ReEn

Green Waste Management Solutions using Artificial Intelligence Technologies

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CHAPTER 1

Introduction

1.1 Energy and Existence

Energy is one of the forms of existence in this universe until eternity, It is one of the basics of life for humans around the world. A person cannot live his full life in darkness. He must see at least sunlight, which is also energy. So, we all agree that energy is a source of life on planet Earth, and it must be provided in a sustainable and uninterrupted manner.

1.2 Energy Sources

To this day, specifically in the twenty-first century, all countries of the world are working to provide energy sources so that they do not disappear from the map, and this matter seems very difficult for everyone, especially with the wide economic growth and the competition of the countries of the world to become major industrial countries, as well as the increasing population growth at an unpredictable pace. For some countries, all this places the countries of the world in a great challenge to provide more sources of energy or alternative energy.

1.3 Factors Affecting Energy

Providing energy sources needs to control many influencing factors. Carbon dioxide is one of the most important factors that negatively affect energy production and threaten human life. According to a recent study prepared by researchers from the American Duke University [1], approximately 153 million people may be exposed to the risk of premature death during this century due to Carbon dioxide emissions, which are estimated according to the latest statistic for this year 2020, that its concentration in the atmosphere amounted to 414.38 parts per million, which is 8 parts higher than it was in 2017, according to a statistic published by NASA [2], and these lives can be saved. Humanity whenever we can reduce its percentage as much as possible, but studies indicate an increasing percentage of concentration is increasing annually unless countries of the world take various measures to reduce this percentage. This is confirmed by the reports of the World Health Organization that there are more than 1.7 million children who die annually due to air pollution and dangerous emissions in the atmosphere [3]. This occurs mainly due to the production of energy from non-renewable sources such as oil, fossil fuels, natural gas, and others. Also, the high concentration of carbon dioxide leads to an increase in weather temperatures due to the global warming process.

1.4 Renewable Energy Sources

Until a late decade, most of the non-developing countries still relied on non-renewable sources for energy production, while developing countries began to search for other alternative sources of energy that might be safer for human life and the environment, even if that was more expensive in the beginning. But human life on this earth is priceless. That is why many countries have set plans to increase the proportion of their production of renewable energy so that they cover their energy needs by 20% of their consumption for this year 2020. [4] At the outset of those countries, the Kingdom of Saudi Arabia, in its future vision 2030, developed a strategic plan to be among the global competitors in the field of renewable energy, due to the presence of strong assets that would help it in this, especially in the field of solar energy and wind energy. [5]

1.5 Renewable Energy Challenges

Countries face many challenges in storing and distributing renewable energy, especially wind and solar energy, and climate and weather fluctuations are a very influential factor in generating wind and solar energy, so frequent air turbulence will be a negative factor on the quantities of energy that will be produced through the sun or wind. , Other than the very high cost that requires the construction of their own stations.

1.6 Renewable Energy Sources

Recently, many developed countries have turned to another unique type of renewable energy, which is waste, which is a neglected wealth in most countries of the world. Most countries have not turned to the process of recycling waste and converting it into energy, organic fertilizer and other raw products because the issue seems complicated and expensive, as they say, but it may seem otherwise, given the advantages of converting waste into a renewable source of energy, we will find that it has many advantages. The main ones are:

1- The amount of waste available daily is very large, which means getting large quantities of the resulting energy as well.

2- The daily availability of waste increases with the increase in population density, which means that it will not be affected by any disturbances that affect the quantities of energy produced.

3- The process of burning waste and converting it into energy, organic fertilizer and other raw products, will lead to a clean, healthy and safe environment, as well as a significant reduction of hazardous emissions in the atmosphere, which lead and thus lead to the preservation of the lives of millions of people.

4- Reducing the percentage of consumed waste for recycling by 90% instead of burying it in landfills.

5- Protecting the lands used for landfilling from soil pollution or harmful emissions inside them, which may also cause corruption, rendering them unfit for construction or agriculture.

6- Reducing the areas used for landfilling and using them in the urban field instead of landfilling in them.

Therefore, countries such as Sweden saw that completely recycling waste and converting it into energy, organic fertilizer and other raw products is an ideal solution, not only to get rid of it, but to supply its cities with energy instead of other energy sources, so Sweden was the first country in the world to reach the saturation stage. In recycling waste, so they decided to "import waste" from neighboring countries, and the trash bin became an essential part of generating energy in Sweden.[6] If according to what has been mentioned, waste will be a basic and important source on which many countries of the world depend.

1.7 NEOM Energy Vision

That is why NEOM has placed in its strategic vision the reliance on building renewable energy sources of high capacity and efficiency, as the city of NEOM will depend 100% on renewable energy, which will make it a green, vital city, free of carbon emissions, and it depends heavily on its geographical location. This will make it a global city capable of developing clean energy sectors and leading the global trend in this field, and one of those sources that NEOM will depend on in generating renewable energy is waste.[7]

But in addition to all of the above, one of the most important factors influencing the environment from waste, recycling and converting it into energy, organic fertilizers and other raw products is community awareness and the use of high-capacity technologies that support to provide best practices and obtain the best results is a very difficult challenge.

Smart cities such as NEOM, which will become a leading tourist destination for all countries of the world, will face a difference in cultures due to the diversity of the population from different countries of the world, and this may affect the application of a system such as systems for recycling waste and converting it into energy, due to the low awareness of some members of the local community, as well as society. Importance of international waste recycling. Therefore, we often notice in areas where the idea of separate waste containers has been applied a lack of commitment from some people, and throwing waste randomly without making sure that the type of waste matches the container allocated to it, and this was confirmed by a survey we conducted on a random sample of more than 500 people with an age group of 20 Up to 60, 21.6% of them said they had trouble deciding which type of separate container is for the waste they want to throw, while 25% said that they might encounter these problems with separate waste containers. [8] That's why we created the ReEn project. To be an ideal solution for NEOM in recycling waste and converting it into energy, organic fertilizers and other raw products, using high ability artificial intelligence technologies.

1.8 ReEn Solution

ReEn will find solutions to the aforementioned problems, providing an intelligent automation system for waste management and recycling processes.

The ReEn project is divided into 3 main sections:

1- The smart container, which is a container that works to separate the waste inside it automatically without the person having to separate it manually, and this greatly reduces the percentage of error that may occur when a person separates the waste by himself in separate containers (the traditional method).

The smart container mainly uses artificial intelligence techniques, specifically a machine learning algorithm called CNNs (Convolutional Neural Networks).

In order to identify all the elements entering the container and classify them, then a notification of the type of item is sent to a robot arm (automatic control stick), which in turn performs the separation process in addition to the presence of some other sensors that greatly reduce the presence of any error in determining the type of item.

The artificial intelligence technologies employed in the smart container will contribute to knowing very accurately the quantities and types of waste consumed, according to residential areas, commercial or industrial areas.

Knowing the quantities of waste is useful in analyzing the data of that waste and knowing the approximate quantities of energy that can be produced after the waste incineration process or the quantities of fertilizer that will be produced from foods over a different period of time. Logistic Regression Algorithm.

2- A network of pneumatic tubes extending under the ground, after the container identifies the elements, the robot arm separates the waste inside the container and places each item in the pneumatic suction tube for this item, whether those items are solid waste, or metal, glass, and paper Plastic, food, or liquids.

So each item will be separately inside its own tube, and these tubes will extend from smart containers to waste recycling plants, and during the process of passing waste from the container to the factory, artificial intelligence techniques will contribute to managing the waste traffic to ensure that no interference occurs in the pipelines distributed over The city as a whole, and to ensure that the waste density is distributed evenly on the pipelines throughout the 24 hours, depending on the amount of waste received from smart containers in each area of the city of NEOM, and the logistic regression algorithms, or CNNs, also contribute to this.

The waste then arrives at the final station in ReEn, the recycling plant, where the waste arrives ready to enter the recycling process directly without the need to separate it, and each type of waste enters its recycling rooms under certain conditions.

The artificial intelligence technology that is employed at this stage helps to control the conditions needed by recycling rooms and waste incineration, in addition to storage and supply.

Thus, at ReEn we fully automate waste management processes without the need for human intervention and to take advantage of it to convert it into energy, compost and other raw products.

NEOM will be the focus of the world's attention in the high-level technological progress and its employment in the production of renewable energy, so ReEn will become an ideal solution to manage and automate one of the most important sources of regular renewable energy around the world, which is waste.

CHAPTER 2

Background Review

2.1 Global Waste

2.1.1 Amount of Annual Consumed Waste

Waste is a problem if it is not dealt with properly due to its daily accumulation. The world's average annual production of waste is approximately 2.1 billion tons, including solid waste such as food residues, plastics and other waste, and the average waste produced per person per day is 0.74 kilograms. It is also expected that the annual amount of waste will increase to reach 3.40 billion tons by 2050.

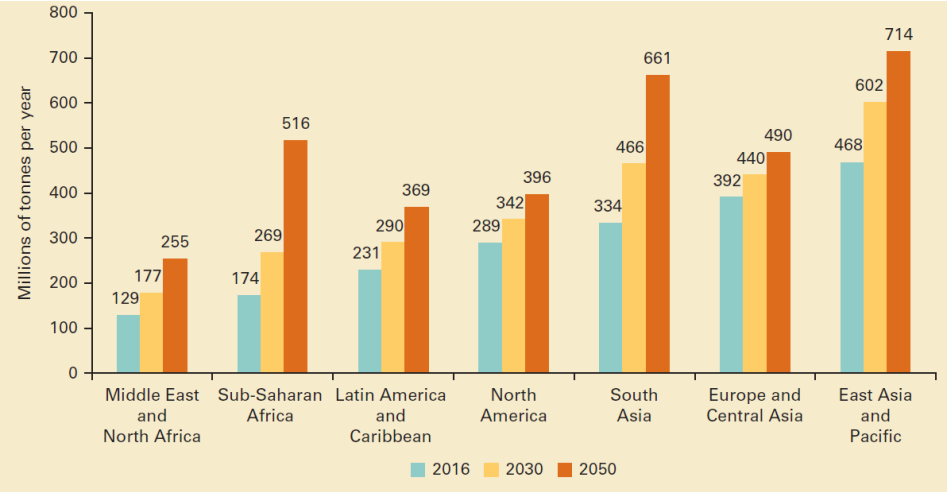

Figure-1: Waste production teams in different countries over the years.

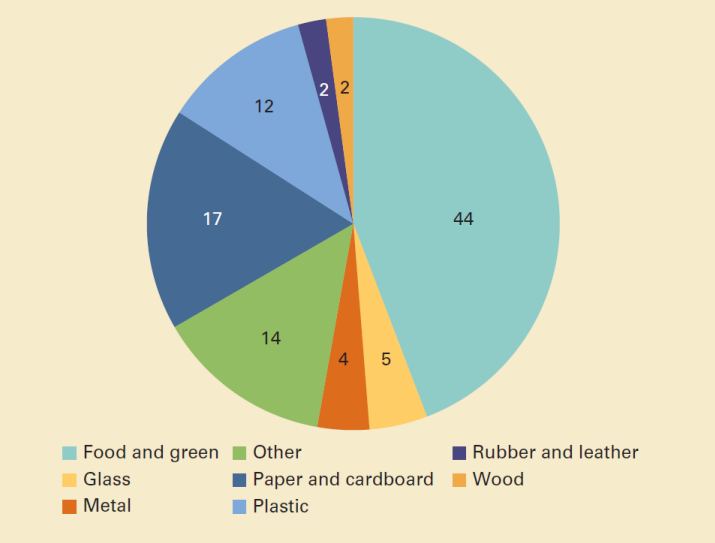

Figure-2: Division of waste quantities according to their type.

With this huge amount of waste, we must deal with it and use it as an energy source to benefit from it. [9]

2.2 Waste in the Kingdom of Saudi Arabia

2.2.1 Amounts of consumed waste annually

The Kingdom of Saudi Arabia produces approximately 15.3 million tons of waste annually, meaning at a rate of 1.8 kilograms per person, and the amount of waste is expected to increase to reach 30 million tons per year by 2033 due to the population increase by 3.4%. Food residue waste constitutes about 40% to 51% of this waste, while plastics is from 5% to 17%, glass residue is 3%-5%, wood residue 2-8%, textile residue 2-6% and iron residue 2-8%.[10]

2.3 Global Waste Recycling

2.3.1 Amounts of waste that are recycled annually.

The total of recycled waste reached 67.2 million tons, of which paper constituted 66%, and metals 12%, while plastic, glass and wood made up between 4-5%. The municipal solid waste converted to compost amounted to about 27 million tons, This included approximately 24.4 million tons of yard trimmings and 2.6 million tons of food waste. In 2017, 34 million tons of MSW were combusted with energy recovery. Food made up the largest component of MSW combusted at approximately 22 percent. Rubber, leather and textiles accounted for over 16 percent of MSW combustion. Plastics comprised about 16 percent, and paper and paperboard made up about 13 percent. The other materials accounted for less than 10 percent each. For more, visit the link.[11]

2.3.2 Methods of Waste Recycling.

There are several ways to recycle various waste. You can recycle paper by collecting and sorting according to its type, then cutting, kneading, washing and cleaning ink from the ink, and in the end it is dried for use again. For more, visit the link[12]. You can recycle plastic either mechanically or chemically, first the plastic is sorted according to its type, then the recyclable plastics are cut and all the impurities are removed from them and then they are melted. There are several things that happen after melting, but I will not go into more details. For chemical recycling, for some polymers, it is possible to convert them back into monomers, for example, PET can be treated with alcohol and a catalyst to form a diallyl terephthalate. Terephthalate distaste can be used with ethylene glycol to form a new polyester polymer, making it possible to use the pure polymer again. For more, visit the link[13]. As for the recycling of metals, it is done by collecting, sorting and smashing them into small pieces, then melting them, melting them, and then hardening them. To read more, visit the link[14]. And to recycle wood by cutting it and using it in compost or sawdust. It can also be made into chipboard. For more[15]. As for the recycling of glass, this is also done by assembling, melting and reforming it again. For more[16].

2.3.3 Recycling process products.

The products resulting from recycling are many, including aluminum cans - car bumpers - carpets - grain boxes - picture books - egg boxes - glass containers - laundry detergent bottles - motor oil - nails - newspapers - tissue paper - steel products - waste bags and so on.

Electric energy can be produced by burning waste that cannot be recycled to produce methane, and methane is used to produce electrical energy. Organic compost can also be produced by converting food waste into organic fertilizer using traditional methods.

2.4 Waste Recycling in the Kingdom of Saudi Arabia

2.4.1 Amounts of waste that are recycled annually:

Recently, the concept of recycling has gained wide attention in the Kingdom of Saudi Arabia, and that importance increased after the announcement of the Kingdom of Saudi Arabia 2030 vision, or as it is sometimes called (the post-oil plan), so the plan focused on relying very mainly on renewable energy sources, including recycling waste[17], so Saudi Arabia produces Approximately 15 million tons of solid waste per year, equivalent to 1.4 kilograms per person, and that number is expected to double by the year 2033 to reach 30 million tons per year with the remarkable population increase, and the waste recycling customer is still in the Kingdom Saudi Arabia is in its early stages, as only 10% -15% of total waste is recycled, and usually it is the non-governmental sector as well. [18]

2.4.2 Ways and methods of recycling waste:

In Saudi Arabia, garbage is collected from individual or community bins and disposed of in landfills or dumpsites. Saudi waste management system is characterized by lack of waste disposal facilities and absence of tipping fees. Most of the landfills are expected to reach their capacities within the next 10 years. Recycling, reuse and energy recovery is still at an early stage, although they are getting increased attention. Waste sorting and recycling are driven by an active informal sector. Recycling rate ranges from 10-15%, mainly due to the presence of the informal sector which extracts paper, metals and plastics from municipal waste.[19]

2.4.3 Recycling process products:

It is estimated that 45 thousand TJ of energy can be saved by recycling only glass and metals from municipal solid waste. This estimation is based on the energy conservation concept, which means xyz amount of energy would be used to produce the same amount of recyclable material. Similarly, a study on waste recycling benefits revealed that only by recycling glass, metals, aluminum and cardboard in Makkah city, climate will be saved from 5.6 thousand tons emission of methane with 140.1 thousand Mt.CO2 eq. of global warming potential (GWP). Furthermore, a net revenue of SAR 113 million will be added to the national economy every year only from Makkah city by only recycling glass, metals, aluminum and cardboard. [20]

The current waste management activities of KSA thus require a sustainable and integrated approach with implementation of waste segregation at source, waste recycling, and valuable material recovery. As a starting point, aluminum and polyethylene terephthalate (PET) bottle recycling in large urban cities like Jeddah, Dammam, Riyadh, Makkah and Medina will provide a long-term viable option for the country, as they will reduce the need for expensive raw materials and fossil fuels. [21]

2.5 Waste and its Impact on the Environment

2.5.1 The impact of waste on the environment:

The waste humans generate waste has been detrimental to our environment for quite some time now. Humans are generating too much trash and cannot deal with it in a sustainable way. Waste that is not biodegradable and cannot be properly recycled is filling our oceans and landfills. Let's take plastic waste as an example. A recent study found that of the 6.3 billion metric tons of plastic waste that has been produced, only 9% of that plastic waste has been recycled. In 2017, for instance, the Environmental Protection Agency calculated that the total generation of municipal solid waste in the United States just that year was 267.8 million tons. Compared with 2015 levels, it was a 5.7 million increase. All together, the amount of waste generated affects the environment in multiple ways: its contribution to the worsening climate crisis, its negative impact on wildlife and the natural environment, and its detriment to our very own public health. [22]

2.5.2 Climate Change:

The way we dispose of waste is troubling. What is worse, in this decade alone, it would seem that waste disposal has become more careless. What we have failed to do is to put into action the ideas we believe will help us mitigate or adapt to climate change. Case in point: the trash that is dumped in landfills releases methane gas. Taken one step further open landfills were found to represent 91% of all landfill methane emissions. The burning of large, open piles of trash in various parts of the world emits dangerous levels of carbon dioxide, a greenhouse gas that is heating up our planet. Researchers have calculated that approximately 40% of the world's trash is burned in this fashion, posing large-scale risks to both our atmosphere and the people that live near these burning sites.[23]

2.5.3 Wildlife Ecosystems

Vary widely from location to location. However, one of the most outsize consequences of our global waste problem manifests itself in relation to our marine life and waterways. Simply put, it affects the people who depend on the ocean for their livelihoods. They cannot distinguish between what is or isn't food. They consume the trash, which results in death because the aquatic animal could not process it. This affects fish, seals, turtles, whales, and many other aquatic animals, as scientists have also found many plastic fragments in over a thousand species. Due to ingestion of trash or plastics, starvation is usually the next step because some species do not have high acidic levels in their stomach to break down the object that they ingested. There are some animals that do but plastic fragments have been known to be able to last 100 years. When it comes to biodiversity, our waste problem is severely plaguing the health of the world's species. Public Health Human health is at risk through our inaction. We keep producing large amounts of trash, we do not dispose of it correctly, and in the end that will be our downfall as it is for the environment and wildlife in the ecosystems we all share. We cannot prevent or promote longevity with how we treat our Earth. The more emissions that we produce due to how much trash we generate, affects us long term. One can develop diseases such as asthma, birth defects, cancer, cardiovascular disease, childhood cancer, COPD, infectious diseases, low birth weight, and preterm delivery. Bacteria, vermin and insects can also be added to the problem that trash causes.[24]

2.5.4 Serious damages caused by hazardous wastes:

Hazardous waste affects tremendously on the environment, as it destroys many natural resources due to its effect on green spaces and agricultural soil, making polluted soil unfit for agriculture or construction.

The effect of hazardous waste extends to water as well, as the chemicals from which the hazardous waste is formed decompose inside the soil and seep into rivers, valleys and lakes, making polluted water unsuitable for use, drinking or agricultural purposes, causing animal disease or may affect the health of the human being who lives. In areas of these estuaries, it may lead to chronic diseases and cancers that kill humans, especially children in the growth stages.

Solid waste also greatly affects atmospheric pollution, due to the increase in the concentration of carbon dioxide released by industrial waste, fossil fuels, and others, and this leads to the destruction of the ozone layer in the atmosphere, which leads to a rise in the earth's temperature.

All this contributes to the fragility and instability of the ecosystem.

2.6 Why ReEn Solution

6.1 How ReEn agrees with and supports Neom's vision

According to its vision in the energy sector, NEOM will rely on renewable energy (clean energy) by 100%.

It will also be the most advanced energy center in the world, and the first in the world to develop an integrated renewable energy system on a large scale.

Therefore, the ReEn System project option would be an ideal and supportive of NEOM's vision for leadership in renewable energy, supporting the global ecosystem to be safer and more stable. [25]

6.2 ReEn impact on the circular and sustainable economy

Recycling waste and converting it into energy, organic fertilizer and other raw products will be an important economic source for the city of NEOM, instead of its importance in terms of the environment, it will be a stable source of income for the city, which will become a global tourism center for all countries of the world, as the rate of consumption in Neom will be high in exchange for that. The consumed resource will become a long-term circular economy in supplying the city with energy and other resources. This means that the value of products and materials will be preserved for as long as possible at the end of their life by recycling them again and again to create additional value.

CHAPTER 3

Existing Models

3.1 Recycling Technologies Used Worldwide

Model (I)

3.1.1 (I) Technology:

Sweden is considered one of the countries with a great culture of environmental protection, with the awareness of its people and citizens throwing waste in the right place. The plastic is placed in an alien container, the glass is placed in another container, and so on with each type of waste. This waste is dealt with and separated into two parts, a section that can be recycled and a section that is not recycled. What is not recycled is burned to convert its combustion energy into electrical energy that serves 250,000 homes in the country. As for those that are recycled, they are recycled by known methods and converted into new materials to be used and used again [26].

3.1.2 (I) Features:

1- Waste disposal.

2- Making waste a source of energy rather than an environmental crisis.

3- Reducing the cost of electricity used in the country.

3.1.3 (I) Disadvantages:

Reliance on electrical energy resulting from burning waste that is not recycled may cause an electricity crisis. As the amount of waste generated per day is not constant, the waste in this month may be small and the electricity generated from burning it will be low, which causes an electricity crisis.

Model (II)

3.1.1 (II) Technology:

Japan is also an environmentally committed country, the town of Kamikatsu is the simplest example of environmental commitment, and it is a small town located in the mountains, which makes implementing the waste recycling system used in cities difficult. Simply, townspeople classify the waste into 34 categories, and then it is transferred to recycling centers, where 90% of the waste is recycled. The city aims to recycle 100% of the amount of waste in the coming years.

As an example of benefiting from recycling in Japan, there are medals for the Tokyo Olympic Games, which are mainly metals that have been recycled and used again [27].

3.1.2 (II) Features:

1- Preventing waste accumulation.

2- Maintaining the cleanliness of the town.

3.1.3 (II) Disadvantages:

Recycling materials requires energy, so if you want to recycle all the daily waste, a lot of energy will be consumed.

3.2 Recycling Technologies Used in KSA

3.2.1 Technology

While some of these measures involve greater education and support for recycling in the home, many of them are in direct support of Cleantech investments and the exploration of innovative new green waste management solutions. Saudi Arabia as the largest waste generator in the region (15 million metric tons a year that will double by 2033). Much of Saudi Arabia's solid waste is food and organic, followed by paper and plastics. It is worth mentioning that municipal solid waste is collected from individual or community containers and disposed of in landfills or dumpsites. Recycling still at an early stage Recycling, reuse and energy recovery are still at an early stage, although they

are getting increased attention. Waste sorting and recycling are driven by an active informal sector. Recycling activities are mostly manual and labor intensive. Composting is also gaining increased interest in Saudi Arabia due to the high organic content of MSW (around 40%). Responding to this growing issue, the Public Investment Fund (PIF) is planning to create the Saudi Recycling Company (SRC), a waste management body that will be empowered to set up and support domestic recycling projects across the country. Currently, Saudi Arabia only recycles around 10% of its waste, the government aims through the SRC to increase this ratio to hit 85% as part of its national strategy called Vision 2030. The government wants to develop 3GW of waste-to-energy facilities by 2030, to manage Saudi Arabia's solid waste, contribute to its base load electricity and to diversify its energy. This development provides an excellent opportunity for Swiss companies in the cleantech- and waste-management-sector.

3..2.2 Features

1- Diversion of 100% of solid waste from landfills.

2- Recycling 81% of that waste.

3- Converting 19% of waste to energy.

3.2.3 Disadvantages

1- The lack of a clear plan for recycling waste.

2- Difficulty sorting huge amounts of waste in recycling factories.

3- Lack of community awareness of the importance of recycling, which makes them not interested in putting waste in the containers designated for it.

3.3 Recycling Technologies Used in ReEn

3.3.1 Technology

It is an ideal solution for NEOM in recycling waste and converting it into energy, organic fertilizers and other raw products, using high ability artificial intelligence technologies.

ReEn will find solutions to the aforementioned problems, providing an intelligent automation system for waste management and recycling processes.

The ReEn project is divided into 3 main sections:

1- The smart container, which is a container that works to separate the waste inside it automatically without the person having to separate it manually, and this greatly reduces the percentage of error that may occur when a person separates the waste by himself in separate containers (the traditional method).

The smart container mainly uses artificial intelligence techniques, specifically a machine learning algorithm called CNNs (Convolutional Neural Networks).

In order to identify all the elements entering the container and classify them, then a notification of the type of item is sent to a robot arm (automatic control stick), which in turn performs the separation process in addition to the presence of some other sensors that greatly reduce the presence of any error in determining the type of item.

The artificial intelligence technologies employed in the smart container will contribute to knowing very accurately the quantities and types of waste consumed, according to residential areas, commercial or industrial areas.

Knowing the quantities of waste is useful in analyzing the data of that waste and knowing the approximate quantities of energy that can be produced after the waste incineration process or the quantities of fertilizer that will be produced from foods over a different period of time. Logistic Regression Algorithm.

2- A network of pneumatic tubes extending under the ground, after the container identifies the elements, the robot arm separates the waste inside the container and places each item in the pneumatic suction tube for this item, whether those items are solid waste, or metal, glass, and paper Plastic, food, or liquids.

So each item will be separately inside its own tube, and these tubes will extend from smart containers to waste recycling plants, and during the process of passing waste from the container to the factory, artificial intelligence techniques will contribute to managing the waste traffic to ensure that no interference occurs in the pipelines distributed over The city as a whole, and to ensure that the waste density is distributed evenly on the pipelines throughout the 24 hours, depending on the amount of waste received from smart containers in each area of the city of NEOM, and the logistic regression algorithms, or CNNs, also contribute to this.

3- The recycling plant, where the waste arrives ready to enter the recycling process directly without the need to separate it, and each type of waste enters its recycling rooms under certain conditions.

And the artificial intelligence technology that is employed at this stage helps to control the conditions needed by recycling rooms and waste incineration, in addition to storage and supply.

3.3.2 Features

1- Replacing the traditional waste separation method in several containers and replacing it with one smart container in which the waste is separated.

2- Reducing error in waste separation by 90% using machine intelligence, in contrast to frequent errors when separating waste manually.

3- Collecting all waste within a single source, which makes it easier to collect data for all types of waste and predict the quantities of energy that will be extracted, compost and other products after the recycling process.

4- Saving time and effort when re-sorting waste in the factory.

5- Eliminate waste transport trucks from garbage containers to recycling factories, in order to contribute to reducing air pollution, supporting a green environment free of carbon emissions sources, in addition to saving budgets allocated to cleaning companies.

6- Utilizing the infrastructure in building a network of pneumatic tubes to transport waste in a smooth, fast and regular way to transport waste to recycling factories in a safe and stable manner.

7- Employing artificial intelligence techniques in automating waste recycling processes within recycling factories and controlling their own conditions.

8- ReEn will be an ideal system in preserving the green environment, generating sustainable energy and circulating the circular economy, only by automating waste management processes through artificial intelligence and machine learning techniques.

3.3.3 Challenges

1- Providing the necessary requirements for the implementation of the project with the highest possible quality and international standards that suit the quality of living in Neom.

2- Building a strong pipeline infrastructure to support the natural conditions of the earth.

3- Fully employing artificial intelligence techniques in reducing the error rate as much as possible.

3- Getting good results in the beginning when implementing the project.

4- The residents and visitors of NEOM interact with the system and adequately absorb its working mechanism and raise awareness of the importance of preserving the green environment and reducing the amount of damage caused by waste, in exchange for recycling and benefiting from it.

CHAPTER 4

Requirements Analysis

4.1 System Requirements

ReEn system will require:

1- Complete information about Neom areas in detail, such as commercial, industrial, recreational, and natural residential areas.

2- Knowing the average capacity of the population in the city, and the periods of time during which the population density increases annually.

3- Information about the nature of the soil and the infrastructure of the city of NEOM and its susceptibility to the supply of air pipelines.

4- The need to know the consumer resources that will be allowed in the city of Neom from the types of plastics, metals, glass, paper, food and other consumer resources to the residents of Neom.

5- Knowing the nature of the city's terrain from winds, sunshine and rain for all seasons of the year.

6- Information about the urban nature of the city of Neom in terms of building architecture, heights, numbers and types.

4.2 Requirements Analysis

Through the strategic plan developed by the implementing agency of the NEOM project, a number of basic requirements can be made to start implementing the project in terms of the total area of the city, as it has an area of 26,500 km2 and extends about 460 km on the Red Sea coast. [28]

The geographical location of Neom is also unique, as it is cooler than the surrounding areas, as the temperature in it is about 10 degrees Celsius lower than the average temperatures throughout the countries of the Gulf Cooperation Council, and this phenomenon is due to the mountainous nature of the areas surrounding the city, in addition to According to the incoming wind currents, the fact that the city is located in the north of the Kingdom of Saudi Arabia, and NEOM is rich in continuous solar wealth (20 megajoules / square meter per day) and an ideal wind speed (an average of 10.3 meters / second). [29]

4.3 ReEn Stockholders

According to an opinion poll we conducted on a local random sample of 563 people, of whom 28.1% said that people are not committed to the concept of separating waste and placing it in the places designated for it, and this is a very large percentage.

On the other hand, 36.6% said that people may be committed to throwing waste. In the places designated for it, and the rest said yes, that all the people who dealt with them are committed to implementing the process of separating waste and throwing it in the right place designated for it.

On the other hand, 23.6% of the same previous sample said that they are sometimes unable to determine the correspondence of the type of waste with the container in which they should throw that waste.

Therefore, 83.5% of the same sample said that they prefer to have a smart container that separates waste on its own without human intervention, in order to avoid human errors that occur when separating it manually, and 77.4% said that the idea of a smart container will be very effective when applied instead of From the traditional waste separation method.

And 70.9% of that sample said that they believe that separating waste via a smart container may be a faster source of renewable energy generation instead of the traditional method.

A ratio of 37.3% of the previous sample confirmed that it is possible for a city in the Kingdom of Saudi Arabia to rely on waste as a primary source of energy generation.

On the other hand, the government of the Kingdom of Saudi Arabia, in its future vision 2030 and specifically in NEOM's strategy, seeks to rely completely on renewable energy, especially solid waste energy, as it believes that waste will cost it a lot when disposed of by traditional methods, unlike if it is invested economically and healthily.

CHAPTER 5

Design

5.1 The Problem

5.1.1 Waste in Saudi Arabia

In Saudi Arabia, waste is dealt with by distributing yellow waste containers in residential neighborhoods and public streets to throw waste into them, and it is collected in waste transport trucks that collect waste from these containers periodically and transfer it to a landfill where it is handled there. There is another way to deal with waste, where there are several containers, each container with a different color and each container designated for a specific type of waste, which is also transported in trucks that transport waste to the landfill. This can cause some problems. For example, the container may be filled before the start of the periodic movement of the waste transport truck, causing waste to accumulate at the container and stinking odors in the street, causing environmental pollution. As for the designated containers, each type of waste may face a problem, which is when the citizen comes to throw a garbage bag that contains a glass box, some papers and some plastic boxes, he will often not open the bag and take out each type and throw it into its appropriate container. Rather, he will throw it in a container to make it easier for himself. This is what has to be dealt with in this project.

5.1.2 Recycling and environmental pollution

Recycling is one of the most important stages of waste management. Because it helps to make use of most of the products several times, and this saves us from manufacturing new products after each use.

Most of the waste can be recycled, for example, plastic can be recycled and used as a bottle of water or juice to refill it again. Or, for example, glass you can recycle to make cups and saucers. You can recycle metals and make them, for example, Olympic Games medals. But there are materials that cannot be recycled, such as plastic and metal containers such as cat food packages, coffee cups, shredded paper and other materials. Leaving this waste in a landfill causes environmental pollution. The Natural Resources Council of Maine website also mentioned that environmental pollution is one of the most important causes of global warming.[30]

5.2 Outcomes, Objectives, and/or Deliverables

This project is designed to solve many problems, including:

1- Problems with accumulation of waste and the exit of stench from exposed containers.

2- Environmental pollution problems from waste analysis and the rise of harmful gases in the air.

3- Problems with difficulty separating waste in the factory for recycling.

4- Problems of accidentally dropping personal items in the container, dealing with waste that is not recycled by converting it into energy rather than leaving it in a landfill.

5.3 Stakeholders

ReEn serves citizen users. Where he helps the citizen to facilitate the throwing of waste without worrying about its separation or accumulation and the spread of its smell, and he has contributed to the recycling cycle. It also serves the government, by saving the government the costs of many expenses, such as: the costs of the waste transport truck where waste is transported through lined underground tubes, the salaries of the cleaners where there will be a strict regime for those who throw waste in the wrong place, effort and energy in recycling where The waste is transported to the factory and is separated from each type of waste separately, it saves energy as the container works through solar energy, helps to produce organic fertilizer by converting food residues into fertilizer, generating enormous electrical energy by burning waste that is not recycled and producing methane gas And converting it into electricity that serves government departments and citizens, helps to record statistics in the presence of a data analysis center to collect and analyze data, record statistics and know the quantities of waste left over daily. And many other services.

5.4 Target Spaces

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5.5 Risks, Constraints, and Assumptions

ReEn is a system that facilitates the separation of waste from the container and the transfer of waste through underground pipes to the factory to start the recycling process. However, many problems or risks can occur in this system, for example a person can throw dangerous tools into the container. To deal with this, the devices inside the container recognize the type of material dumped in the container and know the level of danger, so it sends a notification to the data analysis center that there is something wrong in the container with the specified number so that the competent authorities can take the necessary measures about it. Pipes blockages and waste accumulations can also occur, slowing or disrupting the movement of waste to the factory. To solve this problem, a special robot was installed that checks the tube periodically and checks for the absence of obstacles, and if there are obstacles, it removes and disposes of them. A small chamber on the side of the tube is designated for the robot, from which it exits at the time of its rotating movement, performs its function and then returns to this chamber. One of the dangers of the recycling plant is the rise of harmful gases resulting from the incineration process. Therefore, there must be a system that deals with these fumes in the right ways to preserve the cleanliness of the environment.

5.6 Estimated Cost

As for the expected cost, ReEn can find the average price of the most important devices used in it. RFID tag is just a label to be placed on the products and each product has its own wavelength, each product is recognized by an RFID reader. Where he identifies the type of product by radio ray. The average price of the RFID tag is 0.0667 USD. The average price of a RFID reader is 1186.5 USD. As for the Flat Panel, it is used to identify the presence of sediments inside the garbage cans or bags. Its average price is approximately 10,000 USD. As for the robot's hand, its task is to carry out the tasks according to the data obtained from each waste and put it in its correct place, and its price is approximately 2,700 USD. Source X-ray enhances Flat Panel work, as Flat Panel detects if the bag contains sediment or not. Source X-ray identifies this type of sediment as either sandwich residue or so on. The average price for the Source X-ray is 665 USD. We will also need a Metal & electronic Nano Spray to isolate water from electronic devices and protect them from damage when starting the cleaning process inside the waste. The Ultrasonic sensor is a sensor used to find out if a container is nearing full or not. To transfer the waste to the factory and prevent its accumulation and the exit of its smell. The average price is approximately 5 USD. Of course, these prices are not accurate and may be more or less.

5.7 Approval and Monitoring Processes

ReEn is a huge system at the city level and contains a lot of data that is collected through daily waste, and to manage and monitor this data, a data analysis center responsible for with and organizing this data has been set up through a huge electronic cloud that allows remote control. It also allows controlling containers by knowing the number. Your container. The waste stream in the pipes can also be monitored by monitoring the data regularly sent by the sensors distributed over the pipes. Where the sensors receive the signal by capturing sound vibrations and heat, and thus the sensor knows the passage of waste at the point where it is and sends this information to the data analysis center. The data analysis center is able to know the location, quantity and time of the arrival of the waste, and sends a notice to the factory to prepare to receive this quantity.

5.8 Effectiveness

ReEn has a positive impact on the environment, as it prevents waste odors from escaping outside the waste, causing harm to people and the environment. He helps the beneficiary when throwing the waste. He does not separate the waste for each type separately and then puts it in a designated container. Rather, he puts all his waste in one container and this container is the one that separates the waste. It helps to dispense with waste transport trucks, which cause environmental pollution by spreading the smell of waste while they are transported, as well as pollution resulting from smoke emitted from them. It also helps to make use of products that can be recycled. And do not forget the importance of taking advantage of food leftovers and turning it into organic fertilizer instead of wasting grace and throwing it away. Also, products that are not recycled are treated by burning them at a certain temperature to convert them into methane. But this gas will not be left to pollute the environment. Rather, it will be converted into electrical energy to serve the city's residents.

CONCLUSION

ReEn hopes to be an integral part of participating in building that "dreamy" city as His Highness Prince Mohammed bin Salman called it.

The "City of Dreamers" will become a leading city in all aspects of life, attracting global tourism, a strong competitive economy, with a healthy green, refreshing and safe environment, 0% carbon emissions free, and 100% renewable energy, which ReEn will contribute to its production.

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