Role of solar energy for enhancing sustainable energy and electricity in Myanmar: An outlook

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Abstract. Sustainable Energy Development is a must consideration for energy sector. Energy Trilemma index is quite low in Myanmar as only 40% of the country is electrified. At 66% of Final Energy Consumption, the residential sector was the largest energy consumer, due to the use of fuel wood for cooking. For electricity sector, load shedding problems are frequently occurred in dry season because of insufficient generation. Local peoples are also protesting Coal fired power plants and natural gas is also not available sufficiently. In this paper, the role of solar energy to enhance energy security, affordability and environmental sustainability are analyzed using energy Trilemma index as a tool. Energy Trilemma is used as a tool to determine the sustainability development of the energy sector. According to the analysis, three indices of energy trilemma can be improved by solar energy and it is a vital role for sustainable energy development in Myanmar.

Keywords : Energy Trilemma, solar energy, generation mix, sustainable energy, Myanmar.

1. Energy Sector Review
The Global energy demand is expected to increase just as fast and potentially double by 2050 accordingly to the increasing of demand for power, head and transport. To keep up with global energy demand, the investment requirements for energy infrastructure are nearly US$50 trillion between now and 2050. With such a large portion of money being invested, and the need for energy becoming ever so critical, the method of resource allocation is paramount. There are three challenges that have to be addressed when facing investment in energy and demand, and these three challenges imply a trade-off when choosing one over the other [1].

The World Energy Council considers energy sustainability to be defined by three core dimensions—Energy Security, Energy Equity, and Environmental Sustainability. Together, they constitute a ‘trilemma’, and achieving high performance on all three dimensions entails complex interwoven links between public and private actors, governments and regulators, economic and social factors, national resources, environmental concerns, and individual consumer behaviors [2].

Myanmar has abundant energy resources, particularly hydropower, natural gas, biomass and solar. According to the research survey by Ministry of Energy and Asia Development Bank, the hydropower potential is estimated to be more than 100,000 megawatts (MW) in terms of installed capacity. The amount of onshore and offshore crude oil is already proven as 102 and 43 MMbbl. The proven amount of natural gas is 5.2 TCF for onshore and 11 TCF for offshore. Resource of coal is estimated as 540 million tons. The national average energy from solar is estimated as 52000TWh/year[7]. The However,
the country’s energy sector has been underdeveloped due to a lack of financial and technical capacity and global isolation. Furthermore, inadequate power supply has emerged as one of the most serious infrastructure constraints for the country’s sustainable economic growth. For example, only 40% of the total population had access to electricity in 2018[4].

In Figure 1, the final energy consumption by sectors are described and energy utilization of residential in rural area is extremely high compared with other sectors. Most of the rural area was not electrified and it is important to consider the energy source utilized in rural area.

In Figure 2, the fuel source of energy consumption can be seen. The amount of energy consumption is measured by KTOE. Energy is utilized 17% from hydro, 13% from gas, 17 % from oil and even 51% biomass Type II. In rural area, biomass type such as wood and char coal are mostly used for cooking as there is no electricity. It is a must consideration and a big issue for environmental impact and socioeconomic impact. Even though high carbon emitted resource such as coal is only 2% in the fuel mix, biomass type II is also a high potential for carbon emission and environmental impact.

2. Electricity Sector Review

2.1. Generation Mix
Electricity generation is mostly above 3000 MW and according to the record from Ministry of Energy and Electricity, energy consumption reaches at 3600 MW in peak time. As shown in figure 3, the electricity generation is mainly depended on hydropower. In 2019, solar mega power plant is starting to connect the grid and it will be included in the generation mix soon.
2.2. Interruption Analysis
Electricity interruptions are a major problem in Myanmar and system reliability and security level is still required to upgrade. According to the statistics, the causes of interruption are mainly due to life fault and load shed. As we can see in figure 4, 35% of interruption occurs because of load shedding. Load shedding problems is happened mostly in dry season as the insufficient water supply for hydro power plant. According to the generation mix mentioned in figure 3, hydro power is 69% and it is highly impact on load shedding in dry seasons. Therefore, it is an urgent issue to find an alternative solution.

2.3. Demand Analysis by Regions
In Figure 5, electricity demand in Myanmar is described with the regions which consumed the electricity significantly in every year. According to the data, Yangon region consumes 40% or more than 40% of the generation and the demand of Mandalay region is about 24%. Magway region and other region in dry zone area consumes around 5 or 6% of total generation. Therefore, more than 70% of generations was consumed by Yangon and dry zone area.

3. Role and Potential of Solar Energy

As the previous analysis provides that hydro power has shortage during the dry season and most of the demand are located in Yangon Region and other regions in Dry Zone area. Therefore, solar energy is a must consideration to fulfill the requirement.

3.1. Solar Radiation Statistics

In Figure 6, we can see the trend of solar power energy and solar radiation throughout the year. It is clear that hydro-solar hybrid system can be reversely supported together to the national grid.

3.2. Utilization of Solar Energy

Solar energy can be utilized mainly in two forms for electricity generation as on-grid and off-grid system. For on-grid system, large mega solar power plants and small distributed PV generations in urban area can be used. For Mega solar plant, both photovotatic and concentrated solar plants are technically already matured. For off-grid system, solar home and mini-grid are commercially used. In Myanmar, small distributed PV generation is not able to connect to the grid as the grid code has not been implemented. For mega solar plant, the government has already assigned memorandum of understanding for some projects and power purchase agreement for some projects. There are some solar floating projects are also planning in some dams of hydro power plants such as each 30 MW in Zaung Tu Dam, Kun Chaung Dam and Shwe Gyin Dam[12].
Table 2. Ongoing Project of Solar Mega Power Plant

| No | Name    | Capacity (MW) | Remark |
|----|---------|---------------|--------|
| 1  | Sagaing | 880           | MoU    |
| 2  | Thapyaysan | 100         | MoU    |
| 3  | Shwemyo | 10            | MoU    |
| 4  | Min Bu  | 170           | PPA    |
| 5  | Myingyan | 150         | PPA    |
| 6  | Windwin | 150           | PPA    |

Table 3. Systems of Rural Electrified Villages in the Entire Country

| No | Type             | Utilization |
|----|------------------|-------------|
| 1  | Grid Line        | 35%         |
| 2  | Diesel Generator | 25%         |
| 3  | Mini-hydro       | 5%          |
| 4  | Solar Home       | 33.24%      |
| 5  | Solar Mini-grid  | 0.11%       |
| 6  | Wind             | 0.01%       |
| 7  | Bio-mass, Bio-gas | 1.64%     |

In Table 3, the percentage of current electrified villages is described[13]. The percentage of solar is comparatively high around 34 including solar home and solar mini grid system. The rate of solar utilization in rural area is increasing day by day in Myanmar.

Figure 6. Trends of Hydro Power and Solar Radiation

4. Energy Trilemma Index Improvement by Solar Energy

According to the analysis from the previous section, solar energy can be effectively used for electricity sector in both urban and rural area. Consequently, energy sector can be also improved with the utilization of solar energy. Energy trilemma index or energy sustainability index is a tool to measure the performance of the energy sector. In this section, the factors concerned for three dimensions of energy trilemma index are examined with the consideration of solar energy penetration. Energy trilemma index or energy sustainability index is a tool to measure the performance of the energy sector. In this section, the factors
concerned for three dimensions of energy trilemma index are examined with the consideration of solar energy penetration.

According to the world energy council, three dimensions of energy trilemma or energy sustainability are energy security, energy equity and environmental sustainability as shown in figure 8 [2].

4.1. Energy Security
Energy security can be defined as the effective management of primary energy supply from domestic and external sources, reliability of energy infrastructure, and ability of energy provides to meet current and future demand. The index can be determined based on the following four factors[11]:

1. Concentration (reduced diversity) of total primary energy supply
2. Change in energy consumption in relation to GDP growth
3. Import dependence
4. Concentration (reduced diversity) of electricity generation

Concerning the energy security, it is clear that solar energy can reduce the diversity of energy which can assist to improve the index. Moreover, it can reduce import independence and concentration of electricity generation as well. Reducing these four factors can increase the energy security index.

4.2. Energy Equity
Accessibility and affordability of energy supply across the population is interpreted as energy equity. This index can be calculated considering the following factors[11]:

1. Access to electricity (% of population)
2. Industry electricity price (US cents per kWh)

As only 40% of population in Myanmar is currently got access to electricity and the energy equity level is quite low in Myanmar. The electrification rate can be significantly increased by utilizing solar energy. Regarding the electricity price, government subsidies in present and the price is still cheap around 8 cent per kWh.

4.3. Environmental Sustainability
Environmental sustainability is stated as encompasses achievement of supply-demand side energy efficiencies and development of energy supply from renewable and other low-carbon sources. Environmental sustainability is with two factors[11]:

1. CO2 intensity (kCO2 per US$) (0 - 2)
(2) GHG emissions from energy sector (MtCO2e)

Carbon emission and green house gas emission is clearly reduced without doubt by solar energy. Carbon emission and deforestation in rural area due to utilization of wood and char coal is very huge and it can be reduced partly by solar energy.

4.4. Generation Scenarios

According to the Myanmar energy and electricity master plan reported by Japan International Cooperation Agency and Myanmar government, three generation mix scenarios were reported for 2030[14]. According to the demand forecast, the installed capacity for each scenario and percentage of resource can be seen in table 4. In these three scenarios, the expected installed capacity for solar is 2000 MW and around 7 % or 9 % of the generation mix. Currently, 170 MW solar power plant is under installation. However, coal power plants and large hydro power plants are postponed due to protesting from local people. Therefore, it is necessary to find a solution to overcome the challenges.

| Source        | Scenario I | Scenario II | Scenario III |
|---------------|------------|-------------|--------------|
| Gas           | 17%        | 9%          | 21%          |
| Coal          | 10%        | 18%         | 33%          |
| Hydro(Large)  | 42%        | 42%         | 6%           |
| Hydro(Medium-Small) | 24%      | 24%         | 31%          |
| Renewable     | 7%         | 7%          | 9%           |
| Installed     | 28784      | 28552       | 23518        |

5. Conclusion and Recommendation

According to the review and survey, solar energy potential is plentiful in Myanmar and it has a vital role in sustainable energy development and future energy mix. Moreover, it seems clear to improve energy sustainability. However, it is still challenging in Myanmar for legal framework, tariff and technical knowhow. As the legal Framework, Electricity Regulatory Authority (ERA) is necessary founded and tariff regulation must be established. Moreover, renewable energy policy and the regulation for feed-in-tariff is also still required to implemented. At present, government subsidizes the cost of the electricity and tariff should be high comparing to the current tariff.

Concerning the technical issues, Myanmar national grid system is not strong and it is required to upgrade. Besides, to extend electrification from 50% to 100% is also a big concern. Therefore, a realistic generation mixes considering all of security index, affordability index and environmental sustainability index is need to establish accordance with the UN sustainable development goals. Based on the reviews, the percentage of solar energy integration can be increased more than expected percentage. Mini-grid system and solar roof top systems are also expected to increase dramatically in rural area. Technical know-how system frequency and voltage synchronizing problem is also a must consideration in future for grid connected solar mega power plant.

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