Carbon Negative Projects: Perspectives and Solutions

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Abstract: Global development has been heavily dependent on the overexploitation of natural resources since the Industrial Revolution. Through the widespread use of fossil fuels, deforestation and other forms of land-use change, human activities have contributed to a steady increase in greenhouse gas (GHG) concentrations in the atmosphere, causing global climate change. In response to worsening global climate change, achieving carbon neutrality by 2050 is the most urgent challenge on the planet. In this regard, it is extremely important and difficult to reform existing production systems in order to reduce greenhouse gas emissions and help capture CO2 from the atmosphere. Here we look at innovative technologies that offer solutions for achieving carbon neutrality and sustainable development, including renewable energy production, transforming food systems, adding value to waste, preserving carbon sinks, and carbon-negative manufacturing and construction. The abundance of knowledge presented in this review can inspire the global community and further develop innovative technologies to mitigate climate change and sustainably support human activities.

1 INTRODUCTION

Europe's emission reduction commitments under the 2015 Paris Agreement and its long-term goal of a decarbonized economy by 2050 mean that both the European Union and its member states will have ever tighter emissions budgets. Reflecting the long-term vision of both the EU and the UK (in the Climate Change Act 2008) (Anshin, 2019). A country's ability to realize a sustainable low-carbon future is inextricably linked to its ability to successfully decouple economic and emissions growth. The successful emergence of this new climate-driven economic model must be closely linked to the parallel development of a carbon-free energy system. For Russia to achieve its goal of decarbonizing by 2050, we must ensure that the economy is first on the appropriate low-carbon transition path. As a starting point, policy makers should develop their understanding and vision of what a low carbon economy in the Russian Federation will look like by 2050 (Surowiecki, 2021). Policy makers must identify appropriate measures and appropriate pathways to realize this vision. To minimize the costs of a low-carbon transition, policy makers need to put in place measures. Russia's key climate and energy challenge is to reduce emissions in sectors not covered by the Emissions Trading Scheme (ETS) or non-ETS sectors that cover areas such as agriculture, transport and residential heating. Price signals will encourage major energy producers and consumers to increase their emission reductions through the EU ETS. For non-ETS sectors, there are no such guarantees. Therefore, policy makers have a central role to play in reducing non-PTS releases, recognizing that policy responses must be shaped in the context of reducing future emission budgets (Souter, 2019). A discussion of how Russia can make an energy transition is most appropriate, given the need to decouple emissions and economic growth (Braverman, 2019). The approach to determining the optimal energy balance was based on the use of the cheapest technologies that have already been successfully applied on a large scale. In accordance with the PwC Roadmap, greenhouse gas emissions from residential heating are reduced by 80%. This corresponds to an approximately 71 percent reduction

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in average household heating demand (currently met mainly by oil and gas) (Murtazova, 2021). This is achieved through a combination of building codes that call for emission-free new homes, coupled with an extensive retrofit program for existing homes that improves energy efficiency (better insulation and airtightness) in combination with low-carbon heating sources. Overall, in the industrial and commercial sectors, we estimate that emissions reductions of around 80% could be achieved primarily through building regulation and the phased introduction of higher carbon taxes until 2050 (Gakaev, 2020). In the transport sector, our roadmap sees the mass adoption of electric vehicles instead of traditional petrol and diesel vehicles with heavy duty vehicles powered by biogas in the form of compressed biomethane. This, combined with the electrification of public transport, can reduce transport emissions by 94%. Electric vehicles are emerging as a “winning” technology due to the expected further reduction in the cost of lithium-ion batteries, an increase in the supply of electric vehicle models, and the expectation that electric vehicles will become cost-competitive with internal combustion engines (ICE) from 2025. Our model predicts strong adoption of electric vehicles from 2025 onwards, and by 2050 all vehicles on the road will be electric. According to our estimates, the roadmap can achieve a 92% reduction in electricity emissions. This will require a power grid built on a significant portfolio of renewable generation. Renewable power outages will be addressed by flexible gas-fired generation used in combination with carbon capture and storage. Our roadmap also includes replacing existing coal and peat plants with biomass-based generation and strengthening the interconnection of electricity with key markets, which will allow us to import and export electricity (Vladimirov, 2019).

Climate change is undoubtedly the greatest challenge of our time. The 2016 Paris Climate Agreement sparked renewed optimism that the global community can and will work together to cut emissions and limit warming to safe levels. However, science now shows with frightening clarity how quickly we are running out of time to avoid catastrophic and irreversible changes in the world around us. We need to take urgent action to nearly halve global emissions by 2030 and eliminate them completely by mid-century. It is in this context that the term "net zero carbon" began to come into use. Businesses, government and civil society are grappling with what net zero carbon emissions will mean for them and how this can be achieved in practice. This report aims to sort that out for the construction and real estate industries, as well as reach consensus on the actions needed to achieve zero carbon emissions. The framework outlined in this report is conceived as a first step towards the construction of buildings that meet the goals of the Paris Agreement, namely zero carbon emissions throughout the life of the building (Molchanova, 2019). In practice, however, it would be difficult to realize such ambitions today without better measurement and emission data. Thus, the framework presented here refers to two definitions of zero-carbon buildings – one for the work energy used and one for emissions during the construction process – that should be adopted by any building environment organization that is serious about climate change mitigation. . Initially, the framework is meant to be used as a guide, with more stringent standards and goals developed over time to encourage further action and accelerate change. This is a challenging and new discipline for built environment professionals, so I encourage everyone involved in the design, construction, and operation of buildings to become familiar with the framework and work with us to develop the details in the coming years.

2 RESEARCH METHODS

Industrialization, the engine of economic growth and urbanization, has accelerated the development of various sectors due to the growth of the world's population and wealth. By 2050, the world's population is expected to grow from 7.8 billion people in 2020 to 9.9 billion people, requiring 80% more energy and 70% more food when the accompanying rise in living standards is factored in. Over the past two centuries, the world economy has been heavily dependent on the overexploitation of natural resources and changes in the life-sustaining biogeochemical cycles and processes in the biosphere. The current boom in oil use and deforestation is a response to pressure to meet growing demand for energy, food and other commodities. These environmentally unfriendly practices are the main reasons for the increase in emissions from anthropogenic sources in (Egorova, 2020).

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To achieve carbon neutrality and sustainably support human activities, it is essential to reduce carbon emissions from fossil fuels and food while promoting carbon sequestration in terrestrial and marine ecosystems. Different strategic paths have been mapped out in different countries to achieve carbon neutrality, but due to the magnitude of the flows involved, reducing carbon emissions to zero is a challenging task (Meckling, 2020). According to the International Energy Agency, if the world becomes carbon neutral by 2050, the extraction and development of new deposits of crude oil, natural gas and coal should cease in 2021. In this regard, investment in research and implementation of renewable energy sources from non-carbon sources (i.e. sunlight, tides, wind, water, waves, rain and geothermal energy) and biomass (i.e. organic materials from plants or animals) are the key to bridging the gap between rhetoric and reality about zero CO2 emissions.

Renewable resources can provide more than 3,000 times more than current global energy demand. The global demand for renewable energy sources (in the form of electricity, heat and biofuels) has grown significantly over the past decade, with the share of renewable energy sources in global electricity production rising from 27% in 2019 to 29% in 2020. Despite this progress in the use of renewable energy sources, the pace of transition from traditional to renewable energy sources is not high enough, and the world is not on track to achieve carbon neutrality and sustainable development by 2050 (Gakaev, 2020). Therefore, additional efforts are needed to convert energy. sector into a climate-neutral hub. This can be achieved through the joint work of various interdisciplinary research groups and the application of integrated approaches developed as a result of the latest scientific and technical achievements in the field of civil engineering and ecology, biotechnology, nanotechnology and other fields. In addition to the development of renewable energy sources, there is also a need to optimize the management of food systems in order to improve production efficiency and reduce carbon emissions. This can be achieved through the development of new technologies for more efficient fertilizer production and precision farming, the integration of crop and livestock systems, and the development of carbon neutral food production systems. Given that the world is unlikely to significantly reduce fossil fuel-based CO2 emissions in the short term, harnessing the power of natural resources and processes to remove CO2 from the atmosphere represents a viable path to carbon neutrality. To mitigate climate change, various potential strategies are being explored to increase industrial carbon capture from the atmosphere and carbon sequestration in terrestrial and marine ecosystems.

These include bioenergy with carbon capture and storage; increased weathering of rocks due to the spread of crushed minerals, which are naturally able to absorb CO2 on land or in the ocean; afforestation and reforestation; carbon sequestration in the soil with biochar, compost, direct application of biowaste and conservation tillage, among others; ocean fertilization through the use of iron and/or other nutrients to stimulate the growth of photosynthetic plankton; restoration of coastal wetlands; and direct air capture using chemicals to remove CO2 directly from the atmosphere. The practicality, cost, acceptability and usefulness of each of these so-called negative emissions (NET) technologies for climate change mitigation and its impact on global ecosystems and human activities need to be assessed. There have been many reviews examining pathways to carbon neutrality, focusing on carbon capture and storage from renewable energy sources in terrestrial and marine ecosystems, and transforming food systems. However, to our knowledge, no review has compared strengths and challenges. of all available new technologies towards carbon neutrality or identified uncertainties associated with these new technologies in climate change mitigation. This overview focuses on new technologies to accelerate our race to carbon neutrality in a variety of areas, including for renewable energy, sustainable food systems (increasing soil carbon sequestration and reducing carbon emissions), maintaining the health of Earth's largest carbon stocks (restoration and protection). marine and forest ecosystems) and carbon-neutral chemical industry. The dissemination of information is expected to inspire the global scientific community and generate interest in further research into new ways to achieve carbon neutrality.

3 RESULTS AND DISCUSSIONS

The World Green Building Council is catalyzing the construction and real estate industries to lead the transition to a zero-carbon environment through its Advancing Net Zero campaign. buildings account for about 30 percent of emissions, mainly from heating, cooling and electricity use (Murtazova, 2021). Whereas for new buildings, the embodied emissions from construction can account for up to half of the carbon impacts associated with a building during its life cycle. The term "zero carbon" has a special meaning in recent years of government climate policy. However, this report is intended to introduce an entirely new chapter. While the historical "zero carbon" policy has only focused on operating energy and simulated performance in new buildings, this report very clearly expands the scope to operational performance and covers the lifetime impact of carbon emissions both new and, especially important, existing houses and buildings. . Moreover, it is not exclusively or even primarily a public policy report. This report sets out a comprehensive framework of coherent principles and indicators that can be integrated into policy but primarily used by businesses as a tool to move towards a zero-carbon environment (Gakaev, 2020). The framework was developed by an industry task force of enterprises, trade associations and non-profit organizations in a collaborative and consensus-building spirit. It provides guidance on how to define carbon zero buildings, both residential and non-residential, and a way to demonstrate how a building has achieved carbon zero status. It focuses on a carbon footprint that can be easily measured and mitigated today – operating energy and the embodied building impact. However, a framework cannot be static, and this iteration is just the first step. The scope and minimum requirements of the concept will require periodic improvements and upgrades over the next decade to improve reliability and provide enough flexibility for the industry to lead the transition to zero-carbon buildings throughout their lifespan (Molchanova, 2019).

The Carbon Zero Building Framework sets out the definitions and principles of two approaches to achieving zero carbon that are equally important: Net Carbon Zero Building (1.1) (Vladimirov, 2019):

"When the amount of carbon emissions associated with the building product and construction phases to practical completion is zero or negative, through the use of offsets or net renewable energy exports on site."

Net zero carbon - work energy (1.2):

"When the annualized amount of carbon emissions associated with a building's operational energy is zero or negative. A zero-carbon building is highly energy efficient and is powered by on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.

Developers aiming for zero carbon building construction must design the building in a way that ensures zero release of carbon for energy production and, if possible, this should be achieved annually during operation. Net zero carbon for both construction and industrial energy represents the highest level of commitment to this framework (Gakaev, 2020). A third approach to net zero carbon - whole life is also offered at a high level, but further work will be needed to determine the scope and requirements for this approach. The summary table on the next page shows which principles to follow to demonstrate compliance with zero carbon emissions in construction and energy production. The detailed framework in the full report includes the background rationale for the principle, associated technical requirements, and, where appropriate, any areas for future development of the framework.

Excessive consumption of energy from non-renewable resources increases energy scarcity, greenhouse gas emissions, climate change and environmental degradation, all of which endanger humanity. As a result, humanity's environmental consciousness and the transition to low-carbon or no-carbon energy is now more of a concern than at any time in the past. A number of global policies have been developed to address these issues. Among clean energy sources, renewable energy sources such as solar, wind and ocean power are considered to be among the most important and efficient means of achieving carbon neutrality (Hibbard, 2019). In addition to nuclear energy and hydrogen energy, which have the advantage of low resource consumption and low risk of pollution and are identified as a strategic approach to national energy security and the goal of carbon neutrality, bioenergy is also the key to reorganization. structure of energy supply and consumption. Key technologies for renewable energy and the impact of these technologies on achieving carbon neutrality are discussed below. In particular, the future development and possible progress of these technologies are also presented.

4 CONCLUSIONS

In all cases, a developer, owner or tenant of a building seeking to achieve zero carbon emissions must do so in the largest area of the building over which they have influence or direct control. In all examples, the boundaries and corresponding floor area must be clearly indicated to allow the market to judge the extent to which the developer, owner or tenant of the building has achieved zero carbon emissions. For a carbon zero building, the boundary is defined as all areas included in the lifetime carbon estimate that have been reported and adjusted at near completion. In the case of multiple buildings, the goal should be to achieve zero carbon emissions for the entire development. For net zero-carbon energy, the operating energy frontier (or energy volume) is defined as the sum of all areas under operational control or influence that achieve net carbon zero on an annual basis. The energy sector should be as accessible as possible to allow comparison between buildings. We have developed three principles that can motivate developers to use zero emission technologies (Meckling, 2020).

1. The polluter pays a fine (Egorova, 2020).
1. The costs of eliminating emissions should be borne by the entities responsible for their creation. To the extent possible, any emissions should be measured and offset as they occur to encourage reduction and mitigation as first steps before any form of offset is considered. Where appropriate, the operational use of energy should be delineated between entities that are responsible for and/or have the ability to influence the use of energy.
2. Easy to measure net carbon balance. To the extent possible, emissions from buildings should be based on measurements rather than estimates, and using the best available data. Public disclosure of emissions should also provide transparency on how this information was collected and the approach taken by the building to achieve net zero carbon emissions. Operational energy performance should be based on measured energy consumption and energy production in use, while lifetime carbon emission estimates should be verified and updated at the time of completion.
3. Additional preferences for carbon-neutral developers.

A zero-carbon building environment will require a lifelong carbon approach to zero-carbon buildings, but the framework outlined here is limited to areas where measurement and mitigation is possible today – operational energy use and embodied carbon from construction. High-level principles and indicators have been established for these areas to guide action and encourage public disclosure. The future development of the framework will introduce clearer requirements and targets, such as minimum energy efficiency targets, and expand the scope of a zero carbon lifelong approach.

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