

# The Role of Renewable Energy in Reducing GHG Emissions

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**Abstract:** Energy demand is increasing rapidly in the world due to a lot of factors like industrialization, population growth. The primary energy source that fulfils this demand is conventional energy sources such as petroleum oil and coal. With the burning of lots of fossil fuels, substantial environmental pollution happens widely in the world, and the consequences of these can be catastrophic. One of the effects is climate changes that the world is experiencing in the present due to Green Gas Emissions (GHG). Using Renewable energy(RE) to replace fossil fuel burning is a trending solution for this matter. This paper focuses on the renewable types, the role of Renewable energy in reducing GHG Emission, how much potential in Sri Lanka as a developing country to reduce GHG emission and the problems facing when implementing RE in developing countries.

**Keywords:** Air pollution, Fossil Fuel, Greenhouse gas, Renewable energy.

## 1 INTRODUCTION

Green House Gas Emission has a huge impact on climate change, such as CO<sub>2</sub>, CH<sub>4</sub>, CFCs, halons, N<sub>2</sub>O [1]. The main GHG is the CO<sub>2</sub> and concentration of CO<sub>2</sub> in the air increasing rapidly due to a lot of factors. Fossil fuel plays a significant role in GHG emission. Power generation transportation industrial activities that burn fossil fuels contribute the increasing CO<sub>2</sub> concentration in the world that causes the temperature changes. Significant changes can appear in the global climate if the global temperature by 2 °C [2] such as global warming, melting ice in the arctic that raises the sea level and changes in climate pattern etc. One of a way to reduce fossil fuel is to use alternative energy sources such as solar, wind, biomass, tidal and geothermal energies. After the starting of climate changes in the world, this usage of these renewable energy sources has increased rapidly even though it is still growing little bit by bit. The studies that were conducted by a lot of researchers have proven that it is possible to replace fossil fuel, and there is a lot of potential in RE technologies. The theoretical RE potential is more than all other energy sources [3]. The studies on efficient extraction of RE that available in the world are going on. Not only in developed countries but also the developing countries are planning to implement modern RE technologies. Current potential of technical RE in Sri Lanka is about 180 PJ [4]. The present study consists of a brief discussion about the current trending of renewable energy types and the potential of replacing fossil fuel and the effect on climate changes.

## 2 TYPES OF RENEWABLE ENERGY

There are many types of renewable energy sources available in the world such as solar, wind, hydro, biomass, tidal, geothermal etc. The most available renewable energies are solar and wind energy. Sunlight is the main source of most renewable energies. It caused the wind to drive, biomass to grow, and water cycle to run so we can extract energy from wind, biomass, hydropower, and ocean energy. Geothermal energy can be extracted from the earth's internal heat [5].

### 2.1 Solar energy

Solar energy is the most available energy source in the world. There is enormous energy comes from the sun that is 200 times the total annual commercial energy used by humans[5] and it is about four million

exajoules (1EJ = 1018J) of solar energy[6]. Fig 1 shows the annual solar irradiance distribution all over the world.

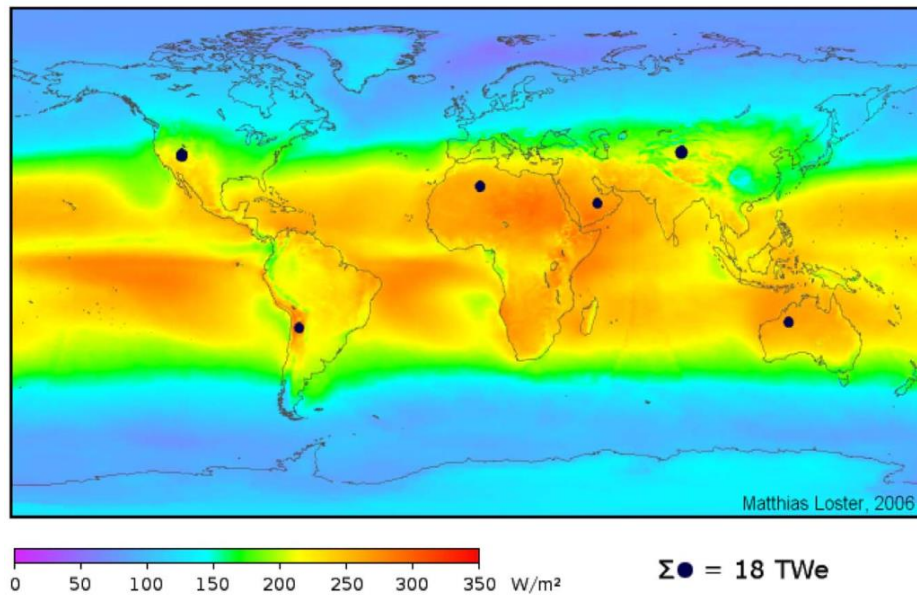


Fig. 1. Annual average solar irradiance distribution over the surface of the Earth[6].

There are two main types of solar energy technologies.

- Passive solar technologies
  - Direct solar gain
  - Indirect solar gain
  - Isolated solar gain
- Active solar technologies
  - Photovoltaic
  - Solar thermal
  - Concentrated solar power

Passive technology is using solar energy without transforming into another energy source such as electricity. The solar energy collecting storing and distribution for heating purposes such as solar water heater is an example of this method [6]. Active solar technologies consist of two methods. In photovoltaic systems, semiconductors are used to convert solar energy to electricity. The efficiency of these cells is about 18%. In solar thermal systems, solar thermal energy use for commercial applications such as drying, heating, cooling and cooking. On the industrial level, concentrated solar energy use for power generation purposes using high magnification mirrors that concentrate the solar heat to power steam turbine [6].

## 2.2 Wind energy

Wind generates due to the temperature and pressure differences caused by the sun. wind power generation has become important after the solar energy because it is one source that available like sunlight. The installed wind power capacity was 487 GW in 2016 and expected to go up to more than 700 GW in 2020 [7]. Fig 2 shows the wind power capacity evolution in two decades. The power can be extracted from wind energy using wind turbine technologies. Wind turbines have been developing rapidly by increasing their size and power rating [7]. There are two kinds of wind turbines, Vertical and horizontal. The basic mechanism of those two is similar. Wind passing through blades create mechanical power that fed through the electricity generator to generate electricity. The location of the wind turbine has a significant influence

on performance in the machine. The height must be higher, and it is about 30m. The most using wing turbine type is horizontal axis turbine that produces 50 to 350kW of electricity [5].

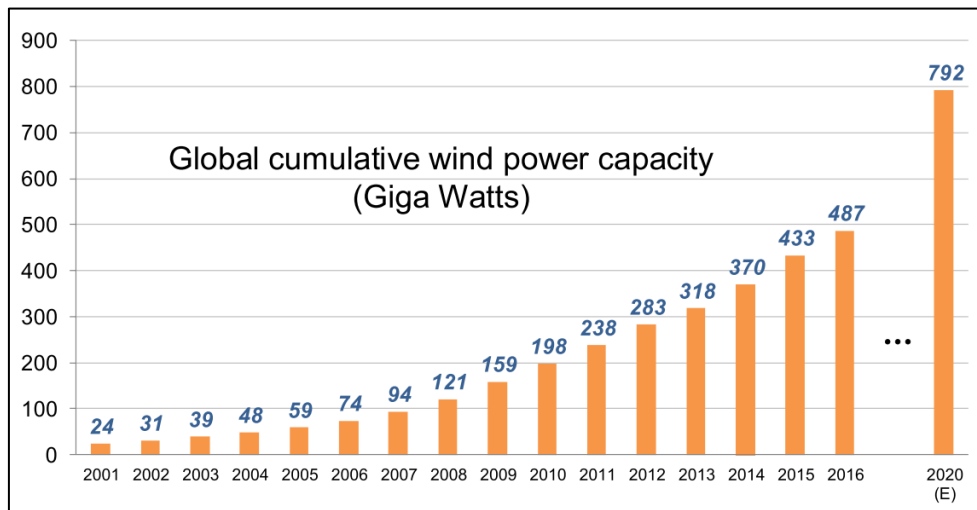


Fig. 2. Global cumulative wind power capacity from 2001 to 2020 [7].

### 2.3 Biomass energy

Biomass is the most used renewable source in the world since ancient time. It is still used by peoples who live in rural areas for their cooking purposes. Even in the modern industries, they use this biomass to run their machines such as boilers because of the low cost. There are many types of biomasses such as woods, agricultural crops, plants and organic, agro-industrial waste and domestic waste [8] (Table 1).

Table 01. Overview of the global potential of bioenergy supply[8]

Biomass category	Technical potential in 2050 (EJ/yr.)
Energy crop production on surplus agricultural land	0 – 700
Energy crop production on marginal land	< 60 – 110
Agricultural residues	15 – 70
Forest residues	30 – 150
Dung	5 – 55
Organic wastes	5 – 50
Total	<60 – 1100

Biomass energy can be separate into two parts, modern and traditional. Modern biomass includes wood agro-industrial waste, urban waste, and biofuels. Traditional biomass includes fuelwood, charcoal and rice husk for domestic use. World production of biomass is about 146 billion metric tons per year [8]. In the decomposition process of biomass, stored energy releases. Using this concept energy can be extracted from biomass. Biogas generation is one of good energy extraction method. This can be used for heating and electricity generation [5].

### 2.4 Tidal energy

Tidal energy extract from the sea waves. Due to the gravitational forces from sun and moon earth cause the patterned rising and lowering of seawater that has kinetic and potential energy [9].The potential and kinetic energy movement of water can be transformed into electricity using turbines. This energy is available across the coastal area and in some locations energy density is about 65MW/mile [5].The cheapest way to extract tidal energy is to use the oscillating water columns that entered into the vertical pipe that compress the air

and drive a turbine to generate electricity. Other than that various turbine technologies use to extract the energy [5]. Fig 3 shows a floating tidal energy power plant.

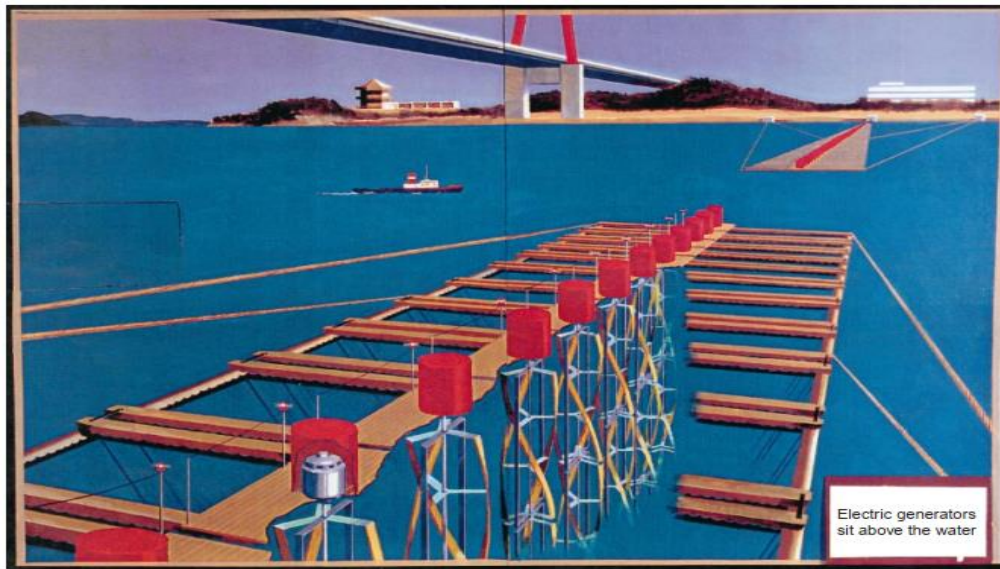


Fig. 3. Floating tidal power plant with vertical triple-helix turbines [9]

### 2.5 Geothermal energy

Geothermal energy is the heat inside the earth. This is a renewable eco-friendly energy source that consists within the earth core from 3 meters to few miles down in the earth temperature increase gradually up to extremely high-temperature magma. In the 3-meter range temperature is about 50° to 60°F. Using heat pump this thermal energy can be extracted to heat buildings in the winter season to save energy [5]. An estimation of the installed thermal power for direct utilization at the end of 2019 is used in this paper and equals 107,727 MWt, a 52.0% increase over the 2015 data, growing at a compound rate of 8.73% annually. The thermal energy used is 1,020,887 TJ/yr (283,580 GWh/yr)[10]. Table 02 indicates Geothermal usage across the world.

Table 02. Summary of direct-use data worldwide by region and continent, 2019 [10]

Region/Continent (#countries/regions)	MWt	TJ/year	GWh/year	Capacity
<b>Africa (11)</b>	198	3,730	1,036	0.597
<b>Americas (17)</b>	23,330	180,414	50,115	0.245
Central America and Caribbean (5)	9	195	54	0.687
North America (4)	22,700	171,510	47,642	0.24
South America (8)	621	8,709	2,419	0.445
<b>Asia (18)</b>	49,079	545,019	151,394	0.352
<b>Commonwealth of Independent States (5)</b>	2,121	15,907	4,419	0.238
<b>Europe (34)</b>	32,386	264,843	73,568	0.259
Central and Eastern Europe (17)	3,439	28,098	7,805	0.259
Western and Northern Europe (17)	28,947	236,745	65,762	0.259
<b>Oceania (3)</b>	613	10,974	3,048	0.568
<b>Total (88)</b>	<b>107,727</b>	<b>1,020,887</b>	<b>283,580</b>	<b>0.300</b>

### 3 RENEWABLE ENERGY IMPLEMENTATION

Fossil fuels consist of a high amount of CO<sub>2</sub> concentration. Due to the complete or incomplete combustion of these fossil fuels, high amount of greenhouse gasses released to the atmosphere. Greenhouse concentration of the atmosphere controlled by the natural event, but anthropogenic activities pump a high amount of greenhouse gasses to the atmosphere and imbalance the natural process. When we talk about anthropogenic activities, fossil fuel burning take place special place other than that because it causes the various amount of environmental and social problems.

In the world, high amount of fossil fuels uses for energy and transportation sectors. When we consider the industries like textile industries, petrochemical industries, and cement production industries contribution are high. World's primary fossil fuel sources are coal, petroleum (crude oil) and natural gas. Since the industrial revolution, fossil fuel consumption is tremendously increasing and that indicated in Fig 4.

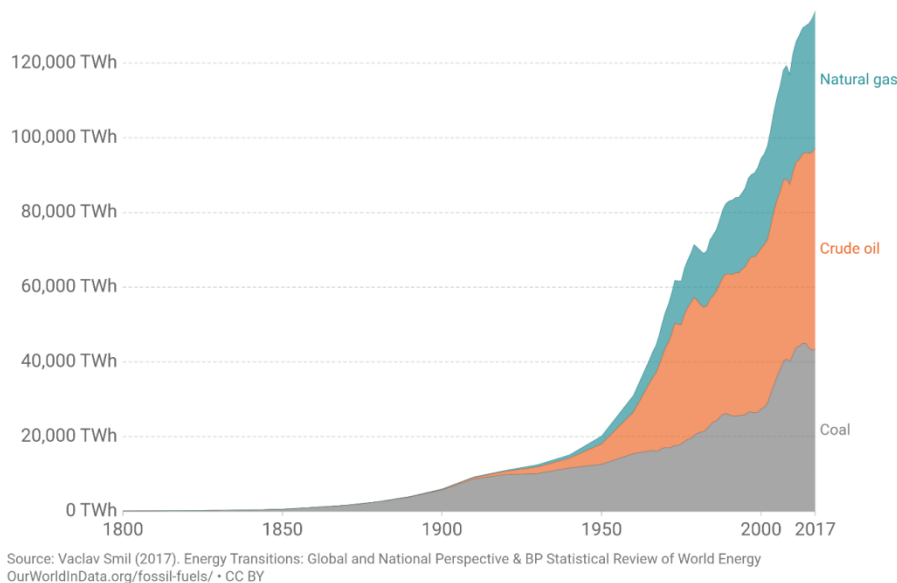


Fig. 4. Global Fossil Fuel Consumption [11].

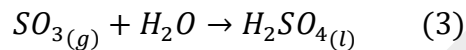
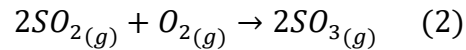
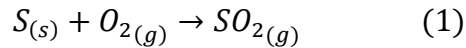
Gas flaring is one of severe environmental problem in the oil-rich regions. Gas flaring is the process of burning the excess gas pumped out from the oil well, and it tends to emit carbon oxide, hydrocarbons and nitrogen. This mainly causes the acid rains. World bank report (2005) indicated that 100 million cubic meters of gas are flared globally per year. Flaring and venting of natural gas from oil and gas wells plays a significant role in greenhouse gas emission. Because due to this process a high amount of methane released to the air and methane has 28 times global warming potential.

The main problem of the greenhouse gasses is they tend to increase global warming. Global warming causes many climate changes such as acid rains, ozone layer depletion, heatwave, rise in sea level, and photochemical smog. The earth warms tremendously increasing day by day over the world. For that developed countries give high contribution like united states of America, China, and Russia. Next, the most significant problem is ozone layer depletion. Due to the increase of greenhouse gas concentration single chlorofluorocarbon (CFC) molecule can destroy about 100000 ozone molecules. As a result, hazardous sun rays entered the atmosphere, and greenhouse gasses absorb the temperature of sun rays. It is the reason for increase the atmospheric temperature.

When we consider about environmental effects of fossil fuel combustion and global warming range, one of significant impact is the heatwave. That means a continuous rise in temperature. In 2005 about 2300-2330

people died due to the heat waves [12]. Another side effect is sea level rising due to the increase of lower atmospheric temperature. Because of that polar ice caps and glaciers are melting and rise in sea level from 20 to 165 cm due to thermal expansion of ocean water. So, this has become a severe problem for the island, coastal areas and arable lands.

Another environmental problem is acid rains. Man-made environmental acidification mainly effects for this and Sulphur dioxide and oxides of nitrogen are the main contributors.



Photochemical smog is another environmental problem, and it occurs due to photons of sunlight. They hit molecules of different kinds of pollutants in the atmosphere, and that is known as a photochemical reaction. Due to the high amount of smog, many health problems are generated like eye and nose irritation, increasing susceptibility to illness, decrease lung's working capacity and cause shortness of breath, sneezing and coughing.

Wildfires are devastating, and they weaken the carbon sink in forests while destroying houses and the entire ecosystem. They kill important plant species; fast-moving animals may be able to survive, but slow-moving animals might be affected. Wildfires lead to pollution and increase CO<sub>2</sub> emission in the atmosphere. Increased temperatures and drought conditions due to climate change can worsen wildfires. Studies found that severe drought in south amazon in 2010 mostly due to climate change. Dryness favours the spread of fire, but humans mainly trigger a fire.

We can replace fossil fuel usage with renewable energies like hydroelectric power, biomass, wind power, geothermal power and solar power. By replacing fossil fuel usage with renewable energies, we can reduce emission from four distinct areas: power generation, hot water/space heating, transport fuels and rural (off-grid) energy services. Renewable energies are more convenient because they have low life cycle CO<sub>2</sub> emission compared with fossil fuels. Not only the power generation sector but also, we need to concern about the automobile sector because globally primary power source for the transportation sector is a fossil fuel. In future, most innovations and inventions consider the clean energies, and there is a high market value for green technologies.

In a country like Sri Lanka, GHG emission can be reduced easily by renewable energy because of the availability of energy sources all over the country. In the past centuries, Sri Lanka was dependent only on renewable energies like hydropower, that was the 100% energy that used for electricity generation. With the increasing demand for energy, the country couldn't only rely on hydropower and power generation from petroleum oil and coal was started that directly affects the environment through GHG emissions [13]. In 2017 net petroleum import cost was USD 3,226 million and net import cost of coal was LKRM 39,493 [14]. That shows a huge amount of money spent on petroleum oil and coal. Currently, the usage of renewable resources increasing rapidly due to cost-effectiveness and environmental impact due to fossil fuels. In Sri Lanka, current trends of renewable energy types are hydropower, wind power, solar and biomass. Fig 5 shows the renewable energy usage in past years in Sri Lanka.



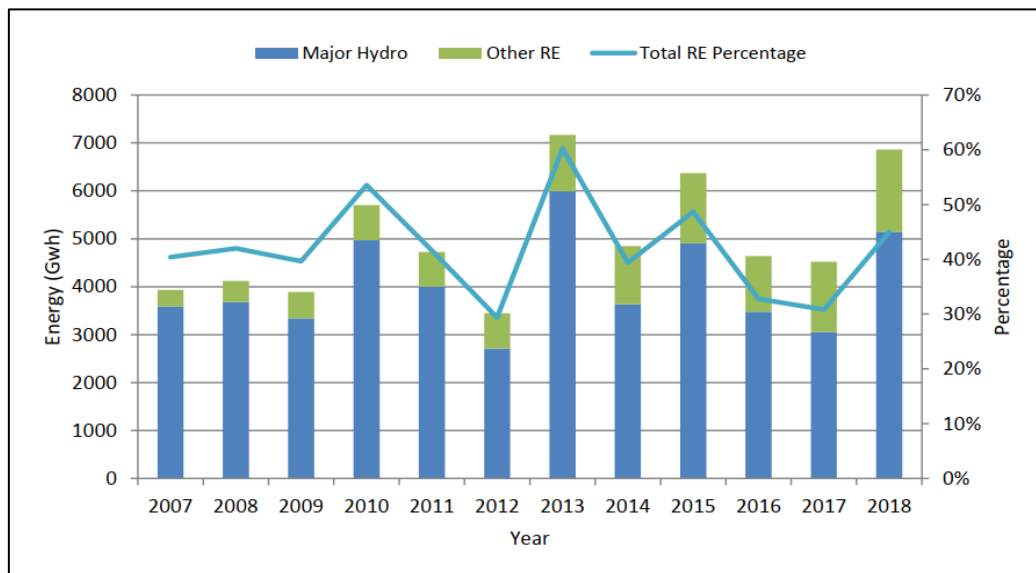


Fig. 5. Renewable Sources usage in past years

Not only in the electricity generation but also some other sectors that affect GHG emissions in Sri Lanka below Table 03 shows CO<sub>2</sub> emission from each sector in Sri Lanka.

Table 03. CO<sub>2</sub> Emissions from fuel combustion [15]

	CO <sub>2</sub> emissions (Million tons of CO <sub>2</sub> )	
<b>Total</b>	<b>20.89</b>	<b>100.0%</b>
Electricity and heat production	8.67	41.5%
Other energy industry own use	0.04	0.2%
Manuf. industries and construction	1.62	7.8%
Transport	9.36	44.8%
Other sectors	1.2	5.7%

According to the emission data, it is clear that not only the electricity generation that supports the GHG emission. This table shows that the majority of GHG emission occurs from transportation and Electricity production that is about 86.3%. Focusing on these major sectors and implementing renewable energy technologies this GHG emission can be reduced greatly. According to the Ceylon Electricity Board, the base case plan that proposed for 2020 – 2039 has mentioned to increase renewable energy power plant capacity by 3650MW this is higher than the proposed non-renewable energy plant. There are currently 4 proposed plans to execute in the upcoming decades [15]. Fig 6 shows the RE implemented plans in Sri Lanka.

1. Reference Scenario – Thermal power plant(coal, oil)
2. Base case Scenario - Thermal power plant(coal, oil), Renewables
3. HVDC Scenario - Thermal power plant(coal, oil), Renewables
4. Energy Mix with Nuclear Scenario - Thermal power plant(coal, oil), Renewables, Nuclear

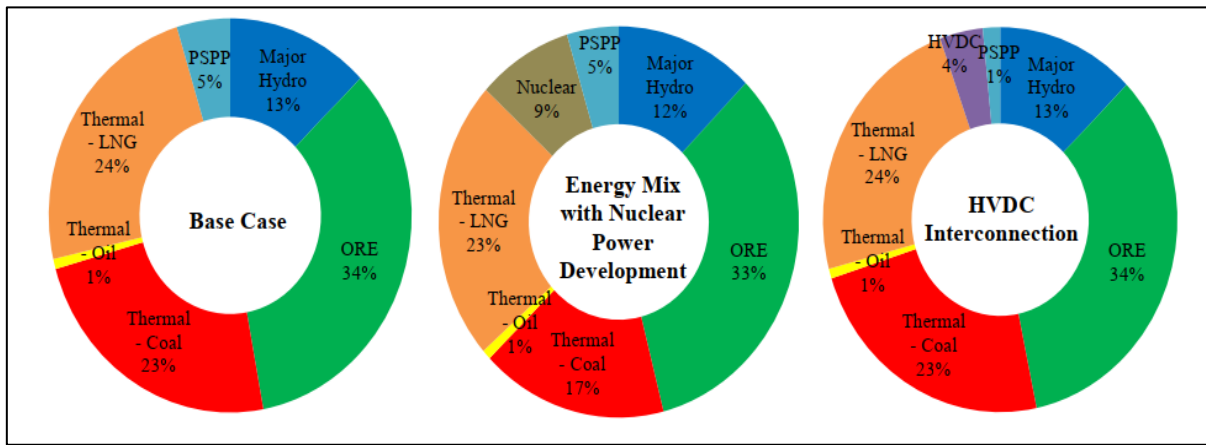


Fig. 6. Installed Capacity Share Comparison in 2039 [15]

After implementing more renewable energy plants, the predicted GHG Emission reduction is shown below in Fig 7. This is based on the reference scenario and the base case scenario. After implementing 3325MW renewable resources, 450MW Natural Gas-fired Combined Cycle, 400MW Pumped Storage Hydro and 39MW Major Hydropower Plants, several thermal power plant additions were eliminated [15].

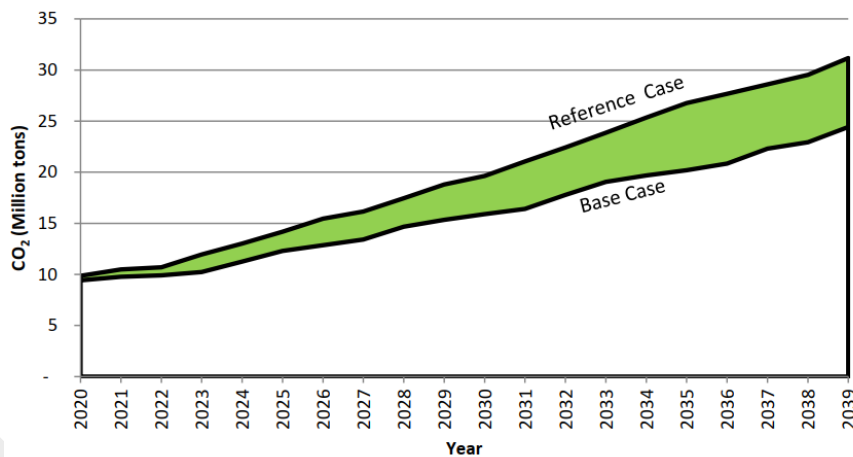


Fig. 7. CO<sub>2</sub> Emission reduction by Base case plan compared to the Reference plan [15]

This data confirms that introducing renewable energy into the electricity generation in Sri Lanka helps to reduce GHG emission by a significant amount. The transport sector is the other biggest contributor to GHG Emission that is mentioned above as 44.8%. This is mainly due to Petrol and diesel vehicles in this sector not only in Sri Lanka but also in the world this is the case. To tackle this problem, Hybrids and Electric vehicles (EV) were introduced by many companies all over the world and it clearly shows that petrol and gasoline vehicle can be replaced by those hybrids and EVs. Even in Sri Lanka, this is becoming a trend but still negligible. Promoting EVs with solar energy technology is the most suitable for Sri Lanka due to the vast availability of sunlight over the year. According to a case study conducted on Greenhouse gas mitigation policies in the transport sector, energy consumption can be reduced by 14 % promoting Hybrids and EVs by 2045 [16].

#### 4 IMPLEMENTATION BARRIERS OF RENEWABLE ENERGY

Renewable energy(RE) has a lot of potentials that can be used to solve environmental issues. Even though every country in the world trying to maximize this potential, some barriers slow the implementation of these



technologies. There are a few aspects of those problems such as policy-wise challenges, technical challenges, economical challenges, Information and human resource-wise challenges [17].

#### **4.1 Policy-wise challenges**

The relationship between Policy and national project implementation is unavoidable. For a successful project policy and regulation should be followed. To improve these renewable technologies, making policies to promote and motivate the private sector to contribute to the energy supply is important. Countries that have supportive policy and regulation towards these RE technologies have been successful in implementing [18]. Lack of involvement in the private sector due to government policies and weak regulation on the environment can be a huge impact on developing country like Sri Lanka [17].

#### **4.2 Technical challenges**

When implementing these modern technologies, technical difficulties limited capacity to design, install, operate and maintenance can occur. Limited local manufacturing of equipment and lack of standard technology and knowledge is a significant barrier that should be eliminated for the success of RE implementation [17].

#### **4.3 Economical challenges**

As a developing country, this is one of the main problems we are facing currently. Even though RE technologies have huge benefits high initial cost of implementation and long payback time pull the development backwards. High installation cost at end-user RE systems cannot be afforded by low and middle-income citizens [17]. Policies and technical challenges affect this high initial cost.

#### **4.4 Information and human resource-wise challenges**

Lack of information, skilled technicians with good knowledge in these modern technologies, is another barrier. Lack of data available, limitation of data collection, potential financiers, awareness of the civil society should be focused. Other than above-mentioned potential barriers, social acceptance is also an essential factor. For developing RE projects land use is important. As an example, a hydropower project or solar energy project can take many land usage that surrounding society may not accept and may be asked for compensation for their lands [3]. RE awareness among civil society is considerably low in a developing country like Sri Lanka. Among a lot of barriers, these are the most important ones that should be eliminated to successfully implement RE technology is not only in Sri Lanka but also in other developing countries.

### **5 CONCLUSION**

This study has shown that the presence of renewable energy across the world that has huge potential to implement in the energy sector in the world. GHG emission from fossil fuel is a huge impact on the world environment issues like global warming and climate changes. The world is now trying to replace fossil fuel with RE technologies and a lot of the countries have implementing and researching towards the green energy to mitigate the environmental impact through GHG emissions reduction. The potential danger cannot be negligible of these negative effects. As a developing country, Sri Lanka has to face the energy crisis like any other developing country with the increasing demand, urbanization, industrialization and population growth. Even though Sri Lanka has a huge RE potential still most of the energy is generated by burning petroleum oil and coal. The amount we are spending on petroleum and coal is considerably large but with the increment of current energy demand, it is not feasible to change into RE easily. Even though we spend a lot of money to purchase the high sulfur content coal, it causes adverse effects such as acid rains, health diseases due to dust particles that contain sulfur. The transport sector is the main contributor to GHG emission in Sri Lanka due to the high usage of fossil fuel-based automobiles and imported used vehicles that

drive across the country. Incomplete combustion in those vehicles increases the GHG emission. Promoting public transport and RE based vehicles can reduce GHG emissions in the transport sector. Implementing these RE technologies has some barriers that pull back the development. The most affecting barrier is policies and regulations. Through the strategic planning of these policies and regulations, it is possible to overcome most problems that occur during RE implementation. Promoting RE in civil society make awareness of GHG emissions and its effects on humankind are more important in the current world than ever. Awareness is not enough if the RE cannot be afforded by society due to the high initial cost that can be reduced by strategic planning, improve the education sector and technical skills to train human resources, motivate private sector for research and development is important. According to the CEB few strategic planning has been done as mentioned above in Sri Lanka. Removing these barriers and make use of the current RE potential for future green energy economy should be more focused and plans should be executed to prevent significant disasters that can happen due to adverse impact on the environment by GHG Emissions.

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