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Review

Energy management in South Asia

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ABSTRACT

In this era, energy is essential to life and its continuous and ubiquitous supply brings much needed economic growth and prosperity to a region. Energy Management (EnM) contributes to the controlling and monitoring of energy and has recently become the subject of great significance. EnM involves analysis, conservation and imperative actions that leads to the minimization of the system losses for efficient use of available conventional and renewable energy resources of the region. This study evaluates the energy management in South Asia (SA) region, as it houses one-fourth of the world's total population with India, Pakistan and Bangladesh being the most populous countries. The study accesses the regional energy mix, distributed generation strategy plans, and present the trends in EnM over the past few decades. South Asian Countries (SACs), especially Pakistan, India and Bangladesh have a huge potential of coal i.e. 17,550, 90,085 and 884 Million Tonnes, respectively. India has rightly explored nearly 70% of its coal potential, whereas Pakistan and Bangladesh despite having the largest potential of the coal have focused on oil (35.4%) and natural gas (91.5%) exploration respectively. It is important to note that India experiences the highest technical losses of 23.5%, followed by 17% percent and 14.11% losses by Pakistan and Bangladesh respectively. Energy Intensity (EI) values for Afghanistan, Bhutan and Sri Lanka have listed these countries as low EI terrain region. Pakistan, India and Bangladesh have EI values ranging between 10,000 and 20,000 btu per $2000 constant. SACs countries have monopolistic electricity markets, however steps are taken to partially implement competition and monopoly regulation by privatization and ensuring equal conditions for all vendors. Analysis show that the SACs are presently far behind to meet their energy demands. The paper also recommends introduction and implementation of effective EnM policies along with large scale utilization of non-conventional energy resources, which will bring necessary changes and will help SACs to overcome economic challenges. The study also concludes that the inclusion of renewable energy resources and development of competitive electricity markets would overall improve the EnM in SA.

1. Introduction

Exploring, management and sustainability are the dire needs for survival in 21st century. The evolution history of life saw energy on earth taking various forms like chemical, mechanical, and electrical etc. The electrical energy was mainly obtained from Conventional Energy Resources (CERs) before 20th century, however, recently a shift is observed towards gaining Clean and Green Energy (CGE). It is envisioned that the initial shift, which gained pace globally is receiving clear threat of extinction in the near future. This created an alarming situation and forced the stakeholders to not only adopt CGE but to conserve and manage the available energy resources. Over the last decade energy management and conservation has been the focus of research to attain self-sustainability and efficient management of available resources [1].

EnM is all about controlling, monitoring and conservation of the energy resources [2,3]. It aims at optimizing energy generation, distribution and utilization in order to minimize energy cost without affecting quality. EnM also aims to protect environment by restricting the prevailing climate changes resulting from the fossil fuels burning. Therefore, EnM actually involves in identification and assessment of energy saving opportunities along with the controlling and monitoring of the energy consumption [4,5].

Public awareness is very important in energy conservation and sometime the identified opportunities can lead to efficient management of existing resources. However, energy conservation or management is not an easy task without the necessary amendments and reforms in the existing system [6]. The desired changes include but not limited to introduction of home energy management, industrial energy

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management, smart grids, demand side management, smart metering, automatic meter reading, smart communication, integration of information and control technologies. Home energy management makes use of smart appliances and devices that consume energy efficiently and economically. Home Area Network (HAN), which is part of home energy management, is used to communicate between smart appliances/devices, utilities and consumers. It connects devices to the internet server and establishes wireless connection, which build realistic intuition among people to adopt efficient energy usage pattern [7]. In addition, smart home appliances/devices enable auto switching by configuring schedule of devices and operations [8]. In an industrial organization, energy management or conservation is the practice of reducing use of energy for the same quality and quantity of the output in industrial applications. Organizations and industries are direct consumers of energy and they always aim at adopting the efficient energy management techniques to conserve energy, thereby reducing cost of the products and increasing profit margin [9]. Smart Grid establishes bidirectional power flow and communication between the distributors and the consumers. It helps to utilize the best available opportunities for efficient energy utilization with economics as major concern [10].

Various policies have also been devised globally to strengthen the concept of EnM like Energy Wheeling Policy (EWP), Net Metering Policy (NMP), carbon pricing, financial incentives [4]. National Electric Power Regulatory Authority (NEPRA) in Pakistan has also introduced EWP and NMP to encourage energy consumers to be power producers. According to EWP, any Bulk Power Consumer (BPC) can import energy from any Generation Company (GENCO), anywhere within the country. Note that BPCs can use the existing transmission and distribution network of the National Transmission and Dispatch Company (NTDC) and Distribution Companies (DISCOs) under the policy based on mutual agreement [11]. According to NMP, the individuals can produce their own energy and can sell it to the national grid. The net metering policy provides the bidirectional flow of energy between consumers and the DISCOs, thereby offering seamless energy options to consumers [12]. Pakistan is rich in renewable energy sources, thus facilitate individuals to produce their own energy through renewable sources, i.e. solar, wind, which will hugely benefit the overall energy situation.

South Asia is the most diversified area in geological sense with abundant energy resources. The region has enormous sustainable thermal energy resources with over 258,578 MW wind potential, 241,330 MW hydro energy potential and solar potential of 5.1 KWh/m^2/day [13]. Pakistan and India, the most populous countries of SA, have 67.37 trillion cubic feet tapped natural gas reserves, with petroleum deposits of 5.89 billion barrels. The world largest coal deposits are situated in South Asia, with Pakistan and India sharing major portion of 453 billion tons deposits [14]. However, despite these potential energy reserves, the energy mismanagement leads to persistent supply-demand gap, which is worst in this region. A shortfall of 7556 MW is regularly observed in India [15]. Afghanistan has over 200 MW shortfall with 519 MW installed electricity generation capacity. It is important to note that Afghanistan has 720 MW demand, despite the fact that only one-third of the population is linked to the national grid [16]. Pakistan regularly suffers 4000–6000 MW shortfall around the year [1]. In Bangladesh, 50% population has access to electricity with an overall shortfall of 2000–3000 MW [17]. These serious deficiencies and a mismatch between supply and demand with abundant energy resources requires immediate conservation and efficient management of energy resources in SA by introducing all possible short and long term measures.

This paper presents an overview of the energy management in South Asia, covering essentials of the generating capacity, energy intensity, energy markets, exploration of renewable energy resources, regional energy cooperation, energy efficient loads and power system losses minimization for the region.

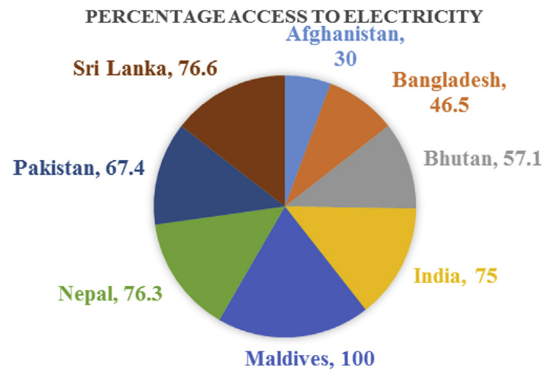

Fig. 1. Access to electricity in SA.

2. Energy management in South Asia

SA has accommodated one-fourth population (24.89%) of the world. India is leading with 1.342 billion residents, followed by Pakistan and Bangladesh with 0.196 and 0.164 billion respectively [18]. The region has a cumulative $2.6 trillion Gross Domestic Product (GDP). Population in SA is expected to increase by 0.4–1.9% [19,20], with 7.4–7.6% annual increase in the energy demand [21,22].

A large proportion of the population in SA is devoid of electricity, with access to electricity data shown in Fig. 1 [23]. According to an estimate by Asian Development Bank, this proportion accounts for more than 700 million people in Asia and Pacific [24]. Among population, who have access to electricity, many face poor quality of electric supply with 5–8 h per day power outages in both urban and rural territories. The regular power blackouts in this region impacts economy and Table 1 shows economic losses occurred due to power outages in different parts of South Asia.

Authors in Ref. [21] state, "Lack of investment in generation, grid extension, problems associated with fuel availability for power plants, and poor financial state of the sector in many South Asian countries continue to hinder the efforts to improve access and availability of electricity". In addition, authors in Ref. [14] state "limited fuel resources, declining economy, lack of capital investment, external and internal security concerns, aged power system, managerial defects and circular debt" are the factors affecting the power industry in South Asia. Some of the key factors influencing development of energy in SA are poor policy and institutional framework, high energy prices and low affordability of energy wastage and losses, with unpredictable consumption patterns and demand trends [7,10].

Uninterrupted and continuous supply of electricity is the predominant factor, which has led to the socio economic development of the developed countries. SACs are rich enough in their energy resources to meet their immediate energy demand. However, owing to the various factors stated earlier, a continued and uninterrupted power supply is still a vision awaiting its realization. In the region, there is a continuous effort to fulfil this dream as soon as possible in order to improve

Table 1
Economic Losses due to power outages in various SACs [23].

Countries	Economic Loss (%)
Afghanistan	06.49
Bangladesh	10.56
Bhutan	04.33
India	06.62
Maldives	00.00
Nepal	26.95
Pakistan	09.16
Sri Lanka	03.00

Table 2
Electricity generation in SACs (GWh).

	Pakistan	India	Bangladesh	Sri Lanka	Maldives	Nepal	Bhutan
Coal	58,177.103	869,181	1225	3506	0	0	0
Oil		23,169	6692	4439	330	10	0
Gas		65,102	44,083	0	0	0	0
Bio fuels		21,809	0	41	0	0	0
Waste	5349	1338	0	0	0	0	0
Nuclear	4996	34,228	0	0	0	0	0
Hydro	32,074	141,637	894	4552	0	3636	7164
Solar PV	26	3433	145	20	0	0	0
Wind	457	33,583	4	272	0	0	0
Total	95,730.103	19,193,480	53,043	12,830	330	3646	7164
Import	335	5598	0	0	0	1072	0
Export	_	5	0	0	0	3	5164

Data for 2013 from United States Energy Information Administration. 2016. Independent Statistics & Analysis. Washington, DC. Data for 2013 from International Energy Agency. 2015. World Energy Statistics 2015, Paris.
Data for 2014 from Government of Bhutan, National Statistics Bureau.
Data for 2014 from Government of Sri Lanka, Sri Lanka Sustainable Energy Authority.
Data for 2017 from Government of Pakistan, Nation Energy Regulatory Authority, and Energy Year book 2013–14, Islamabad.

socio-economic profile of respective countries.

2.1. Installed power generation capacity

In India, the total installed generation capacity was 298,060 MW till March 2016. For the financial year 2015–2016, India planned to generate 1,137,500 GWh using the existing power generation infrastructure [25], indicating an improved effective capacity factor of 44%. India has also planned to attain an average capacity factor of 52% for the thermal power plants (210,675 MW contribution) [26,27]. It is important to note that the power plant operations and their capacity factors are matters decided by the operational economics, however, the capacity shortages reported in India are indicative of the need to raise the availability and efficiency of the existing power plants. Currently, India depends mostly on coal (above 60%) followed by hydro and natural gas for its electricity generation. It has 10,619.45 MW installed capacity of renewable energy resources including small hydro power plants, which makes India the 4th largest wind energy producer in the world. Table 2 shows energy generation in SACs by different energy sources. Note that the numerical value of 58,177.103 GWh shows combined generation from coal, oil, gas and biofuels for Pakistan in GWh. Tables 3 and 4 show the percentage distribution of the electricity generation and consumption from various energy sources in SACs while Table 5 shows the overall energy potential.

In Pakistan, total installed capacity is approximately 17,000 MW [21], with a large share of energy sources provided by the oil and gas. These oil and gas sources constitute approximately three fourth portion of the country's electricity generation [22]. The Water and Power Development Authority (WAPDA) decided to raise the share of the hydropower generation from 31% in 2012 to 50% by 2021, which reflects a well-planned target to raise the hydropower-generating capacity of the country from the present 7100 MW to about 25,000 MW [28]. Note that Pakistan has 185,175 million tons of coal reserves, however, only 0.79% energy demand of the consumer is met from coal [23]. Currently government of Pakistan has taken initiative to exploit the coal reserves

Table 4
Distribution of electricity consumption in SACs [32].

Countries	Fossil Fuels (% of total)	Combustible and Renewable Waste (% of total)	Alternative and Nuclear Energy (% of total)	Difference in generation and consumption (MTOE)
Bangladesh	71.5	28.2	0.2	5.2
India	72.3	24.7	3	208
Nepal	12.5	84.1	2.7	1.4
Pakistan	60.9	34.6	4.5	19.7
Sri Lanka	48.7	47.4	3.9	5.1

Table 5
Energy potential of South Asia.
Source: The report, 'Prospects for Regional Cooperation on Cross-Border Electricity Trade in South Asia' by South Asia Regional Integration (SARI) Project by USAID and Integrated Research and Action for Development. NA = Not Available

Country	Coal (Million tons)	Oil (Million Barrels)	Gas (Million Cubic)	Bio Mass (Million Tons)	Hydro (GW)
Pakistan	17,550	324	33	NA	59
India	90,085	5700	39	139	150
Sri Lanka	NA	150	0	12	2
Bangladesh	884	12	8	0.08	0.33
Nepal	NA	0	0	27.4	483
Afghanistan		1.569 Billion CM	15.687 billion CF		23

Table 3
Distribution of electricity generation in SACs [32].

Countries	Electricity production (kWh billion)	Coal (% of total)	Natural gas (% of total)	Oil (% of total)	Hydropower (% of total)	Renewable energy (% of total)	Nuclear power (% of total)
Afghanistan	1	2.74	5.99	32.43	1.16	57.4 (Solid biomass)	–
Bangladesh	44.1	1.8	91.5	4.8	2	0	0
Bhutan	7.7	–	–	–	–	–	–
India	1052.3	67.9	10.3	1.2	12.4	5	3.2
Nepal	3.3	0	0	0.1	99.9	0	0
Pakistan	95.3	0.1	29	35.4	29.9	0[a]	5.5
Sri Lanka	11.6	8.9	0	50.2	39.7	1.2	5.5

[a] Effective utilization and link to national grid is 0%.

in Thar, Sindh. Sindh Engro Coal Mining Company (SECMC) has planned to produce 660 MW in first phase of the project, with two 330 MW sub critical plants generating a total of 3950 MW power [29]. About 35–38% of electricity produced in Pakistan comes from the thermal power plants, which not only produce expensive electricity (raw material/imported fuel) but also causes hazardous emissions, thus creating harmful effects leading to pollution and environmental degradation [30]. It is important to note that share of renewable energy resources accounts for less than 1% of the country's total electricity generation. It is reported that, Pakistan has great potential to exploit various clean energy resources including biogas, biomass, solar, wind, and micro-hydel using various strategies based on its geological setup and climatological cycles [31].

Bangladesh has a total of 12,780 MW installed capacity in 2016 with additional 600 MW imported from India. Bangladesh has shown competitive progress in power generation since 1990s, as a result the capacity increased from 667 MW to 12,780 MW in 2016. It is expected that under continuous development in energy sector, an additional 3812 MW power will be added to national grid by 2021 [9]. In Bangladesh, generation system is dominated by the gas-fired power plants (91.5%) [3], with most of its generation either from the gas-fired open cycle combustion turbines or gas-fired reciprocating engines. However, these types of power plants have shown comparatively low efficiency in the range of 30% (open cycle) to 42% (reciprocating engine). Note that, it is well established that a combined cycle technology (oil and gas), efficiency can often exceed in excess of 50% [33]. Bangladesh has faced significant shortages of generating capacity for which quick solutions have been sought over the past few decades. To overcome this problem investments have been mostly on open cycle power plants and reciprocating engines, both by the state-owned Bangladesh Power Development Board as well as by the independent power producers [34]. These necessary steps are expected to raise the efficiency of power generation in Bangladesh by 10%.

2.2. Energy intensity

Energy Intensity (EI) for any region is the ratio between energy consumption and GDP, and also generally defines the level of prosperity and progress in the area. Energy Information Administration (EIA) has placed SACs among the least energy consuming regions in the world. Table 6 shows per capita electricity consumption in kWh of SACs till 2014 [14].

India is playing a leading role in the South Asia towards improving EI, however, still it is 95.18% less than the world leading economy of USA having 13,361 kWh energy consumption [14]. Despite having reduced energy consumption, SACs have witnessed considerably higher energy use per unit of GDP i.e. energy intensity. However, surprisingly significant variations as shown in Fig. 2 have been seen amongst SACs. Afghanistan and Nepal presented the lowest and the highest EI values of 1270 and 26,399 btu per $2000 constant respectively [35]. EI values for Afghanistan, Bhutan and Sri Lanka rank them among the countries with lower EI terrain. A probable reason leading to low EI values could be inefficient energy use. Pakistan, India and Bangladesh have EI values ranging between 10,000 and 20,000 btu per $2000 constant. Fig. 2 also shows average energy intensity, GDP and energy use per capita comparison of the SACs. Note that the study period covers values from 2002 to 2014.

Table 6
Electricity consumption comparison of SACs [14].

Countries	Per capita electricity consumption (kWh)
Afghanistan	119.8
Bangladesh	278.1
India	644
Nepal	454.1
Pakistan	457
Sri Lanka	636.3

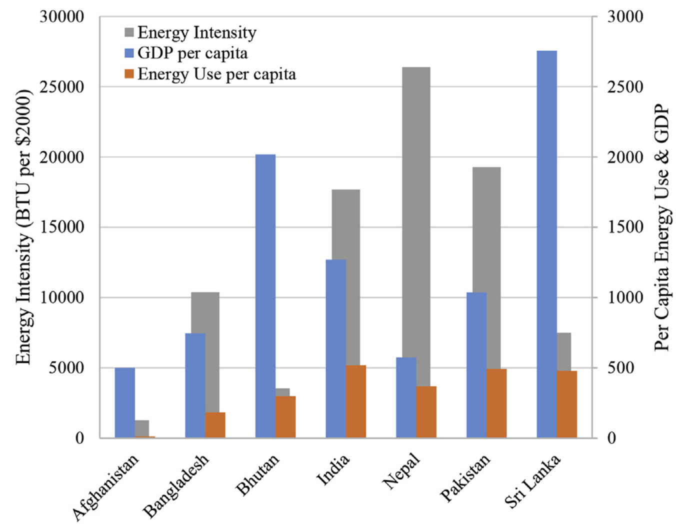

Fig. 2. Average EI, GDP and energy use comparison of SACs.

2.3. Exploring renewable energy resources

In South Asia, most of the countries depend on thermal, coal and hydel power generation, which are usually owned and controlled by the government institutions and regulatory bodies as well as private suppliers. Pakistan generates 66.5% of its total electricity using thermal resources [14], whereas India relies on coal for 67.9% of country's total electricity. In contrary, Nepal shows 99.9% dependency on hydel technology [32]. The main identified problem in these countries, especially India and Pakistan is the continuous widening gap between power generation versus the increased energy demand. Therefore, these countries are suffering from serious shortfall and outages with an average 4.9–7% annual rise in energy demand in India [36,37], 7–8% in Pakistan and 8.2% in Bangladesh [37,38]. To cope with increasing average energy demand of 7.6% in the region, SACs need to explore the existing renewable energy potential to avoid the worsening energy situation in the region. Renewable energy potential of the SACs has been shown in Table 7. Fig. 3 also illustrates that energy management is a serious concern for SACs. It is important to note that the highest predicted growth rates are expected for various countries in Asia-Pacific region by 2022 in terms of home energy management system.

2.4. Regional energy cooperation

Regional energy cooperation (REC) plays a major role in regularization and could also help to manage the energy crisis problem of the region. REC can help enhance system efficiency by exploiting trade opportunities among SACs. According to the World Bank report,

Table 7
Renewable energy generation potential in South Asia.
Source: IRADe 2013; Sri Lanka 2012; Islam 2002; Renne et al., 2003; CWET (n.d), Eillot (2011); SARI/EI; Shukla (2017).

Country	Hydro (MW)	Wind (MW)	Solar (Averages in kWh/m^2/day)
Pakistan	59,000	131,800	5.3
India	150,000	102,778	5.0
Bangladesh	330	–	5.0
Bhutan	30,000	–	4.0
Maldives	0	–	4.9
Sri Lanka	2000	24,000	5.0
Afghanistan	23,000	158,500	6.5

Fig. 3. Global HEMS market growth.

Table 8
Intra-South Asian Etectricity Trade [21,39].

S.No	Countries	Description	Capacity
1	Afghanistan-Central Asia Cooperation	Upgradation of Transmission links with Tajikistan and Turkmenistan	2246 GW
2	Pakistan-Central Asia Cooperation	Link to Gwadar Port	25 MW
3	India-Nepal Cooperation	Pokhra Hydal power project	1 MW
		Dhalkebar-Muzaffarpur 400 kV line project (under implementation)	1000 MW
4	Bhutan-India Cooperation	Chukha Hydro-electric power project	336 MW
		Kurichu Hydro-electric power project	60 MW
		Tala Hydro-electric power project	1020 MW
5	India-Bangladesh Cooperation	400 kV, 30 km double-circuit HVDC line	500 MW
6	India-Sri Lanka Cooperation	400 kV HVDC grid interconnection	500 MW
7	India-Pakistan Cooperation	220 kV (would be upgraded to 440 kV) (under discussion)	250-500 MW

although the SACs are themselves energy hungry countries yet they possess huge potential to adopt intra-South Asia electricity trade by utilizing respective enriched sources. Table 8 shows various ongoing bilateral energy projects among different countries in SA [21,39]. In addition, SA is planning a mega project (Central Asia South Asia Interconnection-CASA 1000) with countries of Central Asia. This would add a capacity of 1000 MW power to share and overcome energy crisis in deficit regions in SA from the surplus regions of Central Asia [40]. CASA-1000 is primarily signed among Kyrgyz Republic and Tajikistan from Central Asia, while Pakistan and Afghanistan from South Asia are the signatories [41]. Note that, once the link is established the project of power sharing can be extended to India and other SA countries [21].

Iran Pakistan India (IPI) and Turkmenistan Afghanistan Pakistan and India (TAPI) gas pipeline projects were also proposed in the past as an attempt to manage energy crisis of the SA countries. Unfortunately, political situation and mismanagement in the region hindered any further development in these projects [4]. Nonetheless, such interconnected power systems benefit the importer and exporter, thereby providing financial strength, effective use of the available resources, optimize power transfer network, system reliability and enhanced energy security between various countries [21].

2.5. *Present trend in South Asia towards energy management*

India suffered from severe electricity blackouts on 31st July 2012, when 620 million people comprising almost 9% of the world population (half of the Indian population experienced this worst outage) were efected. India then started working on small and distributed energy projects to avoid any such predicament in future. The aim is to provide people with the continuous reliable power supply [42].

Pakistan has been victim of energy crises and blackouts since its inception, however, they are now showing interest towards sustainable energy resources to overcome energy shortage. There has been strong effort towards installation and implementation of solar energy, owing to the fact that average day time in Pakistan is about 9 and half hours. Quaid-e-Azam Solar Park Bahawalpur is one such efforts towards achieving self-sufficiency in energy sector. FFC energy Ltd. is also working on a wind power project of 50 MW and has recently started many hydel power projects [13].

Bangladesh has always struggled to become energy rich country, which is partially due to political, managerial and financial influences in power sector. In the beginning, the installed capacity could hardly meet energy need of 3% population in 1971, while in 1974–75, it merely added 10% to the national grid. The country attained a benchmark development in energy sector in 2008 where a 94.78% increase is observed, which makes a total of 12,780 MW (including 600 MW import from India). Government of Bangladesh (GoB) has followed various lucrative techniques as incentives to independent power producers, which are now contributing 46% to the total energy supply. A major trend observed in GoB policies is a reduction in use of oil and a continuous shift towards coal based energy resources. Coal based projects from 2017 to 2021 are expected to generate 2650 MW, 2027 MW, 2763 MW, 2811 MW and 3812 MW per year. In 2011, GoB has also signed Inter-Government agreement with Russia to add 2400 MW nuclear based electricity to national grid by 2024. Establishment of Infrastructure Development Company Limited (IDCL) by GoB showed great interest in introduction of CGE in the country. GoB has also aimed to have 10% share of CGE in its energy mix by 2020, with a broader aim, to attain goal of 'Access to Electricity for All' by 2021 [43].

SA countries are working hard to give their people clean & green energy with quality, efficiency and economy by shifting emphasis towards distributed generation comprising of small renewable generations and a mix of existing conventional system. The existing structure in place is unable to meet the consumers demands due to prevailing condition of losses caused by inefficient generation, transmission losses, energy theft and the unpredictable consumer end loads. Thermal power plants mostly produce expensive electricity for the consumers, hence the plan is to inject renewables like solar, wind and biomass in the existing system, giving additional advantage of being inexhaustible and sustainable [44]. In addition, these countries have started persuing towards energy management through smart devices, smart metering and monitoring of two way communications to implement smart grids. They are keen to use network systems to record, monitor and send the information back to the utilities to enhance efficiency and lower cost. These advancements will help estimate generation and achieve user end synchronization through energy monitoring and metering techniques as well as the necessary data communication between the generation companies, distributors and consumers [45].

2.6. Electrical power system losses

Electrical power systems in SACs are poorly designed and managed, resulting in technical and commercial losses due to reduced performance of the power systems. These losses are also contributing to the persistent energy crisis in the region. Table 9 shows Transmission and Distribution (T&D) losses in electrical power system by different utilities in SA [46]. Note that the utilities with single-digit losses are usually considered efficient part of any power system networks. However, none of SACs have reached to single digit losses except Bhutan. In addition, substandard materials in transmission and distribution lines and transformers cause high technical losses. These losses could be minimized by proper design, use of efficient materials and regular maintenance of the power system networks by periodic systematic field assessment. Commercial losses in this region of the world are usually result of unaccounted electricity consumption. Users, in some cases, attempt to directly bypass energy meters, which is power theft by tapping distribution lines. These actions lead to lower revenue generated by the power utilities and also discourages the regular electricity bill payers. Integral operations of meter inspection, reading and billing, disconnection upon unpaid bills, law enforcement and healthy moral practices can always help in minimization of such losses. In addition to these failures, inefficient administration also put its share in the generation of losses.

Table 9
T&D losses of SACs.

Countries	Losses (%)
Bangladesh	14.11
Bhutan	04.54
India	23.65
Maldives	13.00
Nepal	25.03
Pakistan	17.00
Sri Lanka	10.33

Privatization of state owned utilities and establishment of the partner companies are giving support to SACs especially Pakistan and India, to improve system efficiency by reducing associative losses. Pakistan has recently privatized Karachi Electric Supply Company. India has already privatized New Delhi Vidyut Board in 2002 and established North Delhi Power Limited in 2012 with the joint venture between Government of India and Tata Power. In addition, India has also privatized its six distribution companies in 1990s [46].

2.7. Power trading

Power markets of SACs generally run by the single integrated utility with little or no concept of power trading. India is the only country in the region, where attempts are made to promote power trading. India has Established PTC India Limited (PTC) in 1999 to support the power trading, but the power market is still considered to be in developing stage. Continuous amendments are being made in the Electricity Act of 2003, which was lastly updated in 2013 as per recommendations of PTC [47]. Under the Ministry of Power, the Central Electricity Authority of India monitors three main branches of the electricity; the Generation, Transmission and Distribution Departments (GT&DDs). Generation and transmission are owned by central, state and independent bodies. Note that the distribution network of India is the largest in SA comprising 73 different companies. Table 10 shows the abbreviations and acronyms used in Figs. 4–9. In Fig. 4, we shows the market power structure of India including various stake holders.

It is not surprising to observe that Pakistan and Bangladesh show the identical organizational structure in power sector. The generating companies feed power to single transmitting body i.e. National Transmission and Dispatch Company (NTDC) in Pakistan and Power Grid Company of Bangladesh Ltd. (PGCB) in Bangladesh. The distribution is however, looked after by various distribution companies as shown in Figs. 5 and 6 [48,49].

Unfortunately the electricity department in Afghanistan continuously suffered due to prior wars and civil conflicts. Ministry of power and energy is currently responsible for defining electricity policies, which are further regulated by the Da Afghanistan Breshna Shekat (DABS). DABS is the only governing body, which is solely responsible for total generation, transmission and distribution in the country as shown in Fig. 7 (a) [50]. Nature of the Power sectors in Nepal and Bhutan is not different from Afghanistan. Nepal Electricity Authority (NEA) in Nepal (Fig. 7 (b)) [51] and Bhutan Power Corporation (BPC) (Fig. 8) [50] under Bhutan Electricity Authority in Bhutan are solely responsible to operate GT&DDs. In addition, Druk Green Power Corporation (DGPC) also contributes in electricity generation along with BPC in Bhutan.

In Sri Lanka, Public Utilities Commission of Sri Lanka under the directions of Ministry of Power and Energy issues license for GT&DDs

Table 10
Abbreviations used in energy sector in SACs.

Abbreviation	Meaning	Abbreviation	Meaning
APSCL	Ashuganj Power Station Company, Ltd	IPPs	Independent Power Producers
BPC	Bhutan Power Corporation	LECO	Lanka Electricity Company Private Limited
BPDB	Bangladesh Power Development Board	LESCO	Lahore Electric Supply Company
CEB	Ceylon Electricity Board	MESCO	Multan Electric Supply Company
CGSs	Central Generating Stations	NEA	Nepal Electricity Authority
CTU	Central Transmission Utility	NTDC	National Transmission and Despatch Company
DABS	Da Afghanistan Breshna Shekat	PESCO	Peshawar Electric Supply Company
DESA	Dhaka Electric Supply Authority	PGCB	Power Grid Company of Bangladesh, Ltd
DESCO	Dhaka Electric Supply Company	QESCO	Quetta Electric Supply Company
DGPC	Druk Green Power Corporation	REB	Rural Electrification Board
EGCBL	Electricity Generation Company of Bangladesh, Ltd	RPCL	Rural Power Company, Ltd
FESCO	Faisalabad Electric Supply Company	SEBs	State Electricity Boards
GENCOs	Generation Companies	STU	State Transmission Utilities
GEPCO	Gujranwala Electric Power Company	WAPDA	Water and Power Development Authority
HESCO	Hyderabad Electric Supply Company	WZPDCL	West Zone Power Distribution Co., Ltd
IESCO	Islamabad Electric Supply Company		

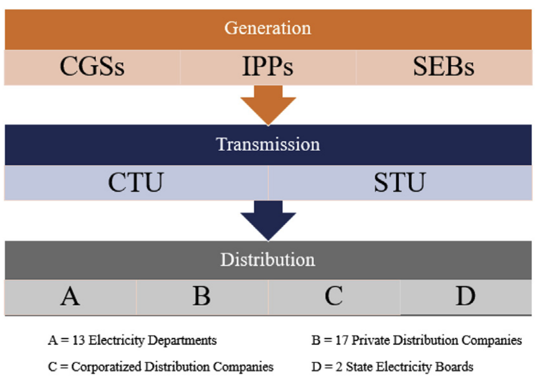

Fig. 4. Power market structure in India.

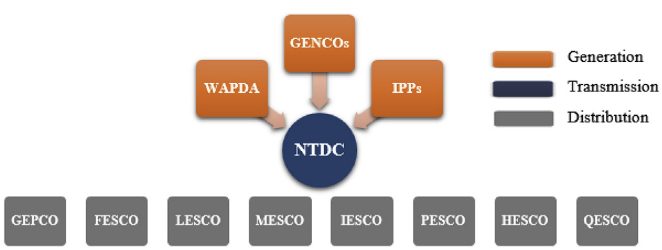

Fig. 5. Power market structure in Pakistan.

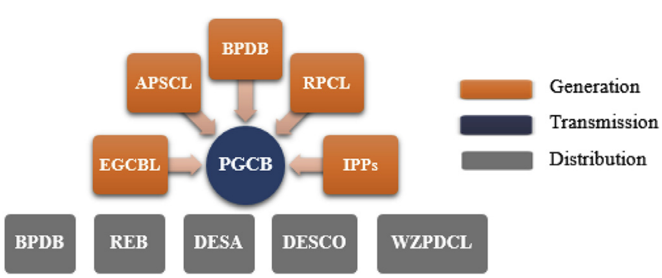

Fig. 6. Power market structure in Bangladesh.

companies. The license are called CEB Licence GL for generation companies and CEB Licence TL for transmission companies. Licences for distribution are termed as CEB Licence DL1, DL2, DL3 and DL4. CEB is acronym for Ceylon Electricity Board, the main electricity body for power generation, transmission and distribution in the country. Transmission is solely done by CEB, whereas IPPs are contributing in generation of electricity. The Lanka Electricity Company Private Limited (LECO) is facilitating the distribution process as shown in Fig. 9 [51].

2.8. Energy efficient load management

According to a recent estimate, the lighting loads consume 20% of the world's power generation. Nearly all the energy consumption due to lighting load is converted into other energy, such as light and heat, which is mostly dissipated in the buildings [5]. The energy consumed by such loads increases the heat flow in the buildings and consequently increases the air conditioning costs needed in the summer. Conventional lighting loads used in South Asian countries are fluorescent bulbs which are also costly and consume more energy, resulting in extra heating up of the buildings [52].

Fluorescent bulbs are now getting common and usually substituted with CFL saver lights and LED lights, which results in reduced energy consumption and cost for the same amount of luminous. These strategies add in lowering the peak load, greenhouse emissions and finally a reduction in the electricity bills to the consumers [53].

The impact of these active energy management policies saw a reduction in the energy usage and energy cost by 23% and 51% respectively. Table 11 shows comparison of various features of different lighting loads. Note that the LED lighting load is the most cost effective form of energy consumption. In addition, LED lights have longer life span when compared with incandescent lights, which are costly and have shorter life span.

2.9. Distributed generation

The concept of Distributed Generation (DG) helps in managing electricity tariffs and also supports in reducing losses in the long transmission lines. DG ensures increased reliability of the power delivered, thereby mitigating the overall demand uncertainty [54]. It inherently discourages the concept of centralized generation, and rather rely on utilization within the boundaries of the local distribution network for a specific catchment area. SA countries are trying to pace up DG implementation with in the frame of integration of Renewable Energy Systems (RES). RES once installed provide almost free energy, which is a positive aspect for SACs, where the economic growth is already challenged by the recessed economy. RES provide green energy and help offset environmental impacts caused by the carbon emission from the thermal power plants and fossil fuels as used in conventional practice of running these plants [55]. Generation by DG in the SA uses first the power contributed by the use of solar, wind and biomass technology in electrifying the rural areas [56–58].

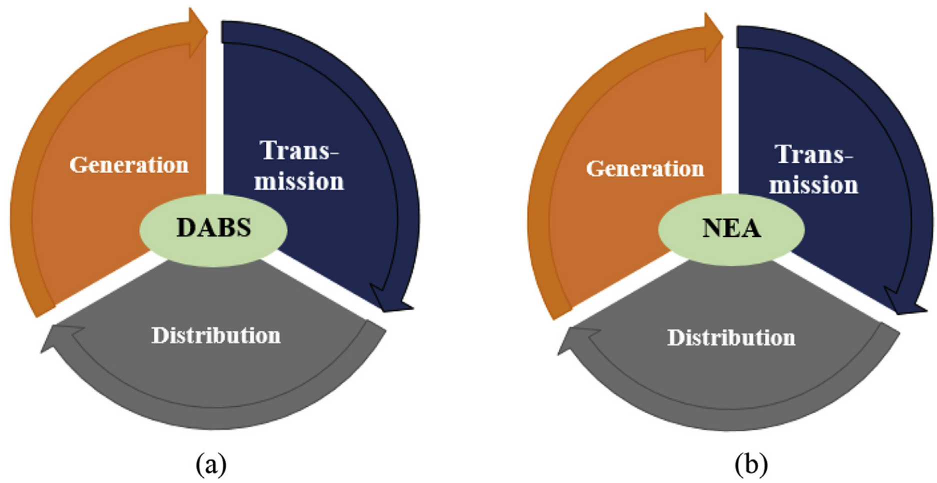

Fig. 7. Power market structure in (a) Afghanistan (b) Nepal.

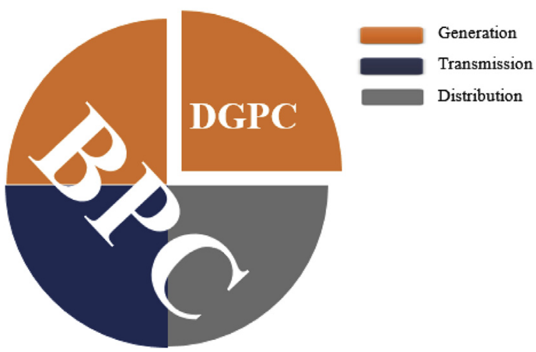

Fig. 8. Power market structure in Bhutan.

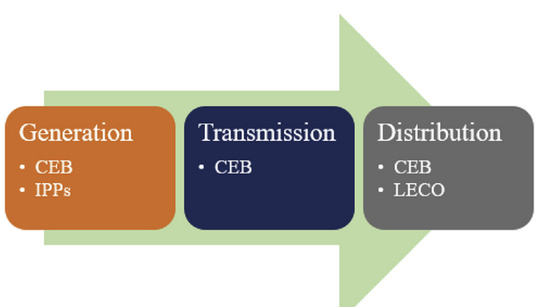

Fig. 9. Power market in Sri Lanka.

Table 11
Comparison of Lighting loads.

Features	LED	CFL	Incandescent	Halogen
Rated Avg. Life	50,000	10,000	750–1000	2000
Life Span	Vastly Longer	Long	Low	Medium
Watts	6–18	3–120	3–500	5–500
Cost to Operate	Lowest	Low	High	Medium
Energy Consumption	Lowest	Low	Medium	Medium
Lumens per Watt	45–75	60	15	25
Color Temp. (K)	2700–5000	2700–6500	2700	3000

2.10. Energy policies

Energy policies regulate the existing and proposed structures in the power industry to improve, strengthen and promote the energy conservation and efficiency. SACs have introduced region specific policies along with the intra-Asia cooperation, which is regularly monitored and updated. Ministry of Power in India have already taken significant actions, which ensured 4.79% growth rate in the installed generation capacity during April 2017. As a result and the power deficit reduced to −0.6% in May 2017. The Government aimed at electrifying all census villages by 2018 and in long term the entire country by 2022, with 10% reduction in the oil imports. The policy also targeted to reduce 33–35% emission intensity by 2030, with the 175 GW share of the clean energy in the system [59].

Ministry of Water and Power in Pakistan envisioned to produce and promote efficient, consumer centric energy, which will ensure sustainable development in the country. National power policy has set following nine goals to overcome energy challenges; 1) increasing generation capacity, 2) introducing energy conservation culture, 3) low cost tariffs, 4) minimizing adulteration and pilferage in fuel supply, benchmarking improvements in 5) generation, 6) transmission and 7) distribution networks, 8) lowering financial losses and 9) the alignment of all provincial and federal ministries/institutions linked with energy sector [30].

Ministry of Power, Energy and Mineral resources in Bangladesh introduced its first national energy policy in late 1990s stating substantial measures to explore existing energy resources of the country. The policy addressed necessary measures for efficient power generation, transmission, distribution and rational utilization [60]. Later in 2004 the policy focused on exploring sustainable energy potential with special focus on reducing greenhouse gases emissions. Overall the policy aims at taking steps to encourage participation of public and private sector to develop and conserve energy management to ensure 100% electrification by 2020 [61].

Overall, SACs have focused on "developing RES, investing on and exploring inter-regional projects, promoting regional cooperation, enhancing prompt energy response", with a view to boosting their countries economy. In recent years, nearly all SACs have established alternate energy ministries/departments to introduce, promote and regularize RES in the region. Table 12 enlists renewable energy boards in SACs. Mission statements are given in the words of respective ministry/department, collected from their official websites.

Note that the Afghan national energy policy 2016 aim is to "ensures energy access to all in Afghanistan in an economically viable, reliable, socially equitable and environmentally sustainable manner". RED in its 2015 policy defined a mechanism to deploy RES in the country to exploit its full potential by the end of 2022. The policy is divided into two major phases, preparatory and commercialization phases.

Bhutan introduced Alternate Renewable Energy Policy in 2013, the policy states "Promote clean renewable energy technologies in Bhutan including solar, wind, bio-mass, geo – thermal, pico/micro/mini/small

Table 12
Renewable energy departments in SACs.
Source: Official websites of respective departments

Countries	Alternate Energy Ministries/Departments	Mission
Afghanistan	Renewable Energy Department (RED)	"Responsible for directing Afghanistan's available renewable energy resources for maximum social and economic benefit, taking into account long-term environmental concerns while giving priority attention to the country's development needs."
Bangladesh	Sustainable and Renewable Energy Development Authority (SREDA)	"Our aim is to generate 2000 MW of electricity from renewable energy by 2021, which will be equivalent to 10% of total electricity generation of that time. We want to increase 20% more fuel efficiency than in 2013, which is expected to save 95 million tonnes of fuel equivalent fuel during this period. Energy savings will be 968 billion rupees or an average annual average of 51 billion rupees annually."
Bhutan	Department of Renewable Energy	–
India	Ministry of New and Renewable Energy (MNRE)	"To develop and deploy new and renewable energy for supplementing the energy requirements of the country"
Nepal	Alternate Energy Promotion Center (AEPC)	"To make renewable energy mainstream resource through increased access, knowledge and adaptability contributing for the improved living conditions of people in Nepal."
Pakistan	Alternate Energy Development Board (AEDB)	"To facilitate, promote and encourage development of Renewable Energy in Pakistan and with a mission to introduce Alternative and Renewable Energies (AREs) at an accelerated rate"
Sri Lanka	Ministry of Power and Renewable Energy	"Provide quality, reliable, sustainable and affordable energy for economic prosperity of the nation."

Table 13
Energy reforms in SACs [30].

Countries	Energy Policy/Law	Regulatory Institution
Afghanistan	Power Consumption Law (PCL), 1982	–
	National Renewable Energy Policy, 2015 [62]	Renewable Energy Department
Bangladesh	Bangladesh Energy Regulatory Commission Act, 2003	Bangladesh Energy Regulatory Commission (BERC)
	Renewable Energy Policy of Bangladesh 2008	Sustainable and Renewable Energy Development Authority (SREDA)
	Guidelines for the Implementation of Solar Power Development Program 2013 [63]	
Bhutan	Electricity Act of Bhutan, 2001	Bhutan Electricity Authority (BEA)
	Alternate Energy Policy, 2013 [64]	Department of Renewable Energy
India	Electricity Act, 2003	Central Electricity Regulatory Commission (CERC) and State Electricity Regulatory Commission (SERC)
	Electricity Act, 2013 (amendments in 2003 Act) [65]	
	National Action Plan on Climate Change (NAPCC), 2008 includes National Mission for Enhanced Energy Efficiency (NMEEE) [66]	Government of India
Nepal	Electricity Act, 2049 (1992)	Government of Nepal
	Renewable Energy Subsidy Policy, 2073 BS (2016) [67]	
Pakistan	Regulation of Generation, Transmission and Distribution of Electric Power Act 1997	National Electric Power Regulatory Authority (NEPRA)
	National Power Policy, 2013 [30]	NEPRA
		Ministry of Water and Power
Sri Lanka	Sri Lanka Electricity Act No. 20 of 2009	Public Utilities Commission of Sri Lanka (PUCSL)
	National Energy Policy and Strategies of Sri Lanka, 2008 [68]	Ministry of Power and Energy
	(To be revised every three year)	

hydropower plants upto 25 MW in size and waste-to-energy technologies". The policy also includes Feed-In-Tariff policy in order to support mechanism to reach the overall national goal.

In general energy policies of SA are characterized by rapid growth in economy and sustainable future, leaving positive impact on environment. Table 13 shows overall the energy reforms taken in SACs [30].

3. Conclusions

In this paper, we have studied EnM in SA region. Economic growth of a region largely depends on the complete electrification along with the continuous and reliable power supply to the industrial production units. South Asia houses some world leading developing countries, which are struggling to give boost to their economy by improving energy generation capacity and exploring sustainable energy resources. SA countries have taken initiatives to reduce their carbon emissions and by introducing various energy policies to strengthen their energy sector. A major step has been taken by Pakistan, who has set nine main goals to tackle the existing problems. Currently all SA countries fail to electrify entire country except Maldives, where 100% [23] of the population have access to the electricity despite over 10% T&D losses [46] in the system. The presence of diverse resources encourages mutually beneficial regional energy cooperation in the South Asia. Afghanistan and Central Asia cooperation have signed highest capacity electric trade of 2246 GW [21], while the lowest trade is observed of 1 MW between Nepal and India Cooperation for the Pokhra Hydel Power Project [21]. SA countries are rich in renewable energy potential, with India leading in hydro and Pakistan in wind resources. The solar energy potential is beyond any bound for the region having almost 4.0 to 6.5 kWh/m^2/day average irradiance (see Table 7). In the region, SACs are recommended to exploit these resources to ensure energy security and economic prosperity. Effective implementation of EnM policies including net metering, energy wheeling, reduction of carbon emissions are recommended to address the energy concerns in SA. Exploitation of renewables and competitive electricity markets will go a long way in providing necessary for EnM improvement in the region.

References

[1] M. Anzar, J. Nadeem, Z. Adnan, A.R. Raja, A. Saeed, R. Sohail, Pakistan's overall energy potential assessment, comparison of LNG, TAPI and IPI gas projects, Renew. Sustain. Energy Rev. 31 (1) (2014) 182–193.
[2] L.A. Tiago, C.M. António, A.F. José, Strategies to make renewable energy sources compatible with economic growth, Energy Strat. Rev. 18 (2017) 121–126 https://doi.org/10.1016/j.esr.2017.09.014.
[3] I. Hanan, Is it wise to compromise renewable energy future for the sake of expediency? An analysis of Pakistan's long-term electricity generation pathways, Energy Strat. Rev. 17 (2017) 6–18.
[4] International Energy Agency, 25 Energy Efficiency Policy Recommendations, International Energy Agency, 2011.
[5] Carlos Alvarez, G. Antonio, A. Molina, Assessment and simulation of the responsive demand potential in end-user facilities: application to a university customer, IEEE Trans. Power Syst. 19 (2) (2004) 1223–1231.
[6] Connolly and David, " "A review of computer tools for analysing the integration of renewable energy into various energy systems."," Appl. Energy, vol. 87.4, pp. 1059–1082, 2010.

[7] M. Anzar, B. Faisal, A. Nabil, Q. Umar, Z.A. Khan, J. Nadeem, An enhanced system architecture for optimized demand side management in smart grid, Appl. Sci. 6 (5) (2016) 122, http://dx.doi.org/10.3390/app6050122.
[8] A.-A. Hamid, "Home Energy Management system in Smart Energy Environment," https://www.ceer.eu/documents/104400/-/-/f8c4826b-eda2-6a95-f032-930b8352b1ee.
[9] Mahmud, F. Syed, The energy demand in the manufacturing sector of Pakistan: some further results, Energy Econ. 22 (2000) 641–648.
[10] M. Anzar, J. Nadeem, A.K. Muhammad, R. Sohail, An overview of load management techniques in smart grid, Int. J. Energy Res. 39 (11) (2015) 1437–1450.
[11] Draft Energy Wheeling Policy, NEPRA, Islamabad, 2015.
[12] Draft and Rules of Net Metering, National Electric Power Regulatory Authority, Islamabad, October, 2014.
[13] N.I. Muhammad, N. Fatima, M. Sardar, A.K. Shahida, Sustainable Energy for All in South Asia: Potential, Challenges, and Solutions, Sustainable Development Policy Institute, 2015, http://www.jstor.org/stable/resrep00612.
[14] A. Saeed, M. Anzar, H. Ahmad, A.S.S. Guftaar, F.U.B. Muhammad, A comparative review of China, India and Pakistan renewable energy sectors and sharing opportunities, Renew. Sustain. Energy Rev. 57 (2016) 216–225.
[15] S. Naveen, "Peak Power Deficit Drops to 5.4% in April: Central Electricity Authority, " Indian Power Sector, [Online]. Available: http://indianpowersector.com/home/tag/power-deficit/. [Accessed 30 12 2017].
[16] Afghanistan Energy Sector, [Online]. Available: https://www.unece.org/fileadmin/DAM/energy/se/pp/eneff/7th_IFESD_Baku_Oct.2016/ESCAP_Elec_CIS/1_W.Aria_AVG.pdf. [Accessed 30 12 2017].
[17] M.A.R. Sarkar, M. Ehsan, M.A. Islam, Issues relating to energy conservation and renewable energy in Bangladesh, Energy Sustain. Develop. 7 (2) (2003) 77–87.
[18] The World Bank, "Population Estimates and Projections," [Online]. Available: http://databank.worldbank.org/data/reports.aspx?source=Health-Nutrition-and-Population-Statistics:-Population-estimates-and-projections. [Accessed 5 1 2018].
[19] L.D. Gouranga, Population and environmental issues in South Asia, South Asia 2015, A Taylor and Francis Group, Routledge, 2014, pp. 61–73.
[20] World Bank, "Population Growth (annual %)," [Online]. Available: http://data.worldbank.org/indicator/SP_POP.GROW. [Accessed 6 6 2107].
[21] J. Parikh, K. Agrawal, D. Khare, R.R. Panda, P. Mohla, Prospects for Regional Cooperation on Cross-Border Electricity Trade in South Asia, SARI/EI, Integrated Research and Action for Development, 2013.
[22] T. Sankar, Energy Security-regional Cooperation in South Asia-issues and Opportunities, World Energy Council Regional Forum, 2005.
[23] S. Anoop, P. Jyoti, K.K. Agrawal, K. Dipti, R.P. Rajiv, M. Pallavi, Prospects for Regional Cooperation on Cross-border Electricity Trade in South Asia, South Asia Regional Integration (SARI) Project by USAID and Integrated Research and Action for Development, 2013.
[24] Asian Development Bank, Access to Energy, [Online]. Available: https://www.adb.org/sectors/energy/issues/access-energy , Accessed date: 5 June 2017.
[25] R.B. Grover, C. Subhash, Scenario for growth of electricity in India, Energy Pol. 34 (17) (2006) 2834–2847.
[26] Central Electricity Authority, Ministry of Power, Government of India, Draft National Electricity Plan, Ministry of Power, Government of India, 2016, http://cseindia.org/soebook/thermal-power-plants.pdf.
[27] OASYS South Asia Research Project," De Montfort University, Leicester.
[28] S. Leena, M. Neha, Promoting regional energy co-operation in South Asia, Energy Pol. 35 (6) (2007) 3360–3368.
[29] Engro Corporation Limited, "Thar Coal Mining Project-Addressing Pakistan's Rising Energy Needs," [Online]. Available: http://www.engro.com/our-stories/thar-coal-mining-project-addressing-pakistans-rising-energy-needs/. [Accessed 7 6 2017].
[30] Ministry of Water and Power, Govt. of Pakistan, National Power Policy, Government of Pakistan, Islamabad, 2015.
[31] N. A. Zaighum and Z. A. Nayyer, Renewable-energy Technologies and Sustainable Development, Islamabad: Commission on Science and Technology for Sustainable Development in the South, COMSATS' Series of Publications on Science and Technology, 2005, p. 65.
[32] K.S. Akash, K. Sudhakar, B. Prashant, Renewable energy resources in South Asian countries: challenges, policy and recommendations, Resour. Eff. Technol. 3 (3) (2017) 342–346.
[33] Bangladesh Power Development Board, An Overview of Power Sector of Bangladesh, Bangladesh Power Development Board, Dhaka, November, 2011.
[34] M.J.I. Kanwar, I.T. Muhammad, Energy Policy in South Asia, SAARC CCI Policy Paper, SAARC CCI, Islamabad, Pakistan, 2012.
[35] World Bank Data, [Online]. Available: http://www.worldbank.org/. [Accessed 29 12 2017].
[36] International Energy Agency, India Energy Outlook, IEA, 2015.
[37] P. Jaswal, M.D. Gupta, Energy Demands and Sustaining Growth in South and East Asia, Institute of Development Studies, Overseas Development Institute, 2006.
[38] The Institute of Strategic Studies, Energy: Sources of Regional Cooperation and Competition, The Institute of Strategic Studies, 2007.
[39] W. Priyantha, P.N. Fernando, An Overview of Energy Cooperation in South Asia, Asian Development Bank, 2013.
[40] Central Asia South Asia, [Online]. Available: http://www.casa-1000.org/. [Accessed 5 6 2017].
[41] Central Asia South Asia, [Online]. Available: http://www.casa-1000.org/MainPages/Participants.php. [Accessed 5 6 2017].
[42] Reddy, K.N. Amulya, P.K. Krishna, Technological alternatives and the Indian energy crisis, Econ. Polit. Wkly. (1977) 1465–1502.
[43] I. Saiful, Z.R.K. Md, A review of energy sector of Bangladesh, Energy Proc. 110 (2017) 611–618.
[44] Kumar, Ashwani, Renewable energy in India: current status and future potentials, Renew. Sustain. Energy Rev. 14 (8) (2010) 2434–2442.
[45] Depuru, S.S.R. Soma, W. Lingfeng, D. Vijay, Smart meters for power grid: challenges, issues, advantages and status, Renew. Sustain. Energy Rev. 15 (6) (2011) 2736–2742.
[46] P. Wijayatunga, T. Siyambalapitiya, Improving Energy Efficiency in South Asia, Asian Development Bank, 2016, https://www.adb.org/sites/default/files/publication/200651/sawp-047.pdf.
[47] K. Dayanand, "Overview of Indian Power Sector," [Online]. Available: https://www.slideshare.net/dayakherwar/power-sector-in-india-37274605. [Accessed 1 1 2018].
[48] J. Amir, "Structure and Regulation of the Electricity Networks in Pakistan," PIDE, [Online]. Available: http://www.pide.org.pk/psde/pdf/AGM29/papers/Amir%20Jahan%20Khan.pdf. [Accessed 2 1 2018].
[49] Integrated Resesarch and Action for Development, "South Asia Regional Initiative for Energy Integration (SARI/EI)," [Online]. Available: https://sari-energy.org/oldsite/PageFiles/Countries/Bangladesh_Energy_detail.html#powersector. [Accessed 2 1 2018].
[50] Integrated Research and Action for Development, "South Asia Regional Initiative for Energy Integration (SARI/EI)," [Online]. Available: https://sari-energy.org/program-activities/cross-border-electricity-trade/country-energy-data/. [Accessed 3 1 2018].
[51] Integrated Research and Action for Development, "South Asia Regional Initiative for Energy Integration (SARI/EI)," [Online]. Available: https://sari-energy.org/oldsite/PageFiles/Countries/Nepal_Energy_detail.html. [Accessed 3 1 2018].
[52] Intelligent building energy management system using rule sets, Building and Environment 42, No. Received 9 March 2006; Received in Revised Form 28 August 2006; Accepted 16 October 2006, (2007).
[53] Horace Herring, R. Robin, Technological innovation, energy efficient design and the rebound effect, Technovation 27 (4) (2007) 194–203.
[54] Thomas Ackermann, A. Göran, S. Lennart, Distributed generation: a definition, Elec. Power Syst. Res. 57 (3) (2001) 195–204.
[55] A. Thomas, A. Göran and S. A. Lennart, "Distributed generation: a definition," Elec. Power Syst. Res., vol. 57, p. 195–204, 2001.
[56] C. G, M. P, Distributed multi-generation: a comprehensive view, Renew. Sustain. Energy Rev. 13 (3) (2009) 535–551.
[57] Kapil Narula, N. Yu, P. Shonali, The role of Decentralized Distributed Generation in achieving universal rural electrification in South Asia by 2030, Energy Pol. 47 (2012) 345–357.
[58] D. Palit, A. Chaurey, Off-grid rural electrification experiences from South Asia: status and best practices, Energy Sustain. Develop. 15 (3) (2011) 266–276.
[59] M. Ritwik, "Draft of National Energy Policy by NITI AAYOG," Indian Power Sector.com, 08 07 2107. [Online]. Available: http://indianpowersector.com/2017/07/national-energy-policy-india-2047-niti-aayog/. [Accessed 12 10 2017].
[60] P. Kogan, Asia and Pacific Review 2003/2004: the Economic and Business Report, Kogan Page Ltd., London, United Kingdom, 2003.
[61] K.E. Charles, Energy and Security in Asia: Cooperation or Conflict? Brookings Institution Press, Washington, DC, 2011.
[62] Ministry of Energy and Power, Renewable Energy Policy, (2015) [Online]. Available: http://www.red-mew.gov.af/wp-content/uploads/2014/11/Afghanistan-Renewable-Energy-Policy-English-and-Dari.pdf , Accessed date: 5 January 2018.
[63] Sustainable and Renewable Energy Development Authority, "Laws. Policies and Rules," [Online]. Available: http://www.sreda.gov.bd/index.php/site/page/cd84-f74c-6e7a-8b20-16a5-73a9-ff7e-fb95-66d8-6fd4. [Accessed 5 1 2018].
[64] Royal Government of Bhutan, Alternate Renewable Energy Policy 2013, (2013) [Online]. Available: http://img.teebweb.org/wp-content/uploads/2015/06/alternative-renewable-energy-policy-2013.pdf , Accessed date: 5 January 2018.
[65] PRS Legislative Research, The Electricity (Amendment) Bill, (2014) [Online]. Available: http://www.prsindia.org/uploads/media/Electricity/Electricity%20%28A%29%20bill%202014.pdf , Accessed date: 7 January 2018.
[66] T.P. Harshal, India's national action plan on climate change, Indian J. Occup. Environ. Med. 13 (1) (2009) 17–19.
[67] Government of Nepal, "Alternative Energy Promotion Centre: RE Subsidy Policy," [Online]. Available: http://www.aepc.gov.np/?option=resource&page=rescenter&mid=3&sub_id=18&ssid=2&cat=RE%20Subsidy%20Policy. [Accessed 28 12 2017].
[68] Ministry of Power and Energy, The Gazette of the Democratic Socialist Republic of Sri Lanka, (2008) [Online]. Available: http://powermin.gov.lk/english/wp-content/uploads/documents/national_energy_policy.pdf , Accessed date: 28 December 2018.