SUSTAINABLE ENERGY AND ENABLING NET ZERO EMISSIONS
Final term project by Group-02
Developing net zero CO_2 emissions (by 2050) plan for China

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Abstract

This report is an effort to develop a comprehensive plan of action for China to achieve net-zero emissions by the year 2050 while maintaining a balance between economic growth and environmental responsibility. In the effort to achieve this, we have developed plans concerning every sector that is emission intensive like industries, energy, transportation, and agriculture, highlighting the importance of renewable energy, energy-efficient technologies, and promising technologies like carbon capture and storage (CCS). Key steps to be taken include ramping up energy production through renewable sources like wind and solar, etc., electrifying the transportation industry, and promoting practices that are sustainable in the long term in the agricultural sector. By breaking the ultimate goal of achieving net zero emissions into short, medium, and long-term targets, this report provides a roadmap that goes hand-in-hand with China's priorities of development and international climate commitments, to ensure a sustainable future.

Introduction

China, the epitome of industrialization and manufacturing, has always surprised the world with its innovations and unreal power generation capacities but is currently facing backlash because of its involvement in emitting a large amount of greenhouse gases into the atmosphere. China is currently the largest consumer of energy in the world and is highly reliant on fossil fuels for energy generation, particularly coal for heat and electricity generation, which results in a great amount of CO_2 emission. Although the country is pushing hard towards renewable energy transitions and in a very short period China has also become the largest market for solar panels and the country is producing a humongous amount of energy with solar, wind and hydro, still, the emissions are a big concern as the rate of emissions has increased exponentially in the last two decades. Many policies have been lined up to make the country net zero but still, there is a long route to cover before the country achieves its NDC target of making the country net zero by 2060.

Greenhouse Gas Emission

China's greenhouse gas emissions have increased rapidly in the last decade. Figure 1 [1] compares China's annual emissions with those of other big emitters, India and the USA.

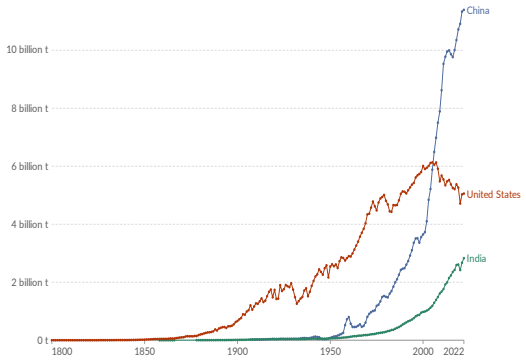

Fig1. Show annual carbon dioxide (CO_2) emissions from fossil fuels and industry

CO_2 emissions by sector, China

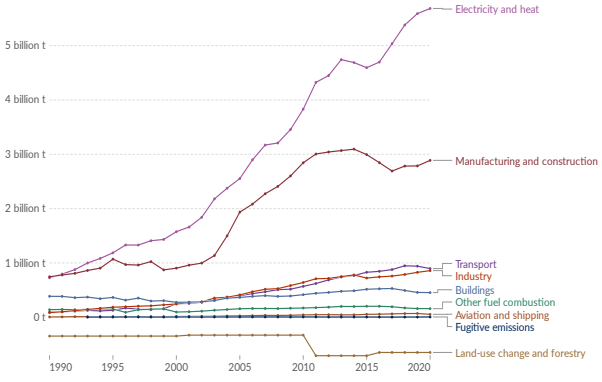

Figure2. CO_2 emissions from different sectors

China is known for its high industrialization and manufacturing, but when it comes to emissions every sector contributes significantly to the GHG emissions. Fig2. [2] Show the emissions from

different sectors since 1990. According to IEA [3] 57% of the total emissions are due to the production of heat and electricity.

Energy Demands

Due to its high population and urbanization, China's energy demands have increased exponentially. The country's primary energy consumption is much greater than that of the USA. At the same time, despite its large population, the per capita energy consumption is still much more than the world's average per capita consumption. Fig. 3 shows the total final consumption by end users. Industries and the residential sectors are the major sectors whose consumption is highest. [3].

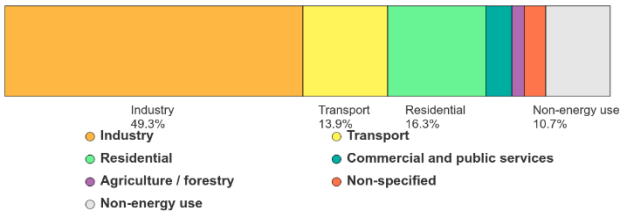

Fig3. Total final energy consumption, China, 2022

Projected energy demand by 2050

China the epitome of the industrial sector is expected to see a decline in primary energy consumption by the year 2050 this is due to the reduction in the rate of urbanization and the country is expected to see the peak energy demand by the year 2035 [4].

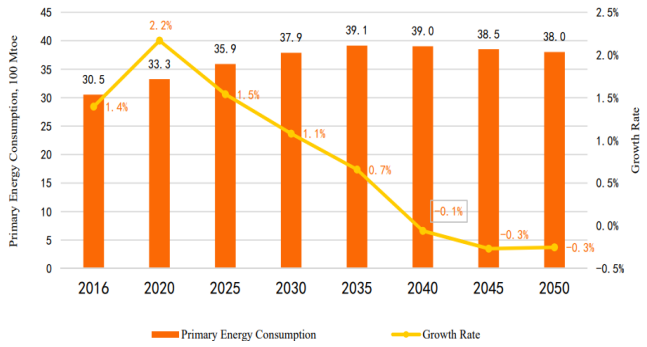

Fig4. Shows primary energy consumption and growth

Energy Demand From Sectors.

Due to urbanization and economic growth, China's primary energy consumption is continuously increasing from 5070 Mtce in 2020, the primary energy demand is expected to reach 5870 Mtce (172 EJ) in 2030.[5]

According to IEA [6] The projected energy demand of China's main sectors that is industry, building, and transport will somewhere fall to 64 EJ by the year 2050 which is nearly 30% less than the energy demand in 2016 which is almost 88 EJ.

Fossil Fuels: China's oil demand is expected to peak by the year 2030 reaching up to 690 million tons demanded by different sectors and then declining up to 570 million tons in 2050.Whereas the gas demand will be nearly 620 and 650 billion cubic meters in 2030 and 2050 respectively.[7]

Coal: As the movement has started to shift towards renewable China's coal consumption will be seeing some sort of reduction, the country's expected coal consumption in 2030 is between 2.195 and 3.699 billion tons [8] And by 2050 the coal consumption will be reduced to less than 1 billion.

Building: To reduce the energy demand China is pushing its limits hard to reduce the demand building sector, but as per the report [6] The demand for the building sector will be about 14 EJ by the year 2030 and by 2050 the residential sector will be consuming about 673 Mtce which is about 19 EJ.

Industry: Although China is the largest producer of iron and steel in the world, the energy demand will be changing drastically as the sector will produce about 700 million tonnes of steel by the year 2050 which will require nearly 1.9 EJ (530 TWh) of energy.[9]

Electricity Demand: The projected electricity demand for China is nearly 15000 TWh which is 54 EJ by the year 2050 as many of the sectors will be using electricity in the form of final energy consumption.

Hydrogen Demand: Since China is continuously pushing hard towards the production of hydrogen, as it will generate a humongous amount of green energy the demand for hydrogen is expected to increase from 33

million tonnes in 2020 to 120 million tonnes per annum by 2060 [10]

Bioenergy Demand: Bioenergy will be the game changer for China by the year 2050 as the demand for bioenergy is expected to increase, bioenergy will be producing about 13 EJ of energy by the year 2050 [9].

Policies to achieve NDC

As per the Forbes report [11] China's energy demand will peak by the year 2030 and thereafter will encounter a dip in the demand. To achieve the NDC and to reduce emissions China's government have lined up many policies, which are as follows:

1. A "low carbon transformation" plan has been initiated that involves the reduction of emissions from existing coal plants using biomass and green ammonia co-firing and involves using CCUS technology [12].
2. To increase the contribution of nuclear energy, the China Nuclear Energy Association (CNEA) is aiming to build 6-8 nuclear power plants annually in future [12].
3. China is looking at hydrogen as a possible replacement for fuel and as per the 14th five-year plan there will be nearly 10,000 new hydrogen refilling stations by the year 2050 [13].
4. To achieve the reduction of energy from the building sector China is highly determined with its Near Zero-emission Buildings Standard (NZEB) which focuses on making buildings more energy efficient using renewable and clean sources
5. In order to reduce transport sector emissions China is highly focused on bringing EVs into the mainstream, for this EVs purchased by the end of 2025 are exempted from vehicle purchase tax while EVs purchased between 1 January 2026 and 31 December 2027 will be asked to pay only half of the total tax [14].
6. The iron and steel sector is one of the biggest culprits that contributes up to 15% of the total country's emissions, for this the country has launched a Special Action Plan that focuses on reducing the emissions by replacing the old blast furnaces with new electric arc furnaces which can reduce the emissions by almost 3% [15].

Current energy generation pattern in China

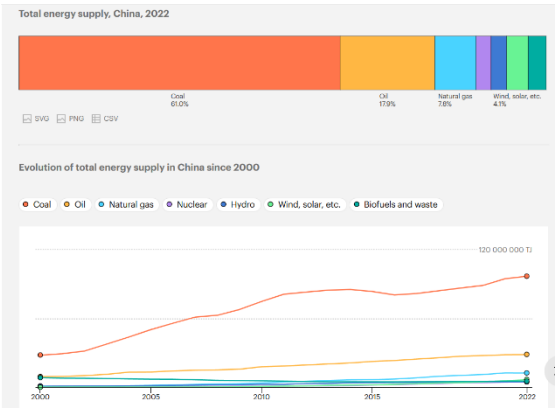

Fig5: Total energy supply by sources [16]

- China's major energy generation is from non-renewable sources and coal is the largest contributor among non-renewable sources around [16]. 56% of primary energy use in 2021 [17] While oil and natural gases were 18.5% and 9% respectively [17]. Coal's share grew by 2.5% from 2000 to 2020[16].
- As a leader in renewable deployment in the world, in 2021 contributed 134 GW, ie. About half of the global renewable capacity [17]. Also, the transition from nonrenewable to renewable is fast as Between 2016 and 2021, non-renewable energy increased by 22.5%, while the contribution of renewable energy has shown a growth of 35.4%. [19]
- In 2022 the final energy for consumption comprises 22.9% Coal, 26.5% oil products, 9.7% natural gases, 28.4% electricity, 7.5% heat, 2.3% wind & solar and other renewables, And 2.6% biofuels and waste [18].

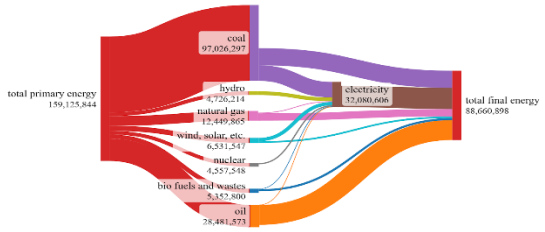

Fig 6: Energy generation pattern in China 2022 [18] (units: terajoules)

Plan for Reducing Carbon Intensity in Power Generation: Measures and Expected Impact

Fig: 6 China's installed power generation capacity and electricity generation mix [19]. To meet the growing zero-carbon energy demand, we can rely on four key technologies: electricity (from renewable or nuclear sources), hydrogen (produced through zero-carbon electrolysis, and usable as ammonia), bioenergy (used as fuel and feedstock), and fossil fuels combined with carbon capture and storage or utilization. By 2050, electricity will take centre stage, either directly powering our needs or producing hydrogen and synthetic fuels. [19].

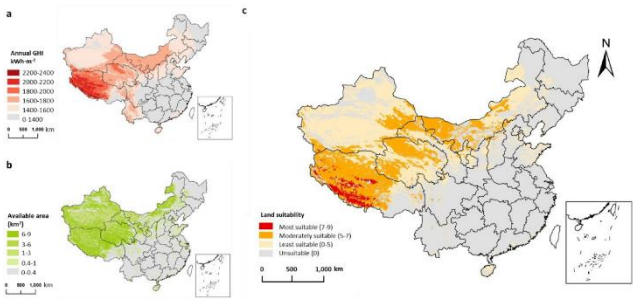

Fig 7: Available and Favorable area for solar PV [20]

To achieve this, China will require a significant increase in electricity production from 7,000 TWh today to around 15,000 TWh and an increase in hydrogen production from 25 million to 81 million tonnes per year. We can achieve this target by majorly deploying 2.7 billion KW of solar, 2.4 billion KW of wind, 100 million KW of nuclear, 140 million of pumped hydro storage power 550 million KW of hydropower. Despite two-thirds of the country having rich solar potential, installing the required amount of solar would take up less than 1% of the land. Furthermore, China's estimated wind capacity of 3,400 GW onshore and 500 GW offshore is way more than what is needed to meet this goal. [19]. The combined total cost to complete this goal is calculated to be approximately $6.06 trillion.[21].

Plans and Policies required to reduce emissions:

To tackle emissions, we need a common goal: net zero by 2050. This is more than a distant target; it's a framework to guide government and businesses in making meaningful, impactful changes right now.

The steps which could be taken to achieve the aim are:

Energy Efficiency and Electrification: Policies focus on improving energy efficiency across all sectors and expanding electrification, especially in transportation and heating, while gradually reducing reliance on coal [20].

Renewable Energy Expansion: There's a strong push to make wind and solar dominant in the energy mix by 2050, with financial incentives and infrastructure support to boost renewable investments [21].

Carbon Pricing and Markets: Carbon pricing and strengthened carbon markets aim to drive investments in low-carbon technologies and encourage emissions reductions [22].

Circular Economy: Policies support recycling and resource efficiency in high-impact sectors like steel and cement to minimize waste and extend resource use [23].

Innovation in Green Tech: Increased investment in R&D is encouraged to advance new emissions reduction and energy storage technologies [21].

Sustainable Agriculture and Land Use: The roadmap promotes eco-friendly farming, reforestation, and land management practices to capture carbon[22].

This policy mix of regulation, incentives, and innovation will set China on course for carbon neutrality by 2050.

Projected Carbon Emissions in 2050:

By 2050, most of the electricity will come from clean sources like solar, wind, hydro, and nuclear, with minimal emissions. For any remaining fossil fuel use, carbon capture and storage (CCS) could eliminate up to 90% of emissions.[9]. Bioenergy can also be made carbon-neutral using BECCS technology. With electricity generation expected to reach 15,000 TWh, emissions from energy production will be nearly zero. Electrifying industries, and transportation, can reduce 3GtCO2 and CCS could prevent 2GtCO2 annually, plus another 5GtCO2 from electrification, also natural carbon sink will constantly help in decreasing the CO2 emissions. Overall, emissions could drop from 14GtCO2 today to 1-2 GtCO2, with carbon removal technologies helping to reach near near-zero emissions by 2050 [19].

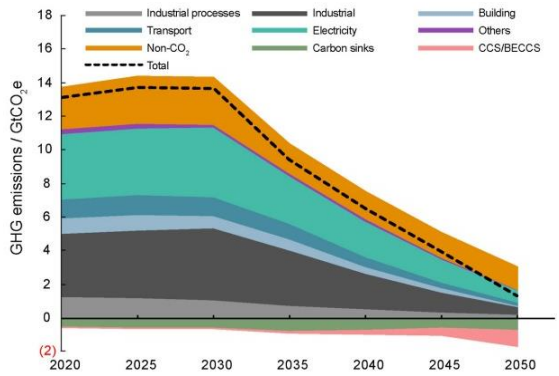

Fig 8: projected net carbon emissions till 2050

Carbon, Capture, Utilization and Storage (CCUS):

CCUS IS THE MAIN PILLAR ON WHICH THE IDEA OF BECOMING CARBON NEUTRAL IS STANDING.

China continuously conducts extensive R&D in CCUS technology. Currently, the country has nearly 49 CCUS projects at different scales, 38 of which are operational. To date, the country has stored 2 million tonnes of carbon dioxide and has an annual capturing capacity of 3 million tonnes.

Although the country is expected to drop its share of coal in electricity generation to up to 5% still there will be some sort of emissions from this 5% and the other fossil fuels that will be used. To achieve carbon neutrality the country needs to focus on its CCUS technology. Analysis shows China's CCUS potential can capture around 400 million tonnes of CO_2 emission by 2030, 600 – 1450 million tonnes by 2050, and 1,000 – 1,820 million tonnes by 2060 [24].

The country is also working on a CCUS project. (CNPC Jilin-CO2 EOR Project) which is estimated to capture around 600,000 tonnes of CO_2 annually [25].

Plans to bring CCUS into the mainstream.

1- The country's current policy does not develop sustainable business cases for CCUS hence new policies are to be formed.

2- Most of the projects are still at the demonstration or pilot scale hence the country needs to speed up its process and better infrastructure is needed for storage and transport.

3- To achieve the NDC target the country must focus on its integrated CCUS project which is although highly complex but is the need of the hour.

4- CCUS is often misunderstood and impeded by false narratives and negative perceptions [24], which needs to be clarified and the country must make it mandatory to use CCUS technology in every sector.

Conclusion:

As per our analysis during this project work, we believe by 2050 China will be in a very good position to achieve its carbon neutrality by the year 2050.

But still, the country has a cover mile before achieving this feat. The country has been trying very hard to bring renewables into the mainstream and in a very short time is already the hub of renewable energy. But the country needs to reduce its dependency on coal, as the processing of that particular fossil fuel is highly carbon intensive and without leaving that particular path the country

cannot achieve carbon neutrality. Although the country has set its bar high to produce 80% of the total energy using non-fossil fuels by 2060, also the country needs to reduce its carbon emissions by 65% compared to 2005 by 2030 and with China expecting its peak emissions between 2030 and 2035 the above statement will be turning out to be very challenging for the country.

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