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Review Article

A Review on Energy Situation "Solar Energy Policies and Targets" in SAARC Countries

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Abstract: Present energy situation of the world is unsustainable due to unequal geographical distribution of natural wealth as well as environmental, geopolitical and economical concerns. Ever increasing drift of energy consumption due to growth of population and transportation has motivated researchers to carry out research on solar energy as an alternative source of primary energy supply. The International Energy Agency estimates that solar energy could make up as much as a quarter of the world's total electricity production by 2050. With an estimated 900 million people in Asia still lacking access to electricity, most beyond the reach of grid development and centralized generation, localized solar plants are a viable solution. This paper presents a complete overview on the solar energy situation of SAARC countries including present status and future policies and targets. A detailed research on solar energy status and prospects of SAARC countries was done during the period September-December, 2016.

Keywords: Energy Demand, Energy Consumption, SAARC Countries, Solar Energy, Future Targets

1. Introduction

Energy plays an important role in our daily life. It ensures the national security of a country and runs the wheel of economy of the country. South Asia is blessed with enormous energy potential for generating sufficient amount of electricity though it is ranked as one of the regions with lowest per capita Energy consumption region particularly in form of electricity [2]. The South Asian Association for Regional Cooperation (SAARC) consisting the countries of Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. It was established in 1985 with the objectives of developing the quality of life and economic growth in the region, to strengthen collective self-reliance and to encourage active collaboration in economic, technical and scientific fields. Afghanistan later joined SAARC as a full member [7]. The countries under SAARC do not produce enough oil and gas for their needs, and thus have to import them from other countries. The cost of these imported oils and gases are very high and come at the expense of other domestic requirements. The recent increase in energy prices, population and industrialization in developing countries are the most considerable threats to energy security [1]. This situation creates major effect on the development goals of the region. All SAARC members need more power for their economic growth, but almost all of them except Bhutan are facing shortage and lack of primary energy [2]. The SAARC countries could improve the situation by purchasing energy among each other where feasible, and by collective imports of joint imports of natural gas and electricity. Recognizing these facts, the member countries of the South Asian Association for Regional Cooperation (SAARC) decided to establish a SAARC Energy Centre, which came into existence following the final approval during the SAARC Summit on 13 November 2005 which is currently housed at the Hydrocarbon Development Institute of Pakistan (HDIP) [7].

There is a wide variation in the energy resource endowments among the SAARC Member States. India and Pakistan are being accounted for the major share of natural gas and coal [20]. Except India and Pakistan, most of the countries have an ascendant dependence on a single commercial energy form. Oil is used as the principle energy form in case of Afghanistan (75-80%), Maldives (95-100%), Nepal (65-70%), and Sri Lanka (78-85%); hydropower for Bhutan (50-55%); and natural gas for Bangladesh (75-80%) [2, 6]. India largely depends on coal that accounts for 50-55% of the total energy consumption [20]. Pakistan has a mixed energy consumption which varies among oil products-25-30%, natural gas-50-55% and primary electricity-10-15%. Nepal and Bhutan have long term hydropower potential and local demand is very little [18]. Only Solar and Hydro power have the potential to meet the energy needs of around 15-20% of the off-grid population in Sri Lanka [20]. Bangladesh has a vast potential for renewable energy and the natural availability of alternative energy creates opportunities of Growth in power sector. The main source of energy in Bangladesh is Natural gas (24%) which is likely to be depleted by the year 2020 [42]. Wind, Solar, Waves and Biomass are some of the most promising options among Maldives renewable energy sources. Afghanistan is endowed with abundant natural resources of recoverable coal reserves of about 65-70 million tons and proven natural gas reserves of 1.5-2 trillion cubic feet [12, 13]. Afghanistan Energy Infrastructure, generation, transmission and distribution were almost destroyed over the past three decades due to the war and conflict [9]. To use the energy resources available domestically, the Government of Afghanistan has put priority on natural gas development by expanding the supply network and increasing production. Solar energy is one of the promising sources of renewable energy for future with unlimited capacity. The solar technology is increasing faster than ever before to respond the limited fossil energy supply. Since solar energy is available in all most all the regions in South Asia including mostly SAARC countries, it could be the main source of producing electrical energy in future to accomplish energy security [21].

2. Present Energy Scenario in SAARC Countries

2.1. SAARC Energy Consumption

The Energy consumption is rising day by day throughout the world [1]. In 1980 total primary energy consumption in South Asia was about 1.75% of the total world energy consumption which grew 2.35% in 2006 [22]. Though the energy consumption increases significantly, this region still remains in the lowest per capita energy consumption region of the world [23]. India is the leading energy consumer of SAARC countries consuming 850 million tonnes of oil equivalent (mtoe) in 2015 and Afghanistan is the lowest energy consuming country having 0.4 mtoe at the same year. In per capita energy consumption also, there exist significant variations, notwithstanding in different consumptions, with Maldives enrolling the highest per capita energy consumption where Afghanistan and Nepal the lowest [24].

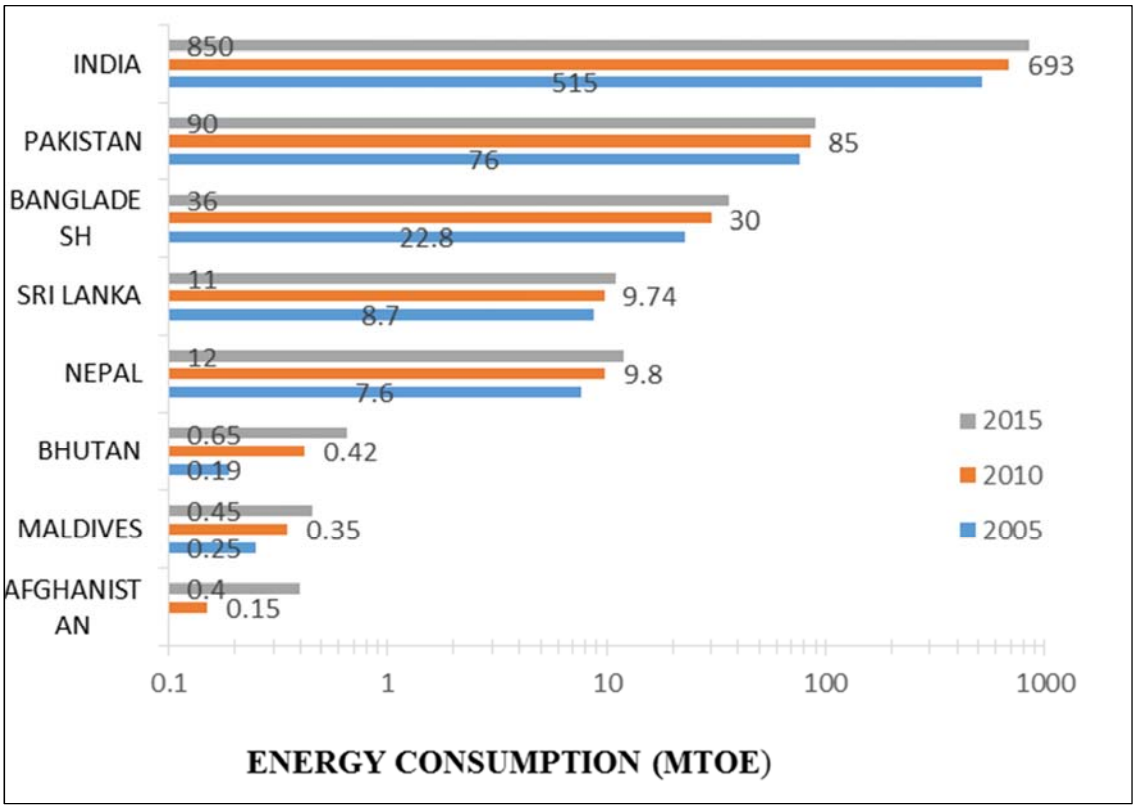

Figure 1. *SAARC energy consumption (2005-2015).*

The three major energy consuming sectors of SAARC countries are residential, industry and transport. Of them, residential is the most energy consumer sector. Energy demand from industry will increase since industry is the driver for economic growth and as SAARC members are aiming at higher GDP growth rates [24].

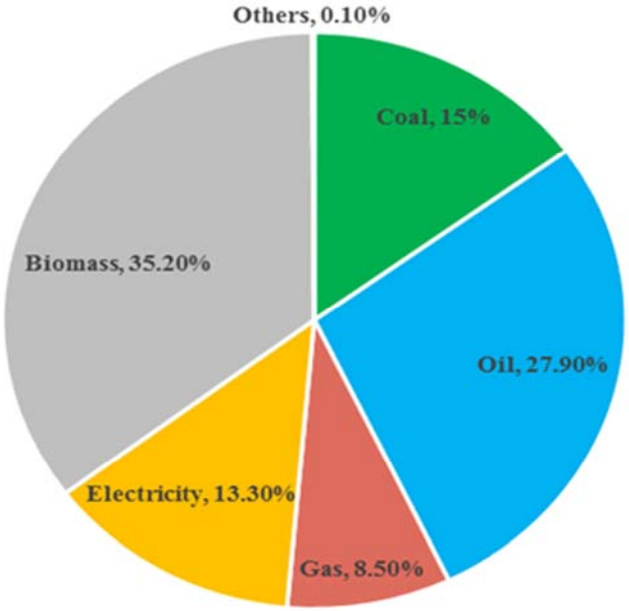

Figure 2. *Sector wise energy consumption in SAARC countries [41].*

By fuel type energy consumption in SAARC countries biomass and oil are the mostly energy consuming sector while gas and electricity have also a significant role.

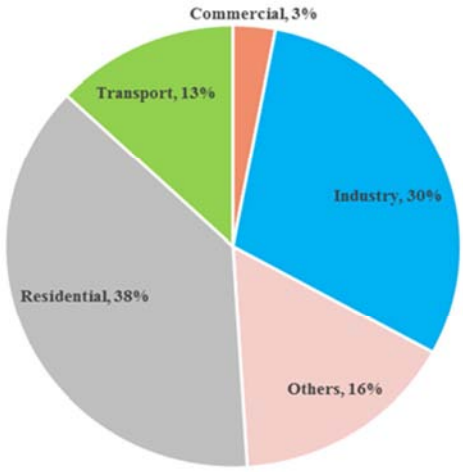

Figure 3. *Energy consumption by fuel type in SAARC countries [41].*

2.2. SAARC Energy Demand

The energy demand of South Asia is expected to increase from 582.1 MTOE in 2005 to 1,264.3 MTOE in 2030, growing at an annual rate of 3.2%. [12]. The renewable energy supply is calculated at 43% and 77% of the demand by the year 2030 and 2050 respectively. Among all the SAARC countries India will have the maximum energy demand of around 1100 mtoe and Maldives will be the lowest in energy demand of 0.7 mtoe by 2030.

An increasing portion of the rapidly growing energy demand in SAARC countries will be met by imports. South Asia's net energy imports are expected to more than triple from 132.6 MTOE in 2005 to 447.6 MTOE in 2030, growing at an annual rate of 4.7%. Among these countries, India's expected increase in oil and gas demand will be increasingly met by imports [12].

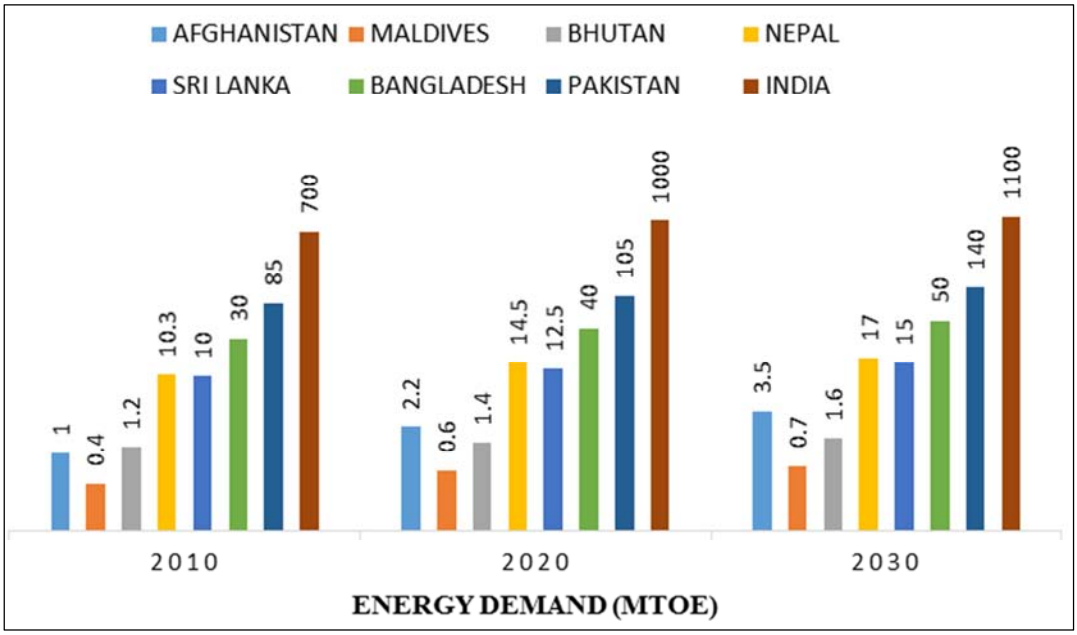

Figure 4. *Estimated primary energy demand of SAARC countries (2010-2030).*

3. Country Wise Solar Energy Scenario

Table 1. *Country wise solar intensity and percentage of population under electricity blessing.*

Country	Solar power Intensity in KWh/m^2 /day	Percentage of population with access to electricity
Afghanistan	2.6 - 7.9	43
Bangladesh	4 - 6.5	62
India	4 – 7	83
Pakistan	5 - 7	93
Nepal	3.9 – 5.1	76
Bhutan	4 – 5.5	75
Sri Lanka	3.4 – 5.7	88
Maldives	4.5 – 6.6	100

3.1. Afghanistan

Afghanistan receives about 5.3 kWh of solar radiation per square meter of horizontal surface on a clear day with a standard deviation of 0.42 kWh. This corresponds to an annual average Global Horizontal Irradiance (GHI) of 1,935 kWh/m^2 (kilo watt hours per square meter). National average seasonal maximum and minimum GHI are 7.84 kWh/m^2/day and 2.38 kWh/m^2/day (kilo watt hours per square meter per day). [25]. Currently, the solar power projects have only been implemented central Bamyan province that provides 1.5 MW power for local residents. The solar power project work is also underway in southern Kandahar province that will produce 12 MW power to the city. The Afghanistan Project is an initiative by a company named Masdar, has installed 600 solar home systems in 27 villages within the Helmand Province of Southern Afghanistan. The project is enhancing the lives of more than 3000 people without access to electricity. The installations include 545 houses and 55 public buildings such as schools, mosques and clinics. Each system includes rooftop solar photovoltaic (PV) panels and battery storage [26-27].

3.2. Bangladesh

On average, Bangladesh receives 4-6.5 kilo watt hours per square meter solar radiation per day. On an estimation the government and many other companies give the benefit of solar energy to 3.5 million houses by installing solar panels with an amount of about 135 MW. For this, solar electricity reaches to more than 13 million beneficiaries, which is around 10% of the total demography of Bangladesh. Bangladesh SHS (Solar Home System) is recognized as the fastest progressing solar power dissemination programs in the world by the international society. An Infrastructure development company limited (IDCOL), Grameen Shakti, a government owned monetary organization was put through most of the capacity connections which is from solar home systems. "Electricity for everyone" within 2021 is the vision of government by using this program. With a guess to produce 220 MW of electricity, IDCOL is aiming to finance 6 million SHS by 2017. At a mean establishment, growth rate of 58% more than 65,000 SHSs are installing in every month now. 3 million systems have already been installed with support from development partners. Owing to the success of the programme, Bangladesh received an additional $78.4 million from the World Bank as soft loan [28].

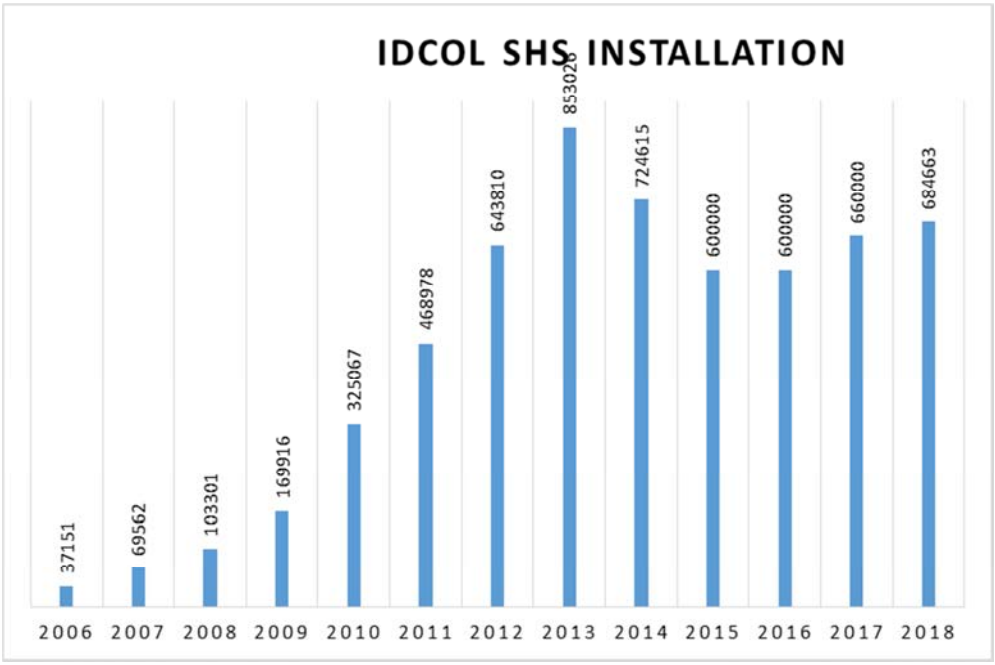

Figure 5. *IDCOL installation of SHS.*

Works are currently underway to build a 400 KW capacity plant at Sulla Upazila of Sunamganj district. Also under construction is a 30 MW PV power plant at Dhorola River Side, Kurigram. Recently, the government has announced plans to build the country's largest single solar energy project, 60 MW solar park, at Raozan Upazila of Chittagong.

3.3. India

With around 300 days of sunshine every year, India has among the best conditions in the world to harness solar energy receiving 4-7 kWh per sq. meter per day. Solar power in India is a first-growing industry. As of 30 September 2016, the country's solar grid has a cumulative capacity of 8626 MW (8.6 GW) [33]. India is already planning to develop one of the largest solar parks in the world. The 2 GW Park in the southern state of Karnata is expected to generate enough electricity to power nearly 1 million households. India is expected to add nearly 4000 MW of solar power in 2016, nearly twice the addition of 2133 MW in 2015 [34]. India's plan to ramp up solar power generation to 100 GW by 2022 is among the largest in the world. It will help bring sustainable, clean, climate-friendly electricity to millions of people of India. The World Bank Group (WBG) is helping India deliver on its plans with more than $ 1 billion in leading over FY 2017.

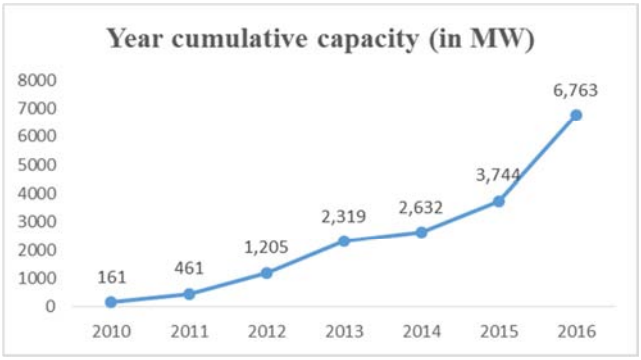

Figure 6. *Installed solar PV in 31 March, 2016.*

The International Finance Corporation (IFC), the World Bank Group's private sector arm, is supporting the India state of Madhya Pradesh set up the 750 MW ultra-mega solar power project in Rewa. This will be the largest single-site solar power project in the world [35].

Table 2. *Jawaharlal Nehru National solar mission.*

Time duration	2010-2013	2013-2017	2017-2022
Utility grid power, including roof top (MW)	1000-2000	4000-10000	20000
Off grid solar application (MW)	200	1000	2000
Solar collectors (sq. meters)	7 million	15 million	20 million

3.4. Pakistan

Pakistan receives one of the best solar-irradiation in the world. Average solar irradiation 5-7 kilo watt hours per square meter per day [29]. The nation has a confirmed solar power potential of over 2.9 million MW [30]. It can produce over a million MW of Solar PV electricity provided adequate space for installation (Source: NREL-USAID- study). On May 29, 2012, first on-grid solar power plant was inaugurated in Islamabad with the cooperation of Japan International Cooperation Agency (JICA) under cool earth partnership. The government of Pakistan has set a target of 5% of total power generation from renewables by 2030, also seeking to develop at least 5000 MW of solar power plants. One of the world's largest solar plants that has been opened in Pakistan spread over more than 200 hectares of desert land in the south of Pakistan's Punjab Province, will generate 100 MW in its initial phase [29]. 31 on grid Solar PV Letters of Intent (709.6 MW) issued by AEDB. Development of solar current on grid power projects - approximately 1500-2000 MW is planned to be added to the National Grid by 2018. Pakistan has over 500,000 Street Lights with a sanctioned load of over 400 MW which can be replaced with efficient solar lighting system and relive the national grid. More than 22 million electricity consumers facing energy shortage. At least 1 million consumers being targeted for solar net metering systems in 2-3 years (approx. 3000 MW addition with an average system of 3 kW). 260,000 electricity operated agriculture water pumps (tube-wells) currently have a sanctioned load of over 2,500 MW. 850,000. Diesel Water Pumps consume 72,000 TOE of Diesel annually. Replacement with Solar Powered efficient pumps can greatly reduce burden on national grid and Government's expenditure on subsidies.

3.5. Sri Lanka

Taking into consideration the land availability in Sri Lanka the exploitable solar is estimated as above 6000 MW. At present there are 4 solar power projects of capacity 40 MW under SPPA signed NCRE projects [18]. According to the strategies laid out by the National Energy Policies and Strategies, new renewable energy development is carried out in the country with the aim of increasing the stake of NCRE in power generation by 10% by 2015. The goal is to further extend to 20% of renewable energy by 2020 including 161 MW from solar energy based as per the 'The development policy framework government of Sri Lanka – Mahindra Chinthana, The way forward (SLSEA Sri Lanka Energy Balance, 2011: 102). Attaining 2020 target is much more challenging, when considering the current progress in the solar powered power plants only 1.4MW installed in two pilot power plants in Hambanthota [8].

Table 3. *Projected NCRE capacity for future generation (Based on Draft LTGEP 2017-2036) [18].*

Year	Solar (MW)	Solar Net Metering (MW)	Total NCRE capacity (MW)
2017	21	20	548
2022	471	50	1583
2027	771	74	2197
2032	1071	98	2811
2036	1271	117	3385

3.6. Nepal

On average Nepal has 6.8 sunshine hours per day, 300 days per year i.e. 2,482 sunshine hours per year with the intensity of solar insolation ranging from 3.9 to 5.1 with national average about 4.7 kilo watt hours per square meter per day. A comparative study shows that total supply from solar energy in Nepal is around 50 MW. Small systems installed in homes 15 MW, large solar powered systems used by telecom

companies 40MW. Around 2000 systems installed in schools, health centers and small and medium business like hotels 6 MW. More than 4000 solar technicians of level 1 and level 2 have been trained and certified by CTEVT [36].

Table 4. *Application of PV based power in Nepal [26].*

Service or Institution	Installed PV Power, kWp	Percentage
Nepal Telecom	9000	28.125
NEA	100	0.003
SHS/AEPC	12000 (400000 system)	37.50
Institutional solar PV system/EU/AEPC	9900	30.937
Water pumping/KUKL	780	0.024
Civil Aviation	50	0.001
Miscellaneous	170	0.005
Total	32000	

3.7. Bhutan

The data record for solar energy shows theoretical technical energy potentials of Bhutan about 58,000 MW [21]. The country shall strive to generate 5 MW by 2020 through solar energy [37]. In Bhutan, domestic demand for electricity has been growing by 17% per year on average. In 2010, Asian development bank made a grant of over 21 million for electrification of rural homes, aiming to provide power both on-grid and off-grid. The on-grid rural electrification subproject has been in good progress, and Bhutan has already achieved 98% of electrification of the whole country [38]. BPC had connected 5,453 households as of Nov 2015 covering the 6 districts, which is beyond the original target of 5,075 households. The off-grid rural electrification subproject has installed 971 solar home lighting systems, covering 894 households and 57 Public Institutions. 1,131 sets of old solar home systems have been rehabilitated. Original target of new installation was 1,896 but demand was less due to people's preference to grid connected electricity.

3.8. Maldives

The Maldives Ministry of Environment and Energy, with support from the World Bank and from the Scaling up Renewable Energy Program (SREP), a funding window of the Climate Investment Fund, has designed a program centered on solar photovoltaic (PV) rooftop installations. Known as ASPIRE (Accelerating Sustainable Private Investments in Renewable Energy), the program is funded with $11.7 million in SREP funds, the equivalent of $16 million in IDA guarantees, and support from the Asia Sustainable and Alternative Energy Program. ASPIRE's goal is to scale up solar PV generation from the present level of ~1.5 MW to between 20–40 MW over the next five years by creating a bankable project structure attractive to the private sector. The first phase of ASPIRE is building 4 MW of solar PV systems on public buildings in Malé, the capital, and Hulhumalé, a large residential island nearby [39]. The Maldives Ministry of Economic Development announced, as part of a national carbon neutral plan, a mandatory target for the country to generate minimum 60% of its electricity from solar power by 2020 [35].

4. Discussion and Conclusion

Due to increase in oil and gas price and adverse effect on environment, solar energy is taking its position every day over fossil fuel. Solar energy offer a renewable source of energy and can play a significant role to reduce dependency on petro–diesel and greenhouse gas emission. With a lot of blessings solar energy have some limitations also. Which are given:

1. Due to low electricity production rate it cannot fulfill the rapid demand of daily life and various necessities.
2. The installation cost of solar panel is much higher which is generally beyond the general people's expectation.
3. Solar power have a low efficiency to meet the increasing energy demand.

Economically, socially or environmentally present energy consumption trends are neither sustainable nor secured. An approaching energy crisis may grasp social and economic growth if there is no change in practice and selection of energy sources. With better targets and solar policy, hopefully, SAARC countries can implement solar as the major substitute of oil and gas and help ensure a cleaner, safer, better world for future generation.

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