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Evaluation of Greenhouse Gas Emissions Released from the Petroleum Refinery Industry using Mathematical Modelling with Aspen HYSYS

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Abstract

Greenhouse gas (GHG) emissions are substances that consume and release radiant energy in the thermal infrared range. Greenhouse gases are the cause of the global greenhouse effect. The most common greenhouse gases in the Earth's atmosphere are water vapor (H_2O), CO_2 and methane (CH_4) and nitrous oxide (N_2O). In the absence of greenhouse gases, the earth's normal surface temperature is about 0 °F instead of the current value of about 59 °F. Greenhouse gas emissions in this sector result in vents, flares and fugitive losses caused by emissions from equipment (such as valves, flanges, pumps). In addition to the emissions from oil refining operations, it also includes the stationary flue gases that have been installed in these plants. In this study, the US EPA method was used to calculate the greenhouse gas (GHG) emissions and carbon rates of the refinery modeled in this study. The Aspen HYSYS software was used to develop computer models for the refinery industry. The research was performed by changing the feed rate of the feed stream, i.e. crude oil, by changing the temperature and changing the pressure. In order to study the impact of the final feed fuel source, the five various fuel sources were chosen, namingly, crude oil, natural gas, municipal solid waste (MSW), bituminous coal, and lignite. This study came to the following conclusions. Under power flow conditions of 3000 USGPM, temperature of 350 °F and 75 psia, the highest carbon cost of the Lignite Fuel source was US $ 524 / h. While at 3000 USGPM, temperature 650 °F, and 75 psia, the lowest carbon cost of the natural gas fuel source was US $ 29.7 / h.

Keywords: Mathematical modelling, Aspen HYSYS, Greenhouse gases, Petroleum Refinery

1. Introduction

Greenhouse gases (GHG) sources such as carbon dioxide (CO_2), water (H_2O), ammonia (N_2O), ozone (O_3), and methane (CH_4). Halogenated materials composed of chlorine, bromine and fluorine are also known as GHG, which are produced during the chemical processes. Halogenated materials composed of fluorine, chlorine or bromine are also called greenhouse gases, which are just the products of chemical operations. hydrochlorofluorocarbons (HCFC) and Chlorofluorocarbons (CFC) are chlorinated halogenated hydrocarbons, while bromofluorocarbons (i.e halons) are bromine-containing halogenated hydrocarbons (Basu 2024), (Kim, Shon et al. (2011), (Sicard and Baker 2020). There are several gases which indirectly influence the absorption of ground or solar radiation by affecting greenhouse gases, such as the formation or destruction of ground and stratospheric ozone, but they have not any direct impact on climate warming. These gases comprise carbon monoxide (CO), nitrogen oxides (NO_x), and NMVOC not classified as CH_4. The aerosols consist of very tiny particles, which cause additional impact on the absorption characteristics of the atmosphere due to the emission of sulfur dioxide (SO_2) and elemental carbon. Even if the major greenhouse gases N_2O, CH_4 and CO_2 exist in the natural environment, anthropogenic activities have also increased their amount in the environment (Ma, Lei et al. 2023). Before the industrialization period (17^{th} century to 19^{th} century) the amount of global greenhouse gases increased correspondingly by 18%, 148%, and 36% (Eggleston, Buendia et al. 2006). The US petroleum refinary industry was the second major largest greenhouse gas (GHG) producer (Ma, Lei et al. 2023) (EPA, 2012)(Elgowainy, Han et al. 2014).

Each year, greenhouse gas emissions from large oil refinery plants are approximately similar to greenhouse gas emissions from traditional coal-fired power plants of approximately 500 MW capacity (Ma, Lei et al. 2023, Van Straelen, Geuzebroek et al. 2010, Hurst, Cockerill et al. 2012).

Although Pakistan is not major country that play the major role in global warming, country's emissions come mainly from the energy, industrial and transportation sectors, and the principal sources are greenhouse gases and ozone pollution (Lin and Raza 2019, Rehman, Ma et al. 2021).

The aim of the current study is to evaluate the greenhouse gas emissions of the distillation unit in the refinery. Aspen HYSYS V10 has been used for the estimation. Approximately 30% of the industrial's greenhouse gas (GHG) emissions are produced from the fabrication processes (Nicholson, Rorrer et al. 2021) (Olayebi 2022). In this sector, the fuel and natural gas industries generate 39% of power generation and 37% of greenhouse gas emissions, respectively. The focus of using fossil fuels in the process is raw materials and energy. Despite the environmental impact, electricity still accounts for half of the operating costs of the refining industry (Elgowainy, Han et al. 2014, Griffiths, Sovacool et al. 2022). Therefore, the oil refining industry has not only increased the potential for greenhouse gas emission reduction but also increased the potential for cost savings. This becomes especially important considering the economic impact of environmental regulations and the importance of reducing greenhouse gases in the oil refining industry. There are few studies on comprehensive analysis of changes in energy efficiency process levels and their impact on reducing greenhouse gas emissions in the system. Although factual research is important for environmental changes, professional literature usually only focuses on improving the efficiency of specific methods (without considering the impact on the system) or conducting advanced equipment research (without in-depth evaluation of the feasibility of the following technologies) (Berrang-Ford, Pearce et al. 2015, Monroe, Plate et al. 2019).

The specific goal of research includes the main objectives: To develop steady-state models of refinery units in Aspen HYSYS, evaluate greenhouse gas emissions by analyzing various types of user simulation models, and calculate carbon taxes based on different levels of greenhouse gas emissions.

2. Materials and Method

2.1 Overview of Atmospheric Coarse Column

Crude oil refineries transport crude oil and modify it into refined products such as gasoline, naphtha, kerosene and diesel. The environmental refinement of the refinery can be originate in the number of units of assets. Once the crude oil is introduced into the atmospheric distillation tower, some valuable fractions will be produced, which are then introduced into other process units, such as hydrotreaters, hydrocrackers, reformers and vacuum distillation towers. This chapter will pay special attention to primitive atmospheric units. In this study, an atmospheric crude oil fractionation tower was simulated. 100,000 barrels/day of light Arabian crude oil is introduced into the heating furnace every day, which will evaporate part of the crude oil. Then, the crude stream is applied to an atmospheric crude column, which runs along the loop with three connected side strippers and three pumps. In this study simulations were repeated three times.

2.2 Model development

To build a rough atmospheric column model, the following steps were followed.

2.2.1 Selection of materials and fluid packaging

A new simulation environment has been developed in Aspen HYSYSV10. A list of components was generated, which consist of gasoline: methane, propane, ethane, i-and n-butane as shown in figure 1.

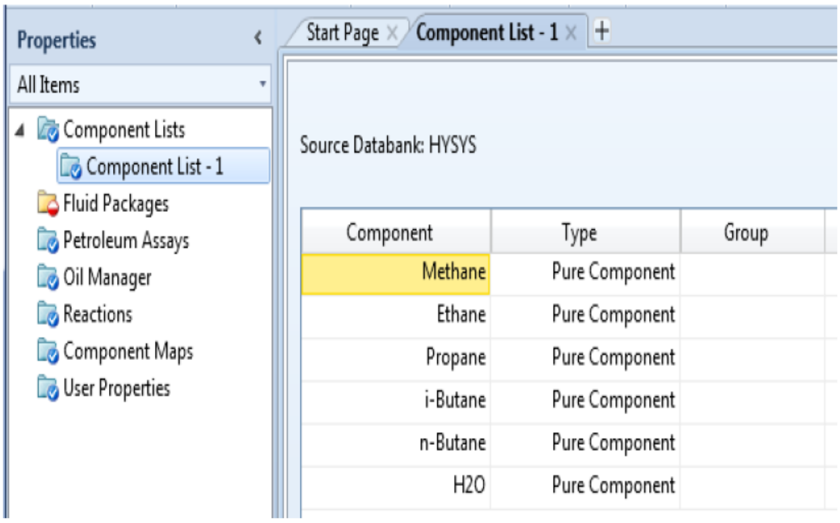
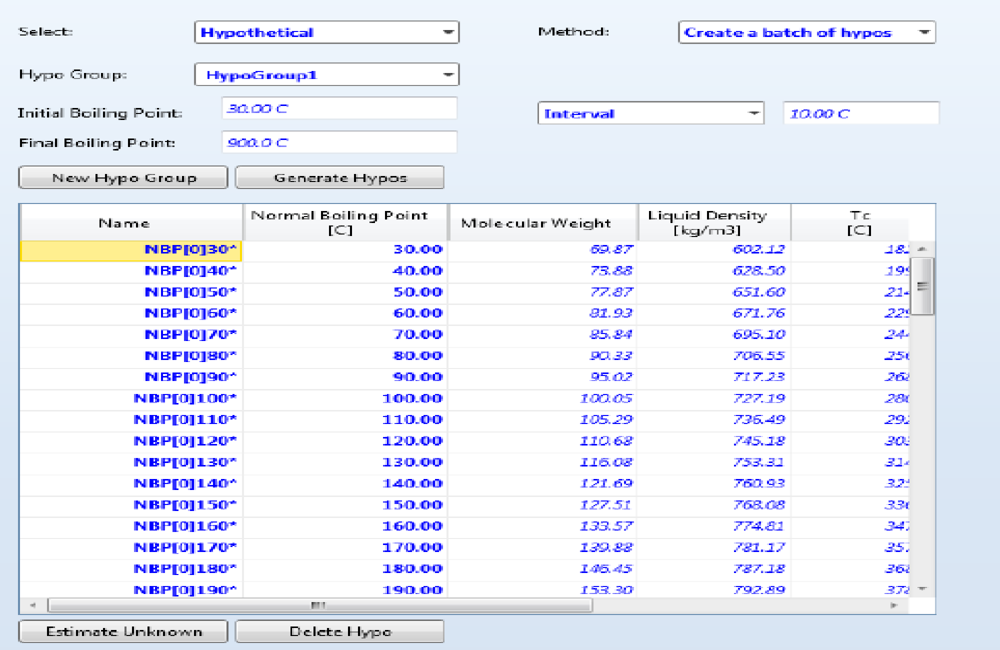


Figure. 1: Creation of component list

Assumptions are also included in the list of components-1. In the above component list, change the selection to the hypothesis. Set the starting value of boiling point at 86°F and then 1652 °F as final boiling point, with a variation of 50°F. After merging the values, generate a set of hypotheses by selecting create hypothesis. The secondary components created are given in figure 2.



Name	Normal Boiling Point [C]	Molecular Weight	Liquid Density [kg/m3]	Tc [C]
NBP[0]30*	30.00	69.87	602.12	18
NBP[0]40*	40.00	73.88	628.50	19
NBP[0]50*	50.00	77.87	651.60	21
NBP[0]60*	60.00	81.93	671.76	22
NBP[0]70*	70.00	85.84	695.10	24
NBP[0]80*	80.00	90.33	706.55	25
NBP[0]90*	90.00	95.02	717.23	26
NBP[0]100*	100.00	100.05	727.19	28
NBP[0]110*	110.00	105.29	736.49	29
NBP[0]120*	120.00	110.68	745.18	30
NBP[0]130*	130.00	116.08	753.31	31
NBP[0]140*	140.00	121.69	760.93	32
NBP[0]150*	150.00	127.51	768.08	33
NBP[0]160*	160.00	133.57	774.81	34
NBP[0]170*	170.00	139.88	781.17	35
NBP[0]180*	180.00	146.45	787.18	36
NBP[0]190*	190.00	153.30	792.89	37

Figure 2: Addition of Hypothetical components

After selecting all the significant resources, the next step is to select the proper state equation, which is often called fluid packaging. The Peng-Robinson liquid package was chosen to develop the model. The defined volume of a gaseous chemical mixture at a certain pressure and temperature is determined using the (PR) state equation. 1.

$$P = \frac{RT}{\hat{v} - b} - \frac{a}{\hat{v}(\hat{v} + b) + b(\hat{v} - b)} \qquad (1)$$

Where

P = Pressure

T = Temperature

R = General gas constant

$\hat{v}$ = Specific volume

Z = Compressibility factor of real gas

2.2.2 Analysis of the characteristics of the oil in the software

The next step is to characterize the oil in the Aspen HYSYS software. In the oil lab folder, select the "Arabic Light" form in the library. Then, fill in the data for the distilled fraction of slightly Arab oil in the table with determination properties and enter the data for the light fraction in the table of light content. This characterizes the oil. You can check the true boiling point curve (TBP), the composition data and crude oil volume characteristics by entering the "Results" tab (Figure 3).

2.2.3 Development and integration of PFD

In HYSYS, the (PFD) process flow diagram must be convergent. The construction of the flow diagram process always initiates through the feed stream. Afterward, the corresponding operation of the unit must be added. The conditions and composition of the supply flow is given in table 1 and the corresponding table. 2.

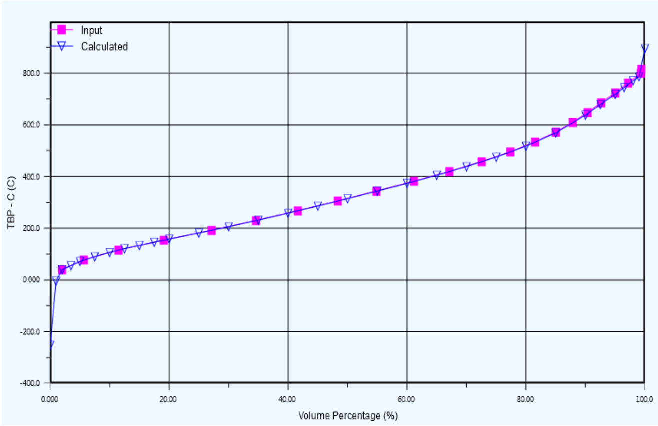


Figure 3: True boiling point curves for both calculated v/s input data

Table 1: The Input data of feed stream (Raw Crude)

Properties	**Raw Crude**	**Unit**
Liquid Volume Flow	2916.667	USGPM
Heat Flow	-923279629	Btu/h
Pressure	75	psia
Mass Flow	1284956.437	lb/h
Vapor Fraction	0.277	-
Molar Flow	6231.067	lbmole/h
Temperature	450	F

Table 2: Arrangement of Feed Stream for feed stream Raw Crude

Component	**Mole Fraction**	**Component**	**Mole Fraction**
N [0] 433*	$3.5647 x10^{-2}$	Methane	$2.84 x10^{-4}$
N [0] 464*	$3.9413 x10^{-2}$	Ethane	$6.24 x10^{-4}$
N [0] 496*	$3.9281 x10^{-2}$	Propane	$8.618 x10^{-3}$
N [0] 528*	$3.5621 x10^{-2}$	i-Butane	$5.439 x10^{-3}$
N [0] 560*	$3.1384 x10^{-2}$	n-Butane	$1.9285 x10^{-2}$
N [0] 592*	$2.7878 x10^{-2}$	H_2O	0
N [0] 624*	$2.4233 x10^{-2}$	N [0] 49*	$3.6381 x10^{-2}$
N [0] 656*	$2.1272 x10^{-2}$	N [0] 79*	$4.3586 x10^{-2}$
N [0]688*	$1.9156 x10^{-2}$	N [0] 111*	$4.2716 x10^{-2}$
N [0]720*	$1.7204 x10^{-2}$	N [0] 144*	$4.1615 x10^{-2}$
N [0] 752*	$1.5275 x10^{-2}$	N [0] 176*	$4.3817 x10^{-2}$
N [0] 784*	$1.3821 x10^{-2}$	N [0] 208*	$4.505 x10^{-2}$
N [0] 830*	$2.2947 x10^{-2}$	N [0] 240*	$4.3747 x10^{-2}$
N [0] 888*	$2.1159 x10^{-2}$	N [0] 272*	$4.1802 x10^{-2}$
N [0] 947*	$2.0919 x10^{-2}$	N [0] 304*	$3.9094 x10^{-2}$
N [0] 1009*	$2.6696 x10^{-2}$	N [0] 336*	$3.62 x10^{-2}$
N [0] 1062*	$3.645 x10^{-2}$	N [0] 368*	$3.4188 x10^{-2}$
N [0] 1124*	$3.5808 x10^{-2}$	N [0] 400*	$3.3389 x10^{-2}$

* Each component with starting name N = NBP [0] are Hypothetical components

The refinery unit convergence diagram is given in figure. 4. The first batch of crude oil is initially directed to the Pre-Flash separator, which separates the vapor and liquid streams. The liquid is heated in the separator, and the raw material is heated in the raw material heater. Then, the heated pre-flash liquid is mixed with the steam in the separator and then sent to the distillation column. In the distillation column, crude oil is separated into different vital fractions, such as naphtha, AGO, diesel and kerosene, etc.

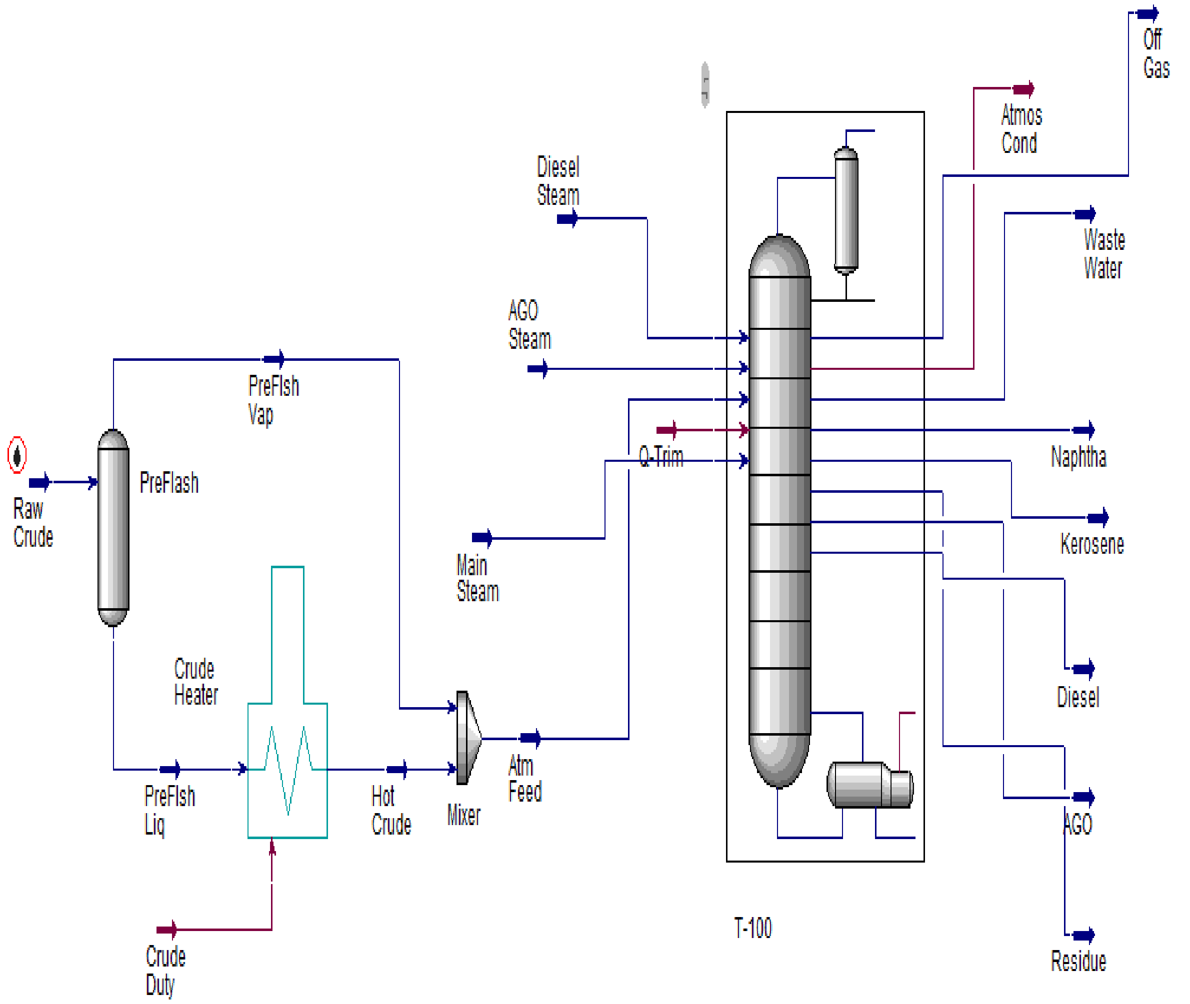


Figure 4: Converged PFD of Atmospheric Crude Column.

3. RESULTS AND DISCUSSION

3.1 Overview

In the current study, the Aspen HYSYS V10 has been used to simulate a thick atmospheric column. Subsequently, the model was used to evaluate greenhouse gas (GHG) emissions by using the US EPA method. The results have been discussed as under.

3.2 Effect of Feed Flow on GHG Emissions Energy Flow

The simulation was performed via changing the feed flow rate to 3,400 USGPM from 3,000 USGPM at a fixed temperature of 450°F and a pressure of 75 psia. figure. 5 (a - e) shows the changes in the mass and energy flow of the service current in relation to the increase in the standard liquid volume flow (ie total flow) of the supply current. All data are developed based on several latest fuel sources, including bituminous coal (figure. 5(a)), lignite (figure 5(b)), and natural gas (figure 5(c)), Total (figure 5(d)) and municipal solid waste (figure 5(d)).

It can be seen from figure 5 (a, b) that the total energy required to heat 3000 USGPM crude oil is 207.3 MMBTU/h, which is enhanced by linearly increasing the flow rate of crude oil to 3400 USGMP from 300 USGMP, reaching 238,5 MMBTU/h. As a result, the mass flow requirement for bituminous coal has also increased to 325777.4 from 28,3192.9 lb/h. It can be observed from all these data that as the power volume flow rate rises, the demand for energy also increases, and therefore, the total mass flow rate of the franchise flow also increases. The main reason for this trend is that, as shown by the convergent PFD figure. 4, the increase in steam separation in the first elimination vessel. There is almost no difference in the trend, changing the fuel source of the final energy.

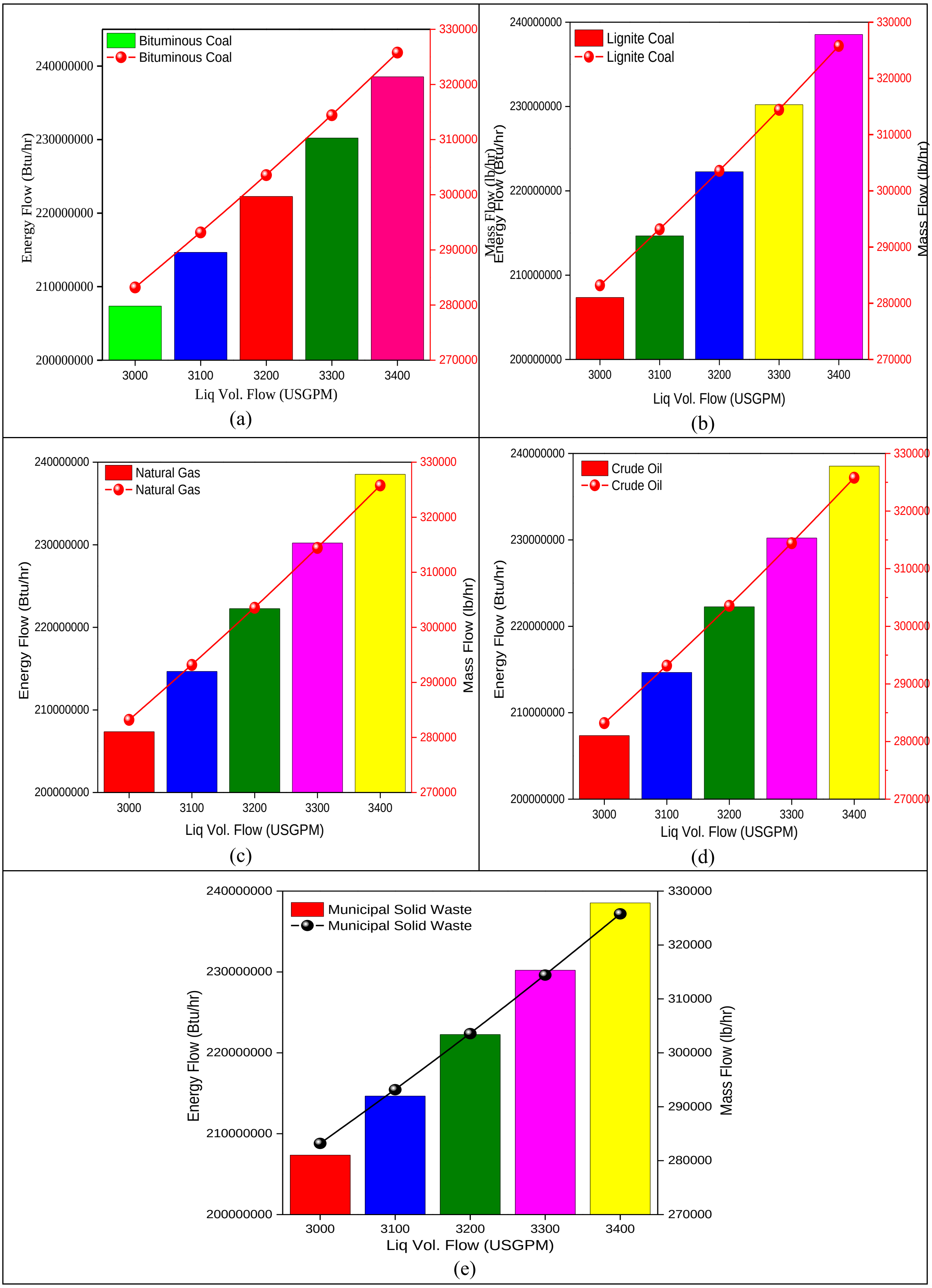


Figure 5: Energy and mass flow of utility with respect to flow of feed stream**:** (a) Ultimate fuel source: Bituminous coal, (b) Ultimate fuel source: Lignite coal, (c) Ultimate fuel source: Natural Gas, (d) Ultimate fuel source: Crude oil, (e) Ultimate fuel source: Municipal Solid Waste (MSW).

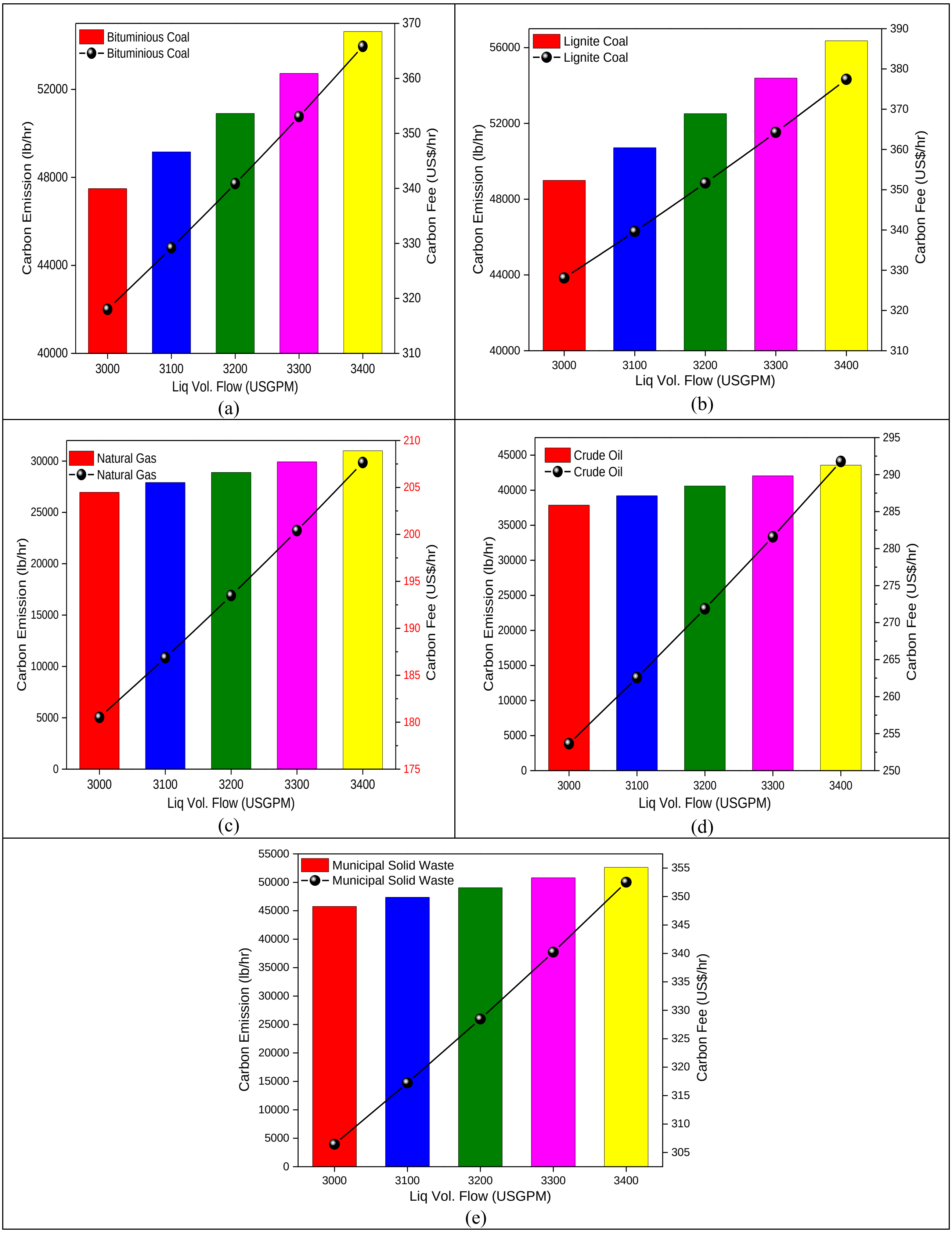


Figure 6: GHG emission and carbon fee with varying feed flow: (a) Ultimate fuel source: Bituminous coal (b) Ultimate fuel source: Lignite coal, (c) Ultimate fuel source: Natural Gas, (d) Ultimate fuel source: Crude oil, (e) Ultimate fuel source: Municipal Solid Waste (MSW)

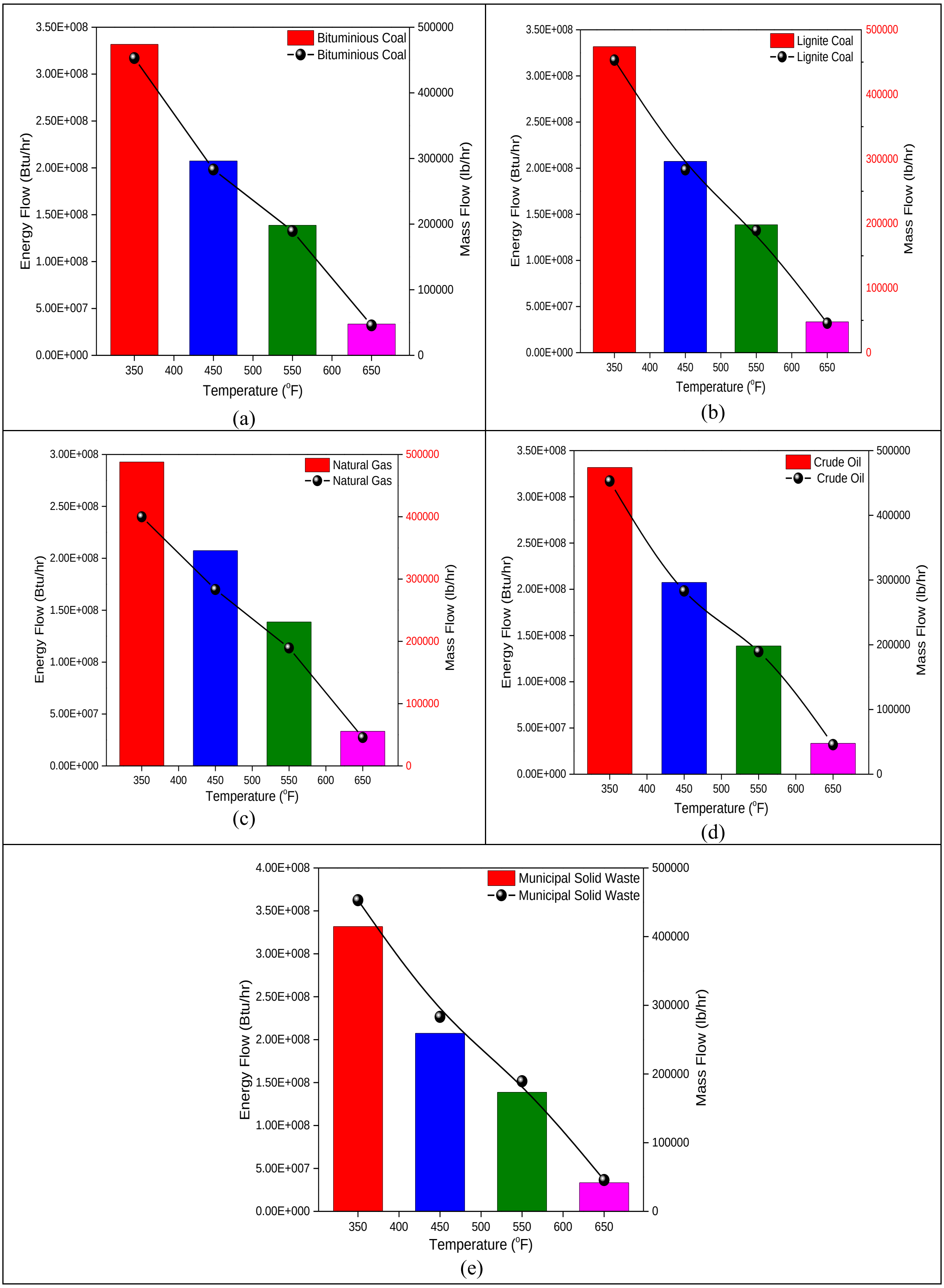


Figure 7: Mass flow Energy and of utility at different temperature feed**:** (a) Ultimate fuel source: Bituminous coal, (b) Ultimate fuel source: Lignite coal, (c) Ultimate fuel source: Natural Gas, (d) Ultimate fuel source: Crude oil, (e) Ultimate fuel source: Municipal Solid Waste (MSW)

In all cases, greenhouse gases (GHG) are calculated in the form of CO_2. The carbon tax or corresponding tax were also calculated by using the US-EPA method. Figure 6 (a-e) shows the changes in greenhouse gas emissions and carbon flow with changes in volumetric flow in different final utility sources. It can be seen that as the feed flow rate increases, greenhouse gas emissions are also increasing. The main logic is obvious, because the demand for energy is also increasing, which indicates that more fuel is burned and therefore more greenhouse gases are produced. It can be seen from figure 6(a) that the total carbon emissions generated by using bituminous coal to heat 3,000 US-GPM crude oil is 47,487.8 lb/h, which is raised by enhancing the crude oil flow rate from 300 US-GMP to 3400 US-GMP and reaches. The corresponding carbon rate of 54628.7 lb/h has been increased to 365.8 from 318 US dollars per hour. Similarly, in figure 6(b), it is observed that the total carbon emission of heating 3,000 US-GPM crude oil by using lignite is 48992.3 lb/h, which is enhanced by rising the crude oil flow rate to 3400 US-GMP from 300 US-GMP, and reaches the corresponding carbon rate of up to 56360.5 lb/h has been increased to 377.4 US dollars per hour from 328 US dollars per hour. According to figure 6(c), using natural gas as the final practical resource, carbon emissions have increased to 3,1009.4 lb/h from 26,956 lb/h, so the corresponding carbon emission rate has increased to US$207 from US$180, or US$6/h. Carbon emissions from using crude oil (figure 6(d)) have raised to 43571 from 37875.5 lb/h with an increase of carbon fee to 291.7 from 253.6 US$/h.

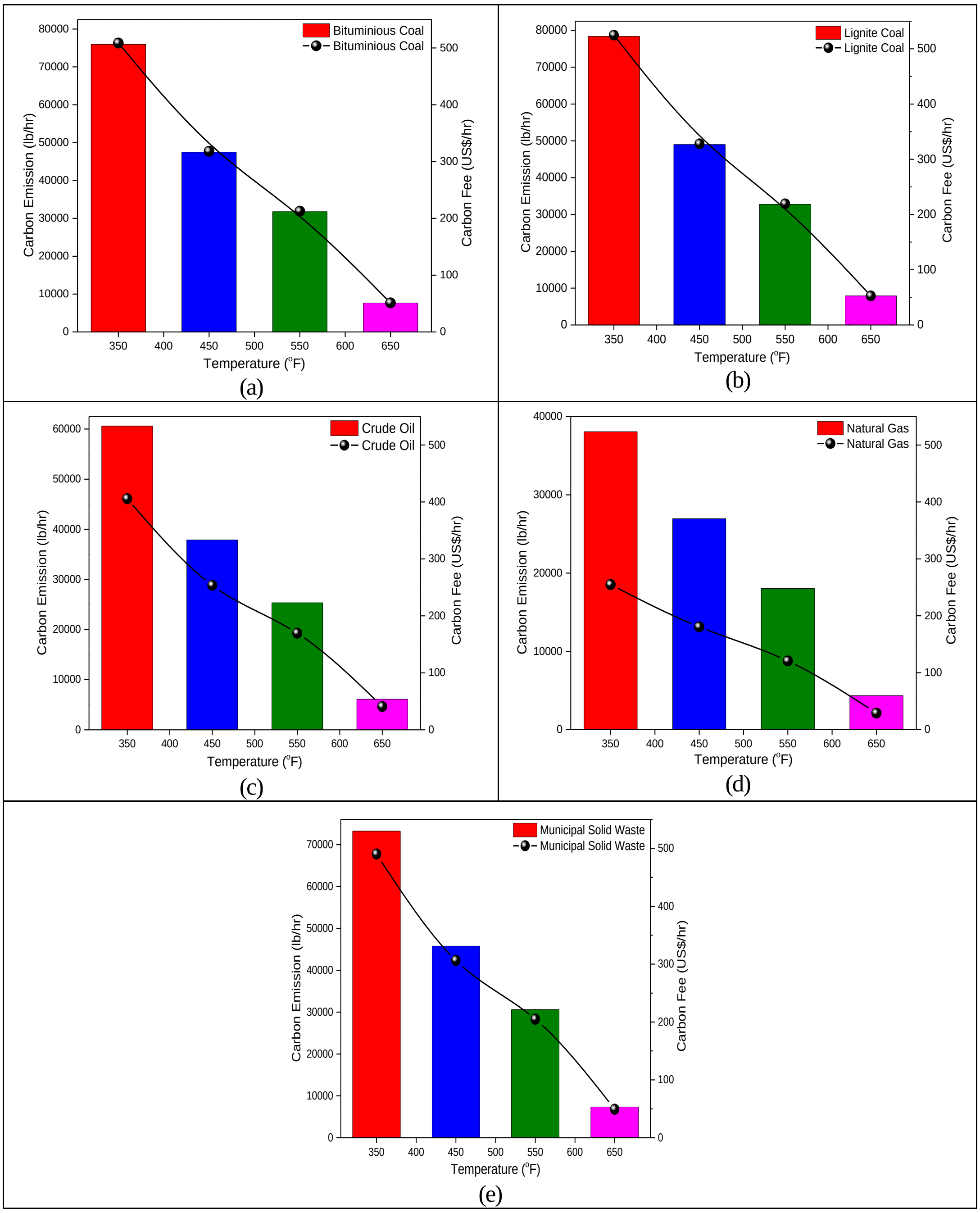


Figure 8: carbon fee and Green House Gass (GHG) emission with different feed temperature: (a) Ultimate fuel source: Bituminous coal, (b)Ultimate fuel source: (c)Lignite coal Ultimate fuel source: crude, (d) Ultimate fuel source: natural gas, (e) Ultimate fuel source: Municipal Solid Waste (MSW)

Ultimately, the carbon emission of MSW (figure 6(e)) raised to 52642 from 45761 lb/h with subsequent carbon fee enhanced to 352.5.7 from 306.4.6 US$/h. The data is evaluated later than with all the ultimate fuel source utilities. From the above results it was determined that by utilizing Lignite Coal as an ultimate source utility the maximum carbon emission was accomplished.

3.3 Effect of Feed Temperature on Energy Flow and GHG Emission

The past simulation was carried out at a constant pressure and temperature (i.e. 75 psia and 450 ° F), only the feed flow rate was changed. Thereafter, the feed flow rate was kept fixed at 3000 USGPM, and the temperature changed between 350 and 650 °F, with a change of 100 °F among individual modeling. The effect of temperature on the utility's mass and energy flow have been given in figure 7 (a-e), and the temperature effect on emissions of carbon and costs is given in figure 8 (a-e). In general, it was observed that the temperature has an opposite effect on the energy flow, on the mass flow of practical energy, and then on carbon emissions and costs. It can be seen in figure 7 (ab) that the total energy required to heat 3000 USGPM crude oil to 350 ° F is 331 MMBTU/h, which can be reduced to a maximum of 33.4 by enhancing the temperature of the crude oil by 350 ° F - 650 ° F Therefore, the mass flow demand for bituminous coal has also been reduced to 45621from 452990lb/h. Another thing observed is that it has nothing to do with the type of utility used. In figure 8 (a), it can be seen that the total carbon emissions of crude oil using bituminous coal to heat 3,000 USGPM to 350 ° F is 75,961 lb /h. By increasing the temperature of crude oil to 650 ° F from 350 ° F, total carbon emissions can be reduced. Carbon emissions, upto 7,650 lb/h. The resulting carbon rate is reduced from US $ 508.6/h to US $ 51.22/h. Similarly, in figure 8(b), the total carbon emissions of 3,000 USGPM crude oil heated to 350°F by using a lignite is 78371 lb/h, which reduces the total carbon emissions to 650 by increasing the crude oil flow temperature to 650 °F from 350°F and reach 7892 lb/h. The resulting carbon rate has been reduced to US$52.8/h from US$524.8/h. According to the figure. 8(c), using natural gas as the final practical resource, the carbon emission has been reduced to 4342 lb/h from 38066 lb/h, so the resulting carbon emission rate has been reduced from 254.9 USD/h to 29 USD/h. The carbon emission of using crude oil (figure 8(d)) has been reduced to 6101 lb/h from 60,585, and the resulting carbon emission rate has been reduced to 40.8 US$/h from 405.7. Lastly, the carbon emissions using RSU (figure 8(e)) were reduced from 73201 lb/h to the corresponding carbon rate to 49 US$/h from 490 US$/h. The data is then corelated with each final fuel source of the dealer.

3.4 Effect of supplied Pressure on GHG Emission and Energy Flow

Subsequently by studying the supplied flow rate and the supplied temperature, the feed temperature and flow rate were kept fixed at 450 ° F and 3000 USGPM, respectively, and the pressure was set from 70 to 85 psia, and the variation between each simulation was 5 psia. The effect of pressure on the utility's mass flow and energy is given in figure 9 (a-e), and the effect of pressure on carbon emissions and costs is given in figure 10 (a-e). In general, the impact of pressure on the flow of energy, on the mass flow of utilities and on carbon emissions and bills first decreases and then increases. It can be observed from figure 9 (ab) that the highest energy needed to heat 3000 USGPM of crude oil to a pressure of 70 psia is 237 MMBTU/h, which is slightly enhanced by raising the pressure of the crude oil to 85 psia from 70 psia. at 241 MMBTU /h. Therefore, the mass flow required for bituminous coal has also enhanced to 328906 lb/h from 324069. Another thing found is that it has nothing to do with the type of utility used. It can be seen in figure 10 (a) that the total carbon emission from the crude oil heated by 3000 USGPM to 70 psia using bituminous coal is 54342 lb/h, which is marginally improved by enhancing the pressure of the crude oil from 70 psia to 85 psia, and achieved to 55153 lb /h. The resulting carbon rate has been enhanced to US$369/h from US$364/h. At 75 pounds per square inch (psia), the lowest carbon emissions and carbon rates observed were 47,488 lb/h and 318 US$/h, correspondingly. Likewise, it can be observed from figure 10(b) that the cumulative carbon emission of 3000 USGPM crude oil to 70 psia by using lignite coal is 56064 lb/h, that is marginally enhanced to 56901 lb/h, thereby enhancing the pressure of crude oil flow rate to 85 psia from 70. The resulting carbon rate has been enhanced from US$375/h to US$381/h. At 75 pounds per square inch (psia), the lowest carbon emissions and carbon rates observed were 48,992 lb/h and 328 US$/h, respectively. As shown in figure 10(c), using natural gas as the final practical resource, the carbon footprint has increased to 31307 lb/h from 30847 lb/h, so the corresponding carbon rate has been marginally enhanced from 206 - $209/h. The carbon footprint of using crude oil (figure 10(d)) has enhanced from 32556 lb/h to 43989 lb/h, and the related carbon rate has enhanced to $294/h from 218. Lastly, the carbon emissions using RSU (figure 10(e)) enhanced from 52366 lb/h to 53148 lb/h, and the corresponding carbon rate increased to 356 US$/h from 350 US$/h.

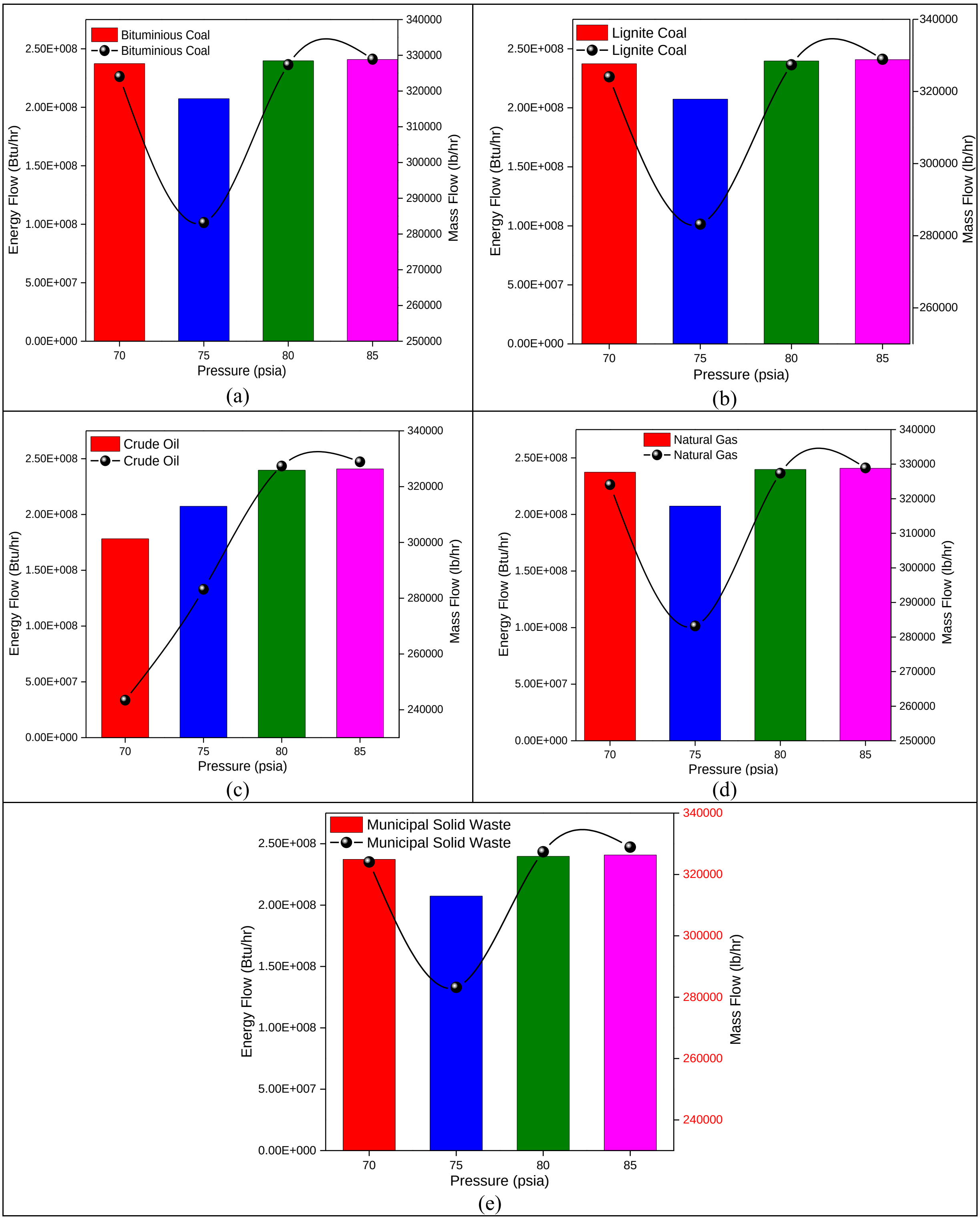


Figure. 9: Mass flow and Energy of utility at different feed pressure: a) Ultimate fuel source: Bituminous coal, (b) Ultimate fuel source: Lignite coal, (c) Ultimate fuel source: crude oil, (d) Ultimate fuel source: natural gas, (e) Ultimate fuel source: Municipal Solid Waste (MSW).

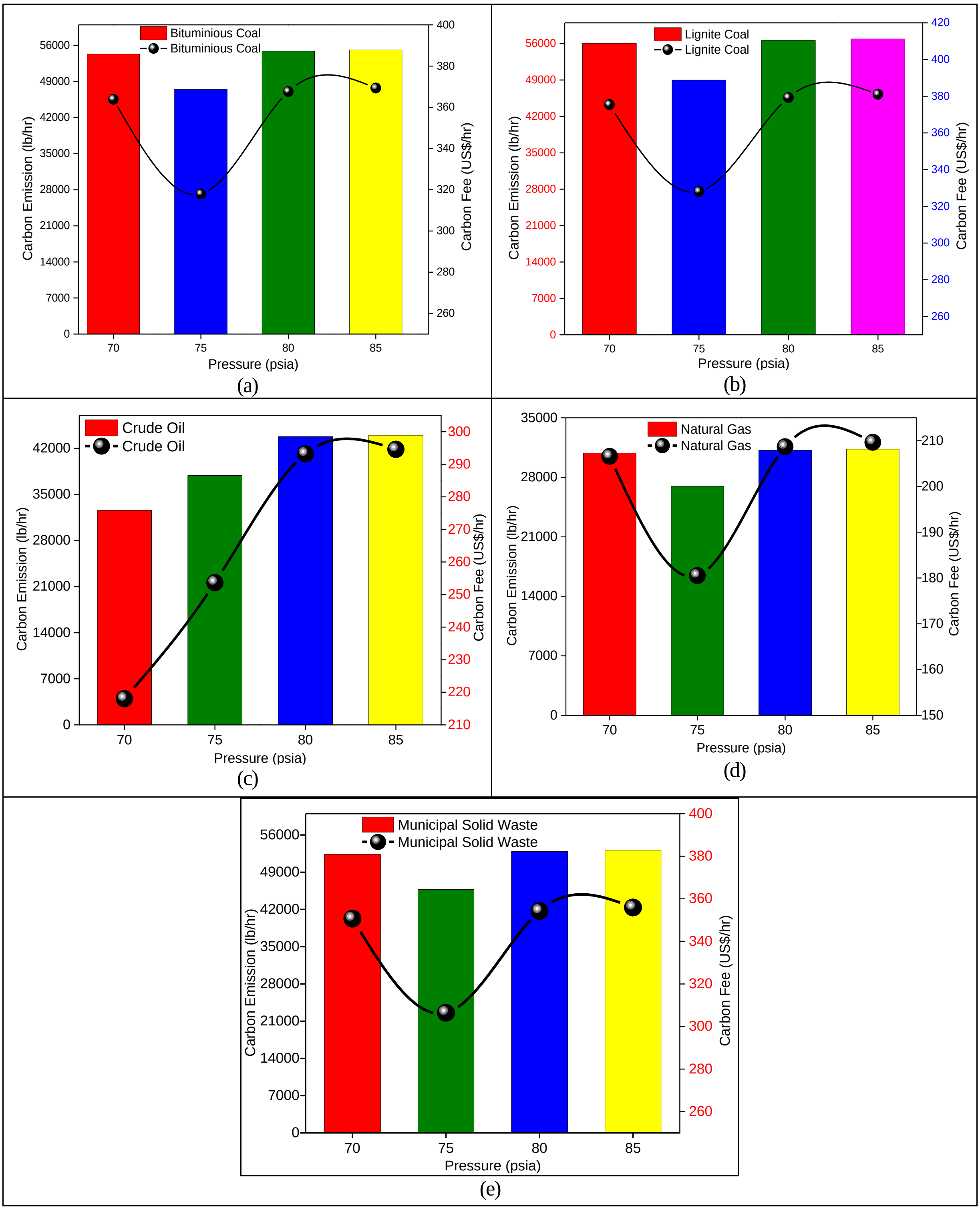


Figure 10: Carbon fee and GHG emission with different feed temperatures: (a) Ultimate fuel source: Bituminous coal, (b) Ultimate fuel source: Lignite coal, (c) Ultimate fuel source: crude, (d) Ultimate fuel source natural gas, (e) Ultimate fuel source: Municipal Solid Waste (MSW)

3.5 Effect of Ultimate Fuel Source

Under different feed flows, temperature, pressure and different final fuel sources, research was conducted on greenhouse gas emissions and the corresponding carbon rates. Compare the data and display it in figure 11 to figure 16. Figure 11 shows carbon emission trends for each utility source utilized in the simulation at different feed flow rates ranging to 3400 USGPM from 300. Carbon emissions increase as the flow from all sources increases. The utility type of lignite shows the highest carbon emissions, while bituminous coal occupies the second place. The public service type of natural gas reaches the lowest carbon emissions. Figure 12 shows the carbon bill trends for each utility source utilized in the simulation at different feed flow rates ranging from 300. This result corresponds to the trend in figure 11. It can be observed that, as traffic to 3400 USGPM from all sources increases, so does the carbon rate. Lignite uses the highest carbon cost, while bituminous coal occupies the second place. The public service type of natural gas reaches the lowest carbon emissions. Figures 13 and 14 respectively given trends in carbon emissions and carbon costs for all utilities used in the simulation at different feed temperatures ranging to 650 from 350 ° F.

It can be seen that as the temperature increases, carbon emissions and therefore the carbon rate are decreasing. The carbon emissions from the lignite are the highest, so the carbon ratio is the highest, and the carbon emissions from the final natural gas fuel are the lowest, so the carbon ratio is the highest. Figures 15 and 16 respectively show the carbon emission and carbon emission rate trends of all practical energy sources used in the simulation under variable air supply pressures of 70 to 85 psia. It can be seen that as the pressure increases to 75 psia from 70 psia, and then slightly increases, the carbon emissions and therefore the carbon rate are decreasing. Here, lignite also shows the highest carbon emissions and therefore the highest carbon rate, while natural gas shows the smallest of these two quantities. It has been seen that the final fuel source has a significant impact on greenhouse gas emissions. The maximum carbon content of bituminous coal is 300068GPM, the flow rate is 3000 USGPM, the temperature is 75 psia, and the temperature is 450°F. The pressure was again increased by enhancing the pressure to 85 psia (up to 55153 lb/h). With lignite as the final use source, the maximum carbon content is 75360 psi/h, the flow rate is 3000 USGPM and 450°F, reaching the final utility source. It was further increased to 78370 psi, reducing the pressure to 70 psi. Under similar conditions, with natural gas as the final fuel source, the lowest GHG is calculated to be 31009 lb/h.

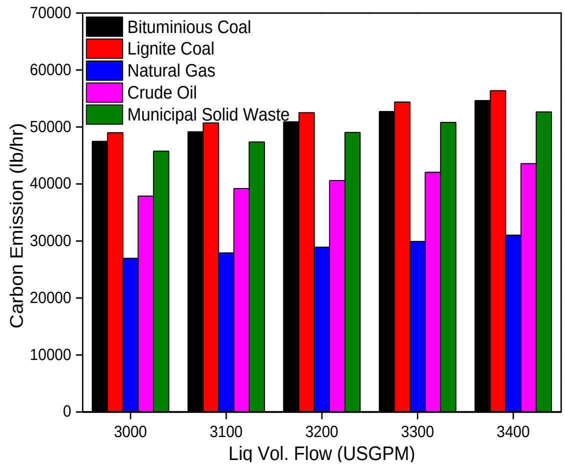


Figure 11: GHG emissions with varying ultimate fuel sources at varying feed flow

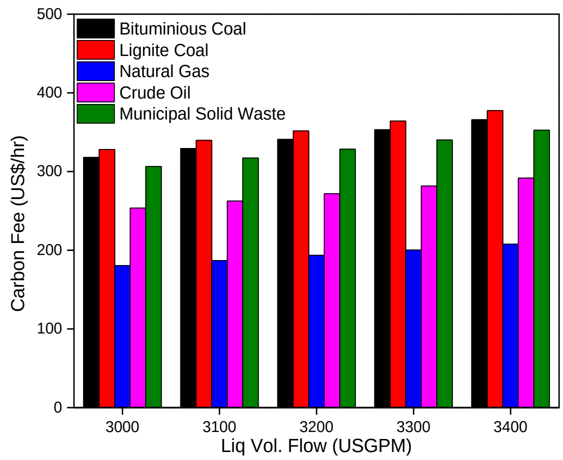


Figure 12: Carbon Fee GHG emissions with varying ultimate fuel sources at varying feed flow

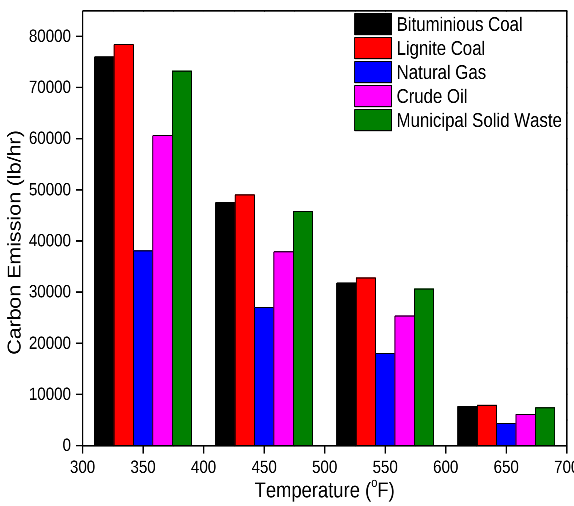


Figure 13: GHG emissions with varying ultimate fuel sources at varying feed temperature

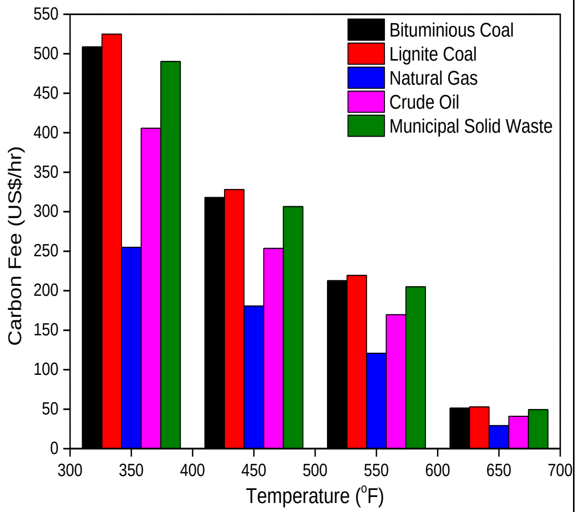


Figure 14: Carbon Fee GHG emissions with varying ultimate fuel sources at varying feed temperature

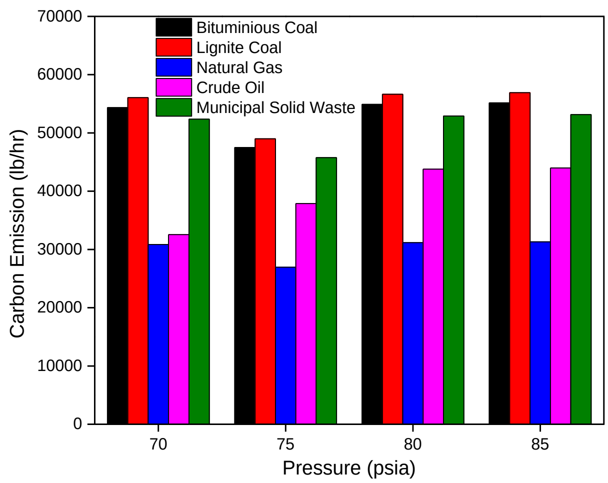


Figure 15: GHG emissions with varying ultimate fuel sources at varying feed pressure

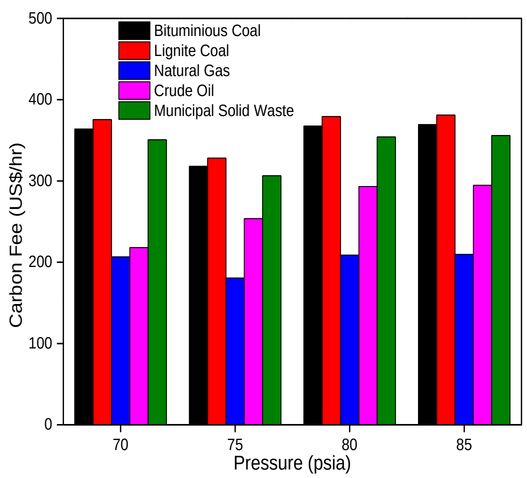


Figure 16: Carbon Fee GHG emissions with varying ultimate fuel sources at varying feed pressure

3.6 Comparison of current study Results with published data

The current results achieved related to the calculation of energy flow in varying feed streams are compared with data in the literature figure. 17. It is found that this value is very similar to the already published findings of Al-muslim et al. (2005), because the basic data of the current modeling comes from this research work. Therefore, compare the readings carefully. Soiket et al. (2019) and Safaei et al. (2019) also compared the other two works, and the results are much lower than the energy values reported in this study. This is because of the difference is that their working direction is different, because Soiket et al. (2019) studied the emissions of the steel sector, while Safaei et al. (2019) calculated the total emissions of different refineries.

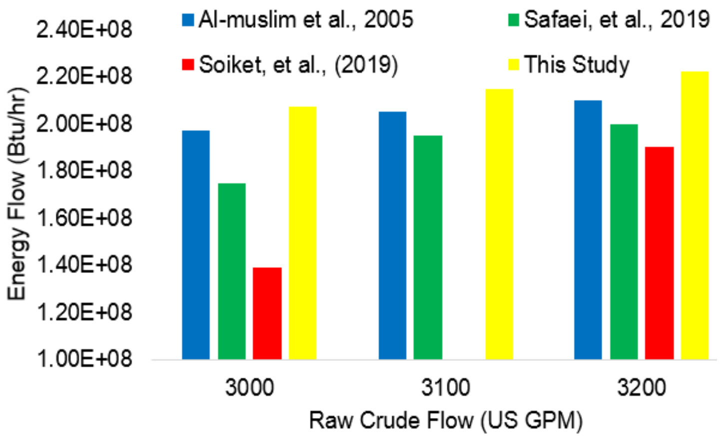


Figure 17: Comparison of study Results with published data

5. Conclusions

The current study, the US EPA method is used to estimate greenhouse gas (GHG) emissions and carbon rates from a simulated refinery unit. A computer-generated model of the refinery was established using Aspen HYSYSV10. The research was carried out by changing the feed flow of the feed stream, that is, the crude oil, changing the temperature and changing the pressure. The Five different fuel sources were selected, namely crude oil, natural gas, bituminous coal, lignite, and solid urban waste (MSW) to study the impact of the concessionaire's final fuel source. This study came to the following conclusions.

• Due to the reduction in energy demand, GHG emissions decrease as the feed flow increases.

• Greenhouse gas emissions decrease as the temperature of the feed material increases and, correspondingly, its carbon cost is also reduced.

• With lignite as the final practical source, at a flow rate of 3,000 USGPM, a temperature of 450 ° F and a pressure of 70 psi, the maximum observed greenhouse gas emission was 78,370 pounds per hour.

• Using natural gas as the final fuel source, the lowest greenhouse gas emissions observed were 18027 pounds per hour.

• The maximum carbon cost of lignite fuel with a feed flow of 3,000 USGPM, a temperature of 350 ° F and 75 psia is 524 US $ / h.

• The minimum carbon rate of $ 29.7 / hour is calculated based on the natural gas fuel source with a feed flow of 3,000 USGPM, a temperature of 650 ° F and 75 psia.

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