Practical Guide Book For Implementing Smart Technologies And Clean Energy Projects In Existing High-Rise Residential Apartments

MAHARASHTRA ENERGY DEVELOPMENT AGENCY (MEDA)
(A Government of Maharashtra Institution)

Message

Maharashtra Energy Development Agency (MEDA) is incredibly glad to appreciate the esteemed work of Thane municipal Corporation for taking the first steps towards Clean & Sustainable Building Practices in High Rise Buildings. We heartily congratulate Thane Municipal Corporation, Shakti Sustainable Energy Foundation & Meghraj Capital Advisors Pvt. Ltd. for their consistent effort in preparing the practical guideline and tool for implementing smart technologies and clean energy projects in High Rise Buildings. This will also help in creating awareness among the residential societies about best practices for conservation of energy & use of smart technologies.

MEDA is committed for developement and implementation of renewable energy and facilitate energy conservation in the state of Maharashtra . It is estimated by Bureau of Energy Efficiency that up to 30% of energy saving can be achieved in the residential sector. To tap the potential for energy conservation Urban Local Bodies can play very important role.

MEDA is providing the financial assistance to residential societies for conducting energy audits and purchase of renewable energy technologies such as solar water Heaters, Solar Roof-top based power generation etc.

We extend our gratitude towards Shakti Sustainable Energy Foundation for supporting this initiative and preparing the “Practical Guidebook for Implementing Smart Technologies and Clean Energy Projects in existing high-rise residential apartments”. We hope the residential societies realize and meet the objective of the guide book, which is to reduce carbon footprint of urban India by facilitating adoption of renewable energy resources and energy efficient technologies in high-rise residential buildings.

We look forward to providing full-fledged support to this initiative, and believe it will set the right example and achieve the desired objectives.

(Rajaram Mane, I.A.S.)
Director General, MEDA

Sr. No. 191, Phase - 1, MHADA Commercial Complex, 2nd Floor, Opp. Tridal Nagar, Yerwada, Pune - 411 006.
Tel. No. : 020-26614393, 26614403, Fax No. : 020-26615031. Email : meda@mahaurja.com Web-site : http://www.mahaurja.com

Shri Sanjeev Jaiswal, IAS
Muncipal Commissioner, TMC

The urban population is increasing in and around cities at an exponential rate. With the area limited, cities have been exploring ways to accommodate the increasing population through vertical expansion for quite some time now. This has led to substantial number of high-rise residential buildings being built in cities. The energy footprints of these buildings are also high. In order to optimize the energy usage in these buildings, it is important to use ways to reduce the energy consumption while not affecting the needs of the residents.

This guidebook – **"Practical guide book for Implementing Smart Technologies and Clean Energy Projects In Existing High-Rise Residential Apartments"**, explores opportunities to reduce the electricity consumption in common amenities of existing high-rise buildings through use of energy efficiency and renewable energy technologies. It also provides in depth information on clean energy technologies like cool-roof, roof-top solar, solar water heating. Additionally, the guidebook has covered the new and efficient technologies that can be employed in water pumping, lighting and elevators which comprise the bulk of the energy consumption in a typical high-rise residential society.

This guide book is also a handbook. It provides in detail all the steps that need to be undertaken from inception to execution of clean energy and energy efficiency projects. It covers regulatory, policy and legal aspects that need to be adhered or incorporated in implementing such projects in New Delhi and Maharashtra. It further lays out in detail, the procedure for seeking various permissions/approvals for having the system registered with authorized agency including availing subsidies from government, if applicable. The guidebook also provides the details of channel partners, manufacturers and their distributors that need to be contacted if a user's wishes to procure and install renewable energy and energy efficient technologies in their buildings. This book further provides feasible business models for project implementation and does a risk analysis for selection of appropriate business models. The payback period calculation and internal rate of return provides added clarity to a user and helps him opt for the right business model. It clearly lays down the roles and responsibilities of the stakeholders and thus avoids ambiguity that may generally come when these projects are implemented.

This guide book aims to encourage users to adopt renewable energy and energy efficiency measures for their residential buildings and contribute to achieve the global target for climate change reduction while attaining energy security.

Jaiswal 12/7/17
(Sanjeev Jaiswal) IAS
Municipal Commissioner

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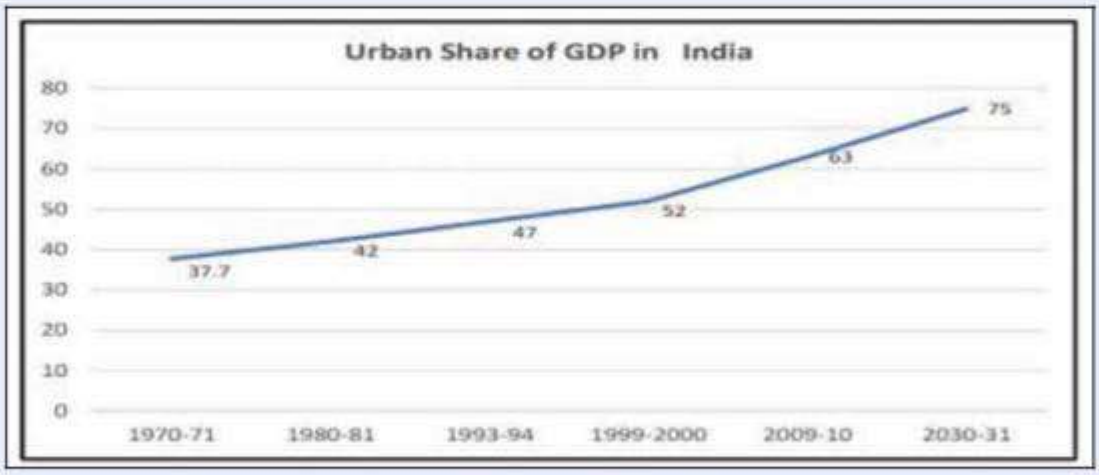
A	Ampere
AC	Alternating Current
APPC	Average Power Purchase Cost
BEE	Bureau of Energy Efficiency
CEA	Central Electricity Regulation Authority
CFA	Central Financial Assistance
CFL	Compact Fluorescent Lamp
CoP	Coefficient of Performance
DDA	Delhi Development Authority
DERC	Delhi Electricity Regulatory Commission
Discoms	Power utilities or electricity Electricity distribution Distribution Company
DPR	Detailed Project Report
DSCR	Debt Service Coverage Ratio
DSM	Demand-Side Management
DT	Distribution Transformer
DTL	Double sided Tube light
EC Act	Energy Conservation Act, 2001
ECBC	Energy Conservation Building Codes
EE	Energy Efficiency
EEREMC	Energy Efficiency and Renewable Energy Management System
EIA	Environment Impact Assessment
EPC	Engineering, Procurement and Construction
ESCO	Energy Service Company working on energy performance contract
ESPC	Energy Saving Performance Contract
FI	Funding Invoice Financial Institution
GBI	Generation Based Incentive
GCRT	Grid Connected Roof-top
GDP	Gross Domestic Product
HT	High Tension
HVAC	Heating, Ventilation and Air Conditioning
IIT	Indian Institute of Technology
IRR	Internal Rate of Return

KCal	Kilo Calorie
KL	Kilo Litre
KVA	Kilo Volt Ampere
kW	Kilo Watt
kWh	Kilo Watt Hour
LED	Light Emitting Diode
LEED	Leadership in Energy & Environment Design
LM	Lumens
LPD	Litres Per Day
LT	Low Tension
MCAPL	Meghraj Capital Advisors Private Limited
MERC	Maharashtra Electricity Regulatory Commission
MNRE	Ministry of New and Renewable Energy
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MT	Million Ton
MW	Mega Watt
NGO	Non-Governmental Organization
O&M	Operation & Maintenance
PF	Power Factor
PMSM	Permanent Magnet Synchronous Motor
PPA	Power Purchase Agreement
PV	Photo Voltaic
RE	Renewable Energy
Shakti	Shakti Sustainable Energy Foundation
SLD	Single Line Diagram
STL	Single Sided Tube light
SWH	Solar Water Heater
SWHS	Solar Water Heating System
VVVF	Variable Voltage Variable Frequency
W	Watt

1.1 OBJECTIVE

Current projections indicate that 66 percent of the world's population will live in cities by 2050. Population equivalent to 7 "New Delhi" cities is added per year to world's urban population. According to the data published by The Energy and Resources Institute (TERI), urban share of GDP in India will rise to 75% in 2030-31.



***Source**: TERI Presentation on GRIHA Rating System*

Figure 1-1: Growth in urban share of GDP in India

As per capita income is increasing, single family houses and vertical expansion (residential high-rise towers) has resulted in exponential growth in the electricity demand for urban areas. The rising share of urban population demands the need of energy efficient cities which can accommodate the growing population achieving sustainable urbanization as well as maintaining a good quality of life. A study by the International Energy Agency (IEA) shows that, if implemented globally, energy efficiency measures in the building sector could deliver CO_2 emissions savings as high as 5.8 billion tonnes (Gt) by 2050, lowering greenhouse gas emissions by 83 percent below the business as-usual scenario. Most of these technologies are commercially available today and many of them deliver positive financial returns within relatively short payback periods.

All the State Governments are planning and implementing Smart City and Solar city programs with the support of the Central Government. A strong Governance structure and funding mechanisms have been created along with innovative business models such as private investments, public private partnership Structures, viability gap funding, risk guarantee funds etc. to support the implementation of smart city programs. The guidebook aims to provide detail information to common man about the clean energy initiatives that could be promoted at city level targeting interventions for restraining growth in energy consumption in the residential sector and documents on how energy saving potentials can be realized. It provides a step by step process to implement smart technologies, clean energy and energy efficiency projects in existing residential high-rise buildings. The high-rise buildings are defined as the buildings above seven floors. The guide book has captured macro level understanding on the issues involved and suggested a pragmatic approach for upscaling the implementation of such initiatives.

1.2 APPROACH AND METHODOLOGY

Shakti Sustainable Energy Foundation (Shakti) engaged Meghraj Capital Advisors Private Limited (MCAPL) for preparation of the Practical guide book for implementing smart and clean energy projects in existing high-rise residential apartments. Shakti together with Meghraj identified key stakeholders for providing guidance and reviewing the work undertaken by the Consultant team. The key stakeholders include

- Thane Municipal Corporation (TMC), Delhi Development Authority (DDA)
- Regulatory and Policy Authorities such as MEDA, MERC, DERC, BEE etc.
- International NGOs such as ICLEI South Asia, ResponsAbility and IIEC
- Local NGOs such as Akshay Urja and other local community based organisations
- Members from selected high-rise residential building societies
- Sectoral Experts

The practical guidebook has been prepared by taking relevant feedback from various stakeholders on the following aspects:

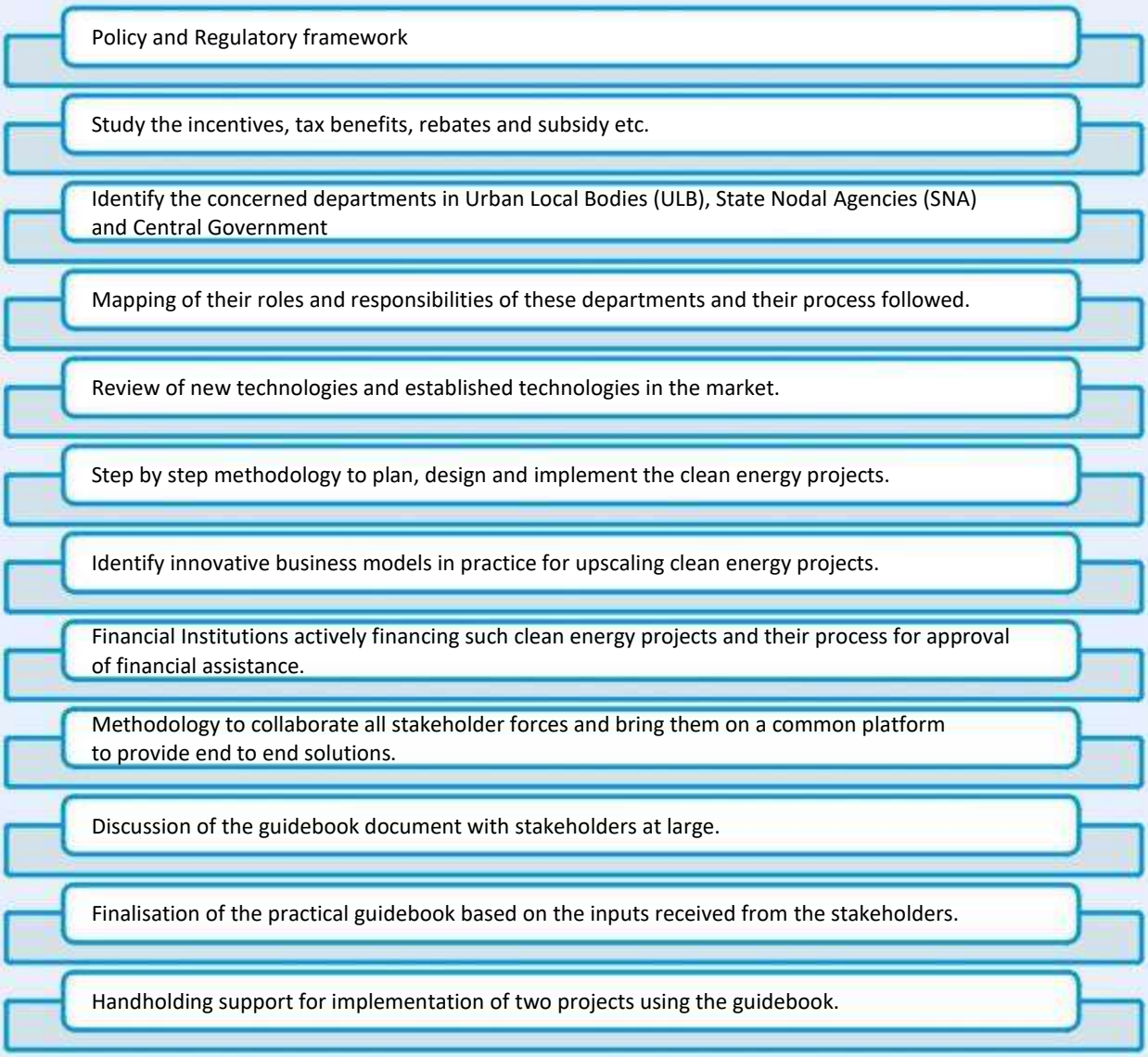


Figure 1-2: Holistic approach for preparation of guide book

1.3 STRUCTURE OF THE PRACTICAL GUIDE BOOK

The guidebook covers the following chapters:

1. **Chapter 1 – Introduction**

This chapter outlines the objectives to design this guide book, elaborates the approach and methodology considered for preparation of this guide book and also provides insight on the stakeholders group and their support for preparing the guide book.

2. **Chapter 2 – Review of policy and regulatory framework**

This chapter focusses on the regulatory and policy framework prevalent in the country at the Central, State and Municipal level that facilitates and/or mandates the uptake of clean energy projects. It also summarises the roles and responsibilities of various statutory authorities, enlist and briefly analyse the rules, regulations and policies laid down by these authorities.

3. **Chapter 3 – Renewable energy technologies for existing high-rise buildings**

The objective of this chapter is to identify renewable energy technologies prevalent in the market and suitable for high-rise buildings, associated costs, market availability and supply chain mechanism and operation and maintenance guidelines. It also provides a detailed process for implementing such technologies and availing incentives from respective statutory authorities.

4. **Chapter 4 – Energy efficiency technologies for existing high-rise buildings**

The objective of this chapter is to identify energy efficiency technologies prevalent in the market and suitable for high-rise buildings, associated costs, market availability and supply chain mechanism and operation and maintenance guidelines. It also provides a detailed process for implementing such technologies and availing incentives from respective statutory authorities.

5. **Chapter 5 – Feasible business models**

This chapter deals with identification and elaboration of feasible business models available for implementing clean energy projects, their advantages and disadvantages, suitability for project type and relevant stakeholders.

6. **Chapter 6 –Risk analysis and selection methodology for proposed business models**

This chapter deals with the recommendations for use of suitable business models for implementation of clean energy projects. The recommendations are typically based on consultations with technology providers, financial institutions, residential society members and statutory bodies.

1.4 MAPPING OF THE HANDBOOK

For the convenience of the users of this handbook, the contents of the handbook have been pictorially mapped and summarised in the figure given below:

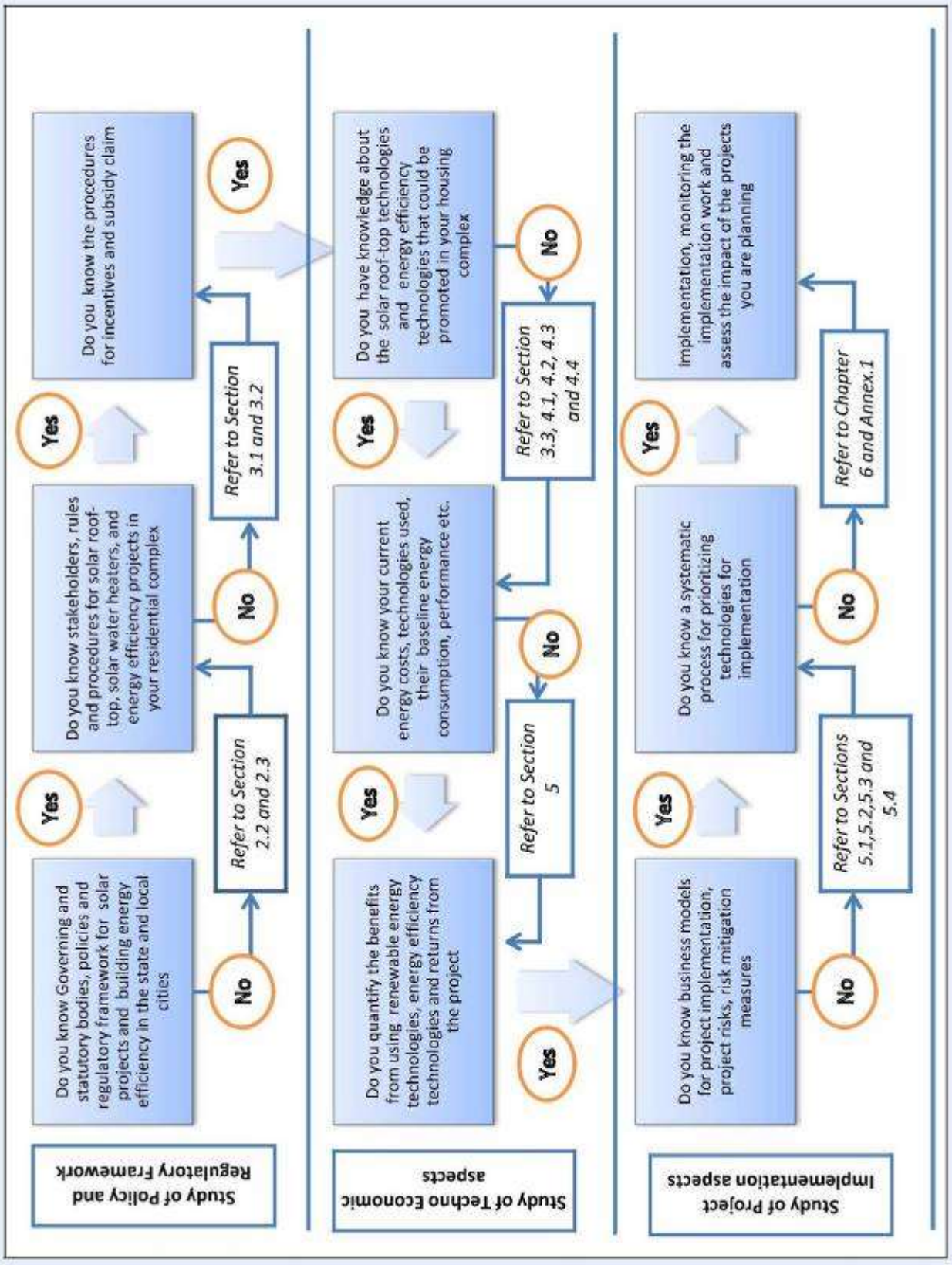


Figure 1-3: Mapping of the handbook

The detail analysis and explanation of institutional set-up, rules, regulations and policies of the local Governments in Mumbai (Maharashtra) and New Delhi pertaining to deployment of Renewable Energy (RE) and Energy Efficiency (EE) technologies in high-rise buildings is presented in this section. It covers following aspects.

- Identification of various Government authorities at the state and municipal levels which govern the implementation of RE and EE initiatives.
- Analysis of the various policy, rules and regulations issued by such Government authorities for RE and EE.
- The salient features of such policy and regulatory framework.

2.1 IDENTIFICATION OF THE GOVERNING STATUTORY BODIES

The following Table identifies the statutory bodies and their respective mandate for implementation of clean energy projects.

Stakeholders	Responsibilities	Outputs
Government - Energy Department and Urban Development Department	Formulation of policies which promote the use of renewable energy as well as energy efficiency in everyday energy consumption by the citizens	• Solar power policy • Energy conservation policy • Byelaws for housing society
Electricity Regulators	Frame suitable rules and regulations which govern the use of renewable energy and energy efficiency technologies in order to standardize the technologies, equipment, supply chain and maintenance	• Renewable Energy tariff regulations • Renewable purchase obligation regulations • Net metering regulations including procedures • Tariff of RE sources
Municipal Authorities	Provide clearances, permissions, guidelines and procedure for implementation of renewable energy and energy efficiency technologies in the municipal area	• List of clearances • Permissions required • Procedures adopted • Guidelines/notifications • Certifications
Power utility or Discoms	The power utility or the Discom is required to provide connectivity, metering and monitoring services for use of RE and EE technologies for its consumers. Power utilities will also provide incentives to consumers for use of energy efficient technologies, demand-side management and renewable energy technologies	• Procedure and guidelines for the consumers desiring connectivity of roof-top solar PV system with Utility Network • Operation of the incentive mechanism

Table 2-1: List of organizations and their responsibilities

In the context of a residential society, the guidebook provides detail analysis of policies, regulatory and institutional framework for solar energy and building energy efficiency. The subsequent section enlists and analyses the policy and regulatory framework for solar rooftop projects and solar water heating projects for residential buildings.

2.2 REGULATIONS AND POLICIES FOR SOLAR ENERGY[1]

The Governments at the Central and State level are promoting the development of solar power projects on the rooftop of residential buildings. At present, approximately 360 MW of solar rooftop projects have been sanctioned by MNRE. The estimated potential of rooftop solar capacity in Delhi is around 2557 MW[2]. Similarly, the estimated potential for solar roof-top on residential buildings Mumbai[3] is 1.3 GWp as per the study carried out by IIT Mumbai[3]. The states have come out with renewable/power policies supporting grid-connected solar rooftop systems (Feed-In-Tariff and Net Metering). This has created sufficient interest in the market to develop and implement solar rooftop projects by adopting suitable business models for implementation.

The detailed study is carried out to present rules, regulations and policies adopted in Mumbai and New Delhi for promotion of solar technologies.

2.2.1 Policy and regulatory framework for roof-top solar energy in New Delhi

This section details the solar policy, net metering regulations and building byelaws prevalent in New Delhi and relevant from the perspective of implementing rooftop solar projects in high-rise residential societies.

[1] The Source of the Policies and Regulations are the websites of the State Government of Maharashtra and Delhi, MERC, MEDA, MNRE, DERC.

[2] Greenpeace- Bridge to India report - Rooftop Revolution: Unleashing Delhi's Solar Potential, 2013 http://www.greenpeace.org/india/Global/india/report/2013/Rooftop-Revolution.pdf

[3] http://www.ncpre.iitb.ac.in/uploads/Estimating_Rooftop_Solar_Potential_Greater_Mumbai.pdf

2.2.1.1 Solar energy policy in New Delhi

Particulars	Description
Policy Name	Delhi Solar Energy Policy, 2016
Applicability	• This policy is applicable for any solar energy generating system with a capacity of 1 KWp or more • This policy applies to all electricity consumers under all electricity tariffs in Delhi.
Scope of the Policy	• This policy governs the installation of solar plants with net metering on all residential buildings, colonies, townships, housing societies, private bungalows, farm houses, etc. • The policy envisages a target capacity addition of solar power of 1995 MW by FY 2025.
Role of the Discom	The Discoms are required to facilitate 1. **Group Net Metering** - As per this arrangement, consumers who have solar rooftop system in their building but are not able to consume all the energy generated locally may have the surplus energy exported to grid. 2. **Virtual Net Metering** - As per this type of net metering arrangement, a consumer can be beneficial owners of a part of collectively owned solar system. This is beneficial to those consumers who do not have suitable roof but wants to be owner of a solar PV rooftop system. According to this system, all energy produced by a collectively owned solar system will be fed into the grid through an energy-meter and the exported energy as recorded by that meter will be pro-rata credited in the electricity bill of each participating consumer on the basis of beneficial ownership. This type of collective ownership of solar plants may be established through housing societies and Resident Welfare Associations.
Financial Incentives	• A Generation Based Incentive (GBI) of INR 2.00 per unit (kWh) of gross solar energy generated is being offered for 3 years, starting from the date of taking effect of the Policy (28 September 2016) where the minimum eligibility is of 1,100 solar energy units (kWh) generated per annum per kWp. • The policy also envisages a fund to be utilized for GBI incentive payments, organizing capacity building and training programs, creating public awareness and other activities deemed necessary for the promotion and faster implementation of solar plants in the State.
Other Incentives (Exemptions)	• The policy envisages exemption of Electricity Tax (currently 5%) for solar energy units generated. • Exemption from Chief Electrical Inspector to Government (CEIG) Clearance (if system installed less than 200 kW) • Exemption on Open Access Charges • Residential consumers opting to implement solar plants to sell power to the grid shall be exempted from the conversion charges requirement of house tax to commercial tax. • Exemption on wheeling, banking, and transmission charges • These plants get a “Must Run” status • Suitable framework for Cross subsidy charges • Entire proceeds of CDM benefit with the generating entity

Table 2 2: Solar energy policy

2.2.1.2 Net metering regulations for rooftop solar PV in New Delhi

The following diagram shows the salient features of the net metering regulations for solar rooftop PV systems in New Delhi.

Eligibility

- The Discom shall allow connectivity to the renewable energy system, on first come first serve basis subject to operational constraints.

Capacity

- The capacity of renewable energy system to be installed at the premises of any consumer shall not be less than one kilo watt peak and not more than the sanction contract demand. Further, it shall be subject to the feasibility of interconnection with the grid, the available capacity of the service line connection of the consumers premises and sanctioned load of the consumer premises.

Connectivity

- Connectivity with Discom and net meters to be governed by CEA Regulations.

Metering

- The cost of Renewable Energy Meter shall be borne by the Discom and the cost of Net Meter shall be borne by the consumer. The consumer or the Discom, who so ever if desires, may install check meter at their own cost.

CommercialInnectivityaspects

- At the end of the each Financial Year, any net energy credits, which remain unadjusted, shall be paid for by the Discom to the consumers as per the rates notified by the Commission from time to time.
- The renewable energy system under net metering arrangement shall be exempted from wheeling, banking, cross subsidy and other charges for a period of five years, unless extended thereafter.
- The quantum of electricity generated under these regulations shall qualify towards compliance of Renewable Purchase Obligation (RPO) for the Discom if Renewable Energy Generator is not an obligated entity.

Safety aspects

- The Renewable Energy Generator (consumer or third party which install the solar roof-top plant) shall be responsible for safe operation, maintenance and rectification of any defect of the Renewable Energy System upto the point of Net Meter beyond which the responsibility of safe operation, maintenance and rectification of any defect in the system, including the Net Meter, shall rest with the Discom.
- If the distribution system of Discom is threatened or the event of possible damage do arise due to the RE system, Discom shall have the right to disconnect the RE system from its distribution system. The RE system may then be given reasonable time to rectify the defect.

Billing aspects - Responsibility of the Discom

- The accounting of electricity generation, consumption and injection shall be effective from the date of connectivity of the RE system with the distribution system.
- The Discom should separately show the units imported, units exported, the energy billed and/or carried forward in the consumer's bill.
- At the end of the each Financial Year, any net energy credits, which remain unadjusted, shall be paid for by the Discom to the consumers as per the rates notified by the Regulatory Commission (currently at the Average Power Purchase Cost (APPC) rate).

Figure 2-1: Key features of net metering regulations in New Delhi

2.2.1.3 Guideline for claiming the generation based incentive[4]

The Consumers	The Discom	The State Nodal Agency (EEREMC)
• Should have a valid CA Number issued from the distribution company supplying power to him. • Should have installed 1 kWp system having generation of at least 1100 kWh in a year. • Should have a Net-meter installed by the Discom under the jurisdiction of which his area falls.	• Should take monthly reading of solar power generated from solar energy meter • Should adjust the amount of GBI against electricity bills of the eligible consumer as is being done in case of electricity subsidy • Will claim the amount (along with proof of solar power generated and payment to consumers) from Energy Efficiency & Renewable Energy Management Centre (EEREMC), annually.	• After verification of the bills shall release the GBI payment to Distribution Companies. • May call data of any eligible consumer or verify the data from solar energy meter installed at the premises. • Can stop payment of GBI if any discrepancy in data is found.

Figure 2-2: Guideline to claim generation base incentives

2.2.1.4 Housing society bye-laws – New Delhi

The Unified Building bye-laws for New Delhi 2016 notified by the Delhi Development Authority has provisions focused on development of green buildings. These provisions for green buildings are applicable on all plots more than 105 sq. m in size.

Water Conservation and Management	Solar Energy Utilization	Energy Efficiency	Waste Management
• Rain Water Harvesting (by Recharge) • Low Water Consumption Plumbing Fixtures • Waste Water Recycle and Reuse • Reduction of hardscape	• Installation of Solar Photovoltaic Panels • Installation of Solar Assisted Water Heating Systems	• Low Energy Consumption Lighting Fixtures (Electrical Appliances – BEE Star and Energy Efficient Appliances) • Energy Efficiency in HVAC systems	• Segregation of Waste • Organic Waste Management

Figure 2-3: Green building provisions notified by New Delhi

[4] http://delhi.gov.in/wps/wcm/connect/b97cdb8040142e9cb510fdd74088f250/Guidelines+on+Disbursement+of+Generation+Based+Incentive.pdf?MOD=AJPERES&lmod=-276071204

- **Relaxation in Building bye-laws for rooftop solar installations**

The solar policy of New Delhi also provides relaxation for installation of solar rooftop projects on buildings which are as follows:

Relaxation in building bye-laws for rooftop solar installations

1. The height of the module structure carrying solar panels shall not be counted towards the total height of the building as permitted by building bye-laws, except near airports where building Regulations issued by the Airports Authority of India take precedence.
2. No approval will be required from concerned Municipal Corporation or other Urban Development Bodies like the DDA for putting up solar plants including any additional system for monitoring the performance of solar plant in existing or new buildings.
3. The support structure on which rooftop solar panels are installed shall be a temporary structure built in accordance with local building codes.

2.2.2 Policy and regulatory framework for roof-top solar energy in Maharashtra

This section details the solar policy, net metering regulations and building byelaws prevalent in Maharashtra and relevant from the perspective of implementing rooftop solar projects in high-rise residential societies.

2.2.2.1 Renewable energy policy in Maharashtra

Particulars	Description
Policy name	The policy is a comprehensive policy for Grid- connected power projects based on New and Re-newable (Non- conventional) Energy Sources - 2015.
Capacity	• The policy envisages a target capacity addition of 7500 MW in solar power projects. • The minimum capacity to be developed under this policy to be 1 MW.
Eligibility	The solar power projects can be installed in the industrial areas, townships, warehouse areas among others.
Treatment for electricity generated from projects	Electricity generated from the projects developed in the PPP mode is to be used for fulfilling RPO of Maharashtra State Electricity Distribution Company Limited at preferential tariff fixed by the state regulator MERC.

Table 2-3: Key features of renewable energy in Maharashtra

2.2.2.2 Net Metering regulations for rooftop solar PV in Maharashtra

The salient features of the net metering regulations for solar rooftop PV systems in Maharashtra are provided below.

Eligibility

- Net Metering arrangement permitted by Discom on a non-discriminatory and 'first come, first serve' basis to Eligible Consumers for grid connected rooftop solar PV system.

Capacity

- The capacity of the roof-top solar PV system to be connected at the eligible consumer's premises shall not exceed his contract demand (in kVA) or sanctioned load (in kW).
- The cumulative capacity of all roof-top solar PV systems under Net Metering arrangements connected to a particular distribution transformer of the Licensee shall not exceed 40% of its rated capacity.
- Voltage wise rooftop capacity is as follows 230/240 V (Single Phase) – Less than 8 kW/40A; 400/415 (Three Phase) – Less than 150kW/187 kVA; 11kW and above - Above 150kW/187 kVA and less than 1000 kVA.

Connectivity

- Connectivity with Discom and Net Meters to be governed by CEA Regulations.

Metering

- Connectivity with Discom and net meters to be governed by CEA Regulations.
- Cost of meter to be borne by the consumer or Discom depending on whether such consumption is to be considered towards the RPO obligation of the consumer or Discom.
- Net metering connection agreement between Discom and consumer, valid for 20 years.

Commercial aspects

- The unadjusted net credited units to be purchased by the Discom at its Average Power Purchase Cost (APPC) rate for that year, within the first month of the following year.
- The Solar energy generated by an eligible consumer in a Net Metering Arrangement under these regulations shall not be eligible for REC.

Safety aspects

- The Renewable Energy Generator shall be responsible for safe operation, maintenance and rectification of any defect of the Renewable Energy System upto the point of Net Meter beyond which the responsibility of safe operation, maintenance and rectification of any defect in the system, including the Net Meter, shall rest with the Discom.
- If the distribution system of Discom is threatened or the event of possible damage do arise due to the RE system, Discom shall have the right to disconnect the RE system from its distribution system. The RE system may use his roof-top solar PV system in islanding mode for his own consumption.

Procedure for Application, Registration and Net Metering Connection

- The consumer of the premises or the Renewable Energy (RE) Generator shall submit the application to the concerned Discom to connect the renewable energy system to the distribution system of the Discom with a registration fee of INR 500 (five hundred) and INR 1,000 (one thousand) for consumers with sanctioned load or contract demand, as the case may be upto and above 5 kW respectively.

Billing aspects - Responsibility of the Discom

- The accounting of electricity shall become effective from the date of connectivity of the Roof-top Solar PV System with the distribution network.
- The unadjusted net credited units of electricity as at the end of each financial year shall be purchased by the Discom at its average cost of power purchase approved by the Regulatory Commission.

Figure 2-4 Key features of net metering policy of Maharashtra

2.2.3 Housing Society bye-laws – Maharashtra

Some of the salient features of The Model bye-laws of Co-operative Housing Society, 2014 are enlisted below:

1. Rooftop solar devices are defined under the 'Common Areas and Facilities' under the bye-laws of co-operative housing society.
2. Being a common area/asset of the housing society, the repairs and maintenance cost for the same is to be borne by the society.
3. Like-wise, water harvesting is also defined under the common area and hence its R&M expenses are to be borne by the society.
4. Bye-laws provide for allotting space to members of the society for installation of solar water heating system and/or solar energy electrical system, subject to availability.

2.2.4 Policy for solar water heating system at national level

Targets for Solar Water Heating System (SWHS) were assigned as part of the Jawaharlal Nehru National Solar Mission (JNNSM). As per the mission, solar water heaters, solar cooking/cooling, industrial process heat applications etc. as part of solar thermal collectors is to be developed over an area of 6.18 million square meters[5].

Subsidy for SWHS from Ministry of New and Renewable Energy (MNRE) under JNNSM has been discontinued from 1st October 2014[6].

As per Energy Conservation Building Codes (ECBC), all residential facilities, hotels and hospitals with a centralized system shall have solar water heating for at least 1/5 of the design capacity except for the systems that use heat recovery for at least 1/5 of the design capacity.

2.2.5 Policy for solar water heating system at state level – New Delhi

As per Delhi Government gazette notification no. F.11 (149) /2004-Power/2387 dated 28/09/2006, the use of solar water heating systems is mandatory for all residential buildings built on a plot having an area of 500 square meters or above falling within the National Capital Territory of Delhi, excluding Delhi Cantonment Area or areas exempted under section 61 of the Energy Conservation Act, 2001. Subsidy for SWHS has been discontinued by the Delhi government.

2.2.6 Policy for solar water heating system at state level – Maharashtra

The Government of Maharashtra under Section 154(1) of Maharashtra Regional & Town Planning Act, 1966 has issued directives for meeting water heating demand of 20% by solar water heating systems in commercial and institutional buildings and recommends use of solar water heating system in residential buildings to the extent possible.

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[5] Source: http://pib.nic.in/newsite/PrintRelease.aspx?relid=108233

[6] Source: MNRE Office Memorandum No. 30/31/2012-13/NSM dated 19th Sep 2014

The Municipal Corporations of Thane, Greater Mumbai, Nagpur, Malegaon, Aurangabad, Pimpri-Chinchwad, Kolhapur, Kalyan-Dombivali, Pune, Nashik and Bhiwandi-Nizampur have already made the installation of solar hot water system mandatory in their area. All new residential, commercial and public houses should install a solar water heater of 2 m_2 per family. The municipal corporations, such as Nanded, Amravati, Dhule and Akola have begun to take the necessary steps for introducing solar bye-laws in their administration.

2.3 POLICY AND REGULATORY FRAMEWORK FOR ENERGY EFFICIENCY

India's domestic energy consumption constitutes 22% of current total energy consumption. Under the business-as usual scenario, the annual electricity use per household is predicted to increase from 650 kWh in 2012 to 2750 kWh by 2050. A study carried out by Global Buildings Performance Network (GBPN) and Centre for Environmental Planning and Technology (CEPT) estimates the energy savings in residential buildings is in the range of 27% to 57%[7]. It is of vital importance for India to develop energy-efficiency strategies focused on the residential sector to limit the current trend of unsustainable escalating energy demand.

2.3.1 The energy conservation building code

The Energy Conservation Building Code (ECBC) was notified by the Govt. of India for new commercial buildings on 27th May 2007 and updated in 2017 (ECBC 2017). ECBC sets minimum energy standards for buildings having a connected load of 100kW or contract demand of 120 KVA and above. While the Central Government has powers under the Energy Conservation Act (EC Act 2001), the state governments have the flexibility to modify the code to suit local or regional needs and notify them. Presently, the code is in voluntary phase of implementation. About 22 states are at various stages of mandating ECBC, where in most of building construction activities are happening across the country.

Complementing the efforts of the Government of India, the ECBC has been integrated in other rating & compliance systems being followed in the country such as EIA (Environmental Impact Assessment) for large area development under MoEF (Ministry of Environment & Forest), Green Rating for Integrated Habitat Assessment (GRIHA) rating system of ADARSH and Leadership in Energy & Environmental Design (LEED) rating system of the Indian Green Building Council (IGBC).

2.3.2 Recommended requirements of lighting as per energy conservation building code

Although the Energy Conservation Building Code is mandatory only for commercial buildings or building complexes that have a connected load of 100 kW or greater or a contract demand of 120 kVA or greater, the code is recommended for all buildings.

The lighting provisions for buildings have been laid out as per below guidelines.

- **Automatic Lighting Shutoff-** Interior lighting systems in buildings larger than 500 m_2 (5,000 ft^2) shall be equipped with an automatic control device. Within these buildings, all office areas less than 30 m_2 (300 ft_2) enclosed by walls or ceiling-height partitions, all meeting and conference rooms, all school classrooms, and all storage spaces shall be equipped with occupancy sensors. Lighting systems designed for 24 hours use are exempted from this requirement.

[7] http://www.gbpn.org/sites/default/files/08.%20INDIA%20Baseline_TR_low.pdf

- **Space Control -** Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space. Each control device shall be activated either manually by an occupant or automatically by sensing an occupant.
- **Control in daylighted areas -**Luminaires in day lighted areas greater than 25 m_2 (250 ft_2) shall be equipped with either a manual or automatic control device that:

  o Is capable of reducing the light output of the luminaires in the day lighted areas by at least 50%, and

  o Controls only the luminaires located entirely within the day lighted area.
- **Exterior Lighting Control -** Lighting for all exterior applications shall be controlled by a photo-sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available or the lighting is not required.
- **Exit Signs -** Internally-illuminated exit signs shall not exceed 5 W per face.
- **Exterior Building Grounds Lighting** - Lighting for exterior building grounds luminaires which operate at greater than 100 W shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor except for any emergency or dwelling lighting.
- **Internal Lighting Power -** The installed interior lighting power for a building or a separately metered or permitted portion of a building shall be calculated in accordance with the guidelines provided in the ECBC. Trade-offs of interior lighting power allowance among portions of the building for which a different method of calculation has been used are not permitted.
- **Installed Interior Lighting Power -** The installed interior lighting power calculated for compliance with Interior Lighting Power shall include all power used by the luminaires, including lamps, ballasts, current regulators, and control devices except as in case of emergency or dwelling lights.
- **Exterior Lighting Power -** For building exterior lighting applications as specified in the ECBC, the connected lighting power shall not exceed the specified lighting power limits specified for each of these applications. Trade-offs between applications are not permitted.

Exterior Lighting Applications	Power Limits
Building entrance (with canopy)	13
Building entrance (without canopy)	90
Building exit	60
Building facades	2 W/m2 (0.2 W/ft2) of vertical façade area

Table 2-4: Exterior lighting power limits

2.3.3 Guidelines for cool roof as per ECBC

As per ECBC, roofs with slopes less than 20 degrees shall have an initial solar reflectance of no less than 0.70 and an initial emittance no less than 0.75. Solar reflectance is determined in accordance with ASTM E903-96 and emittance is determined as per ASTM E408-71 (RA 1996).

3.1 NET METERING CONNECTIVITY PROCEDURE – NEW DELHI

3.1.1 Procedure for application for connectivity of roof-top solar PV system with DISCOMs network

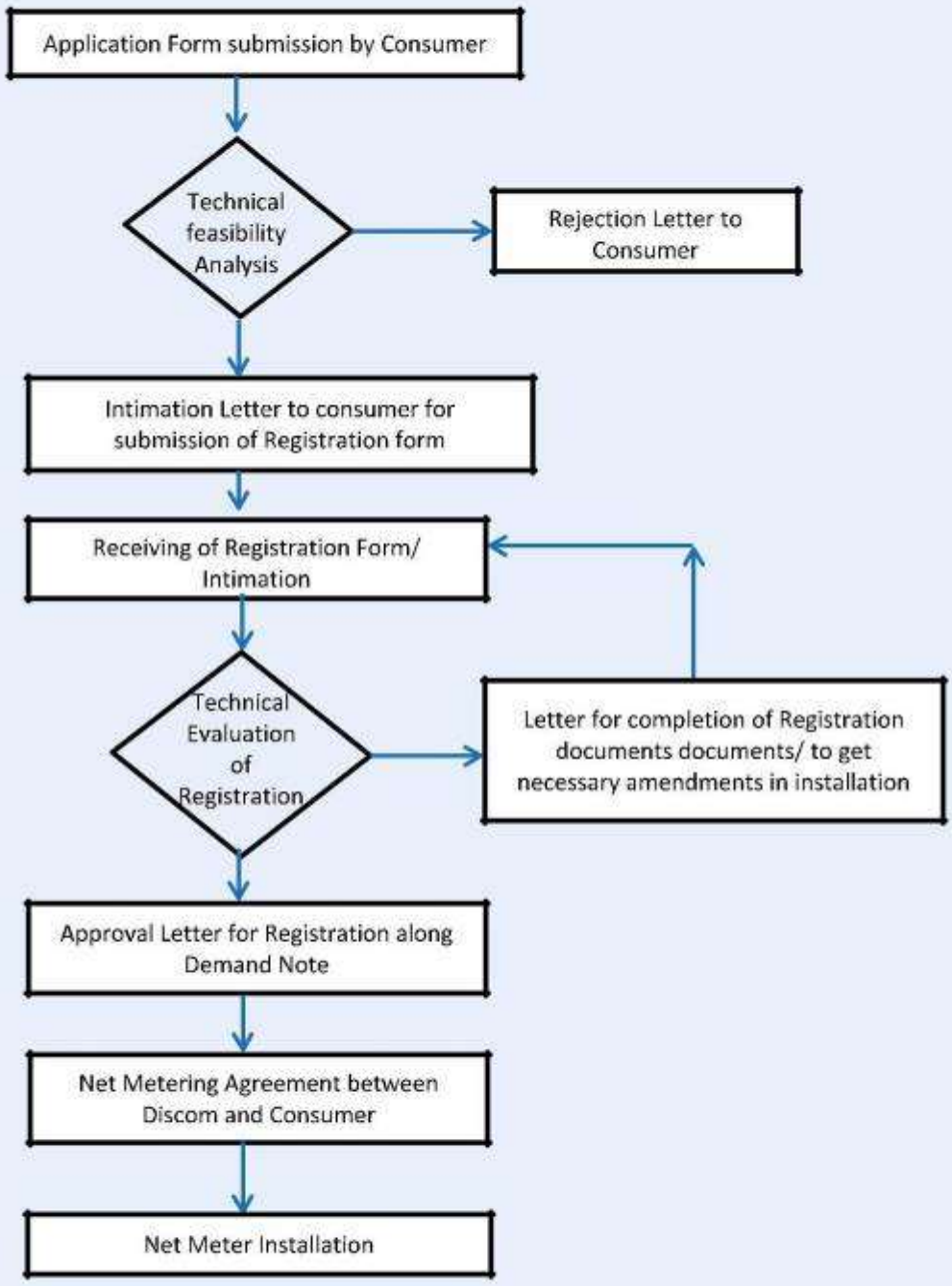
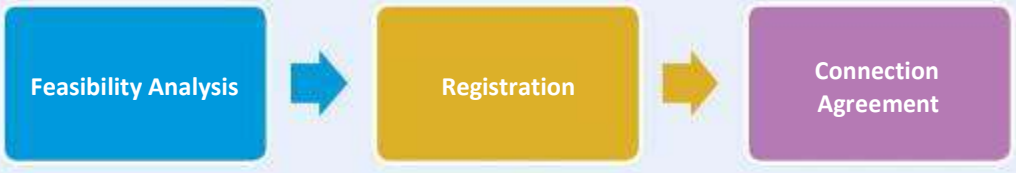


Figure 3-1: Process flow chart – applying for net metering

The standard procedure for availing the net metering facility for the solar rooftop projects in New Delhi is as follows:



Feasibility Analysis

Step 1 - The consumer shall submit an application to Discom, seeking connectivity under the Net Metering regulations, 2014 in the specified format along with an application fee of INR 500/- (Rupees Five Hundred) only to the concerned Discom for feasibility analysis.

Step 2 - The Discom shall acknowledge the receipt of the application form and shall record time, date & serial number of the receipt which shall form the basis for drawing the priority list, for further processing of applications on first cum first serve basis. Such a priority list having validity of one hundred and eighty (180) days from the date of receipt of application shall be displayed at prominent locations in the offices of the Discom and to be uploaded on its website.

Step 3 - In order of priority, the Discom shall complete the feasibility analysis for connecting the renewable energy system to the distribution system within thirty (30) days from the date of receipt of the application.

Step 4 - On feasibility analysis, if it is found that due to certain reasons including operational constraints it is not feasible for the Discom to provide connectivity at all or up to the applied capacity i.e. connectivity is feasible for a reduced capacity, the Discom shall specifically record the reasons thereof and subject to clause 5 of these guidelines, intimate in writing the same to the applicant(s) specifically mentioning that:

1. the applicant has the option, to be exercised in writing, to either
    i. accept the connectivity for the reduced capacity and approach the Discom to process the case; or
    ii. seek refund of its application fee either within seven (7) days of the receipt of the intimation; or
    iii. to stay in the priority list till its validity i.e. up to 180 (one hundred and eighty) days under clause 3(2) of these guidelines, for re-consideration and approval in case of future availability of applied capacity at the distribution transformer level etc. within such period.
2. If the applicant seeks refund, the Discom shall refund the application fee within seven (7) days from the date of receipt of intimation from the applicant in this regard. Thereafter, the Discom shall notify the updated position of the remaining applicants in the priority list.
3. In case the consumer opts to stay in the priority list and even in the validity period of priority list of one hundred and eighty (180) days the required capacity does not get available, the Discom shall refund the application fee on its own within seven (7) days of expiry of such 180 (one hundred and eighty) days period.

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Step 5 - The Discom shall seek prior approval of the commission for not providing connectivity or offering connectivity for a reduced capacity.

Step 6 - On feasibility analysis, if it is found feasible for the Discom to provide connectivity for the applied capacity or a reduced capacity under clause, the Discom within seven (7) days from the feasibility analysis shall inform all such applicants, to apply for registration and further processing. A registration form shall also be furnished with the intimation letter containing the following information:

a. Details of documents to be submitted by the applicant;
b. Technical specifications including the essential safety features;
c. Allowable capacity and technical specifications of the Renewable Energy Meter and Net Meter;
d. Relevant abstract of the applicable rules & regulations;
e. List of approvals / clearances required from respective authorities / agencies for installation of Renewable Energy System;
f. Model Renewable Energy System line diagram for grid connectivity;
g. Model Connection Agreement;
h. SLD charges, if applicable;
i. Applicable charges as specified by the commission from time to time;
j. Any other information/details as may be required to ensure safe and reliable operation of the distribution system with prior approval of the commission;
k. Important clauses related to the technical and interconnection requirements as stipulated in the DERC guidelines.

Registration:

Step 1 - The applicant, within thirty (30) days from the date of receipt of the intimation regarding feasibility and capacity, shall apply for registration of his scheme for installation of the Renewable Energy System in the format specified (registration form) along with requisite documents and the registration charges as stipulated below and other applicable charges:-

Sl. No.	Capacity (kW)	Charges (INR)
1	1 to ≤ 10	1000
2	>10 to ≤50	3000
3	>50 to ≤100	6000
4	>100 to ≤300	9000
5	>300 to ≤500	12000
6	>500	15000

Step 2 - At the time of submission of registration form, the Discom shall perform preliminary checks of all the documents submitted along with the registration form in the presence of applicant or his representative, and if found complete, shall receive the form and acknowledge its receipt.

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Step 3 - The Discom shall scrutinize the registration form within forty five (45) days from the date of its receipt, and shall either,

- Allot a registration number to the applicant, if registration form is found complete and in order, or
- Intimate the applicant about the deficiencies observed in the submitted registration form, if any, along with the instructions to cure such deficiencies.

Step 4 - The consumer shall re-submit the registration form, along with the requisite documents, after curing the deficiencies contained therein within fifteen (15) days of the receipt of intimation.

Step 5 - Within fifteen (15) days from the date of receipt of the re-submitted registration form, the Discom shall scrutinize it and shall

- Register the scheme and assign a registration number if registration form is found complete and in order;
- Give a personal hearing to the applicant and also intimate in writing the deficiencies, found if any, in the registration form and/or the documents submitted by the applicant giving him a final opportunity to cure the deficiencies and its re-submission.

Step 6 - The applicant within fifteen (15) days from such intimation shall cure the deficiencies and re-submit the registration form along with documents to the Discom. If the registration form is found complete and in order, the Discom shall register the scheme and assign a registration number to it. However, if it is observed that certain deficiencies still persist, the application for registration may be rejected under intimation to the DERC.

Connection Agreement:

Step 1 - Within thirty (30) days from the date of registration, the Discom and the consumer shall execute a connection agreement. The connection agreement shall include clauses relating to interconnectivity, billing and settlement, dispute resolution and Standards as per Net Metering regulations, 2014, relevant guidelines, orders thereof, as amended from time to time. In case the applicant fails to execute the connection agreement for reasons assigned to him, the registration shall be treated as cancelled.

Step 2 - The applicant shall avail the connectivity of the Renewable Energy System within one (1) year from the date of registration, failing which the registration may be cancelled under intimation to the commission and the Discom can proceed for allotment of such capacity to other applicants, strictly on the basis of first come first serve basis as per the available priority list.

Step 3 - The applicant shall obtain requisite approvals, in accordance with the provisions of the Central Electricity Authority (Technical Standards for Connectivity of Distributed Generation Resources) Regulations, 2013 (www.cea.nic.in) for commissioning of the renewable energy system, and furnish copies of approvals to the Discom.

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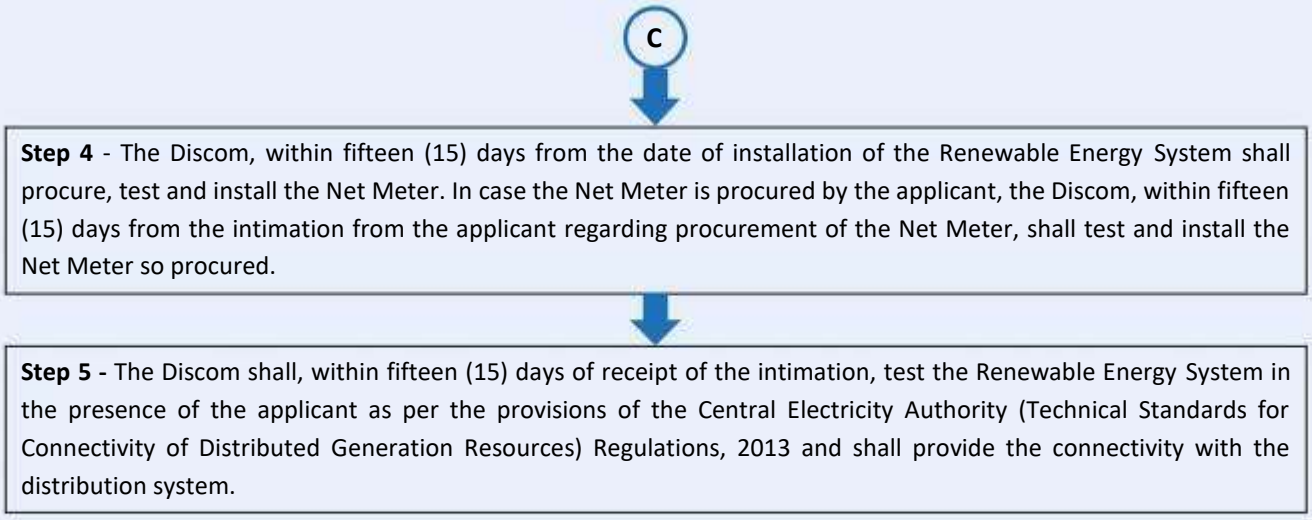

Figure 3-2: Steps for feasibility study

3.2 PROCEDURE FOR APPLICATION, REGISTRATION AND CONNECTIVITY FOR NET METERING - MAHARASHTRA (MSEDCL DISCOM)

3.2.1 General guidelines for the consumers desiring connectivity of roof-top solar PV system with MSEDCL's network under MERC net metering regulations, 2015:

- Any new or existing consumer is eligible to install solar rooftop system for captive use.
- The LT/HT consumer in MSEDCL's area who intends to install a solar PV system less than 1 MW to cater all or part of his own electricity load requirement is eligible for getting connectivity of roof-top solar PV system with MSEDCL's Network which includes consumer catering to a common load such as housing society.
- Such solar generation system may be owned and operated by the consumer itself or by third party leasing such system to the consumer.
- The variation in the capacity of the solar PV system shall be allowed within a range of 5%.

3.2.2 Procedure for application for connectivity of roof-top solar PV system with DISCOMs network

The standard procedure for availing the net metering facility for the solar rooftop projects in Maharashtra is as follows:

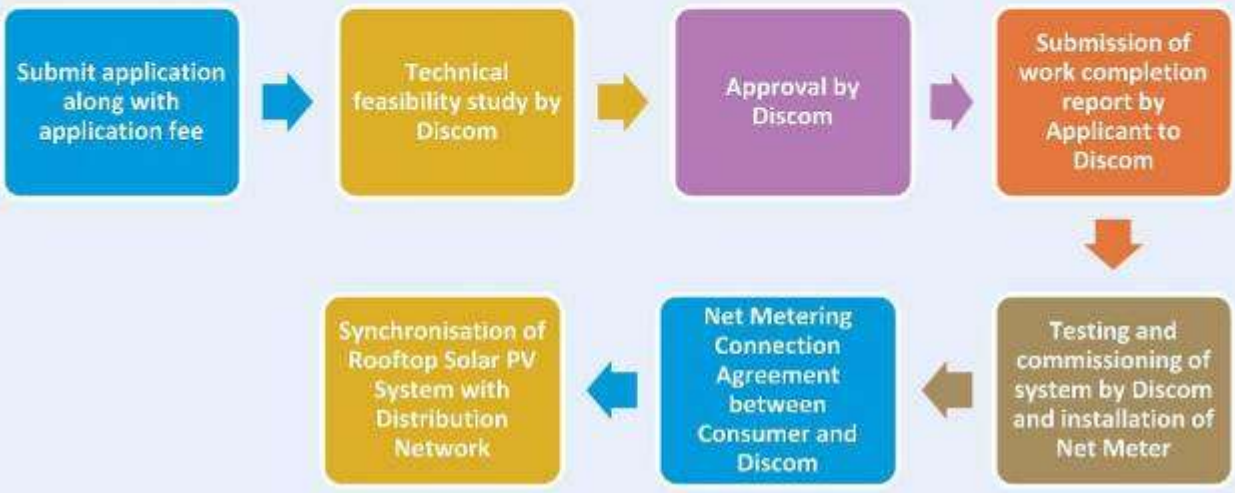

Figure 3-3: Procedure for availing net metering facility for solar roof-top project

The steps for availing the connectivity for solar rooftop system with the DISCOM's network are outlined below:

Step 1 - A consumer intending to set up a Roof-top Solar Net Metering System or who has already installed such a system may download the application form from the MSEDCL's website www.mahadiscom.in and submit it, duly filled, along with technical details of the system to the concerned office of MSEDCL along with registration fee, or apply and pay the fee online.

Step 2 - Duly filled application form, in prescribed format, shall be submitted to the office of the respective authority authorized for billing along with requisite processing fees (non-refundable) and certified true copies of the documents (list given below) as may be required /informed from time to time as shown in the below table:

List of documents to be submitted along with application form:

1. Copy of the latest paid electricity bill.
2. General Power of Attorney in favour of signatory in case of partnership firms; certified true copy of the resolution, authorizing the signatory to deal with the concerned Discom, passed by the board of directors in case of companies (as applicable).
3. Technical details of PV modules, Inverter and other equipment of system proposed to be installed.
4. Proof of payment of registration fee

Voltage Level	Threshold limit of Rooftop Solar PV system	Authority to which the application is to be submitted (MSEDCL concerned office)
230/240 V (1 Phase)	Less than 8kW/40A	Concerned Sub-division Office
400/415 V (3 Phase)	Less than 150kW/187 kVA (in Municipal Corporation areas) and Less than 80kW/100 kVA (in other areas)	Concerned Sub-division Office
11kV and above	Above 150KW/187 KVA and less than 1000 KVA (in Mumbai Metropolitan Region) and Above 80 kW/100 kVA and less than 1000 kVA (in other areas)	Concerned Circle office

Step 3 - MSEDCL's concerned office shall register the application in separate register on first come first basis and acknowledge its receipt within three working days; or intimate the applicant within that period of any deficiency or incompleteness.

Step 4 - MSEDCL concerned office shall conduct a technical feasibility study within 15 working days from the registration of the Application considering the following aspects:

i. AC voltage level at which connectivity is sought;
ii. Sanctioned load / contract demand of the applicant;
iii. Rated output AC voltage of the proposed roof-top solar PV system;
iv. Available cumulative capacity of relevant distribution transformer;

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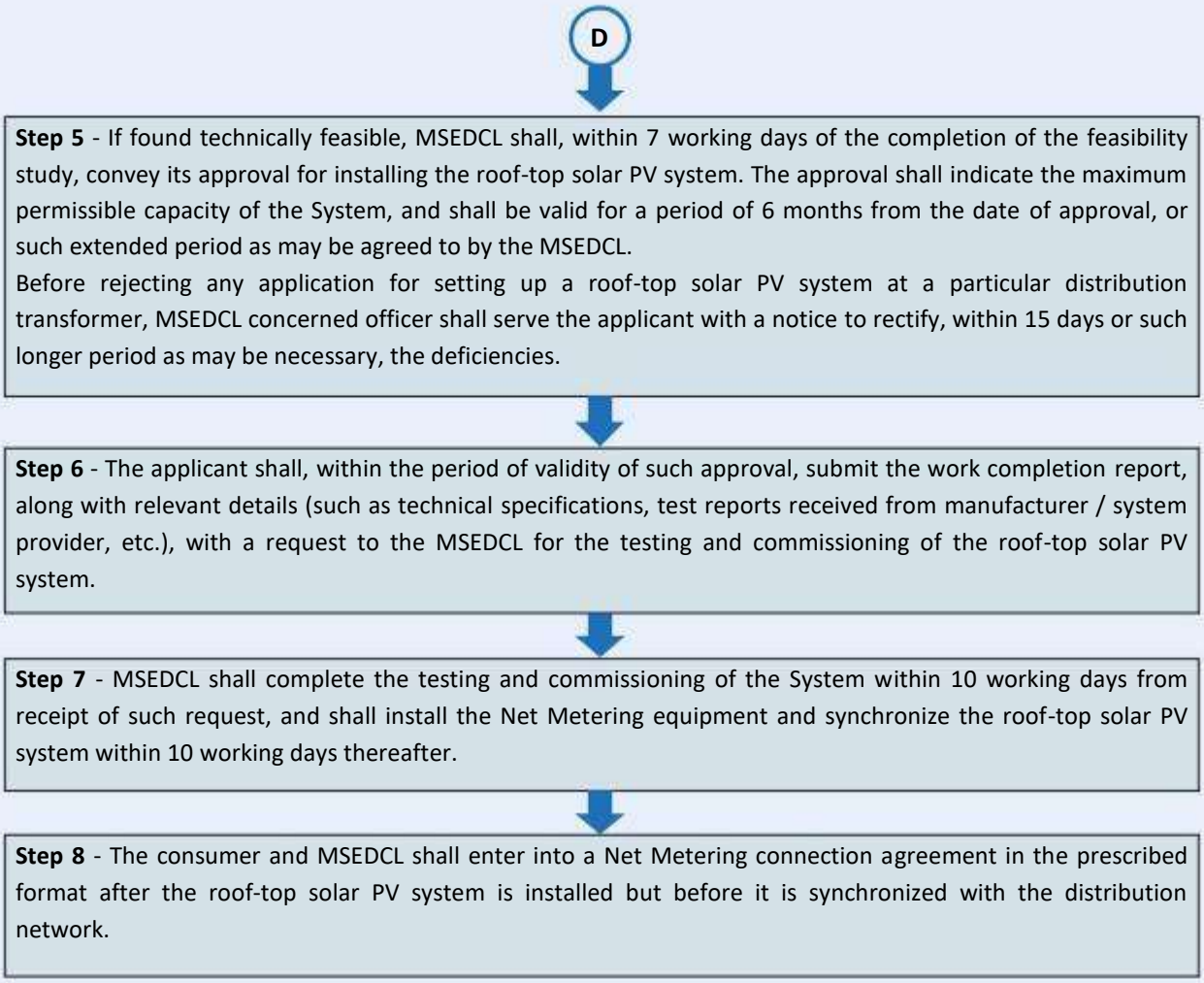


Figure 3-4: Steps for availing grid connectivity for solar roof-top system

3.2.3 Development agency (MEDA)

The developers of solar rooftop system must submit the project proposals through Grid Connected Roof Top (GCRT) software available on MEDA website (www.mahaurja.com) along with the scanned copy of following documents. The residential society needs to provide these documents to the developer for onward submission to MEDA for the developer to avail the CFA. It must be noted here that the cost charged by the developer to the residential society for the rooftop system would be after deducting the CFA from MEDA.

List of documents to be provided by residential society to the developer

1. Purchase order from beneficiary (residential society in this case) i.e. a purchase order issued by a residential society to the channel partner/ implementing agency.
2. Document showing advance received.
3. Net metering application to utility company (Discom).
4. Agreement / consent / certificate / undertaking on INR 100/- stamp paper regarding CFA from Beneficiary.
5. Affidavit / declaration certificate / undertaking on INR 100/- stamp paper regarding specifications from Channel Partner.

6. Undertaking on INR 100/- stamp paper for net of subsidy from beneficiary, if applicable. This certificate is to be issued by the beneficiary for release of CFA to developer. It is to be submitted in hard copy to MEDA.
7. Ownership document of the rooftop from beneficiary.
8. Certificate of society registration / charitable trust registration. (If applicable).
9. PAN card and Aadhar Card of beneficiary.
10. Latest electricity bill.
11. Document regarding MNRE channel partner / channel partner (New Entrepreneur), if available.
12. Detailed Project Report (DPR) or/and engineering documents
13. Single Line Diagram (Approved from competent Authority)
14. Site photographs

Further, the residential society will also need to permit the engineers from MEDA to carry out joint physical inspection of the installed and commissioned system along with the developer. The Net metering installation report of utility also needs to be provided by the residential society to the developer for onward submission to MEDA.

3.3 SOLAR WATER HEATING SYSTEM

Domestic consumers traditionally use geysers, immersion rods and other less efficient equipment for water heating in order to satisfy various needs of hot water. Using of electrical energy to heat water is an inefficient use of energy. Hence, the usage of solar energy to heat water is a viable alternative to electricity based heating, especially due to the fact that it reduces electricity consumption and is clean source of energy.

A solar water heater consists of a collector to collect solar energy and an insulated storage tank to

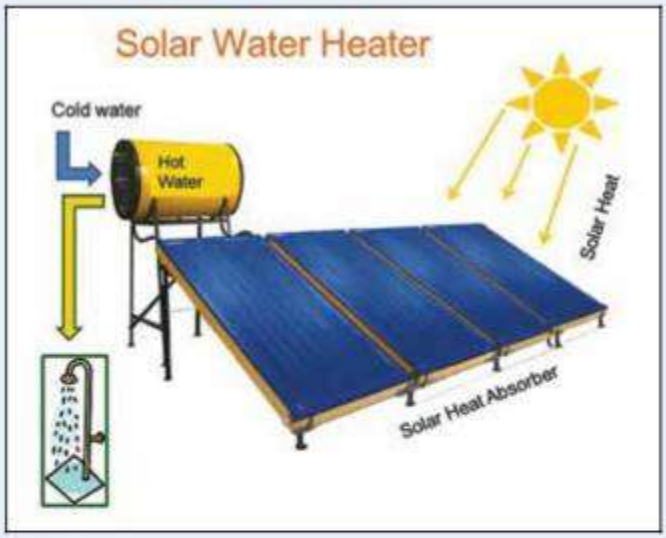


Figure 3-5 Typical solar water heating system

store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the heat to the riser pipes underneath the absorber panel. The water passing through the risers get heated up and are delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80_0 C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar hot water system. A 100 litres capacity SWH can replace an electric geyser for residential use and may save upto 1500 units of electricity annually in turn preventing emission amounting to approximately 1.5 tonnes of carbon dioxide per year.

A good solar water heater should have sufficient collector area for the capacity claimed. The collector area used in the system determines the capacity of water heating. For example, in typical North Indian weather conditions, on a sunny winter day, 1 m_2 of flat plate collector area can be expected to heat approximately 50 litres of water by a temperature of 30-40° C. Typical flat plate collectors made in the country have an area of around 2 m_2 and are thus capable of heating around 100 litres of water in a day. An evacuated tube collector based system of 14 tubes covering an area of 1.5 m_2 can provide 100 Litres of hot water in a day. This proportion serves as a benchmark. Further, the collectors should be of good material and the absorbers should have superior quality coating (BIS approved collectors are being provided by large number of established manufacturers). The system should be mounted on a rigid structure and should be firmly fixed with the roof to prevent damage during high winds. Further, it is better to buy a system smaller than requirement and use back up to compensate for shortage of hot water rather than buying a system which is bigger than requirement. A bigger system may lead to inefficiencies and cause operational problems. Estimated requirement of hot water for a typical home can be arrived at below mentioned basic thumb rule.

Capacity	No. of People	No. of Bathrooms	No. of Kitchens
100 LPD	3-4	1	1
150 LPD	5-6	2	1
200 LPD	6-7	3	2
300 LPD	8-10	4-6	3

Table 3-1: Estimated requirement of hot water

In existing multi-storied buildings, a small solar water heater can be mounted on the window sill/door sill towards the South facing wall similar to a desert cooler.

How the system can be installed

A Solar water heating system (SWHS) system can be installed in domestic establishment in two ways:

a. Through State Nodal Agency:

Consumers who wish to have the solar water heating system installed may contact State Nodal Agency of Delhi/ Maharashtra as per below details:

Delhi Executive Officer Energy Efficiency & Renewable Energy Management Centre Department of Environment, Govt. of NCT of Delhi Vikas Bhawan-II, E-Wing, GPO Building, Civil Lines, Delhi. Tel: 011-23815874 / 23815875 Email: osd_eerem@yahoo.com	**Maharashtra** Director General Maharashtra Energy Development Agency (MEDA) S.No. 191/A, Phase1, 2nd Floor, MHADA Commercial Complex Opp. Tridal Nagar, Yerawada Pune – 411 006. Tel: 020-26614393/26614403/26615322 Email: dg.meda@nic.in , meda@vsnl.com; solar@mahaurja.com

The engineer from the nodal agency will visit the site, provide information on cost, size & other details of system required. The nodal agency personnel will then have the system installed through one of accredited list of manufacturers that the nodal agency has shortlisted.

b. Through Accredited Channel Partners

Interested consumers may contact any of the channel partners accredited by MNRE. The consumer may contact more than one channel partners as well so as to have better option based on economics that he/she can afford. The list of channel partners for Delhi and Maharashtra as provided in **Annexure I**.

3.3.1 Case study for successful solar water heating projects implemented by residential societies and energy savings achieved

The solar water heating system of capacity of 4125 litres was installed in one residential society. The total cost for procurement and installation of the system was INR 7, 38,000. The society accrued energy saving benefits of 27,674 units per year resulting in monetary benefits of INR 1, 32,836 per year. The simple payback is 6 year. Table below provides the detail energy savings calculations

Current technology (Use of electric geysers)		
No of flats in the building	40	Flats
No. of residents	136	
Hot water requirement	25	Lts/day/person
Daily hot water requirement	3,400	Lts/day
1 kWh of electricity	3,600	J
Efficiency of electric water heaters	90%	
Electricity consumption	154	kWh/day
Unit cost of electricity	4.8	INR/kWh
No. of days for hot water requirement	180	days/year
Amount paid towards hot water generation	132,836	INR/year
Recommendation 1: Installation of solar water heating system		
Capacity of solar water heating system (assuming 20% extra)	4,100	Lts/system
Costs & Benefits:		
Total cost of 4100 litres solar water heating system	738,000	INR
Benefits (Amount saved on electricity bill)	132,836	INR/year
Simple payback period	6	Years

Table 3-2: Cost economics of solar water heating project

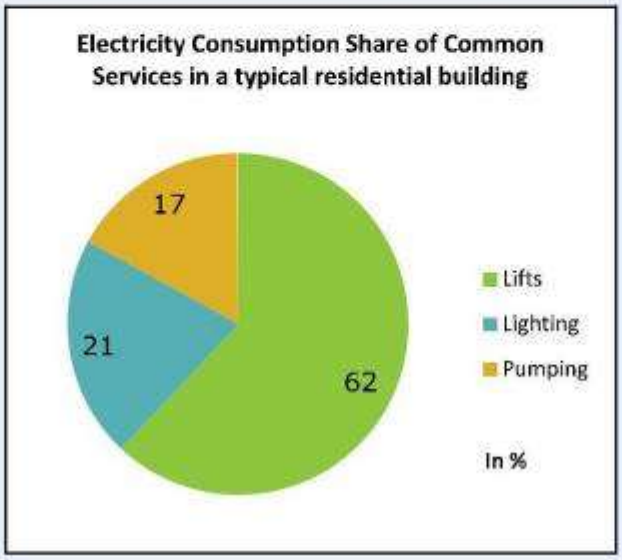
Normally, the design and implementation of energy efficiency projects undergo following steps:

1. Study existing building systems and collect energy information
2. Develop energy cost indices or benchmarking operating performance of utilities
3. Establish and targets energy using utilities for detail study
4. List no cost or low cost measures
5. Prepare comprehensive list of EE measures for further study
6. Conduct detail energy audit on existing system for performance benchmark with cost benefit assessment for all the identified energy efficiency and renewable energy options
7. Shortlist practical EE measures and recommendation for implementation
8. Prepare detail project report for shortlist measures with detail analysis including financial and risk analysis
9. Design and engineering of selected practical EE measures for implementation

10. Implementation plan
11. Select business model for implementation of projects
12. Prepare tender document for selection of vendor for implementation
13. Finalise vendor for implementation of selected projects
14. Monitor project implementation work
15. Evaluate benefits achieved after project implementation

It is observed that residential societies prefer to implement identified projects one by one based on the yearly budgets and funds available with them. LED lighting project is the most simple project to begin with the implementation of EE measures followed by efficiency improvement of water pumping system and then targeting cost intensive projects such as renewable energy, lift retrofitting etc. Residential high-rise buildings built after 2010 by reputed builders such as Godrej Properties, TATA housing, Hiranandani, Lodha, DB reality, Oberoi, Kalpataru already have in-built efficient water pumping and lighting systems and therefore in such complexes it is better to prioritize other measures for implementation such as solar roof-top based power generation, automation and sensor based operations etc.

Residential high-rise buildings use several technologies to meet the primary as well as secondary needs of the residents. It may include water pumping, lighting requirements in common areas, elevators, etc. If an existing high-rise residential building is old (10 years or more), a substantial scope for reduction of energy consumption is available due to age old equipment which are operating with poor maintenance. Typically, energy consumption by water pumping[8], lighting and elevators together comprise approximately 16% of the total energy consumption[9] of a housing complex. The separate break-up of consumption in percentage for the three technologies mentioned above is shown in the adjoining figure.



***Source**: BEE guidelines on EE multi-storey residential building (7 storey, 90 Flats)*

Figure 4-1: Break-up of energy consumption by common services in residential building

Presently, there are multiple Energy Efficiency technologies available in the market. However, the guidebook focusses on those technologies which are relevant for implementation in common facilities in residential societies. The technologies covered in detail are as follows:

- Energy efficient water pumping with auto operations
- LED lighting with auto operations
- Cool Roof Technology
- External Solar Shading
- Lifts/Elevators
- Heat Pumps

[8] Water pumping to overhead tanks

[9] Source: Design Guidelines For Energy-Efficient Multi-Storey Residential Buildings, BEE, 2014

4.1 ENERGY EFFICIENT WATER PUMPING

4.1.1 Introduction

The water requirements of residential high-rise buildings are met through pump system installed within/near the premises of the residential apartment. Typically, in a multi-storey building, water is received from the municipal water supply to a ground-level reservoir. From the ground-level reservoir, the water may be pumped either to an overhead tank or directly to the flats based on the system employed as discussed later. Pumps are among the heaviest energy consumption devices contributing up to half of the total energy consumption and are quintessential for the need of the residents viz. water for drinking (separate purifiers may or may not be installed for augmenting this need), bathing, washing, etc. The electricity consumption in water pumping depends upon (a) Sizing and choice of the pump (b) Choice of motor and its control and (c) Piping design.

The water required for the building may be supplied through following two systems:

Hydro-pneumatic Pumping System	Gravity Based Storage System
• Pumps are used to supply water directly to the taps in apartments from the main reservoir located at the ground level. There is no overead tank. • Pressure sensors are installed at various parts of the plumbing in the building that make sure the availability of a constant pressure system throughout. • Whenever a sensor senses that the pressure anywhere in the system is low, the pump close to the ground level storage tank starts and pushes the water up to the level where it is required. • While the hydro-pneumatic system is expensive to install and operate, the system ensures that each and every point of the plumbing system is provided with same pressure irrespective of the height at which the apartment in the building is located. • The pumps at most of the times may not operate at full efficiency because of its part load operation. • As obvious, the electricity consumption in this system is more due to the continuous On-Off of the pumps.	• In this traditional system, pumps are used to supply water from ground water reservoir to the overhead water tank at the top of the building. • The pumps are running for few hours a day ensuring the water is adequate in overhead tank. • The pumps run at their best efficiency (if right size pump is given for a given load) during the time of operation. • The water is then distributed to the apartments by means of gravity and no electricity is consumed for it. Thus, operational expense of this system is substantially reduced due to absence of any electricity consumption for distribution. • Further, since the pumps run at their best efficiency most of the time, the losses are minimized.

Figure 4-2: Water pumping systems in residential societies

4.1.2 Comparative analysis of pumping systems

While any of the above two systems can be used by the builders as per the requirements of the building and need of its residents, the selection of right pump and its motor as per the design of supply and delivery pipe is itself an important exercise which helps in reduction of energy bill. Further, the pump may need to be replaced if it is too old as the losses may be too high to efficiently run the pump. This may be due to normal operation and wear & tear in an old pump. Further, if any old pump is being used after rewinding of its motor, there are high chances that the losses (Iron and Copper losses) may be contributing a lot in inflated energy bills.

4.1.3 Advantages and disadvantages of a hydro-pneumatic pumping system

Advantages	Dis-advantages
• **Less floor space is required** as there are no large tanks to take up valuable space, and vertical pumps occupy considerably less area than horizontal pumps. • The initial cost can always be off-set with construction of overhead tank and its impact on structural members. • **Uniform pressure can be achieved** at all fixture outlets irrespective of the location • Eliminates Piping distribution networks at terrace Level. • The **piping cost is less** compared to gravity system because of telescoping design. • **Best available option for sloped roof terraces.**	• **Sophisticated controls** - Manufacturer's trained personnel are usually required for adjustments and other routine maintenance. • Each system installation must be evaluated separately. There is n**o emergency water reserve. Power supply and water availability must be 24/7**, The building will be without water if water supply is disrupted or the pumps fail to operate for any reason. • **Noise problems** - If other than multi-stage turbine pumps are used, there is a very serious problem. If centrifugal pumps are used, the danger of low-flow turbulence and high flow cavitation requires special attention. Over-sized pumps aggravate the condition. • **At least one pump must operate continuously**, even for extremely small demands. • There are minimum 3-4 pumps required as the pumps must operate over a wide range of capacities. As per the demand of water, the required pumps operate automatically. The Operating costs is higher. The pumps do not always operate at the optimum point on their curves to achieve max efficiency.

Figure 4-3: Advantages and disadvantages of hydro-pneumatic pumping system

4.1.4 Advantages and disadvantages of a gravity based storage system

Advantages	Dis-advantages
• **Extremely simple** - there is no complicated or sophisticated controls • **Most reliable** - It is the only system which has a reserve capacity in the event of a power or water supply failure • **Economical** - Operating costs are much less, and capital expenditure is generally no higher than for other systems • **Minimum maintenance** - The only requirement beyond those required for all systems is periodic cleaning and possible repairing of the tank. • **Uses less energy** - Pump head and, therefore, horsepower is less than in other systems. The pumps operate only to replenish the tank, and then stop so that a high horse power pump is not required to satisfy low demands as is required in the booster Pump system. The pumps operate at the optimum point on the pump curve for greater efficiency and less energy wastage. • The pumps in a gravity system always **operate at full capacity and peak efficiency**, and shut down when there is no demand. • System pressure is less than 2Kg/sq cm and hence failure of CP fittings is remote. • **Back-up power not necessary.**	• **Tank must be elevated**. Provisions must be made to support the water filled tank adequately. A tank on the roof is unsightly, and if it is enclosed and dressed up there is additional architectural expense. • The weight of the water filled tank can **increase structural costs**. • Tanks required **periodic cleaning and painting**. • If a tank ruptures, large quantities are released which could cause extensive damage. • Terrace floor is full of piping network and ring mains which is a draw back, then these terraces are not treated as common terrace area. • Requires bulky overhead tanks. • **Equal pressure can not be achieved** at all the draw-off points. • The fixtures at floor level immediately below over head tank will not have sufficient residual pressure for efficient operation / working of fixtures unless the staging of overhead tank is increased. • **Not suitable for sloped roof terraces**.

Figure 4-4: Gravity base storage system

4.1.5 Measures to improve pumping efficiency

The first step is to undertake pumping system energy audit of the existing systems in the sequence shown in the figure below:

Analysis of existing system and input data Collection for pump-sets:

- Operation and maintenance record
- Last one year electricity bills

- List of water pump-sets as per the Table 4-1
- Name plate details of motors as per Table 4-2
- Rough sketch of pumping arrangements and piping network

Sl. No.	Location (Name of the Pumping Area)	Kw/HP	Type of Pumping	Year of Installation	Working Pattern	Working Hours	Status
1							
2							
3							
4							

Table 4-1: List of water pumping station

XXXX (Building Name) Pumping System Details			
Description	**Pump-1**	**Pump-2**	**Pump-3**
Manufacturer's Name			
Rated Voltage (V)			
Rated Full load Amps (A)			
Rated Motor Power kW/HP			
Rated Motor Efficiency (%)			
Type of Pump			
Rated Flow (M^3/Hr)			
Rated Head (M)			
Rated Speed (rpm)			
Frequency (Hz)			
Rated Speed (rpm)			
Start-up method (DOL/start-Delta/ATS)			

Table 4-2: Motor & pump details of pumping system for detail energy audit

Detailed energy audit of the Pumping System:

- Study the components of the existing water supply system such as storage tank capacities and water levels, suction pipes and delivery pipes diameters, valve positions pump operation in parallel, series etc.
- Actual electrical measurements as per the format provided in the Table 4-5 below.
- Actual flow measurements as per the format provided in the Table 4-6 below.

Sl. No.	Name/Number of Pumping	Suction pipe and delivery pipe dia.	Power in KW	P.F	Phase-wise Voltage			Phase-wise Current			Comments
					R-N	Y-N	B-N	R	Y	B	
1											
2											
3											
4											

Table 4-3: Actual electrical measurements of pumping system for detail energy audi

Sl. No.	Name/Number of Pumping	Rated Flow (M^3/Hr)	Rated Head (M)	Measured Flow (M^3/Hr)	Measured Suction Pressure (M)	Measured Discharge Pressure (M)	Total Head (M)	Comments
1								
2								
3								
4								
5								

Table 4-4: Actual measurements of pumping system for detail energy audit

With the above measurements, one can benchmark the specific energy consumption (litres per kW) and establish overall efficiency of existing water pumping system. The analysis of measurements will help identify multiple options for energy savings. Table 4-1 list out the probable measures to improve pumping efficiency by rectifying common pumping problems[10] :

Common Problem	Potential measurers to improve efficiency
Unnecessary demand on pumping system	Reduce demand on the system
Oversized pumps	1. Change impeller 2. Trim impeller 3. Fit lower speed pump/motor 4. Select a pump that operates near its best efficiency point
Inefficient pump throttling controls	Fit adjustable or variable-speed drive
Oversized/Inefficient motor	Change motor
Pump wear	Pump maintenance
Overflow of tank in Overhead tank system	Installation of water level based ON-OFF system of pumps
Piping system and design not matching with pump ratings	Normally, if the piping system is older than 12 years, it can be replaced and matched to EE pump rated head and flow capacity. Usually, if PVC pipes are preferred it will drastically reduce the frictional loses

Table 4-5: Measures to improve water pumping efficiency

In most of the residential societies the municipal water supply is during late night or early morning. The pumps are operated by the watchman to fill the overhead tanks during this time. It is observed that overflow of overhead tank is a regular scene and frequent burn out of pump motors due to dry run and poor maintenance. If the pump operation is based on certain level indicator and the pumps operate automatically as per requirement, energy consumption and water wastage can be avoided. The technical specifications for a typical auto ON-OFF system are detailed below:

[10] Source: Energy Efficiency Best Practice Guide: Pumping Systems, Sustainability Victoria

Particulars	Make : Nelso tech specifications	Make : Active Controls specifications
Supply Voltage	230 V AC, 50 Hz	220 V AC, 50 Hz
Compatibility	1 or 3 phase motor	1 or 3 phase motor
Output	2 potential free relay contact	Potential free contacts
Contact Rating	23 Ampere for Pump On relay and 7 Ampere Pump Off relay	
Power Consumption	1.2 Watt	
Temperature	-20 to +70 0C	Upto 120$_0$C
Cost	INR 4725/-	INR 5500/-

Table 4-6: Auto on-off water pumping system

A typical pump specifications and economics are tabulated below:

	Pump Capacity	Centrifugal Monoblock Pump- 5 HP	Centrifugal Monoblock Pump- 10 HP	Monoblock Pump	Monoblock Pump
Pump Specifications	**Make**	CRI Pumps	CRI Pumps	Kirloskar	Kirloskar
	Model No	CTT-25/37T	CTT-38/75T	KDM-535S	KDM-1053S
	Power kW/HP	3.7/5	7.5/10	3.7/5	7.5/10
	Head in meters	40	45	35	41
	Discharge m3/hr	26.6	56	22.5 m$_3$/hr	37.8m$_3$/hr
	Efficiency	78%	92%		
	Voltage/Frequency	415V/50Hz	415V/50Hz	415V/50Hz	415V/50Hz
Price Break-up	**Pump Price Range in INR**	18000-22000	40000-50000	NA	NA
	Piping Foot Valve Price Range in INR	5000-7000	5000-10000	NA	NA
	ON/OFF Control System Price in INR	3000	3000	NA	NA
	Total Price in INR	26000-32000	48000-63000	NA	NA

Table 4-7: Typical pump specifications

However, the actual conditions of individual system may vary and it is suggested that a detailed energy audit of the system should be carried out to ascertain the avenue of energy efficiency improvement.

4.1.6 Implementation of energy efficiency measures for water pumping systems

The typical process to be adopted for implementing energy efficiency measures for water pumping system in high-rise residential buildings is shown in the following diagram.

The steps for design and implementation of energy efficiency initiative are explained below:

1. **Step 1** – Carry out energy audit to develop the understanding on pump population, each pump capacity, study the water supply and distribution system, benchmark performance and actual overall efficiencies. Recommend new designs for water pumping system based on proper understanding of flow, pressure, piping and electrical protective system requirements using the formats provided above.
2. **Step 2** – Based on the energy audit report, the residential society will be able to estimate the energy savings potential and determine the baseline against which the energy consumption and water flow, pressure needs to be benchmarked.
3. **Step 3** – The next step involves preparation of the Detailed Project Report which captures the description of new technologies proposed, technical specifications, bill of material, cost elements, timelines for implementation as well as benefits that will accrue from the replacement of the existing system by energy efficient system. The DPR should also highlight all the risk elements and methods to mitigate them. Thus, the DPR must provide all the information to the society to take the financial decision for implementation of project. Chapter 4 and chapter 5 has given detail process for cost benefit analysis and risk identification and evaluation methods.
4. **Step 4** – Based on the approval of the project for implementation, the building society needs to prepare a tender/ RFP document outlining the scope of work envisaged, qualifying criteria, terms and conditions, timeline for contract and invite bids from interested parties. Subsequently, the bid evaluation should be carried out and a suitable entity should be appointed for implementing the Energy Efficiency initiative.
5. **Step 5** – The implementing agency and the building society should then carry out the implementation of the Energy Efficiency initiative.
6. **Step 6** – The building society and the implementing agency should develop formats and mechanisms to measure and monitor the performance so that any course correction can be implemented, if required.

4.1.7 Case studies for successful water energy efficiency projects implemented by residential societies and energy savings achieved

Few residential societies have implemented water pumping efficiency improvement projects by adopting the implementation process defined in the guide book. They have been able to achieve energy savings in the range of 13-31% with pay pack period of 1-4 years. In one of the residential society the old suction and water delivery pipes were also replaced along with the pump-sets. All the results and their comparisons are provided in the table below.

Particulars	Input Power (kW)	Operating Hours/Day	Overall Pumping System Efficiency (%)	Spec. Power Consumption (m3/kWh)	Electricity Savings from energy meter (kWh/year)	Pump & Installation cost (INR)	Pay Back Period (yrs)
Society 1 New EE pump set supplied by Crompton Greaves, flow: 16.9m3/hr, head: 39m							
Old Pump Set	4.1	1.77	31%	3.0			
New EE Pump Set	4.05	1.28	45%	4.2	1608	50200	5
Society 2 New EE pump set supplied by Ansons, flow: 16.3m3/hr, head: 46m							
Old Pump Set	9.3	1.5	14%	1.3			
New Pump Set	3.98	1.12	52%	4.1	1593	19000	2
Society 3 - New EE pump set supplied by Kirloskar, flow: 12.8m3/hr, head: 45m							
Old Pump Set	6.7	1.62	22%	1.9			
New Pump Set	4.26	1.61	37%	3.0	1225	30000	3

Note: *Cost of electricity for Society 1, Society 2 & Society 3 is calculated from bills as INR 5.9/unit, INR 5.6 per unit & INR 7.1 per unit respectively.*

Table 4-8: Case study for energy saving in water pumping system

4.2 ENERGY EFFICIENT LED LIGHTING FOR INTERNAL AND EXTERNAL USE

4.2.1 Introduction

The lighting system in a high-rise building offers a substantial avenue for energy saving. The common area of the building viz. parking garage, terrace, stairs, streetlights, gym, club, etc. are places where energy efficient lighting may be used. The usage of LED lamps in place of mercury lamps, sodium lamps, incandescent lamps, fluorescent lamps and even compact fluorescent lamps (CFL) can drastically reduce the energy consumption. The LED lamps are also preferred because they have better luminous intensity as well as better life as compared to other bulbs. For the same luminous intensity, typically an LED bulb uses 85% less power than conventional incandescent lamps. With the prices of LED lamps already going down at a substantial pace, it is a better economic decision to replace the conventional bulbs with LED bulbs.

The usage of LED lights can also be adopted by residents for lighting purpose inside their apartments and balconies to reap benefits in individual energy bill. With many distribution companies offering up to 2 or 3 LED lights at a discounted price, it is beneficial to adopt these light bulbs. This not only helps in reducing the energy consumption but also holistically helps in reduction of power purchase cost of Discoms which in turn passes on the benefit to consumers with reduced electricity tariff.

Further, sensors may be installed at various locations where the efficient control of lighting system is

desired. **a. Occupancy based sensors**

In a society, the shared areas such as lift lobby, parking area and staircase are the major electricity consumers and about 80% of the day they are vacant. By the help of occupancy sensors, we can automate the light and make sure that light is switched on only at the time when somebody enters that area.

Working of the sensor

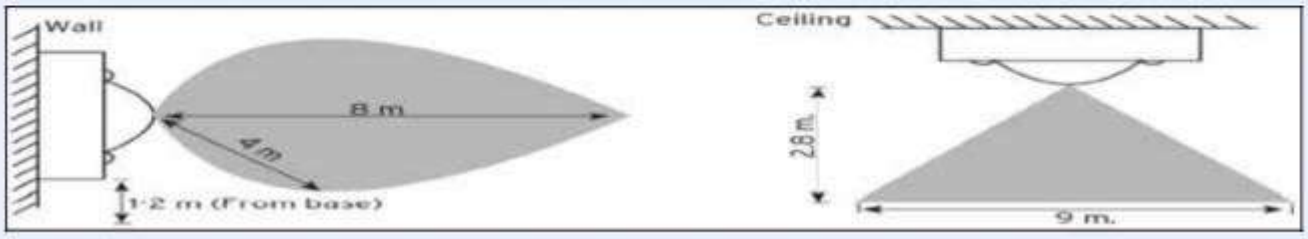


Figure 4-5: Detection area for motion sensors

As soon as somebody someone enters the detection zone of the sensor, the light switches on. We can set the time for which we want the light to stay in switched on mode after the last detection by the sensor.

Effectiveness: with the example of Everest World Society, Thane District, analysis of a 19-floor building, the requirement was:

- One sensor on each floor lift lobby to control two lights
- One sensor for staircase of 2 floors
- A common sensor for 2 car parking slot.

The total requirement was of 40 sensors with total cost of installation as INR 1.6 lacs and the recovery period was found to be 3.5 years. These sensors may dim the light or switch off the lighting system altogether in case of zero occupancy in an area.

b. Lux based sensors

The sensors may further be installed which senses the luminous intensity in and around the ambience and accordingly switches on or off the lights. These may be installed in the areas which are common including streetlights. The daylight varies according to season and this sensor helps in saving few extra units of energy bill.

c. Time-based control

The lights that installed for decoration viz. façade lights may be time-controlled and switched on and off based upon the need to which it caters. Building illumination lights may be timed such that the same is switched off after a time.

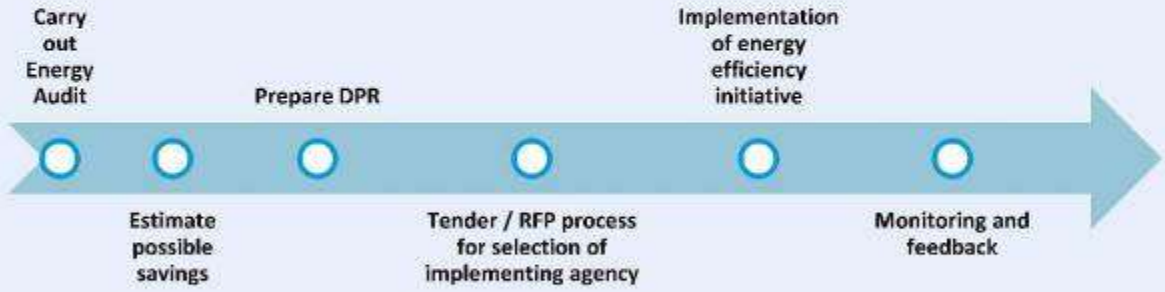
A typical LED system that can be proposed to replace existing lighting system is shown in the below table.

Particulars	Description						
Existing System	Fluorescent Tube-light 40 W			CFL 18W & 36W		Outdoor-70W Pole Light	
Proposed System	Philips LED Tube Lights-18W	Crompton LED Tube Lights-18W	Olive LED Tube Light	Philips LED Down Lights- 8W & 14W	Crompton LED lamps – 7W & 14 W	Philips LED Street Light-36W	Olive LED street Light 36 W
		Specifications	**of Proposed**	**System**			
System lumens in lumens	2100	1600		600-800	600-1400	3400	3600
System efficacy in lm/watt	105		130	80		90	130
Operating voltage range	100–240	230 V	90V -270V	100–240	230 V	220-240	90 -290 V AC
Power factor	0.92		>0.95	Greater than 0.90		0.92	>0.90
Colour Rendering Index (CRI)	>82	>70	>70	>70		>82	>70
Rated Correlated Colour Temperature (CCT)	4000-6500K	6500 K	2700~ 7000K	3000K	6500 K	4000K	6500 k
IP	IP 42		IP 20	IP 66		IP 67	IP 65
Beam Angle	160 degree		120 degree	120 degree		150 degree	120 degree
Price in INR	500-700	429			150 -271	4000-5000	2560

Table 4-9: Specifications of a typical LED system

4.2.2 Energy audit of lighting system

The typical process to be adopted for implementing energy efficiency measures for lighting system in high-rise residential buildings is shown in the following diagram.



The following section captures the energy audit format for lighting system in a typical high-rise residential building.

Detailed energy audit of the Lighting System:

a. Review of present lighting system and prepare accurate lighting inventories

b. Estimation of lighting load at various locations like different floors, garden, roads, parking (Building Campus), pump house, club house and other locations.

c. Detail lux level survey at various locations and comparison with acceptable standards.

d. Recommendations for energy savings and cost benefit analysis.

Particulars	Number of Lamps				
Name of Area	STL Fittings (40 W)	DTL Fittings (40 W x 2 Nos.)	CFL (5/18/36 W)	LED	Total

Table 4-10: Details of lighting system installed for detail energy audit

Name of Area	Type & Watt of luminaire	Mounting ht. of lamp	Measured Avg lux level	Recommended Lux

Table 4-11: Actual lux measurements of lighting system for detail energy audit

Electrical parameters (including ballast consumption)	STL Fittings	DTL Fittings	CFL	LED
	40W	(40 W x 2 Nos.)	(5/18/36 W)	40W
Voltage (V)				
Current (A)				
Power factor (P.F)				
Power (kW)				

Table 4-12: Actual electrical measurements of lighting system for detail energy audit

The steps for design and implementation of energy efficiency initiative are explained below:

Step 1 – Carry out energy audit to develop the baseline of lighting fixtures, electrical and lux measurements of these lighting fixtures etc. using the formats provided above.

Step 2 – Based on the energy audit report, the residential society will be able to estimate the energy savings potential and determine the baseline against which the energy consumption needs to be benchmarked.

Step 3 – The next step involves preparation of the Detailed Project Report which captures the information on the proposed technologies for installation, specifications, bill of material, cost elements, timelines for implementation as well as benefits that will accrue from the replacement of the existing system by and energy efficient system. The DPR should also highlight all the risk elements and methods to mitigate them.

Step 4 – Based on the DPR, the building society needs to prepare a tender/RFP document outlining the scope of work envisaged, qualifying criteria, terms and conditions, timeline for contract and invite bids from interested parties. Incentives, if any from any Government authority also needs to be considered while designing the RFP. Subsequently, the bid evaluation should be carried out and a suitable entity should be appointed for implementing the Energy Efficiency initiative.

Step 5 – the implementing agency and the building society should then carry out the implementation of the Energy Efficiency initiative.

Step 6 – the building society and the implementing agency should develop formats and mechanisms to measure and monitor the performance so that any course correction can be implemented, if required.

4.2.3 Case studies for successful energy efficiency lighting projects implemented by residential societies and energy savings achieved

The lighting audit was conducted in one of the premier residential society in the heart of Mumbai spread over the area of 11,00,000 Sq. Ft. The society has four towers each of thirty floors. The Society Management Committee initiated a project on energy savings and improvement of illumination level in society common areas such as garden, cricket ground, parking area, children play areas, clubhouse, stair case, lobby areas, corridors and lift areas in each tower. The existing inefficient spot lights, tube-lights, CFLs, metal halide and halogen lights were replaced with energy efficient LED lights. Total 5000 LED lights were installed. The project reduce lighting load from 260 kW to 155 kW with 60% reduction in overall lighting energy consumption with LED installations. The result show annual energy cost saving of INR 30 lakhs with an investment of INR 62 lakhs giving a payback period of 2.1 years. The details of LED light fixtures (Philips make) installed at indoor and outdoor areas is provided in Table below.

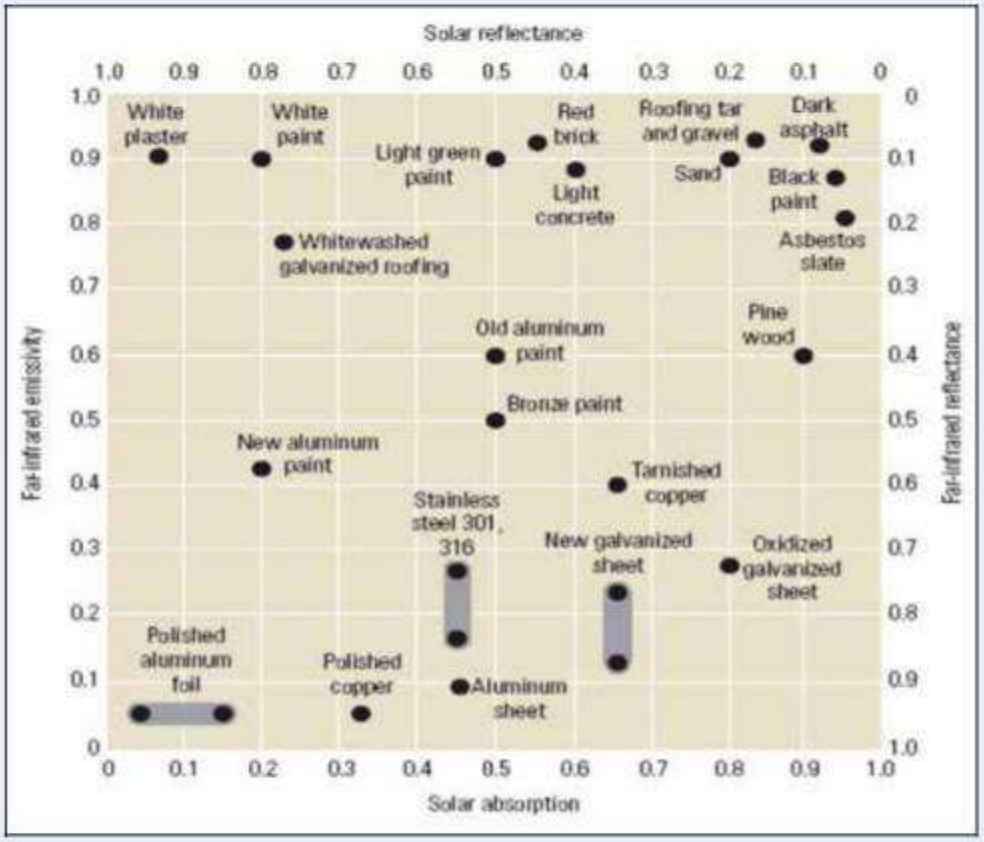
Sr. No	Existing Type of lights	Existing Qty.	Recommended New LED Wattage	Qty. for complete LED fixture replacement	Proposed LED Product Make, Number in Catalogue	Revised Unit Price of New LED light or Fixture (Rs.)	Total Cost of New LED Lights or Fixtures (Rs.)
1	PL (18W) down lighter fixtures (Entire campus)	1000	6-10W	1000	PHILIPS DN 151 LED 6S	**525**	5,25,000
2	PL (2X18W) down lighter fixtures (Entire campus)	1500	12W-15W	1500	PHILIPS DN 151 LED 6S	**525**	7,87,500
3	PL (18W) fixtures wall light in garden sitting arrangement	25	12W-15W	25	GU 10 6W (Retro Fitting) with Holders	**1,000**	25,000
4	PL (18W) fixtures foot lights and garden stair case leading to ground	20	12W-15W	20	BWG 150 LED Foot Lights	**4,500**	90,000
5	Outer wall compound Boundary/Periphery light fixtures (PL 18W)	50	12W-15W	50	GU 10 6W (Retro Fitting) with Holders	**1,000**	50,000
6	Tube lights (40W) + Cove lights 28W	2500	20W	2500	BN021 LED 20S	**480**	12,00,000
7	70W Round pole light fixtures	40	40W	40	Philips BRP409 LED 38S/40S	**4,300**	1,72,000
8	18W Bollard light Fixtures	80	12W-15W	80	BCP150 LED150/WW PSU 220-240V 7043	**7,500**	6,00,000
9	Emergency Stair Case 14 TL light fixtures	400	12W-15W	400	Philips Brightline 10W, 900 Lumens	**400**	1,60,000
10	250W Metal Halide Fixtures	4	170W	4	BVP410 LED 144 : 144W, 14,400 Lumens	**17,500**	70,000
11	50W spot light/garden lights/tree light fixtures	150	8W-12W	150	MR16 7.5W with fixture and Driver :for internal usage only as per my survey	**1,300**	1,95,000
12	70W Halogen spot lights reception entry	100	12W-15W	100	DN170 LED 10S with Metallic Enclosure	-	-
13	Decorative wall light fittings (pillar mounted)	26	40W	26	Its replacement not available	-	-
14	70W metal hallide fixtures	70	40W	75	50W LED Flood light for 70W Metal Halide Fixtures	**6,000**	4,50,000
15	70W metal hallide fixtures	70	40W	25	70W LED Flood Light for badminton court	**6,950**	1,73,750
16	2x1 Hanging LED tube light fixture in Cafetaria	5	Each fixture 42W	5	Cafeteria Kitchen area	**2,600**	
17	40W small threading lamps	24	8W-12W	NA	Screw Type :LED Candle Lamp	**250**	6,000
	Total			**4494**		**Total Amount**	**45,04,250**

Table 4-13: LED light implementation

4.3 COOL ROOF TECHNOLOGY

This technology is based on a simple scientific truth that the lighter surface reflects more of the light incident upon it. More the surface reflects, less heated it is. In an urban landscape, reduced vegetation, increased Green House Gas creates a phenomenon termed as “heat islands”. The air conditioners hence use more energy to cool the room in turn leading to expenditure of lakhs of rupees.

Cool Roof technology promotes usage of material which has high reflectance as well as high emissivity. The magnitude of energy savings depends upon building type, level of roof insulation, ventilation rate between roof and ceiling and roof solar reflectance. Cool roof technologies include coatings, membranes, tiles, etc. While a conventional roof reflects 30 - 60% of the incident solar radiation, a cool roof reflects 80% of the incident solar radiation.



***Source**: An introduction to Cool Roof, USAID*

Figure 4-6: Material used for cool roof

The above figure shows the materials which can be used for cool roof. A material with high solar reflectance and high emissivity is an ideal option for cool roof. As shown in the figure, white plaster is one of the most suitable material for cool roof.

A typical heat resistant product/paint specification is as per below table.

Particulars	Specifications		
Make	Dr. Fixit Heatshield, Pidilite	Ozo Protect	Star Cool Shield
Appearance	Free flowing, homogeneous & uniform paste.		Smooth and Uniform
Colour	White	Brilliant White	White
Sp. Gravity	1.01	1.25	
Solid Content, %	>60	50-60	>65 (by weight)
Tensile Strength N/mm$_2$	0.276		0.878
Abrasion resistance	No wear after 450 litres of falling sand	4000 no. of cycles	
Coverage	3m$_2$ per litre per coat	0.167 kg/Sq.Mt. **200 mic / 2 coats**	
Solar Reflective Index (SRI)	83.8%	104 as per ASTM E 1980	130 as per ASTM E 1980
Thermal Emittance		0.885 as per ASTM ASTM C 1371	0.99 as per ASTM C 1371
Solar Reflectance	0.94	0.83 as per ASTM 1549	1.00 as per ASTM C 1549
Cost in INR	465 per kg (approx.)	530 per kg	490 per kg

Table 4-14: Specifications of heat resistant product/paint

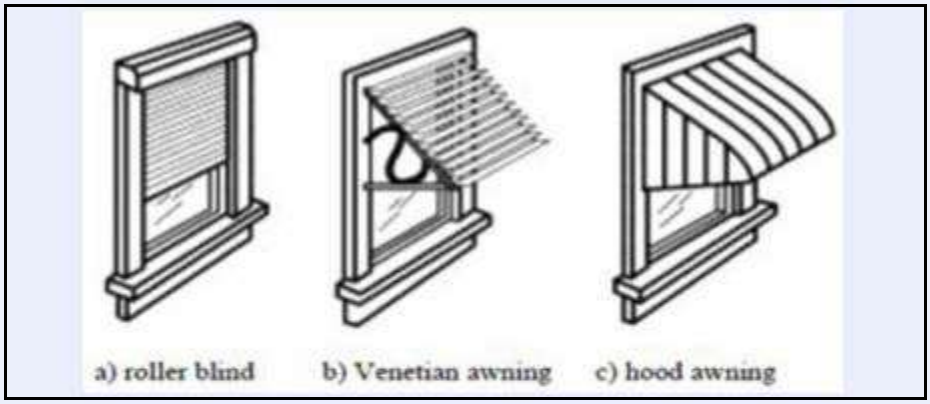
4.3.1 Case studies for successful implementation of cool roof projects in buildings and energy savings achieved

Few commercial establishments have implemented cool-roof technologies.

1. A demonstration project was conducted at two office buildings (two storeys) with roof area of 700 meter-square in Hyderabad. White reflective cool roof coating was applied to the roof. The average daily summer temperatures daily surface roof temperature was reduced by 20° centigrade. The average reduction in energy consumption was around 15%.
2. Godrej Corporate House developed their buildings terrace into original green roof by removing the covering of the “tandoor” roof clay tiles. The green roof has a soil depth of nine inches. The Godrej team measured the reduction in roof temperature by 10$_o$ centigrade by thermal imaging camera. The green roof reduced heat entering the building and has contributed in cooling top floor of the building.

4.4 EXTERNAL SOLAR SHADING

External solar shading is beneficial for reducing cooling demand and increasing thermal comfort. Depending on the amount and orientation of glazing on a building, external solar shading measures can reduce interior temperatures by 6 to 8 °centigrade on a hot day, reducing cooling demand by 30 to 50% in warm climates and avoiding the need for air-conditioning altogether in some more moderate climates.



***Source**: High-rise Refurbishment: The energy efficient upgrade of multi-story residences in the European Union*

Figure 4-7: External solar shading types

4.5 ELEVATORS/LIFTS

In a high-rise residential society, elevators/lifts consume around 50-54% of total energy consumption in common areas. They are quite essential to contemporary needs not only because it reduces time of vertical travel but also because it facilitates movement of elderly people.

Elevators have traditionally been developed and designed based on space restriction, reliability and comfort, riding comfort, etc. Energy efficiency has not been a major market and technological driver in this sector. While it has been known to be energy intensive system, technological developments for reduction in energy consumption in elevators have seen major development economically only in recent years. While replacement of complete lifts is very cost intensive and not recommended but we have touched upon energy efficiency technologies which could be easily retrofitted in old age lifts without major infrastructure changes.

There are two main classes of lifts: traction and hydraulic lifts. Normally, traction lifts are preferred in high-rise buildings. **Traction Lift**

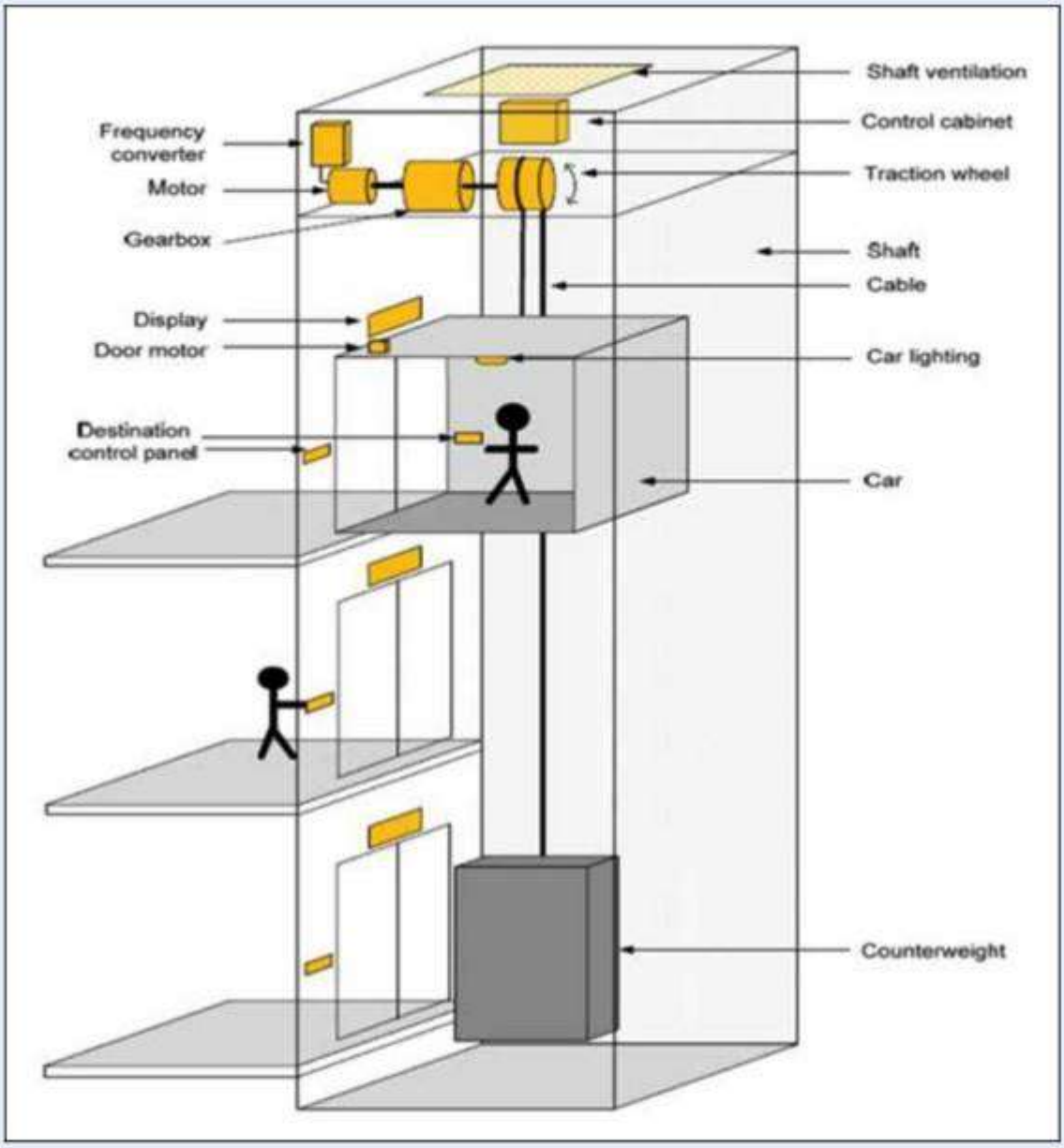
In traction lifts, the car is suspended by ropes wrapped around a sheave that is driven by an electric motor. The weight of the car is usually balanced by a counterweight.

Hydraulic Lift

This type of lift uses a hydraulic cylinder to move the car. An electric motor drives a pump which forces a fluid into the cylinder. Valves control the fluid flow for a gentle descent, allowing the hydraulic fluid (usually oil) to flow back to the tank. Hydraulic lifts only consume energy to lift the car. During downwards travel the car descends due to gravity and controlled oil flow. Typically, hydraulic lifts are not suitable for high-rise buildings.

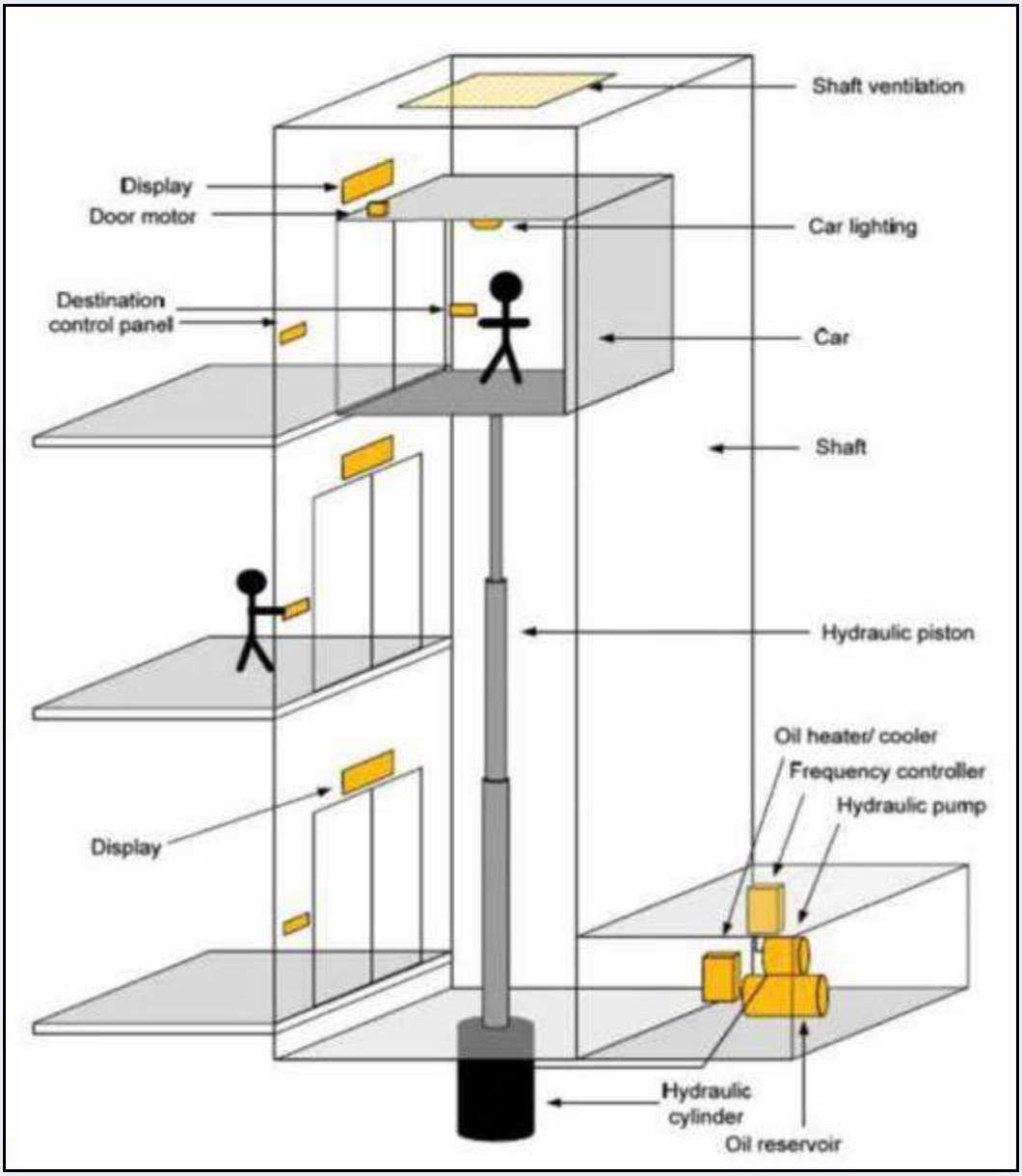
In an elevator system, most common losses are

a. Friction losses
b. Transmission losses
c. Motor losses
d. Brake losses
e. Lighting losses
f. Controller losses



Source: *Energy Efficient Elevators and Escalators, Intelligent Energy : Europe, March 2010*

Figure 4-8: Schematic diagram of a traction lift



***Source**: Energy Efficient Elevators and Escalators, Intelligent Energy : Europe, March 2010*

Figure 4-9: Schematic diagram of a hydraulic lift

4.5.1 Advantages and disadvantages of a typical conventional hydraulic lift over traction lift

Advantages	Dis-advantages
• **Installation** is very **simple and fast.** • **Less space is occupied** by equipment, such as controls, motor, and pump and therefore the overhead machine room becomes unnecessary. These parts are normally located in low-cost areas of the building such as basements or below stairs. • Conventional hydraulic units do not have counterweights which allows for **narrower shafts**. The absence of counter weights also diminishes the load on the building's structure. • The load is transferred to the ground and not to the building's structure which translates into **lower construction requirements and costs**. • **Emergency procedures** in hydraulic lifts are relatively **simple**. The car can be lowered by means of a manually operated emergency valve. Likewise, a hand pump can be used to lift the car in the event of power failure or control equipment failure.	• **High energy consumption** since the entire weight of the car must be lifted. • High demand on the power supply when moving up. • **Limited rise, speed of operation** and number of starts per hour. • Because oil viscosity changes with temperature, **oil cooling or heating** is sometimes **required** to maintain ride quality and performance.

Figure 4-10: Comparison of Hydraulic lift system with traction lift

4.5.2 Energy efficient technologies in elevators

a. Premium efficiency induction motors

Traditionally brushed DC motor have been used in an elevator owing to its widely-known benefits of easy control, ride quality and accurate levelling. But, it requires more maintenance because of the presence of brushes. Hence, in the recent past, Induction motors have been developed to serve the application in an elevator owing to lower cost, less maintenance and robustness. High efficiency induction motors have been developed with superior magnetic materials, larger magnetic circuits with thinner laminations and other technically improved materials and systems to provide improved efficiency, and lower losses.

b. Regenerative drives

Regenerative drives are systems that can convert or store braking energy from a moving lift car. In conventional traction lifts, braking energy is dissipated by a braking resistor. A regenerative system allows energy to be recovered and fed back into the building. In other words, when an elevator with a heavy car load moves downwards or a light car load moves upwards, the traction machine acts as a power generator and transmit power back to the electrical network in the building. Saving potential varies from 30% for small lifts (capacity-630 kg, Speed-2.5m/s) to 40% in lifts installed for heavier traffic (2200 kg, 2.5 m/s). Because it adds a significant cost to the installation, regeneration is not always cost effective, especially with reduced traffic in low- and mid-rise buildings.

c. Double permanent magnet configuration

Use of Permanent Magnet Synchronous Motors (PMSM) presents many advantages, such as simplified mechanical system for the lift, improved comfort, reduced noise and vibration, and energy savings. The permanent magnet motors have higher efficiency and present faster response speeds when compared to conventional induction motors. The use of PMSM helps in avoiding the need of a separate machine room which traditionally houses motor and control system. This results in saving of space and cost.

Also, door system using high-precision PMSM without mechanical reduction gear avoids energy loss of the corresponding structure, while improving transmission efficiency, safety and comfort of elevator.

d. Machine room less elevators (MRL)

The introduction of synchronous motor and Variable Voltage Variable Frequency (VVVF) drive system and PU coated flat wire ropes has brought a revolution in the elevator business. This has helped in reducing the overall weight of the machine unit to a great extent. With reduction in size and weight of the machine unit, it has become possible to install it inside the elevator shaft. The size is so small that it can be installed inside the lift shaft at the top in a small space. These are now termed as machine room less MRL elevators. Beside small in size and light in weight, it is also energy efficient. With gear less unit and use of VVVF drive system energy savings of up to 50% as compared to the conventional elevators can be achieved.

e. Usage of control strategies

Lift is a system which uses a combination of lot of sub-systems based on the type of lift that is in operation. Hence, to have an efficient system, it is important to have a control system that controls the sub-system not only in a flawless but also in an efficient way. In this regard, microprocessor and software based controls provides a better option as compared to traditionally used electro-mechanical relays which are prone to losses and slow.

Lifts consume energy even when they are not raising or lowering loads. This energy consumption can represent more than 90% of the total electricity consumption in lifts with a low number of daily trips and is attributable to equipment that is constantly working, such as control systems, lighting, ventilation, floor displays, etc. To achieve energy savings in these loads, there are two possible approaches: to use equipment with better efficiency than the standard equipment used and to switch off such equipment when the lift is idle. Lighting in particular is one of the loads that contribute to high standby consumption. Ventilation also contributes substantial portion of this standby load. Installation of occupancy sensor or automatic switching off these loads when lift is idle can help in minimizing the standby consumption of electricity.

4.6 HEAT PUMPS

In India, MNRE has been pushing concept of SWH for domestic and commercial applications. The estimated potential of SHW, assuming that 75% of pucca houses of the country, occupied by the owners, will have SHW, could be taken as 140 million m2 of collector area. However, the achievable / economic potential based on purchasing power of people and requirement, availability of space and availability of solar radiation etc. may, however, be taken as 35-40 million m2 of collector area.

Considering all parts of the country and maximum installations in areas where hot water requirement is more during the year, average saving could be taken as 1200 kWh/year for a 100 LPD system

The SWH system has 2-fold benefits, viz.,

- Peak Load Shaving: A 100 LPD system can replace an electric geyser of 2 KW and thus, 1 million such systems would replace 1 million geysers of 2 KW capacity each in homes. Assuming that at least 50% of geysers are switched ON at a time, this will have a peak load shaving of 1000 MW
- CO2 Reduction: A 100 LPD system on an average would save up to 1200 kWh / annum. To generate the same amount of electricity from a coal based power plant, 1.2 MT of CO2 per annum would be released in the atmosphere. One million solar water heating systems installed in homes will, therefore, also result in reduction of 1.2 million MT of CO2 emissions in atmosphere

The SWH systems have become popular in tier-2 cities and towns, where individual homes have terrace space to install the SWH system. However, it has not become very popular in the large cities, where high-rise residential buildings are common. The population density in these cities is very large and number of floor are increased, from a G+3 residential buildings, now a stilt+14 structures have become a norm in cities such as Mumbai, Kolkata, Bengaluru, Chennai, Hyderabad etc. Thus, providing adequate hot water as per the requirements to all the flat owners becomes little challenging. In order to generate surplus hot water, Heat Pumps can be used as supplementary technology to SWH systems for meeting the SHW demand in high-rise residential buildings.

4.6.1 Types of heat pumps

The Heat pumps include a wide range of products that transform low temperature heat from sources such as air, water, soil or bedrock into higher temperature heat that can be used for heating. Heat pumps can also be reversed and function as space coolers.

However the designation heat pump implies to type of refrigeration system where heat rejected at condenser is also used instead of simply being dissipated to the atmosphere.

There are mainly 2 types of Heat Pumps, viz. ‘Ground Source Heat Pumps’ or ‘Air Source Heat Pumps’. These terminologies have been derived from the source of energy being used, which is either ground (earth) or air.

In Europe or North America, where the temperature difference between summer and winter is significant and the earth or ground acts as a source heat. These heat pumps replace boilers, used for heating.

Whereas, in India, where the climate is mild (or temperature difference between summer and winter is not so drastic, “heat in the air” is collected and used by heat pumps for space heating and mainly for hot water supply. These are known as ‘Air source Heat Pumps’.

The Heat pumps can deliver hot water at 50-60° centigrade and the by-product would be chilled water or cool air, depending on the user requirements.

Among the ‘Air Source Heat Pumps’, refrigerant based vapour compression heat pumps are commonly used over thermal heat pumps, i.e. vapour absorption type systems.

Refrigeration based vapour compression heat pumps

Principle of operation of these heat pumps is same as vapour compression air conditioners. Low pressure refrigerant liquid is converted to low pressure vapour after exchanging heat with environment or process cooling fluid. Low pressure vapour from evaporator is compressed to high pressure (as per the requirement of hot water or hot air). This high pressure vapours condensed in evaporator to cater hot water/hot air or process fluid heating. Condensed liquid is fed back to evaporator via expansion device.

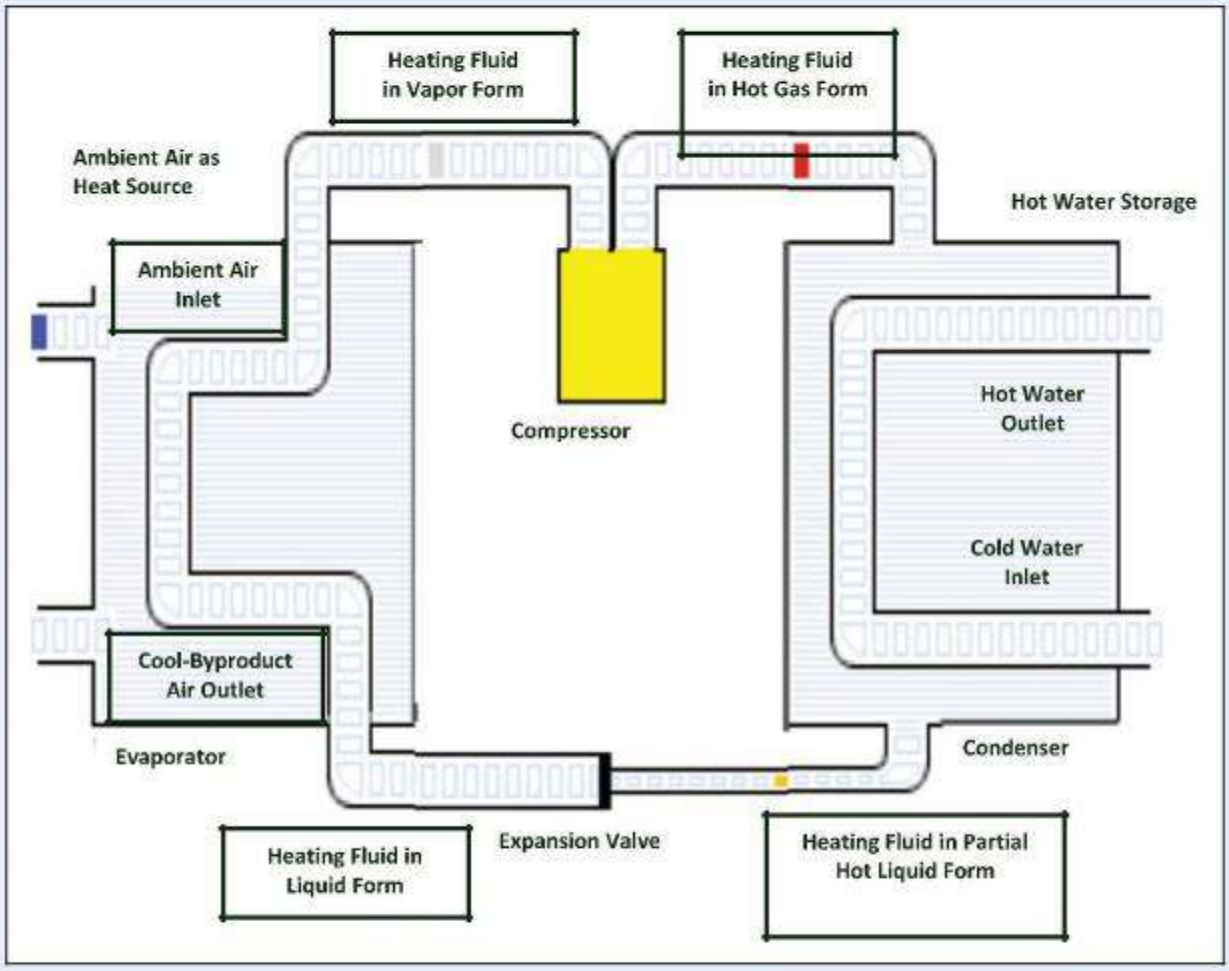


Figure 4-11: Refrigeration based vapour compression heat pumps

4.6.2 Performance of heat pump

Performance of heat pump is expressed in terms of coefficient of performance (COP). COP is the ratio of heating effect to energy input in same units.

For vapour compression system:

COP = (Power to compressor motor + power derived from heat source) / (Power to compressor motor)

For absorption system: COP = (Heat input to generator + cooling load at evaporator) / (Heat in put to evaporator)

Selection criteria

1. Heat pumps are generally selected based on whether cooling load or heating load is governing. Sometimes primary requirement of heat pump is to meet cooling requirement of process/ air conditioning and whatever heating output is obtained is used for the process and vice a versa for primary heating requirement.
2. Vapor absorption type heat pumps are generally selected when there is availability of waste heat or availability of steam generated from solar system.
3. Heat pumps are sometimes also selected to utilize low temperature heat availability at lower temperature to convert it into at high temperature for a process use. For e.g. Earth.
4. For some process especially paint shop there is requirement of hot water at lower temperature at 45 to 50 °centigrade. For such applications it is better to use a heat pump which has lower energy consumption compared to electrical heating.

4.6.3 Green procurement guideline for heat pump

Using an heat pump for simultaneous cooling and heating requirement is itself a green approach, since its energy consumption is much lower than the energy consumption of separate process for generation of heating and cooling.

Following care needs to be taken during the procurement process so that it becomes even greener for environment:

1. Refrigerants are the biggest contributor to environmental issues of Greenhouse gas effect (GHG), Ozone depletion, and global warming. Refrigerant shall be selected based on their potential for above hazards.
2. Detailed feasibility study shall be conducted for estimating heating and cooling load to avoid over sizing or under sizing of equipment.
3. Heat pumps are most energy efficient if both heating and cooling output is utilised.
4. For system which has variability in either cooling or heating load, alternate provision at evaporator and condenser shall be made with proper automation and control. For system which has constant cooling demand but not heating, in that case an ambient condenser shall be kept so that system keeps operating for cooling load.
5. If heat pump is being used for generation of hot water only for domestic purpose than its COP decreases with decrease in ambient temperature.

4.6.4 Case-study

The effectiveness of using Heat Pumps in a congested high-rise building has been illustrated for easy understanding.

- Site Location: Near Mumbai
- Total 11 Buildings with BUA of 2.45 million ft_2
- 1 building has 11 floors X 2 wings X 6 flats per floor
- Other 10 buildings have 30 floors X 4 flats per floor
- Total No. of flats are 1250
- The flats vary from 2 BHK to 4.5 BHK configuration
- There are 3500 bathrooms in the project it contains geysers of 3kW each (@ INR 1500 / geyser) = INR 52 Lakh

The installation of SWH system would be as under:

Total No. of flats	Nos.	1250
Person per flat (Assumed)	Nos.	5
Hot water requirement (as per NBC)	litre/person	40
Total Hot water requirement	KL/day	250
Cold water temperature	°centigrade	25
Hot water temperature	°centigrade	60
Energy needed for water heating	kCal/day	8750000
Electrical Energy needed @90% efficiency	kWh/day	11305
Area required for SWH on terraces	m2	6250

Table 4-15: Calculations for SWH system

The energy consumption of electrical geysers during non-sunny days (i.e. during monsoon) would be 6.78 Lakh kWh and for energy cost @ INR 5/kWh, the amount would be INR 33.90 Lakh.

If we plan to install Heat Pumps to meet the above hot water requirement, the working would be as under:

Capacity of Heat Pump	kL/day	20 each
No. of Heat Pumps to be installed	Nos.	12
Heat Pump Energy Consumption (@223 kWh/day X 12)	kWh / day	2675
Savings in Energy Consumption	kWh / day	(11305 – 2675) = 8630
	kWh / day	8630
Savings (@ INR 5 / kWh)	INR Lakh / annum	158
Cost of Heat Pumps	INR Lakh	450
Added Cost of Piping, Insulation	INR Lakh	100
Simple Payback Period	Months	((450 + 100 – 52) / 158) X 12= 38

Table 4-16: Calculations for heat pump based system

The simple pay-back period for installing Heat Pump works out to be 38 months.

Figure 4-12: Actual image of a 10000 litre/day capacity heat pump

There is immense potential for integration of renewable energy projects such as solar roof-top and energy saving projects in residential societies. The choice of technologies is dependent on cost benefit analysis and priority for implementation. Ideally, the residential societies are suggested to follow a phase-wise approach for implementation of such projects. The low cost and medium cost projects such as indoor and out-door LED lighting with automation and control systems could be implemented in first phase of the project. In second phase they can target water pumping and distribution system for replacement or installation of solar water heating systems. In third phase they can take up long term and cost intensive projects such as roof-top solar power generation, cool roof and lift upgradation. In this chapter we are providing different models available for project implementation and evaluation framework for selection of any model for implementation.

There are following four project implementation models discussed in this chapter:

1. Society will take loan from bank for implementing energy efficiency and renewable energy projects and appoint EPC contractor for implementation.
2. Solar roof-top leasing model - design build own, operate and transfer model for implementation of solar roof-top project.
3. Implementation of energy saving projects based on guaranteed savings by ESCO and annuity base mode of payment - design build own, operate and transfer model for implementation.
4. Creating a pool - building societies come together to implement energy efficiency projects on a larger scale by appointing a common ESCO.
5. Equipment supplier credit is another model largely used by residential societies currently wherein societies make lump-sum payment to supplier after commissioning over time.

The selection of model could be based on the following parameters:

1. Availability of funds with the residential society and competitive market financing available to residential societies for such project implementation.
2. Willingness to implement the project and ease of implementation.
3. Willingness of society to take project risk or pass on the risk to ESCO.
4. Technical capability and availability of time to take up projects for implementation.
5. Ability to ensure efficient operation and maintenance of the technologies.
6. Risk versus returns to residential societies from each of the business models.

The maximum returns to the society will accrue when the society implements the project by appointing EPC contractor and taking term loan from financial institutions for equipment procurement and installation.

It is important to analyse as to how a project will be evaluated from the perspective of a credit department of bank (for which a building society seeks loan from a bank) or how should a building society evaluate a project before deciding on its implementation. The project would typically be analysed on the basis of the following parameters:

1. **Technical Appraisal** – It covers evaluation of energy savings, technology, and proposed project implementation plan.

2. **Financial Appraisal** – It covers evaluation of pre-operative expenses, equipment costs, project implementation charges, interest during construction period, contingencies, promotors contribution, term loans, working capital for yearly operation and maintenance and repairs, profitability or cash flow projections, interest ratio, debt equity ratio, debt service coverage ratio, payback, internal rate of return, weighted average cost of capital.
3. **Environmental Appraisal** – It covers evaluation of Government notifications on pollutions and its applicability to the project.
4. **Legal Appraisal** – Evaluation of statutory obligations, terms and agreement with suppliers, loan security arrangements, title on the property, bank guarantee etc.
5. **Policy and Regulatory Appraisal** – Evaluation of the compliance of the project with the existing policy and regulatory framework prevalent.

Prior to discussing the project evaluation framework, it would be worthwhile to note the definitions of some of the financial terminologies commonly used in project evaluation.

1. **Simple Payback period**: It is the ratio of capital cost to the average annual savings. It does not use discounted cash flow and hence does not indicate the return on project. It also does not consider the savings produced after the payback time. The method is used for projects with short payback period.
2. **Internal Rate of Return (IRR)**: Based on the discounted cash flow method, IRR is rate of discount that equates to present value of energy savings (cash inflow) to the present value of cash outflow. Methodology for calculation of post-tax IRR is given below:
    a. Cash outflow in each year will include capital expenditure cost
    b. Cash inflow includes net energy savings after tax, plus interest, plus depreciation plus, plus salvage value at the end of tenure of the loan
    c. Cash flow projections till the end of tenure of loan (includes moratorium period if any)

    For an EE project, it is recommended that, the post-tax IRR should be greater than or equal to weighted average cost of capital.
3. **Debt Service Coverage Ratio (DSCR)** = (Annual net energy savings post tax + Depreciation + interest on term debt)/ (Repayment of Debt + interest)
    Minimum DSCR should be greater than 1.25 times and average DSCR should be greater than 1.75 times for any project.

The DPR which will be prepared after energy audit study should provide detail techno-commercial feasibility of the project. The framework for evaluation of technical and financial feasibility is illustrated considering an example of replacement of outdoor lighting with LED lights.

- **Project Assumptions** – To compute the payback period or the Net Present Value of the proposed project, a few assumptions need to be made. For example, in case of a LED street light project, in order to assess the savings, the number of hours of operation of the street lighting needs to be assumed based on the typical usage pattern. Similarly, maintenance cost per unit may also need to be assumed. The assumption matrix for a LED street light project is given below:

Assumptions	Units	Values
Total number of days in year	Days	365
Operating Hours Per Day	Hours	12
Annual Operating Hours	Hours	4,380
Project Life	Years	7
Tariff rate for street light INR/kWh (Assuming average residential tariff rate for Mumbai Discoms)	INR/kWh	10
Annual Escalation in tariff rate	%	2
Maintenance cost per SPV light per year	INR	500
Maintenance cost per LED street light per year	INR	300
Annual Escalation for annual maintenance for SPV lights	%	5
Annual Escalation for annual maintenance for LED lights	%	3
Life of SPV street light	Years	3
Life of LED street light	Years	7
Depreciation rate for LED assuming 90% depreciation in 7 years		12.86%
It is assumed that Building Society does not have any tax liability		

Table 5-1: Assumption matrix

- **Cost structure existing and proposed** – The following tables show the existing cost structure for Sodium Vapour lights and the proposed scenario for cost structure

Type of light	Quantity	Watt	Ballast wattage	Cost (INR Per Unit)	Annual energy consumption (million units/ annum)	Capital Cost (INR Lakhs)	Connected load (kW)
Sodium Vapour Lamp 250W	150	250	30	5,500	0.18	8	0.042
Sodium Vapour Lamp 150W	100	150	18	4,500	0.07	5	0.0
Sodium Vapour Lamp 70W	70	70	8	2,500	0.02	2	0.0
Total	320				0.3	14.5	0.1

Table 5-2: Existing light installation – existing scenario

Type of light	Quantity	Watt	Ballast wattage	Cost (INR Per Unit)	Annual energy consumption (million units/ annum)	Capital Cost (INR Lakhs)	Connected load (kW)
LED luminaire	150	125	-	13,500	0.08	20	0.01875
LED luminaire	100	90	-	10,000	0.04	10	0.0
LED luminaire	70	70	-	4,500	0.02	3	0.0
Total	320				0	33.4	0.0

Table 5-3:LED light installation – proposed scenario

- **Capital Structure** – the capital structure is the entity's various sources of funds used to finance its overall project. It is a mix of debt and equity as well as the rate of interest of such debt and expected return on the equity funding. The following table shows the typical capital structure for the LED street light project.

Particulars	Value
Equity Funding	10%
Expected Return on Equity	16%
Debt Funding	90%
Cost of Long Term Debt (interest rate charged by bank)	13.0%
Discount Rate (assumed for calculation of Net Present Value)	13.30%

Table 5-4: Capital structure

- **Computation of energy savings** – the following table shows the computation of energy savings by implementation of LED street lighting project.

Particulars	Values								Total
Year	**-**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Baseline Scenario									
Annual Energy consumption		0.28	0.28	0.28	0.28	0.28	0.28	0.28	
Annual energy cost (INR Lakhs)		28.16	28.72	29.30	29.88	30.48	31.09	31.71	
Annual maintenance cost with escalation (INR Lakhs)		1.60	1.68	1.76	1.85	1.94	2.04	2.14	
Total Operating Cost (a+b)		29.76	30.40	31.06	31.73	32.42	33.13	33.85	
CAPEX for new street lights		-	14.50	-	14.50	-	14.50	-	
Total Cost (a+b)	-	29.76	44.90	31.06	46.23	32.42	47.63	33.85	
Discounting factor	1.00	0.88	0.78	0.69	0.61	0.54	0.47	0.42	
NPV (A)	**-**	**26.26**	**34.98**	**21.36**	**28.06**	**17.37**	**22.52**	**14.13**	**164.67**
Proposed Scenario									
Annual Energy consumption		0.14	0.14	0.14	0.14	0.14	0.14	0.14	
Annual energy cost (INR Lakhs)		14.30	14.59	14.88	15.18	15.48	15.79	16.10	
Annual maintenance cost with escalation (INR Lakhs)		0.96	0.99	1.02	1.05	1.08	1.11	1.15	
Total Operating Cost (a+b)		15.26	15.58	15.90	16.23	16.56	16.90	17.25	
CAPEX for new street lights	33.40								
Interest cost		3.91	3.53	3.11	2.63	2.09	1.47	0.78	**12.07**
Repayment/Amortization (-)		4.29	4.29	4.29	4.29	4.29	4.29	4.29	
Total Cost (a+b+c)	33.40	14.87	14.81	14.71	14.56	14.35	14.08	13.74	
Discounting factor	1.00	0.88	0.78	0.69	0.61	0.54	0.47	0.42	
NPV (B)	**33.40**	**13.13**	**11.54**	**10.11**	**8.84**	**7.69**	**6.66**	**5.73**	**97.09**
Energy savings (Million kWh/annum)		0.14	0.14	0.14	0.14	0.14	0.14	0.14	
Proposed Total Cost Savings	(33.40)	14.88	30.09	16.35	31.67	18.07	33.55	20.12	
Present Value of Proposed Savings (A-B)	(33.40)	13.14	23.44	11.24	19.22	9.68	15.86	8.39	**67.57**
Simple Payback	**2.68**								
Internal Rate of Return	**62%**								

Table 5-5: Computation of energy savings

- The summary of the financial evaluation of the project is provided below:

Particulars	Value
Project tenure	7 years
Equity investment by Building Society (INR Lakhs)	15
Loan from Bank (INR Lakhs)	30
Interest paid to Bank for 7 years (INR Lakhs)	18
Total savings in connected load (MW)	0.0
Total savings in million kWh	97
Total cost savings to Building Society (INR Lakhs)	24
Simple Payback	2.68
Internal Rate of return	62%

Table 5-6: Project evaluation matrix

Thus the project provides very good returns and simple payback period is lesser than 3 years, so the project is viable and needs to be implemented by the residential society.

5.1 DEBT-EQUITY MODEL (LOAN FROM BANK)

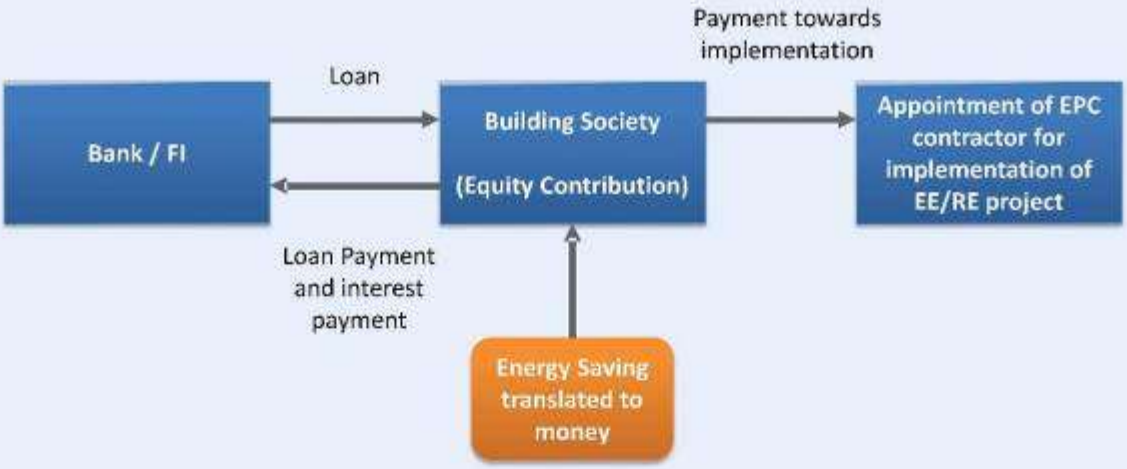


Figure 5-1:Mechanism for debt equity model

5.1.1 Model – debt-equity funding model for implementation

- Under this model, a building society will engage an Engineering, Procurement and Commissioning (EPC) contractor for implementation of the identified Energy Efficiency or Renewable Energy initiative. The building society shall design and procure the material and equipment required according to specifications directly and the EPC contractor will only be responsible for the installation and commissioning of the project.

- The building society shall part fund the project from its internal resources (equity for the project) and the balance funding can be availed from a bank. The consolidated funds shall be used for the following
    - Payment to the EPC contractor
    - Procurement of the material/equipment for the project
    - Consultancy fees
    - Operation & Maintenance of the project
- The energy savings which accrue due to the initiative will translate into a lower energy bill for the society and the money thus saved can be used for the repayment of the loan and interest payment to the bank. The building society should negotiate the tenure of the loan from the bank to coincide with the duration of the EE / RE project.

5.1.2 Roles and responsibilities

Building Society	EPC Contractor
• Design the technical specifications of the EE / RE project. • Procure material / equipment for the project. • Provide space for implementation of the project to the EPC contractor. • Contribute equity funding for the project. • Negotiate a term loan from bank for part funding of the project. • Make payment to EPC contractor for installation and commissioning services/ O&M (if included in the contractor's scope). • Make principal repayment and interest payment to the bank.	• Installation and commissioning of the EE / RE project as per design specifications provided by the building society. • Carry out metering for recording of energy generated for RE projects. • Assistance in Monitoring & Verification for energy savings in EE projects. • Ensure compliance to specifications of the rooftop system. • Liaison with electrical utilities and comply with all the statutory obligations for installation of RE project.

Figure 5-2: Roles and responsibilities of key stakeholder

- In this model, the project risk is borne by the residential society because it has funded the project completely by way of loan from bank and equity from internal resources. However, since the EPC contractor is responsible only for installation and commissioning, the underlying asset will be owned by the building society and the risk is mitigated to that extent. The building society and the EPC contractor should enter into a contract agreement defining the terms and conditions, scope of work, roles and responsibilities, payment mechanism, duration of the project etc. The contract between the building society and EPC contractor can be extended at the end of the period based on mutual agreements and terms and conditions, if required.

5.1.3 Advantages and dis-advantages of the model

Advantages	Dis-advantages
• Ownership of material/equipment is with society. • Energy savings from EE project or RE generation are entirely retained by the building society. • The project is part funded by the bank. • There is proper due-diligence carried out before implementation.	• There is a liability to repay the loan and service the loan (interest payment) to the bank. • Fluctuating interest rates can lead to increase in project cost. • Dependency on the EPC contractor for liaisioning with the utility. • Dependency on EPC contractor for project implementation.

Figure 5-3: Advantages and disadvantage of debt-equity funding model

5.2 ROOFTOP LEASING MODEL

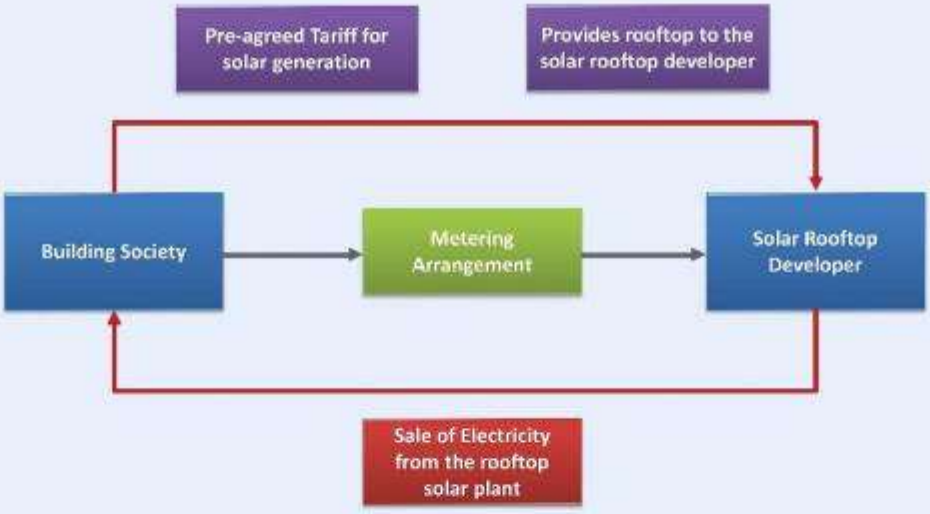


Figure 5-4: Mechanism for roof-top leasing model

5.2.1 Model – design build own, operate and transfer model for implementation

- Under this model, a building society will engage a solar rooftop developer for establishment of the rooftop solar plant. The capacity of solar roof top plant will not exceed the existing contract demand of residential society. Procurement, installation and commissioning and annual maintenance of the solar roof-top power plant will be in the scope of the developer. The residential building society shall lease out the rooftop to the developer for 10 years. There will be power purchase agreement between the developer and residential society. The electricity generated will be purchased by the residential society for its own consumption at a predetermined rate per unit. This rate will be lower than their existing applicable tariff rates for Discoms and will be one of the parameter for bidding and selection of developer. Minimum of 80% of daily solar electricity generated will be used in house by residential

society. A metering arrangement shall be made to record the generation, sale of electricity to residential society and sale of electricity to grid from the solar power plant. The developer will be permitted to sale surplus power to the grid. After 10 years, the developer will transfer the plant to the residential society in fully operational condition. The selection of developer will be based on following bidding parameters:

- Quoted rate for lease of terrace
- Quoted rates for sale of electricity to society
- Quoted rates for operation and maintenance cost per year.

5.2.2 Roles and responsibilities

Building Society	Solar Rooftop Developer
• Ownership of material/equipment is with society. • Energy savings from EE project or RE generation are entirely retained by the building society. • The project is part funded by the bank. • There is proper due-diligence carried out before implementation.	• There is a liability to repay the loan and service the loan (interest payment) to the bank. • Fluctuating interest rates can lead to increase in project cost. • Dependency on the EPC contractor for liaisioning with the utility. • Dependency on EPC contractor for project implementation.

Figure 5-5: Roles and responsibilities of key stakeholder

- In this model, the project risk to residential society is mitigated because the building society does not have to fund the project upfront and the payments to the developer are linked to the sale of electricity to residential society. For creating a payment security mechanism, the parties will create an escrow account with a bank in favour of the developer, where the building society shall deposit money equivalent to its three months' present electricity bill and shall replenish the same after every three months. The solar plant shall be asset of the developer till the contract period. The contract between the building society and rooftop developer can be extended at the end of the lease period based on mutual agreements and terms and conditions.

5.2.3 Advantages and dis-advantages of the model

Advantages	Disadvantages
• No upfront investment by building society. • Efficient use of rooftop and also helps in reduction of ambient temperature of floors below. • Reduces consumption from the power grid and leads to electricity cost saving. • No operation and maintenance by residential society	• If the society implements the project from its own investment the overall project cost will reduce by atleast 12% • Structural integrity of the building needs to be maintained even after installation of solar plant which can pose a challenge. • The roof cannot be used by the society. • Altough society will get solar power for consumption, still they will have to maintain electricity connection from Discoms and pay some monthly electricity bill to Discom • Incase the roof top area and connected load is lesser, the developers may not be interested in working on this model

Figure 5-6: Advantages and dis-advantages of model

5.3 ESCO SHARED SAVINGS MODEL

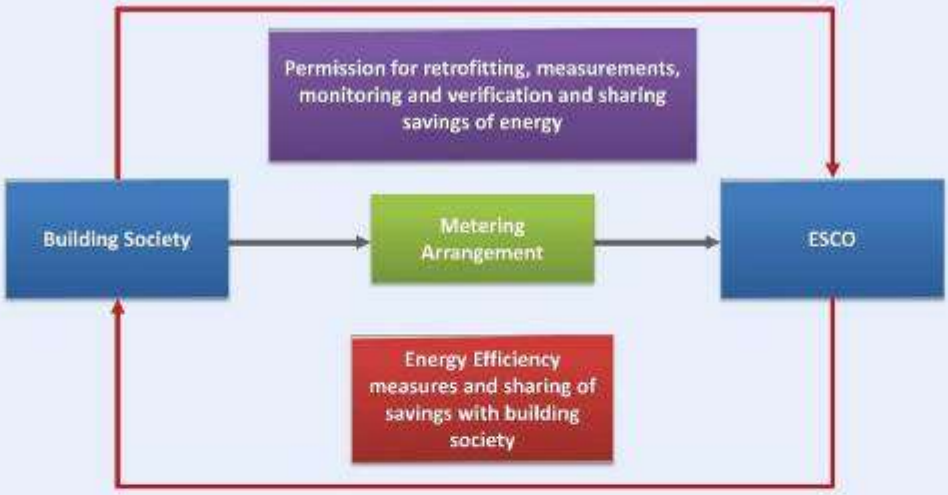


Figure 5-7: Mechanism for ESCO model

5.3.1 Model description

- Under this model, a building society will engage an Energy Service Company (ESCO) for implementation of building energy efficiency measures in the common areas/facilities of the building society. Procurement, installation and commissioning and annual maintenance of energy efficient technologies will be under the scope of the ESCO. The ESCO will demonstrate achievement of minimum guaranteed energy savings post implementation of the energy efficiency project. Based on the achievement of the minimum guaranteed energy savings, the Society will pay to the ESCO a pre-determined annual fee as per the energy service contract agreement.

5.3.2 Roles and responsibilities:

Building Society	ESCO
• Conduct independent energy audit for the lighting and water pumping energy efficiency projects to ascertain the costs and energy savings. • Carry out bidding process to select the ESCO for the project. • Select ESCO and sign energy service performance contract • Provide all support for implementation and give access to the staff of the ESCO as required • ESCO will be paid as per the ESPC after successful installation as per energy saving performance contract. • After completion contract period entire energy savings benefits and new LED common lighting/ EE water pumps will be handed over to the building society.	• Procurement of all material, equipment and labour for implementation of EE projects. • Transportation of material and labour to site. • Make provisions for energy metering on sample basis atleast • Removal of old material and handing it over to society • Ensure compliance to the energy service performance contract agreement (ESPC). • Carry out energy audits for common lighting and water pumping system. • ESCO will finance for initial investments of the EE projects.

Figure 5-8 Roles and responsibilities of key stakeholder

5.3.3 Model design

- Energy Service Performance Contract (ESPC) would be executed between the ESCO and Building Society based on a fixed price for services to be provided. The ESPC will define all the terms and conditions clearly and in case of dispute in project, what will be the process for dispute resolution will be clearly defined in the Contract.
- ESCO will conduct walk through energy audit of pump sets and the common lighting fixtures of the building.
- ESCO will design the new pumping system with proper understanding of flow, pressure, piping and electrical protective system requirements.
- ESCO will design the replacement of existing common lighting fixtures with LED fixtures.
- ESCO will also provide proposed energy efficiency pumps and other electrical and mechanical equipment as per the design specification as well as the LED fixtures.
- Building society will provide a baseline energy consumption and ESCO will install a metering and monitoring system on sample basis.

5.3.4 Financing mechanism –

- The ESCO project based on Annuity-based deemed saving model is the financing mechanism for this model. The tenure of ESCO project is five-seven years depending on the returns to ESCO.
- ESCO would finance the project partly through equity and partly through debt. For such projects, normally a debt-equity ratio of 70:30 is considered.
- ESCO shall arrange funds for equity proportion from its reserves. For debt proportion, banks/FIs can be approached.
- Building society will make fixed yearly annuity payments to the ESCO against achievement of benchmark performance parameters defined in ESPC.
- Financial agreement would be executed between the ESCO and FI for borrowing funds.
- ESCO would make loan repayments from the money collected from the Building Society.
- This method involves multiplying the number of installed measures by an estimated (or deemed) savings per measure, which is derived, based on historical evaluations.
- Deemed savings approach may be complemented by on-site inspections. Under this model, it can be ensured that the best available technology is retrofitted with an overall cost saving to the Building Society.
- The model does not require periodically demonstration of energy cost saving.

5.3.5 Advantages and dis-advantages of model

Advantages	Disadvantages
• No upfront investment by building society. • Reduces energy consumption from the power grid and leads to energy cost saving. • The responsibility for operation and maintenance of energy efficient technologies is with ESCO • Competitive bidding process will ensure the maximum benefits to the society	• In case of replacement of elevators/lifts and its maintenance, such model may not work successfully. • There are few ESCO's in market. • In case of disputes in the project, the ESPC should comprehensively cover all the exit clauses, litigations and dispute resolution methodology etc. • The ESCO since taking the risks prefers to work on higher returns only

Figure 5-9: Advantages and dis-advantages of model

5.4 BUILDING SOCIETY POOLING MODEL

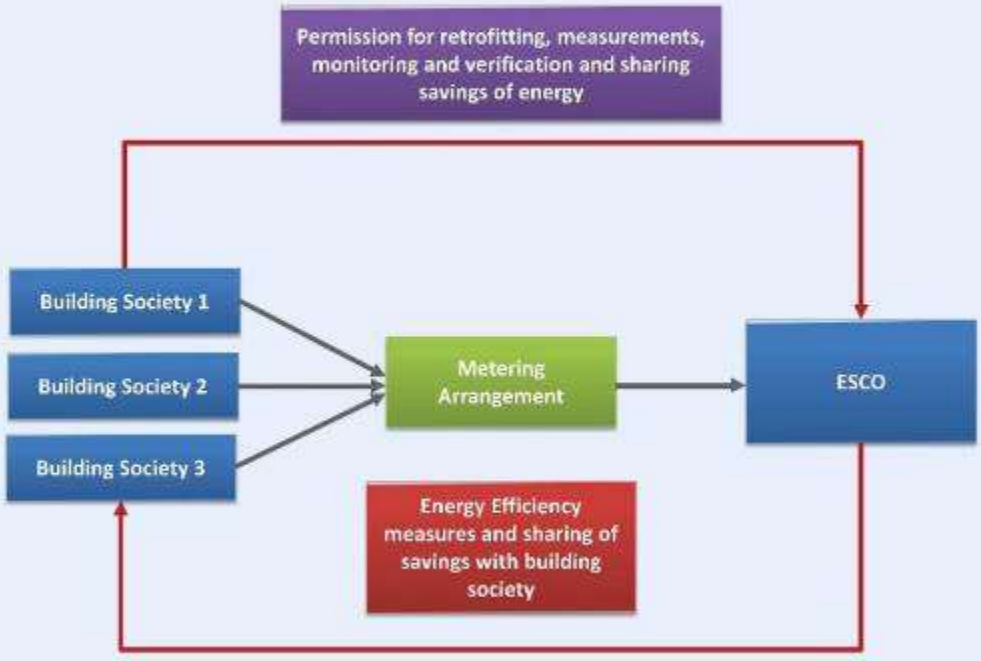


Figure 5-10: Mechanism for building society pooling model

- Under this model, multiple small building societies come together to implement energy efficiency projects on a larger scale by appointing a common ESCO for all the societies for implementing the lighting and water pumping energy efficiency projects.
- Under this model, even smaller building societies which cannot undertake such projects individually get the benefit of ESCO based projects by pooling their projects together.
- For the ESCO, this ensures economies of scale as quantum of retrofitting is higher on a cumulative basis.
- On the downside, managing multiple building societies is a challenge and the project may face risks of implementation, if one or more societies pull out of the consortium formed for implementing these projects.
- An aggregator, who will be the intermediate agency for co-ordination and implementation with responsibility to safeguard the interest of residential societies and ESCO/facility management company, should lead such project. Aggregator could be a Government agency, International NGO or a philanthropic organization.

The risk profile of any project is defined by a combination of the project specific requirements and general factors. The project developer must identify the risks, assess their prospective impact and develop measures to mitigate these risks before project implementation.

The first step in the risk analysis is the identification of the risks for RE and EE projects which are typically different from regular projects owing to their very nature. For e.g. in a debt-equity funding model where the society has a higher exposure to bank finance, the financial risk is higher. Further, risks also depend on various factors such as tech-nology, suppliers, vendors, market parameters etc. However, systemic risks such as political risk, policy and regulatory risk commonly affect both RE/EE as well as regular projects equally.

The next step after identification of the risk is the evaluation of the risk. This can be done by analysing the project outcomes of similar projects carried out in the past or elsewhere and the findings can be applied to the proposed project.

Finally, the project developer should derive measures to mitigate the identified risks involved in the project. Risk mitigation planning is the process of developing options and actions to enhance opportunities and reduce threats to project objectives. The project contract agreement must provide Clauses for adequate risk mitigation and sharing of risks equally between the society and developer.

Further, the building society needs to periodically assess the risk parameters which affect the project and identify course correction or mitigation measures, because risk factors vary with the project implementation.

6.1 RISK ANALYSIS FOR PROPOSED BUSINESS MODELS FOR IMPLEMENTATION

6.1.1 Debt-equity funding model for implementation (Loan from bank)

Debt-Equity Business Model	Risk Description	Risk Mitigation
Technical Risks	• The inaccurate baseline consumption definition can result in ambiguity in savings. • The low quality product selection may impact its performance • The inefficient operation and maintenance of system. • Incomplete metering and monitoring system can result in discrepancies in actual savings and projected savings.	• Detailed energy audit should be carried out for establishment of a correct baseline and engineering design of the project. • The operation and maintenance contract should be entered into after due diligence. The building society may engage a consultant to ensure sound O&M contract. • The contract with EPC contractor should have checks and balances to ensure metering is carried out as per regulatory specifications and is tested before installation.

Debt-Equity Business Model	Risk Description	Risk Mitigation
Financial Risks	• The project cost gets escalated due to time and/or cost over-run. • The tariff escalation is higher than actual • The escalations in operation and maintenance is higher than projected • There is variation in interest rate of the loan funding from the bank.	• The DPR preparation should build in some contingency cost to mitigate project cost escalation. • The Contract with EPC contractor must clearly define the project timelines and penalties for non-adherence to the timelines • Electricity tariffs are beyond the control of the building society and under the purview of the Regulatory Commission. However, past tariff orders/petitions may be reviewed so as to ascertain the trend of increase in tariff. • The DPR preparation should build in some contingency cost to mitigate O&M cost escalation. • Interest rate variation is also beyond the control of the building society however, to mitigate the risk, the society should negotiate the best available lending terms with banks.
Policy/Regulatory risks	• Subsidy/incentive is withdrawn or reduced. • Tax benefits are withdrawn or reduced.	• The building society should try to avail the benefits/incentives as well as tax benefits of the schemes as per the prevalent policy at the earliest so that risk of policy change / regulatory change is mitigated. However, beyond a point, this risk being a systemic one cannot be totally mitigated.
Legal Risks	• EPC contract is biased towards the contractor. • The terms of the loan are very stringent. • Changes in building bye-laws or environmental laws.	• The building society should appoint an expert/ consultant to design an EPC contract which is balanced and not bias against either the society or the contractor. • Similarly, society should appoint an expert advisor to carry out legal due diligence and help in drafting legal agreements under the Contract.
Environmental risks	• EE/RE project may cause environmental damage.	• Unlike large scale projects like solar parks, building society projects are small in scale and hence the risk of environmental damage is not high.

Table 6-1: Risk analysis and mitigation measures for debt-equity funding model

6.1.2 ESCO model for implementation

ESCO Business Model	Risk Description	Risk Mitigation
Technical Risks	• The ESCO may quote higher percentage of savings and may not deliver it. • The ESCO may put the system off and show energy savings. • The inaccurate baseline consumption definition can result in ambiguity in savings. • The poor operation and maintenance of system may impact the savings. • Incomplete metering and monitoring system can result in discrepancies in actual savings and projected savings.	• Most of the project performance risks are with ESCO. • Detailed energy audit should be carried out for establishment of a correct baseline. • Engineering design of the project must ensure installation of best quality and most efficient products. • The operation and maintenance contract should be entered after due diligence. The Building Society may engage a consultant to ensure sound O&M contract. • The Contract with EPC contractor must clearly define the project timelines and penalties for non-adherence to the timelines. • Penalties must be clearly defined. • Estimation of savings potential should be verified by an independent expert to ascertain that it is correct. • The contract with ESCO should have checks and balances to ensure metering is carried out as per regulatory specifications and is tested before installation.
Financial Risks	• Initial investment by the Building Society is nil and hence financial risks are mitigated to a large extent. • The project investment cost for ESCO increases than the projected cost and ESCO goes bankrupt. • The project investment costs are exaggerated to show lower returns to ESCO from the project. • The tariff escalation is higher than actual. • The operation and maintenance cost projects by ESCO is higher than the actual cost. The escalations in operation and maintenance are higher than projections.	• The building society may include terms and conditions in the ESCO contract to facilitate bridge funding by equity / loan for the ESCO to salvage the project. • The Contractmust have provisions to appoint another ESCO in case the original goes bankrupt. Handover process should be clearly defined. • The DPR preparation should build in some contingency cost to mitigate project cost escalation. Further, an expert consultant should verify the investment cost quoted by the ESCO to mitigate the risk of exaggerated project cost. • Electricity tariffs are beyond the control of the building society and under the purview of the Regulatory Commission. However, past tariff orders/petitions may be reviewed to ascertain the trend of increase in tariff. • The DPR preparation should build in some contingency cost to mitigate O&M cost escalation.

ESCO Business Model	Risk Description	Risk Mitigation
Policy/ Regulatory risks	• Subsidy/incentive is withdrawn or reduced. • Change in the society management • Tax benefits are withdrawn or reduced. • Changes in building bye-laws or environmental laws.	• The building society should try to avail the benefits/incentives as well as tax benefits of the schemes as per the prevalent policy at the earliest so that risk of policy change / regulatory change is mitigated. However, beyond a point, this risk being a systemic one cannot be totally mitigated.
Legal Risks	• ESCO contract is biased towards the contractor.	• The building society should appoint an expert/ consultant to design an ESCO contract which is balanced and not favouring either the society or the ESCO.
Environmental risks	• EE/RE project may cause environmental damage.	• Unlike large scale projects like solar parks, building society projects are small in scale and hence the risk of environmental damage is not high.

Table 6.2 : Risk analysis and mitigation measures for ESCO

model 6.1.3 Roof-top leasing model

Rooftop Leasing Business Model	Risk Description	Risk Mitigation
Technical Risks	• The building age and strength is prime factor for installation of solar roof-top • Incomplete metering and monitoring system can result in discrepancies in actual savings and projected savings.	• Technical risks are avoided due to the nature of the business model. • The suitable approvals for installation of solar roof-top panels must be taken from statutory bodies. • The contract should have checks and balances to ensure metering is carried out as per regulatory specifications and is tested before installation.
Financial Risks	• Initial investment by the building society is nil and hence financial risks are mitigated to a considerable extent. • The tariff escalation is higher than actual • The escalations in operation and maintenance is higher than projected	• Electricity tariffs are beyond the control of the building society and under the purview of the regulatory commission. However, past tariff orders/petitions may be reviewed to ascertain the trend of increase in tariff. • The DPR preparation should build in some contingency cost to mitigate O&M cost escalation.
Policy/ Regulatory risks	• Subsidy/incentive is withdrawn or reduced. • Tax benefits are withdrawn or reduced.	• The building society should try to avail the benefits/incentives as well as tax benefits of the schemes as per the prevalent policy at the earliest so that risk of policy change / regulatory change is mitigated. However, beyond a point, this risk being a systemic one cannot be totally mitigated.

Rooftop Leasing Business Model	Risk Description	Risk Mitigation
Legal Risks	• The Contract is biased towards the contractor.	• The building society should appoint a legal expert/consultant to design a contract which is balanced and covers all legal aspects of the project.
Environmental risks	• RE project may cause environmental damage.	• Unlike large scale projects like solar parks, building society projects are small in scale and hence the risk of environmental damage is not high.

Table 6-3: Risk analysis and mitigation for roof-top leasing model

6.1.4 Building society pooling model

Business Society Pooling Business Model	Risk Description	Risk Mitigation
Technical Risks	• All the risks are same as discussed in the earlier models	• All the risks are same as discussed in the earlier models
Financial Risks	• All the risks are same as discussed in the earlier models	• All the risks are same as discussed in the earlier models
Policy/Regulatory risks	• All the risks are same as discussed in the earlier models	• All the risks are same as discussed in the earlier models
Legal Risks	• One or more member societies withdraw from the pool.	• The building societies should enter into an agreement which has strict exit clauses so that only serious members join the pool. An expert legal consultant may be appointed to facilitate such an agreement between the pool members and contractor. • Further, the ESCO agreement should also have similar back-to-back provisions for addition and/or removal of one or more member societies from the project.
Environmental risks	• All the risks are same as discussed in the earlier models	• All the risks are same as discussed in the earlier models

Table 6-4: Risk analysis and mitigation for building society pooling model

In order to take the decision on which model should be selected for implementation, the residential society may follow to the proposed evaluation matrix. It shares key parameters which should be considered for evaluation before taking the final decision.

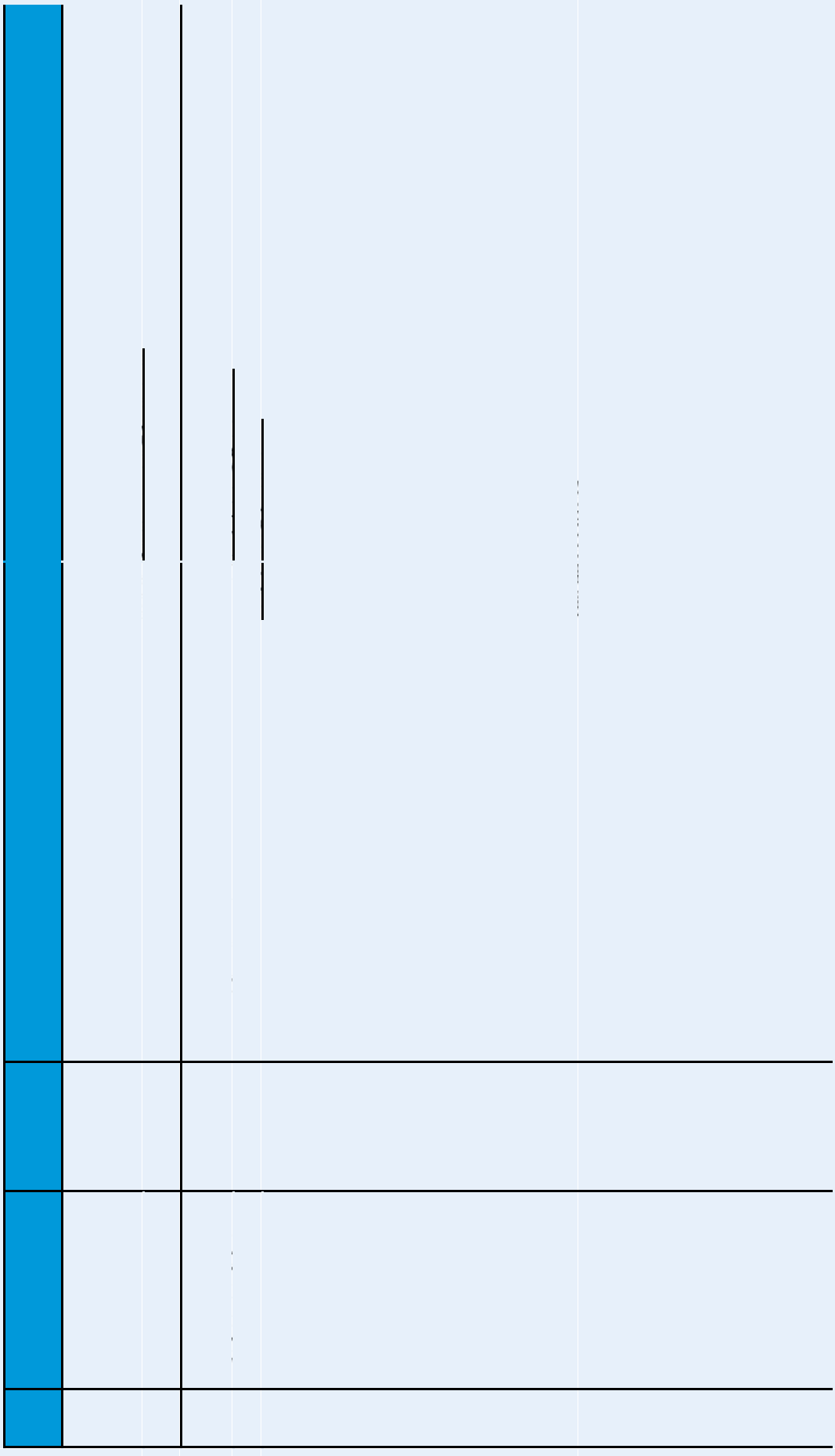
Selection Parameters	Business Models			
	Debt-Equity Model (Loan from bank)	Rooftop Leasing Model	ESCO Shared Savings Model	Building Society Pooling Model
If residential society is willing to take risk of implementation	✓			
If residential society is willing to forgo the larger financial benefits to private developer and reduce their risks		✓	✓	✓
High fund exposure desired by the building society	✓			
Low fund exposure desired by the building society		✓	✓	✓
Asset ownership desired by the building society	✓		✓	✓
Asset ownership not desired by the building society		✓		
Higher percentage of energy saving benefit is pass to residential society	✓	✓		
Lower percentage of energy saving benefit is pass to residential society			✓	✓

Table 6-5: Matrix for selection of model for implementation

7 ANNEXURE I – LIST OF VENDORS AND SUPPLIERS OF TECHNOLOGIES

This Annexure provides the list of channel partners/ vendors for various RE/ EE technologies which includes:

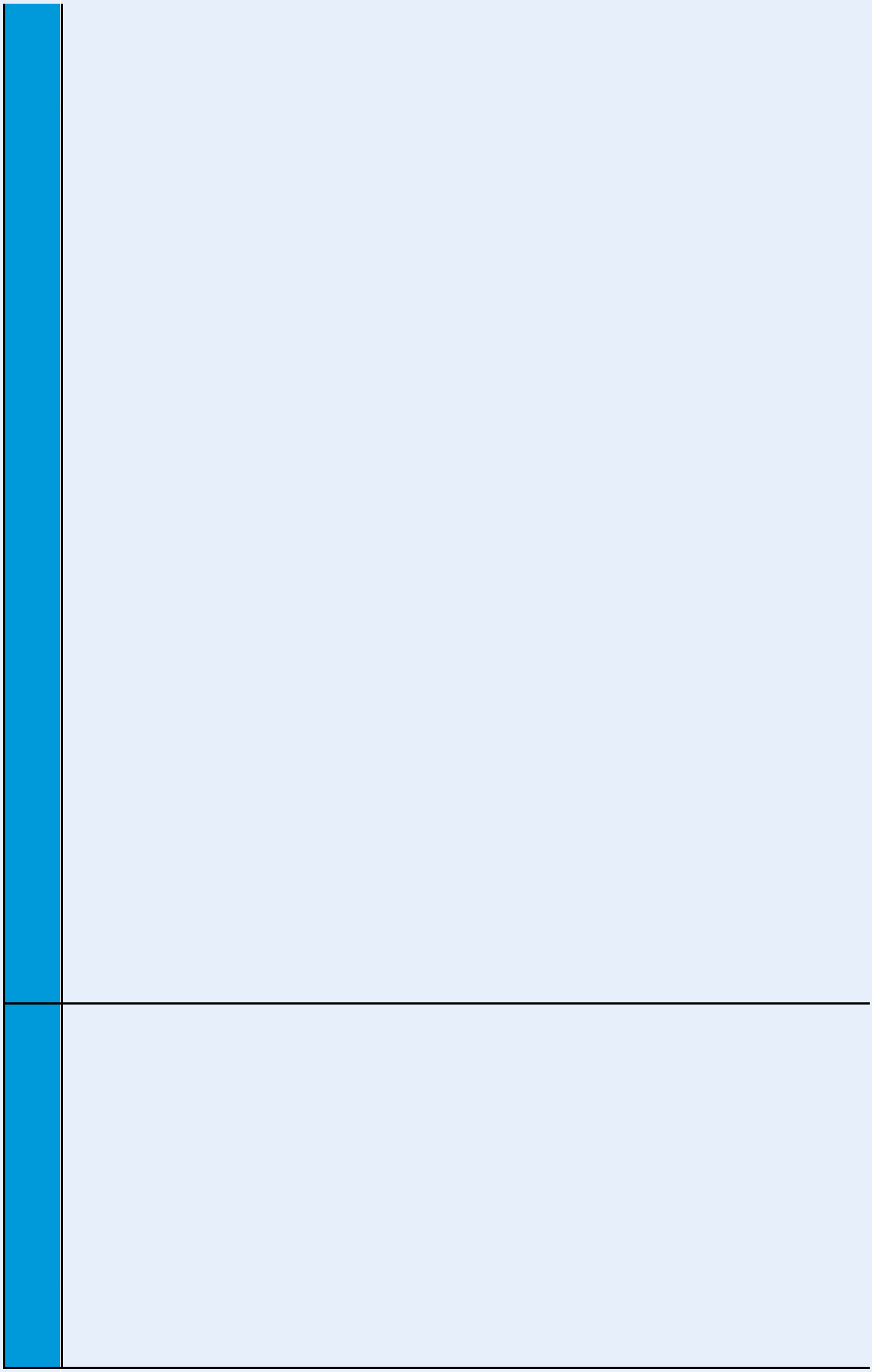
1. Dealers of based manufacturers of Solar Water Heaters
2. List of LED light manufacturers and their dealers
3. List of empanelled agencies under Grid Connected Rooftop of Solar Photovoltaic for Maharashtra and Delhi Division.
4. List of MNRE approved manufacturers of Evacuated Tube Collector Based Solar Water Heating Systems
5. List of suppliers empanelled to promote Solar Water Pumping for Delhi and Maharashtra division.
6. List of vendors and manufacturer for Auto ON/OFF Control method for Pumping Systems.
7. List of vendors and manufacturer for Cool Roof Technologies.
8. List of vendors and manufacturer for water pumping system.



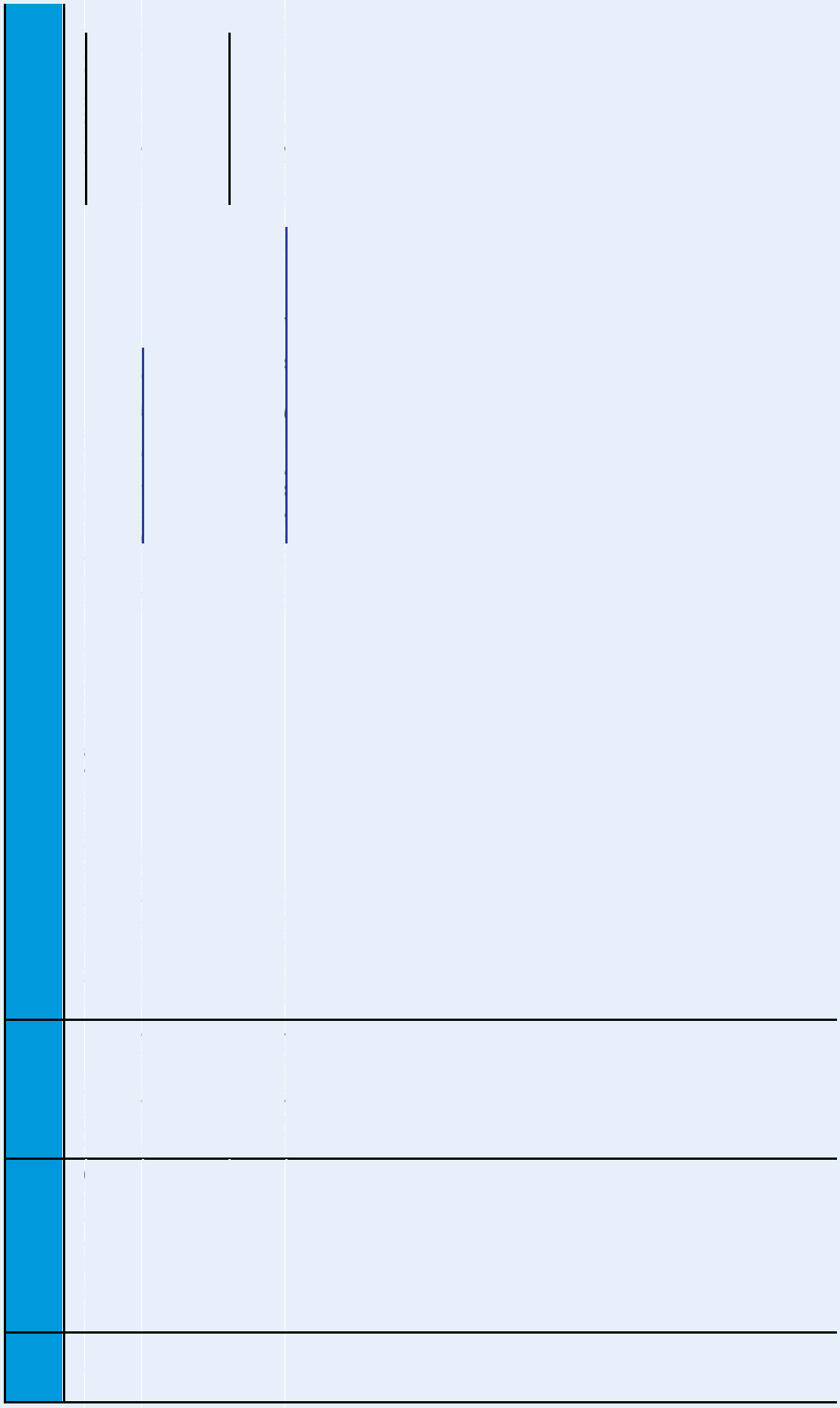
- **List of LED lighting suppliers**

Sr. No.	Agency Name	Agency Type	Agency Address	Contact Details	Empanelled No. / Rating / Validity Date
1.	Bajaj Electricals Ltd	-	601, (8th Floor, Rustomjee Aspiree, Bhanu Shankar Yagnik Marg, Off Eastern Express Highway, Sion (East0 Mumbai – 400 022	K K Kaushal /Pushpa Praveen Chief manager – Business Development Email: kamleshkk@bajajelectricals.com Mobile: +91 9773192193 Email: abhiram.setlur@bajajelectricals.com	-
2.	Anpree Tech India	-	404 Oberoi Chambers – I, Opp SAB TV, New Link Road, Andheri (West), Mumbai – 400 053	Mr Chirjyot Singh Kohli Managing Partner Email: anpreetechindia@gmail.com Mobile: +91 99670 80000	-
3.	Philips Electronics India Ltd,	-	Technopolis Knowledge Park, Mahakali Caves Road, Chakala, Andheri (East) Mumbai 400 093	Vaibhav Manke Regional Key Account Manager (West) Email: vaibhav.manke@philips.com Mobile: +91 9920440271	-
4.	Philips Electronics India Ltd,	-	9th Floor, DLF 9-B, DLF Cyber City, Sector 25, DLF Phase - 3, Gurgaon - 122002	Mr. Manish Thakur, General manager Email: manish.thakur@philips.com Email: vardhaman.jain@philips.com Contact : 991055585	-
5.	Crompton Greaves Limited	-	Kanjur Marg (East) Mumbai 400 042	Mr. Prashant Thorat Manager Contact 9769208605 Email : prashant.thorat@cgglobal.com	-
6.	Servomax India Ltd.	-	#206, Merdian Plaza, Ameerpet, Hyderabad – 500016	Mr. Pradip Kumar Ghosh Chief Operating Officer coo@servomax.net Mobile No. : 9912166229	-
7.	Schneider Electric India Private Limited	-	Plot No. B-12, Ground Floor, Rewari Line, Mayapuri Industrial Area, Phase I,	Amit Chadha Ph: 09953330043	-

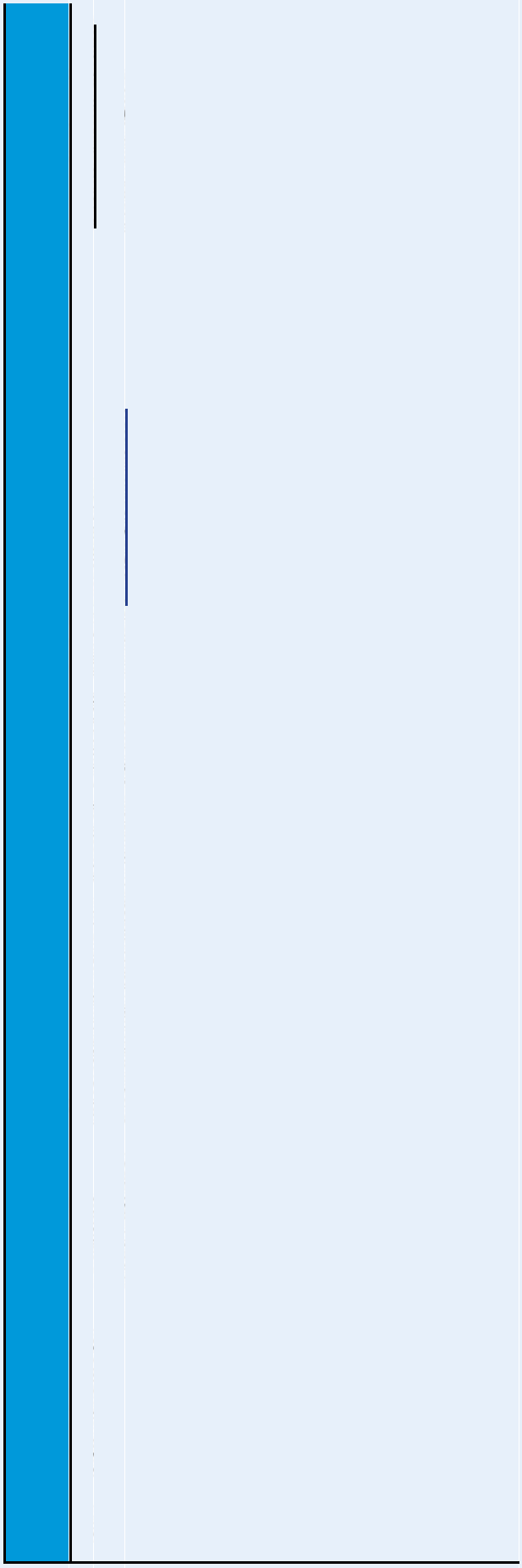
Sr. No.	Agency Name	Agency Type	Agency Address	Contact Details	Empanelled No. / Rating / Validity Date
15.	OSRAM Lighting India Private Limited	-	Western Region Office, A Wing, 503, City Point Commercial Complex, Andheri Kurla Road Andheri (East) Mumbai-400 059	Chaitali Jadhav Regional manager-India Chaitali_jadhav@unilamp.co.th Mobile: 9987214077	-
16.	Havells India Ltd.	-	-	Mukesh Choudhary Sr. Manager Mobile: 9833759597 Email:mukesh1.choudhary@havells.com	-
17.	Keselec Schreder Private Limited,	-	69 Friends Colony 1, New Delhi 110 065	Nayan Kumar Marketing Director Email: narayank@schreder.co.in Mobile: +91 9350889698	-
18.	Goldwyn Limited	-	15 & 16 Noida Special Economic Zone, Noida 201 305	Ajay Goel Chief Executive Officer Email: agoel@GoldwynLED.com Mobile: +91 9810130627	-
19.	Citelum India Private Limited	-	E-2, First Floor, Defence Colony New Delhi – 110024	Akhil Bhargav Managing Director Email: abhargav@citelum.in Mobile: +91 9650350093, 9873079303	-
20.	Darshan Doshi	-	-	Email: deepdarshanelectricals@gmail.com	
21.	M/s Greensense Energy Systems Pvt Ltd	-	Raja Rani Apartments, Padampura, Aurangabad - 431005	-	31/3/2019
22.	M/s Soyo Systems	-	Near Godavari Engg. College, Jalgaon - 425003	-	31/3/2019
23.	M/s Kaushal Solar Equjpments Private Ltd.	-	767/7. Neel Kusum, Deccan Gymkhana, Pune, Maharashtra 411004	-	31/3/2019



Sr. No.	Agency Name	Agency Type	Agency Address	Contact Details	Empanelled No. / Rating / Validity Date
37.	M/s Savemax Solar Systems (P) Ltd.	-	New Sr. No. 48/14-A/2, Plot B, Manji Nagar,Nr. Singad College of Arts & Commerce, Narhe, Pune- 411041	-	31/3/2019
38.	M/s Sunrise Engitech (P) Ltd.	-	Office No. 2, B-Wing, 1st Floor, Mangal MurtiC Complex, above Bank of Maharashtra, Sinhgad Road, Pune-411030, Maharashtra	-	31/3/2019
39.	M/s Tata Power Solar Systems Ltd.	-	4th Floor, M6 Uppal Building, Jasola, New Delhi 110025	-	31/3/2019
40.	M/s Savemax Solar Systems (P) Ltd.	-	New Sr. No. 48/14-A/2, Plot B, Manji Nagar,Nr. Singad College of Arts & Commerce, Narhe, Pune- 411041	-	31/3/2019
41.	M/s Sunrise Engitech (P) Ltd.	-	Office No. 2, B-Wing, 1st Floor, Mangal MurtiC Complex, above Bank of Maharashtra, Sinhgad Road, Pune-411030, Maharashtra	-	31/3/2019
42.	M/s Tata Power Solar Systems Ltd.	-	4th Floor, M6 Uppal Building, Jasola, New Delhi 110025	-	31/3/2019
43.	M/s Unitop Power Electronics (P) Ltd	-	C-124, Flatted Factory Complex. Okhla-III, New Delhi -110020	-	31/3/2019
44.	M/s V.V. Associates	-	Plot No. 38, Ramkrishna Nagar, Khamla Road, Nagpur-440015	-	31/3/2019
45.	M/s Sakar India Pvt. Ltd.	-	C-126. 1st Floor Gate No. 1 Naraina Industrial Area, Phase-1, New Delhi-110028	-	31/3/2019

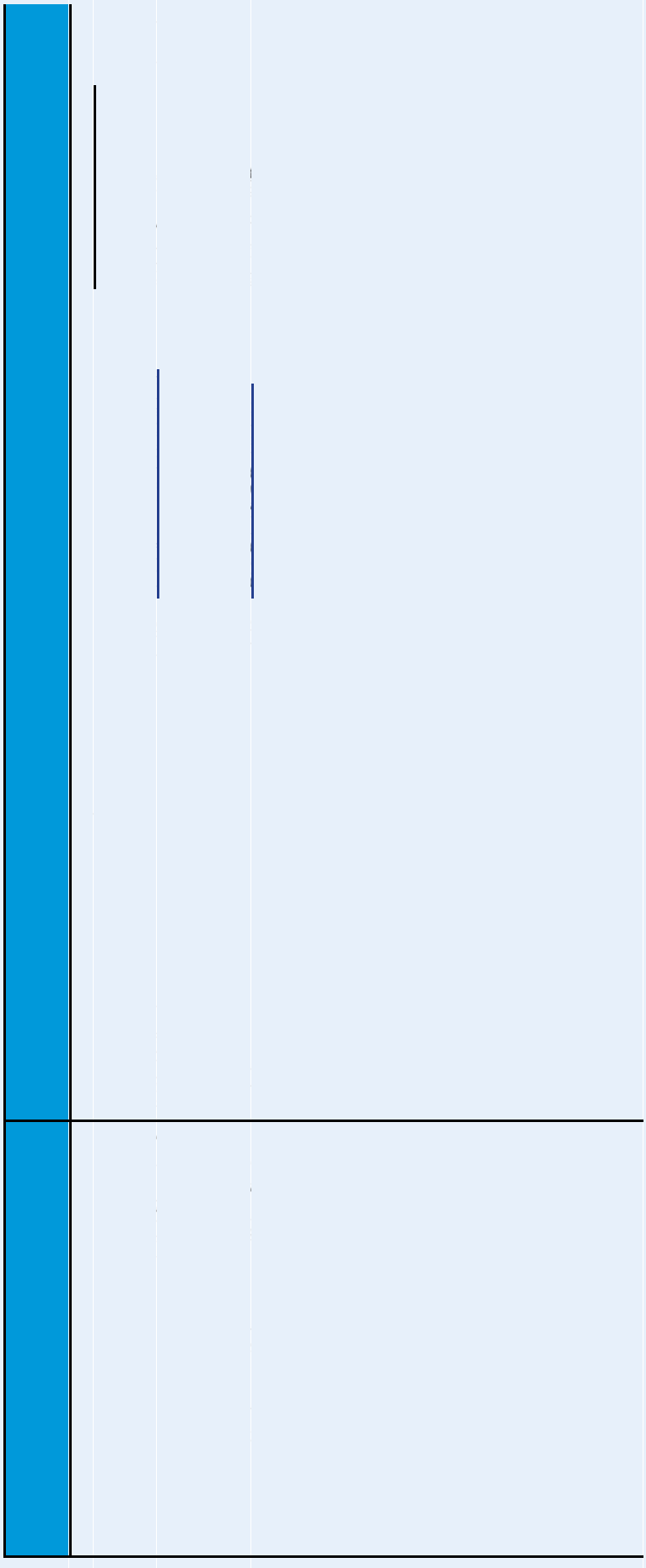


Sr. NO.	Agency Name	Agency Type	Agency Address	Contact Details	Empanelled No. / Rating / Validity Date
7	Devidayal Solar Solution Private Limited	Channel Partner(New Entrepreneur)	Office No-709, Makers Chamber-5,7th floor, Nariman Point, Mumbai. Pin code-400021 District : Mumbai State : MAHARASHTRA	Mobile : 9818585210 Land phone : 022-22849999 Email : janardank@ddsolar.in website : www.ddsolar.in	MNRE/EN/GCRT/1069 MNRE Rating : D Validity : 19-10-2016 to 19-10-2018
8	Electrico Energies Private Limited	Channel Partner(New Entrepreneur)	B-27,Om Rachana CHS Ltd,Plot No.03, Sector-17,Vashi,Navi Mumbai-400703 District : Thane State : MAHARASHTRA	Mobile : 9987273071 Email : swapnil.chavan@electricoenergies.com Land phone : 022-27890005 website : www.electricoenergies.com	MNRE/EN/GCRT/2177 MNRE Rating : D Validity : 29-08-2016 to 29-08-2018
9	Enviro Soins Pvt. Ltd.	Channel Partner(New Entrepreneur)	Unit No 304, Bhoomi Mall, Sector No 15, CBD Belapur, Navi Mumbai 400 614 District : Raigarh State : MAHARASHTRA	Mobile : 9967440055 Land phone : 022-7575775 Email : sansoya@envirosoins.com website : www.envirosoins.com	MNRE/EN/GCRT/1715 MNRE Rating : D Validity : 16-01-2017 to 16-01-2019
10	Friends Engineering Corporation	Channel Partner(New Entrepreneur)	B-4/13 Mahindra Gardens, S.V.Road , Goregaon (W), Mumbai-400062 District : Mumbai (Suburban) State : MAHARASHTRA	Mobile : 9870047059 Email : siddhesh@friendsengg.in	MNRE/EN/GCRT/2342 MNRE Rating : D Validity : 19-10-2016 to 19-10-2018
11	Fuji Technical Services Pvt. Ltd	Channel Partner(New Entrepreneur)	B-403, SAI SANGAM, SECTOR-15, C.B.D. BELAPUR, NAVI MUMBAI-400614 District : Thane State : MAHARASHTRA	Mobile : 9820092007 Land phone : 022-27577828 Email : fuji@vsnl.com website : www.fujitech.net	MNRE/EN/GCRT/2642 MNRE Rating : D Validity : 19-10-2016 to 19-10-2018
12	Global Powersource (India) Pvt. Ltd.,	Channel Partner(New Entrepreneur)	C - 701,702,703, 7th Floor, C-Wing, Neelkanth Business Park, Vidyavihar - West, Mumbai - 400 086. District : Mumbai State : MAHARASHTRA	Mobile : 9940657987 Land phone : 022-25150601 Email : v.raja@rocketbatteries.net website : www.rocketbatteries.net	MNRE/EN/GCRT/644 MNRE Rating : D Validity : 22-06-2016 to 22-06-2018



Delhi Division

Sr. No.	Agency Name	Agency Type	Agency Address	Contact Details	Empanelled No. / Rating / Validity Date
1	8minutes Future Energy Pvt. Ltd.	Channel Partner(New Entrepreneur)	K-317, 3rd Floor, Lado Sarai, Mehrauli, New Delhi - 30 District : South State : NCT OF DELHI	Mobile : 9560230030 Land phone : 011-41086076 Email : vishal@8minutes.com website : www.8minutes.com	MNRE/EN/GCRT/2612 MNRE Rating : D Validity : 19-10-2016 to 19-10-2018
2	8minutes Solar (Opc) Pvt Ltd	Channel Partner(New Entrepreneur)	4073, JOY APARTMENTS, DWARKA, SECTOR 2 District : South West State : NCT OF DELHI	Mobile : 8527098186 Email : anuj@eightmins.com website : www.eightmins.com	MNRE/EN/GCRT/668 MNRE Rating : D Validity : 29-08-2016 to 29-08-2018
3	Aadi Technologies Pvt. Ltd.	Channel Partner(New Entrepreneur)	207, Aggarwal Tower, H-6, Netaji Subhash Place, Pitampura, Delhi-110034 District : New Delhi, State : NCT OF DELHI	Mobile : 7710049345 Email : rajesh@aaditechindia.com website : www.aaditechindia.com	MNRE/EN/GCRT/1810 MNRE Rating : D Validity : 29-08-2016 to 29-08-2018
4	Aditya Suntech Pvt. Ltd.	Channel Partner(New Entrepreneur)	Office No. 123, RG Mall, Sector-9, Rohini, New Delhi - 110085 District : North West, State : NCT OF DELHI	Mobile : 9717792112 Land phone : 011-45097597 Email : sales@adityasuntech.com website : http://www.adityasuntech.com	MNRE/EN/GCRT/531 MNRE Rating : D Validity : 31-08-2015 to 31-08-2017
5	Aditya Techno Products Pvt. Ltd.	Channel Partner(New Entrepreneur)	10/318, Khashra No 266-16, Lalita Park, Vikas Marg, Laxmi Nagar District : East State : NCT OF DELHI	Mobile : 9811935791 Land phone : 0120-4335131 Email : ssparihar@adityatechno.in website : www.adityatechno.in	MNRE/EN/GCRT/1154 MNRE Rating : D Validity : 21-06-2016 to 21-06-2018
6	Ads Projects And Systems Private Limited	Channel Partner(New Entrepreneur)	1st Floor, 40 Hanuman Lane, Connaught Place, New Delhi District : New Delhi State : NCT OF DELHI	Mobile : 7838784466 Land phone : 011-23364217 Email : coo@adsprojects.org website : http://www.adsprojects.org	MNRE/EN/GCRT/264 MNRE Rating : D Validity : 06-07-2015 to 06-07-2017



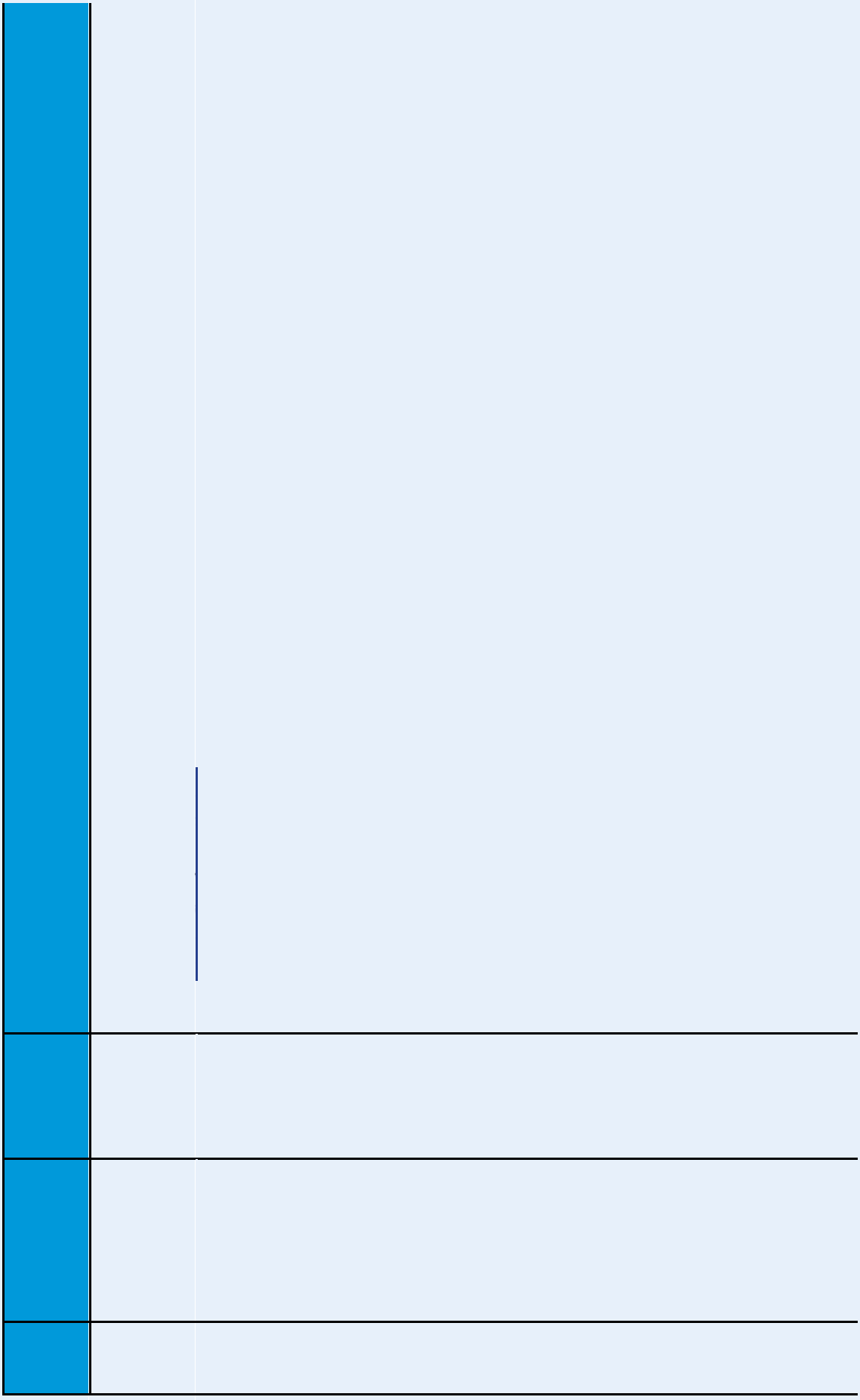
- **Dealers of a few Bangalore & Pune based manufacturers of Solar Water Heaters in & around Delhi**

Sr. No.	Agency Name	Agency Type	Agency Address	Contact Details	Empanelled No. / Rating / Validity Date
1.	Anu Solar Power Pvt Ltd	-	Nahar Singh Complex, Near Bajaj Service, Dundahera, Kapashera, Gurgaon - 122 016.	Mr. Sumith Kumar Phone: 0124 - 3290843 / 09810719261	-
2.	Anu Solar Power Pvt Ltd	-	Shop No. 2, WZ-912, Ring Road, Naraina, New Delhi - 110 028.	Mr. Shashank Kumar Choudhary Phone : 09968374670	-
3.	Anu Solar Power Pvt Ltd	-	Dharam Veer Market, Near Kartik Kunj Apartment, D-13, Sector - 44, Noida - 201 301.	Mr. Dilip Patra Phone : 09899424681	-
4.	Electric india Control Device	-	E-206 , East of Kailash, New Delhi - 110065	Mr. Vicky Vadhera Mob. No. 9810879087	-
5.	Surbi Enterprises	-	138, D.D.A. Flats, Near Satyam Cinema, Near Ranjeet Nagar, New Delhi - 110008.	Mr. Sanjeev Jaitley Mob. No. 9811659311	-
6.	M/s. Aviv Energy Systems Pvt. Ltd	-	8/243, Chattarpur Pahari. New Delhi - 110 074	Phone: 011-26303560 Mobile: 98184-49970 kurian_54@yahoo.co.in	-
7.	M/s Bright Solar Energy	-	T-868 Faiz Road, Opp. Jain Co-operative Bank, Karol Bagh, New Delhi-110005	Mr. Thomas Kurian Tel. 011-23233637 Mob. 9311394959, 9968355704	-
8.	M/s Shree Parvarhi Metals Pvt. Ltd	-	A-140, Shankar Garden, Vikas Puri, New Delhi-110018	Mr. Sathyanarayana Mob. 9313384921 Ph. : 41582033 (O), 9312261353 & 9828280404 (M) spm@ndf.vsnl.net.in	-
9.	M/s AVIV ENERGY SYSTEMS PVT. LTD.	-	8/243, Chattarpur Pahari, New Delhi -110 074.	Mr.Kurian Thomas Mobile: 98184 49970 kurian_54@yahoo.co.in	-
10.	Millenium Energy Systems Pvt Ltd	-	# 901-A, GD-ITL, Twin Towers # B-08, Netaji Subhash Palace Ring Road, Pitampura. DELHI 110 034	Mr.Manmohan Singh Cell : 98183 73221 Tel : 011 27353445	-

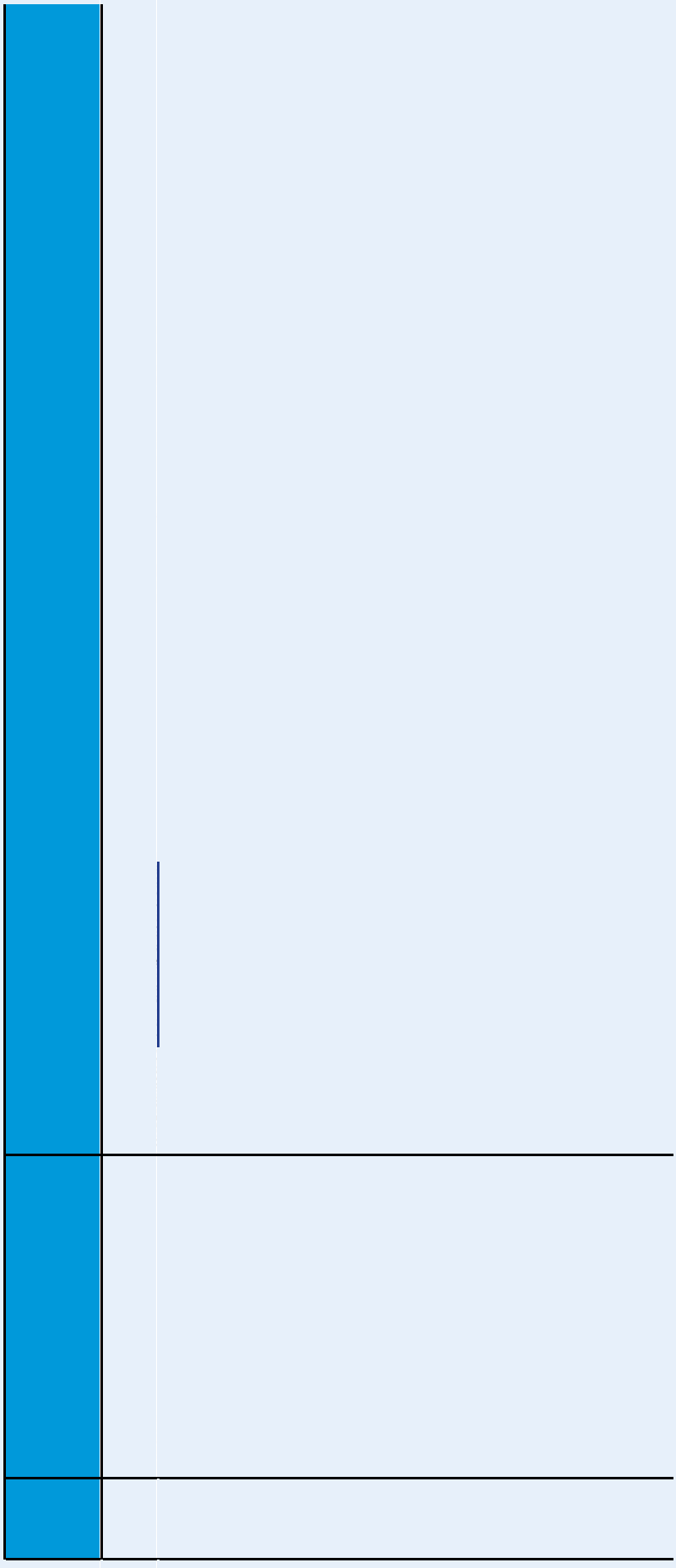
- **List of Suppliers Empanelled to Promote Solar Water Pumping**

Delhi

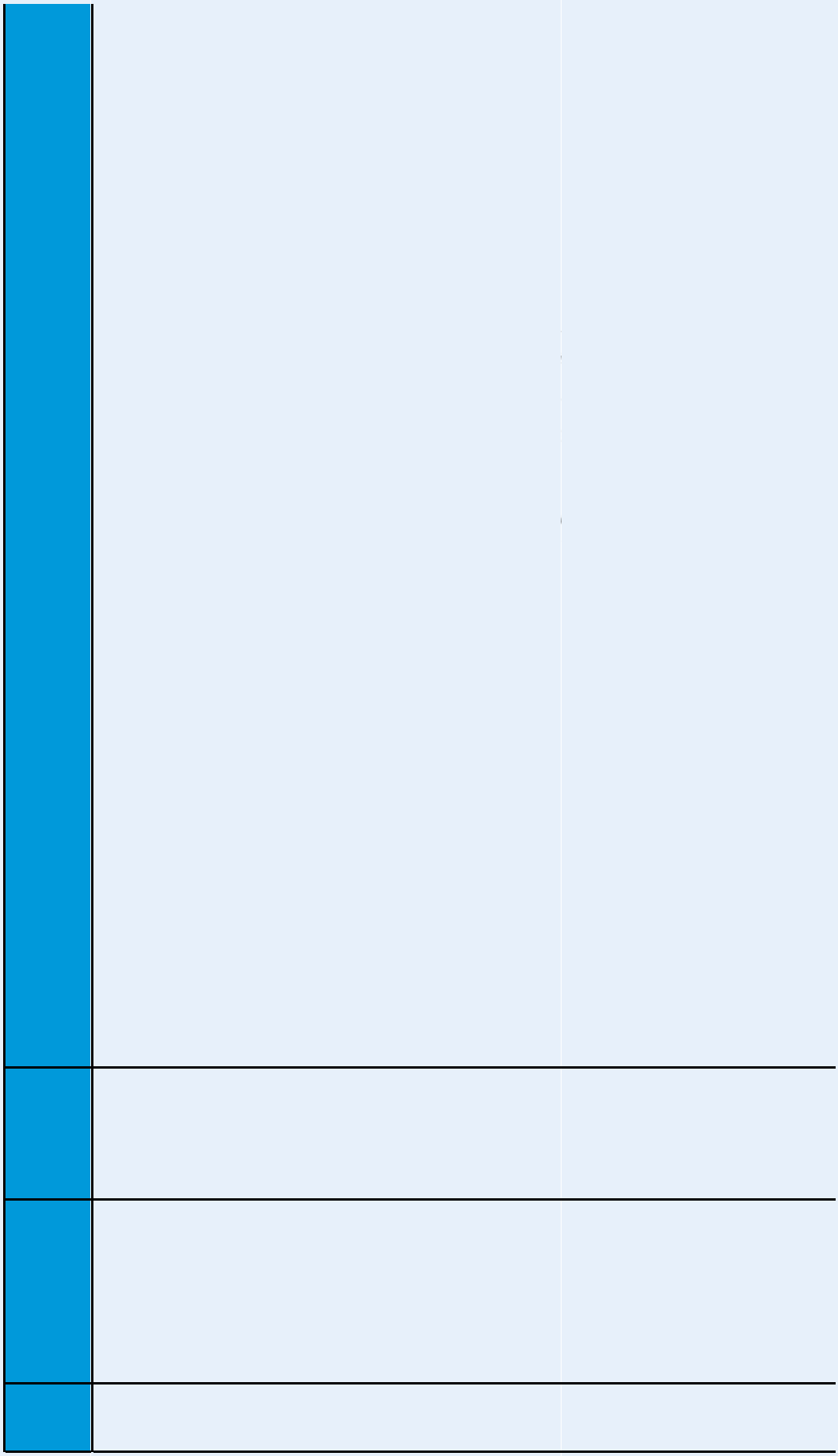
Sr. No.	Agency Name	Agency Type	Agency Address	Area of Operation	Empanelled No. / Rating / Validity Date
1.	M/s Volks Energy Ltd	-	Mr Piyush Goyal,306- Bakshi House, 40-41, Nehru Place, Delhi- 110019 , Email: goyal@volksenergie.in	Madhya Pradesh, Rajasthan, Uttar Pradesh, Haryana, Punjab	-
2.	M/s Claro Energy Ltd	-	Mr Kartik Wahi, Mr. Soumitra Mishra, Mr Gaurav Kumar , F-213/D, 2nd Floor, Old MB Road, Lado Sarai, New Delhi-110030,Contact 09717550189,Mail: Gaurav@claroenergy.in	Uttar Pradesh, Maharashtra, Andhra Pradesh, Telangana, Haryana, Bihar, Chhattisgarh, Punjab. Odisha, Tamil Nadu, Uttrakhand	-
3.	M/s Hygrid Solar	-	Mr Arvind Kumar,X-12, Main Market Phase-1,Budh Vihar Delhi-110086,Contact No 08447755230Mail info@hygridsolar.com	Haryana, Rajasthan, Uttar pradesh	-
4.	M/S Greenworld Solarwares Ltd	-	Mr Uday Bhushan ,F-101, 2nd Floor,Street No 08 Pandav Nagar New Delhi-110091 Contact No 08518878630,Mail uday@gwsolarwares.com,udaybhushan@gmail.com	Chhattisgarh	-
5.	ALPEX EXPORTS PVT. LTD.	-	Nikhilesh Sharma, Mobile: 8130991801, Email id: nikhilesh@alpexonline.com 81/2, FF Sri Aurobindo marg, near hero Honda showroom, Adhchini, NewDelhi-110017. Tel: 011-26547000, Fax: 011-26515355, Email id: info@alpexonline.com	Rajasthan, Uttar Pradesh, Punjab, Maharashtra, Bihar, Haryana	-
6.	M/s Gautam Solar Pvt. Ltd.	-	F – 35 , Okhla Industrial Area Phase -1 New Delhi – 110020 Phone: 011- 49730000. Email: shubhra@gautamsolar.com	Bihar, Chhattisgarh, Delhi, Haryana, Telangana, Uttar Pradesh, Uttarakhand, Rajasthan, Jammu & Kashmir	-
7.	Elcomponics Technologies (India) Pvt. Ltd.	-	B-25, Lajpat Nagar, -II, New Delhi. 0120 -4743300, 4743399 Corporate office- C-24, Phase-II, Noida 201305.	Chhattisgarh, Uttar Pradesh and Delhi	-



Sr. No.	Agency Name	Agency Type	Agency Address	Area of Operation	Empanelled No. / Rating / Validity Date
7.	Kirloskar Brothers Ltd.	-	S.N.Gupta (Zonal Manger – North , Solar Business) & Suman Chakraborty (General Manager & Sector head – Solar and Industry Business) Address - "Yamuna" S. No. 98/3 to7, Baner, Pune 411 045, Tel. 020 27211096 Mail Id : sngupta@kbl.co.in & suman.chakraborty@kbl.co.in Mobile no. 9829063645 & 9830093924	Gujarat, Karnataka, Madhya Pradesh, Odisha, Tamilnadu, Rajasthan, Kerala, West Bengal, Uttar Pradesh, Maharashtra, New Delhi, Jharkhand, Andhra Pradesh, Punjab, Haryana, Jammu & Kashmir, Assam & North East States, Uttrakhand, Chhattisgarh, Bihar, Telangana	-
8.	JAIN IRRIGATION SYSTEMS LIMITED	-	Mr. Vinod Patil Mob. 09422775902 solar.tendermktg@jains.com; maity.swaralipi@jains.com Jain Plastic Park, P. O. Box 7, N. H. No 6, Jalgaon 425001, Maharashtra	Maharashtra, Andhra Pradesh,Telangana,Karnataka,Punjab,Haryana,Delhi, Rajasthan,Gujarat,Uttar-Pradesh, Tamil Nadu,Orrisa, Madhya Pradesh, Jammu & Kashmir, West Bengal, Chhattisgarh, Himachal Pradesh, Uttaranchal, Bihar, Jharkhand, Kerala, Pondichery	-
9.	M/s. Ansons Electro Mechanical Works	-	Ms. Mariam Malia Kakkad House, B wing, 5th floor, Barrack Road, Dhobi Talao, MUMBAI-400020 Tel: (022) 23424764 Email:MariamAnsons@gmail.com www.ansonsancopumps.com	Maharashtra , Gujarat, Rajasthan	-
10.	M/s Laxmi Agro Energy Pvt. Ltd.	-	X-5, MIDC Gokul Shirgaon, Kolhapur.Maharashtra-416234 Toll Free No.1800 233 2025 Tel / Fax No.0231-2672292 Mob No.8605211599 Email:-agro_admin@lsslaxmi.com Website: www.laxmisolar.org ,www.lsslaxmi.com	Maharashtra, Karnataka	-
11.	M/s CNP PUMPS INDIA PVT.LTD.	-	Sunil Joshi Plot No - B 5, 502, Sambhav IT Park, Behind Aplab Company, Wagle Indl. Estate, MIDC, Thane – 400604	Karnataka, Delhi, Telangana, Maharashtra, West Bengal	-

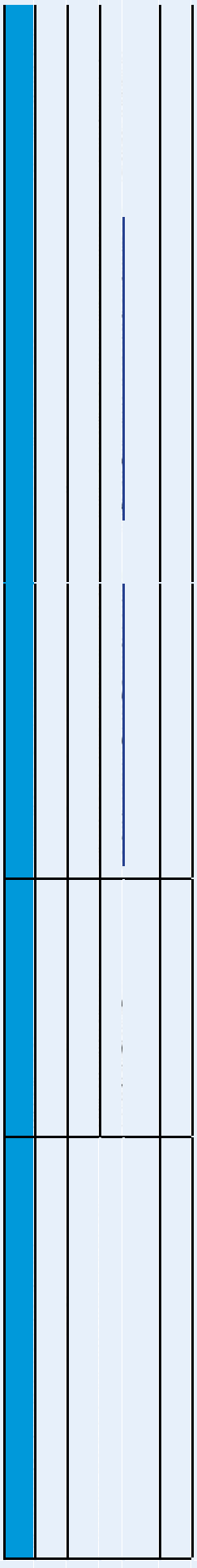


Sr. No.	Agency Name	Agency Type	Agency Address	Contact Details	Empanelled No. / Rating / Validity Date
3.	Nelso Technology Pvt. Ltd.	-	P-96 Sreebhumi, Ichapur, North 24 parganas Pin-743144, West Bengal, India	91 9874 228 400 / +91 9088 999 888 info@nelsotech.com	-
4.	RMG AUTOMATION	-	11/6, Ayanavaram Road, Ayanavaram, Chennai-600 023. Tamilnadu, India.	9940594413 http://www.rmgautomation.com rmgworld@hotmail.com	-
5.	Johnson Automation & Control	-	J-3/314, DDA Flats, Kalkaji New Delhi - 110 019, (India)	91-9811549850 / 9810984614 http://www.pumpautomation.in mktg@pumpautomation.in info@pumpautomation.in johnsonautomation@rediffmail.com	-
6.	eWas automation system	-	Attri Enterprises Ltd. Navin Engineer) 105, Agarwal Plaza, Mukherjee Nagar, Near GTB Nagar Metro Station, Gate No-2, Delhi-110009, India	(91)-8860073455 (91)-7838835279 http://www.ewaterautosys.com/	-
7.	Aquaheal Automation	-	Aquaheal Automation, Pratik Amnaji (Owner) survey No. 48, Gujarwadi Phata, Jadhav Nagar, Katraj Lake, Pune - 411046	8049187423	-
8.	softbit Technologies Pvt. Ltd.	-	F-35A, Shopping Centre-I, Mansarover Garden, New Delhi - 110015 INDIA	91 - 9899445761 / 9899445765 http://www.softbitonline.com info@softbitonline.com automation@vsnl.com	-
9.	KAIZEN AUTOMATION	-	3rd Floor, Balaji InfoTech, Plot No. A-278, Road No. 16-A, MIDC Wagle Industrial Estate, Thane - 400 604.	022-25800899, 022-25810801 http://www.kaizentc.com kaizentc@gmail.com	-
10.	Ossian Agro Automation Pvt. Ltd.	-	305, Munisuvrat Avenue, 3rd Floor, 1089 Shukrwar Peth, Shivaji Road, Swargate Corner, Pune - 411 002, Maharashtra, India.	91-20-24472277 shostwal@yahoo.co.in, info@nanoganesh.com http://www.nanoganesh.com	-



- **List of Vendors and Manufacturer for water pumping system**

Sr. No.	Agency Name	Agency Type	Agency Address	Contact Details	Empanelled No. / Rating / Validity Date
1.	Shakti Pumps India Limited	-	Plot No. 401 & 402, Sector 3, Industrial Area, Pithampur, Madhya Pradesh 454774	072924 10500 info@shaktipumps.com	-
2.	Sleeve India	-	2906 HAMILTON ROAD KASHMERE GATE DELHI DELHI 110006	91 - 11 - 23935708	-
3.	Kirloskar Brothers Limited	-	Udyog Bhavan, Tilak Road, Pune 411 002	91 20 2444 0770	-
4.	KSB Pumps Limited	-	Mumbai-Pune-Road 411018 Pimpri, Pune	91 2710 1000	-
5.	WPIL Ltd	-	10 & 11, Bhagtani Enclave, Off L.B.S. Marg, Sonapur Lane, Bhandup (West), Mumbai - 400 078.	Phone : +91 22 2582 9388 / +91 22 2582 9319 mandowara@wpil.co.in / wrosales@wpil.co.in	-
6.	Yuken India Ltd	-	No. 16/C, Doddanekundi Industrial Area, Mahadevapura Post, Bangalore- 560 048, Karnataka, India.	Mr. Guru Prasad Singh – +919611586886 91-80-41163217 marketing@yukenindia.com	-
7.	Roto Pumps Ltd	-	Plot No. 31, Sector Ecotech XII, Greater Noida – 201008, U.P. INDIA	91 120 2567912-15	-
8.	Bemco Hydraulics Ltd	-	UDYAMBAG, BELGAUM - 590 008, Karnataka, India.	0831-2441980	
9.	Adarsh Plantation Projects Ltd	-	Adarsh Plant Protect Ltd. Plot No. 604, G.I.D.C. Vitthal Udyognagar Anand, Gujrat, India.	02692236705 02692645585 md@adarshplant.com; cs@adarshplant.com; info@adarshplant.com; sales@adarshplant.com; purrchase@adarshplant.com	



- Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support renewable energy, energy efficiency and the adoption of sustainable transport solutions.

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Shakti Sustainable Energy Foundation
The Capital Court, 104B, Fourth Floor
Munirka Phase III, New Delhi 110067, India
www.shaktifoundation.in

Meghraj Capital Advisors Private Limited
2nd Floor, 201 Rajan House, Appasaheb Marathe Marg
Prabhadevi, Mumbai 400 025, India
www.meghrajindia.com