TRIBHUWAN UNIVERSITY

Institute Of Engineering

Pulchowk Campus

Report

On

"Energy Use and Climate change"

Submitted to:

Department of Architecture

Master's in Energy for Sustainable Social Development

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Date: Jan 2017

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LIST OF ACRONYMS

CO_2- Carbon dioxide

CH_4 - Methane

N_2O – Nitrous oxide

IPCC - Intergovernmental Panel on Climate Change

HFCs – Hydrofluorocarbons

PFCs - Perfluorocarbons

SF_6 - Sulfur hexafluoride

NF3- Nitrogen trifluoride

MER – Market Exchange Rate

OECD –

GHG – Greenhouse Gas

LNG – Liquified Natural Gas

TJ- Tera-joule

SNC - Second National Communication

BUR - Biennial Update Report

GWPs - Global warming potentials

LULUCF - Land-use change and forestry

MSW- municipal solid waste

Acknowledgement

We would like to express our sincere gratitude to **Prof. Bhakta Bahadur Ale** for providing opportunity to conduct project on "Climate change and Energy"

We would also like to thank **Prof. Amrit Man Nakarmi** for being External supervisor and providing valuable suggestions for the further improvement in our project.

Last but not the least, I would like to thank the **Department of Architecture** and **NTNU** for conducting the Master's in Energy for Sustainable Social Development (MSESSD) program because of which we got an opportunity to know about Climate change, its impact, adaptation and mitigating measures.

A. Introduction

1. Climate change

Climate change is the alteration of the world's climate naturally as well as due to the human interventions in the environment such as burning of fossil fuels, coal, oil, gas along with the deforestation leading towards the change of the climate within the certain years. The climate of one nation varies with the other depending upon the topography, location, intensity of sun falling over the area, the tilted axis of the earth, geometry of earth round the sun. Climate change has its impact on three levels:

- Global Level (5,000-25,000 Km)
- Regional Level (100-500 Km)
- Local Level (0.001-10 Km)

Globally, in the last 30 years have been the warmest since accurate records began somewhat over 100 years ago. Twelve of the 13 years 1995 to 2007 rank among the 13 warmest in the instrumental record of global surface air temperature that began around 1850, the years 1998 and 2005 being the warmest. The Intergovernmental Panel on Climate Change in its 2007 Assessment states:

"*Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level*." (Houghton, 2009)

2. Causes of Climate change:

Most of the Scientists believe that main cause for the climate change is the increase in Green House gases, Global warming and Greenhouse Effect that are the results of the human activities such as Deforestation, increment in the number of factories, industries, forest fires, animal farming, rice cultivation etc. Because of these activities, the carbon dioxide gas that have been emitted are added to the carbon that are already present in the atmosphere that absorbs most of the radiation coming from the Earth's surface as being the good absorber of heat and act as a blanket over the surface.

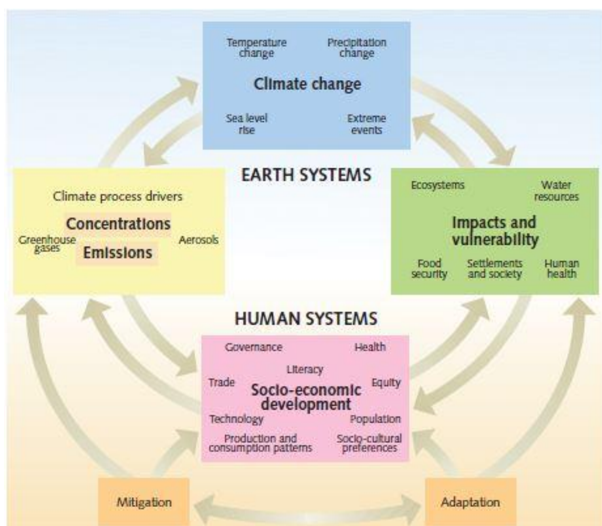


Figure 1: Climate change - an integrated framework (Houghton, 2009)

Greenhouse Effect

The gases that are present in the atmosphere that absorbs and emits radiation within the infrared range is known as greenhouse gases and the effect is known as Greenhouse Effect. Some of the green houses and their mixing ratios are shown in the figure below:

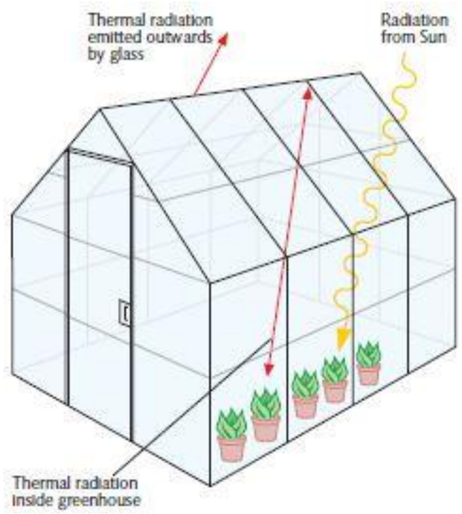


Figure 2: Greenhouse Effect (Houghton, 2009)

Gas	Mixing ratio or mole fraction* expressed as fraction* or parts per million (ppm)
Nitrogen (N_2)	0.78*
Oxygen (O_2)	0.21*
Water vapour (H_2O)	Variable (0–0.02*)
Carbon dioxide (CO_2)	380
Methane (CH_4)	1.8
Nitrous oxide (N_2O)	0.3
Chlorofluorocarbons	0.001
Ozone (O_3)	Variable (0–1000)

Figure 3: The composition of the atmosphere, the main constituents and greenhouse gases as in 2007 (Houghton, 2009)

The gases that are listed in the *Figure 3* are the constituents of atmosphere where nitrogen and oxygen are the major components which neither absorbs nor emit thermal radiation. The water vapour, carbon dioxide and some other minor gases that are present in the lesser quantities absorbs some of the thermal radiation from the sun and act as a partial blanket causing the difference of 20 to 30°C between the actual average surface temperature on the Earth of about 15°C and the temperature that would apply if greenhouse gases were absent.

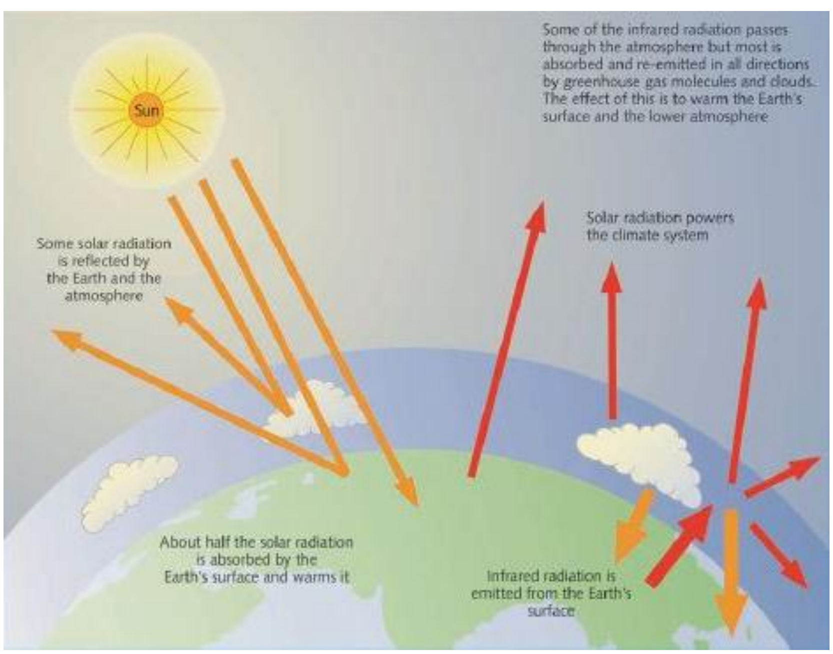


Figure 4: Natural Greenhouse Effect (Houghton, 2009)

Energy, in the simple definition, is the ability or capacity to do the work. The energy resources in Nepal consist of a combination of traditional and commercial sources which include fuel wood, agricultural residue, animal waste and hydropower. The alternative sources of energy are also used such as biogas, solar power and wind power. In spite of this, Nepal has to depend on the import of fossil fuels. The total energy consumption in the year 2008/09 was about 9.3 million tonnes of oil equivalent (401 million TJ). The overall energy consumption of Nepal is largely dominated by the use of non-commercial forms of energy such as fuel wood, agricultural residue and animal waste. About 87 % of the demanded energy is fulfilled by traditional sources, 12% by commercial sources (electricity and fossil fuels) and remaining 1% by alternative sources. (ADAPT- Nepal JV CDES, 2011)

3. Global Emissions by Gas:

At the global scale, the key greenhouse gases emitted by human activities are (EPA, n.d.):

- **Carbon dioxide (CO_2)**: Fossil fuel use is the primary source of CO_2. The way in which people use land is also an important source of CO_2, especially when it involves deforestation. CO_2 can also be emitted from direct human-induced impacts on forestry and other land use, such as through deforestation, land clearing for agriculture, and degradation of soils. Likewise, land can also remove CO_2 from the atmosphere through reforestation, improvement of soils, and other activities.
- **Methane (CH_4)**: Agricultural activities, waste management, energy use, and biomass burning all contribute to CH_4 emissions.
- **Nitrous oxide (N_2O)**: Agricultural activities, such as fertilizer use, are the primary source of N_2O emissions. Biomass burning also generates N_2O.
- **Fluorinated gases (F-gases)**: Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

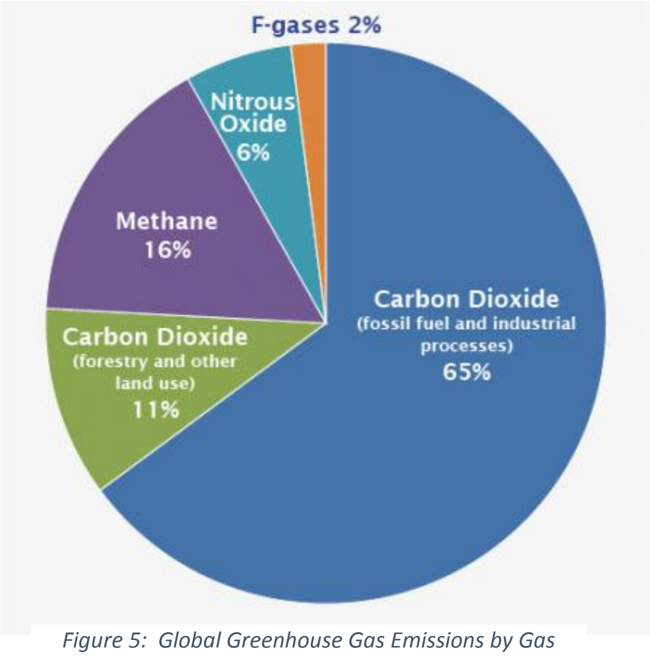


Figure 5: Global Greenhouse Gas Emissions by Gas (EPA, n.d.)

4. Emissions by country:

In 2011, the top carbon dioxide (CO_2) emitters were China, the United States, the European Union, India, the Russian Federation, Japan, and Canada. These data include CO_2 emissions from fossil fuel combustion, as well as cement manufacturing and gas flaring. Together, these sources represent a large proportion of total global CO_2 emissions. Emissions and sinks related to changes in land use are not included in these estimates. However, changes in land use can be important: estimates indicate that net global greenhouse gas emissions from agriculture, forestry, and other land use were over 8 billion metric tons of CO_2 equivalent, or about 24% of total global greenhouse gas emissions. In areas such as the United States and Europe, changes in land use associated with human activities have the net effect of absorbing CO_2, partially offsetting the emissions from deforestation in other regions. (EPA, n.d.)

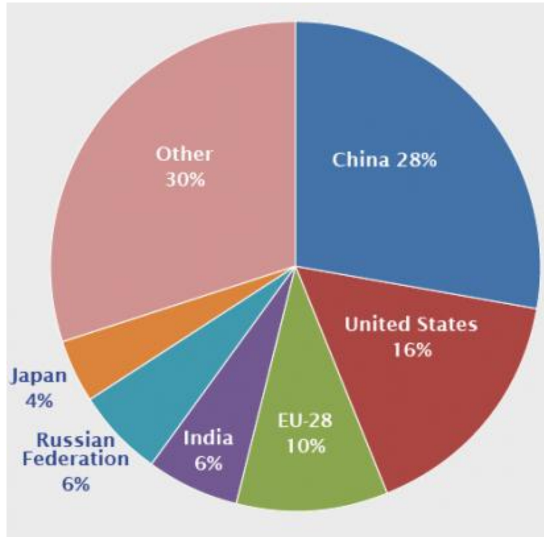


Figure 6: 2011 Global CO2 Emissions from fossil fuel combustion and some industrial processes Source: (EPA, n.d.)

5. Global Emissions by Economic Sector:

Global greenhouse gas emissions can also be broken down by the economic activities that lead to their production.

- **Electricity and Heat Production** (25% of 2010 global greenhouse gas emissions): The burning of coal, natural gas, and oil for electricity and heat is the largest single source of global greenhouse gas emissions.
- **Industry** (21% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from industry primarily involve fossil fuels burned on site at facilities for energy. This sector also includes emissions from chemical, metallurgical, and mineral transformation processes not associated with energy consumption and emissions from waste management activities. (Note: Emissions from industrial electricity use are excluded and are instead covered in the Electricity and Heat Production sector.)
- **Agriculture, Forestry, and Other Land Use** (24% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector come mostly from agriculture (cultivation of crops and livestock) and deforestation. This estimate does not include the CO_2 that ecosystems remove from

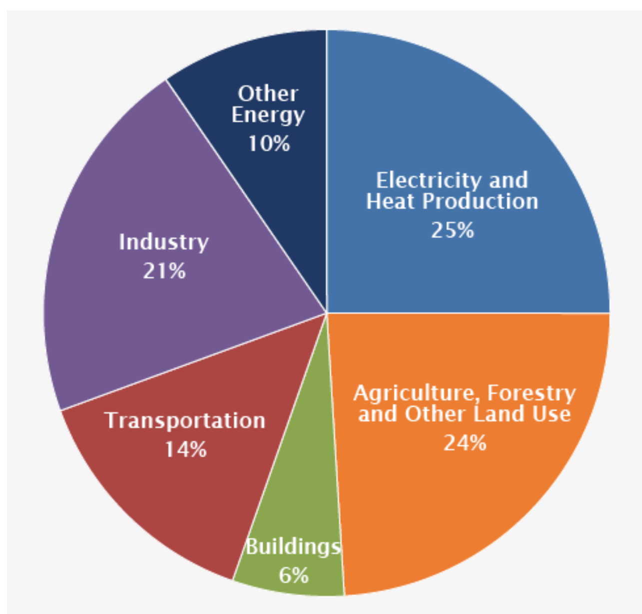


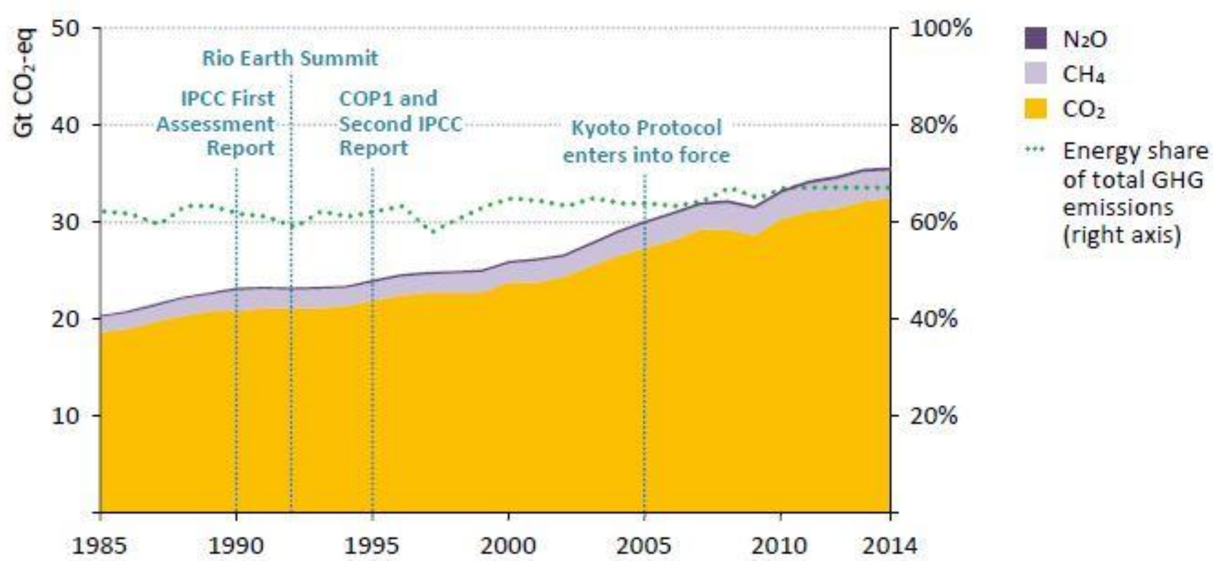
Figure 7: Global Greenhouse Gas Emissions by Economic Sector Source: (EPA, n.d.)

the atmosphere by sequestering carbon in biomass, dead organic matter, and soils, which offset approximately 20% of emissions from this sector.

- **Transportation** (14% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector primarily involve fossil fuels burned for road, rail, air, and marine transportation. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel.
- **Buildings** (6% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector arise from onsite energy generation and burning fuels for heat in buildings or cooking in homes. (Note: Emissions from electricity use in buildings are excluded and are instead covered in the Electricity and Heat Production sector.)
- **Other Energy** (10% of 2010 global greenhouse gas emissions): This source of greenhouse gas emissions refers to all emissions from the Energy sector which are not directly associated with electricity or heat production, such as fuel extraction, refining, processing, and transportation.

6. Historical energy emissions trends:

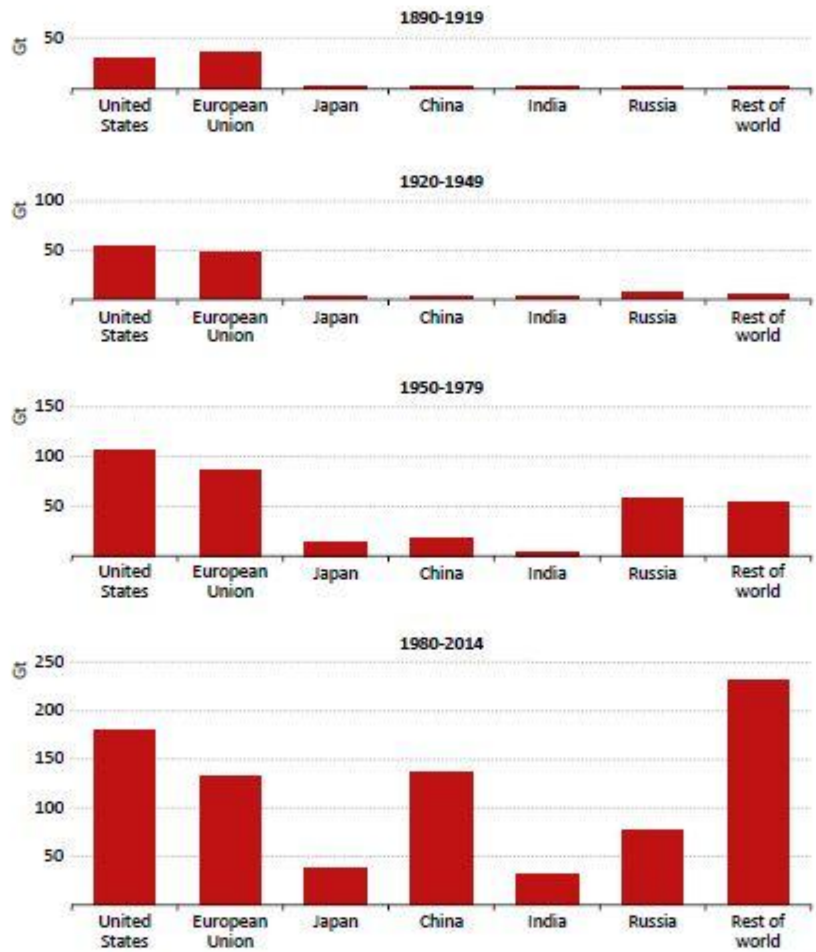
One indicator of the scale of the challenge to the energy sector is the fact that the total volume of global energy sector CO_2 emissions over the past 27 years matched the total level of all previous years. Fossil fuels continue to meet more than 80% of total primary energy demand and over 90% of energy-related emissions are CO_2 from fossil-fuel combustion. Since 2000, the share of coal has increased from 38% to 44% of energy-related CO_2 emissions, the share of natural gas stayed flat at 20% and that of oil declined from 42% to 35% in 2014. While smaller in magnitude (and less long-lasting in the atmosphere, though with higher global warming potential), methane (CH_4) and nitrous oxide (N_2O) are other powerful greenhouse gases emitted by the energy sector. Methane accounts for around 10% of energy sector emissions and originates mainly from oil and gas extraction, transformation and distribution. Much of the remainder us nitrous oxide emissions from energy transformation, industry, transport and buildings. (Report, 2015)



Notes: CO_2 = carbon dioxide, CH_4 = methane, N_2O = nitrous oxide. CH_4 has a global warming potential of 28 to 30 times that of CO_2, while the global warming potential of N_2O is 265 higher than that of CO_2.

Figure 8: Global anthropogenic energy-related greenhouse-gas emissions by type Source: (Report, 2015)

The global distribution of GHG emissions has shifted with changes in the global economy. At the beginning of the 20th century, energy-related CO_2 emissions originated almost exclusively in Europe and the United States. This ration dropped to around two-thirds of total emissions by the middle of the century and today stands at below 30%.



Notes: Emissions for the European Union prior to 2004 represent the combined emissions of its current member states. Emissions for Russia prior to 1992 represent emissions from the Union of Soviet Socialist Republics. Rest of world includes international bunkers.

Figure 9: Cumulative energy-related CO_2 emissions by region Source: (Report, 2015)

Over the past two-and-a-half decades. Global CO_2 emissions increased by more than 50%. While emissions increased by 1.2% per year in the last decade of the 20th century, the average annual rate of increases between 2000 and 2014 accelerated to 2.3%, particularly driven by a rapid rise in CO_2 emissions in power generation in countries outside the OECD: since that start of the 21st century, emissions from electricity and heat generation in emerging and developing countries have doubled, with around two-thirds of this increase coming from China. CO_2 emissions from the industry sector in these countries doubled from 1990 to today being driven by large increases in the production of energy intensive materials, such as cement and steel. In the same period, total CO_2 emissions from the industrial sector in OECD countries fell by a quarter, though these countries still lead global emissions from the transport and building sectors. For transport, this is due to the higher level of vehicle ownership in OECD countries even though, over the past 15 years, CO_2 emissions from transport doubled in non-OECD countries as a result of both of higher levels of private vehicle ownership and strong growth in freight traffic. For buildings, the higher level of emissions in OECD countries is because most non-OECD countries are located in more temperate climates, requiring lower levels of space heating.

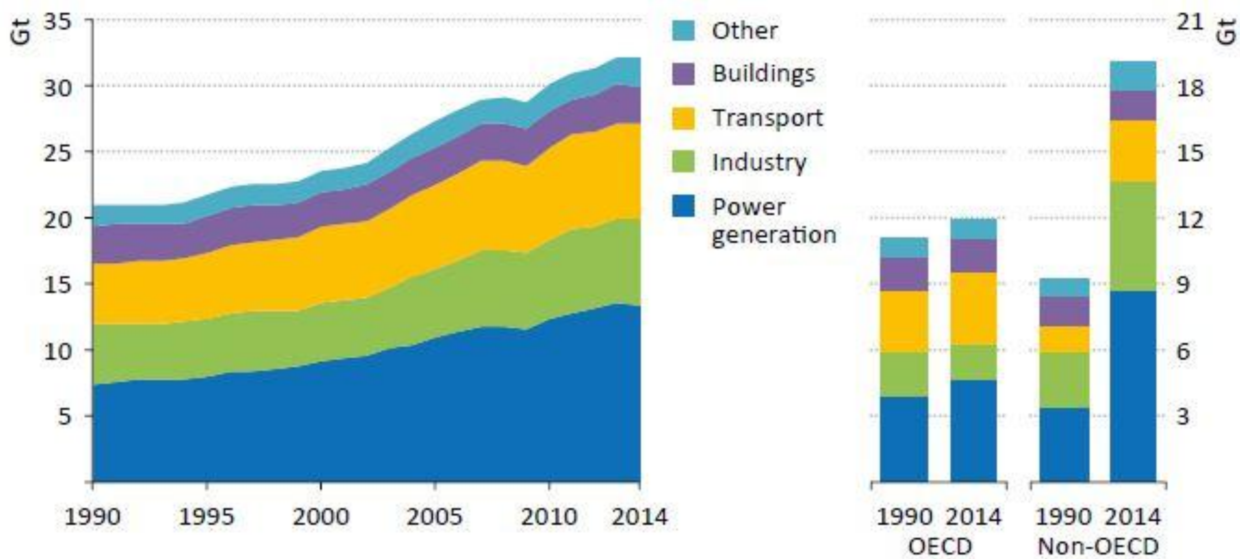


Figure 10: Global energy-related CO2 emissions by sector and region Source: (Report, 2015)

A large share of energy-related CO_2 emissions comes from a small number of countries. In 2012, three countries- China, United States and India – gave rise to almost half of global CO_2 emissions from fossil-fuel combustion, while ten countries accounted for around two- thirds. Since 1990, total emissions in the United States and Japan have increased slightly, while they declined by about a fifth in the European Union. After a fall of almost 30% in emissions from Russia in the early 1990a, the emissions increase thereafter has remained limited. In 2006, China overtook the United States as the biggest CO_2 emitter, while India overtook Russia as the fourth-largest emitter in 2009. (Report, 2015)

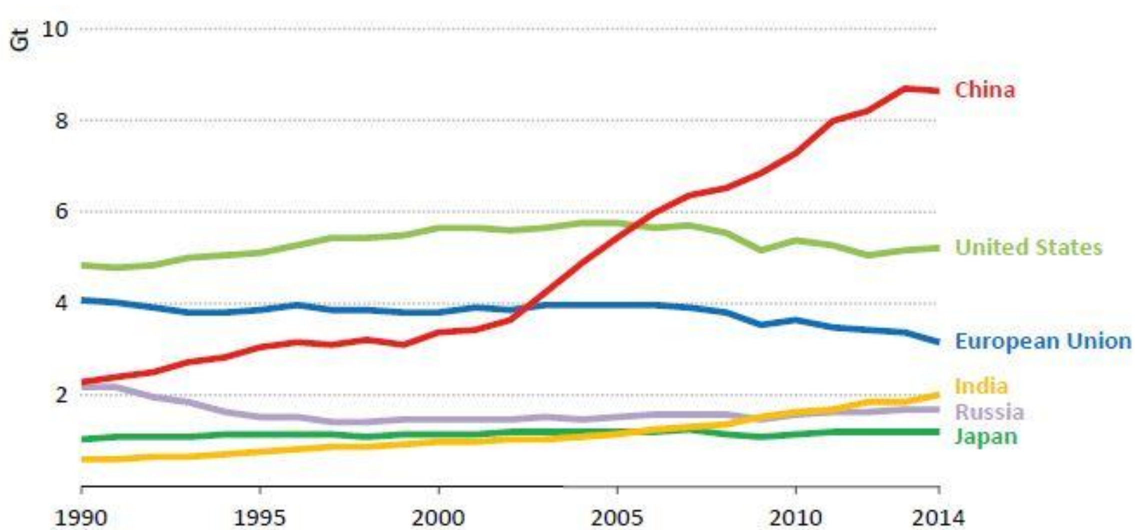
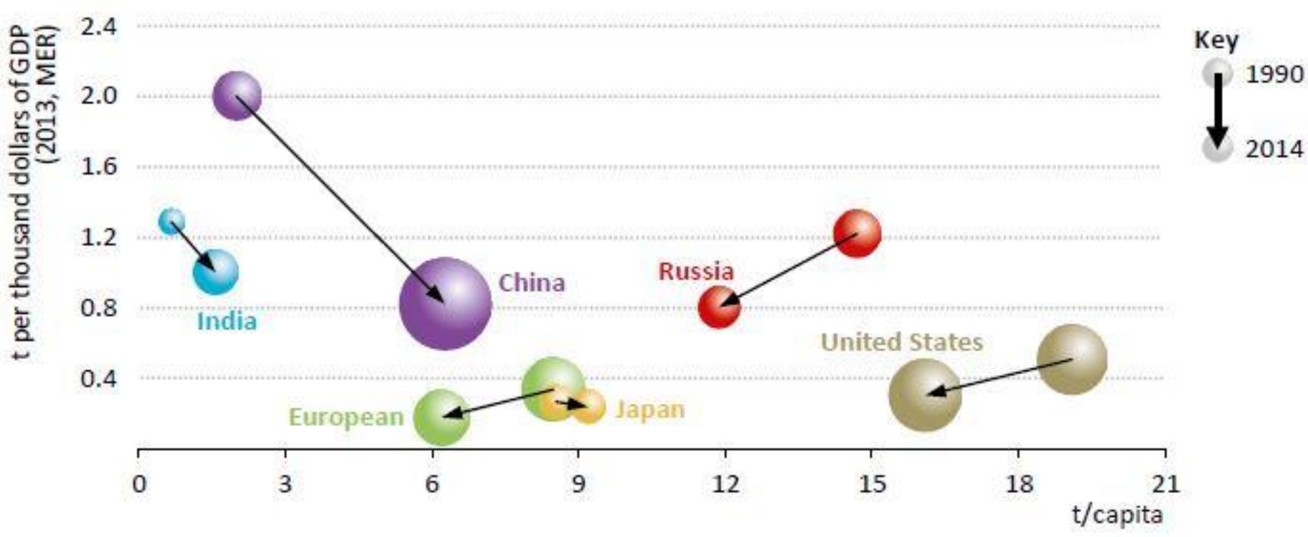


Figure 11: Energy-related CO_2 emissions by selected region Source: (Report, 2015)

Even though CO_2 emissions increased almost three-fold in China and two-and-a-half times in India between 1990 and 2014, per capita emissions in both countries are still below the average level in OECD countries. China's per-capita emissions in 2014 reached 6.2 tonnes, matching the level of the European Union, but a third lower than the OECD average. India's per-capita emissions were 1.6 tonnes in 2014, or about 10% of the level in the United States and 25% of the level in China. Significant differences across regions exist, not only in terms of per-capita emissions but also in terms of CO_2 emissions per unit of economic output. While all of the major regions reduced the CO_2 intensity of their economy, China emitted 0.82 tonnes CO_2 per thousand dollars of economic output in 2014, which compares to 0.3 tonnes in the United States and 0.18 tonnes in the European Union.



Notes: Bubble area indicates total annual energy-related CO_2 emissions. MER = market exchange rate.

Figure 12: Energy-related CO_2 emissions per capita and CO_2 intensity by selected region Source: (Report, 2015)

7. Energy-related CO2 emissions in 2014:

The growth trend in global energy-related CO_2 emissions stalled in 2014 with an estimated total of 32.2 Gt, unchanged from the preceding year. This occurred even with the world economy growing by around 3% in the same year. Across the OECD as a whole, emissions fell by 1.8% while the economy grew by1.8%, on average. This continues the clear break between economic growth and energy- related emissions growth that has been observed in the OECD in recent years reflecting increased deployment of renewables and enhanced efforts to increase energy efficiency. (Report, 2015)

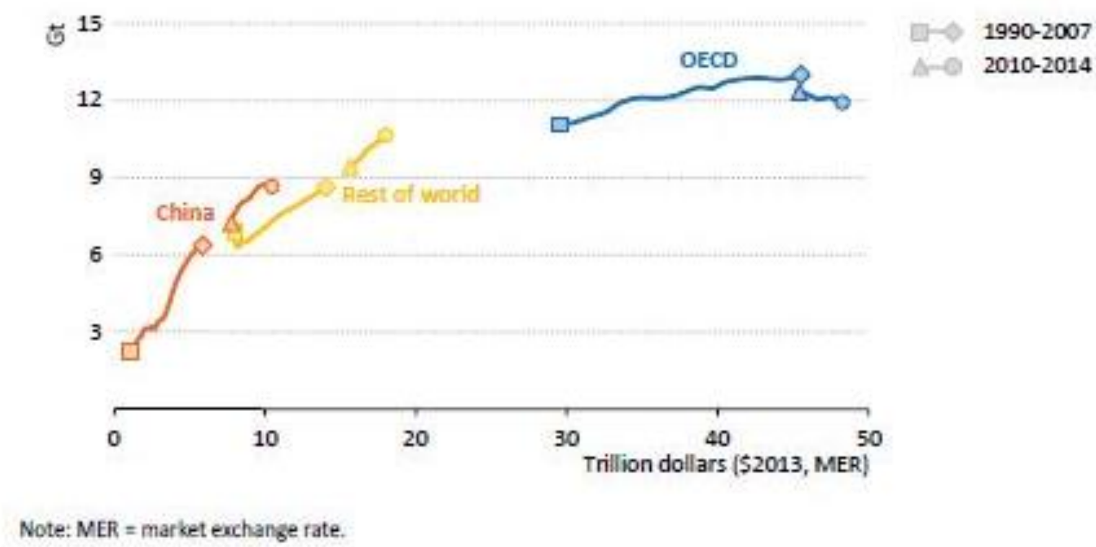


Figure 13: Energy-related CO_2 emission levels and GDP by selected region Source: (Report, 2015)

Energy-related CO_2 emissions in the European Union dropped by more than 200 Mt (over 6%), as demand for all fossil fuels declined: natural gas demand declined by 12%, partly due to the mild winter, while power generation from non-hydro renewables grew by 12% as they continued to benefit from active de-carbonization policies. Japan's CO_2 emissions are estimated to have been down by around 3% in 2014 relative to 2013, mainly due to lower oil demand; but LNG imports remained at a comparably high level, as a consequence of the shutdown of Japan's nuclear capacity. In the United States, energy related CO_2 emissions in 2014 were 41 Mt higher (less than 1%) than the previous year but around 10% below their peak in 2005 (5.7Gt). Emissions from the power sector in the United States were down, due to an 11% increase in generation from non-hydro renewables and only a limited increase in electricity demand, while there was an increase in natural gas use in industry and buildings.

Placed in the context of recent trends, China's emission figures in 2014 are also consistent with a weakening of the link between economic growth and increased emissions, though it is not yet broken. Emissions in China declined in 2014 for the first time since 1999, registering a drop of around 130 Mt (1.5%). Demand for coal, which has seen extraordinary growth in China in recent decades, declined by around 3%, an outcome that is partly cyclical and partly structural. On the one hand, there was tremendous growth in hydropower generation in 2014 (22%), mainly due to a particularly wet year. On the other hand, power generation from wind and solar increased by 34% and demand for natural gas grew by 9%, both suggesting demand for coal may be suppressed on a more sustained basis. Overall, low-carbon forms of power generation accounted for one-quarter of China's electricity supply in 2014, up from around one-fifth in 2013. In parallel, there are signs that economic growth in the future will be dominated by consumption, particularly for services, rather than investment in energy intensive industries, which characterized the picture in the past.

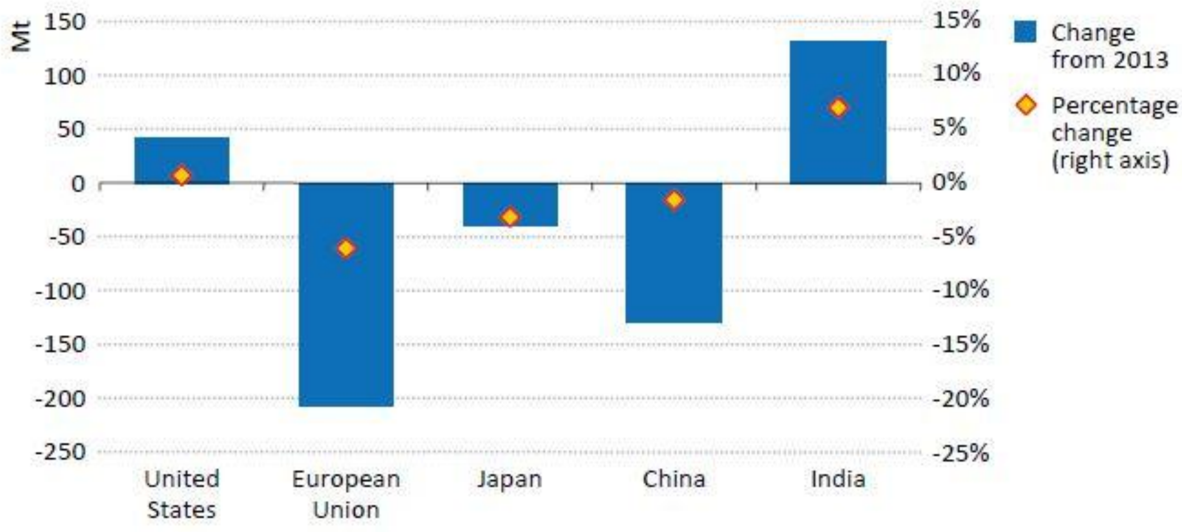


Figure 14: Change in energy-related CO_2 emissions by selected region 2013-2014 Source: (Report, 2015)

CO_2 emissions outside the OECD and China were up by around 290 Mt in 2014, led by increased use of coal for power generation in India and Southeast Asia. Indeed, across most emerging and developing countries, the relationship between economic growth and emissions growth remains strong as these countries are in the energy-intensive process of building up their capital stock.

The signs of a decoupling between energy-related emissions and economic growth in some parts of the world are encouraging – for the first time in 40 years, a halt or reduction in total global emissions has not been associated with an economic crisis. However, definitive conclusions cannot be drawn from the data for a single year. Part of the reduction in emissions in 2014 in the European Union, for example, was due to warmer weather which significantly reduced CO_2 emissions related to heating. Nonetheless, there are positive signs that committed climate action has the potential to achieve such a decoupling, creating a world economy which does not rely on ever greater consumption of fossil fuels, achieving deep cuts in GHG emissions but also supporting economic growth, boosting energy security and bringing energy services to the billions who, today, have no such access.

8. GHG from Energy Sector:

The inventory for the Energy sector under the SNC (Second National Communication) was prepared for the period of 1996-2010, with consideration of the three main GHGs: CO_2, CH_4 and N_2O as well as indirect gases Co, Nox, NMVOC, So_2; using 2000 as the base year. The inventory comprises the emissions resulting from fuel combustion of solid, liquid and gaseous fuels. Activity data are taken from the energy balances which are issued annually by the Water and Energy Commission Secretariat. (ADAPT- Nepal JV CDES, 2011)It is a very broader topic and generally classified into five sectors. They are: Residential sector, Industrial sector, Commercial sector, Transportation and Agricultural sectors. Other sectors are: Road,

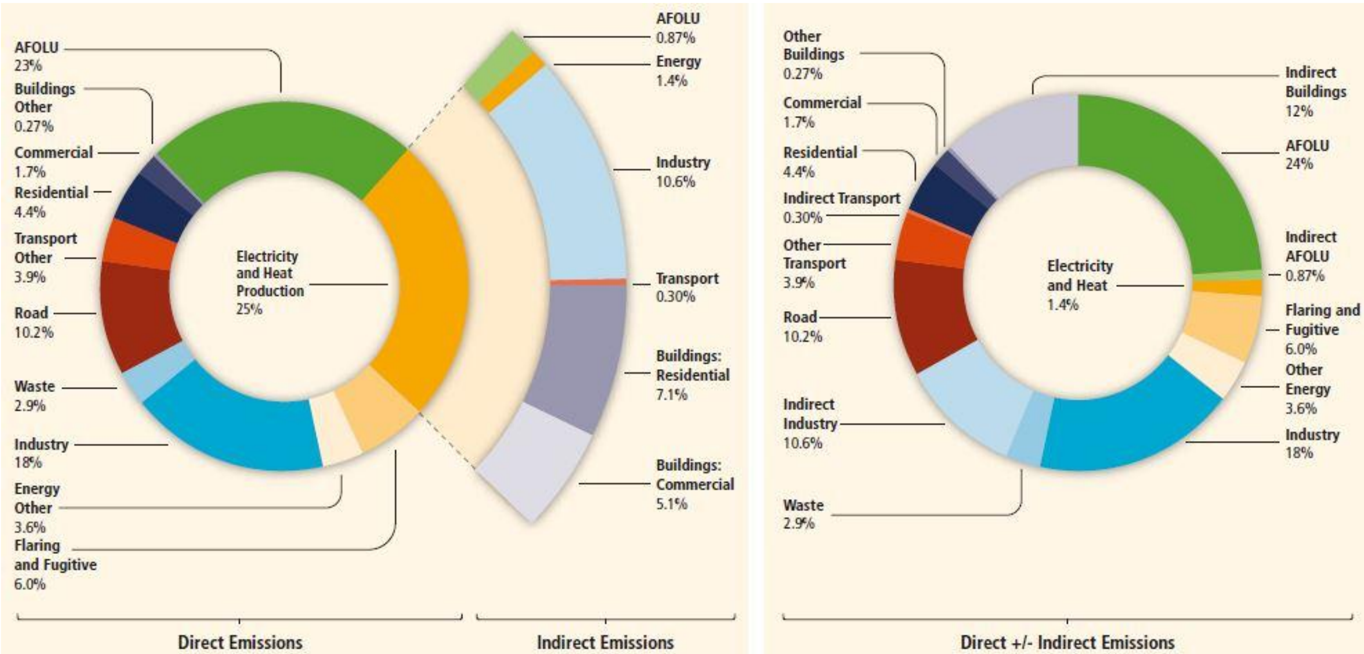


Figure 15: Total GHG emissions in 2010 across five sectors, Source: (IPCC, n.d.)

waste etc. According to the IPCC fifth assessment report, the GHG (Greenhouse gas) according to the

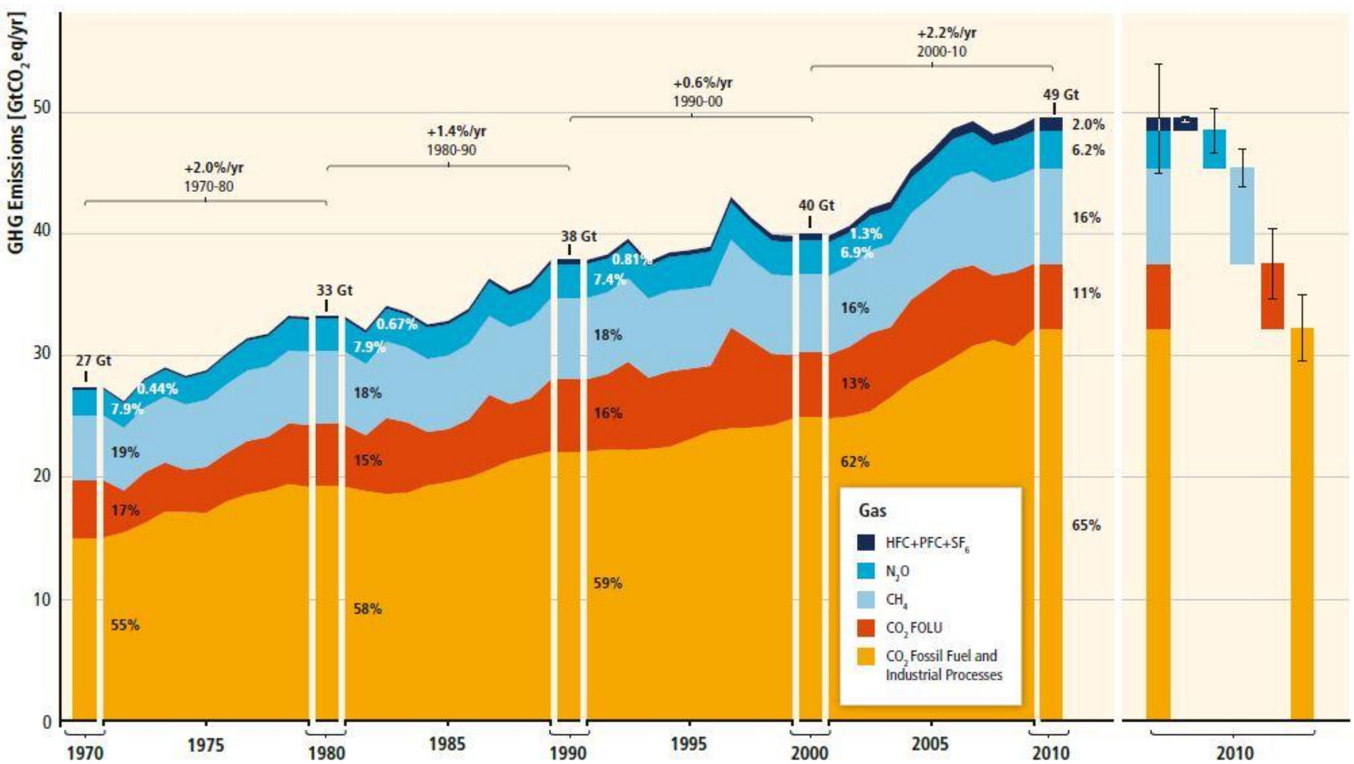


Figure 16: Total annual GHG emissions by groups of gases (1970 -2010), Source: (IPCC, n.d.)

various sectors in the global context are shown in the figure below.

B. Context of world

Sector wise greenhouse gases emissions:

- Industrial sector
- Residential and Commercial
- Transportation
- Agriculture
- Electricity Generation

1. Industrial sector:

At the global level, the industrial sector is a key energy consumer and greenhouse gas producer. Manufacturing industries account for more than one-third of total energy consumption and 37 percent of CO2 emissions from energy use. At the global level, data on non-CO2 gases and non-combustion CO2 emissions have higher levels of uncertainty. A small number of industries account for a large percentage of global industrial emissions. In 2007, five industries (chemicals and petrochemicals, iron and steel, non-metallic minerals, pulp and paper, and non-ferrous metals) accounted for 50 percent of total industrial energy use.

Trends in global industrial energy use and emissions include:

- Overall industrial energy use increased between 1971 and 2004, with demand growing especially rapidly in emerging economies.
- Energy efficiency in energy-intensive manufacturing industries has increased, with Japan and Korea generally achieving the highest levels of energy efficiency.
- Cost-effective greenhouse gas mitigation opportunities exist for the industrial sector but are currently under-utilized in both developed and developing countries. The adoption of best practice commercial technologies by manufacturing industries could reduce industrial sector CO2 emissions by 19-32 percent annually by, for example, improving the efficiency of motor systems.
- Since 1970, several energy-intensive industries have seen significant growth. For example, production of steel increased 84 percent; paper, 180 percent; ammonia, 200 percent; aluminum 223 percent; and cement, 271 percent.
- Developed economies usually have a more energy-efficient industrial sector, and a larger fraction of their output comes from non-energy-intensive sectors than is the case for developing economies. On average, industrial energy intensity, which is the industrial sector's energy consumption per dollar of economic output, is double in developing countries. Energy-intensive manufacturing industries are growing in many developing countries. Industrial energy use frequently accounts for a larger portion of total energy consumption in these countries; for example, an estimated 75 percent of delivered energy in China was used by the industrial sector in 2007.
- In 2007 the industrial sector comprised 51 percent of global energy use, and is projected to grow at an annual rate of 1.3 percent.

2. Residential and commercial sector

On a global scale, energy use and greenhouse gas emissions data for the residential and commercial sectors can be difficult to quantify. Globally, the quantity of energy use attributed to buildings, as a proxy for the residential and commercial sectors, varies by country and climate. Energy consumption levels and primary fuel types of buildings in a specific country depend on economic and social indicators, such as national income and level of urbanization. Some key trends observed include:

In general, developed countries consume more energy per capita than developing countries; developed countries tend to have bigger building sizes for comparable building functions, and they tend to use more appliances and other energy-using equipment than developing countries.

Urban areas in developed countries use less energy per capita than rural areas; this is because of, district heating in higher-density areas, decreased transportation-related energy consumption, and other factors. However, the opposite effect can be seen in many developing countries where energy useis higher in cities than in rural areas because residents often have higher incomes and greater access to energy services.

In some countries, grid-connected power remains unavailable or unaffordable for households. In these areas, which include large portions of sub-Saharan Africa, as well as parts of India and China, biomass and coal are often the primary fuels for heating and cooking. This has important implications both for global greenhouse gas emissions and development goals, including:

- Global data on GHG emissions often do not account for emissions from biomass that is collected and burned locally. Household-level combustion of biomass and coal are estimated to account for about 10 percent of global energy use and 13 percent of direct carbon emissions.
- The use of woody biomass, unless sustainably managed, can lead to widespread deforestation. Forests play important roles as local resources and as global carbon sinks.
- Indoor combustion of biomass and coal is a significant health concern; high rates of respiratory illness have been documented in areas that predominantly use biomass or coal for heating and cooking. Reducing GHG emissions through appropriate technology advances, energy efficiency improvements, and the use of alternative fuels will have important health co-benefits.
- Commercial energy intensity in developed countries, the energy use per dollar of income as measured by GDP, is currently almost twice that of developing countries. Commercial buildings' energy consumption is projected to be the fastest-growing end-use sector for energy in developing countries. Economic growth in developing countries will likely lead to increased global demand for energy, and, without energy efficient products and practices, could lead to substantially higher global energy consumption and GHG emissions.

3. Transportation sector:

Transportation activity is expected to grow significantly in all countries of the next 25 years. Over the next two decades, vehicle ownership is expected to double worldwide, with most of the increase occurring in non-OECD countries. The U.S. Energy Information Administration projects that non-OECD transportation energy use will increase by an average of 2.8 percent per year from 2010 to 2040, compared to an average decrease of 0.3 percent per year for OECD countries.[8] Figure 6 shows projected worldwide energy consumption in the transportation sector.

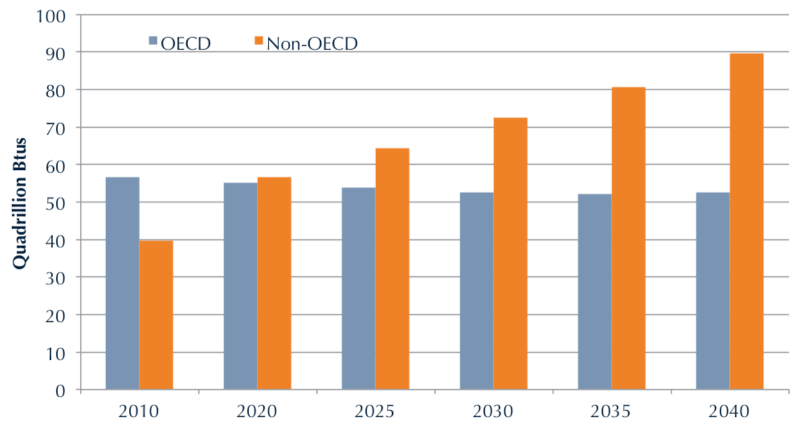


Figure 17: Global projections for transportation sector, Liquids Consumption, 2010-2040, Source: U.S. Energy Information Agency, International Energy Outlook 2014. http://www.eia.gov/forecasts/ieo/more_overview.cfm

4. Agriculture:

Agricultural land, which includes cropland, managed grassland, and permanent crops, occupies about 40-50 percent of the world's total land surface. In 2005, non-energy direct greenhouse gas emissions from agriculture accounted for 10-12 percent of total global greenhouse gas emissions from human-made sources. Agriculture accounts for 60 percent of global N2O emissions and 50 percent of CH4 emissions. A combination of population growth and changing diets has led to increased emissions of these gases from the agricultural sector since at least 1990. This increase can be attributed to the increased use of nitrogen-based fertilizers and the increased number of livestock being raised, especially cattle.

Population growth, changing diets, and changing standards of living will continue to affect the amount and type of food demanded. Recent years have also seen greater interest in and demand for dedicated energy crops. These trends have several possible implications on greenhouse gas emissions:

Increasing land use change to increase the amount of cropland available for food or energy crops will affect carbon storage. The effect of land use change on carbon change will depend on a variety of factors, including previous land use, land management practices, and type of crops grown. An expansion of croplands could result in an overall loss of plant and soil carbon.

Increasing crop yields will likely require more inputs, such as water and fertilizer, for a given a unit of land. Increasing agricultural inputs will result in higher emissions per unit of agricultural output because more energy will be required to produce the inputs and direct emissions from fertilizer use will increase.

Rising demand for meat and dairy products will increase methane emissions from enteric fermentation and manure production. The Intergovernmental Panel on Climate Change (IPCC) projects that methane emissions from livestock could increase 60 percent by 2030, depending on whether greenhouse gas-mitigating feeding practices and manure management are used. Larger livestock populations could also result in land use change to create grazing lands.

Growing interest in the lifecycle carbon emissions of food may also change patterns of food production and consumption. Lifecycle emissions arise from agricultural inputs (including water and fertilizer), equipment for cultivating and harvesting crops, and transportation to consumers. Possible outcomes of using lifecycle analysis include more localized production—producing food close to its point of consumption—and using organic farming methods that minimize fertilizer use. Particularly in today's globalized food market, accounting for life cycle emissions will be crucial in reducing greenhouse gas emissions associated with agriculture and livestock.

5. Electricity generation

Globally, CO2 is the most abundant anthropogenic greenhouse gas, accounting for 76 percent of total anthropogenic greenhouse gas emissions in 2008; the CO2 emissions from fossil fuel use alone account for 62 percent of total greenhouse gas emissions. Electricity generation is by far the largest single source of CO2 emissions.

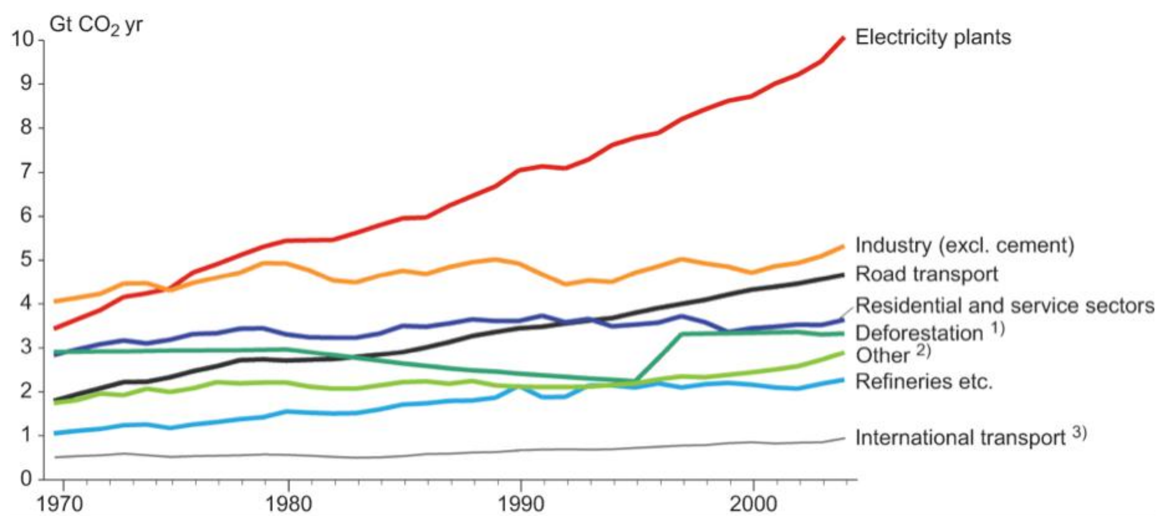


Figure 18: Sources of Global CO_2 emissions (1970-2004, Direct Emissions by Sector Only), Source: Intergovernmental Panel on Climate Change (IPCC), "Introduction." In Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report.

The generation profile of global electricity production is similar to that of the United States, with coal being the largest energy source for electricity production. Globally, 5.1 percent of electricity is generated by oil, whereas in the United States oil makes up less than 1 percent. Also, hydropower makes up a larger share of global electricity generation, while the United States gets a greater proportion of its electric power from nuclear. The United States contributes more than one-fifth of global carbon dioxide emissions from electricity and heat production; China and the United States are the largest single emitters.

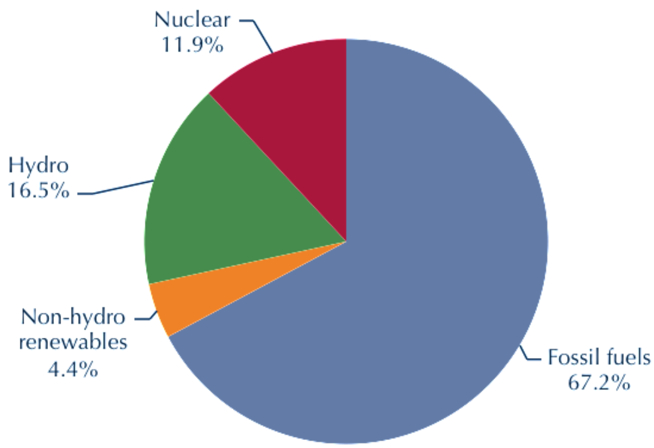


Figure 19: World Electricity Generation by Fuel (2011), Source: Energy Information Administration (EIA), International Energy Statistics, 2014.

C. Global Context of United States.

In 2014, total U.S. greenhouse gas emissions were 6,870.5 MMT or million metric tons carbon dioxide (CO_2) Eq. Total U.S. emissions have increased by 7.4 percent from 1990 to 2014, and emissions increased from 2013 to 2014 by 1.0 percent (70.5 MMT CO_2 Eq.). The increase in CO_2 emissions from fossil fuel combustion was a result of multiple factors, including:

1. Colder winter conditions in the first quarter of 2014 resulting in an increased demand for heating fuel in the residential and commercial sectors;

2. An increase in transportation emissions resulting from an increase in vehicle miles traveled (VMT) and fuel use across on-road transportation modes; and

3. An increase in industrial production across multiple sectors resulting in slight increases in industrial sector emissions. Since 1990, U.S. emissions have increased at an average annual rate of 0.3 percent.

In the US, approximately 82% of the energy consumed was produced through the combustion of fossil fuels. The remaining 18% came from other energy sources such as hydropower, biomass, nuclear, wind and solar energy which is shown in the figure below: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

Overall, from 1990 to 2014, total emissions of CO_2 increased by 440.9 MMT CO_2 Eq. (8.6 percent), while total The emissions of methane (CH_4) decreased by 43.0 MMT CO_2 Eq. (5.6 percent), and total emissions of nitrous oxide (N_2O) decreased by 2.7 MMT CO_2 Eq. (0.7 percent). During the same period, aggregate weighted emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) rose by 78.1 MMT CO_2 Eq. (76.6 percent). Despite being emitted in smaller quantities relative to the other principal greenhouse gases, emissions of HFCs, PFCs, SF_6, and NF_3 are significant because many of them have extremely high global warming potentials (GWPs), and, in the cases of PFCs, SF_6, and NF_3, long atmospheric lifetimes. Conversely, U.S. greenhouse gas emissions were partly offset by carbon (C) sequestration in managed forests, trees in urban areas, agricultural soils, and landfilled yard trimmings. These were estimated to offset 11.5 percent of total emissions in 2014.

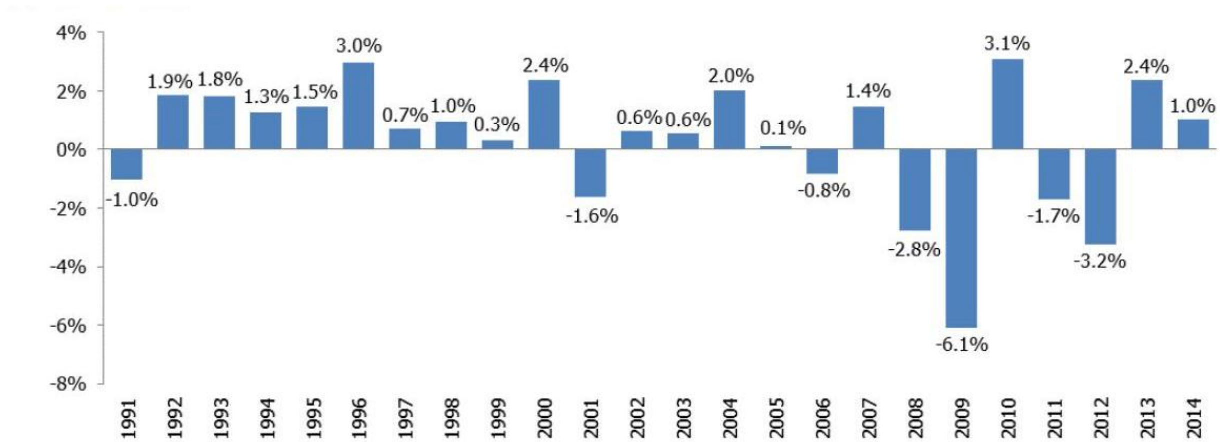


Figure 20: Annual percent change in U.S. Greenhouse gas emissions relative to the previous year source: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

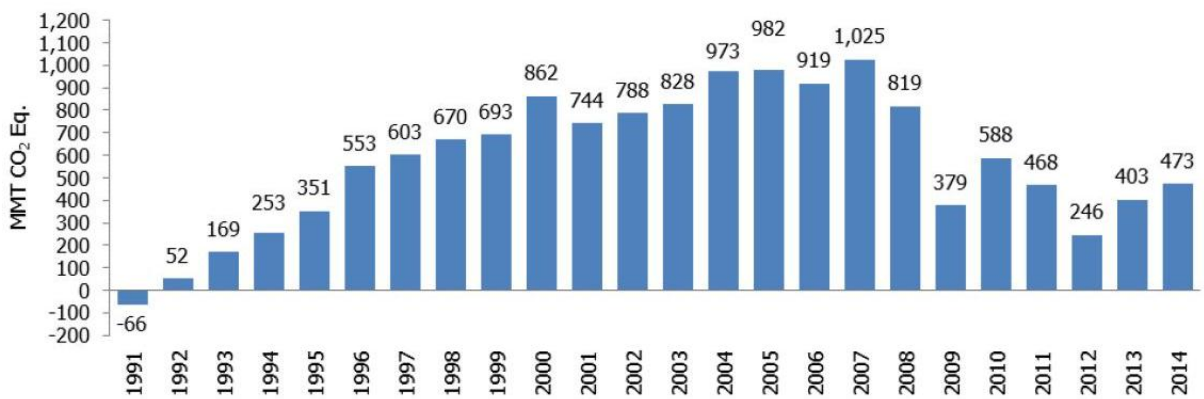


Figure 21: Cumulative change in annual U.S. Greenhouse gas emissions relative to 1990 (1990=0, MMT CO_2 Eq.) Source: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

Changes in CO2 emissions from fossil fuel combustion are influenced by many long-term and short-term factors, including population and economic growth, energy price fluctuations, technological changes, energy fuel choices, and seasonal temperatures. On an annual basis, the overall consumption of fossil fuels in the United States fluctuates primarily in response to changes in general economic conditions, energy prices, weather, and the availability of non-fossil alternatives. For example, in a year with increased consumption of goods and services, low fuel prices, severe summer and winter weather conditions, nuclear plant closures, and lower precipitation feeding hydroelectric dams, there would likely be proportionally greater fossil fuel consumption than in a year with poor economic performance, high fuel prices, mild temperatures, and increased output from nuclear and hydroelectric plants. In the longer term, energy consumption patterns respond to changes that affect the scale of consumption (e.g., population, number of cars, and size of houses), the efficiency with which energy is used in equipment (e.g., cars, power plants, steel mills, and light bulbs), and behavioral choices (e.g., walking, bicycling, or telecommuting to work instead of driving).

Table 1 Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (MMT CO2 Eq.)
Source: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

Gas/Source	1990	2005	2010	2011	2012	2013	2014
CO_2	**5,115.1**	**6,122.7**	**5,688.8**	**5,559.5**	**5,349.2**	**5,502.6**	**5,556.0**
Fossil Fuel Combustion	4,740.7	5,747.1	5,358.3	5,227.7	5,024.7	5,157.6	5,208.2
Electricity Generation	*1,820.8*	*2,400.9*	*2,258.4*	*2,157.7*	*2,022.2*	*2,038.1*	*2,039.3*
Transportation	*1,493.8*	*1,887.0*	*1,728.3*	*1,707.6*	*1,696.8*	*1,713.0*	*1,737.6*
Industrial	*842.5*	*828.0*	*775.5*	*773.3*	*782.9*	*812.2*	*813.3*
Residential	*338.3*	*357.8*	*334.6*	*326.8*	*282.5*	*329.7*	*345.1*
Commercial	*217.4*	*223.5*	*220.1*	*220.7*	*196.7*	*221.0*	*231.9*
U.S. Territories	*27.9*	*49.9*	*41.4*	*41.5*	*43.6*	*43.5*	*41.0*
Non-Energy Use of Fuels	118.1	138.9	114.1	108.5	105.6	121.7	114.3
Iron and Steel Production & Metallurgical Coke Production	99.7	66.5	55.7	59.9	54.2	52.2	55.4
Natural Gas Systems	37.7	30.1	32.4	35.7	35.2	38.5	42.4
Cement Production	33.3	45.9	31.3	32.0	35.1	36.1	38.8
Petrochemical Production	21.6	27.4	27.2	26.3	26.5	26.4	26.5
Lime Production	11.7	14.6	13.4	14.0	13.7	14.0	14.1
Other Process Uses of Carbonates	4.9	6.3	9.6	9.3	8.0	10.4	12.1
Ammonia Production	13.0	9.2	9.2	9.3	9.4	10.0	9.4
Incineration of Waste	8.0	12.5	11.0	10.5	10.4	9.4	9.4
Carbon Dioxide Consumption	1.5	1.4	4.4	4.1	4.0	4.2	4.5
Urea Consumption for Non-Agricultural Purposes	3.8	3.7	4.7	4.0	4.4	4.2	4.0
Petroleum Systems	3.6	3.9	4.2	4.2	3.9	3.7	3.6
Aluminum Production	6.8	4.1	2.7	3.3	3.4	3.3	2.8
Soda Ash Production and							

CH_4	**773.9**	**717.4**	**722.4**	**717.4**	**714.4**	**721.5**	**730.8**
Natural Gas Systems	206.8	177.3	166.2	170.1	172.6	175.6	176.1
Enteric Fermentation	164.2	168.9	171.3	168.9	166.7	165.5	164.3
Manure Management	37.2	56.3	60.9	61.5	63.7	61.4	61.2
Wastewater Treatment	15.7	15.9	15.5	15.3	15.0	14.8	14.7
Rice Cultivation	13.1	13.0	11.9	11.8	11.9	11.9	11.9
Stationary Combustion	8.5	7.4	7.1	7.1	6.6	8.0	8.1
Abandoned Underground Coal Mines	7.2	6.6	6.6	6.4	6.2	6.2	6.3
Composting	0.4	1.9	1.8	1.9	1.9	2.0	2.1
Mobile Combustion	5.6	2.7	2.3	2.2	2.2	2.1	2.0
Field Burning of Agricultural Residues	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Petrochemical Production	0.2	0.1	+	+	0.1	0.1	0.1
Ferroalloy Production	+	+	+	+	+	+	+
Silicon Carbide Production and Consumption	+	+	+	+	+	+	+
Iron and Steel Production & Metallurgical Coke Production	+	+	+	+	+	+	+
Incineration of Waste	+	+	+	+	+	+	+
International Bunker Fuels[b]	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*

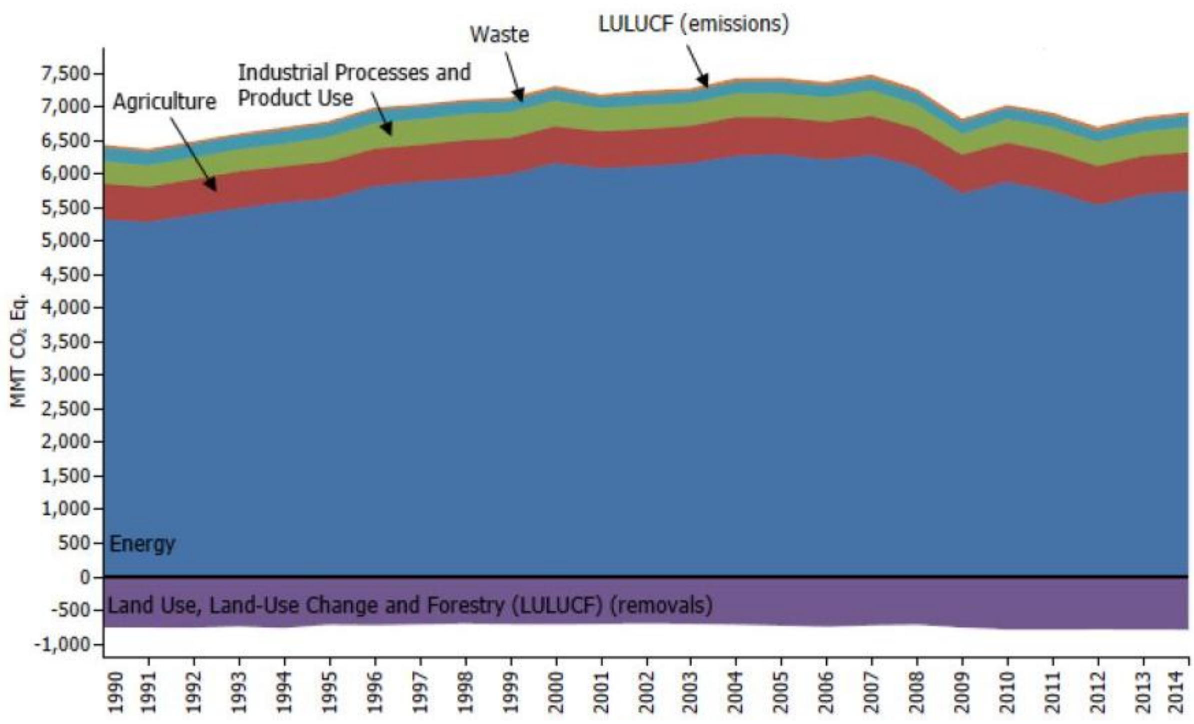


Figure 22: U.S. Greenhouse gas emissions and sinks by chapter/ IPCC sector (MMT Co_2 Eq.)
Source: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

Table above illustrates that over the twenty five-year period of 1990 to 2014, total emissions in the Energy, Industrial Processes and Product Use, and Agriculture sectors grew by 421.3 MMT CO_2 Eq. (7.9 %), 38.3 MMT CO_2 Eq. (11.2 %), and 41.6 MMT CO_2 Eq. (7.8 %) respectively. Emissions from the Waste sector decreased by 27.9 MMT CO_2 Eq. (14.0 %). Over the same period, estimates of net C sequestration for the Land Use, Land-Use Change, and Forestry sector (magnitude of emissions plus CO_2 removals from all LULUCF categories) increased by 24.5 MMT CO_2 Eq. (3.3 %).

Emissions from Energy:

In 2014, approximately 82 percent of the energy consumed in the United States (on a Btu basis) was produced through the combustion of fossil fuels. The remaining 18 percent came from other energy sources such as hydropower, biomass, nuclear, wind, and solar energy. A discussion of specific trends related to CO_2 as well as other greenhouse gas emissions from energy consumption is presented in the Energy chapter. Energy-related activities are also responsible for CH_4 and N_2O emissions (45 percent and 10 percent of total U.S. emissions of each gas, respectively). (Inventory of

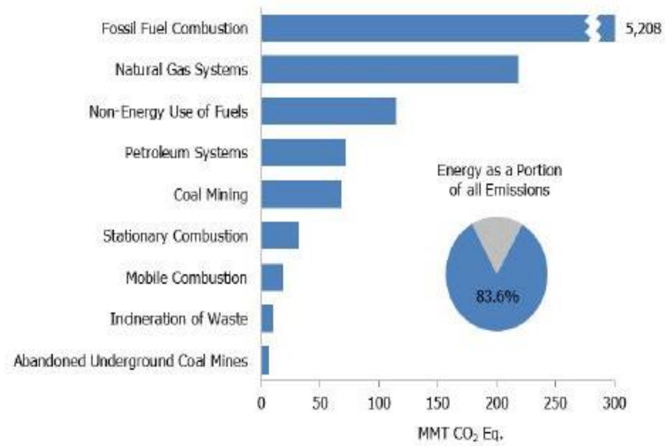


Figure 23: 2014 Greenhouse gas sources (MMT CO_2 Eq.)
Source: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-

Table 2 CO_2 Emissions from Fossil Fuel Combustion by End-Use Sector (MMt CO_2 Eq.) source: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

End-Use Sector	1990	2005	2010	2011	2012	2013	2014
Transportation	**1,496.8**	**1,891.8**	**1,732.7**	**1,711.9**	**1,700.6**	**1,717.0**	**1,741.7**
Combustion	1,493.8	1,887.0	1,728.3	1,707.6	1,696.8	1,713.0	1,737.6
Electricity	3.0	4.7	4.5	4.3	3.9	4.0	4.1
Industrial	**1,529.2**	**1,564.6**	**1,416.5**	**1,398.0**	**1,375.7**	**1,407.0**	**1,406.8**
Combustion	842.5	828.0	775.5	773.3	782.9	812.2	813.3
Electricity	686.7	736.6	641.0	624.7	592.8	594.7	593.6
Residential	**931.4**	**1,214.1**	**1,174.6**	**1,117.5**	**1,007.8**	**1,064.6**	**1,080.3**
Combustion	338.3	357.8	334.6	326.8	282.5	329.7	345.1
Electricity	593.0	856.3	840.0	790.7	725.3	734.9	735.2
Commercial	**755.4**	**1,026.8**	**993.0**	**958.8**	**897.0**	**925.5**	**938.4**
Combustion	217.4	223.5	220.1	220.7	196.7	221.0	231.9
Electricity	538.0	803.3	772.9	738.0	700.3	704.5	706.5
U.S. Territories[a]	**27.9**	**49.9**	**41.4**	**41.5**	**43.6**	**43.5**	**41.0**
Total	**4,740.7**	**5,747.1**	**5,358.3**	**5,227.7**	**5,024.7**	**5,157.6**	**5,208.2**
Electricity Generation	**1,820.8**	**2,400.9**	**2,258.4**	**2,157.7**	**2,022.2**	**2,038.1**	**2,039.3**

[a] Fuel consumption by U.S. Territories (i.e., American Samoa, Guam, Puerto Rico, U.S. Virgin Islands, Wake Island, and other U.S. Pacific Islands) is included in this report.
Notes: Combustion-related emissions from electricity generation are allocated based on aggregate national electricity consumption by each end-use sector. Totals may not sum due to independent rounding.

U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

Table 3 Emissions from Energy (MMT CO_2 Eq.) Source: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

Gas/Source	1990	2005	2010	2011	2012	2013	2014
CO_2	**4,908.0**	**5,932.5**	**5,520.0**	**5,386.6**	**5,179.7**	**5,330.8**	**5,377.9**
Fossil Fuel Combustion	4,740.7	5,747.1	5,358.3	5,227.7	5,024.7	5,157.6	5,208.2
Electricity Generation	*1,820.8*	*2,400.9*	*2,258.4*	*2,157.7*	*2,022.2*	*2,038.1*	*2,039.3*
Transportation	*1,493.8*	*1,887.0*	*1,728.3*	*1,707.6*	*1,696.8*	*1,713.0*	*1,737.6*
Industrial	*842.5*	*828.0*	*775.5*	*773.3*	*782.9*	*812.2*	*813.3*
Residential	*338.3*	*357.8*	*334.6*	*326.8*	*282.5*	*329.7*	*345.1*
Commercial	*217.4*	*223.5*	*220.1*	*220.7*	*196.7*	*221.0*	*231.9*
U.S. Territories	*27.9*	*49.9*	*41.4*	*41.5*	*43.6*	*43.5*	*41.0*
Non-Energy Use of Fuels	118.1	138.9	114.1	108.5	105.6	121.7	114.3
Natural Gas Systems	37.7	30.1	32.4	35.7	35.2	38.5	42.4
Incineration of Waste	8.0	12.5	11.0	10.5	10.4	9.4	9.4
Petroleum Systems	3.6	3.9	4.2	4.2	3.9	3.7	3.6
Biomass-Wood[a]	*215.2*	*206.9*	*192.5*	*195.2*	*194.9*	*211.6*	*217.7*
International Bunker Fuels[b]	*103.5*	*113.1*	*117.0*	*111.7*	*105.8*	*99.8*	*103.2*
Biomass-Ethanol[a]	*4.2*	*22.9*	*72.6*	*72.9*	*72.8*	*74.7*	*76.1*
CH_4	**363.3**	**307.0**	**318.5**	**313.3**	**312.5**	**321.2**	**328.3**
Natural Gas Systems	206.8	177.3	166.2	170.1	172.6	175.6	176.1
Petroleum Systems	38.7	48.8	54.1	56.3	58.4	64.7	68.1
Coal Mining	96.5	64.1	82.3	71.2	66.5	64.6	67.6
Stationary Combustion	8.5	7.4	7.1	7.1	6.6	8.0	8.1
Abandoned Underground Coal Mines	7.2	6.6	6.6	6.4	6.2	6.2	6.3
Mobile Combustion	5.6	2.7	2.3	2.2	2.2	2.1	2.0
Incineration of Waste	+	+	+	+	+	+	+
International Bunker Fuels[b]	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
N_2O	**53.6**	**55.0**	**46.1**	**44.0**	**41.7**	**41.4**	**40.0**
Stationary Combustion	11.9	20.2	22.2	21.3	21.4	22.9	23.4
Mobile Combustion	41.2	34.4	23.6	22.4	20.0	18.2	16.3
Incineration of Waste	0.5	0.4	0.3	0.3	0.3	0.3	0.3
International Bunker Fuels[b]	*0.9*	*1.0*	*1.0*	*1.0*	*0.9*	*0.9*	*0.9*
Total	**5,324.9**	**6,294.5**	**5,884.6**	**5,744.0**	**5,533.9**	**5,693.5**	**5,746.2**

+ Does not exceed 0.05 MMT CO_2 Eq.
[a] Emissions from Wood Biomass and Ethanol Consumption are not included specifically in summing energy sector totals. Net carbon fluxes from changes in biogenic carbon reservoirs are accounted for in the estimates for LULUCF.
[b] Emissions from International Bunker Fuels are not included in totals.
Note: Totals may not sum due to independent rounding.

The main driver of emissions in the Energy sector is CO_2 from fossil fuel combustion. Electricity generation is the largest emitter of CO_2, and electricity generators consumed 34 percent of U.S. energy from fossil fuels and emitted 39 percent of the CO_2 from fossil fuel combustion in 2014. Electricity generation emissions can also be allocated to the end-use sectors that are consuming that electricity, as presented in figure above. The transportation end-use sector accounted for 1,741.7 MMT CO_2 Eq. in 2014 or approximately 33 percent of total CO_2 emissions from fossil fuel combustion. The industrial end-use sector accounted for 27 percent of CO_2 emissions from fossil fuel combustion. The residential and commercial end-use sectors accounted for 21 and 18 percent, respectively, of CO_2 emissions from fossil fuel combustion.

D. Regional Context (India):

The energy sector in India is responsible for 69% of country's total greenhouse gas emissions (GHG's), a report from India to the United Nations on climate change has revealed. The 'Biennial Update Report' (BUR) was submitted to the UN Framework Convention on Climate Change as part of India's responsibility to report the progress made on its promises to fight climate change and tackle temperature rise. At the 2009 Copenhagen climate summit, India had promised to reduce its emissions intensity or emissions per unit of gross domestic product by 20-25%. As per the BUR, India has achieved a 12% reduction in emissions intensity by 2010. The BUR report accounted the emissions of carbon dioxide, nitrous oxide, hydro fluorocarbons (HFCs), Perfluorocarbons (PFCs) and sulfur hexafluoride to calculate total emissions. (DNA, n.d.)

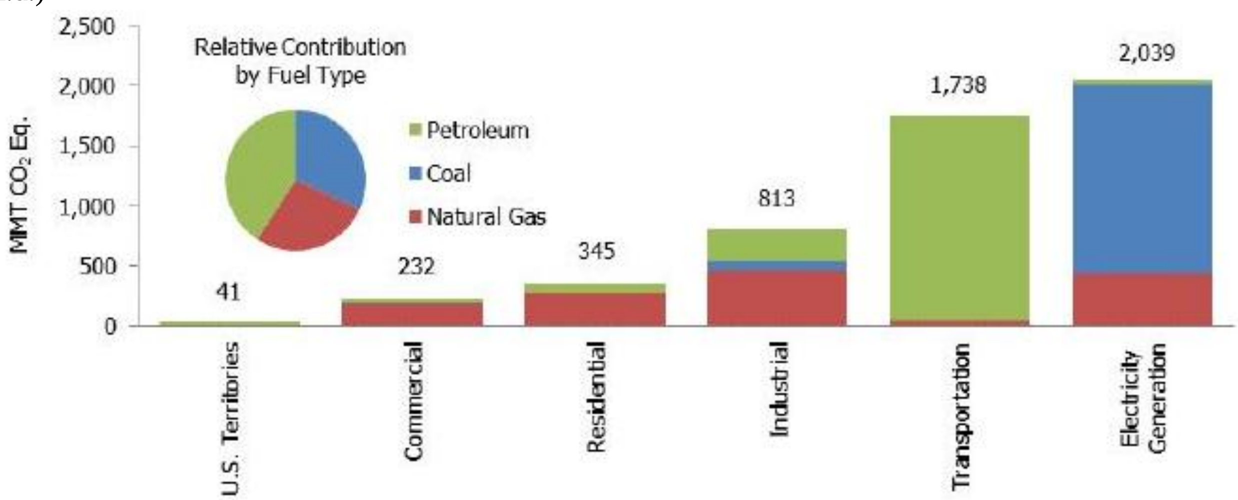


Figure 24: 2014 CO_2 emissions from Fossil Fuel Combustion by Sector and Fuel Type (MMT CO_2 Eq.)
Source: (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2014)

The emission intensity of GDP has reduced by 12% from 2005 to 2010, on course to meeting the voluntary target of 20-25% reduction in emission intensity of GDP by 2020," Union minister of environment, forest and climate change Prakash Javadekar said in the report. Even as the report majorly studied the 2005-2010 period, the trend in GHG emissions shows that in the period 2000 to 2010, the emissions increased from 1,301.2 million tonnes in 2000 to 2,136 million tonnes. (DNA, n.d.)

According to DNA, carbon dioxide or CO_2 dominates the total GHG emissions and the energy sector comprising of electricity production, manufacturing industries, transport sector and fugitive emissions generates the maximum CO_2 in the country. Methane, nitrous oxide and halogenated gases are the other major GHG's emitted in the country. While the energy sector accounts for 69% of emissions, agriculture sector emits 19% GHG's followed by Industrial Processes and Products Use (IPPU) sector that accounts for

9% with 3% from waste sector. The methane or CH_4 accounts for most of the GHG emitted in the agriculture sector along with nitrous oxide. This happens mainly due to livestock rearing, rice cultivation, burning of crop lands and use of chemicals and fertilizers. Emissions in the IPPU sector were from major sources such as mineral industries – cement, lime, glass, and ceramics – chemical industries and metal production. The dominant emitter in the IPPU sector, though, is the minerals industry.

Sector wise greenhouse gases emissions (Regional Context):

The energy sector accounted for 69% of the total emissions, the agriculture sector contributed 19% of the emissions, 9% of the emissions was from the industrial processes and product use, and only 3% of the emissions was attributable to the waste sector. (Sharma, et al., 2011 August)

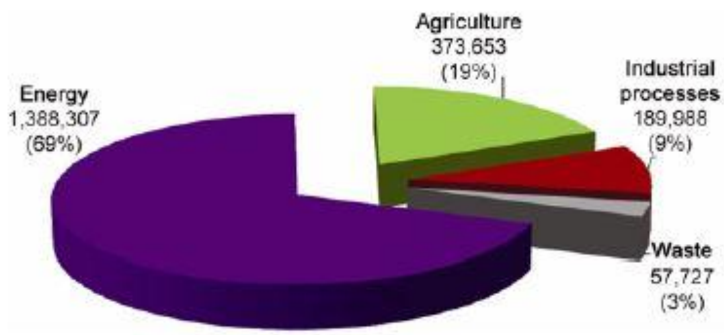


Figure 25: Greenhouse gas emissions by sectors (Gg) in 2007 without land-use change and forestry sector (CO2 equivalent). (Sharma, et al., 2011 August)

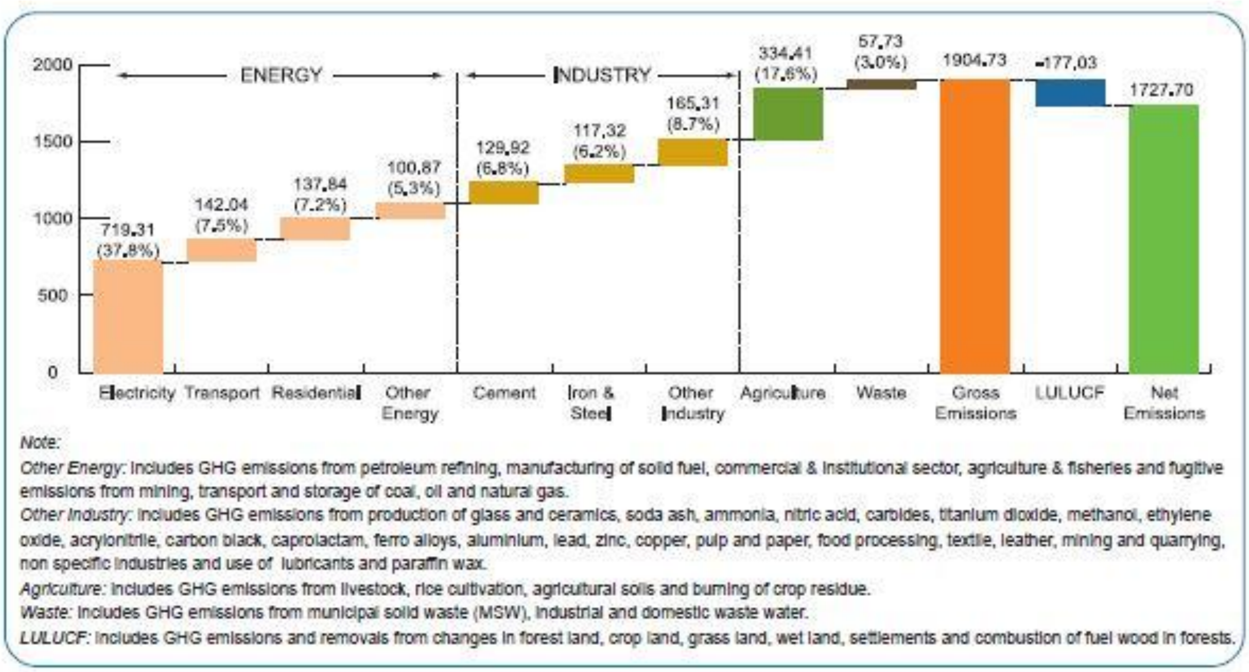


Figure 26: GHG emissions by sector in 2007 (million tons of CO2 eq). (Sharma, et al., 2011 August)

The net Greenhouse Gas (GHG) emissions from India that is emissions with LULUCF, in 2007 were 1727.71 million tons of CO_2 equivalent (Eq.) of which CO_2 emissions were 1221.76 million tons;

- CH_4 emissions were 20.56 million tons; and
- N_2O emissions were 0.24 million tons

GHG emissions from Energy, Industry, Agriculture, and Waste sectors constituted 58%, 22%, 17% and 3% of the net CO_2 Eq. emissions respectively. Energy sector emitted 1100.06 million tons of CO_2 Eq., of which 719.31 million tons of CO_2 Eq. were emitted from electricity generation and 142.04 million tons of CO_2 Eq. from the transport sector. Industry sector emitted 412.55 million tons of CO_2 Eq. LULUCF sector was a net sink. It sequestered 177.03 million tons of CO_2. India's per capita CO_2 Eq. emissions including LULUCF were 1.5 tons/capita in 2007.

	1994	2007	CAGR (%)
Electricity	355.03 (28.4%)	719.30 (37.8%)	5.6
Transport	80.28 (6.4%)	142.04 (7.5%)	4.5
Residential	78.89 (6.3%)	137.84 (7.2%)	4.4
Other Energy	78.93 (6.3%)	100.87 (5.3%)	1.9
Cement	60.87 (4.9%)	129.92 (6.8%)	6.0
Iron & Steel	90.53 (7.2%)	117.32 (6.2%)	2.0
Other Industry	125.41 (10.0%)	165.31 (8.7%)	2.2
Agriculture	344.48 (27.6%)	334.41 (17.6%)	-0.2
Waste	23.23 (1.9%)	57.73 (3.0%)	7.3
Total without LULUCF	1251.95	1904.73	3.3
LULUCF	14.29	-177.03	
Total with LULUCF	1228.54	1727.71	2.9

Note: Figure in brackets indicate percentage emissions from each sector with respect to total GHG emissions without LULUCF in 1994 and 2007 respectively

Figure 27: Comparison of GHG emissions by sector between 1994 and 2007 in million tons of CO_2 Eq. (Sharma, et al., 2011 August)

Table 3. Inventory of GHG emissions of anthropogenic origin by sources and removals by sinks for the year 2007 (in Gg; 1 Gg = 1000 tonnes)

Sector	CO_2 emission	CO_2 removal	CH_4	N_2O	HFCs: HFC-134a	HFCs: HFC-23	PFCs: CF_4	PFCs: C_2F_6	SF_6	CO_2 equivalent
Energy										
Fuel combustion activities	1,285,814.30		2,457.22	55.53						1,354,629.04
Energy industries	784,367.53		11.22	11.01						788,016.99
Electricity production	715,829.84		8.08	10.66						719,302.73
Refinery	67,643.22		3.14	0.34						67,814.93
Manufacturing of solid fuel	894.47		0.01	0.02						899.33
Manufacturing industries and construction	258,101.76		3.80	2.97						259,102.38
Transport	138,984.01		17.89	8.25						141,918.47
Commercials/institutional	1,657.00		0.30	0.02						1669.50
Residential	69,427.00		2,420.00	33.00						130,477.00
Agricultural/fisheries	33,277.00		4.00	0.27						33,444.70
Fugitive emission from fuels			1,603.71							33,677.99
Sub-total	1,285,814.30		4,060.93	55.53						1,388,307.03
Industrial process and product use										
Mineral products	82,141.98									82,141.98
Chemicals	19,088.65		10.58	17.13						24,622.46
Metal production	52,004.91		0.08				1.47	0.15	0.004	62,991.45
Others*					1.67	1.24			0.12	19,382.48
Non-energy product use	849.49									849.49
Sub-total	154,085.03		10.65	17.13	1.67	1.24	1.47	0.15	0.12	189,987.86
Agriculture										
Enteric fermentation			10,609.73							222,804.36
Manure management			120.44	0.08						2,553.55
Rice cultivation			3,323.30							69,789.30
Agricultural soils				225.93						70,036.75
Field burning of agricultural residues			257.21	6.67						7,469.11
Sub-total			14,310.68	232.67						372,653.07
Land use, land-use change and forestry										
Forestland		67,800.00								–67,800.00
Cropland		207,520.00								–207,520.00
Grassland	10,490.00									10,490.00
Settlement		38.00								–38.00
Wetland	NE									NE
Others	NO									NO
Fuel wood use from forests	87,840.00									87,840.00
Sub-total	98,330.00	275,358.00								–177,028.00
Waste										
Solid waste disposal on land			604.51							12,694.71
Managed waste disposal on land			604.51							12,694.71
Waste-water handling			1,911.00	15.81						45,032.10
Industrial wastewater			1,050.00							22,050.00
Domestic and commercial wastewater			861.00	15.81						22,982.10
Sub-total			2,515.51	15.81						57,726.81
Grand total (Gg)	1,538,229.33	275,358.00	20,897.77	321.14	1.67	1.24	1.47	0.15	0.12	1,831,646.77
Memo item										
International bunkers	3,454.00		0.03	0.10						3,484.45
Aviation	3,326.00		0.02	0.09						3,355.31
Marine	128.00		0.01	0.003						129.14
CO_2 from biomass	566,788.00									566,788.00

*Includes production of halocarbons and consumption of SF_6.

Agricultural sector:

The agriculture sector includes non-CO_2 emissions from enteric fermentation from livestock, manure management, rice cultivation, agricultural soils and burning of crop residue in the fields. Enteric fermentation in livestock is a digestive process by which carbohydrates are broken down by microorganisms, leading to emission of CH_4. The amount of CH_4 that is released depends on the type, age and weight of the animal, the quality and quantity of the feed, and the energy expenditure of the animal. The decomposition process of manure under anaerobic conditions also leads to release of CH_4, while some nitrogen in the manure is converted to N_2O resulting into emission. As mentioned earlier, anaerobic decomposition of organic material in flooded rice fields produces methane. The amount of CH_4 emission depends on irrigation practices, rice species, number and duration of harvests, soil type and temperature, and usage of fertilizer. Burning of crop residues is considered C neutral, as it is reabsorbed during the next growing season. However, burning is a significant source of CH_4 and N_2O amongst other non- CO_2 emissions. The N_2O from agricultural soils is released due to the microbial processes of nitrification and denitrification in the soil resulting in direct or indirect emissions. Direct soil emissions may result from nitrogen input to soils such as synthetic fertilizers, animal waste, through biological nitrogen fixation, from reutilized nitrogen from crop residues, and from sewage sludge application, and from organic soil due to enhanced mineralization. Indirect N_2O emissions take place after nitrogen is lost from the field as NO_x, NH_3 or after leaching or run-off. In 2007, the total emissions of CH_4 and N_2O from these activities in India were 14.3 Tg and 0.23 Tg respectively, resulting in 372.65 Tg of CO_2 equivalent emissions, which was 19% of the total GHG emissions from the country without inclusion of LULUCF (Land-use change and forestry). (Sharma, et al., 2011 August)

Type	Emission factor (kg CH_4/ha)
Irrigated	
Continuously flooded	162
Single aeration	66
Multiple aeration	18
Rainfed	
Drought-prone	66
Flood-prone	190
Deep-water	190

Figure 28: Emission factor used for estimation of emissions from rice cultivation (Sharma, et al., 2011 August)

Industrial sector:

Industrial production processes also produce GHGs from a variety of industrial activities which chemically or physically transform materials. During these processes, many different GHGs, including CO_2, CH_4, N_2O, HFCs, PFCs and SF6 are released. Cement and iron–steel production are notable examples of an industrial process that releases a significant amount of CO_2. Different halocarbons and SF6 are also produced or used as alternatives to ozone-depleting substances in various applications. In some instances industrial process emissions are produced in combination with fuel combustion emissions, where the main purpose of the fuel combustion is to use the heat released; the resulting emissions are included as energy emissions, not industrial process emissions. There are, however, some chemical processes or stages of processes, which oxidize carbon as a feedstock and are exothermic. The reduction of iron in a blast furnace through the combustion of coke is an example. In some cases not all fuel feedstock delivered to petrochemical plants is used for manufacture of other products. These constitute important factors for estimating the GHG emissions from the industrial process sector. In 2007, the industrial processes, comprising metal industries, mineral industries, chemical industries, use of non-energy products such as paraffin wax and lubricants, and consumption and production of HFCs and SF6, have resulted in an emission of 154,085.03 Gg of CO_2, 10.65 Gg of CH4, 17.13 Gg of N2O, 1.67 Gg of HFC- 134a, 1.24 Gg of HFC-23, 1.47 Gg of CF4, 0.15 Gg of C2F6 and 0.12 Gg of SF6. Together this resulted in an emission of 189.99 Tg of CO_2 equivalent, which was 19% of the total GHG emissions without LULUCF.

Energy sector:

The energy sector comprises emission estimates due to combustion of fossil fuel in stationary sources, mobile sources, and fugitive emissions from mining and handling of coal, oil and natural gas. Stationary sources include fossil-fuel combustion in electricity generation, manufacturing of solid fuels, refineries for refining crude oil, manufacturing industries and fossil-fuel use in residential, commercial/institutional, and agriculture/fisheries activities. CO_2 emissions result from the release of carbon in the fuel during combustion and the quantity of emission depends not only on the quantity of the fuel combusted, but also on the carbon content of the fuel and the technology of combustion. Most of the carbon (C) is emitted as CO_2 immediately during the combustion process. However, some carbon is released as CH_4, carbon monoxide (CO) or non-CH_4 volatile organic carbon (NMVOC), which oxidizes to CO_2 in the atmosphere within a period of a few days to about 12 years. The quantity of CH_4 and N_2O released depends on the technology used in mobile combusting source. Mobile sources include road transport, civil aviation, railways and navigation. Fugitive emissions of CH_4 occur from coal seams trapped during the geological process of coal formation.

Generally, deeper underground coal seams contain more *in situ* methane than shallower surface seams. Fugitive emissions from oil and natural gas activities include all emissions from the exploration, production, processing, transport and use of oil and natural gas, and from nonproductive combustion (e.g. flaring). The total emissions from the energy sector in 2007 were 1388.31 Tg of CO_2 equivalent. Of this, 1285.81 Tg was emitted as CO_2, 4.06 Tg as CH_4 and 0.06 Tg as N_2O. The energy sector contributed 69% of the total emissions in 2007 without LULUCF.

Waste sector:

GHG emissions from the waste sector have been estimated from activities related to management of municipal solid waste (MSW), industrial wastewater, domestic wastewater and commercial wastewater practices in India. Systematic disposal over the years in solid waste sites led to degradation of organic C present in the waste in anaerobic conditions, resulting in CH_4 emissions. MSW management is carried out systematically only in the cities of India. It is estimated that MSW generation and disposal resulted in 0.60 Tg of CH_4 emissions or 12.69 Tg of CO_2 equivalents in 2007. Similarly, domestic wastewater from urban centres (class I and II cities) and also the industrial wastewater are handled systematically. Domestic wastewater emitted 0.86 Tg of CH_4 and 0.016 Tg of N_2O, resulting in 22.98 Tg of CO_2 equivalent. The industrial wastewater management practices for industries such as pulp paper, food and beverage and tanneries, lead to emissions of 1.05 Tg of CH_4, resulting in 22.05 Tg of CO_2 equivalent. The total amount of GHG emitted from the waste sector in 2007 was 57.73 Tg of CO_2 equivalent.

E. Local Context (Nepal)

Nepal has experienced an average maximum annual temperature increase of 0.06° C. This rate of increase is higher in the mountains than in other regions. Despite having only 0.4 percent of the total global population and being responsible for only 0.025 percent of total GHG emissions in the world, Nepal will be affected disproportionately, especially from increasing atmospheric temperature. Changes in the annual rainfall cycle, intense rainfall and longer droughts have been observed. Similarly, both days and nights are presently warmer. The number of days with 100 mm of heavy rainfall is increasing. The timing and duration of rainfall is changing. As glaciers recede from rapid snow and ice melting, glacier lakes are expanding. The adverse impacts of climate change have been noticed in agriculture and food security, water resources, forests and biodiversity, health, tourism and infrastructures. Climate-induced disasters and other effects have caused damages and losses to life, property, and livelihoods. Millions of Nepalese are estimated to be at risk to climate change. In the past 90 years, a glacier in the Sagarmatha region has receded 330 feet vertically. Because of glacier melting, new glacier lakes have formed. Although there will be an increase in river flows untill 2030, this is projected to decrease significantly by the end of this century. The problems arising due to climate change are increasing over the years. Nepal has to implement adaptation programmes even if it is not being responsible for climate change. Hence, Nepal has considered climate adaptation as a national agenda and has taken several initiatives for implementing different programmes for risk reduction in the recent years.

1. Energy system in Nepal

According to Central Bureau of Statistics, the country's total population is 26.49 million, compared to 23.15 million in 2001, and the annual population growth rate is 1.35 percent (CBS, 2012). Out of the total population, 83 percent live in rural areas. In terms of geographic distribution, Terai constitutes 50.27 percent (13,318,705) of the total population while Hill and Mountain constitutes 43 percent (11,394,007) and 6.73 percent (1,781,792) respectively. Though Nepal is among the least urbanized countries in the world, its urban population is growing rapidly at an annual rate of 3.4%, which is more than 3.5 times the growth rate of rural population (CBS, 2012).

Biomass and hydropower are the major indigenous energy resources available in the country. Nepal is endowed with a significant amount of water resources; the theoretical potential of its hydropower is estimated to be 83 GW while the estimated economical potential is 42 GW (WECS, 2010). So far, Nepal has an installed electricity generation capacity of only 719 MW (NEA, 2012). Despite the large hydropower potential, only a small fraction of the hydropower resources (i.e., less than 2% of the economic potential) is harnessed so far and only 67% of the population had an access to electricity from grid and off-grid systems in 2011 (CBS, 2012).

Besides hydropower there exist several other locally available renewable energy resources which are mostly suitable for fulfilling the distributed energy demand in rural communities of the country. These include solar, wind, geothermal etc. The possible renewable energy technologies, which can generate power by exploiting the locally available energy resources, includes pico-hydro and micro-hydro power, biomass (biogas, briquettes, gassifier), liquid bio-fuel, improved cooking stove (ICS), solar photovoltaic, solar thermal and wind powered plants. Of these technologies, micro-hydro, biogas, improved cooking stove, solar photovoltaic (PV) home systems, and solar water heaters are becoming popular and are at varying stages of commercialization. However, technologies such as solar cooker, solar dryer, briquettes, wind and geothermal are only in the research and demonstration phase, and still need to be commercialized (Chaulagain and Laudari, 2010). The estimated total potential of biogas plants is about 1.1 million plants of which 277,226 biogas plants of varying capacities (4, 6, 8, 10, 15 and 20 m3) have been installed as of December 2012. There exist a huge potential for biomass technologies like ICS, small scale briquetting technologies and gassifier. More than 663,114 ICS have so far been installed through various governmental and non-governmental organizations. Besides large capacity hydropower, there exist potential of installing about 110MW of small scale pico-hydro and micro-hydro plants suitable for supplying electricity to distributed rural population mostly in the hilly and mountain regions of the country. As of 2012 altogether 3.2 MW of pico-hydro and 33.6 MW of mini-grid micro-hydro plants have been installed. There exist mechanical power capacity of about 33 MW of improved water mill (IWM), of which one third have been exploited. Nepal receives ample solar radiation with average value varies from 3.6–6.2 kWh/m2/day, and the sun shines for about 300 days a year. With national average sunshine hours of 6.8/day and solar insolation intensity of about 4.7 kWh/m2/day, there is a huge potential for solar PV as well as solar thermal devices such as solar PV home system, solar PV pumping, solar water heaters, solar dryers, and solar cookers. About 285,000 units of solar PV home system have been installed till 2012. Presently, solar water heaters have been fully commercialized and, till 2009, more than 200,000 of them have been installed in the country. Wind is still an unharnessed energy resource in the country with recently estimated commercial potential as 3,000 MW (estimated under Solar & Wind Energy Resource Assessment in Nepal (SWERA) program). A pilot project for demonstration and dissemination is being carried out by various organizations like AEPC, Practical Action, etc. (Chaulagain and Laudari, 2010).

Total primary energy supply (TPES) in the country was about 292 Peta Joule (PJ) in 2005. As shown in the Figure 6.1, it increased at the growth rate of 2.46% to reach 400 PJ by 2008/09 (WECS, 2010). The use of fossil fuels consisting of petroleum products, LPG and coal has increased at the growth rate of 3.93% mostly due to rapid increase in LPG consumption. Likewise electricity mostly from hydropower increase by 7.82% and other renewable excluding hydropower and traditional biomass increases by 15.19%. In terms of energy mix biomass still dominates with its share of 87.1% in 2008/2009 though its share has been slightly reduced as compared to 91.7% share in 1995/1996. However, there is an increase in the shares of LPG (by 1.1%), coal (by 0.9%), electricity (by 9.5%), and other renewable (by 0.5%) as shown in the Primary Energy Supply in Nepal during 1995/1996 to 2008/2009, PJ.

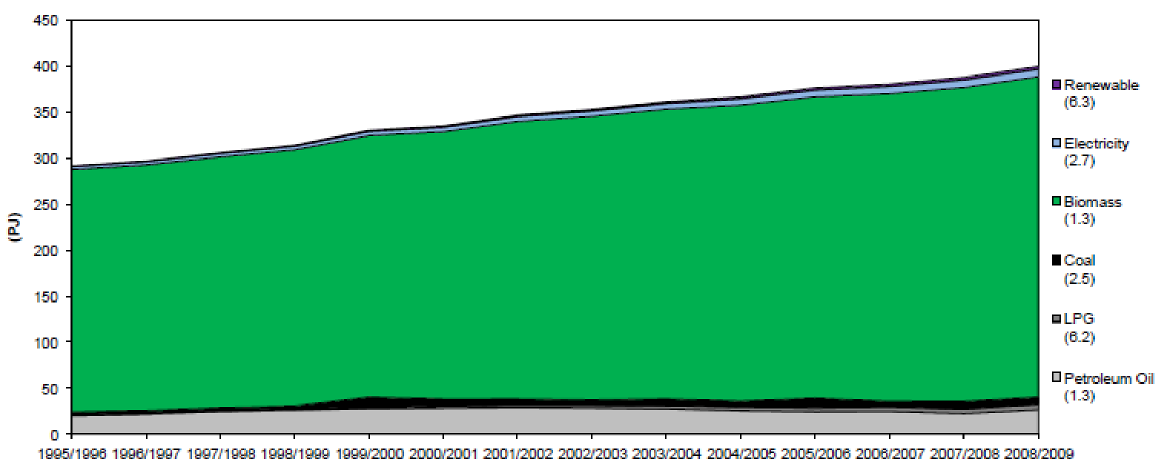


Figure 29: Primary energy supply in Nepal during 1995/1996 to 2008/2009, PJ , Source: (CES, 2013)

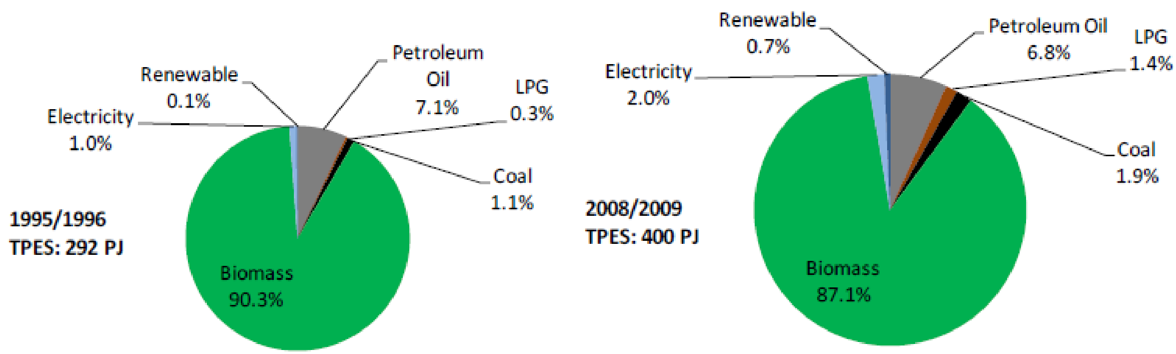


Figure 30: Fuel Share in the Primary Energy Supply, %, Source: (CES, 2013)

2. Sector wise energy consumption

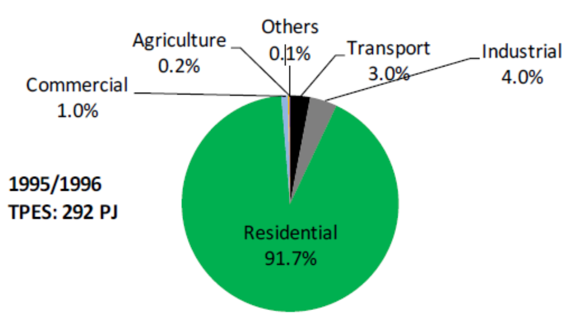


Figure 31: Sectoral Share in Energy Consumption, %, Source: (CES, 2013)

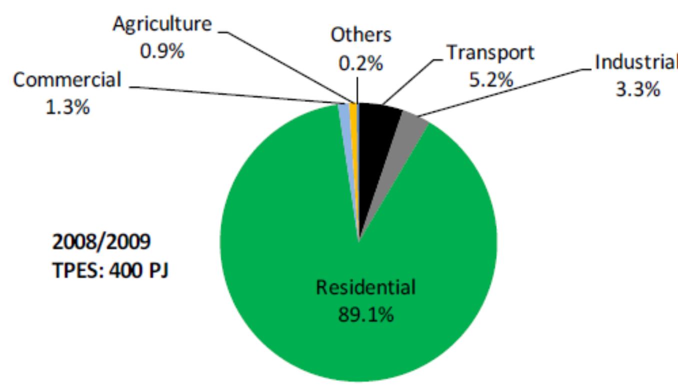


Figure 32: Sectoral Share in Energy Consumption, %, Source: (CES, 2013)

The energy consumption per capita increases by 10.1% from 14.26 GJ/capita in 1995/1996 to 15.71 GJ/capita in 2008/2009. In terms of fossil fuel consumption, the per capita consumption of fossil fuel increases by 32.4% from 0.12 GJ/capita in 1995/1996 to 0.16 GJ/capita in 2008/2009 indicating growing dependence on the imported fossil fuels. Likewise, economic activities shows improvement in terms of energy consumption with energy intensity of GDP at constant price changes from 90.04 MJ/100 NRs in 1995/1996 to 67.87 MJ/100 NRs @ 2000 price in 2008/2009.

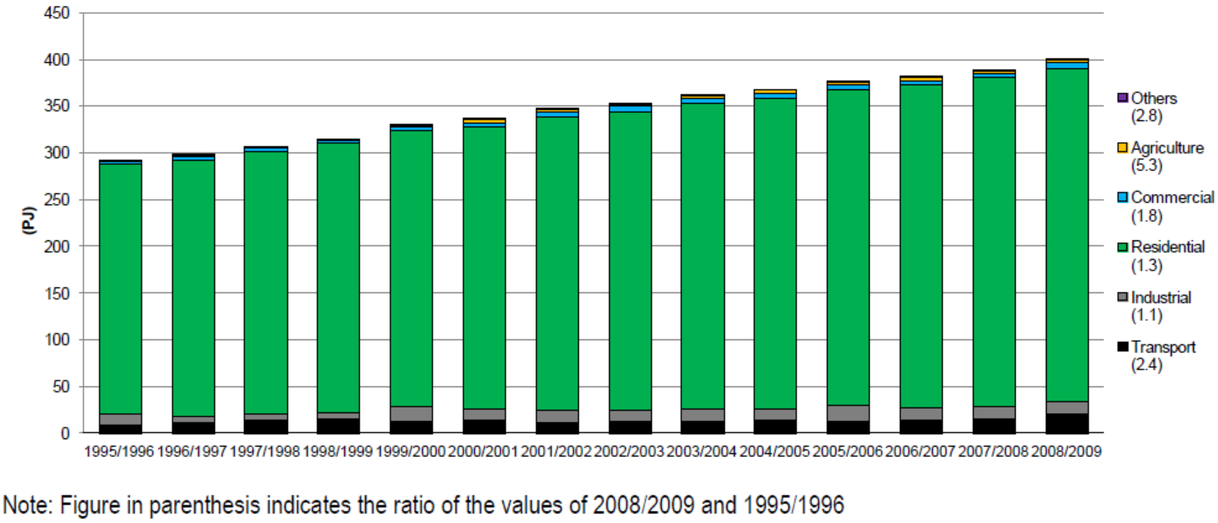


Figure 32: Sectoral Energy Consumption in Nepal during 1995/1996 to 2008/2009, PJ, Source: (CES, 2013)

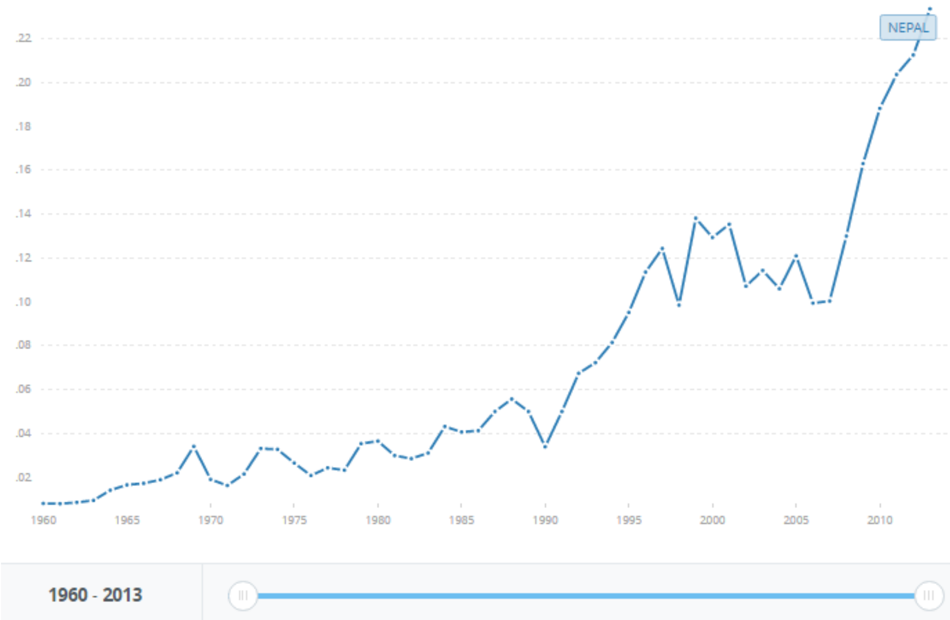
As can be seen in figure above, the sector wise energy consumption has grown at the rate of 6.9% in the transport sector, 4.6% in the commercial sector, 2.2% in the residential sector and 1% in the industrial sector between 1995/1996 to 2008/2009. The energy consumption in the agricultural sector grew at 13.7% mostly due to increase in diesel consumption. Over the period, the share of the residential sector shows decrease from 91.7% in 1995/1996 to 89.1% in 2008/1009. The share of industrial sector shows decrease from 4% to 3.3%, whereas the share of the transport and commercial sectors indicates increase from 3% to 5.2% and 1% to 1.3% respectively during 1995/1996 to 2008/2009. The share of agriculture and and other sectors shows increase from 0.2% to 0.9% and 0.1% to 0.2% respectively during 1995/1996 to 2008/2009.

The detail socio-economic and energy-environmental data is given in Table below.

Table 6.1: Socio-economic and Energy-environmental Indicators of Nepal

Parameters	1995/1996	2000/2001	2004/2005	2008/2009
Energy consumption(TJ)	291827	335421	367208	400506
GHG (1000 tons CO2e)	4147	5516	5587	6149
Population	20459237	22892696	24161739	25501130
Fossil fuel consumption(TJ)	24700	38732	36522	40765
Energy per capita (TJ/capita)	0.014	0.015	0.015	0.016
GHG per capita (ton CO2e/capita)	0.203	0.241	0.231	0.241
Energy Intensity of GDP (MJ/100 NRs)	90.044	75.970	73.775	67.870
GHG Intensity of Energy (kg CO2e/TJ)	14.211	16.446	15.214	15.353
Fossil fuel consumption per capita (TJ/capita)	0.0012	0.0017	0.0015	0.0016

3. CO2 emissions (metric tons per capita)



Country	1960	2013
Nepal	0.0	0.2

Figure 34: CO_2 emissions per person in Nepal from 1960 to 2013 in metric tons, Source: http://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2013&locations=NP&start=1960&view=chart

4. Nepal's contribution for greenhouse gases of the world

As of 2010, Nepal's own emissions make up less than 0.1% of global emissions. With its current policies, Nepal's GHG emissions are expected to increase to between 50–53 MtCO2e by 2030 (an increase of 55–66% compared to 2010 levels). Even with this increase, the country's per capita emissions would only grow from 1.2 tCO2e/cap as of 2010 to 1.5–1.6 tCO2e/cap by 2030, still far below the 2012 world average of 7.6 tCO2e/cap (JRC, 2016).

5. Greenhouse Gas Emission Evolution in Nepal

Increasing trend of fossil fuels has contributed in an increase in the GHG emission in Nepal. As no time series GHG emission from the consumption of energy in the country is available from the related national government agencies, an IPCC default emission factors for individual greenhouse gas (CO2, CH4 and N2O) as mentioned in 2006 IPCC Guidelines for National Greenhouse Gas Inventories for dedicated economic sectors were used for estimating the national GHG emission (IPCC, 2006). It has been observed that, GHG emissions from energy use has increase by 48.3% from 4.1 million tons CO2e (i.e., CO2 equivalent) in 1995/1996 to 6.1 million tons CO2e in 2008/2009 (Table 6.1). Figure 6.5 shows the sector wise GHG emissions from energy use during 1995/1996 to 2008/2009. The GHG emissions from the transport, industrial, and agriculture sectors would increase by 138%, 35% and 479% respectively during the period mostly due to dominance of the fossil fuels in their energy consumption. While the emissions from the residential and commercial sectors would increase by 23% and 44% respectively. The sectoral shares in total GHG emission are shown in Figure 6.6. In 1995/1996, residential sector dominates in the share of GHG emission with over 66.2%, followed by transport sector with 15.6% share and industrial sector with 13.9% share. Remaining sectors constitute about 4.4% in the sectoral GHG emission mix in 1995/1996. However, sectoral contribution of GHG emission changes significantly in 2008/2009, with residential sector constituting 54.9%, transport sector consisting of 25.1% and Industrial sector constituting 12.6%. Remaining sectors contributes 7.4% in the sectoral GHG emission mix in 2008/2009.

6. Sectoral breakdown of greenhouse emissions in 2010

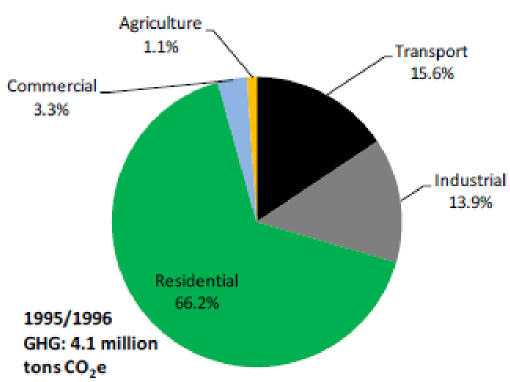


Figure 35: Sectoral Shares in GHG Emission in the Base Case, %, Source: (CES, 2013)

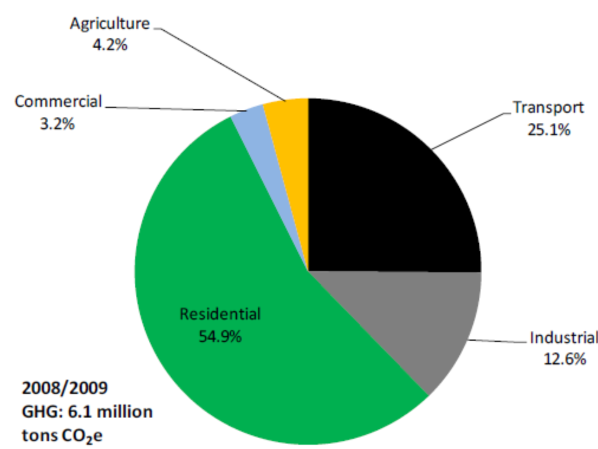


Figure 36: Sectoral Shares in GHG Emission in the Base Case, %, Source: Source: (CES, 2013)

The per capita GHG emission increases from 0.20 ton CO2e/capita in 2005 to 0.24 ton CO2e/capita in 2030. This indicates, future life style would be inclined towards carbon intensive fossil fuels mostly due to the limitation in the supply of the biomass energy resources and capital intensiveness of hydropower and other renewable resources.

Table 4: nepal's National Greenhouse Gas Inventory in 1995/95 (Gg)

Greenhouse Gas (Source and Sink Categories)	CO_2 Emission	CO_2 Removal	CH_4 Emission	N_2O Emission
1. Energy	**1465**		**71**	**1**
A. Fuel Combustion	1465		71	1
Energy & Transformation Ind.	71			
Industry, Mining & Construction	320			
Transport	456			
Other sectors	618		71	1
B. Fugitive Emissions from fuels	0			
2. Industrial Processes	**165**			
A. Mineral Production	165			
Cement Production	163			
Lime Production	2			
3. Solvent and Other Product Use	**0**			
4. Agriculture			**867**	**29**
A. Enteric Fermentation			527	
B. Manure Management			34	2
5. Land Use Change & Forestry	**22895**	**-14778**		
A. Changes in Forest & Other Woody Biomass Stocks	0	-14738		
B. Forest & Grassland Conversion	18547			
C. Abandonment of Managed Land		-40		
D. CO_2 Emission and Removals from Soil	4348			
6. Wastes			**10**	**1**
A. Solid Waste Disposal on Land			9	
B. Wastewater Handling			1	
C. Waste Incineration				
D. Other				1
Total Emission and Removal	24525	-14778	948	31
Net Emission	9747		948	31

Table 5: Total CO_2 Equivalent Emissions of Nepal in 1994/95

	Emission (Gg)	Global Warming Potential (GWP)	CO_2 Equivalent	% of Total
CO_2	9,747	1	9,747	25
CH_4	948	21	19908	51
N_2O	31	310	9610	24
Total			39265	100

Carbon dioxide:

- Net emissions of CO2 : 9747Gg.
- The contributor includes the transport sector (31%), Industrial sector (27%), Residential sector (22%), Commercial sector (11%) and the remaining (9%) is shared by Agriculture sector.

Methane:

- Total methane emissions : 948Gg.
- 867Gg from Agriculture sector.
- Energy related combustion activities, such as biomass burning;
- Solid waste disposal and waste water treatment.
- CH4 emissions from enteric fermentation in domestic livestockand manure management

Nitrous Oxide:

- Agriculture soils from where 27 Gg of this gas were released to the atmosphere.
- 2 Gg from manure management.
- Indirect N2O emissions from human sewage were estimated to be 1.10 Gg for the base year 1994/95.

8. Problems and challenges:

Problems:

There are very few studies about the effects and likely impacts of climate change in Nepal. Scientific evaluations are yet to be carried out to understand the types and degrees of impacts on specific geographical region and development sector. Activities related to climate modelling and assessing the ongoing effects and likely impact of climate change in natural resources, including water resources and other economic sectors from the mountain and hill regions to the plains in the south, have not been carried out due to inadequate human and financial resources and lack of appropriate equipment. Detailed studies, surveys and monitoring of snow and glacier melting and glacier lake outburst floods (GLOFs) have yet to be conducted.

The detailed impacts from climate change on agriculture, water resources, forests and biodiversity, public health, disaster incidence, tourism and other related sectors has yet to be assessed. Similarly, programmes for avoiding, minimizing or adapting to the changing climate by developing appropriate technologies for risk reduction and disaster preparedness have also yet to be implemented. The major challenge is the lack of an effective framework for addressing the adverse impacts of climate change; such a framework should consider the UNFCCC provisions and decisions of the Conference of the Parties, including adaptation, mitigation, finance, technology development and transfer, capacity building, and climate resilience. Although climate change has become an issue of global importance, there is a lack of institution which can examine climate change from the perspectives of science and technology.

Challenges:

- National efforts to make the socio-economic sectors climate-resilient is a great challenge due to the lack of knowledge, scientific data and information related to the science of climate change and its impact on different geographical and socio-economic development sectors and use of climate modelling to assess likely impacts.
- It is also a challenge to assess the effects and likely impacts of climate change, to identify the vulnerable sectors and enhance their adaptive capacity, and to develop a mechanism for reducing GHG emissions.
- It is necessary to create an enabling environment for technical and financial opportunities at the national and international level in the process of addressing climate change impacts.
- It is equally necessary to make the country's socio-economic development climate friendly, and to integrate climate change aspects into policies, laws, plans and development programmes, and implement them.
- Current and likely adverse impacts of climate change have to be established between upstream and downstream areas so as to promote regional cooperation.
- In order to achieve the U.N. Millennium Development Goals and avoid or minimize the impacts of climate change on mountain environments, people and their livelihood, and ecosystems, the country should be able to take full advantage of the international climate change regime.
- There is a need to effectively enhance the capacity of public institutions, planners and technicians, private sector, NGOs and civil society involved in development work.
- It is equally important to give attention to develop a capable organizational structure with necessary financial and human resources for addressing climate change issues.

9. Way forward:

In order to face the challenges and solve the problems mentioned above, succeed in current efforts and maximize the benefits from the Climate Change Convention, formulation of a new policy with the following aspects is urgently required:

- To inform Parties to the UNFCCC about the implementation of the Convention along with institutional development, capacity enhancing, technology development and utilization, fund flow and GHG measurement, and updating data and information;
- To promote climate adaptation, mitigation and carbon sequestration; to mobilise the financial resources and make it accessible for expanding activities in technology development and transfer and capacity building for the formulation, implementation, monitoring and evaluation of programmes;

- To implement adaptation programmes according to the national development agenda and to ensure at least 80 percent of the total funds available for climate change activities flow to the grassroots level;
- To make natural resources management climate-friendly for socio-economic development and climate-resilient infrastructure development;
- To increase public awareness, enhance capacity and promote negotiation skills through multi-stakeholder participation; and
- To manage and mobilise additional technical and financial resources from clean and renewable energy development, carbon trade and other mechanisms related to reducing the impacts of climate change.

F. Analysis

1. Comparative chart showing CO2 eq/ per capita

Country	**1990** metric ton CO2eq/capita	**1995** metric ton CO2eq/capita	**2000** metric ton CO2eq/capita	**2005** metric ton CO2eq/capita	**2010** metric ton CO2eq/capita	**2011** metric ton CO2eq/capita	**2012** metric ton CO2eq/capita
World Total	7.20	6.81	6.63	7.26	7.38	7.56	7.58
China	**3.34**	**4.07**	**3.97**	**5.92**	**8.22**	**8.82**	**9.04**
India	**1.60**	**1.73**	**1.81**	**1.88**	**2.30**	**2.32**	**2.43**
Nepal	**1.39**	**1.31**	**1.35**	**1.22**	**1.22**	**1.22**	**1.48**
United States	**24.11**	**23.75**	**24.49**	**24.09**	**21.50**	**17.00**	**20.87**

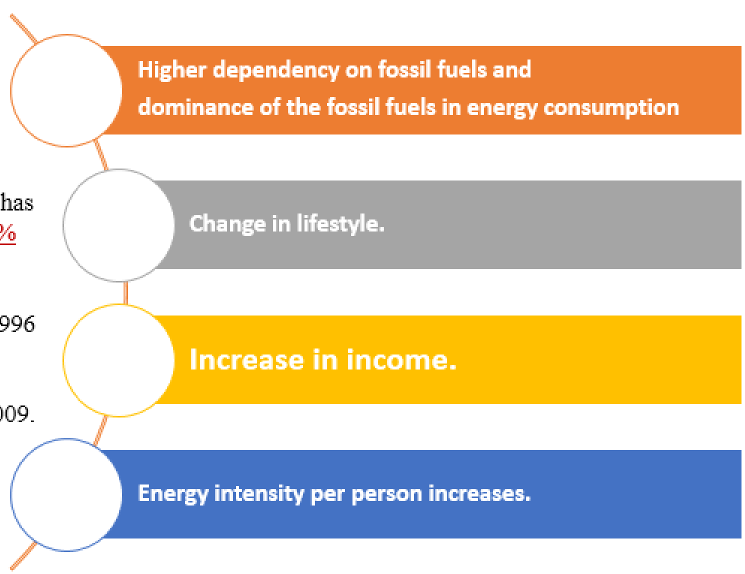
Source: (European Commission, 2016)

2. Observations for individual sectors

	Observation	Analysis
Residential and Commercial sector	Energy use in developed countries is more as compared to developing countries	• Have bigger building sizes • More appliances and equipment • Higher incomes and greater access to energy services.
Transportation sector	Over the next two decades, vehicle ownership is expected to double worldwide	• Modernization. • Income of people are increasing • So more CO_2 in coming years
Agriculture sector	Increasing greenhouse gases from agriculture	• Increased use of nitrogen-based fertilizers • Increased number of livestock being raised, especially cattle
Electricity generation	Electricity generation is by far the largest single source of CO_2 emissions.	• Source of electricity generation by fossil fuels is 67.2% • More greenhouse emissions in future

3. Data showing increasing energy consumption in Nepal and reasons for increasing energy consumption

- GHG emissions from energy use has increase by 48.3%
- 4.1 million tons CO2e in 1995/1996
- 6.1 million tons CO2e in 2008/2009.



4. Comparative chart for global, regional and local level

	U.S.	India	Nepal
Sector with highest Greenhouse emissions	Electric Generation	Energy	Residential and Commercial
Fuel use for Primary Energy supply	Fossil fuels		Biomass
Emission per capita (t) in 2014	16.5	1.8	0.1 (in year 2000)
Contribution to global emissions (%)	16% (year 2010)	6% (year 2007)	0.1% (year 2010)
CO2 emissions (kt) in 2014	5,334,000	2,341,000	3234.3 (in year 2000)

G. Impacts on Global and Local level

1. Global impacts

- Extreme weather
- Melting of polar ice caps
- Coral bleaching
- Wildfires
- Deforestation
- Drought
- Mountain glaciers
- Animal migration
- Food prices rise
- Pollen allergies
- Endangered species

2. Local effects

- Water
  - Drought, drying of springs, groundwater depletion, reduction in river flow, floods etc
- Glaciers
  - Rate of retreat of some glaciers is estimated to be as high as 20 m /year
  - Evidence in the Main Rongbuk glacier (in Mount Everest): lost 330 feet of vertical ice, at a rate of more than 4ft/yr, between 1921 and 2007
  - Snow and glacier melt might increase water in Nepal's river system - 5.7% till 2030, decrease by 28% by the end of this century
- Change in ecosystem
  - Impacts on Forest ,Wetland and Agro eco system
- Human health
  - Increase in prevalence of vector and water borne diseases
  - Declining domestic water supply, poor sanitation

- Mountain livelihoods, women and Indigenous groups
  - Loosing of traditional livlihoods in high mountains
  - Women work in few locations nearly 17 hours (mainly to fetch water)
  - Livestock have to be moved to higher elevations for grazing: affecting lives of mountain women
  - Climate induced disasters in the mid-mountain and Churia-Tarai regions, could force more people, mostly male, to migrate in search of work
- Agriculture
  - Increase in temperature by 3ºC: predicted increase in annual irrigation water demand by 11%, keeping other parameters of water demand constant
  - Continuingly decreasing Food Security
- Natural disaster
  - 1983-2005, 938 persons lost their lives every year due to different type of natural disasters
  - Economic loss: nearly Rs. 1208 million per year

3. Long term local impacts

- Biodiversity and Habitat Loss
  - Four species of mammals and seven species birds are believed to be extinct
  - Nepal's deforestation rate is 1.7 percent and the global average of 1.3 per cent
- Water
  - Water deficit, for four to five months outside the monsoon seasons
  - Decline in natural recharge of aquifers and over exploitation of groundwater
  - Within Narayani River Basin : Groundwater level dropped from 50 to 70 feet below G L boundary Nature
- Socio-economic conditions
  - Crop failure and loss of livestock
  - Changes in snow patterns: affect tourism industry
  - Expected changes in water availability: likely to lead to conflicts

H. Adaptation

Adaptation is the principal way to deal with the impacts of a changing climate. It involves taking practical actions to manage risks from climate impacts, protect communities and strengthen the resilience of the economy. Adaptation refers to dealing with the lowering risk posed by the impacts of climate change while Mitigation addresses the root causes of climate change by reducing greenhouse gas emissions. Adaptation is a shared responsibility. Governments at all levels, businesses and households each have complementary roles to play. Individuals and businesses will often be best placed to make adaptation decisions that reduce climate risks to their assets and livelihoods. (Australia, n.d.)

Humans have been adapting to their environments throughout history by developing practices, cultures and livelihoods suited to local conditions. However, climate change raises the possibility that existing societies will experience climatic shifts (in temperature, storm frequency, flooding and other factors) that previous experience has not prepared for them.

Adaptation measures may be planned in advance or put in place spontaneously in response to a local pressure. They include large-scale infrastructure changes – such as building defences to protect against sea-level rise or improving the quality of road surfaces to withstand hotter temperatures – as well behavioural shifts such as individuals using less water, farmers planting different crops and more households and businesses buying flood insurance.

According to the IPCC, climate change has been determined by three factors: exposure to hazards (reduced rainfall), sensitivity to those hazards (such as economy dominated by rain-fed agriculture) and the capacity to adapt to those hazards (for instance, whether farmers have the money or skills to grow more drought – resistant crops). Adaptation measures can help reduce vulnerability – for example by lowering sensitivity or building adaptive capacity – as well as allowing populations to benefit from opportunities of climatic changes, such as growing new crops in areas that were previously unsuitable. (the guardian, n.d.) (IPCC, IPCC, n.d.)

Table 6 Selected examples of planned adaptation by sector

Sector	Adaptation option/strategy	Underlying policy framework	Key constraints and opportunities to implementation (Normal font = cosntraints; italics= opportunities)
Energy	Strengthening of overhead transmission and distribution infrastructure; underground cabling for utilities; energy efficiency; use of renewable sources, reduced dependence on single sources of energy	National energy policies, regulations, and fiscal and financial incentives to encourage use of alternative sources; incorporating climate change in design standards	Access to viable alternatives; financial and technological barriers; acceptance of new technologies; *stimulation of new technologies; use of local resources*

Table 7 Selected examples of key sectoral mitigation technologies,policies and measures, constraints and opportunites

Sector	Key mitigation technologies and practices currently commercially available. Key mitigation technologies and practices projected to be commercialized before 2030 shown in italics.	Policies, measures and instruments shown to be environmentally effective	Key constraints or opportunities to implementation (Normal font = cosntraints; italics= opportunities)

Energy supply	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of carbon dioxide capture and storage (CCS) (e.g. storage of removed CO_2 from natural gas); CCS for gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and wave energy. Concentrating solar, and solar photovoltaics	Reduction of fossil fuel subsidies; taxes or carbon charges on fossil fuels	Resistance by vested interests may make them difficult to implement
		Feed-in tariffs for renewable energy technologies; renewable energy obligations; producer subsidies	*May be appropriate to create markets for low emissions technologies*

Examples of Adaptation practices:

There is a long record of practices to adapt to the impacts of weather as well as natural climate variability on seasonal to inter annual time-scales – particularly to the El Niño-Southern Oscillation (ENSO). These include proactive measures such as crop and livelihood diversification, seasonal climate forecasting, community-based disaster risk reduction, famine early warning systems, insurance, water storage, supplementary irrigation and so on. They also include reactive or ex-poste adaptations, for example, emergency response, disaster recovery, and migration. Recent reviews indicate that a 'wait and see' or reactive approach is often inefficient and could be particularly unsuccessful in addressing irreversible damages, such as species extinction or unrecoverable ecosystem damages, that may result from climate change. (IPCC, n.d.)

Table below provides an illustrative list of various types of adaptations that have been implemented by a range of actors including individuals, communities, governments and the private sector. Such measures involve a mix of institutional and behavioural responses, the use of technologies, and the design of climate resilient infrastructure. They are typically undertaken in response to multiple risks, and often as part of existing processes or programmes, such as livelihood enhancement, water resource management, and drought relief.

Table 8Examples of adaptation initiatives by region, undertaken relative to present climate risks, including conditions associated with climate change (IPCC, n.d.)

REGION Country Reference	Climate-related stress	Adaptation practices
AFRICA		
Egypt	Sea-level rise	Adoption of National Climate Change Action Plan integrating climate change concerns into national policies; adoption of Law 4/94

El Raey (2004)		requiring Environmental Impact Assessment (EIA) for project approval and regulating setback distances for coastal infrastructure; installation of hard structures in areas vulnerable to coastal erosion.
Sudan *Osman-Elasha et al. (2006)*	Drought	Expanded use of traditional rainwater harvesting and water conserving techniques; building of shelter-belts and wind-breaks to improve resilience of rangelands; monitoring of the number of grazing animals and cut trees; set-up of revolving credit funds.
Botswana ***FAO (2004***	Drought	National government programmes to re-create employment options after drought; capacity building of local authorities; assistance to small subsistence farmers to increase crop production.
ASIA AND OCEANIA		
Bangladesh ***OECD (2003a); Pouliotte (2006)***	Sea-level rise; salt-water intrusion	Consideration of climate change in the National Water Management Plan; building of flow regulators in coastal embankments; use of alternative crops and low-technology water filters.
Philippines ***Lasco et al. (2006)***	Drought; floods Sea-level rise; storm surges Drought; salt-water intrusion	Adjustment of silvicultural treatment schedules to suit climate variations; shift to drought-resistant crops; use of shallow tube wells; rotation method of irrigation during water shortage; construction of water impounding basins; construction of fire lines and controlled burning; adoption of soil and water conservation measures for upland farming. Capacity building for shoreline defense system design; introduction of participatory risk assessment; provision of grants to strengthen coastal resilience and rehabilitation of infrastructures; construction of cyclone-resistant housing units; retrofit of buildings to improved hazard standards; review of building codes; reforestation of mangroves. Rainwater harvesting; leakage reduction; hydroponic farming; bank loans allowing for purchase of rainwater storage tanks.
AMERICAS		
Canada ***(1) Ford and Smit (2004) (2) Mehdi (2006)***	Permafrost melt; change in ice cover Extreme temperatures	Changes in livelihood practices by the Inuit, including: change of hunt locations; diversification of hunted species; use of Global Positioning Systems (GPS) technology; encouragement of food sharing. Implementation of heat health alert plans in Toronto, which include measures such as: opening of designated cooling centres at public locations; information to the public through local media; distribution of bottled water through the Red Cross to vulnerable people; operation of a heat information line to answer heat-related questions; availability of an emergency medical service vehicle with specially trained staff and medical equipment.
United States	Sea-level rise	Land acquisition programmes taking account of climate change (e.g., New Jersey Coastal Blue Acres land acquisition programme to acquire

Easterling et al. (2004)		coastal lands damaged/prone to damages by storms or buffering other lands; the acquired lands are being used for recreation and conservation); establishment of a 'rolling easement' in Texas, an entitlement to public ownership of property that 'rolls' inland with the coastline as sea-level rises; other coastal policies that encourage coastal landowners to act in ways that anticipate sea-level rise.
EUROPE		
The Netherlands, ***Government of the Netherlands (1997 and 2005)***	Sea-level rise	Adoption of Flooding Defence Act and Coastal Defence Policy as precautionary approaches allowing for the incorporation of emerging trends in climate; building of a storm surge barrier taking a 50 cm sea-level rise into account; use of sand supplements added to coastal areas; improved management of water levels through dredging, widening of river banks, allowing rivers to expand into side channels and wetland areas; deployment of water storage and retention areas; conduct of regular (every 5 years) reviews of safety characteristics of all protecting infrastructure (dykes, etc.); preparation of risk assessments of flooding and coastal damage influencing spatial planning and engineering projects in the coastal zone, identifying areas for potential (land inward) reinforcement of dunes.
United Kingdom ***Defra (2006)***	Floods; sea-level rise	Coastal realignment under the Essex Wildlife Trust, converting over 84 ha of arable farmland into salt marsh and grassland to provide sustainable sea defences; maintenance and operation of the Thames Barrier through the Thames Estuary 2100 project that addresses flooding linked to the impacts of climate change; provision of guidance to policy makers, chief executives, and parliament on climate change and the insurance sector (developed by the Association of British Insurers).

Example of Nepal (Local context):

Adaptation measures are also being put in place in developing country contexts to respond to glacier retreat and associated risks, such as the expansion of glacial lakes, which pose serious risks to livelihoods and infrastructure. The Tsho Rolpa risk-reduction project in Nepal is an example of adaptation measures being implemented to address the creeping threat of glacial lake outburst flooding as a result of rising temperatures.

Tsho Rolpa Risk Reduction Project in Nepal as observed anticipatory adaptation

The Tsho Rolpa is a glacial lake located at an altitude of about 4,580 m in Nepal. Glacier retreat and ice melt as a result of warmer temperature increased the size of the Tsho Rolpa from 0.23 km2 in 1957/58 to 1.65 km2 in 1997. The 90-100 million m3 of water, which the lake contained by this time, were only held by a moraine dam – a hazard that called for urgent action to reduce the risk of a catastrophic glacial lake outburst flood.

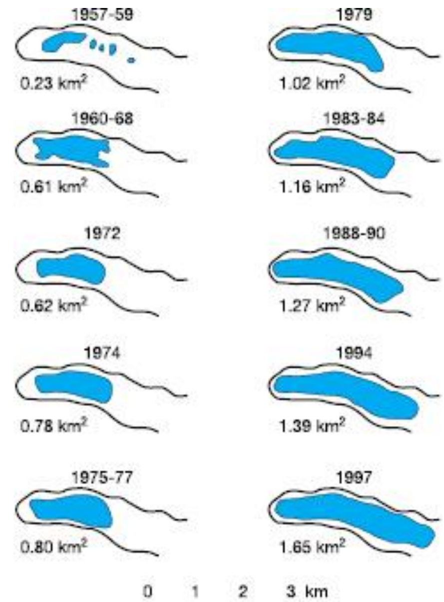


Figure 37: Tsho Rolpa Risk Reduction Project in Nepal as observed anticipatory adaptation (IPCC, n.d.)

If the dam were breached, one third or more of the water could flood downstream. Among other considerations, this posed a major risk to the Khimti hydropower plant, which was under construction downstream. These concerns spurred the Government of Nepal, with the support of international donors, to initiate a project in 1998 to lower the level of the lake through drainage. An expert group recommended that, to reduce the risk of a GLOF, the lake should be lowered three metres by cutting a channel in the moraine. A gate was constructed to allow for controlled release of water. Meanwhile, an early warning system was established in 19 villages downstream in case a Tsho Rolpa GLOF should occur despite these efforts. Local villagers were actively involved in the design of the system, and drills are carried out periodically. In 2002, the four-year construction project was completed at a cost of US$3.2 million. Clearly, reducing GLOF risks involves substantial costs and is time-consuming as complete prevention of a GLOF would require further drainage to lower the lake level.

The transition to a low-carbon economy requires changes to the global energy system that depend upon giving the right signals to innovators and financiers within an appropriate market structure. Government intervention will be required in, at least, the following respects: accelerating the creation of sustainable markets for low-carbon technologies; investing in RD&D where there are critical funding gaps; supporting the creation of the necessary infrastructure; and encouraging international collaboration.

Sustainable low-carbon markets must provide an enduring incentive to improve technologies. As a policy, carbon pricing (i.e. penalising higher emissions technologies) has yet to be pursued sufficiently rigorously to create long-term investor confidence: the price is often low and there is political uncertainty surrounding its future. More successful forms of intervention, so far, have included capital grants, tax breaks, production subsidies and performance standards, re-shaping investment decisions in CCS projects, electric vehicle fleets and solar PV value chains. Electricity markets are beginning to require more fundamental adjustments to accommodate emerging patterns of supply and demand. Well-designed government interventions can reduce technology costs, support more efficient supply chains and financing, and help technologies to become established. As their efforts become more apparent and a low-carbon transition takes hold, affordable capital is expected to flow more freely, allowing such policies to be withdrawn.

Government investments in RD&D can provide the leadership necessary to yield major returns in terms of jobs, investment and results. Financing for large-scale CCS projects is needed in the near term to generate the improvements that will allow lower costs to emerge from large-scale activity in the long term. In the case of EVs, the commercial race to develop the best battery has already begun. For variable renewables, attention may need to be directed more to the provision of system flexibility than simply to more efficient generation technologies.

To achieve a self-sustaining low-carbon transition will require parallel investments in the enabling infrastructure. Governments have a crucial role to play in ensuring that such projects go ahead in a timely manner, in many cases, by investing directly in them, but also by providing the conditions which attract multilateral financial commitments. CO2 storage capacity development, provision of EV charging stations and encouragement of additional transmission grid interconnections are just three examples where this may be the case. Alongside these physical considerations, technology collaboration between countries and across sectors can be highly productive. Though the comparative advantages of different countries and their comparative needs for particular energy technologies will differ in a lowcarbon transition, innovation can be stimulated by joint activity and sharing deployment experience. Initial deployment may not always be in countries with the highest potential (consider, for example, solar PV in Germany and Italy), but shared experience can help to reduce costs more broadly. Pooling such learning sometimes can be important in accelerating technology development and should be prioritized in appropriate international fora.

4. Mitigation measures

1. Sector wise mitigation measures:

- Industrial sector
- Residential and Commercial
- Transportation
- Agriculture
- Electricity Generation

5. Industrial sector

There is a diverse portfolio of options for mitigating greenhouse gas emissions from the industrial sector, including energy efficiency, fuel switching, combined heat and power, renewable energy sources, and the more efficient use and recycling of materials. The diverse opportunities for reducing emissions from the industrial sector can be broken down into three broad categories:

- **Sector-wide options**
  Some mitigation options can be used across many different industries, for example energy efficiency improvements for cross-cutting technologies, such as electric motor systems, can yield benefits across diverse sub-sectors. Other sector-wide mitigation options include the use of fuel switching, combined heat and power, renewable energy sources, more efficient

electricity use, more efficient use of materials and materials recycling, and carbon capture and storage.

- **Process-specific options**
  Certain mitigation opportunities come from improvements to specific processes and are not applicable across the entire sector. For energy-intensive industries, process improvements can reduce energy demand and, therefore, greenhouse gas emissions and energy costs. Other improvements can reduce emissions of non-CO2 gases with high global warming potentials. Case studies can help illuminate the effectiveness of these process-specific options. For example, Alcoa's aluminum smelters collectively reduced their emissions of perfluorocarbons (PFCs) from anode effects, which occur when a particular step in the smelting process is interrupted, by more than 1.1 million tons in 2008.

- **Operating procedures**
  A variety of mitigation opportunities can be achieved through improvements to standard operating procedures. These options can include making optimal use of currently available technologies, such as improving insulation and reducing air leaks in furnaces. A variety of public and private efforts have been developed to help reduce industrial greenhouse gas emissions, energy use, or energy intensity. Some of these programs include:

6. Residential and Commercial

Green buildings provide abundant opportunities for saving energy and mitigating CO2 emissions Building green can reduce CO2 emissions while improving the bottom line through energy and other savings. Examples of measures that can be taken to improve building performance include:

- Incorporating the most efficient heating, ventilation and air conditioning systems, along with operations and maintenance of such systems to assure optimum performance
- Using state of the art lighting and optimizing daylighting
- Using recycled content building and interior materials
- Reducing potable water usage
- Using renewable energy
- Implementing proper construction waste management
- Siting the building near public transportation
- Using locally produced building materials

Reducing emissions from the residential and commercial sectors can be done in a variety of ways and on a number of scales:

- **Addressing landfills**
  Landfill waste can be reduced (thereby lowering the volume of decomposing material that produces methane, a powerful greenhouse gas) or harnessed as an energy source. Methane-capture systems in landfills prevent greenhouse gases from being released into the atmosphere.

- **Reducing embodied energy in building materials**

Embodied energy refers to the energy used to extract, manufacture, transport, install, and dispose of building materials. Choosing low carbon materials—such as local materials, materials that sequester carbon, and products manufactured at efficient industrial facilities reduces emissions.

- **Improving building design and construction**
  Building designs and construction techniques can maximize the use of natural light and ventilation, which minimizes the need for artificial light and HVAC equipment. Using building shading techniques, installing windows to minimize or maximize solar intake (depending on the region), and properly insulating against unwanted air flow between indoor and outdoor spaces improve energy use. Many other options are available and "green" builders are continually creating innovative ways to maximize efficiency in building spaces.

- **Increasing end-use energy efficiency**
  Using efficient appliances can minimize energy consumption and concomitant GHG emissions from electricity and direct fossil fuel combustion.

- **Adopting new energy-use habits**
  Following conservation guidelines and making personal choices to reduce the use of appliances, artificial lighting, and HVAC equipment (for example, by shutting them off when they are not in use) will reduce energy use. Also, opting for smaller residential and commercial spaces can reduce the energy needed for building construction and operation.

7. Transportation

- Fuel-efficient vehicles use less gas to travel the same distance as their less efficient counterparts. When we burn less fuel, we generate fewer emissions. When emissions go down, the pace of global warming slows.
- Cleaner fuels produce fewer emissions when they're burned. Some fuels—such as those made from cellulosic biofuels—can reduce emissions by 80 percent compared to gasoline. And better regulations would help prevent the gasoline we do use from getting any dirtier.
- Electric cars and trucks use electricity as fuel, producing fewer emissions than their conventional counterparts. When the electricity comes from renewable sources, all-electric vehicles produce zero emissions to drive.
- These and other solutions are here today—but more can be done. Learn more about our plan to Half the Oil, or find out what you can do for clean vehicles.

8. Agriculture

Mitigation opportunities can be identified from each of the four types of interactions that agriculture has with the climate system. A wide range of options exist, but with different levels of technical feasibility, cost-effectiveness, and measurement certainty. A number of the mitigation options for the agricultural sector, including soil management practices, also bring a variety of co-benefits, such as improved water quality and reduced erosion. To date, a number of policies thought to have climate benefits have been pursued in order to achieve one or more of these co-benefits.

- **Reduce greenhouse gas emissions**

Reduce greenhouse gas emissions from energy use: Energy-related greenhouse gas emissions from the agricultural sector can be reduced in a number of ways, including the use of more fuel-efficient machinery and the installation of on-site renewable energy systems for electricity.

- *More efficient fertilizer use:* Increasing the efficiency of nitrogen use reduces the need for additional fertilizer inputs. This can be achieved by fertilizing during the most appropriate period for plant uptake, fertilizing below the soil surface, and balancing nitrogen fertilizers with other nutrients that can stimulate more efficient uptake. These measures can reduce N2O emissions.
- *Improved manure management:* When manure is held in an oxygen-poor (anaerobic) environment—such as a holding tank—for an extended period of time, bacteria decompose this material and release methane as a byproduct. Reducing the moisture content and the amount of storage time are two options for reducing methane emissions from manure.
- *Improved animal feed management:* Facilitating the digestive process for livestock—such as using easy-to-digest feed—can reduce methane emissions from enteric fermentation.
- *Improved rice cultivation practices:* When rice paddies are flooded, the oxygen-poor (anaerobic) environment allows certain bacteria to create methane through a process called methanogenesis. Periodically draining rice paddies can inhibit this process by aerating the soil.

- **Increase vegetation and soil carbon stocks**
  - *Land-use changes to increase soil carbon:* Reforestation and afforestation initiatives can increase the amount of biomass in a given area of land, thereby sequestering carbon in plant material.

  - *Land management practices that increase soil carbon:* A variety of land management practices can be implemented to increase soil carbon. These include the use of high-residue crops, such as sorghum, that produce a large amount of plant matter left in the field after harvest; the reduction or elimination of fallow periods between crops; the efficient use of manures, nitrogen fertilizers, and irrigation; and the use of low- or no-till practices. Importantly, local conditions will determine the best practices for a given location, and all of these practices do not increase carbon storage in all locations.

- **Substitute biomass feedstock and products for fossil fuels**
  The use of bio-based products as fuels and product substitutes has the potential to reduce fossil fuel combustion and associated greenhouse gas emissions. However, careful life-cycle analysis is necessary to ensure that the substitution yields a net reduction of greenhouse gas emissions.

- **Non-greenhouse gas related climate interactions**
  Less attention has been given to mitigation options that do not affect greenhouse gas emissions, but a 2009 study did suggest that crops could be bred or genetically engineered to be more reflective to help reduce warming by reflecting more solar energy from the land surface.

- **Uncertainty and Mitigation Potential**
  Key aspects of the agricultural sector's climate interactions involve complex biological processes. These processes continue to be studied by scientists to fill gaps in our understanding of how these

processes work and to reduce the uncertainty associated with current data on greenhouse gas fluxes from agricultural systems. Although the agricultural sector is sometimes identified as having a potentially large role in mitigating climate change, especially by increasing carbon storage in developing countries, further scientific advances will be necessary for the agricultural sector to achieve its full mitigation potential.

Estimates of agriculture's mitigation potential in the United States vary for different practices. For example, emissions of N2O could be reduced by 30 to 40 percent with improved fertilization practices. Methane (CH4) emissions could be reduced by 20 to 40 percent by improving livestock and methane management. Croplands could store up to 83 MMT of carbon per year, equivalent to about 1 percent of total U.S. greenhouse gas emissions, through widespread adoption of best management practices.

9. Electricity Generation

In general terms, greenhouse gas emission reductions from the electric power sector can be achieved through:

- Efficiency (i.e., eliminating waste),
- Conservation (i.e., reducing the amount of electricity generated),
- Switching fuel sources (i.e., from coal to lower-emitting natural gas), and
- Incorporating low- and zero-carbon electricity generation technologies (i.e., reducing the emissions associated with electricity generation), such as renewable energy, carbon capture and storage, and nuclear power.

2. Role of RET in GHG Mitigation Potential and Cost in Nepal

Intensive literature review on the GHG emission reduction from the RET, installation potential, cost of the technology, economic life and other parameters were done based on the existing national and international publications and literatures. Altogether 12 renewable energy related cleaner technology options were considered for the analysis of their contribution in GHG mitigation and investment requirement associated with it. The selected RET based on the available data for the estimating the GHG reduction potential in Nepal constitute, biogas, improved cooking stoves, solar PV home systems, solar thermal systems, solar PV pumping, wind electric generator.

The study shows that altogether 4.17 million tons of CO2e of the GHG emission can be mitigated by deploying seven major RET options consisting of biogas, improved water mill, stand-alone micro-hydro plants, mini-grid micro-hydro plants, solar PV home systems, mud-ICS and metal-ICS after 2012. This figure is within the range mentioned by other studies by Chaulagain and Laudari (2010), Dhakal and Raut (2010), Pokharel (2007) and Shrestha et al. (2013). The details on the parameters considered, assumptions used are mentioned in the Table 6.2. Shrestha et al. (2013) estimated the total GHG mitigation potential from thirteen different RET and energy efficient options for the year 2020 as 0.83 million tons CO2e. This figure is quite low mainly due to the limited number of RET options (solar PV home system, stand alone micro-hydro plants and improved cooking stoves) considered for estimating GHG mitigation potential. The study used data intensive bottom-up least cost optimization model (MARKAL) for the analysis. Pokharel (2007) estimated the GHG mitigation potential from RET as 1.42 million tons of CO2 in 2012. It compared the GHG emission due to the penetration of the selected RET technologies between 2000 and 2012. On the other hand, Chaulagain and Laudari (2010) estimated the GHG mitigation potential from RET as 4.98 million ton CO2e using accounting approach. Likewise Dhakal and Raut (2010) estimated GHG mitigation potentials from intervention of full potential of ICS, biogas and solar PV home system as 8.16 million ton CO2e.

In terms of shares of the RETs in GHG mitigation, biogas can contribute the most with GHG mitigating potential of 2 million ton of CO2e (48.1% of the total GHG mitigation potential from RET) with the installation of 722,774 number of biogas plants after 2012 (Figure 6.7). This is followed by the installation of 898,487 ICS with the GHG mitigation potential of 1.8 million ton of CO2e (share of 44.2%). The stand alone and mini-grid micro-hydro plants can contribute 170 thousands ton of CO2e (4.1% of the GHG mitigation potential) by installing 73.2 MW of their combined capacity. IWM and Solar PV home system can contribute 114 thousands ton of CO2e (share of 2.7%) and 114 thousands ton of CO2e (share of 0.9%) of the estimated GHG mitigation potential from selected RETs by installing 22.7 kW of IWM and 215,903 solar PV home system respectively.

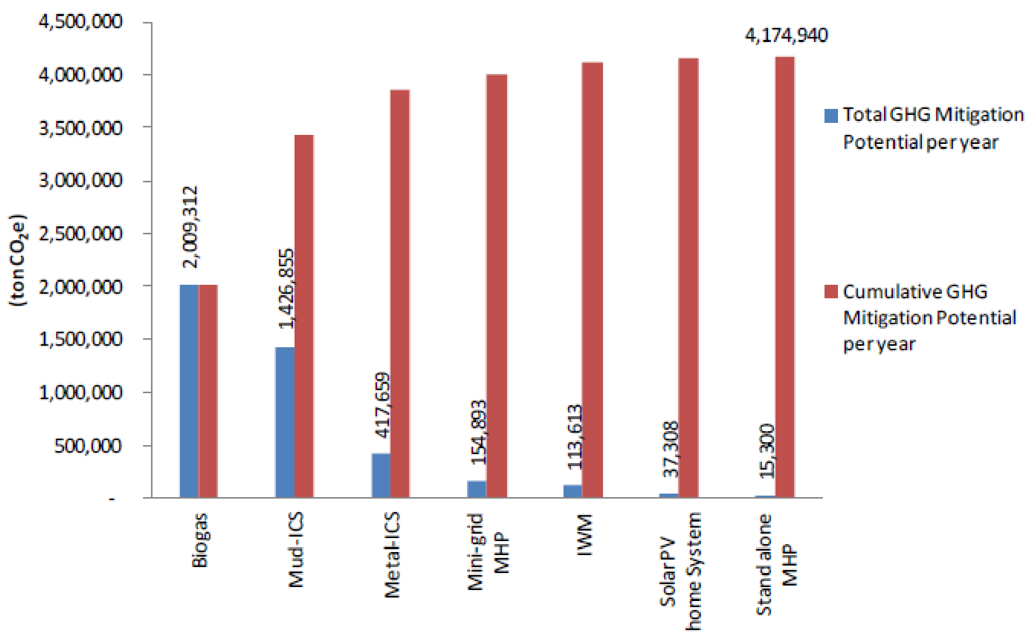


Figure 5: GHG Mitigation Potential of Renewable Energy Technologies in Nepal, ton CO_2e, Source: (CES, 2013)

5. Policy for energy sector

Trends in energy consumption generally follow the economic growth of the country. Keeping in view the significance of energy in national development the energy sector during the Eighth Five-year Plan (1992-1997), received high priority. The plan had sought implementation of the following strategies:

- To maximize the development of indigenous energy resources
- To promote fuel efficient stoves with a strategy to minimize fuel wood consumption
- To promote cost effective and environmentally sensitive energy conservation and demand management practices
- To devise appropriate mechanisms for financing hydropower projects through commercial sources, as well as encouraging other means of financing

- To formulate rational energy pricing so that it reflects the social costs without compromising overall national goals
- To enter into energy import/export agreement keeping in mind the national interest
- To give authority to the respective ministries to solve the environmental problems associated with energy supply and demand
- To examine the possibility of transferring ownership of government-owned energy sector utilities to the private sector. Further, the government for the first time also fixed 5 MW capacity target for Micro-Hydro (MH) development. During this plan period only 24 percent of the target was fulfilled.

In the Ninth Five-year Plan (1997-2002), the MH development target was fixed at 5.2 MW capacities and focused on a coordinated approach to rural energy development. The Tenth-Plan (2002-07) emphasizes on an integrated approach with focus towards poverty alleviation and sustainable development through decentralized mechanisms like the establishment of rural energy development fund at the village and district levels.

Energy switching has been emphasized in 9th and 10th Plan with several alternative energy sources to reduce the domestic use of wood and fossil fuels with more use of hydropower and bio-gas. Besides, Nepal has implemented policies to import Euro-1 standard vehicles to increase the efficiency of the transport sector and reduce pollution from this sector.

6. Conclusion

Energy is consumed in every activities we carry out in our daily lives. Every sectors consumed energy with residential sector topping the chart in the context of Nepal. if the trend is to be noticed, it is clear that life styles is changing with increasing dependency of fossil fuels in sectors especially in transportations sector which has various negative impact on climate and induces climate change. The climate change in turn hampers the living organisms. Hence, the source of energy use has to be redefined with inclination towards more renewable and clean sources so as to retain the environment of world so that it is appropriate for healty living.

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