Chapter 4

Energy Outlook of Energy Supply Security Scenario

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Chapter 4

Outlook for the Energy Supply Security Scenario

The outlook for the energy supply security (ESS) scenario was based on the business as usual (BAU) scenario of the Myanmar Energy Outlook 2020 (ERIA, 2020). The outlook analyses the future energy demand and supply of Myanmar until 2040 using the national historical data 2000–2016 from the Myanmar National Energy Statistics 2019 (ERIA, 2019).

The basic assumptions of the BAU scenario are the same as for the ESS, which are a population growth rate of 0.7% per year and a GDP growth rate of 6.3% over the 2016–2040 period. The difference with the BAU scenario is that the ESS scenario considers the following conditions discussed in chapter 3. These are:

- *Fossil fuel production level*

	2020	**2025**	**2030**	**2035**	**2040**
Crude Oil (ktoe)	514	397	307	238	184
Natural Gas (Bcm)	50.6	35.5	19.4	14.0	4.1
Coal (ktoe)	200	1033	1033	1033	1033

- *Biomass level in total primary energy supply (TPES)*

	2020	**2025**	**2030**	**2035**	**2040**
Biomass (Mtoe)	10.40	10.76	11.12	11.36	11.52

- *Power generation mix in 2040*

- Coal : 26%
- Natural gas : 23%
- Hydro : 44%
- Other Renewable : 7%

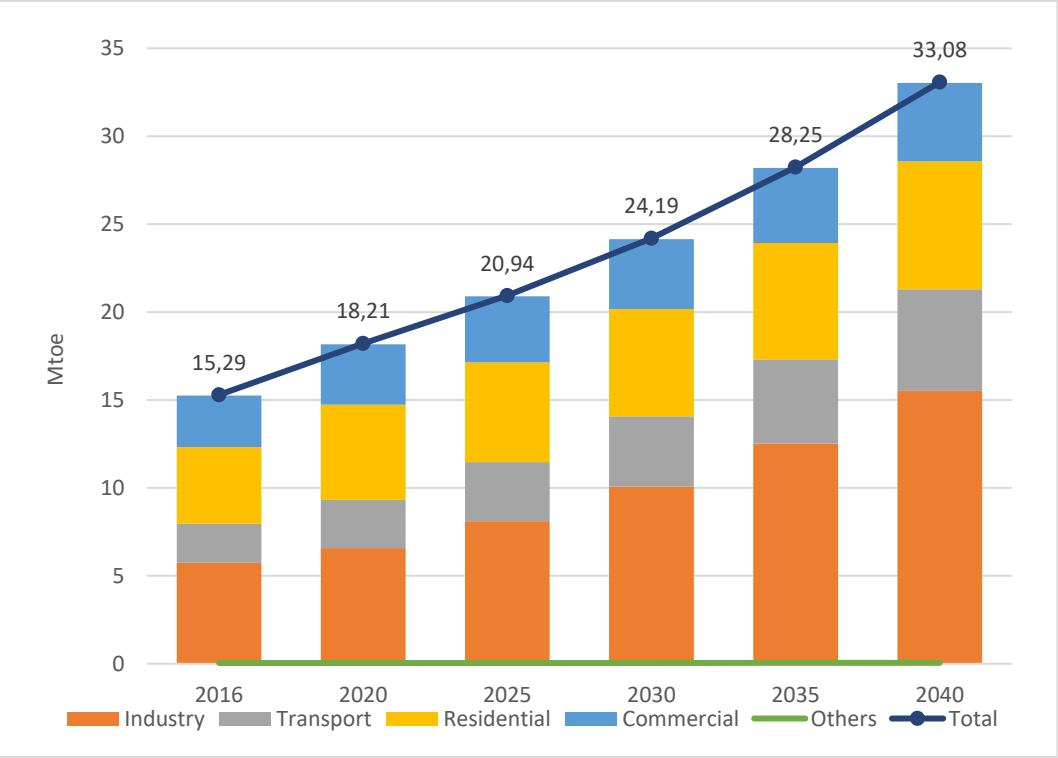
This chapter provides the results of the simulation runs for the ESS scenario, including the impact on CO_2 emissions and energy security indicators. The Energy Balance Table for the ESS scenario is shown in Table 4.1, whilst the BAU scenario is shown in Table 4.2.

4.1 Final Energy Consumption

Total final energy consumption (TFEC) of Myanmar is projected to increase at an average rate of 3.3% per year from 15 million tons of oil equivalent (Mtoe) in 2016 to 33 Mtoe in

2040 (Figure 4.1). Most of the demand will be from the industry sector and the growth in demand will be the fastest at 4.2% per year over the planning period. The transport sector demand will grow slightly slower at 4% per year, whilst the residential and commercial sector demand will grow at 2.2% and 1.8% per year, respectively.

Figure 4.1: Final Energy Demand by Sector



Mtoe= million tons oil equivalent.
Source: Authors' calculation.

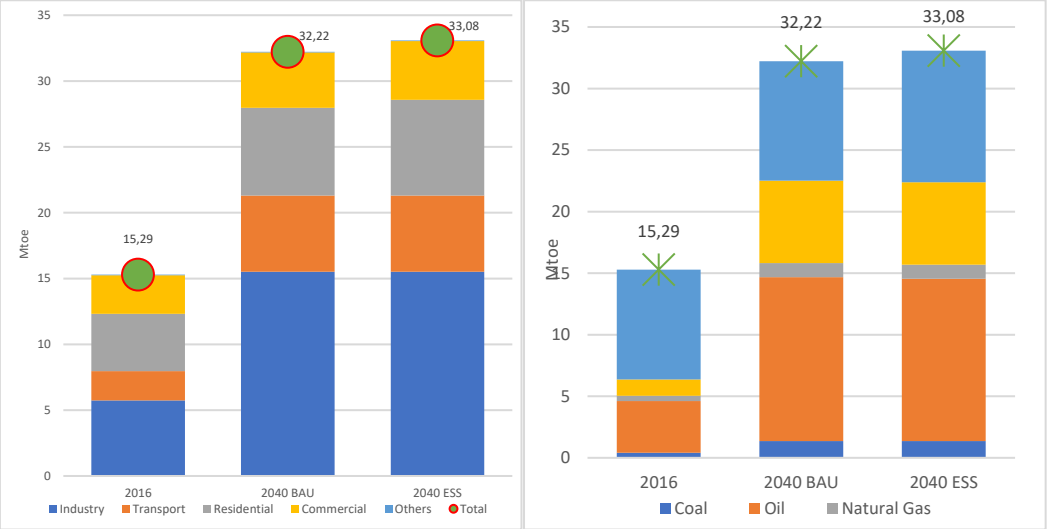
By type of fuel, electricity consumption will grow the fastest, at 7% per year followed by coal at 5.1% per year, oil at 4.9% per year, and natural gas at 4.2% per year. Electricity, coal, and natural gas demand growth contributed to the rapid increase of the industry sector demand. In the case of oil, the majority of the demand is in the transport sector, especially road transport. Growth in the number of cars and motorbikes will contribute to the increase in oil demand in the future.

Biomass is mainly consumed by the residential sector for cooking purposes. As more households shift from biomass to LPG and electricity, and more efficient biomass stoves become more available, the increase in biomass demand will be small. In addition, industry will also use more efficient heating fuel, so that biomass will be replaced by diesel. In the BAU scenario, biomass will grow at an average of 0.3% per year over the 2016–2040 period.

In case of the ESS scenario, biomass supply is assumed to reach around 11.5 Mtoe by 2040. This amount is almost 70% of the 17 Mtoe total potential of biomass energy in 2017 (Tun and Juchelková, 2019). Consequently, the biomass demand under the ESS scenario

has a higher rate of increase than the BAU scenario. In this case, biomass demand will increase at an average rate of 0.6% per year. Since more biomass is available for use, the ESS scenario will have smaller LPG demand than in the BAU scenario. Figure 4.2 shows the comparison of final energy demand in the BAU scenario and the ESS scenario by fuel and by sector.

Figure 4.2: Final Energy Demand Comparison



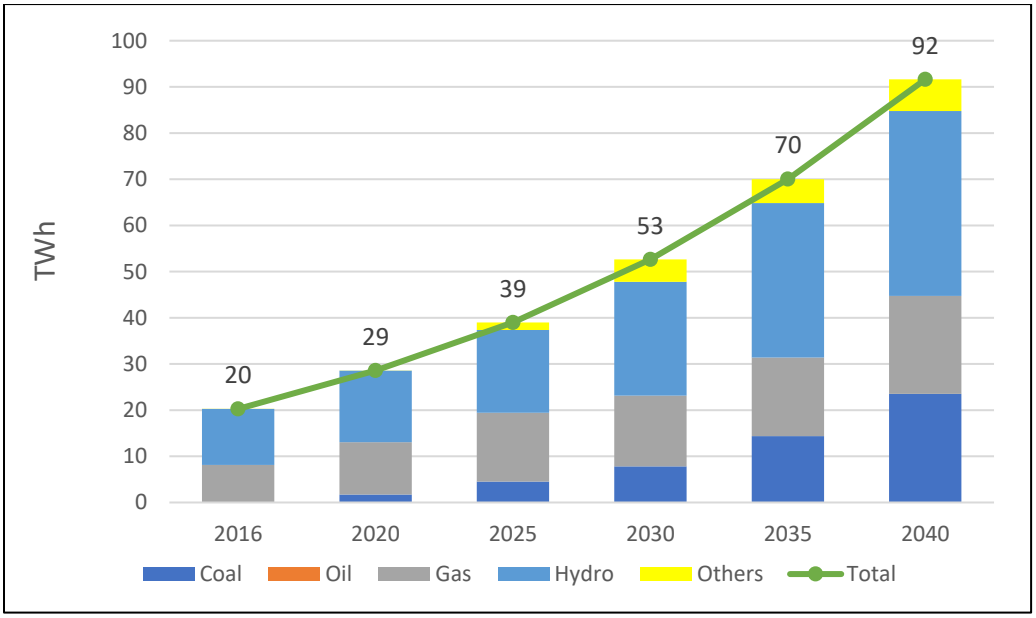
BAU = business as usual, ESS = energy supply security, Mtoe = million tonnes of oil equivalent.
Source: Authors' calculation.

a. Power Generation

Based on the energy statistics, Myanmar's export of electricity in 2016 was 205 ktoe (2.8TWh). In the BAU scenario as well as the ESS scenario, this amount is sustained until 2040. Thus, electricity generation will be able to meet both domestic and export demand. Transmission, distribution, and own use also need to be included in estimating electricity generation.

In the BAU scenario, total power generation will increase from 26 Mtoe in 2016 to 89 Mtoe in 2040 at an average growth of 6.4% per year (Figure 4.3). In the ESS scenario, growth is slightly higher at 6.5% per year. Electricity imports are still possible in the BAU scenario if domestic supply is not sufficient to meet demand. In the ESS scenario, the assumption was to exclude electricity imports in the model to enhance the security of energy supply.

Figure 4.3: Power Generation Mix ESS



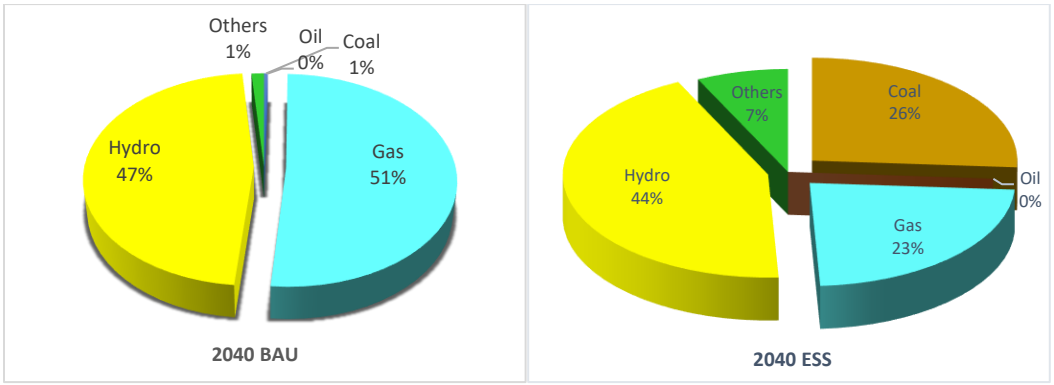
ESS = energy supply security, TWh = terawatt hours.
Source: Authors' calculation.

Based on the assumed generation mix for the ESS scenario, renewable energy (hydro plus other renewable) will be dominant in power generation at 51%, whilst the remaining will come from fossil fuel generation. There will be no oil-based generation assumed for the future.

The hydro share in total generation has been assumed to be 44% in 2040, whilst other renewables are around 7%. In the BAU scenario, generation from hydropower plants will be higher (47%). As a result, electricity generation from hydropower plants in 2040 will be lower in the ESS scenario as compared to the BAU scenario, 40 TWh versus 42 TWh, respectively. Other renewable share, on the other hand is lower in the BAU scenario (1.3%) with total generation of 1.2 TWh. Electricity generation from other renewables reaches 6.6 TWh in the ESS scenario, covering solar PV, wind, and biomass power plants. No generation from biomass plants was assumed in the BAU scenario since no plan existed for its development.

In the case of generation from fossil power plants, the share in total generation for coal-fired power plants in the ESS scenario was assumed to reach 26% by 2040, whilst natural gas was around 23%. In the BAU scenario, natural gas plants share in total generation will be 51% of the total generation, whilst coal was small. The development of new coal-fired power plants, particularly with large capacity, has raised opposition from environmental organisations as well as local and regional organisations. Based on this, no additional large coal-fired power plants have been assumed in the BAU scenario. Figure 4.4 shows the generation mix in ESS as compared to the BAU scenario for 2040.

Figure 4.4: Power Generation Mix Comparison with BAU in 2040



BAU = business as usual, ESS = energy supply security.
Source: Authors' calculation.

b. Primary Energy Supply

Myanmar's primary energy supply in the ESS scenario will be 40 Mtoe by 2040 with oil having the largest share of 33% followed by biomass at 29% (Figure 4.5). Although the share of these fuels in TPES are high, the growth over the 2016–2040 period is much slower than coal. Coal supply will grow at an average rate of 12.5% per year, whilst the rate of oil and biomass will be 4.9% and 1% per year, respectively.

As explain in the power generation section, the rapid growth of coal supply will be due to the increase in the use for power generation. Coal supply increase from 0.4 Mtoe in 2016 to 7 Mtoe in 2040. The ESS scenario coal supply in 2040 will be 4.5 times higher than in the BAU scenario.

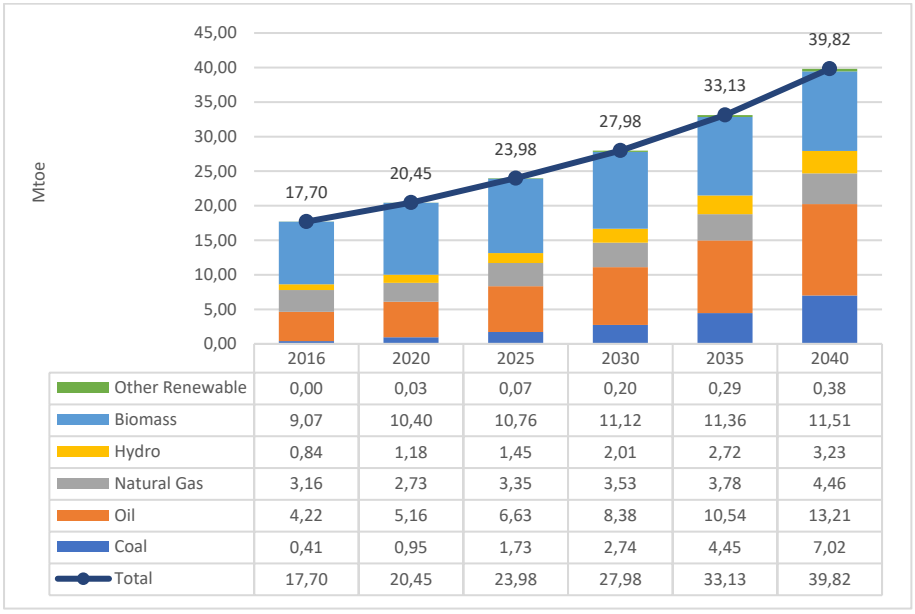
Oil supply in the ESS scenario will slightly be lower than the BAU scenario because the substitution from biomass to oil was assumed lower in the residential and commercial sector. Use in the transport sector remains the same between the ESS and BAU scenarios. Thus, the saving in oil supply between the ESS and BAU scenarios will only be around 0.1 Mtoe in 2040 (around 1% reduction of the BAU supply) 1% in 2040.

In case of biomass, the supply in the ESS scenario has been assumed to reach around 70% of the total potential by 2040. As a result, the biomass supply will increase by almost 17% in 2040 as compared to the BAU scenario. As discussed previously, the differences will mainly be in the residential sector and the power sector. In the BAU scenario, no assumption was made for biomass use in power generation, whilst in the ESS scenario, it was possible to ensure supply reached the target assumed for the scenario.

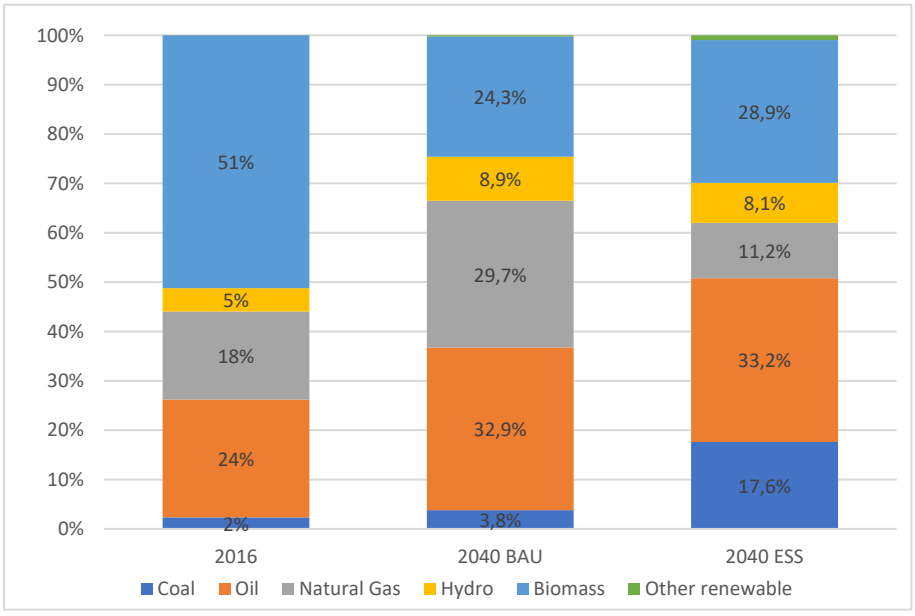
Natural gas supply, on the other hand, will be lower than in the BAU scenario because the ESS scenario assumes lower use for generating electricity. The average growth of natural gas supply in the ESS scenario will be 1.5% per year whilst in the BAU scenario, the growth was 5.7% per year. The reduction in natural gas supply of the ESS scenario in 2040 as compared to the BAU scenario will be around 63%.

Similarly, for hydropower, the supply in the ESS scenario will be growing more slowly than in the BAU scenario, 5.1% per year compared to 5.3% per year. For other renewables (solar and wind), the growth in the ESS scenario will be faster than the BAU scenario due to the increase installation of solar PV. The average growth of renewable supply will almost reach 29% per year whilst in the BAU scenario, it will be 22%. The renewable supply in 2040 for the ESS scenario will almost be four times higher than the BAU scenario. Figure 4.5 shows TPES of the ESS scenario and the comparison for the BAU scenario in 2040.

Figure 4.5: Primary Energy Supply of ESS and Comparison with BAU



	2016	2020	2025	2030	2035	2040
Other Renewable	0,00	0,03	0,07	0,20	0,29	0,38
Biomass	9,07	10,40	10,76	11,12	11,36	11,51
Hydro	0,84	1,18	1,45	2,01	2,72	3,23
Natural Gas	3,16	2,73	3,35	3,53	3,78	4,46
Oil	4,22	5,16	6,63	8,38	10,54	13,21
Coal	0,41	0,95	1,73	2,74	4,45	7,02
Total	17,70	20,45	23,98	27,98	33,13	39,82

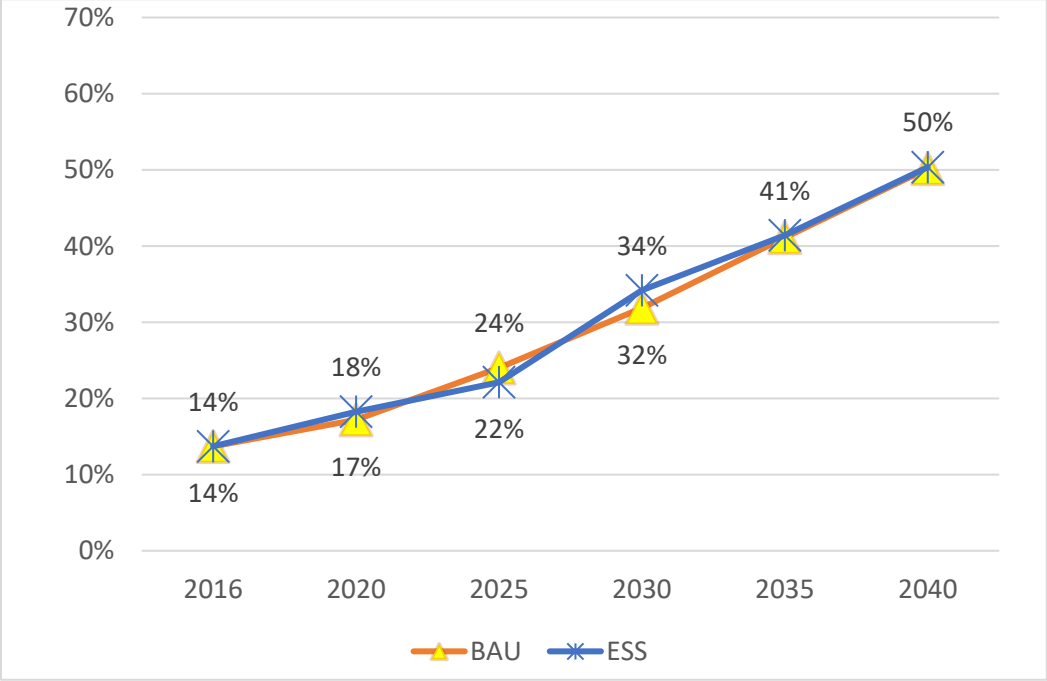


BAU = business as usual, ESS = energy supply security, Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

c. Energy Security Indicator

As explained in section 2.4, import dependency ratio (IDR) is defined as the ratio between the total energy import and the total energy supply. In the ESS scenario, the import dependency ratio increases from 14% in 2016 to 50% in 2040 (Figure 4.6). Compared to the BAU scenario, this ratio is similar, indicating that the assumption for the ESS scenario is not sufficient to decrease the ratio. Oil is the main import fuel, and the transport sector has the largest share in TPES for both the BAU and ESS scenarios. Natural gas imports are more in the BAU scenario than the ESS scenario, but in the ESS scenario, coal imports increase significantly as natural gas imports decrease. The increase of biomass use and renewable must be higher than assumed in the ESS scenario.

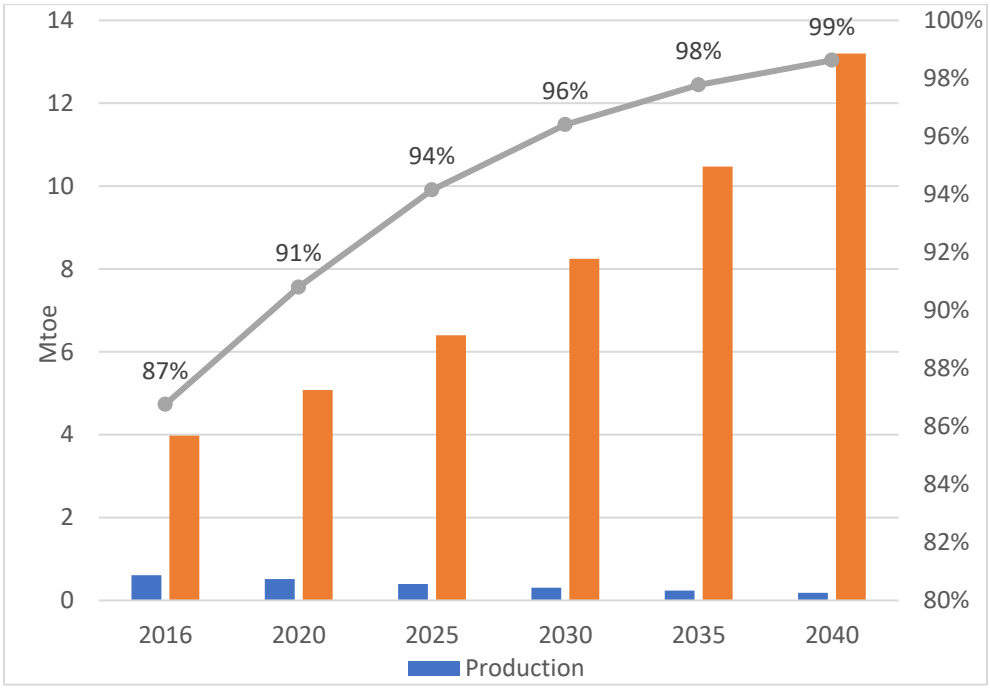
Figure 4.6: Import Dependency Ratio BAU and ESS



BAU = business as usual, ESS = energy supply security.
Source: Authors' calculation.

Oil dependency ratio was already 87% in 2016. Since oil demand increases at almost 5% per year over the 2016–2040 period, whilst production is declining, the imports will increase more than threefold by 2040 in the ESS and BAU scenarios. The IDR for oil in the ESS scenario will increase to 99% in 2040 (Figure 4.7).

Figure 4.7: Import Dependency Ratio for Oil

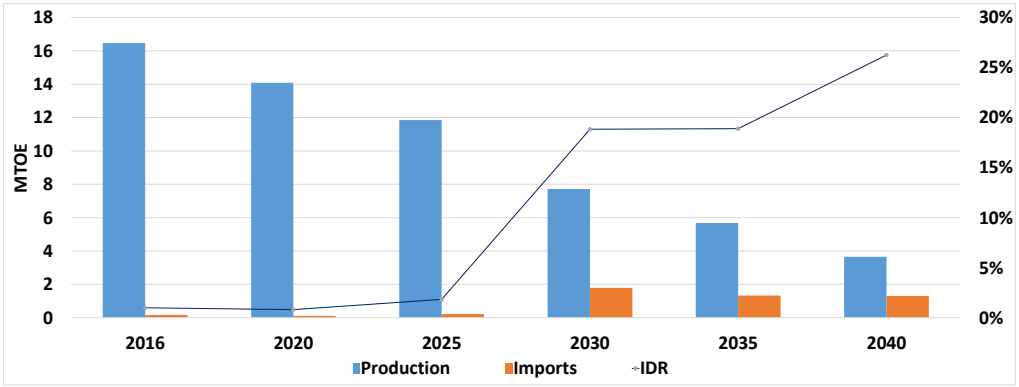


IDR = import dependency ratio, Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

The import dependency ratio for oil can be smaller if Myanmar increases the use of alternative fuels such as electricity or biofuels in the road transport sector. In the case of electric vehicles, electricity demand will increase. In the ESS scenario, the option will be by using more hydro and other renewables to significantly decrease the import dependency ratio. If gas or coal generation, it will again impose imports since the domestic supply of these fuels will also be declining in the future. Both electric vehicles and biofuel options were excluded in the ESS scenario since more data and information will be required to estimate the substitution potential.

In the case of natural gas, Myanmar has exported natural gas to Thailand since 2000 and to China since 2014 with a total amount of around 75% of total production (ERIA, 2019). Since production is declining and domestic demand is increasing, Myanmar plans to import LNG to meet domestic demand, whilst maintaining current export contracts. Chapter 3 estimated natural gas production to decline at an average rate of 6% per year reaching 4.1 billion cubic meters (Bcm) in 2040. Assuming the same declining rate for production and export, the projected natural gas import in ESS will be 0.88 Mtoe in 2040. This will result in an import dependency ratio of 26% for natural gas in 2040 (Figure 4.8). Although not as high as oil, the ratio is increasing from the 2016 level (1%).

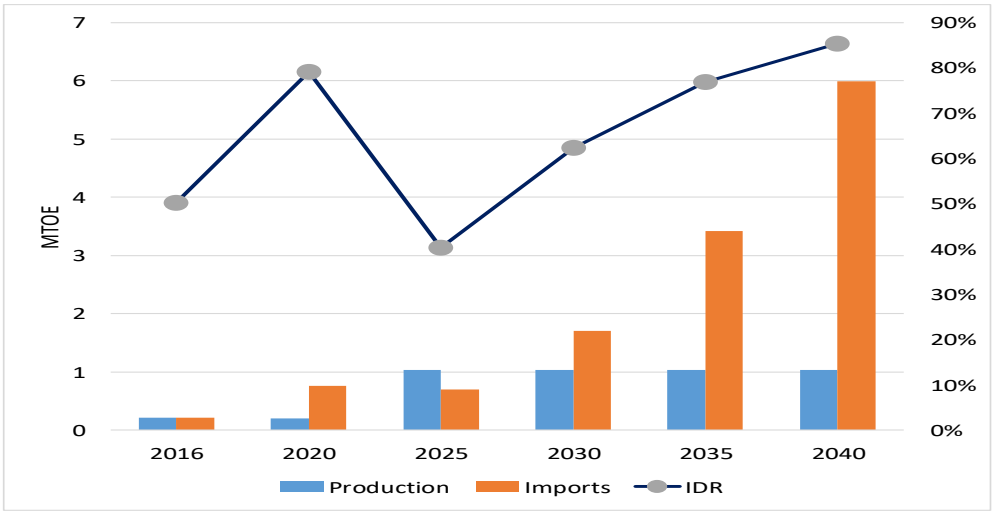
Figure 4.8: Import Dependency Ratio for Natural Gas



IDR = import dependency ratio, Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

Coal imports will increase as demand for industry and power generation continue to grow. The ESS applies the same production level and power generation share as explained in chapter 3. As a result, imports of coal in ESS increase to around 6 Mtoe in 2040 from 0.2 Mtoe in 2016. The import dependency ratio for coal increases from 50% in 2016 to 85% in 2040 (Figure 4.9). In 2025. Myanmar increase the coal production in 2025, resulting in a decline in the ratio for 2025. Production levels maintain at the 2025 level until 2040 but demand continues to increase. Consequently, the ratio increases again since 2025.

Figure 4.9: Import Dependency Ratio for Coal



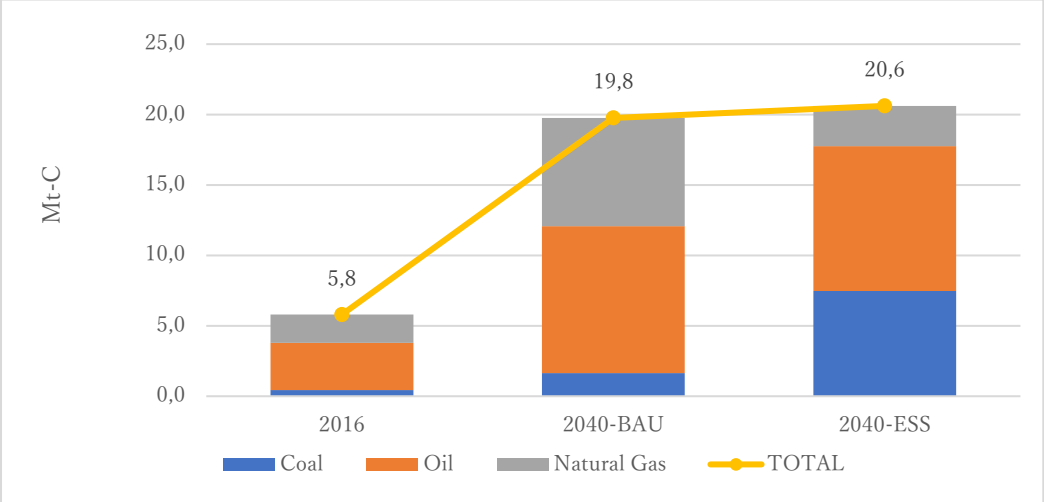
IDR = import dependency ratio, Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

d. Impact on CO_2 Emissions

The ESS scenario will have more coal and less natural gas in the total TPES compared to the BAU scenario. The oil supply will be similar in the BAU and ESS scenarios. As a result, CO_2 emissions of the ESS scenario will be higher than the BAU scenario since the emissions factor of coal is higher than oil and gas. The CO_2 emissions of ESS 2040 will be 21 million ton-c (in terms of carbon content) or about 75 million ton-CO_2 (Figure 4.10). Compared to the BAU scenario, the CO_2 emissions of the ESS scenario will be 4% higher in 2040.

Oil combustion will still be the major source of CO_2 emissions since its share in TPES will still be higher (33% in 2040) than that of coal and natural gas. The share of CO_2 emissions from oil, however, will decrease from 56% in 2016 to 53% in 2040 because of the increasing use of coal in power generation and industries. The CO_2 emissions from combustion of coal increase from 0.4 to 7.5 million ton-c over the 2016 to 2040 period. CO_2 emissions from natural gas will increase from 2 to 3 million ton-c over the same period.

Figure 4.10: CO_2 Emissions Comparison in 2040 of BAU and ESS



BAU = business as usual, ESS = energy supply security, Mt-C = million tons of carbon equivalent.
Source: Authors' calculation.

e. Overall evaluation of ESS scenario

Table 4.1 shows a comparison between the BAU and ESS scenarios in terms of selected energy indicators. The ESS scenario will shift to more use of coal and renewables such as solar PV and biomass. As a result, there will be a large saving in domestic natural gas consumption. Natural gas demand in the ESS scenario will only be 4.46 Mtoe in 2040 compared to the 12.03 Mtoe in the BAU scenario, reducing significantly the production of natural gas from 8.01 Mtoe in the BAU scenario to 3.64 Mtoe in the ESS scenario.

The increased use of coal in the ESS scenario will be more than fourfold of the BAU scenario by 2040, from 1.54 Mtoe in BAU to 7.02 MTOE in ESS. Since the existing coal supply chain in Myanmar is not sufficient to bring coal from the mining sites (north) to the

demand sites (south), the ESS scenario suggests imports of coal to meet the increasing demand. Considering that coal sources are more scattered in the world (not like oil that is concentrated in the Middle East), this import dependency of coal is less serious in terms of the country's supply security due to the diverse coal supply sources in the world.

The ESS scenario will also increase the use of solar PV systems because of the wider field potential for solar PV generation in the central area of Myanmar and the continuous declining trend in the price of solar PV systems. In the case of hydropower, the ESS scenario was supposed to increase hydropower generation because it is an affordable and clean energy source. Considering the strong public complaints in the construction of hydropower plants, the ESS scenario assumes the same hydropower generation level as in the BAU scenario.

As a conclusion, the ESS scenario is a better energy security policy than BAU according to the following reasons:

a. Import dependency is the same level of BAU
b. Share of domestic and affordable energy per TPES is much higher than BAU
c. Myanmar will continuously export natural gas to Thailand and China because proven reserves of natural gas will be maintained due to the saving in domestic use
d. Imports of oil will be slightly lower due to the continuous use of biomass for cooking in households
e. CO_2 emissions will be a little bit bigger than in the BAU scenario, although larger coal consumption has been assumed

Table 4.1 Summarised Comparison Between BAU and ESS

ITEM	BAU	ESS
1. Energy Share per TPES		
Coal	3.8%	17.5%
Gas	29.7%	11.1%
Oil	32.9%	33.0%
Hydropower	9.0%	8.6%
Renewable	0.2%	0.9%
Biomass	24.3%	28.8%
Total	100.0%	100.0%
2. Import Dependency		
Overall	50.1%	50.3%
Coal	45.4%	85.3%
Natural Gas	53.1%	26.3%
3. Share of Affordable Energy (Coal + Hydropower + Biomass)	37.1%	55.1%
4. Oil Import (Mtoe)	13.1	12.9
5. CO_2 Emissions (Mt-C)	19.8	20.6

BAU = business as usual, ESS = energy supply security, Mtoe = million tons of oil equivalent, Mt-c = million tons carbon equivalent, TPES = total primary energy supply.
Source: Authors' calculation.

Table 4.2 Energy Balance Table 2040, Energy Supply Security (ESS) Scenario (in Mtoe)

	Coal	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	1,03	3,64	0,18	3,43	0,38	11,51	-	-	20,20
Imports	5,99	1,30	0,26	-	-	-	-	12,94	20,48
Exports	-	-0,48	-	-	-	-	-0,21	-0,17	-0,86
Total Primary Supply	7,02	4,46	0,44	3,43	0,38	11,51	-0,21	12,77	39,82
Coal production	-	-	-	-	-	-	-	-	-
Crude oil production	-	-	-	-	-	-	-	-	-
Natural gas production	-	-	-	-	-	-	-	-	-
Charcoal processing	-	-	-	-	-	-0,16	-	-	-0,16
Refinery	-	-	-0,44	-	-	-	-	0,42	-0,02
Electricity generation	-5,66	-3,31	-	-3,43	-0,38	-0,66	7,88	-	-5,58
Loss and own use	-	-	-	-	-	-	-0,98	-	-0,98
Total Transformation	-5,66	-3,31	-0,44	-3,43	-0,38	-0,82	6,90	0,42	-6,74
Industry	1,36	0,26	-	-	-	3,34	2,36	8,20	15,52
Transport	-	0,88	-	-	-	-	-	4,90	5,78
Residential	-	-	-	-	-	4,32	2,91	0,04	7,28
Commercial	-	-	-	-	-	3,03	1,41	0,02	4,46
Others	-	-	-	-	-	-	0,02	0,03	0,05
Total Demand	1,36	1,15	-	-	-	10,69	6,70	13,19	33,08

Source: Authors' calculation.

Table 4.3 Energy Balance Table 2040, Business as Usual (BAU) Scenario (in Mtoe)

	Coal	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	0,70	8,01	0,67	3,62	0,10	9,84	0	0	22,95
Imports	0,84	9,02	0	-	-	-	0,19	13,07	23,12
Exports	-	-5,00	-0,25	-	-	-	-0,21	-0,17	-5,63
Total Primary Supply	1,54	12,03	0,42	3,62	0,10	9,84	-0,01	12,89	40,43
Coal production	-	-	-	-	-	-	-	-	-
Crude oil production	-	-	-	-	-	-	-	-	-
Natural gas production	-	-	-	-	-	-	-	-	-
Charcoal processing	-	-	-	-	-	-0,14	-	-	-0,14
Refinery	-	-	-0,42	-	-	-	-	0,42	-
Electricity generation	-0,18	-10,88	-	-3,62	-0,10	-	7,68	-	-7,10
Loss and own use	-	-	-	-	-	-	-0,98	-	-0,98
Total Transformation	-0,18	-10,88	-0,42	-3,62	-0,10	-0,14	6,71	0,42	-8,22
Industry	1,36	0,26	-	-	-	3,34	2,36	8,20	15,52
Transport	-	0,88	-	-	-	-	-	4,90	5,78
Residential	0,00	-	-	-	-	3,66	2,91	0,09	6,67
Commercial	-	0,00	-	-	-	2,70	1,41	0,09	4,20
Others	-	-	-	-	-	-	0,02	0,03	0,05
Total Demand	1,36	1,15	-	-	-	9,70	6,70	13,31	32,22

Source: Authors' calculation.