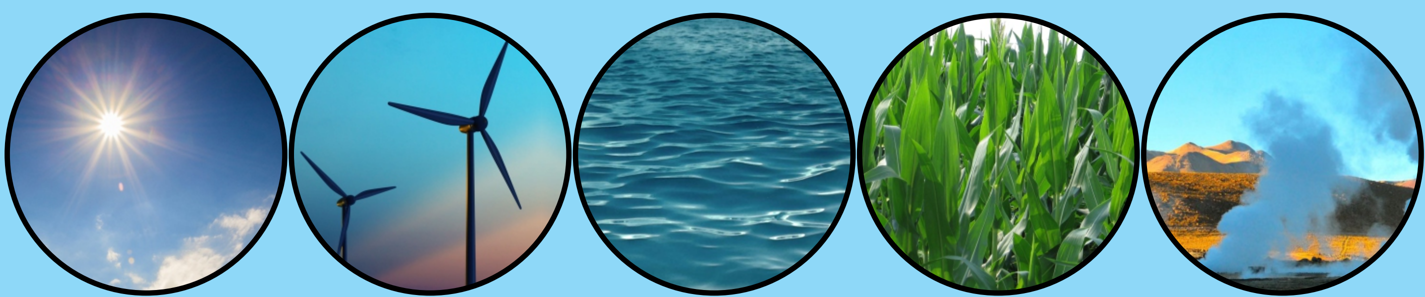
RENEWABLE ENERGY ROADMAP FOR AFGHANISTAN

RER2032



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FOREWORD

Energy access and energy security are two key requisites for the socio-economic growth of Afghan societies. Renewable energy resource with their enormous potential in Afghanistan, can successfully be harnessed to meet these two requirements. The development of renewable energy sector is thus a priority area for the Government of Afghanistan and all its supporting partners.

An important pillar for the RE sector development is the engagement of the private sector and financing institutions. The Asian Development Bank through a Technical Assistance (TA) has addressed these challenges by way of developing the Roadmap for Renewable Energy in Afghanistan which is a strategic document aiming at meeting the objectives of the Afghanistan Renewable Energy Policy and the National Energy Supply Programme. The Roadmap is designed to increase the supply of energy from domestic resources; improve energy supply to load centers, provincial capitals, and rural population; and increase the capacity within the Government to plan and implement renewable energy projects. It includes prioritization of RE technologies and projects, designing appropriate business models for their implementation and identifying enablers for market development.

One of the important outcomes of this TA is the design and development of strategic and relevant projects which are trendsetters in their respective domains and their implementation will help in opening markets for different renewable energy technologies and applications in Afghanistan. These projects are - Daikundi mini-grid, Kabul roof-top solar, Hisar-E-Shahi industrial park solar project and Farah PV-wind-diesel hybrid project.

I hope that this Roadmap will provide a confidence to the private sector in preparing to invest its resources in supporting the RE sector in Afghanistan.

Engineer Ali Ahmad Osmani

Minister of Energy and Water

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ABBREVIATIONS AND ACRONYMS

AC	Alternating Current
ADB	Asian Development Bank
AFG	Afghanistan
AISA	Afghanistan Investment Support Agency
ANDS	Afghanistan National Development Strategy
AREU	Afghanistan Renewable Energy Union
ASERD	Afghanistan Sustainable Energy for Rural Development
ASHP	Air Source Heat Pump
ATC	Aggregate Technical & Commercial
BMC	Billing, Metering and Collection
BOOM	Build-Own-Operate-Maintain
CAPEX	Capital Expenditure
CBO	Community Based Organization
CCSAP	Climate Change Strategy and Action Plan
CdTE	Cadmium-telluride
COAM	Conservation Organisation for Afghan Mountain Areas
COP	Coefficient of Performance
CPSU	Central Public-Sector Undertaking
CPV	Concentrating PV
CSH	Concentrating Solar Heat
c-Si	crystalline Silicon
CSO	Central Statistics Office
CSO	Civil Society Organizations
CSP	Concentrating Solar Power
CTCN	Climate Technology Centre and Network
DABS	Da Afghanistan Breshna Sherkat
DC	Direct Current
DF	Distribution Franchisee
DNI	Direct Normal Irradiance
DPR	Detailed Project Report
DRE	Decentralised Renewable Energy
ECO	Economic Cooperation Organization
ERDA	Energy for Rural Development in Afghanistan
ESCO	Energy Service Companies
ESIA	Environmental-Social Impacts Assessment
ETC	Evacuated tube collectors
FAO	Food and Agriculture Organization of the United Nations
FiT	Feed-in-Tariffs
FPC	Flat-plate collectors

FPV	Floating PV
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoI	Government of India
GoIRA	Government of Islamic Republic of Afghanistan
GW	Gigawatt
HPP	Hydro Power Plant
ICT	Information and Communications Technology
IDCOL	Infrastructure Development Company Limited
INDC	Intended Nationally Determined Contributions
IPP	Independent Power Producer
IREDA	Indian Renewable Energy Development Agency Limited
IRENA	International Renewable Energy Agency
ISA	International Solar Alliance
kW	Kilowatt
kWh	Kilowatt-hour
LFR	Linear Fresnel Reflector
MAIL	Ministry of Agriculture, Irrigation and Livestock
MEW	Ministry of Energy and Water
MFC	Microbial Fuel Cells
MFI	Microfinance Institutions
MHPs	Micro Hydropower Plants
MJ	Multi-Junction
MNRE	Ministry of New and Renewable Energy (India)
MRRD	Ministry of Rural Rehabilitation and Development
MW	Megawatt
MWh	Megawatt-hour
NAMA	Nationally Appropriate Mitigation Actions
NESP	National Energy Supply Programme
NGO	Non-Governmental Organizations
NISE	National Institute of Solar Energy
NRVA	National Risk and Vulnerability Assessment
NSP	National Solidary Program
NZAID	New Zealand Aid Programme
O&M	Operation and maintenance
OPEX	Operational Expenditure
PCU	Power Control Unit
PPA	Power Purchase Agreement
PPP	Public-Private-Partnership

PSMP	Power Sector Master Plan
PTC	Parabolic trough collector
R&D	Research and Development
RAGA	Rapid Assessment Gap Analysis
RE	Renewable Energy
RENP	Afghanistan Renewable Energy Policy
RESCO	Renewable Energy Service Company
RETs	Renewable Energy Technologies
SAARC	South Asian Association for Regional Co-operation
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SECI	Solar Energy Corporation of India
SHS	Solar Home Systems
SHWs	Solar Hot Water System
SPEED	Smart Power for Environmentally-sound Economic Development
SPPD	Solar Power Park Developer
SPPs	Solar Power Park
SPV	Solar Photovoltaics
SREP	Scaling Up Renewable Energy Program
SS	Standalone Systems
T&D	Transmission and Distribution
TES	Thermal Energy Storage
TPL	Torrent Power Limited
TWh	Terawatt-hours
VAM	Vapor Absorption Machine

THE ROADMAP

The Renewable Energy Roadmap for Afghanistan is developed to realize the vision and intent of the Renewable Energy Policy (RENP) for Afghanistan that sets a target of deploying 4500 – 5000 MW of renewable energy (RE) capacity by 2032 and envisions a transition from donor grant-funded RE projects to a fully-private sector led industry by 2032.

Objectives and scope

The objectives of the Roadmap are three-fold:

1. To increase the supply of energy by domestic resources
2. To augment energy services to population and load centres that are either not served or are poorly served
3. To enhance energy access to remote rural population for their livelihood needs

The scope of the Roadmap includes an estimation of technology specific achievable targets based on RE potential that has already been mapped and segregated region-wise. Technologies utilizing solar, wind, biomass, hydro and geothermal resources are considered for this purpose. The Roadmap comprises of prioritization of technologies and projects, designing appropriate business models for their implementation and identifying enablers for market development using a Stage-Gate analysis approach.

The Roadmap also estimates costs for achieving the RE generation targets based on the international/ regional costs and experiences from implementing RE projects in Afghanistan. Further, it proposes applicable sources of funds for development of RE sector.

An essential component of the Roadmap is the institutional arrangement for its implementation and enhancing the capacities of various stakeholders through training on knowledge products particularly the project selection and decision-making tool and system optimization models.

Methodological framework and presentation of Roadmap

The framework and approach for RE Roadmap rests on four pillars- an assessment of RE resource potential and its deployment through various technologies and projects; appropriate markets and business models for using these technologies; enablers (both policy and market related) that are required to implement the appropriate business models; and estimation of system costs in Afghanistan for financing of the Roadmap. (Figure 1)

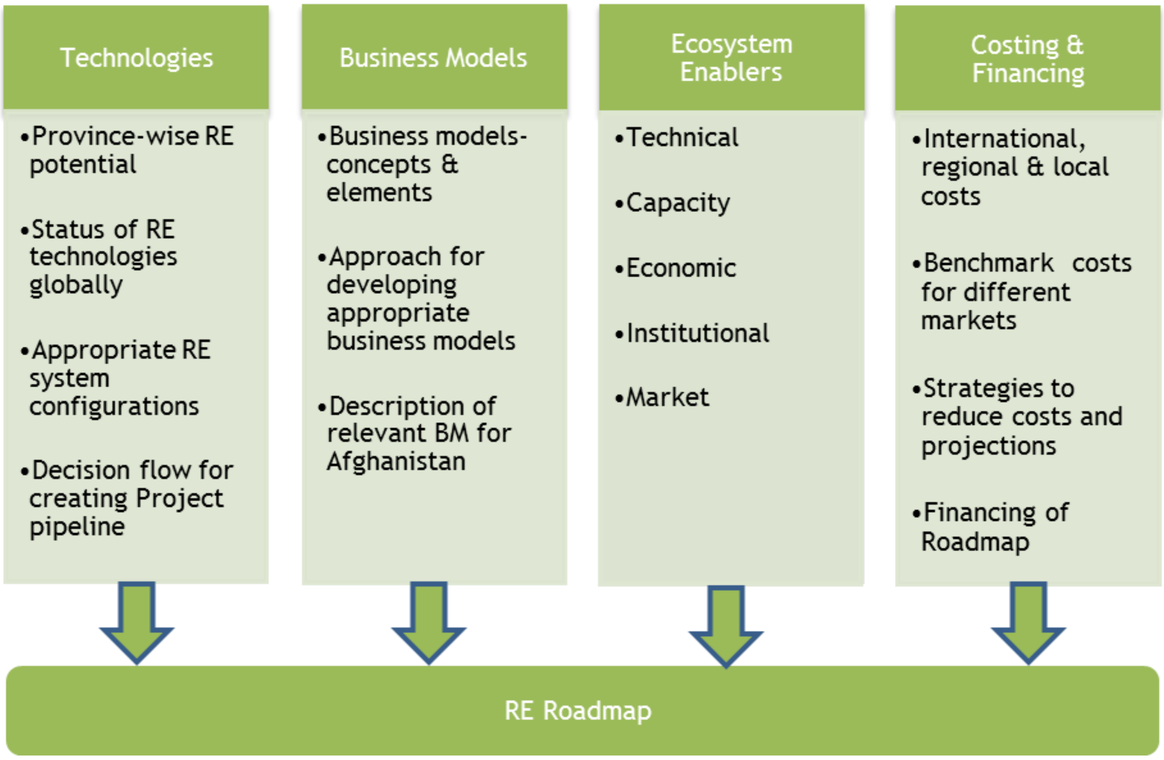


Figure 1 - Framework for RE Roadmap

Technologies and systems

1. The available RE resources in Afghanistan and their technical potential include solar, wind, hydro (small, mini and micro), biomass (including waste-to-energy) and geothermal. These resources can be harnessed through a variety of technologies and systems addressing electrical and thermal energy needs. The systems are categorized as utility scale, mini-grids and off-grid/ stand- alone which also represent the RE market segments in Afghanistan. Some of these technologies and systems include MW scale solar PV (both flat plate and concentrating); roof-top and stand-alone PV systems; concentrating solar thermal for power generation and for low grade process heat applications; wind farms and stand-alone wind-electric generators; small hydro power projects; mini-grids and biogas digesters.
2. The process for developing project pipeline follows a 3-level decision process:
   a. Level 1 assesses the possibility of utility scale RE projects on the basis of good quality RE resource, availability of national grid for power evacuation, road connectivity and overall security situation. If not satisfied, it points at options of mini-grids and off-grid stand-alone systems.
   b. Level 2 assesses the viability of setting up either RE/ hybrid mini-grids or stand-alone systems on the basis of population concentration, nature of loads (i.e. domestic, institutional, enterprises, anchor loads such as telecom towers), and operational diesel mini-grids that can be hybridised or replaced with RE.
   c. Level 3 assesses the feasibility of specific projects on the basis of primary energy surveys, topographical studies, environmental and social impact assessment (if required), community engagement activities, stakeholder consultations etc.

The decision process evolves into a flow-chart and is presented as the decision tool to develop RE project pipeline for Afghanistan.

Markets and business models

3. Further, for each of the market segments (i.e. utility scale, mini-grids, off-grid/ stand-alone), the Roadmap recommends business models that identify the roles of the government, DABS, private sector (already present and likely to be present), MFIs, NGOs and communities. Regional and international best practices have been studied and customized for designing the businesses models for Afghanistan. Solar Power Parks, solar roof-top with net-metering, RESCO (Renewable Energy Service Company) and microfinance aided sale of stand-alone devices (i.e. Pay-As-You-Go) are some of the business models selected for RE projects in Afghanistan.

Ecosystem enablers

4. The Roadmap uses a Stage-Gate model to discuss the enablers that are required for development of RE markets across several technologies and business models. Market development is expected to commence with the introduction of policies and guidelines for specific technologies and business models, such as the feed-in tariffs, and net-metering policy. Implementation of model projects across technologies as public – private – partnership (PPP) projects, will further develop this sector. This initial stage is termed as **Market Seeding**.
5. With favourable policies and an enabling business environment, commercial-scale projects may be implemented, moving the market from seeding to **Market Creation** stage. The first few commercial projects, led by the private sector, will comprise low-risk options where risks and gains are shared across the government, private sector and beneficiary communities. The subsequent stage is that of **Market Transformation** where technologies and markets are mainstreamed within the overall energy sector.

Costing and financing

6. The costs for applicable RE technologies and projects in Afghanistan have been collected through primary research by directly consulting with project developers, mainly members of Afghanistan Renewable Energy Union (AREU) and a few NGOs and donors. These costs are compared with regional and international costs to understand and then benchmark RE costs for Afghanistan.
7. The above exercise helps in estimating the financing requirements for the Roadmap and suggesting enablers that can help in reducing the costs in future. An analysis of various available mechanisms- globally, regionally and locally- is undertaken to recommend possible ways to finance the Roadmap.

Implementation arrangement

8. It is important to recognize the hierarchy of this document (the Roadmap) within the renewable energy development planning process. The RENP sets the vision and goals for RE development in Afghanistan and the Roadmap develops a strategy for achieving these goals. The next logical step is to implement the strategy laid out in the Roadmap by carrying out activities and initiatives and monitoring their progress with the help of a tracking system. A brief discussion on the implementation arrangement

with focus on institutional structure, skill enhancements and training is also included in this document.

Figure 2 elaborates the process of Roadmap development.

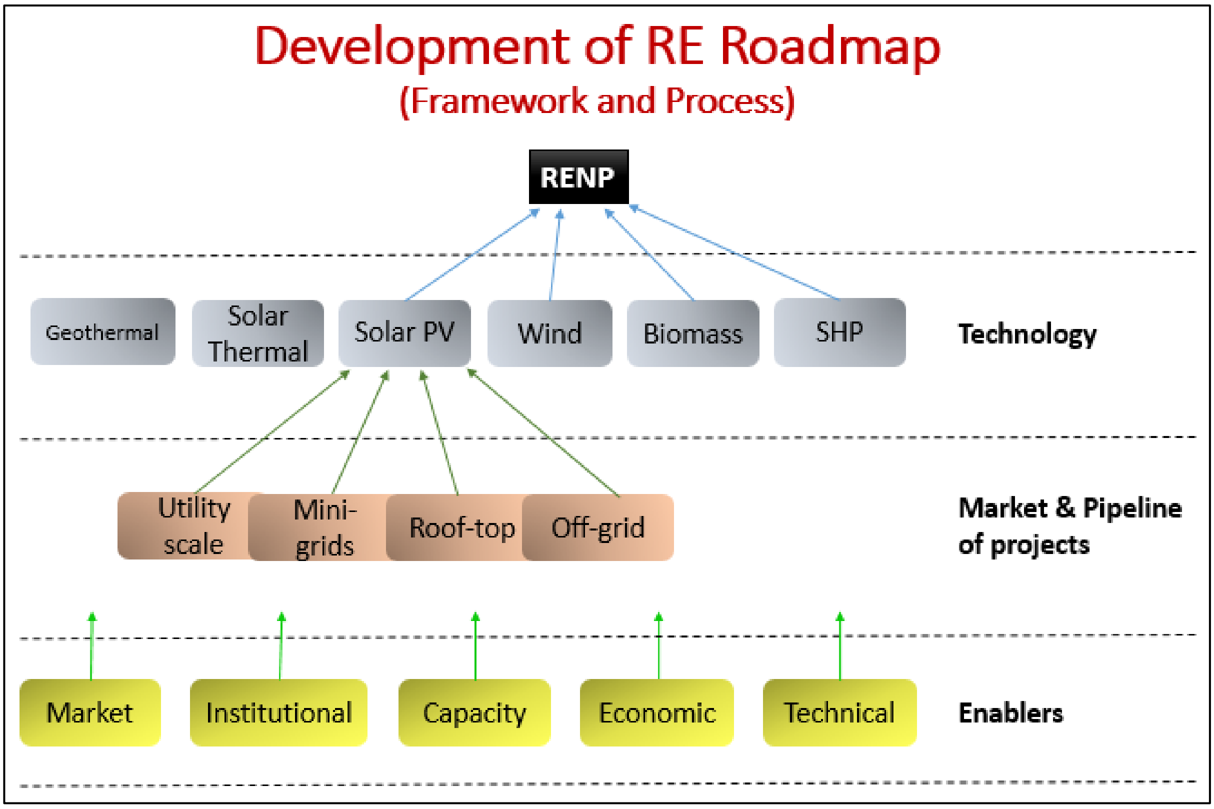


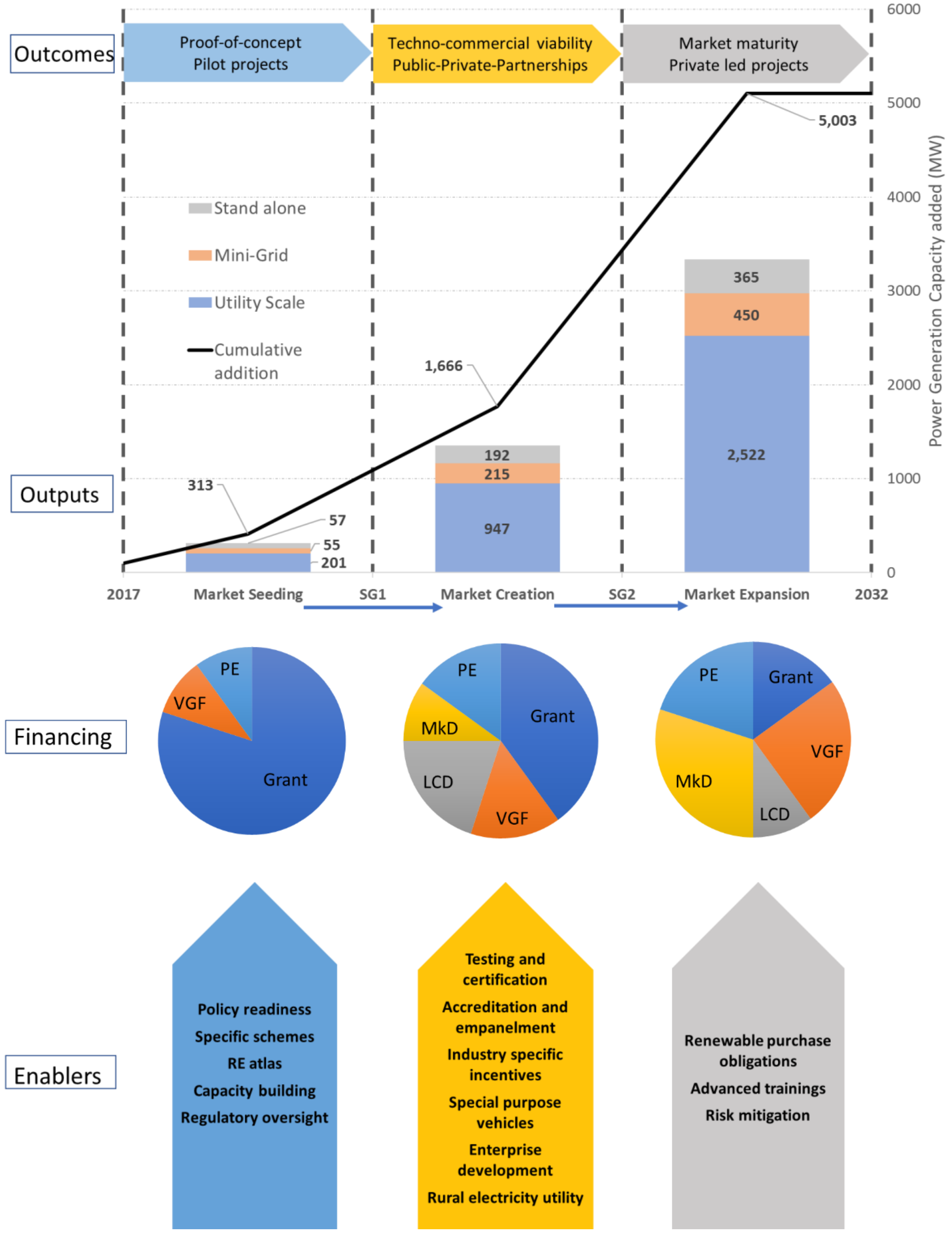
Figure 2 - Process of Roadmap development

Presentation of Roadmap

The Roadmap is presented in eight chapters. It maps the RE resource potential across different regions; selects appropriate and viable RE technologies; identifies applications and categorises markets for selected RE technologies; develops project pipeline for identified markets and designs suitable business models for each market category. This analysis is based on the Decision Tool, specifically developed for this purpose and applied across Afghanistan.

Subsequently, the Roadmap focuses on enablers and actions required for achieving the targets and milestones using the Stage-Gate model customised for market categories and business models. The enablers are analysed across technical, financial, regulatory and institutional landscape, as applicable to Afghanistan. Further, the analysis also includes estimation of costs for various technologies in Afghanistan. The outcome of this analysis are the financial requirements and financing modalities; regulatory & institutional framework for setting up business models; assessment and planning for institutional capacities and evaluation of overall impacts of implementing the Roadmap.

Figure 3 presents the Roadmap, summarising its outputs, outcomes and ecosystem elements required to achieve the outcomes.



Legend:
Grant: Grants from Government and Partners
VGF: Viability Gap Funding
LCD: Low Cost Debt
MkD: Market Debt
PE: Promoter Equity / Community Contributions

Figure 3 - Stage-Gate model for Afghanistan

1 INTRODUCTION

1.1 Rationale

Renewable energy sector development is one of the priority areas for the Government of Islamic Republic of Afghanistan (GoIRA) for immediate purpose of providing access to modern energy to remote and rural population and for medium to long term purpose of providing energy security to the country. Afghanistan is rich in energy resources, both fossil fuel based and renewables. However, it still depends heavily on imported electricity and fuels and has one of the lowest per capita consumption of electricity in the world. Lack of domestic generation remains the key challenge for energy security and energy access in Afghanistan. Its 30% electrification rate ranks it in the lowest 5% in per capita energy consumption globally. Out of the total 519 MW installed capacity, 51% is thermal (diesel and furnace oil) with a generation cost of $0.25-0.35 per kWh, which is four times that of imported electricity. The remaining 49% (254 MW) is from hydropower, which is seasonal and has a capacity factor of less than 40%. Over 80% of total electricity supply is imported[1].

The Roadmap for renewable energy for Afghanistan identifies pathways for reaching about 5,000 MW of renewable energy based generation capacity by 2032, in line with the Afghanistan Renewable Energy Policy targets and vision. It provides an inclusive, medium to long-term vision of the renewable energy sector, taking into cognizance inter-dependencies between energy, environment and overall socio-economic development. It also provides a 'portfolio approach', integrating technologies and market structures that are based on viable business models and finance options.

1.2 Contextual analysis

The foundation of the RE development is based on the Afghanistan National Development Strategy (ANDS, 2008) which provides the overall vision and goals of the energy sector; Power Sector Master Plan, (PSMP, 2013) that provides the overall status and priorities of power sector network planning and expansion, including identification of regions where network expansion in not economically viable; and the National Energy Supply Program, (NESP, 2013). The NESP has set the short-term (by 2015) and long-term (up to 2022) targets for electricity supply, energy efficiency and renewable energy sector, energy institutions and private sector participation, as well as capacity and regulatory framework development. Recently approved Renewable Energy Policy (RENP, 2015), as an overarching policy instrument, has set ambitious targets for RE development in the country. The Afghanistan Integrated Energy Policy is proposing to put the RE sector development as one of its strategic intents.

The above is broadly in sync with the Sustainable Energy for All (SE4All) target for energy access for all by 2030, which is developed as a country level plan of action to ensure access to energy for all. Development of renewable energy is also one of the priority areas for low emission development for Afghanistan (NAMA, 2015) particularly in the context of energy access to rural communities to think and act beyond lighting energy.

[1] Inter-Ministerial Commission for Energy (ICE) Report (2016)- Ministry of Economy, Afghanistan

The Climate Change Strategy and Action Plan for Afghanistan (CCSAP, 2015) targets 100 percent electricity coverage by 2100 as mandated within the National Priority Programs. It further targets at least 40 percent share of renewable energy in the Afghanistan national grid by 2100, with an increased presence of decentralised renewable energy based systems to cater to off-grid areas. Subsequently, the Intended Nationally Determined Contributions (INDC) have identified access to renewable energy for 25% of rural population as the goal.

Many donors and international organisations are supporting the development of renewable energy sector in Afghanistan. The Asian Development Bank, GIZ, DFID, Islamic Development Bank are among a few.

According to the Ministry of Energy and Water (MEW), about 5100 RE Projects have been jointly implemented/ under implementation by MEW/MRRD/DABS and other developers, the installed capacity of the mentioned projects is 55 MW (Table 1)[2]. MEW has recently invited private sector to invest in 30 RE projects totalling upto 100 MW and comprising biogas, solar, wind, hydro and hybrid technology options[3].

Table 1 - Status of RE projects in Afghanistan

Projects		**Total**
Total No of Renewable Energy Projects Completed		4,602
Total No of Renewable Energy Projects Planned		99
Total No of Renewable Energy Projects Under Construction		493
Total Capacity of Renewable Energy Projects (no.)		5,911
Total Capacity of Renewable Energy Projects Completed and (kW)		55,011
RE type	**Total number**	**Capacity (kW)**
Biomass	44	0
MHP	2,678	52,913
Solar	2,450	1,868
Wind	22	230
Total	5,194	55,011

2 http://www.red-mew.gov.af/database/ren-database/. Last visited in May 2017

3 Consultants estimate the RE projects installed capacity to be around 100 MW

1.3 Business environment and industrial landscape

The renewable energy industry in Afghanistan is in infancy. The AREU is a newly formed body with about 45 members and consist of equipment manufacturers and system integrators. The status of financial sector remains a constraint for private sector development and limited access to credit is limiting the growth and involvement of local RE industry in rural and renewable energy sector. The business environment is characterised by grant based delivery models. Private sector engagement in the RE market is still weak and unsystematic.

The tariff regime is largely dominated by Da Afghanistan Breshna Sherkat (DABS), the national utility. DABS operates on a cost-plus pricing basis. As a result, tariff rates can be high, and they often are. The weighted average tariff in 2014 was Afs 7.3 (0.11 $) per kWh. Commercial customers of DABS almost everywhere pay around 8-10 Afs (0.15 $) per kWh. Further, DABS finances are affected by foreign exchange movements; since imported power is purchased in USD while local revenues are in AFN. Increasing the proportion of supply from domestic sources is one lever to manage this risk.

Table 2 - Renewable energy policy landscape and other initiatives in Afghanistan

Name of the Document	Dated and Version	Key highlights
Power Sector Master Plan	2013, Final	Precursor to all policies: provided a national perspective on medium to long term energy planning for Afghanistan
Afghanistan Renewable Energy Policy	2015, Approved	Comprehensive and overarching policy document that promises to give a stimulus to the RE sector in the country
Rapid Assessment Gap Analysis	2015, Draft	Targets sustainable energy access for all by 2030, syncs well with PSMP's 2032 target profile, also demands higher intensity of renewable energy and energy efficiency projects
Strategy and Guidelines for Implementation of RENP	2015, Draft	Supports and supplements RENP in many directions, including but not limited to financial planning
Power Services Regulation Law	2015, Approved	De-licenses and deregulates small scale power production through renewables of upto 100 kW generation plants
Feed-in-Tariff Policy	2015, Final Dari Version	Provides critical comfort levels to the private sector in terms of revenue assurances. Major enabling factor in fast-tracking projects in the RET sector

Investment Policy	2015, Final Dari Version	Significant in terms of facilitating and attracting investment in the Afghan economy – strong links for private participation in the RET sector
EOI for 100 MW	2016, Final Version	First batch of projects launched, considered as a curtain raiser to increased activity in the RET sector.
Public Private Partnership Law	Approved, 2016	Provides the policy guidelines for setting up public-private partnerships, with the objectives of regulating PPPs keeping in mind transparency, competition and cost-effectiveness; key provisions include formation of a Central Public Private Partnership Authority (CPPPA).
Afghanistan energy sector 5-year self-sufficiency plan	Approved, 2016	The plan describes recommended outcomes, outputs, and required tasks for the energy sector
Power Purchase agreement for Kandahar 10 MW solar project	Signed, 2016	Up-front capital subsidy, PPA tariff decided through reverse auction

1.4 Renewable and rural energy programs and key outcomes

The renewable energy landscape in Afghanistan is dominated by hydropower and solar PV technologies. National Solidarity Program (NSP)/ NABDP and Energy for Rural Development in Afghanistan (ERDA) within NABDP, have been the flagship programs of MRRD for rural energization.

In addition to MRRD, DABS also carries out grid extensions to rural areas under the NESP of MEW. Apart from the MRRD and MEW programmes, there are efforts by FAO, NZAID and GiZ at a smaller scale which are also supporting village electrification. There are also small-scale efforts by NGOs such as COAM and Geres targeting thermal energy issues. However, the thermal energy needs are not being addressed in any significant scale by existing programmes and there has not been much penetration of energy efficient devices. Dependence on fuel wood and other non-renewable biomass is very high and indoor air pollution and resultant lower respiratory illnesses is the biggest cause of pre-mature deaths in Afghanistan.

Along with hydropower, solar home systems have also proliferated across the country. The main reasons behind solar PV's popularity are its affordability and portability, due to its highly scalable and modular structure. However, as on date the renewable energy landscape is dominated by smaller systems, catering mostly to lighting and household level demand.

Some experience has been generated recently on the use of solar PV pumps both for drinking water and for irrigation by the MRRD's National Rural Water Supply, Sanitation and Irrigation

Programme (Ru-WatSIP), and also on large scale (between 500 kWp to 1 MWp) of solar PV based mini-grids.

The rural electrification efforts supported by the international community has led to key learning including[4]:

- There is a need to go beyond household electrification for lighting by addressing household thermal energy needs and engaging anchor customers for productive use in the commercial sector and public service opportunities in rural government institutions. Monthly expenditure on solid fuels during winter months is considered to be 10 times higher than the spend on kerosene for lighting[5].
- There is a need for integrated planning for energy projects along with infrastructure projects that will get direct benefits from reliable energy and vice-versa. For instance, planning for agriculture based livelihoods projects (i.e. cold-storages) should include a component of energy provision and likewise planning for energy projects (i.e. MHP) should identify and support enterprises and public institutions that will use the electricity thus generated.
- The mini-grid systems are infrastructure projects and hence require standard approaches of engineering services, project planning and operational management. All the projects should be planned and implemented in a coherent manner using standard guidelines and practices. In this regard, internationally accepted forms of contract, contract management and engineering supervision should be used.
- New technologies and technology innovation must be tracked by the planning and engineering teams and integrated within the overall framework of electricity service provision. Further, system planning and optimisation tools for maximising the benefits of hybrid configurations for generation from renewable energy and distributed generation topologies must be used.
- A common and accepted understanding of the roles and responsibilities in the ownership, operation and management, maintenance, payment for services, regulation, funding and financing, etc. are critical and should be achieved.
- Financing model of almost all the cost of the installation and maintenance with donor funding is not sustainable, collecting fee-for-services from the consumers is important for O&M of the plant.
- It will be important to create rural energy service delivery models that engage the private sector and financial institutions and leverage donor and government sources to create scalable and replicable models.
- There is a need to include gender perspective in the planning and implementation of rural energy projects and gender mainstreaming should be an integral component of any policy and planning framework.

[4] compilation by consultants on the basis of several stakeholder consultations, including GiZ IDEA team
[5] COAM, 2012, Shan Foladi village survey

1.5 Relevance of mapping the road to RE development

Mapping the road to RE development (The Roadmap), is important not only for meeting the internal objectives of energy access and energy security, but also to keep Afghanistan aligned with international initiatives on climate change adaptation and mitigation; sustainable development goals, and regional energy trade. At the macro level, the Roadmap shall contribute to achievement of sustainable development goals (SDGs), especially towards reduction of poverty (SDG 1), affordable and clean energy (SDG 7) and industry, innovation and infrastructure (SDG 9). It also addresses concerns in good health and wellbeing (SDG 3) and quality education (SDG 4) through provision of energy security for better service delivery in social sectors. Consistency with climate action (SDG 13) is maintained by linking the Roadmap's broad vision and outputs with key national climate policy documents such as the Afghanistan CCSAP and INDC.

Following figure highlights the relevance of the Roadmap.

Prospects

- Only 30% energy access in rural areas and 65% in urban
- Estimates suggest 222 GW of solar, 66 GW of wind and 23GW of hydro potential
- Role of RE recognized for energy access, energy security, SDGs and climate resilient development

Situation

- Forward looking and conducive policy regime
- RED (MEW), a dedicated department to develop RE sector
- Donors support to further the sector
- Private sector taking interest

Roadmap

Requirements

- Efficient and effective regulatory and policy landscape to attract private sector
- Regulatory and policy landscape to be efficient and effective for private sector to participate in RE development
- Strong pipeline for economically sustainable and financially viable projects
- Local industry to be strengthened to support the implementation of RE projects
- Synergistic approach by donors and other developmental partners
- Institutions absorptive to the capacity building and strengthening initiatives

Obstacles

- Internal security, particularly for international companies and experts
- Safety and connectivity related issues for travels to remote areas
- Availability of trained personnel
- Lack of funds and financing

Figure 4 - Relevance of Roadmap

2 TECHNOLOGIES AND MARKETS

2.1 From vision to targets

The vision of this Roadmap is to guide policy makers, the private sector, developers and other key stakeholders in shaping the renewable energy sector in Afghanistan. As discussed, the target for 2032 is to achieve around 5,000 MW of RE capacity to be realised as the RE market traverses three stages- Seeding, Creation and Transformation. The process for achieving these targets starts with an assessment of applicable and appropriate RE technologies for Afghanistan on the basis of a) RE resource potential, b) techno-commercial status at global level and c) appropriate system designs and configuration for various applications and markets.

2.2 Renewable energy outlook for Afghanistan

2.2.1 RE resource potential

Afghanistan's renewable energy potential is estimated to be over 300,000 MW[6], consisting of solar (222,849 MW), wind (66,726 MW), hydro (23,310 MW) and biomass (4,000 MW). Geothermal needs more detailed assessments to ascertain realizable potential.

Table 3 provides a summary of the total potential for RE resources in different provinces in Afghanistan. RE technical resource maps for Afghanistan are provided in Annexure A.

Table 3 - Region-wise RE technical potential in Afghanistan

S. No.	Province/ Capital	RE resource technical potential					
		Solar (MW)	Wind (MW)	Hydro (MW) (River basin)	Biomass- Electrical Energy Production potential (MWhr/ year)		
					MSW	Animal Manure	Crop Residue
1	Kabul (Kabul)	432	41	1,941 (Kabul)	126,884	69,089	465,372
2	Kapisa (Mahmud-e-Raqi)	183	81		13,848	171,438	442,103
3	Parwan (Charikar)	548	127		20,287	160,281	565,369
4	Wardak (Meydan Shahr)	1,043	18		18,231	84,917	529,715
5	Lowgar (Pol-e Alam)	451	-		11,984	72,713	842,423
6	Ghazni (Ghazni)	5,802	48		37,542	227,860	1,343,574
7	Paktia (Gardez)	5,042	99		13,291	144,569	475,755
8	Khost (Khost)	364			17,563	367,769	376,509
9	Nangarhar (Jalalabad)	1,687	146		46,124	626,687	1,749,774
10	Konar (Asadabad)	447	81		13,773	313,913	449,026
11	Laghman (Mehtar Lam)	842	255		13,622	269,201	654,148
12	Nuristan (Nuristan)	888	-		4,526	156,503	93,491
13	Badakhshan (Faizabad)	3,736	331		29,029	452,658	598,604
14	Bamian (Bamian)	1,863	24		13,667	143,149	286,562

[6] Source: Renewable Energy Department, Ministry of Energy and Water (http://www.red-mew.gov.af/)

S. No.	Province/ Capital	RE resource technical potential					
		Solar (MW)	Wind (MW)	Hydro (MW) (River basin)	Biomass- Electrical Energy Production potential (MWhr/ year)		
					MSW	Animal Manure	Crop Residue
15	Takhar (Taloqan)	2,543	1,199	20,137 (Panj-Amu)	29,990	269,732	1,524,344
16	Baghlan (Pol-e Khomri)	1,536	208		27,742	296,943	1,442,236
17	Kunduz (Kunduz)	1,279	7		30,636	388,437	1,863,114
18	Samangan (Aybak)	2,912	266	760 (Northern)	11,846	53,134	416,541
19	Balkh (Mazar-e-Shariff)	2,900	786		39,993	196,478	1,731,926
20	Jowzjan (Sheberghan)	2,230	43		16,449	75,809	906,725
21	Sar-i Pol (Sar-i Pol)	4,131	182		17,086	124,985	616,743
22	Faryab (Maymana)	4,679	252		30,450	182,703	1,350,830
23	Badghis (Qaleh-ye Now)	5,328	191	202 (Harirod-Murghab)	15,157	148,016	577,837
24	Herat (Herat)	28,539	18,473		28,250	382,275	2,013,776
25	Farah (Farah)	27,137	30,677		15,495	162,717	375,425
26	Ghowr (Chaghcharan)	10,539	84		21,109	232,387	406,450
27	Helmand (Lashkar Gah)	33,282	936	270 (Helmand)	57,174	424,513	1,732,510
28	Nimruz (Zaranj)	22,618	10,725		5,030	47,449	299,114
29	Kandahar (Kandahar)	31,079	117		36,973	406,866	1,111,055
30	Zabol (Qalat)	9,464	816		9,292	70,405	261,469
31	Uruzgan (Tarin Kowt)	6,530	495		10,712	159,410	584,592
32	Daikondi (Nili)	1,911	-		14,085	209,599	194,405
33	Panjshir (Bazarak)	510	-	-	16,863	237,601	616,076
34	Paktika (Sharan)	374	18		4,693	37,076	185,815
Total		222,849	66,726	23,310	819,396	7,367,282	27,083,408

Appropriate technologies for harnessing the above RE resources are briefly discussed below.

2.2.2 Technologies and markets

The RE resource potential available in Afghanistan can be harnessed using various technologies, some of them are already available and used in Afghanistan, while some others are yet to be introduced. These RE technologies can be configured into different types of systems suitable for specific applications and markets.

The RENP has identified three main categories of applications and markets that require the use of RE technologies and systems. These are:

- Utility scale (MW and above) essentially grid-connected to increase the domestic supply into the energy generation mix of the country
- Mini-grids for serving the load centers and population clusters for enhancing the livelihoods
- Stand-alone for servicing the basic and productive needs to off-grid communities

2.3 Description of RE technologies and systems

2.3.1 Solar photovoltaics (PV)

Afghanistan has a good solar resource that can be harnessed for electricity generation and for thermal applications. The country enjoys particularly long sunny days with high irradiation, ranging from 4.5 - 7 kWh/m²/day.

Technologies that convert solar energy into electric energy and usable heat are classified into two types: Solar Photovoltaic (PV) and Solar Thermal technologies respectively. Solar PV is one of the most advanced and universally applicable RE technologies that also boasts of a fastest growth curve in the recent years. Global installed capacity for Solar PV stands at 303 GWp, of which, the largest capacity exists in China, followed by Japan and Germany[7].

Basis description of solar PV technology

Solar cells, the building block of PV system, convert sunlight directly into DC electricity. These are categorized based on materials they are made of, such as wafer-based crystalline silicon (c-Si) (either mono-crystalline or multi-crystalline silicon) and thin-films using amorphous Si (a-Si/ c-Si), cadmium-telluride (CdTe) and copper-indium-gallium-selenide (CIGS). Figure 5 gives the current market share of PV technologies as per year 2015[8].

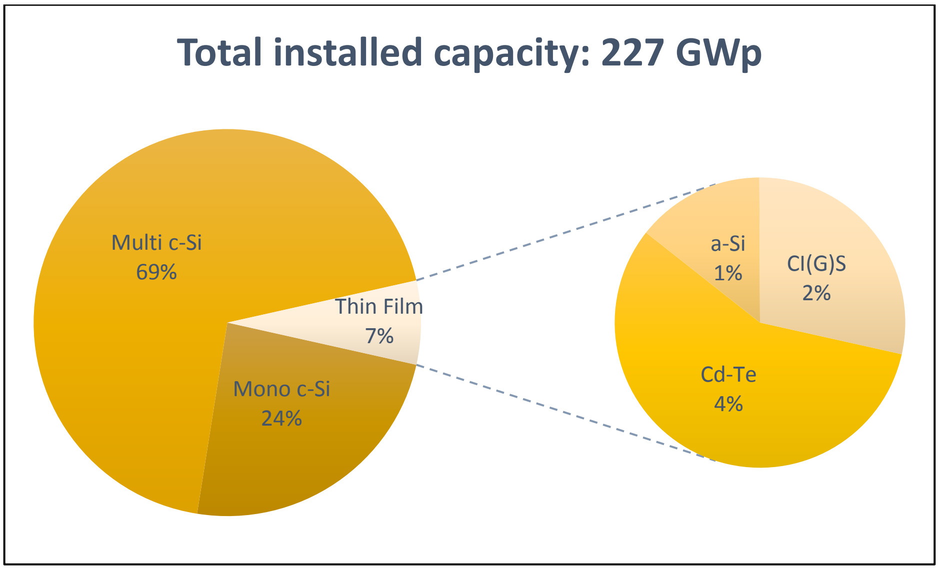


Figure 5 - Market share of PV technologies in 2015

Solar cells are assembled and electrically interconnected to form solar PV modules. In a c-Si PV module, slices (wafers) of solar-grade (high purity) silicon are made into cells that are assembled into modules and electrically connected. Thin film PV modules consist of thin layers of semiconductor material deposited onto inexpensive, large-size substrates such as glass, polymer or metal. Several solar PV modules are connected in series and/ or in parallel to increase voltage and/or current, respectively. An inverter is needed to convert direct current (DC) into alternating current (AC) for grid integration and use with most electrical appliances. Solar PV Modules and balance of system (i.e. inverter, mounting structures,

[7] REN21 Renewables 2017 Global Status Report
[8] Photovoltaics Report November 2016, Fraunhofer ISE

power control unit (PCU), cabling and batteries, if any) form a modular PV system with a capacity ranging from picowatts to gigawatts.

System configurations

Solar PV systems are used to generate electricity for both grid-connected and off -grid applications, such as residential and commercial buildings, industrial facilities, remote and rural areas and large power plants.

Based on the system configurations, grid connectivity and system portability, solar PV systems are generally categorized mainly into 4 types:

- Utility scale
- Roof-top (which can be both grid connected and stand-alone)
- Mini-grids
- Stand-alone

The choice of solar PV technology for installation is often based on a trade-off between investment cost, module efficiency and electricity tariff. Thin film solar PV technology is generally cheaper, though significantly less efficient and requires substantially more surface area for the same power output than c-Si-based systems. Conversion efficiencies of commercially available PV modules are given in Table 4[9]:

Table 4 - Conversion efficiencies of commercial PV modules

PV Module Technology	**Crystalline silicon (c-Si)**		**Thin Film (TF)**		
	Mono c-Si	Multi c-Si	a-Si	Cd-Te	CI(G)S
Efficiency Range	14-20%	13-15%	6-9%	9-11%	10-12%

I. Utility scale PV systems

Utility scale solar PV systems are typically in MW range and are generally ground-mounted. These are deployed either as Independent Power Projects (IPPs) or in Solar Power Parks (SPPs). Electricity generated from these projects is evacuated through the national (or private, as the case may be) transmission network.

II. Roof-top solar PV systems

Roof-top solar PV is a modular, grid-connected or standalone system that has electricity generating solar panels mounted on the roof of any building. By virtue of being mounted on a roof, these systems are small compared to ground mounted solar PV stations that could be in the MW range. Typically, solar PV roof-top systems range from 1 kW and upto 100 kW in terms of installed capacity.

Figure 6 below shows a roof-top mounted and a ground mounted solar PV system respectively.

[9] IEA. Photo Voltaic Solar Technology Roadmap. Paris: IEA Publications, 2010.

Roof-top Solar PV, Madhya Pradesh, India

Charanka Solar Park in Gujarat, India

Figure 6 - Grid connected Solar PV Systems

III. Solar PV mini-grids

Solar PV mini-grids have their own generation source (solar) and a local distribution grid. These are an ideal alternative to grid electricity in areas (such as remote villages) that do not have grid connectivity. Mini-grids also provide more reliable electricity, as any power cuts or interruptions to electricity supply can be quickly identified and corrected. Additionally, having the site of power generation closer to the load also reduces transmission and distribution (T&D) losses associated with centralised generation.

In most cases, solar PV mini-grids are either hybridized with other RE sources (i.e. wind) or with diesel and are backed up with batteries to increase the reliability and supply of electricity, particularly in case where electricity is required for after sun-shine hours. Typical sizes of mini-grids are from 10 kW to 1 MW. Figure 7 shows a typical solar mini-grid system.

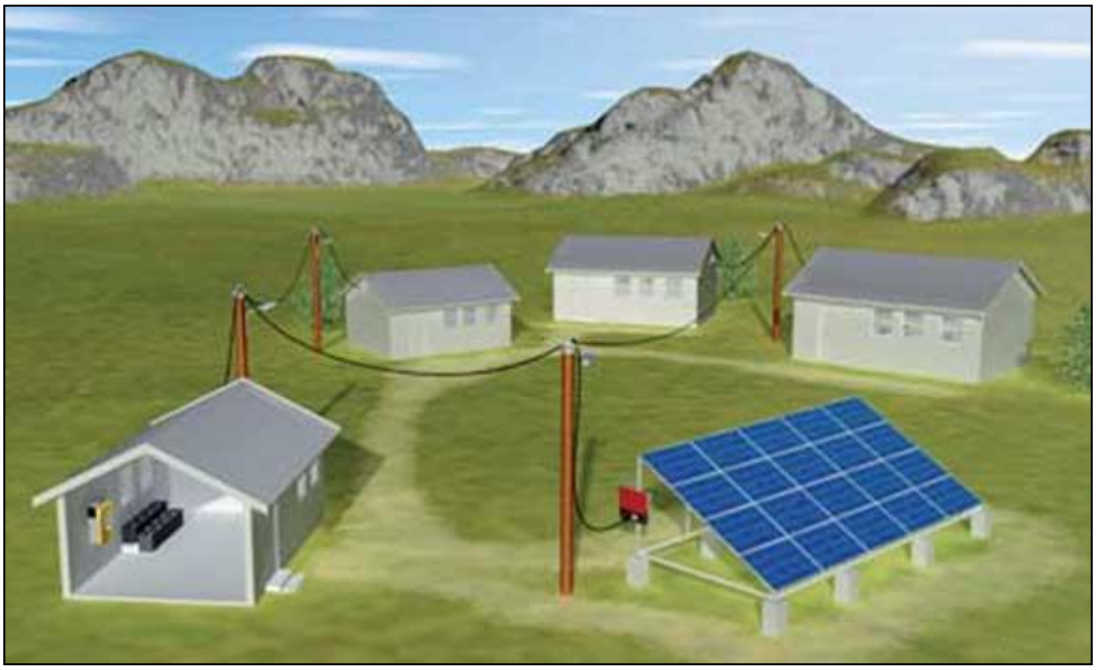


Figure 7 - Solar PV Mini-grid System

IV. Stand-alone solar PV systems

Stand-alone solar PV systems have many different applications across different sectors such as lighting, pumping and battery charging. The most popular stand-alone solar PV systems are:

1. Solar lanterns
2. Solar home systems (SHS)
3. Solar streetlights
4. Solar battery charging systems
5. Solar power packs (defence, telecommunication, etc.)
6. Solar pumps

In addition to the above proven system configurations, there are some new and emerging concepts which are worth mentioning here. These are the floating PV installations on static water bodies (such as lakes and reservoirs), canal-top PV systems, and concentrating PV.

V. Floating solar systems

Floating PV systems are installed over the surface of stationary water bodies such as reservoirs, lakes and ponds to generate electricity. It allows efficient use of the water body by reducing evaporation of water and improved yield from solar PV panels due to lowered ambient temperatures. These installations are particularly useful when availability of land is a constraint. However, there are some challenges which need to be overcome before this concept can become a techno-commercial viable application. These are related to design and materials of float, including the anchoring, impact on aquatic flora and fauna and social impacts on fishermen, local communities etc.

Figure 8 - A floating PV system of 1.15 MW capacity installed in Okegawa, Japan

Table 5 - Top Five Floating PV projects globally based on installed capacity

Rank	Size (kW)	Name of reservoir (lake) / Name of Plant	Country	City/Province	Operating from
1	20,000	Coal mining subsidence area of Huainan City	China	Anhui Province	April, 2016
2	7,500	Kawashima Taiyou to shizen no megumi Solarpark	Japan	Saitama	October, 2015
3	6,338	Queen Elizabeth II reservoir	UK	London	March, 2016
4	3,000	Otae Province	South Korea	Sangju City Gyeongsang Bukdo	October, 2015
5	3,000	Jipyeong Province	South Korea	Sangju City Gyeongsang Bukdo	October, 2015

(Source: Saori Minamino (Solarplaza) & Camille Marliere (Ciel & Terre), Floating Solar Plants - Niche Rising to the Surface?)

VI. Canal-top PV systems

Canal-top PV systems are installed across the canals and water channels. It allows efficient use of the canals by reducing evaporation of water. The capacity of canal-top PV systems may vary from small-scale (kW-sized) to larger-scale (MW-sized) installations. Although similar in capacity to ground mounted systems, this system varies significantly because of the need of a longer, wider and stronger mounting structure to support its installation over the width of the canal.

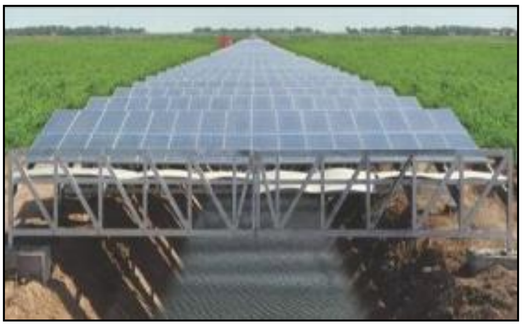


Figure 9 - 1 MWp Canal-top PV system installed over Narmada canal in Gujarat, India

VII. Concentrating photovoltaic (CPV) systems

CPV uses lenses and curved mirrors to focus sunlight onto small, but highly efficient, multi-junction (MJ) solar cells. In addition, CPV systems often use solar trackers and sometimes a cooling system to further increase their efficiency. Ongoing research and development (R&D) is rapidly improving their competitiveness in the utility-scale segment and in areas of high insolation.

Figure 10 - 3 MWp CPV project in Golmud, China

Global status and outlook

Global Solar PV installations at the end of 2016 stand at 303 GWp, contributed both by industrialized and developing countries[10]. The size and number of large-scale power plants continue to grow globally. During early 2016, at least 120 (70 in the previous year) solar PV plants of sizes 50 MW and larger were operating in 23 countries. Increase in market for solar PV is due to its increasing competitiveness, new government programmes, rising demand for

[10] Renewables 2017 Global Status Report, REN21. http://www.ren21.net/future-of-renewables/global-futures-report/

electricity and increased awareness of solar PV's potential as countries seek to reduce pollution and CO_2 emissions.

Until 2014, developed countries (namely Germany, Italy and Japan) dominated investment in solar. In 2015, developing countries such as China, India, Chile, South Africa and a few others increased the level of deployment of both utility and small-scale investment in solar PV. Solar power (both solar PV and thermal) investment in 2016 in developed countries was USD 56.2 billion, compared to USD 57.5 billion in developing and emerging economies.[10]

Status and relevance in Afghanistan

As per IRENA, a cumulative capacity of 1MW[11] has been installed in Afghanistan by 2016. The largest one is 1MW solar PV off grid system, which is installed in Bamyan province, supported by New Zealand Government. Some other important installations are: a 250KW solar PV off-gird system installed near the Kabul airport by the Japan Embassy, a 100kW solar PV off-grid system installed in Gardiz province, many roof-top solar PV systems through NSP in remote areas & villages and a number of standalone systems. Majority of these are installed through donor driven programmes.

Solar PV systems have a significant role to play in overall development of electricity sector in Afghanistan on account of the following:

- Majority of the population in remote areas doesn't have access to electricity and off-grid solar PV systems are a viable option where population is dispersed and scattered over a wide area
- Demand for electricity for irrigation is currently met through DG systems, which can be replaced by solar water pumping systems
- Utility scale solar PV projects can contribute to generation at the national level
- Solar PV systems are useful and applicable for nomads[12] (Kuchi people)

2.3.2 Solar thermal

Solar thermal systems convert solar radiation into heat. These systems are used to raise the temperature of a heat transfer fluid which can be air, water or a specially designed fluid. The heated fluid can then be used directly for hot water needs or space heating/cooling needs, or a heat exchanger can be used to transfer the thermal energy to the final application. The heat generated can also be stored in a storage tank for use in the hours when the sun is not available.

Solar thermal systems find various applications such as electricity generation, water heating, space heating/ cooling, industrial process heating, electricity generation etc. Solar thermal technologies can be divided into two broad categories: non-concentrating and concentrating.

Non-concentrating solar thermal technologies

Solar thermal technologies in which sunlight is directly absorbed and is not concentrated, are called non-concentrating solar thermal technologies. They work on the principle of exposing a dark surface to solar radiation so that the radiation is absorbed. Non-concentrating collectors absorb both direct and diffuse radiation. The absorbed radiation is

[11] http://resourceirena.irena.org/gateway/dashboard/ ; viewed on 27/05/2017
[12] Nomads are a community of people who live in different locations, moving from one place to another.

then transferred to a fluid, like air or water. There are two main types of non-concentrating solar thermal collectors: flat-plate collectors and evacuated tube collectors.

I. Flat-plate collectors (FPC)

FPC system consists of tubes carrying a fluid running through an insulated, weather-proof box with a dark absorber material and thermal insulation material on the backside that also prevents heat loss. FPC systems are typically used for heating swimming pools and other low-temperature applications.

II. Evacuated tube collectors(ETC)

ETC system use parallel rows of glass tubes, each of which contains either a heat pipe or another type of absorber, surrounded by a vacuum. This greatly reduces heat loss, particularly in cold climates. ETC systems are typically used in solar water heating systems (SWHs).

Concentrating solar thermal technologies

Concentrating solar thermal technologies use mirrors to concentrate sunlight and produce heat and steam to generate electricity via a conventional thermodynamic cycle. Unlike solar PV, concentrating solar thermal uses only the Direct Normal Irradiance (DNI) and provides heat and power only in regions with high DNI. Concentrating solar thermal systems can be equipped with a heat storage system to use heat energy even under cloudy skies or after sunset. Concentrating solar thermal systems used to generate electricity as an outcome are known as Concentrating Solar Power (CSP) systems and those used to generate heat as an outcome are known as Concentrating Solar Heat (CSH) systems.

There are four main concentrating solar thermal system configurations, that are commercially available:

I. Linear Fresnel Reflector (LFR) system

Linear Fresnel Reflector (LFR) systems use a series of ground-based, flat or slightly curved mirrors placed at different angles to concentrate the sunlight onto a fixed receiver located several meters above the mirror field.

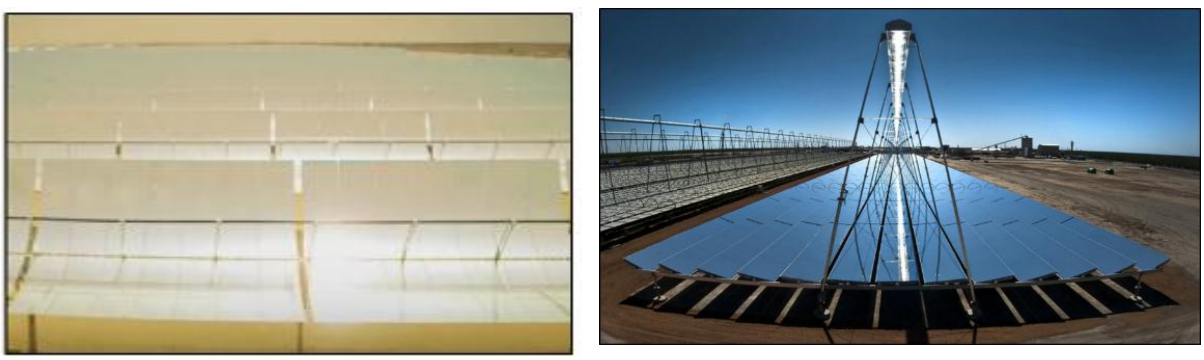


Figure 11 – Parabolic Trough Collector (left) & Linear Fresnel Reflector system (right) [13]

[13] http://www.concentratedsolarpower.it/en/fresnel/

II. Parabolic trough collector (PTC)

Parabolic trough systems consist of parabolic mirrors that concentrate the sun's rays on heat receivers (i.e. steel tubes) placed on the focal line. Receivers have a special coating to maximize energy absorption and minimize infrared re-irradiation and work in an evacuated glass envelope to avoid convection heat losses.

The solar heat is removed by a heat transfer fluid (e.g. synthetic oil, molten salt) flowing in the receiver tube and transferred to a steam generator to produce the super-heated steam that runs the turbine. Mirrors and receivers (i.e. the solar collectors) track the sun's path along a single axis (usually East to West). Parabolic troughs are desirable for certain industrial and commercial needs to provide large amounts of hot water and/or for producing electricity by running steam turbines.

III. Parabolic dish system

Parabolic dish systems consist of a parabolic dish shaped concentrator (like a satellite dish) that reflects sunlight into a receiver placed at the focal point of the dish. The receiver may be a Stirling engine (i.e. kinematic and free-piston variants) or a micro-turbine. Parabolic dish systems require two-axis sun tracking systems and offer very high concentration factors and operating temperatures. The main advantages of parabolic dish systems include high efficiency (i.e. up to 30%) and modularity, which is suitable for distributed generation.

IV. Central receiver tower system

A central receiver tower system consists of a large number of mirrors (heliostats) that track the sun individually over two axes and focuses on the central tower where the solar heat drives a thermodynamic cycle and generates electricity. The heat transfer medium used for most modern type solar towers includes water/steam, molten salts, liquid sodium, oil and even air. The sunlight from many mirror-like dish reflectors spread over a large area is focused to one central point achieving an extremely high temperature which is used to produce high pressure steam which is then used to generate electricity.

Figure 12 - Parabolic Dish System (left) & Central Receiver Tower (right)

In addition to renewable heat and power generation, concentrating solar technologies have other economically viable and sustainable applications, such as co-generation for domestic and industrial heat use, water desalination and enhanced oil recovery in mature and heavy oil fields.

Market share of different CSP technologies, both operating and under construction as per year 2015 is presented in Figure 13[14].

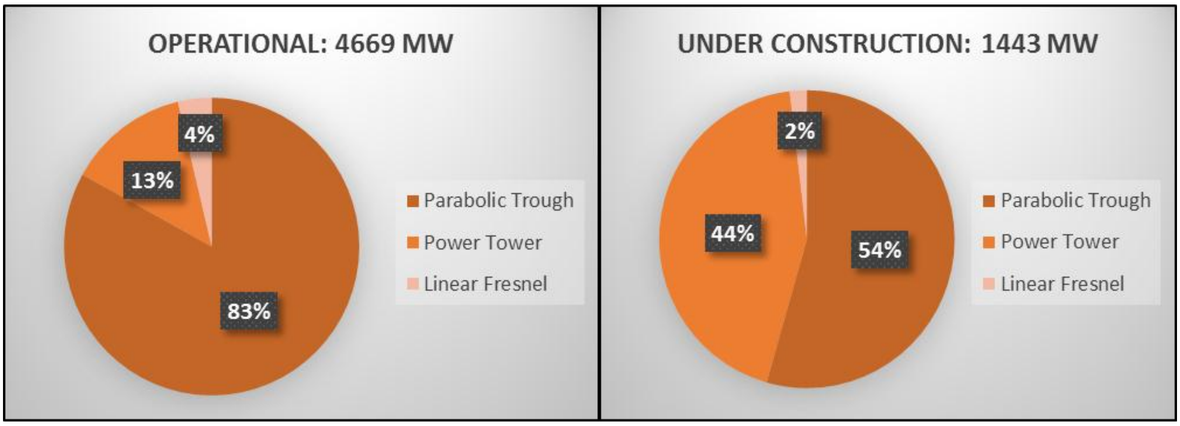


Figure 13 - Market share of different CSP technologies

Global status and outlook

Solar thermal market is less established as compared to solar PV though its applications are vast and varied, particularly in developing countries' context. Total concentrating solar power installed capacity has reached 4.8 GW at the end of 2016[15] with a further 11 GW in pipeline[16]. Globally, costs for solar thermal technologies are declining, several new technologies are under development, and thermal energy storage (TES) is becoming increasingly important and remains the focus of extensive research and development. CSP is gathering increased policy support in nations with limited oil/gas reserves, constrained power networks or strong agenda for industrialization and job creation. Top ten CSP installations in the world is provided in Table 6[17].

Table 6 - Top ten CSP Installations in the world

Rank	Size (MW)	Project Name	Technology	Country	City	Operating from
1.	392	Ivanpah Solar Electric Generating System (ISEGS)	Power Tower	USA	California	2014
2.	280	Mojave Solar Project	Parabolic Trough	USA	California	2014
3.	280	Solana Generating Station (Solana)	Parabolic Trough	USA	Arizona	2013
4.	250	Genesis Solar Energy Project	Parabolic Trough	USA	California	2014
5.	170	NOOR I	Parabolic Trough	Morocco	Ouarzazate	2015
6.	125	Dhursar	Linear Fresnel Reflector	India	Dhursar, Rajasthan	2014

[14] Graph created based on NREL SolarPACES data on CSP Projects accessed in November 2016
[15] Renewables 2017 Global Status Report, REN21
[16] http://social.csptoday.com/markets/installed-csp-capacity-now-over-45-gw
[17] Table created based on NREL SolarPACES data on CSP Projects accessed in November 2016

7.	110	Crescent Dunes Solar Energy Project (Tonopah)	Power Tower	USA	Tonopah, Nevada	2015
8.	100	KaXu Solar One	Parabolic Trough	South Africa	Poffader	2015
9.	100	Shams 1	Parabolic Trough	UAE	Madinat Zayed	2013
10.	89	Solar Electric Generating Station VIII (SEGS VIII)	Parabolic Trough	USA	California	1989

Status and relevance in Afghanistan

The largest solar thermal system (20m^3/day) has been installed in Kabul University's women's dormitory funded by the World Bank. Some other small solar thermal systems (domestic and large scale) are installed in the schools, dormitories, children garden and military bases since 1980.

Different types of solar thermal systems are manufactured in the country, like solar concentrated system for cooking, flat plate hot water system among others. Currently, advance solar hot water system (SHWS) are imported from China and India and are being used in the houses and for commercial purposes. Small and large scale of solar driers are made and used in agriculture sector.

There is a huge potential of solar thermal systems such as SHWS, which can be utilized in domestic sector, schools and mosques. Solar dryers can increase the quality of the local products in the agriculture sector. Local fabrication of the components can help create jobs and utilize locally manufactured materials. Solar cookers can be useful and applicable for rural communities and nomads.

Solar Thermal-LPG Hybrid Smart Cooking

Solar Thermal- LPG Hybrid Smart Cooking system has been commissioned at NTPC- Dadri, India which has been hybridized with Concentrating Solar Thermal M90 Dishes and efficient LPG Fired Burner. During day time (sunny hours) the system uses concentrating solar heat from M90 dishes for cooking, and during non-sunny periods, the LPG Fired burner automatically fires up, to provide completely automated-uninterrupted heat to the kitchen for cooking. Solar Thermal M90 Dishes at NTPC bear low running cost, the payback period is less than four years.

Figure 14 - Solar Thermal-LPG Hybrid Smart Cooking at a Power Plant Staff kitchen at NTPC- Dadri, India

Configuration of Concentrating Solar M90 Dishes at NTPC- Dadri, India:

Peak Capacity at STC	80,000 kcal/hr.
Application	Cooking (Baking, Boiling and Frying)
System Configuration	Hot Thermic Oil at 220°C
Integration	Hybridized with LPG Thermic Oil Heater
Peak Capacity at STC	80,000 kcal/hr.
Total Concentrator Area	2 Nos. of M90 Dishes totaling 180 m^2

Solar-Biomass Hybrid Cold Storage-cum-Power Generation system for Rural Applications

A new concept whereby available biomass and solar resource could be used to operate a small, decentralized cold storage right at the village level is implemented in National Institute of Solar Energy (NISE), India and is now operational. In addition to providing the cold storage facility to the farmers, such a system could also supply grid-quality power to the village; thereby offering a holistic solution to some of the key problems facing agrarian population.

Figure 15 - Solar-Biomass Hybrid Cold Storage-cum-Power Generation system for Rural Applications installed at NISE, India

The system, comprises a 15 kW (~5 TR) vapor absorption machine (VAM) coupled with a 50 kWe biomass gasifier system and a field of solar concentrating collectors. The biomass gasifier produces synthesis gas using locally available woody biomass, which is then used to run an engine-generator to produce electricity. The waste heat from the biomass gasifier along with the heat energy from the solar concentrating collectors is utilized by the VAM to cool the cold storage chamber. Since, the cold storage can be cooled to temperature as low as 0ºC, a wide variety of fruit, vegetables, and horticulture produce can be stored there. The electricity generated by the system is enough to power domestic, community, as well as productive loads in a typical village.

2.3.3 Hydro

Technology

Hydropower is a mature technology that is currently used to produce cost-effective, renewable electricity. In hydropower technology, water's potential energy is converted to kinetic energy and spins the blade of a turbine, which activates a generator to produce electricity.

Hydropower plants have two basic configurations: dams with reservoirs and run-of-river plants, with no reservoirs. The dam scheme can be sub-divided into small dams with night-and-day regulation, large dams with seasonal storage and pumped storage reversible plants (for pumping and generation) for energy storage and night-and-day regulation.

Pumped storage plants consist of two or more natural or artificial (dams) reservoirs at different elevations. When electricity generation exceeds grid demand, the energy is stored by pumping water from the lower to the higher reservoir. During peak electricity demand periods, water flows back to the lower reservoir through the turbine, thus generating electricity. In these kinds of plants, reversible Francis devices are used both for pumping water and for generating electricity.

Small-scale hydropower is normally designed to run in-river. This is an environmentally friendlier option because it does not significantly interfere with the river's natural flow. Small-scale hydro is often used for distributed generation applications to provide electricity to rural populations.

In Afghanistan, hydropower plants are classified as pico-hydro (0 to 5 kW), micro-hydro (5 to 100 kW), mini-hydro (101kW to 1000 kW), small-hydro (1001Kw to 10,000 kW) and large-hydro (above 10,001 kW) [18].

Hydropower also provides other key services, such as flood control, irrigation and potable water reservoirs. Hydropower is an extremely flexible electricity generation technology. Hydro reservoirs provide built-in energy storage that enables a quick response to electricity demand fluctuations across the grid, optimization of electricity production and compensation for power losses from other sources.

Global status and outlook

Globally, a total capacity of 1,096 GW hydropower has been installed by the end of 2016[19]. Countries such as China, Brazil, USA, Canada, Norway, India, and Russian federation accounted for 62% of installed capacities at the end of 2016. Other than increasing new capacities, there is always a demand for refurbishment of existing plants to improve the efficiency of output, as well as environmental performance in the face of new regulatory requirements. Innovations in hydropower technology include variable speed technology for new and refurbished pumped storage plants, which assist in further integration of variable renewable resources.

Status and relevance for Afghanistan

In Afghanistan, micro hydropower plants (MHPs) are commissioned and working in different provinces. In 2014, 7 MHP systems ranging from (200 kW to 500 kW) were commissioned in Badakhshan province. These MHPs were later handed over to DABS and are currently run by

[18] RENP
[19] Renewables 2017 Global Status Report, REN21

DABS. Afghanistan, has many feasible sites for MHP plants. Local expertise is available for operation and maintenance of these systems in Afghanistan. MHP systems can play a crucial role in economic and social development in the remote areas in Afghanistan.

As per ICE Energy Sector Report (Q2 2016), 42 MW Salma Hydro Power Plant (HPP) is in the final stage of completion by Indian government support and a 7.2 MW hydropower plant at Faizabad in KfW funding is under construction. Kajaki I HPP is expanding to a capacity of 18.5 MW with funding support from USAID and construction contract for Kajaki II HPP with 100 MW capacity has been signed with a private company. Construction of Surobi II HPP at Kabul with capacity of 180 MW and Baghdara HPP with capacity of 240 MW is under progress with support from private sector.

Micro Hydro Kinetic Turbine

Tata Power in India has successfully commissioned and tested a 10-kW low-head micro-hydro turbine, installed in the tailrace of the 150 MW Bhira hydro power plant in Maharashtra. The micro turbine generator was indigenously manufactured in Mumbai by Casmir Group based on the patented technology licensed from the University of Southampton.

Figure 16 - 10 kW micro hydro turbine at Bhira

The turbine utilizes the existing flow rate available to generate clean energy. The AC power generated by the turbine generator is a function of the following three factors combined:

- Average water velocity in the range of 1.25 m/s to 4 m/s (Increased power generation in faster flow)
- Minimum machine diameter of 2.1m requires 2.5m of water depth (Increased power generation in sites with deeper waters using the longer blade variants available)
- Continuous flows: total power generated depends on number of hours of water flow available at a site

Other than applications in tailraces of existing hydropower plants, rivers and canals, the micro hydro turbine has a bi-directionality option to facilitate operations in tidal currents as well.

Source: http://www.tata.com/article/inside/Tata-Power-integrates-a-micro-hydro-turbine-at-its-Bhira-hydro-power-station-in-Maharashtra

2.3.4 Wind

Technology

The kinetic energy of the moving air (or wind) is transformed into electrical energy by wind turbines or wind energy conversion systems. The wind forces the turbine's rotor to spin, changing the kinetic energy to rotational energy by moving a shaft which is connected to a generator, thereby producing electrical energy through electromagnetism.

Wind power systems are categorized primarily by the grid connection (connected/ stand-alone) and wind turbine type (vertical/horizontal-axis). The specific system configuration is determined mainly by the wind condition (especially wind speed), land availability (or where the plant is sited), grid availability, turbine size and height, and blade size. Most large wind turbines are up-wind horizontal-axis turbines with three blades. Most small wind turbines are also horizontal-axis.

Horizontal-axis turbines are being used commercially all over the world. The rotating shaft is mounted parallel to the wind flow/ground, and the turbines can have two types of rotors: up-wind and down-wind. The advantage of up-wind turbines is that they are minimally influenced by the turbulence caused by the tower. However, a yaw mechanism is needed to align the turbine with the prevailing wind.

A group of wind turbines in the same location used for production of electricity constitutes a wind farm. A large wind farm may consist of several hundred individual wind turbines distributed over an extended area, but the land between the turbines may be used for agricultural or other purposes.

Wind energy is very consistent from year to year but has significant variation over shorter time scales. It is therefore connected to the national electricity grid or can even be used as a hybrid option with other electricity generating/ storage sources to give a reliable electricity supply such as wind-solar hybrid, wind-diesel hybrid etc. Such hybrid options can be used as mini-grids for supplying electricity to areas with no electricity grid.

Wind energy projects are common for off-grid applications such as water pumping and electricity supply through wind power systems, wind-solar/ wind-diesel hybrid systems.

Global status and outlook

Globally, 487 GW of wind power technology has been installed by the end of 2015 of which, the largest capacity exists in China, followed by United States, Germany and India. The wind power capacity at the end of 2016 was enough to meet almost 4% of total world electricity production[20]. Wind power is now considered as the most cost-effective option in a large number of countries for new power generating capacity.

Status and relevance for Afghanistan

Afghanistan has a good wind resource potential especially in South East part of the country. Sixteen wind monitoring stations have been installed in different parts of the country. A few small wind turbine systems (<50kW) are installed in different locations of the country. The first ever wind turbine system of capacity 100 kW with battery backup system has been installed in Panjsher province. A couple of local wind turbine manufacturers are available in Kabul city who can fabricate up to 20kW wind turbines with accessories.

Wind power systems can be used in various configurations such as the following:

- Wind farms can contribute significantly to national grid electricity
- Wind mechanical pumps, which can be very useful for irrigation purposes especially in Farah, Nimroz and Herat provinces, because of high wind speeds
- Small mechanical wind turbine can be hybridized with DG sets for remote areas, institutional and agricultural loads

2.3.5 Biomass

Technology and systems

Bio-energy is generated from organic matter derived from plants or animals available on renewable basis also known as “Biomass”. It is used for energy applications covering a variety of practices and technologies, ranging from traditional heat production for cooking and/ or space heating to modern combined heat and power generation or biofuels

[20] Renewables 2017 Global Status Report, REN21

production. Majority of the biomass energy is consumed in developing countries for traditional uses with very low efficiency (10%-20%) such as cooking, while modern uses of biomass for heat and power generation include mainly high-efficiency, direct biomass combustion, co-firing with coal and biomass gasification.

Direct, traditional uses of biomass for heating and cooking applications rely on a wide range of feedstock and simple devices, but the energy efficiency of these applications is very low because of biomass moisture content, low energy density and the type of the basic input. Pre-treatment is done in order to improve biomass characteristics and make handling, transport, and conversion processes more efficient and cost-effective such as:

- Drying to reduce moisture content and transport costs of biomass feedstock and improve combustion efficiency;
- Palletisation and Briquetting to mechanically compact bulky biomass, such as sawdust or agricultural residues;
- Torrefaction (for woody biomass) in which biomass is heated in the absence of oxygen to between 200-300°C and turned into char, with a process that is similar to traditional charcoal production.
- Pyrolysis is a further thermo-chemical pre-treatment process during which biomass is heated to temperatures of 400-600°C in the absence of oxygen to produce pyrolysis oil (also referred to as bio-oil), along with solid charcoal and a by-product gas.

Biomass is distributed worldwide and is extensively used for energy, however, securing good quality feedstock at affordable prices over a plant's lifetime is crucial for biomass power projects.

Bio-energy is also being used in other forms and applications such as:

I. Improved cook-stoves

Improved cook-stoves is basically a combustion device which burns biomass fuel more efficiently with reduced emissions and offers cleaner cooking energy solutions. These are basically of two types; fixed type and portable type. The portable cook-stoves are also of two types; natural draft and forced draft. Forced draft cook-stoves are more efficient cook-stoves compared to natural draft ones. Each type of cook-stove can be used for domestic as well as community cooking applications. The improved cook-stoves may be made with metal, ceramic and terracotta/ pottery (durable type) and combination thereof.

Figure 17 - Improved cook-stove & Biogas system setup

II. Biogas systems

Biogas refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, industrial waste, plant material, sewage, green waste or food waste. Biogas systems provide:

- Clean gaseous fuel for cooking and lighting
- Digested slurry from biogas plants to be used as enriched bio-manure to supplement chemical fertilizers
- Improved sanitation in villages and semi -urban areas by linking sanitary toilets with biogas plants

III. Waste to energy systems

Waste to Energy systems allow treatment and processing of waste from urban & rural areas and industries, resulting in energy generation. Energy is generated from the organic fraction of waste (biodegradable as well as non-biodegradable) through thermal, thermo-chemical, biochemical and electrochemical methods.

- **Thermal conversion**: The process involves thermal degradation of waste under high temperature. In this complete oxidation of the waste occurs under high temperature. The major technological option under this category is ***Incineration***.
- **Thermo-chemical conversion**: This process entails high temperature driven decomposition of organic matter to produce either heat energy or fuel oil or gas. They are useful for wastes containing high percentage of organic non-biodegradable matter and low moisture content. The main technological options under this category include **Pyrolysis and Gasification**. The products of these processes (producer gas, exhaust gases etc.) can be used purely as heat energy or further processed chemically, to produce a range of end products.
- **Bio-chemical conversion**: This process is based on enzymatic decomposition of organic matter by microbial action to produce methane gas, and alcohol etc. This process, on the other hand, is preferred for wastes having high percentage of organic, bio-degradable (putrescible) matter and high level of moisture/ water content, which aids microbial activity. The major technological options under this category are **anaerobic digestion (bio-methanation) and fermentation**. Of the two, anaerobic digestion is the most frequently used method for waste to energy, and fermentation is emerging.
- **Electrochemical conversion**: Electrochemical conversion in the context of waste to energy refers typically to microbial fuel cells (MFC). These systems are developed to trap the energy from wastes, where the reduction-oxidation machinery of immobilized microbial cells is catalytically exploited, for the accelerated transfer of electrons from organic wastes, to generate electricity and bio-hydrogen gas. However, this methodology needs extensive evaluation studies on bulk scale liquid waste treatments and stands at a nascent level, worldwide.

Global status and outlook

Globally bio-power capacity reached 112 GW by the end of 2016. The share of bio-energy in total global primary energy consumption has remained steady since 2005, at around 10.5%.

By country, the United States is the largest producer of electricity from biomass sources and by region, European Union leads both the bio-power generation and capacity[21].

Status and relevance in Afghanistan

Most of the rural population in Afghanistan is active in agriculture and livestock sector, however bio-energy technologies are still in a nascent stage. Only a limited number of family type biogas plants have been installed in eastern provinces and central parts of the country through MRRD, BORDA Afghanistan and a couple of NGOs. Recently, some studies are under process for biomass energy projects in Kabul city and Balkh province under supervision of Kabul Municipality, Ministry of Urban development. Applications of bio-energy such as waste to energy and biogas units are relevant to Afghanistan. Raw material (municipality waste) is available in the cities which can be utilized in the waste to energy projects for electricity generation. In remote areas, agricultural wastes are available that can act as a raw material for biogas plants. Improved cook-stoves can also help to improve indoor air quality and offers cleaner cooking energy solutions. These can improve health protection of women and society in villages and keep the environment clean.

2.3.6 Geothermal

Technology

Geothermal electricity generation is a mature, baseload generation technology that utilizes steam or hot water from geothermally active areas to provide very competitive electricity where high-quality resources exist. Geothermal energy originates from the geological processes during formation of the planet, radioactive decay of minerals, and from solar energy absorbed at the surface. Geothermal energy is available around the clock, independent of the surface climatic conditions. Geothermal resources include dry steam, hot water, hot dry rock, magma, and ambient ground heat.

Global status and outlook

Globally, 13.5 GW of geothermal power has been installed at the end of 2016[21]. Top five leading countries in the geothermal power generation are USA, Philippines, Indonesia, Mexico and New Zealand. Geothermal direct use capacity has increased by a yearly average rate of 6% in recent years, while direct heat consumption has grown by 3.5%[21]. The geothermal industry continues to face significant project development risk; various efforts are under way to ameliorate such risks.

Status and relevance in Afghanistan

Geothermal energy is a highly valuable, clean and reliable heat and power source in Afghanistan, which is still untapped. Historically, geothermal energy in Afghanistan has been only used for medical bathing[22]. Further geological, geochemical, and geophysical studies are required to characterize the reservoirs of numerous geothermal prospects in Afghanistan for electricity generation and other applications.

2.3.7 Other related technologies

In addition to the above RE technologies, there are other related technologies which are significant for RE development in Afghanistan.

[21] Renewables 2017 Global Status Report, REN21
[22] http://www.mindfully.org/Energy/2004/Afghanistan-Geothermal-Energy1feb04.htm

Air source heat pump

An air source heat pump (ASHP) is a system which uses energy to draw heat from outside to inside a building, or vice versa. This heat can then be used to heat radiators, underfloor heating systems and hot water circuit. Air source heat pump can absorb heat from the air even when the temperature is as low as -15° C.

The energy that is produced by the air source heat pump is considered as a renewable because the air is heated by sun which then heats the house, even though the pump itself is powered by electricity. Air source heat pumps are an attractive alternative to conventional domestic heating systems such as LPG boilers. The air source heat pump is promising solution for building segments with limited roof area availability.

A heat pump system consists of a compressor and two coils made of copper tubing. In heating mode, the refrigerant in the outside coils extracts heat from the air and evaporates into vapor form. The indoor coils release heat from the refrigerant while it condenses into a liquid. A reversing valve changes the direction of the refrigerant flow for cooling in summer.

There are two main types of air source heat pump systems: Air to Water and Air to Air. Air-to-Air systems typically use fans to circulate warm air around the home and cannot be used to heat water. The performance of air source heat pumps is measured by the coefficient of performance (COP). A COP of 3 means the heat pump generates 3 units of heat energy for every 1 unit of electricity it consumes. Globally the market for heat pumps is assessed at 58.3 million units (2013) and predicted to increase at a CAGR of 10.6% for 2014-2020[23]. Air source heat pumps have become widely available commercially only in the past few years.[24]

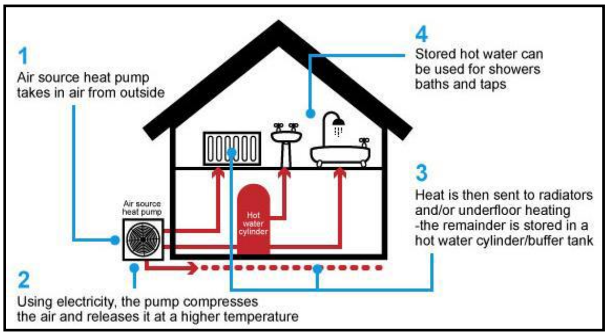


Figure 18 - Schematic of Air Source Heat Pump[26]

The efficiency of heat pumps is expected to improve by 2030 by 30-50% for heating and 20-40% for cooling. Cost reductions are also expected due to technology improvements, market penetration and synergy with thermal storage systems[25].

The figure illustrates the working of an Air Source Heat Pump.

Energy storage

Renewable energy sources are intermittent in nature, producing energy when the sun is shining and the wind is blowing, and therefore energy storage becomes important for supplying uninterrupted energy. Energy storage technologies absorb energy when production is more than the demand and store it for a period before releasing it to supply energy. By storing the energy produced and delivering it on demand, it can level out peaks in output to create a continuous, reliable stream of power throughout the day.

Energy storage technologies are divided into following six main categories.

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[23] Heat Pumps (Heating, Cooling and Hot Water) - A Global Market Overview
[24] Radisson Blu Hotel in Pune, India has installed 40 TR Air source heat pump to generate hot water for bathing and kitchen with a capital cost of INR 1.9 million and having a payback of 1.3 years.
[25] ETSAP - IRENA Heat Pumps Technology Brief
[26] Roundtable discussion on "Renewable Energy onsite generation and use in Buildings": Prayas and Greentech Knowledge Solutions; New Delhi, 20th Oct. 2016

- **Electric batteries** store electricity in the form of chemical energy and are mainly of two types – rechargeable and non-rechargeable
- **Flywheels** are mechanical devices that stores electricity as rotational energy which is harnessed to deliver instantaneous electricity
- **Compressed air energy storage** stores off-peak electricity to compress air which is later discharged to the gas turbine to generate electricity during peak periods
- **Thermal storage systems** store thermal energy by heating or cooling a storage medium which can be used at a later stage for heating and cooling applications and power generation
- **Pumped hydropower storage** facilities store energy in the form of water in an upper reservoir, pumped from another reservoir at a lower elevation. During periods of high electricity demand, power is generated by releasing the stored water through turbines in the same manner as a conventional hydropower station.

Today, energy (electricity and thermal) storage technologies exist at different levels of development, from the R&D to demonstration and commercialization. Figure 19 shows the development stages of various energy storage technologies. The energy storage market is estimated to grow to an annual installation size of 6 GW in 2017 and over 40 GW by 2022 from 0.34 GW installed in 2012 and 2013.

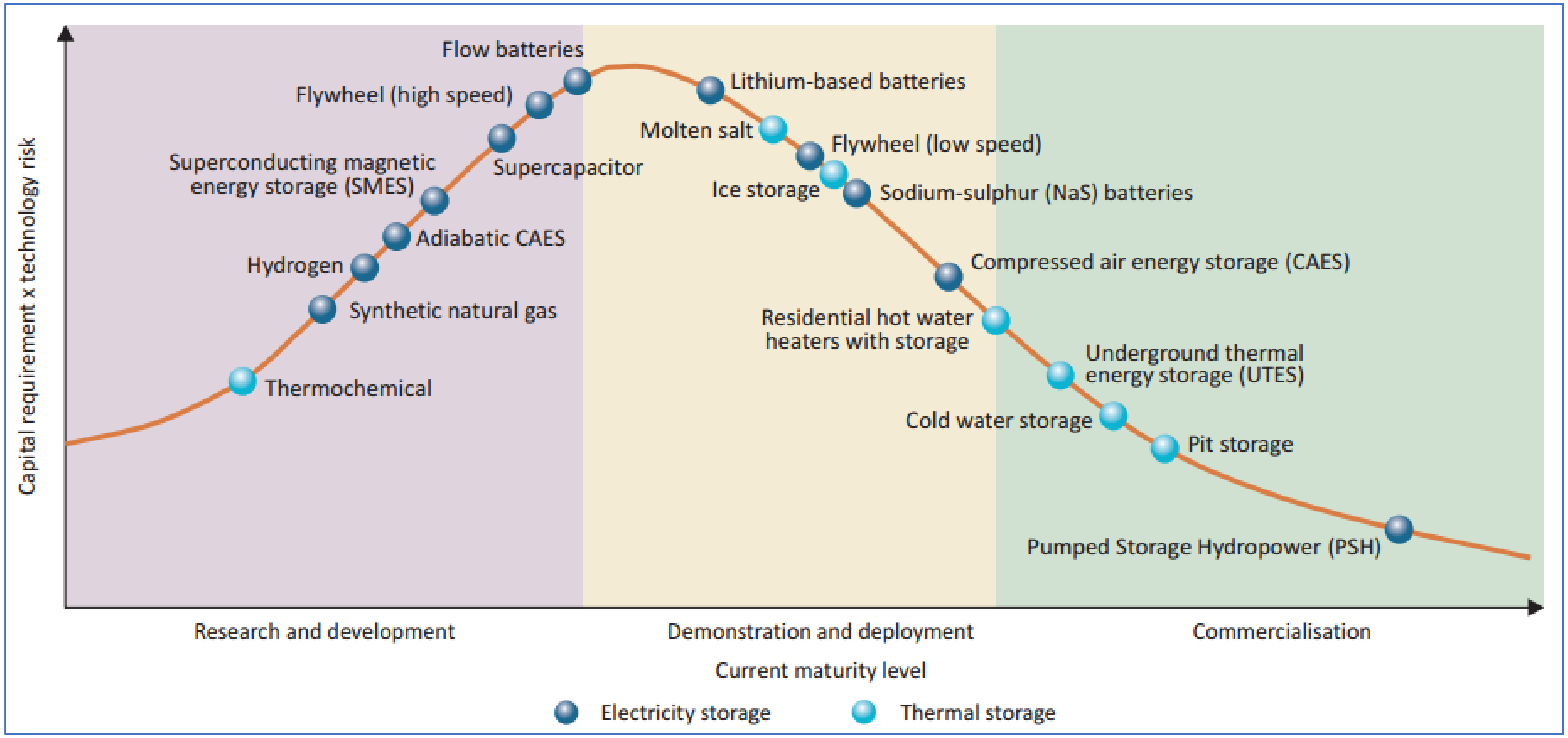

Figure 19 - Maturity of energy storage technologies[27]

[27] Technology Roadmap Energy Storage IEA 2014

2.4 Recommended RE technologies and systems

This chapter has discussed and provided a long list of technologies that are to be harnessed in Afghanistan.The following table gives a summary of all RETs that are being studied as possibilities for implementation, along with their applications.

Table 7 - RE technologies and their applications in Afghanistan

Technology	Market	System Configuration	Application
Solar Photovoltaic	Utility	Solar Power Parks	Utility Scale Generation
		Floating PV	Utility Scale Generation
		Concentrating PV	Utility Scale Generation
		Solar IPPs	Utility Scale Generation
	Mini-grid	Hybrid: Diesel + Solar	Localised loads
	Stand alone	Roof-top with Net-metering	Captive consumption/export to grid
		PV home systems	Off-grid/rural markets
		Solar pumping	Off-grid irrigation/drinking water supply
Solar Thermal	Utility	Concentrating solar power	Utility Scale heat and electricity Generation
	Stand alone	Evacuated tubes/Flat plate	Thermal energy generation for heating purposes
Hydro	Utility	Large Hydro Power plants	Utility Scale Generation
	Mini-grid	SHP + MHP	Localised loads
		Hybrid: Diesel + MHP	Localised loads
Wind	Utility	Wind IPPs	Utility Scale Generation
	Mini grid	Hybrid: Diesel + Wind	Localised loads
Biomass/ Biogas	Utility	Power generation from agri residues	Utility Scale Generation
		Methanation of organic manure/agri waste	Utility Scale Generation
		Bio-methanation of Municipal solid waste	Utility Scale Generation
	Mini-grid	Hybrid: Diesel + Biomass	Localised loads
	Stand alone	Biogas for thermal energy	Space heating/captive consumption
		Improved cook stoves	Cooking (domestic and community)
Geo-thermal	Utility	Heat pump applications and electricity generation	Utility Scale Generation

Key highlights of Renewable energy sector

- By the end of 2016, the renewable energy installed capacity was enough to supply an estimated 24.5% of global electricity, with hydropower providing about 16.6%. The world now adds more renewable power capacity annually than it adds (net) capacity from all fossil fuels combined. [Renewables 2017 Global Status Report, REN21]
- The record lab solar PV cell efficiency has reached 25.6 % for mono-crystalline and 20.8 % for multi-crystalline silicon wafer-based technology. [Photovoltaics Report 2016, Fraunhofer ISE]
- Even in conservative scenarios and assuming no major technological breakthroughs, solar power will be the cheapest form of electricity in many regions of the world. Depending on annual sunshine, power cost of 4–6 cents/kWh are expected by 2025, reaching 2–4 cents/kWh by 2050[28]
- By end of 2015, global concentrating PV (CPV) capacity reached 360 MW, most of which are high-concentration systems (CR: 300-1000) [Renewables 2016 Global Status Report, REN21]. With concentrator technology, module efficiencies of up to 38.9 % (lab record) & 33 % (commercially) have been reached. [Photovoltaics Report 2016, Fraunhofer ISE]
- Since first floating plant installation in 2007, the total installed capacity globally has now reached 93 MWp with 70 floating PV plant worldwide. The biggest floating plant has a capacity of 20 MWp[29].
- A new form of CSP, called STEM (Solar Thermo Electric Magaldi), which uses fluidized silica sand as a thermal storage and heat transfer medium to produce 24-hour industrial scale power for off-grid applications is receiving international interest. By using fluidized solids as alternative to other storage media, the use of corrosive or environmentally unfriendly fluids can be cut down and the receiver can be operated at much higher temperature[30]. On 30th June 2016, the first STEM industrial model plant started operations in San Filippo del Mela (Sicily).[31]
- Repowering, i.e. replacing old wind turbines with modern higher capacity turbines, is on the rise. It has led to increase in wind power while reducing the footprint. A 2 MW wind turbine with an 80-m diameter rotor now generates four to six times more electricity than a 500 kW, 40 m diameter rotor built in 1995. [IEA Website]
- Bioenergy accounts for around 7% of all industrial heat consumption, and has not increased in recent years. [Renewables 2017 Global Status Report, REN21]
- Asia has the highest number of small-scale biogas digesters, with more than 100 million people in rural China and 4.83 million people in India have access to digesters to produce gas for cooking and space heating. [Renewables 2016 Global Status Report, REN21]
- Two lithium ion battery storage projects totalling 37.5 MW & 150 MWh is under construction phase in Southern California. When completed, the larger, 120 MWh (30 MW for 4 hours) project will be the single biggest lithium ion battery in service on a utility grid in the world. In March 2016, a project with 50 MW, 300 MWh sodium-sulfur battery facility went into service.[32]
- In October 2016, the Powerwall 2 (an upgrade to its previous version), a home battery unit, was unveiled by Tesla Company. It is considered a game changer for the residential energy storage market. The improved version has a capacity of 13.5 kWh and has an inbuilt Inverter of 5 kW. The cost per kWh of the battery with inverter is around 407 USD but after deducting the cost of inverter, it is only 259 USD.[33]

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[28] Current and Future Cost of Photovoltaics: Agora Energiewende & Fraunhofer ISE

[29] Saori Minamino (Solarplaza) & Camille Marliere (Ciel & Terre), Floating Solar Plants - Niche Rising to the Surface?)

[30] http://www.altenergymag.com/article/2015/08/the-efficient-use-of-concentrating-solar-power-technology/21029/

[31] http://blog.bulk-online.com/news-english/magaldi-the-first-stem-solar-thermo-electric-magaldi-plant-starts-operations-in-sicily.html

[32] http://www.utilitydive.com/news/inside-construction-of-the-worlds-largest-lithium-ion-battery-storage-faci/431765/

[33] http://seekingalpha.com/article/4019651-teslas-powerwall-2-right-product-right-time

3 DEVELOPMENT OF PROJECT PIPELINE USING DECISION TOOL

The type of projects that could be taken up for each RE technology, are identified through a process that is developed specifically for this Roadmap and is presented here in the form of a Decision Tool.

3.1 Developing the project pipeline

A 3-level process is developed for creating a pipeline of RE projects in Afghanistan ensuring RE resource are exploited by suitable system configurations. Level 1 takes into account the techno-economical RE resource potential, grid availability, land availability and logistics which are very region-specific in Afghanistan. This process gives an idea about suitable RE resource and the implementing technology and also point at suitability of utility scale vs off-grid systems. The next Level 2, evaluates various factors such as existing load profiles, energy consumption pattern, terrain characteristics, population densities, available energy resources, and other social factors to indicate mini-grids vs stand-alone system choices. Level 3 discusses about requirements of actual implementation of RE projects by conducting surveys, devising suitable business models, and involving existing institutions such as NGOs, MFIs, and CDCs.

The 3-level process evolves into a Decision Tool that is presented in this chapter. This decision tool is aligned with the needs of the government, the project developers and the users, and acts as a guiding principle to assist them in decision making. It is presented in the form of a flow chart, supported by qualitative and quantitative parameters. The Decision Tool can be linked with the GIS system for strategic planning of projects.

3.2 Decision process and levels

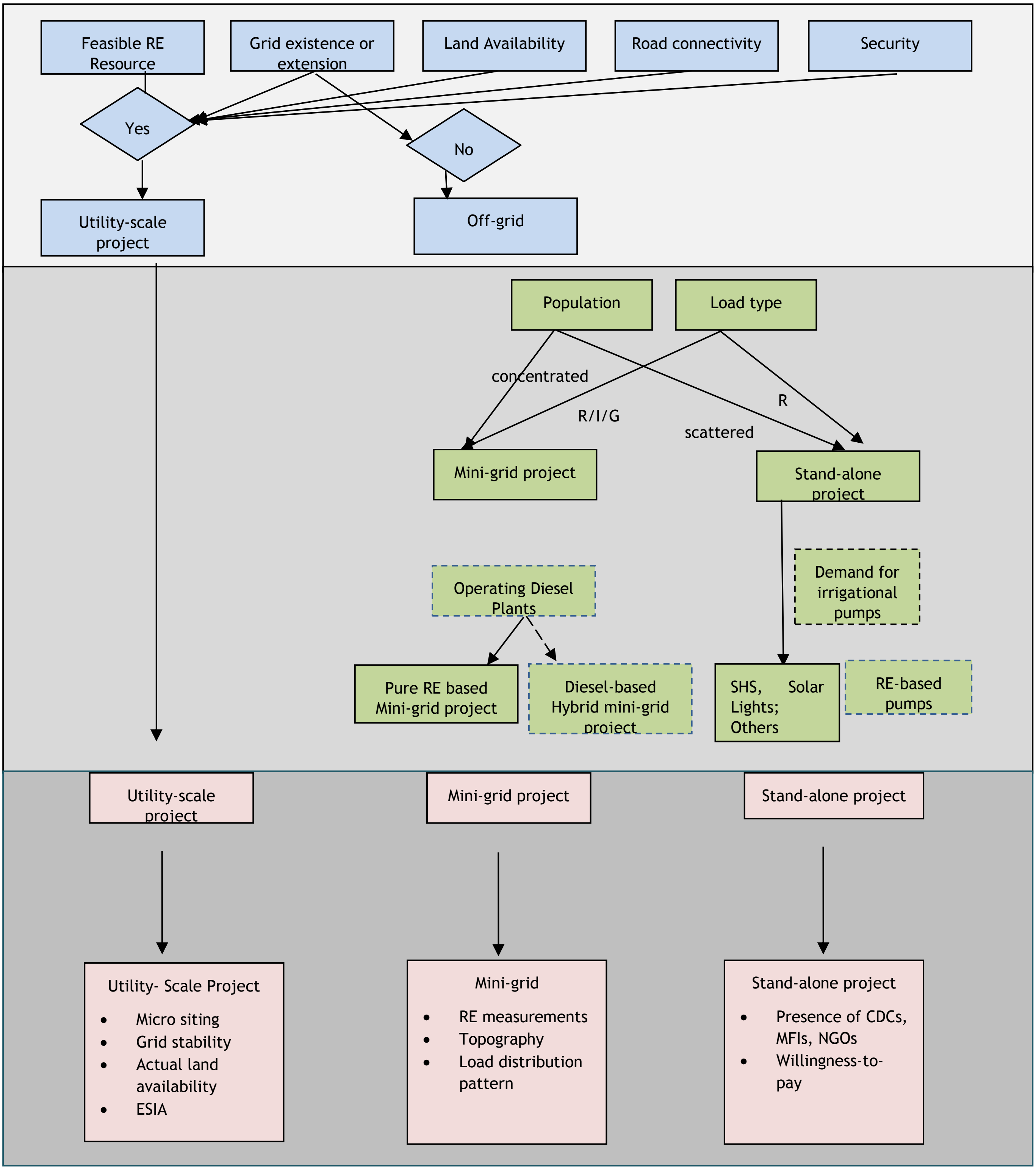
Level 1: At level 1, Decision Tool aids the policy makers who are at the first level of the decision-making hierarchy in deciding whether to plan for utility scale grid- connected or off-grid projects. The decision is aided by ensuring the feasible RE resource at the first step and grid availability or any grid extension plan in the near future for electricity evacuation. Next immediate factor to consider is availability of land and proper road connectivity to the proposed site for installation of a grid-connected/ utility-scale RE project. Finally, an important point for consideration is security of the proposed site as grid-scale project developers would prefer safe and secured operating environment. Thus, this level serves as a quick and practical indicator to decide between grid-connected/ utility scale or off-grid markets.

Level 2: The outcome at level 1 is further evaluated to determine the most appropriate RE system configuration. A complete solution depends not only on the technical and financial parameters, which are quantitative in nature, but also on qualitative socio-economic parameters. The first indicator at this stage is the concentration of population to be served by the RE system. This gives an idea about the presence of load demand in the area. For instance, stand-alone systems work well in locations with scattered population and dispersed demand. The second indicator is the existing load type that defines the prevalent electricity consumer category- industrial, residential or rural, and government; and any application-specific demand. Presence of other energy supplying sources such as diesel plants allows opting for RE-diesel hybrid mini-grid market.

Level 3: The final level aids in realizing ease of implementation of the identified system configuration at levels 1 and 2. These are used to micro-site the project and evaluate the social acceptability and financial viability of the utility-scale, mini-grid or stand-alone RE project. Ultimately, these parameters enable the project developers and the users in developing a mutually agreed upon business model, thus suggesting project design for the project pipeline.

3.3 Decision Tool

Figure 20 illustrates the flow of the 3-level process as the Decision Tool.



Legend: "R"-Residential, "I" -Industrial, "G" -Government

Figure 20 - Decision Tool for creating project pipeline

3.4 Description of parameters

Parameters used in the Decision Tool are described in the following table:

Table 8 - Description of parameters

Parameter	Description	Source
Level 1		
RE resource availability	Technical potential of various RE resources across the country helps to know about the deployable RE technology(s) among solar, wind, hydro, biomass, and geothermal energy	NREL, RE Resource maps from MEW (Annexure A)
Grid availability or grid extension plan	Presence of grid for power evacuation makes utility scale RE project a viable choice for that area. Future plans for grid extension can help determine the choice between grid compatible mini-grid configurations and future utility scale options	Power system planning maps from DABS (Annexure B)
Land availability	Land availability is critical for setting up utility-scale RE power projects. Likewise, the availability of large water bodies/roof areas can help determine the choices of land neutral/roof-top solutions respectively	Land authority, Central Statistic Organisation (CSO)
Road connectivity	Road connectivity helps utility scale project development by easing the transportation of labour and heavy equipment during the construction phase. Likewise, the operation and maintenance phases are also improved by good road access	Road maps of Afghanistan
Security	A secured project site is essential when going for utility-scale projects, for developers and other consumers, as it ensures a safe operating environment for the project as well as better revenue inflow	UN security map and internal security maps
Level 2		
Population concentration	Population concentration helps decide between mini-grid or stand-alone system configuration. An area with high population concentration, without grid connection, is suitable for mini-grid type projects. However, a scattered population, covering a large area is more suited to standalone systems	CSO
Presence of industrial, commercial, residential, and institutional Loads	Presence of existing consumers (or load), i.e. industrial, commercial or residential, in a region helps to understand the prevalent energy usage pattern and local supply options at the proposed site. Potential for enterprise development further helps in selecting mini-grids or stand-alone options	CSO
Level 3		
Presence of CDCs, MFIs and NGOs	Presence of NGOs, MFIs and CDCs enable sustainable project deployment by providing finance and preparing communities to accept stand-alone and mini-grid facilities. It increases the ease of project implementation for the government, donor organizations, or the project developers and implementers	Project feasibility study including primary survey and desk analysis
Topography	Topographical studies will help determine the ideal sites for RE projects based on various geographical factors and also for distribution network design	AGS and USGS topographic maps
Load centers and distribution pattern	Availability of load centers helps determine the proximity of the project as well as the design of the distribution network	DABS, Primary surveys and desk analysis
Micro-siting	Micro-siting helps in the optimal setup of utility scale power projects to maximize the power output from the given site	RE Resource atlas
Grid-stability	Grid-stability should be ensured so that the coupling of new utility scale power plants with the grid does not cause any issues	Grid network analysis
Land demarcation	Once land availability is certain, then land demarcation must be followed to ascertain the exact land that is needed from the available land area so as to not trespass over public or private property	Primary survey and desk analysis

Applying 3-level process for developing project pipeline

1. **Level 1**
   a. Check for RE resource potential from the RE resource maps.
   b. Check for grid availability and grid extension plan. If "Yes" then utility scale projects can come up. If "No", then mini-grid or stand-alone projects can come up.
   c. Then check for land availability, road connectivity, and security if "utility-scale" is the outcome above. If all are "Yes", then conclude at utility-scale projects and move to Stage 3.

2. **Level 2**
   a. Check for population concentration and load type. If the answer for population is "concentrated" and the load type is "residential, industrial, and government", then RE mini-grid projects are possible. Also, check for other operational electricity sources available in a particular region. If "Yes", then RE- hybrid mini-grid projects are possible.
   b. If population is "scattered" and load type is "residential" then stand-alone systems are possible. Check for application specific demand such as for irrigation pumps, and others, then stand-alone RE pumps are suggested.

3. **Level 3**
   a. For "Utility-scale", enabling steps such micro-siting, grid-stability, actual land availability, etc. are taken up.
   b. For "Mini-grid", load distribution pattern, site topography etc. are to be studied.
   c. For "stand-alone projects" check for presence of NGO's, MFI's and CDC's that enable implementation through community preparedness, financing, creating awareness, etc.

3.5 Application of Decision Tool for creating the project pipeline

The Decision Tool and its 3-level process is a dynamic process which can be modified to suite the changing RE market environment. The process is applied by considering the identified RE potential, technology application, and suitable markets.

As per chapter 2, the recommended technologies for utility scale projects are solar, wind, biomass, hydro and geothermal. Table 9 identifies provinces suitable for this market by applying the five criteria as in level-1 of the Decision Tool. Afghanistan National Grid Plan map has been referred to at this level. (Annexure B)

Table 9 - Suitable provinces for utility-scale RE projects

S. No.	Provinces	Solar Radiation > 6 KWh/m²/day	Wind Power > 600 W/m²	Waste generation > 150 tonne/day	Biogas from animal manure > 500 thousand m³ /year	Crop residues > 400 thousand tonnes/year	Grid connectivity (> 110 kV)	Land availability	Road connectivity	Security
1	Badakhshan						O	O	O	O
2	Badghis	✓					O	O	O	O
3	Baghlan						O	O	O	O
4	Balkh			✓	✓	✓	O	O	O	O
5	Bamian	✓					O	O	O	O
6	Daikondi	✓					O	O	O	O
7	Farah	✓	✓		✓		O	O	O	O
8	Faryab				✓		O	O	O	O
9	Ghazni	✓					O	O	O	O
10	Ghowr	✓					O	O	O	O
11	Hilmand	✓			✓	✓	O	O	O	O
12	Herat	✓	✓	✓	✓	✓	O	O	O	O
13	Jowzjan						O	O	O	O
14	Kabul			✓			O	O	O	O
15	Kandahar	✓		✓	✓		O	O	O	O
16	Kapisa				✓		O	O	O	O
17	Khost				✓		O	O	O	O
18	Kunduz					✓	O	O	O	O

19	Kunar				✓		O (red)	O (green)	O (yellow)	O (yellow)
20	Laghman				✓		O (green)	O (green)	O (yellow)	O (yellow)
21	Lowgar						O (green)	O (green)	O (yellow)	O (red)
22	Nangarhar				✓	✓	O (green)	O (green)	O (green)	O (yellow)
23	Nimruz	✓	✓				O (green)	O (green)	O (yellow)	O (yellow)
24	Nuristan				✓		O (red)	O (yellow)	O (red)	O (red)
25	Paktika	✓			✓		O (red)	O (green)	O (yellow)	O (red)
26	Paktiya						O (green)	O (green)	O (yellow)	O (yellow)
27	Panjshir						O (red)	O (yellow)	O (yellow)	O (green)
28	Parwan						O (green)	O (yellow)	O (green)	O (green)
29	Samangan						O (green)	O (yellow)	O (yellow)	O (green)
30	Sar-i Pol	✓					O (yellow)	O (green)	O (yellow)	O (yellow)
31	Takhar				✓		O (yellow)	O (green)	O (yellow)	O (yellow)
32	Uruzgan	✓			✓		O (yellow)	O (green)	O (yellow)	O (red)
33	Wardak	✓					O (green)	O (green)	O (yellow)	O (red)
34	Zabol	✓					O (yellow)	O (green)	O (yellow)	O (red)

Legend

Colour	Grid Connectivity - present and planned (funded only)	Land availability	Road connectivity	Security
O (green)	Grid exists or planned in capital and some districts	Land available	Road is metalled	Highly secure
O (yellow)	Grid exists or planned only in capital	Limited/scattered availability	Road exists by not all weather	Major parts are secured
O (red)	No grid plan	Land not easily available	Road is poor or does not exist	Exposed to heavy security risks

Further, the provinces with no or limited grid availability but high solar radiation are considered ideal for mini-grid or stand-alone projects in level 2 of the Decision Tool. Subsequently, population concentration and load characteristics are used for identifying potential mini-grid projects. Highly populated provinces are assumed to contain load mix of “residential, industrial, commercial, and government”. The presence of operating diesel gensets are prioritised for developing diesel-RE hybrid mini-grids with an understanding that it will immediately reduce the dependence on diesel, while simultaneously providing a reliable back-up or supplement power supply system to RE based mini-grid.

Accordingly, all the provincial capitals and trade clusters are suitable to implement stand-alone or DG-based hybrid SPV mini-grid projects. The exact sizing and technical design is to be done on the basis of detailed feasibility for each project considering topography, demand pattern, among others which takes the user to the third-level of the Decision Tool.

Finally, stand-alone projects are designed and customised for specific sites and for specific loads, i.e. power packs for universities, solar pumps for irrigation or drinking water supply, power supply units for telecom towers, biomass gasifiers for community cooking or electricity needs etc. The third level of the Decision Tool helps in conducting site specific studies and analysis for all types of stand- alone projects, including user survey, stakeholder consultations, enterprise development studies etc.

3.6 Prioritizing RE projects

The Decision Tool provides a method to create a project pipeline. However, deployment of RE projects may vary from each other on the basis of several considerations and hence, need to be prioritised. Some of these considerations would be:

- Simplicity: How easy they are to construct, operate and maintain
- Scalability: Whether they can be implemented across a variety of sizes and locations
- Familiarity: What is their familiarity in Afghanistan on the basis of past experience
- Viability: Whether they are a financially sound option

The above considerations are used in a customised *knock-out criteria* method[34] to qualify them as hot (high priority) and cold (low priority) and is applied below to prioritise the deployment of some RETs and downgrade some others in the context of Afghanistan.

[34] http://www.proz.com/kudoz/English/engineering_general/5285381-knock_out_criteria.html

Table 10 - Prioritizing the selection of RETs for Afghanistan

Technology	Simplicity	Scalability	Familiarity	Viability	Overall Applicability *
Solar PV Grid-connected utility scale	O (red)	O (red)	O (red)	O (red)	O (red)
Solar PV Mini-grids	O (red)	O (red)	O (red)	O (blue)	O (red)
Solar PV Roof-top Systems	O (red)	O (red)	O (blue)	O (red)	O (red)
Solar PV Standalone systems	O (red)	O (red)	O (red)	O (red)	O (red)
Concentrating Solar Thermal Grid-connected utility scale systems	O (blue)	O (blue)	O (blue)	O (blue)	O (blue)
Non-concentrating Solar Technologies - Flat Plate and ETC	O (red)	O (red)	O (blue)	O (red)	O (red)
Concentrating Solar Heating Systems for Industrial Applications	O (blue)	O (blue)	O (blue)	O (blue)	O (blue)
Micro / Mini -hydro powered mini grids	O (red)	O (red)	O (red)	O (red)	O (red)
Utility Scale Wind Power	O (red)	O (red)	O (blue)	O (red)	O (red)
Wind powered thermal energy	O (red)	O (blue)	O (blue)	O (blue)	O (blue)
Hybrid Systems (wind - biomass - solar - diesel)	O (blue)	O (red)	O (blue)	O (red)	O (red)
Biomass based standalone	O (blue)	O (blue)	O (blue)	O (red)	O (blue)
Waste to Energy	O (blue)	O (red)	O (blue)	O (blue)	O (blue)
Biogas systems - thermal	O (blue)	O (red)	O (red)	O (red)	O (red)
Biogas systems - electrical	O (blue)	O (red)	O (blue)	O (blue)	O (blue)
Improved cookstoves	O (red)	O (red)	O (red)	O (red)	O (red)
Geothermal	O (blue)	O (red)	O (blue)	O (blue)	O (blue)

*: Overall Applicability is indicated as 'hot' if the technology scores 'O' (red) in two or more fields. 'Cold' is represented in 'O' (blue).

The High priority and strategically important projects and their achievable targets are described here:

a) Solar PV utility scale

The Decision Tool points at setting up a total of 800 MW of solar utility scale PV through Solar Power Parks (SPPs) and Independent Power Producers (IPPs), with an optimum capacity of 100 MW for SPPs and 10 MW for IPPs. Land requirement will roughly be of the order to 1250-1400 hectares for 800 MW. The proposed 100 MW SPP at Naghlu and 10 MW IPP at Kandahar will be trailblazers in this segment. SPP model is discussed in details in next chapter.

b) Utility scale wind farms

Utility scale wind power projects, commonly known as wind farms, both in power parks mode and IPP mode, are high priority projects and upto 600 MW capacity addition is recommended using this technology.

c) Roof-top solar PV

This market segment is of strategic importance to Afghanistan's major cities and provincial capitals on account of unmet captive demand and dependence on diesel genset in most of government, public and private buildings, and available roof space. Assuming an average 1 kWp system on residential households and multiples of 10 kWp in public and private institutional buildings, an aggregate capacity of 420 MWp can be installed using this technology. The proposed 10 MWp roof-top PV project in Kabul would be the first-of-its kind, which will be followed by similar projects in other major towns and provincial capitals that are/ will be connected to the national/ provincial grids.

d) Bio-methanation of municipal solid waste

The conversion of municipal solid waste into energy is of strategic importance to Afghanistan considering the amount of solid waste generated in major municipalities. For instance, Kabul generates approximately 1600 tonnes of MSW daily. The first proposed pilot project for 6.0 MW in Kabul municipality is an encouraging initiative. The Roadmap recommends more such projects, totalling to about 56 MW aggregated installed capacity.

e) Mini-grids - Solar PV, MHP and hybrids

Mini-grids have emerged as viable alternative to grid extension for rural/ semi-urban communities' world over. Diesel based mini-grids are commonly used in Afghanistan, which need to be either replaced or hybridized with solar, wind and MHP technologies. In addition, new mini-grids need to be installed in load centers and provincial towns. Roadmap recommends a total of 720 MW of installed capacities. About 25 mini-grids on average 500 kW capacities are being proposed under the ASERD programme of MRRD, which will kick-start this segment.

f) Solar PV stand-alone systems, include solar pumping

Solar PV stand-alone systems consisting of street lights, home lighting and domestic systems, power packs for telecom towers, solar pumps, portable lights and battery chargers are some of the systems that can play a critical role in improving energy access of rural communities. Upto 126 MWp worth of aggregate capacity can be installed in this segment as per this Roadmap. Private enterprises are already marketing these systems in Afghanistan.

Initiatives such as 'Citizens' Charter Afghanistan Programme' will provide a further boost to this segment.

g) Non-concentrating solar thermal systems

Given the requirement of hot-water (and low-grade heat) for domestic, community and commercial purposes throughout the year in Afghanistan, non-concentrating solar thermal systems (flat-plate or ETC) can play a critical role in providing thermal energy to these applications. Accordingly, Roadmap suggests a total target of 60 MW under this category[35].

h) Biogas and improved cookstoves for cooking energy

In addition to solar thermal systems, biogas and improved cookstoves will make a significant contribution in thermal energy sector by providing clean energy for cooking. This Roadmap suggests a deployment of such systems with an aggregate capacity of around 6.7 MW.

i) Concentrating Solar Power (CSP)

Although CSP has not yet been introduced in Afghanistan, it is a proven technology and there are operational power plants globally as well as in the region. Since the solar radiation levels, particularly DNI levels are high in Afghanistan, at least a few pilot CSP plants are recommended to be set up in any one the provinces high with solar radiations levels. Most commonly sized capacity amongst operational CSP plants globally is 50 MW.

j) Floating PV (Floatovoltaics)

Though a relatively new concept world-wide, there are already 70 FPV projects currently operational, most of these in Japan. The sizes range from as small as 5 kWp to the largest one being 20 MWp. Most of these FPV plants are installed on reservoirs. Considering the fact that Afghanistan has significant numbers of reservoirs and dams for irrigational and electricity generation purposes, this Roadmap recommends setting up of 10.5 MWp of floating PV plants of varying capacities on the basis of detailed feasibility studies, including Environmental-Social Impacts Assessment (ESIA) studies.

k) Large hydro projects

Large hydro projects are now being considered as renewable energy projects.[36] Their contribution to Afghanistan's total energy mix is significant. While the plan for installing large hydro projects under NSSP is already underway, this Roadmap recommends focussing on nearly 1750 MW worth of projects that are stalled due to several reasons.

Table 11 - Current unfunded hydro projects

Project	Location	Capacity /MW	Estimated Design Cost / USD Mil	Estimated Construction Cost / USD Mil
Baghdara HPP	Kapisa	240	5	526
Sarobi 2 HPP	Kabul	180	4	300
Shal HPP	Kunar	798	10	1636
Kajaki 2 HPP	Helmand	100	25	200

[35] approximate estimation based on calculations from the IEA report: Solar Heat Worldwide, 2016 edition
[36] http://planetsave.com/2016/10/24/indian-ministry-pushes-reclassify-large-hydro-projects-renewable/

Qala e Mumaee HPP	Badakhshan	420	8	1459
Ghor MHPP	Ghor	4	Completed	16

With these and other projects being commissioned, 2000 MW of additional renewable energy capacity can be added.

The table below provides a summary of above discussion and presents technology-wise contribution to meet the targets of RENP. Institutional and market mechanisms or business models and ecosystems enablers required to deploy these technologies and implement RE projects are discussed in subsequent chapters.

Table 12 - Technology-wise contribution for meeting RENP targets

Market	Technology	Type	Target Capacity (MW)
Utility scale	Solar PV	Solar Power Parks (SPP)	590.0
	Solar PV	Solar IPPs	210.0
	Solar Thermal	Concentrating Solar Power (CSP)	110.0
	Solar PV	Floating PV	10.5
	Solar PV	Concentrating PV	6.0
	Wind	Wind IPPs	600.0
	Large Hydro	Large Hydro	2,000.0
	Biomass	Power generation from agri-residues	30.0
	Biogas - Electricity	Methanation of organic manure & agri waste	2.0
	Waste to Energy	Bio-methanation of municipal solid waste	56.0
	Geothermal	Heat Pump Applications & Geothermal Energy	55.0
Mini-grid	Hybrid	Diesel + wind / solar / mini hydro	300.0
	MHP & SHP	MHP + SHP	420.0
Stand alone	Solar PV	Roof-top with net-metering / FiT	420.0
	Solar PV	PV Home Systems, telecom towers & others	75.0
	Solar PV	Solar Pumping	51.0
	Solar Thermal	Evacuative Tube & Flat Plate - Thermal energy	60.6
	Biogas	Thermal Energy	4.1
	Improved Cookstoves	Thermal Energy	2.6
Total			**5,002.8**

Note: The existing capacity of 100 MW is not included in the above table

4 BUSINESS MODELS FOR RE PROJECTS IN AFGHANISTAN

The renewable energy market in Afghanistan is still in its nascent stages. As a result, structured business models, which characterize mature markets, are not yet in place. The market landscape is dominated by government programmes, supported by bilateral or multilateral development partners. The private sector acts as turnkey or installation contractors, with little or no financial liabilities in the project.

However, the introduction of RENP and feed-in tariffs for connecting such projects to the grid has given a fillip to the sector. As a result, there is a push for structured and standardized business models, aimed at engaging key stakeholders (private sector, government and communities) to exploit win-win possibilities in the market.

This chapter seeks to present business models relevant to Afghanistan, which are in sync with the national context. These could be introduced so as to guide and steer renewable energy development in a structured manner. Importantly, implementation of the business models shall serve to engage the private sector, thereby infusing private capital in the market.

As discussed in the subsequent chapters, development of the RE sector shall take place in stages. Each stage is the outcome of policy directions issued by government, and the resultant response from the private sector and other stakeholders. As the Stage-Gate model later explains in next chapter, the expansion of the RE sector and its components follows the 3 stages of market seeding, market creation and market transformation. This chapter also attempts to demonstrate how, and to what extent, the implementation of business models helps in transformation of the markets in each stage.

4.1 From markets to business models

The renewable energy market in Afghanistan is segregated into three categories (i.e. utility scale, mini-grids, and stand-alone) each addressing a specific objective of the Roadmap as presented below:

Large, utility scale

The large-scale project landscape is dominated by state run power generation units and independent power producers. The business model for large power producers is based on considerations of assured and long-term power off-take. Financing is also a key requirement given the capital-intensive nature of power plants. In addition, producers need proper infrastructure to set up their MW scale power plants. Thus, the power purchase agreement (PPA) assumes primary importance for large scale, MW scale power plants.

Small and medium, micro-utility or mini-grid application

In this segment, the operator manages a self-contained grid (resembling a micro utility), it has to manage loads and ensure that outages are minimized to improve the viability of the project. Load development and management is a key feature of business models in this segment.

The business model requires the entrepreneur to make investments in power generation and/or distribution systems that would optimally serve its command area. This segment is also marked by use of new technologies and the application of ICT enabled features to ensure optimality in production and distribution.

Micro, standalone systems

The standalone segment has seen some market movement via outright purchases of solar powered home systems. However, this market is largely non-formal and lacks quality assurances. The segment has significant potential in Afghanistan with the centralized grid not being a cost-effective option in several pockets of the country dominated by mountainous terrain and spatially dispersed communities.

With this generic categorization of markets, the approach adopted in developing business models for Afghanistan is to bring the understanding of what has worked globally, and customize it to the local Afghan context. For each market segment, the following section identifies business models customized in the Afghan context.

Table 13 - RE business model classification

Roadmap objectives	Market type and project scale	Proposed Business Model
Increase domestic RE supply	Utility scale, large projects (I MW or more)	Solar Power Parks
Enhance energy supply to population centers without grid connection + captive power plants	Mini-grids, small & mid-scale (10 kW to 1 MW)	Renewable (rural) Energy Service Companies (RESCO)
		Distribution franchisees
		Roof-top solar PV systems through net-metering and FiT
Provide basic energy services to Isolated and remote populations	Stand-alone, micro- and mini (pico to kW)	Standalone solar home systems supported by Microfinance
		Pay-as-you-go business models

4.2 Solar Power Parks (SPP)

Description

SPP is a dedicated and demarcated zone for development of solar PV power projects. Several power producers operate within a SPP. The park provides project developers with proper infrastructure and access to facilities for power generation and export to the grid against a firm Power Purchase Agreement (PPA). In doing so, project development risks are minimized for the individual developer. SPPs facilitate developers by reducing the number of required approvals. The solar park is typically developed and operated by a Special Purpose Vehicle or a service provider, usually called the Solar Power Park Developer or SPPD.

While this section discusses the SPPs, similar approach may also be considered for setting up of wind power parks/farms.

Salient features

As defined above, a single SPP can accommodate several projects promoted by a number of private sector entities, all facing roughly similar conditions for power generation and sale, which are governed in their individual power purchase agreements signed with the off-taker, such as DABS in this case. The activity of setting up the infrastructure for a SPP is generally anchored by a government entity. This entity, in the role of the SPPD, executes the following:

- Acquisition of land and developing it for SPP
- Getting land related clearances and approvals that are required to convert it to land suitable for SPP development
- Developing approach roads, water supply and distribution, drainage and other related infrastructure to each project within the SPP
- Creating the power transmission network within the park and maintaining it; also setting up power evacuation infrastructure to connect to the grid
- Providing security for SPP

After execution of these tasks, the project developers are invited to invest in setting up solar PV projects through a bidding process. Projects are set up through Build-Own-Operate-Maintain (BOOM) process. Project developers are expected to undertake investments related to setting up and maintaining the projects over the tenure of their PPAs. Projects may be transferred to the government upon expiry of PPA.

In addition, the following features may be relevant in the specific context of Afghanistan:

- Specific policies for SPPs are required, to provide regulatory support to private sector/other stakeholders. These could be generic, or tailored to suit the needs of a specific SPP.
- A corporate body is needed to act as the SPPD. This could be a subsidiary of a utility or any other PPP arrangement. This corporate body shall need to develop its own business plan, outlining revenues, costs and a plan to break even over the long run.
- Larger scale solar projects need to be encouraged in view of their higher potential to bring down the cost of power generation. This is because capital costs per MW of developing solar PV projects reduce with an increase in project scale.
- The land in SPP shall be leased to project developers. The tenure of such leases shall be equal to the duration of the PPA.

- Power purchase is governed by the PPA between each project developer and the utility i.e. DABS. Feed-in tariffs may be used to pre-determine tariffs for SPPs. In addition, tariffs could be announced by the government in advance or determined as part of a bidding process.
- Power is evacuated as must-take, purchased by the national transmission utility, DABS. Standards for metering and connectivity to grid shall follow the guidelines set out in Electricity Law and other relevant guidance documents.
- PPA tenures may extend to 20 to 25 years, with suitable clauses governing tariff movements over time.
- Projects shall have well-defined pathways after the expiry of the PPA. These pathways could include sale of asset to government, extension of PPA and others.

In terms of the institutional engagement in SPPs, major responsibilities of different institutions are expected to pan out as follows:

- **Power sector regulatory body**: The regulator shall define conditions for power evacuation (must-run and must-take), long term access, PPA and others.
- **Ministry of Energy and Water**: Policy direction for setting up of the SPPs. These shall be classified under separate notification for a "SPP Scheme".
- **Special Purpose Vehicle**: Govt. may set up a Special Purpose Vehicle (SPV) in the PPP mode (similar to AISA) for setting up and managing SPPs, like a Solar Power Park Developer (SPPD). This agency shall be entrusted with the task of setting up and managing the SPPs, and shall execute the following activities:
    - Preparation of Detailed Project Report (DPR) for each SPP
    - Site development for SPPs as indicated above
    - Facilitate single-window clearance for SPPs
    - Maintenance of the SPPs
    - Providing security for SPPs

  Investments made by this agency can be realized from lease rentals and other fees against services that are paid by project developers.

- **Da Afghanistan Breshna Sherkat (DABS)**: DABS shall, as the transmission and distribution utility, shall finalize tariff rates for procurement of power from SPPs and procure the power. Wherever necessary, escrow mechanisms may also be set up to provide revenue assurance to project developers.
- **Project Developer**: The project developer shall set up its solar PV project and operate and maintain the same throughout the life of the PPA. Depending upon the terms of agreement, after expiry of the PPA the developer may hand over the project to the government.

The significant advantage of the SPP in Afghanistan is that it can unlock private capital through the engagement of the private sector in the generation of MW scale power in the country. Thus, it would largely eliminate the need for national and/or provincial governments to invest their resources in power generation, whether centrally or in decentralised fashion.

Furthermore, with the right incentive structures, the SPP model may be able to generate revenues for government agencies such as the SPPD. Finally, the SPP model is designed for locations where land is plentifully available. This shall build infrastructure such as roads, power and water lines to the site and around, thus developing the local micro-economy and resulting in decentralised development and reversing the course of migration.

Global experience demonstrates that SPPs or solar farms are typically around 100-200 MW in size, although SPPs of around 750 MW have recently been commissioned in Rewa, Madhya Pradesh[37]. There are over twenty (20) countries, which have set up SPPs. However, in USA, China and India SPPs have tended to be larger in size, especially those installed in the past few years (2012 onwards). Importantly these countries started off with 100 MW size parks, and gradually moved up in scale with time.

The following schematic shows the SPP in terms of process flows and roles/ responsibilities of various actors.

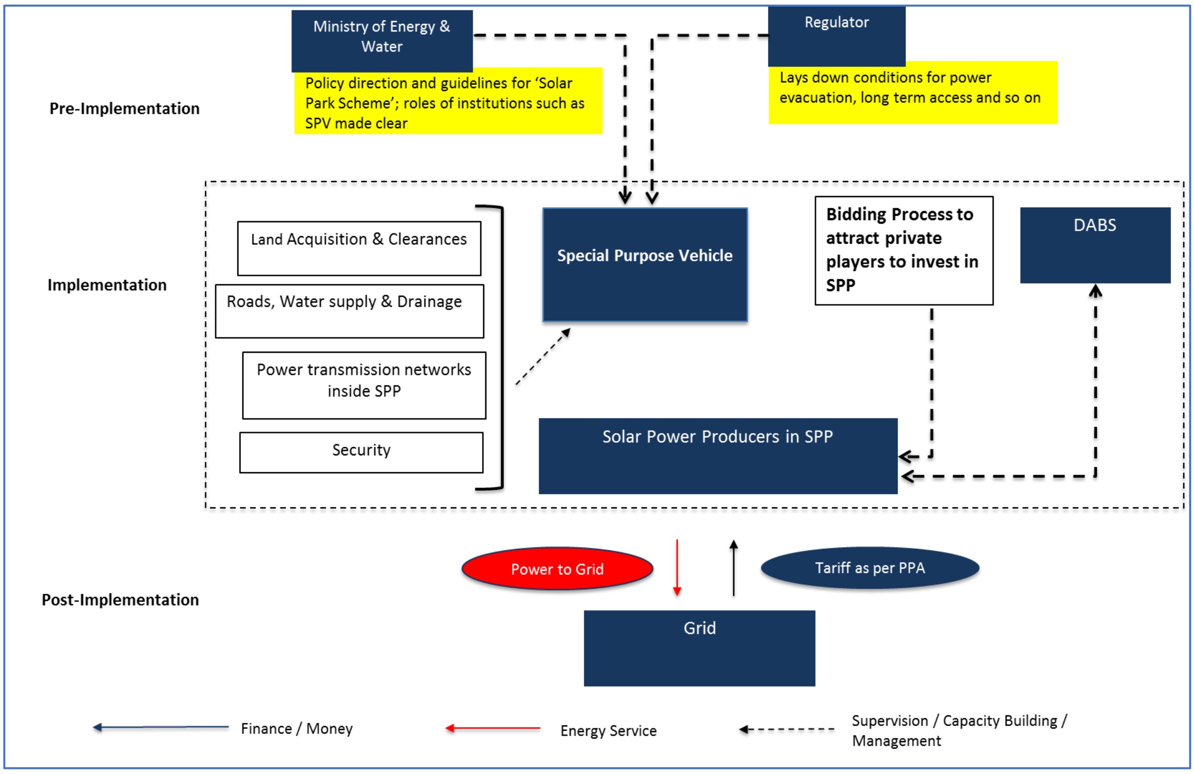


Figure 21 - Process flows and roles / responsibilities of various stakeholders for SPPs in Afghanistan

4.3 Distribution Franchisee (DF)

Description

A Distribution Franchisee (DF) is an entity authorised by a distribution utility to distribute electricity on its behalf, in a particular area within the utility's area of supply. The DF may invest in improvements in the existing distribution network to improve technical and commercial losses, better power quality and improved overall service delivery.

The DF business model works around a cluster of consumers such as industrial parks and municipalities, with DABS as generator and an independent qualified entity as the DF. Examples of DF could be the industrial park union, association of residents of a housing society, or any private agency interested in purchasing power from DABS (generator) and distributing it within the mandated zone (park, housing society etc.).

[37] http://cleanenergyinfo.in/rewa-gets-ready-for-750-mw-solar-park

Charanka Solar Park in Gujarat, India

The experience of neighbouring India on solar power parks has been noteworthy. Under the aegis of the Solar Energy Corporation of India (SECI), as many as 33 SPPs, with a cumulative capacity of 19,900 MW are either operational or under implementation. SECI has identified nodal agencies in prominent Indian states where solar power parks are planned. These nodal agencies form joint ventures with SECI and act as the SPPD

The Charanka Solar Park with an installed capacity of 590 MW was set up in the Indian state of Gujarat, by the Gujarat Power Corporation Limited. The park, located in Patan district, is spread over 5,384 acres of unused land. By the end of 2016, Charanka solar park has installed capacity of nearly 350 MW (March 2016).

Among the first solar PV parks to be installed in India, Charanka has been developed as part of Gujarat solar parks. Policy support for solar power parks in India was derived from the Jawaharlal Nehru National Solar Mission (JNNSM), which laid down the broad objectives and guidelines.

Subsequently, the Solar Energy Corporation of India (SECI) was set up by the Ministry of New and Renewable Energy (Ministry of New and Renewable Energy), Government of India. States interested in developing solar parks has to set up a Special Purpose Vehicle, generically called a Solar Power Park Developer (SPPD), who could form a joint venture with SECI, or choose to remain an independent agency. As a third option, the individual state could give responsibility to SECI to become the agency within the state. The choice of technology and identification of entrepreneurs within a solar park may be kept open and subjected to a bidding process.

Figure 22 - Charanka Solar Park

The SPPD is responsible for setting up the solar park with the required infrastructure. For Charanka, the Gujarat Power Corporation Limited acted as the SPPD. With its overall mandate for power development, and considering favorable wind speeds in Charanka, few wind turbines were also commissioned to generate additional power.

The distribution franchisee can operate in several ways. It can use a basic model for operation and maintenance services against a commission or a fee, where the DF is responsible for billing, maintenance and collection activities. It can also have an advanced model where the DF invests in the local grid, improves technical performance and reduces Aggregate Technical & Commercial (ATC) losses, thereby providing 24x7 quality power at a premium. For energy-deficit industrial areas and parks in Afghanistan, the DF approach could be a cost-effective solution to meeting the industries' needs of quality, low to high voltage power demand.

Salient features

The DF business model necessarily includes a generator that is owned by an entity different from the DF. The generator such as DABS (national utility) is then responsible for selling bulk power to DF for a pre-demarcated territory. The salient features are as follows:

- The utility sells electricity to the DF at a single point (such as a transformer) at a pre-agreed, bulk tariff that is governed by a power purchase agreement. DF distributes electricity to individual consumers at pre-agreed consumer tariff. This step assures the utility of payments from the DF, and thus de-risks it from engaging with a multitude of consumers. Usually, the DF is appointed in a zone where utility faces challenges in servicing the customer profitably.
- The utility and DF enter into a long-term time bound contractual agreement wherein utility commits to supplying electricity to the DF. DF commits to undertaking Billing, Metering and Collection (BMC) activities, or making required investments / improvements in the distribution network, as the case may be.
- The DF represents the utility on the ground and is provided with security and other administrative support. This is especially relevant in the context of Afghanistan, where local security issues could be present in certain provinces. The DF could be a local entity familiar with site-specific dynamics, which would assist in de-risking revenue collection and establishment of business ties with community members.
- The DF may invest in setting up / upgrading / strengthening the distribution network, which may belong to the utility. Its investments include:
    - Installing transformers, feeders and conducting continuous maintenance of the network
    - Enhancing safety and security of the network by installing protective measures
    - Reducing theft and other commercial losses
    - Installing smart meters at consumers' ends and maintaining a helpline to enhance customer care
- The DF may invest in additional back-up power generation options to provide 24x7 power to the consumers. This is more relevant for industrial and urban consumers
- DF realizes its returns on above investments by charging pre-agreed consumer tariffs, that are usually at a premium (in return for better service delivery)
- Benefits to consumers served by the DF include improved power supply (both qualitatively and quantitatively) and improved complaint redressal
- Benefits to utility include assured revenue collection (from a single-bulk-consumer) and reduced manpower deployment costs in the zone where DF operates
- DF benefits from financial returns from a performance turnaround in its zone, and may look to expand operations to similar zones. It also enjoys a customer base for 10-15 years, which will offer opportunities for further business expansion

Roles and responsibilities of various agencies in the DF model are explained below:

- **Regulator**: Lays down guidelines within the Electricity Law for defining and setting up distribution franchisees in Afghanistan
- **Ministry of Energy and Water (MEW)**: Designs the DF Scheme in Pan-Afghanistan context along the above guidelines and provides policy support for its roll- out
- **Da Afghanistan Breshna Sherkat (DABS)**: Identify areas where power distribution can be licensed to DF. Enters into contract for sale of power and for the maintenance of DABS's distribution infrastructure in the area now under the franchisee's operations.

DABS shall provide necessary support to DF on the ground in the form of security and any other administrative / legal support as and when required

- **Distribution Franchisee (DF)**: Invests in, operates and maintains the distribution infrastructure over the tenure of its terms of agreement with DABS. Provides services to the consumers in the manner outlined in its terms of agreement
- **Consumers**: Enter into agreement with the DF and pay tariffs as agreed upon.

The roles are further explained through the following flowchart:

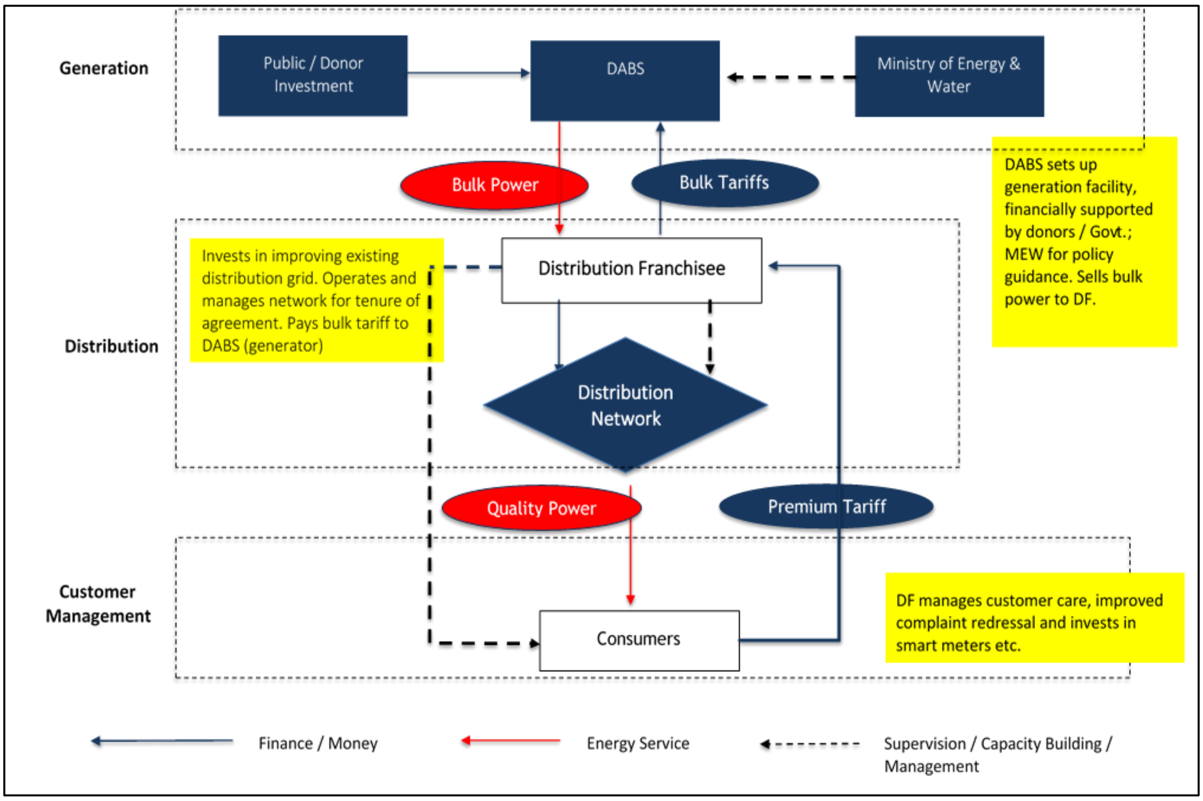


Figure 23 - Process flows and roles/ responsibilities of various stakeholders for DF model in Afghanistan

DF models have been successful across several countries, as a de-risking mechanism that enables both the generator and the franchisee to build on their individual competencies in a strategic, mutually beneficial scenario. In the neighbouring country, India for example, Torrent Power Limited (TPL) launched one of the first input based distribution franchisee operations in Bhiwandi circle of Maharashtra in western India. Reviewed by an independent agency, the model has successfully shown that aggregate technical and commercial (ATC) losses coming down from a high of 58% in 2007 to 18.5% in 2011, and around 20% as of 2015[38], providing profitable solutions for all stakeholders. Importantly, TPL has a ten-year mandate in Bhiwandi Circle, which is needed for it to recover its investments and make returns.

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[38] http://www.pmanifold.com/knowledge/blog/performance-analysis-of-distribution-franchisee-bhiwandi-case-study-by-torrent-power-limited/

4.4 Roof-top solar PV through net metering

Description

In Afghanistan, there is significant potential of roof-top solar PV systems on account of levels of solar radiation consistently above 5.5 kWh/m^2 as well as available roof-top space, especially in urban locations. With largely low-rise architecture prevalent in the cities and towns, there is ample opportunity for development of roof-top solar PV projects due to abundance of sunshine. On the demand side, lack of reliable energy access coupled with high demand for electrical energy for lighting and other applications provide a ready market for roof-top based solar PV systems. With the advantage of net metering, households can also sell unused electricity back to the grid and provide more power for distribution.

Net metering facility allows the user to export power from the solar PV unit as and when such power is unutilized. Similarly, if power supplied from the solar PV unit falls short of current demand at the user's end, then the user draws electricity from the grid. At the end of a billing cycle (typically a month), the net power consumed / exported by the user is calculated (using the net meter), and the user either paid or charged accordingly. Net metering allows the user to partially recover its investment by selling surplus electricity generated.

Salient features

There are two main business models used in roof-top solar: CAPEX and OPEX models

- CAPEX model:
    - The Capital Expenditure (CAPEX) model involves the owner of the roof and electricity distributor (DABS, in this case). The owner purchases all the necessary equipment for the generation of roof-top solar and sells the electricity generated to the distributor via a net-metering mechanism
    - The operation and maintenance (O&M) of the system is generally done by an external contractor hired by the owner
    - The roof-top owner can enjoy government tax benefits and incentives for generating clean power
- OPEX model:
    - The Operational Expenditure (OPEX) model involves the owner of the roof, a third-party implementation company and the electricity distributor. The roof owner rents out their roof to a third party in order for them to generate electricity from solar PV panels. The third party sells the electricity generated to the distribution company. In turn, the owner collects rent from the third party, after taking into account any other arrangements, like electricity purchase, profit-sharing, etc. Alternatively, the roof owner can get into a power purchase agreement (PPA) with the third party, in order to get electricity for their building at a lower rate
    - The maintenance of the system is handled by either the third-party developer or by the roof-top owner, depending on the agreement between them
    - The third-party developer enjoys government tax benefits and incentives as generator of clean power
    - In the case of Afghanistan, DABS could also become the third-party so as to generate more grid-connected energy at a relatively low cost

To ensure long-term sustainability of roof-top solar PV systems, distribution companies purchasing power through net metering, for instance, shall need to ensure complementarities in power interface with the utility (DABS) grid, so that there is seamless integration with national power systems and management of local interconnection issues. Moreover, the financial health of the utility such as DABS is vital to secure revenues for the seller.

The institutional framework for roof-top solar is a mix between standalone captive systems and a grid-tied solar PV system. Like grid-tied systems, feed-in tariffs play an important role. At the same time, the model is based on a single consumer, similar to standalone systems. Afghanistan in currently establishing its net metering policy, which will catalyse the roof-top market. Figure below presents the model.

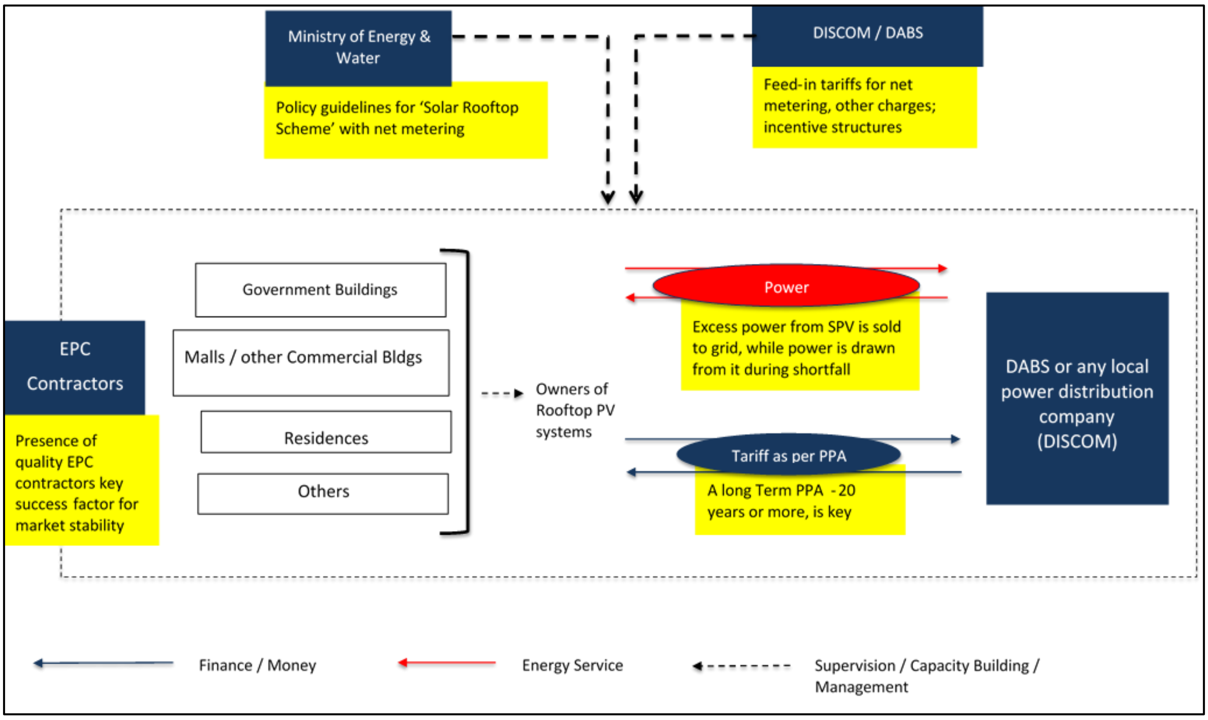


Figure 24 - Process flows and roles/ responsibilities of various actors for roof-top solar PV- net metering model in Afghanistan

Globally, the European Union and especially Germany has been a proven leader in roof-top solar power development. In terms of regional success stories, roof-top solar PV schemes are popular in India and Sri Lanka within the South Asian region. In Sri Lanka, the net metering policy is open to all generators of renewable energy (hydropower, solar etc.) with a cap of 1,000 kW per user. The excess power sold to the grid is valued at the PPA and credited to the user in terms of energy credits, with the user to have flexibility on when user chooses to monetise them. In addition, countries where roof-top solar PV are present have introduced prior regulation to facilitate setting up of these systems.

The German Roof-top success story

With a total generation of 36.6 terawatt-hours (TWh; equivalent to 36,600 GWh) from solar PV in 2015, and a total installed capacity of 29.6 GW (29,600 MW) **exclusively** through solar PV roof-tops, Germany has over 7% of its total electricity demand being fed by solar systems.

Germany's solar roof-top installations are characterized by less than 10 kW units, mounted on the roof of a house. Beginning from a stage of negligible solar PV capacity in the 1990s, the country has targeted 45,000 GWh by 2020. Importantly, the approach puts importance on roof-top as a key enabler. Today, the roof-top segment contributes almost 75% of Germany's PV capacity. Germany's EnergieWiende claims that investments in solar PV have helped the economy phase out nuclear power plants.

Behind this significant success lies the Renewable Energy Guarantee Act that guarantees priority grid access to all electricity generated by renewables. In addition, policies significantly incentivize owners to mount solar roof-top systems, through Feed-in-Tariffs (FiT). While in the initial years the FiT was high so as to encourage homeowners to mount solar PV in their roof-tops, more recently (2014) the policy is tweaked to ensure auctioning of tariffs, which presents a more competitive picture.

As per German EnergieWiende, the opening up of the solar PV market also had significant co-benefits. These were in terms of employment generation, greening of the energy sector, combating climate change impacts in Germany and Europe. Being roof-top installed, the aesthetic appeal of the houses was also not hampered, since roof-top units are usually not visible from the ground.

4.5 Renewable (Rural) Energy Service Company (RESCO)

Description

RESCO is an entity that provides energy services to consumers in a particular area by setting up a mini-utility, usually in an off-grid location. As a mini-utility, RESCO combines both generation and distribution functions. The RESCO business model is built on enhancing community level incomes through reliable and affordable energy access. These incomes pay for energy consumed, sustaining the micro-utility function.

In the Afghanistan context, there are several areas where the national utility (DABS) may encounter difficulty in providing reliable electricity access. These are pockets best served by decentralised, renewable energy based systems. RESCO projects, acting as a complete micro-or mini-utility by combining generation and distribution services under a single roof, can meet power demand and contribute to local growth by facilitating enterprise development.

Thus, RESCO models are more relevant in areas characterized by high levels of unmet demand for energy, usually for agriculture (irrigation), farm-based enterprises (cold storage and drying) and anchor loads (24x7 demand such as telecom, market centers and hospitals) along with high population densities.

Salient features

The broad features of the RESCO business model are as follows:

- The RESCO mirrors a utility on the ground. Typically, RESCO sets up a cluster of projects in a district to reduce management overheads and ensure viability. RESCO businesses undertake several pre-project activities such as site selection, load and enterprise development, feasibility study preparation and engineering design. For power generation, RESCO utilizes locally available RE resources such as solar, biomass and wind.
- Power is sold to consumers across all load categories, viz. household, commercial (shops) and enterprises.
- RESCOs are assisted by local entities such as Civil Society Organizations (CSO) and other community based organizations. These entities play important roles in project identification, community mobilization, load development and tariff fixation. CSOs, largely being local, build trust bridges between RESCO and communities. Security and other administrative support relevant in the local context are managed by the RESCO with the support of CSO / local partner.
- To ensure long-term sustainability of operations, RESCOs can ensure complementarities in interface between the mini-grids constructed by them and the utility (DABS) grid, so that there is seamless integration with the national grid as and when it reaches in future.
- From a financing perspective, RESCOs are often implemented as public-private partnerships with government agencies (MRRD, MEW etc.) providing support to RESCOs to reduce their risk exposure levels.
- One of the key aspects leading to the success of a RESCO is the presence of an anchor load. An anchor load is defined as a load type that can provide sustained demand for power generated from the RESCO project. Other intermittent or seasonal loads can then be built around the anchor load to provide stability and higher levels of capacity utilization. For instance, telecom towers have 24x7 demand and can act as anchor loads. Another good example is that of cold storages that need power round the clock.
- Significant benefits to the community (as consumers) accrue through a RESCO project through sustainable energy access, especially for enterprise development. This also leads to economic growth in the nearby region. With a “clustering” approach, district level impacts are also possible.
- RESCO benefits from revenues earned by powering various loads in the area under its command. It also forges a long-term relationship with communities in the region, which will help to scale up the business to other locations. The RESCO also gains knowledge of various aspects of an energy-based business.
- Benefits to government accrue through provision of environmentally sustainable energy in un-electrified areas, thereby complementing government efforts.

The RESCO business model has strong potential in Afghanistan, mostly because decentralised energy is expected to contribute significantly in the country’s overall energy sector. In the process of setting up the RESCO, the following institutional roles are envisaged:

- **Regulator**: The regulator shall demarcate regions within Afghanistan where grid may not reach in a certain foreseeable future. These shall ring-fence zones where RESCO can operate. It would also open up the market for private sector players to act as potential RESCOs.
- **Ministry of Energy and Water (MEW) & Ministry of Rural Rehabilitation & Development (MRRD)**: As RESCOs are widely expected to be set up in rural

ecosystems, MRRD would play an important role in institutionalizing this business model in all its energy programmes. MEW will set up guidelines for technical design, safety and quality of power delivered for RESCO projects. MEW shall also carry out capacity building activities for RESCOs. MRRD can empanel potential RESCO organizations and work in tandem with relevant Community Development Councils and other grassroots organizations to identify RESCO project opportunities. Capacity development of RESCOs can also be jointly taken up by the two ministries along with DABS.

- **Da Afghanistan Breshna Sherkat (DABS)**: DABS shall, as the transmission utility, lay down guidelines for interconnection of distribution networks for mini-utilities projects with the grid, so as to facilitate seamless transition in the event of grid interface. DABS shall build capacities of RESCOs on technical and commercial aspects of the distribution business including billing, metering and collection activities.
- **RESCO**: The role of the RESCO encompasses building, operating and maintaining the micro-utility ecosystem throughout the life of the PPAs signed with various consumers.
- **Consumers**: Enter into agreement with RESCO and pay tariffs as agreed upon.

With this above background, the following diagram shows a flow diagram of how the RESCO is expected to operate.

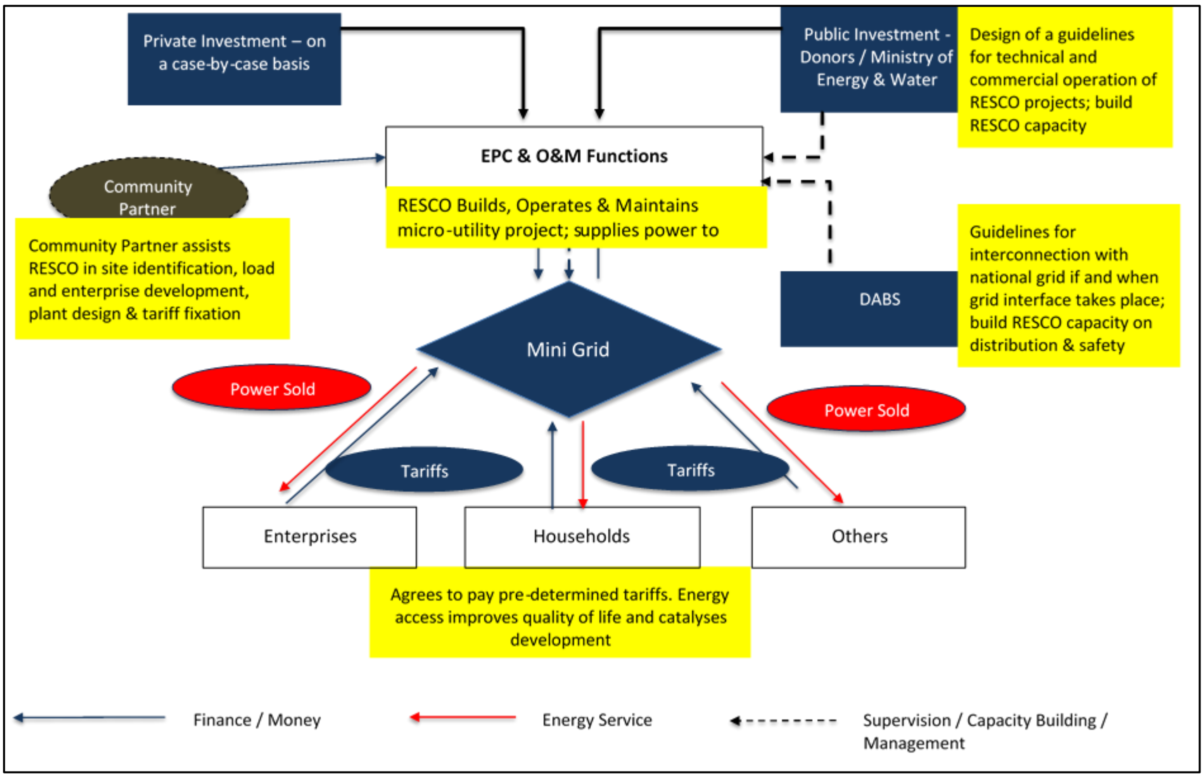


Figure 25 - Process flows and roles / responsibilities of various stakeholders for RESCO model in Afghanistan

In Afghanistan, RESCO projects are assumed to be in the 100 kW – 1,000 kW range, in terms of installed capacity. A typical RESCO project is expected to cover 3 – 7 villages, thereby connecting between 1,000 - 2,000 households or roughly 6,000 – 15,000 individuals. This scale is higher than normal RESCO projects in the South Asian region (which vary between

10 kW – 500kW). One major reason behind this is that a number of districts and rural areas are expected to remain disconnected from the national grid, thereby allowing larger scale RESCO projects.

Global success on RESCO projects is based upon private enterprise in off-grid locations, where entrepreneurship sets up its own micro-utility to provide electricity solutions. More prevalent is the diesel generator operator, who functions as an energy service provider using diesel generator sets, essentially providing lighting energy to markets in Asia and Africa.

In India, the Rockefeller Foundation has been at the center of empowering rural communities with environmentally sustainable energy supply options through the well-known SPEED programme.

The SPEED Story

Smart Power for Environmentally-sound Economic Development (SPEED), an initiative by the Rockefeller Foundation to connect remote, rural households in India with renewable energy based systems.

The SPEED model is structured around empowering enterprises, and is built around the concept of *anchor loads*. Anchor loads allow a generating station to perform at higher levels of capacity utilization. The programme sought to support Energy Service Companies (ESCO) to enter the rural energy market, a segment marked with high transaction costs relative to volume.

Over the past 6 years since 2010, the SPEED programme (and now its successor the Smart Power for Rural Development) has worked with over 50 ESCO organisations, contributing to its goal to energize 1,000 Indian villages with ‘smart power’.

Figure 26 - Impact of the SPEED program

The rural mini-grids are equipped with efficient LED lights, prepaid meters and tamper proof distribution networks that ensure safety and security. Several micro-enterprises have been energized, viz telecom towers, drying and processing units, small garment making businesses, cold storages, training centres and numerous shops. Agricultural pumping has also been a major beneficiary.

4.6 Pay-as-you-go or Micro-finance based standalone systems

A stand-alone solar PV system is a modular, photovoltaic-based electrification system that provides amenity power for a captive consumer, typically a household. Being modular in nature, the stand-alone system is often designed to suit the needs of the customer. The business model sustains on providing reliable, easy-to-afford energy access at the household level. Using pay-as-you-go or microfinance based financing models, these systems provide basic electricity supply at negligible upfront costs. For affluent users, larger and more sophisticated systems can be introduced.

There are several versions and variants that may be adapted for stand-alone models. This section shall attempt to highlight some of the best practices followed globally, seeking to capture the various nuances involved in these systems.

Salient features

Overall, the following salient features broadly describe the stand-alone, home based solar PV systems business model:

- Stand-alone systems are provided as either one-time outright purchase or a hire-to-purchase or a pay-as-you-go model. Hire-to-purchase as well as pay-as-you-go models have sequenced ownership rights.
- The model may typically comprise a technical entity (who could be the manufacturer itself) entrusted with the design of systems, and a implementation partner who identifies and engages with end users. Optionally, a financial intermediary may be involved.
- Stand-alone models are typically characterized by the presence of ICT enabled, 'smart' features. These may include systems that are integrated with central servers through Radio Frequency tags, prepaid usage, "black box" designs etc.
- The models exhibit optimal and efficient energy use devices such as LED lights, energy efficient fans, multi-function devices (chargeable lantern–cum–torch–cum–FM radio; or a hand-cranked or bicycle powered battery to provide supplementary charge). These features also make the stand-alone device a lifestyle tool.
- In order to cater to a large number of customers, the routes to market adoption for stand-alone systems often involve innovative channels. While most manufacturers use the NGO – community based organization (CBO) route, there are other models that have utilized existing distribution channels for petroleum products (Reliance Solar), or linking with education programmes (Kotak Urja) in India, or selling energy coupled to other infrastructure services such as water (as done by Grundfos in Africa[39]). Yet, others have developed their own dealer-distributor networks.
- To ensure scale up of stand-alone home-based systems a financing partner is needed. The partner partly resolves cash flow issues for the end user and the technical partner or the implementing agency. Typically, the financing partner extends micro-credit to the user. Financing of the systems by the technical partner and/or implementing agency is also common. As these systems replace fossil fuels such as kerosene, the financing terms are tuned to ensure that financial savings from avoided fuel expenses are utilized to pay monthly lease rentals for the stand-alone systems. In addition, there are significant advantages in terms of avoided indoor emissions from kerosene use, in addition to GHG emission reductions.
- Stand-alone models are often implemented as public-private partnerships, with the government providing investment support to implementing partners. These forms a win-win solution for government who are unable to extend the main grid to remote areas.

[39] http://www.grundfos.com/cases/find-case/grundfos-lifelink-projects-in-kenya.html

- Communities (as consumers) accrue significant benefits through a stand-alone system from household energy access, especially for education and improving the quality of life for the family.
- Implementing agencies and technical partners benefit from accessing a larger user base. In deferred payment models, user charges typically run for 60–84 months, within which the user has invariably increased its demand so as to ask for a second– or a larger–system. In presence of microfinance agencies in the SS model, such trends are significantly more pronounced.

Unlike other business models, the stand-alone system market does not require much regulatory provisions: broadly this market is characterized by transaction between a service provider (commonly the implementing agency) and a customer. However, there are strategic roles played by institutional players that determine the success of this market. These are outlined below:

- **Ministry of Energy and Water (MEW)**: MEW can set up guidelines for household scale systems, specifying technical design, safety and power delivered from a given system. MEW can also carry out capacity building activities for implementing agencies and provide support to technical partners.
- **Microfinance (MF) or financing entity**: The financing entity often holds the key to any large-scale programme. The role of the MF entity is typically to ensure that cash flows are positive for the implementing entity (typically the intermediary who as the implementing agency is the interface between the manufacturer and user). At the same time, by providing upfront cash for the systems on behalf of the seller, the MF enters into a financing agreement with the end user, allowing him to make small repayments every month. In pay-as-you-go systems, the financing entity may finance the implementing agency with a debt-equity combination, which de-risks the implementer from delayed payments. The user, who is not financed, pays off for the system every month through user charges. These charges typically run for 60 – 84 months, following which the user owns the asset
- **The Implementing Agency**: This agency plays a central role in putting together the entire programme. At the sourcing end, it interacts with financial institutions to ensure microfinance and other financial tie-ups. At the same time, it works closely with manufacturers to ensure that devices being sold cater to the needs of the consumers. Finally, it controls the operational aspects of the programme to ensure smooth performance, absence of leakages (systems being sold to wrong end-users, stolen, or traded internally for arbitrage etc.). Crucially, the implementing agency is responsible for overall after-sales service and maintenance performance of the programme as well. In many cases, the implementing agency is multi-tiered: involving two or three levels. Large programmes (at a national level) require an apex entity, supported by entities at the provincial level such as NGOs or CSOs
- **Consumers**: Consumers can be simple end-users, who can undertake outright purchase of a system. They can also participate in the programme under a deferred payment or a pay-as-you-go model.

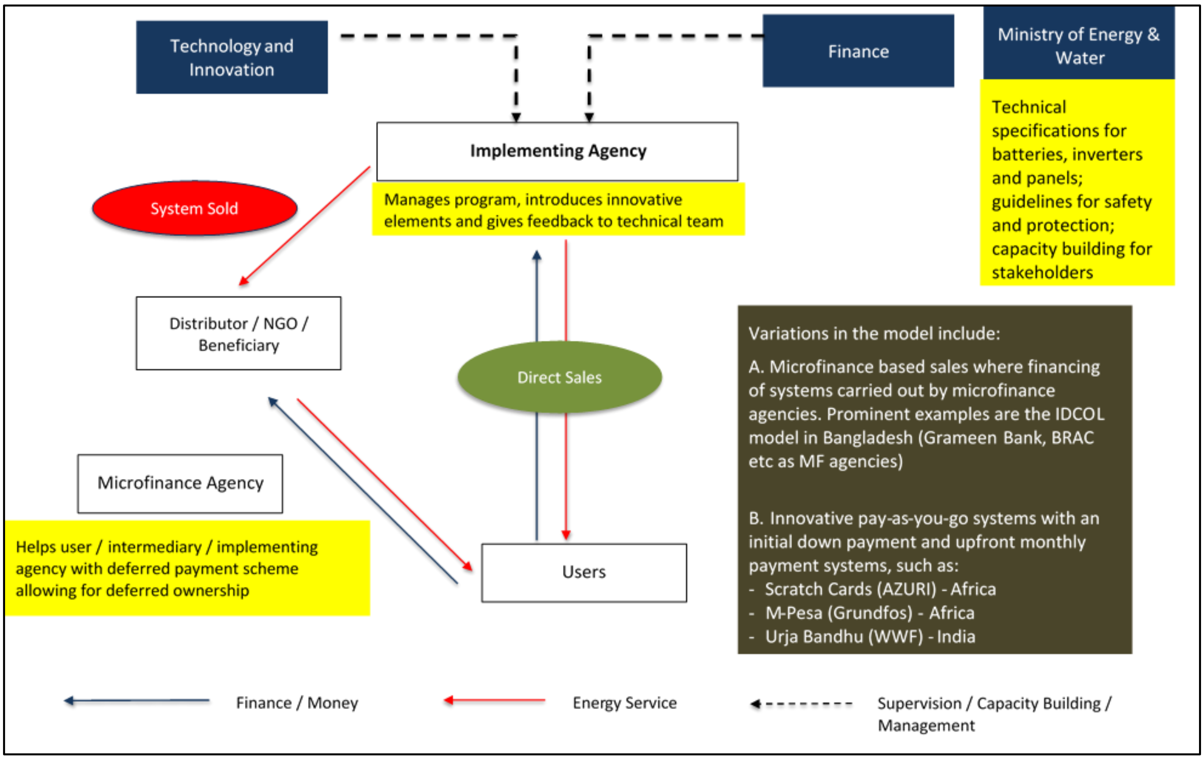


Figure 27 - Process flows and roles / responsibilities of various actors for standalone system (SS) model in Afghanistan

The schematic flowchart above outlines the overall process and identifies roles and responsibilities of various stakeholders in a simplified version of the standalone system.

In the Afghanistan context, stand-alone solar PV has been widely in use across rural areas, driven largely by lack of options for electricity supply. Most of these systems are assembled out of imported components or systems from neighbouring countries. As a result, these units usually are not certified, and could be of questionable quality.

Stand-alone devices are expected to have significant impact in Afghanistan in the years to come, especially with participation from microfinance agencies. As a result, the implementation of the business models for stand-alone systems could also have far-reaching impacts. Perceived as a low-risk intervention and already present in the local markets, various agencies are in the process of introducing state-of-the-art stand-alone systems for the Afghan market, through a financial intermediary[40].

The implementation of business models requires generic as well as specific support in terms of policy readiness, financing, technical-cum-managerial capacities among others. These ecosystem enablers are critical for initiation and sustainability of business models. The next chapter of the Roadmap presents these enablers and their role in stage-wise development and maturity of RE markets.

[40] Mercy Corps, for instance has a plan to introduce 4,800 solar home systems aggregating 3.4 MWp of installed capacity, across four districts of Afghanistan

The Azuri Pay-as-you-go Model in Sub-Saharan Africa

The Azuri model, called the Indigo Duo solar home system is a simple kit with a 2.5 Wp PV module and a 3,300 mAh battery, connected to two LED lights (60 lumens each), and the Indigo controller (the black box). The battery and the controller are housed in the black box with a keypad (see picture).

The black box allows power in the sockets only when the system has been recharged using a valid code provided to the user. This code is obtained when the user makes a payment, typically for a one-week or four-week duration.

The business model works through distribution channels as Azuri does not have any direct sales strategy. Hardware and services are sold to distribution partners, say in Sub Saharan Africa. Distributors are trained in the Azuri system, and they are demarcated areas of coverage. The cloud based Azuri database stores details of all distributors and consumers, providing each and every consumer with a unique ID (like a serial number).

For the user, there are eighty instalment payments after purchase of his system. Each of the payments contributes something towards the cost of the system. After expiry of the installments, the system becomes free at the hands of the user.

Figure 28 - Indigo Duo solar home system

5 ENABLERS AND ACTIONS FOR MARKET DEVELOPMENT- A STAGE GATE APPROACH

Development of RE markets is often a stage - wise process wherein each stage is the outcome of policy directions and actions facilitated by government, and the resultant responses from the private sector and other engaged stakeholders. Each stage thus requires broad-based as well as targeted enablers for various technologies and business models to develop and mature. The Stage-gate model as explained below, facilitates an understanding of these enablers.

5.1 Stage-Gate model for market development – *look back to move ahead*

The stage-gate model is technically understood as a management technique in which an initiative or a project is divided into *stages*, separated by *gates*. At each *gate*, the approach is '*look back to move ahead*'. In other words, the continuation of the initiative is contingent upon certain conditions to be met, review to be done, risks to be assessed at each *gate*, and then an informed decision to be taken to move ahead to the next stage.

In the current context, the RE market in Afghanistan would follow three (3) stages: market seeding to market creation and then to market transformation, with each stage being built on certain enablers (technical, regulatory/ policy, financial/ economical and institutional or related to capacities) that are put in place. As mentioned earlier, there are some overarching enablers that are required for the entire RE sector *per se*, but there are also specific and targeted actions that need to be undertaken for specific technologies and business models to grow. This chapter discusses the Stage- Gate model as applicable to Afghanistan, followed by a discussion on overarching as well as targeted enablers and actions for each stage of the market development.

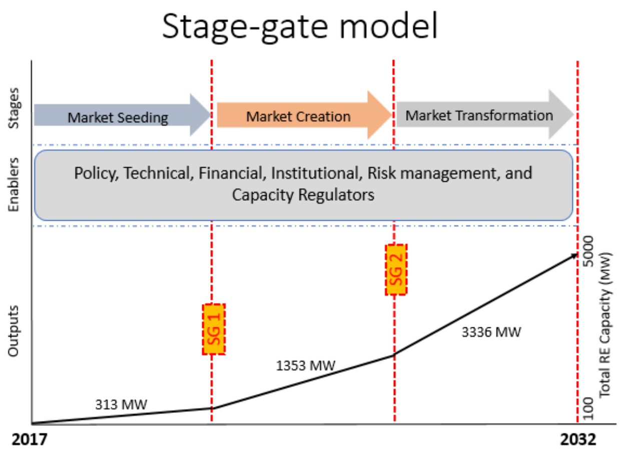


Figure 29 - Stage-Gate framework

Figure 29 presents the Stage-Gate framework of the above-discussed approach. As shown in the graph, the Stage-Gate figure juxtaposes capacity additions in renewable energy over time, so as to demonstrate the trajectory of growth of the energy sector circa 2032.

5.1.1 Market seeding & Stage- Gate 1 (SG1)

The Stage- Gate 1 is the successful completion of the first stage representing seeding of the RE market. This stage is characterized by the following:

- This stage builds upon existing experience in the country on renewable energy and *proof of concept* for some RE technologies that have not been tried at all or at the scale that the Roadmap suggests.
- The thematic focus remains on identifying *tried-and-tested* technologies, together with the processes, in terms of policies and guidelines and initiating a few pilots to seed the markets.

- Increase in installed capacities for technologies identified as *highly applicable* in Afghanistan in the current context (as shown in Table 10 in chapter 3). This includes solar PV, mini and micro hydro technologies, and wind power.
- In terms of specific technology applications, the highest focus remains on utility scale power projects, whether installed as a power park or as IPPs. Other important contributions are from mini-grids (solar as well as hydro) and stand-alone solar PV.
- New technologies to be piloted include waste to energy, roof-top solar, stand-alone solar for strategic applications such as telecom tower and pumping, solar thermal applications and domestic cooking using improved cookstoves and biogas.
- This stage is supported by government and partner (donor) funds as the market is still premature and needs structural support. Details are discussed in chapter 6 on 'Costing and Financing of Roadmap'

5.1.2 Market creation & Stage- Gate 2 (SG2)

- The market creation stage represents demonstration of '*techno-commercial viability*' and confidence building of private sector.
- The focus shifts to setting up more projects in order to create the markets. In this stage, various business models are implemented and customized to achieve success in the Afghan context.
- In addition to technologies that are initiated in SG1 and are now (expectedly) being implemented at a commercial scale, SG2 introduces new technologies such as CSP, Floatovoltaics, CPV, Biomass power generation, and geothermal energy particularly for heating applications.
- SG2 is still supported by grants and government support, but their share is expected to reduce, from almost 80% finance (as in SG1) to around 40%. This share is taken up by promoter's equity, while the grant component could be redistributed as viability gap funding and other sources of low cost debt.

5.1.3 Market expansion & Stage- Gate 3 (SG3)

- This stage represents market maturity and expansion, led by private initiative.
- Stakeholders (mainly private sector, represented both by local and global) are fully familiar with the ground rules vis-à-vis RE markets in Afghanistan, and a number of enterprise models are operating to transform the sector to higher levels of growth.
- Government inputs and support are strategic in nature, focusing on newer technologies, newer policies and newer initiatives.
- In this stage, grants may still exist for a few *sunrise* applications, but overall forms a small share of the pool of funds (15%). Promoter contributions exceed 50% with own equity, market debt and low-cost debt.

The suggested targets for each of the three stages is presented below:

Table 14 - Suggested targets for three stages

Market	Type	Stage Gate I	Stage Gate II	Stage Gate III	Target Capacity (MW)
Utility scale	Solar Power Parks (SPP)	65.0	175.0	350.0	590.0
	Solar IPPs	10.0	50.0	150.0	210.0
	Concentrating Solar Power (CSP)	0.0	10.0	100.0	110.0
	Floating PV	0.0	0.5	10.0	10.5
	Concentrating PV	0.0	1.0	5.0	6.0
	Wind IPPs	20.0	180.0	400.0	600.0
	Large Hydro	100.0	500.0	1,400.0	2,000.0
	Power generation from agri-residues	0.0	5.0	25.0	30.0
	Methanation of organic manure & agri waste	0.0	0.2	1.8	2.0
	Bio-methanation of municipal solid waste	6.0	20.0	30.0	56.0
	Heat Pump Applications & Geothermal Energy	0.0	5.0	50.0	55.0
Mini-grid	Diesel + wind / solar / mini hydro	25.0	75.0	200.0	300.0
	MHP + SHP	30.0	140.0	250.0	420.0
Stand alone	Roof-top with net-metering / FiT	50.0	150.0	220.0	420.0
	PV Home Systems, telecom towers & others	5.0	20.0	50.0	75.0
	Solar Pumping	1.0	10.0	40.0	51.0
	Evacuative Tube & Flat Plate - Thermal energy	0.6	10.0	50.0	60.6
	Thermal Energy (Biogas)	0.1	1.0	3.0	4.1
	Thermal Energy (Improved Cookstoves)	0.1	0.5	2.0	2.6
Total		**313.0**	**1,353.2**	**3,336.8**	**5,002.8**

As discussed at the beginning of the chapter, the essence of the Stage-Gate developmental model is the effective presence of enablers and actions. Sections below discuss the key enablers and actions required for meeting the targets through each of the three stages. The stages contain certain provisos, which if realized could translate into additional power generation and eventual contribution to the RENP policy target of 5,000 MW by 2032.

5.2 Key enablers and actions

5.2.1 Policy readiness and programmatic support

One of the recurrent prerequisites discussed in the context of RE sector development is the need for policies and regulatory direction from the government. Among the landmarks achieved, Renewable Energy Policy for the country has been finalized. Another vital regulatory instrument is the Feed in Tariff Policy. In addition, Energy Investment Policy and others are also in the process of being approved.

While these policies provide a legal and regulatory framework for managing the overall energy and renewable energy domains, there is also a need for other specific enablers which include the following:

a. **Programmatic guidelines (or Schemes) for promoting specific business models**: National level programmatic guidelines for development of Solar (or Wind) Power Parks and for Distribution Franchisees shall unlock the markets for SPPs and pave way for distribution franchisee or mini-utilities in the country. The guidelines should include as a minimum - the definition; framework and processes; institutional roles and responsibilities; permissions, clearances and statutory requirements; power evacuation and financing mechanisms.

b. **Policy on mini-grids**: A dedicated policy on mini-grids is required to kick-start this segment in Afghanistan. The policy should expectedly include the definition and description; technical standards and guidelines for designing, operating and maintaining the mini-grids; tariff methodologies; structure and roles for the energy service company (RESCO); regulations and incentives; and involvement of local enterprises, communities in sustaining the mini-grids.

c. **Regulatory guidance on power distribution and grid integration for off-grid systems**: There is a need to provide guidelines for setting up of roof-top and off-grid power projects in a manner that would allow safe and seamless integration with the national grid when it reached these locations.

d. **Demarcation of areas for electrification through decentralised (localized) generation**: Taking DABS' proposed network as the starting point, districts or zones may be identified where power may be generated and consumed locally. These shall not only open the market for decentralised renewable energy projects, but also allow DABS to identify its own priority areas. It would also provide clear guidance for electrification efforts in Afghanistan.

e. **Greening of strategic sectors**: Telecommunication, agricultural pumping, transportation, food processing, buildings and construction, internal and border security, etc. are some of the strategic sectors that require reliable electricity. A scheme for promoting the use of RE in these sectors would create demand and provide the 'pull' for RETs in the country.

f. **Incentives for use of solar hot water systems**: As a part of Afghanistan building energy codes and regulations, use of solar hot water systems should be incentivized so that the dependence on electric or thermal heating systems for water is reduced. Some of the incentives would be discounts in monthly or yearly electricity bills, rebate on home loans, reduced property tax etc.

5.2.2 Technological and technical support

g. **Developing the RE resource atlas:** While available RE resource maps that are developed by MEW are useful to conduct pre-feasibilities of projects, improvements such as demarcation of RE resources using time series data of key variables such as GHI, DNI (for solar), wind speeds, flow rates for MHP and SHPs shall enhance the quality of the maps. The preparation of RE atlas is thus an important action that need to start as early as possible to facilitate project developers in designing the projects in market creation stage.

h. **Testing and certification of systems and components**: In order to ensure the quality and safety of RE systems and components, and to ensure the designed and expected performance, it is important to create a state-of-the-art national level testing and certification facility that could later be expanded at provincial levels. Existing efforts in this direction taken by the Afghanistan National Standards Authority (ANSA) may be complemented.

i. **Technical training and education:** In order to provide a constant stream of educated and skilled workforce to sustain this sector, it is important to mainstream the RE education and skill development as a part of national level educational and vocational training infrastructure. A specialist organisation may also be set up, or existing institutions such as the Vocational Training Centre (VTC) strengthened, so as to meet this challenge in a systematic manner.

5.2.3 Institutions and Institutional framework

j. **Independent regulatory agency**: Role of the regulatory agency would be to introduce and guide regulations on various subjects such as tariffs, power access and transmission, determination of a national 'grid code', issuance of licenses for power generation and distribution operations. It can issue guidance on demarcated zones for decentralised and off-grid power generation, facilitate development of solar power parks, open access and power purchase / sales and so on. Thus, the regulatory agency shall be a key enabler in structuring the electricity sector and complement the efforts of the Ministry of Energy and Water.

k. **Specialized institutions or Special Purpose Vehicles:** These shall be formed to carry out activities specific to a sub-sector or project type. For instance, the Solar Power Park Developer (SPPD) may be entrusted with the task of setting up and managing solar PV parks. Similarly, there could be a dedicated entity managing the roof-top sector. These specialized bodies, set up under the aegis of the MEW can be given executive power, thereby according them ownership and responsibility.

l. **Rural electricity utility:** The rural electricity utility may be given responsibilities for generation, transmission and distribution exclusively in rural areas. In terms of ownership, the utility could be a public corporation or a government owned company. Given that most of rural Afghanistan is not connected to the national grid, a dedicated rural utility shall provide greater focus on meeting the rural power shortage scenario.

m. **Dedicated financial institution:** As the sector grows and enters the *market creation* stage, it would require a dedicated institution to generate and manage funds for the implementation of RE projects. The institution will be developed to manage local as well as international grants and lines of credit. This shall create a *basket-fund* approach, in which development partners and other agencies can pool in resources and enable the entity to offer a string of financial solutions to suit various project types. The financial entity may empanel prospective project developers (private sector players, micro-finance companies, NGOs) who can avail of financial support through it.

n. **Coordination mechanism and an oversight:** coordination between institutions responsible for electricity generation, distribution and application is important for realizing the potential of RE in Afghanistan. Therefore, an effective coordination mechanism amongst these institutions is an important step to ensure synchronized development of the sector.

o. **Institutional capacities on project planning, managing, monitoring and reporting**: RE sector will grow on the shoulders of strong and capable national level institutions. Building and strengthening of institutions is therefore a pre-requisite for developing RE sector in Afghanistan. Specifically, capacities need to be strengthened across MEW, MRRD and other key ministries and provincial governments on technical, managerial, administrative and financing aspects of RE projects. This would be a continuous process, as there would be a need to keep abreast with the latest developments in RE sector internationally and also to incorporate learnings from local as well as international experiences.

p. **National level awareness generation:** since the success of RE sector depends on its effective uptake by various sections of the society and communities, it is critical to make them aware of and educate them about the use and benefits of RE systems. An all-encompassing and multi-stakeholder targeted national level campaign on RE is expected to help catalyze the growth of the sector.

5.2.4 Access to finance

One of the key enablers for RE sector in Afghanistan is access to finance, which spans across all finance needs, viz. large, medium, small and micro. In this direction, the relative weakness in the Afghan domestic financial system implies that private resources are not readily available for investment in the renewable energy sector.

As a result, the main sources of finance lie in the public domain. The RENP has rightly identified the unlocking of private capital as a means to finance investments in the renewable energy sector. Engagement of banking sector & investment finance can take place at the following levels:

q. **Bank (Debt) Finance:** Bank finance for large and medium scale projects in the renewable energy sector shall in-turn mobilize both private and public capital. Currently, most projects in this domain get supported by concessional donor funds and government contributions. Currently Afghan banks are more focused on retail operations, however donor or government guaranteed debt instruments can leverage additional capital. These can be utilized to expedite implementation of renewable energy projects, especially for solar power parks, larger RE technology projects and setting up of power distribution franchisees.

r. **Microfinance:** Primarily for micro scale projects at the user level, microfinance supported renewable energy projects has had significant success in ecosystems similar to Afghanistan, across Asia and Africa. Similar potential exists here, with high levels of household energy demand for consumption as well as micro-enterprise development.

s. **Working capital finance**: In addition, working capital finance, which is currently available from Afghan banks for large businesses and industrial groups, is a potential enabler for easing the capital constraints of the RE market.

5.2.5 Local manufacturing and enterprise development

t. **Enterprise development:** In a rural economy, enterprises form the backbone, supporting the economy with employment, trade and commerce. Enterprises also enable communities to adapt to climate-induced exigencies that lead to lower farm incomes and consequently higher climate vulnerability. From an energy security perspective, enterprises are a key enabler as they are able to utilise energy for productive applications, thereby generating incomes to sustain both the enterprise as well as the energy generation unit.

   There is a role for social enterprise incubators, who provide various value-add services such as sales and marketing tie-ups, advice on operating businesses and start-up capital. In the Afghan context, the incubator landscape is dominated by donors and CSOs, which provide inputs to enterprise development. However, there is a need for strengthening enterprises as well as enterprise incubation services. Several government agencies, especially MRRD and MAIL (Ministry of Agriculture, Irrigation and Livestock), in collaboration with development partners, have set up incubators to facilitate rural enterprise development.

u. **Support programme for local RE industry:** since local industry is expected to provide the back-bone of RE sector in Afghanistan, it is important to design and implement a support programme for local manufacturers, system assemblers and others by way of enhancing their capacities, providing networking opportunities with international industry, access to technology and technical know-how, financial incentives, mentoring and incubation, involvement through regular consultations for policies and overall RE sector's improvement etc.

v. **Private – Public – Partnerships or PPP:** The PPP model works on the premise of getting the best out of public and private sectors to work together for a common goal. While the public sector brings socially responsive pro-poor approach to project design, the private sector focuses on financial viability of the project. The PPP model also helps in developing the confidence of the private sector through risk sharing mechanism.

   With spatially distributed communities, PPP projects are especially an enabler in unlocking private capital for financing renewable energy projects in rural sector. This model is particularly pertinent in mini-grid sector where DABS along with a local RESCO can work together to build, operate and maintain (or transfer) mini-grids, and in the process, builds the capacities of local enterprises to undertake such projects in future.

w. **Fiscal and financial incentives for RE sector:** while the sector will continue to benefit from already available support and incentives for the private sector led infrastructure projects, the RE sector would require customized fiscal and financial incentives particularly in terms of customs duty and import tax waivers.

5.2.6 Risk management

Management of risks is a key enabler in providing the right environment for stakeholders engaged in the sustainable energy sector. Although risks and their mitigants could be varied, broad risk classes are outlined below:

x. **Mitigating business risks**: Business risks include delays in import and transportation, absence of insurance or high insurance premium, lack or absence of skilled labor, risks of theft of plant and machinery (during transit, or during implementation / operation) etc. These risks, most of which are present in Afghanistan, can be mitigated by policy interventions and / or improvement in overall business environment.

y. **Managing project risks**: As distinct from business risks, project risks are intrinsic to the project location. These could include revenue risks arising from non-payment of dues from consumers, cost overrun risks from delayed implementation, safety risks from possible accidents etc. Some of these risks overlap with business risks as well. Better project design and management will help in mitigating these risks.

z. **Addressing security risks**: Finally, the delicate security situation in the country poses a risk as well. While the success of telecommunication in Afghanistan has indicated that rural infrastructure may not always be threatened by the security situation, the potential for disruption remains active. Direct mitigating measures include use of security, while more passive options could be to build trust capital with local communities as a means to counter subversive forces.

Management of these risks reduces chances of project failure and are crucial for the success of the renewable energy sector in general.

The following table maps enablers along with the stage of implementation in terms of the applicable stage-gate when the enabler is expected to be introduced.

Enablers as applied to relevant RE applications and business models are discussed in next section.

Table 15 - Enablers and their applicability in various stages

#	Enabler	SG 1	SG 2	SG 3
a.	Programmatic guidelines (or Schemes) for promoting specific business models	✓	✓	
b.	Policy on mini-grids	✓		
c.	Regulatory guidance on power distribution and grid integration for off-grid systems	✓	✓	
d.	Demarcation of areas for electrification through decentralised (localized) generation	✓		
e.	Greening of strategic sectors		✓	✓
f.	Incentives for use of solar hot water systems	✓	✓	
g.	Developing the RE resource atlas	✓		
h.	Testing and certification of systems and components		✓	✓
i.	Technical training and education	✓		
j.	Independent regulatory agency	✓		
k.	Specialized institutions or Special Purpose Vehicles	✓	✓	
l.	Rural electricity utility		✓	
m.	Dedicated financial institution		✓	✓
n.	Coordination mechanism and an oversight	✓		
o.	Institutional capacities on project planning, managing, monitoring and reporting	✓	✓	✓
p.	National level awareness generation	✓	✓	
q.	Bank (Debt) Finance		✓	
r.	Microfinance	✓		
s.	Working capital finance		✓	
t.	Enterprise development	✓	✓	✓
u.	Support programme for local RE industry		✓	✓
v.	Private - Public - Partnerships or PPP		✓	
w.	Fiscal and financial incentives for RE sector		✓	
x.	Mitigating business risks		✓	✓
y.	Managing project risks	✓	✓	✓
z.	Addressing security risks	✓	✓	✓

5.3 Enablers for implementation of specific business models

This section breaks down some of the enablers outlined in the sections above, into enabling activities specific to the context of business models and technologies discussed in this Roadmap.

5.3.1 Enablers for Solar Power Parks

For implementation of SPPs in Afghanistan, some of the key enablers and actions, their impacts in a stage-wise manner in realizing the SPP business model are presented below:

	Enablers and actions	Stage	Impact
1	Guidelines for SPP	1	Stakeholders, particularly project developers, have clarity and direction, and are empowered to take decisions
2	Special Purpose Vehicle as SPPD in place	1	Learning curve for all stakeholders and expedites market growth
3	Guidelines for power evacuation and long-term access	1,2	Long-term access to central transmission utility allows private producers to sell to buyers, thereby opening up the market for private – private sale of power
4	RE resource atlas	2,3	Will encourage private sector to set up large scale SPPs, and IPPs with confidence and will help in designing robust PPAs
5	Manging business and security risks	2, 3	Private sector shall come forward with investments in SPPs.

5.3.2 Enablers for Distribution Franchisee

It is expected that Distribution Franchisee projects shall be implemented in urban and industrial areas of Afghanistan, although a modified version could be equally applicable for RESCO projects. Success factors and visibility of DF projects shall lead to greater proliferation of DF projects. Key enablers for effective implementation of Distribution Franchisee business model and their impacts are given below:

	Enablers	Stage	Impact
1	Policies and guidelines for DF	1	Stakeholders have clarity and direction, and are empowered to take decisions
2	Demarcation of areas to be franchised and first DF set up as proof of concept	1	Learning curve for all stakeholders and expedites market adoption of DF model

3	Modified DF model introduced to RESCO business model	1,2	RESCO model could out-source billing, metering and revenue collection (BMC) to local agencies
4	Incentives and support for DF agencies	2	DFs play an increasingly active role in areas where national utilities fail to realize targeted revenues

5.3.3 Enablers for Roof-top solar

The key enablers and their impacts in the implementation of this business model are:

	Enablers	Stage	Impact
1	Policy on solar PV roof-tops with incentives for stakeholders	1	Policies will provide direction to stakeholders, while incentives will encourage private sector players to enter the market
2	Kabul Solar Roof-top PV project as first project	1	Pilot project shall launch implementation of solar PV roof-tops
3	Accreditation of EPC contractors as qualified third-parties to Build-Own-Operate (or variants of the above), and also as aggregators	1,2	Qualified EPC contractors can deliver long term and lasting roof-top systems that shall yield revenues and reduce risks. Aggregators shall also de-risk the user from O&M responsibilities
3	Escrow accounts with utilities to enable utility payments to net sellers. Also, retail financing of solar roof-tops	2,3	Inability of utility to pay consumers for net power purchased is a bottleneck. Techno-commercial solutions like escrow shall unlock the market further

5.3.4 Enablers for mini-grids and RESCO business model

Key enablers and their impacts on mini-grid market are presented below:

	Enablers	Stage	Impact
1	Policy for rural mini-grid projects, demarcation of areas to be electrified only by decentralised projects	1	Will provide clear direction and focus to stakeholders on prospective zones for RESCO development

2	Financial support or other mechanisms to support RESCOs in pre-project activities	1,2	In Afghanistan, terrain and weak infrastructure pose higher costs for RESCO projects; as such project identification and design costs are expected to be higher in the initial stages. Pre-project support will strengthen the business case for RESCOs
3	Empanelment of RESCOs	2	As RESCO market expands, eligibility norms for applicant RESCOs shall ensure participation of credible entities. This shall improve sector viability and encourage financial sector lending
4	Access to financial instruments	2,3	Key to unlocking RESCO potential in long run lies in RESCO projects accessing finance. One of the required interventions is for a dedicated rural energy funds to support RESCO projects with a combination of debt, grant and last stage equity

5.3.5 Enablers for microfinance supported stand-alone PV market

Key enablers for a successful, microfinance based solar PV standalone systems model are identified as follows:

	Enablers	Stage	Impact
1	Strengthening and capacity building of MFI to lend to solar stand-alone systems	1	Will assist in providing upfront capital for procuring a state-of-the-art system for rural Afghan households. Enable the household to move away from expensive fossil fuels and use the solar system to generate streams of avoided cash flows
2	Diversification into larger systems and variety of products	2,3	Will provide more options to the end user. As a result, markets can also merge – larger solar home systems could be financed by MFIs, set up in roof-tops and coupled to a net metering system for power consumption and export

As discussed, the Stage-Gate framework of development is contingent upon the introduction and implementation of enablers, both overarching and specific to business models. An important enabler for the overall RE future development is related to availability of funds and financing instruments which are discussed in the next chapter in details

6 COSTING AND FINANCING OF ROADMAP

The purpose of this chapter is to outline the framework that can be used to estimate initial costs for achieving Roadmap targets, and to outline mechanisms that can be used to reduce the cost to the government and international development partners by incentivizing investment by the private sector.

The RE market in Afghanistan is in infancy and hence there is no clear 'market price' for RE in Afghanistan. Wide variations in costs exist even amongst similar RE system configurations. This is a consequence of projects being grant funded by a wide variety of donors (with corresponding variations in standards, overheads, and costs), a small and fragmented market, the lack of focus on commercial sustainability, and an emphasis on system commissioning rather than on ongoing operations and maintenance.

A framework is designed for evaluating potential costs required to reach the targets of Stage- Gate I of this Roadmap. Costs for these RE technologies are estimated based on broad international benchmarks obtained from credible sources. The framework allows costs to be calculated by technology (e.g. Solar PV) and market (e.g. utility scale). It then outlines a mechanism to put in place financial instruments appropriate to the market type (i.e. utility scale, mini-grids, etc.).

This framework is not technology specific, but does make note of the degree of maturity of these technologies in Afghanistan. This degree of maturity can be used to evaluate useful instruments for the current stage of the market and make efforts to put in place mechanisms that will be useful at future stages. The framework is geared towards maximizing the role and investment of the private sector, and targeting donor / government subsidies to that end. Private-sector led growth is both in line with the RENP (and economic development efforts more generally), and is cost-effective, as international experience suggests that a robust competitive private sector dominated market with effective regulation promotes the greatest market growth and lowest prices.

In keeping with the overall structure of this Roadmap document, the goal is to move towards a liberalized energy market. To date, there has been very limited investment by private sector RE developers or commercial financial institutions, although surveys conducted suggest an interest and willingness provided risks are adequately addressed. The financing strategy is to gradually reduce the proportion of public investment in favour of higher share of investment by the private sector in the forms of viability gap funding, debt, equity, and various hybrid financing and risk mitigation products.

The framework is built upon deploying the right financial mechanisms based upon business model or market type (e.g. utility scale projects), and the stage of market development (e.g. market creation). The financial mechanisms are selected based upon the likely barriers being faced to private sector led market growth at that stage and are organized into three broad areas; subsidies and grants, risk reduction/ mitigation instruments, and climate change related funds / mechanisms.

6.1 RE benchmark costs and global cost trends

Globally, RE prices have dropped consistently over the past few years, a trend that is expected to continue for at least the next decade. Future costs for renewable energy will depend on a variety of inter-related factors including technological advancement, market expansion and regulatory action. However, the core premise is that costs will reduce as the market expands, which is supported by international experience. The following figure shows the trends in utility scale solar PV auctions throughout the world. It is clearly visible that the prices are going down at a rapid rate.

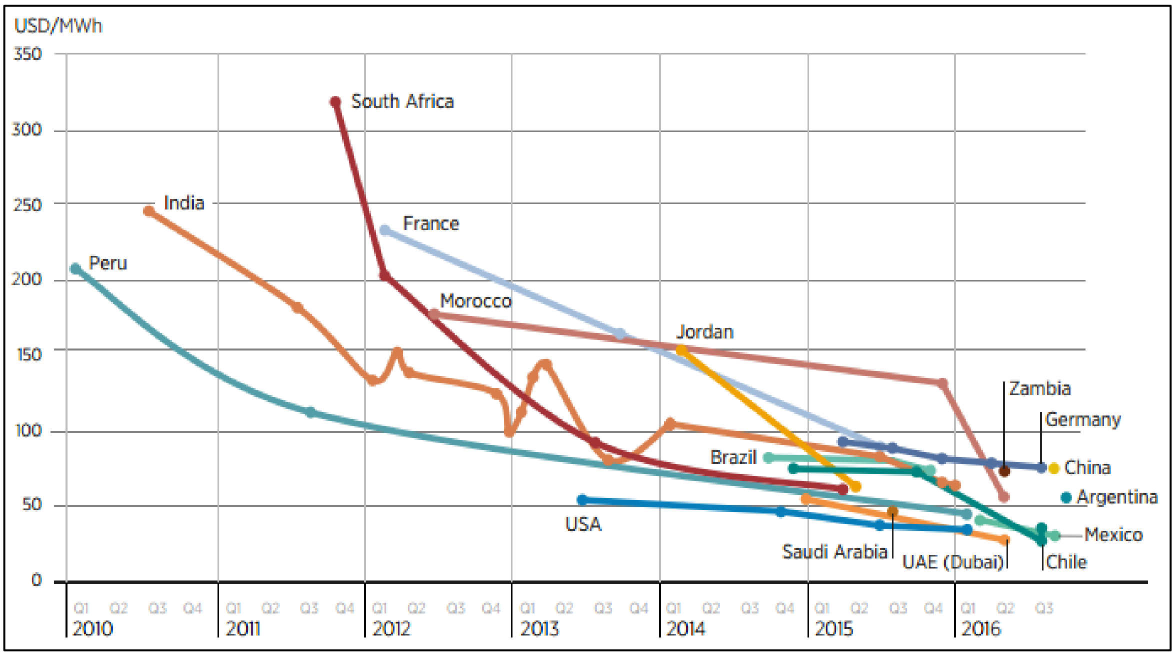


Figure 30 Trends in Solar PV Utility scale auction prices[41]

In fact, utility scale solar PV is even achieving parity with fossil fuel (coal) based systems in some countries. As an illustrative example, the figure below shows how the tariffs bid by developers (the price) has changed as the installed capacity for utility scale PV has increased (market expansion) in India[42] :

[41] IRENA Rethinking Energy 2017

[42]As per the recently opened bid for solar park, the lowest bid was INR 2.97/kWh (0.04 USD/kWh). http://energy.economictimes.indiatimes.com/news/renewable/solar-tariff-reaches-a-historic-low-of-rs-2-97-a-unit-at-rewa-bidding/57084519

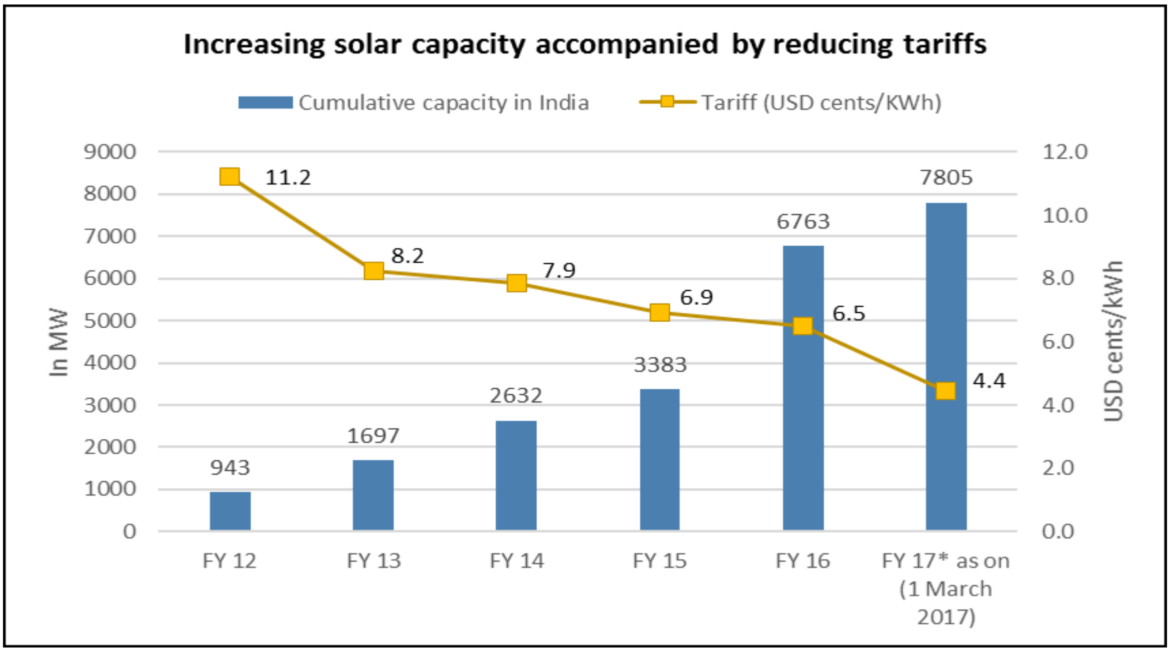


Figure 31 Market expansion and price declines in the Utility Scale Solar PV sector in India

The following figures, obtained from IRENA show the expected trends in LCOEs of utility scale solar PV up to 2025 (**Error! Reference source not found.**) and the overall LCOE ranges expected for various RE technologies in 2025 (**Error! Reference source not found.**).

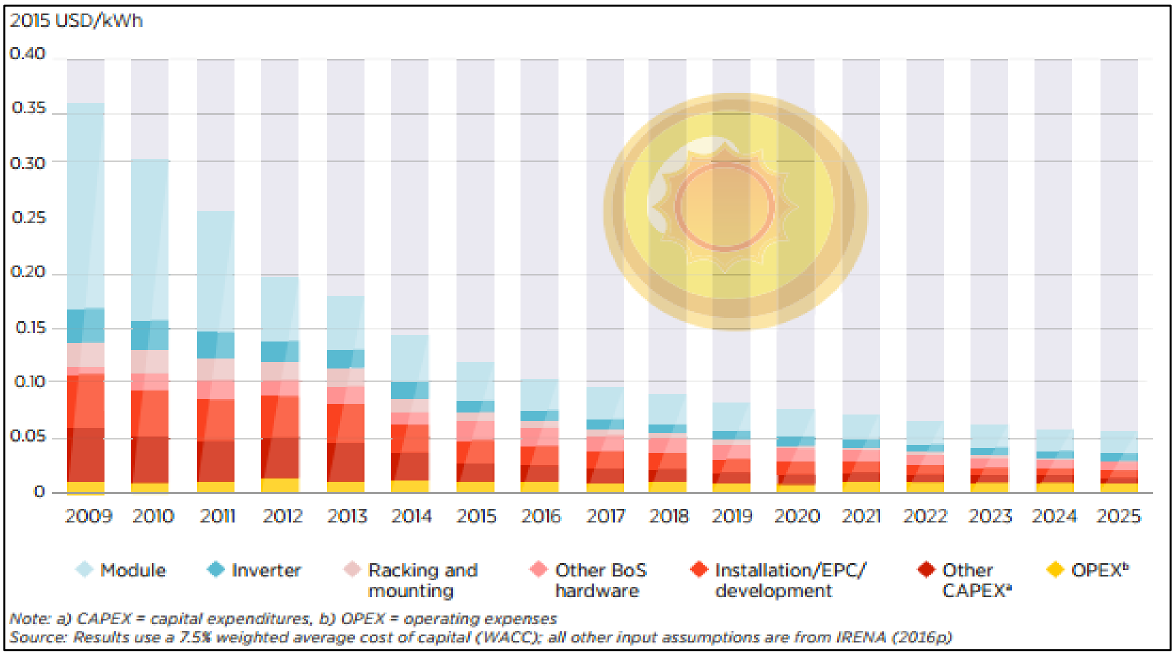


Figure 32 Projected trends in global LCOE of utility scale solar PV[43]

[43] IRENA Rethinking Energy 2017

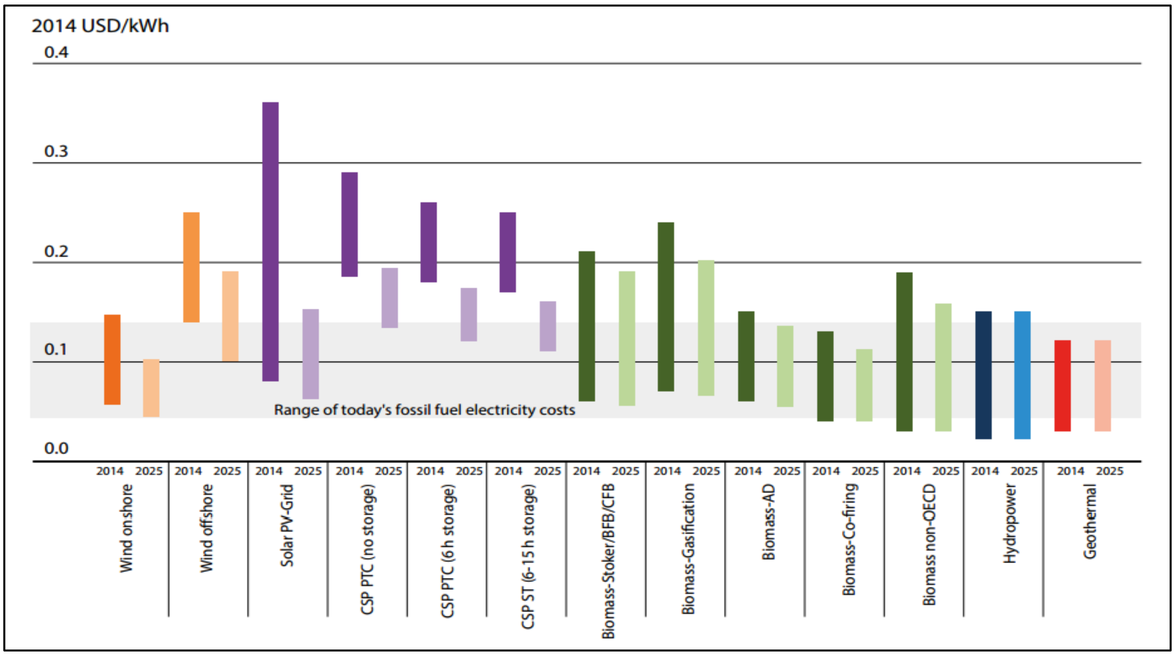


Figure 33 Expected global LCOE ranges for RE in 2025 as against the 2014 values[44]

Global PV utility scale costs and wind power costs are expected to halve over the next decade. Biomass and hydropower, as mature technologies, are not expected to fall too much in prices. However, based upon current technological trends and research, prices for the core mini-grid system are predicted to drop by over 50% in the next twenty years.

New tenders (particularly in the Middle East) also reveal such low prices. While it remains to be seen if projects bid at these rates will be financially viable (and it should be noted that complex financing and PPA structures can make this published cost difficult to compare), these projects do point to the potential for cost savings given a mature market.

6.2 RE costs in Afghanistan

To establish the cost baseline in the absence of an established market in Afghanistan, costs for reference systems were procured from local RE organizations. In the case of solar PV, the AREU was asked to provide quotations for systems in each of the proposed markets (1 MW with no storage (utility scale market), 100 kW with some storage (mini-grid market), and 10 kW stand alone with battery backup (large household system market). The graph below shows unit costs (USD/ Watt) for solar PV systems of different configurations, as provided by the AREU.

[44] IRENA Renewable Power Generation Costs in 2014

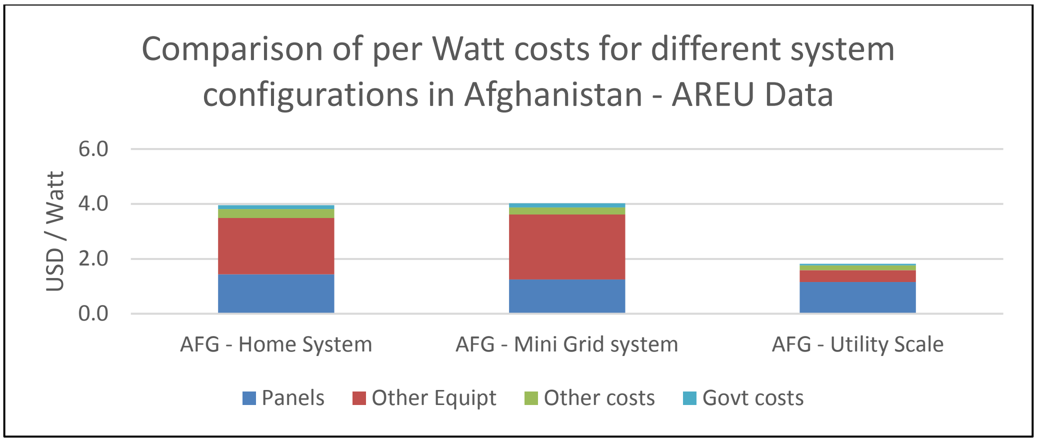


Figure 34 PV price comparison

Solar panel costs were broken out separately, while other costs were grouped within the categories of other equipment, other costs, and government costs for sake of comparison as shown below. It should also be noted that land costs and security costs are not included as these are highly variable and site specific.

<u>Other equipment</u> Inverters, batteries, PV panel stands, battery racks, grounding, cabling, safety ropes, nuts, and bolts and other miscellaneous minor equipment required for plant construction
<u>Other costs</u> Equipment transport to site, management and administration charges, site labour charges, site design and civil works and other miscellaneous design and site preparation costs.
<u>Government costs</u> Taxes and permitting fees

It appears that economies of scale are present in panel costs (as evidenced by lower panel unit costs as system sizes increase). However, quotations received indicate that the greater system complexity including additional charge controllers required for a mini-grid as compared to a home system negate these economies of scale when overall costs are considered. In contrast, the lack of storage (battery costs are approximately 40% of the equipment cost for home systems and 30% for mini-grids) and simpler configurations required for a utility scale system result in overall unit costs below 50% as compared to home systems and mini-grids.

When compared to global and regional benchmarks, it was found that costs are higher in Afghanistan. Higher equipment costs are likely a reflection both of higher transportation and logistics costs as well as of a smaller market and the lack of intense competition for large utility-scale projects. The higher labour costs reflect the lack of skilled technical labour available for large-scale installations, which can be partially addressed by training programs.

The proportion of costs (as shown below) for utility-scale systems in India and Afghanistan is similar, even though the logistics, market, and tax regime in India are different to

Afghanistan. It suggests that a reduction in taxes, other supportive policies and an expanded market has the potential to drive costs down across both equipment and labour costs.

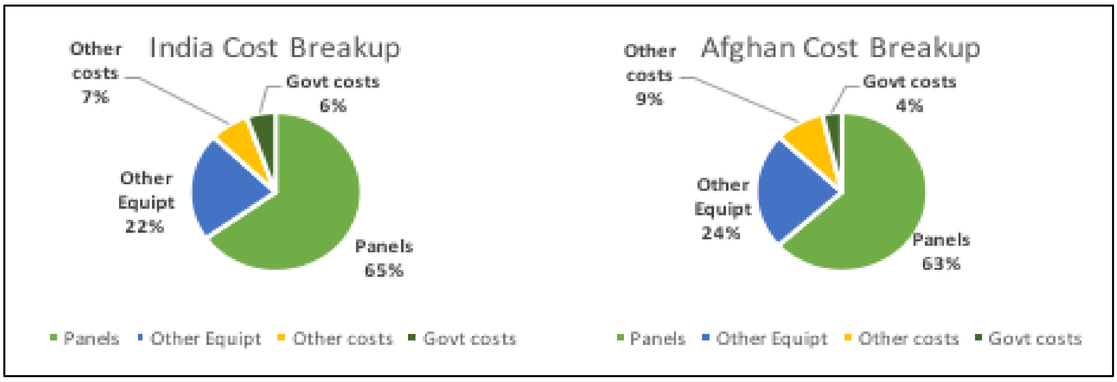


Figure 35 Cost elements for utility-scale systems, Afghanistan and India

Following scenario/developments will lead to rapid cost reductions in future:

- Rapid progress towards integration into international RE market enabling country to benefit from regional economies of scale
- Rapid improvement in logistics costs due to improved infrastructure particularly towards sites for large utility-scale projects
- Positive regulatory environment, established track record and significantly reduced Afghanistan risk premium

6.3 Cost of achieving Stage-Gate I target

The global costs mentioned in previous section have provided a basis for estimating the costs per MW of generation capacity for the various proposed technologies in Afghanistan. The assessment is limited to the cost of constructing and commissioning RE equipment and does not include costs for transmission/distribution grid infrastructure, materials/equipment replacement and O&M costs. The assessment also does not consider the land and security costs required. These costs vary markedly across the country, and in many deployments land and security will either be provided by the government, the community or owners' associations (as in the case of industrial parks).

Stage- Gate I represent the phase when technology deployment is at a nascent stage and projects are generally intended to confirm the sufficient availability of natural resource (e.g. wind availability at the site) or to demonstrate technical viability and refine standard designs through pilot projects. Private-sector led capital investment at this stage is often challenging, and faces the barriers of a lack of confidence in the natural resource and (once the resource potential is established) confidence in the techno-economic viability of the project.

The table below provides an indication of what costs might be based upon international benchmarks provided above to give an indication of the scale of investments required to reach the roadmap targets in Stage- Gate I. However, as it should be noted again that these costs represent broad global averages rather than Afghanistan specific costs. Further, these costs represent a wide range of sites, financing, and market conditions, and often consist of only 'core' costs (not including distribution, O&M, capacity building, etc.). Nevertheless, applying these broad benchmarks suggests that the overall capital costs to achieve the roadmap targets in Stage- Gate I will be around 500 million USD.

Table 16 Total cost of stage gate I

Technology	Cost Estimate[45] (USD/MW)	SG I Target (MW)	Total Cost Estimate (USD million)
Solar PV (Utility Scale)	1.57	75.0	117.8
Solar PV (Mini-grid)	2.90	25.0	72.5
Wind (Utility Scale)	1.28	20.0	25.6
Large hydro	0.45	100.0	45.0
MHP+SHP Mini-grids	3.50	30.0	105.0
Bio-methanation of municipal solid waste	0.40	6.0	2.4
Solar PV Roof-top	1.90	50.0	95.0
Various Stand alone	3.50	7.0	24.5
Total		**313**	**488**

6.4 Financing of Roadmap

The sections above on costing outlined a framework to estimate the range of costs for deploying RE technology/market combinations as per the Roadmap targets. This section outlines a framework to judge and put in place financing instruments appropriate to the market type (e.g. utility scale, mini-grid) and stage of expansion, but is not technology-specific. It should also be noted that these financing mechanisms are only one aspect of a robust private sector. This chapter does not discuss financing modalities for the broader infrastructure for the energy sector that must be built (such as transmission infrastructure), nor does it discuss financing of improved logistics, security, etc.

6.5 Framework for financing

The framework for suitable financing actions is aligned with the broader Roadmap framework that approaches RE development in terms of technologies, markets and stages. At each of these stages (market seeding, market creation, market expansion), the market tends to be dominated by particular project types (e.g. resource assessments and pilot projects tend to occur during the market seeding stage). These activities, particularly when attempted by the private sector, face risks and barriers. Each of these barriers is targeted by financial mechanisms, which are organized into grants / subsidies and risk mitigation mechanisms. Funding for these mechanisms is the form of instruments (e.g. grants through the newly-announced Citizens' Charter Program). This approach is outlined below:

[45] IRENA, Renewable Power Generation costs in 2014

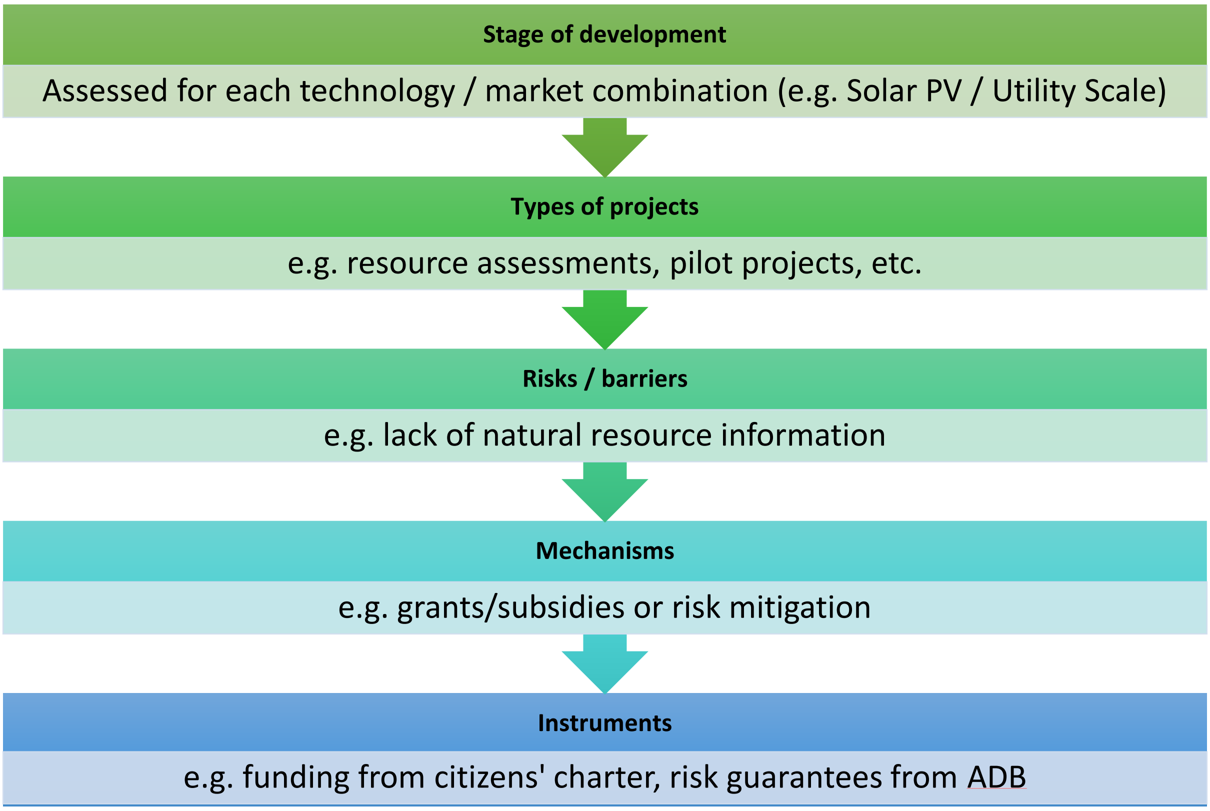


Figure 36 - RE Roadmap Financing Approach

6.6 Funding instruments and mechanisms

In this analysis, climate fund instruments are called out separately due to their particular applicability to renewable energy. Risks and barriers to RE development have been previously discussed in the policy framework for RE development (the RENP) and are unique to a particular market and stage of development, and a brief definition of the types of financial mechanisms[46] is provided below:

Subsidy/Grant: These are monetary benefits given to private sector participants and consumers so as to reduce the financial impact of commissioning and maintaining RE projects. The purpose of these mechanisms is to recognize and address commercial issues that can make a RE project unviable if the only funding available was from the private sector. These can include generation-based capital subsidies (where grants are provided to project developers for commissioning plants), ongoing Power Purchase Agreement (PPA) or Feed-in-Tariff subsidies (where monies are provided based upon ongoing generation) or concessional finance (where monies are used to provide a cheaper source of capital such as equity or debt to RE developers).

The payment of the grant or subsidy is linked wherever possible to outputs; a certain capacity installed or energy generated over time. To date, the financing ecosystem for

[46] At this stage, a distinction needs to be made between funding and financing. Funding implies that the government or any public agency provides the capital, often consequent to an agreement and is usually free of charge. Financing, on the other hand, is the sum of money provided with an expectation that the receiver repays the amount in due time.

renewable energy in Afghanistan has been almost completely dominated by grants. Instruments under this mechanism include design-build or design-build-operate contracts financed by international development agencies, grants for infrastructure such as under the NSP (and by the newly-launched Citizens' Charter Programs) and funding by NGOs. An overview of some of these types of grant/subsidy funding mechanisms is provided below:

Table 17 - Overview of financing options

Financing Option	Advantages	Limitations	Experience in RE sector in Afghanistan
Donor/GoA Grants	Direct support;	Lacks sustainability, can "crowd-out" private investment	Dominates current Afghanistan funding landscape
Viability Gap Funding / Guarantee Funding	Complements finance that is already in place, facilitates scale up	Difficult to be multiplied across several projects and ecosystems; programme driven	Co-financing is tried out in limited form through UNDP Small Grants Programme
Low-cost Debt	Leverages equity and other forms of financing; ties up the borrower in a formal and legal framework	Needs government support for main-streaming; not all variants may be compliant with Islamic Finance principles	Not present
Equity	Purest form of financing where stakeholders share risks equally. Supports up-scaling and leveraging of debt	Possible at scale in mature markets; not all variants may be compliant with Islamic Finance principles	Not present

Risk mitigating instruments: These are insurance and risk mitigation mechanisms that are guaranteed by public (e.g. donor or government) monies but which are paid out not in the normal course of commercial business, but during a specified non-business event. The purpose of these mechanisms is to recognize and address non-commercial risks that prevent private sector participants from investing. These mechanisms and events include resource risk guarantees (paid out when exploratory or resource assessment investigations by the private sector fail to uncover sufficient natural resource potential such as geothermal basin heat capability); political / sovereign risks (e.g. political insurrection) and to serve as re-insurance for commercial insurers.

While risk mitigation financial mechanisms have not yet been used in the renewable energy industry in Afghanistan, they are being attempted in areas such as natural-gas fired power generation. Risk mitigation instruments are usually provided by development banks such as the World Bank Group and the Asian Development Bank.

Climate funds: These are financial mechanisms / monetary incentives specifically designed to increase the penetration of climate friendly technologies. Although in practice they can take the form of a subsidy or risk mitigation mechanism, they are called out here separately as they are specific to RE development. There are a variety of climate funding opportunities that serve different purposes and which are designed to be deployed at particular stages of market evolution. Pilot projects and programs have previously accessed climate funding, and larger integrated programs have applied for funding from the Green Climate Fund (GCF).

6.7 Financing approaches for different stages of development

Stage 1: market seeding

This is when technology deployment is at a nascent stage and projects are generally intended to confirm the sufficient availability of natural resource (e.g wind availability at the site) or to demonstrate technical viability and refine standard designs through pilot projects. Private-sector led capital investment at this stage is often challenging, and faces the barriers of a lack of confidence in the natural resource and (once the resource potential is established) confidence in the techno-economic viability of the project.

The type of **direct grant** funding that has been traditionally employed by development partners in Afghanistan is useful at this stage. Public grant money also has a role to play in helping ensure that any results or lessons learned from resource assessments are shared as well as helping to provide legitimacy (by assisting with certification and monitoring) for resource assessments. Certification and legitimacy of resource assessments and pilot project results also help provide proof points that give confidence for the private sector to begin investing in projects, and for commercial banks to provide financing.

Rather than a direct grant, a **resource risk guarantee** can be useful in instances where there is the possibility of pursuing an integrated strategy with a project developer for resource assessment and an initial commercial project (e.g. the private developer agrees to perform the geothermal resource assessment at a site, and if successful, then develop the site into a commercial project). A resource risk guarantee is structured such that if the initial resource investigation proves to be unviable, the resource risk guarantee compensates the developer for all or part of the cost of the resource investigation.

With regard to **climate funds** appropriate mechanisms at this stage are those that focus on technology transfer and can be mobilized quickly. The Climate Technology Centre and Network (CTCN) and Poznan Technology Transfer mechanisms are designed for this purpose.

Stage 2: market creation

At this point, natural resource availability and technical viability have been established, and technology application is no longer new to the country as a result of multiple pilot projects. The focus at this stage is demonstrating that the designs and business models developed during pilot projects of the Market Seeding stage can be scaled and replicated. Private sector entities at this stage start exhibiting interest in mechanisms apart from pure grant-funded contracting (as is normally the case in the pilot projects of the previous phase). The barriers faced to private-sector led growth revolve around longer-term viability such as continued O&M and cost recovery (initial technical and financial viability having been established) and the perception of risk regarding political climate and security.

Grant / subsidy mechanisms chosen at this stage are selected to let the market decide the level of risk that private sector entrants are willing to bear. It is possible that subsidies will still need to be offered to elicit private sector interest (especially in markets where electricity tariffs are regulated) and will involve some combination of subsidies for capital investment and for ongoing operation. It is recommended that subsidies/grants be explicitly linked to effective output; such as payment upon some defined capacity commissioned and certified, or linked to per unit of continued energy production. The government has the opportunity to incentivize developers through mechanisms that forego revenue but increase the market; tax holidays for profits and import duty exemptions for equipment. It is also recommended that market mechanisms be used to determine the level of subsidy required through strategies such as auctions for the level of capital subsidy and PPA tariff. In the recent 10 MW Kandahar solar project, an element of this model has already proved successful; the PPA tariff that DABS would pay to the developer was decided based upon a reverse auction, while the capital subsidy was decided up-front. The next stage could be the use of a reverse auction mechanism for both the capital subsidy and the PPA tariff.

The subsidy demanded by the market can be further reduced (and more private sector entrants enticed) through the use of **risk mitigation products**. Development organizations such as the World Bank, ADB, and OPIC provide these instruments, with variations for required eligibility (OPIC's mechanisms are in place to aid US businesses). These instruments provide a guarantee for specified recompense in the event of a defined political event or in the event that the government utility cannot make good on its commitments. To ensure that the government also has protection, the contract terms of the IPP can specify that the asset will pass to DABS in the event of independently-assessed non-performance.

Climate funds at this stage of market evolution should be targeted towards programs rather than individual projects. Larger funding packages such as those available from the GCF can build upon the proof points and lessons from the pilot programs commissioned during the market seeding stage to propose programmatic interventions. Conceivably, the results from one climate-funded initiative can be used to apply for funding from another source; using a CTCN intervention for initial technology transfer and assistance, Global Environment Facility (GEF) or Climate Investment Funds (CIF) funds to build upon CTCN, and using these results to form the basis for a GCF proposal.

Stage 3: market expansion

At this stage, the market has been proven and viable combinations of technical designs and business models are in place. The focus at this stage is to select financial structures to reduce the cost deploying systems in the commercial market. **Grant / subsidy** mechanisms are selected to assure demand, either through standardized FITs (again auctioned where possible) and access to concessional finance. In mature markets, government mechanisms are formed (such as IREDA in India) that allow concessional finance funds (from government funds and institutions such as the ADB, World Bank and KfW) to be pooled and accessed by project developers. In the case of Afghanistan, it will also be necessary to align these instruments with Islamic Finance principles where required. With regard to risk mitigation, it is anticipated that in a mature market, a project developer will be able to access conventional sources of **project insurance**; and should an Afghanistan risk premium persist, re-insurance sponsored by multilateral agencies can reduce this premium. Climate funding (if available) is past the pilot, scale-up and market creation mechanisms and takes the form of active **trading of carbon credits**.

The framework as applied to the three roadmap market types (utility scale, mini-grid and stand-alone) is presented below, along with an assessment of the current maturity of technologies in each of these markets.

6.7.1 Financing framework applied to the Utility Scale market segment

"Utility Scale" systems are typically characterized by larger projects that feed to the grid and sell bulk power, typically on a per unit (KWh) basis. During the **market seeding** stage, private sector developers face the risk of unknown natural resource potential at the site (which in turn can affect generation and revenue) as well as technical risks including the ability to connect and inject power into the grid. At this stage, grant funding is useful to help locate suitable sites with natural resource potential and required infrastructure, and fund resource assessments, as well as for studies that demonstrate that generated power can be evacuated by the grid.

To establish a track record of successful operation in areas of perceived increased risk, initial projects in the country are likely to be grant funded. Since the electricity sale is usually to the utility, capacity building and technical assistance to train utility personnel in effectively managing the introduction of private sector power into the grid may also be useful. As mentioned, in some cases (such as geothermal development), private sector participants may be willing to fund resource assessments as part of an integrated strategy that leads to development if they are compensated in the event of the resource not being sufficient for commercial development.

During the **market creation stage**, initial technical viability has been established and the focus is on sustaining operations and revenue. In many instances, the cost of generating power is higher than that of other sources of grid supply (such as imported power from Central Asia) and the regulated prevailing user tariff. Public monies will then be required to fill this 'viability gap' between the unit cost of generating renewable energy for the developer and a per-unit revenue (tariff) realized by the utility. To reduce the overhead costs of development and limit the developers' risk to the extent possible to technical generation of power, public monies are also useful to develop 'Renewable Energy Parks' wherein suitable site selection, ancillary infrastructure and security are arranged for by the government.

Technical assistance to the government to effectively manage private sector participants (such as the structuring of contracts and tariff mechanisms) is also useful to safeguard the interests of the government and consumers. Since the electricity is sold to one customer (the utility), the risks a private sector investor faces include default or non-payment on the part of the utility/government. As mentioned previously, instruments exist to insure the developer against non-payment by the government or defined political risks.

During the **market expansion stage**, the focus is on expanding the variety and scope of finance available to private sector developers as well as to ensure continued demand for renewable energy. A model that has proved successful in the region is for the government to set up a pooled finance mechanism for renewable energy development that is structured to accept concessional finance from development agencies and in turn lend (after appropriate due diligence) to project developers at favourable rates. In some cases, this finance can take the form of an equity stake rather than debt.

The risk of insufficient demand can be reduced by transparent policies by the government to commit to renewable energy targets through mechanisms such as renewable purchase obligations, which compel government agencies (and in some cases large industrial and commercial consumers) to source a certain percentage of their power from renewable sources. With regard to risk mitigation, the risk guarantee instruments that insure against political risk or non-performance by the utility can continue to be useful, as can international development agencies facilitating access to commercial insurance.

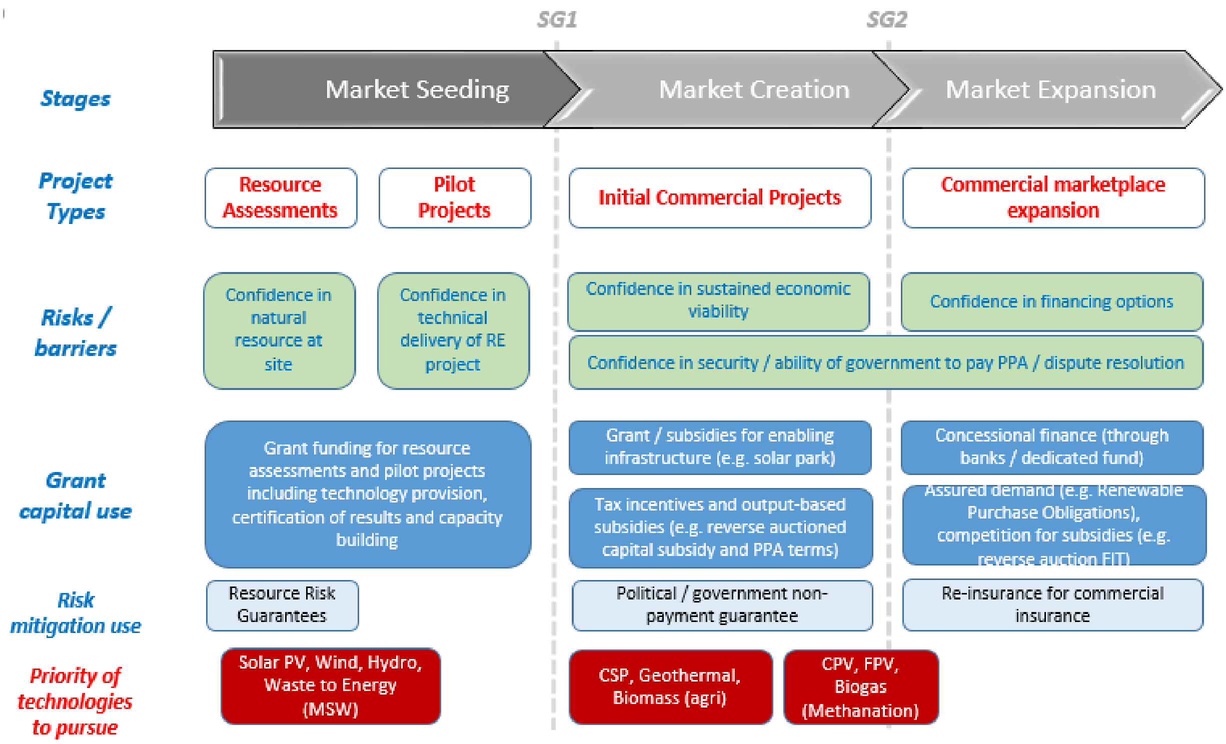


Figure 37 - Financial Mechanisms and Market Stage - Utility Scale Market

6.7.2 Financing framework applied to the Mini-grid market segment

The mini-grid market shares some similarities with the utility scale market (such as the project type) but also has several important differences. For one, the barriers to successful commercial operation rely on effective revenue collection and buy-in from a group of (often rural) consumers, rather than bulk sales to the grid. Systems are smaller and unless methods of aggregating assets into a portfolio are implemented and partnerships with local banks formed, the small scale of financing requirements often makes the cost of due diligence and oversight problematic for multilateral development agencies and larger commercial banks. The distributed / rural nature of many operations also presents challenges in terms of directing financing appropriately towards system sustainability. Finally, site selection must be coordinated with grid expansion plans so that systems do not become unviable due to competition from cheaper grid power.

During the **market seeding stage**, grant funding is useful for site-specific resource assessments, technology transfer and technical assistance, and capacity building both amongst the mini-grid operators and the local community. The emphasis at this point is to use public monies to refine the business model, select appropriate technology and to develop the knowledge and training tools for both producers and consumers of energy.

During the **market creation stage**, lessons from these individual pilot projects are expanded into programs. Grant / subsidy funds are directed towards funding the non-core aspects of successful mini-grid operation such as knowledge platforms (for both consumers and providers), equipment standards certification, and providing technical assistance and technology transfer support. It may be likely that subsidization of minigrids will be required to ensure financial viability for the operators, especially if tariffs are regulated and set to compete with grid power.

Evidence from previous systems suggest that longer-term maintenance and sustainability of systems is an issue. For this reason, it is also prudent to ensure that backstop operation and finance capability exists (supported by public monies) so that if a mini-grid operator cannot carry out their functions, alternatives can be put in place to prevent the loss of the asset and faith of the user base. The market creation stage is also when a tighter integration between the larger government and development banks and rural banks becomes useful to help with the issue of aggregation mentioned previously and to ensure financing is available for local mini-grid operators in a manner that is aligned with acceptable business practices (e.g. Islamic Finance).

During the **market expansion stage**, after the technical and financial viability and sustainability of mini-grid systems has been prove, the focus is on ensuring adequate finance for scale-up and demand for services. International experience suggests that this finance is best conducted by local banks, who are in turn able to access concessional finance provided by public monies. Finance for technology transfer and technical assistance will still be required, but directed towards assistance in managing a portfolio of projects rather than individual sites.

As the market expands, private sector developers will wish to secure insurance to guard against expropriation of assets by the government, loss of demand should the grid be expanded to the area and political and security risks. As in the case of utility scale systems, existing risk mitigation mechanisms such as guarantees and insurance can be deployed to allay private sector concerns.

While the diagram and discussion below focus on financing mechanisms, these considerations are intrinsically linked to site and business model selection, discussed in greater detail in chapters 3 and 4. Viability depends also on a supportive and transparent regulatory environment and protection of the rights of producers and consumers.

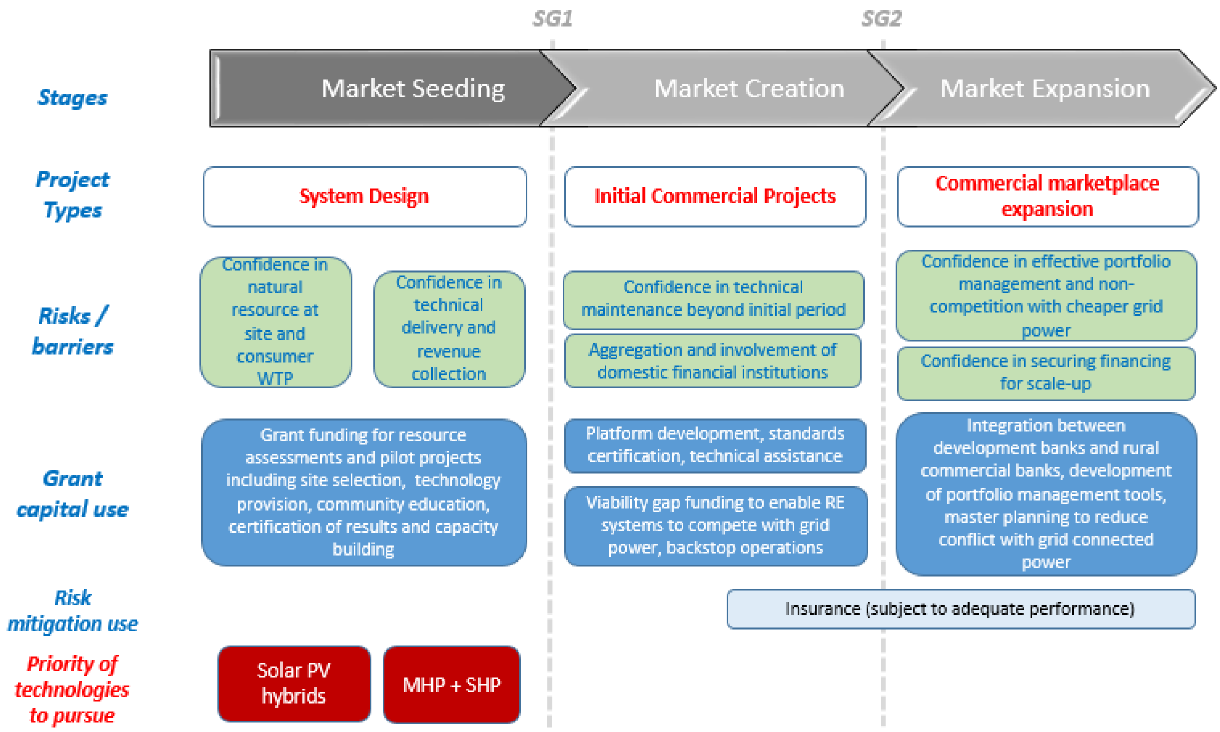


Figure 38 - Financial Mechanisms and Market Stage - Mini-grid Market

6.7.3 Financing framework applied to the Stand-Alone market segment

The challenges to private sector participation in the stand-alone market are similar to those faced in the mini-grid (e.g sustainability of rural service delivery) but are nuanced by the need for operations and maintenance over a wider group of consumers, the need for individual consumers to mobilize the up-front capital for such systems, user confidence in initial technical quality of systems, and ensuring that private sector participation is not 'crowded out' by purely grant funded external systems that are deployed in the same service area of coverage. International experience suggests that a viable stand-alone ecosystem can be enhanced by a tight integration between technology providers, microfinance / commercial finance institutions, and government / multilateral development agencies.

During the **market seeding stage**, the focus is on developing standardized designs and business models that can be deployed commercially. Many of the uses of grant funding in the mini-grid market have applicability here; technology transfer, community engagement and demand assessment; feasibility studies; certification and measurements of benefits, and capacity building both for the suppliers and consumers of systems.

During the **market creation stage**, integration between government / international development partners, commercial banks and technology providers has proved useful in other regions. This requires public funds to fund an organization to certify equipment and vendors; extend concessional finance for microfinance / banking institutions that in turn perform due diligence and extend credit (compliant with Islamic Finance) towards the purchase of certified equipment to users, and, where required, subsidize systems such that they are affordable. Although stand-alone PV systems have been deployed in Afghanistan, evidence suggests that this lack of integration between technology and finance has prevented sustainable operation of many systems.

During the **market expansion stage**, the involvement of the local banks is expanded to extending credit to systems providers so that they can expand operations, while continuing credit facilities to consumers to purchase and maintain their systems. As in the case of mini-grids, this requires capacity building and concessional funding to commercial banks so they have the tools to perform commercial due diligence on these systems providers and extend credit in a manner compliant with Islamic Finance principles (where required). Public and grant funding also has a part to play in building awareness of the benefits and on proper use of the systems, and funding subsidies to ensure used equipment such as batteries are disposed of in an environmentally friendly manner.

Risk mitigation mechanisms typically do not come into play in the stand alone market due to the lower capital investment and distributed assets. However, should sufficiently large private sector players be evidenced in the market who seek international commercial funding or insurance but require political risk / expropriation guarantees, risk mitigation mechanisms might be useful at that later stage of market development.

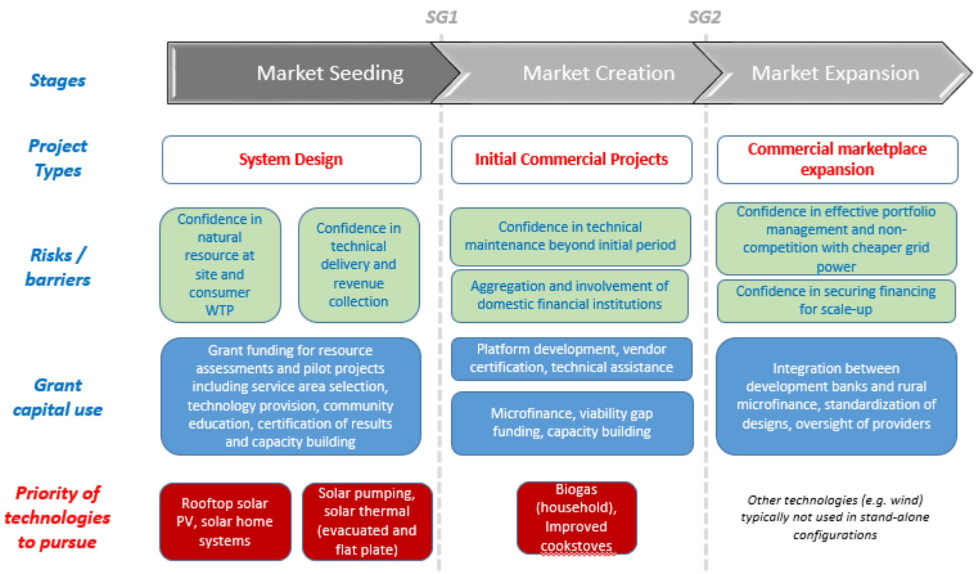


Figure 39 - Financial Mechanisms and Market Stage - Stand-alone Market

6.8 Conclusion- from dependent to self-reliance

The focus of the above discussed financing strategy is to incentivize private sector participation and investment. It is geared towards using government /donor monies to assist the transition from a purely donor grant-driven reality to a vibrant competitive sector dominated by private sector led growth. International experience suggests that as the market expands and greater penetration of RE development is apparent, the relative contribution of direct subsidies will decrease in place of risk mitigation mechanisms and concessional finance. Following figures summarize the overall financial framework and a possible financial landscape covering all stages of RE sector development towards self-reliance.

	SG I		SG II	
Stages	**Stage I**	**Stage II**		**Stage III**
Stage Description	Grant funding by GOIRA / donors	Grants partially replaced by financing & private sector contribution		Project financing using debt & equity, some grant & subsidies as incentives
Project Types	Resource Surveys, pilot projects	Initial commercial projects		Fully commercialized projects
Financing Stakeholders	Govt. & donors, some private sector entities and MFIs	Banks, private sector entities and microfinance		Bank finance, supported by private investment, venture equity, MFIs
Financing Instruments	Grants & Subsidies, some micro financing, VGF	Grant and subsidies supported by bank debt, VGF, mezzanine debt and equity		Senior debt, other debt, equity, venture equity, micro financing, VGF and subsidies

Figure 40 Overall Financing Framework - All Stages

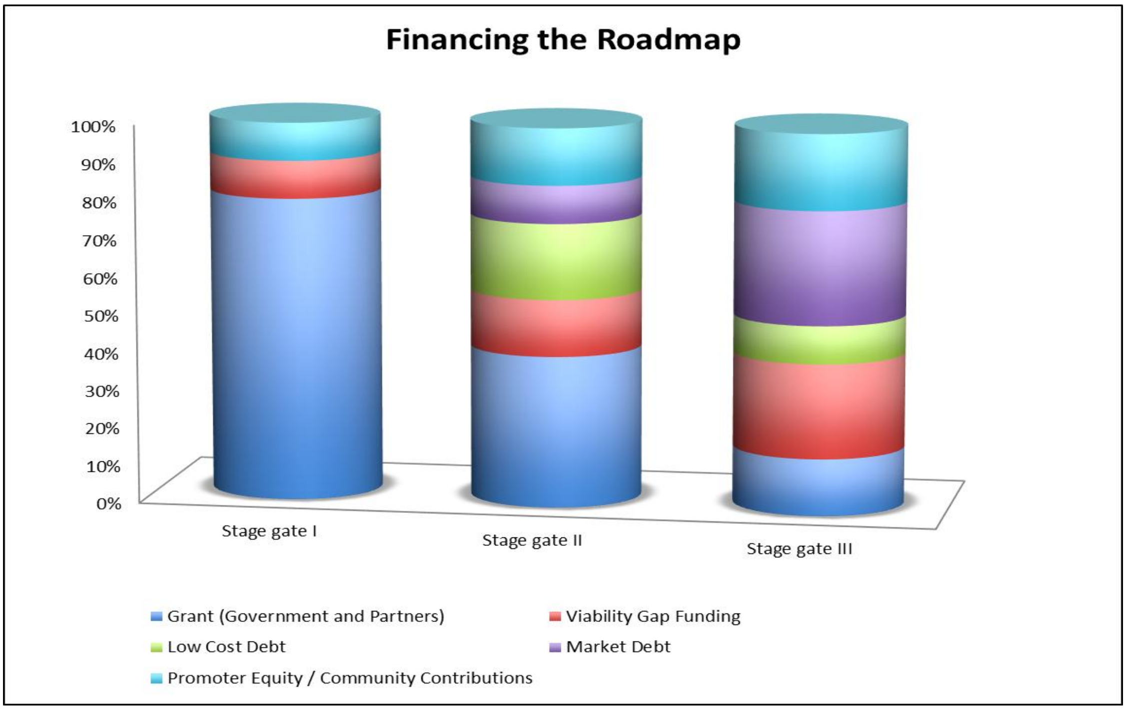


Figure 41 Financing the Roadmap - All Stages

7 IMPLEMENTATION OF ROADMAP

The strategic rationale, methodology, project prioritization, technical considerations and financial strategies for achieving a step change in renewable energy deployment have been the focus of this work. The above is proposed to be achieved through the *roadmapping* exercise by which a roadmap is created, implemented, monitored and updated as necessary[47]. The Renewable Energy Roadmap -RER2032- an output of this work, is a high level strategic plan that sets the pathways to achieve the intended objectives of RE sector development in Afghanistan. The RER2032 has set milestones, outlined tasks and prioritised actions.

The next logical step is to implement the Roadmap by carrying out activities and initiatives that address Roadmap tasks and priorities and monitoring their progress with the help of a tracking system. Accordingly, the 4Ps - Proponents, Projects and People- are considered at the core of the Roadmap implementation plan. These are briefly discussed here.

7.1 Principles

The implementation of the Roadmap is based on four guiding principles:

a) **Empowered and dedicated institution(s)** - to oversee the implementation of the Roadmap in a time bound and coordinated manner
b) **Participatory and collaborative approach**- among various ministries, departments, donors, public institutions, private sector and communities to work towards the common goals of achieving energy security and energy access by deploying renewable energy resources in Afghanistan
c) **Optimisation of existing and raising new financial resources**- through a mix of donor funds, national funds and private finances with a focus on private-sector led growth, and corresponding use of public monies to incentivize private sector participation.
d) **State-of-the-art global practices and techniques**- customised to the local conditions and adopted effectively across all departmental functions and projects

7.2 Proponents

Proponents are a set of state-led institutions spanning across financing and implementation space that are needed to realize the intents of the Roadmap. It is critical that these institutions work in close collaboration with legislative and regulatory authorities to ensure that renewable energy development is within a transparent legal framework. At the project level these institutions shall work closely with private sector players, thereby effectively bridging the gap between policy and practice. Finally, these public institutions shall also be able to work with development partners, donors and civil society organisations and thus be

[47] According to the IEA, *a roadmap is a strategic plan that describes the steps an organisation needs to take to achieve stated outcomes and goals. It clearly outlines links among tasks and priorities for action in the near, medium and long term. An effective roadmap also includes metrics and milestones to allow regular tracking of progress towards the roadmap's ultimate goals.*

http://www.iea.org/publications/freepublications/publication/TechnologyRoadmapAguidetodevelopmentandimplementation.pdf able to grow independently in future. Following three institutions are relevant for the growth of RE sector in Afghanistan:

Table 18 - Setting up key institutions

Description	Purpose and key features (in brief)
Renewables energy project development organisation	• a for-profit public-private partnership organization focused on utility-scale generation • set up along the lines of AISA with overlapping functions to DABS • to catalyse and foster growth of RET (solar and wind) based power parks, and IPPs in collaboration with private sector • would act as a single-window clearance for future IPPs
Rural electrification agency	• Promote rural electrification projects, specifically mini-grids through site selection, land acquisition, access to finance, and regulatory approvals • set up along the lines of DABS, but would set up generation and distribution of electricity in rural areas only • shall support local enterprises as RESCO as distribution franchisees of DABS • serve to minimize risk to private sector's engagement in rural electrification • shall work in close collaboration with ministries and departments serving rural population and requiring energy services
Financing institution for clean energy sector	• a dedicated and empowered institution to finance renewable energy and energy efficiency projects • facilitating a basket-fund approach • ensuring ring-fencing of funds for clean energy sector • shall provide debt and equity to project promoters and developers • can also extend financial support by way of conditional grants and last-stage equity that can provide viability-gap financing • be able to raise funds through internal as well as external markets

The above institutions are governed and guided by the government Ministries which are primarily policy and law-making authorities. There are good examples from the region that have served the purposes as described above. Some of these are Infrastructure Development Company Limited (IDCOL), Bangladesh; Indian Renewable Energy Development Agency (IREDA), India; Solar Energy Corporation of India (SECI), India; and Alternate Energy Promotion Centre (AEPC), Nepal.

7.3 Projects

To meet the targets of the RENP, it is imperative to find success on the ground with projects that are implemented in the 'first stage' of the Roadmap. The second focus area shall therefore be the development of strategically important and trendsetting projects in addition to priority sectors outlined in Roadmap.

A list of the such projects along with their description is provided in the table below:

Table 19 - High priority, strategically important and trendsetting projects

	Project Title	Brief description
1	Solar power park	De-risking deployment of utility-scale wind and solar projects by Identifying suitable sites, providing infrastructure for evacuation and security, and streamlining regulatory clearance. SPPs may be set up by DABS as the SPPD, and eventually owned by private sector partners
2	Mini-grids with RESCO model	A cluster of mini-grid projects to be developed and bid out either individually or collectively following the RESCO business model
4	Solar hot water systems for institutions	As an effective demand-side-management strategy to reduce electricity generation requirements, while offering potential for economic development through local manufacture, SHWS to be promoted in a programmatic mode
5	Kabul roof-top solar	Following the maturity and proven viability of this market globally, Kabul roof-top solar pilot project will seed this market for Afghanistan
6	RE atlas	A national-level initiative that could build upon the RE database and provide both a national strategic overview of RE deployment and link to project-level monitoring; thus, providing insights on new development opportunities and overall RE roadmap progress.
7	Pilot scale Geothermal	In line with the 55 MW Roadmap target, and recognizing the need for impetus in this sector, geothermal resource assessment linked where viable to pilot geothermal projects (either direct heat or electricity) to catalyze activity
8	Pilot scale REEEP project	Although not directly identified in Roadmap, this pilot scale project to integrate RE with energy efficiency measures in the commercial and industrial sector shall improve the viability and acceptance of RETs

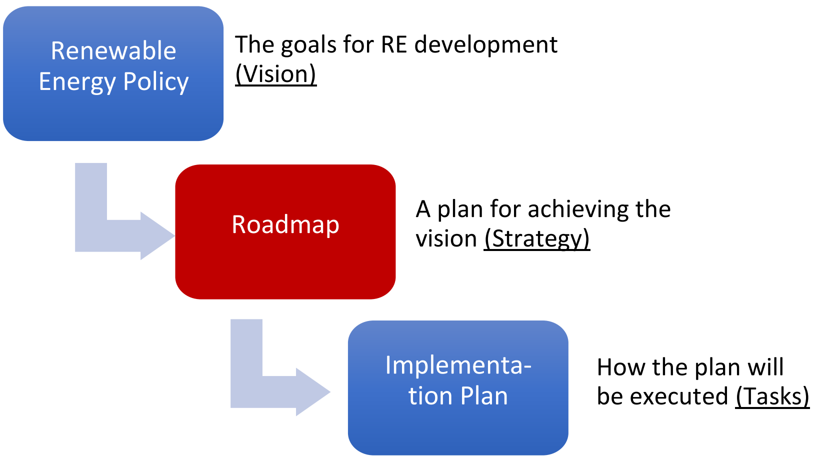
9	Daikundi Mini-grid	Mini-grids being strategically important for Afghanistan, this project will help in standardizing mini-grid designs and business models
10	Hisar-e-Shahi industrial park solar project	Strategically important project for industrial development that forms the backbone of Afghan economy

7.4 People

The intent of the RE sector development in Afghanistan is its people who need energy for their well-being, livelihoods and development. The implementation of the Roadmap will also be shouldered by people who will perform technical, managerial, financial, administrative and other functions. The Roadmap therefore needs to be inclusive of people's expectations and involvement for whom it will be implemented; while at the same time be owned by people who will implement it.

Awareness and skilling are two important people centric attributes that the Roadmap will focus on for it implementation effectively. A national level initiative to raise the awareness levels of multi-stakeholders at multiple-levels will support the development of the RE sector, while short-term and long-term skill enhancement initiatives will make it impactful. Vocational training programs focusing on RE system design, installation and maintenance along with university level programmes targeting energy sector planners and managers will be required to both ensure sufficient local capacity exists to develop and maintain RE infrastructure while capitalizing on RE as an opportunity for employment generation.

As illustrated below, detailing of the implementation plan along with its monitoring and verification plan, are the next logical steps to move towards realizing the set objectives of the RE development in Afghanistan. The expected impacts, upon the successful implementation of the Roadmap are elaborated in the next and the final chapter.



8 IMPACTS OF THE ROADMAP

The Roadmap facilitates the transformation of RE sector in Afghanistan from a 'current project' centric thinking and approach to a programmatic or an ecosystem approach that encompasses technologies, markets, institutions, finances and other enablers. These ecosystem elements synergise to achieve the objectives of the Roadmap which are energy security, energy access and socio-economic growth as listed in chapter 1 of this document. Moreover, the Roadmap has *Broader Impacts* that go beyond the said objectives. These broader impacts span across local, regional and international issues and boundaries as presented as discussed here:

Local impacts

1. Employment generation and livelihood creation
2. Infrastructure development and enterprise development
3. Local manufacturing and supply chain creation
4. Co-ordinated planning and budgeting across various government departments
5. Co-benefits of climate change mitigation and resilience/adaptation
6. Sustainable development through leap-frogging

Regional impacts

7. Cross border trade and energy security
8. Knowledge creation and sharing through regional platforms such as SAARC and ECO

Global impacts

9. Potential to explore climate and sustainable development funds
10. Membership of IRENA, ISA and other organisations
11. Advancement of SE4All and SDGs agenda

8.1 Employment generation and livelihood creation

Employment in the renewable energy sector has been growing rapidly at the global level. In 2015, the number of direct and indirect employees in the sector increased by 5%, to 8.1 million supporting a total of 1095 GW.[48] Many of these jobs are in the solar PV sector, and their share in the total is increasing every year. Accounting for large scale hydropower projects adds a further 1.3 million to the 8.1 million.

According to Wei et al.[49], upstream RE sector creates 10 jobs per MW related to construction, operation and maintenance of projects; with solar creating nearly 15 jobs/MW, and wind/hydro producing 6 job/MW capacity. Thus, the addition of 5000 MW RE capacity is likely to support 50,000 jobs in Afghanistan.[50]

Further, RE projects will also create livelihood opportunities in the downstream sector. About 70% of Afghan population is not served by the grid[51]. The bulk of the population resides in rural areas. The deployment of RE mini-grids and other stand-alone projects in rural areas with unmet demands for electricity and thermal energy can significantly improve the rural economy, contributing to sustainable livelihoods through affordable agriculture, farm based

[48] REN21: Renewables 2016 - Global Status Report

[49] http://rael.berkeley.edu/old_drupal/sites/default/files/WeiPatadiaKammen_CleanEnergyJobs_EPolicy2010.pdf

[50] Energy Matters sees a potential for 1.3 million jobs being created in India due to the rise of solar and wind energy with the proposed targets of 100 GW in solar and 60 GW in wind by 2022. http://www.energymatters.com.au/renewable-news/solar-jobs-india-em4689/

[51] Afghanistan Power Sector Master Plan, 2012

and off-farm enterprises. These would in turn imply more employment, induced by the setting up of the electricity infrastructure. For instance, a rural mini-grid of 1 MW could positively impact around 1,000 households and create or sustain 50 – 60 livelihoods, including direct jobs generated[52] (such as new opportunities as maintenance engineers for the electricity setup). This does not include indirect benefits accrued from better access, such as better healthcare and education facilities, which shall attract new jobs as well.

Thus, there are far-reaching and tangible induced impacts that can be derived through provision of reliable and competitively priced energy services.

8.2 Infrastructure development and enterprise development

Apart from benefits related to livelihood creation and employment, RE projects provide a boost to local economy by setting up new infrastructure and strengthening the existing ones. Specifically, solar and wind power parks and other utility scale projects necessitate building of roads and facilitate setting up of water supply and other facilities. Enhanced energy access through RE projects facilitates movement of industries to the otherwise virgin locations as well as in the creation of new cottage industries, that are well served by electricity.

Improved energy infrastructure would also have a positive effect on larger industries in terms of their competitiveness and their exports. Afghanistan Chambers of Commerce in their Business Monitor indicated energy shortage as the major bottleneck (88%)[53] in the development of industries. Industrial parks such as the ones in Hisar-e-Shahi would also benefit greatly from reliable electricity supply, as having such a source would help them lower their overhead costs and hence create goods at a lower price. Finally, energy access would catalyse setting up Rural Economic Zones – or rural business hubs including a market for agri produce and inputs, repair and maintenance services and farm based enterprises such as processing plants and units.

On the social side, creation and operation of hospitals and schools are strongly dependent upon provision of electricity and thermal energy. Not surprisingly, best facilities for health and education in Afghanistan are to be found in the cities. Improvements in the energy supply would help the urban as well as rural hospitals, schools and other community institutions invest in state-of-the-art equipment, and hence improve their overall services.

In terms of local economies, some of the impacts are as follows:

- Agriculture: Though the most important employment sector is agriculture and livestock where 39% Afghan population is employed, the productivity in the agriculture sector is low, with agriculture contributing just over 25% of GDP. Improved electricity access would impact the farming structure, cropping patterns and behaviour, due to better irrigation. This would lead to better farm incomes, and better agricultural services[54]
- Financial services, especially microfinances, could be developed more easily. They would be both a giver and a recipient of the benefits provided by energy access. Over time, this could also stretch to core banking services such as local co-operatives

[52] Concept Note prepared for and on behalf of ASERD Programme to Green Climate Fund

[53] Business Monitor, 2013 edition; published in 2014

[54] According to Afghanistan Export Promotion Agency, fresh and dried fruits make the biggest contribution to country's exports. However, a major obstacle for an increase in fruit exports is the lack of facilities to process and package these products to international standards. Energy supply will alleviate this problem

- Labour markets: The employment by sector and gender would also improve with expansion in the farming and services sectors.

8.3 Local manufacturing and supply chain creation

Setting up RE projects would require local manufacturing of auxiliary as well as main components and equipment in Afghanistan. Focusing on local manufacturing would help improve the upstream and downstream supply chains develop in capacities and capabilities as well. The elements of local manufacturing and supply chain would not only limit to fabrication, assembly and system integration, but would also extend to transportation, warehousing, engineering, procurement and construction activities. RE supply chain, once created, will benefit other sectors as well.

8.4 Co-ordinated planning and budgeting across various government departments

One of the re-requisites for implementing the Roadmap, is to inculcate a practice of coordinated planning and budgeting of resources across various departments within the MEW and also with other Ministries. The mechanism of 'basket fund' would trigger this practice which will have far-reaching impacts in terms of optimum utilisation and effective deployment of resources, for efficient gains to the overall economy of Afghanistan.

8.5 Co-benefits of climate change mitigation and resilience/ adaptation

Afghanistan is a high-risk profile country according to the National Risk and Vulnerability Assessment (NRVA 2012). The Global Adaptation Index 2012, ranks it as the most vulnerable in country in the world, taking into account the country's exposure, sensitivity and ability to cope with climate related hazards, worsened by the socio-political conflicts and security. Coping with the impacts of climate change is a major challenge for development in Afghanistan given that its negative effects are likely to be most severely felt by the poor and marginalized due to their high dependence on subsistence agriculture and limited capacity to cope with the impacts of climate variability and extremes.

The access to reliable and cost-effective energy will strengthen community-level coping strategies and improve income, thereby increasing their resilience to climate change impacts i.e. adaptation related benefits. Besides, the deployment of RE as per the Roadmap, will reduce the dependence of communities on conventional fuels such as kerosene, diesel and biomass, contributing to mitigation elated benefits as well.

8.6 Sustainable development through leap-frogging

Afghanistan currently has one of the lowest per-capita carbon emissions in the world. However, in order to develop itself into a successful economy, its energy use would have to increase greatly. This will in-turn increase its greenhouse gas (GHG) emissions. By developing its RE potential, Afghanistan is in a unique position where it can leapfrog over carbon intensive energy sources like coal and oil, while at the same time following sustainable development pathways.

8.7 Cross-border trade and energy security

Afghanistan gets more than 60% of its power requirements via imports. It also faces issues from grid snaps in its neighbouring countries, causing blackouts in cities like Kabul. As per the Roadmap, Afghanistan's power generation capacity from domestic RE resources would reach 850 MW by the end of Stage 1, which would potentially replace around 40% of imports at the current levels, avoiding drain of foreign exchange that is required to finance energy imports. Focussing on renewables for domestic power generation, would ensure power generation and grid stability for its current and future energy needs, and would thus help Afghanistan achieve energy security.

The decreasing prices of renewables and their increased generation could be an opportunity for Afghanistan to be a net energy supplier in the long term. In the short term, it could also act as a conduit transporting energy from Central Asian and West Asian economies (Tajikistan and Turkmenistan) to the energy starved South Asian countries (India/Pakistan/Nepal), while using its own generated energy within the country.

8.8 Knowledge creation and sharing through regional platforms

Roadmap has introduced knowledge tools for developing projects, customising business models, benchmarking for RE costs, stage-gate framework for sector development etc. These knowledge tools, geared towards planning for RE sector will be useful for other countries in the region and Afghanistan can use regional platforms such as ECO and SAARC to share this knowledge. Besides, the valuable experience to be generated through implementing different types of RE projects for various applications would create a body of knowledge that can also be shared with other countries in the region.

8.9 Potential to explore climate and sustainable development funds

The development of RE sector as envisaged in the Roadmap, will be aligned to the global agenda of climate change and sustainable development. Afghanistan will thus be able to explore global resources and funds that are available for these sectors i.e. Green Climate Funds (GCF), Global Environment Facility (GEF), Scaling up Renewable Energy Programme (SREP) among others. Some of these funds are already made available to Afghanistan. However, their portfolio can be expanded to support the RE and related sectors.

8.10 Membership of IRENA, ISA and other organisations

Renewable Energy Roadmap is a strong endorsement of the GoIRA for supporting this sector. The introduction/ presence of an enabling ecosystem will further showcase the commitment at all levels to promote this sector. These actions will facilitate Afghanistan to become member of international organisation such as International Renewable Energy Agency (IRENA) and International Solar Alliance (ISA). These memberships will further support the development of RE sector through tangible well as non-tangible instruments such as demonstration projects, feasibilities studies, mapping of resources, monitoring and evaluation studies, knowledge exchange etc.

8.11 Advancement of SE4All and SDGs agenda

Afghanistan, despite its internal challenges related to poverty, security etc., will adopt the global agenda towards sustainable energy for all and sustainable development goals through the implementation of the Roadmap. This will catalyse a progressive thinking and approach to development, impacting not only the internal well-being but also propagating an enterprising image of Afghans.