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# Greenhouse gases in urban areas

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The majority of citizens live in urban areas that dominate the economy and energy use. People living in these areas can affect the balance of nature since the gradual increase in the earth's surface temperature is caused predominantly by human activity. Humans cause the emission of gases such as carbon dioxide through exhaust from cars and power plants. If this negative effect continues, climate change due to global warming is inevitable. While CO2 concentration was around 250-280 parts per million (ppm) in the late 1800s, according to the National Oceanic Atmospheric Administration, it reached 380 ppm in the 2000s and 400 ppm in 2015. If we do not act and if emissions continue to increase, the global mean temperature may increase by over 30C by 2030. In this study, GHG emissions for 2020 are predicted for some countries then arithmetic means and standard deviations for GHG emissions are calculated by Excel. Data on GHG emissions for Europe, Turkey and the U.S. are used for the periods 2004-2013, 1990-2010 and 2000-2011, respectively. Chemical processes to mitigate GHG in the atmosphere are explained. Oxidation and methanol synthesis are useful processes to decrease the amount of GHG. Therefore, energy consumption in urban areas is very important. Reducing energy consumption in cities is possible by increasing the density (increasing the number of people per square meter in the city), the use of public transport such as subways, buses, trams, and light rail, and the use of energy derived from waste.

**Keywords:** Urban; Global warming; Energy consumption; Air quality

## INTRODUCTION

Ecologically important types of urban biotopes are rivers, lakes, marshes, cliffs, sand dunes, forests, scrub, and valleys [1]. People living in urban areas have ecological impacts on the environment because of land used for housing, traffic and industrial areas [2]. Human activities like the burning of fossils fuels and deforestation intensify the greenhouse effect. Increasing concentrations of greenhouse gases cause global warming, ocean acidification, smog pollution, and ozone depletion. The air temperature in the world has increased by about 0.7-0.8$^0$C over the last 100 years. Precautionary measures should have been taken against this increase. Global warming can cause fish migration, increased melting of glacial ice and snow, desertification, rises in sea levels, changes in the amount of precipitation, stronger storms and extreme events.

### *Global warming and climate change*

Greenhouse gases absorb and emit radiation in the atmosphere. These gases are water vapor, carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and ozone and their contributions to the greenhouse effect are 36-72%, 9-26%, 4-9%, and 3-7%, respectively [3]. The greenhouse gas (GHG) effect increases the temperature of the earth because radiation from the planet's atmosphere warms the surface of planet. Greenhouse gases produced by human activity are known as anthropogenic greenhouse gases. Greenhouse gas concentrations have increased since the beginning of the Industrial Revolution [4]. GHGs are covered by the Kyoto Protocol. This international treaty was adopted in 1997 and entered into force in 2005. Turkey became a party to the United Nations Framework Convention on Climate Change Kyoto Protocol in 2009. High global warming potential (GWP) gases are mostly anthropogenic. Gases that have a greater impact on climate change are $CO_2$, $CH_4$, $N_2O$, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride ($SF_6$). $SF_6$ has a much longer lifetime and stronger radiative properties than $CO_2$. However, 72% of totally emitted greenhouse gas is $CO_2$, 18% is $CH_4$ and 9% is $N_2O$. The most important cause is $CO_2$. This emission is created by industrial, transportation and agricultural activities, producing energy, and burning fuels like oil, natural gas, diesel, petrol, and ethanol [5].

### *Climate change conferences*

The first conference on climate change, the United Nations Framework Convention on Climate Change, was held in 1992 when 195 countries and nearly 150 world leaders met in Paris for the United Nations Climate Change Conference (COP21) from 30 November to 12 December 2015. National

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leaders came to an agreement that will enable us to realize the transition towards a clean economy and stop dangerous climate change. By limiting emissions the aim of the Paris Agreement is to keep the temperature increase to below $2^0$C. Finance flows are planned for low GHG emissions and climate-resilient development. The Agreement will be open for signature from 22 April 2016 to 21 April 2017. The period for implementation or contribution is between 2021 and 2030.

Developing countries need financial aid to adapt to changes being wrought by climate change. They need to replace fossil fueled development with cleaner alternatives. The financial, technology and capacity-building support was agreed in Cancun in 2010. Industrialized countries committed to providing funds rising to $100 billion a year by 2020 for developing countries for both mitigation and adaptation actions [6]. Low carbon technologies that are energy efficient and renewable energy can play central roles in global efforts. Improving forest management also reduces emissions.

### *Climate change in turkey*

Different regions of Turkey can be affected differently by climate change although its impact is quite heterogeneous across the country. For example, the Southeastern Anatolia region and the Central Anatolia region are both arid areas under threat of desertification. The Aegean and Mediterranean regions do not have enough water resources so these areas will also be affected. The impacts of global warming on agriculture are changes in temperature, sea level, rainfall, heat waves, $CO_2$, ozone, pests, diseases, and the nutritional quality of foods. The extinction risk to animal and plant species, the migration of animals, adaptation and water resource problems can all be blamed on global warming [7].

Between 1990 and 2012, Turkey's gross domestic product and population increased by 230% and 30%, respectively. Turkey's energy demand increases by 6-7% per year. Turkey's total emissions in 2012 expressed in $CO_2$ equivalent were 440 million tons. The emission equivalent rates for these sectors are 70.2 percent in energy, 14.3 percent in industrial processes, 8.2 percent in waste and 7.3 percent in agriculture. Turkey's per capita GHG emission was 5.9 tons $CO_2$ equivalent for 2012. Including industrial emissions, Turkey's ratio for global emissions is 0.7 percent. The Republic of Turkey's intended nationally determined contribution (INDC) has been presented with decisions 1/CP.19 and 1/CP.20. Turkey plans to reduce GHG by up to 21 percent from the business as usual level by 2030. GHGs in the national inventory include $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$, and nitrous trifluoride (NF3). Turkey's INDC covers seven sectors: energy, industry, transport, building and urban transformation, agriculture, waste and forestry. Hydroelectric and solar powered electricity production will be increased. In addition to these power sources, nuclear power plants are planned. Electricity transmission and distribution losses will be reduced to 15%. The rehabilitation measures will take place within electric power plants. Energy efficiency in industry and the use of waste as an alternative fuel will be increased. Fuel saving and controlling the use of fertilizers are included in plans for agriculture areas. Materials can be recovered and recycled from waste and converting waste to energy with methane production will apply in landfills. Transport will be improved by increasing maritime and rail transport instead of road transport, the use of combined and sustainable transport, promotion of alternative fuels and clean vehicles and the scrapping of old vehicles. Constructing energy efficient buildings and the dissemination of Green Buildings, passive energy, and zero energy buildings are other plans for reducing energy consumption [8].

## EXPERIMENTAL

### *Energy circulation plan in urban areas*

Urban areas are the most crowded places in the world. Population growth and land use change in urban areas should be analyzed. Elemental needs of human beings such as infrastructure, shelter, energy, and water should be planned for urban regions. Cities have significant amounts of global energy demand and GHGs. If urban areas organize an energy circulation plan, a sustainable urban future is possible for livable places. Important targets can be reducing waste and fuel consumption and optimizing transportation. Some examples can be given for these items. Building more public rail transit facilities can reduce the number of cars and take their carbon footprints off the roads. With housing development, residents should be able to live in public housing with nearby jobs, schools and public transport. Undesirable and dangerous walkways prevent people from walking so pedestrian paths should be created to encourage walking [9]. When people walk or bike they do not add to air pollution and will be generally healthier. When people need to use a vehicle they should be able to find a convenient bus stop [10].

Buyers of hybrid/electric cars might pay lower purchase tax. Increasing the number of people per square meter in the city is possible with tall buildings. Subways, buses, trams, light rail and other forms of public transport reduce travel by private vehicle. This gives people energy efficient choices. Gray water from showers, bathtubs, laundry and bathroom sinks in the home can be treated and reused.

In Diyarbakir, green spaces are proposed to represent at least 7-8m$^2$ per person [11]. The number of roadside trees and green spaces can be improved. Trees can be planted in children's parks and school playgrounds, on roofs and walls and around apartment complexes [12].

Energy efficient design, building insulation and user behavior can reduce the amount of energy used for heating, cooling, lighting, ventilation, and cooking. These lower energy consumption so air pollution is reduced [13, 14].

*Greenhouse gas chemistry*

Many trace gases such as $CH_4$, CO, and HCFCs are removed from the atmosphere by oxidation. OH is the initiator of radical-chain oxidation. CO and methane are sinks for OH [15].

All GHGs but $CO_2$ and $H_2O$ can be removed by chemical processes. While GHG containing H atoms can be removed by reaction with hydroxyl radicals (OH) in the troposphere, $N_2O$, PFCs, SF6, CFCs and halons can be destroyed by solar ultraviolet radiation (UV) at short wavelengths [16].

Capture, disposal or chemical recycling technologies can be used to mitigate GHG. After recycling in a chemical process, $CO_2$ and methane can be formed as useful products such as methanol or dimethyl ether. Methanol is a liquid material so it is easily stored and transported. Methanol is an important industrial chemical and potential fuel. Conventional vehicles can use methanol in the same way as gasoline or diesel to power an internal combustion engine. Methanol has an energy density of 17.6kJ/cm, which is about twice that of hydrogen. Methanol synthesis is a method of converting hydrogen to methanol with $CO_2$ in a thermal reactor at about 220$^0$C under moderate pressure (20-50 bars) [17].

The synthesis of methanol and dimethyl carbonate leading to the utilization of $CO_2$ can be used in industry. Dry reforming is the most recognized method because it uses $CO_2$ [18, 19].

Greenhouse gas emission estimation for Europe

Linear regression is an approach for modeling the relationship between a scalar dependent variable y and one or more independent variables. GHG emissions for 29 countries between 2004 and 2013 are shown in Fig. 1 [20]. Data on GHG emissions for Europe are taken from the European Environment Agency. This study investigated GHG emissions. Statistics on GHG emissions between 2004 and 2013 are applied to provide estimates for 29 countries (Table 1).

Linear regression estimation for 29 countries was applied. Arithmetic means, standard deviations, regression formulas, coefficients and predictions for GHG emissions are calculated by Excel (Table 1). Predictions of GHG emissions in 2020 range from three million tonnes to 826 million tonnes while the global GHG emission prediction for 2020 is 3505.56 million tonnes.

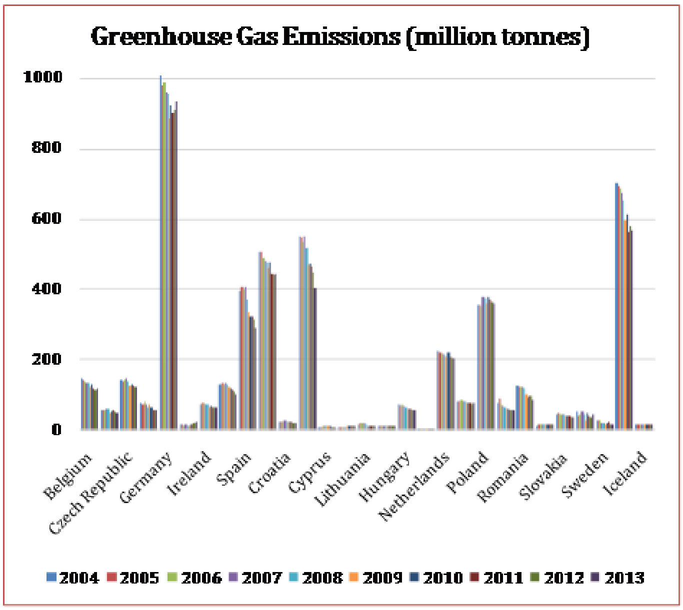


**Fig. 1.** GHG emissions for 29 countries between 2004 and 2013 [20].

**Table 1.** Linear regression estimation for 2020.

| Country | Arithmetic Mean (million tonnes) | Standard devitation | Regression formula | Prediction of GHG emission in 2020 (million tonnes) |
|---|---|---|---|---|
| Lithuania | 14 | 3.90 | y = 0.6606x + 5,3151 | 16.55 |
| Luxembourg | 12 | 0.65 | y = -0.2048x + 13,001 | 9.52 |
| Hungary | 64 | 6.39 | y = -2.1747x + 76,26 | 39.29 |
| Malta | 3 | 0.10 | y = 0.0068x + 2,9584 | 3.07 |
| Netherlands | 213 | 7.39 | y = -2.2063x + 224,81 | 187.30 |
| Austria | 79 | 3.45 | y = -1.0345x + 84,551 | 66.96 |
| Poland | 365 | 10.69 | y = 1.0723x + 358,67 | 376.90 |
| Portugal | 66 | 10.34 | y = -3.2483x + 83,722 | 28.50 |
| Romania | 109 | 14.52 | y = -4.7352x + 134,81 | 54.31 |
| Slovenia | 14 | 0.99 | y = 0.0699x + 13,904 | 15.09 |
| Slovakia | 41 | 3.31 | y = -1.0111x + 46,999 | 29.81 |
| Finland | 43 | 7.10 | y = -0.9827x + 48,207 | 31.50 |
| Sweden | 21 | 5.40 | y = -1.5287x + 29,14 | 3.15 |
| United Kingdom | 634 | 52.78 | y = -17.622x + 730,86 | 431.29 |
| Iceland | 16 | 0.46 | y = 0.0707x + 16,078 | 17.28 |

**Table 2.** Turkey's sectoral regression estimations.

| Country | Arithmetic Mean (million tonnes) | Standard devitation | Regression formula | Prediction of GHG emission in 2020 (million tonnes) |
|---|---|---|---|---|
| Lithuania | 14 | 3.90 | y = 0.6606x + 5,3151 | 16.55 |
| Luxembourg | 12 | 0.65 | y = -0.2048x + 13,001 | 9.52 |
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| Iceland | 16 | 0.46 | y = 0.0707x + 16,078 | 17.28 |

**Table 3.** U.S.'s sectoral regression estimations.

| Sector | Arithmetic Mean (million tonnes) | Standard devitation | Regression formula | Prediction of GHG emission in 2020 (million tonnes) |
|---|---|---|---|---|
| Energy | 4166.00 | 132.81 | y = -24.416x + 53156 | 3835.68 |
| Transportation | 1835.75 | 65.56 | y = -10.383x + 22669 | 1695.34 |
| Industrial processes | 332.75 | 17.38 | y = -3.3182x + 6990.7 | 287.94 |
| Agriculture | 450.25 | 12.30 | y = 2.7857x - 5139.3 | 487.81 |
| Forestry and land use | 28.25 | 6.38 | y = -0.0325x + 93.396 | 27.75 |
| Waste | 133.00 | 3.67 | y = -0.7143x + 1566.2 | 123.31 |
| Forestry and land use (Sinks) | -868.50 | 115.44 | y = -16.286x + 31809 | -1088.72 |
| Total net emissions | 6077.50 | 232.44 | y = -52.364x + 111145 | 5369.72 |

*Greenhouse gas emission estimations for sectors in Turkey and the U.S.*

Sectoral GHG emissions of Turkey and U.S. are estimated by linear regression for 2020. Sectoral GHG emission data for Turkey and the U.S. are taken respectively from T.C. Turkish Statistical Institute and Inventory of U.S. Greenhouse Gas Emissions and Sinks in Figs. 2, 3. In this study, arithmetic means, standard deviations, regression formulas, coefficients and predictions for GHG emissions are calculated by Excel (Tables 2, 3).

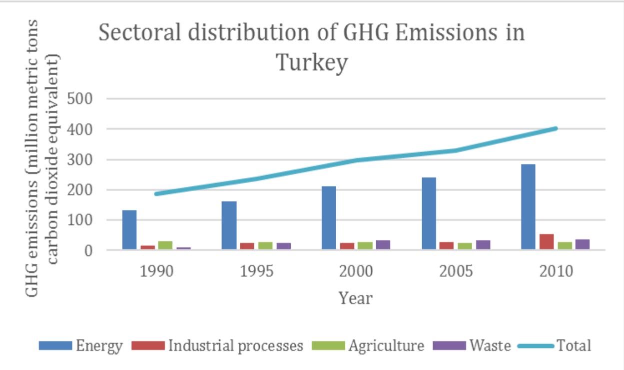


**Fig. 2.** Sectoral distribution of GHG emissions in Turkey [21].

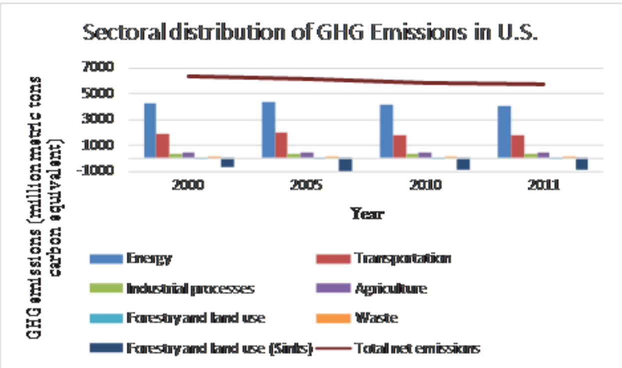


**Fig. 3.** Sectoral distribution of GHG emissions in the U.S. [22].

Sectoral GHG predictions in Turkey and in the U.S. are shown respectively in Tables 2 and 3. Linear regression estimations for Turkey and the U.S. are respectively 499.88 million tonnes and 5369.72 million tonnes for 2020.

## RESULTS AND DISCUSSION

High global warming potential (GWP) gases and their chemical properties are explained in this study. GHG emissions are increasing because of population growth and the increase in living standards. Linear regression estimations for Turkey and the U.S. are respectively 500 million tonnes and 5370 million tonnes for 2020. Prediction of GHG emissions in 2020 range from three million tonnes to 826 million tonnes for Europe. Global GHG emission prediction for 2020 is 3506 million tonnes. Precautionary measures that should be taken against global temperature increase are explained. Chemical processes like oxidation and methanol synthesis reduce the amount of GHG in the atmosphere. Energy circulation items against further temperature rise can be the planting of trees in school gardens and on roofs and walls and around public institutions and religious buildings, the expansion and reformation of green areas in children's parks, and improving green areas around buildings and on roadsides.

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