Comparative Study for the Prevailing Tariff of Renewable Energy Projects in Member States and Assessing Options such as Net-metering, Banking and Wheeling

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CONTENTS

FOREWORD

Rapid economic growth in Asia and the Pacific Region, which is expected to continue outpacing the rest of the world in coming years, will make the region the largest energy consumer in the foreseeable future. SAARC Region is blessed with huge potential for Solar, Wind, Hydro and Biomass power generation. The absorption of energy through Renewable resources to national electricity grids of SAARC Member States is an essential and inevitable requirement. The Renewable Energy promotion regimes around the globe always commenced with a regulatory framework consisting of policy, legal and regulatory guidance. These policy and contractual frameworks need to be put in place in shape of implementing rules and regulations for effective deployment of Renewable Energy generation projects.

Distributed generation, especially from household and commercial scale roof top solar PV systems, can reduce power system inefficiencies by avoiding grid losses. The technical challenges associated with distributed generation, such as net-metering equipment and voltage fluctuations, can be addressed using well-established technologies, operating standards, and regulatory best practices. The introduction of Distributed Generation options such as Net-metering, Banking and Wheeling would open doors for private sector investment in the RE sector. The flooding of new equipment and technologies to the market must follow quality performance standards and labelling. Also, the licensing, certifying and permission into the electrical grid becomes a complex technical challenge to the distribution utilities.

As the role and share of distributed and grid-connected renewable energy sources increase globally and in South Asia, several best practices are emerging so are some challenges. SAARC Member States, blessed with immense renewable energy sources, have the opportunity to use distributed generation systems for increasing energy security and moving towards a low-carbon energy system.

In this context, SEC has conducted a study – 'Comparative Study for the Prevailing Tariff of Renewable Energy Projects in Member States and Assessing Options such as Net-metering, Banking and Wheeling' which will assess the situation in SAARC countries and propose an action plan.

I commend the efforts of Dr. Binu Parthan as this important research study will complement the overall mission of SAARC Energy Centre to mitigate energy poverty by using Renewable Energy Technologies within and across South Asia for a better tomorrow.

(Muhammad Naeem Malik)
Director, SAARC Energy Centre

ACRONYMS AND UNITS

€	Euro
ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
AREP	Alternative Renewable Energy Policy 2013, Bhutan
ASPIRE	Accelerating Sustainable Private Investments in Renewable Energy
BERC	Bangladesh Energy Regulatory Commission
CEB	Ceylon Electricity Board
dB	Decibels
DC	Direct Current
DG	Distributed Generation
DPV	Distributed Photovoltaics
DRE	Department of Renewable Energy, Bhutan
DSO	Distribution System Operators
FiT	Feed-in-Tariff
GDP	Gross Domestic Product
GW	Giga-watt
HV	High-Voltage
IEC	International Electrotechnical Commission
IPP	Independent Power Producer
ISO	International Organisation for Standardisation
kgoe	kilograms of oil equivalent
kWh	kilo watt-hours
LV	Low-Voltage
m/s	Meter per second
mA	Milli-Ampere
MEA	Maldives Energy Authority
MEW	Ministry of Energy and Water, Afghanistan
MHP	Micro-Hydro Power
MNRE	Ministry of New and Renewable Energy, India
MOEA	Ministry of Economic Affairs, Bhutan
mt	million tons
MW	Mega-watt
NA	Not applicable
NEA	Nepal Electricity Authority
NEPRA	National Electric Power Regulatory Authority
PUCSL	Public Utility Commission of Sri Lanka
PV	Photovoltaics
QMS	Quality Management System
REC	Renewable Energy Certificates
Ren 21	Renewable Energy Policy Network for the 21st Century
REP	Renewable Energy Policy 2008, Bangladesh
RGoB	Royal Government of Bhutan
RPS	Renewable Portfolio Standards
SAARC	South Asian Association for Regional Cooperation
SAMANEM	SAARC Model for Accelerated Net Energy Metering
SE4All	Sustainable Energy for All
SEC	SAARC Energy Centre
SREDA	Sustainable and Renewable Energy Development Authority
STC	Standard Test Conditions

TVET	Technical and Vocational Education and Training
UK	United Kingdom
US	United States
UV	Ultra Violet
WB	World Bank

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I would like to thank SAARC Energy Centre for this opportunity to contribute to this important energy issue of net-metering of distributed generation by way of this study report. The constant guidance and support that I have received from the SEC was invaluable and I want to express my gratitude to the Director, Mr. Muhammad Naeem Malik and Mr. Ahsan Javed, Research Fellow in particular. I also want to thank the peer reviewer Mr. Hussnain Zaigham Alvi, Senior Adviser, NEPRA for very strategic and helpful comments which have contributed significantly in improving and targeting the study report.

During the course of the study, a large number of energy experts and policy makers from SAARC countries provided their inputs which were very critical for the development of this report. I want to in particular thank Aman Ghalib, Deputy Minister for Energy and Water, Afghanistan, Siddique Zobair, Joint Secretary, Government of Bangladesh, Chhimi Dorji, Executive Engineer, Department of Renewable Energy, Bhutan, Ram Dhital, Executive Director of AEPC, Nepal, Hitendra Shakya, Director, NEA, Nepal, Dr. Anil Cabraal, Adviser, SEA, Sri Lanka and Gamini Herath, Deputy Director General of PUC, Sri Lanka for their valuable inputs and suggestions.

Finally I wanted to thank my family for their understanding and support in allowing me the flexibility to work on this report which often limited the time available to them.

Dr. Binu Parthan

EXECUTIVE SUMMARY

SAARC countries in general have limited fossil fuel energy reserves but very high level of fossil energy consumption, thus making SAARC an energy insecure region. However, the energy intensity and energy access levels remain relatively lower in comparison to neighbouring Regions. SAARC countries also have rich renewable energy resources with plentiful solar and hydro resources. Some of the SAARC countries also have sizeable biomass and wind energy resources which can be harnessed. Most SAARC countries also have a high level of dependence on traditional biomass fuels. Some countries have developed their hydro, wind and biomass power potentials. However, the development of solar energy potential has lagged behind other renewable energy sources in this region. SAARC countries in generally have used financial incentives such as capital subsidies and tax incentives to promote renewable energy. Policy and regulatory instruments such as FiTs have had a secondary role and instruments such as RECs and RPSs have had a limited role.

Net-metering has emerged as a very potent regulatory instrument to promote DG systems in the electricity grid. Net-metering when combined with banking has encouraged the development of DPV systems. The regulatory instruments such as FiTs have helped in the development of DG markets. Due to widespread resource availability and price reductions as well as other market factors, PV systems have emerged as the leading DG technology in SAARC countries with over 537 MW[1] of installed capacity. Some SAARC countries like India and Sri Lanka have moved early and several other SAARC countries are also progressing with their plans. While the policy makers, regulators and the industry have been positive about net-metered PV systems, the electricity distribution companies and energy utilities in some of the countries have not shown the same level of support due to concerns of revenue loss. The European and North American net-metered DG system markets are at an advanced stage of development than SAARC countries and could offer lessons to South Asia in terms of policy, regulation and financing of DG systems.

The high level of penetration of DPV systems in distribution networks can have the potential to cause issues of high voltages, network overload, frequency variations and load shedding. However, the probability of such instance to occur in SAARC countries is very low. Moreover, the SAARC utilities should be able to manage these challenges the same way they have been managing demand fluctuations in their existing systems. A financial analysis revealed that the prospect of PV net-metering is an attractive proposition in many of the SAARC countries if the PV system is designed specifically for self-consumption and not for exporting power to the distribution grid. Currently, the distribution companies or utilities offer very lower tariffs for purchase of power from residential solar PV. It is however, noted that stand-alone off-grid PV systems are considered to be feasible in locations at a considerable distance from the electricity grid, especially in rural areas when compared to diesel alternatives.

The technical specifications for net-metered PV system components have been specified with emphasis on the inverter. Recommendations have also been made for installation and commissioning, imports, testing and development to ensure better system performance and a sustainable and healthy growth of the markets. Guidelines have also been provided for energy regulators and electricity distribution companies to ensure an orderly and sustainable development of the net-metered DG markets in SAARC countries.

[1] 525 MW in India, 10.28 MW in Sri Lanka, 1 MW in Maldives, 0.8 MW in Nepal and 0.35 MW in Pakistan

Recommendations have been made in the realms of policy, regulation, financing, testing and certification as well as manufacturing and service delivery aimed at SAARC governments, electricity companies, financiers and industry towards a South Asian model – South Asia Model for Accelerated Net Energy Metering (SAMANEM) for an orderly growth of the DG market. There exists considerable scope for regional cooperation among SAARC countries in the areas of testing & certification, trade, knowledge and experience sharing of DG systems. An action plan for SAARC countries to be coordinated by SEC has also been proposed which envisages organising and convening stakeholders, building a knowledge base, cooperation in testing & certification, trade, further development of the SAMANEM model for the benefit of all SAARC countries. The action plan is envisaged to cover a period of 3 years and based on the results and state of market development at the end of this period, the actions for a future period can be further defined.

1.0 BACKGROUND

1.1 CONTEXT

The South Asian Association for Regional Cooperation (SAARC) is an economic and regional organisation of eight countries in South Asia: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka[2] with nine observer states[3]. SAARC was established in 1985 at a first summit hosted by Bangladesh. The SAARC secretariat is situated in Kathmandu hosted by Nepal. SAARC aims to promote welfare economics, collective self-reliance among the countries of South Asia, and to accelerate socio-cultural development in the South Asian region.[4] The combined economy of SAARC nations is the 5th largest in the world in terms of nominal Gross Domestic Product (GDP) and with a GDP growth rate of 7.6% is currently the fastest growing region in the world[5].

SAARC has established regional cooperation programmes in 16 areas one of which is energy[6]. SAARC also has 11 regional centres that promote regional co-operation on issues of regional priority[7]. The SAARC Energy Centre (SEC) is a regional centre of excellence established in 2006 under the aegis of SAARC and based in Islamabad. SEC is responsible for the initiation, coordination and facilitation of SAARC programs in energy sector. SEC aims to strengthen South Asia's capacity to collectively address global and regional energy issues and also enhance cooperation in the use of new and renewable energy sources in the region, thereby contributing towards more sustainable development in the SAARC member countries.

As the role and share of distributed and grid-connected renewable energy sources increase globally including in South Asia, several best practices are emerging along with some challenges. SAARC countries which have abundant renewable energy sources have the opportunity to use distributed generation systems for increasing energy security and moving towards a low-carbon energy society. In this context SEC has commissioned a study titled – 'Comparative Study for the Prevailing Tariff of Distributed Generation Projects in Member States and Assessing Options such as Net-metering, Banking and Wheeling'. This study report prepared by Dr. Binu Parthan has assessed the situation in SAARC countries comparing against global best practices, provides guidelines and proposes an action plan for SAARC countries and makes recommendations. The preparation of the report also benefitted significantly from inputs to a questionnaire survey that was carried out among SAARC member countries. The questionnaire that was used for the survey is available at Annex A. The institutions and the individuals who contributed to the survey are also listed in Annex B.

1.2 REGIONAL ENERGY SCENE

SAARC countries are in a region with limited fossil based energy sources and the energy sector relies heavily on imported petroleum resources for its commercial energy needs. India and Pakistan have significant reserves of coal; India, Pakistan, Afghanistan and Bangladesh have relatively high levels of natural gas reserves. Oil reserves are quite limited with only India

[2] Myanmar has expressed interest to become a Member

[3] Australia, China, the European Union, Iran, Japan, Mauritius, Myanmar, South Korea and the United States

[4] SAARC Charter available at http://www.saarc-sec.org/SAARC-Charter/5/

[5] South Asia Economic Focus Spring, World Bank, 2015

[6] http://www.saarc-sec.org accessed in July 2015

[7] http://www.saarc-sec.org accessed in July 2015

having considerable reserves. The status of fossil fuel energy reserves in South Asia are shown in Table 1:

Table 1: Fossil Fuel Energy Reserves in SAARC economies

SAARC Country	Coal Reserves (million tons)	Oil Reserves (million barrels)	Natural Gas Reserves (trillion cubic feet)
Afghanistan	440	NA	15
Bhutan	2	0	0
Bangladesh	884	12	8
India	90,085	5,700	39
Maldives	0	0	0
Nepal	NA	0	0
Pakistan	17,550	324	33
Sri Lanka	NA	150	0

(Source: Energy Trade in South Asia, ADB, 2011)

There is a high level of dependence on fossil fuels for their energy needs among SAARC countries. The countries like Maldives and Afghanistan are highly dependent on fossil fuels most of which are imported from outside the region. India, Bangladesh and Pakistan also rely on fossil fuels to meet majority of their energy needs. Nepal, Bhutan and Sri Lanka are less dependent on fossil fuels due to use of hydro energy for electricity generation and high levels of traditional biomass use. The net energy imports in the SAARC countries are relatively moderate except for countries such as Sri Lanka which needs to import almost half of its energy needs. Energy use per capita and the GDP per unit of energy use denote the industrialisation of the economies and the share of services in the economy vis-à-vis traditional energy consuming industries. The Energy use per capita is high for the more industrialised economies of India, Sri Lanka and Pakistan while it is at a lower level for Nepal and Bangladesh. Some SAARC countries such as Maldives, Pakistan and Sri Lanka have made significant progress in providing electricity to its populations. However, countries such as India, Bhutan and Nepal have moderate levels of electricity access while Bangladesh and Afghanistan lag behind. The characteristics of the energy sector in SAARC countries are shown in Table 2.

Table 2: Energy Sector in SAARC economies

SAARC Country	Fossil Fuel Energy Consumption (%)	Net Energy Imports (%)	Energy Use Per Capita (kgoe)	Access to Electricity Rate (% of Population)	GDP Per Unit of Energy Use ($/kgoe)
Afghanistan	NA	NA	NA	43	NA
Bangladesh	73.2	15	216	59.6	13.2
Bhutan	NA	NA	NA	75.6	NA
India	72.4	33	606	78.7	8.4
Maldives	NA	NA	NA	100	NA
Nepal	15.5	16	370	76.3	5.9
Pakistan	60.1	24	475	93.6	9.4
Sri Lanka	45.9	46	488	88.7	21

(Source: World Bank website; Key Indicators for Asia and the Pacific, ADB, 2015)

1.3 REGIONAL RENEWABLE ENERGY SCENE

In contrast to the situation with fossil fuel energy sources, SAARC countries are endowed with considerable renewable energy sources especially hydro and solar energy. Being in the tropics, SAARC economies are endowed with high levels of solar insolation. The range of annual average solar insolation in SAARC countries ranges from locations with 3.95 kWh/m^2/day to 6.07 kWh/m^2/day. Tropical monsoons and several major river systems many of which originate in the Himalayas also contribute to the hydro power potential and the total hydropower potential among SAARC countries is estimated at 294.3 GW[8]. Similarly, the SAARC economies and in particular India, Afghanistan, Nepal and Bhutan also have large volumes of biomass resources which can be utilised for energy purposes. Due to terrain features in SAARC countries which accelerate or decelerate geostrophic wind regimes, the wind speeds range from places with annual average low speeds of 0.9 m/s to high speeds of 5.6 m/s. Finally the estimated biomass resources in SAARC countries amount to over 250 million tonnes/year. An overview of the richness of renewable energy resources in South Asia are given in Table 3.

Table 3: Renewable Energy Resources in SAARC economies

SAARC Country	Hydropower Potential (MW)	Biomass Resources (million tons)	Annual Average Wind Speeds (m/s/year[9] [10])	Annual Average Solar Insolation (kWh/m^2/day) [11]
Afghanistan	25,000	18-27	4.3-5.6	4.7-5.47
Bhutan	30,000	26.6	4.4	4.63
Bangladesh	330	0.08	1.9-2.9	4.51-4.99
India	150,000	139	0.9-4.6	3.95-6.07
Maldives	0	0.06	3.7 -5	5.8 -5.88
Nepal	42,000	27.04	2.9-4.6	5.03-5.37
Pakistan	45,000	NA	2.1-5.6	4.02-5.54
Sri Lanka	2,000	12	1.9-5.2	4.8-5.88

(Source: Energy Trade in South Asia, ADB, 2011; Parthan 2014; NASA Langley Research Centre, 2015)

However despite the rich local resource endowments, SAARC countries have only succeeded in varying degrees to harness their renewable energy potential. Almost all SAARC countries have developed their hydro power resources which correspond broadly to their potential. However, the development of biomass resources has lagged significantly behind the available potential. The development of electricity through wind has also been limited across SAARC countries except in India. Similarly solar power developments have significantly lagged behind their potential across SAARC countries although there has been an increased level of activity in recent years particularly in India and Bangladesh. It can also be seen that use of traditional biomass fuels is quite significant in those SAARC countries which are in the Himalayan ranges. Considering that many[12] SAARC countries face electricity shortages in the range of 8 to 27%[13]

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[8] Energy Trade in South Asia: Opportunities and Challenges, ADB, 2011
[9] At 10 m heights
[10] These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center (https://eosweb.larc.nasa.gov/project/sse/sse_table)
[11] These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center (https://eosweb.larc.nasa.gov/project/sse/sse_table)
[12] Except Maldives, Sri Lanka and Bhutan
[13] Energy Trade in South Asia: Opportunities and Challenges, ADB, 2011

and are dependent on sources outside the region for their petroleum energy sources, there is a clear need to increase the level of utilisation of renewable energy resources other than hydro, which are widely available in the region.

Table 4: Renewable Energy Achievements in SAARC economies

SAARC Country	Hydro Energy Capacity (MW)	Biomass Energy Capacity (MW)	Wind Energy Capacity (MW)	Solar Energy Capacity (MW)	Dependence traditional biomass fuels (%)
Afghanistan	253	0	0	1	85
Bhutan	1,488	0	0	0	91
Bangladesh	230	0	2	163	52
India	44,356	5,152	22,465	3,290[14]	28
Maldives	0	0	0.1	1	2
Nepal	730	0	0	30	88
Pakistan	7,224	314	305	141	38
Sri Lanka	1,622	17	76	10	56

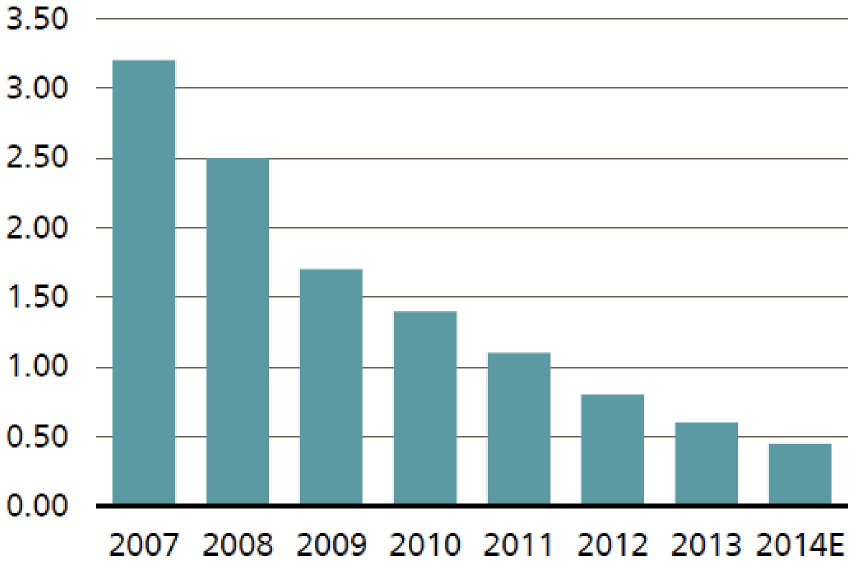
(Source: IRENA 2015, ADB 2011, Parthan 2014, AEPC 2015, CEB 2015)

1.4 DISTRIBUTED GENERATION

Distributed generation (DG) is also called decentralised generation, on-site generation or embedded generation. Conceptually distributed generation would involve embedding energy generation closer to the locations where energy is used. Such an approach does save investments in grid infrastructure relating to transmission and distribution and also saves energy lost as transmission and distribution losses. Distributed energy systems are typically small-scale power generation systems in the range of few kWs to few MWs. Typical energy conversion technologies used as distributed generation options include Photovoltaic (PV) Systems, Diesel, petrol or gas engine-generators, Natural gas fired Micro-turbine generators, Small wind power systems and Biomass based generators. Distributed Photovoltaic (DPV) power systems have witnessed a major uptake in the last few years driven by reductions in the cost of PV modules and solar electronics components. The cost reduction for PV modules in the recent past is illustrated in Fig 1.

[14] Including 231 MW of Concentrating Solar Power

Fig 1: Reduction in Costs of Photovoltaic Modules (€/Wp)



(Source: UBS[15], 2014)

A large number of developing and developed countries allow interconnection of DPV to distribution networks. They also allow for net-metering, where a consumer is able to offset fully or partially the electricity consumption with electricity generated from the DPV system often mounted on the rooftop of the home or the facility. DPV system installations have been growing steadily with 13,000 MWp of DPV systems installed globally in 2014[16]. The major countries with high levels of DPV installations include China, US, Japan, Germany, UK, Italy, Spain etc.

It is expected that in future, further price reductions will be made possible in PV modules, electronics, structures as well as a reduction in engineering costs of the DPV system. There are options such as zero upfront cost, leasing and service contract, and crowd funding models available to homes and businesses in the US and other developed markets.

SAARC countries are embarking on distributed generation programmes primarily with DPV systems that are connected on the Low-Voltage (LV) distribution networks. Efforts for putting in place the necessary regulatory instruments and policy frameworks are also underway. It is estimated that the total installed DG/DPV capacity across SAARC economies is currently 537.43[17] MW with India and Sri Lanka being the early movers. Efforts are underway in almost all SAARC countries to develop the DG/DPV markets and physical achievements are expected to increase significantly in the coming years.

1.5 REGULATORY INSTRUMENTS FOR DISTRIBUTED GENERATION

A number of electricity regulatory provisions and instruments are important to facilitate DG systems to be inter-connected to the distribution network and for the technical and business operations of such DG systems. Four regulatory principles and instruments are considered

[15] Global Research: Will solar, batteries and electric cars re-shape the electricity system? pp 14, Fig 18, UBS, 2014
[16] BNEF, New Energy Outlook, 2015
[17] 525 MW in India, 10.28 MW in Sri Lanka, 1 MW in Maldives, 0.8 MW in Nepal and 0.35 MW in Pakistan

important viz. net-metering, wheeling, banking and feed-in-tariffs. These regulatory instruments are explained below:

1.5.1 NET METERING

Net-metering is a methodological arrangement which consists of technical and commercial aspects in which electricity generated using the DG system by the electricity consumer is utilised to off-set and delivers surplus electricity to the electricity distribution companies[18]. The applicability of Net-metering is defined in the context of billing cycles and billing periods of the electricity distribution company. The technical arrangement for net-metering involves either a bi-directional energy meter capable of recoding both export and import of electricity and showing the net export/import value or through a pair of meters, one each for recording the import and export of electricity. The availability of net-metering and priority access by DG systems to the distribution network is an important requirement for encouraging distributed renewable energy generation.

Net metering can be carried out for both single phase and three phase electricity supply by the consumers. In the case of single phase electricity supply at the location where the DG system is installed, the DG system is directly connected to the supply. The import and export of electricity is metered through a bidirectional single-phase meter or a two-meter arrangement. Generally three-phase electricity supply is more prevalent with commercial and industrial consumers than at the house hold levels. When the electricity is supplied through three-phases, there are two options for net-metering. In the first case where each of the phases of electricity supply is metered through a single phase meter, the DG system supplies one of the phases through single-phase electricity supply. The net-metering is then carried out only on one of the three phases through a bidirectional meter or a two-meter arrangement. In the second option, the existing metering arrangement involves a three-phase meter, in such a case a three phase electricity supply is provided[19] by the DG system and the net-metering is then carried out through a bi-directional or two-meter arrangement.

1.5.2 WHEELING

Wheeling is a methodological arrangement which enables an Independent Power Producer (IPP) or an electricity supplier to use the electricity distribution network to 'wheel' or route the electricity generated to another consumer connected to the electricity distribution network. A regulated or negotiated 'Use-of-system charge' is levied by the electricity distribution company for wheeling. The use-of system charge is levied either in monetary terms of each unit of electricity transported or as a share of the total energy wheeled. Two separate meters are used for wheeling – an export meter at the point of electricity generation and supply to the distribution network and an import meter at the point of consumption.

Wheeling of electricity in the distribution network is relevant where electricity generation cannot be performed at the location of consumption which is an issue with wind or hydro based generation. Wheeling is also relevant in electricity markets where IPPs are allowed 'third-party sale' i.e. selling of electricity to customers rather than the energy utility. Wheeling is normally not relevant for DG systems such as DPV which are located at or near the point of consumption and often on the rooftop of the facility. However in some of the states in the United States (US), a 'virtual net-metering' is possible which is actually a type of wheeling.

[18] Either the electricity distribution company or the vertically integrated utility
[19] Either using a three-phase inverter or three separate single phase inverters in the case of PV systems.

Wheeling is primarily an instrument for independent generation of power and third party sale[20] of electricity or for self-consumption, but not all grid-networks and regulatory regimes allow for wheeling. However in the case of 'virtual net-metering', wheeling is used although the generation and the consumption happen at the same or adjacent location. This is relevant in the case of multi-family housing or in office parks and complexes usually housed in a large multi-storied building or adjacent buildings. In this arrangement a large single DG system often DPV, is installed on site or adjacent to the site/location. All the electricity generation from this DG system is directly exported to the distribution utility's network. The electricity consumption by each of the individual home-owners or offices is metered as before. However an allocation agreement is made by all the home-owners/offices and the distribution utility based on which the electricity exported by the DPV system is netted off against the consumption of each of the individual meters and accounts. This arrangement allows for a single larger DG system than a large number of small systems thereby reducing the cost of investment and simplifications.

1.5.3 BANKING

A banking arrangement is allowed if the consumer is unable to utilise the generated and exported electricity within the billing cycle or the wheeling period. Under the banking arrangement, the net energy exports or the wheeled energy exports are allowed to be 'banked' for a certain grace period within which the energy will need to be consumed. The banking period could be a single month or several months depending on the type of generation and the electricity system. Banking is highly relevant for power generation and export that is seasonal in nature such as wind power and bagasse based electricity. For such arrangements if the user is unable to utilise all the exported energy within the banking period, the energy supplied cannot be consumed thereafter. Banking is only relevant for net-metered systems where the utility does not purchase the excess electricity generation from the DG system.

Banking is applied normally in the cases where a DG system is wheeling the energy generated for own consumption or for third party sale. In such cases the electricity utility allows for a grace period in which the electricity generated by the DG system must be consumed by the third party or self. In the second case, banking is applied in case of net-metering systems where the electricity distribution utility does not purchase the excess energy generated. Thus, a grace period is provided by the utility for the net-metering consumer who has installed the DG system to consume the excess generation. The banking periods are a normal regulatory requirement in many jurisdictions and are often limited to DG systems where the energy resource cannot be stored or variable such as solar and wind energy systems. Typical banking periods are 12 months although 6 month banking periods are also practiced.

1.5.4 FEED-IN-TARIFFS

Feed-in-Tariffs (FiT) are defined for both centralised and distributed generation, and denote the tariffs that are paid by the electricity utility to the IPP or the electricity supplier. Uniform FiT for renewable energy generation are either specified as part of government policies or determined by market through reverse-bidding to discover the lowest competitive FiT. The supplier or the IPP is then compensated for the electricity exported at the FiT rates. Generally FiTs are not relevant for net-metering or wheeling arrangements. In wheeling arrangements involving third party sale, the energy sale price is agreed between the IPP and the consumer. Generally in net-

[20] Normally sale to consumers directly than to the distribution utility.

metering arrangements, the surplus energy which is exported to the grid is purchased by the electricity supplier at the same rate as the electricity sales tariff.

There are two ways in which FiTs are established, the traditional way has been for governments and energy regulators to establish FiTs based on assumptions about cost of investments and desired/allowable return on investments. In such approaches, governments and regulators often provide higher FiTs to certain technologies that are considered to be more desirable. Normally, FiTs are announced for a specific period of time or with set limits on the total capacity of systems that will be offered the FiTs. In the second and the more recent market-based approach, the developers are invited to make reverse bids for the FiT on a competitive basis[21] and the bidders who request the lowest FiTs are offered to develop DG or centralised systems. The reverse bidding for FiTs have been used with great effect by several developing countries such as China, Brazil, India, South Africa etc. to lower the FiTs compared to the traditional top-down approach.

For DG systems, FiTs can also be classified as gross FiT and net FiT. In the case of gross FiTs, all the energy generated by the DG system is purchased and compensated at a pre-determined gross FiT, irrespective of the level of consumption. In the second option of net FiT which accompanies a net-metering scheme, all the generation by the DG system is offset against the consumption by the net-metering consumer. Any excess generation which is higher than the consumption in a billing period is offered a net FiT. The net FiT is often kept at a lower level than the retail electricity tariffs to encourage such DG systems to be designed to reduce and off-set generation rather than encouraging excess generation.

[21] Sometime through on-line e-auctions that are transparent.

2.0 CURRENT STATUS

2.1 STATUS OF POLICY AND INCENTIVE FRAMEWORKS

SAARC member countries use different types of policies, regulation and fiscal incentives to encourage uptake of renewable energy including DG. Almost all countries have policies and regulations for renewable energy and some countries also have incentive frameworks for renewable energy. The SAARC countries in general have focussed more on financial incentives than policy and regulatory incentives to promote renewable energy. The most popular instrument for promoting renewable energy was capital subsidy followed by tax incentives. Amongst policy and regulatory instruments, FiTs are the most widely used instrument among SAARC countries after renewable energy targets. Use of Renewable Energy Certificates (REC) and Renewable Portfolio Standards (RPS) as renewable energy policy and regulatory instruments are less prevalent among SAARC countries. An overview of the renewable energy policy and incentive frameworks for renewable energy is given in table 5.

Table 5: Renewable Energy Policies and Incentives in SAARC economies

SAARC Country	Renewable Energy Targets	Feed-in-Tariff	Renewable Portfolio Standards	Renewable Energy Certificates	Capital Subsidy	Tax Incentives	Tendering/ Reverse Auctions
Afghanistan	No	No	No	No	Yes	No	No
Bhutan	Yes	Yes	No	No	Yes	Yes	Yes
Bangladesh	Yes	No	No	No	Yes	Yes	Yes
India	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maldives	Yes	Yes	No	No	No	No	Yes
Nepal	Yes	Yes	No	Yes	Yes	Yes	Yes
Pakistan	Yes	Yes	No	Yes	Yes	Yes	No
Sri Lanka	Yes	Yes	Yes	No	Yes	Yes	No

(Source: Ren21 2015, RGoB 2013, Parthan 2014)

2.2 POWER PURCHASE TARIFF STRUCTURE OF RENEWABLE ENERGY

As is shown in table 5, many of the SAARC countries have announced renewable energy power purchase tariffs using a FiT established through a policy or regulatory instrument and others have arrived at the power purchase tariffs using reverse auctions. A number of countries have offered attractive tariffs to encourage renewable energy generation due to energy security concerns. While it is not advisable to compare power purchase tariffs across countries as the tariffs may be affected by a number of factors such as renewable energy resource availability, cost and other parameters of local/ international finance, local manufacturing capability, technology advance, and credit worthiness of the purchasing utility. However, an attempt is made to present the current purchase tariffs for renewable electricity in SAARC countries in Table 6.

Table 6: Renewable Energy Tariff Structure for SAARC economies (US$[22])

SAARC Country	Small Hydro Energy Tariffs	Biomass Energy Tariffs	Wind Energy Tariffs	Solar Energy Tariffs	Other Renewable Energy Tariffs
Afghanistan	NA				
Bhutan	NA				
Bangladesh[23]	NA	NA	0.144	0.162-0.180	NA
India[24]	0.055-0.08	0.058-0.096	0.049-0.078	0.068[25]-0.124	0.162 -165[26]
Maldives	NA				
Nepal	0.08 in winter and 0.046 in rainy season	NA			
Pakistan	NA	0.102[27]	0.101 -0.121	0.102-11	NA
Sri Lanka	0.116-0.122	0.123	0.143-0.148	NA	0.18[28] - 0.182[29]

Based on the existing experience with renewable energy tariffs in SAARC countries, the following observations can be made:

- Three SAARC countries i.e., India, Pakistan and Sri Lanka have established preferential tariff structures for renewable energy while regulatory frameworks are emerging in Bangladesh and Nepal;

- It can be seen that wind and small hydro power projects can be developed in most SAARC countries under a lower tariff, compared to biomass, solar or other technologies;

- The renewable energy technologies that need considerably higher tariff levels for development include Concentrated Solar Power (CSP)[30], dendro power[31] and municipal solid waste based electricity. The factors contributing to relatively higher tariffs includes technology, investment costs, operation and maintenance costs;

- The markets through a competitive mechanism of reverse bidding are able to offer renewable electricity at lower tariffs than tariffs which are established by governments or regulators using various assumptions. This is evident in the case of the Indian solar

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22 Where the tariffs are specified in local currency, relevant foreign exchange rates as in December 2015 have been used for conversion to US$
23 The tariffs for Bangladesh has only been proposed
24 In India the tariffs are set by state regulatory agencies and for solar the rate is determined by reverse bidding. Therefore a range of the available tariffs are provided based on tariffs from leading states like, Gujarat, Tamil Nadu, Maharashtra, Andhra Pradesh, Karnataka etc.
25 Lowest Tariff contracted in the latest solar energy auction
26 Solar Thermodynamic Electricity
27 Applicable for Bagasse cogeneration projects
28 For Dendro biomass
29 For Municipal Solid Waste
30 Technologies such as solar tower with heliostats, concentrating solar troughs, concentrating solar dish etc, with use the thermal properties of solar energy using the Rankine cycle to produce electricity;
31 Sustainably grown biomass in an energy plantation used for electricity generation using combustion or gasification.

electricity tariffs where reverse bidding has resulted in significant reductions in power purchase tariffs over last few years. Currently, the purchase tariff for solar power in Indian states which have used reverse bidding is almost half the solar tariff paid by states which was set by the state's regulatory agency;

- Globally the practice of preferential tariffs for renewable energy set by governments and regulators are on the decline as the rate of technology innovation, falling prices and changes in public opinion have all resulted in governments and regulators changing and even back-tracking on several terms of the tariffs. The developing countries such as Brazil, China, South Africa have used reverse-bidding to use the market forces to drive down renewable power purchase tariffs. European countries such as Germany, France and Poland have already started processes of reverse bidding and the European Union (EU) is also moving to a regime where tariffs are being set by reverse auctions. SAARC countries are beginning to move along this path which is expected to intensify in the coming years.

2.3 STATUS OF DISTRIBUTED GENERATION POLICIES

A status update on the current policy, incentive frameworks and achievements for DG systems among SAARC countries is detailed below:

2.3.1 AFGHANISTAN[32]

Currently, Afghanistan does not have a policy for grid-connected DG systems. The Ministry of Energy and Water (MEW) plans to install a pilot grid-connected PV system to study the performance of grid-connected DPV systems in Afghanistan. The MEW is also collaborating with international donor and technical assistance agencies to seek support for development of a policy and programme for DPV systems.

2.3.2 BHUTAN[33]

Bhutan has an Alternative Renewable Energy Policy (AREP) which was enacted by the Royal Government of Bhutan (RGoB) in 2013. The AREP defines Decentralised Distributed Generation (DDG) projects which are serving remote villages and rural communities as micro or mini-grids and not envisaged as connected to the national grid. The AREP also defines grid-connected renewable energy projects as those that are connected to the High-Voltage (HV) electrical networks[34] rather than being connected to the Low-Voltage (LV) electrical distribution networks. However, Bhutan is currently developing policy and regulatory instruments for grid connected renewable energy systems connected to distribution networks.

[32] Based on discussions and feedback on the questionnaire survey with Aman Ghalib, Director, MEW, Afghanistan.
[33] Based on feedback on the questionnaire survey by Chhimi Dorji, Executive Engineer, Department of Renewable Energy, Ministry of Economic Affairs, Bhutan.
[34] Specified as 11 KV and above by AREP

2.3.3 BANGLADESH[35]

While there isn't a specific policy for DG in Bangladesh, the Renewable Energy Policy (REP) of 2008 does provide for establishing renewable energy generation of a capacity up to 5 MW without the need for licences from the Bangladesh Energy Regulatory Commission (BERC). The REP also provides for third party sale and wheeling of the renewable energy generation. BERC is currently preparing FiTs for solar and wind energy sources, and the draft FiT regulations make explicit provisions for rooftop solar PV systems. The draft FiT regulations have also introduced a limit of 1 MWp for PV rooftop with two sub-categories of less than 10 kWp and 10-1000 kWp.

The REP does not specify net-metering but allows wheeling and third-part sale. It also does not consider banking of power. The Draft FiT regulations by BERC suggest a flat 25-year FiT based on assumptions of investment cost, lifespan and other operational and financial parameters. The proposed FiT for PV rooftop/small systems up to 1 MWp is 14.13 Taka[36]/kWh. The Draft FiT regulations are expected to be finalised by BERC soon.

2.3.4 INDIA

India has been placing an emphasis on contribution of solar energy in the energy mix, including as DG option particularly for rooftop solar energy. In India, the electricity laws and regulations are the domain of the respective states of India. Therefore, the state governments and state energy regulators take policy decisions on grid-connected DG and the relevant regulatory options. Currently, 16 out of 29 Indian states and all 7 union territories allow DPV as a DG option[37]. The state level policies for grid-connected DG vary and some states have specified limits on system sizes, eligibility conditions and solar energy generation from the systems. Some states have also placed limits of penetration of solar PV systems as a share of distribution transformer capacity. It is estimated that a total of 525 MWp of net-metered DPV capacity[38] has been installed in India.

Indian state DPV programmes have generally attempted to either allow individual system sizes as per user needs or have placed limits according to the consumption at the facility or the contracted electrical load size. Many states have also specified maximum system sizes which have either been 500 kW or 1 MW but some have not placed any limits[39]. There has been a tendency in Indian states to place a penetration limits on solar energy generation for each distribution transformer with the range being 15-80% of the distribution transformer capacity with 30% being the most commonly used limit. Table 7 provides an overview of net-metering policies and achievements among the States and Union Territories in India.

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[35] Based on feedback on questionnaire survey and discussions with Siddique Zobair, Joint Secretary and Member, Sustainable and Renewable Energy Development Authority (SREDA)
[36] US¢ 18 as in July 2015
[37] Ministry of New and Renewable Energy, http://mnre.gov.in accessed July 2015
[38] Bridge to India, India Solar Handbook, 2015
[39] The exception has been West Bengal which has a rather low limit of 5 kW

Table 7: Net-metering Policies and Achievements in Indian States

State/ Union Territory	Total Installed capacity (MW)[40]	Limit of solar Electricity Supply/ Size[41]	Limit on System Size	Feed-in-Tariff for Excess Solar Energy Supplied	Limit of Grid Penetration Limit as % of Distribution Transformer Capacity
Andhra Pradesh	32	100% of consumption	1 MW	Yes, Solar tariff of 0.076	No
Chhattisgarh	14	49% of generation	50 kW to 1 MW	50% of regulated Solar tariff of US$ 0.066	No
Delhi[42] [43]	20	System size Less than contracted load	More than 1 kW	Yes, Solar tariff of US$ 0.083	20
Goa and Union Territories[44]	12	No	1 kW to 500 kW	Yes, Solar Tariff of US$ 0.0137	30
Gujarat	44	No	1 kW to 1 MW	Yes, the Average Power Purchase Cost of the Discom	No
Haryana	17	90% of annual consumption	1 kW to 1 MW	No, banking allowed	15
Himachal Pradesh	NA	No	1 MW	Yes, Solar Tariff of US$ 0.076	No
Karnataka	34	No	500 kW	Yes, Solar Tariff of US$ 0.145	80
Kerala	14	No	1 kW to 1 MW	No, banking allowed	50
Madhya	9	No	No	No	No

[40] Total capacity in India is more than the total of this column as states such as Bihar, Jammu and Kashmir, Telangana and others which do not have policies have also installed significant amounts of rooftop solar.
[41] A number of Indian states have placed a limit on energy generation from individual DG systems. Few states have also placed limits on size of DG systems in reference to contracted electrical load in kW.
[42] Guidelines under DERC (Net Metering for Renewable Energy) Regulations, 2014, page 7
[43] Delhi bulk supply tariff rate (INR 5.49/ unit) for BSES-Delhi Electricity Distribution Company was taken from one of their presentation
[44] The Joint Regulatory Commission for Goa and the Union Territories passed the Solar Net-metering regulations in 2014.

State/ Union Territory	Total Installed capacity (MW)[40]	Limit of solar Electricity Supply/ Size[41]	Limit on System Size	Feed-in-Tariff for Excess Solar Energy Supplied	Limit of Grid Penetration Limit as % of Distribution Transformer Capacity
Pradesh					
Maharashtra[45]	52	No	No	No, Banking allowed	No
Manipur	11[46]	80% of consumption	500 kW	No, but third party sale allowed	30
Meghalaya	11	No	1 MW	No	No
Odisha	7	90% of consumption	No	No	No
Punjab	20	System size < 80% of contracted load	1 kW to 1 MW	Yes, same as retail tariff – currently US$ 0.097	30
Rajasthan	32	System size < 80% of contracted load	1 kW to 1 MW	Yes, Regulated Solar Tariff of US$ 0.113	30
Tamil Nadu	76	90% of consumption	No	No	30
Uttar Pradesh	36	Less than contracted load	More than 1 kW	Yes, Solar Tariff of US$ 0.007	15
Uttarakhand	6	No	5 kW to 500 kW	Yes, Solar Tariff of US$ 0.139	No
West Bengal	9	No	Up to 5 kW	Yes, above 100 kWp PPA of US$ 0.0129	No

(Source: Bridge to India, 2015, MNRE, 2015, Manipur 2014, Gujarat 2012)

Indian states of Tamil Nadu, Maharashtra, Gujarat, Uttar Pradesh, Karnataka and Rajasthan lead others in the uptake of rooftop PV systems. 143 MW have been installed by households, followed by 172 MW by the commercial establishments and 210 MW by industries. The Government of India has set a target of rooftop PV systems totalling 40 GW by 2022[47] and is in the process of taking policy, regulatory measures and an incentive framework to achieve this ambitious target.

[45] Maharashtra only has a draft policy as of July 2015 and is yet to be approved.
[46] Total capacity installed in north-eastern states including Meghalaya and Manipur
[47] Renewable Energy Akshay Urja magazine, June 2015, Ministry of New and Renewable Energy

2.3.5 MALDIVES

Maldives already has about 1 MW of rooftop PV systems installed in public building roofs in Male', the capital and other nine islands viz Villingili, Maafushi, Guraidhoo, Thulusdhoo, Himmafushi, Kaashidhoo, Magoodhoo, Kudahuvadhoo and Ungoofaaru. While the Maldives does not have a national policy for grid-connected rooftop PV systems, Maldives Energy Authority (MEA) has promulgated technical guidelines for grid-connection of PV systems. Currently plans are underway to leverage the support available under the World Bank funded Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE) to guarantee and facilitate private investments in the PV rooftop segments.

2.3.6 NEPAL[48]

Nepal has a large and successful Micro-Hydro Power (MHP) programme which has for decades been providing electricity to remote communities. Nepal is also working for interconnecting MHPs to the national grid. Nepal has allowed MHPs of a capacity higher than 100 kW to be connected to the national grid and for using net-metering arrangement on the 11 kV HV lines. The national standards in Nepal also provide grid connected MHP with a backup of 120 minutes through lead-acid battery storage. Currently, 90 MHPs with net capacity of 2.7 MW have been grid-connected.[49]

Nepal also has grid connected PV systems which have been in operation since 2002 and the total installed capacity is about 700 kW. Since 2012, 5 distributed rooftop PV pilots of 1.1 kWp each have been in operation. Based on this experience, Government of Nepal in 2015 has announced the introduction of net-metering for rooftop PV systems.[50] It is expected that net-metering policies and regulations including Feed-in-Tariffs will be developed to support DG technologies such as MHP and PV. It is anticipated that in future, distributed rooftop PV systems will be offered a net-metering arrangement and MHPs will be offered a FiTs. Nepal has also announced plans to develop 25 MW of distributed PV in collaboration with World Bank.

2.3.7 PAKISTAN

Distributed generation has been encouraged through the Renewable Energy Policy 2006 of Pakistan. The policy allowed for de-licenced and deregulated net-metered systems up to a capacity of 1 MW[51] and offers options of wheeling and banking of energy. These policy guidelines were translated into a regulatory framework for net-metering and distributed generation by National Electric Power Regulatory Authority (NEPRA) in September 2015.

The regulations enacted in September 2015 allow for solar and wind electricity generators up to 1 MW to be connected to the electrical distribution grid and use net metering[52]. Banking of excess energy as well as the sale of excess energy to the distribution utility at the retail tariff applicable to the customer is permitted. No limits have been placed on energy supply by the DG

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[48] Based on inputs from Ram Prasad Dhital, Executive Director, Alternative Energy Promotion Centre (AEPC), Nepal and Hitendra Dev Shaky, Director, System Planning Department, Nepal Electricity Authority (NEA)

[49] http://www.worldbank.org/en/news/feature/2015/09/26/ensuring-sustainable-rural-electrification-in-nepal, accessed on 30th Dec 2015

[50] AEPC, 2015, Technical Standard for Rooftop Grid-connected PV

[51] Policy for the Development of Renewable Energy for Power Generation, Pakistan, 2006

[52] Distributed Generation/Net Metering Rules, NEPRA, 2015

to the grid or limits on capacity of distribution system. Pakistan currently has a total of 356 kW of distributed net-metered photovoltaic installations[53], but has ambitious plans to offer net-metering to 1 million customers over the next 2 to 3 years resulting in an installation base of 3 GW[54].

2.3.8 SRI LANKA[55]

The national energy policy of Sri Lanka in 2008, established a target of achieving 10% share of renewable energy in the electricity mix of Sri Lanka[56]. While there is no specific regulation that governs net-metering, the Net-Metering Manual published in 2010 by the Ceylon Electricity Board (CEB) lays out the conditions and procedures for DG systems. The net-Metering facility is available to all renewable energy technologies i.e., solar, wind, biomass, hydro and waste to energy up to a limit of 1 MW[57]. The net-metering contract is valid for 10 years and banking of energy is allowed for an unlimited period. However CEB does not compensate the DG systems for excess energy exported to the grid network. Currently, Sri Lanka has 1,732 DG systems of mostly Solar PV technology using net-metering facility with total installed capacity of 10.279 MW[58].

2.4 STATUS OF NET-METERING IN SAARC COUNTRIES

Generally, all SAARC countries are moving towards DG from renewable energy sources. Those countries which have moved earlier are showing higher levels of achievement. An overview and comparison of Net-Metering in SAARC countries is shown in table 8. There are 5 SAARC countries which have yet to develop DG or net-metering policies, the policies are under consideration and development in countries such as Bangladesh and Nepal. Three countries i.e., India, Pakistan and Sri Lanka have net-metering regulations and their markets are in varying stages of development. In case of India, the policies vary across the states and some states have taken the lead while others have lagged behind.

[53] At the buildings of Pakistan Planning Commission and the Pakistan Engineering Council.
[54] Renewable Energy in Pakistan (Potential and Prospects), Awan Amjad Ali, 2015
[55] Based on inputs from Anil Cabraal, Adviser, Sustainable Energy Authority and Gamini Herath, Deputy Director General, Public Utilities Commission of Sri Lanka
[56] National Energy Policy and Strategies of Sri Lanka, Ministry of Power & Energy, 2008
[57] Net Energy Metering Manual for contract demand up to 1000 kVA, Ceylon Electricity Board, 2014
[58] Statistical Digest, CEB, 2014

Table 8: Comparison of Net-metering in SAARC Countries

SAARC Country	Total Installed capacity (MW)	Limit of Electricity Supply/ System Size[59]	Banking	Wheeling	Feed-in-Tariff for Excess Solar Energy Supplied	Grid Penetration Limit as % of Distribution Transformer Capacity
Afghanistan	NA	Policy doesn't exist				
Bhutan	NA	Policy doesn't exist				
Bangladesh	NA	No limit on generation but Size limit of 1 MW	Policy doesn't exist	Policy doesn't exist	Proposals being developed	Policy doesn't exist
India[60]	525	State level limits as a % of consumption or % of connected load	Allowed in some states	Allowed in some states	Some states have tariffs which range from US$ 0.007 to 0.145	15-80 with 30% being most common
Maldives	1 MW	Policy doesn't exist				
Nepal	0.111	Policy doesn't exist				
Pakistan	0.359	No limit on generation but Size limit of 1 MW	Yes	Yes	Yes, same as retail tariff - US$ 0.120[61]	No
Sri Lanka	10.279	No limit on generation but Size limit of 1 MW	Yes	No	No	No

While there are distinct differences between national and state level models of net-metering in South Asia, a generic SAARC net-metering model which illustrates the common features is shown in Fig 2 and can be elaborated as follows:

- There seems to be a shared belief among policy makers and regulators in SAARC countries that renewable energy based DG connected to the electricity distribution networks is positive and should be encouraged;

- The wide-availability of solar resources across SAARC countries and the recent decreases in investment cost may help Solar photovoltaic to be the leading DG technology in South Asia. The other Renewable Energy technologies may not have a sizeable impact compared to Solar PV due to policy constraints, proven technology and non-availability of resource at point of consumption;

[59] A limit on individual system sizes either on the basis of the energy consumption in terms of kWh or in terms of maximum possible power demand or connected load in kW.

[60] More details about state level tariffs in India are given in Table 7.

[61] Schedule of electricity tariffs, Islamabad Electric Supply Company website 2015

- Only three SAARC countries viz. India, Pakistan and Sri Lanka have tariff regimes for DPV and DG systems as well as regulatory frameworks that cover net-metering, wheeling and banking. The offered tariffs, regulatory frameworks and instruments vary significantly across states in India;

- Tariffs for purchase of electricity from DG systems and DPV systems are usually not relevant as the purchase tariff is often the same as the retail electricity tariff to the end-user. Separate tariffs exist only in some of the Indian states. There is a proposed tariff being considered in Bangladesh while in all other SAARC countries tariff regimes for DG systems is yet to emerge;

- In India, eight states purchase excess electricity generated through net-metered systems at the retailed tariff. However, the six states of Chhattisgarh, Himachal Pradesh, Karnataka, Rajasthan, Uttar Pradesh and Uttarakhand offer specific tariffs for solar electricity ranging from US$ 0.007-0.145 per kWh;

- Distributed PV is seen more as an option to offset existing electricity consumption of end-user rather than a supplementary generation option;

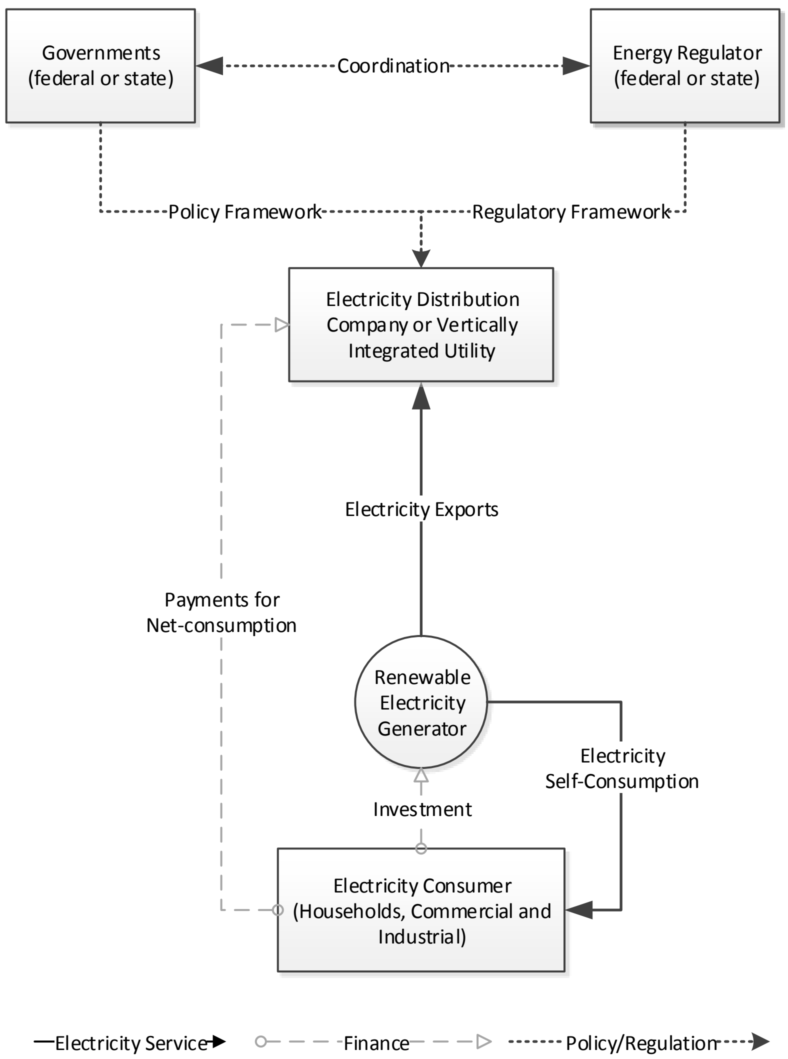
- In Pakistan, a feed in tariff for DG systems is same as the electricity retail rate of the Distribution Companies. In case of Sri Lanka, if during a billing cycle, the excess electricity fed into the grid is not utilized by the consumer, the respective units are not paid by Distribution Company. Indian states generally offer the retail tariff as the tariff for purchase of electricity from DG systems. However, six states have specified solar feed-in-tariffs for DG systems which covers a wide range of tariffs. The Tariff regimes for DG systems are yet to be put in place in other SAARC countries;

- In Nepal and Maldives, DG systems have been installed as a direct result of projects and in absence of policies. These countries may get benefit from experience of these projects.

- In India and Sri Lanka, the electricity utilities especially the vertically integrated utilities resist and retard the market development primarily due to revenue loss considerations[62]. In these markets, restrictions such as penetration limits linked to distribution capacities or unfavourable FiTs or limits on individual system sizes are being introduced.

[62] In markets such as India and Sri Lanka higher tariff paying customers from the industrial and commercial consumer segments are the drivers of rooftop PV systems. As a result the utilities are losing high value customers.

Fig 2: Net-Metering for Distributed Generation in SAARC Countries



2.5 GLOBAL NET-METERING EXPERIENCE FROM SAARC PERSPECTIVE

Once we compare the current SAARC country net-metering model with the experience in North America and Europe, we can observe differences in the national policies implemented in Europe and US. However, a generic model which brings together the commonalities can be identified which is given in Fig 3. The following points can be noted on the European and US experience from a SAARC perspective:

- In US, Net-Metering is wide spread within residential customers because the retail electricity tariffs for commercial and industrial customers are lower than residential customers in these markets and the Net-metering tariffs are the same as the retail tariffs. In SAARC countries as the commercial and industrial sectors pay higher electricity tariffs, they are likely to be the initial market segments to develop;

- Governments and regulators have either awarded or considering to award compensations to Distribution System Operators (DSO)s for net-metered distributed generation in European countries such as Germany, Belgium, Denmark etc. as well as US states like Arizona, Hawaii, Indiana, Oklahoma, Utah etc.

- The distributed PV markets in the US has accelerated through 'zero upfront financing' where development and financing companies finance and install PV systems on rooftops for net-metering and offer a lease payment option or a power purchase option to the facility owner;

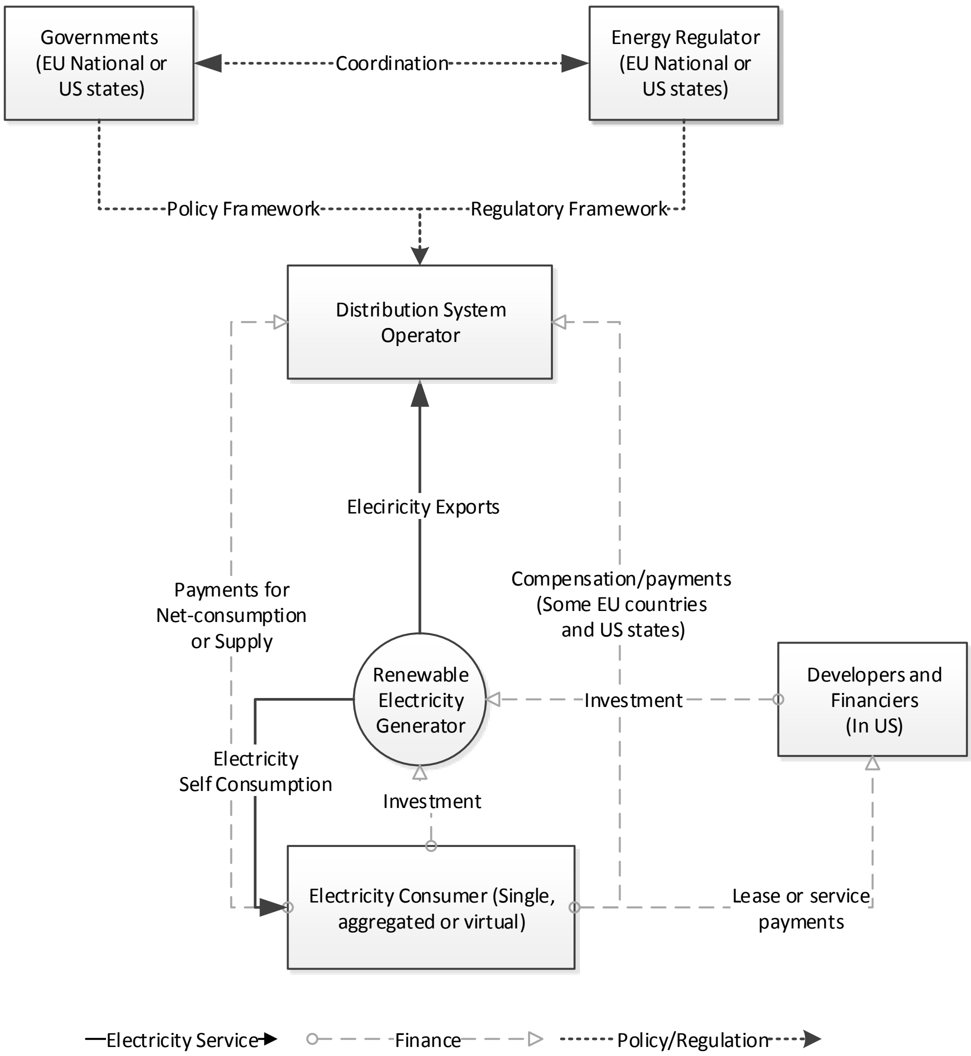
- Net-metering programmes have also evolved from single facility based net-metering to aggregated net-metering where apartment blocks, communities, campuses containing several individual facilities and electricity consumers can come together to have net-metering programmes. In Virtual net-metering, the generation and consumption does not take place in the same facility and allows users to offset consumption through generation which is at a different location i.e. a version of wheeling.

- The US and European countries have more experience with net-metering schemes. The evolution of the policies, regulations and the development of markets in their countries may offer lessons to SAARC countries. However, the conditions are different in SAARC countries since electricity markets here are at an early stage of development with energy shortages, projected demand increases, heavy public sector and government involvement, higher population densities and related socio-economic and development complexities. Therefore, solutions for SAARC countries may be found within the region or other developing countries.

- Summer electricity rates in California are US$ 0.24/kWh for households compared to US$ 0.16/kWh for commercial consumers while in Germany households pay on an average €0.24/kWh while commercial and industrial consumers on an average pay €0.24/kWh.[63]

[63] Bundesverband der Energie- und Wasserwirtschaft, 2015, Erneuerbare Energien und das EEG: Zahlen, Fakten, Grafiken (2015) - Pacific Gas and Electric, 2015

Fig 3: Net-Metering for Distributed Generation in US and European Countries



The policy makers and energy regulators in SAARC countries should consider these global developments and consider issues like aggregation, wheeling/virtual net-metering and compensation for electricity distribution companies to develop progressive frameworks.

3.0 TECHNICAL AND FINANCIAL ANALYSES

As the major technology which is driving the global diffusion of DG is photovoltaics and considering the trend and the resource base, SAARC countries will also have high levels of PV technology deployment. We examine the possible impacts of high levels of PV in grid systems in SAARC countries. We also analyse the costs of PV rooftop systems with and without battery storage from the consumer perspective and also discuss if grid connected micro-hydro DG system is a technical and economically feasible option.

3.1 GRID STABILITY AND PV PENETRATION

The existing developed market of DG in SAARC and the future global trends show that net-metered PV rooftop systems will continue to have the major share of the DG market among SAARC countries. The distribution system operators in Europe and North-America have started resisting the proliferation of distributed net-metered PV systems primarily due to revenue loss considerations. While revenue loss is an important concern, there have been technical issues such as limits on the energy generation or capacity of the system or limits on systems that can be connected to the distribution grid in a location. Such resistance have also been witnessed from electricity distribution companies and vertically integrated utilities in SAARC countries such as India and Sri Lanka.

The very high levels of penetration of PV and Wind DG systems compared to the installed generation capacity of the network will have the characteristic of variability of generation. This variability exists as resources such as wind and solar vary on an annual/ monthly/ daily basis and there are also variations over a short time period. Such variability of renewable DG systems especially PV contrasts with traditional DG systems such as diesel generators where fuel can be stored and the generation is on demand and does not vary. This variability of DG systems especially PV has been cited as a concern by electricity distribution companies and vertically integrated utilities to discourage PV net-metering schemes. Another factor to consider is the power quality issues in the distribution networks where there are voltage fluctuations and sometimes black-outs which pose technical challenges to integration of DG systems in the low voltage distribution networks.

From a technical perspective, there is a possibility of four types of effects on grid stability as a result of high levels of penetration of PV rooftop systems in electricity networks. These are explained below.

3.1.1 HIGH VOLTAGE

It is important for electrical networks to maintain voltages at all points in the network within safe limits to protect the electricity consumers and their electrical equipment. There could be a situation whereby concentration of Rooftop PV and/or other DG generation systems are at a large distance from the distribution transformer. A high voltage may result from such a large cluster of DG systems or through a single large DG system in electrical distribution networks. Such instances where power is fed at the end of distribution lines could result in excessively high voltages that could damage electrical equipment being used by consumers. However, in case of SAARC countries, the remote locations those are away from the distribution transformer experience lower voltages than the rated voltages during peak load hours. Sometimes these consumers are subject to high voltages during non-peak hours. Therefore, PV Rooftop systems can be effectively used to provide voltage support in remote locations of the grid especially during day-time peak period.

3.1.2 NETWORK OVERLOAD

The overloading of electrical network cables and distribution feeders generally occur when there is higher demand in the electrical network than the capacity or when there are higher levels of generation fed into the distribution network beyond the capacity of the cables and the feeder. The network overloading doesn't occur if DPV systems are spread out evenly in the distribution network. However, if the DPV systems are clustered close to the distribution feeder or in a particular location in the electrical network there may be thermal overloading of the electrical network. In case of India, several states have specified limits to penetration of PV systems as a percentage of the distribution feeder capacity. Such limits are indicated in table 7 with range between 15-50% and 30% being the most commonly used limit. The specifications of such limits are quite safe as the thermal overload depends on several factors with the main factor being demand rather than the DPV systems. However, it may be noted that it will take considerable amount of time before even such conservative limits such as 30% of the feeder capacity is reached by DPV systems in all SAARC countries. Generally based on experience in US and Europe, DPV is evenly distributed across the electrical network without incidence of overloading problems.

3.1.3 FREQUENCY VARIATIONS

There could be minor variations in frequency due to DG systems as their generation varies during the day time; this is specifically relevant in network systems where the level of DG systems is significantly higher. In such cases, the PV generation is low during the early hours of the day and peaks during mid-day and then decreases towards the later part of the day. There will also be variations in generation due to seasons where PV electricity generation is high during summers; and low during winter and/or periods with high levels of precipitation. The variation in frequency may also occur due to the cloud cover over the PV array which may reduce PV generation by as much as 80%[64]. Such variations due to cloud cover where PV generation increases or decreases significantly and the consequent frequency variations may pose a serious challenge for electrical utilities to manage. However, these frequency variations due to DG systems are similar to variations in demand which also affect the frequency of the electrical distribution network. Thus, electricity distribution companies have the experience to manage frequency variations due to changes and variations in demand. To reduce the occurrence of such cases, the electricity distribution companies in India have also specified overall limits to PV penetration in the grid as a percentage of total generation capacity or as a percentage of distribution feeder capacity.

[64] When a cloud covers a PV array, the direct or beam component of the solar radiation which comprises of about 80-85% of the solar insolation does not reach the plane of the array. Only 15-20% of the diffuse radiation reaches the array during the period with cloud cover.

3.1.4 LOAD SHEDDING AND SAFETY

The sudden decreases or increases in PV generation due to cloud cover poses challenges to electricity distribution companies due to the possibility of load shedding and possible collapse of the grid. Such instances are only relevant when the penetration of PV in the electrical network is very high compared to the installed power generation capacity in the network. When frequency changes, generation is increased or decreased to maintain the frequency within allowable limits and if the frequency drops below specified limits load-shedding at the distribution feeder level is carried out to prevent a total system black-out. Such possibilities for load-shedding and system black-outs are quite low as the utilities often maintain a spinning reserve generation to increase or decrease power generation on account of load fluctuations. Such back-up spinning reserve generation[65] can be used to compensate for the decrease or increase in PV generation due to cloud cover in the same manner as electrical load fluctuations. When the spinning reserve generation is not enough to stabilise the system the utilities often resort to load-shedding to avoid black-outs. Such a situation would be quite unlikely in most cases as the magnitude of sudden decrease or increase in power generation from PV needs to be of a very high magnitude considering the energy generation and demand at the time. In reality for this to happen a very large cloud needs to cover all the distributed PV systems in an electrical network in a matter of minutes. In SAARC countries such a scenario is unlikely due to the large geographical spread of the electricity network and the relative size of the electricity generation capacity vis-à-vis possible penetration of PV. However the frequency variations and resultant safety measure of load shedding or a system black-out due to a cloud cover is a possibility for Maldives due to small land area of the islands and small size of the power systems. In Maldives, the inhabited islands are powered by diesel generators and as the penetration of PV rooftop or distributed systems increase in such small island grids, there may be potential for sudden changes in PV generation due to cloud cover that may affect the system stability. In such cases, the penetration of PV in grid network may be limited and in accordance with the minimum operating level[66] of the diesel generator sets in the diesel mini-grid and the unit size of the diesel generator. In general, the safety issue for the overall grid network due to cloud cover is not significant for SAARC countries.

3.1.5 GRID STABILITY ISSUES AND PV PENETRATION IN SAARC COUNTRIES

The above mentioned four issues which may arise due to high levels of DPV in electrical distribution networks are unlikely to pose any serious challenge to electricity distribution companies and/or utilities in SAARC countries. The utilities in SAARC region have ample experience in managing such technical issues arising from demand fluctuation. However, the issue of frequency variations due to sudden changes in PV power generation in an area due to cloud cover could affect micro and mini-grids in SAARC countries such as Maldives. The use of Demand Side Management (DSM) techniques as well as the use of energy storage could also help SAARC utilities to address such variations easily. It can be said that accelerated penetration of distributed PV does not create any major grid stability issues in SAARC countries.

[65] Generators generating below their rated capacity with the possibility of quickly increasing or decreasing generation to compensate for load fluctuations.
[66] As a percentage of the rated power generation capacity.

3.1.6 PICO AND MICRO HYDRO POWER AS DISTRIBUTED GENERATION IN SAARC COUNTRIES

Micro-Hydro Power (MHP) systems[67] have been a popular DG option in SAARC Countries of Afghanistan, India, Nepal, Pakistan and Sri Lanka. They are used for powering isolated grids which are offering village electrification in remote and mountainous regions located close to rivers and streams. There are also Pico hydro[68] systems for household level electrification in these SAARC countries. Mostly, micro and pico hydro systems are located away from the national electrical grid networks and are operated by communities or private parties. Due to the large distance from the electrical grid and complexity of the terrain, these DG systems have remained isolated from the national grids. In many cases, as and when the national electric grid is extended to the service areas of these MHP or pico hydro systems, the systems have been abandoned in favour of the more reliable grid based electricity supply. The electric utilities in countries like Afghanistan and Nepal have discouraged connecting the MHPs to the national grid due to concerns about the quality of energy supply. As explained in section 2.3.6, Nepal is in the process of interconnecting a number of MHPs of capacity larger than 100 kW to the 11 kV high voltage line with the possibility of energy storage by lead acid batteries. There are very few instances of pico hydro systems getting connected to the low voltage distribution network. The micro and pico hydro power systems will continue to play an important role as DG systems for electrification of households in remote and mountainous regions. However, there are limited prospects of micro and pico hydro power systems on net-metering mode due to issues of remote areas and power quality.

3.2 FINANCIAL ANALYSIS OF NET-METERED PV SYSTEMS

3.2.1 ANALYSIS AND RESULTS

A financial analysis was carried out for a representative case of a PV system as per the cost and energy meteorological data for three SAARC countries such as India, Pakistan and Sri Lanka. The analysis evaluated below mentioned 3 scenarios for India, Pakistan and Sri Lanka using RETScreen®, the highly popular clean energy project analysis software[69]:

- A grid-connected net-metered PV system without a battery back-up;
- A grid-connected net-metered PV system with a battery back-up;
- An off-grid PV system with a battery back-up.

The costs of Solar PV system in the respective countries were estimated as per prevailing regional prices (Solar System including Balance of System costs US$ 1.6 per watt) and the solar insolation data was used from global solar resource database. The assumptions used for the analysis are shown in table 9. Based on the assumption of a continuous load of 1 KW[70], a PV system was designed without batteries as a net-metering configuration for each of the three locations. The system configuration was optimised for the solar insolation levels at the location.

[67] With hydro power generation capacity of less than 100 kW
[68] With hydro power generation capacity of less than 1 kW
[69] With over 435, 000 users in more than 220 countries. More details at www.retscreen.net
[70] The load assumptions were used to calculate the monthly energy consumption and to size the PV array for the selected locations.

Table 9: Assumptions for Financial Analysis of PV Systems

Assumption	India	Pakistan	Sri Lanka
Location for Analysis	New Delhi	Islamabad	Colombo
Coordinates[71]	28.61 N, 77.1 E	33.71 N, 73.06 E	6.9 N, 79.9 E
Inflation (%)	4.8%[72]	5%[73]	0.91%[74]
Exchange Rate to 1 US$	66 INR	104 PKR	140 SLR
Electricity Consumption Tariff (US¢/kWh)	9.09[75]	12.89[76] [77]	14[78]
Solar Feed-in-Tariff (US¢/kWh)	8.31[79] [80]	12.02[81]	0[82]
System Life (Years)	25	25	25
System Configuration	5.2 kWp Poly-crystalline Silicon Array with a 5 kW Inverter	6.6 kWp Poly-crystalline Silicon Array with a 7 kW Inverter	5.8 kWp Poly-crystalline Silicon Array with a 6 kW Inverter

The analysis was carried out assuming that the investment will be made by the net-metering consumers without the need to borrow money. The current electricity tariffs and feed-in-tariffs in the three locations i.e., New Delhi, Islamabad and Colombo were taken for the analysis. A system life of 25 years was also assumed which is consistent with standard international practices. The results of the financial analysis of net-metered PV systems without battery are shown in table 10.

Table 10: Results of the Financial Analysis of Net-Metered PV Systems without battery

Parameters	India	Pakistan	Sri Lanka
Investment Costs ($)	8,320	10,560	9,280
Total Annual Revenue from savings and income ($/Year)	806	1,130	1,226
Payback Period (Years)	8.3	7.6	7.3
Internal Rates of Return (IRR) (%/Year)	13.6	15	13.5

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[71] The exact geographical location is important to determine the solar insolation at the location of DG system installation and to determine the solar geometry for system design.
[72] www.tradingeconomics.com/india/forecast, Inflation Rate, economics forecast 2020
[73] www.tradingeconomics.com/pakistan/forecast, Inflation Rate, economics forecast 2020
[74] www.tradingeconomics.com/sri-lanka/forecast, Inflation Rate, economics forecast 2020
[75] Distribution Tariff for FY 2015-16 for New Delhi Municipal Council, September 2015, page 107
[76] Schedule of electricity tariffs, Islamabad Electric Supply Company website 2015
[77] Daily average tariff of electricity for users with sanctioned load exceeding 5 kW is taken as PKR 13.41/kWh
[78] Tariff plan, Central Electricity Board, 16th Sept 2014
[79] Guidelines under DERC (Net Metering for Renewable Energy) Regulations, 2014, page 7
[80] Delhi bulk supply tariff rate (INR 5.49/ unit) for BSES-Delhi Electricity Distribution Company was taken from one of their presentation
[81] S.R.O. 892(1)/2015 dated 1st Sept 2015, NEPRA Regulations of Distributed Generation
[82] Net Metering Development in Sri Lanka, Public Utilities Commission of Sri Lanka

The Analysis also included a scenario with back-up battery bank to the net-metered PV system which may allow the system to work on a hybrid mode.[83] Such a practice is noticed in parts of SAARC countries where electricity supplies are unreliable and where businesses and households invest in back-up power supply through battery banks. A battery bank with autonomy of 2 hours may be able to supply uninterrupted power during 2 hours of grid-electricity outage. The results of the financial analysis of Net-Metered PV Systems with battery are given in Table 11.[84]

Table 11: Results of the Financial Analysis of Net-Metered PV Systems with Battery Storage

Parameters	India	Pakistan	Sri Lanka
Investment Costs ($)	8,988	11,320	10,040
Total Annual Revenue from savings and income ($/Year)	806	1,130	1,226
Annual O&M costs ($/Year)	106.88	121.6	121.6
Payback Period (Years)	9.9	8.8	8.7
Internal Rates of Return (%/Year)	11	12.7	11

Another analysis was done where the prospects of a 1kW and 2kW off-grid PV system including battery was evaluated against Diesel generator. The solar insolation data was used from global solar resource database for Islamabad, Pakistan. To achieve this, the autonomy of both systems was increased to 1 day which may supply the energy requirements (5kWh) for a day in the absence of solar electricity generation.[85] The off-grid PV systems were compared with the baseline option of a Diesel generator in the financial analysis.[86] The results of the financial analysis of an independent off-grid PV Systems with battery are given in Table 12. However, it should be noted that such systems are considered as alternatives in un-electrified remote locations where a diesel generator is the possible electrification option.

Table 12: Results of the Financial Analysis of Off-grid PV Systems with Battery Storage

Parameters	1 kW system	2 kW system
Investment Costs ($)	3,500	7,000
Annual O&M Costs ($)	304	608
Total Annual savings ($/Year)	1,213	1,778
Payback Period (Years)	3.4	5.1
Internal Rates of Return (%/Year)	32.2	22.1

[83] Cost estimate for Valve-regulated lead-acid battery used in analysis were taken from each country's market (US$ 167/kWh for India and US$190/kWh for Pakistan, Sri Lanka of total battery capacity)
[84] A battery bank of 4kWh will be replaced after every 5 years.
[85] A battery bank of 10kWh for 1kW and 20kWh for 2kW PV systems will be replaced after every 5 years.
[86] Cost of a diesel generator of 1kW capacity was taken as US$1,000 and 2kW capacity as US$1,700 which will be replaced 3 times in total life of project. Annual O&M cost (monthly Oil change and regular maintenance) of US$600 was taken. Fuel cost of diesel was taken as 0.80 cents/litre.

3.2.2 FINANCIAL ASPECTS OF NET-METERED PV IN SAARC COUNTRIES

The analysis of the various costs and benefits associated with Net-metered PV systems in three different locations of SAARC countries has revealed the following:

- The prospect of PV net-metering is an attractive proposition in any of the SAARC countries if the PV system is designed specifically for self-consumption and not for exporting power to the distribution grid. Currently, the distribution companies or utilities offer lower tariff rates for purchase of energy from residential solar PV.

- The PV system prices are comparable across SAARC countries and so are the system configurations. There is a change in the system configuration across countries as Islamabad requires a larger system while Colombo and New Delhi require smaller systems due to variations in solar resource availability. These variations do affect the investment cost of the systems.

- The use of battery storage to provide back-up power doesn't affect the financial benefits from the systems. Such an option may be justified in situations where the financial loss due to electricity outage is very high. However, the addition of few hours of autonomy through a battery bank does not have a significant impact on financial parameters.

- The option of residential consumers in SAARC countries becoming totally independent of the grid electricity service through use of DPV is very unattractive. For such an option to be worthy of consideration, the retail tariffs will need to increase or the investment costs will need to reduce significantly.

- The results of an off-grid PV system with battery are very encouraging in un-electrified locations. The analysis was conducted with diesel generator as a benchmark in remote and decentralised region.

3.3 FINANCIAL ANALYSIS OF MICRO AND PICO HYDRO

As explained in section 3.1, pico and micro hydro systems are popular in many SAARC countries as a DG option often as an isolated grid or as a home based system. These systems are popular in India, Nepal and Pakistan apart from Afghanistan and Sri Lanka. A financial analysis has been carried out for India, Nepal and Pakistan for a MHP powering a largely domestic energy requirement and some agro-processing with an average load of 2 kW and utilisation factor of 30% and assuming a system life of 15 years.

Table 13: Assumptions for Financial Analysis of Micro Hydro Systems

Assumption	India	Pakistan	Nepal
Location for Analysis	Arunachal Pradesh	Khyber Pakhtunkhwa	Mid-West
Inflation (%)	4.8%[87]	5%[88]	8.3%[89]
Exchange Rate to 1 US$	66 INR	104 PKR	106 NPR

[87] www.tradingeconomics.com/india/forecast, Inflation Rate, economics forecast 2020
[88] www.tradingeconomics.com/pakistan/forecast, Inflation Rate, economics forecast 2020
[89] www.nrb.org.np Nepal Rastra Bank, accessed December 2015

Electricity Consumption Tariff (US¢/kWh)	9.09[90]	12.02	7[91]
System Life (Years)	15	15	15
System Configuration	4 kW Cross-flow turbine with induction generator and distribution at 230 V	3 kW Cross-flow turbine with induction generator and distribution at 230 V	4 kW Cross-flow turbine with induction generator and distribution at 230 V

The financial analysis was carried out for each of these three locations with the assumption that the hydro power availability is perennial assuming the financial parameters detailed in table 13. The analysis was carried out by sizing the hydropower system to fully meet the load requirements and applying the investment coats and the other financial parameters. The results of the financial analysis for the three countries are presented in Table 14. Hydro power projects were not analysed on a grid interactive mode or with battery storage as such instances are not generally prevalent across SAARC countries.

Table 14: Results of the Financial Analysis of Micro-Hydro Systems

Parameters	India	Pakistan	Nepal
Investment Costs ($)	7,680[92]	4,500[93]	6,000
Total Annual Income ($/Year)	796	1,051	613
Payback Period (Years)	7.8	3.8	7
Internal Rates of Return (%/Year)	11.2	28.3	14.7

From the analysis it can be seen that due to a number of factors such as lower investment costs, higher utilisation factor etc. hydro power projects as DG systems do have a higher internal rates of return and a shorter payback period. While it is evident that DG system possibilities from hydro present a better financial alternative to PV, their application is limited by the availability of locations with hydro potential near the points of consumption, power quality challenges and proximity to the grid. However hydro power especially MHP presents a very promising option for village electrification through isolated grids in SAARC countries.

[90] www.ndmc.gov.in New Delhi Municipal Corporation, accessed September 2015
[91] NEA, 2014, NEA Electricity Tariff Rates
[92] Inputs from Hydro Power Network
[93] Inputs from Hydro Power Network and Agha Khan Rural Support Programme, Pakistan

4.0 GUIDELINES

4.1 GENERAL GUIDELINES

4.1.1 EQUIPMENT

Globally, the most popular DG system used is the distributed PV installed on rooftops of buildings/homes and offices. It is also considered as the most appropriate DG system in SAARC countries as well. Therefore the guidelines relating to equipment is given below for Photovoltaic systems only. The DPV systems generally have two major components i.e., PV array and the Inverter; while some systems may have a battery bank but this is not considered a normal practise.

4.1.1.1 PHOTOVOLTAIC ARRAY

PV modules have now reached a stage where they offer high reliability and long service life of approximately 25 years. It is recommended that SAARC countries use either crystalline silicon photovoltaic module type certified according to IEC 61215[94] or thin-film photovoltaic module type certified according to IEC 61646. In addition a minimum warranty of 25 years with degradation of power generated not exceeding 10% over the entire 25-year period is required for all PV Modules.

4.1.1.2 INVERTER

Inverters are an important component of the DPV systems and there is a wide range of quality inverters in the market. Then quality of the inverters varies with both local South Asian manufacturers and international sources. The selection of the inverter is quite important to ensure grid quality power injection as well as long term reliable operation in South Asian conditions. All the local and imported inverters should be certified according to IEC 61727 and IEC 62109. A copy of test certification should be mandatory before import/supply and should be authorised by the relevant SAARC country's quality/standards institute. The inverter should have the capability to be on a utility interactive mode. Rated output voltage shall be AC 230V± 10% over the full range of PV array operating voltages. That is, when the input DC voltage varies from 80% to 120%, the output AC voltage must be within 10% of the rated voltage[95]. The inverter output frequency should be 50Hz and the variation should not be over 1%. The inverter output waveform should be pure sine wave and the output waveform total harmonic distortion should be no more than 5%. The inverter shall be capable of operating continuously for 10 hours at its rated power under ambient temperatures of 40° Centigrade or temperatures that are relevant to the SAARC countries.

Inverter circuits must include protection against over-current when working current is greater than 150% of the rated current, short circuit of input and output terminals, reverse polarity on DC input terminals and lightning induced transients. The maximum quiescent current draw of the inverter circuit must not exceed 3% of the rated input current of the inverter. The noise produced by the inverter unit should be no more than 65dB at a distance of 3 meters from the

[94] Some SAARC countries have national standards that are harmonised with IEC standards. Wherever such national harmonised standards are available, they may be used.
[95] These grid quality specifications and the voltage range can be modified according to the relevant standard in the applicable SAARC country.

inverter. The power factor shall be 0.95[96] leading to unity relative to the electricity distribution company or the utility's Electricity supply.[97] Protection should be provided to isolate the PV system connected through the inverter to the electricity distribution company/Utility distribution system when the mains supply is lost or when the level of DC injection exceeds 5 mA. The loss of mains protection must ensure that the inverter disconnects from the electricity distribution network within 5 seconds and does not reconnect until at least 3 minutes after the electricity supply has been restored. When the system is disconnected this must be achieved by the separation of mechanical contacts and electrical disconnection alone is not sufficient. The casing of the inverter should provide adequate protection for the electronic components housed inside and should be Ultra Violet (UV) resistant and water-proof. Charge regulator boxes should display good workmanship and should provide protection according to the standard IEC 60529. For indoor installations the reference under IEC 60529 will be IP 32 and for outdoor installations it will be IP 54. For inverters installed on the external wall of the facility, the casing should be able to resist at least 25 year life of outdoor exposure in climate conditions that are relevant to the SAARC country without suffering significant damage or corrosion.

If batteries are used, the inverter should be upgraded to a Power Conditioning Unit (PCU) which also includes a battery charge regulator. The charge regulator must protect the battery from over-charging, but at the same time allow the battery to reach a full state of charge efficiently. The upper voltage thresholds of the charge regulator must be suitable for tubular plate deep cycle batteries and the expected range of battery operating temperatures based on the battery manufacturers data. Built-in temperature compensation should be provided for over-charge protection and override facilities to permit equalisation charges. The charge regulator discharge control must ensure that the battery is not discharged below a suitable level by providing deep-discharge protection. The maximum depth of discharge should be selected to ensure that discharges down to this level will not cause premature damage to the battery[98]. Current and temperature compensation may be required on the load-shed voltage, for adequate battery protection.

4.1.1.3 BATTERY

It is not recommended to use a lead-acid battery for energy storage along with the grid-connected PV system as the electrical grid acts as the storage. If batteries are used, they should be certified according to IEC 61427. The recommended battery type for SAARC countries is flooded lead-acid type with positive tubular plate[99]. If batteries are used, is suggested to provide 3-4 hours of autonomy while determining the battery size depending on duration and time of day of electricity outages.

4.1.2 INSTALLATION AND COMMISSIONING

Proper installation and commissioning of the systems is quite important to ensure safety to the users of the facility and to the electrical network. Proper installation and commissioning is also required to ensure maximum performance of the systems. The following guidelines are provided to ensure that DPV systems in SAARC countries are installed and commissioned to ensure safe and optimal performance:

[96] This value may be adjusted as per the specifications by the electricity distribution company or the utility's requirements in the SAARC country.
[97] Leading power factor is VARs absorbed by the inverter.
[98] As established from battery manufacturer's data
[99] Modified SLI or 'Solar' batteries are also being used by some installations in South Asia

- The PV array and the support structures should preferably be mounted on the roof of the consumer. The PV array support structure should be fixed at an optimal tilt angle[100] facing the South/Equator. The support structure should be designed to ensure the modules are mounted with reduce effects of shading. It should be ensured that the entire space requirement of the array is met within the shade free space limits available at the facility.

- PV modules should be mounted on non-corrosive support structures to be made of stainless steel, aluminium or galvanised iron (with a protective layer of 30 μm). Support structure design and foundation or fixation mounting arrangements should be able to withstand minimum horizontal wind force of 150 km per hour and should be able to resist at least 25 year life of outdoor exposure in the climatic condition relevant to the SAARC country[101] without suffering significant damage or corrosion.

- The DPV system installers should provide wiring and protection on the DC side and on the AC side up to the interface with the existing electrical system of the electricity distribution companies. The maximum current of a PV array (or sub-array) shall be regarded as 130% of the nominal short-circuit current of the array (or sub-array) rated under Standard Test Conditions (STC).

- In the two-conductor DC wiring system on the PV array side, the negative conductor should be grounded, by direct connection to a good earth contact. The connection to earth shall not contain any fuses or switches. The conductor connecting the grounded conductor to earth must not be less than the largest conductor in the circuit. Hence all switches, fuses and interrupts must be installed in the ungrounded positive conductor.

- The following conventions shall be followed for two-conductor DC wiring the PV power systems, Positive-Red and Negative-Black. Separate earth conductors, if present, should be green or bare. Fuses and circuit-breakers shall be rated for DC service, have voltage ratings greater than the maximum circuit voltage and have current ratings between 125% and 150% of the maximum design current for the circuit.

- The voltage drop in the cables between the PV array and the inverter shall normally not exceed 1% of the nominal voltage, at maximum rated array current. The minimum cross sectional area of the copper cables to be used on the DC side should be calculated according to the following formula $S = 0.3 \times L \times I_m / \Delta V$[102]
- The DPV power system should be installed only by a technician who has the relevant Technical and Vocational Education and Training (TVET) qualifications and certifications that are relevant to the SAARC country. If national level schemes for certification of solar energy or renewable energy technicians exist, such schemes may be used.

[100] The optimal fixed tilt angle can be calculated or obtained using the heuristics of adding 15 to the latitude of the location.
[101] Saline marine climate in the Maldives to high altitude cold climates in Bhutan and Afghanistan.
[102] Where S is the cross-sectional area of the cable in mm^2, L is the cable length in meters, I_m is the maximum current in Amperes, and ΔV is the maximum allowable voltage drop in % which should be set as 1%.

- Adequate training should be provided by the company to the user[103] to enable them to safely operate the system and to carry out basic upkeep and maintenance. A user manual with illustrations and easy to understand narration in English and/or the national or regional language in the SAARC country should be provided to the user. The user manual should essentially cover the basic principles of PV, illustration and description of the grid-connected PV system and components, regular maintenance and operation procedures, 'Do's and Don'ts etc. as well as contact numbers of the supplier for support and service.

- Final testing and commissioning of the distributed PV system should be done by the system supplier/installer, electricity distribution company engineer and the consumer.

4.1.3 IMPORTS, TESTING AND DEVELOPMENT

It is likely that a large share of PV modules and inverters that will be used in PV systems will be imported by all SAARC countries. It is therefore important to ensure that the equipment imported into SAARC countries are of superior quality and comply with internationally accepted norms. The following guidelines are provided for SAARC countries that import PV systems and components:

- Wherever local test laboratories conforming to IS0/IEC standards exist in SAARC countries, the conformity tests with specified IEC standards for PV modules and inverters that are imported should be carried out locally.

- Where local testing laboratories do not exist, the national standardisation and quality control bureau or authority may verify and confirm that the conformity tests are issued by an accredited international laboratory and that the standard used is the relevant or equivalent IEC standard. It is suggested that the documentation be approved by the national bureau or national laboratory before permission to import is provided.

- It is encouraged to use IEC standards for national laws & regulations relating to DPV systems as SAARC countries can have a wide range of supply sources apart from ensuring high levels of performance and safety. A list of IEC standards relevant for distributed PV systems is given at Annex C.

- In addition to conformity tests of PV modules and inverters, the certification of Quality Management System (QMS) of the production facilities where the equipment is produced should be mandatory. This will ensure that all the equipment produced in the production facilities have uniform specifications.

- The customs and import officials at the import facilities i.e., seaports, airports and road border crossings should be provided training on the relevant test certification requirements that can be accepted for PV systems and components.

- If batteries are used in the system, the PV system supplier will be responsible for collection and safe disposal of used lead-acid batteries after the useful lifetime. The

[103] Appropriate member of the household in the case of domestic installations and an electrical technician or an equivalent in the case of commercial installations.

supplier should provide details of arrangements for collection and disposal of lead acid batteries. Used lead-acid batteries are considered as hazardous waste and cannot be imported into or exported from SAARC countries.

- The capability to test PV modules, inverters, electronic components and batteries may be established in the national electrical, power or electronics laboratories. If possible, such laboratories may be certified according to ISO/IEC 17025 which will provide recognition to its issued certificates.

- If national testing facilities for DG systems and its components are established in the SAARC countries, it will also encourage in future the indigenous development of associated products of DG systems and their certification by local researchers, product developers and enterprises. This is particularly true for inverters, batteries and power conditioning units. The future investments by SAARC governments in such infrastructure may help the development of local enterprises in field of testing and calibration. Other SAARC countries may also access these regional laboratories.

4.2 OPERATING GUIDELINES

To ensure that DG systems have an important role in the energy systems in the future, the electricity distribution companies/ energy utilities and the energy regulators will have an important role to play. The general scenario currently in SAARC countries is one in which the regulators and policy makers seems to encourage DG systems but the electricity distribution companies and utilities are progressing cautiously and sometimes discouraging the development due to concerns about revenue loss. The following guidelines are suggested for electricity distribution companies and regulators:

4.2.1 ENERGY REGULATORS

The Energy regulators in SAARC countries should continue to encourage DG systems based on renewable energy which will provide positive long term economic benefits to SAARC countries. Some of the recommended ways for SAARC energy regulators to ensure orderly development of DG systems in South Asia are:

- Allow DG systems, especially DPV to be connected to the distribution grids by all consumers. However, a limit may be placed on the size of the systems so that the emphasis is on meeting self-consumption rather that electricity sale to utilities. The possible ways in which such limits can be placed include making it mandatory for the systems to be on the roof of the household or facility, or limiting the annual energy generation to the present annual consumption of the consumer;

- Allow banking of electricity so that the users have the flexibility to use the energy as per their demand, thereby accommodating diurnal and seasonal variations in solar insolation;

- Discourage oversized systems that generate more than the current or projected energy demand. This may be achieved by offering relatively low FiTs for energy purchase by electricity distribution companies after the banking periods;

- Allow net-metering, aggregated net-metering and virtual net-metering for groups of consumers;

- Encourage and incentivise innovative financing schemes that offer zero upfront financing to consumers who wish to install DG systems and use net-metering schemes. In terms of regulation, this may mean flexibility of interpretation of system ownership with the requisite checks and balances;

- Consider mechanisms to encourage electricity distribution companies and utilities to benefit from the market development of DG systems through innovative business models where electricity distribution companies could sell or lease DG systems to prospective consumers;

- Consider and establish mechanisms that compensate electricity distribution companies for banking of energy generated by net-metered DG systems. Such mechanisms can be performance based rather than simplified periodic payments that are pegged to the size of the systems;

- Allow electricity distribution companies to charge reasonable costs for metering – either bi-directional meter or an extra export meter as well as for application processing, inspection and commissioning to compensate for the equipment and services rendered. Regulators can ensure that such fees and costs are not set high by electricity distribution companies to discourage prospective prosumers;

4.2.2 ELECTRICITY DISTRIBUTION COMPANIES

Partnership between the electricity consumers who are turning into prosumers and the electricity distribution companies are crucial for the success of the DG systems market development and the net-metering schemes. For net-metered DG systems to realise their full potential in South Asia, the electricity distribution companies are suggested the following:

- Strictly ensure that quality of DPV systems especially the conformity and quality of the inverter or the Power Conditioning Unit are as per required safety and quality standards. Also strictly monitor the quality and conformity of the installation and commissioning of the whole system;

- Establish a single window speedy clearance of all net-metering applications by consumers and establish clear processes, formats, fees and costs requirements for processing, inspecting and commissioning net-metered distributed PV systems[104];

- Encourage daily and seasonal energy banking of energy by net-metered consumers and charge reasonable service fees that fairly value the energy banking services provided by the utility;

- Offer services of supply and installation of PV and other DG systems to the customers as a revenue generating business proposition. Such business model innovation could result in significant revenues to electricity distribution companies from DG systems. The electricity distribution company may take advantage of the consumer base.

[104] CEB in Sri Lanka has a good manual which outlines the requirements and the processes.

5.0 ENABLING ENVIRONMENT

It is important for SAARC governments, energy regulators and energy utilities to facilitate market development of DG systems in South Asia. All South Asian economies will benefit from DG systems in the long run. However to ensure that DG systems continue to play a sustainable long term role, the following recommendations are made:

- Both SAARC regulators and electricity distribution companies should ensure that only high quality DG systems are connected with the grid and there is compliance with all the adequate safety provisions as recommended in section 4. This is very important to ensure that the performance and safety aspects of the systems are addressed early on in the market development;

- SAARC Governments should make policies that encourage households, commercial and industrial buildings to install DPV systems. This may be done through making DG systems mandatory for new buildings or by providing incentives for those who wish to install DPV in existing facilities and residences;

- SAARC Governments may finance the establishment of local testing, certification and calibration facilities for DG system components so that international exporters and local manufacturers can test equipment and system components nationally/regionally;

- SAARC governments may also consider and provide incentives for establishment of manufacturing facilities for components of DG systems in SAARC countries. Such incentives could involve single window clearances, tax holidays, access to land, utilities at preferred rates, full repatriation of profits by foreign investors, low interest loans for establishment of such facilities etc;

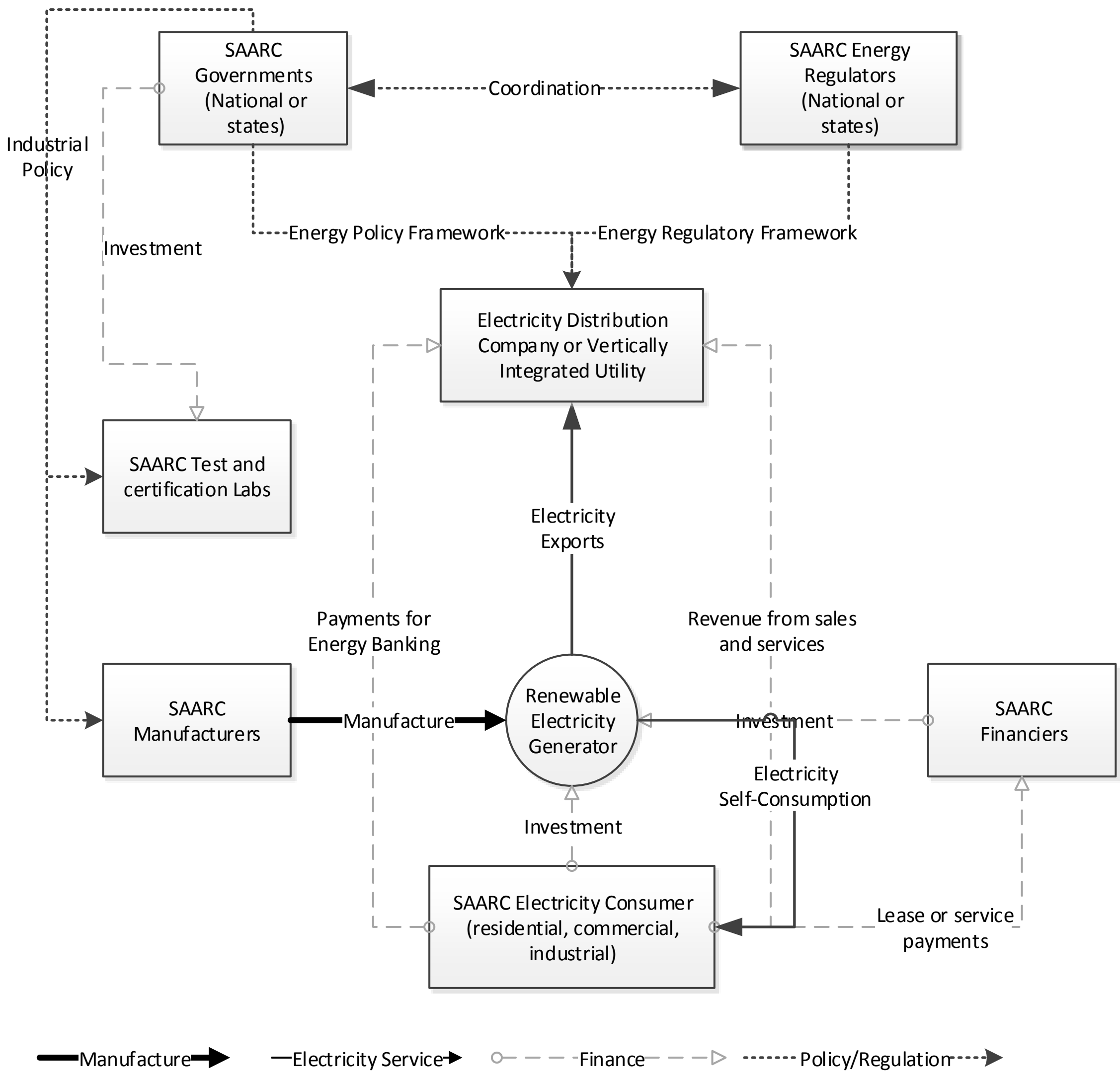
- There is an opportunity for employment in manufacturing, services, engineering, installation, commissioning and maintenance of DG systems. The employment opportunities in services are expected to be more than the manufacturing job opportunities. SAARC governments should place emphasis on public/private technical and vocational training for engineers and technicians; this may help in skill development of local resource as the market develops in future;

- Establish regulatory and incentive frameworks by Regulators and financing institutes which may encourage SAARC electricity distribution companies and vertically integrated utilities to reform and restructure their business model. This would help distribution companies in making additional revenues from energy banking fees, fees for processing, inspection, upgrading/sales of meters, sales and installation of DG systems;

- Encourage public and private financiers to provide financing models and options such as leasing of net-metered DG systems to large businesses, industries and affluent households.

All of the above measures and suggestions if adopted may help in creating a South Asian model for net-metering called SAARC Model for Accelerated Net Energy Metering (SAMANEM). The SAMANEM model is illustrated in Fig 4.

Fig 4: SAARC Model for Accelerated Net Energy Metering (SAMANEM)



6.0 REGIONAL CO-OPERATION AND ACTION PLAN

6.1 REGIONAL COOPERATION

Regional cooperation among SAARC countries in the area of net-metered distributed renewable generation could provide significant economic benefits to all member countries and increase collective self-reliance in energy and improve energy security of the region as a whole. SAARC economies will also be able to accelerate the rate of proliferation of net-metered DG systems through regional cooperation by using each other's infrastructure and sharing of knowledge. Such regional cooperation efforts could also increase SAARC regional trade in goods and services, thereby supporting the growth of businesses and creation of employment. Since energy is one of the 16 areas identified for regional cooperation and as SEC exists as a centre of excellence in energy, SAARC and SEC could provide an effective platform for such regional cooperation on DG systems. The elements that could constitute such a regional cooperation programme are explained below:

- The testing, certification and calibration laboratories existing in SAARC member countries could be used for testing of DG systems and components manufactured in South Asian region, thereby saving resources and encouraging local product research, development and manufacturing. The following institutions in SAARC countries provide the testing and certification facilities of DG equipment:

    - ✓ Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, Bangladesh
    - ✓ National Institute of Solar Energy, Faridabad-Gurgaon Road, Gwal Pahari, India
    - ✓ Renewable Energy Test Station(RETS), NAST Compound, Khumaltar, Lalitpur, Kathmandu, Nepal
    - ✓ Pakistan Council for Scientific and Industrial Research, Islamabad, Pakistan

- Facilitate and encourage regional trade in goods and services for Renewable energy equipment amongst SAARC countries through existing free trade frameworks. This will allow South Asian renewable energy companies a larger market access;

- Further development and elaboration of the SAMANEM model through creation of a toolkit that may be used by DG stakeholders in all SAARC countries. The toolkit may include recommending ways for development of regulatory instruments, policy instruments, electricity tariffs and incentives, utility business models and finance models etc;

- A web portal of all DG stakeholders in South Asia may be created to share and disseminate the knowledge and information among themselves The portal may also help in Identifying, analysing and interpreting global best practices of DG systems in the areas of products, policy, and financing;

- Exchange of experience in implementing net-metering schemes for DG systems and sharing of lessons among stakeholders from SAARC member countries. This could be done through regional fora and events organised by SEC.

-

6.2 SAARC ACTION PLAN

Within the framework of SAARC and energy cooperation area, SEC is well placed to develop and implement an action plan to significantly increase the role of net-metered DG systems in South Asian electricity networks. A stepped approach to a SAARC Action Plan of Net-Metering for an initial period of 3 years is suggested below:

- Establish a list of key stakeholders in South Asia consisting of institutions and individuals such as energy policy makers, energy regulators, electricity distribution companies/energy utilities, manufacturers, engineering and installation service companies, test and certification laboratories, NGOs, research institutions, financial institutions, individual experts etc. An initial list of institutions obtained through the questionnaire survey in SAARC countries is available at Annex D, which could be the starting point. SEC could take a lead in this activity which can be established in a timeframe of 6 months.

- Establish and build a knowledge-base on DG systems and net-metering consisting of global best practices, DG statistics in SAARC countries, case studies and relevant reports. Establish an electronic group and a web portal to disseminate information on DG systems to the identified South Asian Stakeholders. SEC could take a lead in this activity which can be completed in a period of 12-24 months.

- Supporting the development and elaboration of the SAMANEM model through conducting short term research studies on issues such as testing and certification cooperation, trade in DG systems, components and services in South Asia etc. This activity can be coordinated by SEC in collaboration with other centres in South Asia and can be completed in a period of 36 months.

- Organise an event on DG systems and net-metering in South Asia at an appropriate South Asian location to enhance and strengthen regional cooperation and exchange of experiences and lessons. If possible, site visits to DG installations of various types may be organized at the location. This event can be organised by SEC within 12 months.

- SEC could use the SAARC energy cooperation framework to enhance cooperation in DG systems. Also, trade and test laboratory cooperation can be addressed through governmental consideration and support.

- Establishing advisory panels or task forces to guide and leverage SECs further work in the area of DG and net-metering. These task forces and advisory panels could guide the initial 3-year work plan and could also identify the priorities for the future work plans beyond the initial 3 years. SEC would coordinate the task forces and advisory panels for the initial period of 36 months and may extend the plan and mandate beyond the period of 36 months in line with the work plan.

The action plan is envisaged to cover a period of 3 years and based on the results and state of market development at the end of this period, the actions for a future period can be further defined.

7.0 CONCLUSIONS

Based on the questionnaire, literature survey, interviews and analysis of the net-metering and DG systems in SAARC countries, the following conclusions can be drawn:

- SAARC countries in general have limited fossil fuel energy reserves but very high level of fossil energy consumption, thus making SAARC an energy insecure region. However, the energy intensity and energy access levels remain relatively lower in comparison to neighbouring regions;

- SAARC countries have rich renewable energy resources with plentiful solar and hydro resources. Some of the SAARC countries also have sizeable biomass and wind energy resources which can be harnessed;

- Some countries have developed their hydro, wind and biomass power potentials. However, the development of solar energy potential has lagged behind other renewable energy sources in this region;

- SAARC countries in generally have used financial incentives such as capital subsidies and tax incentives to promote renewable energy. Policy and regulatory instruments such as FiTs have had a secondary role and instruments such as RECs and RPSs have had a limited role;

- Net-metering has emerged as a very potent regulatory instrument to promote DG systems in the electricity grid. Net-metering when combined with banking has encouraged the development of DPV systems. The regulatory instrument such as FiTs have helped in the development of DG markets;

- Due to widespread resource availability and price reductions as well as other market factors, PV systems have emerged as the leading DG technology in SAARC countries with over 537 MW of installed capacity;

- While the policy makers, regulators and the industry have been positive about net-metered PV systems, the electricity distribution companies and energy utilities in some of the countries have not shown the same level of support due to concerns of revenue loss;

- The European and North American net-metered DG system markets are at an advance stage of development than SAARC countries and could offer lessons to South Asia in terms of policy, regulation and financing of DG systems;

- The high level of penetration of DPV systems in distribution networks can have the potential to cause issues of high voltages, network overload, frequency variations and load shedding. However, the probability of such instance to occur in SAARC countries is very low. Moreover, the SAARC utilities should be able to manage these challenges the same way they have been managing demand fluctuations in their existing systems;

- A financial analysis revealed that the prospect of PV net-metering is a viable proposition in a number of the SAARC countries if the PV system is designed specifically for offsetting electricity purchases and not for exporting power to the distribution grid.

Currently, the distribution companies or utilities have set up very lower tariff rates for purchase of residential solar PV.

- The use of battery storage to provide back-up power doesn't improve the financial benefits from the systems. Such an option may only be justified in situations where the financial loss due to electricity outage is very high.

- The results of an off-grid PV system with battery are very encouraging. The analysis was conducted with diesel generator as a benchmark in remote and mountainous region.

- The technical specifications for net-metered PV system components have been specified with emphasis on the inverter. Recommendations have also been made for installation, commissioning, imports, testing and development to ensure better system performance and an orderly growth of the DG systems markets;

- Guidelines have also been provided for energy regulators and electricity distribution companies to ensure an orderly and sustainable development of the net-metered DG markets in SAARC countries. These have attempted to address the revenue concerns by utilities and to ensure a sustainable growth;

- Recommendations have been made in the realms of policy, regulation, financing, testing and certification as well as manufacturing and service delivery aimed at SAARC governments, electricity companies, financiers and industry towards a South Asian model – SAMANEM for an orderly growth of the DG market;

- There exists considerable scope for regional cooperation among SAARC countries in the areas of testing & certification, trade, knowledge and experience sharing of DG systems;

- An action plan for SAARC countries to be coordinated by SEC has also been proposed which envisages organising and convening stakeholders, building a knowledge base, cooperation in testing & certification, trade, further development of the SAMANEM model for the benefit of all SAARC countries;

- As South Asian countries move into an important phase of net-metered DG market development, regional cooperation through the SAARC framework if implemented properly could offer a good platform for economic cooperation and knowledge exchange. DG systems and their accelerated development can contribute significantly to improving the energy self-reliance and increasing energy security of SAARC countries.

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ANNEX A : QUESTIONNAIRE USED FOR SURVEY

Study of Distributed Generation- Questionnaire

1. Does {SAARC Country} have policies and regulations for distributed grid-connected renewable energy (such as rooftop PV, small wind/biomass etc.) systems? Also are there feed-in-tariffs for distributed renewables? If so can you provide links or copies of relevant documents?

2. Does {SAARC Country} have technical standards for distributed grid-connected renewable energy (such as rooftop PV, small wind/biomass etc.) systems that covers equipment and installation/commissioning? If so please provide links/copies.

3. Are there limits in terms of grid penetration of distributed grid-connected renewable energy systems? Does {SAARC Country} encourage distributed generation systems with on-site energy storage or stand-alone distributed storage? Grateful for elaboration or links or copies of relevant documents.

4. Are there specific requirements and regulations for licencing, certifying and permitting connection of distributed renewable energy systems on the low-voltage distribution network? If so can you provide relevant documentation/links?

5. Which are the key technology and research institutions in {SAARC Country} that should be candidates for a possible SAARC wide regional collaboration on distributed generation? Can you provide contact (e-mail, Tel) details?

6. Which other national programme around the world do you consider as a model for {SAARC Country} in grid-connected renewable energy programme? What are the reasons for this choice?

7. Are there any aspects (technical, economic, policy, regulatory etc.) that SAARC countries should consider while developing a progressive and sustainable distributed generation programme?

ANNEX B: CONTRIBUTIONS TO THE SURVEY

List of Persons/Institutions that have contributed to the SAARC Study[105]

Institution	Contact Person	Contacts	Response/ comments
Afghanistan			
Ministry of Energy and Water	Aman Ghalib Renewable Energy Director	amanghalib@hotmail.com Kabul, Afghanistan Tel.: +93 794 444443 www.red-mew.gov.af	Discussion in Manila on 18th June.
Bangladesh			
Sustainable and Renewable Energy Development Authority (SREDA)	Siddique Zobair Joint Secretary and Member (EE&C)	siddique.zobair@gmail.com Power Division, 10th Floor, Biddyut Bhaban, 1, Abdul Gani Road, Dhaka Cell: +880 1714110610	Responses to questionnaire received on 12th June, meeting in Manila on 19th June.
Bhutan			
Department of Renewable Energy	Chhimi Dorji Executive Engineer	chhimidorji@moea.gov.bt Ministry of Economic Affairs, PB No 141 Thimpu Tel: 322709	Responses to questionnaire received on 14th July
Maldives			
Sandeep Kohli	World Bank		Data inputs not received
Nepal			
Alternative Energy Promotion Center	Ram Prasad Dhital Executive Director	ram.dhital@aepc.gov.np Ministry of Science, Technology and Environment Government of Nepal Khumaltar, Lalitpur, PO Box 26143 (GPO Kathmandu)	Responses to questionnaire received on 9th July
Nepal Electricity Authority	Hitendra Dev Shakya Director, System Planning Department	hitendradev@hotmail.com Central Office, Durbarmarg Kathmandu Nepal Tel: +977-1-4153052	Responses to questionnaires received on 4th June

[105] Information about Pakistan and India already available with SEC and the expert.

Institution	Contact Person	Contacts	Response/ comments
Sri Lanka			
Sustainable Energy Authority	Anil Cabraal, Adviser	racabraal@msn.com	Inputs received on 8th June
Public Utilities Commission of Sri Lanka	Gamini Herath Deputy Director General	gaminih@pucsl.gov.lk 6 th Floor, BOC Merchant Tower, 28 St Michael Road, Colombo 03 Sri Lanka. Mobile : +94772304156	Responses to questionnaires received on 10th July

ANNEX C: LIST OF RELEVANT IEC STANDARDS

1. IEC 61724 ed1.0 (1998-04): TC/SC 82: Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis
2. IEC/TS 62257-8-1 ed1.0 (2007-06): TC/SC 82 : Recommendations for small renewable energy and hybrid systems for rural electrification - Part 8-1: Selection of batteries and battery management systems for stand-alone electrification systems - Specific case of automotive flooded lead-acid batteries available in developing countries
3. IEC 60904-SER ed1.0 (2011-10): TC/SC 82: Photovoltaic devices - ALL PARTS
4. Project IEC 61730-1-am2 ed1.0 (2012-12): TC/SC 82 : Amendment 2 - Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction
5. IEC WHITE PAPER EES ed1.0 (2011-12): TC/SC MSB : Electrical Energy Storage
6. IEC 60068-2-5 ed2.0 (2010-04): TC/SC 104: Environmental testing - Part 2-5: Tests - Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing
7. IEC 60269-6 ed1.0 (2010-09): TC/SC 32B: Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
8. IEC 60364-7-712 ed1.0 (2002-05): TC/SC 64: Electrical installations of buildings - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
9. IEC 60529 ed2.2 (2013-08): TC/SC 70: Degrees of protection provided by enclosures (IP Code)
10. IEC 60891 ed2.0 (2009-12): TC/SC 82: Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics
11. IEC 60904-1 ed2.0 (2006-09): TC/SC 82: Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage characteristics
12. IEC 60904-2 ed2.0 (2007-03): TC/SC 82: Photovoltaic devices - Part 2: Requirements for reference solar devices
13. IEC 60904-3 ed2.0 (2008-04): TC/SC 82: Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data
14. IEC 60904-4 ed1.0 (2009-06): TC/SC 82: Photovoltaic devices - Part 4: Reference solar devices - Procedures for establishing calibration traceability
15. IEC 60904-5 ed2.0 (2011-02): TC/SC 82: Photovoltaic devices - Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method
16. IEC 60904-7 ed3.0 (2008-11): TC/SC 82: Photovoltaic devices - Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices
17. IEC 60904-8 ed2.0 (1998-02): TC/SC 82: Photovoltaic devices - Part 8: Measurement of spectral response of a photovoltaic (PV) device
18. IEC 60904-9 ed2.0 (2007-10): TC/SC 82: Photovoltaic devices - Part 9: Solar simulator performance requirements
19. IEC 60904-10 ed2.0 (2009-12): TC/SC 82: Photovoltaic devices - Part 10: Methods of linearity measurement
20. IEC 61215 ed2.0 (2005-04): TC/SC 82: Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval
21. IEC 61345 ed1.0 (1998-02): TC/SC 82: UV test for photovoltaic (PV) modules

22. IEC 61427 ed2.0 (2005-05): TC/SC 21: Secondary cells and batteries for photovoltaic energy systems (PVES) - General requirements and methods of test
23. IEC 61646 ed2.0 (2008-05): TC/SC 82: Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval
24. IEC 61683 ed1.0 (1999-11): TC/SC 82: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
25. IEC 61701 ed2.0 (2011-12): TC/SC 82: Salt mist corrosion testing of photovoltaic (PV) modules
26. IEC 61724 ed1.0 (1998-04): TC/SC 82: Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis
27. IEC 61725 ed1.0 (1997-05): TC/SC 82: Analytical expression for daily solar profiles
28. IEC 61727 ed2.0 (2004-12): TC/SC 82: Photovoltaic (PV) systems - Characteristics of the utility interface
29. IEC 61730-1 ed1.0 (2004-10): TC/SC 82: Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
30. IEC 61730-1-am1 ed1.0 (2011-11): TC/SC 82: Amendment 1 - Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
31. IEC 61730-2 ed1.1 Consol. with am1 (2012-11): TC/SC 82: Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
32. IEC 61730-2 ed1.0 (2004-10): TC/SC 82: Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
33. IEC 61730-2-am1 ed1.0 (2011-11): TC/SC 82: Amendment 1 - Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
34. IEC 61829 ed1.0 (1995-03): TC/SC 82: Crystalline silicon photovoltaic (PV) array - On-site measurement of I-V characteristics
35. IEC/TS 61836 ed2.0 (2007-12): TC/SC 82: Solar photovoltaic energy systems - Terms, definitions and symbols
36. IEC 61853-1 ed1.0 (2011-01): TC/SC 82: Photovoltaic (PV) module performance testing and energy rating - Part 1: Irradiance and temperature performance measurements and power rating
37. IEC 62093 ed1.0 (2005-03): TC/SC 82: Balance-of-system components for photovoltaic systems - Design qualification natural environments
38. IEC 62108 ed1.0 (2007-12): TC/SC 82: Concentrator photovoltaic (CPV) modules and assemblies - Design qualification and type approval
39. IEC 62109-1 ed1.0 (2010-04): TC/SC 82: Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
40. IEC 62109-2 ed1.0 (2011-06): TC/SC 82 : Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
41. IEC 62116 ed1.0 (2008-09): TC/SC 82: Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters
42. IEC 62446 ed1.0 (2009-05): TC/SC 82: Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection
43. IEC 62509 ed1.0 (2010-12): TC/SC 82: Battery charge controllers for photovoltaic systems - Performance and functioning

ANNEX D: DG STAKEHOLDERS IN SAARC COUNTRIES[106]

Afghanistan

1. Ministry of Energy and Water, Kabul Afghanistan

Bhutan

2. Department of Renewable Energy, Ministry of Economic Affairs, PB No 141, Thimpu, Bhutan
3. College for Science & Technology, Phuntsholing, Bhutan
4. Jigme Namgyel Polytechnic, Deothang, Samdrupjongkhar, Bhutan

Bangladesh

5. Sustainable and Renewable Energy Development Authority (SREDA), Power Division, 10th Floor, Biddyut Bhaban, 1, Abdul Gani Road, Dhaka, Bangladesh;
6. Institute of Energy, University of Dhaka. Bangladesh;
7. Bangladesh University of Engineering & Technology (BUET), Dhaka, Bangladesh
8. Bangladesh Energy and Electricity Research Council
9. Bangladesh Council of Scientific and Industrial Research (BCSIR)
10. Bangladesh Centre for Advance Studies (BCSAS)

India

11. Ministry of New and Renewable Energy, Block-14, CGO Complex, Lodhi Road, New Delhi-110 003, India.
12. National Institute of Solar Energy, Gwal Pahari, Bandhwari, Haryana 122005, India
13. Solar Energy Corporation of India, 1st Floor, D-3, A Wing, Religare Building District Centre, Saket, New Delhi – 110017, India
14. Standardisation, Testing and Quality Control Directorate, Department of Electronics & Information Technology, Ministry of Communications & IT, Electronics Niketan, 6 CGO Complex, New Delhi - 110 003, India

[106] Note that these institutions represent the ones which were suggested by SAARC government agencies who were surveyed as part of the study.

Maldives

15. Ministry of Environment and Energy, Handhuvaree Hingun, Malé 20392, Maldives;

16. Maldives Energy Authority, Ameenee Magu, Malé 20392, Maldives

Nepal

17. Alternative Energy Promotion Center (AEPC), Khumaltaar Heights, Lalitpur Sub Metropolitan City, Nepal

18. Nepal Electricity Authority, Baglung Bazar, Baglung 33300, Nepal

19. Institute of Engineering, Tribhuvan University, Pulchowk Campus, Lalitpur, Nepal

20. Nepal Academy of Science and Technology, GPO Box: 3323, Khumaltar, Lalitpur, Nepal

21. Kathmandu University, Budol, Dhulikhel 45200, Nepal

Pakistan

22. Alternative Energy Development Board, Ministry of Water and Power, OPF Building, Shahrah-e-Jamhuriat, G-5/2, Islamabad

23. National Electric Power Regulatory Authority, NEPRA Tower Attaturk Avenue (East), Sector G-5/1, Islamabad.

24. Pakistan Council for Scientific and Industrial Research, Constitution Avenue, Sector G-5/2 , Islamabad, Pakistan

25. Applied Physics Computers and Instrumentation Centre, PCSIR Laboratories Complex, Ferozpur Road, Lahore-54600, Pakistan

26. Electrical and Measurement and Test Laboratory, PCSIR Laboratories Complex, Ferozpur Road, Lahore-54600, Pakistan

27. Alternative Energy Research and Innovation Lab, Al-Khawarismi Institute of Computer Science, University of Engineering and Technology Lahore, GT Road Lahore, Pakistan,

Sri Lanka

28. Sri Lanka Sustainable Energy Authority, Block 05, 1st Floor, BMICH, Bauddhaloka Mawatha, Colombo 07, Sri Lanka

29. Public Utilities Commission of Sri Lanka, 06th Floor, BOC Merchant Tower, St. Michael's Road, Colombo 03. Sri Lanka

In addition to the above list, the relevant electricity distribution companies or the energy utility companies are also considered key stakeholders. However, they are not specifically listed due to the large number of such entities.

Similarly, private manufacturers and installation companies that are active in the DG markets in South Asia are also not listed here due to the large number of members.