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CARBON EMISSION FROM VARIOUS SECTORS AND WAYS TO REDUCE THOSE EMISSIONS

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Abstract:

This study tackles the challenge of cutting carbon emissions across industries. To combat climate change, it explores innovative strategies in transportation, energy, agriculture, and manufacturing. It focuses on decarbonizing transportation via electric vehicles, better public transit, and alternative fuels. Renewable energy sources like solar and wind power are highlighted for their potential to replace fossil fuels. In manufacturing, it examines eco-friendly processes, recycling, and circular economy principles to reduce emissions. The study considers their economic, social, and environmental impacts, discussing policy recommendations to incentivize these strategies' adoption.

Key Words: Carbon Emissions, Decarbonizing, Alternative Fuels, Renewable Energy, Adoption Strategies

1. Introduction:

Climate change necessitates urgent action to reduce carbon emissions across industries. This study delves into this challenge across pivotal sectors like transportation, energy, agriculture, and manufacturing. It highlights the need for innovative, low-carbon solutions in transportation and the imperative shift towards renewable energy sources in the energy sector. Agriculture's underestimated emissions require sustainable practices, while manufacturing needs to balance efficiency with carbon reduction. The study emphasizes strategies, technologies, and policies for emission reductions, spanning from transportation advancements to sustainable agriculture and renewable energy proliferation.

Beyond technological solutions, this exploration considers economic, social, and environmental implications, emphasizing the importance of balancing emission cuts with economic growth and social equity. Ultimately, the aim is to offer a comprehensive understanding of challenges and opportunities in reducing carbon emissions across sectors. Identifying effective strategies and assessing their feasibility contributes to discussions on climate change mitigation. This study advocates actionable measures aligned with sustainable development goals, aiming to propel informed action toward a sustainable, low-carbon future.

2. Carbon Emission Reduction Potentials in Diverse Industrial Sectors:

Reduction of fossil carbon emissions from diverse industrial sectors is central to efforts to reduce fossil carbon emissions due to the large material's flows they process and to the large quantities of energy they consume. If the energy is used inefficiently, this will lead to higher carbon emission levels. It becomes necessary to base the economic, the energy and the environmental policies on the efficient use of resources, in particular on energy efficiency. Carbon emissions are generated in almost all activities of industrial sectors, extraction of materials from the earth's crust, production, procurement, inventory management, order processing, transportation, usage and end-of-life management of used products. However, as aggregate carbon emissions continue to rise, necessary improvements in industrial practices are lagging behind.

- **The Iron and Steel Industry:**

Iron and steel production contributes significantly to CO_2 emissions, impacting global temperature targets. Policies aiming to internalize CO_2 impacts could spike prices, particularly affecting regions reliant on fossil fuels like China, India, and South Korea. China, the largest producer, faces challenges meeting steel demand due to high CO_2prices and fossil fuel dependence [2]. As this industry accounts for 10% of China's CO_2 emissions, transitioning it away from fossil fuels is crucial. Industrial symbiosis, focusing on waste energy sharing and material exchanges, emerges as a vital pathway for CO_2 reduction. Measures like recycling blast furnace and coke oven gases and selling blast furnace slag to cement companies prove effective. Leveraging waste and byproducts has more potential for CO_2 reduction than heat recovery, emphasizing the scope for cleaner production within integrated steel mills.

- **The Cement Industry:**

Cement is the basic and most widely used building material in civil engineering, the quantity of which has increased dramatically because of vast and rapid urbanization. The cement industry is also one of the most significant carbon emitters. This sector accounted for about 1.8 Gt of CO_2 emissions in 2006, approximately 7% of the total anthropogenic CO_2 emissions worldwide [7]. Study also reviewed various CO_2 emissions reduction strategies, including energy efficiency improvements, waste heat recovery, the substitution of fossil fuel with renewable energy sources, the production of low carbon cement and CCS. In addition, the use of supplementary cementitious materials, such as fly ash, silica fume, copper slag, sewage sludge, ground-granulated blast furnace slag, are often promoted as ways to reduce carbon emissions. China is the biggest producer and CO_2 emitter in the global cement industry [7]. The cement industry accounts for 14.8% of total CO_2 emissions from China, thus it is a critical sector within which to help China to meet its national 40 to 45% carbon emissions reduction target.

- **The Aluminium Industry:**

The global primary aluminium industry contributes 1% of carbon emissions. China's production surged to 22 Mt in 2013, accounting for 41% globally, with high indirect emissions from power use, double the global average in 2005. Facing import restrictions and lower-quality bauxite, China's aluminium industry anticipates challenges. Adapting processes like the Sinter-Bayer Series and upgrading Bayer Processes could cut emissions by 6%. To further reduce emissions, China should modernize and phase out outdated smelters while pushing for technological advancements like lower electrolyte temperatures and innovative cathodes and anodes.

- **The Oil Sands Industry:**

Exploitation of the oil sands can produce a variety of fossil fuel products, such as gasoline and heavy fuel oil. Products derived from oil sand's crudes face competition from lighter and often less expensive crudes in the global market. Study revealed that while there is a consensus on the need to further standardize life cycle assessment (LCA) methods and data quality requirements for crude oil products to make comparisons more accurate, participants in the standardssetting process may be unwilling to share the information that would make this possible. A credible standards-setting process may help to overcome this challenge, only if the ability to revise the standard can be anticipated in its initial development process, particularly with respect to its long-term effects on the development of new technologies.

3. Reducing Carbon Dioxide Emissions from the Electricity Sector:

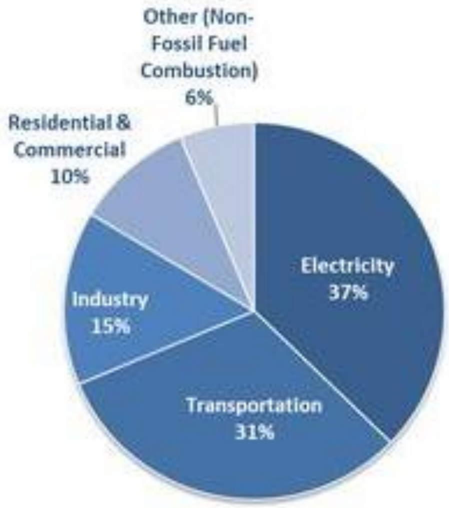

Figure 1: Sources of CO_2 emissions by sector (worldwide, 2009) [9].

The electricity sector is the primary source of the total global CO_2 emissions responsible for approximately 40% worldwide, followed by transportation, industry, and other sectors as shown in the Figure 1 [8, 9]. The Smart Grid (SG) can be regarded as a vision [11], a concept, a framework, or an umbrella for a modernized, evolutionary, next-generation step of our electrical power system. It is an integration of complementary components, subsystems, and services under the control of highly intelligent management and control systems throughout the electricity power system. It is a combination of enabling technologies-hardware, software, or practices-that collectively make the electric power infrastructure environment-friendly, safe, secure, reliable, self-healing, efficient, and sustainable [10]. Also called intelligent grid, or future grid, the concept of a SG is that of a “digital upgrade.”

The smartness of the SG lies in the decision intelligence layer, all the computer programs that runin relay, innovative electronic designs, substation automation systems, and control centres [14]. SG technologies could contribute to greenhouse gas emission reductions by increasing efficiency and conservation, facilitating renewable energy integration, and enabling plug-in hybrid electric vehicles.

4. Reducing Carbon Dioxide Emissions from the Transportation Sector:

Climate change and emissions mitigation have already attracted extensive attention in recent years. Transport accounts for around one-fifth of global carbon dioxide (CO_2) emissions [24% if we only consider

CO2 emissions from energy]. Road travel accounts for three-quarters of transport emissions. Most of this comes from passenger vehicles - cars and buses - which contribute 45.1%. The other 29.4% comes from trucks carrying freight [17].

Since the entire transport sector accounts for 24% of total emissions, and road transport accounts for three-quarters of transport emissions, road transport accounts for 15% of total CO2 emissions. Aviation - while it often gets the most attention in discussions on action against climate change - accounts for only 11.6% of transport emissions. It emits just under one billion tonnes of CO2 each year - around 2.5% of total global emissions. International shipping contributes a similar amount, at 10.6%.

Global transport demand is set to surge due to population growth and rising incomes, doubling passenger kilometers, increasing car ownership by 60%, and tripling aviation demand by 2070, [16] causing a spike in transport emissions. However, technological advancements, particularly in electric vehicles, offer a solution to curb emissions from passenger vehicles. The shift to low-carbon electricity sources could rapidly decarbonize some sectors like motorcycles by 2040, rail by 2050, and small trucks by 2060. While regions like the EU, US, China, and Japan aim to phase out conventional vehicles by 2040, challenges persist in decarbonizing long-distance road freight, aviation, and shipping. The limitations of hydrogen and battery technologies in these sectors, due to range and power requirements, pose obstacles. Despite emission reductions in the scenario, transport remains the largest contributor to energy-related emissions in 2070 [16]. Achieving net-zero emissions necessitates offsetting these emissions through negative emissions strategies like carbon capture from bioenergy or direct air capture in other energy sectors [17].

Major economies have adopted important policies to support the uptake of electric vehicles and promote transport decarbonization across multiple modes

- China continued to lead in total volume of electric vehicle (EV) sales in 2022, not only in cars - accounting for nearly 60% of global sales - but also for light commercial vehicles (LCVs) (more than 40%), 2-wheelers and buses (both more than 80%), and trucks (more than 85%).
- The United States made significant policy progress towards decarbonizing transport in 2022, including through the Inflation Reduction Act, which contains a suite of policies designed to accelerate EV adoption and production of biofuels, synthetic fuel, and hydrogen. The US Departments of Energy and Transportation together articulated a bold framework for transport decarbonization, and the US Environmental Protection Agency (EPA) recently proposed multi-pollutant emissions standards for light- and heavy-duty vehicles, with the aim of meeting national 2050 net zero emissions targets.
- The European Union launched a strong push on the transition to EVs through the Green Deal Industrial Plan, released in February 2023, and political agreement on the Alternative Fuels Infrastructure Regulation that will mandate member states to roll out public charging for light- and heavy-duty vehicles. A political agreement has also been reached on a law that will mandate the adoption of low-emission alternatives to fossil-derived jet kerosene in aviation, as well as low-emission fuels in maritime. A proposal to revise the EU's Emissions Trading System (ETS) to cover maritime emissions, and create a separate new ETS that also includes road transport emissions, is being formulated.
- India adopted the Production Linked Incentives (PLI) scheme in 2022, which includes a program to boost domestic battery manufacturing, with a budget of INR 181 billion (Indian rupees) (USD 2.2 billion), as well as the Automobile and Auto Component PLI scheme which grants incentives for sales of advanced automotive components and vehicles, including battery electric and hydrogen fuel cell vehicles.
- In the first quarter of 2023, Australia committed to putting in place a fuel efficiency standard for light-duty vehicles and formulated a National Electric Vehicle Strategy to accelerate the adoption of EVs.

5. Industrial Emission:

Industries, including petroleum refining and manufacturing, contribute about a third of global greenhouse gas emissions, making it the largest emitter. Key sectors like cement, steel, and chemicals contribute over half of these emissions. To combat this, businesses are embracing decarbonization technologies and strategies to reach net-zero goals without compromising profits or efficiency. Policies like research support, carbon pricing, emission standards, and energy efficiency are pivotal in this effort toward a more sustainable future [15].

Even without taking into account the indirect emissions from purchased electricity and heat, the industrial sector still constitutes around one-fifth of global GHG emissions. Three industries alone - cement, iron and steel, and plastics and chemicals - account for around 55% of industrial emissions. Plus, the 10 leading industries produce up to 90% of industrial emissions, according to data from Energy Innovation [18].

Ways by Which Industries Can Reduce Their Emission:

There are many ways that industrial sectors and organizations can reduce their direct and indirect emissions. However, the key starting point for organizations to understand the potential impact of mitigation projects is developing a GHG Inventory [19]. It's no surprise to see that manufacturing is one of the biggest contributors to carbon emissions in the World due to the sector's energy-intensive processes. While it's not possible for the sector to completely eliminate those emissions, there are ways it can reduce them and balance them out to reach a point of carbon neutrality [15, 18].

- **Improved Energy Efficiency:**

Improving the efficiency of equipment, motors, and heating is crucial for reducing industrial carbon emissions. These factors account for 30% of the industry's total energy usage across various sub-sectors. New digital technologies and the Internet of Things connected smart equipment have created opportunities to enhance energy efficiency and implement automation. According to one study, this could reduce global CO2 emissions by 15% by 2030. Combined heat and power systems (CHPs) could also reduce energy consumption across industrial sectors.

- **Using New Manufacturing Techniques:**

Improvements in manufacturing processes can reduce energy requirements and GHG emissions. Switching raw materials and inputs may also lower emissions in some cases. Such as using fly ash from coal power plants instead of high-emitting clinker in the production of cement, for instance.

- **Switching to Lower-Emitting Fuels:**

Electrifying the industrial sector to a larger degree and using decarbonized pipeline gas can lower emissions. On-site fossil fuel burning is the primary direct source of emissions. Energy-efficient solutions must be implemented to ensure that industrial producers are lowering their direct emissions sources. Rather than converting them into indirect emissions sources by consuming excess energy through electrification.

- **Developing an Internal Carbon Price:**

Internal carbon pricing enables industrial organizations to measure financial impacts and progress against carbon reduction targets using robust scenario analysis. A carbon pricing tool like SINAI aids businesses in quantifying targets, emission gaps, and carbon budgets. All while implementing pricing mechanisms based on an optimal business approach.

- **Carbon Capture, Utilization, and Storage:**

Industrial carbon capture, utilization, and storage (CCUS) can play a major role in reducing GHG emissions. CCUS technologies can be used in cement, chemicals, fertilizer, steel, hydrogen, and refining plants, and is quickly becoming more widely available to private-sector businesses.

6. Conclusion:

The comprehensive review of carbon emissions across multiple sectors underscores the urgency for concerted efforts towards emission reduction. Implementing a blend of innovative technologies, stringent regulations, and behavioral changes can pave the way for substantial carbon mitigation. By implementing a combination of cleaner energy sources, efficient technologies, and proactive policies, we can pave the way towards a sustainable future, fostering environmental preservation while ensuring continued economic growth. This review underscores the urgency for collaborative action to combat climate change and emphasizes the transformative potential of concerted efforts across sectors in achieving meaningful carbon reduction goals.

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