Chapter 6

Assessment of Future Simulation Results

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Chapter 6

Assessment of Future Simulation Results

Shigeru Kimura

There were several scenarios or cases studied for the Lao People's Democratic Republic (Lao PDR) Energy Outlook as described in Chapter 5. The base case is defined as the Business-As-Usual (BAU) scenario. The other cases studies are the gross domestic product (GDP) scenarios, oil price scenarios, energy efficiency and conservation (EEC) promotion scenarios, and renewable energy (RE) development scenarios.

This chapter provides the result of the simulation runs for the BAU scenario and the other case studies.

6.1 Business-As-Usual Scenario

The BAU scenario is developed based on the assumptions that the Lao PDR's demand for energy will continue to increase based on historical trends and future growth in the GDP, population, and oil price in the absence of additional policies for EEC and RE promotion. Table A6.1 and Table A6.2 (see Annex) are the base year (2015) and the projected 2040 Energy Balance of the Lao PDR.

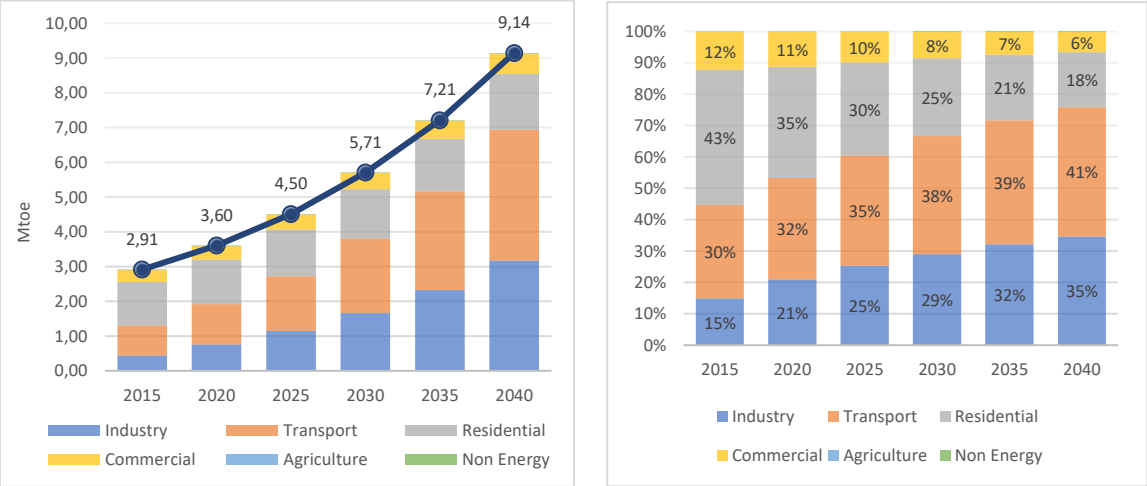
Final energy consumption

The total final energy consumption (TFEC) of the Lao PDR increased at an average rate of 4.5% per year, from 1.5 million tons of oil equivalent (Mtoe) in 2000 to 2.9 Mtoe in 2015. Given the assumed economic and population growth, the growth in the TFEC will continue at a slightly higher rate of 4.7% per year during 2015–2040 under the BAU scenario (Figure 6.1).

This growth is brought by the rapid increase of energy consumption in the industry and transport sectors. Coal consumption in the industry sector contributed to the growth of the sector in the past (2000–2015), while in the future, it will be electricity consumption. The

industry's electricity consumption will grow at an average rate of around 10% per year under the BAU scenario, while coal is at 7.7% per year.

Figure 6.1 Total Final Energy Consumption by Sector



Mtoe = million tons of oil equivalent.
Source: Author's calculations.

Final energy consumption in the transport sector in the BAU scenario will grow more slowly than in the past, at an average rate of 6.0% per year. Road transport will dominate, due to the growth at 6.1% per year while air transport will grow at 3.0% per year.

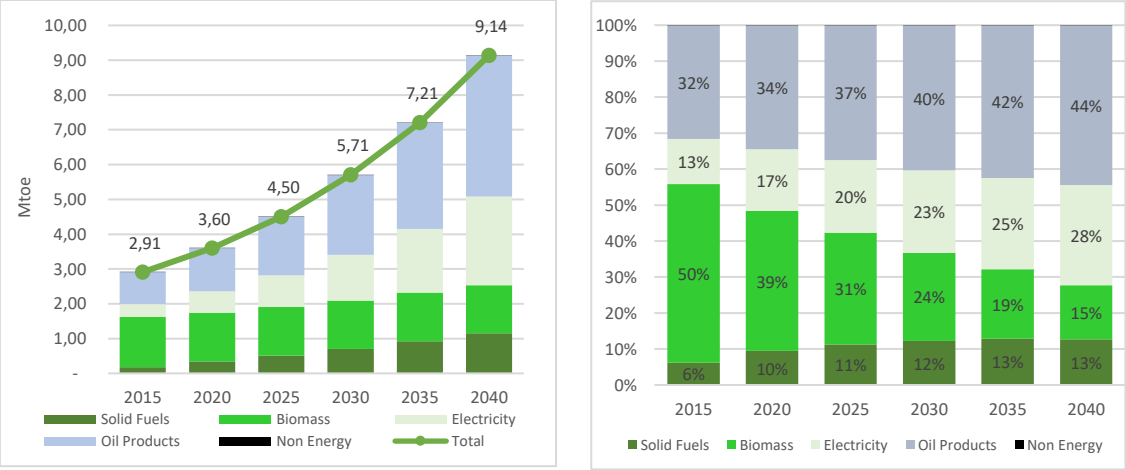
Final energy consumption of the 'Others' sector (mainly consisting of residential and commercial) will grow at an average of 1.3% per year over the outlook period, slower than it was in the past (2.1% per year between 2000–2015). The growth in consumption of the commercial sector will be 2.1% per year, while the residential sector will grow at 1% per year.

The residential sector, although growing the slowest, has had the highest share in the TFEC in the past. This is due to its consumption of biomass for cooking. The share of biomass will decline in the future as household appliances become more efficient and households use more alternatives, such as liquefied petroleum gas (LPG). The residential sector share in the TFEC will decrease from 43% in 2015 to 18% in 2040.

The transport sector had the second largest share in the TFEC (30% in 2015), while the share of the industry sector was 15% and the commercial sector share was 12%. By 2040, the share of the transport sector consumption in the TFEC will increase to 41% and industry to 35%. As a result, the commercial sector's share will decline to 6% by 2040.

In the future, demand for all fuels, except biomass, will continue to increase. For electricity, the demand will increase the fastest at an average rate of 8.1% per year to 2.5 Mtoe in 2040. Coal demand will continue to grow rapidly, but at a slower rate than in the past. The annual growth rate for coal demand would be 7.7% per year over the 2015–2040 period (Figure 6.2).

Figure 6.2 Total Final Energy Consumption by Fuel Type



Mtoe = million tons of oil equivalent.
Source: Author's calculations.

Oil demand will continue to grow in line with the increase in the number of passenger cars as the income level of the Lao PDR increases. The annual growth rate for oil demand will be 6.1% per year. The share of biomass demand is expected to decrease an average rate of 0.2% per year.

According to the slower growth of biomass demand in the future, the share of this fuel in the TFEC will decline significantly, from 50% in 2015 to 15% in 2040. In its place, oil will become the dominant fuel with its share reaching 44% in 2040.

Electricity demand although growing the fastest, will still have a lower share than oil. The share of electricity in the TFEC increases from 13% in 2015 to 28% in 2040. The remaining share will be that of coal, increasing from 6% in 2015 to 13% in 2040.

Power generation

The Lao PDR's power generation came mainly from hydro sources prior to 2015. Power generation from hydro sources increased from around 3.5 terawatt hours (TWh) in 2000 to 14.5 TWh in 2015 at an average rate of 9.9% per year. In 2015, the Hongsa coal-fired power

plant was in full operation, generating around 3 TWh making the total electricity generation of the Lao PDR 17 TWh.

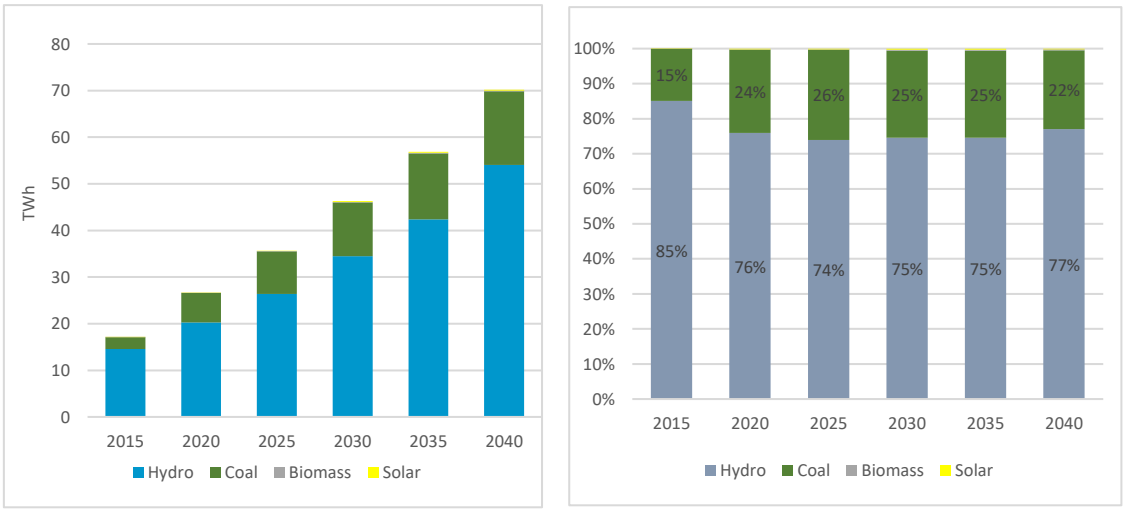
The majority of the electricity produced, especially from the Hongsa power plant was exported to Thailand. Therefore, the future total generation of electricity in the Lao PDR will not only meet the domestic demand but also meet the contracted export target. In addition, the own use and losses (transmission and distribution) of electricity must be included in the future generation of electricity of the Lao PDR.

In the BAU scenario, total electricity production of the Lao PDR will reach around 70 TWH in 2040, where 53% of this amount will be for export purposes. The projected average annual growth of electricity production between 2015 to 2040 will be around 5.8% per year, slower than between 2000 to 2015 (Figure 6.3).

By type of fuel, generation from other renewable sources which consist of solar, wind, and biomass will grow the fastest at an average rate of 18.4% per year. The main reason for this very rapid growth is that this energy outlook is influenced by national RE targets. Generation from coal will grow at an average rate 7.6% per year while hydropower generation will grow at 5.4% per year.

The share of hydropower will remain dominant in the total power generation of the country. Its share in total power generation, however, will decline to 77% in 2040 from 85% in 2015. Hydropower in 2040 will be replaced by coal (22%), biomass, and other renewables (solar and wind).

Figure 6.3 Power Generation by Fuel Type



TWh = terawatt hour.
Source: Author's calculations.

Primary energy supply

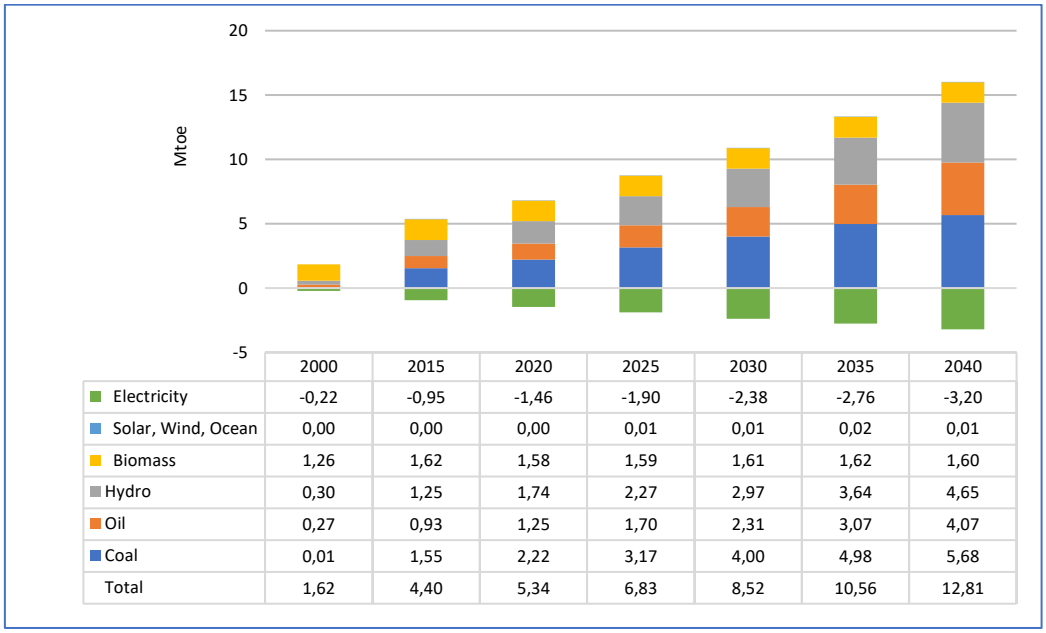
The total primary energy supply (TPES) in the Lao PDR grew faster than the final energy consumption at about 6.9% per year, from around 2 Mtoe in 2000 to 4 Mtoe in 2015. Amongst the major energy sources, the fastest-growing fuel between 2000 and 2015 was coal at 40.8% per year. This is mainly due to the requirement of the Hongsa coal-fired power plant which started production in 2015, resulting in a significant increase in coal supply that year. The Hongsa power plant was constructed only for export purposes to Thailand.

Hydropower, the main supply for power generation in the country grew at an average rate of 9.9% per year over the 2000–2015 period. Oil, the major supply for the transport sector, grew at a slower rate of 8.5% per year and biomass, the major supply for the residential sector, grew at an average rate of 1.7% per year.

The Lao PDR exports most of its electricity to Thailand. However, it also imports electricity, especially during the dry season and to areas not connected to the national grid. Electricity in the TPES reflected the net electricity trade (import minus export), and a negative value indicated that the Lao PDR has been a net electricity exporting country. The electricity export in the TPES increased significantly at an average rate of 10.1% per year. Another renewable supply (solar) has been be used since 2005, but the amount was small, amounting to 0.09 Mtoe in 2015.

In the BAU scenario, the Lao PDR's TPES is projected to increase more slowly than in the past, at an average annual rate of 4.4%, reaching 13 Mtoe in 2040 (Figure 6.4). Coal is projected to continue growing, but at a slower rate of 5.3% per year compared to the past. Hydropower will also increase at a slightly higher rate than coal at 5.4% per year. Oil is projected to increase at an average annual rate of 6.1% over 2015–2040 and it will be highest as compared to coal and hydropower. Biomass, on the other hand, will experience a declining trend as LPG and more efficient biomass stoves will be used in the residential sector.

Figure 6.4 Total Primary Energy Supply



	2000	2015	2020	2025	2030	2035	2040
Electricity	-0,22	-0,95	-1,46	-1,90	-2,38	-2,76	-3,20
Solar, Wind, Ocean	0,00	0,00	0,00	0,01	0,01	0,02	0,01
Biomass	1,26	1,62	1,58	1,59	1,61	1,62	1,60
Hydro	0,30	1,25	1,74	2,27	2,97	3,64	4,65
Oil	0,27	0,93	1,25	1,70	2,31	3,07	4,07
Coal	0,01	1,55	2,22	3,17	4,00	4,98	5,68
Total	1,62	4,40	5,34	6,83	8,52	10,56	12,81

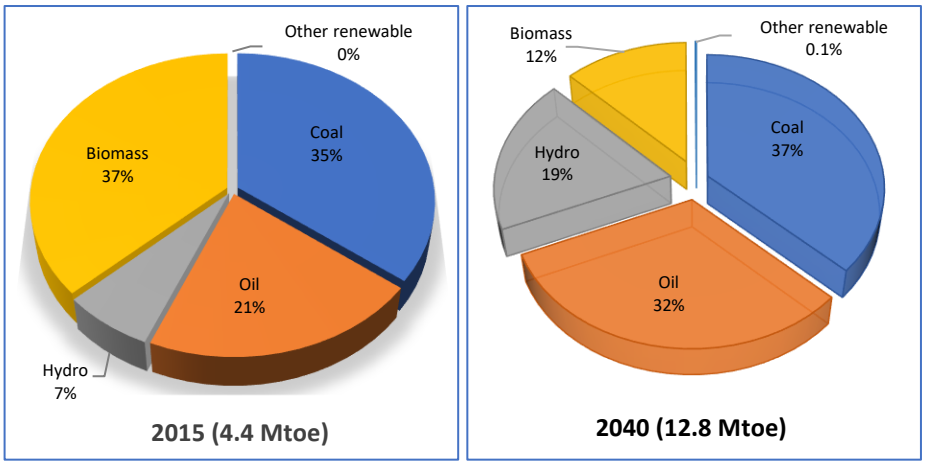
Mtoe = million tons of oil equivalent.
Source: Author's calculations.

The Lao PDR will continue its export target, and the net electricity trade in the total supply will reach 3.2 Mtoe, increasing on average by 5% per year between 2015 to 2040.

In terms of share in the TPES, biomass had the highest share over the 2000 to 2015 period. The share, however, declined from 78% in 2000 to 37% in 2015. The coal share was only 1% in 2000, but its share became the second largest in 2015 (35%) because coal was used not only for industry but also power generation. The oil share in the TPES was second highest in 2000 (17%). In 2015, the share increased to 21%, which was lower than coal. Hydropower share in the TPES increased from 5% in 2000 to 7% in 2015. The electricity trade value in the TPES was mostly from hydropower resources.

In the BAU scenario, the coal share in the TPES will be the highest in 2040 (37%) in line with the expansion of the Hongsa power plant. The oil share will also increase to 32%, and hydro's share in the TPES will increase to 19% by 2040. As a result, the share of biomass in the TPES will decrease to 12% by 2040. The other renewables share remains very small (Figure 6.5).

Figure 6.5 Energy Mix of the Total Primary Energy Supply

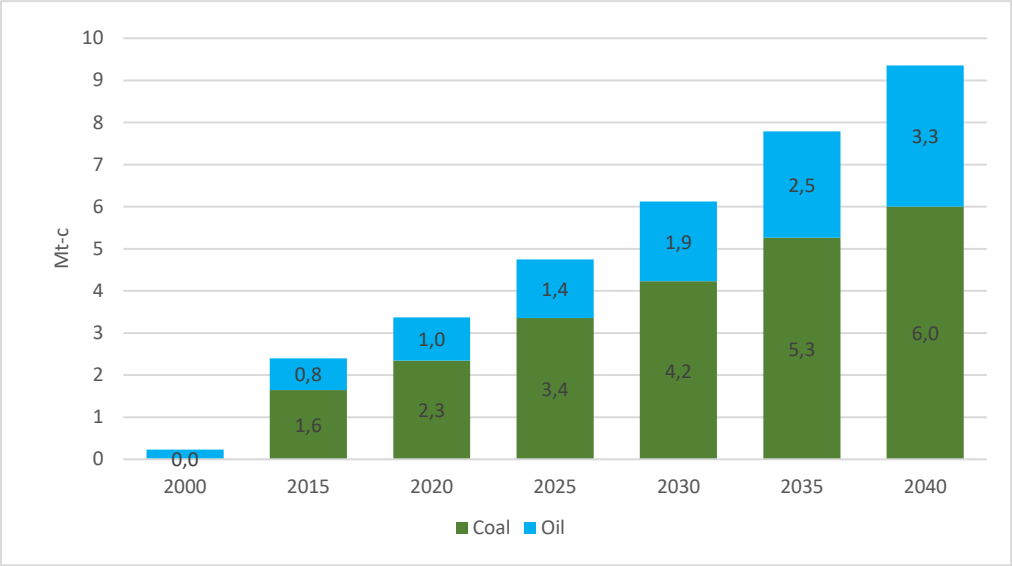


Mtoe = million tons of oil equivalent.
Source: Author's calculations.

CO_2 emissions

The major sources of CO_2 emissions from fuel combustion in the Lao PDR are solid fossil fuel (coal) and liquid fossil fuel (oil). In 2015, the CO_2 emissions from coal combustion was 68%, because the coal share was 35% of the TPES, while oil was only 21%. Therefore, the majority of CO_2 emissions came from burning coal. Total CO_2 emissions were 2.4 million ton-c (in terms of carbon content) or approximately 8.8 million ton-CO_2 in 2015. The CO_2 emissions will reach 9.4 million ton-c (Mt-c) by 2040 in the BAU scenario, increasing at an average rate of 5.6% per year. Coal combustion will still be the major source for CO_2 emissions since its share in the TPES increases to 37% due to increased use of coal in power generation and industry (Figure 6.6).

Figure 6.6 Total CO_2 Emissions



Mt-c = million tons of carbon.
Source: Author's calculations.

Energy indicators

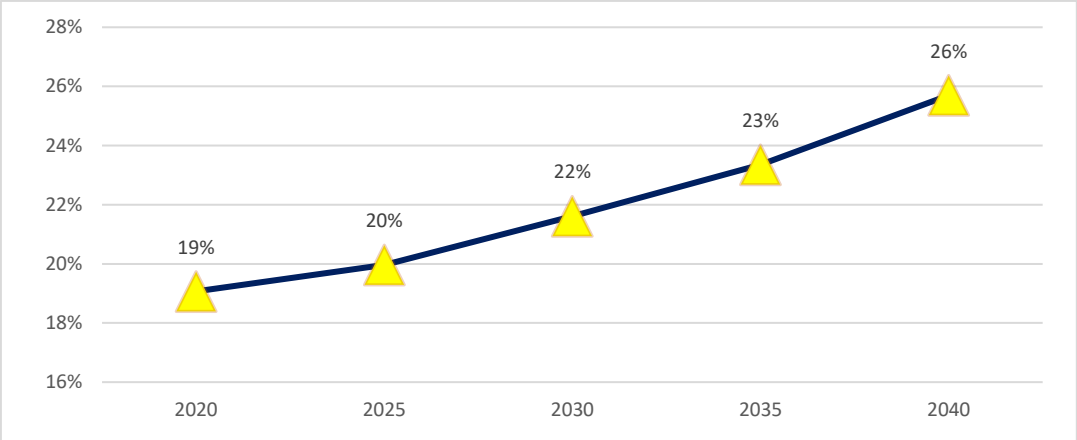
Energy indicators are often used to analyse a country import dependency on energy, energy consumption per capita, energy consumption per GDP, elasticity between TPES and GDP, as well as CO_2 emissions.

Import dependency

In terms of import dependency, the Lao PDR imported all its oil requirements and some electricity to meet consumption during the dry season and in the border areas without electricity access. Measuring import dependency is by dividing the total energy import to the total energy production. The total production of the Lao PDR consisted of coal, hydropower, biomass, solar and wind.

The import dependency ratio was 19% in 2015, an increase from 17% in 2000 due to the increase in oil consumption, particularly in the transport sector. In the BAU scenario, the Lao PDR import dependency is projected to continue increasing and will reach 26% by 2040 (Figure 6.7). If the Lao PDR increases domestic coal consumption for power generation instead of hydropower generation, the import dependency ratio should decline because of different thermal efficiency between coal power plants and hydropower plants. Nevertheless, oil consumption will increase faster than coal, which will result in an increase of the import dependency ratio.

Figure 6.7 Import Dependency



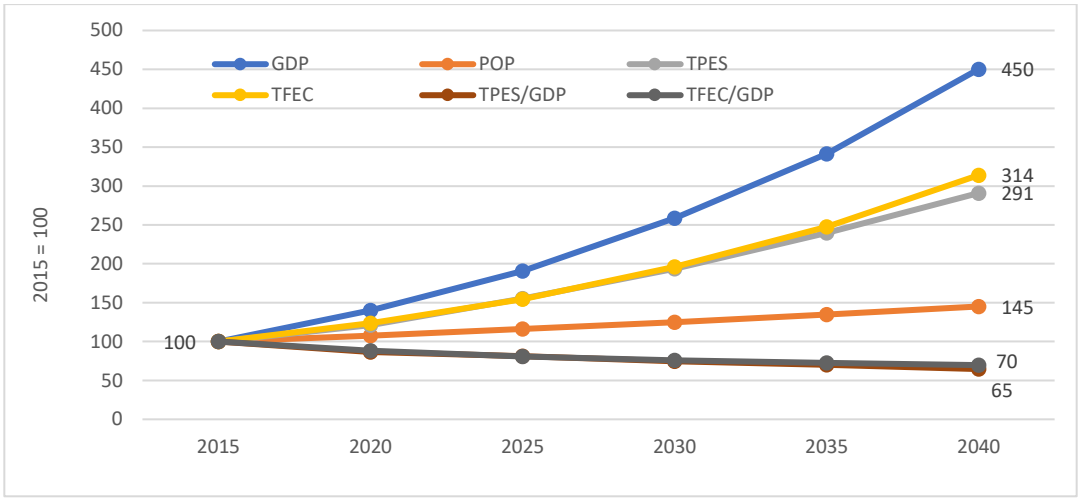
Source: Author's calculations.

Energy and CO_2 emissions intensity

Energy intensity is defined as the total primary energy supply or total final energy consumption (TPES or TFEC) divided by the gross domestic product (GDP). GDP, as explained in the previous chapter will grow at an average rate of 6.2% per year over the projection period, while population growth will be 1.5% per year. Based on these assumptions, GDP in 2040 will be 4.5 times what it was in 2015, while the population will be 1.5 times. TPES and TFEC will triple in the next 25 years, indicating a slower growth than the GDP. Consequently, the TPES and TFEC intensity will decline (Figure 6.8).

The TPES intensity in the BAU scenario will decline at an average rate of 1.7% per year, from 424 to 274 toe/million US$ over the 2015 to 2040 period. TFEC intensity will decline at a slower rate of 1.4% per year, from 281 to 196 toe/million US$. Declining energy intensities indicate that there is an improvement of energy consumption (primary and final) in all sectors. Primary and final energy intensity in the BAU scenario will improve by 30% and 35%, respectively in 2040 compared to 2015. Unfortunately, improvements do not come from the promotion of energy efficiency in the Lao PDR. It comes from energy diversification from biomass to conventional energy such as oil and electricity and biomass will take the role of absorber which mitigates the increase of conventional energy.

Figure 6.8 Energy Indicators (2015 = 100)



GDP = gross domestic product, POP = population, TFEC = total final energy consumption, TPES = total primary energy supply.
Source: Author's calculations.

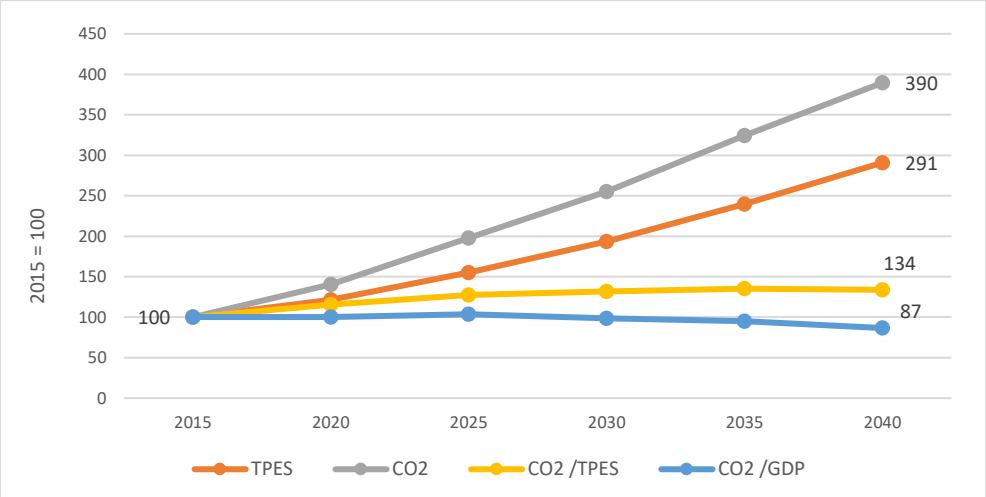
Per capita energy consumption, measured as the ratio of TPES to the total population, was 0.7 toe/person in 2015 higher than it was in 2000 (0.3 toe/person). This increase in energy per capita indicates improvement in energy access of society, which was reflected by the electrification ratio. In the BAU scenario, energy consumption per capita will continue to increase and will reach 1.4 toe per person in 2040.

Energy elasticity, which is the ratio of percentage growth in energy and the GDP will improve from 0.9 over the 2000–2015 period to 0.7 over the projection period regarding the TPES. For the TFEC, the elasticity will shift from 0.6 to 0.7 over the same period.

As with energy intensity, CO_2 intensity measures the ratio of GDP or the TPES to the CO_2 emissions. Both the CO_2/GDP and CO_2/TPES increased in the past as coal and oil consumption increased significantly faster than the GDP growth.

Under the BAU scenario, CO_2 emissions in 2040 will almost be four times from the 2015 level, indicating a slower growth than the GDP. As a result, the CO_2/GDP will decline by 0.9 times in the next 25 years (Figure 6.9). Initially, the CO_2/GDP will increase until 2025 then start to decline to 2040. Overall, the CO_2/GDP will decline at an average rate of 0.6% per year, from 232 ton-c/million US$ in 2015 to 200 ton-c/million US$ in 2040.

Figure 6.9 CO_2 Emissions Intensity (2015 = 100)



GDP = gross domestic product, TPES = total primary energy supply.
Source: Author's calculations.

The CO_2/TPES will increase to 0.73 ton-c/toe by 2040 from 0.55 ton-c/toe in 2015. This change will come from the diversification of the energy share to shift from low carbon energy (biomass and hydro) to fossil fuels (coal and oil) in the Lao PDR.

6.2 Case Studies

The case studies being considered in this outlook are:

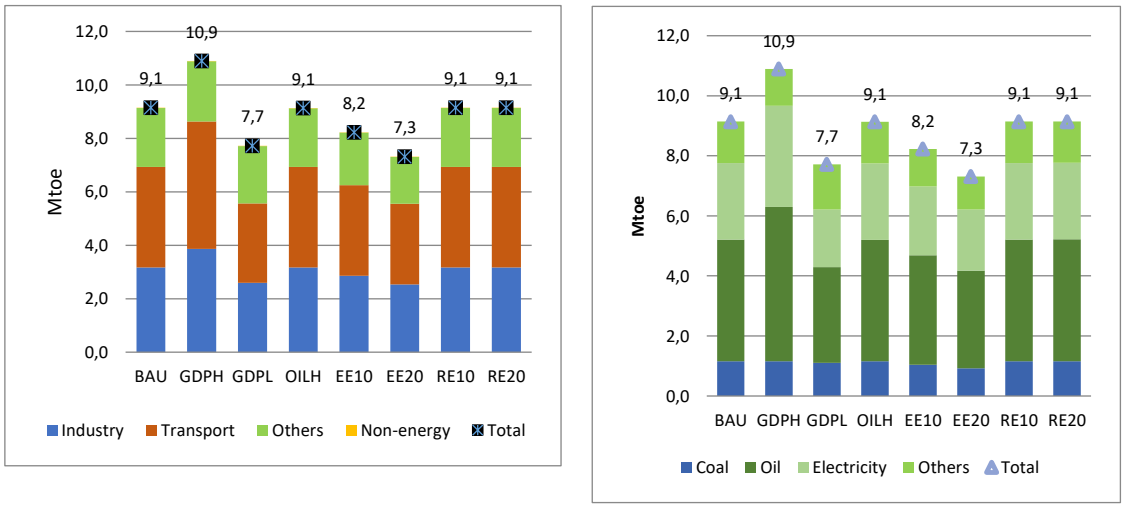
1) **Changes in GDP (GDPH and GDPL)**: It is assumed that the GDP annual growth rate could increase or decrease with additional ±1% as compared to the BAU scenario.
2) **Higher oil price (OILH):** It is assumed that the crude oil price could increase from US$150 by 2030 and US$200 by 2040 in the BAU scenario to US$200 by 2030 and US$250 by 2040, respectively.
3) **EEC promotion:** It is assumed that the TFEC would reduce by 10% (EE10) and 20% (EE20) in 2040 compared to the BAU scenario through the implementation of EEC activities.
4) **RE development:** It is assumed that the share of power generation outputs from RE sources (solar and wind) could reach 10% (RE10) and 20% (RE20) of total power generation (compared to negligible share of the BAU scenario) by 2040. These additional increases are assumed for replacing coal-fired thermal power plants.

A detailed assumption applied in the case studies has been outlined in Chapter 5. The impacts of the different case studies will be compared to the BAU scenario.

Final energy consumption

The projected TFEC in 2040 by sector and by fuel for the different case studies as compared to the BAU scenario is shown in Figure 6.10. The TFEC for the case studies will be different than the BAU scenario except for the RE development case studies. Under the RE development case studies, the TFEC will be the same as in the BAU scenario because the assumption was on the power generation side, not on the demand side. In the RE case studies, the RE sources (solar and wind) share in the total generation will increase to 10% (RE10) and 20% (RE20) in 2040. Thus, increasing coal-fired thermal power plants will not be as much as in the BAU scenario since some will be replaced by RE sources.

Figure 6.10 Total Final Energy Consumption in 2040 by Cases



BAU = Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, Mtoe = million tons of oil equivalent, RE = renewable energy.
Source: Author's calculations.

Under the GDPH, increasing 1% of the GDP growth rate of the BAU scenario will increase the TFEC by 19% in 2040. Under the GDPL, the TFEC will decrease by 16%. Increasing the oil price by US$50 in 2030 and in 2040, respectively from that of the BAU scenario (OILH) will also decrease the TFEC, but only by 0.1%.

Under the EE20, the TFEC will be 20% lower than that of the BAU scenario while under the EE10, the difference will be 10%. These scenarios are tentatively assumed for assessing the sensitivity of this outlook.

Under the GDPL, reduction in different sectors is not the same. The reduction in the TFEC of the transport sector will be 21%, while for the industry sector 18% and the 'Others' sector 2%. The non-energy sector relates to the transport sector (lubricants), so the reduction will also be similar (21%). The transport and industry sectors are more sensitive to the changes in GDP due to a zero or small share of biomass.

In case of the 'Others' sector, the majority of the consumption is that of the residential sector. Since biomass has the major share in the TFEC of the residential sector, changes in the GDP will not directly impact biomass consumption. In fact, biomass consumption will increase under the GDPL case and decrease under the GDPH case. Under the GDPL, the highest reduction will be in electricity (25%), followed by oil (21%) and coal (5%). The reduction in oil consumption mostly occurs in the road transport sector.

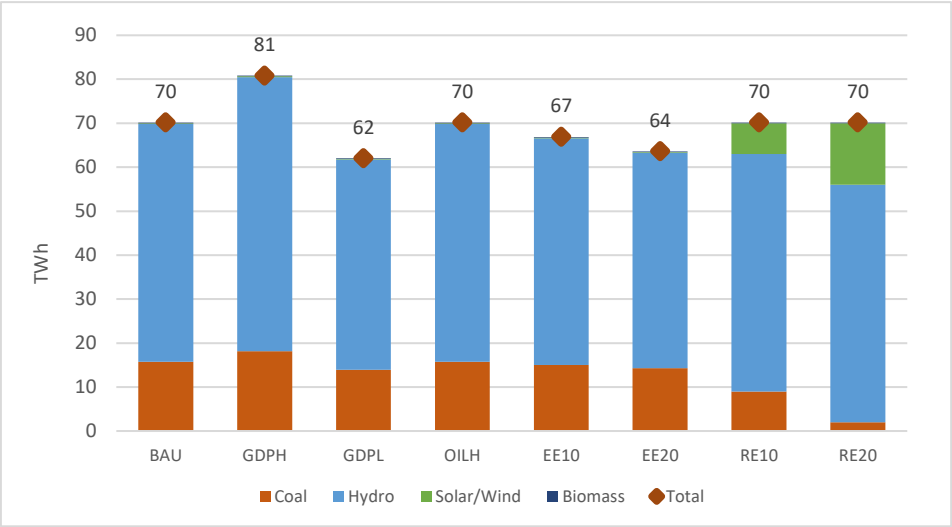
Power generation

As mentioned previously, the electricity demand of the final sector is 25% lower than the BAU scenario under the GDPL. Under the EE20, electricity consumption is only 20% lower than the BAU scenario. Since the electricity export will be the same for all cases, then electricity generation will be the lowest under the GDPL (Figure 6.11).

Under all cases, hydropower is the major source for electricity generation in the Lao PDR (77%). The second largest source for electricity generation will be coal (22%) under all cases except RE cases (RE10 and RE20). The remaining share will be that of biomass and other renewables (solar and wind).

Under RE10 and RE20, the share of solar and wind will be 10% and 20% higher than the BAU scenario. The substitution is assumed only for coal-fired power plants. Thus, the share of coal in total power generation will decrease to 13% under RE10 and 3% under RE20.

Figure 6.11 Comparison of Scenarios to Electricity Generation by 2040



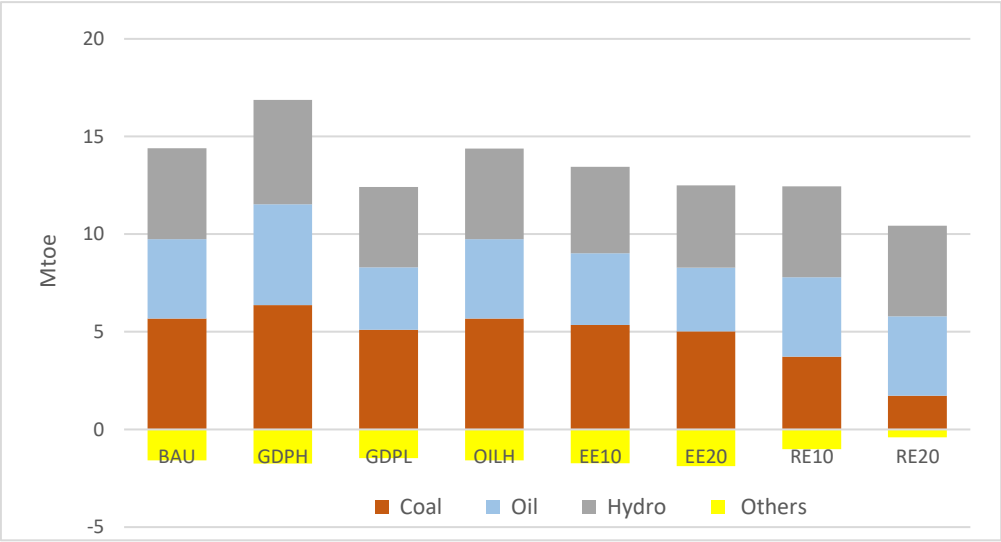
BAU = Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, RE = renewable energy, TWh = terawatt hour.
Source: Author's calculations.

Primary energy supply

The TPES of the Lao PDR in 2040 will be 18% higher than the BAU scenario under the GDPH (Figure 6.12). This increase will mainly come from the use of hydropower and other renewables (solar and wind) to meet the higher electricity demand. Hydropower and other renewable supply under the GDPH will be 15% higher than in the BAU scenario. Coal supply will also be 12% higher than the BAU scenario. Biomass supply, on the other hand, will be 9% lower than the BAU scenario since households tend to use more efficient stoves (such as LPG and electricity) as incomes increase due to the improvement in the economy.

In a reverse situation, where GDP growth declined by 1% (GDPL), biomass supply will increase while the other sources will decrease. Biomass supply will increase by 8% under the GDPL as compared to the BAU scenario. Hydropower and other renewables will decrease by 12%, while coal decreases by 10% resulting in an overall decrease of the TPES by 15%. Under the OILH case, the TPES will also be lower than the BAU scenario, but only by 0.04%.

Figure 6.12 Comparison of Scenarios to TPES by 2040



BAU = Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, Mtoe = million tons of oil equivalent, RE = renewable energy.
Source: Author's calculations.

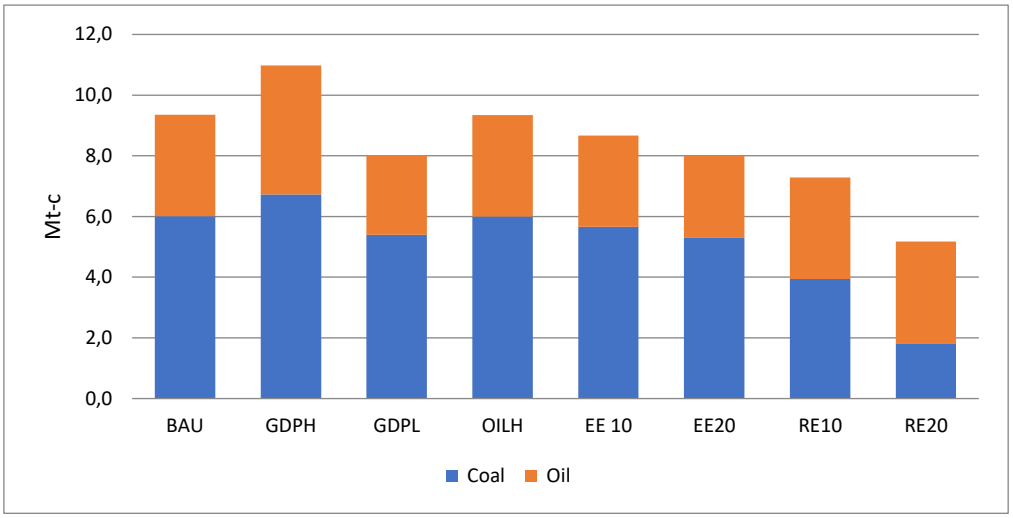
The EE20 and RE20 cases reduce the TPES more than the GDPL. The TPES of EE20 will be 17% lower than BAU while under RE20, the TPES will be the smallest; 22% lower than BAU. This is possible because solar and wind power plants have 100% efficiency, while coal-based power plants efficiency are 30%. So, increasing the share of solar and wind sources in the total electricity production as substitutes to coal-fired power plants (RE20) will reduce coal demand significantly and thus avoid any additional coal import of the Lao PDR.

CO_2 emissions reduction

The CO_2 emissions in the BAU scenario will reach 9.4 Mt-c by 2040, 4.5 times more than it was in 2015. If the GDP growth rate was 1% lower than that of the BAU scenario (GDPL), the TPES will also be lower than the BAU scenario. Consequently, this will result in a lower CO_2 emissions. Total CO_2 emissions under GDPL will be 8.0 Mt-c by 2040, which is 14% lower than the BAU scenario (Figure 6.13). If the GDP growth assumption increased by 1% (GDPH), then the CO_2 emissions will increase to almost 11 Mt-c by 2040; around 17% higher than the BAU scenario. Increasing price of oil (OILH) does reduce the TPES, but very slightly. Therefore, the CO_2 emissions in 2040 will almost be the same as in the BAU scenario.

Other cases (EE10, EE20, RE10, and RE20) will also result in lower TPES compared to the BAU scenario. The EE10 case will reduce CO_2 emissions of 2040 by 7% as compared to BAU, while EE20 can reduce the CO_2 emissions by 15%.

Figure 6.13 Lao PDR CO_2 Emissions by Cases



BAU = Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, Mt-c = million tons-c, RE = renewable energy.
Source: Author's calculations.

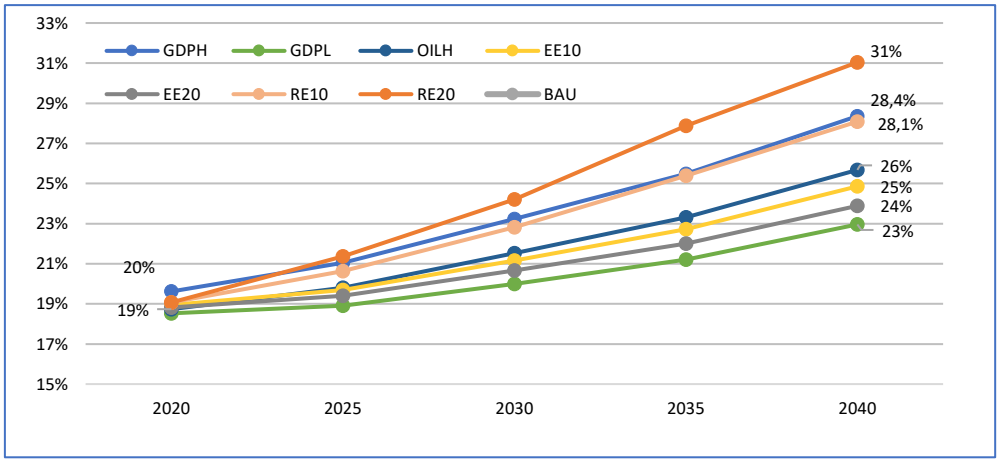
The CO_2 emissions in 2040 will be significantly reduced if the Lao PDR promotes solar and wind power generation instead of coal-fired power plants. If the policy is to increase the share of solar and wind in the total power generation by 10% (RE10), the CO_2 emissions reduction in 2040 will reach 22%. If the share increases to 20%, then the CO_2 emissions reduction will reach 45%; the lowest from all cases.

Energy indicators

Import dependency

In the BAU scenario, the Lao PDR import dependency will reach 26% by 2040. Import dependency will be the highest at 31% under RE20 (Figure 6.14). The RE20 case increases the role of solar and wind in power generation by 20% to substitute electricity produced by coal-fired power plants. Since coal use will decrease in RE20, the domestic production of coal will be lower than in the BAU scenario. In addition, an increase in solar and wind supply will not be as much since renewable plants have 100% efficiency, while coal is only 30%. As a result, the import dependency ratio will be higher than in the BAU scenario. In the RE10 case, the reduction in total energy production will not be as low as in RE20, so that import dependency will only reach 28% in 2040.

Figure 6.14 Lao PDR Import Dependency Ratio



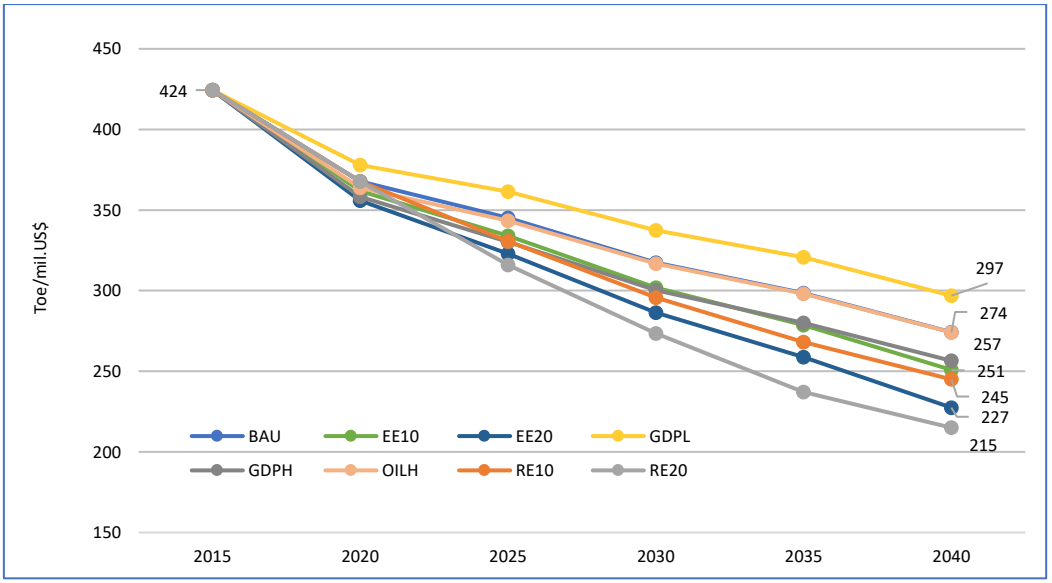
BAU = Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, RE = renewable energy.
Source: Author's calculations.

Energy intensity

In the BAU scenario, primary energy intensity of the Lao PDR will reach 274 toe/million US$ by 2040. If the share of the coal-fired power plant decreases significantly as a result of the increasing renewable solar and wind share to 20% of total power production (RE20), the intensity will be the minimum (215 toe/million US$). This is around 22% lower than BAU (Figure 6.15). If the increment of the solar and wind share is only 10%, the primary energy intensity will decline to 245 toe/million US$; almost 11% improvement from the BAU scenario.

The other cases (EE10, EE20, and OILH) will also improve the energy intensity but not as much as the RE20. The improvement of energy intensity from the BAU scenario will be 9% and 17% for the EE10 and EE20, respectively. In the case of OILH, the energy intensity is almost the same as in the BAU scenario since the difference in TFEC and TPES is small.

Figure 6.15 Primary Energy Intensity

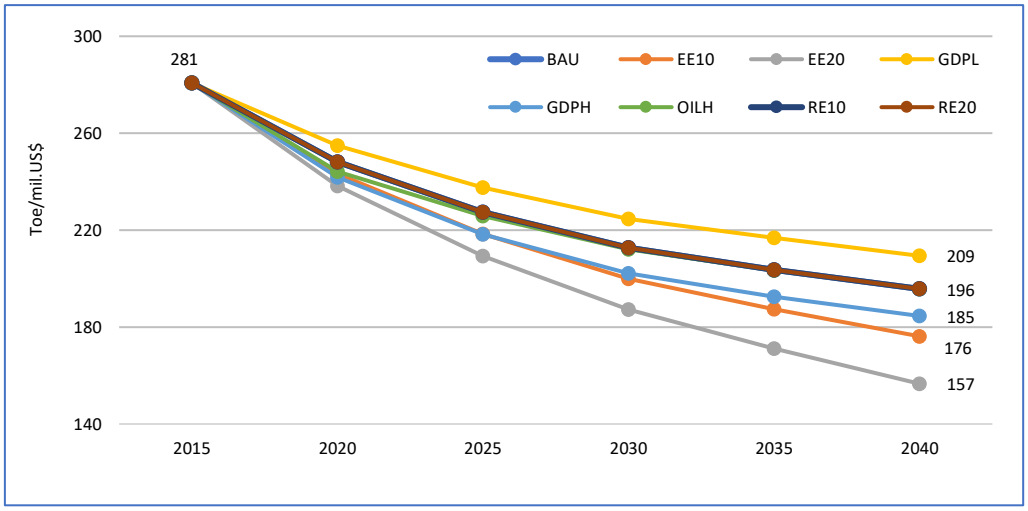


BAU = Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, toe = tons of oil equivalent, RE = renewable energy.
Source: Author's calculations.

If the GDP growth rate is 1% lower than the BAU scenario (GDPL), both the TPES and GDP will be growing more slowly. The result of the primary energy intensity in 2040 will be 257 toe/million US$ in 2040, slightly higher than EE10 (254 toe/million US$). The primary energy intensity will be higher than in the BAU scenario if the GDP is growing faster (GDPH); 297 toe/million US$ toe/million US$.

The final energy intensity of the BAU scenario in 2040 will be 196 toe/million US$; 0.7 times lower than in 2015. Implementing a 20% energy saving target (EE20) will result in a 20% improvement of BAU final energy intensity (Figure 6.16). The final energy intensity under the EE20 will be 157 toe/million US$ in 2040. In the EE10, the final energy intensity will only be 10% lower than the BAU scenario, which is 176 toe/million US$. Higher GDP growth (GDPH) will result in a lower final energy intensity than BAU (185 toe/million US$) and lower GDP growth (GDPL) will result in a higher intensity (209 toe/million US$).

Figure 6.16 Final Energy Intensity



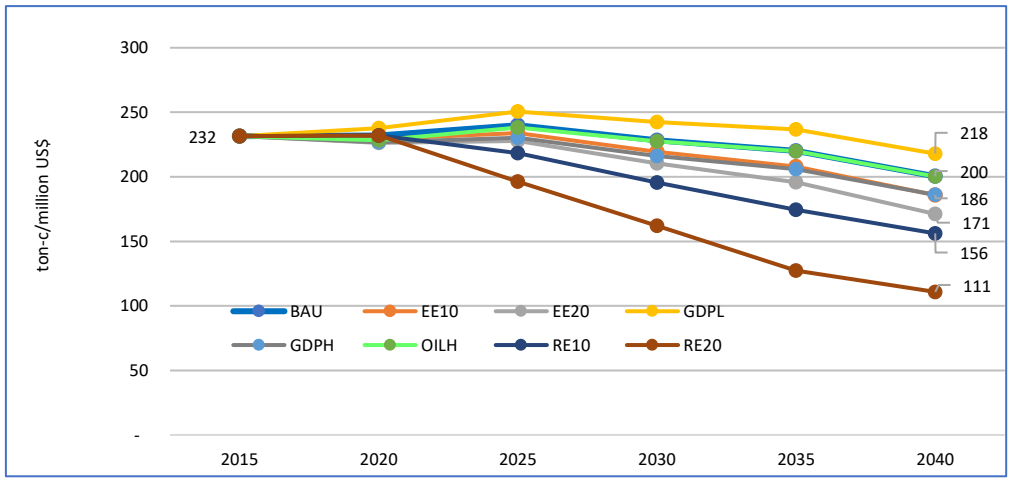
BAU Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, toe = tons of oil equivalent, RE = renewable energy.
Source: Author's calculations.

The final energy intensity remains the same as the BAU scenario for the RE10 and RE20 because these two cases impact only on the TPES. The higher oil price will reduce the TFEC, but as discussed above, only very slightly. So, the final energy intensity will almost be the same as that of the BAU scenario.

CO_2 emissions intensity

The CO_2 emissions intensity in 2040 will be lower than the BAU scenario for all cases with the same GDP assumption of BAU because the total CO_2 emissions will be lower as explained above. In the BAU scenario, CO_2 emissions intensity (CO_2/GDP) will be 200 ton-c/million US$. Promoting RE development by 20% (RE20) will result in the lowest CO_2 emissions intensity of 111 ton-c/million US$, which is 45% lower than the BAU scenario. If RE development is only 10% (RE10), the improvement of CO_2 intensity s compared to the BAU scenario will only be 21% (Figure 6.17).

Figure 6.17 CO_2 Emissions Intensity (CO_2/GDP)



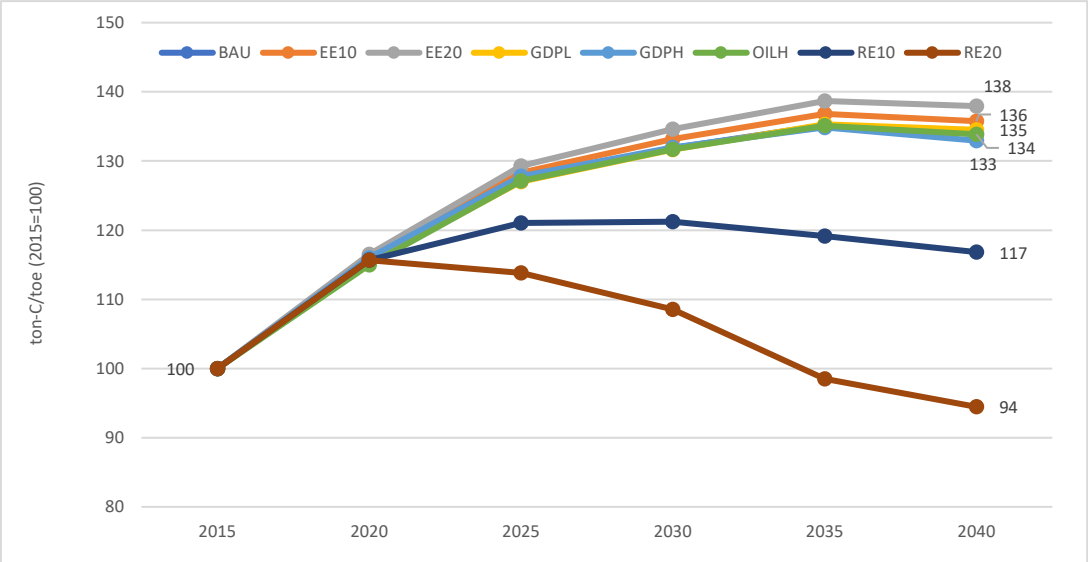
BAU = Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, RE = renewable energy.
Source: Author's calculations.

The EE promotion case only improves the CO_2 intensity by 7% under the EE10 but can be more (15%) under the EE20. Increasing oil prices (OILH) will also improve the CO_2 emissions intensity but by a very small amount (0.1%).

In case of different GDP levels, the CO_2 emissions intensity will be 9% higher than the BAU scenario under GDPL. Under GDPH, the CO_2 emissions intensity will improve 7% more than in the BAU scenario.

The CO_2/TPES of the BAU scenario will be 0.73 ton-c/toe in 2040 and except for the RE development cases (RE10 and RE20), the ratio of other cases will still be around 0.7 ton-c/toe. The RE development cases will decrease the coal share in the TPES significantly, consequently the total share in the TPES will decrease by 2040. In the RE10, the fossil fuel share in the TPES will reduce to 60% from the 70% in BAU and to 40% in the RE20. Consequently, the CO_2 emissions of the country will decrease very sharply in RE development cases and CO_2/TPES intensity will be 13% and 29% lower than BAU under the RE10 and RE20, respectively. Figure 6.18 shows the evolution of the CO_2/TPES intensity of the BAU and the study cases (with index 2015=100).

Figure 6.18 CO_2/TPES Intensity



BAU = Business-As-Usual, EE = energy efficiency, GDP = gross domestic product, RE = renewable energy, TPES = total primary energy supply.
Source: Author's calculations.

Annex

Table A6.1 Energy Balance Table 2015, BAU

	Coal	Hydropower	Solar and Wind	Biomass	Electricity	Oil	Non-energy	Total
Production	1552	1250	0	1619	0	0	0	4422
Imports	0	0	0	0	177	968	2	1147
Exports	0	0	0	0	-1126	-41	0	-1167
From Stock Change	0	0	0	0	0	0	0	0
Total Primary Supply	1552	1250	0	1619	-949	927	2	4402
Refinery	0	0	0	0	0	0	0	0
Electricity Generation	-1371	-1250	0	-2	1470	0	0	-1153
Transmission and Distribution	0	0	0	0	-157	0	0	-157
Total Transformation	-1371	-1250	0	-2	1314	0	0	-1310
Statistical Differences	0	0	0	172	0	9	0	181
Industry	181	0	0	56	150	46	0	433
Transport	0	0	0	0	0	868	0	868
Residential	0	0	0	1116	137	1	0	1254
Commercial	0	0	0	274	74	2	0	351
Agriculture	0	0	0	0	3	0	0	3
Non-energy	0	0	0	0	0	0	2	2
Total Demand	181	0	0	1446	365	918	2	2912

BAU = Business-As-Usual.

Source: Author's calculations.

Table A6.2 Energy Balance Table 2040, BAU

	Coal	Hydropower	Solar and Wind	Biomass	Electricity	Oil	Non-energy	Total
Production	5676	4649	15	1600	0	0	0	11939
Imports	0	0	0	0	15	4103	11	4129
Exports	0	0	0	0	-3220	-41	0	-3261
From Stock Change	0	0	0	0	0	0	0	0
Total Primary Supply	5676	4649	15	1600	-3204	4062	11	12808
Refinery	0	0	0	0	0	0	0	0
Electricity Generation	-4519	-4649	-15	-52	6032	0	0	-3202
Transmission and Distribution	0	0	0	0	-283	0	0	-283
Total Transformation	-4519	-4649	-15	-52	5749	0	0	-3485
Statistical Differences	0	0	0	172	0	9	0	181
Industry	1157	0	0	134	1615	264	0	3169
Transport	0	0	0	0	0	3767	0	3767
Residential	0	0	0	985	611	9	0	1605
Commercial	0	0	0	257	317	12	0	586
Agriculture	0	0	0	0	3	0	0	3
Non-energy	0	0	0	0	0	0	11	11
Total Demand	1157	0	0	1376	2545	4052	11	9142

BAU = Business-As-Usual.

Source: Author's calculations.