل انتقال الحرارة بين بيئتين بدرجات حرارة مختلفة. والنتيجة هي زيادة كفاءة استخدام الطاقة في المباني، وتحقيق وفورات كبيرة في تكاليف الطاقة.

• و عليه ، فإن طوب DKG الجبســي هو خيار صديق للبيئة وجذاب للمستخدمين النهائيين للمباني عند اكتمال البناء.

تنظيم الرطوبة النسبية

• نظـرًا لطبيعته والمسـامية العاليـة لمعدن الجبـس، يمكن للمادة أن تمتـص الرطوبة الموجـودة في الهواء عندما تكـون الرطوبة عالية (كما هو الحال فـي أجزاء من بلادنا) ويمكن ويمكـن أن تطلقها في بيئة جافة. ومن ثم يعمل طوب DKG الجبسـي كمنظم للرطوبة من أجل بيئة صحية تسهم في تحقيق جودة المعيشة.

• عـلاوة على ذلك، يمكن تجنب تكثف المياه علـى الجدران في الغرف والمناطق الرطبة عند استخدام طوب DKG الجبسي.

مقاومة الحريق

• طوب DKG الجبسـي غير قابل للاشتعال تمامًا ومقاوم للحريق. على هذا النحو، لا ينتج طوب DKG الجبسي أبخرة ولا تنبعث منه ملوثات أثناء الاحتراق.

• بما أن المياه المخزنة في الجبس تشـكل حوالي 21٪ من تركيبته، فإنه يعتبر مادة بناء مناسـبة للحماية مـن الحرائق. تتبخر بلورات الماء في حالة نشـوب حريق، مما يقلل من انتشار الحريق.

• نظـرًا لخصائصها المقاومة للحريق التي تقلل من المخاطـر على مكونات نظام الجدار والأنابيـب والتركيبـات الأخرى، يعتبـر طوب DKG الجبسـي بمثابة مادة بنـاء مثالية للاستخدام في المباني التي تتطلب حلول مقاومة للحريق. من أجل تحقيق نفس الأداء مع الطوب الأسمنتي التقليدي، يجب أن يكون نظام الجدار الخرساني أكثر سماكة.

• مـن الواضح أيضًا أن طوب الجبس هو الخيـار الطبيعي لجدران المناور. حيث يمكن بناء المناور بدون هياكل أساسـية خاصة والعمل الذي يسـتغرق وقتًـا طويلاً على الجوانب الداخلية التي يصعب الوصول إليها.

• تختبر اختبارات الاسـتجابة للحريق كيفية تصرف المواد المختلفة أثناء الحريق من حيث انبعاث المواد السامة ودرجة القابلية للاشتعال ودرجة كثافة الدخان والمزيد.

• يقاوم طوب DKG الجبسي الحريق لمدة لا تقل عن 120 دقيقة.

المرونة

• سواء بالموازاة مع بناء الهيكل أو قبل وقت قصير من الانتهاء من إنشاء المبنى: يمكن دمج طوب DKG الجبسي بسلاسة في عملية البناء في أي وقت.

• لا يتعــارض أو يتداخل طوب DKG الجبســي مع تمديدات التدفئــة أو الكهرباء. بل من السهل إلى حد ما العمل مع طوب DKG الجبسي حيث يمكن دمجها في أي شكل من أشكال التركيب الغير منتظم أو الدقيق.

• مع مراعاة القيود على درجات الحرارة الدنيا والقصوى على استخدامات الغراء الجبسي كما يحددها المنتِج ، ونظرًا لأن طوب DKG الجبسي يستخدم فقط للجدران الداخلية،لذلك فإن الظروف الجوية في بلادنا لا تؤثر في إستخدامه بشكل عام.

• القواطع المصنوعة من طوب DKG الجبســي تتيح إنشاء مساحة فعالة وعالية الجودة في المباني السكنية والتجارية مع أقصى قدر من المرونة في تصميم المساحة الداخلية دون الإضرار بالأرضيات (الحالية). يوفر هذا مزيدًا من المرونة في التحديد المتأخر لتقســيم المساحة أثناء عملية البناء.

• يمكن وضع طوب DKG الجبسي مباشرة على الأرضيات الموجودة أو فوق الصف الأول من الطوب الأسمنتي (مفصولة بشريط من الفلين / شريط عزل).

• تتيح طريقة التركيب المرن لـطوب DKG الجبسي أيضًا إمكانية بناء قواطع دون الحاجة إلى ســكك حديدية، حيث يمكن وضــع الكتل فوق الأرضيات الموجودة وتظل ســليمة ومحمية.

• إزالة القواطع بســبب التغييرات في تقسيم تصميم المساحة الداخلية يتم أيضًا بسهولة وبسرعة عن طريق تفكيك طوب DKG الجبسي دون إتلاف الأرضيات.

• نظرًا للوزن الخفيف لطوب DKG الجبسي، فإن إنشاء فتحات الأبواب والنوافذ أمر بسيط وسهل. يتم استخدام أسكفية/عتبة مجلفنة لتثبيت الطوب فوق الفتحات.

• يمكن إعادة ترتيب فتحات الحائط في أي مكان وفي أي وقت، ويمكن توسيع فتحات الأبواب الحالية بســهولة. بعد كل شــيء، الجدران لها نفس الخصائص من حيث مساحة السطح والمقطع العرضي.

• على جدار طوب DKGالجبسي، حتى أحمال الكونسول الأثقل يتم تثبيتها بمقابس حائط عادية/قياسية.

• من الســهل للغاية إصلاح طوب DKG الجبســي: يتكامل جــص DKG والغراء تمامًا في مكون المبنى، ويتكيف معجون السطح مع الأسطح بشكل مثالي.

• أخيرًا وليس آخرًا، ينتج عن الجدران الفاصلة الرفيعة من طوب DKG الجبسي مساحة أكثر فاعلية ومساحة وحيز قابل للبيع.

• باختصار، لا يرتب طوب DKG الجبســي متطلبات كبيرة على البنائين والمستخدمين - إن عمليــة التثبيــت والإصلاح والفتح بســيطة ولا تتطلب درجة عالية مــن الخبرة من فنيي الخدمة.

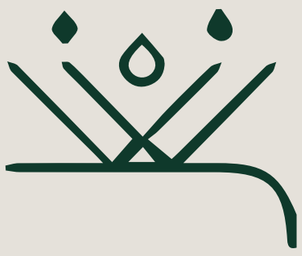
إعـــادة التدوير

• يمكن تفكيك طوب DKG الجبســي ببساطة عن طريق نشر وقطع لوح الحائط إلى حجم الطوبة المطلوب دون الإضرار بركيزة هيكل المبنى المتبقية.

• يمكن بعد ذلك إعادة استخدام الطوب المقصوص لبناء جدار جديد باستخدام غراء DKG أو يمكن طحنها وتحويلها إلى مســحوق جبس لاستخدامها مرة أخرى في تصنيع قطع طوب جديدة.

نظــرًا للتخلص من الشــبكة المعدنية أو التجصيص أو تقوية الفــولاذ ، يمكن هدم الطوب وإعادة تدويره بســرعة دون التســبب في أي مخلفات/نفايات (طوب DKG الجبسي يعتبر منتج خالٍ من النفايات).

مقاوم للماء



• يتطلب بناء الغرف الرطبة اســتخدام مواد مناسبة وعالية الجودة من أجل منع أي خطر على صحة السكان وإلحاق الضرر بالممتلكات بأكملها.

• في الحمامات والمراحيض وحتــى المطابخ يمكن أن يظهر تكثف المياه على الجدران والســقف. يتم امتصاص هذه الرطوبة من خلال الجص إلى لبنــة البناء ويمكن أن تتلف الأنظمة المختلفة بالداخل.

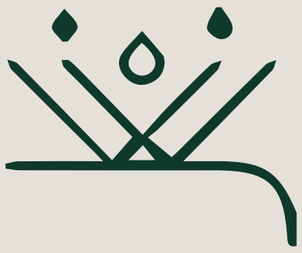
• يمكــن أن تتســبب الرطوبة أيضًا فــي انفلات/انفصال البلاط مــن الحائط ، مما يجعل استبداله مكلفًا ومعقدًا.

• بالنســبة للمســاحات الرطبة، تنتج DKG طوب جبســي مقاوم للماء (100 ملم و 150 ملم)، والتي تستخدم لبناء القواطع في المناطق الرطبة من المبنى.

• نظــرًا لطريقة الإنتاج المقاوم للماء هذه، فإن طوب DKG الجبســي تعتبر مقاوم للماء دون الحاجــة إلــى أي متطلبــات عزل/إحــكام إضافي/ة، ممــا يقلل من وقــت البناء والتكاليف.

• عند نقع طوب DKG الجبســي في الماء لمدة ســاعتين، يكون متوسط امتصاص الماء حوالــي 2.5٪ وفي جميع الحالات أقل مــن 5٪ وهو ما يصل إلى المعايير الدولية ذات العلاقة.

مقاوم للماء



• في حالة حــدوث عطل في الأنبوب، فإن معالجة طــوب DKG الجبس المقاوم للماء ستكون سهلة ورشــيقة. في مثل هذه الحالة، لن يتم امتصاص الرطوبة أو انتشارها إلى أماكن أخرى. سيتم تحديد إنتشار بقعة الرطوبة، لذلك سيتركز الإصلاح على مكان البقعة فقط.

• تختفي ظاهرة التكثيف بســهولة في الغرف والقواطع المبنية باستخدام طوب DKG الجبسي المقاوم للماء.

• أيضًا، تخلق الرطوبة المتراكمة بقعًا رطبة وفطرية، وهذه تشــكل تهديدًا حقيقيًا لصحة الســكان حيث تطلق الفطريات جراثيم مجهرية يمكن أن يتسبب استنشاقها في مشاكل شديدة في التنفس.

• بفضــل خصائصه الممتــازة في الظــروف الرطبة، فإن طوب DKG الجبســي هو حل مناســب للبناء الخفيف - ليست هناك حاجة لاســتخدام مواد منع التسرب على الجدران، حيث يتفاعل الطوب بشــكل مستقل مع مســتويات الرطوبة ويمنع ظهور التأثيرات غير المرغوب فيها والمخاطر.

• يمكن أيضًا لصق البلاط مباشرة على طوب DKG الجبسي المقاوم للماء دون أي أعمال إضافية.

• لذلك ، فإن استخدام طوب DKG الجبسي يقلل التكاليف ووقت البناء بشكل كبير.

عـــزل الصوت

- الجبس مادة مسامية بشكل طبيعي تسمح بامتصاص الضوضاء.

- يوفر نظام الجدران من طوب DKG الجبسي عزلًا للصوت، حيزاً هادئاً وجودة الحياة.

- تضمــن الكثافة المُقاســة لطوب DKG الجبســي تقليــل الضوضاء مقارنــةً بالقواطع التقليدية.

- يخدم طوب DKG الجبسي صناعة البناء كأداة ممتازة للعزل الصوتي.

- يقلل استخدام نظام الجدران والقواطع بواسطة طوب DKG الجبسي من تكاليف العزل الصوتــي للمشــروع إلى حــد كبير ويضمــن جودة عزل صوتــي عالية مقارنــة بالطوب الإسمنتي وجدران الخرسانة العادية.

- يمكن اســتخدام طوب DKG الجبسي كعازل صوتي حتى في المساحات الكبيرة حيث يكون امتصاص الصدى ضروريًا (مراكز التسوق والجامعات وما إلى ذلك):

- أظهرت الدراسات أن التعرض للصدى أثناء محاضرة جامعية يسبب شعورًا بالإرهاق لدى المستمعين بسبب جهودهم في التمييز بين الصوت والصدى.

- ينطبق الشــيء نفسه على أماكن العمل حيث يعمل العديد من الأشخاص في مساحة مشــتركة كبيرة: تنخفض إنتاجية الموظفين بشــكل كبير حيث يســعون جاهدين لتحديد الصوت الذي يريدونه بين الضوضاء والأصداء الأخرى (محادثة مع زميل ، مكالمات هاتفية ، إلخ)

وبالتالي، فإن استخدام طوب DKG الجبسي يحسن القيمة الصوتية ويوفر استجابة جيدة لامتصاص الصدى ، بحيث يمكنك الاســتماع بحرية إلى محاضرة أو العمل أو قضاء الوقت في مجمع التسوق دون المعاناة من ضوضاء الخلفية.

صديق للبيئة

• يحتوى مســحوق الجبس على كبريتات الكالســيوم والماء وهى المادة الاساسية التى تســتخدم فى صناعة طوب DKG الجبسي. مسحوق الجبس غير سام للإنسان والبيئة. لذلك، فإن استخدام طوب الجبس هو خطوة ذكية كحل بناء صديق للبيئة.

• يضمن طوب DKG الجبســي بناءًا ســهلًا ودائمًا دون التسبب في النفايات الملوثة التي تنتج عادةً من التجصيص عند استخدام الطوب الأسمنتي.

• تساهم خاصية العزل الحراري للجبس بفاعلية في تقليل استخدام أجهزة التكييف وأجهزة التهوية والســخانات في المبنى مما يؤدي إلى تقليل انبعاثات ثاني أكسيد الكربون التي تؤدي إلى الاحتباس الحراري.

• الفورمالديهايد مركب يحمل الصيغة الكيميائية بالرمز CH_2O المركب النقي عبارة عن غاز عديم اللون ذو رائحة نفاذة يتبلمر تلقائيًا إلى بارافورمالدهيد ، وبالتالي يتم تخزينه كمحلول مائــي. يمكن أن يكون تنــاول الفورمالديهايــد قاتلاً ، والتعرض طويل الأمد لمســتويات منخفضة منه في الهواء أو على الجلد يمكن أن يســبب مشاكل تنفسية تشبه الربو وتهيج الجلــد مثل التهاب الجلد والحكــة. تركيز 100 جزء في المليون تشــكل خطرا على الحياة والصحة.

• الجبــس هو أحد أفضل حلول مواد البنــاء لأنظمة جودة الهواء الداخلي الذي يخلق بيئة داخلية أكثــر صحة عن طريق إزالة حوالي 70٪ مــن الفورمالديهايد داخل المبنى. الجبس يلتقــط المواد الضارة داخل المباني ويحولها إلى مركب خامل، مما يحســن جودة الهواء داخل المباني.

• أصبح طوب الجبس المســتخدم في صناعة البنــاء بمثابة الخلفية الضرورية لمكان العيش المستدام.

• تماشــياً مع طموح DKG فــي أن تصبح النقطــة المرجعية في فلســطين لبيئة العيش المســتدامة، تقوم DKG بتطوير حلول مبتكرة وفعالــة للمباني الداخلية، مراعية في ذلك تقليل الأثر السلبي الصحي والبيئي لمنتجات وأنظمة DKG في كل مرحلة من مراحل دورة حياتها.

• مبــادئ DKG واضحة: تحقيــق توفير في الطاقــة والمواد الخام، وعــدم تلويث البيئة، واســتخدام المواد الاســتهلاكية والمواد الفعالة من حيث التكلفة وتقليل النفايات أثناء البناء وبعده.

• بالإضافــة إلى قدرتها على الامتثال للمعايير الحاليــة للمباني الخضراء، فإن اطوب DKG الجبسي ومنتجات الجبس الأخرى مفضلة بيئيًا وتتمتع بدرجة عالية من الكفاءة الاقتصادية المكتسبة من خلال عمرها الطويل الأجل.

ملاطة / قصارة الجبس مقارنة مع ملاطة / قصارة الإسمنت:

قصارة الجبس	قصارة الإسمنت
تقلل الحمل على المبنى	تزيد الحمل على المبنى
يتطلب وقت إعداد أقل	تتطلب وقت إعداد أطول
تقلل من تكلفة المشروع	تزيد من تكلفة المشروع
أقل من تكلفة قصارة الإسمنت	أكثر من تكلفة قصارة الجبس
منتج بناء أخضر (منتج صديق للبيئة)	ليس منتج بناء أخصر (منتج غير صديق للبيئة)
ينتج عن إستعمالها حيز أكبر وأكثر جمالاً	ينتج عن إستعمالها حيز أصغر غير جذّاب
تتكون فقط من مادة الجبس	تتكون من الرمل، الإسمنت والماء
يمكن إستخدامها للأسقف والجدران الداخلية	يمكن إستخدامها للمسطحات الداخلية والخارجية
قصارة مضادة للفطريات	غير آمنة من الفطريات
يمكن تطبيقها على الأسطح الملساء والأسطح الخشنة	لا يمكن تطبيقها على الأسطح الملساء
تنتج أسطح ملساء جداً وجاهزة للدهان	تنتج أسطح خشنة غير جاهزة للدهان
فاقد/هدر معتدل/قليل	فاقد/هدر عالي
تمنع التشققات	يمكن أن ينتج عنها تشققات
لا تحتاج وقت للمعالجة/الجفاف	تحتاج إلى وقت ما قبل المعالجة وما بعد المعالجة
تعمل كحاجز وتحمي الطوب والخرسانة والحديد	في حال الحرق، لا تحمي الطوب، الخرسانة أو الحديد
عامل مثالي للوقاية من الصدأ	ليست مانع للصدأ
مخلوط مسبقًا، وبالتالي دقيق، مما يؤدي إلى إهدار أقل للوقت والعمالة والمواد	يتم إجراء الخلط في الموقع بنسب محددة بواسطة العمالة غير الماهرة، وبالتالي فهي غير دقيقة
يوفر تشطيبات داخلية ناعمة للسقف والجدران ويشكل خلفية مثالية للدهانات وورق الحائط عالي الجودة	مطلوب استخدام المعجونة / التسوية من أجل تشطيب السطح بشكل أفضل ومستوي لتلقي الطلاء

استخدامات وتطبيقات طوب DKG جبسي

المباني السكنية	
المكاتب	
تجاري ومحلات التجزئة	
المرافق الصحية	
المرافق التعليمية	
المرافق الترفيهية	
المباني الصناعية	
أخرى	

نطاق منتجات DKG:

• طــوب DKG بســيط - لا يحتاج بناء الجدار إلا إلــى عدد قليل من المكونــات لتثبيتها بالأرضيات والجدران الجانبية وأســقف الجدران الخرسانية. يتم تصنيع طوب DKG عالية الجودة بأنواع وأحجام مختلفة.

• يتوفر كذلك غراء DKG الجبســي، وشــريط مرن وفليــن لعزل الصوت ومقاومة تســرب الماء، ومعجون لتشطيب الأسطح بواسطة DKG.

• يعتبر طوب DKG الطريقة الأكثر اقتصاداً لإنشــاء مساحات معاصرة عند الأخذ بعين الإعتبار نظم الجدران الآخرى المتاحة.

• لا يتطلب طوب DKG الجبســي أي بنية تحتية داعمة مثل مواد التقوية الفولاذية أو التجصيص التي تزيد من تكاليف البناء.

الجدول التالي يلخص نطاق المنتجات التي تقدمها DKG:

المنتج	الطول(ملم)		العرض/الارتفاع(ملم)		السماكة(ملم)	
	صلب	مفرغ	صلب	مفرغ	صلب	مفرغ
DKG Gypsum Blocks						
Normal 100 mm	667	667	500	500	100	100
Water-Repellent 100 mm	667	667	500	500	100	100
Normal 150 mm	555	555	450	450	150	150
Water-Repellent 150 mm	555	555	450	450	150	150
Mortars	**Weight (kg per Bag/Barrel)**					
Plain Construction Mortar	25					
Waterproof Construction Mortar	25					
Plain Repairs Mortar	25					
Waterproof Repairs Mortar	25					
Plain Smoothening/Finishing Mortar	25					
Waterproof Smoothening/Finishing Mortar	25					
Putty – Magic Bond®/Shpachtel	28					
Ready Tiles Glue	20					
Powder Tiles Glue	20					
Plastering Gypsum Glue for Cement Surfaces	25					
Accessories						
Floor Sealing Strip	Linear Meter					
Flat Ceiling & Walls Sealing Strip	Linear Meter					
Lintels	Linear Meter					
Polytan Foam	Can					
Fixing Angels & Screws	Units/ No.					

For more information, please contact:

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