World Academy of Science, Engineering and Technology
International Journal of Architectural and Environmental Engineering
Vol:16, No:3, 2022

# Challenge of Net-Zero Carbon Construction and Measurement of Energy Consumption and Carbon Emission Reduction to Climate Change, Economy and Job Growths in Hong Kong and Australia

Kwok Tak Kit

Open Science Index, Architectural and Environmental Engineering Vol:16, No:3, 2022 publications.waset.org/10012478.pdf

***Abstract*—**Under the Paris Agreement 2015, the countries committed to address and combat the climate change and its negative impacts and agree to the target of reducing the global greenhouse gas (GHG) emission substantially by limiting the global temperature to 2 $^0$C above the pre-industrial level in this century. An international submit named "26th United Nations Climate Conference" (COP26) was held in Glasgow in 2021 with all committed countries agreed to finalize the outstanding element in Paris Agreement and Glasgow Climate Pact to keep 1.5 $^0$C. In this paper, we will focus on the basic approach of waste strategy, recycling policy, circular economy strategy, net-zero strategy and sustainability strategy and the importance of the elements which affect the carbon emission, waste generation and energy conservation will be further reviewed with recommendation for future study.

***Keywords*—**Net-zero carbon, climate change, carbon emission, energy consumption.

## I. Introduction

A systematic based analysis approach will be adopted for discussion on the net zero carbon emission construction and measurement of energy consumption and carbon emission and their implementation and contribution to the economy and job growth in different countries and cities. In this paper, a more holistic study of the importance of the basic factors in terms of carbon emission, waste generation and conservation of energy will be critically and systematically reviewed and analyzed. Recommendation based on the finding can provide further research and future discussion for different stakeholders in the industry.

## II. Background of Paris Agreement 2015 and COP26 2021

The Paris Agreement 2015 addressed climate change and its negative impacts. The agreement aims to substantially reduce global GHG emissions to limit the global temperature increase in this century to 2 °C above pre-industrial levels. In 2015-2017, parties to the agreement began submitting climate action plans known as nationally determined contributions (NDCs). Initial commitments and fully implemented would only be enough to slow warming to 3 °C. Urgent calls for action and ambition gained momentum as the plans would not stop catastrophic impacts. In the lead-up to the COP26 climate talks in 2020-2021, countries have begun revising their NDCs to strengthen climate action. With science affirming a shrinking window of opportunity, the plans must include urgent actions to cut carbon emissions and reach net zero by 2050.

The 26th United Nations Climate Change Conference (COP26) was held in Glasgow in 2021. In the Submit, all countries agreed to the Glasgow Climate Pact to keep 1.5 °C and finalized the outstanding elements of the Paris Agreement.

## III. Factors and Steps to Achieve Net Zero in Building and Construction Industry

The concept of net zero is evolving and has become the trend of building and construction development in various countries in future. According to [1], [9], the waste strategy is defined to provide the capacity to handle the waste as a primary approach, recycling policy is to manage the waste resources in a more efficient way, circular economy strategy is to minimize waste and maximize their value, net zero strategy is the action to take for carbon neutrality and finally sustainability is to achieve a longevity without impact to the environment and our planet. The factors related to net zero carbon emission and considered have significant influence to the achieve sustainability and environmental conservation including the following:

(1) Net-zero Carbon Emission in Building and Construction Industry

a) Reduction of Energy Demand

The optimization of the energy efficiency facilities and building is the major factor for decision making in the building and infrastructure construction planning stage [6]. In the design phase, the enabling infrastructure, building and facilities associated with the pre-assumption energy strategy plan have to be carefully and holistically assessed with the aim to reduce the energy consumption to a certain level which can meet the high energy performance by inclusion of sustainable architectural design, sustainable engineering and adoption of extensive renewable energy supply. Architecture, Engineering and Construction (AEC) professionals should work together and recommend the most efficient proposal and improvement solution like form, structure, facade material, construction

Kwok Tak Kit is with DLN Architects Limited, Hong Kong (e-mail: tkepisode@gmail.com).

Open Science Index, Architectural and Environmental Engineering Vol:16, No:3, 2022 publications.waset.org/10012478.pdf

method and mechanical, electrical and plumbing (MEP) system to meet the target and optimize the reduction of fossil energy consumption and carbon emission [7].

Instead of achieving the minimum regulation standards, a performance-based assessment and methodologies should be carried out in the design stage to estimate the expected energy consumption with reference to client expectation, estimated occupancy and intended use to achieve the optimization of future operational energy consumption and provide a more accurate reflection of energy consumption.

b) Reduction of Embodied and Upfront Carbon

The construction process contributes a significant part of carbon emission during the manufacturing, transportation and construction. Embodied carbon emissions are produced primarily before a building is operational and decommissioned. The upfront embodied carbon emission is associated with the construction of a building and it cannot be later improved. In the early design stage, it is important to select net zero embodied and upfront carbon in order to achieve the decarbonization; for example, (i) using local and internationally recognized environmental assessment tools for proposing a best practice embodied carbon reduction strategy and (ii) monitoring the whole construction process as well as the final performance of buildings.

In the past few years, the concern of construction carbon emission during the building cycle and reducing embodied carbon is increasing in the AEC industry. However, there is no statutory or internal standard published to regulate the control of embodied carbon with a quantified baseline for the AEC industry to follow. In most of the transport, infrastructure and building and construction enabling building and infrastructure projects, the AEC can only rely on their own professional judgment with client commercial decisions on the selection of low upfront embodied carbon building material to minimize the impacts in the construction phase as practically as possible. A publication by the World Green Building Council [8] recommended the target of reducing the construction-related embodied carbon by 40% by 2030, which is the latest guideline for AEC to make reference to in new projects. In the new planning of transport, infrastructure and building and construction development, practitioners should also make reference to other international guidelines and life cycle carbon assessment during the planning and construction phase to achieve the net zero target by reducing the use of upfront embodied carbon material in view of the environmentally sensitive nature of transport, infrastructure and building and construction development.

c) Green Energy and Renewable Energy Supply

The problem of heavily relying on national fossil fuel power supply in transport, infrastructure and building and construction enabling development is a prime concern. Adoption of on-site generation of low carbon heat and hot water supply, technology of energy storage and renewable energy in development for decarbonization can be more practically implemented with the support of government agents and aggressive stakeholder's vision. Depending on the geology, business model and other characteristics of countries and cities, adoption of suitable types of renewable energy including bioenergy, low emissions fossil fuel, solar, wind, hydrogen, etc. should be developed as far as possible.

d) Zero Carbon Policy

Government support and establishment of incentive and funding schemes to encourage stakeholders to contribute and commit to the mission of a net-zero target and development are the most important influential and essential factors. Clear regulations and rules on zero carbon emission other than pollution and conservation control should be launched as early as possible to accelerate the integration of net zero commitment in development particularly transport, infrastructure and building and construction. Government incentive scheme to encourage zero carbon footprints during planning and construction phase can achieve the sustainability goal of net zero carbon emission.

e) Circular Economy

The circular economy aims to economic natural and social capital. It is a systems level approach to economic development designed to benefit business, society and the environment. The ways to adopt the principles of the circular economy for carbon emission reduction including designs out waste and pollution, keep products and materials in use and finally regenerate natural systems. Circular economies can help reduce carbon emission and provide opportunities for reducing resource demand and waste, increasing biodiversity gain and mainstreaming health and well-being opportunities into the built environment. Government should establish a clear policy for banning the import of waste including waste fiber, plastics, glass, tires, etc. from other countries and encourage the recycling of waste generated locally. During the planning and construction phase, circular economy principles can improve the environmental performance by adoption of modular building construction technologies which enables the optimized use and reassembly of building components and materials. During the operation phase, circular economy principles provide the solution for the use of renewable energy and new technologies to improve resource efficiency in building.

f) Transportation

The transportation sector is considered as one of the largest sources of GHG emission due to their high demand of burning fossil fuel. Promotion of the use of electrical charging vehicles and development of more advanced technology of electricity operated machinery can significantly reduce the reliance on conventional transportation models.

2) Indoor Energy Performance and Carbon Reduction Control

Commercial buildings are responsible for the major part of GHG emission while residential buildings generate most of the household waste daily. High performing buildings are more profitable and more productive. Building owners shall

Open Science Index, Architectural and Environmental Engineering Vol:16, No:3, 2022 publications.waset.org/10012478.pdf

participate and improve their energy use pattern and invest more in better buildings and equipment. This can, in turn, achieve increased productivity, reducing operating costs, increase of property value and attract higher rental returns. Energy efficiency provides a more comfortable, sustainable and quality environment for the occupants. Better equipment such as insulation or an advanced MEP system to control heating and air conditioning is one of the ways to provide benefits to the occupants at the lowest operation costs. Analysis of energy performance and commitment to energy reduction also creates new job opportunities for skilled labor and professionals, and enhances the investment in solar, lighting technology investment and associated industry development

a) Measuring, Verifying and Managing Building Performance are Key Drivers of Economy and Job Growths: Local government shall provide incentives for developers to commit high energy performance or beyond the building code by providing financial incentive for developers to improve their culture of measurement and annual improvement of energy performance.
b) Reducing Carbon Emissions and Impacts on the Environment: Importance Role of the Building Sector: Carbon emission from materials used in construction such as steel and cement are the largest source of carbon emissions in the building sector. Action on reducing emission from building materials is therefore crucial to meet the net-zero targets by 2050. Acceleration on net-zero buildings, particularly in the focus on energy efficiency in new and existing buildings, has become the most important factor to achieve the goal. Industry stakeholders including developers and construction companies shall work together to reduce the emission from construction materials and measure the embodied carbon in the buildings for lifecycle analysis.
c) Role of Building Sustainability to Build Sustainable Future to Deliver on Climate Action

i. Collaboration of Industry Leaders in Building Sector: Establishment of an energy management plan can maintain the energy usage and ensure the building owners to achieve the required energy reduction goal and look for further improvement. Measurement and monitoring of the energy performance is an effective and less expensive way to determine how the building is performing to meet the net-zero target and ensure a long-term monitoring to minimize energy wastage e.g., unusual high electricity usage spotted can be verified by regular measurement and monitoring to rectify the problem of energy waste as early as possible.

d) Role of Stakeholders in Waste Management and Measurement Includes:

i. Building Management: Implementation of contamination management plan with the participation of contractors and key stakeholders to assess waste services, measure material recovery rate and regular report and audit of the measurement results to keep track of the proper waste disposal. Regular meeting should be arranged with tenants to review any challenges and to make necessary system improvement for the plan
ii. Tenants: User education and their awareness is considered necessary like promoting staff training and their internal target setting.
iii. Increase investment in technology including energy optimization to improve energy efficiency: In view of the rapidly aging population and responding to climate change, sustainable innovation can help to tackle the problem and challenges at once. More attention to improvement of energy efficiency and sustainability for the commercial, residential and particularly for the residential aged care sector to address the environmental impact and improve the comfort and quality of life and particularly provide an environmentally-friendly living space for elderly people.
iv. Mandatory disclosure has a net positive economic impact on companies and society, technology and energy efficiency programs lowering emission and providing long-term economic benefit. Disclosure of energy efficiency performance information of the commercial office premises or apartment to prospective buyers and tenants can create a more informed property market with quantitative information, encouraging more energy efficient building and reduced emission. Educating tenants to increase their awareness of the importance and benefits of better energy performance is crucial for long term net-zero carbon achievement.

e) High Quality Carbon Offset: Carbon offsetting is the carbon emission generated through an activity that can be compensated for by financial support by the building owner. Building owners should develop a carbon offsetting strategy and encourage the procurement of high-quality carbon offsets through carbon capture and storage such as bioenergy to compensate for residual emissions.
f) Procurement of 100% Off-site Energy from Renewable Backed Sources: The source and supply of off-site energy is not guaranteed from place to place. Incentive or refund to building owners to negotiate with the renewable generation facilities suppliers to explore options and purchase the renewable energy as appropriate as possible shall be provided by the government.
g) Maximize Supply of On-site Renewable Energy: On-site renewable supply may not be practical and financially viable for all types of building projects. With the rapid development of renewable energy generation technology such as solar energy, building owners should calculate their energy consumption and review the adoption of solar photovoltaic panels to achieve on-site renewable energy supply.
h) Reduction of Operational Carbon: Building owners and tenants should be well trained to raise their awareness of operational carbon reduction during the operation and maintaining of the building. For example, selection of furniture, renovation material should be carefully done with the concept of net zero carbon supply chain and

Open Science Index, Architectural and Environmental Engineering Vol:16, No:3, 2022 publications.waset.org/10012478.pdf

reduction of operation carbon emission.

## IV. Contribution to the Economy and Jobs Growth

The approach of sustainable engineering and circular economy creates the opportunities to significantly reduce the use of natural resources, minimize waste generation, recover resources, and overloading of dumping sites, and mitigates noise, air and water pollution to the community and environment. Circular economy approaches allow to mitigate environmental impacts throughout the value chain in various ways. Circularity can also have a positive net effect on job creation which favors repair, maintenance, upgrading, remanufacturing, reuse and recycling of material and attracting more labor intensive than linear extraction and manufacturing processes.

Notwithstanding the benefit to the environment, sustainable engineering and a circular economy also create job opportunities for different sectors including IT, light and heavy industry, logistics and facilities management. Most importantly, sustainable engineering provides many major benefits to the industry and the economy as compared with traditional building and infrastructure construction practice including:

1) Minimizing the intensive demand of skilled construction labor with the concern of ageing population;
2) Creating opportunities for A/E practitioners to diversify their professionals;
3) Job creation for other sectors with collaboration of different expertise and professions;
4) Reduction of immediate environment impact to the environment and community;
5) Reduction of carbon emission, GHG emission and provision of a long-term strategy to tackle environmental impacts;
6) Value added to building projects and increase in industry reputation;
7) Reduction in the government resources used in construction waste treatment and material sorting;
8) Increase in the productivity, durability and sustainability of building and infrastructure;
9) Driving greater resource productivity; and,
10) Delivering a more competitive economy.

## V. Case Study

The extent and degree of adoption of the approach and the current practice on net carbon implementation as discussed is varied in different countries and cities. Hong Kong and Australia are well known as the leading smart cities and countries in Asia in innovation and development to achieve the commitment of net zero carbon emission in recent decades. A comparison review of the current progress of the net zero race in Hong Kong and Australia is discussed in this case study.

Most importantly, the index of carbon dioxide emission in relation to the population shall be equally assessed and reviewed. A comparison of the structure of energy generation and renewable energy adoption and development in Hong Kong and Australia is reviewed.

TABLE I
Comparison Review of the Current Progress of Net-Zero Race in Hong Kong and Australia

| Key Areas | Hong Kong (Linear Economy) | Australia (Circular Economy) |
|---|---|---|
| Reduction of Energy Demand | Voluntary Energy Efficiency Labeling Scheme | National Integrated System Plan<br>Trajectory for Low Energy Buildings<br>National Energy Productivity Plan |
| Reduction of Embodied and Upfront Carbon | Non-government organization, Construction Industry Council (CIC) initiated Carbon Labeling Scheme for Construction Product | Carbon Capture, Use and Storage Development (2020)<br>Emissions Reduction Fund (ERF) |
| Green Energy and Renewable Energy Supply | Feed-in Tariff Scheme<br>Renewable Energy Certificate | Renewable Energy Target (RET)<br>Renewable Energy Certificate Registry<br>(Australian Renewable Energy (Electricity) Act 2000 |
| Zero Carbon Policy | Hong Kong's Climate Action Plan 2050 | Australia's Whole-of Economy Long-Term Reduction Plan (2021) [1] |
| Circular Economy | Waste Blueprint for Hong Kong 2035 | National Waste Policy and Action Plan<br>Ban the export of waste plastics, paper, glass and tires and develop strategy to increase capacity to generate and market high value recycled commodities. |
| High Quality Carbon Offset | Heavily relied on fossil fuel energy and partially development to solar energy in voluntary basis by individual owners and tenants | Widely adoption of varied type of renewable energy including geothermal energy, solar energy, wind energy, etc. |

TABLE II
Comparison of the Structure of Energy Generation and Renewable Energy Adoption in Hong Kong and Australia

| Mode of Energy Structure | Hong Kong | Australia |
|---|---|---|
| Population | 7,451,000 [2] | 25,357,533 [2] |
| Energy Generation | Coal being the major fuel mix power generation (24%), natural gas (48%) and nuclear power / renewable energy (28%) [3] | Coal being the major fuel mix power generation (40%), oil (34%), natural gas (16%), hydro (5%) and wind (2%) [5] |
| Energy Consumption (Electricity/Capita (GJ)) | 21.41 [2] | 244.3 [2] |
| Fossil $CO_2$ Emission (Megatons $CO_2$/yr) | 44.016 [4] | 433.379 [4] |
| Potential Renewable Energy Development | Solar, wind | Bioenergy, low emissions fossil fuel, solar, wind, hydrogen |

Results showed that differences between two places in terms of population, culture, politics, regulations, economic condition and construction practices are expected to have a

significant impact on the achievement of net zero carbon race performance.

## VI. Conclusion

Some of the key elements and experience on the net zero carbon emission construction and measurement of energy consumption and carbon emission was discussed in this review. The experience of the implementation and contribution of net zero carbon to the economy and job growth in different countries and cities is revised and shared in the paper. The implementation to achieve the target set by different countries and cities toward net-zero carbon depends on different factors including the government policy, financial incentive and funding, geology, economy structures, business model and population. However, research demonstrated that the basic principle in sustainable engineering and circular economy proved to be the effective way to achieve the target and improve the job creation. Key factors and recommendations are outlined in this paper for further discussion and research.

## References

[1] Aojoy Kumar Shuvo, Shayla Sharmin, Carbon Emission Scenario of Conventional Buildings, Journal of Construction Engineering, Management & Innovation 2021 Volume 4 Issue 3 Pages 134-150
[2] EMSD, Hong Kong Energy End-use Date 2020, www.emsd.gov.hk
[3] Environmental Bureau, The Government of the Hong Kong Special Administrative Region, www.enb.gov.hk
[4] Fossil CO2 Emission of All World Countries, JRC Science for Policy Report, 2020 Report, op.europe.eu
[5] Geoscience Australia, Australian Government, www.ga.gov.au/scient
[6] Jana Lippelt and Maximilian Sindram, Global Energy Consumption, CESifo Forum · January 2011
[7] Martin Siegert, The Net- zero Carbon Transition, Enterprise Risk Management · September 2021(a4) Department of Industry, Science, Energy and Resources, Australian Government, www.energy.gov.au

Open Science Index, Architectural and Environmental Engineering Vol:16, No:3, 2022 publications.waset.org/10012478.pdf