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Formulation of a Net Zero Assessment System for Healthcare Facilities

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Abstract

The international efforts to limit climate change are increasing, that during the COP26 convention, reaching Net Zero Greenhouse Gas emissions became part of the global goals for many countries and entities. One of the sectors that holds the responsibility of addressing the impacts of climate change is the healthcare sector, and accordingly, it is also encouraged to take a leading role in maintaining its sustainability and be a role model for the other sectors. Additionally, the buildings sector, through the World Green Building council, has taken the initiative to launch the Net Zero Carbon Buildings Commitment for the sector. Based on these practices, the work presented aims to introduce and formulate an Approaching Net Zero assessment methodology to be integrated as part of the sustainability criteria and rating system for healthcare facilities in developing countries. The methodology planned is based on four different aspects which are: 1) Approaching Net Zero Energy, 2) Approaching Net Zero Wastewater, 3) Approaching Net Zero Solid Waste, and 4) Approaching Net Zero GHG emissions. The facility should have achieved a Green Building certification through any certification body, and then apply for the aspect on which it requires to be assessed. The assessment methodology follows a systematic approach, where a baseline year of normal operation is determined for existing facilities to act as a base of assessment, and normal design practices for new facilities Based on the assessment and proof of performance enhancement, the facility will either be awarded a basic certificate for achieving continuous savings, or additionally be awarded a best performance certificate compared to other facilities in the same category.

Keywords

Healthcare Facilities, Sustainability, Net Zero Concept, Water Efficiency, Energy Efficiency, Cradle-to-Cradle/Waste Reduction, GHG Emissions

1. Introduction

One of the most critical and sought after services globally nowadays is the health service, which became an essential part of the wellbeing of all communities, especially with the UN Sustainable Development Goals (SDG) dedicating a separate goal for this end which is Goal 3: Global Health and Well-being. Moreover, in the wake of the COVID-19 pandemic, the healthcare sector has been required to further advance the service provided to respond to the consequences, which caused both an increase of healthcare expenditure and a contraction in the global economy. During the year 2020, which represents the first year of the pandemic, the global healthcare expenditure reached almost US $9 trillion representing 10.8% of the Global GDP, with an increase of US $0.5 trillion over the previous years' numbers, while the global GDP decreased by 3.4% compared to the previous year (WHO (World Health Organization), 2022a).

The negative health impacts related to climate change are increasing, with the low-and middle-income countries being the most impacted by this change. According to the World Health Organization (WHO) estimates: between the years 2030 and 2050, climate change has the potential to cause an additional 250,000 deaths/year and that the corresponding relief healthcare cost is estimated to increase by 2 - 4 billion dollar/year by the year 2030 (The World Bank, 2017).

In general, the buildings sector's estimated contribution in Greenhouse Gas (GHG) emissions in the year 2022 was about 8.5% of the global emissions (2.9 Gigatons out of 33.9 Gt Total CO_2e emissions), and an estimated share of 40% of the energy-related emissions in 2022 (IEA (International Energy Agency), 2021). While specifically, the healthcare sector's share of global emissions through a report by Health Care Without Harm (HCWH) to be 4.4% of the global emissions (2 Gigatons CO_2e) based on 2014 data, with emissions directly attributed to healthcare facilities and the indirect energy use makeup 29% of the emissions and the rest come from the related supply change, services, and disposal of goods (Health Care Without Harm et al., 2019b).

To limit the climate change impacts, a continuous global effort has been exerted, starting with the Paris agreement (COP21 in 2015) where a census was reached to maintain the rise in temperature well below 2˚C, and an aim to limit the increase to 1.5˚C of the pre-industrial levels (European Commission, 2015). An agreement that was renewed by the world leaders, especially with the studies reporting an actual increase already estimated at 1.2˚C by the end of 2021 (Climate Action Tracker, 2021). Later, during the COP26 summit in Glasgow (2021), the international agreement to maintain the 1.5 degrees limit by 2050 through promoting net zero emissions was renewed (UK Government & United Nations Climate Change, n.d.). Accordingly, several countries have already announced their net zero commitments, with an encouragement from the UN for individual investors, businesses, cities, and regions to join in the efforts to reach the goal (UN (United Nations), n.d.).

One of the sectors that took a major step is the COP26 Health Programme that was promoted to be Alliance for Transformative Action on Climate and Health (ATACH), with the aim that it should work on supporting countries to develop and implement two main commitments: the first is a climate resilient health system; and the second is a sustainable low carbon health system. In other words: achieving Net Zero health system emissions from the high ambition and high emitter countries, including the supply chain, targeted by 2050, and for all countries to develop a baseline assessment and a low carbon action plan (WHO (World Health Organization), 2021b, 2022b).

Furthermore, the COP27 which took place in Sharm El-Shiekh during November 2022 accomplished several general climate change achievements, including the emphasis given to the development of a "Global Climate Observing System". Also, for the first time, an agreement was reached for the development of a loss and damage fund which aims to the protection of the most vulnerable of the population and their ecosystems as well, which is considered one of the greatest achievements of the conference (UNFCCC (United Nations Framework Convention on Climate Change) & UN (United Nations), 2022; UNFCCC (United Nations Framework Convention on Climate Change), 2022). In specific, related to the healthcare sector, a number of negotiation panels were held to further coordinate the role of ATACH, highlight the negative impacts of temperature rise and pollution on the human health, encourage the capacity building of health professionals regarding climate change, and discuss the methods of achieving low carbon sector advancements in the Middle East and Africa regions (WHO (World Health Organization), 2022c).

Early on, as a driver for climate change response actions, the building sector represented by the World Green Building Council (World GBC) initiated the Advancing Net Zero global project in 2016, with the aim of neutralizing carbon emissions from new buildings by 2030 and from all buildings by 2050 (World Green Building Council, 2016). Then in 2018, the Net Zero Carbon Buildings Commitment, was also launched as a step towards recognizing the role of leadership required by the building and construction sector and invited all the sector's key players to sign (World Green Building Council, n.d.).

As the healthcare sector is recognized to be the main respondent to climate change health impacts, it was assigned a leading position to be a role model for other sectors in reducing the climate footprint (Watts et al., 2019). One of the initiatives started by the UNFCCC is the "Race to Zero" that aims to bring other actors other than the United States on board during the race to zero, including the healthcare sector and the building sectors (UNFCCC, n.d.). While the WHO published a number of leading guidelines that aim to support the healthcare facilities towards a more climate resistant operation, as part of the operation and preparedness to face climate impact related emergencies as well as decreasing the related impacts from operation (WHO (World Health Organization), 2015, 2020, 2021a).

Following suite of the international direction of supporting the healthcare sector to achieve net zero carbon emissions, the aim of this work is to develop a systematic approach that can be followed to encourage the application of net zero concept in Egypt as a case study for middle income countries with a growing healthcare sector. In this regard, this work formulates a methodology that can be followed to quantify, assess, and reward the efforts done by healthcare facilities to approach net zero for different operational parameters, namely: energy, water, waste and finally greenhouse gas emissions. The achievement of these reductions will build on the implementation of sustainability criterion that was formulated through previous work as a start and additionally, the innovative ideas that shall emerge from the facilities' operations.

To act as a base of the Net Zero methodology preparation, the following sections will discuss the methodology followed by a number of international Green Building Councils for the calculation and reward of Net Zero performance. Additionally, some basic healthcare facilities sustainability criteria can be used as a roadmap for actions to be implemented in to reach Net Zero design or operation in developing countries. Then finally the main focus of the work is presented as the methodology that is formulated to assess and reward the results achieved upon the implementation of the different actions that target reaching a Net Zero facility for the four aspects targeted which are energy, wastewater, solid waste and finally the overall GHG emissions.

2. Net Zero Guidelines Worldwide

To act as a base for the net zero calculation and assessment methodology, international systems are consulted as a reference. For example, considering the building sector in general, several Green Building Councils have joined in the Net Zero Carbon buildings commitment that was initiated by the WGBC. They started their efforts in working in this framework, as buildings are considered one of the major sectors affecting the road Net Zero energy. The built floor area is expected to increase by 75% from 2020 to 2050, with most of this addition in developing countries (IEA (International Energy Agency), 2021). Examples of the countries that are currently signatory include: the US, UK, Canada, Germany, Australia, Jordan, United Arab Emirates, Kenya, and Egypt among others (WGBC, n.d.-b). The efforts done by the different GBCs varied between integrating the Net Zero in their rating systems, adding additional criteria for Carbon Neutrality, formulating strategies and guidelines towards achieving the Net Zero goal, and supporting companies to join the commitment as well (WGBC, n.d.-a).

Different GBCs developed assessment and reward tools, including the USGBC that assess Carbon neutrality through the published LEED Zero Program Guide in April of 2020, is applicable to currently LEED certified buildings, and requiring that these buildings submit Net zero achievement proofs in one or more of the following areas: Carbon, Energy, Water and/or waste, whichever is achieved by the building at the time of application (USGBC, 2020).

Moreover, the UKGBC has published Net Zero Carbon Building Framework in August 2020, with the implementation scope divided between new construction and operational buildings. It is mainly focused on the actual construction and operation related carbon emissions and excluding the embedded materials emissions and end of life disposal for the current application scope. The UKGBC methodology for new constructions can be summarized as: reduction of the construction impacts and embodied carbon from the materials used in new buildings and major renovations to the extent possible, followed by an offset of the remaining balance through reduction or trading techniques according to the choice of the facility management. While for operational buildings, the major focus is the reduction of operational energy followed by utilizing renewable energy on-site and off-site, followed by an offset of the remaining balance. The assessment and reward standard requires the energy consumption and offset amounts to be publicly disclosed on annual basis (UKGBC, 2020).

The German Sustainable Building Council (DGNB), which is one of the Green Buildings rating systems that follows the cradle-to-cradle concept of assessment, has additionally developed a dedicated Framework for Carbon neutral buildings and sites with the aim to reach carbon neutral buildings by 2050. The first version was published in 2018, and the current version was updated in August 2020. Additionally, the climate actions were incorporated into the DNGB criteria version updated in 2020, through which buildings operating in carbon neutrality mode are awarded a Climate Positive award, that is obtained in addition to the DGNB certificate of performance. The award can be obtained by all existing buildings for all uses based on the performance data evidence for a whole year of operation (DNGB (German Sustainable Building Council), 2022a, 2022b).

In general, it was found that the Net Zero Concept was interpreted differently by the different assessors in accordance with what is viewed suitable to their specific rating system in order for the assessment criteria to be measurable. The areas which are covered by the concept are categorized as a combination of the following: net zero energy, net zero water, net zero waste, and/or net zero carbon, in other words: carbon neutrality. For all these categories, the Net Zero Concept requires that either the consumption of the building be equal to the production, or, that the facility offset the excess in one of the methods accepted by the assessor.

Additionally, the discussed Net Zero rating and award systems, as well as others developed in several countries, are based on the concept of the facility applying a green building or sustainability rating system as a first step of achieving the performance targets. Therefore, it is recommended that healthcare facilities as well consult sustainability guidelines and rating systems, which are reviewed next in brief, to form a guidance for the required actions for implementation, especially for developing countries where the know-how is still being developed and updated.

3. Integrating the Net Zero Concept in Sustainability Rating System

To follow suit the international guidelines and offer applicable action criteria for healthcare facilities to achieve Net Zero, the work methodology presented through the current work is a continuation of the previously prepared sustainability criteria for new and existing facilities. These criteria are composed of a set of specific actions that the facilities can follow and apply as appropriate to its situation. The sustainability criteria were divided into three main categories: energy, water, and habitat, and additionally, overarching requirements as general prerequisites were included as a condition for the continuation of the assessment process for the rest of the categories. These prerequisites are the top management commitment and environmental management plan. Additionally, each of the three categories, forementioned, have prerequisites that should be fulfilled as well as a number of credit points that are awarded based on the action criteria specified, with the different weight of each category summarized in **Table 1**. The awardable levels suggested for the system were divided into four levels: Certified (40 - 49), Silver (50 - 59), Gold (60 - 69) and Platinum (≥70) (ElMitainy & El-Haggar, 2019).

Another important guidance document is the WHO guideline. It aims at promoting climate resilience, as well as environmental sustainability in healthcare facilities. This importance is rooted in the fact that the guidance document targets healthcare facilities of different sizes. This WHO guidelines mentions that healthcare systems, including the facilities are to strive to achieve net zero by 2050 or before, however, the guidelines are more focused on establishing the overall climate resilience system within the health ecosystem rather than formulating a net zero roadmap. The guidance documents focus on aspects such as: the workforce, infrastructure, technologies and products, energy, water resilience, hygiene, and finally healthcare waste (WHO (World Health Organization), 2020).

The following part discusses the work methodology that is suggested to be followed to promote the achievement of net zero as a concept for healthcare facilities in developing countries, with an example, in this case taken from the Egyptian context, and based on the existing international best practices.

Table 1. A summary of the healthcare facilities rating system suggested for Egypt (ElMitainy & El-Haggar, 2019).

Main Category	New Facilities		Existing Facilities	
	Prerequisites	Awardable Points	Prerequisites	Awardable Points
General Criteria	2	-	2	-
Energy	2	39	1	37
Water	1	18	1	18
Habitat	2	43	1	45
Total awardable points		100		100

4. Net Zero Concept Integration Methodology

The work suggested aims to approach three different specialized Net Zero Concepts which are: energy, wastewater, and solid waste, eventually striving towards Net Zero emissions in the facility using a step-by-step approach. Due to the differences in the actions that could be used to approach Net Zero in each of the four areas focused on, a general Net Zero Strategy shall be followed for assessing and rewarding the actions taken by the facilities (El-Haggar et al., 2015).

The Net Zero Strategy step-by-step approach that shall be followed is explained hereafter, and summarized in **Figure 1** below:

- As a first step, the facility applying for one or more net zero assessment(s) and award(s) should have achieved a certified level, at least, based on the sustainability criteria mentioned previously or any other Green Buildings rating system.
- The facility then shall identify and communicate the Net Zero area of intervention that it judges that savings have been achieved relative to the chosen baseline year, that is explained in the next step.
- An auditor or auditors' team (will be referred to as the auditor hereafter) will be assigned to the facility to support the data collection and consecutive calculations that shall be carried out as part of the assessment process and verify the accuracy of data collected.
- The auditor together with the facility representative will determine a baseline year of assessment; where this baseline year should represent a normal facility operation routine and contain almost all the equipment and facilities used in the consecutive years, therefore no major addition or removal should have occurred after the chosen year.

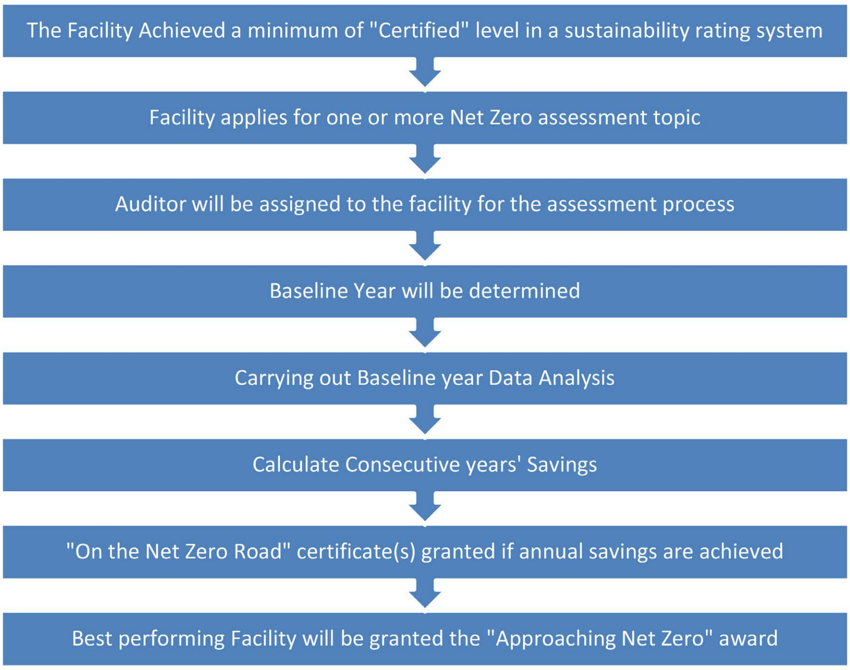

Figure 1. Net Zero Assessment methodology for the specialized concepts suggested.

- The next step will entail carrying out the baseline analysis that includes the details of the facility description, such as footprint area, as well as all the consumption or production of the available users in the baseline year. Based on the data collected, the baseline benchmark will be calculated for the whole facility.
- The same calculations will then be repeated for consecutive years which should include the savings that were achieved by the facility in the determined Net Zero Aspect.
- As a beginning, all facilities that successfully achieve annual savings will be awarded a certification under the title "On the Net Zero Road" in the specific aspect of assessment that was applied for.
- After several facilities have been assessed, and a database of consumption benchmarks (consumption per floor area or number of beds) are collected, the facilities can then be compared to each other in the specific Net Zero assessment topic, and an "Approaching Net Zero" award will be granted to the highest achievers.

In all cases, the most accurate information that represents the conditions of a certain country should consider categorization bases such as the type of facility (fully operating hospital, smaller service units, clinics, etc.), facility size, and the climate zone in which the facilities are located. To support the facilities with the process of Approaching Net Zero in the different areas of action targeted; several international best practices have been consulted and presented in the following parts, to act as preliminary guidance to the facilities in developing countries, until a more comprehensive database and best performance standards are obtained.

4.1. Approaching Net Zero Energy

It is important to note that healthcare facilities, especially hospitals, operate continuously throughout the day and nighttime, consuming electrical energy as well as fuels as part of its operation. For example, it was reported that hospitals in the US consumed 10% of the total energy consumed by commercial buildings although they represent only 4.2% of the total floor area surveyed in the year 2018; placed as the second higher energy consuming building usage. According to the survey, the reported energy consumption intensity as an average for inpatient and outpatient hospitals was 711.5 kWh/m^2; where the climatic regions requiring heating were reported to consume more fuel, while areas requiring cooling were reported to consume more electricity (U.S. Energy Information Administration & Commercial Buildings Energy Consumption Survey (CBECS), n.d.-b, 2021).

Data similar in nature, was reported for the Canadian commercial sector; where hospitals represented 2% of the floor area surveyed and contributed to 4.8% of the total energy consumption for the year 2008, with a reported energy intensity of 672.2 kWh/m^2 which was the second highest reported energy intensity after the food and beverage stores (Office of Energy Efficiency & Natural Resources Canada, 2013). Moreover, a study of the German hospitals that considered/calculated the correlation between energy consumption and several factors including the floor area, number of beds, number of workers, as well as the location and weather conditions has concluded that the average energy consumption for a German hospital is 270 kWh/m^2 (23,410 kWh/bed) (González et al., 2018).

Accordingly, and for comparison with other international facilities' performance, the benchmark for the approaching Net Zero energy is suggested to be the facility consumption of energy divided by the total facility floor area in kWh/m^2, or alternatively kWh/bed. The energy sources considered will be those acquired from outside the facility through public or private production companies, which will be affected by the energy efficiency actions that will result in savings. Additionally, onsite energy production—through the usage of renewable energy for example—will also be counted as a replacement of the conventional energy sources, given that these actions are carried out after the baseline year.

4.2. Approaching Net Zero Wastewater

The second aspect is wastewater, which is the final product that is emitted from any facility after the use of fresh water the drainage of the used water. The uses of fresh water inside healthcare facilities are generally a mixture of typical domestic-like uses such as cooking, cleaning, handwashing, and showering, in addition to other facility operation requirements that include laundry, steam generation for the operation of medical equipment, and other uses such as autoclaves operation for equipment and waste sterilization. Moreover, facilities with green areas use water for irrigation whether outdoors gardens, or smaller green areas integrated within the facilities. A typical division of water usage inside a fully operating hospital is shown in **Figure 2**, which is the result of surveying 7 hospitals in the U.S. (Massachusetts Water Resources Authority, n.d.).

Similar to energy consumption, water usage is correlated in literature to either the built floor area of a facility or the number of beds in a fully operating hospital. While the health centers' consumption is estimated based on the number of

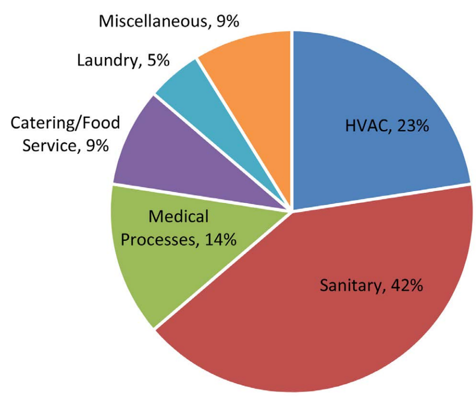

Figure 2. The distribution of water usage in a survey of 7 hospitals in the U.S. (Massachusetts Water Resources Authority, n.d.).

patients served. The average water consumption reported for inpatient health-care facilities in the U.S. was around 2 m^3/m^2 of built floor area in the year 2012 (U.S. Energy Information Administration & Commercial Buildings Energy Consumption Survey (CBECS), n.d.-a).

Another study conducted in Spain, included 13 public hospitals, resulted in a correlation between the facilities' cold and hot water consumptions as related to the built floor area as a first parameter and the number of beds as a second parameter, as both were found to be significant parameters. The water consumption considered in the study excluded the laundry facilities, and irrigation water for gardens. The average annual cold-water consumption based on the surveyed facilities was found to be 1.63 m^3/m^2 (262.8 m^3/bed) and the hot water consumption was valued at 0.59 m^3/m^2 (92.96 m^3/bed), which totaled to an annual water consumption of 2.22 m^3/m^2 (355.78 m^3/bed). Additionally, the study included a direct relation between the number of beds and the built surface area of the facilities studied as shown in **Figure 3** (García-Sanz-calcedo et al., 2017). Such correlation can be used as an estimate in case of lack of data at a facility level until accurate data can be obtained for the facility itself or at the level of the region of study in general to reflect the actual conditions.

For hospitals in the UK, the range of water usage in hospitals ranged from 1.17 m^3/m^2 for small hospitals without a laundry facility, while a large hospital with a laundry facility had a reported consumption of 1.66 m^3/m^2 of built-up area, with a reported significant contribution from the laundry facility only, with a suggested benchmark consumption that is nearly 80% of the reported average annual consumption (National Health Service (UK NHS), 2013).

The water consumption, and consecutive wastewater production for the facility will be calculated based on a year of normal operation—as stated before in the methodology—then a relation will be obtained for the consumption based on the floor area, or the number of beds in m^3 per m^2 or m^3 per bed for the chosen year. Based on literature case studies: the water efficiency measures can start at 25% of the annual water consumption and can reach more than 60% reduction

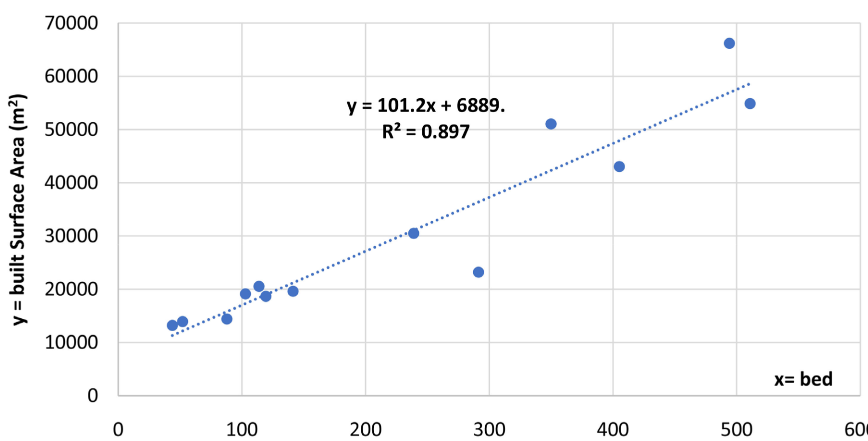

Figure 3. The relation between the built floor area and number of beds for 13 hospitals in Spain (García-Sanz-Calcedo et al., 2017).

in other cases (National Health Service (UK NHS), 2013; Smith et al., 2010). Accordingly, the basis for reward for this category will be the level of approaching net zero wastewater effluent which acts as an indicator of water use efficiency within the facility.

4.3. Approaching Net Zero Solid Waste

Of the most critical products of the healthcare service is the solid waste produced from the different activities. These wastes are divided into two main categories; first: non-hazardous waste and second: hazardous waste. Each can be sub-divided into different streams. The non-hazardous waste is similar in nature to domestic waste which contains plastic, metal, paper, glass, organic waste and is estimated to represent 75% - 90% of the waste generated from the facility building. In case the facility contains a garden, then seasonal agricultural waste will also be generated. On the other hand, hazardous waste is considered more critical. It can be divided into different streams, each one requires to be collected, handled, and treated separately. Starting with the medical related streams such as infectious wastes, chemical wastes, and radioactive wastes, which represent around 10% - 25% of the building-generated waste. In addition to a separate stream that results from the operation of the facility such as: e-wastes, and other obsolete medical or non-medical equipment with a generation rate that differs according to the facility operation, age, and size (Chartier et al., 2014).

The improper waste management causes several negative impacts: including public health risk in case that the infectious waste is not treated and disposed of properly posing a risk to everyone who handles the waste or comes in close proximity to the disposal sites. Also, improper treatment using equipment that is not designed to handle infectious medical waste can result in carcinogenic emissions and contamination of the surrounding environment. Moreover, an economic burden is experienced due to the cost of disposal in the different types of landfills, according to the level of treatment before disposal, and most importantly the loss of resources that is experienced with this disposal in what is called the "cradle-to-grave" concept (Chasseigne et al., 2018; Chen et al., 2014; El-Haggar, 2007).

The aim of approaching the Net Zero Solid Waste Concept is to divert the business-as-usual waste management practices to follow the "cradle-to-cradle" concept, which ensures that almost no wastes generated from the facility are disposed of, but rather reutilized as a resource after assurance of the material safety. Such goal can be achieved through first: the reduction of materials during the procurement process, then: responsible choice of the materials that can be reused, recycled, or upcycled, and finally: ensuring that the material is reutilized as should be by the facility management and responsible personnel (El-Haggar et al., 2015; El-Haggar & Samaha, 2019).

The solid waste generation from healthcare facilities is most commonly expressed in terms of: kg per bed per day, and is usually a function of the size of the facility, and the activities carried out in the process of service provision. A study conducted to collect the average waste generation in different countries based on literature data was performed. The waste streams studied were the non-hazardous and hazardous wastes generated in different countries. The average amount of waste generated for the different continents was reported to be highest in the two American continents with a value of 4.41 ± 3.0 kg/bed/day which was the highest deviation due to the inclusion of the U.S. and Canada data, which reported more than 8 kg/bed/day, along with the data from South American countries in the same category. In comparison, Europe, Asia, and Africa, reported averages were 3.10 ± 1.1, 2.44 ± 1 and 0.8 ± 0.23 kg/bed/day, respectively. The study also correlated the waste generation rate to the GDP and resulted in a direct relation, as shown in **Figure 4** (Minoglou et al., 2017).

The solid waste generation from hospitals in Egypt were reported in several sources to be on average around 1.03 kg/bed/day of both non-hazardous and hazardous wastes, with the reported amounts in the range of 0.23 - 2 kg/bed per day according to the type of hospital whether public or privately operated (Abd El-Salam, 2010; Shouman et al., 2013). Of the waste generated, the hazardous fraction of the waste was estimated by experts to be around 0.3 kg/bed per day, while the amount of total hazardous waste generated all over Egypt was mostly estimated with a generation rate ranging from 77.5 ton/day in 2010, to reach around 100 ton/day in 2018, while other experts estimate the amount at about 294 ton/day in 2020, which is considered a significant rise difference that might result from the fact that the experts quantification considers that all wastes contaminated with a fraction of hazardous waste is considered hazardous as well (Egyptian Ministry of Environment & Waste Management Regulatory Authority, 2020; SWEEP-Net, 2014; The World Bank & Ministry of Health and Population, 2018; UNDP (United Nations Development Programme) & GEF (Global Environment Facility), 2015).

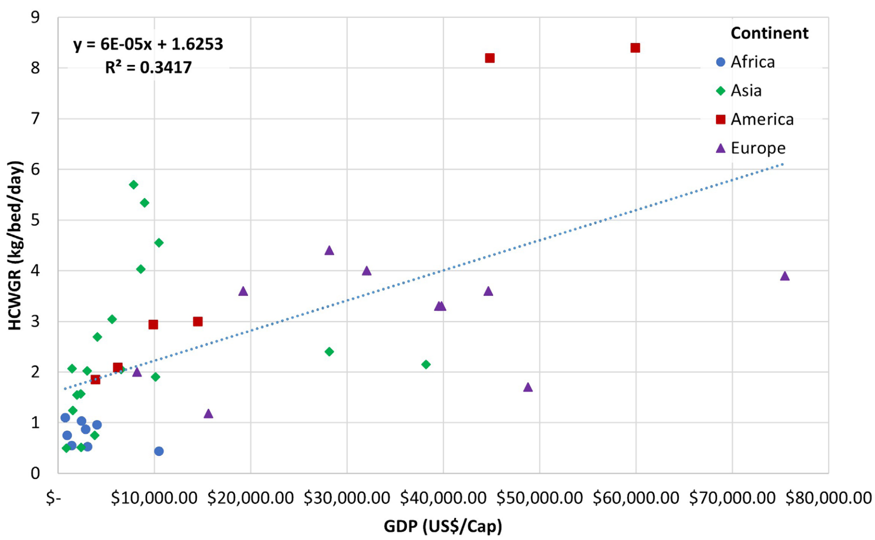

Figure 4. Waste generation rates as related to GDP in different countries (Minoglou et al., 2017).

The method of approaching Net Zero Solid Waste is suggested to utilize the cradle-to-cradle methodology of materials handling, which entails repurposing the waste materials through reuse, recycle, or upcycle of the materials that are deemed unusable by the generating facility (El-Haggar, 2007). The repurposing can be done onsite within the facility or outside the facility by a specialized service provider based on the condition that proper documentation can be provided regarding the method of repurposing used. For quantification of the Approaching Net Zero Achievement, the non-hazardous and hazardous waste streams will be studied separately due to the great difference in their composition and the achieved level of maturity of the materials reutilization through market companies or research.

4.4. Approaching Net Zero GHG Emissions

The terms *Net Zero Emissions* and *Carbon Neutrality* are usually used as indicators of the same concept, which is the balancing of the emission and removal of the GHGs resulting from the operation of a certain activity (UNFCCC (United Nations Framework Convention on Climate Change) & Climate Neutral Now, 2021). Greenhouse gas emissions are represented as carbon dioxide equivalent (CO_2e), which requires that all greenhouse gases emitted be compared in impact to carbon dioxide as a method of measurement unification. The GHG Protocol (GHGP) has defined three different scopes of emissions from any source which are considered the calculation base for all climate change quantification exercises, and they are: (World Business Council for Sustainable Development et al., 2011, 2015)

- Scope 1: direct emissions released from the facility itself; like combustion of the fuel used to operate onsite boilers, gases released during anesthesia, and operation of facility owned vehicles.
- Scope 2: indirect emissions produced from purchased energy in the form of electricity, heating or cooling requirements that are produced outside the facility.
- Scope 3: All other support services that the facility uses which are not produced by the facility or under its direct control. These can be divided into upstream emissions like: the supply chain and water, and downstream emissions like: the waste produced and its treatment or disposal method.

Estimates indicate that the healthcare sector is responsible for the production of a significant share of Greenhouse Gas (GHG) emissions estimated at 4.4% of the global carbon dioxide equivalent emissions with a contribution of 2 gigatons of emissions based on the data collected from 43 countries, with a few low- and middle-income countries included in the study. The largest reported healthcare sector percentage contribution in a country's total emissions was reported from the US at 7.6%, followed by Switzerland and Japan at 6.7% and 6.4%, respectively, while the lowest contributions were reported from Indonesia and India comprising only 1.9% and 1.5%, respectively. These emissions are divided into 17%

of direct emissions from the healthcare facilities and transportation (scope 1), 12% are generated from purchased services like electricity supply (scope 2), and the majority of emissions come from the supply chain of pharmaceuticals, equipment, services and their disposal (scope 3), of which plastic and rubber with solid waste treatment compromise 4.6% on their own (Health Care Without Harm et al., 2019b).

As Egypt is considered one of the vulnerable countries to climate change, with several sites marked as sensitive areas, various initiatives have been carried out in the field of climate change focused on both mitigation and adaptation actions. Lately, in 2022, the National Climate Change Strategy 2050 was adopted outlining several actions towards the reduction of GHG emissions and adaptation actions that are planned to be expanded on by the governmental institutions and different stakeholders. The strategy includes the importance of mitigation measures in the building sector, among other sectors, as well as highlighting the healthcare sector's role as the main predictor and responder to climate change impacts, and therefore its role in the preparedness for adaptation to the expected diseases and the different climate impacts (Arab Republic of Egypt-Ministry of Environment, 2022).

Following the above, in the course of this work, the scope of quantification suggested for healthcare facilities in the Egyptian context is intended to include, as a start, scope 1 and scope 2 emissions accounting for carbon dioxide and methane emissions as the main sources of emissions (Health Care without Harm et al., 2019a). While adding other GHGs like nitrous oxide and hydrofluorocarbons whenever relevant data can be collected from the facilities. Additionally, solid waste treatment and disposal will be quantified as a first step towards the inclusion of scope 3 emissions, based on the fact that: healthcare facilities, especially, should follow-up on the treatment and disposal methods used for the waste generated as part of their activities to ensure that the health risks associated with such practices are reduced as much as practically possible.

5. Conclusion

The work presented aims at providing an assessment and reward methodology for four different Net Zero aspects as an addition to the previously developed sustainability rating system targeting the healthcare sector facilities in developing countries (ElMitainy & El-Haggar, 2019). The Net Zero specialized assessment aspects suggested are namely: 1) approaching Net Zero Energy, 2) approaching Net Zero Wastewater, 3) approaching Net Zero Solid Waste, and 4) approaching Net Zero GHG emissions.

Out of the aspects presented, the facility should identify the assessment area it requires, for which a baseline year will be chosen to calculate the benchmark and all successive savings achieved. An assessor will be assigned to the facility to support the data collection and assessment process. This assessment process should use the international best practices presented in this work for guidance in the calculations and formulating local benchmarks until sufficient national level data is collected through the participating facilities.

The facility that is able to provide data indicating continuous savings will be awarded a base level of achievement certificate, and with the increasing in the number of participating facilities, a special performance award will be granted to the best achievers. Thus, encouraging the healthcare facilities to implement measures to improve their performance and approach Net Zero operation through receiving recognition for the efforts exerted and the subsequent results achieved.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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