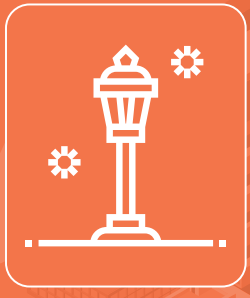
सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India



Energy Efficient Street Lighting in the City

TRAINING MANUAL

Climate Centre for Cities

ClimateSmart Cities Assessment Framework

Energy and Green Buildings

सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India

Energy Efficient Street Lighting in the City

TRAINING MANUAL

ClimateSmart Cities Assessment Framework

Energy and Green Buildings

Climate Centre for Cities

Energy Efficient Street Lighting in the City
Training manual

Developed by:
Climate Centre for Cities, NIUA

Author
U. Chandra Kumar.

Editors
Umamaheshwaran Rajasekar and Vaishnavi T G Shankar

Contact information

Climate Centre for Cities
National Institute of Urban Affairs
1st Floor, Core 4B, India Habitat Centre,
Lodhi Road, New Delhi -110003, India
Telephone: (91-11) 24617517, 24617543, 24617595
Website: www.niua.org, www.niua.org/c-cube

Photo Credits: Jack B on Unsplash

Executive Summary

OOn one hand, cities are a significant contributor of carbon emissions aggravating climate change and on the other, cities are considerably impacted by climate disasters. The recently released Global Climate Risk Index 2021 ranks India as the 7th most affected country from climate related extreme weather events (storms, floods, heatwaves etc.). Further, studies indicate that poor planning and urban management are expected to cost Indian cities somewhere between $2.6 and $13 billion annually.[1] Cities are increasingly at the forefront of addressing both urbanization and climate change and to strengthen climate-sensitive urban development, a holistic understanding of the urban development from a climate lens is crucial. The ClimateSmart Cities Assessment Framework (CSCAF) launched in 2019 by the Ministry of Housing and Urban Affairs (MoHUA), Government of India aimed to address this gap. This first-of-its-kind assessment with 28 progressive indicators across 5 thematic areas helps cities to benchmark their development, understand the gaps and further prioritize climate relevant development.

With a focus on building local capacities to develop and adopt climate measures, the Climate Centre for Cities (C-Cube) at the National Institute of Urban Affairs (NIUA) initiated a series of training aligned to the thematic areas of CSCAF - Energy and Green Buildings, Urban Planning, Green Cover & Biodiversity, Mobility and Air Quality, Water Management, Waste Management. The focus of the training is to provide a step-by-step approach of conducting studies, assessments and stakeholder consultations, establishing committees, developing action plans and implementing relevant measures that not only

1. *Mani, M. et al., 2018. South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards, WashingtonD.C.: World Bank Group.*

makes the cities climate resilient but also helps them progress across the assessment of CSCAF.

Street lighting is a major contributor to the city's electricity consumption resulting in greenhouse gas emissions. Improper designing of street lights will not only lead to lighting pollution but also creates vision related fatigue/discomfort for the users. Hence the module emphasizes on the need to design the lighting system properly with least consumption of energy.

The objective of the module is

- To emphasize the importance of lighting design principles,
- To underscore the possible energy savings in the retrofit options,
- To understand the business models to aid execution of EE street lighting projects

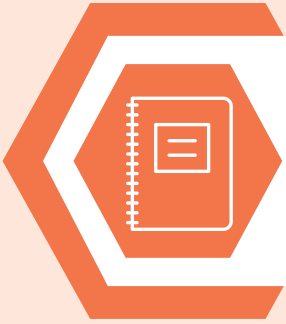
The key concepts that are discussed are street lighting design, renewable power, control systems, battery and lux standards, business models and M&V protocols. The challenges during the energy efficient street lighting implementation could be addressed by proper preliminary design which are discussed in detail. The training is designed such that the trainee understands energy efficient street lighting with good practices and establishes baseline parameter using ready to use templates.

Who is the training manual designed for?

What is the focus of the training manual?

How to make use of this manual?

What are the Learning outcomes of the training?



Scope and limitations of the training

City planners, lighting designers, PWD Engineers, corporation and municipality administrators with utility experience

The training will focus on imparting an understanding of the technical, financial, commercial, legal, energy auditing, policy and regulatory aspects of EE street lighting projects.

Street lighting technology is an evolving subject and hence prompt decision making on early stage saves a lot of energy being consumed during the lifetime of the project. The participants can refer to this manual as a guide for the same.

The learning outcomes are design knowledge of energy efficient street lighting, appropriate use of renewable street lighting and control systems to reduce the life cycle cost of the project.

The scope of the training is to improve knowledge on 'Energy Efficient Street Lighting' systems – its planning, implementation and financial solutions. Further, to enable stakeholders on data collection and visualization to understand their status and provide guidance to increase the percentage share of EE Street lights systematically. It is important to note that the manual can be used a guide but keeping in mind the evolving lighting technology and the lighting codes that are in practice.

Contents

List of Figures

List of Tables

Abbreviations

ULBs	Urban Local Bodies
CSCAF	Climate Smart Cities Assessment Framework.
EE	Energy Efficient
PRSF	Partial Risk Sharing Facility
ESCO	Energy Saving Companies

1

Introduction

India's urban transformation shows a significant opportunity to address municipalities' future energy usage, an insight to their greenhouse gas (GHG) emissions, their energy requirements, and their budgets. In order to disengage the limited city budget from the supply constraints of current energy systems, it is essential to ensure that cities develop in an energy-efficient manner and contribute to national energy security. Street lighting is a key consumption component of a city's share of energy.

Municipalities, Corporations and PWD engineers who undertake the street lighting projects are bundled with legacy lighting systems with manual controls. The energy consumption, therefore is more which leads to significant power bills. New projects which are currently being planned has to be designed in such a way that the control system and lighting systems are Energy Efficient (EE) and the power required for their operation is met through renewable energy sources.

As a city grows and expands, the energy needed to meet the growth increases rapidly. With new energy-efficient lighting technologies like LEDs (light-emitting diodes) available in the market today, streetlights represent one of the most cost-effective opportunities for energy savings and for reducing municipalities' energy costs and GHG emissions. As street lighting loads require electricity during peak demand hours, EE street lighting projects are considered attractive investment projects by electricity supply utilities also. Energy efficient and renewable energy operated street lighting systems will reduce the dependence on electricity from fossil fuels thus indirectly reduce GHG emissions in the city.

Energy Efficient Street Lighting is one of the key transformations Indian cities are adopting and the same is assessed as one of the critical indicators under the Energy & Green Buildings thematic area in CSCAF. The indicator assess the extent to which cities have adopted use of energy efficient and renewable energy operated streetlights. Energy efficient streetlights should have lamps with luminous efficacy of more than 85 lumens per watt (e.g. LED, Sodium vapor lamps etc.). The ratio is calculated for the total number of energy efficient and renewable energy operated streetlights in the city to total number of streetlights in the city.

Formula:

$$\frac{\text{Total number of energy efficient street lights + renewable energy operated street lights in the city}}{\text{Total number of street lights in the city}} \times 100$$

*Double counting of the streetlight should be avoided

Unit: %

Maximum Score: Total score for the indicator is 100. Cities will be marked in 5 levels with scores ranging from 0 to 100.

Table 1.1 Performance Evaluation

	1	2	3	4	5
Progression Levels	No streetlights in the city is energy efficient	Up to 25% streets lights in the city are energy efficient or renewable energy operated	Up to 50% streets lights in the city are energy efficient or renewable energy operated	Up to 75% streets lights in the city are energy efficient or renewable energy operated	All streets lights in the city are energy efficient or renewable energy operated
Evidence/ Data sources	• Total number of measures implemented. Cities will be marked in 5 levels with scores • Municipal records/documentary evidence for the number of streetlights with energy efficient lamps, • Municipal records/documentary evidence for the number of streetlights operated with renewable energy, • Map of all streetlights in the city as .kml files. (point geometry with optional attributes for energy efficient lamps)				
Responsible Department/ Agency	ULBs				
Reference Documents	Energy Efficient Street Lighting (BEE; 2010) https://tinyurl.com/sorzgrz				
Score	0	25	50	75	100

Photo Credits: TDP Trending

2

Implementation Strategies

There are numerous applications of lighting in a city. The scope of overall lighting is in a city include:

1. Street lighting
2. Security lighting
3. Decorative lighting
4. Utility Areas (Harbour, Railway, Airport)
5. Sports lighting
6. MRTS
7. Highway lighting

The Training manual however, focuses on the scope of street lighting in an energy efficient manner.

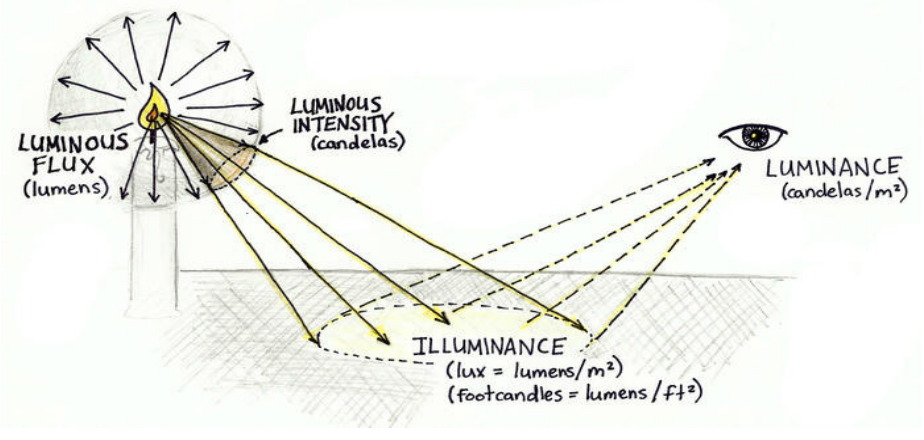
2.1. Basic Lighting principles

Lighting can be better understood by revisiting the terms. Below are the common terms associated with lighting.

1. Luminous Flux- It is the measure of brightness of a light source in terms of energy being emitted. Luminous flux, in SI units, is measured in the lumen (lm).
2. Luminous Intensity- In photometry, luminous intensity is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle, based on the luminosity function, a standardized model of the sensitivity of the human eye.
3. Illuminance- It is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle, based on the luminosity function, a standardized model of the sensitivity of the human eye.

4. Luminance- It is a photometric measure of the luminous intensity per unit area of light travelling in a given direction.
5. Colour Rendering Index- This index measures the ability of a light source to reveal colours of objects in contrast to a natural light source
6. Correlated Colour Temperature- Is a specification of the colourƒ appearance of the light emitted by a light source, relating its colour to the colour of light from a reference source when heated to a particular temperature, measured in degrees Kelvin (K).

Fig 2.1 Common Lighting Terminologies

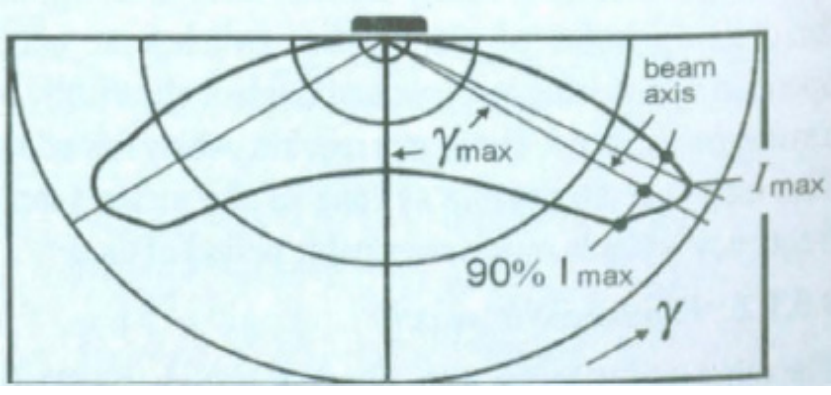


2.2. Photometry

Each lamp, irrespective of the type has a photometry polar diagram. It is imperative to obtain and understand the photometry data for better suitability for an application.

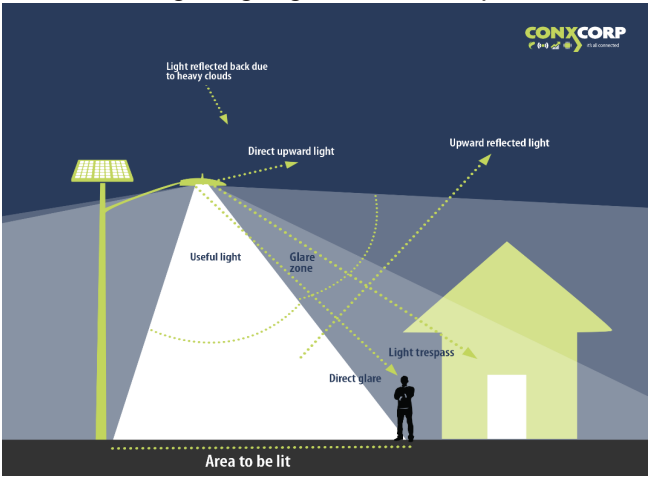
The diagram illustrates the distribution of luminous intensity, in candelas, for the transverse (solid line) and axial (dashed line) planes of the luminaire. The curve shown provides a visual guide to the type of distribution expected from the luminaire e.g. wide, narrow, direct, indirect etc. in addition to intensity.

Fig 2.2 Typical Photometric Polar Diagram, Ref: BIS – NLC Pg 244



1. Throw – The extent to which the light from the luminaire is distributed along a road
2. Spread, I_{max} – The amount of Sideways spread of the light, across a road and
3. Control, SLI – The extent of the facility for controlling glare from the luminaire Lighting pollution

Fig 2.3 Lighting Pollution, Conxcorp

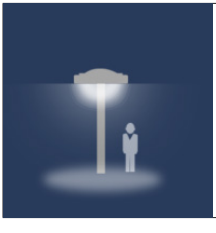


In Urban areas, mostly it is found that the lighting is in excess of optimum levels thus leading to light pollution. Following is the diagram depicting the useful light, glare, light trespass, upward light and reflected light, Light reflected back due to heavy clouds

- Uniformity is the ratio of Minimum illuminance to Average illuminance

2.3. Steps to Progress

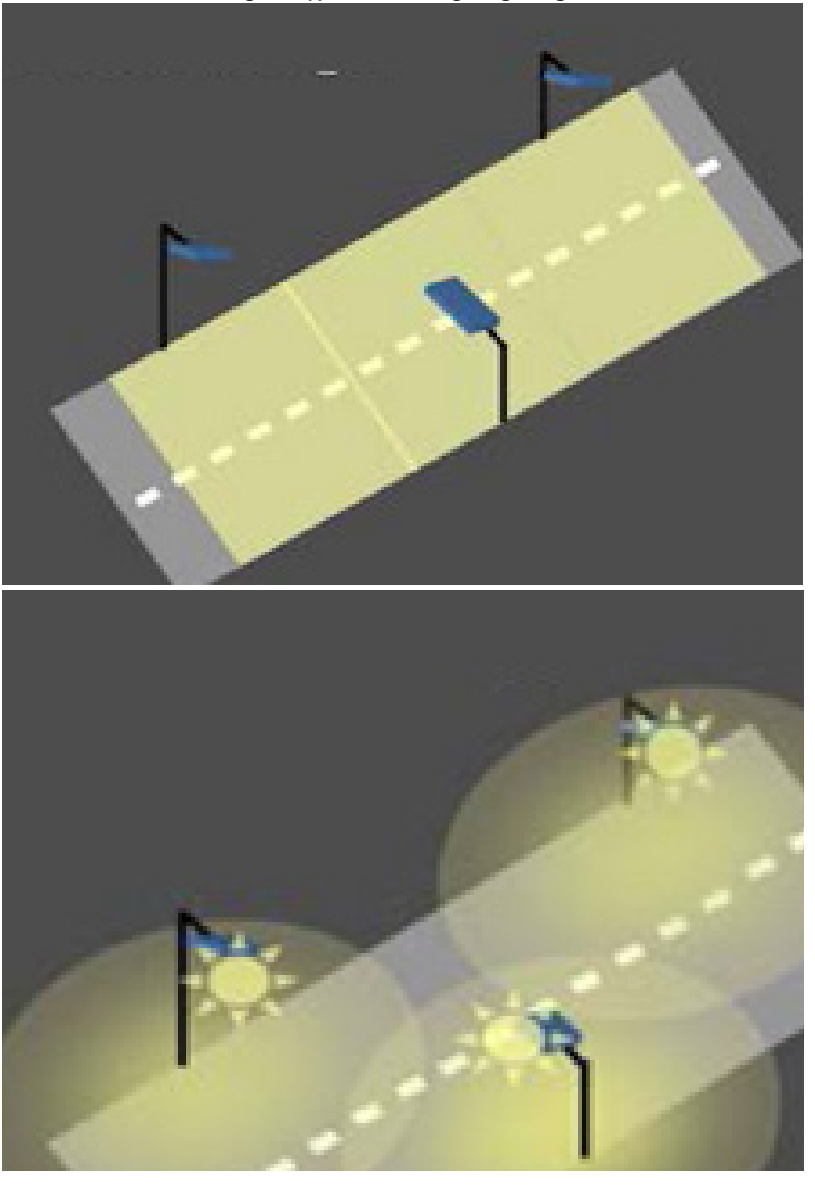
Following are the steps which can help cities improve the street lighting system design.

	This image shows how street lighting was designed without proper luminaire causing glare across the skylight
	This shows the presence of luminaire which limits to glare to some extent, partially.
	This shows further reduction in glare, which is better than the above designs.
	The ideal Street lighting design is shown here which is lighting only the required area and doesn't not glare the unwanted areas. The energy consumed is optimum also the desired light output is reached.

2.4. Street light Design

Traditionally the street lighting design is done in a manner as depicted below in Fig 2.4. It can be observed that there are over lit spots and dark spots present across the road, leading to the discomfort of the commuters. Ideal design to be incorporated is where the lighting is evenly spread across the road, thereby reducing the discomfort to the users.

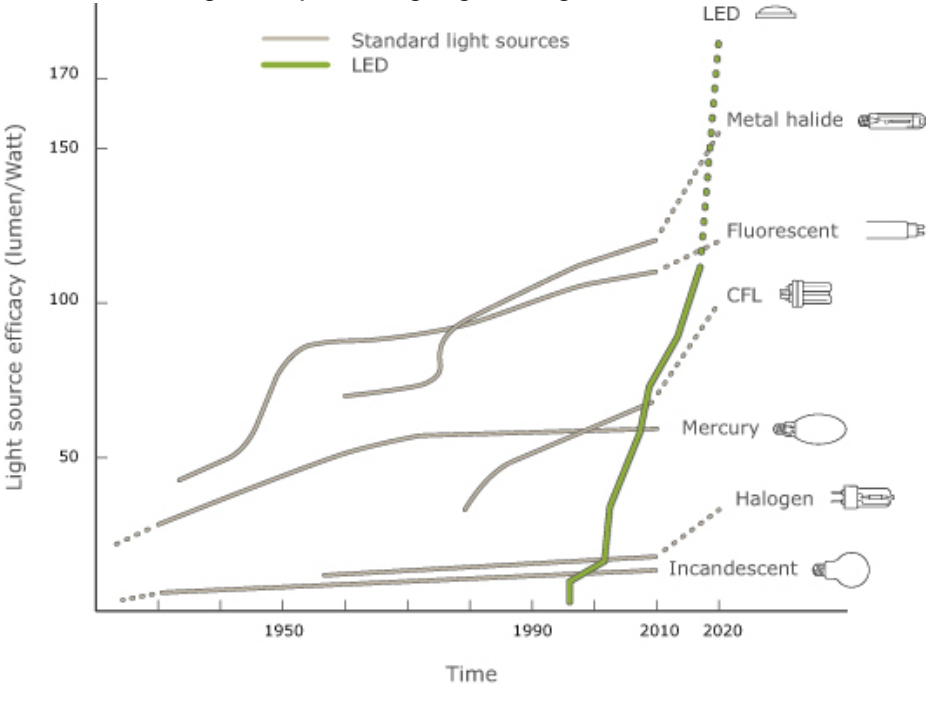
Fig 2.4 Types of street lighting design



2.5. Comparison of lighting technologies

It is necessary to understand the lamping/lighting technology evolution, to appreciate the benefit of retrofitting the LED lamps in the existing setup. It can be noted from this chart that the rise of LED technology has been phenomenal in the recent years, leading to its adoption widely in the existing street poles. The retrofit savings is discussed in the following sections.

Fig 2.5 Comparison of lighting technologies, Science Direct



Wattage Comparison of Conventional & EE Street light

Following is a comparison of the conventional metal halide lamp and the LED lamp. It can be inferred that the wattage required by LED lamp is almost half of the conventional lamp, for providing similar lux levels, thereby significantly reducing the energy consumption levels.

Other major inferences that can be observed from the above example are that there is

a. 0.5 kwh saved/day/fixture which is equivalent to 0.4 Kg of Co2 reduction/day
b. Around 150 Kg of Co2 reduction/year/fixture in emissions
c. Thus for 1000 fixtures, 150 tons of Co2 emission reductions/year can be achieved.

Table 2.1 Wattage Comparison of Conventional & EE Street light

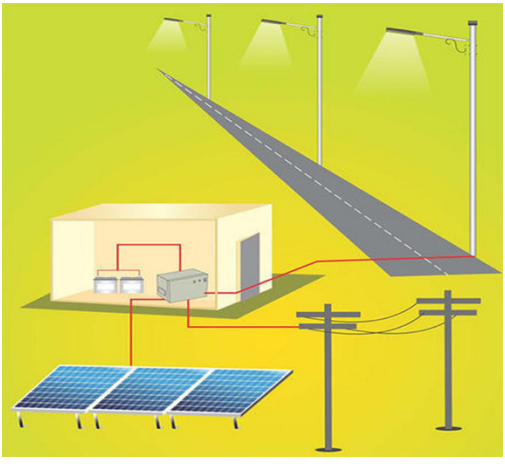
Parameters with Units	Conventional Lamp (MHL)	LED Lamp
Wattage, W	150	70
System watts , W	172	70
Pole height , m	7	7
Spacing , m	25	25
Avg lux	18	22
Total Energy Consumption for 6 hrs in Wh	1032	420
Saving		> 40 - 55 %
Life in hours	6000 - 15000	25000 - 100000

2.6. Different Energy Efficient Solutions

Renewable Street lighting

One of the recent advents in street lighting is the adoption of solar in the design. There are two types of design. First one is PV module on the top where the solar module and the battery is located on the street pole itself. This type of design is very effective in the mountain roads, where there is difficulty in laying the cables for connection. The solar module has to be oriented in such a manner that there is sunlight falling on the module for a significant amount of time.

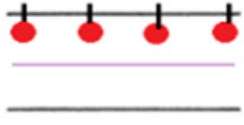
Fig 2.6 Grid Type



The other alternative design is the grid type model, where the PV modules are located centrally and are connected with the street light poles at a distance. The advantage over the previous design is that the PV modules can be cleaned at ease and the there is an ease of maintenance, thereby improving the longevity of the project components.

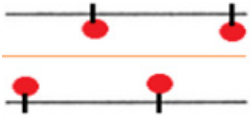
Street lighting pole arrangement[1]

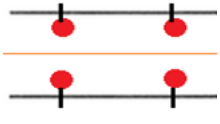
The arrangement of street lighting poles on a given road is also playing a significant role in the lighting. Following are some of the arrangements with their merits and demerits given.



This image shows how street lighting was designed without proper luminaire causing glare across the skylight

This shows the “Both Side staggered” method of arrangement of poles which provides better uniformity of lighting across the road. The Mounting height is taken as 0.8 times the width of road

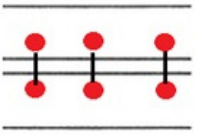




This is the “Both side opposite” model which is better in wet conditions for lighting. The mounting height is taken at 0.5 times the width of the road.

[1] *Parmar, J. 2019. How to Design efficient Street lighting-(Part-1). Electrical notes and articles. Available at: https://electricalnotes.wordpress.com/2019/04/24/how-to-design-efficient-street-lighting-part-1/*

This depicts the “Twin Central Pole” which is aiding in the ease of maintenance. Also the mounting height is 0.8 times the width of the road.



Street lighting pole height

The wattage of the lamp can be determined roughly using the mounting height at which it is placed. The figure shows the mounting height and the corresponding preferred wattage that is required for the street lighting. This is an indicative only and also depends on the street width and the traffic that is prevailing on the road, apart from the pole arrangement.

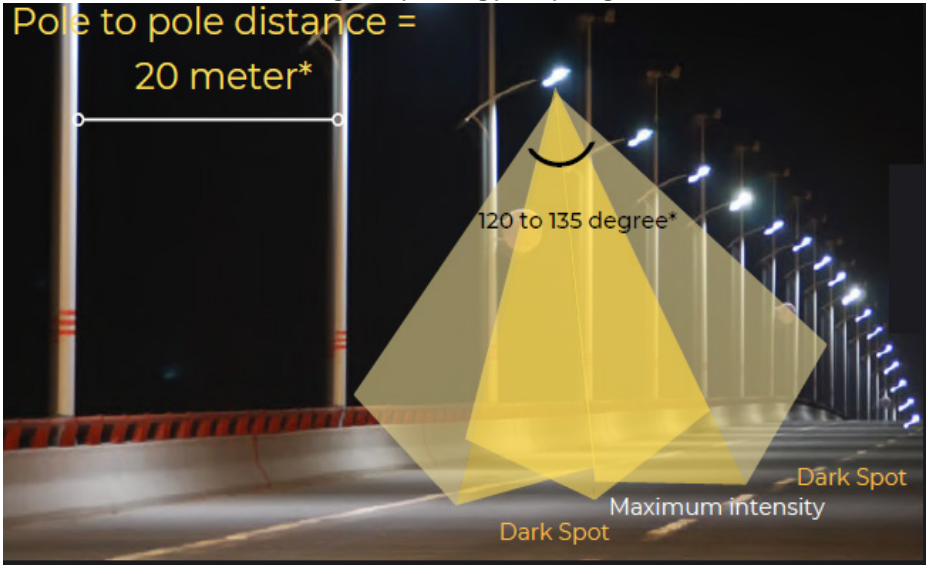
Fig 2.7 Street lighting pole Height vs Wattage

This also segregates the high mast requirements which are above 50 meters of mounting height. The lamps are required to be of IP 66 (ingress and dust protection) which are aiding in the ease of maintenance.

Pole spacing optimization

One of the energy conservation measure is to optimize the pole space, especially during the design stage. For a Conventional pole illustrated in the figure, spacing of 20 m for 120 to 135 deg of lighting coverage is achieved.

Fig 2.8 Optimizing pole Spacing



The life cycle cost of conventional model and energy efficient model of 160 degrees is compared and given below. It is observed that the conventional model requires 50 lights/km while the Energy efficient model requires only 30 lights/Km. Thus there is an immediate saving in the procurement cost of around 1.1 lakhs. This is having an larger impact on the life cycle cost as the 5 year savings result in 1.8 lakhs in addition to the procurement cost/day. There is about 3 lakhs savings while comparing on cost/km basis for 5 years.

For 100 kms this translates to Rs.3 crores savings for 5 years. The lighting wattage is also marginally reduced from 75 W to 60 W

Table 2.2 Comparison of Models on Life Cycle Cost, cvdeetech

	120-135 deg model	160 deg model
Fixture Wattage, W	75	90
lights / Km	50	30
Cost / fixture, Rs	6000	6200
Procurement Rs.	3 Lakhs	1.86 Lakhs
5 Years Electricity cost at 5 hrs/day	5.4 Lakhs	3.6 Lakhs
Installation & Servicing	Rs. 75000	Rs. 45000
5 Years Life Cycle cost /Km	Rs. 9.15 Lakhs	Rs. 5.91 Lakhs

EE Luminaire price range

The cost of the luminaires is an important factor in determining the procurement cost. The typical market price of the solar street light is given below for a reference.

Table 2.3 Typical Price range of Solar Street light

Watt	Price in INR
20 Watt Solar Street Light	15,000
30 Watt Solar Street Light	22,500
40 Watt Solar Street Light	30,000
60 Watt Solar Street Light	45,000
80 Watt Solar Street Light	60,000
100 Watt Solar Street Light	75,000
120Watt Solar Street Light	90,000

MNRE BENCHMARK PRICE

Every year Ministry of New and Renewable Energy (MNRE) releases the notification on the benchmark cost. This is done to ensure that the subsidy amount is aligned to the current market price.

Table 2.4. Bench mark costs by MNRE for 2020-2021

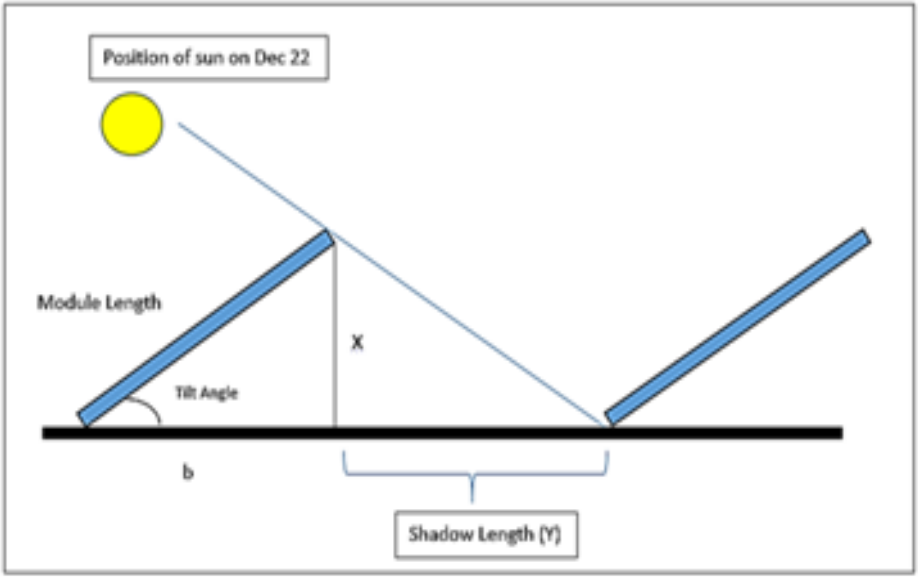
Bench mark costs by MNRE for 2020-2021		
System	General category states	For NE states & Island UTs
Solar street light	19400	21340
For 75 Wp panel, 12 W LED with 12.8 V with 30 Ah Li battery		
Cost inclusive of installation, commissioning, transport, insurance, maintenance for 5 years, taxes and remote monitoring sytem		

Design details of PV

The Solar Photovoltaic modules has to be designed properly for obtaining the maximum performance. The standalone solar pv designs come within built battery with module. The centralized model of PV design require proper designing of modules.

The Inter row of PV panel spacing has to be optimized for lower space requirement, especially during the maximum shadow period of December 22. Roughly around 20 W/ Sq. ft of space is assumed. Also the system of DC or AC has to be decided and accordingly designed.

Fig 2.9 Inter row PV Panel spacing



Design details of Li & LFP battery

Ministry of New and Renewable Energy adopts the specification of the street light with batteries. For Lithium battery type following is the minimum specification that has to be met for the purpose of obtaining the subsidy if claimed.

Table 2.5 MNRE Specification for Lithium Battery

MNRE Spec for Lithium Batteries	
Specific Energy	Min 120 Wh/kg
C rate Charging	Min C/4
C rate Discharging	Up to 1C
Charge Discharge Cycles	Min 2000 Cycles at C/10 rate at 25 deg C
Thermal Runaway	Min 120 C
Depth of Discharge	Min 85% at 25 deg C
Temperature of Operation	10 to 50 deg C (outside ranges with Thermal mgmt. system)

For the Lithium Ferro Phosphate type of batteries, following is the MNRE specification.

Table 2.6 MNRE Specification for Lithium Ferro Phosphate Battery

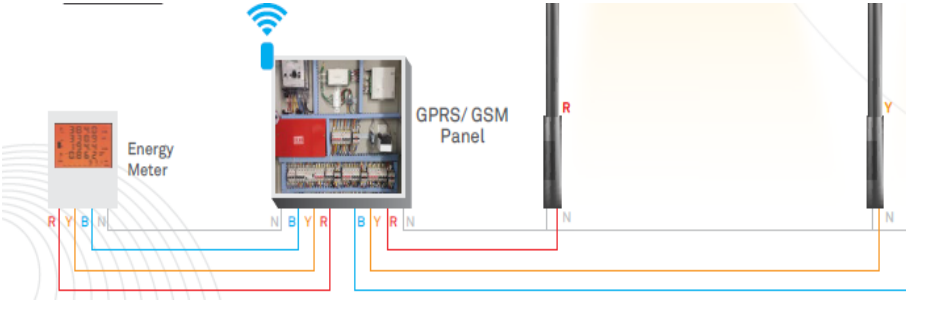
MNRE Spec for Lithium Ferro Phosphate batteries	
Minimum 12.8V, 30 AH capacity	
Battery pack should have proper 'Battery management System' (BMS) for cell balancing, over charge and over temperature protection	
Battery should conform to the latest BIS/ International standards.	
Charge Discharge Cycles	Min 2000
Depth of Discharge	Min 85% at 25 deg C

Control and monitoring systems

It is necessary to design the control method during the initial project stage, ensure proper provisions during the implementation stage. By employing proper control strategies, lights can be switched on/off remotely and also can be monitored through the centralized control and monitoring systems. Following are some of the methods that are normally utilized.

a. Photoelectric switch
b. Programmable timers
c. Panel level dimming
d. Group & Individual control
e. SCADA (Supervisory Control and Data Acquisition)

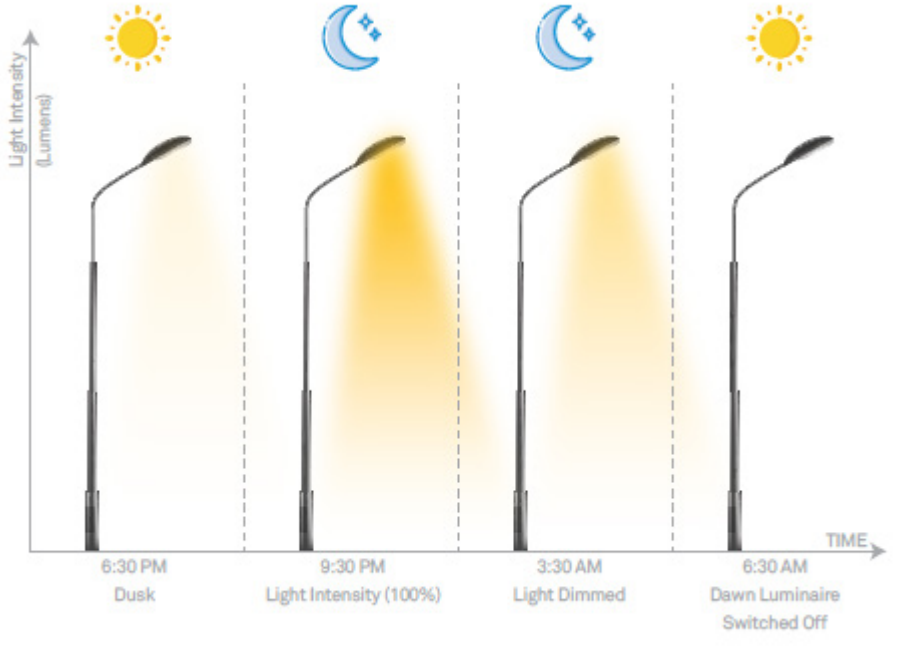
Fig 2.10 Typical Monitoring System



Another evolving control systems is the Astronomical Switch type of operation where the lighting intensity can be changed according to the time during the night with subsequent change in traffic in the road. Initially during the evening, the lighting is switched on for full

intensity and during the midnight when the traffic is less, it may be designed for dimming to lower intensity. After the set time say 6 am, settings may be adjusted to switch off completely.

Fig 2.11 Astronomical Switch Operation



3

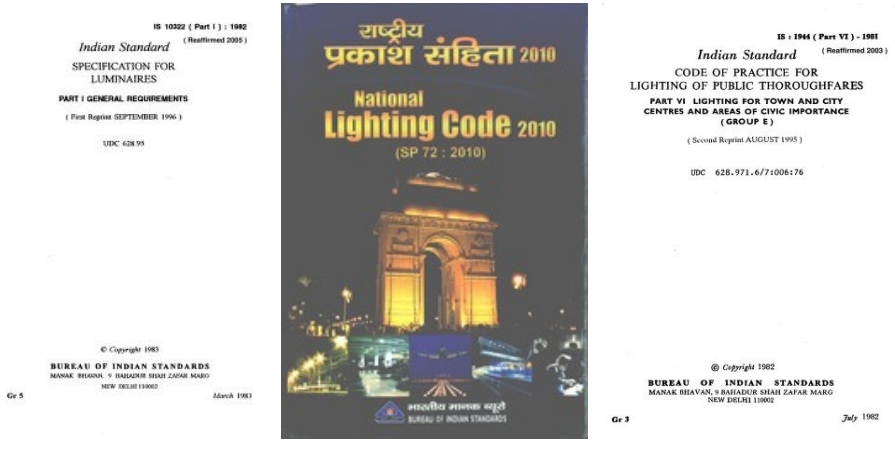
Institutional Framework

3.1. Standards In Lighting

Street lighting design and lux standards are given by the BIS (Bureau of Indian Standards) and Various international bodies. Some of the frequently referred standards are

- IS 10322 Safety requirements
- NLC 2010
- IS 1944
- IS 732 Wiring
- IS 16106
- IS 13383 Luminaries Photometry
- IEC standards
- FRLS -Fire resistant low smoke with low O2 index

Fig 3.1 BIS Lighting Standards

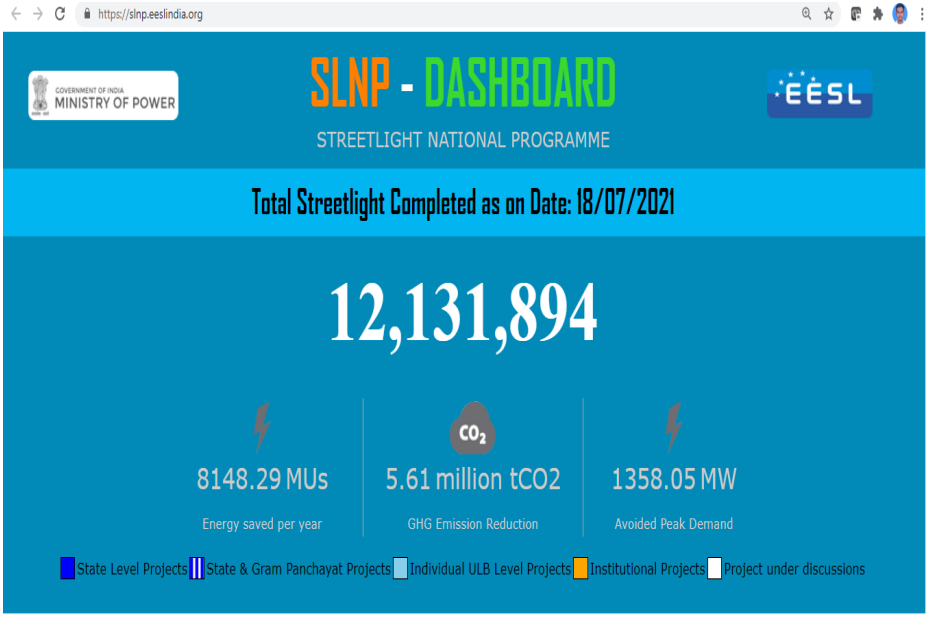


In India following two labs are adequately equipped to address the testing requirements.

- NISE Lab for SPV
- National Test House for LEDs

3.2. National Initiatives

Fig 3.2 EESL SLNP Dashboard



On National Level, Ministry of New and Renewable Energy (MNRE) and Energy Efficiency Services Ltd (EESL) has been pioneering the Energy Efficient lighting. The success of the EESL program can be seen in the dashboard. See link for more details: https://slnp.eeslindia.org/

3.3. Business models

The Energy Saving Companies (ESCO) are the institutions registered under Bureau of Energy Efficiency which are engaged in the retrofit of light fittings. It is important to understand the various business models of their operation.

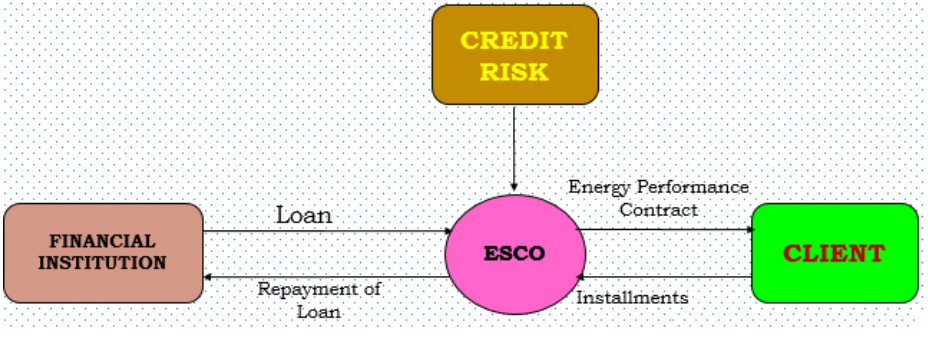
ESCOs, offer energy efficiency improvement services which may also include guarantee of the savings. The remuneration of ESCO is linked to the projects' performance which means that the ESCO's payment is directly linked to the amount of energy saved.

ESCOs are important vehicles to capture energy-efficiency potential and the business model they use, energy performance contracting, helps overcome a number of market barriers.

Shared Savings Model

Under a shared savings structure the ESCO finances the project, usually by borrowing money from one or more third parties. In the case of shared savings, the ESCO assumes not only the performance risk, but also the financial risk (including the underlying customer credit risk). The customer assumes no financial obligation other than to pay a percentage of the actual savings to the ESCO over a specified period of time. This obligation is not considered debt and does not appear on the customer's balance sheet. The portion of savings paid to the ESCO is always higher for shared savings than the guaranteed savings projects, reflecting the ESCO's significantly greater risk and expense for borrowing money.

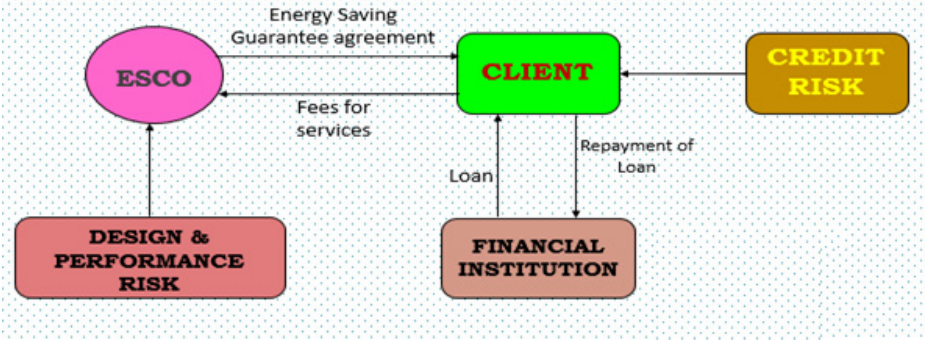
Fig 3.3 Shared Savings Model



Guaranteed Savings Model

Under a guaranteed savings structure, the customer finances the project in return for a guarantee from the ESCO that the project's energy savings will cover the customer's debt service. Thus, the customer assumes the obligation to repay the debt to a third party financier, which is often a commercial bank or a leasing company. If the project savings fall short of the amount needed for debt service, the ESCO pays the difference. If the savings exceed the guarantee amount, the customer and the ESCO usually share the excess savings. The size of the share and the method of calculation vary widely, depending on the degree of risk assumed and the extent of services provided by the ESCO.

Fig 3.4 Guaranteed Savings Model



Deemed Savings Model

The salient features of Deemed savings model are

- Fixed payment by the Project Host for receiving ESCO's services.
- Measurements are generally done for the first year
- Useful for projects where Project Hosts may operate at various operating capacity levels which determine varying levels of savings.

4

Finances, monitoring and evaluation

The Lighting projects usually require large amount funding, given its vast coverage spread across the city. It is therefore handy to know about some of the funding mechanisms that support energy efficient lighting projects. Some of them are listed below:

- Partial Risk Sharing Facility operated by SIDBI bank
- State Energy Conservation Fund by BEE (Respective State Designated Agencies)
- Convergence Energy Services Ltd (*https://convergence.co.in/*)
- State specific Policies
- Rural Electrification Corporation (*https://www.recindia.nic.in/*)
- Smart cities program (https://smartnet.niua.org/)

Partial Risk Sharing Facility

PRSF is currently operated by SIDBI (Small Industries Development Bank of India) and managed by World Bank. The objective is to assist India in achieving energy savings with mobilization of commercial finance and participation of ESCOs. For availing the benefits, following are the eligibility conditions. The snapshot of Partial Risk Sharing Facility being utilized by the street lighting projects is given the table:

4.1. Monitoring and evaluation

It is important to have a strong Monitoring & Verification Protocols in the interest of maintenance and sustainability of the project. Following are key points to be kept in the consideration while designing the project.

- Liquidated Damages (delay <5% of contract) & Penalty (for Performance) in contract
- The VMC was also the first city in the country to install and implement) in street light

service. This programme was implemented with installation of microprocessor-based intelligent street light controller with GSM technology for remotely monitoring and controlling street lights.

- O&M is usually 3% of Capex
- Maintenance friendly design (Water, bamboo, ground pv, DOD alert)
- Overall routine system and Third party monitoring
- Guarantee of Disposal/ Recycle
- Patrol cost, Energy cost, Relamp cost
- Maintenance factor across years to include Non recoverable factor

The recommended parameters for lighting design are now generally based on 'maintained values' which are the average luminance/illuminance at the 'certain period' of the above definition when maintenance has to be carried out.

Table 4.1. Impact of PRSF project on Street lighting

	UoM	Street Lighting
No. of Projects guaranteed	Nos.	9
Guarantee amount	INR Mn	69
Loan amount guaranteed	INR Mn	92
Total loan Amount	INR Mn	134
Project Cost	INR Mn	286
Annual Energy Savings	GWh	7.30
Annual GHG emission reduction	ton of CO_2	5,787

Lighting systems have different maintenance characteristics and this should be one of the important assessments made in the early stages of project design. This part discusses the various influencing factors and gives data based on practical solutions which enable the maintenance factor for different types of systems and environments to be derived.

Fig 4.1. Degradation of initial illuminance across hours of use

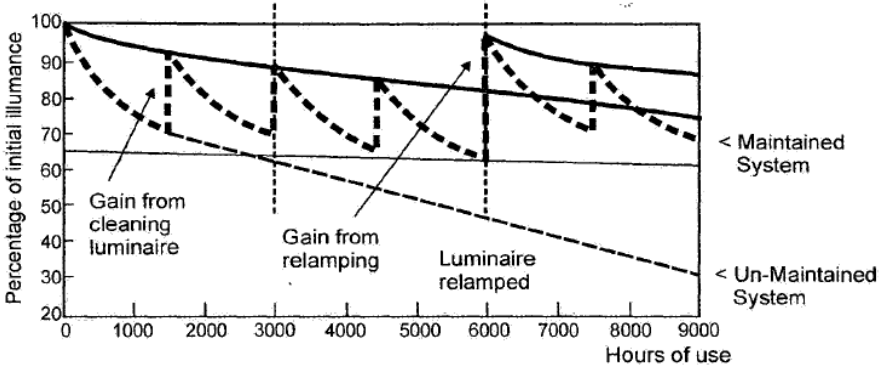


Photo Credits: Aboodi Vesakaran on Unsplash

5

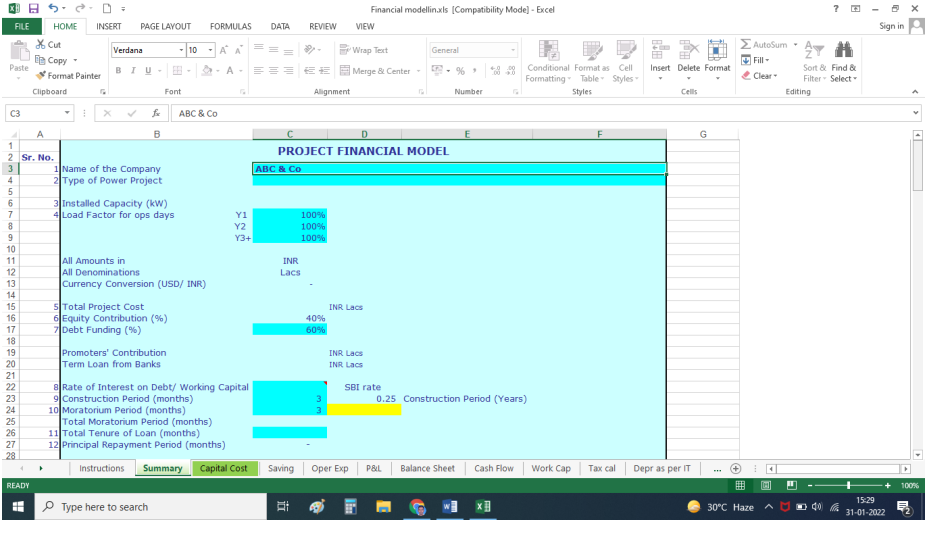
Interactive Exercise

The objective of the exercise is to perform a financial modelling of the lighting retrofit project which provides an insight in to the project's anticipated financial performance and the Projected Energy Savings.

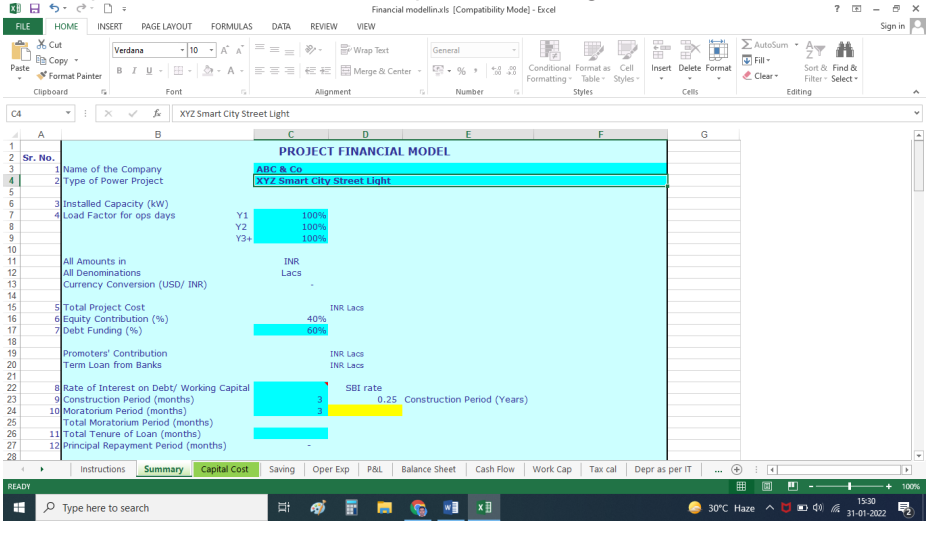
The exercise is in the form of an excel based tool that has sheets. Summary and the capital cost sheet which lists out the required data from the user. Filing the project date on these sheets, automatically provides the rest of the calculated data in the rest of the sheets with ample financial insights.

Steps followed in the exercise:

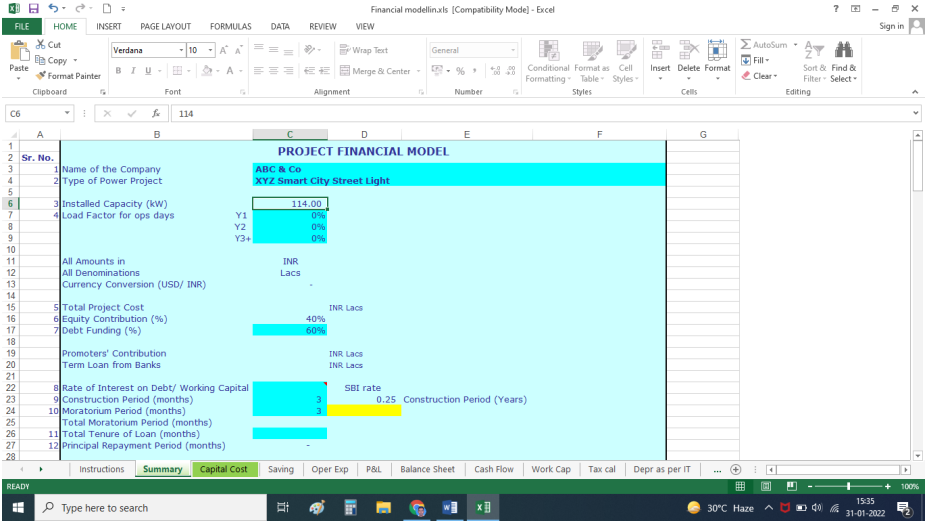
1. Please insert name of your city



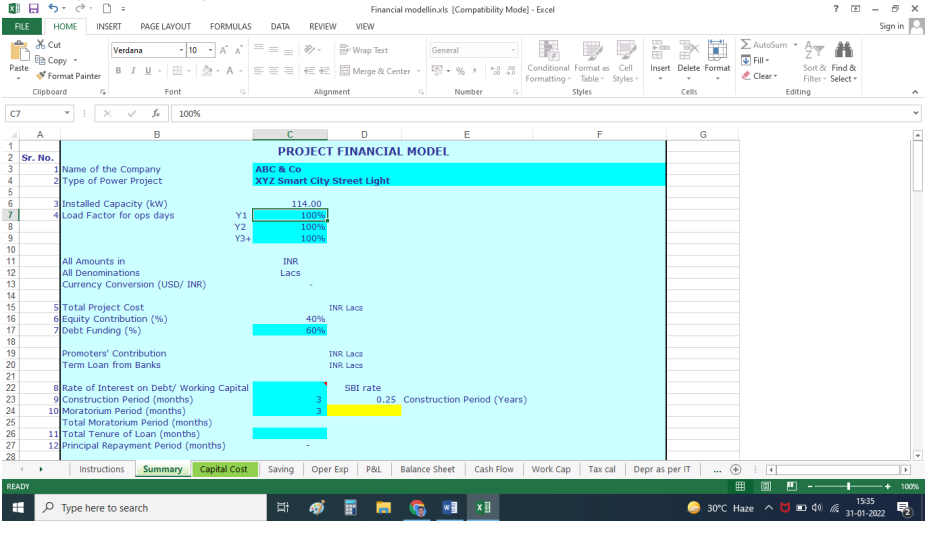
2. Please insert type of project: New Project, Expansion of project, Diversification, modernisation of project. Please specify the name of project also for eg. Street Light or replacement of incandescent lamp with T5 tube light



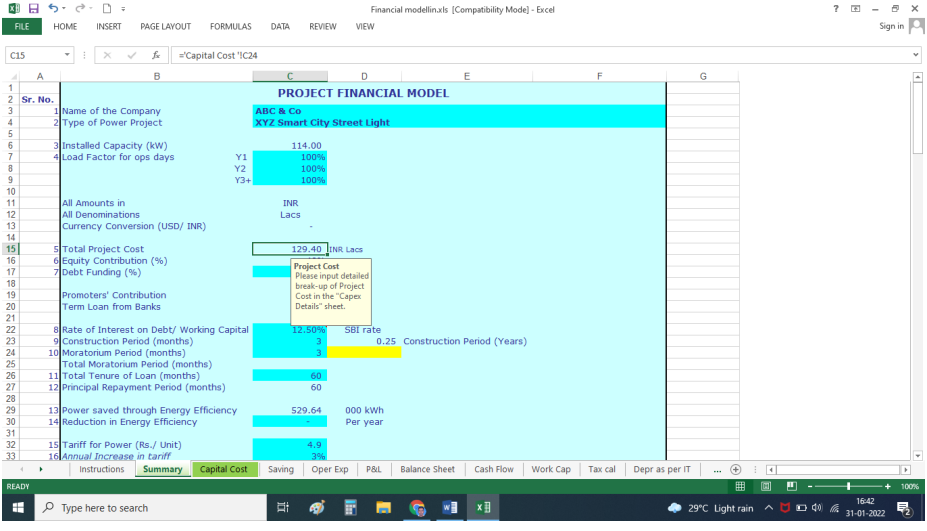
3. Installed capacity of the project in kW



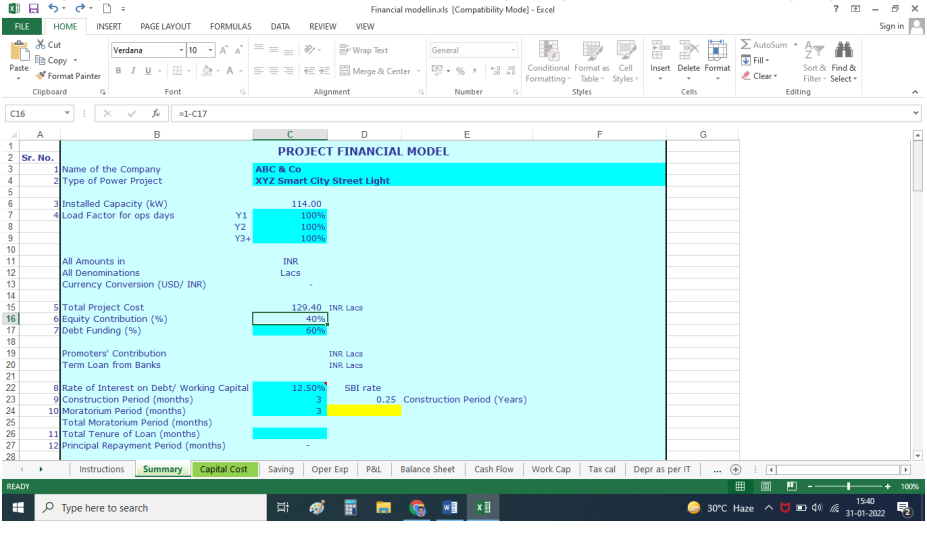
4. Load factor - Its a measure of the output of a project compared to the maximum output it could produce.



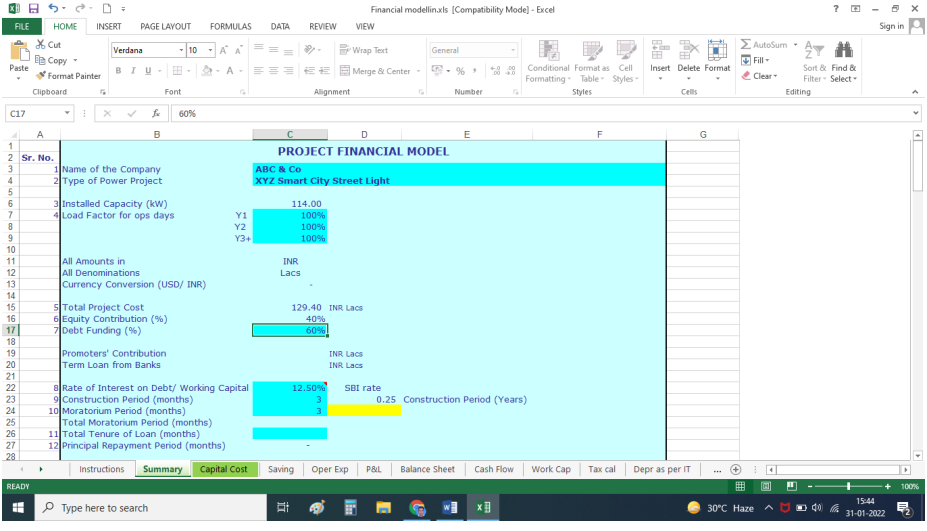
5. Total Project Cost: Project Cost includes cost of Fixed assets such as Plant & Machinery, Land, building etc., any contingency expense, Interest during construction, Preliminary & Preoperative exp. incurred during the installation of the project



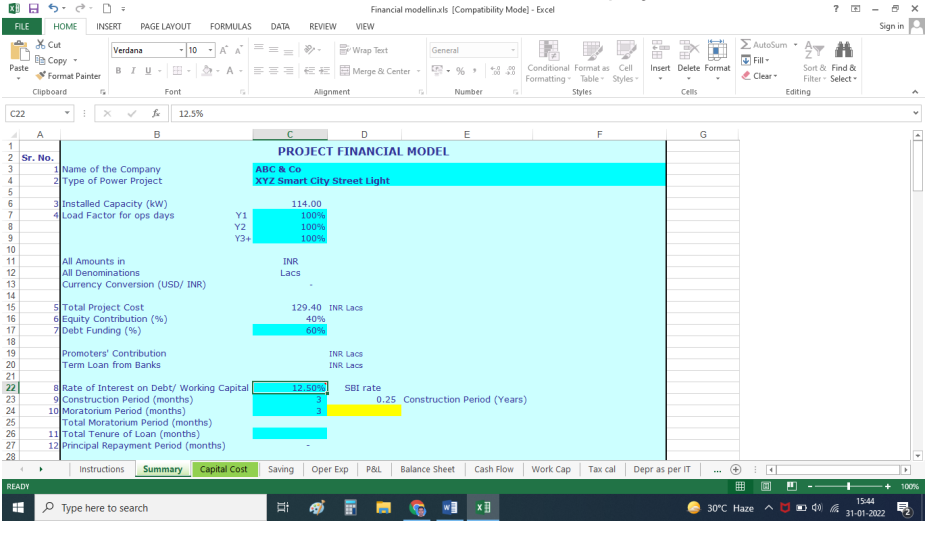
6. Equity Contribution % - Own fund infused by the promoters of the company



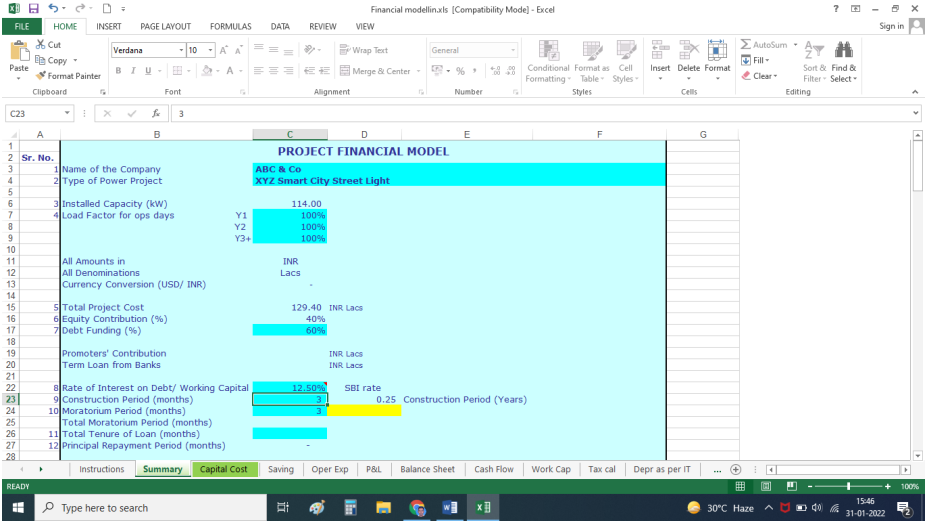
7. Debt Funding %: Debt/ Loan taken from bank or financial institution for this particular project



8. Rate of Interest on Debt/ Working Capital: Rate at which the project company has availed loan from Financial Institution or Bank for this project

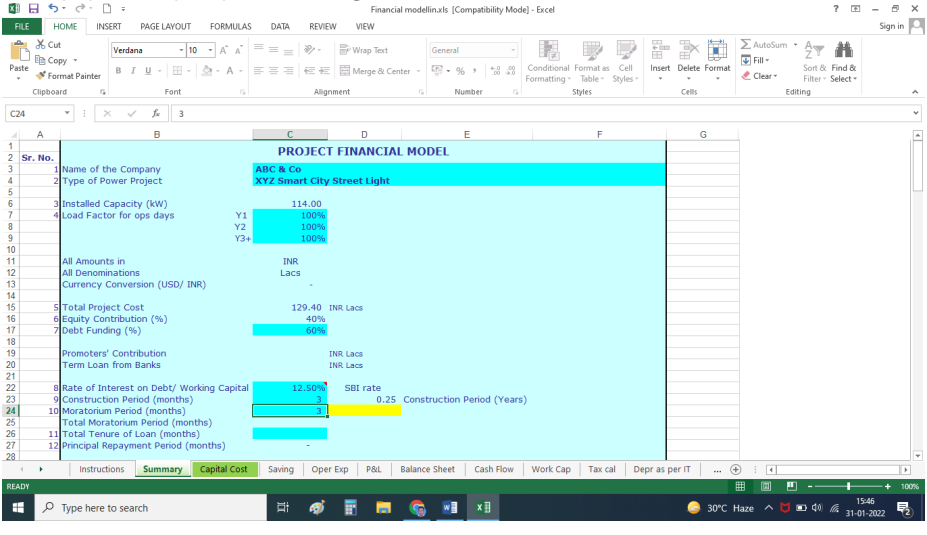


9. Construction Period: Period or time for commencement/ Implementation of the project



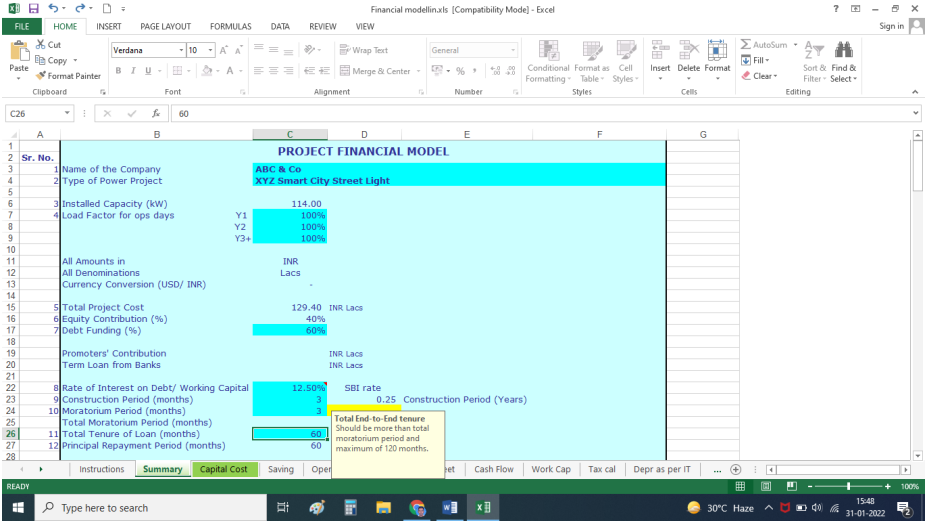
Sr. No.			
	PROJECT FINANCIAL MODEL		
1	Name of the Company	ABC & Co	
2	Type of Power Project	XYZ Smart City Street Light	
3	Installed Capacity (kW)	114.00	
4	Load Factor for ops days	Y1	100%
		Y2	100%
		Y3+	100%
	All Amounts in	INR	
	All Denominations	Lacs	
	Currency Conversion (USD/ INR)	-	
5	Total Project Cost	129.40	INR Lacs
6	Equity Contribution (%)	40%	
7	Debt Funding (%)	60%	
	Promoters' Contribution		INR Lacs
	Term Loan from Banks		INR Lacs
8	Rate of Interest on Debt/ Working Capital	12.50%	SBI rate
9	Construction Period (months)	3	0.25 Construction Period (Years)
10	Moratorium Period (months)	3	
	Total Moratorium Period (months)		
11	Total Tenure of Loan (months)		
12	Principal Repayment Period (months)	-	

10. Moratorium Period: A moratorium period is a time during the loan term when the borrower is not required to make any repayment. It is a waiting period before which repayment by way of EMIs begins

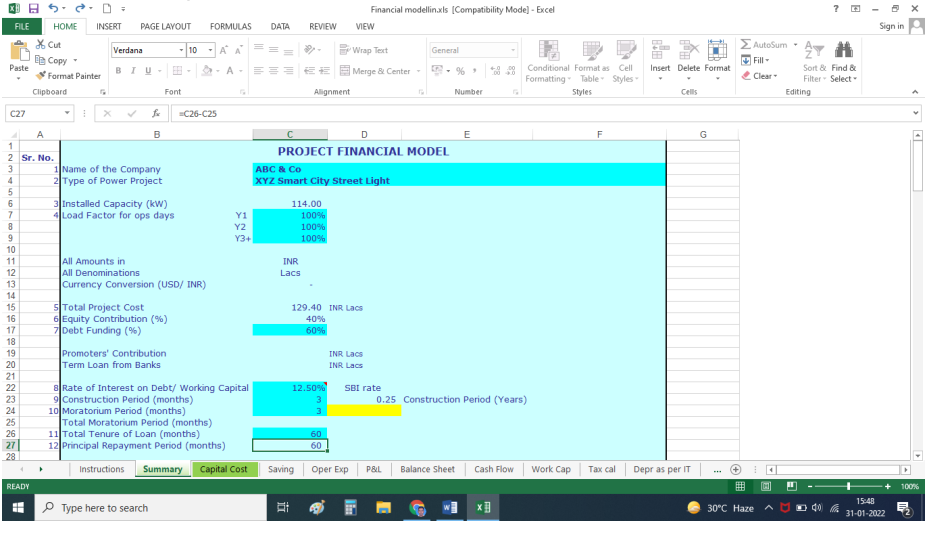


Sr. No.			
	PROJECT FINANCIAL MODEL		
1	Name of the Company	ABC & Co	
2	Type of Power Project	XYZ Smart City Street Light	
3	Installed Capacity (kW)	114.00	
4	Load Factor for ops days	Y1	100%
		Y2	100%
		Y3+	100%
	All Amounts in	INR	
	All Denominations	Lacs	
	Currency Conversion (USD/ INR)	-	
5	Total Project Cost	129.40	INR Lacs
6	Equity Contribution (%)	40%	
7	Debt Funding (%)	60%	
	Promoters' Contribution		INR Lacs
	Term Loan from Banks		INR Lacs
8	Rate of Interest on Debt/ Working Capital	12.50%	SBI rate
9	Construction Period (months)	3	0.25 Construction Period (Years)
10	Moratorium Period (months)	3	
	Total Moratorium Period (months)		
11	Total Tenure of Loan (months)		
12	Principal Repayment Period (months)	-	

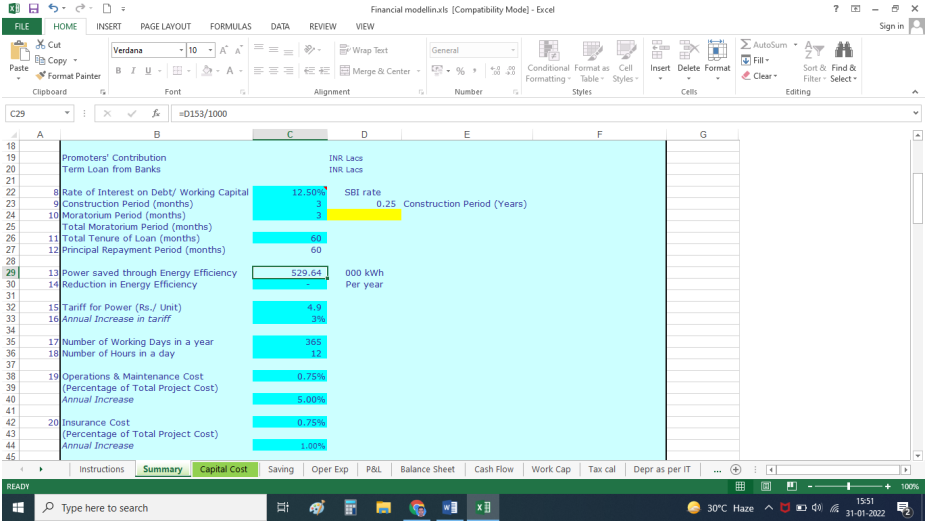
11. Total Tenure of Loan: No. of years/ Months/ Days for which the loan has been taken from Financial Institution of Bank



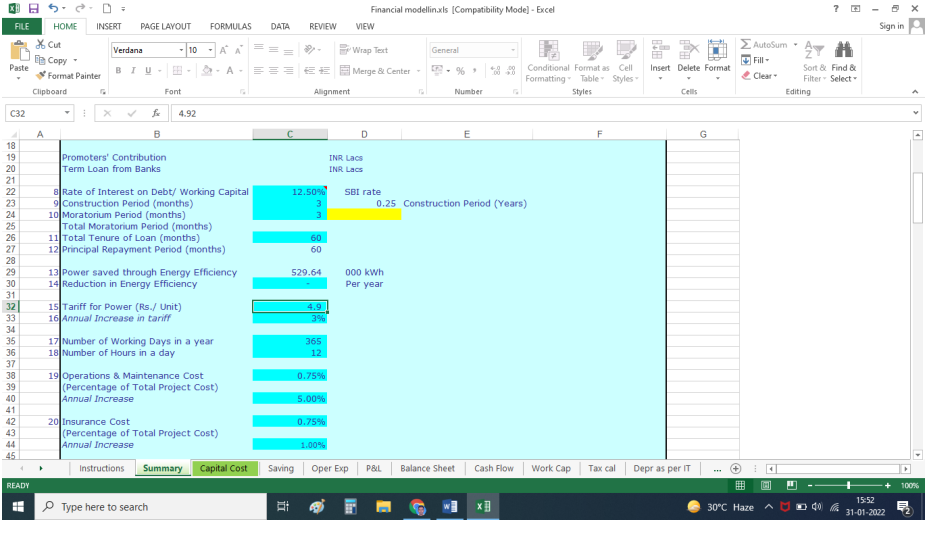
12. Principal Repayment Period: Period in which repayment would be spread for example loan will be repaid in 20 months



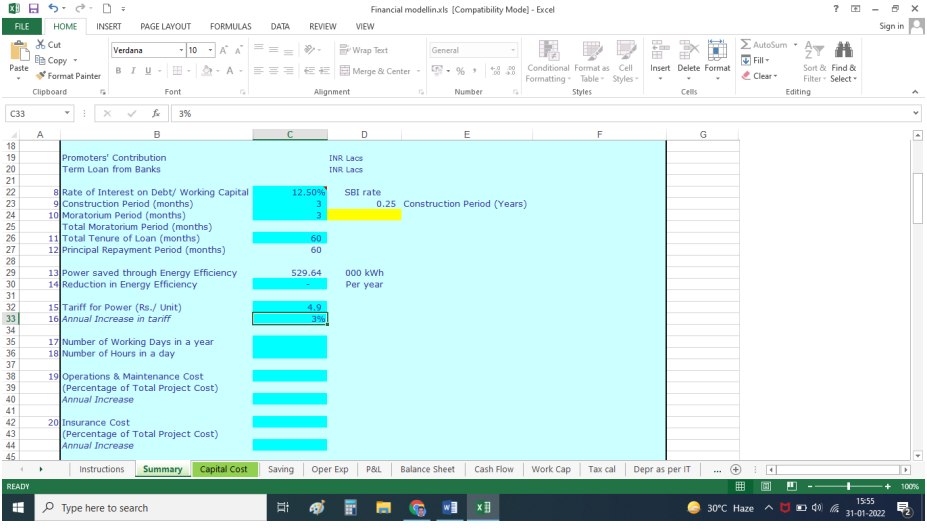
13. Power saved through Energy Efficiency: Number of units saved (kWh) through Energy Efficiency. (This figure is arrived from the Detailed Project Report)



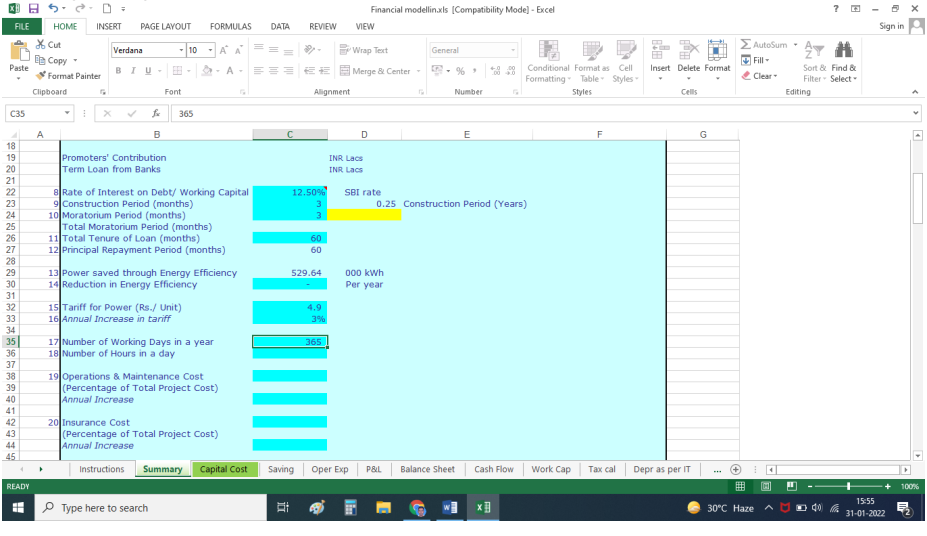
14. Reduction in Energy Efficiency: factor considered year on year to reduce the savings through Energy Efficiency
15. Tariff for Power: Per unit rate of power for the particular category for eg. Domestic, Commercial, Industrial, Street Light determined by State Electricity Regulatory Commission (SERC)



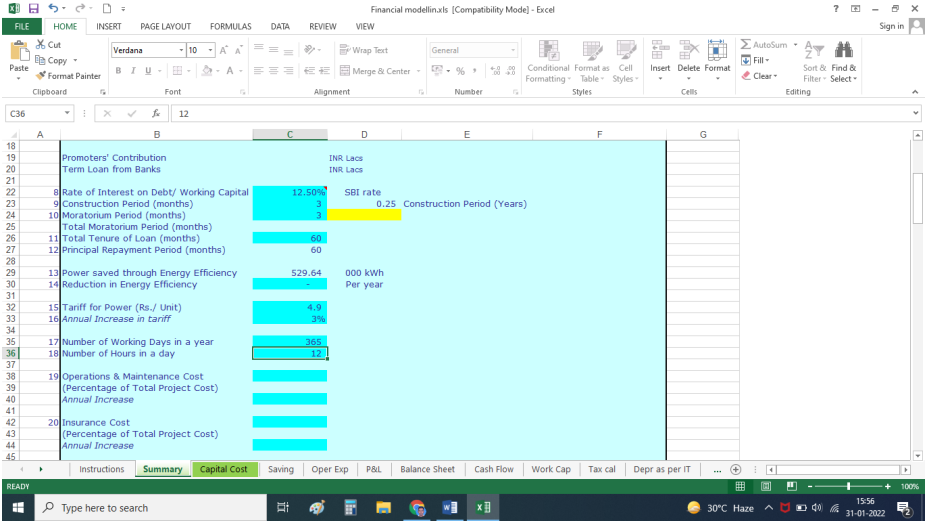
16. Annual Increase in tariff: Assumption to project power rate for defined life of the project



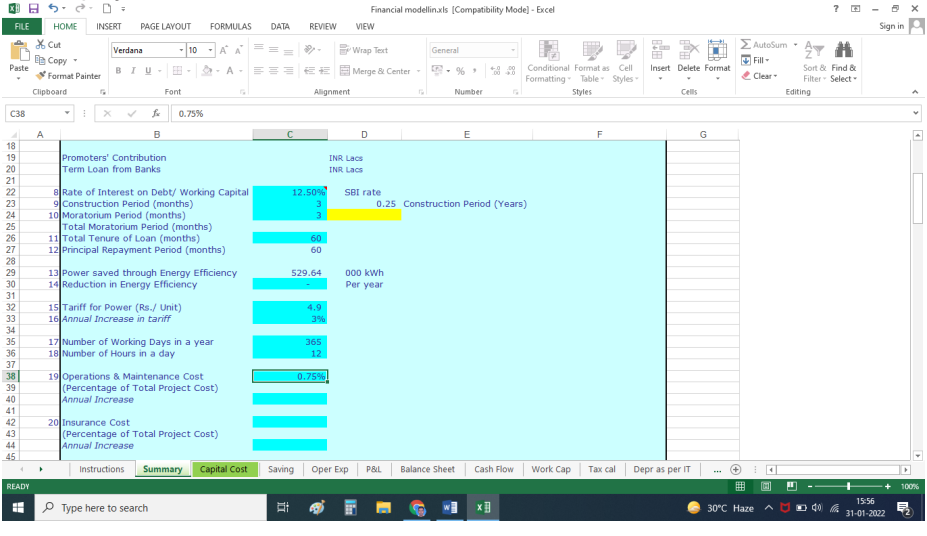
17. Number of Working Days of project in a year: eg. A street light would operate for 365 Days in a year



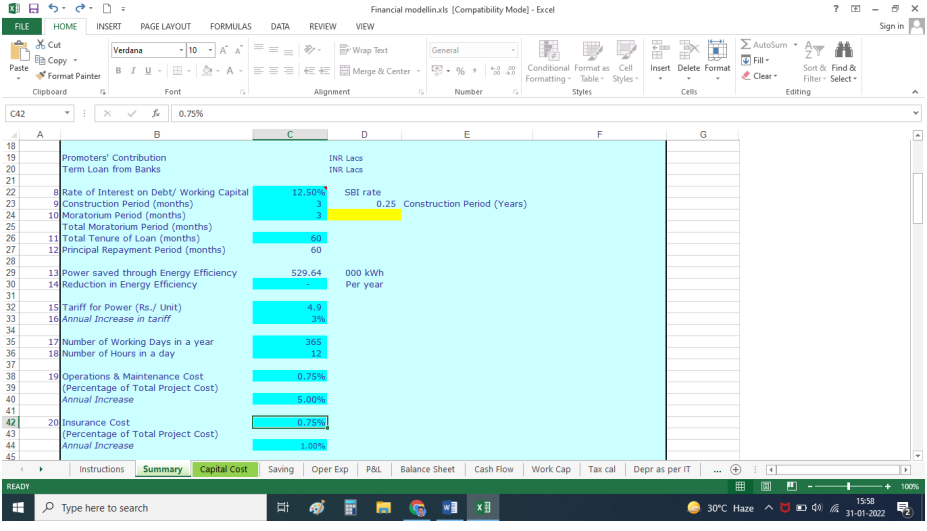
18. Number of Hours in a day: Total number of hours in a day when the project would run for eg. A street light would operate for 10 hrs in a day.



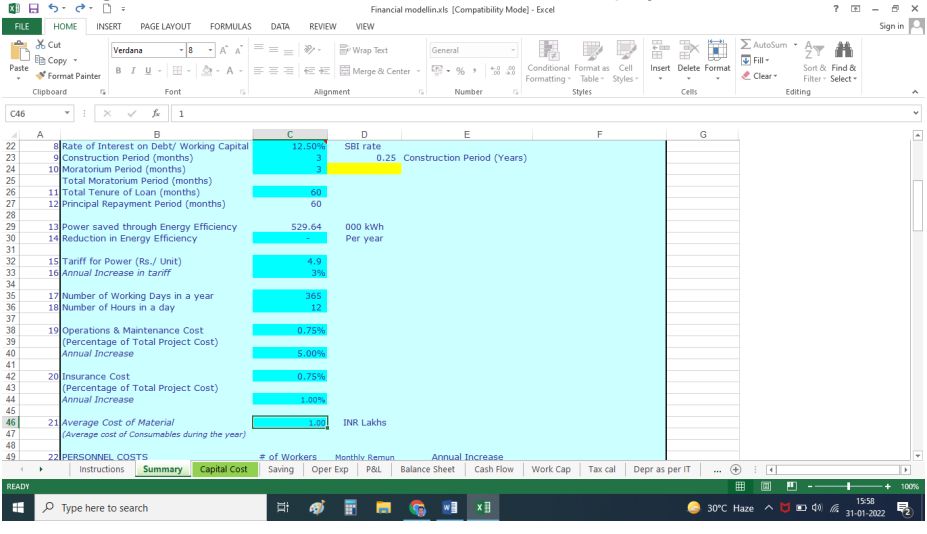
19. Operations & Maintenance Cost: The cost incurred in operation and maintenance of the project



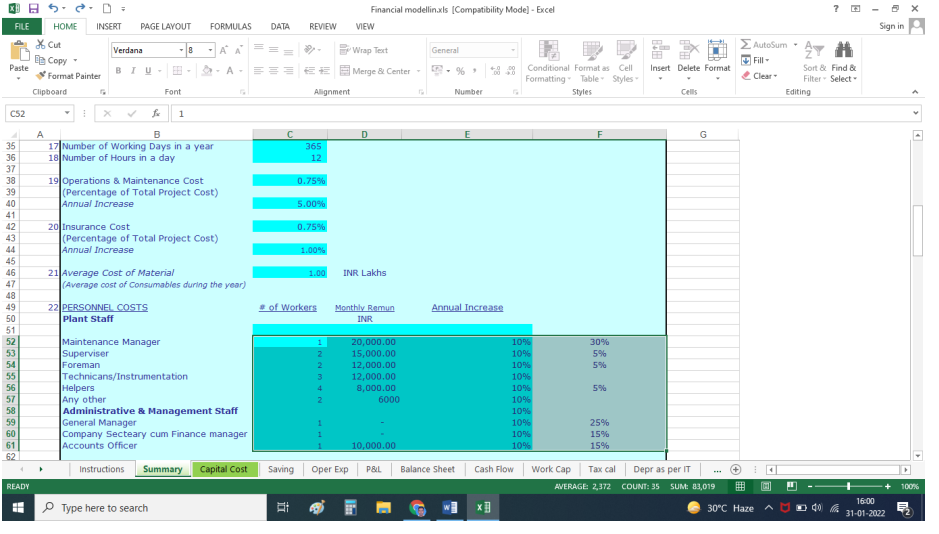
20. Insurance Cost: Cost incurred to insure the project which may affect the operations of the project



21. Average Cost of Material: Cost of consumables for the project

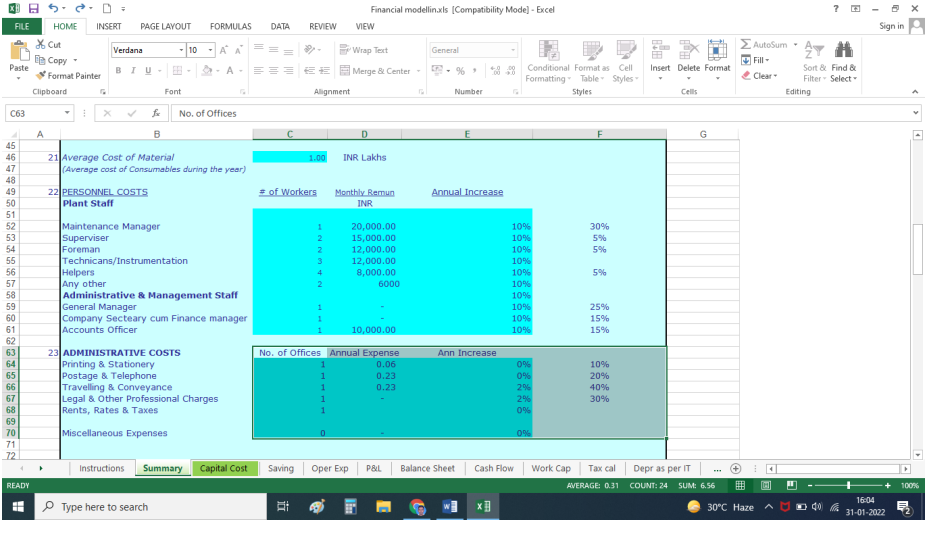


22. Personal Cost: Includes manpower cost at various level to run the project for eg. Salary cost of Plant Manager, Maintenance Manager, Shift Supervisor, Foreman, Technicians/ Instrumentation, Helpers, Administrative & Management Staff, General Manager etc.



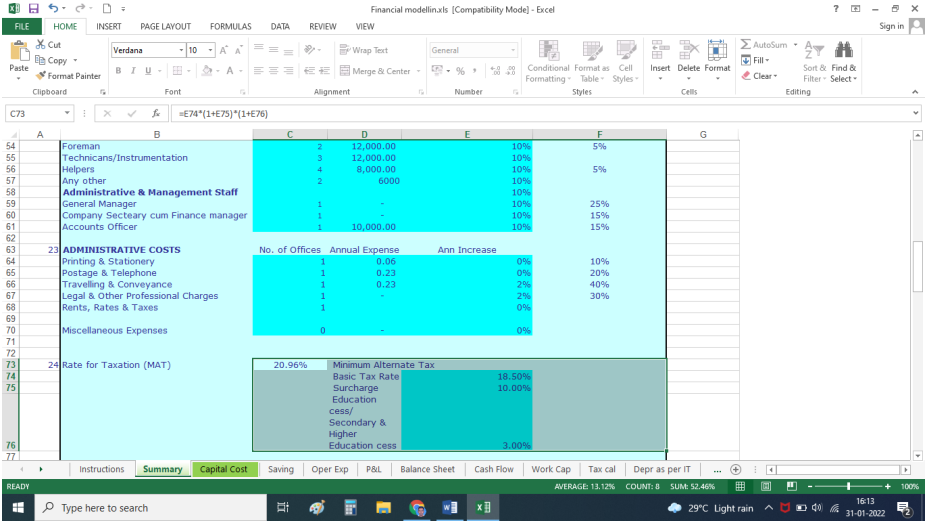
17	Number of Working Days in a year	365			
18	Number of Hours in a day	12			
19	Operations & Maintenance Cost	0.75%			
	(Percentage of Total Project Cost)				
	Annual Increase	5.00%			
20	Insurance Cost	0.75%			
	(Percentage of Total Project Cost)				
	Annual Increase	1.00%			
21	*Average Cost of Material*	1.00	INR Lakhs		
	(Average cost of Consumables during the year)				
22	PERSONNEL COSTS	# of Workers	Monthly Remun INR	Annual Increase	
	Plant Staff				
	Maintenance Manager	1	20,000.00	10%	30%
	Supervisor	2	15,000.00	10%	5%
	Foreman	2	12,000.00	10%	5%
	Technicans/Instrumentation	3	12,000.00	10%	
	Helpers	4	8,000.00	10%	5%
	Any other	2	6000	10%	
	Administrative & Management Staff			10%	
	General Manager	1	-	10%	25%
	Company Secteary cum Finance manager	1	-	10%	15%
	Accounts Officer	1	10,000.00	10%	15%

23. Administrative Cost: day to day cost for running the project like Printing & Stationery, Postage & Telephone, Travelling & Conveyance, Legal & Other Professional Charges etc.

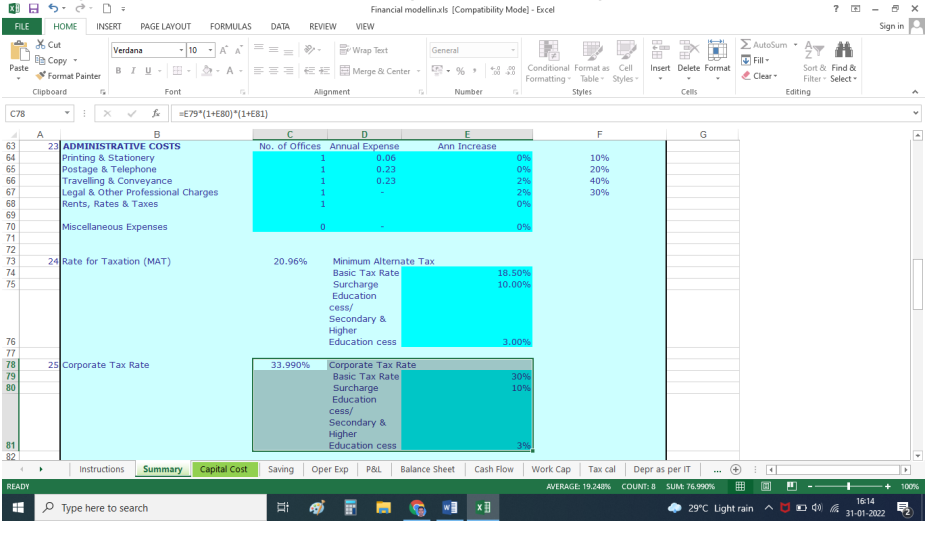


21	*Average Cost of Material*	1.00	INR Lakhs		
	(Average cost of Consumables during the year)				
22	PERSONNEL COSTS	# of Workers	Monthly Remun INR	Annual Increase	
	Plant Staff				
	Maintenance Manager	1	20,000.00	10%	30%
	Supervisor	2	15,000.00	10%	5%
	Foreman	2	12,000.00	10%	5%
	Technicans/Instrumentation	3	12,000.00	10%	
	Helpers	4	8,000.00	10%	5%
	Any other	2	6000	10%	
	Administrative & Management Staff			10%	
	General Manager	1	-	10%	25%
	Company Secteary cum Finance manager	1	-	10%	15%
	Accounts Officer	1	10,000.00	10%	15%
23	**ADMINISTRATIVE COSTS**	No. of Offices	Annual Expense	Ann Increase	
	Printing & Stationery	1	0.06	0%	10%
	Postage & Telephone	1	0.23	0%	20%
	Travelling & Conveyance	1	0.23	2%	40%
	Legal & Other Professional Charges	1	-	2%	30%
	Rents, Rates & Taxes	1		0%	
	Miscellaneous Expenses	0	-	0%	

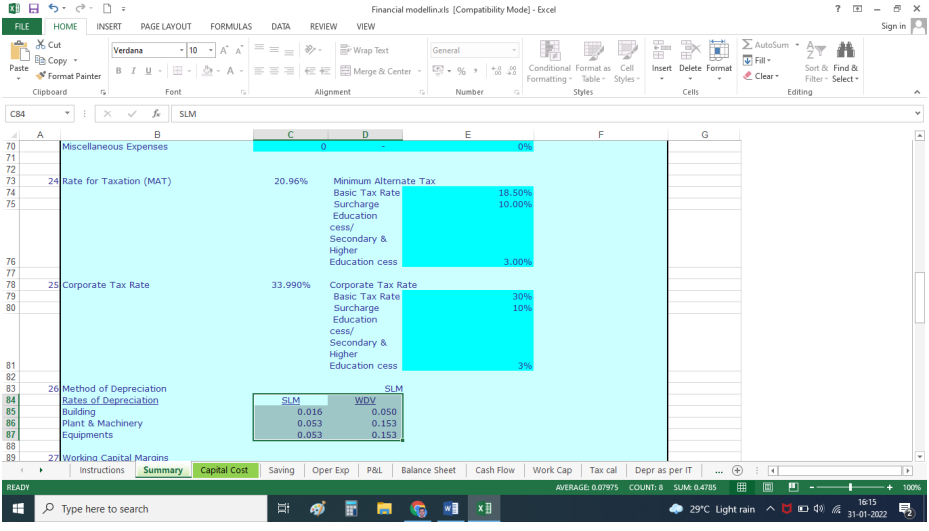
24. MAT Rate: its a tax that has to be paid by the companies that are enjoying tax benefits or tax exemption under various schemes



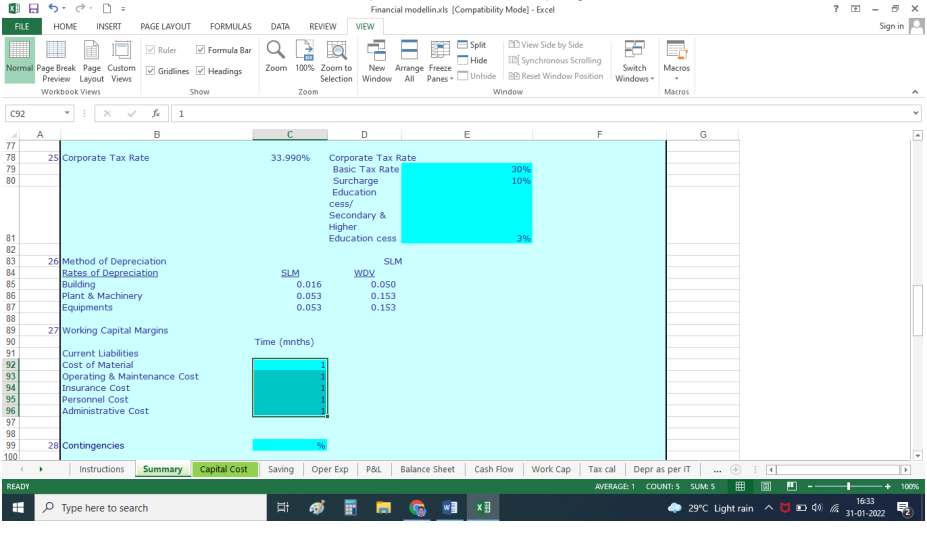
25. Corporate Tax Rate: considered as per income tax department of India



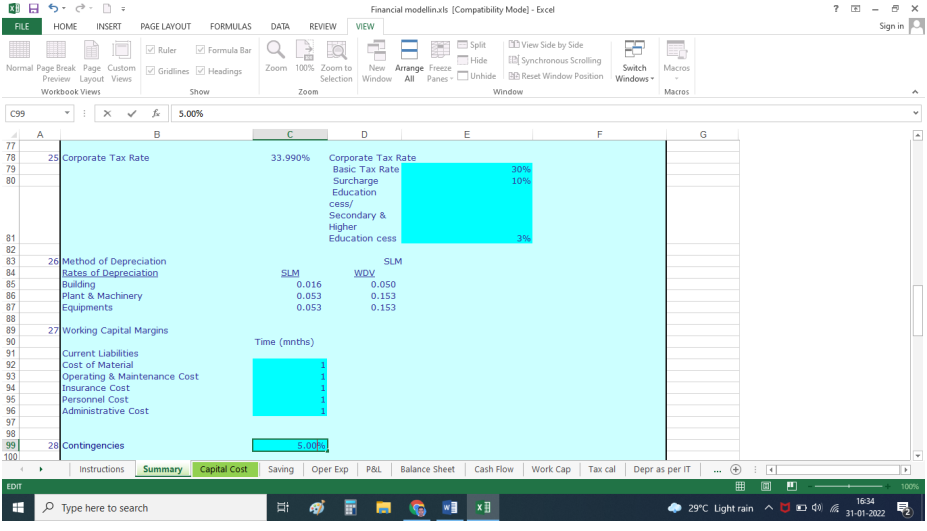
26. Method of Depreciation: Method of charging depreciation on fixed assets value of the project – Straight line method and Written Down V



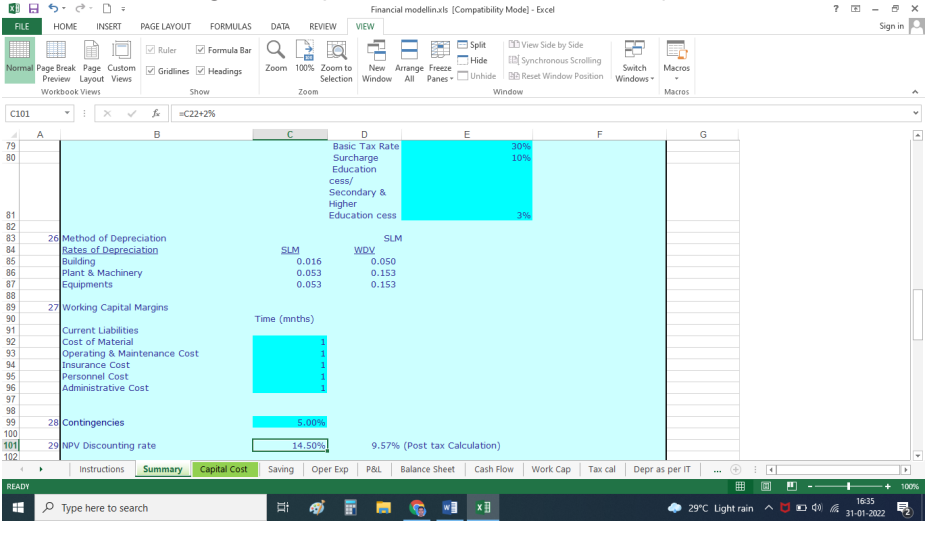
27. Working capital Assessment: capital used in day-to-day operations of a business/ project. Cost of Material, Operating and maintenance cost, insurance cost, personal cost, administrative cost are required to run the project.



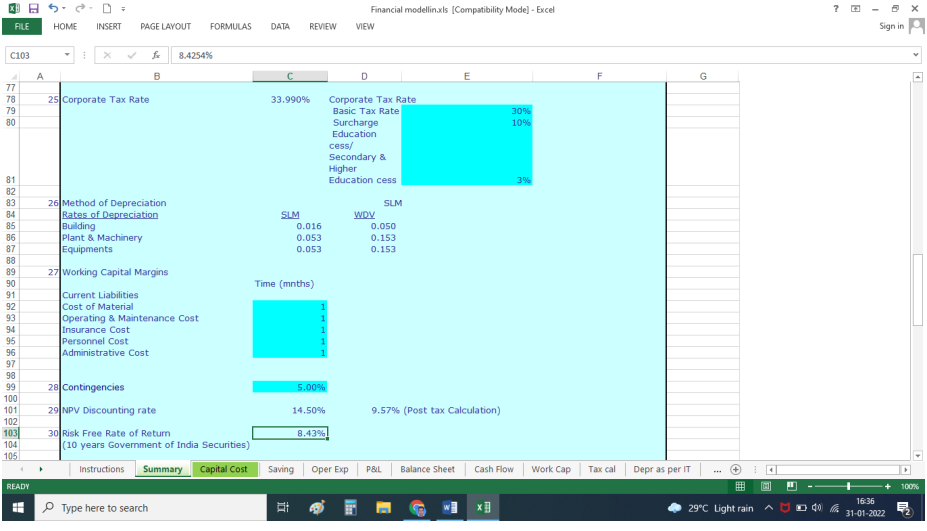
28. Contingencies: amount kept aside as cash reserve to meet the contingencies in capital (assumed)



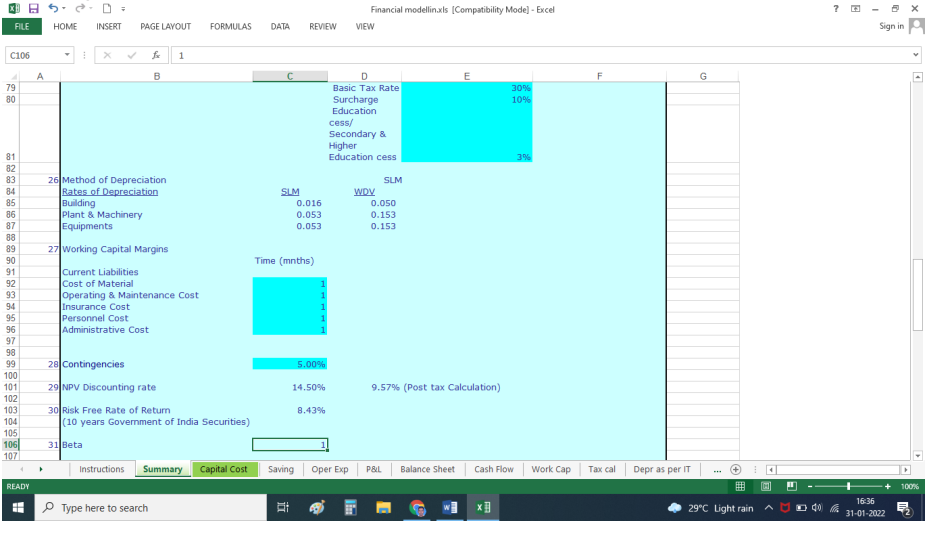
29. NPV Discounting rate: it represents the time value of money



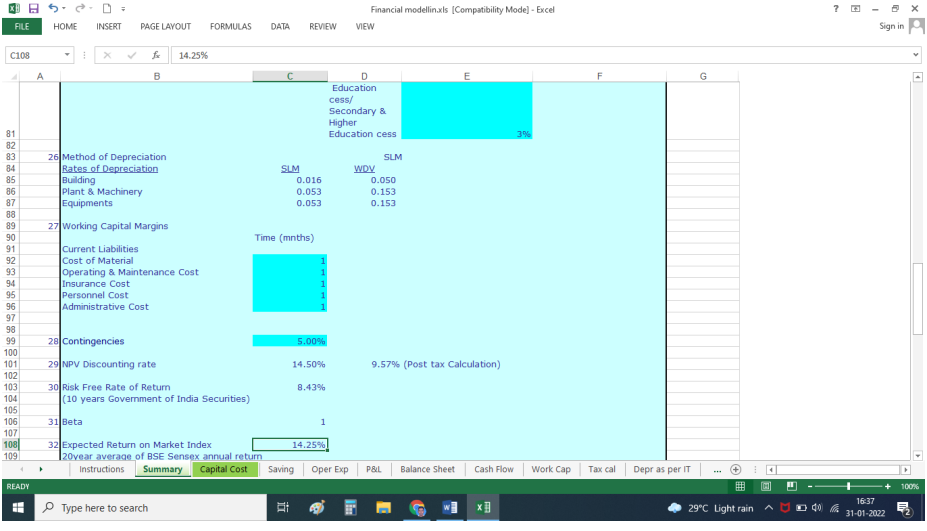
30. Risk Free Rate of Return: The risk-free rate represents the interest an investor would expect from an absolutely risk-free investment over a specified period of time, here average 10 years Government of India Securities rate have been considered



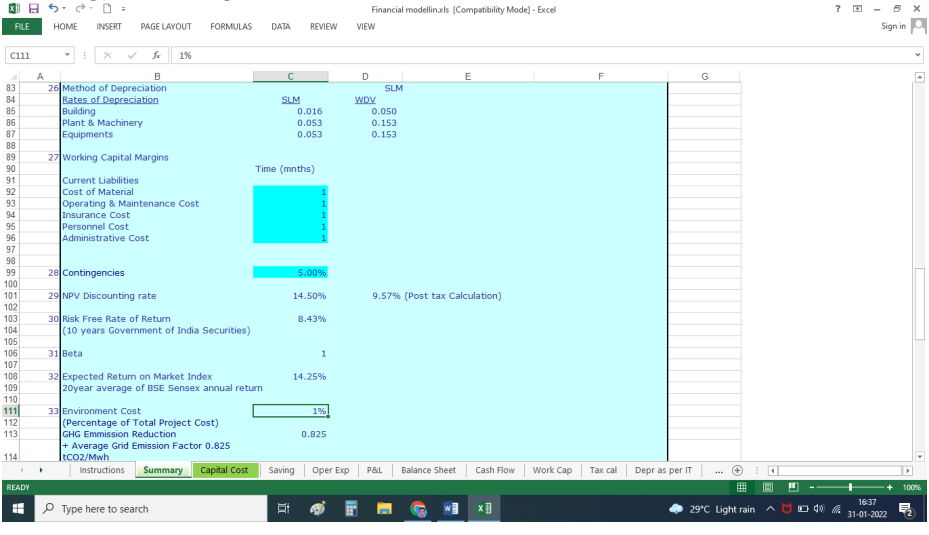
31. Beta: A measure of the volatility, or systematic risk, of a security or a portfolio in comparison to the market as a whole.



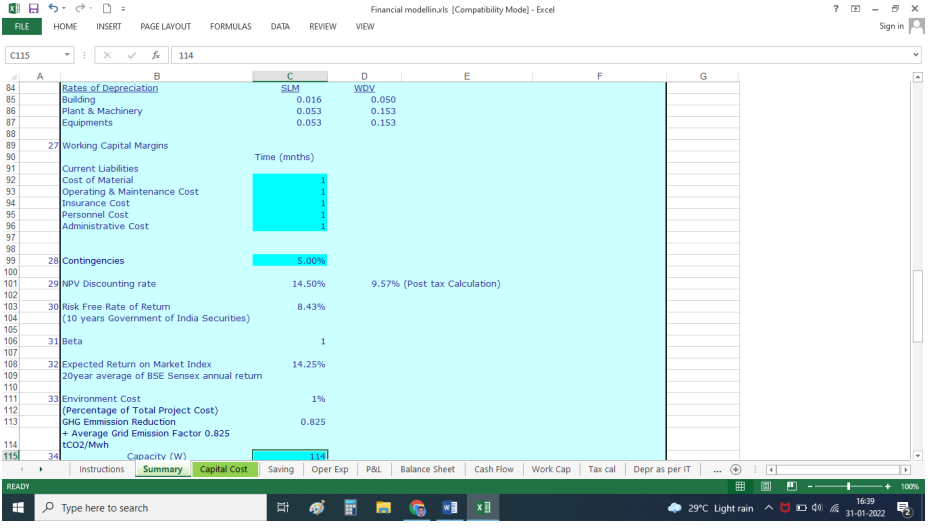
32. Expected Return on Market Index: considered on 20 year average of BSE Sensex annual return



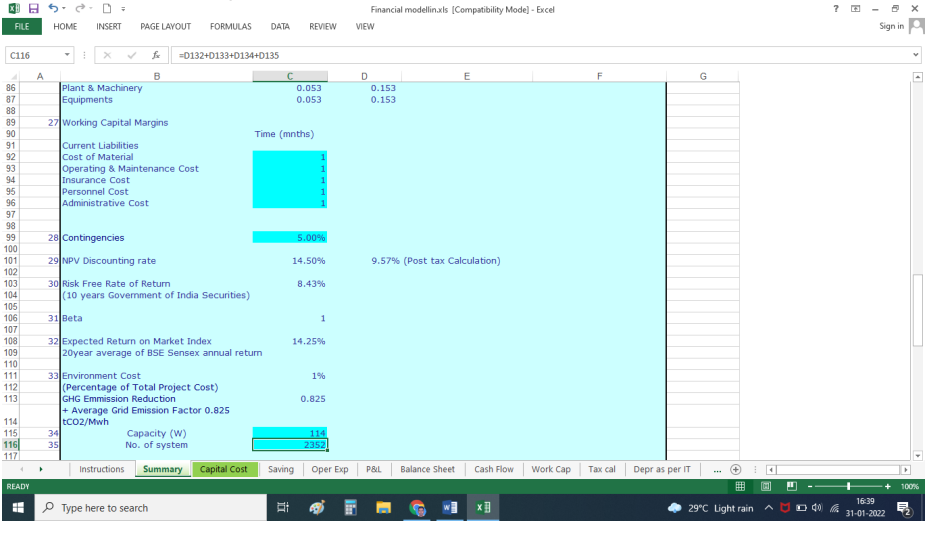
33. Environment Cost: Assumed as 1% of total project cost. It is the cost to environment for eg. the cost born for disposing off incandescent bulb after replacement with energy efficient lights



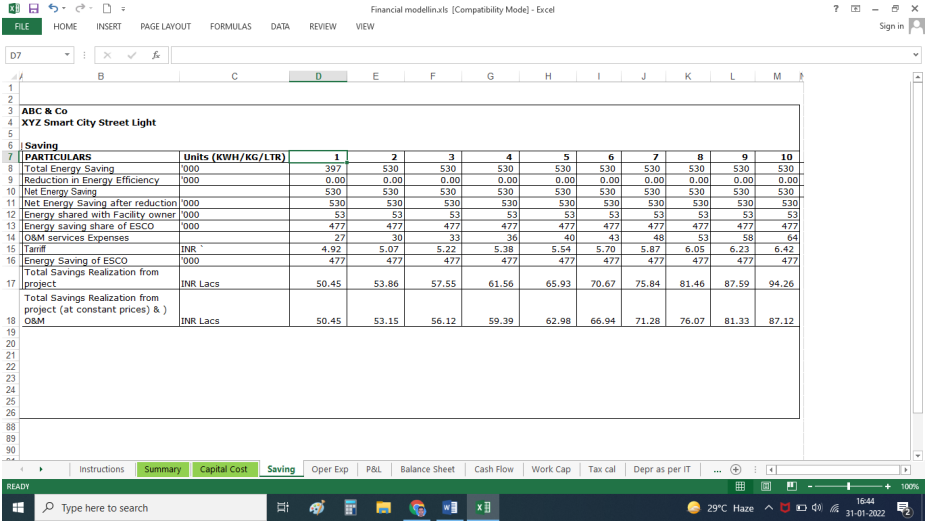
34. Installed capacity of the proposed system



35. Total Number of systems to be installed. This is to be obtained from the DPR



36. After completing the above steps, we can observe the Financial performance parameters of the proposed project, indicating its viability.



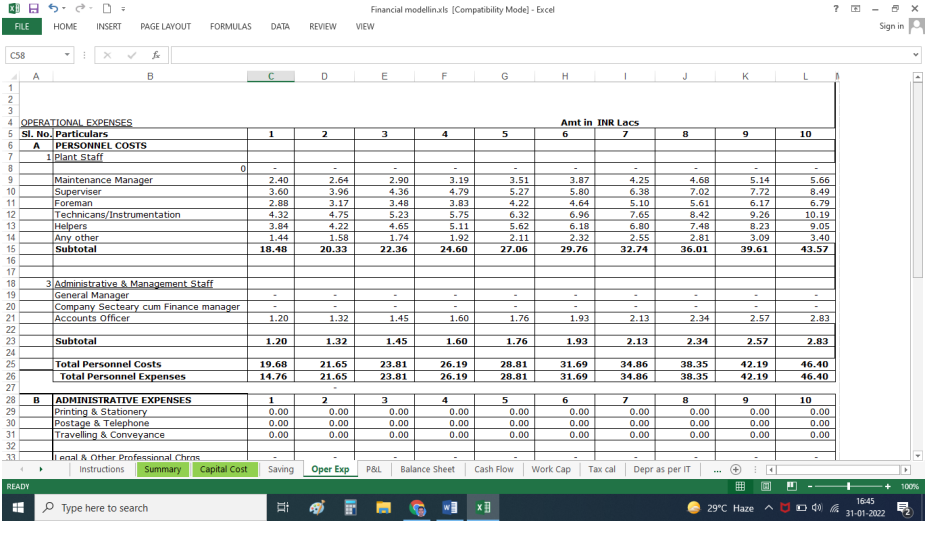
Financial modellin.xls [Compatibility Mode] - Excel

ABC & Co
XYZ Smart City Street Light

Saving

PARTICULARS	Units (KWH/KG/LTR)	1	2	3	4	5	6	7	8	9	10
Total Energy Saving	'000	397	530	530	530	530	530	530	530	530	530
Reduction in Energy Efficiency	'000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Energy Saving		530	530	530	530	530	530	530	530	530	530
Net Energy Saving after reduction	'000	530	530	530	530	530	530	530	530	530	530
Energy shared with Facility owner	'000	53	53	53	53	53	53	53	53	53	53
Energy saving share of ESCO	'000	477	477	477	477	477	477	477	477	477	477
O&M services Expenses		27	30	33	36	40	43	48	53	58	64
Tariff	INR `	4.92	5.07	5.22	5.38	5.54	5.70	5.87	6.05	6.23	6.42
Energy Saving of ESCO	'000	477	477	477	477	477	477	477	477	477	477
Total Savings Realization from project	INR Lacs	50.45	53.86	57.55	61.56	65.93	70.67	75.84	81.46	87.59	94.26
Total Savings Realization from project (at constant prices) &) O&M	INR Lacs	50.45	53.15	56.12	59.39	62.98	66.94	71.28	76.07	81.33	87.12

Instructions | Summary | Capital Cost | Saving | Oper Exp | P&L | Balance Sheet | Cash Flow | Work Cap | Tax cal | Depr as per IT

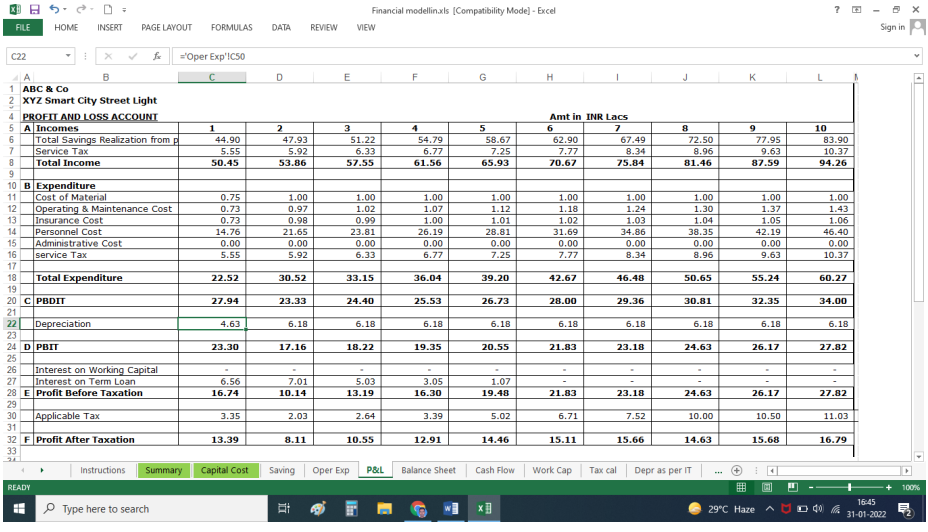


Financial modellin.xls [Compatibility Mode] - Excel

OPERATIONAL EXPENSES — Amt in INR Lacs

Sl. No.	Particulars	1	2	3	4	5	6	7	8	9	10
A	PERSONNEL COSTS										
1	Plant Staff										
0		-	-	-	-	-	-	-	-	-	-
	Maintenance Manager	2.40	2.64	2.90	3.19	3.51	3.87	4.25	4.68	5.14	5.66
	Superviser	3.60	3.96	4.36	4.79	5.27	5.80	6.38	7.02	7.72	8.49
	Foreman	2.88	3.17	3.48	3.83	4.22	4.64	5.10	5.61	6.17	6.79
	Technicans/Instrumentation	4.32	4.75	5.23	5.75	6.32	6.96	7.65	8.42	9.26	10.19
	Helpers	3.84	4.22	4.65	5.11	5.62	6.18	6.80	7.48	8.23	9.05
	Any other	1.44	1.58	1.74	1.92	2.11	2.32	2.55	2.81	3.09	3.40
	Subtotal	**18.48**	**20.33**	**22.36**	**24.60**	**27.06**	**29.76**	**32.74**	**36.01**	**39.61**	**43.57**
3	Administrative & Management Staff										
	General Manager	-	-	-	-	-	-	-	-	-	-
	Company Secteary cum Finance manager	-	-	-	-	-	-	-	-	-	-
	Accounts Officer	1.20	1.32	1.45	1.60	1.76	1.93	2.13	2.34	2.57	2.83
	Subtotal	**1.20**	**1.32**	**1.45**	**1.60**	**1.76**	**1.93**	**2.13**	**2.34**	**2.57**	**2.83**
	Total Personnel Costs	**19.68**	**21.65**	**23.81**	**26.19**	**28.81**	**31.69**	**34.86**	**38.35**	**42.19**	**46.40**
	Total Personnel Expenses	**14.76**	**21.65**	**23.81**	**26.19**	**28.81**	**31.69**	**34.86**	**38.35**	**42.19**	**46.40**
B	**ADMINISTRATIVE EXPENSES**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Printing & Stationery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Postage & Telephone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Travelling & Conveyance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Legal & Other Professional Chrgs	-	-	-	-	-	-	-	-	-	-

Instructions | Summary | Capital Cost | Saving | Oper Exp | P&L | Balance Sheet | Cash Flow | Work Cap | Tax cal | Depr as per IT



Financial modellin.xls [Compatibility Mode] - Excel

C22 ='Oper Exp'!C50

ABC & Co
XYZ Smart City Street Light

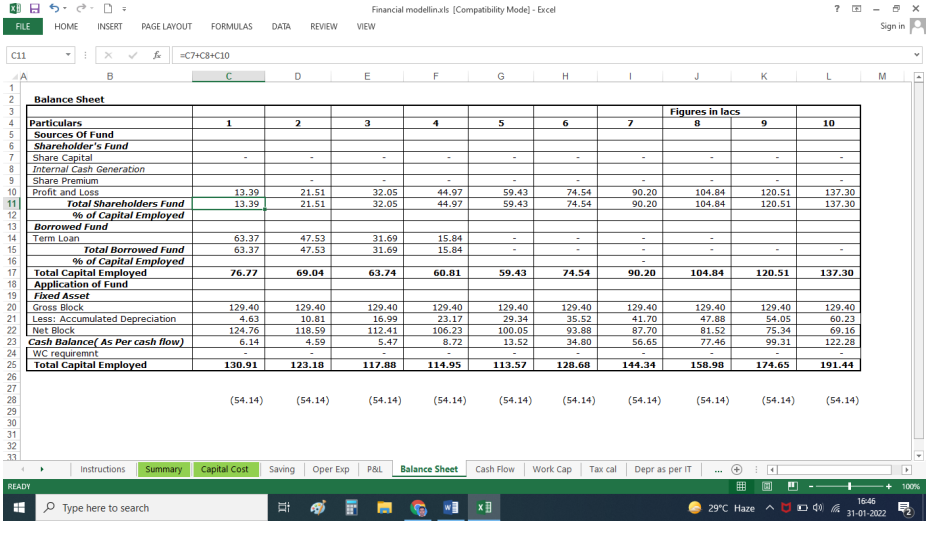
PROFIT AND LOSS ACCOUNT — **Amt in INR Lacs**

		1	2	3	4	5	6	7	8	9	10
A	**Incomes**										
	Total Savings Realization from p	44.90	47.93	51.22	54.79	58.67	62.90	67.49	72.50	77.95	83.90
	Service Tax	5.55	5.92	6.33	6.77	7.25	7.77	8.34	8.96	9.63	10.37
	Total Income	**50.45**	**53.86**	**57.55**	**61.56**	**65.93**	**70.67**	**75.84**	**81.46**	**87.59**	**94.26**
B	**Expenditure**										
	Cost of Material	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Operating & Maintenance Cost	0.73	0.97	1.02	1.07	1.12	1.18	1.24	1.30	1.37	1.43
	Insurance Cost	0.73	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06
	Personnel Cost	14.76	21.65	23.81	26.19	28.81	31.69	34.86	38.35	42.19	46.40
	Administrative Cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	service Tax	5.55	5.92	6.33	6.77	7.25	7.77	8.34	8.96	9.63	10.37
	Total Expenditure	**22.52**	**30.52**	**33.15**	**36.04**	**39.20**	**42.67**	**46.48**	**50.65**	**55.24**	**60.27**
C	**PBDIT**	**27.94**	**23.33**	**24.40**	**25.53**	**26.73**	**28.00**	**29.36**	**30.81**	**32.35**	**34.00**
	Depreciation	4.63	6.18	6.18	6.18	6.18	6.18	6.18	6.18	6.18	6.18
D	**PBIT**	**23.30**	**17.16**	**18.22**	**19.35**	**20.55**	**21.83**	**23.18**	**24.63**	**26.17**	**27.82**
	Interest on Working Capital	-	-	-	-	-	-	-	-	-	-
	Interest on Term Loan	6.56	7.01	5.03	3.05	1.07	-	-	-	-	-
E	**Profit Before Taxation**	**16.74**	**10.14**	**13.19**	**16.30**	**19.48**	**21.83**	**23.18**	**24.63**	**26.17**	**27.82**
	Applicable Tax	3.35	2.03	2.64	3.39	5.02	6.71	7.52	10.00	10.50	11.03
F	**Profit After Taxation**	**13.39**	**8.11**	**10.55**	**12.91**	**14.46**	**15.11**	**15.66**	**14.63**	**15.68**	**16.79**

Instructions | Summary | Capital Cost | Saving | Oper Exp | P&L | Balance Sheet | Cash Flow | Work Cap | Tax cal | Depr as per IT

READY 100%

Type here to search 29°C Haze 16:45 31-01-2022



Financial modellin.xls [Compatibility Mode] - Excel

C11 =C7+C8+C10

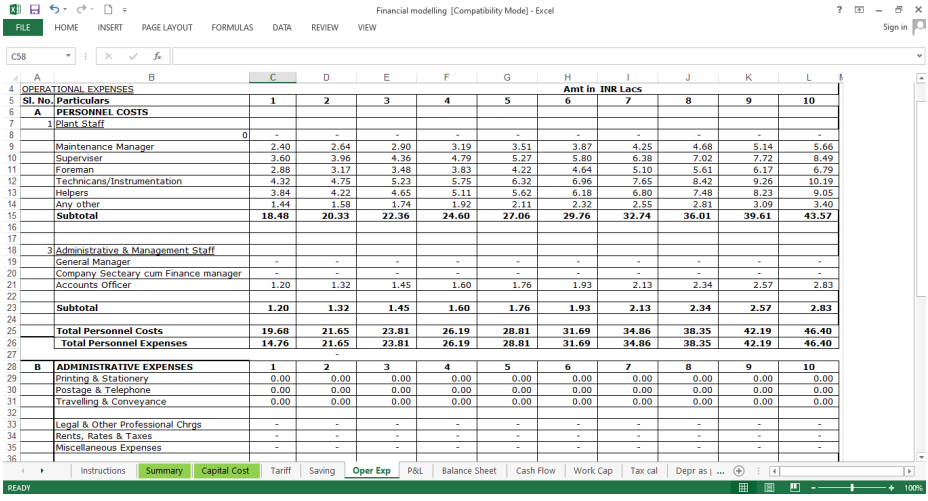
Balance Sheet

Particulars	1	2	3	4	5	6	7	Figures in lacs 8	9	10
Sources Of Fund										
Shareholder's Fund										
Share Capital	-	-	-	-	-	-	-	-	-	-
Internal Cash Generation										
Share Premium	-	-	-	-	-	-	-	-	-	-
Profit and Loss	13.39	21.51	32.05	44.97	59.43	74.54	90.20	104.84	120.51	137.30
Total Shareholders Fund	13.39	21.51	32.05	44.97	59.43	74.54	90.20	104.84	120.51	137.30
% of Capital Employed										
Borrowed Fund										
Term Loan	63.37	47.53	31.69	15.84	-	-	-	-		
Total Borrowed Fund	63.37	47.53	31.69	15.84	-	-	-	-	-	-
% of Capital Employed							-			
Total Capital Employed	**76.77**	**69.04**	**63.74**	**60.81**	**59.43**	**74.54**	**90.20**	**104.84**	**120.51**	**137.30**
Application of Fund										
Fixed Asset										
Gross Block	129.40	129.40	129.40	129.40	129.40	129.40	129.40	129.40	129.40	129.40
Less: Accumulated Depreciation	4.63	10.81	16.99	23.17	29.34	35.52	41.70	47.88	54.05	60.23
Net Block	124.76	118.59	112.41	106.23	100.05	93.88	87.70	81.52	75.34	69.16
Cash Balance(As Per cash flow)	6.14	4.59	5.47	8.72	13.52	34.80	56.65	77.46	99.31	122.28
WC requiremnt	-	-	-	-	-	-	-	-	-	-
Total Capital Employed	**130.91**	**123.18**	**117.88**	**114.95**	**113.57**	**128.68**	**144.34**	**158.98**	**174.65**	**191.44**
	(54.14)	(54.14)	(54.14)	(54.14)	(54.14)	(54.14)	(54.14)	(54.14)	(54.14)	(54.14)

Instructions | Summary | Capital Cost | Saving | Oper Exp | P&L | Balance Sheet | Cash Flow | Work Cap | Tax cal | Depr as per IT

READY 100%

Type here to search 29°C Haze 16:46 31-01-2022



Financial modelling [Compatibility Mode] - Excel

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW

Sign in

C58

	A	B	C	D	E	F	G	H	I	J	K	L
4	OPERATIONAL EXPENSES							Amt in INR Lacs				
5	Sl. No.	Particulars	1	2	3	4	5	6	7	8	9	10
6	A	PERSONNEL COSTS										
7	1	Plant Staff										
8	0		-	-	-	-	-	-	-	-	-	-
9		Maintenance Manager	2.40	2.64	2.90	3.19	3.51	3.87	4.25	4.68	5.14	5.66
10		Supervisor	3.60	3.96	4.36	4.79	5.27	5.80	6.38	7.02	7.72	8.49
11		Foreman	2.88	3.17	3.48	3.83	4.22	4.64	5.10	5.61	6.17	6.79
12		Technicans/Instrumentation	4.32	4.75	5.23	5.75	6.32	6.96	7.65	8.42	9.26	10.19
13		Helpers	3.84	4.22	4.65	5.11	5.62	6.18	6.80	7.48	8.23	9.05
14		Any other	1.44	1.58	1.74	1.92	2.11	2.32	2.55	2.81	3.09	3.40
15		**Subtotal**	**18.48**	**20.33**	**22.36**	**24.60**	**27.06**	**29.76**	**32.74**	**36.01**	**39.61**	**43.57**
16												
17												
18	3	Administrative & Management Staff										
19		General Manager	-	-	-	-	-	-	-	-	-	-
20		Company Secteary cum Finance manager	-	-	-	-	-	-	-	-	-	-
21		Accounts Officer	1.20	1.32	1.45	1.60	1.76	1.93	2.13	2.34	2.57	2.83
22												
23		**Subtotal**	**1.20**	**1.32**	**1.45**	**1.60**	**1.76**	**1.93**	**2.13**	**2.34**	**2.57**	**2.83**
24												
25		**Total Personnel Costs**	**19.68**	**21.65**	**23.81**	**26.19**	**28.81**	**31.69**	**34.86**	**38.35**	**42.19**	**46.40**
26		**Total Personnel Expenses**	**14.76**	**21.65**	**23.81**	**26.19**	**28.81**	**31.69**	**34.86**	**38.35**	**42.19**	**46.40**
27			-									
28	**B**	**ADMINISTRATIVE EXPENSES**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
29		Printing & Stationery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30		Postage & Telephone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31		Travelling & Conveyance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32												
33		Legal & Other Professional Chrgs	-	-	-	-	-	-	-	-	-	-
34		Rents, Rates & Taxes	-	-	-	-	-	-	-	-	-	-
35		Miscellaneous Expenses	-	-	-	-	-	-	-	-	-	-
36												

Instructions | Summary | Capital Cost | Tariff | Saving | Oper Exp | P&L | Balance Sheet | Cash Flow | Work Cap | Tax cal | Depr as | ...

READY

100%

6

Case Study

6.1. Case study of Mohali municipality

The project involves replacement of 21,800 existing street lights. Wherein the total energy savings because of energy efficient measures is envisaged at 62%.

The energy saved would be shared between ESCO and the municipality in the ratio of 90:10.

Project Cost: Rs. 2100 Lakhs (USD 3.23 Mn)
Loan Amount: Rs. 1500 Lakhs (USD 2.31 Mn)
Loan Availed by: ESCO
Loan Availed from PFI: Yes Bank Limited
Guarantee Amount and Issuance Date under PRSF: Rs. 1125 Lakhs (USD 1.73 Mn)
Baseline Energy Consumption: 10671.6 MWh
Annual Energy Savings: 6915 MWh
Annual tons of CO_2 Savings: 5,670

6.2. Case study of Shahjahanpur Nagar Palika

This case study pertains to the retrofit of LED street light in Shahjahanpur Nagar Palika in Uttarpradesh.

ESCO Project Details: Installation of 8604 LED street lights
Project Cost: Rs. 814.63 Lakhs (USD 1.25 Mn)
Loan Amount: Rs. 600 Lakhs (USD 0.92 Mn)
Loan Availed by : ESCO
Loan availed from PFI: Corporation Bank
Guarantee Amount and Issuance Date under PRSF: Rs. 450 Lakhs (USD 0.69 Mn)
Baseline Energy Consumption: 5585 MWh

Annual Energy Savings: 4530 MWh
Annual tons of CO2 Savings: 3,756

6.3. Other Case studies

More smart poles will be put up to aid traffic management in Chennai, says Commissioner

'Intelligent Traffic Management System introduced in Anna Nagar successful'

R. SIVARAMAN
CHENNAI

The Chennai city police are planning to improve traffic management by installing more smart poles, which are integrated to a command centre, and are eliciting the opinions of police personnel on the field, according to Commissioner of Police Shankar Jiwal.

Smart poles have been installed in about 50 locations by the Greater Chennai Corporation (GCC). "We plan to expand the scope of traffic management through smart poles. These cloud-based poles will be able to monitor the status of traffic in an area and relay the status to nearby police officers as well as the control room. The proposed new Command and Control Centre will have a state-of-the-art data centre and analytical capability, apart from manual interface through wall screens," Mr. Jiwal told *The Hindu*.

Keeping an eye: The poles will relay the traffic status to nearby police officers and the control room. • B. VELANKANNI RAJ

The Smart City project is being implemented by the GCC and other departments at a cost of ₹900 crore. The project has a component for traffic information and management, which includes smart poles.

The poles will have advanced cameras, and will give inputs on a real-time basis to the proposed Command and Control Centre.

Meanwhile, an Intelligent Traffic Management System, introduced recently on a pilot basis at five junctions in Anna Nagar and Thirumangalam, has been successful.

CONTINUED ON ▸ PAGE 4

NHAI to provide solar lighting along roads

SPECIAL CORRESPONDENT
CHENNAI

The National Highways Authority of India (NHAI) is looking to install solar lights along its roads in the State. On a trial basis, the project will be carried out on the Krishnagiri-Walajapet National Highway.

"Going solar would cut down the heavy power bills of toll operators. Also, since it is to be connected to the grid, they will get some relief on the investment. Some contractors pay power bills of up to ₹20 lakh a month for road lighting, which could be brought down," explained a senior official of the NHAI.

As a first step, the toll plazas will get solar lighting. "We have to study the system for a couple of months before we extend solar power to other places along the highway," said another official.

However, the only hitch in the proposal is the low rate of ₹2 per unit being offered by Tangedco.

"Now, commercial connections are charged ₹9 per unit. We are proposing to supply power to the grid. In such a case, a better rate is only fair. The State government should consider our request," he said. Tangedco sources said they were only collecting the rates on the basis of what had been stipulated by the Tamil Nadu Electricity Regulatory Authority.

7

Template for a sample DPR

Investment Grade Detailed Project Report (IGDPR)-Report Format

ACKNOWLEDGEMENT

(On Letter Head)

We hereby declare that we have gone through the contents of Investment Grade Energy Audit Report (IGDPR) of our Smart city submitted by (_____) and have verified the same.

We confirm that the Energy Conservations /Efficiency Measures identified during Detailed Energy Audit done by(_____) as indicated at Para-3.11 of the IGDPR are acceptable to us and we shall implement the same.

We confirm that the IGDPR is acceptable to our Management and a copy of the report may be submitted to Funding Agencies.

Thanking You

Yours Faithfully

Signature

Name:

(Authorized Signatory with Seal)

CONTENT / INDEX

LIST OF ANNEXURE

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

Executive Summary

The Scope of Work:

1. Conducting walk-through audit
2. Conducting detailed energy audits(DEA) and Finalising recommendations of DEA
3. Preparation of IGDPRs and Endorsement of IGDPRs by the respective Smart Cities
4. Facilitation and implementation support EE projects

- Brief Introduction of the Smart City

Name of the Unit	
Constitution	Town/Municipality/Corporation/Smart City
Population Classification	
No. of years in operation	
Address: Registered Office:	
Administrative Office	
PWD/Supervising Office	
Facility Audited	
Scope of the Facility	
Name(s) of the Departments	
Existing banking arrangements along with the details of facilities availed	

- Brief highlights of the past financial position of the Smart City

S. No	Particulars	FY (Audited)	FY (Audited)	FY (Audited)
1	Net worth			
2	Net current assets			
3	Bank Borrowing for Working Capital			
4	Term loans from banks / FIs / Others			
5	Total Income			
6	Gross Profit			
7	Net Profit			
8	Debt Equity Ratio			

Brief description about the methodology / process adopted for conducting Detailed Energy Audit of the unit, its production process and summary of major findings in the DEA.

- Recommended Energy Savings Options for implementation in the Smart City (after discussions and obtaining consent of the Smart City) along with its benefits

S. No	Parameters	
	Energy Saving Measures	
	Annual Energy Savings	
	Investment Cost Rs. lakh	
	Monetary Savings (Rs. Lakh / p.a.)	
	Simple Payback (M/Yrs)	
	Tons of Co2equl.	
	Electricity (kWh)	
	Coal (MT)	
	Other Fuels (LDO, FO, HSD, Gas, etc.)	
	Overall Benefits	

- Likely other benefits to the unit after implementation of the recommended EE Options (Improvement, Environment & Social benefits, etc.)
- Cost of Project & Means of Finance
  i. Cost of Project
  ii. Means of Financing
  iii. Results of Financial Analysis
    a. Project IRR
    b. NPV
    c. DSCR
- Projected Financial Highlights along with Financial Parameters – For the Smart City as a whole after implementation of recommended EE options (Projected Financial Statements unit as a whole after implementation of recommended EE options should be for 5 years (Both self financing or Loans from banks / FIs).
- Conclusion.

1. Introduction

1.1. Background and Project Objectives

1.2. Scope of Work (Particular to the Smart City)

- Conducting walk-through audit
- Preparation of walk-through energy audit report
- Discussing the walk-through audit reports with the unit
- Seeking consent/commitment from Smart City for undertaking detailed energy audits and IGDPR preparation
- Conducting detailed energy audits
- Finalising recommendations of DEA
- Preparation of IGDPRs
- Endorsement of IGDPRs by the respective Smart City
- Facilitation during financing of EE projects
- Support during implementation of EE projects
- Monitoring and Verification Protocol

1.3. Methodology-Study Approach-Audit Duration

(Provide your methodology, study approach according to the particular unit and audit duration as well covering the above scope of work)

2. About The Smart City

2.1. Particulars of the Smart City:

A	Name of the Smart City		
B	Constitution		
C	Population		
D	Date of incorporation / commencement of business		
E	Name of the Contact Person		
	Mobile / Ph. No		
	Email		
F	Address: Registered Office:		Whether owned / leased / rented
	Administrative Office		Whether owned / leased / rented
	Supervisory Office / Centralized Command Center:		Whether owned / leased / rented
G	Sector		
H	Population Served		

I	No of Hours Operation/Shift	
J	No of Shifts/ Day	
K	No of Days /Year Operation	
L	Installed Capacity	
M	Whether the Project is Retrofit (Yes / No)	
N	Quality Certification, if any	

2.2. Brief Bio-Data Of Each Smart City:

1	Name			
2	Age (years)			
3	Educational Qualification			
4	Relationship with the chief promoter			
5	Shareholding in the unit			
6	Experience in what capacity/ industry/ years			
7	Net worth as on FY 2011-12 (lakh)			
8	Income Tax / Wealth Tax Status			
9	Other concerns interest / in which capacity / financial stake			

2.3. Particulars of Previous Assistance from Banks: (in Lakh)

S. No	Name of bank/inst.	Date of sanction	Nature of assistance	Amount Disbursed	Outstanding as on Date	Defaults (if any)
1						
2						
3						
4						

2.4. Analysis Of Balance Sheet and Working Results: (in Lakh)
Detailed analysis of balance sheet and profit & loss statement of the Smart City is given at Annexure 7.

Brief highlights of the past financial position of the Smart City for the last three years is given below:

S. No	Particulars	FY 2010 (Audited)	FY 2011 (Audited)	FY 2012 (Audited)
1	Net worth			
2	Net current assets			
3	Bank Borrowing for Working Capital			
4	Term loans from banks / FIs / Others			
5	Total Income			
6	Gross Profit			
7	Net Profit			
8	Debt Equity Ratio			

2.5. Manpower:
The existing manpower and the proposed requirement in various cadres are as under:-

(Sample Table, may be change as per ground situation)

S. No	Particulars	Existing	Proposed	Total
1	Engineers			
2	Technicians / Operators / Supervisors			
3	Administrative staff / office staff			
4	Others (drivers/security staff/ attendees, etc)			
	Total			

2.6. Status of Government / Statuary Approvals

S. No	Particulars	Status (Yes / No)
1	Registration	
2	Pollution Control Board	
3	Others	

3. Detailed Technical Feasibility Assessment of the Unit

3.1. Brief Description about Process Along with Project Layout of the Smart City
3.2. Inventorization of Equipments and Utilities
(Provide complete Detail in Annexure-3)
3.3. Types of Energy Used and brief description of their usage pattern
3.4. Energy Sources, availability & Tariff Details
3.5. Analysis of Electricity bills of Unit
(Past 24/12 months: average electrical energy consumption, maximum demand, energy & demand charges, power factor details and other charges, graphical

representation of month-wise variation in demand and power factor along with observations)

3.6. Details of DG Sets in Unit
(Past 24/12 months detail in Tabular form &month-wise graphical representation of Diesel Consumption versus electricity generated, SFC, Operating Efficiency versus loading pattern etc.)

3.7. Analysis of other fuels
(Other fuel consumption details (type of fuels e.g. Liquid, solid or gaseous fuel used in unit, etc with past 24/12 months consumption details, Cost etc),

3.8. Graphical Representation of share of thermal energy from various fuels &electrical energy from Grid and Observations

3.9. Baseline Parameters for M&V

3.10. Identified Energy Conservation measures in the plant

3.11. Recommended Energy Savings Options for implementation in the Unit (after discussions and obtaining consent of the unit).

3.12. Detailed calculations with regard to electrical / thermal / fuel savings in quantity and value terms is given in Annexure-3

S. No	Parameters	
	Energy Saving Measures	
	Annual Energy Savings	
	Investment Cost Rs. lakh	
	Monetary Savings (Rs. Lakh / p.a.)	
	Simple Payback (M/Yrs)	
	Tons of Co2equl.	
	Electricity (kWh)	
	Coal (MT)	
	Other Fuels (LDO, FO, HSD, Gas, etc.)	
	Overall Benefits	

3.13. Proposed M&V Protocol

- Procurement and Implementation Schedule (Bar Chart)
- Procurement
- Bank Loan/Own Fund Mobilization
- Commissioning
- Trail Run
- Commercial Operation
- Availability of Proposed Equipments along with List of Equipment Providers
- Pre Training Requirements required if any
- Process Down Time Required During the Implementations etc
- Add if required more information

4. Other Benefits

4.1. Quality Improvements

4.2. Environmental Benefits

- CO_2 Reduction
- Reduction in other pollution parameters (Gas, Liquid and Solid)

4.3. Social Benefits

- Improvement in Working Environment
- Increase in Manpower Skills
- Increase in Wages/Salary of Workers
- Health & Safety of Plant & Personnel
- Promotion of gender equity
- Consultative process improves decision-making and reduces Grievances

4.4. Compliance of ENVIRONMENT RISKS

5. Project Financials

5.1. Cost of Project and Means of Finance

5.1.1. Cost of Project

S. No	Details	Total Amount in Rs. Lakh
1	Civil Works	
2	Plant & Machinery (incl. installation) -Indigenous -Imported	
3	Misc. fixed assets	
4	Contingency provision, if any *	
5	Margin money for working capital Incremental if any	
6	Others	
TOTAL		
*Furnish the basis of contingencies provision / Prel. & Pre-operative expenses /Others		

Details of civil construction as applicable (Area, floor, type, construction cost, basis of cost estimation, etc.)	

5.1.2. Particulars of Equipments proposed for the project

Name of, (model / specification)	Name of manufacturer, Contact personnel-mail address, Telephone no. and postal address	Estimated price based on budgetary offers (for indigenous machinery) /CIF price (for imported) (Rs. lakh)	Basis of selection of supplier

- Furnish competitive quotations, catalogues / invoice for each machinery proposed to be acquired
- In case of fabricated machinery, indicate the need / reasons for acquiring such machinery.

5.1.3. Details of Equipment Proposed

Total Cost			
Particulars	**Unit**	**Value**	**Total Value**
LED cost	Rs		
GSM based Online Monitoring System	Rs		
Labour, instalation and Other Cost	Rs		
Total	Rs		

Type of lighting to be replaced		LED
A-1	No.	W
A-2	No.	W
B-1	No.	W
B-2	No.	W
	Total	

5.1.4. Means of Finance

S. No.	Details	Total
1	Additional (share) capital	
2	Internal accruals	
3	Interest free Unsecured Loans	
4	Term Loan proposed from Bank / FI	
5	Others	
	Total	

5.2. Projected Financial Statements along with Financial Parameters with all assumptions (Projected Financial Statements unit as a whole after implementation of recommended EE options should be for 5 years (Both self financing or Loans from banks / FIs) - (Provide in Table Format)

5.3. Risk Analysis and Mitigat

6. Conclusion & Recommendations

ANNEXURE

Annexure-1: Last Two (02) / 03 Years Audited Balance Sheets of The Unit

Annexure-2: Copy of Certificates from the Competent Authorities (Msme,Dic,Pcb Etc)

Annexure-3: Performance Analysis of Utilities

(Sample Information)

(Provide the information of Each Equipments with Specifications, measured parameters like energy consumption, Temperature etc., Assessment of losses & Efficiency and Observations)

- Energy Efficiency and Performance assessment of Utilities like Transformer, DG Sets, Pumps, Motors ,Lighting, Solar Panels etc
- Specific energy consumption of Unit in terms of Electrical, Thermal, Overall
- Detailed calculations with regard to electrical / thermal / fuel savings in quantity and value terms for each Energy saving measure.

Annexure-4: Budgetary Offers / Quotations For Proposed Energy Savings Measures

Annexure-5: Instruments Used (Sample Table)

Sr. No.	Instrument Name	Application	Accuracy Level / Features	Calibration Status
1				
2				
Etc.				

Annexure-6: Standards and Codes Followed, if any

Annexure-7: Analysis of Balance Sheet

Rs. lakh

		AS ON	AS ON	AS ON
		xx-yy-zz	xx-yy-zz	xx-yy-zz
	FIXED AND NON-CURRENT ASSETS	AUDITED	AUDITED	AUDITED
1	Gross Block			
	(a) Land			
	(b) Buildings			
	(c) Plant & Machinery			
	(d) Others			

		AS ON	AS ON	AS ON
		xx-yy-zz	xx-yy-zz	xx-yy-zz
	FIXED AND NON-CURRENT ASSETS	**AUDITED**	**AUDITED**	**AUDITED**
	Gross Fixed Assets			
2	Less: Depreciation to date			
3	Less: Revaluation Reserves			
4	**Net Fixed Assets (1-2-3)**			
5	Capital Work-in-Progress (Incl. adv. for capex)			
6	Non Current Assets			
	(a) Sundry debtors over 6 months			
	(b) Investment/ Advances to Group Cos./ Subsidiaries			
	(c) Other Investments			
	(d) Deferred Tax Assets			
	(e) Security Deposits			
	(f) Others			
	Sub-total			
7	**Total Fixed and Non-Current Assets (4+5+6)**			
	CURRENT ASSETS			
8	Inventory			
	a) Raw Materials			
	b) Stock-in-Process (SIP)			
	c) Finished goods			
	d) Consumable Stores & Spares			
	Total Inventory			
9	Sundry Debtors less than 6 months			
10	Advances to Suppliers of RM and Stores/ Spares			
11	Investments			
12	Cash & Bank Balances			
13	Loans and Other Advances			
14	Other Current Assets			
15	**Total Current Assets (8 to 14)**			
	CURRENT LIABILITIES			

		AS ON	AS ON	AS ON
		xx-yy-zz	xx-yy-zz	xx-yy-zz
	FIXED AND NON-CURRENT ASSETS	**AUDITED**	**AUDITED**	**AUDITED**
16	Sundry Creditors			
17	Bank Borrowings for Working Capital			
18	Installments (Payable in one year)			
	(a) Bank Term Loan(s)			
	(b) Other Term Loan(s)			
	(c) Deferred Payment Credits			
	(d) Interest Bearing Unsecured Loans			
	(e) Interest Free Unsecured Loans			
	Sub-total			
19	Advances			
20	Provisions			
21	Other Current Liabilities			
22	Total Current Liabilities (16 to 21)			
23	Net Working Capital (Surplus of CA over CL) (15-22)			
24	**Net Tangible Assets (7+23)**			
	LONG TERM LIABILITIES			
25	Term Loan(s)			
26	Other Term Loan(s)			
27	Deferred Payment Credits			
28	Interest Bearing Unsecured Loans			
29	Interest Free Unsecured Loans			
30	Other Long Term Liability			
31	Deferred Tax Liabilities			
32	**Total Long Term Liabilities (25 to 31)**			
33	**Net Worth (24-32)**			
	Net worth represented by			
34	Equity Share Capital			
35	Equity Share Capital- Banks / Others			
36	Preference Share Capital			
37	Reserves & Surplus			
38	Subsidies			
39	Profit & Loss Account (only credit balance)			

		AS ON	AS ON	AS ON
		xx-yy-zz	xx-yy-zz	xx-yy-zz
	FIXED AND NON-CURRENT ASSETS	AUDITED	AUDITED	AUDITED
40	Less: Intangibles/ Misc. / Prelim. / Def. Rev.Exp. not written off			
41	Less: Accumulated Losses			
42	**Net Worth (34+35+36+37+38+39-40-41)**			
43	Contingent Liabilities (Rs. lakh)			
44	Repayment of loan during the year (Rs. lakh)			

Analysis of Profit & Loss Account

(Rs. lakh)

	For the year ended on		
	xx-yy-zz	xx-yy-zz	xx-yy-zz
SALES/ TOTAL INCOME	AUDITED	AUDITED	AUDITED
Capacity Utilisation (%)			
Gross Sales			
Domestic Sales			
Export Sales			
Gross Sales (1+2)			
Less : Excise Duty			
Net Sales (3-4)			
% age rise or fall in net sales			
Income from Job Work			
Other Operational Income			
Total Income (5+6+7)			
COST OF PRODUCTION/ SALES			
Raw Material Consumed			
Consumable Stores & Spares			
Power, Fuel & Other Utilities			
Factory Salaries & Wages			
Repairs & Maintenance			
Other Manufacturing Expenses			
Other Variable Expenses - Import Expenses			

	For the year ended on		
	xx-yy-zz	xx-yy-zz	xx-yy-zz
SALES/ TOTAL INCOME	**AUDITED**	**AUDITED**	**AUDITED**
Depreciation			
Sub-total (9 to 16)			
Add: Opening Stock in Process			
Less: Closing Stock in Process			
Cost of Production (17+18-19)			
Add: Opening Stock of Finished Goods			
Less: Closing Stock of Finished Goods			
Cost of Sales (20+21-22)			
Selling, Packing & Distribution Expenses			
Administrative & Misc. Expenses			
Sub-total (23+24+25)			
Profit before Interest, Lease Rentals (PBIT) (8-26)			
Interest on Term Loan(s)			

29	Interest on Other Term Loan(s)			
30	Interest on Interest Bearing Unsecured Loans			
31	Interest on Bank Borrowing			
32	Lease Rentals			
33	**Operating Profit (27-28-29-30-31-32)**			
34	Misc. exp. / def. rev. exp. / prelim. exp. Written off			
35	Non-operational Income/ Expenses			
36	**Profit before Tax (PBT) (33-34+35)**			
37	Provision for Taxation			
38	**Profit after Tax (PAT) (36-37)**			
39	Dividend			
40	Retained Earnings (38-39)			
41	Gross Cash Accruals (16+34+38)			
42	Net Cash Accruals (16+34+40)			
43	Net Forex Inflows (Rs. lakh)			

8

List of Additional Materials

1. **City and County of Denver "Street Lighting Design Guidelines & Detail, Department of Public Works, Engineering Division September 2019**
   https://www.denvergov.org/files/assets/public/doti/documents/standards/pwes-012.2-street_lighting_design_guidelines.pdf

2. **D7.1 Methods for the dynamic measurement and verification of energy savings – European Union – Horizon project.**
   https://zenodo.org/record/4695123/files/Methods%20for%20the%20dynamic%20measurement%20and%20verification%20of%20energy%20savings.pdf

3. **Gazette Notification of Bureau of Energy Efficiency (Particulars and Manner of their Display on Labels of Self-ballasted LED lamps) Regulations, 2017**
   https://beeindia.gov.in/sites/default/files/LED_Notification%20including%20Amendment.pdf

4. **BEE CODE – LIGHTIING https://nredcap.in/PDFs/BEE_manuals/BEE_CODE_LIGHTING.pdf**

5. **Handbook on Quality Control for Street Lighting Projects of EESL**
   https://eeslindia.org/wp-content/uploads/2020/10/QualityControlHandbookStreetLighting.pdf

Notes:

Notes:

Notes:

सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India