Green House Gas Accounting - Energy Management

Sithari. G.M, T.G.A.H.R.Thalagahawaththa, Tharakie. G.M
Faculty of Technology, University of Sri Jayewardenepura

Abstract: The energy sector is the contribution of 37% of worldwide Greenhouse gas emissions. Emission of GHG is increased due to fossil fuel-based resources, lack of efficiency, and lack of knowledge. Improving energy efficiency in the industry through Energy management contributes to reducing GHG emissions and reducing energy waste. Different methods can reduce energy management and GHG emissions, and they should be implemented in the building, industrial, and transportation sectors. Energy management techniques and the contribution of it to GHG mitigation are described in this article.

Index Terms: Building, Energy Management, GHG mitigation, Industry, Transportation

1 INTRODUCTION

Energy demand in the world is increased due to growth in the world population. Countries that have fast economic growth are consumed an enormous amount of energy. The energy consumption of the world is projected to increase by 33% in 2030 from 2010. The industrial sector is the primary energy consumption when compared with other sectors. It is about 37% of world energy consumption. The groups of industries that consume energy are agriculture, construction, mining, and manufacturing. Energy-related activities in industrial sectors are space conditioning, lighting, processing, and assembly [1]. These industrial sectors are responsible for the emission of greenhouse gasses, and it causes global warming and other environmental impacts. Implementing energy management techniques improve energy efficiency and reduce GHG emission in the energy sector.

2 ENERGY MANAGEMENT

Energy plays a major role in every industry, the domestic and public sector in a country. Electricity, fuel for transportation, fuel for steam generation in a boiler, fuel for cooking purposes in house, etc., are some examples of energy. The energy demand is increasing day by day while the environmental impact by the energy is increasing. The CO_2 emission from the energy use is projected to increase in 2025 in 7981 million metric tons from 2003 emission is 5789 million metric tons [2]. In worldwide, 40% of energy is used by industries, and its contribution to global GHG emission is 37% [3]. GHG emissions from the industries and other sources are the main reason for global warming. The energy sector's contribution to GHG emission is increasing day by day. Implementing Energy Management systems in the industry will help for energy saving as well as GHG emission reduction. Simply Energy Management describes reducing the wastage of energy without affecting production and quality while minimizing environmental impact [1]. Implementing new technologies, manufacturing processes, new materials, and equipment with new technologies in industry will improve the product and service quality and productivity in the form of energy management. Also, it reduces GHG emission, energy costs while increasing productivity and product quality [4].

3 ENERGY MANAGEMENT ACTIONS

A wide range of energy management actions is used for reducing GHG emissions. Energy management actions can be taken not only for the industries but also for commercial/ household and transportation sectors. These sectors are contributed to the emission of GHGs. In the industrial sectors, emission reduction is achieved by

energy efficiency technology. For example, use more efficient devices, renewable energies, and alternative fuel instead of fossil fuels responsible for GHG emissions by industries. The possible methods for energy management in the industrial sector are energy auditing and economic analysis. Other possible energy management methods are done under these sectors. They are boiler and firing systems. Steam and condensate system, waste-heat recovery, building envelop, HVAC system, and lighting. Thus, GHG emission reduction can be achieved through those energy management methods [4].

In the industrial sector, an energy audit is done to identify equipment and facility which use energy and recommend changing operation practices and equipment. Also, energy-saving and energy efficiency methods for boiler and fired systems are introduced. The most significant energy consumers in the industry are boilers and firing systems. GHG emissions from the boiler and fired system are also high due to consuming fossil fuel energy. So, energy-saving opportunities such as heat recovery, alternative fuel, and efficiency improvement are introduced. In the commercial sector, lighting and HVAC systems are consuming more energy. To reduce energy consumption and GHG mitigation, HVAC system design and lighting system changes and lighting controls can be done. In addition to that, GHG emissions from the transportation sector can be reduced by applying energy efficiency improvements such as alternative fuel [4].

4 HOW ENERGY MANAGEMENT ACTIONS CONTRIBUTE TO GHG MITIGATION

Energy is essential for both domestic and industrial purposes. Then the most energy-related processes cause emit greenhouse gas emissions. Greenhouse gas emissions badly affect to the human and environment. In the case of that, it is essential to use energy management methods to mitigate greenhouse gas. Some of the methods are discussed here.

4.1 Industrial sector

There are several technologies to reduce greenhouse gasses by managing energy efficiency [3].

Sector-wide technologies

Motor systems used about 65% of electricity in the industry [3]. There are several methods to increase motor system efficiencies. They are loss reduction in motor windings; better magnetic steel want to be used, improvements in motor aerodynamics, and manufacturing tolerances improvements. In these systems, end-use devices like pumps and fans also want to subject to improve the efficiencies. It is also essential to reduce the losses of mechanical and electrical transmission lines by accurately maintaining the operational procedures. Energy consumption can be reduced by introducing more efficient motor-driven systems or by improving the existing ones. Another important part is steam generation. It is about 15% of industrial energy used for steam generation [3]. So the efficiency of current steam generators like boilers efficiency can be improved up to 85% by using combustion controls, using alternative fuels, repairing leak traps, and using condensate recovery. In boiler systems, the efficiency can be checked by the flue gas. They are so improving the boiler efficiency cause to reduce the GHG emission to the environment.

Another part is using energy recovery techniques to improve energy management. It can be done by power, heat, and fuel recovery. The waste heat can be used for other processes in the industry. For example, the flue gas can be used through a heat exchanger to increase the feedwater temperature. Pressure recovery turbines can produce electricity through small pressure differences; then, they can be used to recover the power. The industrial cogeneration method also can be used to combined heat and power. It is about 150 $MtCO_2$ that can be mitigated by cogeneration [3].

Energy efficiency improvements in inter-industry sector

Cement manufacturing is one of the manufacturing processes that emit a huge amount of CO_2 to the environment. So using granulated slag from steel industries in cement manufacturing can reduce both CO_2 emissions and energy consumption. Here the most useful method industrial symbiosis can be used as an effective method. In that process, the industry's byproducts can be used as input for a manufacturing process in another industry. As an example eco-industrial park concept in Fig. 1 can be taken in industrial symbiosis. Another cascading heat system can be used to enhance the usage of waste heat from one industry to another. As well as waste fuels released by industry can supply it to another industry.

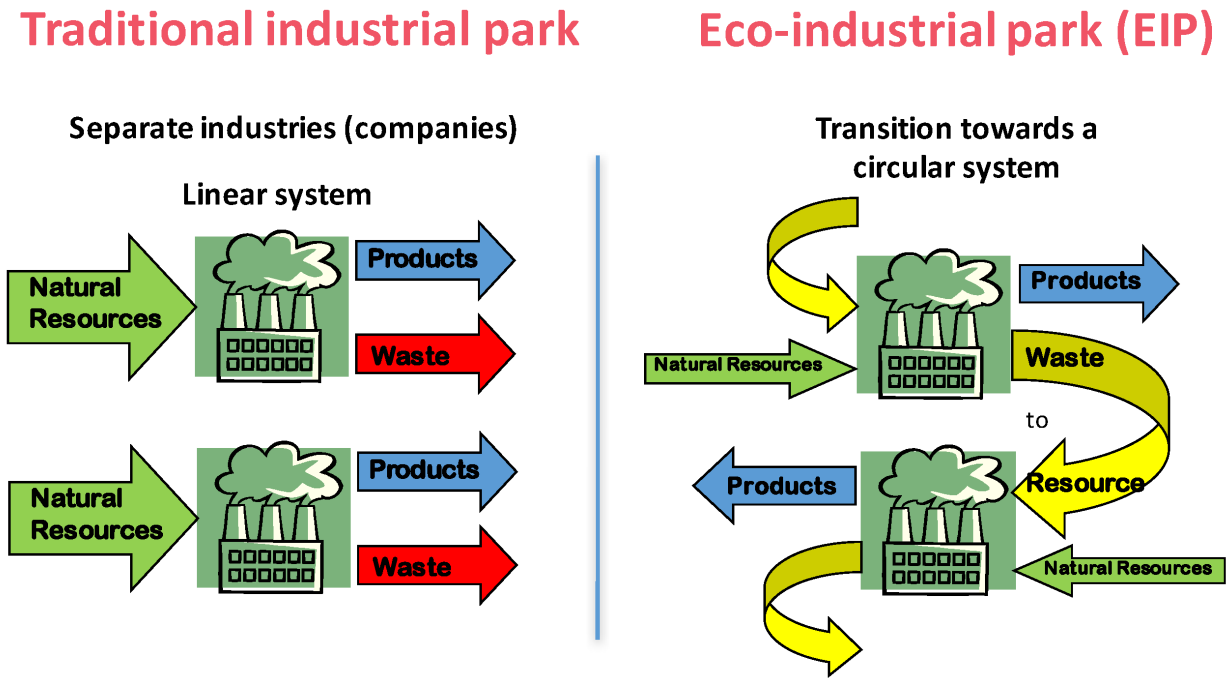

Fig. 1. Eco industrial park concept

Process specific measures and technologies

Under this section mitigating options are discussed for chemicals, iron and steel, minerals, cement, and pulp and paper.

Iron and steel industry

It is about 6% of anthropogenic emissions happen from steel industries [3]. It is mainly from coke manufacturing. When considering India and China, $3.5tCO_2$ and $3.1tCO_2$ are respectively emitted in steel manufacturing [3]. This variation occurs due to the differences in fuel mixing, different retrofitting levels, and using different technologies. So by comparing these factors, it shows that waste energy and process gas recovery and more effective electric air furnaces design are the factors that need to be managed to reduce GHG emission. As well as energy-efficient methods can be used in available production routes.

Chemical and fertilizer industries

In chemical industries, major energy consumption areas are chemical synthesis, separations, and process heating. As an example, membranes can be improved for separations; for that purpose, Nanotechnology inspired membranes can be used in separations. And more selective catalysts can be used for synthesis. In addition to that heat, requirements can be filled by introducing heat exchangers. When considering plastic

products related to industries, ethylene is the primary energy-consuming material [3]. Ethylene is produced by subjecting hydrocarbon feedstock to steam cracking in the ethane to the gas oil process. This causes to produce by-products like hydrocarbons, methane, hydrogen, and propylene.

All these by-products are dependent on the feedstock. So feedstock management also contributes to the GHG mitigations. Another one that is the most energy-consuming stage in the chemical industry is the steam cracking process for olefin production. So, several technologies like improvements in cracking tube materials and furnace can be used to reduce energy consumption. Another one is absorption technologies that can be used to conserve energy and mitigate GHG emissions. In fertilizer manufacturing, most of the energy is used to produce ammonia. For that purpose, modern ammonia plants can be used to reduce energy consumption.

Cement industries

In cement industries, most of the CO_2 is emitted from the calcination of limestone as well as a high amount of electricity is also used for grinding the raw material. Energy consumption and GHG emissions can be done using alternative fuel mixes, cement types, and kiln technologies. Here, the clinker to cement ratio can be changed by different additives [5].

Pulp and paper industries

In this category, paper and wood-related industries emit about 264 $MtCO_2$/year. In pulp and paper industries, energy efficiency improvements, cogeneration methods, and biomass fuel use can reduce both energy consumption and GHG emissions.

4.2 Building sector

Building envelope and mechanical environmental control systems

The interior of the building can be affected by several variables, as in Fig. 2 [6]. That shows that the architecture of the building is also affects energy consumption. Because the orientation and layout of the building mostly affect passive cooling and heating. Using solar shading techniques, utilizing thermal mass, using windows that can retain heat directly impact the efficiency of the space heating and cooling methods. By managing these techniques effectively, it affects the usage of heating and air conditioning systems. Then it leads to reduce the GHG emission also. Then planting the vegetation that covers the buildings from solar radiation highly affects to retain the coolness in the building.

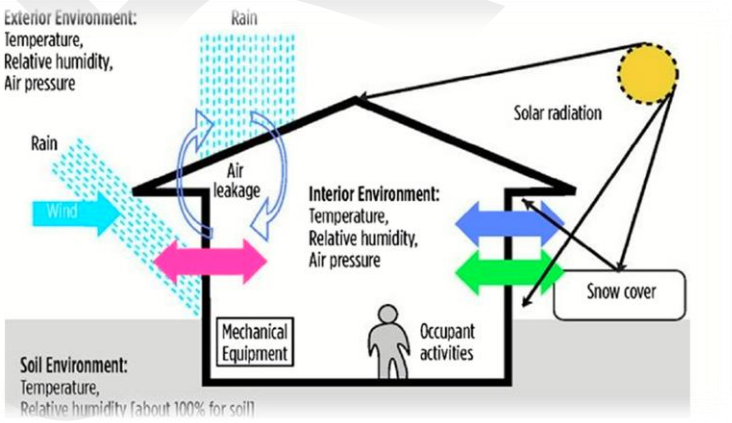

Fig. 2. Impact of variables in interior of the building [6]

During the winter seasons, some countries use heating systems in buildings. But improper insulation causes the heat to lose to the outside environment. It can be reduced by using a triple glazed window of low emissivity, as

in Fig. 3 largely helps to reduce the heat loss. This window consists of two emissivity coating layers and a krypton/argon oil-filled layer [7].

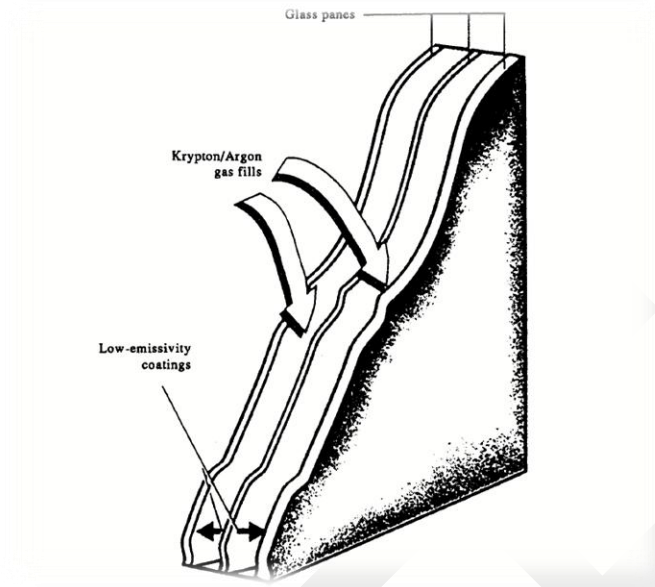

Fig. 3. Triple glazed window [7]

When considering heating and air conditioning systems, their system efficiency can be improved by several factors that also contribute to reducing GHG emissions. One of them is designs of impeller, motors and heat exchangers must be improved and condenser water pump can be optimized to save energy.

Lightning

Lightning is the main sector of a building that consumes most of the electricity. It can be used efficiently by introducing several techniques. Some of them are discussed below.

Day lightning

The efficient way to supply light to a building in a natural way is by using the sun. It leads to zero emissions. This can achieve by installing large size windows and using openings in a building. One of the methods is using a solatube. This device has mainly three parts, as in Fig. 4. Dome is the entrance to the sun's rays. Tube transfers the captured sun rays, and the diffuser delivers the light to space [8].

Fig. 4. Structure of a Solatube [8]

Use of compact florescent lamps and LED

These types of bulbs reduce the usage of electricity as it needs low power to work. We know that electricity is also one method of emitting greenhouse gasses because electricity is supplied through the coal-fired plants that emit most greenhouse gases.

Lightning controls

The one method to save energy is using lightning controls. The following factors include in an efficient lighting system [7].

- Reduce light levels by tuning.
- Maintenance of luminance
- Load shedding

As well as another way to control the light systems is using an automated lighting system.

Domestic appliances

There are two types of appliances that are used mostly in buildings. They are fridges and cookers. In refrigerators, most of the electricity is used by compressors. So more techniques want to be used to improve the efficiency of the compressor. The following options can improve the efficiency of the refrigerator system.

- Increase door insulation thickness
- Compressors and evaporators fans should be more efficient
- Using two compressor systems
- Fiberglass in doors can be substituted by foam insulation

When considering cooking stoves, they are some stoves that are opened which use biomass fuels. Then it causes to emit the gasses also. For that, we have to use LPG gas stoves or biogas, which are more efficient. Otherwise, using biomass leads to cut more trees which almost purifies the CO_2.

4.3 Transportation sector

The prominent fuel used for transportation is petroleum-based products. In most cases, CO_2 emits from fuel combustion in transportation [7]. So it is essential to introduce new methods to reduce both energy consumptions and GHG emissions. Some of the methods are discussed below [7].

Fuel economy improvement

There are several methods to improve fuel economy as follows.

- Material substitution to reduce vehicle weight. It can be done by using aluminum frames for body parts and using different composites.
- Aerodynamic drag reduction through wheel openings.
- Tire rolling resistance reduction by using good quality tiers.
- Accessories like an alternator, air conditioner, oil pumps, and light need to be improved.

Reducing emissions

This is the most important method that need to be considered to reduce the GHG emissions. Several steps can be taken to reduce the emissions in transportation. Some of them are,

- By introducing canisters and modifying pump nozzles in the gasoline delivery system to reduce the evaporative gasoline emissions.
- Sculpture content of diesel wants to be reduced.
- Fuel water content used for internal cooling.

Using alternative fuels

One efficient way to reduce energy consumption and GHG emissions is to use alternative fuels, not petroleum-based products. Those alternative fuels can be mentioned as follows.

- Wood using biomass- methanol and ethanol
- Using non-fossil sources to drive vehicle via electricity
- Using hydrogen that is non-fossil electricity

The following Table 1 shows how these fuel consumption leads to GHG emissions [9].

Table 1. Fuels and GHG emissions [9]

Fuel	**Net GHG emission (kg CO2e)**
Gasoline	11.17/gge
Natural gas	9.20/gge
Hydrogen	12.2/gge
Biofuel	5.0/gge

This table further shows that using hydrogen and biofuels can reduce the net GHG emissions than gasoline. The best example is when considering hydrogen using as fuel; it only emits water as a waste from the vehicle known as fuel cell electric vehicles [9].

Transportation system alternatives

In the world, most of the people used to transport through different vehicles. So using alternative transporting systems can be used to save both energy and the environment.

- Road designs improvements and construct alternative routes to reduce traffics
- Mass transit system need to strengthen such as trains and busses
- Work style of the people needs to be changed. Then they can communicate with others via mobiles etc.
- Encouraging people to use bicycles.
- Introducing better aerodynamics, regenerative braking, and exhaust heat recovery to save energy in trucks.

5 CONCLUSION

Energy management is very important as energy-related processes affect GHG emissions. Then it is essential to identify the actions that can be taken to mitigate GHG emissions by energy management. The main sectors that using energy in the world are the industrial sector, the building sector, and the transportation sector. Even building architecture also indirectly affects GHG emissions because of the failures in interior designs. Many researchers found that these sectors need to improve by energy efficiencies to mitigate the GHG emissions.

6 REFERENCES

[1] E.A. Abdelaziz, R. Saidur, S. Mekhilef, A review on energy saving strategies in industrial sector, Renewable and Sustainable Energy Reviews 15, 150–168, 2011.

[2] Frank Kreith, D.YogiGoswami, Energy Management and Conservation Handbook, 2008.

[3] Ernst Worrell, Lenny Bernstein, Joyashree Roy, Lynn Price, Jochen Harnisch, Industrial energy efficiency and climate change mitigation, Energy Efficiency, 2:109–123, 2009

[4] Wayne C. Turner, Steve Doty, Energy Management Handbook, 3rd edition, 1-100, 2007.

[5]HrvojeMikulčić, Milan Vujanović, NatašaMarkovska, Risto V. Filkoski, Marko Ban, NevenDuić, CO2 Emission Reduction in the Cement Industry, chemical engineering transactions, VOL. 35, 2013.

[6] Ingy El-Darwish , Mohamed Goma, Retrofitting strategy for building envelopes to achieve energy efficiency, Alexandria Engineering Journal, 2017.

[7] W.A. Kamal, improving energy efficiency—the cost-effective way to mitigate global warming, 1995.

[8] Toluwalogo David Babarinde, HalilZaferAlibaba, Achieving Visual Comfort through Solatube Day lighting Devices in Residential Buildings In Nigeria, 2018.

[9] Board on Energy and Environmental Systems, National Research Council, Transitions to Alternative Vehicles and Fuels, 2012.