Black combustion

Menofia STEM School

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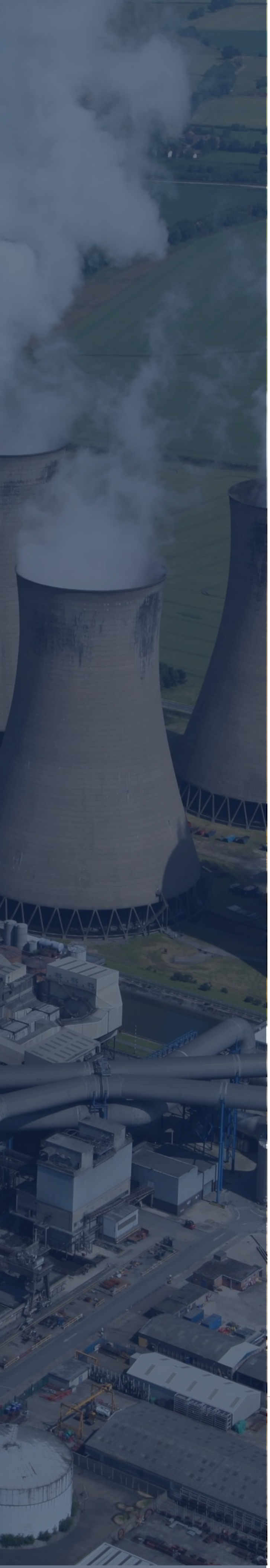

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Present and Justify a Problem and Solution Requirements

Section 1.1:

Egypt Grand Challenges

Reduce and adapt to the effect of climate change

Fig (1)

The Earth's climate is changing. Some of this change is due to natural variations that have been taking place for millions of times, but decreasingly, mortal conditioning that releases heat-enmeshing feasts into the atmosphere is warming the earth by contributing to the "greenhouse effect". Climate change adaption refers to actions that minimize the negative effects of climate change while seizing any new possibilities that may arise.

It entails modifying laws and practices as a result of seen or anticipated climatic changes. Adaption can be reactive, being in response to climate impacts, or anticipant, being before impacts of climate change are observed. In utmost circumstances, anticipant acclimations will affect lower long-term costs and be more effective than reactive acclimations. Adaption isn't a new concept. Nonetheless, the quantum and rate of unborn climate change will pose some new challenges. The fact that wisdom now allows communities to anticipate a range of implicit climate conditions, and thus act before the worst impacts are incurred, makes adaption to unborn climate change different.

Single programs and measures can be designed to help attack both mitigation and adaptation. For illustration, as the climate changes, a projected advanced frequency and intensity of rain storms may increase stormwater runoff and the eventuality of localized flooding in civic areas. Planting road trees is an action that cosmopolises can apply to both reduce stormwater runoff (adaption) and increase carbon storehouse (mitigation).

Importance:

Human actions are to blame for climate change, which is endangering both our way of life and the planet's future. We can create a sustainable world for everyone by addressing climate change.

People and their property are being impacted by extreme weather and increasing sea levels in both industrialized and developing nations. Everyone is affected by climate change, but it particularly affects the poor and vulnerable, as well as marginalized groups including women, children, and the elderly.

Several attributes are impacted by climate change:

- Climate change will mean big changes for creatures around the world, for case, snow leopards, turtles, and polar bears. So, if we watch about inconceivable species, we must watch about how a changing climate will make it harder for them to find food, and drop their territories – from timber to ocean ice to the UK's gutters, and aqueducts.

- Under the stress of our changing climate, warmer air and ocean temperatures beget coral bleaching, where corals lose their color and may die. Ocean acidification – from increased CO2 in the atmosphere – composites the problem. moment, the ocean is 26 further acidic than it was in 1990, and the Great hedge Reef has just experienced unprecedented back-to-back bleaching events in 2016 and 2017.

- 2 in every 3 people worldwide reside in regions of severe water failure. Indeed, a small increase in global temperatures will destabilize the water cycle and could make water failure much worse. Climate change affects downfall patterns, meaning both failure and flooding will be more common, and more violent.

Unique, irreplaceable, and frequently described as 'the world's lungs', rainforests are some of the most precious territories on the earth. They are amazing; the Amazon, for illustration, is home to an astonishing 1 in 10 of all the given species on Earth. Yet over a third of the Amazon rainforest is formerly hovered by climate change.

- It’s a double-whetted brand too worldwide, timber destruction – substantially for husbandry – is a major cause of climate change, generating an inconceivable quantum of hothouse feasts.

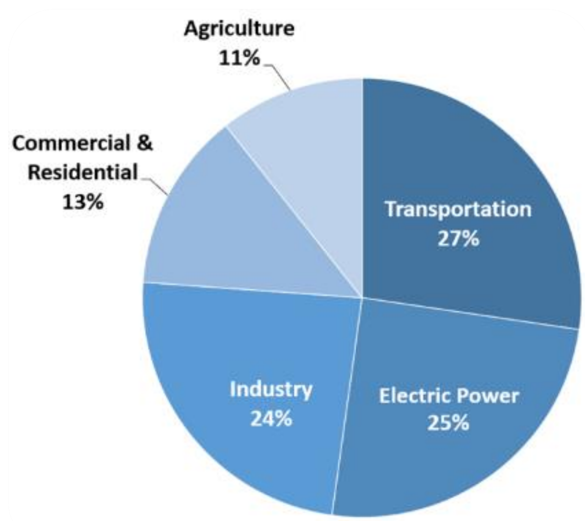
- With adding climate change that leads to an increase in carbon emigration, it stands to reason that we face compromised air quality. This affects mortal health, especially children. Air pollution can lead to asthma, and heart and lung complaints.

- Furthermore, all of us will be impacted by climate change, not just trees, coral reefs, or even people in distant countries. People throughout the world will experience the effects of it, from more harsh weather to rising food prices to recreation and fewer opportunities to appreciate the natural world.

Reasons why we face climate change

The greenhouse effect is the primary cause of climate change. Some gases in the Earth's atmosphere mimic the effect of greenhouse glass by trapping solar heat and preventing it from escaping back into space, which would otherwise contribute to global warming. Many of these greenhouse gases are produced naturally, but due to human activity, some of them are becoming more prevalent in the atmosphere.

In particular, carbon dioxide (CO_2), methane, nitrous oxide, and fluorinated gases are becoming more prevalent.



Pi-chart (1): represents the percentages of the reasons of climate change

The main source of CO_2 created by human activity is global warming. Its atmospheric concentration increased to 48% over pre-industrial levels by 2020. (before 1750).

Factors for rising emissions

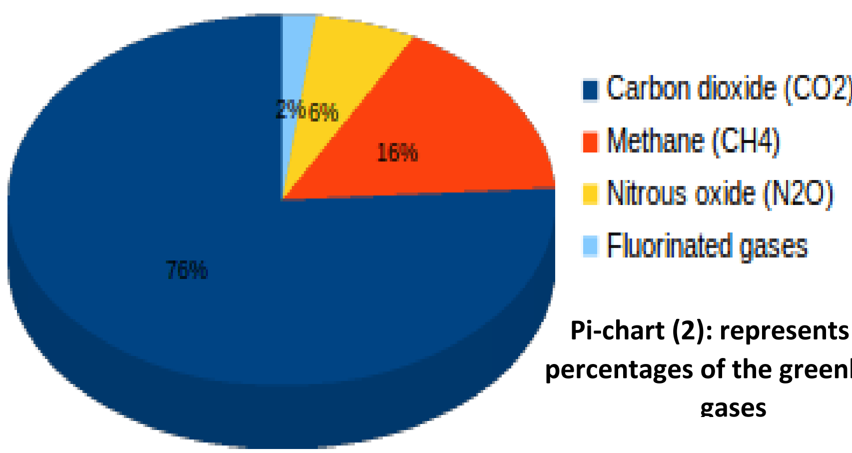
Carbon dioxide and nitrous oxide are produced through the burning of coal, oil, and gas.

- Cutting forests (deforestation). By absorbing CO_2 from the atmosphere, trees assist in controlling the climate. This advantageous impact is lost when trees are cut down, and the carbon they have stored is released into the atmosphere, increasing the greenhouse effect.

- Growing the livestock industry. When cows and sheep digest their meal, they release a lot of methane.

- Nitrous oxide emissions are produced by fertilizers with nitrogen.

- Products and equipment that employ fluorinated gases release fluorinated gases. Such emissions have a warming effect up to 23 000 times stronger than CO2 in the atmosphere.



Pi-chart (2): represents the percentages of the greenhouse gases

Improve the scientific and technological environment for all

The development of the scientific and technological environment is a very important challenge for countries. The world is constantly changing and many phenomena and challenges appear from time to time, and we must keep pace with these changes, be familiar with them and explain them well so that we can overcome them and face them. Science and technology are both important and complement each other. The correct scientific basis and modern and advanced equipment and tools have helped us accomplish many tasks and projects and solve many problems and challenges facing us in all fields. Later, we will learn about the importance of each field separately, and we will also clarify how they relate to each other and arrange them on each other.

Fig (2)

First, regarding the scientific environment and the importance of science and scientists in facing major challenges:

There is no doubt that science is of great importance in all areas of our lives, and continuous and modern research and experiments represent the basis for all operations and tasks. Scientists work hard in several attempts to study all conditions in terms of the conditions of the land, climate, population and their characteristics and characteristics of the places in which they reside, knowledge of resources, and studying all phenomena in all fields, whether in the field of energy sciences, astronomy, chemistry or even environmental sciences. In this project, we will discuss more science and research that specialize in the fields of energy and industry. Scientists focus on studying many phenomena, the most important of which is the phenomenon of overcrowding and the increase in population numbers in many areas.

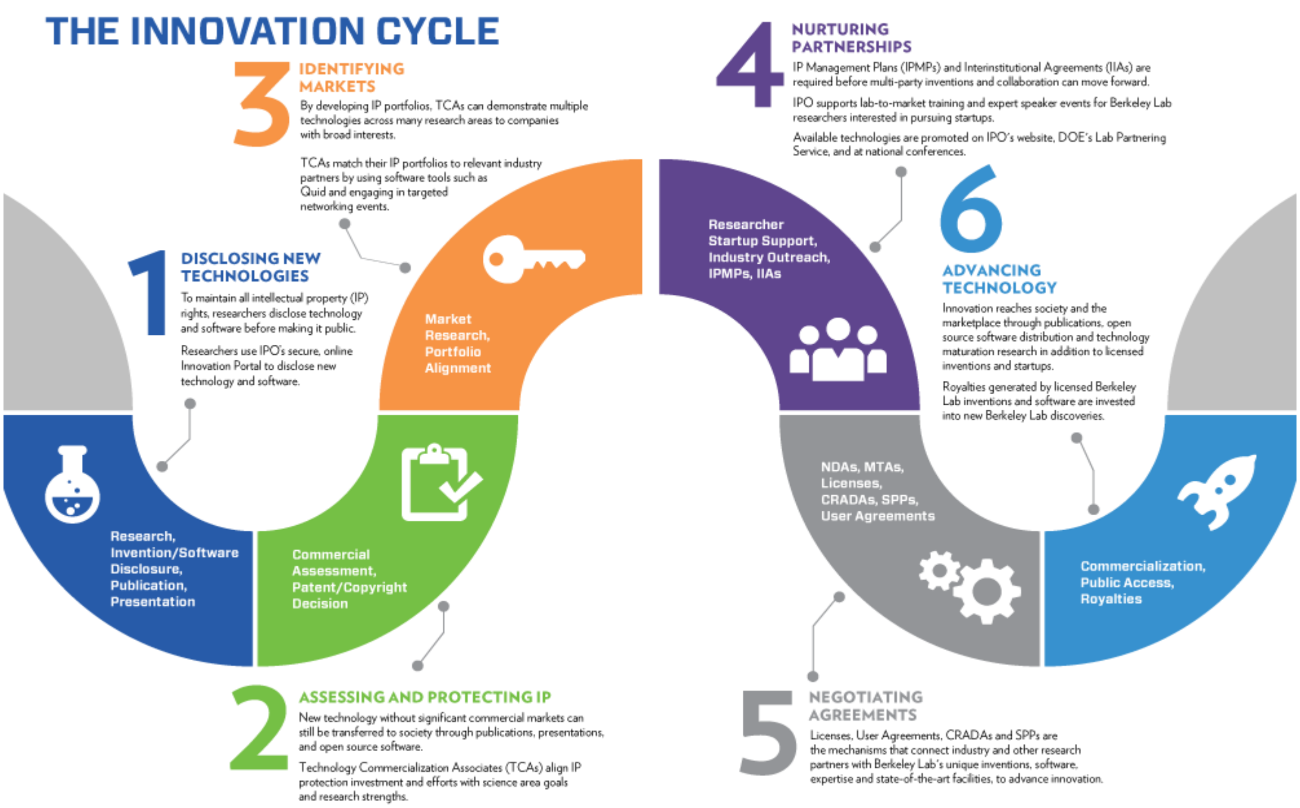
And therefore, they study their situation and needs for resources and they make statistics of resources and materials to manage their manufacture and use well. Scientists also study well-manufactured materials to know the expected quantities and whether the waste resulting from different industries can be recycled, thus reducing pollution, which affects the environment and climate. Scientists study the available energy materials and search for renewable energy sources and study their properties well to facilitate their effective and safe use. All these studies are very important and benefit the industry and their development of them increases the efficiency of products and improves their management and thus improves the economy. The strategies used in research and studies should also be developed to suit the environmental development and to give more accurate and effective results, and thus fit the change in quality and validity standards for the products demanded by the population.

Second, the technological environment and the importance of technology in solving problems:

Technology has become an important and indispensable thing in many, if not all. fields.

All fields are applying digitization and developing their strategies and techniques used in many operations. Information technology and modern equipment helped achieve the modern scientific basis that was proven by scientists, and it was very difficult to implement it on the ground. Now everyone can buy products and give their opinions and demands through mobile devices and websites. Many heavy industries are easily implemented as a result of the use of modern and highly efficient equipment that uses clean energy sources, and some of them use renewable energy such as solar ovens, solar cells, wind energy, and hydroelectricity. There are now multi-use computers that are used in factories to manage and operate equipment, whether used by scientists during their research and studies, or equipment and machines that are used in factories in the production of tools and various products. Some modern devices and machines also check the products well before they are exported and sold to ensure the validity and quality standards of the products, and this is what we will work on throughout this semester. All these machines and equipment need highly experienced programmers in the field to be able to update and develop their systems first and add everything new to them to improve productivity and increase efficiency. Specialists in programming devices and equipment must train well and work diligently in their field so that they can develop equipment first-hand without delays or errors.

And now we conclude from the above that the technological and scientific environments both complement and support each other and are of great importance in developing and improving production and the economy.



Infographic 1: represents the innovation cycle

Section 1.2:

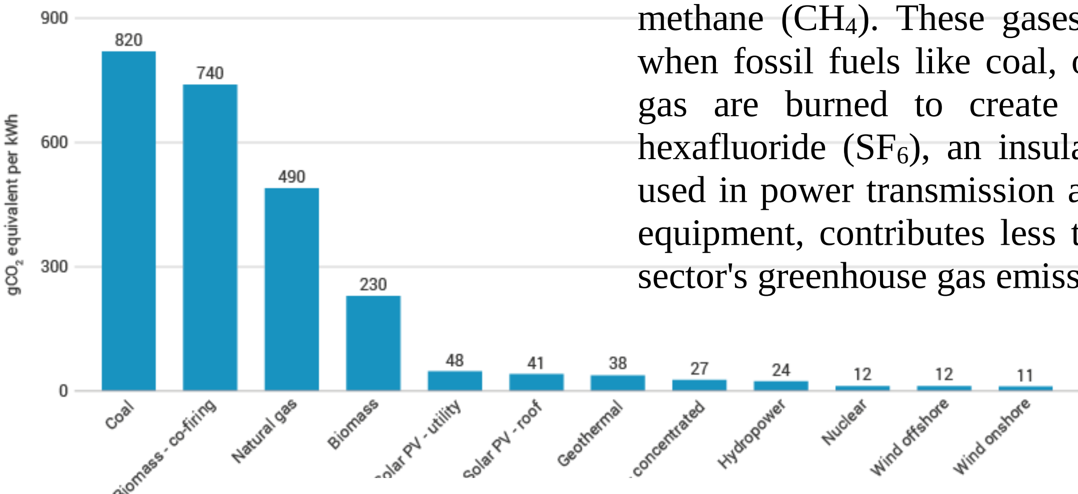
Problem to be solved

Coal combustion is more carbon-intensive than burning natural gas or petroleum for electric power production. Although coal use accounted for about 54% of CO_2 emissions from the sector, it represented only 20% of the electricity generated in the United States in 2020. Natural gas use accounted for 39% of electricity generation in 2020, and petroleum use accounted for less than 1%. The remaining generation in 2020 came from non-fossil fuel sources, including nuclear (21%) and renewable energy sources (20%), which include hydroelectricity, biomass, wind, and solar.1 Most of these non-fossil sources, such as nuclear, hydroelectric, wind, and solar, are non-emitting.

Burning coal produces more carbon dioxide than burning natural gas or petroleum to make electricity. Despite producing roughly 54% of the sector's CO_2 emissions, coal accounted for only 20% of the electricity generated in the US in 2020. In 2020, the production of electricity was 39% powered by natural gas and less than 1% by petroleum.

Nuclear energy (21%) and renewable energy sources (20%), such as hydroelectricity, biomass, wind, and solar, provided the remaining generation in 2020. 1 The majority of these non-fossil fuels, including nuclear, hydroelectric, wind, and solar power, don't generate any emissions.

The generation, transmission, and distribution of electricity are all part of the electricity sector. Most of the greenhouse gas emissions from this industry are carbon dioxide (CO_2), although there are also minor emissions of nitrous oxide (N_2O) and methane (CH_4). These gases are generated when fossil fuels like coal, oil, and natural gas are burned to create power. Sulfur hexafluoride (SF_6), an insulating substance used in power transmission and distribution equipment, contributes less than 1% of the sector's greenhouse gas emissions.



(Graph 1)

Causes:

Sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (PM), carbon dioxide (CO_2), mercury (Hg), and other pollutants are released when fossil fuels are burned in power plants. Mercury exposure can increase the risk of health problems ranging from cancer to immune system damage, while NO_X and SO_2 emissions help to generate ground-level ozone and fine PM, which can cause respiratory and cardiovascular disorders.

If the problem is solved, there might be some changing and some advantages might result from solving this problem

- Reducing pollution won't just benefit humans; it will benefit all living things, including animals.
- Decrease the effecting the health of miners, workers and surrounding communities.
- Reducing Greenhouse Gas Emissions Can Improve Air Quality and Save Lives. Reducing global greenhouse gas emissions to slow climate change.

If the problem is not solved, there are going to be some disadvantages that might result

- Emissions of greenhouse gases and other air pollutants will increase, especially when a fuel is burned therefore it will increase climate change.
- Levels of air pollution will rise.
- Some of the harmful consequences of being exposed to CO_2.
- Exposure to CO_2 can produce a variety of health effects; these may include (headaches, dizziness, restlessness, a tingling or pins or needles feeling, difficulty breathing, sweating, and tiredness).

Section 1.3:

Research

Topics we searched about the problems:

▪ Reduce and adapt to the effect of climate change.

▪ Climate change definition.

▪ Climate change emissions.

▪ Importance of decreasing the global temperature.

▪ The problem of climate change consequences.

▪ Climate change and greenhouse gases problem in Egypt.

▪ Benefits of reducing climate change emissions.

▪ Sequences and impacts in both negative and positive side.

▪ Communication methods.

▪ Some types of sensors in some communication systems.

▪ Communication system main parts.

▪ Impacts and sequence of improve the technological environment.

Topics we searched about the solution:

▪ Using technology in IOT systems.

▪ How would using communication and technology be better and easier to solve the climate change problem?

▪ IoT, AI, Robotics, Arduino, and other technological and communication methods.

▪ Prior solutions that use communication in a climate change problem.

▪ How did communication effect the climate change problem? Did it solve the problem or made it complicated?

▪ Advantages and disadvantages of each project.

▪ Benefits from each project.

Other topics related to the solution: -

▪ gases increase the climate change.

▪ The main cause of climate change in Egypt.

▪ Gases come from burning coal.

▪ Electricity production in Egypt.

▪ The efficiency and difference in shapes and mechanisms.

▪ How to get the most correlation and best way to apply a new solution with IOT.

Technology and scientific topics that we discuss:

▪ Climate change.

▪ Electricity production.

▪ Internet of things.

▪ Forecast.

▪ PCB board

▪ Arduino Uno.

▪ Sensor types and functions.

▪ CO_2 sensors.

▪ Temperature sensors.

▪ Electronics and coding.

▪ Thing Speak.

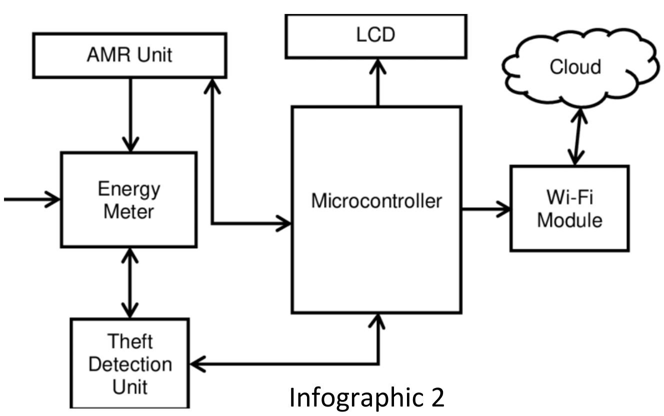
▪ Electronic circuit

Section 1.4:

Other Solutions Already Tried

Smart energy monitoring:

Consumption affects the environment. First, burning fossil fuels to generate electricity and heat releases greenhouse gases. Some areas of use are quite large. For example, HVAC systems in commercial buildings consume more than 40 percent of total energy use. The Internet of Things has opened avenues to improve energy use. It works with the help of voice-activated smart plugs, thermostats and other IoT enabled devices, reducing energy consumption. IoT environmental monitoring sensors can automatically detect room occupancy and adjust lighting, cooling and heating systems to save energy.



Infographic 2

Strength points: -

Allows for faster outage detection and restoration of service.

- Provides customers with greater control over their electricity use when coupled with time-based rates.

- Helps the environment by reducing the need to build power plants, or avoiding the use of older, less efficient power plants as customers lower their electric demand.

- increases privacy because electricity usage information can be relayed automatically to the utility for billing purposes without on-site visits by a utility.

Weakness points: -

- Older smart meters become “dumb” once you switch.

- In-Home Display may be inaccurate.

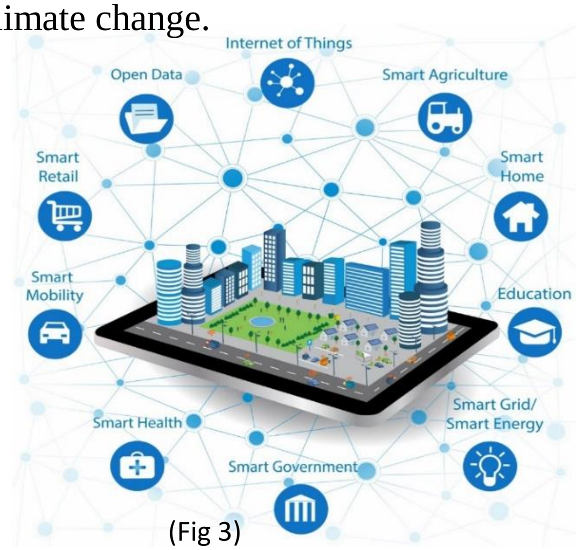
- Prepay friendly.

Smart Cities

A Google search for "what is a smart city'" has 41,500,000 results. The idea of building smart cities has been popular since the last decade and coming up with applications and ideas worldwide. The International Telecommunication Union defined a smart city as *an innovative city that uses IoT and ICTs and other means to improve quality of life, the efficiency of urban operation and services, and competitiveness while ensuring that it meets the needs of present and future generations concerning economic, social and environmental aspects.*

The importance of sustainable city development is seen in one of the Sustainable Development Goals (SDGs), which is working to make cities and human settlements inclusive, safe, resilient and sustainable.

The share of global CO2 emissions attributed to cities varies from 80 percent (Robert Zoellick, 2011), to more than 70 percent and to more than 50 percent (Intergovernmental Panel on Climate Change, IPCC, 2014). It appears that the C40 estimate is the most widely accepted estimate. Countering ambivalence about the role of cities in climate change mitigation, experts make the case that municipalities are the key to fighting climate change.



(Fig 3)

How do Smart Cities solve the problem?

The features and characteristics of smart countries differ from one city to another depending on the problem to be developed or solved, and they also differ in the scientific and technological method of implementation. Below we will show some applications for some smart cities:

1. Singapore and China bilateral cooperation:

The development of smart cities has been further supported via bilateral cooperation. These partnerships include the Memorandum of Understanding (MoU) on the Strategic Collaboration on Smart City Development between Singapore and China (Shenzhen). This MOU, which came into effect in 2020, listed out cooperation such as in digital connectivity, and technology collaboration. Moreover, Germany launched a project in 2018 to help three Indian cities to become sustainable smart cities.

Map 1: Location of 100 cities selected under the Smart Cities Mission

Advantages of Smart City

1. Better transportation services.
2. Safer Communication.
3. Efficient public services.
4. Improvement of infrastructure.
5. Decrease of crime.

Disadvantages of Smart City

Though Smart City has many advantages, there are some disadvantages. Knowing these can help one to understand the flip side of the coin. The disadvantages are as follows:

1. **Limited privacy:** Since the authorities or the government will have access to security cameras and intelligent systems connected through many different spaces, the citizens will have difficulty in maintaining their anonymity. Facial recognition and such things will drastically change the concept of privacy or personal space.
2. **Social control:** The people who can track and centralize the data they gather with security cameras will have greater power. It can be a government, a private agency, or other authorities.
3. **Excess network trust:** Since the citizen of these smart cities will rely almost entirely on electronics and networks, they will lose autonomy in their decision-making and could become incompetent.
4. **Difficulty in the pre-commerce stage.**
5. **Pre-training is required:** If the people of the city don't know about technology, then they will not be able to use it.

Monitoring of Carbon Footprint

Sustainable development indicators are needed to provide a solid basis for decision-making regarding climate change. The carbon footprint is an indicator of sustainable development that has been applied in the past few years as a general description of greenhouse gas emissions from human activities. The Ecological Footprint Framework addresses climate change in a comprehensive way that goes beyond measuring carbon emissions. It shows how carbon emissions compare and compete with other human demands on our planet, such as food, fibers, timber, and land for housing and roads.

(Fig 4)

The carbon footprint is an important component of the ecological footprint, since it is one of the competing demands for a biologically productive space. Carbon emissions from burning fossil fuels accumulate in the atmosphere if there is not enough biocapacity dedicated to absorbing these emissions. Therefore, when the carbon footprint is reported in the context of each consumer's total environmental footprint, tons of carbon dioxide emissions are expressed as the amount of land area produced that is required to sequester these carbon dioxide emissions. Measuring a carbon footprint does not mean that carbon sequestration is the answer to the carbon dilemma. It just shows how much biocapacity is needed to nurture untreated carbon waste and avoid carbon buildup in the atmosphere.

Strength points: -

- Ease of understanding and implementation globally.

- Widely applicable and easy.

- Simplify the process of getting carbon from products and help set emissions reduction priorities.

Weakness points:

- Inadequate accuracy of data and methods to allow the carbon footprint product to fluctuate supply chains.

- In addition to local environmental exclusivity, there are different ways of dealing with carbon footprint issues.

- Differences between current methodologies increase climate change as a single impact category.

Optimizing farming efficiency

A cloud-based temperature monitoring system using IoT makes it easier to monitor and access humidity, temperature, and the weather across connected devices. With this data, farmers can adjust environmental conditions within controlled spaces to ensure year-round crop production and higher yields. Also, smart sensors enable real-time monitoring of irrigation systems, soil quality, livestock health and crop conditions to ensure efficient use of resources.

Fig 5

For example, by installing smart traps, farmers can detect pest infestations and determine where and how to manage pesticides, reducing the use of chemicals to reduce emissions.

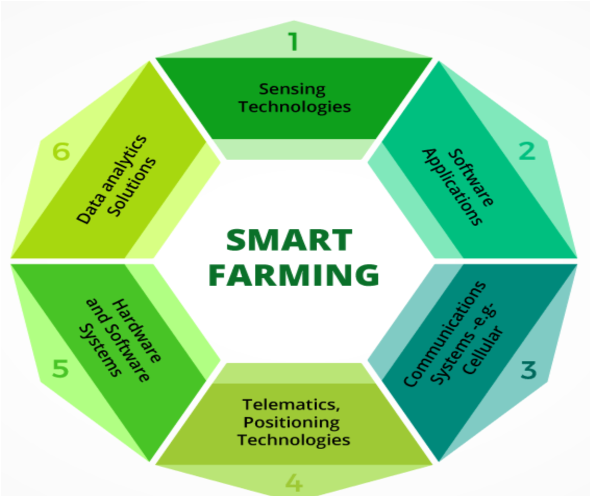


Fig 6

Strength points:

- Any land can be used for cultivation in spite of fertile or non.
- Most products are available in the market needed for hydroponics such as nutrient solutions, plant growing Kit etc.
- Availability of agriculture university and research institutes for technical support.
- Producers can start their own business without owning agricultural land.

Weakness points: -

- Availability of many subsistence farmers.
- Most farmers lack basic entrepreneurship knowledge and skills related to smart farming.
- Assumptions that plants grown in soilless environment are unnatural.

Forecast

Wildfires cause billions of dollars in damages every year and are expected to increase in intensity due to climate change. The latest current wildfire propagation models are based on FireCast. FireCast combines artificial intelligence (AI) technologies with geographic information systems (GIS) data collection strategies. FireCast predicts areas around burning wildfires that have a high risk of wildfire propagation in the near future, based on historical fire data and using modest computational resources. FireCast is compared to the random prediction model and the commonly used wildfire propagation model, Farset, which outperforms both in terms of completeness.

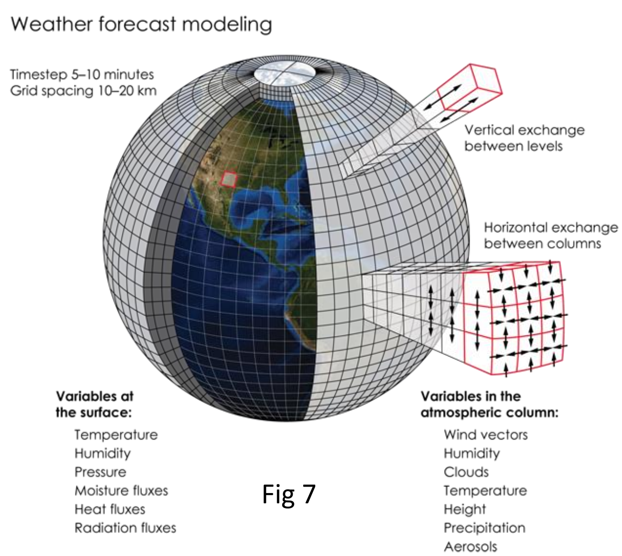


Fig 7

Advantages:

- No need for feature normalization/ scaling

• Easy to measure the relative importance of each future.

• Can handle categorical and numerical features.

Disadvantages:

• Can take long time to train with a large number of trees.

• They are no easily interpretable.

• Will not necessarily exhibit lower bias than individual decision trees.

Green computing

Green computing is the environmentally responsible and eco-friendly use of computers and their resources. In broader terms, it is also defined as the study of designing, manufacturing/engineering, using and disposing of computing devices in a way that reduces their environmental impact. Green computing also is known as green information technology (green IT), is the analysis and practice of making productive use of computational resources. The objectives are to reduce the use of hazardous materials, maximize the energy efficiency during the lifetime of the product and promote the recyclability or biodegradability of defective products and waste from factories.

Advantages: -

•Reduced Energy Consumption.

•Decreased Greenhouse Gas (GHG) Emissions.

•Dematerialization.

•Use of Renewable Energy Sources.

•Remove the Burden from IT.

•Decrease Costs in Infrastructure.

•Facilitate Remote Working and Collaboration.

•Increase Availability of Resources.

Disadvantages:

•The initial implementation is costly.

•Frequent change in technology.

•Green IT cause more burden to an individual.

•The disparity in the level of understanding across various companies, professionals, and end-users.

•Fewer courses and publications related to green computing.

Fig 8

02

Generating and Defending a Solution

Section 2.1:

Solution and Design Requirements

The project must adhere to several crucial requirements to get the best outcomes, make it effective, and avoid mistakes. Therefore, the following design criteria must be implemented:

1. Accuracy:

When comparing the indicated value at the sensor's output to the real value, the accuracy of the sensor is defined as the largest difference that can be made. We aim for getting accuracy sensors:

- Digital temperature and humidity sensor with ±5 degrees Celsius accuracy.

2. Dynamic range:

The dynamic range is the ratio of the maximum to minimum signal acquired by the sensor. We'll use that in our sensor, for instance, to ensure that our prototype achieves:

- Sensor that measures the concentration of eCO2 (equivalent calculated Carbon Dioxide) within a range of 600 to 4000 ppm.

3. Constructing prototype testable, and based on IoT system.

Our main theme in building prototypes is constructing a prototype using communication. And IoT system, and temperature in addition to building a clean code.

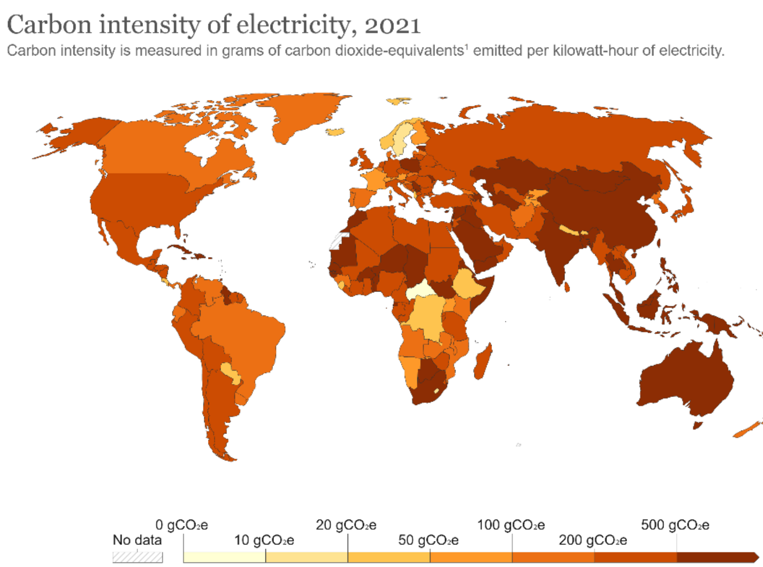
4, Building a relationship between one independent variable with a dependent variable that causes climate change.

The main goal of our project is to study the changes in CO2 and temperature concerning time in a simulated environment to predict a relation between them.

Section 2.2:

Selection of Solution

The real challenge that we have focused our efforts on, is to solve is the problem of climate change. Climate change is one of the most serious problems facing the planet, and all countries have begun to move to solve the problem and to reduce gas emissions that increase the global temperature. After conducting research, we found that carbon dioxide is one of the most toxic gases that lead to climate change, global warming. By looking at the outputs of the industries, we found that power generation from burning coal is the most contributing to carbon dioxide emissions and an impact on the climate. As Coal emits far more carbon than other fossil fuels that are used to generate electricity. Coal power plants emit 2,249 pounds of CO_2 for each megawatt hour of electricity created. For comparison, oil emits 1,672 pounds each megawatt hour fc, and natural gas emits 1,135 pounds.



Map 2

Therefore, with using the Internet of Things, we decided to develop a solution as follows. We will create a device that measures the specific percentage produced by factories of carbon dioxide and other particles, and the amount of temperature change. We will make these circuit. We will make these sensors able to work by activating them with their own codes and then connecting them to a laptop to read the data they produce. We have decided to do our project on a closed system due to the small amount of coal that we will burn relative to the amount used in the factories. After reading and recording the final results, we will be able to produce recommendations for factories that burn coal to reduce the percentage of gases emitted from their industry.

Section 2.3:

Selection of Prototype

Each IoT system integrates four distinct components: sensors and/or devices, connectivity, data processing and the user interface. We will use some basic steps to prepare our project as follows: choosing the sensors, connecting the circuit, creating the PCB, writing the code and displaying the data.

1. Based on the solution we chose, which is creating a relation between the increase of temperature and the percentage of CO2 and PM, we started selecting our sensors. For the temperature sensor we chose DHT11 Temp & Humidity Sensor Module. It has a dynamic range from 0°C to 50°C, and it has low cost with relatively high accuracy. We used Air Quality and Dust Sensor GP2Y1014AU0F to measures Total Volatile Organic Compounds (TVOCs), provides 1-minute average of equivalent carbon dioxide (eCO2). It also measures dust level from large house dust to from large house dust to microscopic particles of 0.5 microns like bacteria, pollen, mold and cigar smoke. To detect the percentage of CO2, we used 1psc CCS811 HDC1080 CO2 Sensor Module Board. The CCS811 is a digital sensor with metal oxide (MOX) gas sensor to also measure VOCs. But the sensor is more specialized in measuring "equivalent CO2" (eCO2).

2. After determining the sensors required for our project, we will start connecting each sensor as follows:

- DHT11 module: it has three pins. The GND connects to the ground of the circuit, the VCC which is considered the power supply connects to 5V power. Sometime 3.3V power isn't enough so, it is better to use the 5V power, lastly, the Signal or Data pin which outputs both temperature and humidity through serial data connects to 11 in the Arduino.

to 11 in the Arduino as shown in fig 9.

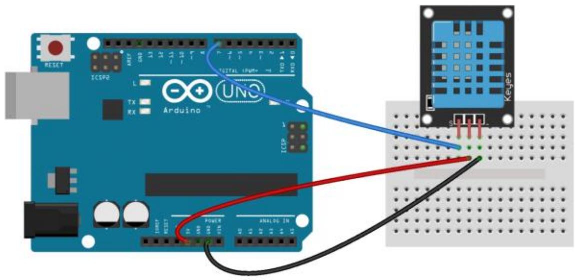


Fig 9

- 1psc CCS811 HDC1080 CO2 Sensor Module Board: it has 8 pins. The VCC (the power pin) uses 3.3V to power the board. But since we will already use the 5V pin for the DHT11, we will use 3.3V. The second pin is the GND. Then SCL and SDA pins are connected respectively to the SCL and SDA on Arduino. The other pins remain without wiring as shown in fig 10.

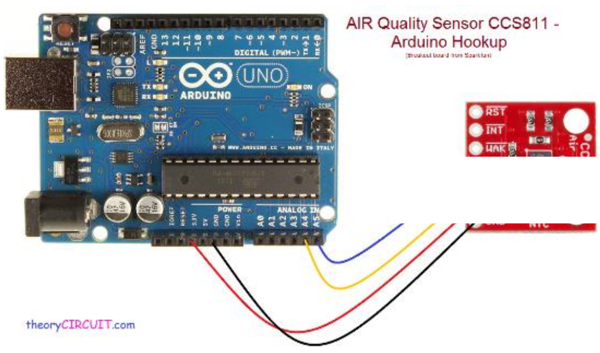


Fig 10

- Air Quality and Dust Sensor GP2Y1014AU0F: V-LED (the white wire) represents the VCC pin of the LED. We will connect this pin to the 5V pin of the Arduino with a 150Ω Current Limiting Resistor. The LED-GND connects to the Ground pin of the Arduino. Then, the LED Pin can be used to Toggle the LED on/Off. It connects to any digital pin of Arduino. We connected it to 7. GND connects with the ground pin of Arduino. Vout is the output can connect it to any analog pins of the Arduino. The last pin is the VCC Power Pin of the Dust Sensor Module connects to 5V or 3.3V pin of the Arduino. We connected it to 5V alongside with the VCC of the DHT11.

2. We will use the previous circuit connection data to create a Printed Circuit Board layout of the circuit using free-use application called EAGLE|PCB Design and Electrical Schematic Software. On the analysis section, we will discuss the reasons why we choose to make a PCB

instead of a wired circuit. We will take a printout of the PCB layout as shown in figure 11.

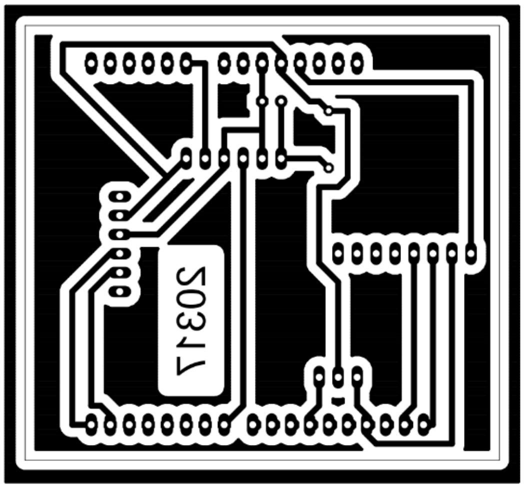


Fig 11

Then, we will cut a copper plate for the circuit board according to the size of layout. We used a width of 5.5±1 cm and a height of 6.2±1 cm. Consequently, we will rub the copper side of PCB using steel wool or abrasive spongy scrubs. This removes the top oxide layer of copper as well as the photo resists layer. Afterwards, we will put the printed layout on the copper surface of the board and iron the image side down to copper side as shown in figure 12.

Fig 12

Then we need to heat up the Electric iron to the maximum temperature. After that we will dip the PCB into the Etching solution (Ferric chloride solution, Fecl3) for approximately 30 mins. The Fecl3 reacts with the unmasked copper and removes the unwanted copper from the PCB. Thenceforth, we use pliers to take out the PCB after it has been printed on the copper as shown in figure 13.

Fig 13

Following, we will hollow the points to put the pins as shown in figure 14.

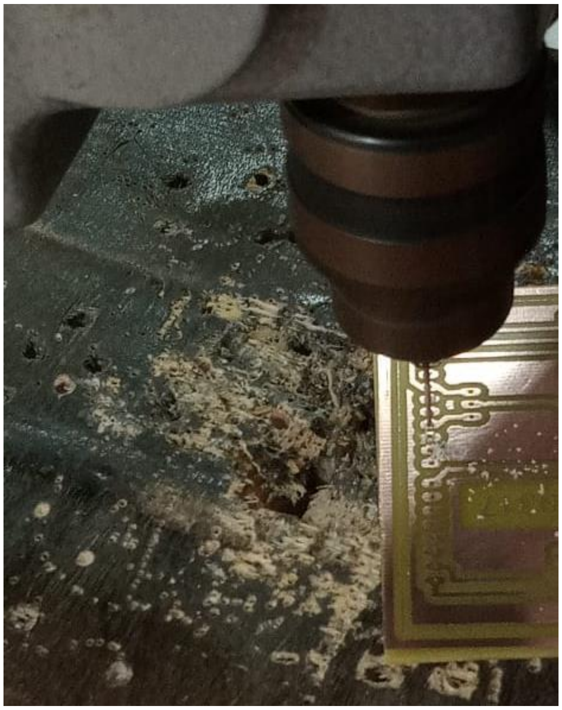


Fig 14

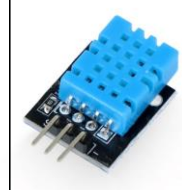
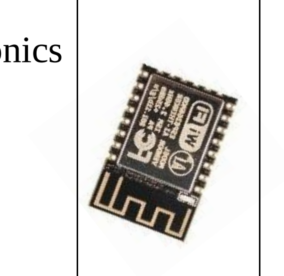
3. After finishing the connection, we will write our code. We will follow a simple criterion which uses the example codes of each the sensor and collect it in one code. We will creat an account on a on a site called IoT Analytics: ThingSpeak Internet of Things, and then create a channel with the name of our project to display the results.

03

Constructing and Testing a Prototype

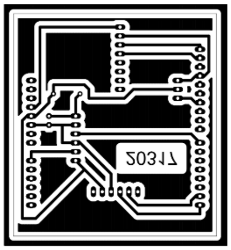
Section 3.1:

Materials and Methods

Item	Quantity	Description	Usage	Cost	Source	Photo
Arduino Uno	1		Ability to connect different robotic parts including sensors, actuators, etc.	330	Makers electronics	
DHT11 Temp & Humidity Sensor Module	1	Supply voltage: from 3.3 V to 5.5 V. Measuring temp range from 0 °C to 50 °C	Measuring temperature and humidity.	35	Makers electronics	
WiFi ESP8266-12-F Serial TTL Module	1	The ESP8266 is a highly integrated chip designed for the needs of a new connected world for IoT.	It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or offload all Wi-Fi networking functions from	65	Makers electronics	

			another application processor.			
1psc CCS811 HDC1080 CO2 Sensor Module Board	1	CCS811 HDC1080 module is a gas sensor system-on-chip (SSoC) + temperature and humidity sensor.	Provides equivalent CO2 level or Total Volatile Organic Compound (TVOC) indicators.	300	Makers electronics	
Glass Box	1	Glass box with a small hollow from the top side	Creating a simulating closed-system	50	Glassiko shop	
Coal	¼ kg	________________	Used in the test plan.	10	Shop	

Methods

- Each IoT system integrates four distinct components: sensors and/or devices, connectivity, data processing, and the user interface. We divided the basic steps to prepare our project into three main steps as follows: connecting the circuit, creating the PCB, writing the code, and displaying the data.

- After determining the sensors required for our project, we started by checking if all the sensors work by using the example codes. Afterward, we started connecting each sensor to a simulating application.

  We used the circuit connection data to create a Printed Circuit Board layout of the circuit using a free-use application as shown in fig x. We took a printout of the PCB layout. Then, we cut a copper plate for the circuit board according to the size of the layout. We used a width of 5.5±1 cm and a height of 6.2±1 cm. Consequently, we rubbed the copper side of the PCB using steel wool or abrasive spongy scrubs. This removes the top oxide layer of copper as well as the photo resists layer. Afterward, we put the printed layout on the copper surface of the board and iron the image side down to the copper side. Then we needed to heat the Electric iron to the maximum temperature. After that, we dipped the PCB into the Etching solution (Ferric chloride solution, $FeCl_3$) for approximately 30 mins. The $FeCl_3$ reacts with the unmasked copper and removes the unwanted copper from the PCB. Thenceforth, we used pliers to take out the PCB after it has been printed on the copper.

- After finishing the connection, we started writing our code. We followed a simple criterion that uses the example codes we used at the beginning to make sure all of the sensors work and collected it in one code. We created an account on a site called IoT Analytics: ThingSpeak Internet of Things, and then created a channel with the name of our project. We used the channel ID to connect the readings of our sensor with the channel using the code.

Safety precautions

To make sure we are safe we have followed some rules which are listed below:

- Place the soldering iron in the holder when not in use.
- Always solder over a workbench.
- Never work on electronic equipment with wet hands or in wet areas.
- Wear safety glasses and gloves.
- Do not take out tools and equipment from the Fab Lab.
- Work in the presence of a lab supervisor.
- Do not touch things directly with your hands and avoid inhaling the emitted fumes.
- Wearing face masks during the test plan.
- Be careful while dealing with any heated material.

Section 3.2:

Test Plan

During the construction of the prototype, we made sure to meet the stated design requirement as follows:

- **Accuracy**

- We chose DHT 11 (Temp And humidity sensor module) with an accuracy of +- 2 degrees Celsius accuracy to meet our requirements which were +- 5 degrees Celsius accuracy.

- **Dynamic range**

- We chose the CCS-811 sensor with a range of measuring Eco2 (equivalent calculated Carbon Dioxide) from 400ppm to 8192ppm which met our design requirement range which was a range of 600ppm to 4000 ppm.

- **Build a relationship between CO2, and temperature**

- After the test plan was done. We found out that when temperature increases when we put it beside a hole that simulates the electricity production industry by making a closed system, and burning coal inside the system. In addition, to the increase in temperature, the carbon dioxide gas increases rapidly during the time of the test plan.

- After finishing the prototype, a test plan had been established to determine whether or not the prototype met the design requirements.
- As we know, the test plan is a very important step that told us if the project succeeds or not. To do the test plan we followed some steps which are:

1. We started by burning some coal and putting them into a glass box.
2. The glass box has a hole from the top; to simulate the industries that use burn coal, for instance, electricity production.
3. We put our IoT part beside the hole to get the most accurate results.
4. We calculated the rates every 17 seconds, and we conclude that when the temperature from burning increases, the CO2 rapidly increases.
5. We made sure to take more than 5 trials, to get the most accurate data, and graphs later.

Section 3.3:

Data Collection

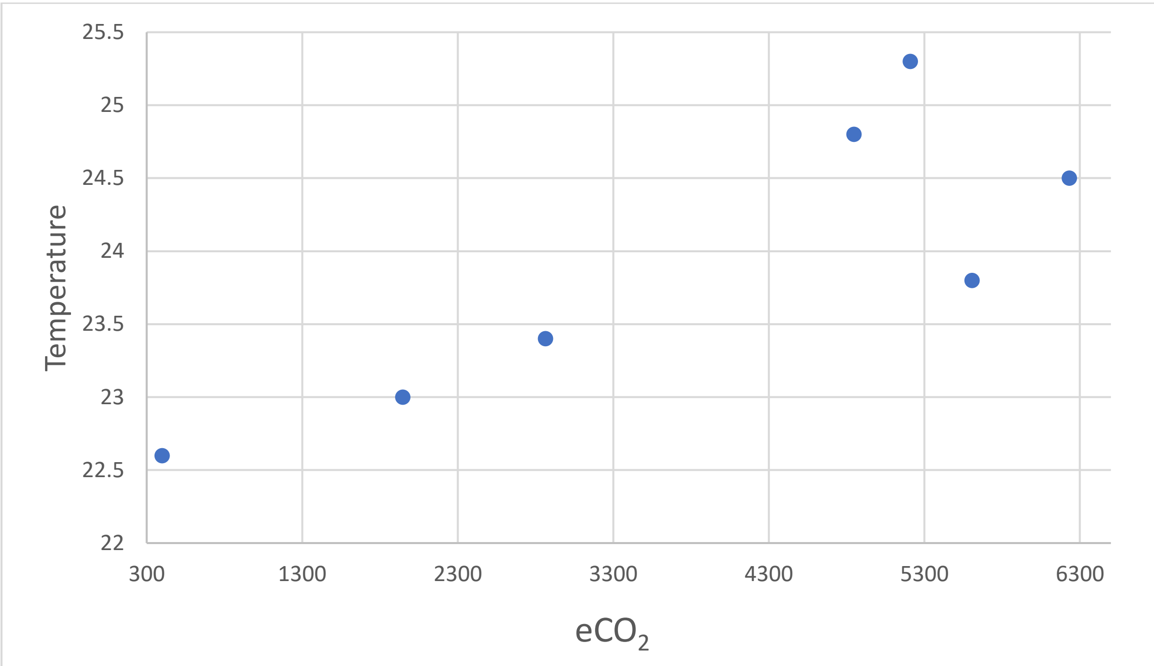
When we began testing our prototype in accordance with the plan that we devised. Calculate the results and measures needed to prove design requirements in order to measure the success of the prototype in seven different trials to ensure precision and accuracy.

We calculated the CO_2, and the temperature every 17 seconds after putting the sensors beside the hole to simulate burning coal inside factories

We collected data from Thing speak, during the test plan, and the following data have been collected:

Trial	*1*	*2*	*3*	*4*	*5*	*6*	*7*
CO2	400	1946	2864	5607	6232	4847	5211
Temperature	22.6	23.0	23.4	23.8	24.5	24.8	25.3

- From this table, we can conclude that our design requirements were achieved. The minimum value for CO_2 (X) was 400 ppm, and the maximum value was 6232 ppm. In addition to temperature minimum value was 22.6, and the maximum value was 25.3.
- We used DHT 11 to measure temperature with an error of +-1.5.
- Our rate was one trial per 17 seconds.



Based on the data gathered in table (2), we set out to fulfill our third design need, which called for establishing a relationship between eCO2 and temperature in order to forecast future values for the temperature. We plotted the data on a graph, designating the eCO2 (the independent) on the x-axis and the temperature on the y-axis(dependent), and concluded that CO2 and the increase in temperature are directly related.

The correlation (r) has been calculated to be 0.8352995789. From this value, we started forming the equation of the line of regression. The equation of the line of regression will meet our design requirement as it provides a scientific calculation for identifying and predicting future outcomes. Using the outcomes, the line of the regression equation is: $22.434\boldsymbol{X}+3.8235391\times10^{-4}$

04

Evaluation, Reflection, and Recommendations

:

Graph 1

Section 4.1:

Analysis and Discussion

Climate change is one of the most serious problems facing the planet. By looking at the outputs of the industries, we found that power generation from burning coal is the most contributing to carbon dioxide emissions and an impact on the climate.

Therefore, using the Internet of Things, we have decided to develop a solution as follows: we created a device that measures the relationship between carbon dioxide produced by factories, and the amount of temperature change. After testing and analyzing the results of our system, we found that the solution achieves the design requirements which are:

- Accuracy: We chose DHT 11 (Temp And humidity sensor module) with an accuracy of ±2 degrees Celsius accuracy to meet our requirements which were ± 5-degree Celsius accuracy.

- Dynamic range: We chose CCS-811 sensor with range of measuring eCO_2 from eCO2 from 400ppm to 8192ppm which met our design requirement range which was range of 400ppm to 4000 ppm.

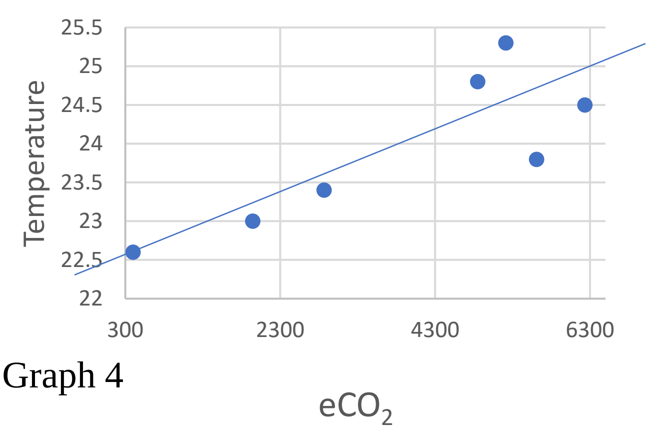
- Constructing prototype testable, and based on IoT system.

- Building a relationship between one independent variable and a dependent variable that causes climate change: the main goal of our project is to study the changes in CO2 and temperature concerning time in a simulated environment to predict a relation between them.

The most commonly used techniques for investigating the relationship between two quantitative variables are correlation and linear regression. Correlation quantifies the strength of the linear relationship between a pair of variables. The data can be represented by the ordered pairs (x, y) where x is the independent variable, and y is the dependent variable. The independent variable is the cause, whereas, the

the effect, its value depends on changes in the independent variable.

In our study, we represented the change in CO2 as the independent variable -i.e. the cause-, while in contrast, the temperature is the dependent variable. We started by representing the data of the testing phase on a scatter plot (as shown in graph 2) which can be used to determine whether a linear (straight line) correlation exists between two variables.



Graph 4

After representing the x and y variables, we begun calculating the correlation coefficient. The correlation coefficient (r) is a measure of the strength and the direction of a linear relationship between two variables.

The symbol r represents the sample correlation coefficient. The range of the correlation coefficient is -1 to 1. A relation is called significant if is between the range of [0.5:1] or [-1:-0.5]

The formula for r is:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

Where:

r=correlation coefficient,

x=values of the x-variable in a sample, y=values of the y-variable in a sample, n=number of pairs of data

x	y	xy	x^2	y^2
400	22.6	9040	160000	510.76
1946	23.0	44758	3786916	529.0
2864	23.4	67017.6	8202496	547.56
5607	23.8	133446.6	31438449	566.44
6232	24.5	152684	38837824	600.25
4847	24.8	120205.6	23493409	615.04
5211	25.3	131838.3	27154521	640.09
$\sum x$ =27107	$\sum y$ =167.4	$\sum xy$ =658990.1	$\sum x^2$ =133073615	$\sum y^2$ =4009.14

Consequently, with table 2, we got the value of r, which has been found to be= 0.8352995789

The value indicates that is a directly strong, also called significant, between the eCO2 and temperature. Hence, after verifying that the linear correlation is significant, we determined the equation of the line that can be used to predict the temperature for a given value percent of eCO2.

The equation formula of a regression line is: ŷ=ax+b

where ŷ is the predicted y-value for a given x-value, a is the slope, and b is the y-intersect.

To get a and b, we used the following formulas:

$$m = \frac{n(\Sigma xy)-(\Sigma x)(\Sigma y)}{n(\Sigma x^2)-(\Sigma x)^2} \qquad b = \frac{\Sigma y - m(\Sigma x)}{n}$$

According to our o utcomes, we calculated a and be to be: a= 22.43364751, b=3.823539088×10-4

In the end, the equation of the regression line is: 22.434X+3.8235391×10-4

Code:

We started the code by including the required libraries, defining our variables, and the pins. We also connected the ID of ThingSpeak with the code to collect the readings of the sensors. We set the receiving time to every 17 seconds as shown in fig 1.

In the Setup Void, we made a function to check the internet connection, it is responsible for sending messages to the serial monitor with the name of the network, and the device IP. It is not necessary for the code, and nothing depends on it. Then the loop will check for the time to keep reading as long as the program is running as shown in fig 2.

The readSensor function gives the variable t for temperature, co2 for eCO2, and readings as shown in fig 3. In fig 4, we represent the ThingSpeak code. It first starts getting the readings on the right field of the chart. Then, it prints it on the graph.

thingspeak_code §

```
String myAPIkey = "9M6HXVMIKI7FKCII";

long writingTimer = 17;
long startTime = 0;
long waitTime = 0;

unsigned char check_connection=0;
unsigned char times_check=0;
boolean error;

#include "DHT.h"
#define DHTPIN 11
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);
float t;

int measurePin = 0;
int ledPower = 7;
int samplingTime = 280;
int deltaTime = 40;
int sleepTime = 9680;
float voMeasured = 0;
float calcVoltage = 0;
float dustDensity = 0;

//ccs_811 library
#include "Adafruit_CCS811.h"
#include <Adafruit_I2CDevice.h>
Adafruit_CCS811 ccs;
int co2;
```

Picture 1

thingspeak_code §

```
void setup()
{
  Serial.begin(115200);
  startTime = millis();
  Serial.println("AT+RST");
  delay(2000);
   while(check_connection==0)
  {Serial.print("AT+CWJAP=\"menna\",\"menna156\"\r\n");
   Serial.setTimeout(5000);
 if(Serial.find("WIFI CONNECTED\r\n")==1){break;}
 times_check++;
 if(times_check>3){times_check=0;}
  }

  ccs.begin();
  pinMode(ledPower,OUTPUT);
  dht.begin();

}

void loop()
{
  waitTime = millis()-startTime;
  if (waitTime > (writingTimer*1000))
  {
    readSensors();
    writeThingSpeak();
    startTime = millis();
  }
}
```

Picture 2

thingspeak_code §

```
void readSensors(void)
{
   t = dht.readTemperature();
   if(ccs.available()){ccs.readData();co2=ccs.geteCO2();}

  digitalWrite(ledPower,LOW); // power on the LED
  delayMicroseconds(samplingTime);
  voMeasured = analogRead(measurePin); // read the dust value
  delayMicroseconds(deltaTime);
  digitalWrite(ledPower,HIGH); // turn the LED off
  delayMicroseconds(sleepTime);
  calcVoltage = voMeasured * (5.0 / 1024.0);
  dustDensity = 170 * calcVoltage - 0.1;
}
```

Picture 3

thingspeak_code §

```
///////////////////////////////////////////

void writeThingSpeak(void)
{
  startThingSpeakCmd();
  String getStr = "GET /update?api_key=";
  getStr += myAPIkey;
  getStr +="&field1=";
  getStr += String(t);
  getStr +="&field2=";
  getStr += String(co2);
  getStr +="&field3=";
  getStr += String(dustDensity);
  getStr += "\r\n\r\n";
  GetThingspeakcmd(getStr);
}
```

Picture 4

\

Section 4.2:

Recommendations

We suggest the following for the project's upcoming work:

• To help reduce carbon impact it is recommended that all new Terp carbon powered sensors be supported, to reduce energy consumption and generate renewable energy on site and perform closed- circuit measurements of carbon consumption and waste.

• Replacing certain sensors with ones that are more efficient. For instance: The DHT22 temperature sensor, which has a wider dynamic range, can replace the DHT11 temperature sensor.

• We recommend using PCB instead of traditional wiring. A printed circuit board can contain a number of parts and elements because they utilize copper tracks rather than actual wires, it allows for the same types of results without using current-carrying wires. The boards are less substantial and smaller.

• As we mentioned previously, the problem of electricity production from coal combustion produces many greenhouse gases, including carbon dioxide, PM, and NO_x. In our project, we studied the carbon dioxide variable. We intend to investigate more influencing factors and build more correlations in order to further the research.

- **Learning outcome**

CH3.01	According to the basic steps of the scientific method, we can learn the steps we take to solve our challenge concepts of uncertainty and precision, Helping calculate values accurately. Comparison of quantitative analysis and the qualitative analysis helped to define the loneliness and loneliness parameters.
CH.3.02	Emphasis on studying the basic laws of chemistry, for example: Conservation of mass and conservation of energy, it is concluded that the gases coming out of the prototype should be equal to or slightly less than the input coal a definite ratio law and a multiple ratio are required in the calculation of values.
CH.3.03	Learn the molecular collision theory that is used to predict the rates of chemicals. The interactions, especially for gases, can help in understanding the mechanism of the sensors. By knowing how electrons move and their kinetic energy.
PH.3.4	The basic elements of communication help to understand communication the system. For example, an antenna can act as a transmitter and receiver Like a mobile app. The types of wave propagation (earth, sky, space) were most useful in it Determine the transmitted signal.
PH.3.5	learned the two types of modulation (frequency modulation amplitude modulation), they can be distinguished because AM differs in length wave but FM differs in wave energy. In addition, digital comparison with analog the digital number is a specific value but the digital number is a range Value. Study Wi-Fi and how it works. Sampling and quantity coding process.
EN3.01	We learnt how to write native essays that help us to write the poster and the portfolio
ST 3.02	We have studied regression analysis. The benefit of regression analysis is that it can be used to understand all kinds of patterns that occur in the data. That helped us understand what could make a difference to our results.
BI3.01	According to the study of the nervous system and its similarity with communication system, and concluded that the structure of neurons (structural and functional unit) are very similar. It depends on the representation (transmitter) to the receiver, hub (medium), and terminals (receiver). The It's like adapting every bit of sensor code and all-or-nothing laws as well.
MA3.02	Studying the rate of change in time helps us to know and calculate the amount of change in a particular value with respect to other value.
HU3.01	It helped us in identifying the most harmful industries that humans do to the environment and produce carbon dioxide, which made it easier for us to choose the industry that we will work in.

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