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Prediction of Energy Crisis in Indonesia Through Simulation Models System Dynamic

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ABSTRACT.

According to the Ministry of Energy and Mineral Resources (2016), the development of the times accompanied by an increase in the world's population, makes energy use also increase. Especially with the industrial revolution that triggers industrial growth in all sectors, making energy use also increase. The fulfillment of energy needs must be balanced with the availability of energy in an appropriate, integrated and sustainable manner in order to facilitate activities in all sectors of energy users, such as the household sector, transportation, industry, commercial, and others. The balance between energy supply and energy demand needs to be analyzed in order to give an idea of the impending energy crisis in Indonesia. The data used in this report is secondary data collected by literature study technique. The problem faced by Indonesia is that energy consumption is increasing, especially in the transportation sector, increasing to 15,000,000 terajoules in 2060, while energy production in Indonesia has increased which is not too significant. This resulted in an energy crisis. Judging from the simulation of the dynamic system approach, it is predicted that Indonesia will experience an energy crisis in 2051. In order to overcome the problem of the energy crisis in Indonesia, energy conservation is needed in various layers, both from the aspect of energy management and from the community.

Keywords: energy, energy crisis, simulation, dynamic system

I

. Introduction

Energy is a basic need that cannot be separated from humans. Almost all sectors in this life require energy to meet human needs [1]. Meanwhile, over time conventional energy sources such as oil and coal are running low, this is because these conventional energy sources are non-renewable energy sources. This means that energy sources like this one day will run out [2]. Under such conditions, the use of energy must be done wisely, productively and efficiently. In addition, creating and using renewable energy sources is a demand for all parties, especially the government. However, the current problem is that alternative energy sources have not yet produced optimal results for commercial use. On the other hand, prices for domestic energy sources show an increasing trend, this is due to the increase in world oil prices, which is increasing and has an impact on increasing domestic energy prices, plus the depletion of national oil reserves. [1].

From the aspect of supply, Indonesia is a country rich in energy resources, both unrenewable and renewable. However, exploration of energy resources is more focused on fossil energy, which is unrenewable resources, while renewable energy is relatively not widely used. This condition causes the availability of fossil energy, especially crude oil, to be increasingly scarce which causes Indonesia to become a net importer of crude oil and its derivative products. [3].

The fulfilment of energy needs must be balanced with the availability of energy in an appropriate, integrated and sustainable manner in order to facilitate activities in all sectors of energy users, such as the household sector, transportation, industry, commercial, and others. The balance between energy supply and energy demand needs to be analyzed in order to provide an overview of the impending energy crisis in Indonesia [4].

1. Data and Data Collection Methods

The data used in this report is secondary data collected by literature study technique. The data collected includes data on energy consumption by sector, data on energy production in Indonesia, data on vehicle growth and population growth in Indonesia. The main data sources are Indonesia's energy balance data obtained from the Ministry of Energy and Mineral Resources and data from the Statistics Indonesia

Table 1. Primary Energy Export and Import Data in Indonesia

Year	2015	2016	2017	2018	2019
Import (Terajoule)	2.316.952	2.195.016	2.314.907	2.339.404	2.037.850
Export (Terajoule)	11.617,757	11.379.784	11.430.006	12.127.917	12.541.008

Table 2. Energy consumption data

Year	2015	2016	2017	2018	2019
Industrial (Terajoule)	1.659.509	1.487.041	1.427.810	2.022.026	2.463.953
Other (Terajoule)	214.593	299.538	330.068	312.681	353.443

Table 3. Energy production data

	2015	2016	2017	2018	2019
Mining (Terajoule)	17.109.978	17.559.268	17.472.657	19.112.024	20.600.280
Powerplants (Terajoule)			262.656	276.319	281.757

Table 4. Additional data

Number of 4-Wheel Vehicles in 2019	15.592.419 (unit)
4 Wheeled Vehicle Growth Percentage	6,10% (per year)
Number of 2-Wheel Vehicles in 2019	112.771.136 (unit)
2 Wheel Vehicles Growth Percentage	6,20% (per year)
Number of Population in 2019	266.911.900 (person)
Percentage of Population Growth	1,411%

2. Result and Discussion

From the problems that have been described, a causal loop diagram (CLD) model can be drawn up as below (Fig 1):

For the level of energy consumption, there are several sectors that can increase energy consumption in Indonesia, such as the transportation sector, the industrial sector, the household sector, and others such as public lighting. Of course, the transportation and household sectors cannot escape the influence of the population, where the increasing population, the higher the level of energy consumption from the transportation and household sectors. The level of energy production is influenced by mining and power generation. The greater the energy produced by the power plant, the higher the level of energy production. Likewise, with mining. The higher the energy generated from the mining process, the higher the level of energy production. Energy consumption and energy production cannot be separated from the influence of technological developments, because the more advanced technology is, the greater the level of energy consumption and the level of energy production.

The following is a dynamic system diagram in predicting the occurrence of an energy crisis in Indonesia (Fig 2)

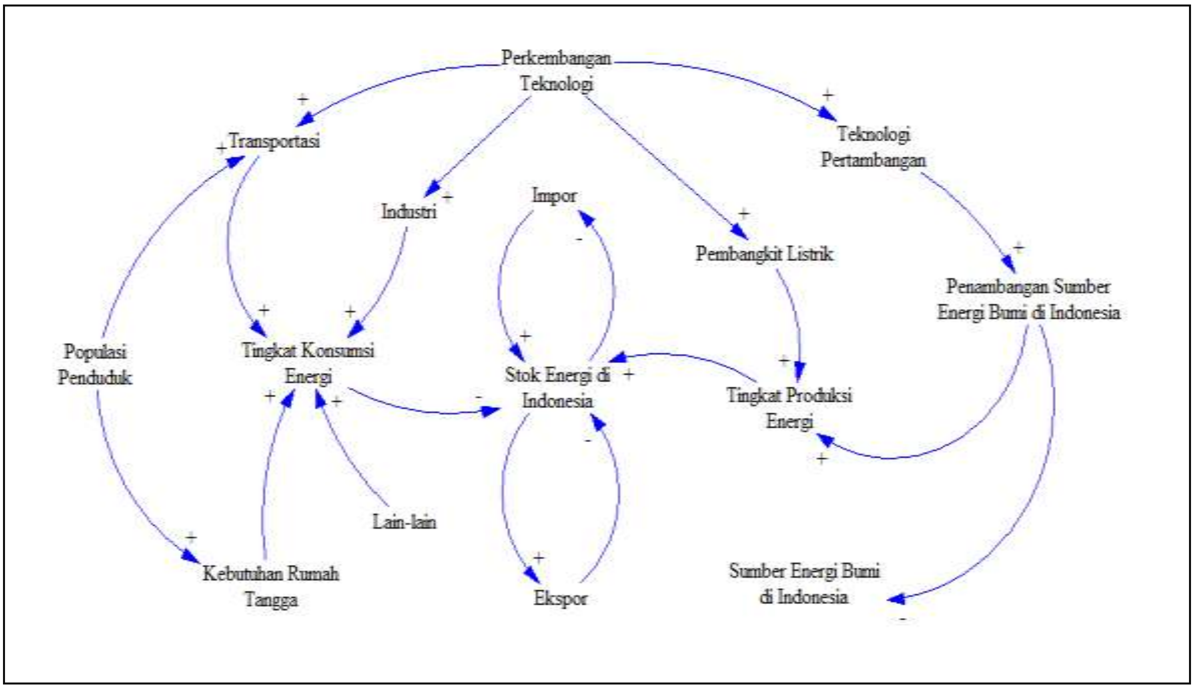

Fig1. Causal loop diagram of energy stock in Indonesia

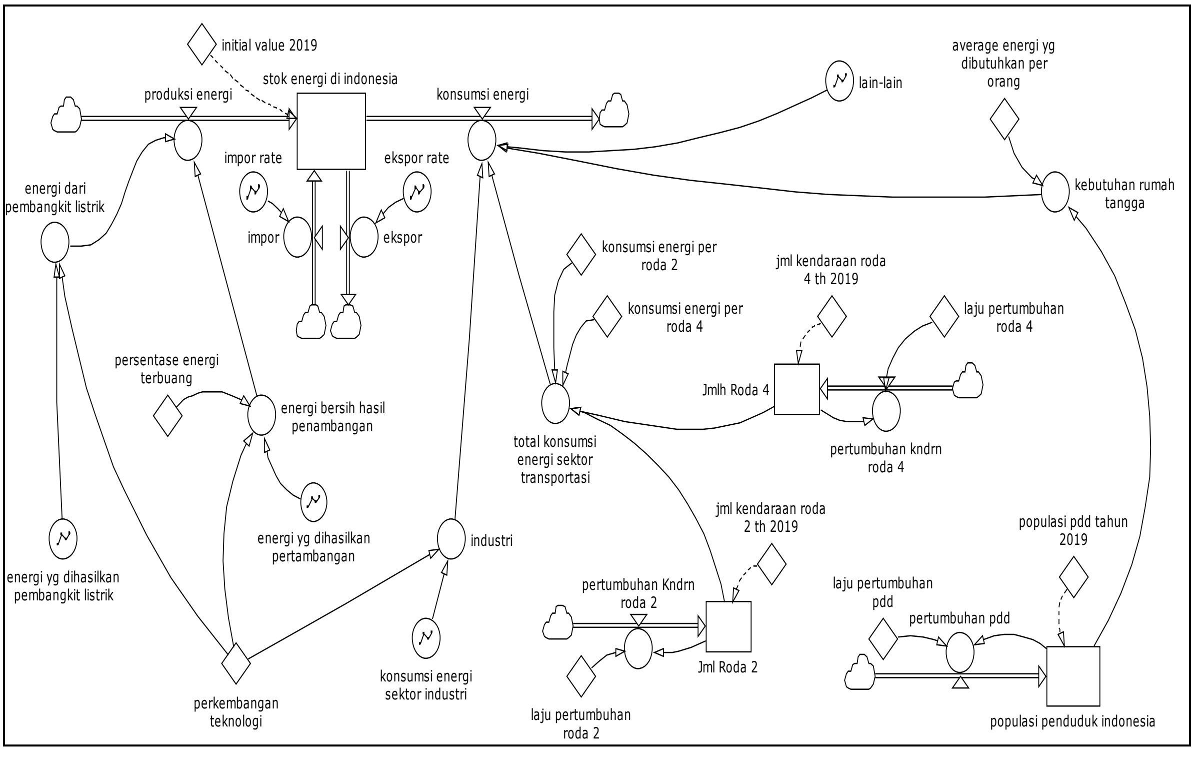

Fig 2. Dynamic system diagram

The definition of each variable in the dynamic system diagram that has been designed is as follows:

Table 5. Types of level variables in dynamic systems

Type	Variable Name	Definition	Flows
Level	stok energi di indonesia	'initial value 2020'	[+dt*('produksi energi') -dt*(ekspor) +dt*(impor) -dt*('konsumsi energi')]
	jmlh roda 4	'jml kendaraan roda 4 th 2019'	[+dt*('pertumbuhan kndrn roda 4')]
	jml roda 2	'jml kendaraan roda 2 th 2019'	[+dt*('pertumbuhan kndrn roda 2')]
	populasi penduduk indonesia	'populasi pdd tahun 2019'	[+dt*('pertumbuhan pdd')]

Table 6. Type of constant variable in dynamic system

Type	Variable Name	Definition
Constant	initial value 2019	10023342
	persentase energi terbuang	0.143984
	konsumsi energi per roda 2	0.0081178
	konsumsi energi per roda 4	0.018577
	laju pertumbuhan roda 2	0.062
	laju pertumbuhan roda 4	0.061
	jml kendaraan roda 2 th 2019	112771136
	jml kendaraan roda 4 th 2019	15592419
	perkembangan	1.035771

	teknologi	
	populasi pdd tahun 2019	266911900
	laju pertumbuhan pdd	0.01411
	average energi yg dibutuhkan per orang	0.0057473

Table 7. Type of auxiliary variable in dynamic system

Type	Variable Name	Definition
Auxiliary	energi yg dihasilkan pembangkit listrik	GRAPHCURVE(TIME,2017,1,{262656,276319,281757//Min:0;Max:400000//})
	energi dari pembangkit listrik	'energi yg dihasilkan pembangkit listrik'*'perkembangan teknologi'
	energi yg dihasilkan pertambangan	GRAPH(TIME,2015,1,{17109978,17559268,17472657,19112024,20600280//Min:0;Max:25000000//})
	energi bersih hasil penambangan	('energi yg dihasilkan pertambangan'*'perkembangan teknologi')-('energi yg dihasilkan pertambangan'*'perkembangan teknologi'*'persentase energi terbuang')
	produksi energi	'energi bersih hasil penambangan'+'energi dari pembangkit listrik'
	impor rate	GRAPH(TIME,2015,1,{2316952,2195016,2314907,2339404,2037850//Min:0;Max:5000000//})
	impor	'impor rate'
	ekspor rate	GRAPH(TIME,2015,1,{11617757,11379784,11430006,12127917,12541008//Min:0;Max:15000000//})
	ekspor	'ekspor rate'
	konsumsi energi sektor industri	GRAPH(TIME,2015,1,{1659509,1487041,1427810,2022026,2463953//Min:0;Max:3000000//})

	industri	'konsumsi energi sektor industri'*'perkembangan teknologi'
	pertumbuhan pdd	ROUND('laju pertumbuhan pdd'*'populasi penduduk indonesia')
	pertumbuhan kndrn roda 2	ROUND('laju pertumbuhan roda 2'*'Jml Roda 2')
	pertumbuhan kndrn roda 4	ROUND('laju pertumbuhan roda 4'*'Jmlh Roda 4')
	kebutuhan rumah tangga	average energi yg dibutuhkan per orang'*'populasi penduduk indonesia'
	lain-lain	GRAPH(TIME,2015,1,{214593,299538,330068,312681,353443//Min:0;Max:400000//})
	total konsumsi energi sektor transportasi	'Jml Roda 2'*'konsumsi energi per roda 2'+'Jmlh Roda 4'*'konsumsi energi per roda 4'
	konsumsi energi	industri+'kebutuhan rumah tangga'+'lain-lain'+'total konsumsi energi sektor transportasi'

From the simulation results with a time span of 2019 to 2060, a comparison graph between energy production and energy consumption is obtained as follows:

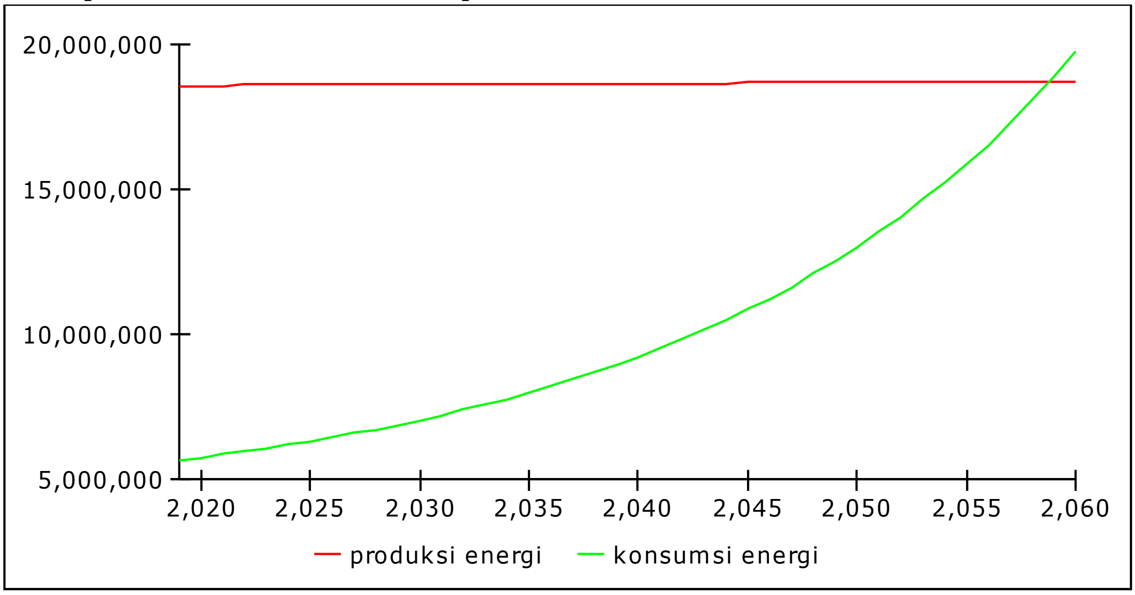

Fig 3. Energy production and energy consumption comparison graph

Seen from the graph, energy production in Indonesia continues to increase but the increase in energy production when compared to energy consumption looks much smaller. Energy consumption has increased drastically from year to year. By 2060 the energy produced or produced is the same as the energy consumed. This makes it possible for an energy crisis to occur in that year if the government still has not implemented policies to prevent an energy crisis in Indonesia.

Table 8. The simulation results of the prediction of the energy crisis in Indonesia

year	produksi energi	konsumsi energi	stok energi di indonesia
2,019	18,556,796.88	5,644,680.50	10,023,342.00
2,020	18,560,299.60	5,740,753.17	12,432,300.38
2,021	18,563,802.32	5,841,728.08	14,748,688.82
2,022	18,567,305.04	5,947,893.48	16,967,605.06
2,023	18,570,807.76	6,059,555.18	19,083,858.62
2,024	18,574,310.48	6,177,037.72	21,091,953.20
2,025	18,577,813.20	6,300,685.44	22,986,067.96
2,026	18,581,315.91	6,430,863.76	24,760,037.71
2,027	18,584,818.63	6,567,960.43	26,407,331.86
2,028	18,588,321.35	6,712,386.93	27,921,032.07
2,029	18,591,824.07	6,864,579.96	29,293,808.48
2,030	18,595,326.79	7,025,002.94	30,517,894.59
2,031	18,598,829.51	7,194,147.73	31,585,060.44
2,032	18,602,332.23	7,372,536.27	32,486,584.22
2,033	18,605,834.94	7,560,722.55	33,213,222.17
2,034	18,609,337.66	7,759,294.56	33,755,176.56
2,035	18,612,840.38	7,968,876.30	34,102,061.67
2,036	18,616,343.10	8,190,130.13	34,242,867.75
2,037	18,619,845.82	8,423,759.04	34,165,922.72
2,038	18,623,348.54	8,670,509.22	33,858,851.50
2,039	18,626,851.26	8,931,172.66	33,308,532.81
2,040	18,630,353.97	9,206,590.04	32,501,053.40
2,041	18,633,856.69	9,497,653.71	31,421,659.33
2,042	18,637,359.41	9,805,310.84	30,054,704.31
2,043	18,640,862.13	10,130,566.88	28,383,594.88
2,044	18,644,364.85	10,474,489.06	26,390,732.13
2,045	18,647,867.57	10,838,210.31	24,057,449.91
2,046	18,651,370.29	11,222,933.23	21,363,949.17
2,047	18,654,873.00	11,629,934.42	18,289,228.22
2,048	18,658,375.72	12,060,569.06	14,811,008.80
2,049	18,661,878.44	12,516,275.72	10,905,657.47
2,050	18,665,381.16	12,998,581.59	6,548,102.18
2,051	18,668,883.88	13,509,107.82	1,711,743.76
2,052	18,672,386.60	14,049,575.48	-3,631,638.19
2,053	18,675,889.32	14,621,811.58	-9,511,985.07
2,054	18,679,392.03	15,227,755.69	-15,961,065.33
2,055	18,682,894.75	15,869,466.87	-23,012,586.99
2,056	18,686,397.47	16,549,131.08	-30,702,317.11
2,057	18,689,900.19	17,269,068.94	-39,068,208.73
2,058	18,693,402.91	18,031,744.12	-48,150,535.47
2,059	18,696,905.63	18,839,772.13	-57,992,034.68
2,060	18,700,408.35	19,695,929.69	-68,638,059.18

If seen from Table 8, the energy stock in Indonesia from 2019 was 10,023,342 terajoules, continuing to increase every year until its peak in 2036, Indonesia has an energy stock of 34,242,867.75 terajoules. After that, the energy stick in Indonesia continues to decline until in 2051 Indonesia will experience an energy crisis.

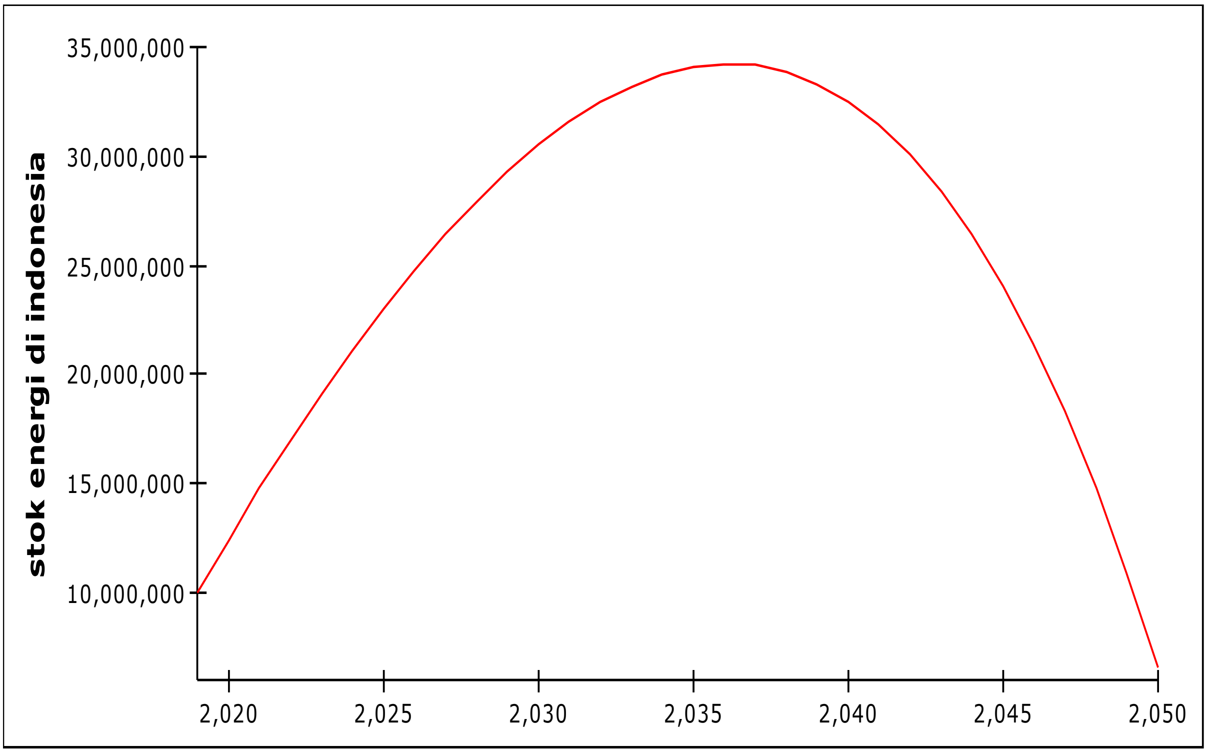

Fig 4. Energy stock in Indonesia

If we look at energy consumption in Indonesia from each sector, the graph is obtained as follows
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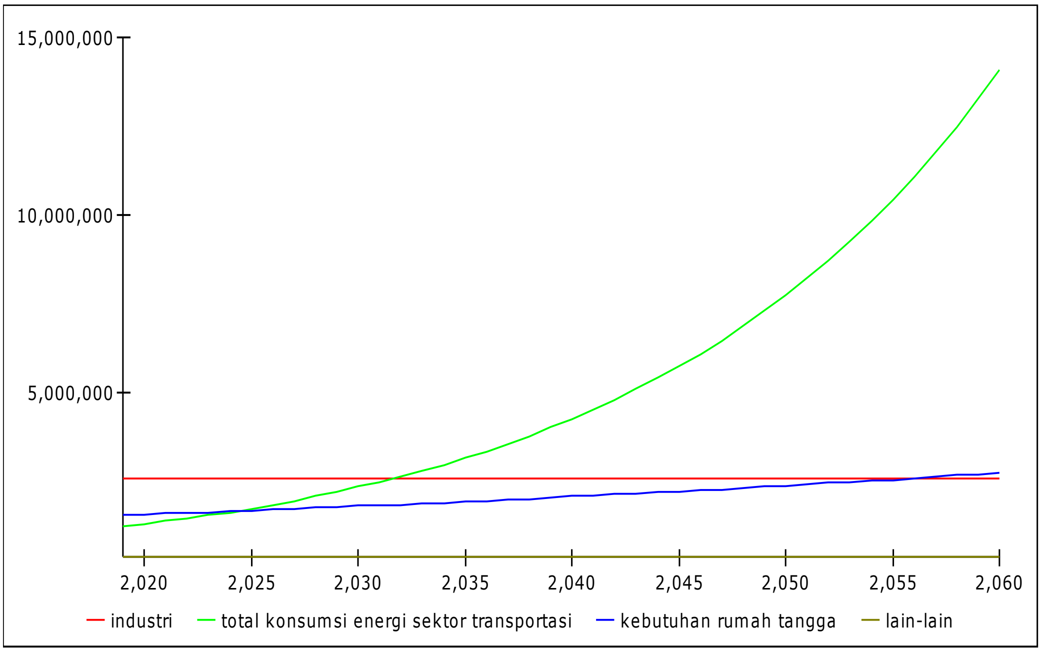

Fig 5. Energy consumption in Indonesia by sector

It can be seen in the picture above, that the reason for the soaring energy consumption in Indonesia is in the transportation sector. The increasing growth of vehicles in Indonesia every year greatly affects the soaring energy consumption in Indonesia. Energy needs for the transportation sector will even reach 15,000,000 terajoules in 2060.

3. Conclusion

From the description above, it can be seen that the problem faced by Indonesia is the increasing energy consumption, especially in the transportation sector, which will increase to 15,000,000 terajoules in 2060, while energy production in Indonesia has increased which is not too significant. This resulted in an energy crisis. Judging from the simulation of the dynamic system approach, it is predicted that Indonesia will experience an energy crisis in 2051.

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