Eight Strategies for Implementing Zero Energy Cities for Zero Carbon Nations.

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الاستراتيجيات الثمانية للمدن صفرية الطاقة من اجل دول صفرية الكربون

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Abstract

A zero-carbon economy is an inevitable choice for achieving economic and ecological sustainable development. It is highly important to analyze zero-energy cities for the interest of zero-carbon nation development level scientifically and reasonably. Just over 50% of the world's population currently lives in one. By 2050, this figure will have grown to almost 70%, and by 2080 almost 80% of the world's then 9 billion people will be urbanized. In raw terms, that's roughly 7.5 billion people. Over 80% of global GDP is already generated in cities. However, this magnetic appeal could hasten global disaster. Cities are the major consumers of fossil fuels, which have risen from 4% of global energy consumption in the early 1900s to over 86% at present time and contribute to 70% of the world's greenhouse gas output.

Without a rethink of the city's growth model and its relationship with carbon emissions, it will be challenging to stay under the 1.5°C of global warming target put forward by the 2015 Paris Agreement. Hence, it is necessary to reduce energy consumption in cities, and necessary steps have to be taken to make cities more environmentally sustainable.

A zero-energy city uses renewable energy sources to meet the energy requirements. In this paper, we have carried out and created the eight strategies for implementing a zero-energy city for future sustainable cities including: green energy, green transportation, green real estate, green construction, green supply chain management, carbon sequestration, sustainable water use and human behavior. It focuses on developing a platform for a high quality of life where inhabitants can find the zero carbon footprints towards achieving zero-carbon nations.

Keywords: Energy consumption - Climatic change - Zero energy building - Zero energy transportation - Zero-carbon city

المستخلص

يشهد العالم حاليا ارتفاعاً سريعاً غير مسبوق في درجات الحرارة بسبب الأنشطة البشرية، ويرجع ذلك أساساً إلى حرق الوقود الأحفوري الذي يولد انبعاثات غازات الدفيئة. ويعد تغير المناخ أكبر تهديد صحي وبيئي يواجه البشرية، وتسبب آثاره أضرارا صحية من خلال تلوث الهواء، والأمراض، والظواهر الجوية الشديدة، والتهجير القسري، وانعدام الأمن الغذائي، والضغوط على الصحة البدنية والعقلية، وتسبب العوامل البيئية وفاة حوالي ١٣ مليون شخص سنويا. كما يسبب تغير المناخ انتشار الجوع، حيث يساهم الاستخدام غير المستدام للأراضي والتربة والمياه والطاقة من أجل إنتاج الغذاء في انبعاثات غازات الدفيئة التي تسبب ارتفاع درجات الحرارة. ويؤثر ارتفاع درجات الحرارة بدوره على الموارد المستخدمة لإنتاج الغذاء. في عام ٢٠٢٠، تعرض ما يصل إلى ٨١١ مليون شخص للجوع في العالم، بزيادة ١٦١ مليون عن عام ٢٠١٩، والذي يؤدي بشكل مباشر وغير مباشر لوفاة اكثر من ٣٦ مليون شخص سنويا.

الأرض الآن أكثر دفئاً بنحو ١,١ درجة مئوية مما كانت عليه في القرن التاسع عشر. لسنا على المسار الصحيح لتحقيق هدف اتفاقية باريس لمنع درجة الحرارة العالمية من تجاوز ١,٥ درجة مئوية فوق مستويات ما قبل الثورة الصناعية. ويعتبر هذا الحد الأعلى لتجنب أسوأ التداعيات المحتملة لتغير المناخ.

وكشفت أحدث تقارير الامم المتحدة ان الحفاظ علي البيئة ومنع تغير المناخ يحمي البشر من ارتفاع درجات الحرارة أكثر مما هي عليه الآن، وارتفاع منسوب البحار، والعواصف الشديدة، والأمطار غير المتوقعة، وارتفاع حمضية المحيطات. كما ان التحول إلى الاقتصاد الاخضر المنخفض او الخالي من الكربون يؤدي إلى مكاسب اقتصادية عالمية مباشرة قدرها ٢٦ تريليون دولار حتى عام ٢٠٣٠ مقارنةً بالأعمال المعتادة ويمكن أن يخلق أكثر من ٦٥ مليون وظيفة جديدة خضراء.

لذلك فان التحول الي الاقتصاد الصفري كربون أصبح حتميا من اجل البقاء وتحقيق التنمية الاقتصادية والبيئية المستدامة. فمن الأهمية دراسة وتحليل المدن صفرية الطاقة للمساهمة في ان تصبح الامم خالية من الكربون. حيث يعيش حاليًا ما يزيد عن ٥٠٪ من سكان العالم في المدن وبحلول عام ٢٠٥٠ ستكون النسبة تصل الي ٧٠٪ ، وبحلول عام ٢٠٨٠ ما يقرب من ٨٠٪ من سكان العالم البالغ عددهم ٩ مليارات نسمة. كما يتجاوز ٨٠ ٪ من حجم الناتج المحلي الإجمالي العالمي في المدن. ومع ذلك، فإن هذا التسارع يمكن أن يؤدي الي كارثة عالمية. فالمدن هي المستهلك الرئيسي للوقود الأحفوري الذي ارتفع من الاستهلاك بحوالي ٤٪ في أوائل القرن العشرين إلى أكثر من ٨٦٪ في الوقت الحالي ويسهم بنسبة ٧٠٪ من إنتاج الغازات المسببة للاحتباس الحراري في العالم. وبدون إعادة التفكير والتخطيط في التنمية العمرانية وارتباطها الوثيق بانبعاثات الكربون، سيكون من الصعب البقاء تحت ١,٥ درجة مئوية لتحقيق هدف اتفاقية باريس لعام ٢٠١٥. ومن ثم فمن الضروري تقليل استهلاك الطاقة في المدن واتخاذ الخطوات الضرورية لجعل المدن أكثر استدامة. واحد اهم الحلول لتحقيق ذلك هو انشاء وتطوير المدن لتصبح صفرية الطاقة. ويقصد بالمدن صفرية الطاقة التي تستخدم محصلة من استهلاك الطاقة وانبعاثات الكربون سنويا مقدارها صفر. ويمكن تحقيق ذلك من خلال اعتماد المدن صفرية الطاقة علي مصادر الطاقة الخضراء التي تشمل الطاقة المتجددة وتعظيم كفاءة الطاقة لتلبية متطلبات المدينة من الطاقة.

وفي هذه الورقة البحثية، أجرينا دراسة تقدم سبعة إستراتيجيات للمدن صفرية الطاقة لتصميم وتخطيط وتنفيذ تلك المدن المستدامة المستقبلية والتي تشمل استخدام الطاقة الخضراء، والنقل الاخضر، والعقارات الخضراء، والبناء الاخضر، وسلاسل الامداد الخضراء، وعزل الكربون أو إزالة غاز ثاني أكسيد الكربون، والاستخدام المستدام للمياه، وتقويم السلوك البشري. كما تستهدف الورقة البحثية انشاء منصة استرشادية لحياة عالية الجودة للسكان وتطوير وانشاء المدن صفرية الطاقة بما يحقق "بصمة كربونية صفرية" وبلدان خالية الكربون من اجل البقاء والرخاء بالقرن الحادي والعشرين.

الكلمات الدالة: استهلاك الطاقة- التغير المناخي- بناء صفر الطاقة - نقل صفري الطاقة- مدينة خالية من الكربون

Introduction

The 21st century will be an era of the zero energy cities and zero-carbon economy for zero carbon nations. The low or zero carbon economy provides more economic output by reducing the consumption of natural resources and reducing environmental pollution, it is a way and an opportunity to create a higher standard of living and a quality of life and it creates opportunities for the development, application and export of advanced technologies. It also creates new business opportunities and more job opportunities [Chu and Majumdar 2012]. Characteristics of a low or zero carbon economy include reducing greenhouse gas emissions as the goal and building a system of economic development based on low energy consumption and low pollution, including low or zero carbon energy, technology and industry systems. Cities are the major consumers of fossil fuels, which have risen from 4% of global energy consumption in the early 1900s to over 86% at present time and contribute 70% of the world's greenhouse gas output [Allen et al 2019].

Climate change is a global challenge; the future development of the city must be a sustainable zero-carbon economy. In 2017, global carbon disintegration was set as the long-term goal of the Paris Agreement. Unfortunately, the Arab nations consume twice as much as resources can be regenerated and assimilated by their natural systems [AFED 2015]. Facing post-Paris climate challenges, Arab nations should develop a bold strategy for low or zero energy cities and zero-carbon economy towards achieving zero-carbon nations.

Then, the aim of this paper is to provide proposed eight strategies for designers and planners to achieve zero-energy and zero-carbon goals with sustainable design approaches that facilitate fulfilling energy future requirements. These design approaches include the utilization of green energy, transportation, real estate, construction, supply chain management, carbon sequestration, sustainable water use and human awareness. In addition, the strategies are to achieve sustainable development objectives and in turn reduce negative impacts of pollution on the nations.

1- Literature Review

On the low carbon level of the city, the research on the urban low carbon is carried out from the perspectives of energy consumption, carbon emissions and urban social construction [OECD 2016]. The urban environment is responsible for between 71% and 76% of carbon emissions from global final energy use and between 67% and 76% of global energy use [Seto et al 2018]. Within the urban environment, buildings represent the greatest unmet energy savings and carbon emission reduction potential because existing and future buildings will determine a large portion of global energy demand [Lucon et al 2016]. As developing countries keep building and maintaining their standard of living by providing housing and infrastructure, the total energy use in urban environments -particularly use related to buildings- could triple by mid-century [Allen et al 2019]. To date, primary research about the urban environment related to climate change has focused on energy efficiency or resilience. For energy efficiency, the ultimate goal is to realize the net zero energy (NZE) goal. NZE and resilience have overlapping origins in systems ecology [Hwang et al 2017] but have developed independently. Investigating how they develop allows us to see how they can influence each other's future development and potentially be integrated to create a more holistic framework for evaluating sustainable development. The energy-centric approach is easy to understand and easily implemented in the building code. Large amounts of research have quantified building energy performance, and robust methodologies have been developed and established. The number of net zero buildings increased by over 700% between 2012 and 2020 in the United States [NBI 2021], and the steep upward curve can be expected to continue. Lynn et al. [2013] tracked energy efficiency and emissions reductions through energy use and carbon dioxide emissions and established benchmarks for evaluation. Moriarty et al [2014] proposed to reduce energy consumption and carbon emissions by changing human lifestyles and establishing low-carbon cities. Khanna et al. [2014] further defined the meaning of low-carbon cities—they evaluated and analyzed China's low-carbon pilot city and proposed from the policy, energy and other aspects to enhance low-carbon levels. Urban [2018] emphasized the importance of low-carbon technological innovation for the development of a low-carbon economy in China and emphasized that raising the level of the low-carbon economy in China is of great significance to global low-carbon transformation and climate change mitigation. Fankhauser et al. [2017] suggested that energy is necessary for economic growth. Low-carbon is the future energy trend and will eventually lead to a low-carbon economy. Wang et al. [2017] evaluate the low-carbon economy in China, mainly from the assessment of coal consumption, electricity consumption and put forward corresponding suggestions.

2- Concept and Principles of Zero-Energy Cities

As we know that a zero-energy city is also known as a net zero energy-city, which means that buildings, transportation, watering and supply chain with net zero energy consumption that the total amount of energy is used by a city on an annual basis is equal to the amount of renewable energy. It is based on the concept that a city -within its boundaries- produces as much energy as it consumes on an annual basis. In order to be appropriate for use, a city should be providing comfort condition for people who live there.

That is to say, “it is the city that on the annual basis produces as much energy as it uses” (Fig.1). This definition of zero-energy technology is applied solely in the context of cities and is applied on the whole developmentratherthanindividualbuildings.

The aim of a zero-energy city is reducing carbon emissions from buildings, reducing waste, transport, materials and food emissions by 50% globally. It can be achieved as shown in (fig. 2) by the following energy hierarchy:

Fig. 1 Concept of zero-energy cities

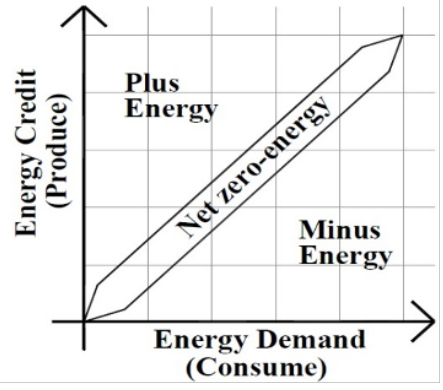
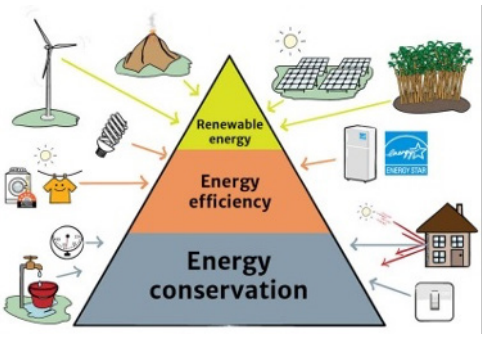


Fig. 2 Energy Pyramid



Source: The figures are designed by the author

The zero-energy goal is applied on carbon emissions arising from energy use in domestic, nondomestic, public spaces and structures in a completed development. In another context, there are 10 principles that are proposed to create an eco-city [Mark 1997] the developers of Dongtan have used them in order to create a zero-carbon city.

1) Revise land use priorities, create green, and safe mixed communities

2) Revise transportation priorities, favor foot, bicycle, cart and public transit over automobile

3) Restore damaged urban environments

4) Create decent, safe, and economically mixed housing

5) Nurture social justice and create improved opportunities

6) Support local agriculture, Create community gardens

7) Promote recycling and resource conservation

8) Work with businesses to support ecologically sound economic activity

9) Promote voluntary simplicity

10) Increase awareness of the local environment

Thus, the challenge for urban designers & planners is to apply all 10 principles together in order to generate a sense of purpose through a combination of new technology, city design and community-based innovation.

3- The Global Growth Challenge

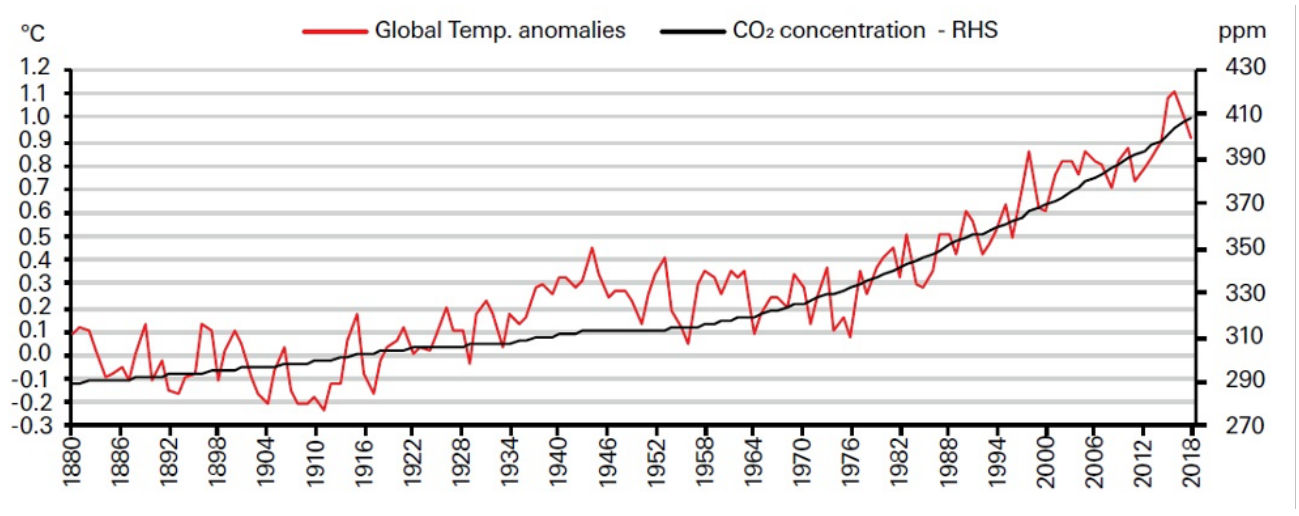
Humanity's past, present and future on this planet can perhaps be summed up by two curves on one graph as shown in (Fig. 3). One curve maps the growth of carbon dioxide in the atmosphere since the late 19th century, when our species went all in on fossil fuel energy. The other registers the rise of global temperature across the same period. They map each other closely, both rising sharply the closer they get to the present day. The world has already warmed by 1.0°C above pre-industrial levels due to human activities.

Urbanization and global warming have enjoyed a symbiotic relationship over the past two centuries. As their populations increased, cities began to devour the electricity produced by traditional fossil-fuel power plants. This led to further urbanization, and greater demand for power. In 1800, cities with populations of over 1 million were the exception. Now, dozens across the world have populations running into the tens of millions. Many urban environments have been built around the car, pushing transport into one of the top carbon-emitting spots. New infrastructure, commercial buildings and housing require huge amounts of concrete, the creation of which is extremely carbon intensive. Expanding urban areas destroy natural environments. The growth of the city will continue, but the rise in carbon emissions and the consequent temperature increase must not.

At the current rate of warming of 0.2°C per decade, global warming will reach 1.5°C at some point between 2030 and 2052. If carbon emissions are left to grow unchecked, the world could experience warming of between 3°C and 6°C by 2100. This would be a political, economic and environmental disaster for our planet.

In 2015, 174 countries signed the Paris Agreement that aims to limit the global temperature increase to 1.5°C. This objective also falls under the UN Sustainable Development Goals (SDGs) for 2030. Cities can influence how quickly temperatures rise or fall. More than 100 cities have pledged to take actions in reducing emissions, aiming for at least a 70% reduction in greenhouse gas by 2050. By 2030, cities and local governments could eliminate 1.4 billion tons of new carbon dioxide emissions [Allen et al 2019].

Fig (3) Carbon dioxide and global temperature across the same period [Allen et al 2019]



Source: Allen, M. et al. (2019). IPCC Sixth Assessment Synthesis Report-(AR6) Climate Change Synthesis Report; IPCC. Geneva. Switzerland

Energy and Environment are two sides of the same coin. Moreover, Cities are the focal points and drivers of socioeconomic development in all countries. At the same time, they are the largest consumers of energy and other natural resources. For all these reasons, cities are biggest resources of pollution and greenhouse gas emissions on the planet. Mitigating CO2 emissions and adapting to climate change are essential at the city level. It is important that cities curb waste, manage their full water cycle and contribute to renewable energy generation to become “low carbon” or “zero carbon” cities.

At the regional level, the transportation sector in Egypt consumed the largest share of energy, with the final consumption amounting to 18,000 kilotons of oil equivalent (ktoe). Moreover, the industry sector followed closely consuming roughly 17,500 ktoe. Energy consumed for residential reasons ranked third, with the final consumption amounting to around 14,000 ktoe.

About 28% of final energy consumption in Egypt is in the building sector (including residential, non-residential and public buildings). The largest share of which (22%) is consumed in residential buildings. As more than 95% of primary energy needs are covered by natural gas and oil (IEA, 2017); this leads to high emissions both in absolute terms and in the buildings sector. Accordingly, 26% of GHG

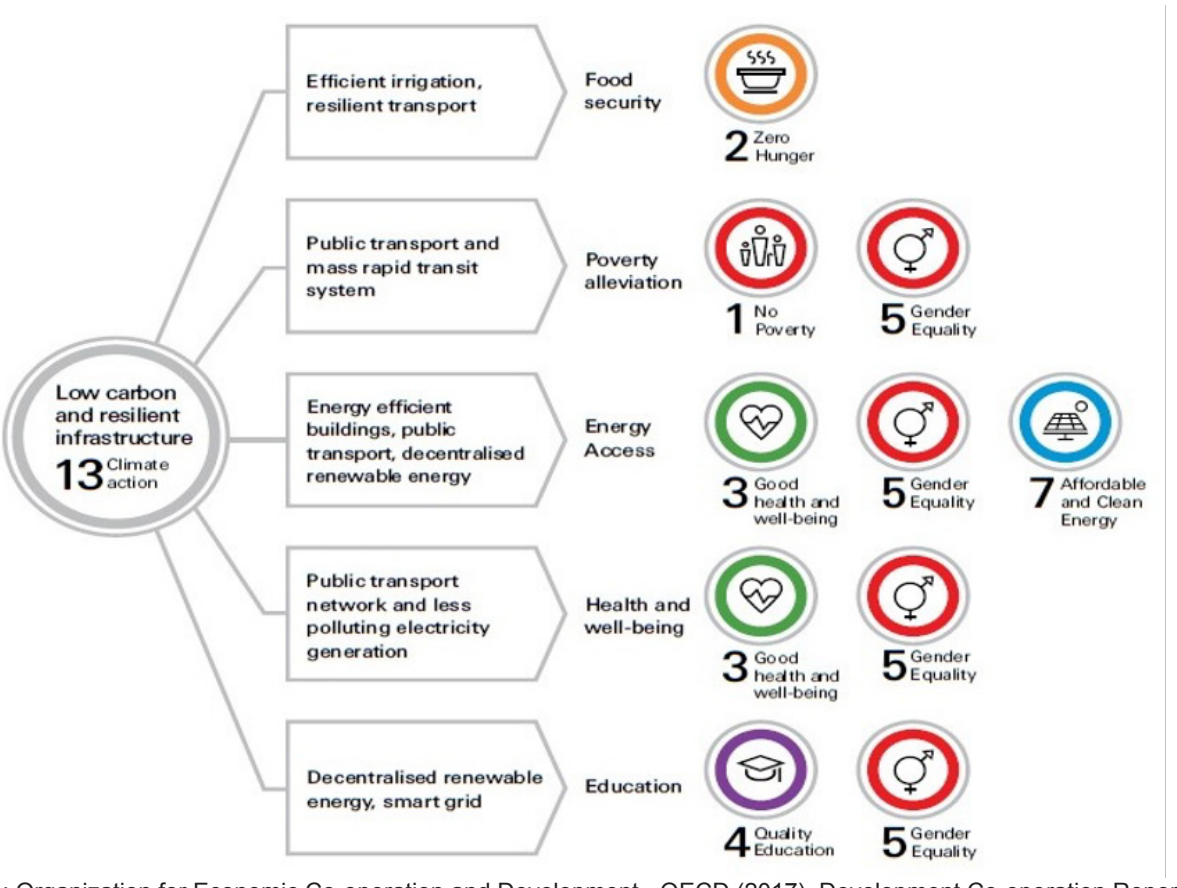
emissions are generated in the residential sector. Energy demand in the building sector will continue to grow, especially through heating and cooling in both residential and non-residential buildings. Space heating and cooling each account for about 13% of household energy consumption, while hot water production is responsible for about 11% (World Bank, 2017). This is expected to change with rising living standards and a wider distribution of space cooling equipment. For cooling and heating, people usually use fans, AC, and water heater appliances units, which are powered by electricity. Thus, smart renewable energy technologies should be considered an integral part of the Egyptian energy policy framework.

4- Zero Energy for Zero-Carbon Benefits

Getting to the zero-energy stage will not be a swift or clear transition – it will involve incremental, overlapping changes from a wide range of economic and governance sectors. However, there will be also clear benefits along the way, both in terms of addressing climate change and in other areas.

(Fig. 4) shows the links among low-energy, low-carbon, climate-resilient, infrastructure and the UN Sustainable Development Goals (SDGs).

Fig (4) Investing in Climate, Investing in Growth



Source: Organization for Economic Co-operation and Development - OECD (2017). Development Co-operation Report 2017: Data for Development. OECD Publishing Paris.

4-1 Environmental Preservation

Most of the world's major cities are sited on coasts or near the mouth of major rivers. As such, they are exposed to the rising sea levels that will be a result of climate change. Even if global temperature increase is kept to 1.5°C degrees, sea levels will still rise by half a meter. This will make damage to cities and their surrounding environs from tidal and storm flooding more likely and extensive.

4-2 Improved Health and Quality of Life

According to the World Health Organization (WHO), ambient air pollution is estimated to cause 4.2 million premature deaths per year globally via heart diseases, strokes, chronic obstructive pulmonary diseases, lung cancer, and acute respiratory infections in children. Millions of people are also negatively affected to a less serious degree.

particulate matter, nitrogen dioxide and Sulphur dioxide from transport, factories and coal-fired power stations, which are the primary causes of such pollution. Reducing or eliminating emissions from these sources could significantly ease this health crisis. Reducing traffic noise and numbers can also bring benefit through reduced stress levels and safer streets for pedestrians. Tackling climate change as a whole will also reduce chances of major heat waves, which are proven to be lethal to many vulnerable people living in cities.

4-3 Job Creation and Greater Productivity

Fears of job losses in carbon-intensive industries have been long used to forestall serious actions on climate change. However, any transition to the zero-carbon city will involve significant job creation, through the manufacture of green energy technologies and electric vehicles, new transport and energy infrastructure, and building construction. According to an International Labor Organization (ILO) Report, most economies will experience net job creation and reallocation across industries by 2030 as a result of zero-carbon efforts, with as many as 24 million new jobs created globally [ILO 2018].

4-4 Better Quality Services

Zero-energy transition will require cities to make a significant investment in new services, particularly public transportation, energy supply, and water use. In transport, residents should see a rise in the availability of suburban rail, allowing commuters and other passengers to ditch their cars in favor of the train. The development of autonomous electric vehicles could also increase mobility more generally, and especially for those unable to access private cars or public transport easily. The rise of the innovation economy and use of data to make cities more efficient should see and improved access to Wi-Fi and 5G services for the population as whole. This will allow for more localized, more productive economies where people do not have to travel to office every day in order to do their job.

4-5 Cost Savings

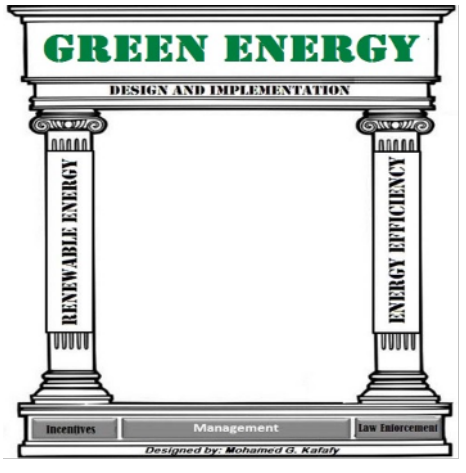
According to the World Bank, extreme natural disasters produce USD 520 billion of consumption loss globally every year. Mitigating or repairing the damage of floods, droughts and wildfires depletes city resources, and places a drag on economic growth. Each drop of cash spent in these areas is one drop less spent on other vital sectors, such as social care, healthcare or education. The private sector will also have to funnel resources into dealing with a changing climate– the increased cost of cooling buildings, and moving offices and factories away from vulnerable areas, for instance. As temperatures continue to rise, these costs are set to go up, placing a greater strain on national and city budgets.

5- Eight Strategies for Implementing Zero-Energy City

Possible carbon reduction is not just concentrated in the world's megacities. In fact, the greatest potential lies with the roughly 5000 small and medium-sized urban centers dotted all across the globe. The 100 cities already pledged to carbon reduction must act as the spearhead of a broader movement. Existing climate change policy is signposted by the Paris Agreement, but the work of translating this into reality will largely be done by panoply of national government, local authority and city mayor plans. As these plans take shape, cities also have to confront other challenges beyond global warming. Some of these sit comfortably with carbon reduction goals, but others do not. Therefore, this paper presents the following proposed 8 strategies for implementing a zero-energy city with connotation of the key principles for net zero presented by the IEA [2021]. It also introduces 10 principles to create an eco-city published by Mark [1997], which include: Green Energy, Green Transportation, Green Real Estate, Green Construction, Green Supply Chain Management, Carbon Sequestration, Sustainable Water Use and Human Behavior.

5-1 Green Energy

(Fig. 5) Twin Pillars of Green Energy



Source: the figure is designed by the author

Energy efficiency (EE) and renewable energy (RE) are the "twin pillars" of a green energy policy. Both resources must be developed aggressively if we are to stabilize and reduce carbon emissions in our lifetimes. Efficiency is essential to slowing the energy demand growth so that rising clean energy supplies can make deep cuts in fossil fuel use. If energy use grows too fast, renewable energy development will chase a receding target. Likewise, unless clean energy supplies come online rapidly, slowing demand growth will only begin to reduce total emissions. Reducing the carbon content of energy sources is also needed. Any serious vision of a green energy economy, thus, requires major commitments to both efficiency and renewable.

Decarbonising power sets a strong foundation for many of the steps that cities need to take. Similarly, electrification in other sectors is a key decarbonisation strategy, for instance for transport, logistics, real estate, and energy intensive digital industries and applications.

Huge inroads have been made into making renewable power sources such as wind and solar energy more reliable and more affordable. Solar power has grabbed the most headlines here.

Thanks to private innovation and government subsidy, the cost of photovoltaic modules has dropped by 99% in the past 40 years [Seb et al 2021]. The development of large scale, more efficient wind turbines mean that in many places they can compete with coal and nuclear power on a price-per-kilowatt/hour basis.

With renewable energy, grids will need to be smarter, and more flexible. They need to be able to absorb and distribute intermittent power loads from a larger number of dispersed, localized sources – offshore and onshore wind arrays scattered along entire coastlines and landmasses, solar panels on individual houses and building, for example.

These upgrades will come at a cost. In London, the mayor's zero-carbon action plan predicts a required investment of just under GBP 4 billion by 2050 to make the necessary changes to grid infrastructure, including reinforcement of up to 180 primary substations [Seb et al 2021]. However, much of this investment would have been required anyway in the normal upgrade cycle.

5-2 Green Transportation

After power generation, transportation is perhaps the next big greenhouse gas target. Internal combustion vehicles– everything from mopeds up to commercial airliners and container ships – contribute to roughly 20% of man-made carbon emissions globally.

In cities, the problem is particularly acute. Many urban centers are clogged with traffic jams, and are heavily reliant on busy airports and ports for movement of people, goods and raw materials. Internet shopping and the increase in home delivery has intensified the use of vans and other large vehicles for logistics. The pollution problem gives cities an extra reason to transition to clean modes of private and public transport.

5-3 Green Real Estate

One asset that is common to all cities is physical infrastructure – houses, roads, schools, shops, offices, and hospitals. Our built environment consumes power and heat in vast quantities, making it a significant contributor to urban greenhouse gas emissions.

In many cities, much of the built environment is decades or even centuries old, constructed long before the age of environmental regulations or efficiency standards. That means a lot of wasted heat and electricity, putting further demands on resource consumption. Any route to the zero-energy city will involve an extensive retrofitting of existing structures and strict efficiency standards on new developments.

5-4 Green Construction

Construction is perhaps one of the more unseen contributors to climate change. Until recently, it has not grabbed the headlines like gas-guzzling cars, or air travel, or fossil-fuel power-stations. However, 15% of global carbon dioxide emissions come from the construction industry. The industry itself is expected to expand by 85% in just the next decade or so.

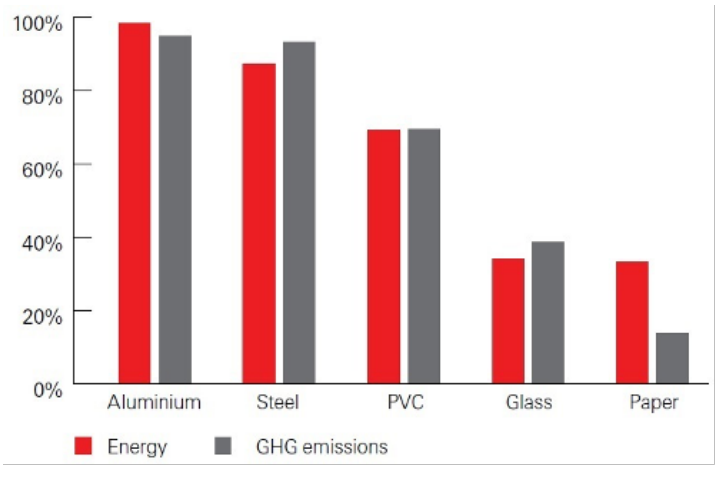
Building materials generate significant amounts of greenhouse gases during their production and transportation –a term known as 'embodied' carbon, which counts to their carbon output before construction even begins.

Concrete production is a major part of this problem, producing over half of the construction sector's emissions, about 8% of the world's total [CIOB 2015].

Embodied carbon can be reduced through a greater recirculation of materials, more efficient use of materials in buildings and optimization of the efficiency and robustness of materials during the course of their lifespan. This can include:

- Recycled concrete aggregates, blended cements and concrete;
- New materials with lower embodied carbon can also substitute conventional carbon intensive materials. These can include natural 'carbon sinks' – materials that absorb carbon throughout their lifespan, like wood and bamboo; and,
- Low-carbon alternatives to traditional cement and concrete, such as recycled metals or green tiles made up of recycled glass and other minerals.

(Fig. 6) Energy & GHG emissions from building materials



Source: Global Construction Perspectives and Oxford Economics (2015). Global Construction 2030.

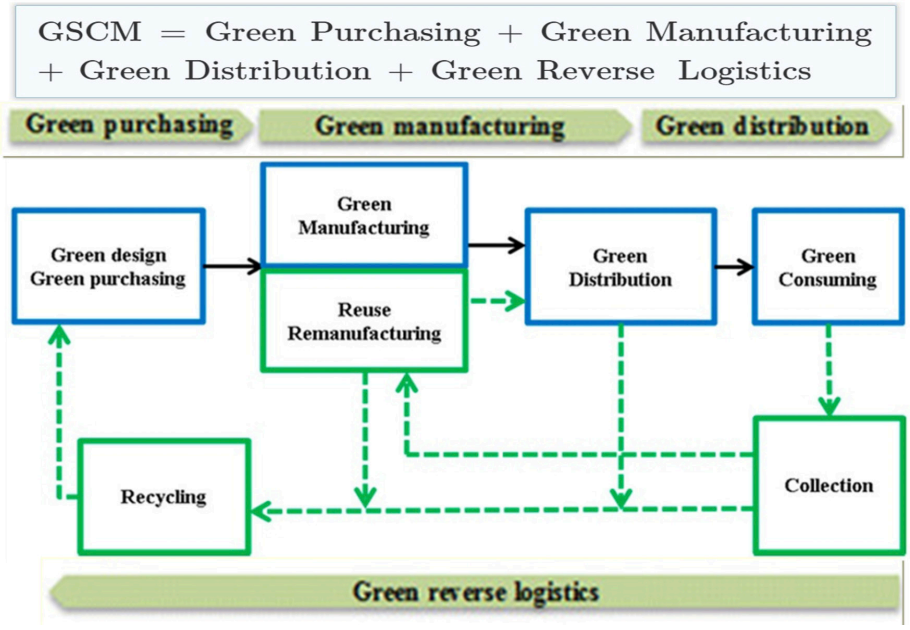
Fig (6) shows potential energy and greenhouse gas emissions savings achieved through recycling compared to primary material production.

5-5 Green Supply Chain Management (GSCM)

Humanity has a serious waste problem on its hands. However, GSCM refers to the methodology of integrating sustainable environmental processes into the traditional supply chain as shown in

(Fig. 7). Undeniably, reducing air, water, energy and waste pollution is the main goal of green supply chain management, while green operations also enhance firms' performance in terms of less waste manufacturing, reuse and recycling of products, reduction in manufacturing costs, greater efficiency of assets, positive image building, and greater customer satisfaction [Achillas et al. 2019].

(Fig. 7) Green Supply Chain Management



Source: Achillas, C. et al. (2019) Green Supply Chain Management, Routledge Publisher.

Plastics, for instance, have leached into every part of our natural world, from deep sea trenches to mountain plateaus. Over 270 million tons of plastic goes to waste every year. Roughly 20% is recycled. A further 20% is incinerated, often an extremely toxic process. The remainder is discarded, finding its way into the ocean, onto landfills, or simply left exposed to the elements. Plastics are just part of the mess. Vast quantities of food go to waste every day. Metals, timber and masonry also find their way on to the waste heap when they could be reused in other ways [ESCAP 2018].

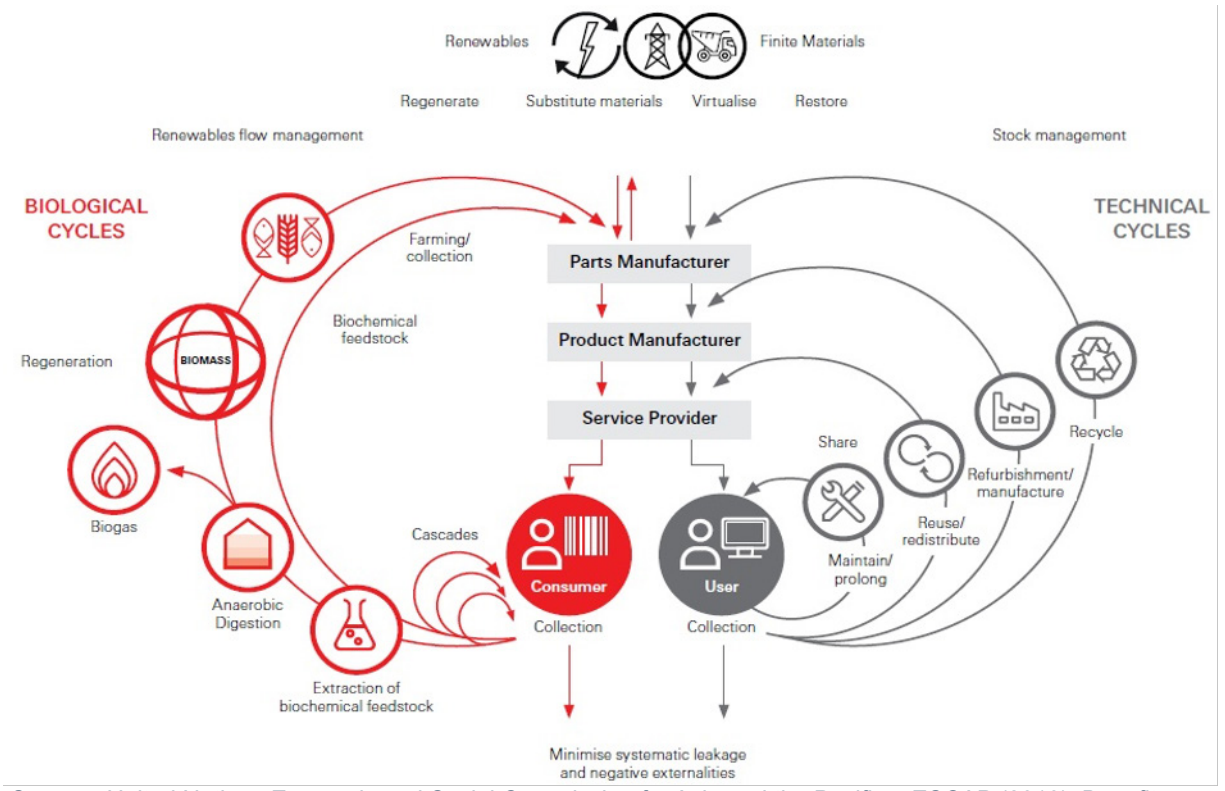
The GSCM with connotation of circular economy closes the loop between consumption and production by reducing, re-using, recycling, and recovering materials where possible. This relies on three main principles:

- Optimizing the way resources are used;

- Preserving the value of input materials in production processes and final products; and,

- Improving the productivity in production and consumption.

(Fig. 7) Circular Economy



Source: United Nations Economic and Social Commission for Asia and the Pacific – ESCAP (2018). Benefits of environmental action, including through enhanced regional cooperation. Committee on Environment and Development, ESCAP/CED/2018/2 fifth session. Bangkok.

The new business models arising from the circular economy can support cities and companies in achieving their zero-carbon agenda.

5-6 Carbon Sequestration

It is generally accepted that it will be impossible to eliminate all greenhouse gas emissions. Therefore, in order to achieve Net Zero greenhouse gas emissions, it is essential that these residual emissions are removed from the atmosphere through some form of carbon sequestration. It is the process of capturing and storing atmospheric carbon dioxide for reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change [Ontl and Schulte 2012].The two major types of carbon sequestration: geologic and biologic. Geologic carbon sequestration is the process of storing carbon dioxide (CO2) in underground geologic formations. CO2 is usually pressurized until it becomes a liquid, and then it is injected into porous rock formations in geologic basins. Biologic carbon sequestration refers to storage of atmospheric carbon in vegetation, soils, woody products, and aquatic environments by encouraging the growth of plants—particularly larger plants like trees—advocates of biologic sequestration hope to help remove CO2 from the atmosphere.

5.7 Sustainable Water Use

One modern theory points to problems with a single vital resource: water. Water was supported by a highly sophisticated system of canals and reservoirs, which is designed to irrigate crops and handle an unpredictable monsoon season. The changing climate of the 1400s is believed to have produced a series of droughts and floods, overwhelming the water storage system and contributing to the decline of the city.

A similar fate could befall modern cities. Climate change increases the likelihood of both prolonged droughts and sudden floods. Melting glaciers threaten the supply of fresh water to many millions of people. By 2040, the demand for fresh water could exceed supply by 50%.

At the same time as protecting freshwater resources, cities must maintain defenses against unwanted water from floods or sea level increase. Many of the world's major cities lie on the coast, putting huge chunks of national economies at risk from further climate change.

The way we use water is also a contributor to the emissions problem. Current wastewater practices produce small amounts of methane, which is an extremely potent greenhouse gas. All told, these small amounts add up to a lot - 10% of global methane emissions are produced in this way [Jackson, 2018].

5.8 Human Behavior

Efforts to reduce emissions will be harder to achieve if urban dwellers cannot be convinced to alter zero carbon-intensive behaviors, i.e. awareness for sustainability is a must.

The individual citizen can't invent practical electric vehicles, or advance the progress of renewable energy or the heat efficiency of buildings, all by themselves. Until recently, society has created a choice structure that all but guarantees a carbon-heavy lifestyle, especially in developed economies.

However, there are actions that the individual can take which, on a collective level, could help reduce carbon emissions significantly. The most basic of these is to be more considerate of consumption and generate less waste. Developed-world economies are incredibly consumer driven.

The city of Barcelona advocates for more responsible consumption through the introduction of deposit systems, repair workshops and buying local produce. The city has also opened energy advice points to offer information as well as grants for citizens to improve energy efficiency at home. The city is planning to allocate EUR 200,000 in subsidies every two years up to 2030 to finance local organizations or projects that promote the reduction of greenhouse gas emissions.

Conclusion and Recommendation

- Conclusion

-Zero-energy cities for zero-carbon nation future are not just an aspiration. In fact, the greatest potential lies with the roughly 5,000 small and medium-sized urban centers dotted all across the globe. The 100

cities already pledged to carbon reduction must act as the spearhead of a broader movement.

- In the master plan of a zero-energy city, the eight strategies: green energy, transportation, real estate, construction, green supply chain management, carbon sequestration, sustainable water use and human behavior will need to be integrated solution in multiple challenges including design for reduced energy demand, comfort, climate change adaptability, and flexibility to integrate future zero-energy techniques for zero-carbon nation.

- Leading a community towards zero-energy technologies is ambitious and necessary for sustainable development. Fortunately, many cities around the world have begun this innovative kind of future-oriented process. Based on the experience of zero-energy projects in many countries, it is important to improve, innovate and modernize policy and management activities.

- A zero-energy city creates a model for eco-design worldwide. It is characterized by strength points such as minimizing the ecological footprint, creating green jobs, bettering quality services, developing zero-carbon economy with highest productivity, improved health and quality of life as well as making people aware of their carbon impact.

- Zero-energy strategies have positive opportunities through self-sustaining in terms of energy needs, development of carbon sequestration technologies and encouraging efficient resources and green designs.

- Recommendations

- Adding concepts and applications within schools and universities curricula and applied research as well as all types of media to appreciate the benefits of zero-energy cities and zero-carbon economy for zero-carbon nations.

- Acting upon this growing demand for zero-energy cities by governments and legislating creating and enforcing green accounting and resources efficiency laws as well as carbon tax

- Adopting a compulsory change in energy, transportation, real estate, construction, supply chain management, carbon sequestration, water use practices and human behavior as the most suitable strategies of achieving the goals of zero-carbon nations.

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