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Overview of the Regulations of Different Regions to Reduce Carbon Dioxide Emission, and Building Policy

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Abstract. This paper assesses the global urgency to decarbonize the buildings and construction sector, which around 40% of annual global emissions, against the backdrop of record atmospheric concentrations (426 ppm in 2025). The research reviews the carbon strategies and building regulations of major global emitters, including the EU, USA, China, Russia, India, and Brazil, and evaluates the challenge posed by the existing and projected global building stock. Analysis reveals significant policy disparity: the European Union leads with legally binding targets and directives, mandating net-zero new buildings by 2028, while policies in other large economies (e.g., Russia) remain very moderate to reduce fossil carbon emission. Furthermore, achieving the net-zero building stock goal by 2050 is severely challenged by the inertia of existing buildings and dynamic growth in emerging economies. Two-thirds of today's buildings will remain in use in 2040, yet the annual deep renovation rate in the EU is only around 0.2%. With 80% of new construction growth expected in developing nations, a radical acceleration of deep renovation (to 2–3% annually) and uniform global adoption of mandatory net-zero standards for all new construction by 2030 are imperative.

1 Introduction

The global warming is already proven by the temperature and extremely raising concentration of carbon dioxide in the atmosphere. The up to data value is 426 ppm on 20th November and still raising massively. The carbon concentration was about 304 ppm a century ago and even 369 ppm in the year 2000. Beside the actual concentration the annual global emissions rate is much more important. Global CO_2 emissions in 2024 increased by 0.8-0.9% compared to the previous year, reaching a record 37.4 billion tonnes, driven by emissions from fossil fuels and cement production [1]. Total carbon dioxide emissions, which include both fossil CO_2 and emissions from land-use change such as deforestation are expected to rise to 41.6 billion tonnes in 2024. Atmospheric CO_2 concentrations increased by 3.75 ppm during 2024, the highest annual increase since modern measurements began in 1958 [2]. At current emissions

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rates, the Global Carbon Budget team estimates that in about six years there is a 50% chance that global warming will permanently exceed 1.5°C [3].

The consequence of further increase seems to be dramatic not only for the humankind but the nature also. The extreme weather affects deeply the living conditions of plants and animals all over the world. Ensuring liveable conditions needs an intense intervention globally. These means the actions of different countries and unions, especially the ones having a high ratio of the carbon dioxide emission. The governments have the opportunity to influence emission reductions through regulations, because market competition between multinational companies does not facilitate meaningful production intervention to reduce emissions. That is why the policy and commitment of governments are of decisive importance. There are significant differences in the ambition, implementation and legal frameworks of carbon emission control across the world. While some regions have adopted strict, legally binding targets and comprehensive packages of measures, others are taking a less ambitious or delayed approach.

In recent paper we wanted to give an overview to the regulations and directives of featured regions and countries how they regulate the production processes the products and the expectation of building materials and any other sections of the economy they control.

1.1 The roles of buildings in the carbon emissions

The buildings and construction sector is responsible for approximately 37-40% of annual global emissions. The buildings and construction sector accounted for 36% of final energy use and 39% of energy and process-related carbon dioxide emissions in 2018, of which 11% came from the production of construction materials such as steel, cement and glass [4]. According to the European Commission, buildings in the EU are responsible for 40% of our energy consumption and 36% of greenhouse gas emissions. 27-28% of global emissions are directly related to the operation of buildings, i.e. heating, cooling and lighting. According to the statement of study in publication building operations are responsible for approximately 27% of total emissions annually.

This operational carbon dioxide represents one of the biggest challenges in the construction industry, as it is directly related to the daily energy use of buildings. Operational emissions are projected to decline from 75% to 50% of the sector’s total emissions in the coming decades, suggesting that while progress is being made in this area, the importance of so-called “embodied carbon” is increasing.

2 Carbon policy of different regions and countries

It was collected the main strategies of the highest carbon dioxide emitting countries such as the European Union, United States, China, Russia, India and Brazil. The population of these countries covers almost half of the population on the Earth. In this collection we try to focus to the regulations concerning building sector including the new built and the renovation processes.

2.1 European Union

The European Parliament has supported the revision of the Energy Performance of Buildings Directive (EPBD), the main objectives of which include significantly reducing greenhouse gas emissions and energy consumption in the EU construction sector by 2030 and making the sector climate-neutral by 2050 [4]. According to the adopted text, all new buildings must be net-zero emissions from 2028, and new buildings used or owned by public bodies from

2026. The EU aims to be climate-neutral by 2050 a net-zero greenhouse gas economy. This objective is at the heart of the European Green Deal and has been made a legally binding target through the European Climate Law. The European Union is accelerating its clean energy transition to achieve climate neutrality by 2050 through targeted policies, among which the Energy Performance of Buildings Directive (EPBD) plays a key role in reducing energy consumption in buildings [5].

As part of the European Green Deal, the revised Energy Performance of Buildings Directive (EPBD) entered into force on 28 May 2024, and Member States must transpose the requirements into national law by 29 May 2026. The new rules aim to reduce the energy use and emissions of buildings in the EU, including the target of all new buildings being net-zero by 2030 and the phasing out of fossil fuels in the heating systems of buildings by 2040.

The Corporate Sustainability Reporting Directive (CSRD), adopted by the European Commission in November 2022, builds on the Non-Financial Reporting Directive (NFRD), introducing more detailed reporting requirements. All large companies doing business in the EU, including those incorporated outside the EU, will be required to disclose their emissions, including Scope 3 supply chain emissions, from 2024. Around 50,000 companies, including a large number of construction material producers, and building contractors, will be required to disclose the risks and opportunities that their business practices pose in terms of social and environmental factors. Companies will have to start reporting in 2024 with a view to publishing reports in 2025. In February 2024, the Commission presented a Communication and a detailed impact assessment, which launched the process of setting a 2040 climate target for the EU. In July 2025, the Commission proposed an amendment to the Climate Law, setting a net greenhouse gas emission reduction target of 90% by 2040 compared to 1990 levels. In November 2025, Member States agreed in the Council on a general approach on a legally binding 90% overall 2040 target, of which 85% would be domestic targets and up to 5% would be international carbon credits [5].

By these regulations the European Union plays a leading role in building regulations and setting targets, despite of there are considerable differences of climatic conditions of the EU territories and significant differences in the strategy and commitment of member states.

2.2 The carbon policy at the United States of America

In the United States, federal climate policy has undergone significant changes in recent years and is highly dependent on government policy direction. In July 2025, President Trump signed the One Big Beautiful Bill Act (OBBB), which dismantles much of the Inflation Reduction Act (IRA) efforts to reduce emissions from the electricity, transportation, industry, and buildings sectors [4]. The Trump administration is considering revising the electricity and transportation emission standards that the Biden administration strengthened in 2024. In April 2024, the United States Environmental Protection Agency (EPA) finalized greenhouse gas standards and guidelines for existing coal-fired steam generating units and repealed the Affordable Clean Energy (ACE) rule. Greenhouse gas standards for new gas-fired combustion gas turbines were finalized in April 2024.

New York City's building performance standard, which begins compliance in 2024, requires buildings larger than 25,000 square feet to reduce their carbon dioxide emissions intensity per square foot over time. Several states, including New Jersey, New York, and Pennsylvania, have introduced significant measures to decarbonize the construction sector, including public procurement standards and incentives for low-carbon concrete [6].

The U.S. Department of Energy’s Zero Emission Building Strategy 2024 will create the market alignment, supply chains, and workforce needed to scale up zero-emission new construction and renovations.

2.3 China's regulations and policies

The regulation entered into force on 1 May 2024 and aims to provide a legal framework for the operation of China's carbon emissions trading market and ensure the effectiveness of related policies. China has been operating the ETS since 16 July 2021, which allows online trading and covers 40% of China's total emissions equivalent to 5.1 billion tonnes of CO_2 emissions, three to four times the size of its European counterpart, the EU ETS. China's ETS currently covers only electricity generation [7]. In 2020, China updated its NDC and formally submitted it to the UNFCCC in October 2021. The updated targets are: peaking carbon emissions before 2030 and achieving carbon neutrality before 2060; reducing carbon dioxide emissions per unit of GDP by 65% by 2030 compared to 2005 levels; increasing the share of non-fossil fuels in primary energy consumption to about 25% by 2030. China's CO_2 emissions are rising, but according to the goals, it will reach a peak before 2030 is out of sight. The sooner the emissions peak arrives, the better China's chances of achieving carbon neutrality on time. The main sources of China's emissions are the energy sector 48% of CO_2 emissions, industry 36%, transport 8%, and buildings 5%. Compering to other western countries the 5% of building sector seems to be very low, however in China the industrial sector is much more dominant for energy consumption than other countries.

2.4 Russia's climate policy

Russia approved the "Strategy for Socio-Economic Development with Low Greenhouse Gas Emissions by 2050" in October 2021 and submitted it to the UNFCCC Secretariat in September 2022. The CAT rates Russia's current policies as "Extremely Insufficient". Russia is committed to supporting its fossil fuel industry, and its Arctic policy aims to expand hydrocarbon production deeper into the Arctic Circle.

In 2021, the Federal Law on Limiting Greenhouse Gas Emissions was adopted. It established a state registration system for greenhouse gas emissions and required mandatory reporting for large companies emitting more than 150,000 tonnes of CO_2-equivalent per year until 2024 and more than 50,000 tonnes after 2024. However, the law does not impose emission quotas or impose penalties on large carbon emitters.

Russia's economy-wide emissions are expected to continue to grow until 2030, when they should decline rapidly, especially for such a large emitter. It is also worth noting that Russia's Energy Strategy until 2035, adopted in 2021, focuses almost exclusively on promoting the extraction, consumption and export of fossil fuels [8].

Under the "baseline" scenario, emissions would increase from current levels and peak in 2030. Even after subsequent reductions, emissions in 2050 would be higher than current levels. The Russian Federation ranks 64th in this year's CCPI, remaining among the very low performers.

2.5 Climate policy of India

Eco Niwas Samhita 2018, Part I – Building Envelope (Energy Saving Building Code for Residential Sector) was developed and introduced in 2018. It has been developed to lay down minimum building envelope performance standards to limit heat gain for cooling-dominated climates and heat loss for heating-dominated climates while ensuring adequate natural ventilation and daylight. The code is applicable to all residential building projects with a plot area ≥ 500 m² [9].

In June 2017, India took a major step forward by introducing the revised Energy Conservation Building Code (ECBC) 2017. The code sets energy efficiency standards for new commercial buildings to reduce energy consumption and promote low-carbon growth.

It sets parameters for builders, planners and architects to integrate renewable energy sources into building design, with the aim of achieving a 50% reduction in energy use by 2030.

India, with strong policies in industry and electric vehicles, among others, is expected to achieve an annual improvement of 2.5% in 2024 [9]. India and Africa are among the few places that have seen growth in energy efficiency employment in recent years, creating over 50,000 and 15,000 new jobs in this category since 2019, respectively.

2.5.1 Challenges and opportunities

While a variety of policy instruments have long existed in the EU and China, India's building energy efficiency policies are relatively new and limited. Detailed analyses of building energy codes, information disclosure and financial incentives reveal differences in ambition, scope and implementation, even with common policy instruments [10].

By 2030, around 80% of the growth in floor space is expected to occur in these economies (developing and emerging), where many countries lack adequate energy efficiency requirements. Thus, the IPCC report emphasizes that by 2050, the building sector in developing countries has the greatest mitigation potential.

2.6 Brazil regulation for carbon reduction

Brazil was the second nation to submit a climate plan for the third generation of Nationally Determined Contributions (NDCs), which set out a 59–67 percent reduction in greenhouse gas emissions by 2035 [11]. The NDC sets out two main targets: a "less ambitious" target that would reduce emissions to 1.05 billion tonnes of carbon dioxide equivalent ($GtCO_2e$) by 2035; and a more ambitious target that would reduce emissions to 0.85 $GtCO_2e$ by 2035. These would result in a 59% or 67% reduction in emissions compared to 2005 levels [12]. Regarding industry, the country will reduce its emissions intensity by gradually replacing fossil fuels with biofuels and electrification.

Energy efficiency regulations for the building sector started in an early stage. Since 1984, initiatives have been introduced in the country with the creation of the Brazilian Labelling Program (PBE), led by INMETRO, which began to produce comparative labels for the energy efficiency of equipment, providing consumer education and promoting more efficient products. Complementary measures exist to reduce energy demand in homes, including performance standards (ABNT NBR Nº 15.220 and Nº 15.575), labelling standards (PBE Edifica) and approval seals (Procel Edifica) for buildings, and the promotion of the use of alternative energy generation.

A law approved in August 2014 requires that public buildings have an energy efficiency label. This new label, PBE Edifica, will be mandatory for all new buildings with a floor area of more than 500 m^2, as well as for all buildings undergoing major renovations. Three aspects are taken into account for this new label: the building envelope, the lighting system and the air conditioning system.

In Brazil, buildings are responsible for 48% of the country's electricity consumption, with the commercial sector accounting for the majority of energy use (90% of electricity use), with a small contribution from other sources [13].

3 Building stock in the world

3.1 The existing and predicted building stock

The size and composition of the global building stock are critical for energy consumption, greenhouse gas emissions and the renovation strategies needed to achieve climate neutrality. Around two-thirds of the total floor area of the global building stock that exists today will still be in use in 2040. This is particularly important as it highlights that renovating existing buildings is at least as critical as constructing new, energy-efficient buildings. The global building stock was 162.8 billion square metres in 2017 and is expected to grow to 183.5 billion square metres by 2026.

In advanced economies, the building stock is expected to increase by about 1.4 times an about 100 billion square metres by 2070 compared to 2020 levels, while in developing economies it is expected to increase by 2.2 times about 313 billion square metres [4]. This means that developing countries are expected to experience much more dynamic growth in the coming decades.

In 2022, the floor space in developing and emerging economies was 201 billion square meters and is expected to increase to nearly 298 billion square meters by 2030. In advanced economies, the total floor space will increase from 57 billion square meters to 60 billion square meters over the same period [14]. This suggests that the vast majority of the growth in new building stock will occur in developing countries.

3.2 The rate of replacement and renovation

The slow replacement of the building stock is one of the biggest challenges for decarbonisation. In Europe, more than 40% of the building stock was built before 1960 and 90% before 1990. Most of these buildings will still be standing in 2050. Each year, new construction in Europe accounts for around 1% of the building stock. The overall building stock is increasing over time, as the rate of new construction exceeds the rate of demolition of old buildings. The key point is that both demolition and construction rates are low. For example, for residential buildings, the average annual demolition rate in eight EU countries between 1980 and 2005 was around 0.1%, while the annual new construction rate ranged between 1% and 1.5% [4].

Currently, around 35% of buildings in the EU are over 50 years old, and almost 75% of the building stock is energy inefficient, while only 0.4–1.2% of the building stock is renovated annually. The renovation rate of existing buildings is currently around 1%, and most of this is superficial, shallow renovation. While the current annual deep renovation rate in the EU is only 0.2% on average, the deep renovation rate should increase to 3% per year by 2030 as soon as possible and be maintained until 2050 to meet the climate target set for the building sector.

The International Energy Agency’s Net Zero Emissions 2050 Scenario (NZE Scenario) sets ambitious targets for the transformation of the building stock. Renovating 20% of the existing building stock to carbon neutrality by 2030 is an ambitious but necessary milestone to reach a net-zero building stock by 2050. To achieve this, an annual deep renovation rate of more than 2% is needed from now onwards [15].

The IEA projects that the global building stock will grow by 75% over the next 30 years, with around 80% of this growth occurring in emerging markets and developing economies. In 2020, only 5% of new buildings were carbon neutral, and a number of advanced technologies, regulations and policies are needed to reach the 100% target by 2030.

After 2030, all new buildings will have to be carbon neutral, and the renovation rate in advanced economies will reach 2.5%. As a result, around 20% of the existing building stock will be carbon neutral by 2030. By 2050, this proportion will exceed 80% [15].

It is clear that reality falls far short of the plans that would ensure carbon neutrality. In case the EU or any other country would like to fulfil the goal to 2050 there will needed much more radical regulations and activity in this area. It might include national and regional programs with founding the renovation processes.

4 Features of different regions

Europe: The European Union is investing over €5 trillion in energy efficiency in buildings by 2050 to achieve net zero emissions through the "Fit for 55" initiative, which requires €275 billion per year to reduce greenhouse gases. More than 40% of buildings in Europe were built before 1960 and 90% before 1990, most of which will still be in use in 2050, so the need for planned renovation is very high.

Eastern Europe: The construction market in Eastern Europe is expected to reach USD 482.05 billion in 2025 and grow to USD 628.53 billion by 2030, at a CAGR of 5.45%. This region is undergoing significant infrastructure development, particularly in Hungary, Romania and Poland.

United States and Advanced Economies: In advanced economies, the focus is on renovation and energy efficiency improvements, as much of the building stock is already in place and replacement is slow.

Emerging Asia: Approximately 80% of the growth in the global building stock will occur in emerging markets and developing economies. In particular, significant growth is expected in China and India, where rapid urbanization and economic development are leading to the creation of a large new building stock.

5 Conclusions

The escalating global climate crisis, underscored by record atmospheric concentrations, currently 426 ppm and still rising with increasing annual emissions (37.4 billion tons in 2024), needs very urgent and decisive global intervention. The buildings and construction sector is a critical focus area, being responsible for approximately 37–40% of global annual emissions. Achieving the target of a net-zero carbon building stock by 2050 requires radical changes in both policy and activity, particularly concerning the existing building stock and new construction in rapidly developing economies.

An analysis of carbon strategies across major global emitters including the EU, USA, China, Russia, India, and Brazil reveals significant disparity in ambition and implementation.

- The European Union leads with stringent, legally binding frameworks like the European Climate Law and the revised Energy Performance of Buildings Directive (EPBD). The EU mandates all new buildings to be net-zero emissions by 2028 and aims for climate neutrality by 2050, accelerating efforts to address both operational and embodied carbon.
- In contrast, the United States climate policy has shown volatility, heavily influenced by shifting political administrations, though certain states and cities (like New York City) are implementing aggressive decarbonization standards for buildings.
- China operates the world's largest Emissions Trading System (ETS) but currently focuses primarily on the energy sector. While committed to peaking emissions before 2030 and achieving carbon neutrality before 2060, the country's rapid growth needs greater regulation of its industry and also in building sectors.
- Russia's commitment remains very moderate, because of the abandoned fossil resource with policies primarily focused on promoting this traditional fuel extraction rather than meaningful emission reductions.

- India and Brazil have implemented important energy efficiency standards (e.g., India's Eco Niwas Samhita and Brazil's PBE Edifica), yet their policies are newer and have a limited scope compared to the EU, despite having the greatest mitigation potential in the coming decades.

The sheer scale and inertia of the global building stock present the biggest challenge to the 2050 carbon neutral building sector goal. Concerning the Global Building Stock the following conclusions can be drawn:

- The global floor area is projected to grow dramatically, with an anticipated 75% growth over the next 30 years. Crucially, approximately 80% of this new growth will occur in emerging markets and developing economies. This would make necessary that these regions immediately adopt and enforce net-zero standards for all new construction, a measure currently falling short of global requirements.
- The existing building stock is equally critical. Around two-thirds of the buildings standing today will still be in use in 2040. In the EU, which region is the leading in carbon neutralization, 75% of the building stock is energy inefficient. The current average annual renovation rate is only around 1%, with deep renovation rates as low as 0.2%. To meet climate goals, the deep renovation rate should be raised urgently up to 2–3% per year.

5.1 Future Imperatives

In conclusion, while global policies, particularly in the EU, are setting ambitious targets, the current pace of change is dangerously inadequate. The current reality falls far short of the International Energy Agency’s Net Zero Emissions 2050 Scenario requirements. Meeting the 2050 net-zero target requires for the entire world:

- Uniformity of Policy: Global alignment on ambitious, mandatory net-zero carbon standards for all new construction by 2030. This could mean the strategic unity and the designated common goals, followed by the domestic regulatory agenda of countries.
- Renovation Acceleration: Immediate and radical government-backed programs with substantial funding to boost the annual deep renovation rate of the existing building stock to 3%. The driving force could be the saved energy by the renovated buildings, and the process can accelerate itself as the saved energy increases exponentially.
- Targeting Growth: Focused regulatory and financial support for emerging economies, where the majority of new building stock growth will occur, to ensure they bypass high-carbon development paths. Unless the new buildings of this regions will not be Nearly Energy Zero the energy demand will increase dramatically and beside global warming could cause an energy crises.

According to the available information, in policies of the significant carbon emitter countries it cannot be seen the united efforts to reduce carbon emissions and to suppress the usage of fossil fuels. The global building stock is far away from the carbon neutral position and the intensity of the approach to this is not satisfactory either.

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