INNOVATION CARBON EMISSIONS TO ZERO: STRATEGIES TO ACHIEVE CARBON NEUTRALITY

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INTRODUCTION

The 2009 Copenhagen climate conference made experts realize that it was impossible to cut emissions wholly and quickly enough to meet policymakers' temperature targets. They believed it was imperative to reduce carbon emissions and concerns were raised to actively remove greenhouse gases from the atmosphere, leading to the rise of the concept of achieving "net zero."

There is consensus among policymakers across the globe that in order to ensure that global temperatures do not rise above 1.5 degrees Celsius, we must achieve “net zero” emissions by 2050 at the latest. The real question then becomes- how do we meet this rapidly approaching deadline without destroying our economy and exposing the most vulnerable?

tudies have shown that the majority of emissions are caused by various human activities. It is also evident that industries such as manufacturing and aviation will be unable to reduce their emissions completely. The politics of emission is also equally challenging. Countries responsible for producing historically large levels of emissions are reluctant to embrace responsibility because of the high costs associated with things like repatriation and creation of climate relief funds. Nations with emerging economies are even more reluctant to commit to more stringent laws as it could result in slower economic growth. Also critically for every country, domesitc political scenario will greatly influence what type of international treaties and pacts national governments will be able to commit to. Aside from that, there is a political battle in which countries that are the largest producers of these emissions today are hesitant to accept responsibility because they are just entering the global economy and believe that the most developed economy should take charge and accept responsibility.

As the global population is rising exponentially, the world is facing an unlimited number of crises to keep up with the growing demand for all kinds of resource, ranging from food to fertilizer, minerals to metals for machiners that power prosperity. As huge swaths of population in emerging superpowers like China, India, and huge swaths of Africa continue to rise out of poverty, it will inevitabely accelerate the demand for resources. Companies that wish to serve and thrive in these markets will need to make find ways to reduce costs and a primary way of achieving that goal is by making the most of resources available. As a result, sustainability has become an integral part of an organization's growth strategy. This has urged and inspired many companies to come up with innovative ideas to combat resource crisis and climate change. One major area which most companies have set eyes on is the “net zero energy buildings (NZEB)”.

Net Zero Energy Buildings

What do you think uses more energy yearly? 1000 cars or a single medium-sized hospital building? The hospital is the answer. Buildings, as they are designed today, are a never satisfying sink of energy. In one of his TEDx Talks, Davis Shad discusses how a building consumes more energy than trucks, trains, ships, boats, planes, and other modes of transportation combined. He emphasizes how the construction industry is overlooked compared to other areas or mediums that use energy because they are less marketed or promoted. To explain this, he uses the concept of how electric vehicles are marketed, whereas carpenters with limited budgets do not market buildings, so we don't hear about them very often.[1][OBJ][2].[3]

The alternative is as simple to understand as it is complex to execute. Net-zero buildings are energy efficient and use renewable resources to generate energy on-site or from renewable energy sources

[1] https://www.youtube.com/watch?v=bi-Zu09vX3o

[3] https://www.youtube.com/watch?v=bi-Zu09vX3o

off-site, using various techniques such as heat pumps, high-efficiency windows, insulation, and solar panels.[4] Net-zero buildings are designed with efficiency in energy consumption in mind while also looking at ways to generate electricity via means like solar panels. Over a consumption cycle, usually a period of one year, these buildings aim to supply more energy to national grids than what they consume. The primary goal of these Net Zero Emission Buildings (NZEBs) is to reduce the emission of greenhouse gases by reducing dependence on energy produced from means like coal or petrol-powered power plants and increasing the share of clean energy sources like solar, wind, and hydroelectricity. Moreover, the concept has compound benefits such as tax breaks and cost savings, the ability to earn income by selling excess energy produced, and most importantly, the ability to reduce the negative impact on the environment caused by energy consumption.

Why Net Zero buildings?

Zero-carbon buildings are buildings that don't release any greenhouse gases when they are operated or constructed. They are an important part of the effort to reduce emissions from buildings. While zero-carbon buildings are a new concept and there is still a lot we have to figure out about the ways we build and maintain them, what is undeniable is the fact that they are an important step towards reducing our energy needs.

Statistics show that not only are traditional sources of energy getting more expensive, they are also harder to come by. For example, in the United States, the price of regular motor gasoline increased by 49% from January to June 2022, while diesel fuel increased by 55%. Although fuel prices in the country fell in July 2022, they still remained double what they were in early 2020.[5] Besides the inflationary pressure data, the use of coal in energy production has increased exponentially. In Europe, for example, coal use increased by 14% in 2021 and is projected to rise further in the future. Similarly,

4 https://www.c40.org/accelerators/net-zero-carbon-buildings/

5 https://www.bts.gov/data-spotlight/record-breaking-increases-motor-fuel-prices-2022

global coal consumption is expected to rise by 0.7%, or 8 billion metric tons, by the end of 2022.[6] Consequently, as the price of natural gas has sored up, it has made coal more competitive in many markets, and some countries have increased their use of coal as a substitute for potential energy rationing in winter 2022/2023.[7]

As the cost of alternative energy technologies falls and the cost of traditional fossil fuels rises, the goal of net-zero energy becomes more feasible, and so does the idea of NZEB.

- **Cost-effective:** In comparison to water and waste expenses, energy, specifically electricity, natural gas, and heating oil, are more expensive. Hence, reducing energy consumption can save money. It further insulates the building owners from future energy price increases. Likewise, the reduced total cost of ownership due to improved energy efficiency is observed. Consequently, a reduced total net monthly cost of living is experienced. Although energy-efficient homes are expensive and a luxury that few can afford, there are numerous examples of how they have helped to reduce pollution as well as costs in many regions, including the Netherlands. Energiesprong, a company that retrofits entire houses in the Netherlands, was awarded funding to retrofit 150 homes in Nottingham, resulting in a 50% reduction in energy bills for local residents.[8]

- **Emission reduction:** There are many reasons why it is necessary to embrace the zero-carbon building concept. Buildings are one of the largest sources of greenhouse gas emissions, and the construction sector is one of the most emissions-intensive sectors. There are also life cycle impacts to consider, from the materials used in the construction process to the emissions from the buildings themselves once they are operational. In order to make a real difference in the battle against climate change, we need to tackle emissions from all parts of the system, not just from individual products. Energy has a high carbon footprint, particularly electricity[9]. As a result, reducing energy consumption is a significant way to reduce the carbon footprint of a building. There are well-established methods for significantly reducing building energy consumption and carbon footprints, including adding insulation, replacing furnaces with heat pumps, installing low-emissivity, triple or quadruple-glazed windows, and installing solar

6 https://www.iea.org/news/global-coal-demand-is-set-to-return-to-its-all-time-high-in-2022

7 https://www.cnbc.com/2022/06/21/ukraine-war-europe-turns-to-coal-as-russia-squeezes-gas-supplies.html

8 https://climatechampions.unfccc.int/what-will-your-zero-carbon-home-look-like/

9 https://en.wikipedia.org/wiki/Carbon_footprint

panels on the roof. These measures may seem expensive, but research shows that while the costs of building a zero-carbon home are initially high, they are significantly lower when they are incorporated into all new buildings rather than being installed after completion. Furthermore, by utilizing carbon offsets, often in the form of renewable energy investments, the buildings contribute to achieving net zero emissions.[10] For instance, when heating, the average UK household emits 2.3 tonnes of CO2 into the atmosphere. When compared to conventional houses, zero-emission houses built with passive house tools have reduced heating needs tenfold, thereby helping to reduce carbon emissions.[11]

- **Cost intent energy solution:** NZCB offers increased comfort as a result of more uniform interior temperatures (as demonstrated by comparative isotherm maps), reduced risk of loss due to grid blackouts, and also has more dependable energy systems. For example, photovoltaic systems have 25-year warranties and rarely fail due to weather issues. For example, the 1982 photovoltaic systems on Walt Disney World's EPCOT (Experimental Prototype Community of Tomorrow) Energy Pavilion were used until 2018, despite three hurricanes. They were demolished in 2018 to make way for a new ride.[12] Carbon-neutral homes typically share common design elements, such as strong building insulation, which helps to retain heat in winter and cold in summer, resulting in a temperature that is widely consistent. In addition, the designs incorporate solar panels as an alternative energy source, ensuring a consistent supply of energy in the home.[13]

- **Tax aversion and money back garauntee:** Future energy price increases for NZC building owners will be minimal to nonexistent, reducing the need for energy austerity and carbon emission taxes. It is also likely to push up property prices, as currently there is more demand for NZC buildings than supply. Further, when energy costs rise, the

10 https://wrirosscities.org/ZeroCarbonBuildings

11 https://en.wikipedia.org/wiki/Zero_carbon_housing

12 https://notesfromneverland.com/news/solar-panels-removed-from-universe-of-energy-building-at-epcot/

13 https://idbinvest.org/en/blog/climate-change/coming-soon-zero-carbon-affordable-housing

value of a ZEB building should rise in comparison to a comparable conventional building, as the former will incur significantly lower operating costs.

- A comparative study of the cost of ownership of zero-energy homes in Vermont confirms that zero net worth is a better investment than a similarly coded home, even without discounts or incentives, both in the first year and over the 30-year loan period.[14] Similarly, another study titled 'Net Zero and Living Building Challenge Financial Study: A Cost Comparison Report for Buildings in the District of Columbia' shows that the energy efficiency premium was 1%–12% depending on the type of building, and this increased to 5%–19% for net zero energy.[15]

HOW TO BUILD A NET ZERO BUILDING ?

There are a number of ways we can build a zero-carbon building. Technological advancements have made it possible to build structures that produce virtually no greenhouse gases when in use. Michael Lio, president of buildABILITY and a Toronto-based local engineer and zero-energy housing expert, identifies retrofitting the exterior of a home, such as windows and insulation, as key ways to make a cost-effective transition to zero energy[16] To create homes with low utility costs and emissions, new zero-efficiency buildings combine energy efficiency and renewable energy production. In most cases, zero-emission homes are 1–8 percent more expensive than traditional homes that do not use solar or energy-efficient appliances. According to the Rocky Mountain Institute, constructing a zero-cost home costs 1–8% more than constructing a standard home.[17]

Design strategies are also important in terms of zero-carbon buildings. For instance, by using materials like insulation and solar panels, we can reduce the need for energy to be consumed by the building. This can lead to significant reductions in emissions. Construction processes

14 https://zeroenergyproject.com/buy/cost-less-to-own/

15 https://www.bdcnetwork.com/study-quantifies-cost-premiums-net-zero-buildings

16 https://ensia.com/features/net-zero-energy/

17 https://www.attainablehome.com/how-much-does-building-a-net-zero-home-cost/

are also important when it comes to zero-carbon buildings. For instance, we need to make sure that the buildings are constructed using sustainable methods, such as using recycled materials. Finally, we need to consider the built environment when it comes to zero-carbon buildings. This includes things like the layout of the building, the materials used in construction, and the design of the lighting and heating systems. Building materials that are energy efficient also help reduce the carbon footprint of homes. Buildings can achieve zero-carbon emissions by using on-site and/or off-site renewable energy, reducing the use of high-heating-potential refrigerants globally, using low-carbon fuels, and reusing or recycling materials in construction. Similarly, by utilizing carbon offsets from renewable energy investments, buildings can achieve net zero emissions.[18]

NATIONAL POLICIES TOWARDS ZERO-CARBON HOUSING

Although the concept of zero-carbon housing has been around for decades, it is only recently that governments have started to put in place policies and energy consumption requirements for housing. The objectives of these policies range from reducing energy consumption to encouraging the use of environmentally friendly construction materials and techniques.

United Kingdom

In 2021, the UK announced a new building code that aims to reduce the carbon emissions of buildings by 27%. As a part of a 6.6 billion-pound investment program, the goal is to improve energy efficiency by using the funds to help low-income households install solar panels, insulation, more efficient heat pumps, and other decarbonization measures.[19] Furthermore, the country's building regulations also require that before construction work starts in a new building, the concerned party "must analyze and take into account the technical, environmental, and economic feasibility of using high-efficiency alternative systems". Additional regulations relating to insulation, boilers,

18 https://www.weforum.org/agenda/2021/09/how-to-build-zero-carbon-buildings/

19 https://www.gov.uk/government/news/new-homes-to-produce-nearly-a-third-less-carbon

ventilation, and lighting have also been put in place to be implemented for all buildings whose construction starts after June 15, 2023.[20]

Australia

The Zero-carbon Housing policy in Australia aims to reduce the carbon emissions of new residential buildings to zero. This is achieved through a combination of energy-efficient design and the use of renewable energy sources such as solar panels and battery storage. The policy is currently being implemented by the Australian government through the National Energy Efficiency Building Project (NEEBP), which provides funding for the development of zero-carbon housing. The NEEBP also provides support for building owners and developers to undertake energy-efficient upgrades and retrofits. According to a report by the Australian Renewable Energy Agency, the adoption of zero-carbon housing in Australia could reduce national greenhouse gas emissions by up to 4%.[21]

United States

The United States does not have a specific national policy for zero-carbon housing. However, there are several initiatives and programs at the state and local levels that promote energy efficiency and renewable energy in the housing sector. One example is the Energy Star program, which encourages the use of energy-efficient appliances and building materials. The Department of Energy also provides funding and technical assistance for research and development of advanced energy technologies for housing. Additionally, many states have renewable portfolio standards, which require a certain percentage of energy to be generated from renewable sources. Some cities and states, such as California and New York City, have also set targets for reducing greenhouse gas emissions from buildings.[22] States like California

[20] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1099626/ADL1.pdf

[21] https://www.energy.gov.au/government-priorities/buildings/residential-buildings

[22] https://programs.dsireusa.org/system/program/ca

also have a self-generation incentive program whereby households are eligible for payouts if they produce energy using renewable sources like solar and wind and can supply it to the national grid. [23]

Japan

Japan's zero-carbon housing policy aims to reduce greenhouse gas emissions from the housing sector and promote energy efficiency and renewable energy. The Japanese government has implemented several policies to achieve this goal, including the Energy Conservation Act and the Act on Promotion of the Use of Renewable Energy. The Energy Conservation Act requires new buildings to meet certain energy efficiency standards, and the Act on Promotion of Use of Renewable Energy encourages the use of renewable energy in the housing sector.

The government also offers various financial incentives for individuals and companies to invest in energy-efficient and renewable energy technologies for housing. For example, the Ministry of the Environment provides subsidies for the installation of solar panels on homes, and the Ministry of Economy, Trade, and Industry offers subsidies for the construction of energy-efficient homes. The goal is for new construction projects built after 2030 to be completely carbon-neutral.[24]

Additionally, Japan has set a target to reduce greenhouse gas emissions from buildings by 80% by 2050, compared to 2013 levels. This goal is expected to be achieved by a combination of energy efficiency measures, such as the use of energy-efficient building materials, and the increased use of renewable energy sources, such as solar and wind power.

[23] https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/self-generation-incentive-program
[24] https://www.archdaily.com/978260/the-future-of-sustainable-housing-in-japan-paving-the-way-to-net-zero-energy-housing#:~:text=In%20April%202014%2C%20the%20Japanese,using%20renewable%20energy%20on%2Dsite.

BARRIERS TO ADOPT ZERO-CARBON HOUSING

There are several key barriers to the widespread adoption of zero-carbon housing, including cost, lack of awareness, and lack of regulations.

i. Cost: One of the main barriers to zero-carbon housing is the cost associated with implementing energy-efficient and renewable energy technologies. According to a study by the National Renewable Energy Laboratory (NREL), the upfront costs of constructing a zero-energy home can be higher than those of a conventional home, even if the total cost of owning the home over its lifespan is lower.[25] This can be a significant barrier for homeowners and developers who may not have the financial resources to invest in zero-carbon housing.

ii. Lack of Awareness: Another barrier to zero-carbon housing is a lack of awareness about the benefits and cost-effectiveness of these technologies. A survey by the National Association of Home Builders found that while 82% of homebuilders are familiar with green building practices, only 24% have built homes with zero-energy or net-zero-energy features.[26]

iii. Lack of regulations: The lack of regulations and standards for zero-carbon housing is another barrier to its adoption. In many countries, the energy efficiency standards for buildings are not as high as they need to be to make zero-carbon housing a viable option. Additionally, in most countries, the regulations for renewable energy are not as developed to enable the wide adoption of renewable energy technologies.

PROGRESS MADE IN TECHNOLOGIES AVAILABLE TO ADVANCE ZERO-CARBON HOUSING

There have been several recent developments in the technology used for zero-carbon housing over the past decade.

[25] https://zeroenergyproject.com/buy/cost-less-to-own/
[26] https://www.nahb.org/-/media/NAHB/advocacy/docs/industry-issues/sustainability/green-and-healthier-homes-2015.pdf

i. Energy efficient building materials: One of the most promising developments in the technology used for zero-carbon housing is the use of energy efficient building materials. For example, the use of insulated concrete forms (ICF) and structural insulated panels (SIP) can reduce energy consumption by 32-60%.

a. Insulated Concrete Forms (ICF) are a type of building material used in the construction of homes and buildings. They consist of two layers of insulation material that sandwich a layer of concrete. The insulation material can be made of polystyrene, polyurethane, or another type of foam. ICF blocks are made in various sizes, so they can fit together to form the walls of a building, and once the concrete is poured, they provide a monolithic structure, meaning they act as a single solid element, which offers a high level of resistance against natural hazards, fire, and sound. ICF can save as much as 44% energy for buildings. [27]

b. Structural Insulated Panels (SIPs) are a type of building material that consist of an insulated core sandwiched between two layers of structural material, typically oriented strand board (OSB). These panels are used in walls, floors and roofing, they are typically manufactured in a factory, then transported and assembled on-site. The use of SIPs in the construction of buildings can reduce energy consumption by up to 60% compared to traditional construction methods. [28] SIPs have a high insulation value, making them more energy-efficient than other building materials, and they also have a faster installation time and a higher strength-to-weight ratio. They are also more effective in preventing heat loss and cold gain, improving overall thermal comfort and providing more environmental-friendly building.

[27] https://www.greenbuildingsolutions.org/blog/pushing-energy-envelope-icfs/
[28] https://acmepanel.com/benefits-comparisons/energy-efficiency-r-values/#:~:text=SIPs%20Homes%20have%20repeatedly%20demonstrated,over%20a%20typical%20mortgage%20period.

ii. Building-integrated photovoltaics (BIPV): BIPV is a technology that integrates solar panels into building materials such as roofing, siding, and glazing, to generate electricity from renewable energy sources. These solar cells are placed in a way that they are part of the construction, not just an add-on. BIPV is a cost-effective and attractive way to generate electricity while also reducing the energy consumption and increasing the architectural design of the building. According to a study by the Natural Resources Canada, the use of BIPV can reduce energy consumption by up to 60%.[29]

iii. Smart home technology: Smart home technology allows for the monitoring and control of energy use in a home through the use of a central control system. This technology can help to reduce energy consumption by up to 15% by providing real-time information on energy usage and allowing for adjustments to be made.[30]

iv. Ground-source heat pumps: Ground-source heat pumps (GSHP) are a type of heat pump that use the consistent temperature of the earth to heat and cool buildings. They work by extracting heat from the ground, or a body of water, during the winter and transferring it into the building, and during the summer, extracting heat from the building and transferring it back into the ground. GSHP are highly efficient, as they take advantage of the earth's constant temperature to provide heating and cooling at a fraction of the energy consumption of conventional systems.The GSHP system includes a heat exchanger that is buried in the ground, typically by drilling a series of wells or by excavating a trench, and then connecting it to a heat pump unit located inside the building. The heat exchanger captures the heat from the ground and sends it to the heat pump, which then distributes the heat throughout the building. According to a study by the U.S. Department of Energy,

[29] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/files/2011-040.pdf
[30] https://www.enercare.ca/blog/smarter-home/8-ways-your-smart-home-can-save-energy#:~:text=Nest%20Labs%20released%20a%20smart,by%20using%20a%20smart%20thermostat.

the use of ground-source heat pumps can reduce energy consumption by 30-70% compared to traditional heating and cooling systems.[31]

BEST PRACTICES FOR ZERO-CARBON HOUSING CONSTRUCTION

There are several best practices that can be implemented to ensure that a building is zero-carbon housing:

i. Energy efficiency: Implementing energy-efficient design principles and building materials is crucial for achieving zero-carbon housing. This includes using high-performance windows and insulation, efficient heating, ventilation, and air conditioning (HVAC) systems, and energy-efficient lighting and appliances.
ii. Renewable energy: Incorporating renewable energy sources such as solar, wind, or geothermal power into the building can significantly reduce its carbon footprint. Installing building-integrated photovoltaics (BIPV) or a ground-source heat pump (GSHP) can provide a significant portion of the building's energy needs.
iii. Energy management system: Implementing an energy management system (EMS) can help to monitor and control energy usage in the building, allowing for real-time monitoring of energy consumption and identifying opportunities for energy savings.
iv. Water conservation: The building should be designed to conserve water through water-efficient fixtures, rainwater harvesting, and greywater reuse.
v. Building orientation: Orienting the building to optimize natural light and passive solar heating can reduce the energy consumption of lighting and heating systems.
vi. Green roofs and walls: Incorporating green roofs and walls in the building design can significantly reduce the energy consumption of the building while providing a number of

[31] https://www.energy.gov/eere/buildings/building-america

benefits, such as reducing the heat island effect, promoting biodiversity, and improving air quality.

vii. Certifications: Obtaining certifications such as LEED, Energy Star, or Passivhaus can provide a framework to ensure that the building is designed, constructed, and operated in a sustainable manner.

viii. It's important to notice that these best practices should be adapted to the specific location, climate, and context of the building, and it's recommended to consult with local authorities, experts, and studies that reflect the specific case you are addressing.