Sustainability Innovation

How Can We Help Reduce Greenhouse Gases Emissions In Shanghai Schools?

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Summary

Climate change, global warming and extreme weather becomes the hottest topic in environmental science. Extreme weather has caused the significant economic, social and environmental losses every year. The main reason for climate change is the excessive greenhouse gases emission to the atmosphere. How to help reduce greenhouse gases emission in Shanghai school?

In history, the temperature of the earth has changed many times. In the last 650,000 years, the glacier has gone through seven cycles of advance and retreat. The end of the last ice age was 11,700 years ago. It marked the emergence of the modern climate and the beginning of human civilization. However, most of these temperature changes are caused by subtle changes in the earth's orbit. These small changes have changed the amount of solar energy our planet receives. Now, the environment around us is getting warmer and warmer. Since the middle of the twentieth century, more than 95% of the global warming is caused by human activities. Such global warming is unusual because it is developing at an unprecedented speed for decades to thousands of years. The United States (US) Texas winter storm in spring 2021 killed lots of people. There’ s power outage, forest fires, food and water shortage because of the extreme weather in the US Texas. The unusual freezing cold in the US Texas is the consequences of climate change. We need to take effective action to alleviate the climate change problem. (CNN, 2021)

We conducted questionnaire survey and interviews with the primary principal and Director of Operations of our school. We understand the significance of climate change from our research. We have listened to the opinions from students, teachers, principals, employees, and parents in our school. We proposed the theoretical frameworks on climate change and the potential solutions. We did the data research and field observations on campus. We tried to give feasible solutions to the Shanghai school campus.
Emphasis will be put on environmental education on climate change in our campus. Health and education sector is selected because the Project Based Learning (PBL) is mainly for education purpose. Different comments from the students, teachers, principal, parents, staff and campus are integrated in this report.

Literature review would be carried out to provide precise explanation on the definitions and their relationships on climate, data, the school and effective action. It forms the theoretical framework on climate change and the potential solutions.

The criteria on climate change is are the global warming potential (GWP), carbon dioxide equivalent (CO_2e), emission factors.

We generated the climate change solutions on developing the green campus. Besides, we evaluated the climate change solutions by matching our solutions to the Chinese Government' s action on climate change. They should match the goals of carbon neutrality and peak carbon dioxide emissions.

The action plan would be the daily green habits in the school campus to promote the environmental awareness and help reduce greenhouse gases emissions.

The prototype and test are the environmental education and publicity in the Shanghai schools. Various research methods will be used to collect first-hand information. Questionnaire surveys on the students will be conducted. Individual interviews are arranged with the principal, director of operations, teacher, parent and student. Site visit are also conducted in the campus to promote the green habits to help solve the climate change problems. The survey respondents and interviewees are all the stakeholders of our school. The comments from the people outside the school are not involved.

We believe that the climate change problems can be finally solved if all the people around the Earth help reduce the greenhouse gases emission by adopting sustainable lifestyle with green habits every day.

Choose the Topic

Identify the Challenges

The challenges are the climate change, global warming and extreme weather. Many countries join together to sign the Paris Agreement and have the Climate Ambition Summit to combat climate change.

Climate change, global warming and extreme weather
Climate change refers to the global warming and extreme weather created by the increased concentration of greenhouse gases in the atmosphere. Climate change leads to ecosystem damage, air pollution and natural resources depletion. (Youmatter, 2021)

Global warming means the average increase in global temperature that made the Earth warmer than it should have been. Global warming also causes higher risks of spreading diseases, melting of glacier ices, animal migrations, etc.

Extreme weather means that the weather in a specific area changes extremely and have total damage to its full extend that could happen for a specific kind of weather. They include forest fires, drought, hurricanes, tornadoes, freezing weather, etc. Extreme weather is unexpected, unusual, severe and unseasonal weather. The weather is at the extremes of the historical distribution. The extreme events are based on a location’ s recorded weather history and defined as lying in the most unusual 10%. Extreme weather has significant impacts on human society, economy loss and damage to natural ecosystem. (Wikipedia, 2021)

Greenhouse gases include many different types of chemicals. They include carbon dioxide, methane, nitrous oxide, water vapor, HFCs, CFCs, HCFCs, PFCs, SF6, etc. They cause the Earth to become warmer because it traps the heat energy from sunlight in the atmosphere. (NASA, 2021)

Greenhouse gases cause climate change by trapping heat. They also contribute to respiratory disease from smog and air pollution. Extreme weather, food supply disruptions, and increased wildfires are other effects of climate change caused by greenhouse gases. (Conserve Energy Future, 2021)

The driving question
The driving question is "How can we help reduce greenhouse gases emission in Shanghai schools?” “We” means the shanghai schools. The stakeholders include the principal, teachers, students, parents and relevant staff. “Greenhouse gases

emissions" means the gases that lead to climate change. Climate change includes both global warming and extreme weather. Climate change is a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates. Primary data include the questionnaire survey results, interview comments and site visits. Secondary data include the researched newspaper, videos, pictures, statistics, journal articles, etc. The effective action means the solutions to climate change in the Health and Education sector and the green habits.

Causes of climate change

The main causes of climate change are the drastically increased human use of fossil fuels. These non-renewable energies include coal, petroleum and gas. They are used to generate electricity in power plants, as fuel in car engine for transportation and to provide energy in the manufacturing industry. Deforestation is also one of the causes of climate change, because living trees absorb and store carbon dioxide.

The increase in the emission of greenhouse gases results in the enhanced greenhouse effect. Both living animals and human beings are responsible for all this. Human built factories to make various kinds of consumer products. In the manufacturing process, huge amount of carbon dioxide gases is released to the atmosphere. The people use cars, machines and devices that need the power from fossil fuels. So, greenhouse gases are continuously emitted from the human activities. (WWF, 2021)

The burning fossil fuels in transportation caused the more frequent foggy weather. Besides, the amount of fossil fuel becomes less. In the meat and dairy industry, the cows fart. The cattle generate lots of methane gases to the atmosphere in farting. Methane has a higher global warming potential than carbon dioxide. Other causes of climate change include rapid industrialization, energy use, agricultural practices, consumer practices, resource extraction and pollution. (National Geographic, 2021)

Effect on climate change

Global climate change has a significant impact on the environment. Glaciers are shrinking. The ice in the frozen rivers and lakes melts earlier in the arctic region. The range of flora and fauna changes and trees bloom earlier. Scientists have predicted that global climate change will have lots of adverse effects. The loss of ocean ice accelerates the sea-level rise. So, there will be longer and more intense heat waves if global warming continues to increase. There will be much more disasters to happen in the future. There are not simply limited to the extreme weathers like earthquakes, droughts, tsunamis, floods, etc. (VOA, 2021)

The climate change directly leads to both global warming and extreme weather. Global warming means the average temperature around the world will continue to increase by 2℃. At the same time, extreme weather will lead to the occasional

serious freezing weather caused by extreme weather. The extreme weather causes some regions to become really hot (about 45℃ or higher) or really cold (about -20℃ or lower). For example, part of the United States (e.g., Texas) is now suffering really cold weathers in the March 2021. They have insufficient food supply and power outage. The big snow and strong wind in very cold weather have broken the electricity transmission system. The natural gas pipes are frozen so that the fuel cannot be transferred to the power plants properly. (Skynews, 2021)

The global warming is becoming more serious from 2000 onwards. If people around the world continue to damage the environment, we will suffer from the climate change. The social and economic impact of climate change include the higher cost of adapting coastal areas to rising sea levels, loss of the capacity to work due to heat and more wars to gain access to limited resources. Fresh water will be in short supply in some areas. There are relocation of whole towns and shrinking productivity of harvests. Prices of basic foodstuffs and consumer goods will rise. Extreme meteorological phenomena will cause widespread poverty. Diseases will spread due to higher temperature. (Peachy essay, 2021)

Sustainable Development (SD)

Sustainable development means that the economic, social and environmental development is balanced. The fulfillment of human needs is balanced with the protection of natural resources. These needs can be met not only in the present, but in the indefinite future. The consequence of climate change includes the poor air quality and resources depletion in the future. So, the global ecosystem will be seriously damaged. Climate change is a topic that raises the environmental awareness of the scientists, adults and young people. The young girl Greta Thunberg made a speech in the United Nations to improve the environmental awareness to climate change. She also explained the human activities that lead to climate change and provided solution to help reduce greenhouse gases. Our point of view is similar to her opinion. (UNDP, 2021)

Paris Agreement

The Paris Agreement is a legally binding international treaty on climate change. Many countries signed this convention at the 21st Conference of the Parties held in Paris on December 12, 2015. It entered into force on November 4, 2016. Its goal is to limit global warming to less than 2 degree Celsius and, if possible, to 1.5 degree Celsius. It helps many countries enter a common cause, making them work together to deal with climate change and adapt to its impact. Its formulation cycle is 5 years, and many countries have taken effective climate change actions. (UNFCCC, 2021)

Climate Ambition Summit 2021

Convened by the United Nations, United Kingdom, and France, in partnership with Chile and Italy, the world’ s most ambitious climate leaders meet at the 5th

Anniversary of the Paris Agreement in the build-up to COP26 in Glasgow.

At the Climate Ambition Summit, they will announce new, more ambitious nationally determined contributions and long-term strategies to net zero, new climate finance pledges and ambitious adaptation plans. The summit will be live-streamed and on-demand video content will be available.

The PRC President Xi Jinping said in the Climate Ambition Summit 2021, "Earth is our only and shared home. Let us build on past achievements, work together to make steady progress in implementing the Paris Agreement, and launch a new journey for global climate actions."

Mission on climate change of our school
Our school pursues and promotes "Academic Rigor", "21st Century Skills" and "A Living Environment" to empower students who are guardians of the planet and ambassadors of the local and global community by leading with their hearts, achieving with their minds and growing in knowledge and skills. (HQIS, 2021) The 13th sustainable development goal is the Climate Action. The actions on climate include "learn about climate solutions", "call for more renewable energy in your country", "eat more plants and cut down on meat, walk and cycle rather than drive" and "demand leaders take bold climate action today". (United Nations, 2021)

Identify a Root Cause

The root cause of climate change is excessive greenhouse gases in the atmosphere.

Climate and weather
Climate describes the average conditions of the atmosphere in a large region for a long period of time (over 10 years or more). For example, the average water temperature rises in the Great Barrier Reef in Australia over 10 years. (National Geographic, 2021)

Weather describes the specific conditions of the atmosphere is a small area at a specific time. For instance, the temperature and humidity (26oC and 74%) in Shanghai at 9am on 7th September 2021. (National Geographic, 2021)
Both climate and weather explain the temperature, precipitation, humidity, atmospheric pressure, solar radiation, wind, extreme weather, etc.

Greenhouse effect
The greenhouse effect is the result that heat is closely trapped on earth’ s surface and atmosphere. The greenhouse gases mainly include water vapor, carbon dioxide, methane, and nitrous oxide. The greenhouse effect occurs naturally to keep the earth in the normal range of temperature for humans, animals and plants to survive. However, the amount of greenhouse gases continues to increase in the atmosphere. The enhanced greenhouse effect makes the Earth’ s temperature rise quickly and it makes our living planet more dangerous. (NASA, 2021)

Natural greenhouse effect
Natural greenhouse effects refer to the natural process of warming up the earth’ s atmosphere. This happens when the sun’ s energy reaches earth and mostly absorbed by greenhouse gases. Natural greenhouse gases include water vapor, carbon dioxide and ozone. The Earth’ s surface and atmosphere absorb the heat energy from the sunlight. (Australian Government, 2021)

Enhanced greenhouse effect
Enhance greenhouse effect refers to the problem of excessive greenhouse effect created by human activities. These actions include continuous global usage and burning of fossil fuels, including coal, oil, and natural gas. The urban development removes the natural rainforests and trees. The sunlight directly shines on the ground and it makes the Earth even hotter. (Encyclopedia, 2021)

Definition of greenhouse gases

Greenhouse gases have the function of absorbing infrared radiation emitted from the surface of the earth. Then, they reflect the infrared radiation to the Earth’ s surface, which contributes to the greenhouse effect. The most important and abundant greenhouse gases are carbon dioxide, methane, and water vapor. Although greenhouse gases account for only a small part of the earth’ s atmosphere, they have an extraordinary effect on the earth’ s energy budget. In past century, the concentration of these greenhouse gases has changed greatly and they have made great changes to the global climate. (Britannica, 2021), Generally speaking, the concentration of greenhouse gases is particularly high during warm periods, and the concentration of greenhouse gases is particularly low during cold periods.

Types and sources of greenhouse gases

Carbon dioxide (CO2)

There are natural and man-made carbon dioxide emission sources in the world. Natural sources of carbon dioxide emissions include decomposition, ocean release, and cellular respiration. The human sources of carbon dioxide emissions are cement production, deforestation and the burning of fossil fuels. The common fossil fuels include coal, petroleum and natural gas. Since the Industrial Revolution, the concentration of carbon dioxide in the atmosphere has been rising so much that the current concentration of carbon dioxide has reached a dangerous level. The abnormally high concentration of carbon dioxide has disrupted the Earth's natural balance. The original carbon dioxide levels are balanced and safe. In the ancient times, the amount of carbon dioxide released from the animal and plants are approximately equal to the amount of carbon dioxide absorbed by the ecosystem. Since the human carbon dioxide emissions have added extra carbon dioxide gases to the atmosphere, they disrupt the natural balance in the global ecosystem. (CHE, 2021)

Methane (CH4)

Methane (CH4) is a colorless and odorless gas. It is the organic hydrocarbon, which is usually used as fuel. It is the second largest greenhouse gases which contribute to the enhanced greenhouse effect. It comes from fossil fuels, wetlands, and termites. It has led to many explosions, the greenhouse effect, burns, suffocation, diseases, and climate change. According to the National Aeronautics and Space Administration (NASA), methane contributed to about 23% of climate change in the 20th century. The release of methane into the atmosphere before combustion is harmful to the environment. Compared with other greenhouse gases, methane has a relatively short life span in the atmosphere. But comparing it with other gases, it can absorb heat better. (Conserve Energy Future, 2021)

Nitrous oxide (N2O)

Nitrous oxide is 300 times more effective than carbon dioxide in absorbing heat. It can also deplete the ozone layer. Its short lifespan contributes significantly to global warming. The main source of nitrous oxide comes from agriculture, especially the fertilized soil and animal manure. Nitrous oxide is mainly produced in the food production process. (Inside climate news, 2021)

Water vapor (H2O)
Water vapor is the most abundant greenhouse gas. Human activities have little direct effects on the water vapor content in the atmosphere. The water vapor generated during the evaporation of agricultural irrigation and the burning of fossil fuels accounts for less than 1% of the water vapor content in the atmosphere. The indirect human influence on water vapor increases the amount of water vapor in the atmosphere. A warmer climate will increase the amount of water vapor in the atmosphere. More water now exists in the form of gas rather than liquid. The increase in water vapor will have a great impact on humidity, cloud formation and precipitation. However, water has a positive and negative impact on the climate. Therefore, it is difficult for us to judge the net impact of water vapor changes on the global climate. (NCCO, 2021)

Hydrochlorofluorocarbons (HFCs)
There are three types of greenhouse gases, including HFCs, CFCs and HCFCs. HFCs stand for hydrofluorocarbons, which are mainly used in air conditioning and as refrigerants. They are man-made organic compounds that contain hydrogen and fluorine (organofluorides).

CFCs stand for chlorofluorocarbons. They are organic compound that contains carbon, chlorine and fluorine. CFCs are volatile derivatives of methane and ethane.

HCFCs stand for hydrochlorofluorocarbons. They are organic compound that contains hydrogen, chlorine, fluorine. These three kinds of greenhouse gases all act to warm the planet. (Askinglot, 2021)

Perfluorocarbons (PFCs)
PFCs (perfluorocarbons) is a group of chemical substances closely related to PFAS (Per- and polyfluoroalkyl substances). PFCs and PFAS have similar characteristics. They all contain fluorine and carbon atoms and can exist in the environment for a long time. The difference between PFCs and PFAS is that PFCs molecules only contain carbon and fluorine atoms. PFCs are used and discharged in different industries. PFCs are powerful greenhouse gases that were introduced as alternatives to ozone depleting substances. PFCs replace CFCs (chlorofluorocarbons) in manufacturing semiconductors. PFCs are non-toxic and will not directly affect people's health. They are one of the longest-lasting greenhouse gases produced by human activities. PFCs are also used as solvents in the electronics industry, and as

refrigerants of some specialized refrigeration systems. (EPA, 2021)

Sulfur Hexafluoride (SF6)

SF6 is a colorless, odorless, non-toxic and non-flammable compound. SF6 is a gas whose molecules consist of one sulfur atom and six fluorine atoms. It has extremely high chemical stability. It is obtained through a series of chemical reactions between sulfur and fluorinated gas produced by the electrolysis of anhydrous hydrofluoric acid. It has a high latent heat of vaporization and a very low sublimation temperature. Because of its high chemical stability and excellent electrical properties, it is often used as an insulating material for electrical equipment. It is also used in electrical circuit interrupters, electric piping and a gaseous insulator. (AGC Chemicals, 2021)

Generate Solutions

Even though the situation of the climate change is still a huge concern, we can still help solve it by various kinds of solution. The direction to solve climate change is to use renewable energy instead of fossil fuels. Burning fossil fuels releases too much carbon dioxide to the atmosphere, which trap the heat energy. By using renewable energy, hopefully we can reduce carbon dioxide and slow down the process of increase average global temperature in the future. (Scientific American, 2021)

Another direction to solve climate change problem is to eliminate the combustion of coal, oil, and natural gas. This is the most difficult challenge for human societies at present because the residents of many developed countries rely on the consumer products made from petroleum. For example, plastic products, clothing, transportation, etc. They need the petroleum products at work, dining, work, entertainment and even sleeping. (Linkedin, 2021)

The health and education sector and 10 chosen solutions to climate change
There are numerous solutions to climate change. The sectors include electricity, food and agriculture, industry, transportation, buildings, land sinks, coastal and ocean sinks, engineered sinks, health and education.

We focus on the health and education sector and have chosen 10 potential solutions to climate change. They include dynamic glass, green and cool roofs, reduced food waste, LED lighting, building automated systems, micro wind turbine, insulation, smart thermostat, recycling and plant-rich diets.

Dynamic glass
Dynamic glass can reduce the energy load of buildings for cooling, heating, and lighting by responding to sunlight and weather. Installing the effective windows can reduce greenhouse gases emissions. Disposable glass windows have long become a standard configuration in the world nowadays. This kind of glass is gorgeous. It can allow sunlight to enter the building interior environment without affecting the weather. It can also keep the indoor temperature warm to save energy. It improves heating and cooling efficiency. It can automatically change from transparent to opaque based on the temperature outside and vice versa. One of the disadvantages of dynamic glass is the high financial cost. We expect the price of dynamic glass will drop in the next few decades when the environmental technology improves.

Green and cool roofs

The green roofs use soil and vegetation as the biological insulation materials. The cool roof reflects the sunlight and provides heat insulation. It reduces the building energy used for heating or cooling. The green and cool roof can withstand the temperature 90 oC higher than the surrounding air. The green roof is the real habitat at the top of the building. They are covered with plump and self-sufficient ground cover. It can be used to minimize the building temperature fluctuation. It will be cool in summer and warm in winter. When the energy used for heating system and air conditioners are reduced, the greenhouse gases emissions will drop. The expenses on electricity fee will also be lower. When the sunlight shines on the traditional dark roof, only 5% of the energy is reflected to the atmosphere. The heat energy makes the building and surrounding air warm. When green and cool roofs are used, it can reflect up to 80% of the solar energy back to the sky. A cool roof can reduce the heat absorbed by the building. So, the urban heat island effect of the city can be minimized.

Reduce food waste

We should try our best to reduce food waste. The food waste will be sent to the recycling for composting, animal feed production and anaerobic digestion for electricity generation. The remaining food waste will be sent to landfill. The food waste will be decomposed by bacteria. The greenhouse gas methane will be generated. The food waste will also generate sewage, which pollutes the river and lakes. Therefore, people need to reduce food waste to reduce methane emission.

LED lighting

The LED light bulb refers to the light-emitting diodes. LED lamps are significantly more energy efficient than the incandescent lights and most fluorescent lamps. The energy efficiency of the LED lights can be 200 lumens per watt (Lm/W). The commercial LED lamps have a much longer lifespan than incandescent lamps. There are many advantages of LED lighting. LED lights can help reduce electricity bills and have a long life. It is good for children’ s eyesight because ultraviolet rays are not coming out. These advantages can benefit the natural environment. LED lights can use electricity from renewable sources, including solar power, wind power and geothermal power.

Building automation system

Building automation systems is a solution created for the purpose of controlling heat, cooling process and lightning. Most buildings have their central computer system to control the air conditioning, water heating, fire alarms and elevator. These computer systems are usually controlled manually. However, if we change the central computer systems to automated system, the electricity consumption can be reduced by 10% to 20%. Therefore, the greenhouse gases emissions can be reduced.

Micro wind turbine

Micro wind turbines are used to generate clean energy in diverse locations from urban to rural areas. The micro wind turbines are used in small places to capture and transfer the kinetic energy of wind. Today, this is also used for pumping water, charging batteries, and supplying electricity without producing any greenhouse gas. The energy efficiency of wind power is very high. The installation of micro wind turbine is easy and the electricity storage and transmission system should work with the micro wind turbines.

Insulation

Insulation is an energy saving method to reduce heat loss and keep the building warm. It is useful for cities with freezing weather, including Russia, Finland, Sweden, Norway, Denmark and Iceland. Heat energy is transmitted by conduction, convection and radiation. If we put insulating materials in the walls of the building, the heat loss can be minimized and thus the fuel and electricity need in the heating system can be reduced.

Smart thermostat

The smart thermostat can control the room temperature and keep it at about 25 oC. It is connected to the air conditioning, heating and ventilation system. So, the indoor air quality, temperature and humidity are automatically adjusted to keep it comfortable to the people. The first smart thermostat is the Nest. It came to the market in 2011, which is developed by a team of former iPhone engineers. Smart thermostats can also detect the room occupancy, understand the people' s preference and encourage energy efficient behaviors of the room users.

Recycling

Recycling helps to tackle climate change and promote sustainable economic growth. Recycled raw materials can be used to make new consumer goods. Less energy is needed in the manufacturing process. Less rubbish is sent to incinerators and landfills. So, the greenhouse gases emissions are reduced. In the waste hierarchy, the most preferred options are reduce, reuse and recycling. Energy recovery and landfill disposal are least preferred options. The Bureau of International Recycling states that recycling can save over 700 million tonnes in CO2 emissions every year. Recycling is the effective solution to climate change.

Plant-rich diets

A plant-rich diet mainly consists of plant foods, including fruits, vegetables, grains, legumes, etc. Meat, dairy products and eggs are avoided. Plant-based food is rich in dietary fibers, vitamins and minerals. The vegetables are free of cholesterol, low calorie and little saturated fat. For example, cultivating plant-based food by crop rotations and polyculture and improve the resources utilization, including energy, water and land. The plant food can be potatoes, tomatoes, carrot, vegetables, rice,

wheat, barley, etc. The greenhouse gases emission in agriculture can be reduced and the soil fertility is improved.

Identify the Criteria

The criteria to evaluate the climate change effects and greenhouse gases emissions are the global warming potential and carbon dioxide equivalent. Emission factor may be considered on the air pollutants.

Global warming potential (GWP)
Global Warming Potential (GWP) is a relative measure of how much heat that greenhouse gases trap in the atmosphere. The GWP for carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulfur hexafluoride (SF6) are explained in the table.

Greenhouse gases Global Warming Potential (GWP)
Carbon dioxide (CO2) 1
Methane (CH4) 25
Nitrous oxide (N2O) 298
Hydrofluorocarbons (HFC) 124 – 14,800
Perfluorocarbons (PFC) 7,390 – 12,200
Sulfur hexafluoride (SF6) 22,800

Carbon dioxide equivalent (CO2e)
Carbon dioxide equivalent is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global warming potential (GWP). The CO2 equivalent is abbreviated as CO2e. It converts the heat trapping ability of the greenhouse gases to the equivalent amount of carbon dioxide with the same global warming potential (GWP). Carbon dioxide is the reference point, in which the GWP is 1. Both the mass of gas (in kg) and the global warming potential (GWP) are considered.

The formula for calculating CO2e is:
CO2e = mass of gas (kg) x GWP

The three main greenhouse gases and their 20-year global warming potential compared to carbon dioxide are:

- 1 x – carbon dioxide (CO2)
- 25 x – methane (CH4)
- 298 x – nitrous oxide (N2O)

Every greenhouse gas has a different global warming potential and continues a

different length of time in the atmosphere. (Climate Change Connection, 2021)

Emission factor

The emission factor is a value that relates to the number of pollutants released into the atmosphere. These factors are usually expressed as the weight of pollutants divided by a unit weight, volume, distance, or duration of the activity emitting the pollutants. The air pollutants may work with the greenhouse gases to have the enhanced greenhouse effects. (EPA, 2021)

Evaluate the Solutions

We evaluate our climate change solutions by checking whether they are in line with the Chinese Government environmental policies, carbon neutrality and peak carbon dioxide emission goals to help reduce greenhouse gases emissions.

Chinese Government' s action on climate change
The President of the People' s Republic of China Xi Jinping emphasizes the environmental protection concept "Lucid water and lush mountains are invaluable assets." It is the correct direction for effective solution to help solve the problem of climate change.
The influence of China in environmental protection and climate change is significant. China has the determination to solve climate change problems because they believe good environment can lead to high standard of living and good lifestyle. The PRC President Xi Jinping also mentioned that high water quality and ecosystems are like gold and silver mountains. China has concrete action to solve the climate change problem. We can see lots of new green trees planted in most of the Chinese cities. The environmental quality is continuously improving. The environmental non-government organization (NGOs) also takes effective action to help solve climate change issues. The green groups are non-profit and work with volunteers to help clean up the environments. There are also green donors to provide financial funding to the green groups to help save our planet. (BBC, 2021)

The Chinese citizens generally have recognized that air pollution has a poor impact on their health and quality of life. The Chinese Communist Party Premier Li Keqiang has launched the "Blue Sky Protection Campaign". He has ordered the factories to reduce the steel production and let people to reduce the production of steel and closed some coal-fired electricity power plant. He switched to use more renewable energy, including the wind power, solar power, hydroelectric power, biomass, etc. So, the Chinese people and companies can burn fewer fossil fuels to reduce greenhouse gases emissions and air pollutant in the atmosphere. The overall air quality has improved a lot in Chinese cities in the past 10 years. Although human activities still damage the environment, we believe that all the people in the world understand the importance of having a healthy and green environment. (National Geographic, 2021)

In 2021, the effects of climate change are getting more serious. Many countries have also begun to tackle the climate change problems. The PRC President Xi Jinping announced that China' s commitment and goal on climate change is to

reach peak emissions by 2030 and achieve carbon neutrality by 2060. The declaration is interpreted as the important step to fight against climate change issues. (Xinhuanet, 2021)

Carbon neutrality

The extreme weather of climate change has resulted great economic, social and environmental losses globally. Examples of extreme weather include drought, flooding, heavy rain, tornadoes, hurricanes, rising sea levels, etc. Besides, biodiversity losses, species extinction and landslide become more frequent around the world. Therefore, the Intergovernmental Panel for Climate Change (IPCC) set the threshold that it is safe to limit the global warming to 1.5 degrees Celsius. The European Union promised to achieve carbon neutrality by 2050 under the European Climate Law. The Paris Agreement signed by 195 countries also aim at carbon neutrality.

Carbon neutrality refers to net-zero carbon dioxide emissions. There should be balance between the carbon emission (e.g. from burning fossil fuels) and the carbon absorption (e.g. by plant photosynthesis) from the atmosphere to carbon sinks. Greenhouse gas (GHG) emissions in the world are going to be counterbalanced by carbon sequestration in order to achieve the goal of net-zero carbon emissions.

Carbon sequestration is the process of capturing and storing carbon dioxide. No artificial carbon sinks can clear the atmospheric carbon dioxide in a large scale to fight global warming. Carbon sink is anything that absorbs more carbon from the atmosphere than it releases. For example, plants, the ocean and soil. Forest fires burn the forests and great amount of carbon dioxide is released to the atmosphere. If we protect the forest well, the trees are good carbon sinks to absorb carbon dioxide by photosynthesis. Forest management is important to achieve carbon neutrality. (European Parliament, 2021).

Peak carbon dioxide emissions

Peak carbon emissions refer to the annual carbon dioxide emissions reaching the highest value in history, and then experiencing a plateau period into a continuous decline in a region. It is the historical turning point of carbon dioxide emissions from increasing to decreasing, marking the decoupling of carbon emissions from economic development. The peak target includes both the peak year and peak value.

The Covid-19 pandemic has started globally in 2020. Most of the people have stayed at home for study and work. The roads were empty; the airport became silent and the restaurants are closed. The coronavirus epidemic reduced the human activities and fossil fuel combustion. The greenhouse gases emissions have been reduced. The Global Carbon Project states that the global carbon dioxide emissions had declined by 7%, which is about India’ s annual CO2 emissions. It was the

greatest drop in carbon dioxide emissions in history.

Despite the great death toll (about 4.6 million) in Covid-19 pandemic, the greenhouse gases emission has been greatly reduced. However, 7% decline in CO2 emissions is not enough to combat global warming, which is likely to be a temporary drop. Zeke Hausfather, the climate scientist in Breakthrough Institute, believes that the Covid-19 pandemic had accelerated the timeline of peak carbon dioxide emissions.

Some researchers are skeptical about whether the carbon emissions have truly peaked. If the coronavirus is under control, the economic activities will be fully recovered. The CO2 emission level will resume to original level. Therefore, the peak carbon dioxide emission has probably not been achieved in 2020. (Grist, 2021)

We believe our proposed solutions in the health and education sector (e.g. dynamic glass, green and cool roofs, reducing food waste, etc.) matches the Chinese Government environmental policies. They can also achieve the goals of carbon neutrality and peak carbon dioxide emission.

Make an Action Plan

We walked around our school campus to research for the daily life habits for environmental protection. The following photos are taken at the school campus and we recommend these green habits to help solve climate change.

1. Do proper garbage sorting
2. Saving drinking water
3. Use reusable cups
4. Turn off the tap to save water
5. Switch off the light to save energy
6. Use less paper hand towel
7. Use reusable tableware and plates
8. Play and learn from environmental books and boardgames
9. Place more potted plants in the campus.
10. Celebrate the Earth Day every year.
11. Use the blank side as draft paper. Print the document double-sided.
12. Use electronic documents instead of printed copies.

Who: all the Shanghai school students. (All the people around the world if possible)
What: these green habits
When: every day
Where: in the school campus (in any location if possible)
Why: help reduce greenhouse gases emissions and solve climate change problems.
How: do the right thing every day.

Importance: if most people around the world adopt these green habits, the overall effect on greenhouse gases emission reduction will be great. It is feasible because the green habits are actually easy to do. The main difficulty is that only some students adopt sustainable lifestyles.

Make an action plan

Prototype and Test

Prototype Design

Our action plan is the green habits. Therefore, the prototype is the environmental education and publicity in the Shanghai schools. The green habits are intangible and service-based. The main goal is to educate the students on the climate change issues and the correct action to combat climate change. We hope that the students can really adopt sustainable lifestyle in their daily life. Therefore, we conducted questionnaire and interviews in the school as the primary data to support the Envirothon Sustainability Innovation Project-based Learning (PBL) climate change report.

The prototype is based on the selected solution and action plan in this climate change report. We hope to develop the green campus and students' green habits. We test the prototype with the students, teachers and school management by using questionnaire survey and interviews to collect effective feedbacks using these correctly-set questions.

Feedbacks learnt from users

Questionnaire survey
We have conducted the questionnaire survey in the school on the students. The sample size is 30. The respondents are given five options to choose. They include "1. Strongly disagree", "2. Disagree", "3. Neutral", "4. Agree" and "5 Strongly agree". There are 4 questions in total. The last question is the open-ended question to allow the respondents to express their answers freely.

The questionnaire survey questions and answers include:
Question 1: Do you think Shanghai schools need to take action to help solve the climate change problem?
Answer 1: the weighed score = 3.90. The students generally agree.

Question 2: Do you think whether there is a chance to save the climate change/global warming?
Answer 2, the weighed score is 3.67. The students slightly agree.

Question 3: Do you think food waste is a serious problem in Shanghai schools?
Answer 3: the weighed score is 3.97. The students generally agree.

Question 4: What is the most effective solutions of climate change?
Answer 4: The students think that the most important solution of climate change is "Do not waste food and energy". Other comments include stop using plastic, recycling, less cars; do not waste paper and less beef.

Interview
We conducted 5 interviews in our school. The interviewees include the primary principal Mr. Roel Cruijff, the Director of Operations Mr. Craig Su, the teacher Mr. Lyle Sylvander, the parent Laura's mother and the student Helli Wang. Laura is the student Yishan Li. The comments from the major stakeholders are considered in the Sustainability Innovation Project-based Learning (PBL) report.

The interview questions and answers include:

Question 1: What do you think about climate change?

Answer 1:
Roel: Climate change is the biggest problem that the world is facing. There will be many more scary problems in the future. Our lives are good now. However, due to the effect of climate change, our next generations will be more likely to suffer from the problems created by climate change.

Craig: Climate change is happening now and affecting us. It relates to global warming and extreme weather. Climate change becomes part of our lives.

Lyle: I concern about climate change. I believe what the scientists said about climate change is true and real.

Laura's mother: Human beings have long ignored the laws of nature and blindly abused their intelligence and abilities. Human activities cause serious damage to the natural world. Climate change is the consequences.

Helli: I think climate change is very bad.

Question 2: Can we do something in our school to help solve climate change?

Answer 2:
Roel: Our school can raise the environmental awareness on climate change for the students by environmental education. However, we cannot solve the climate change

problem completely. We can do something to help reduce greenhouse gases emissions. Currently, there are many people who are trying to solve the climate change. We can learn from them and be inspired by their actions.

Craig: Our school is working on the climate change to be cleaner and greener. We have the green air conditioning system, thermosystem and green energy. We are using water as a cycle to power the air conditioners. We are providing environmental education to the students on climate change. Elementary school has been teaching the kids about climate change and the environment.
Our school has taken many effective actions to try our best to make some contribution to the solution of climate change. We have much high-tech air conditioner equipment.

Lyle: We can do better on recycling. We should avoid overuse of paper. We can use electronic documents instead of printed copies.

Laura’ s mother: We should plant as many trees as possible on campus to strengthen ecological protection. Our school should control the air conditioner use on the temperature and time settings to slow down greenhouse gas emissions.

Helli: We can do better in mandatory garbage sorting and reducing food waste.

Question 3: Do you think climate change relates to our school?

Answer 3:
Roel: Our school should do well and do more on climate change and environmental protection. All other schools and people are in the same situation. We can monitor the natural resources usage, including paper and electricity power. Our power systems should make the light automatically turns off at night after school. We have the solar panel to collect sunlight for energy. Other schools have the similar system. We can plant more trees to absorb the CO2 and refresh the air. We can eat less beef to reduce methane emissions from cattle frat. We should discourage the rainforest deforestation. The young environmentalist Greta Thunberg has proposed big changes and possible solutions to climate change. Shanghai or Beijing will be inhabitable.

Craig: Climate change is part of our student lives. Our school should think about how to do better for our Earth. We should support people to live in the correct way.

Lyle: Everyone in the world is connected with climate change, including our school. All the people globally contribute to the cause of climate change and partly lead to the extreme weather disaster. Humans have a role to reduce greenhouse gases emissions.

Laura’ s mother: Climate change is related to each of us and of course related to our school. We should take the lead in taking countermeasures, including energy conservation, environmental technology development and improving the environment by using advanced technology. It is the parents’ responsibility and obligation to improve students' environmental awareness. We should consciously pay attention to climate change issues. We should also help improve and protect the ecological environment.

Helli: Yes, climate change is related to our school.

Improvement for next iteration

Questionnaire survey

We studied the questionnaire survey results and reflect critically for minimizing the greenhouse gases emission.

Question 1 reflects that the students agree to take the responsibities to adopt green habits to help reduce greenhouse gases emission.

Question 2 reflects that there is hope to solve the climate change problem, which is the motivation to adopt and promote green habits.

Question 3 reflects that the students would like to reduce the food waste in the canteen to decrease the methane gases emission.

Question 4 reflects that saving energy, saving food, stop using plastics, do recycling, walking instead of driving, using less papers and eating less beef are the major green habits that the students would actually do, which matches our action plan.

We studied the interview results and reflect critically for reducing greenhouse gases emission.

Question 1 reflects that the school management, teachers, students and parents are aware of the problem of climate change. They generally agree to reduce greenhouse gases emission to combat climate change. Extreme weather and global warming make them suffer economically, socially and environmentally.

Question 2 reflects that the school operation aims at developing a green campus. We should use green air conditioning system and renewable energy. Environmental

education
should be promoted in the school to encourage the green habits like recycling, garbage sorting, reducing leftover and tree planting.

Question 3 reflects that the school management, operation, teachers and students would like to be responsible for climate change. The school should use the natural resources and energy wisely. Saving paper and water. Environmental technology can be applied to the campus to reduce greenhouse gases emissions. For example, 5G smart water, AI robots, cloud computing and big data, etc. Sustainable development should be emphasized to promote green habits in our daily life.

Conclusion
Climate change is the significant environmental challenges that relates to all the people around the world. Global warming and extreme weather have resulted great economic, social and environmental losses to many countries. We need to minimize the greenhouse gases emission to achieve carbon neutrality. We can monitor the greenhouse gases emission by carbon dioxide equivalent (CO_2e). The green campus and green habits are effective solutions to climate change if everyone adopts sustainable lifestyle. The solutions are verified by questionnaire survey, interviews and campus visits. They also match the Chinese government environmental policies.

Lucid water and lush mountains are invaluable assets. Let’ s take action together to make our Earth a better place.

Team Credits

Yingyan Xu is the Captain of the Envirothon Sustainability Innovation PBL project. She decides the Project Title and wrote the Summary and Conclusion of the climate change report. She also participates in all parts of the project-based learning (PBL) and coordinate the team members. She is also responsible for "Team Credits" and "Onsite Conference File"

Hingyu Cheung is responsible for the "Identify the Challenges" and "Identify a Root Cause".

Jeongmin Sung is responsible for "Generate Solutions", "Evaluate the Solutions" and "Make an Action Plan".

Yishan Li is responsible for "Identify the Criteria", "Prototype Design" and the "Questionnaire survey".

Yukchun Chan is responsible for "Prototype and Test", "Feedbacks learnt from users", "Improvement for next iteration" and "Interview".

Onsite Conference File

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Judge Comments

" I appreciate the team picking up what I consider the biggest environmental challenge of the current generation, climate change. The team did a good job in laying out the core impacts of climate change in various natural systems as well as society and have identified many of the anthropogenic causes for the same. Given the focus of the project on the school systems in Shanghai, it would have been helpful to see some more context on what the GHG footprint of the schools are, what the the primary GHG generation components are, and any potential trends there that can form the basis of a targeted intervention as part of the project.
Great job in identifying potential solutions within the school environment – I like that there is also a focus on food systems and nutrition as part of the study. Since it is a comprehensive look at solutions, I would also suggest including transportation options to/from school as well as resource consumption (by the school as well as the students) when you take this forward further. I would also suggest that the team build out a criteria to identify which of the solutions have the best chance for success – alignment with government' s goals could be one of the sub criteria, along with other crucial factors like affordability, acceptability among stakeholders, ease of implementation etc. It is very insightful of the team to try to align your solutions to what is already being considered at the national level. That said, a systematic analysis of the opportunities will help the team understand where the real opportunities for change are – the good news is that there are numerous great opportunities out there!
It is clear from the project description that the team understands how interlinked GHG is to all aspects of society (and the school ecosystem, specifically). I wish them the best in taking their education forward to meaningfully address emissions in their school campus, and in their careers as they progress.
"