

Business Proposal to TVS

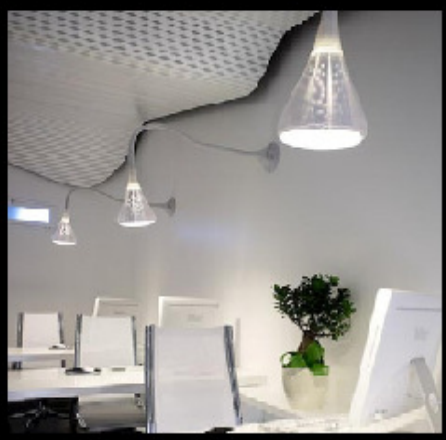
For

LED Lighting Solutions



AEG, TVS Motor Company





Contents

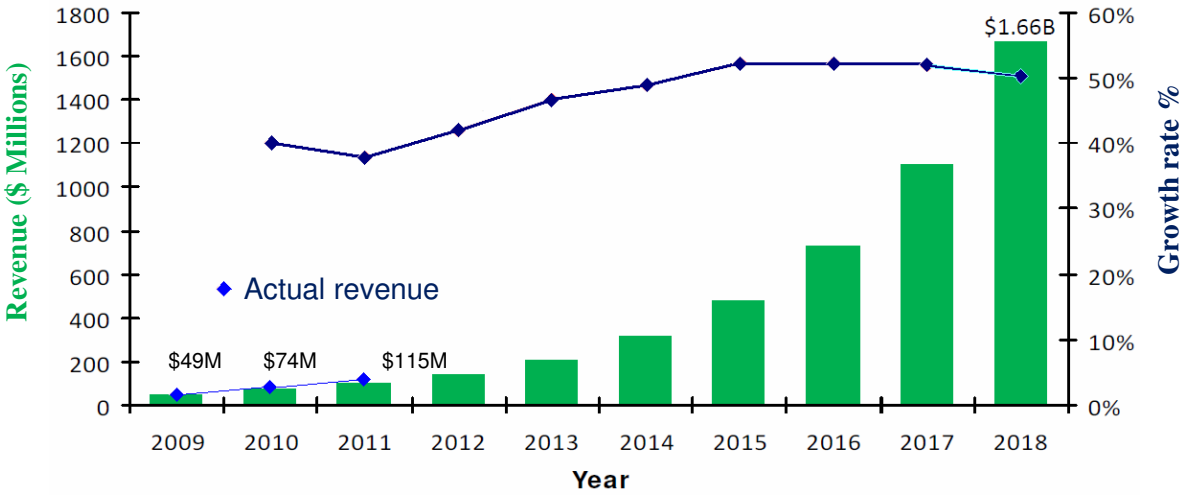
1 Executive Summary

Lighting systems based on LED technology offer higher efficiency and longer life. LED is a semiconductor based technology. Many corporate companies are now moving towards greener solutions in their office and industrial lighting. LED lighting is considered as green solution because of it high efficiency, longer life and non utilization of hazardous materials like mercury. Institutions like BEE, ELCOMA are lobbying with central and state governments to adopt LED technology in street lighting as well. Organizations employing LED lights are eligible for carbon credits. Reducing semiconductor prices and increasing utilization of LEDs offer significant potential for market transformation towards LED lighting.

Currently lighting accounts 18% of total power consumption. Penetration of LEDs in India could significantly reduce lighting load, peak power demand and overall energy consumption. There would be compulsions on governments to push high efficient lighting systems to bring down lighting energy consumption to meet increasing power demands. Indian Lighting market is currently at around INR 9000crores and it is growing at CAGR around 15%.

LED Lighting Market Revenue Forecast (India), 2009-2018

Source: Frost and Sullivan's 2nd Annual Executive congress on LED Lighting in New Delhi, 2011



Indian LED lighting market is around INR 580 crores for the year 2010-11 which is 6.5% of general lighting. It is expected that by 2021, the LED technology will penetrate 57% of the lighting market. This penetration may be accelerated by the demonstrated leadership by the

government initiatives. Private sector by its cost economics will be early adopters in LED market. As shown in the figure in executive summary, Frost & Sullivan forecasts bright future for LED lighting solutions in terms of revenue. It is estimated that by 2031, LED occupies more than 80% in lighting.

The rise of LED in lighting has just begun and set to take dominant position by 2020. It is the right time to enter LED lighting market to take the early entry advantage. Major competitors are Philips, Havells, Bajaj Electricals, Wipro, Crompton Greaves etc. Presence in many categories and vast experience in marketing its products, TVS Group has the advantage in taking up LED lighting business opportunity. With its experience and brand value, TVS could manage a minimum of 8% LED market share in India in 4 years from start of sales. Currently Indian lighting market's profit margin is around 9% considering big and small players. Since the initial investment is low, positive results can be seen even before 2 years from start of sales. Unlike the competitors, TVS could focus only on LED technologies in lighting. In the adverse conditions, exiting the business is not difficult as the investment is low, and further conditions are discussed in detail in upcoming sections.

TVS can add LED lighting as an additional product portfolio to one of its group companies. TVS can also creative new entity to handle this business opportunity. The new entity's product portfolio can be extended to other domestic electrical equipments in due time.

2 LED lighting Market trends & projections and justifications

2.1 Indian lighting market

Current Indian lighting market is pegged at around INR 9000 crores. For the last three years, it has been growing at CAGR over 15%. Current lighting market comprises of technologies like incandescent, Fluorescent tubes, Compact fluorescent tubes, HID and LED. With the ever rising electricity bills, Indian lighting market is moving towards energy efficient lighting. CFL market has gained momentum from early 2005 and is continuously rising in numbers to replace incandescent market. CFL is 3 times more efficient compared to incandescent bulb. In commercial establishments from 2009 onwards, LED lighting has found place and is around 6.5% in 2011 in sales value. LED light consumes 2.5 times lower electrical power compared to CFL bulb for the same light output. Figure 2.2 shows the differences among these technologies. Figure 2.1 represents the LED light unit basic parts.

LED lighting would penetrate the general lighting by a minimum of CAGR 45% by 2018 and it means INR 7800 crores market in India. This is according to the *Frost & Sullivan*, *Strategies Unlimited* and *Mckinsy* Global research reports on lighting. Figure 2.3 indicates the market projections for LED lighting in India till 2018.

In 2009, *Strategies Unlimited* had given projections for LED penetration in general lighting. Figure 2.4 indicates the same for worst, expected and best cases. Current LED market in 2012 is in the midway of best and expected cases of old forecasts. According to *Mckinsy* Global Lighting professionals, LED lighting penetration would be around 55% in general lighting globally by 2018.

Street lighting business is more to do with state and central governments. Figure 2.9 indicates the projections for the LED lighting revenues excluding street light business. Figures 2.10 and 2.11 indicate the short and long term potential applications in LED lighting. Street lighting, office lighting and industrial lighting are the immediate focus and Automotive and domestic lighting are of long term focus. Indoor, outdoor, commercial are automotive lighting are major contributors in terms of revenue after street lighting.

Figure 2.1: Representation of LED lighting unit basic parts

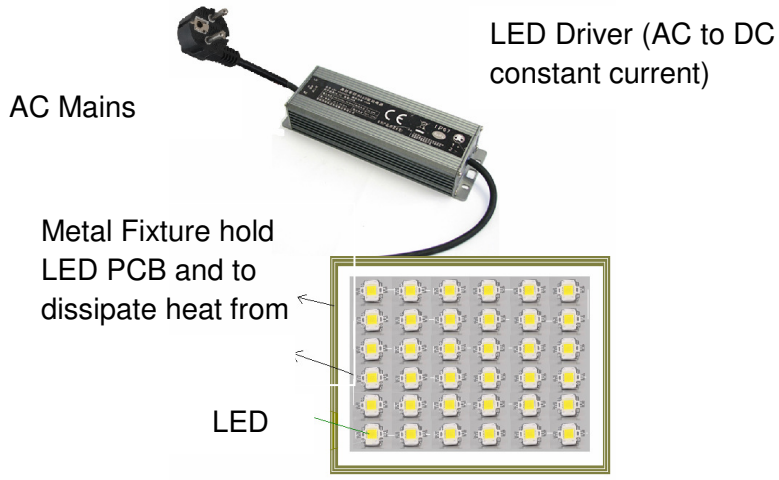


Figure 2.2: Comparison of different lighting technologies

Source: ELCOMA website

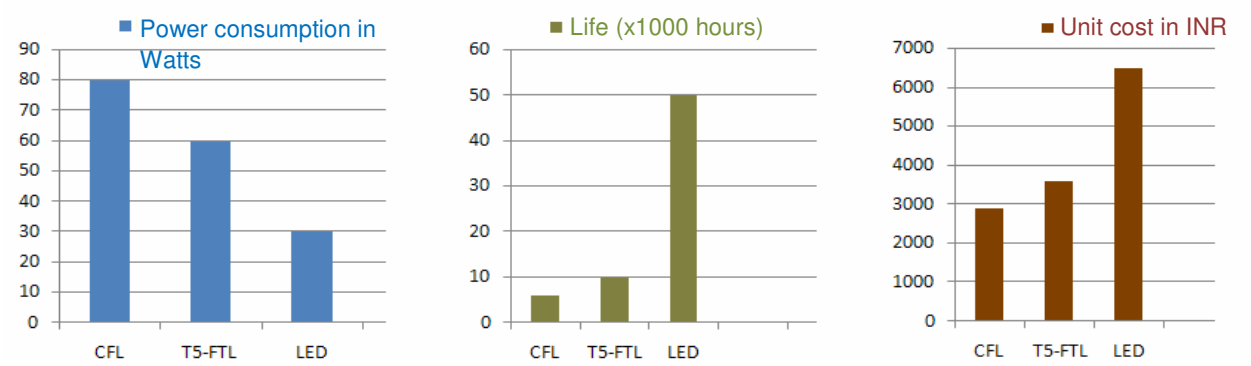


Figure 2.3: LED lighting market revenue forecast (India), 2009-18 (Revenue actual for 2009, 2010 and 2011)

Source: Frost & Sullivan's forecast report on Indian LED lighting market and data from ELCOMA, India website

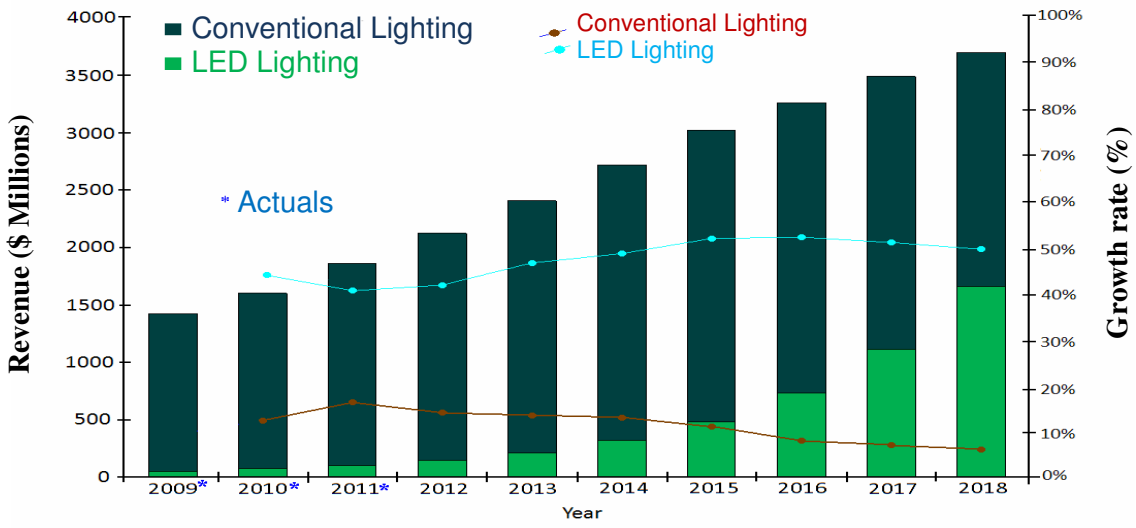


Figure 2.4: LED penetration forecast for general lighting

Percent Source: Strategies unlimited, strategy analytics, Fredonia, Philips, Vecco

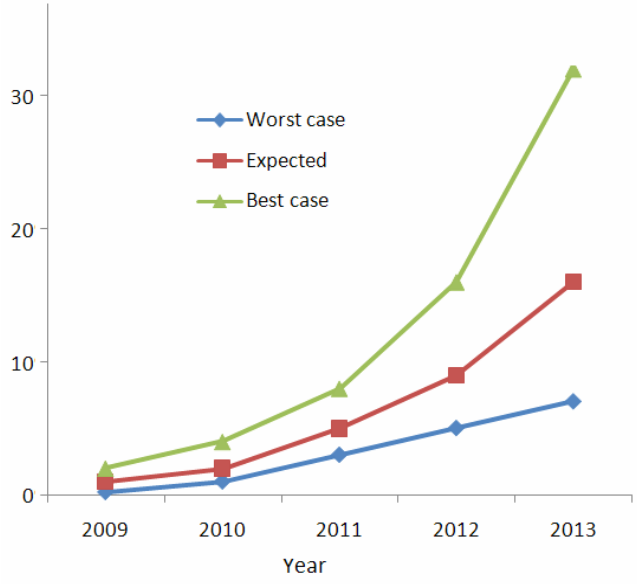


Figure 2.5: Segment wise LED penetration forecast

Percent Source: Mckinsy Global Lighting Professionals & Consumer Survey

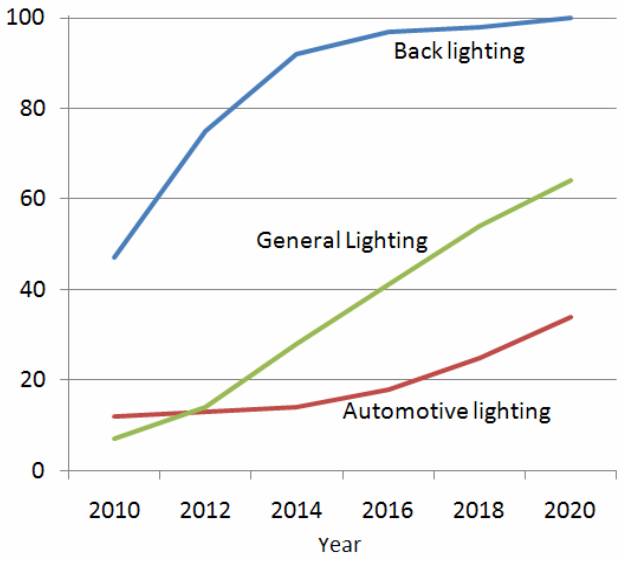


Figure 2.6: Recent Indian Lighting market growth rate

Percent Source: ELCOMA presentation in Taipei – March 12□15, 2012

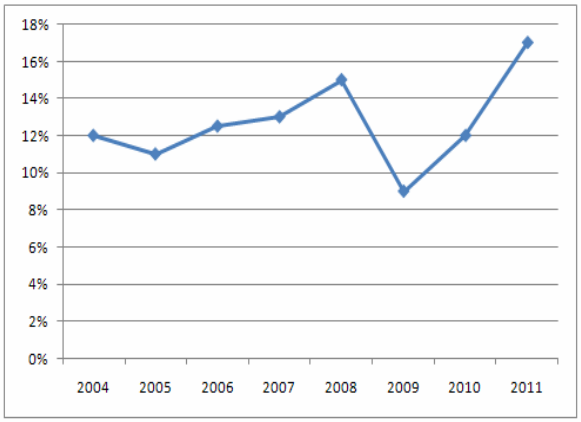
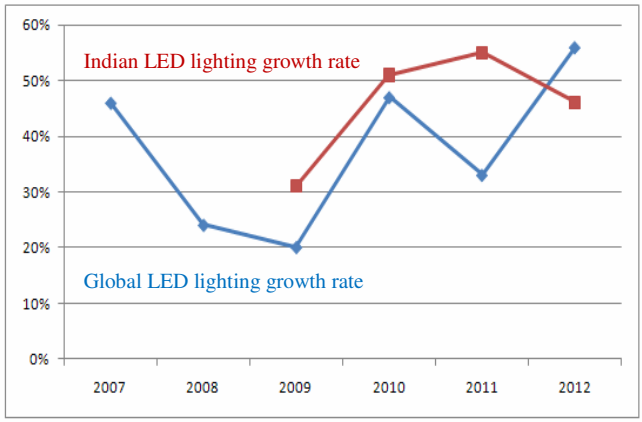


Figure 2.7: Recent LED Lighting market growth rate

Percent Source: IMS research and ELCOMA presentation in Taipei – March 12□15, 2012



Indian Lighting marketing is witnessing a double digit growth for the past ten years as shown in figure 2.6 and would continue to grow owing to Indian infrastructure requirements. Globally LED lighting market growth is more than 30% for the last three years and it has seen a dismal growth rate of 20% during the 2008 recession time. Advantages of LED lighting coupled with the LED chips' expected price fall would see high positive growth rate irrespective of market conditions. The price fall projection for LED chip is indicated in figure 2.8. This fall is attributed the increasing volumes.

Figure 2.8: LED chip pricing and production projections
Source: DOE-USA, Arthur D Lite

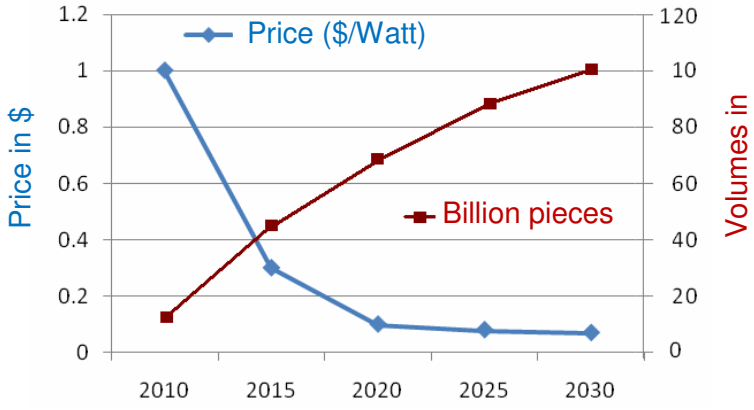


Figure 2.9: LED lighting market revenue forecast excluding Street lights, 2009-18
Source: Frost & Sullivan's forecast report on Indian LED lighting market, 2011

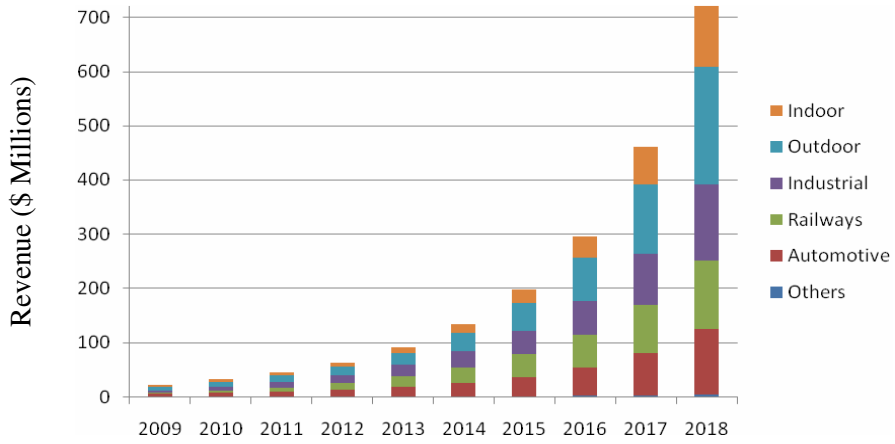


Figure 2.10: Indian lighting market pie chart as of 2010.

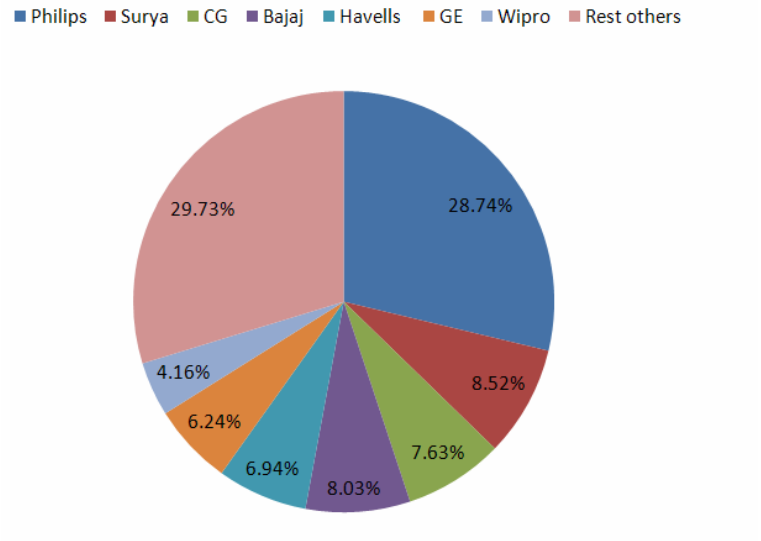


Figure 2.11: High Potential Applications for short

Source: Frost and Sullivan's 2nd Annual Executive congress on LED Lighting in New Delhi, 2011

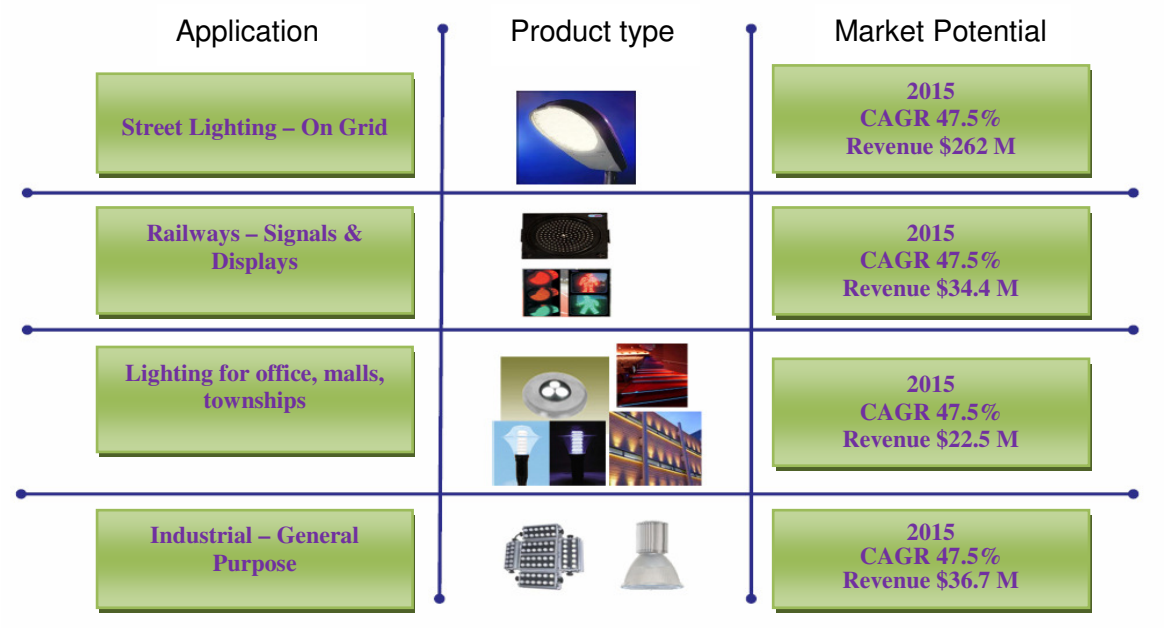
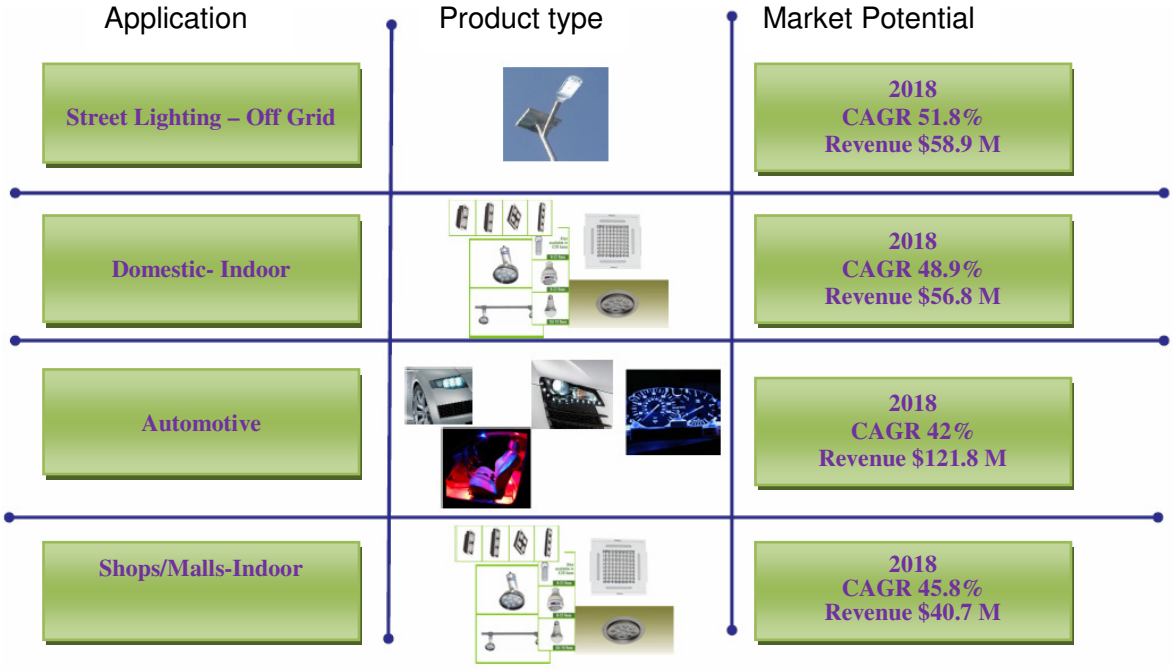


Figure 2.12: High Potential Applications for Long

Source: Frost and Sullivan's 2nd Annual Executive congress on LED Lighting in New Delhi, 2011



2.2 Market forecast justifications

As mentioned in the earlier sections present market demand for lighting in India is around INR 8500 crores. LED lighting market share in general lighting is around 6.5% which is around INR 550 crores. Figure 2.6 from the section 2.1, indicates that the Indian lighting market's lowest growth is more than 9% in the past ten years. Figures 2.3 represents the annual Indian LED lighting market growth rate and the same is projected to rise by more than 45% annually till 2018. LED lighting penetration in general lighting would be more than 40% by 2018 and 60% by 2021 as per figure 2.5.

Figure 2.7 represent the recent LED lighting market growth annually for both global and Indian market. Annual growth of LED lighting market is more than 50% for the last three years in India. From the same figure it is observed that even during the market slowdown in 2008-09, the global LED lighting annual growth was never lower than 20%.

From the current LED lighting market data, sales forecast for three cases (optimistic, realistic and pessimistic) are considered. Realistic case assumes market growth at 40% annually. This number is chosen to be lower than the projections from several market research agencies. The optimistic case assumes that the growth rate as exists from 2010 onwards and continuous to exist. The same growth in optimistic case could be partly due to the rise in electricity bills or due to the expected LED chip price fall. A trend of power consumption bills and price of LED chip are indicated in figure 3.1 and figure 2.8 respectively. The pessimistic case assumes that the growth is limited to 20% annually as it was in 2008-09 market slowdown time.

Figure 2.10: Indian General Lighting Market revenues by technology

Source: Frost & Sullivan's 2nd Annual Executive Congress on LED, New Delhi 2011

It is assumed that percentage of LED lighting sales in total lighting market is 6.5% currently and penetration of LED would increase irrespective of market conditions. Pessimistic, realistic and optimistic cases assume the that penetration of LED lighting in general lighting would be 15%, 42% and 51% respectively by 2018. According to *Frost & Sullivan's* forecast, LED penetration would be more than 45% by 2018.

2.3 TVS market share forecast and justification

Today, the growth of LED lighting market is very much close to the optimistic prediction done few years back. As a whole LED lighting market is a realistic business opportunity. As the LED lighting market is in growth phase, all new market entrants at this stage have the opportunity to get rightful market share. But with the quality of products, right pricing and good network for sales and service, it is possible to achieve greater market share. TVS can use its experienced human resources and dealership networks in marketing the product. It was projected that by 2021, LED lighting market share will be more than 65% in general lighting market. TVS Group's experience would benefit the LED lighting division in terms of supplier chain management, designing, packaging and thermal management of its products.

TVS group's interest would be all the segments of LED lighting. All the business cases considered are based on the general lighting excluding street lighting. Managing the contracts

from the government agencies is a major problem in street lighting. Street lighting was intentionally left to see the business viability in the business cases. TVS would be developing products for street lighting segment. But these products will cater to the commercial, industrial and construction sectors. Gaining of street lighting contracts from government is an additional benefit for TVS without extra efforts and resources.

Market share forecast for TVS in LED lighting is represented in figureA1.3 of Annexure-1. The pessimistic case assumes market share growth very close to that of *Greenwich Nexen*. *Greenwich Nexen* is a Bangalore based LED lighting manufacturer and was established in 2009. Customers would be highly reluctant to purchase from unknown companies like *Greenwich Nexen*. Since it was a new entrant into the same field of TVS's interest and was an unknown brand, its performance is considered for the pessimistic case for TVS.

Realistic case assumes slightly higher market share growth, and could be associated with the brand value leveraged by TVS. This represents a case where TVS is recognized as a familiar brand existing in the market and customers do not worry about warranty issues because of the good will that exists in the market.

The optimistic case assumes even higher market share growth rate. This could be attributed to high brand reorganization for TVS and its products & services and better marketing strategies. In this case TVS products are uniquely identified for their USPs and valued by customers. TVS is identified as a strong market player among other market players from outside India, and is identified as a technology promoter. Although TVS is entering into the market where there are already few market pioneers, it is assumed that TVS concentrates on new segment in Lighting in order to achieve high market share. Realistic and optimistic cases assume that TVS would focus on all the sub segments in general lighting such as street lighting, office lighting, etc.

Profit margins are assumed for pessimistic, realistic and optimistic cases, to represent the variation of raw material costs and final product price reduction by competitors. It is estimated that LED lights are sold by manufacturers at an operating profit margin of around 15%, since

most of these sales are based on brand value, and is the latest technology into Lighting. For the business cases, it is estimated that TVS will have margins ranging from 6% to 10% considering that initial design and processes will not be most cost effective.

Rest of the projections of TVS sales and profits are drawn from above assumptions only. Any kind of market conditions within the assumed range will result in sales ranging between best case and worst case of the projected future trends. However, the pessimistic case as assumed in the business cases is highly unlikely to occur since LED is proven and best technology in the recent times.

2.4 Breakeven points

Present market for LED lighting in India is around INR 550 crores. It is expected reach INR 5,000 crores by 2020 when street lighting is excluded. As presented in this section, LED lighting market forecasts for India are robust. Government would push LED lighting to reduce the lighting power demand owing to lower LED power consumption.

Breakeven time durations for three business cases (case1, case2 and case3) are represented in image A1.1, A1.2 and A1.3 of Annexure-1. X-axis represents time in years from start of project. T1 (T0+1 years, i.e. 2014-15 fiscal year) is expected as start of sales, and T2 sees sales turnover rising from zero. In each image, the point at which the investment curve joins the profit curve can be termed as the breakeven point. Breakeven points are different for different market conditions and also for different investment conditions.

In the image A1.1 of Annexure-1, it may be observed that breakeven is taking longer time for the case with maximum investments being made when the market performance is at its worst. It is advised in such cases to cut down licensing charges for the technology transfer. The worst case assumes sales rise of 25% as against 45% of projected growth with maximum investment. Chances of worst case occurrence are very remote owing to LED technology advantages and it's no near future alternative to challenge.

3. Customer segmentation, buying behavior and expectations

3.1 Customer segmentation

TVS would focus on all lighting segments**.**

Segment	Customers
General lighting	Municipalities, malls, institutes, townships, railway platforms, General public for home lighting, Corporate for office area lighting, industries
Back lighting	Railway Signalling & general information indicating boards
Automotive lighting	LED lighting for automobiles

Customers can be broadly categorized as:

- State and Central governments for street lighting
- Corporate for office and industrial lighting
- General public for domestic lighting
- Railways for LED based traffic signal indicating systems
- Automotive industry for lighting

3.1.1 State & Central governments in street lighting

Street lighting is the largest contributor to LED lighting revenues in India, thanks to the government initiatives through the municipalities.

Typical requirements of street lighting:

1. This lighting segment needs high power LED lights (typically 60 to 70W).
2. Street lighting needs Automatic on/off control to avoid lights glowing day time.
3. Dimming control to reduce intensity after the traffic hours in the night.
4. Lighting requirements vary based on the speed of the traffic. High speed traffic roads need higher luminance.
5. Aesthetic look for city streets

Retrofit to the existing lighting fixtures is the USP for TVS lighting. Construction sector with the planned residential layouts is part of the customers in this segment.

3.1.2 Corporate for office and industrial lighting

Commercial and office areas are generally air conditioned. Any heat generating devices in the air conditioning room increases the AC power consumption. Installing energy efficient lighting systems would reduce the energy bills. Additionally, corporate could also save on the AC bills. This segment LED lighting power requirements vary from 10W to 100W depending upon the area and height of the roof. By 2018, market for this segment would be around INR 2500 crores.

Competitive pricing and support on sales and service coupled with corporate relationship would reap benefits to TVS. Construction sector is the other focusing area to cater to the needs of townships, malls and other commercial buildings in this segment.

3.1.3 Railways for traffic signal indication

Railways are one of the early adopters of LED lighting for back lighting. Indian Railways has proposed the LED lighting for all its stations and would implement phase wise by 2020. TVS would focus on general lighting initially and later on add back lighting to its portfolio. Railways sector might need lobbying for getting the lighting contracts.

3.1.4 General public for domestic Lighting

Consumers are conscious of energy efficient lighting with the ever rising electricity bills. Longer life and initial cost drive the market growth. Growth in this segment for LED lighting would be slow till the LED prices drop and could only see a reasonable sales and growth after 2018. TVS should focus and be ready with the products before this segment evolves.

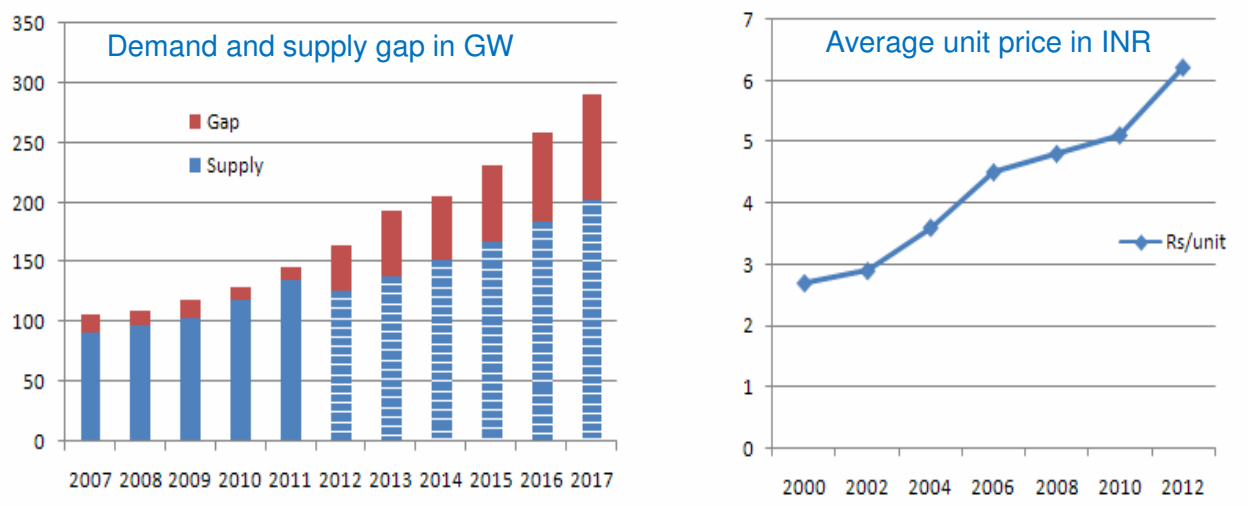
3.1.5 Automotive industry

Lighting consumption is around 3 to 6% in a typical vehicle. Changing lighting to LED would reduce the consumption significantly (0.5 to 1%). This would reduce the burden on battery and would improve distance range for a single charge in electric and hybrid electric vehicles. By 2018, LED automotive market would be around INR 600 crores.

3.2 Customer behavior and Expectations from LED lighting

State electricity boards in India are raising electricity charges regularly to meet generation costs. From 2000 to 2012, unit charges are raised by around 9% annually. For electricity consumers, lighting accounts for about 15 to 20%. Ever raising electricity bills are making the consumers think about efficiency of the units they install. The following figure indicates the electricity generation and supply gap and rise of per unit charges.

Fig 3.1: Electricity Demand & Supply gap and average charges in India
Source: Compiled data from Ministry of Power & electricity boards of Maharastra, AP, TN and Delhi



Currently the customers to LED lighting are corporates, industries, automotive & constructions companies and government sectors. Projections are indicating that the domestic lighitng segment to cater general public would pickup sales only after 2018. For the Indian LED lighting manufacturers, general public is not the priority sector for now.

Abstract set of customer expectations (Data is collected from the presentations on lighting industry and from few people around)	
Cost	- Low procurement cost - Power consumption of product should be low. - Should not require any replacement for at least 5 years. - Long product life
Performance	- Should provide sufficient brightness. - Should not be sensitive to frequent power cycling – should not burn or explode in very high or very low voltage conditions. - Should turn on instantly and work fine in cold temperatures. - Should not generate any heat.
Ease of procurement (it should be supplied immediately on demand)	
Ease of disposal (it should not require special means for disposal, should be disposable along with other waste).	
Ease of replacement (replacing the bulb without needing to purchase a new fixture).	
Should not be harmful to environment	
Should be compact and sturdy	
After sales service and warranty at least for 5 years	
Should allow dimming – reducing brightness without turning off the lamp.	

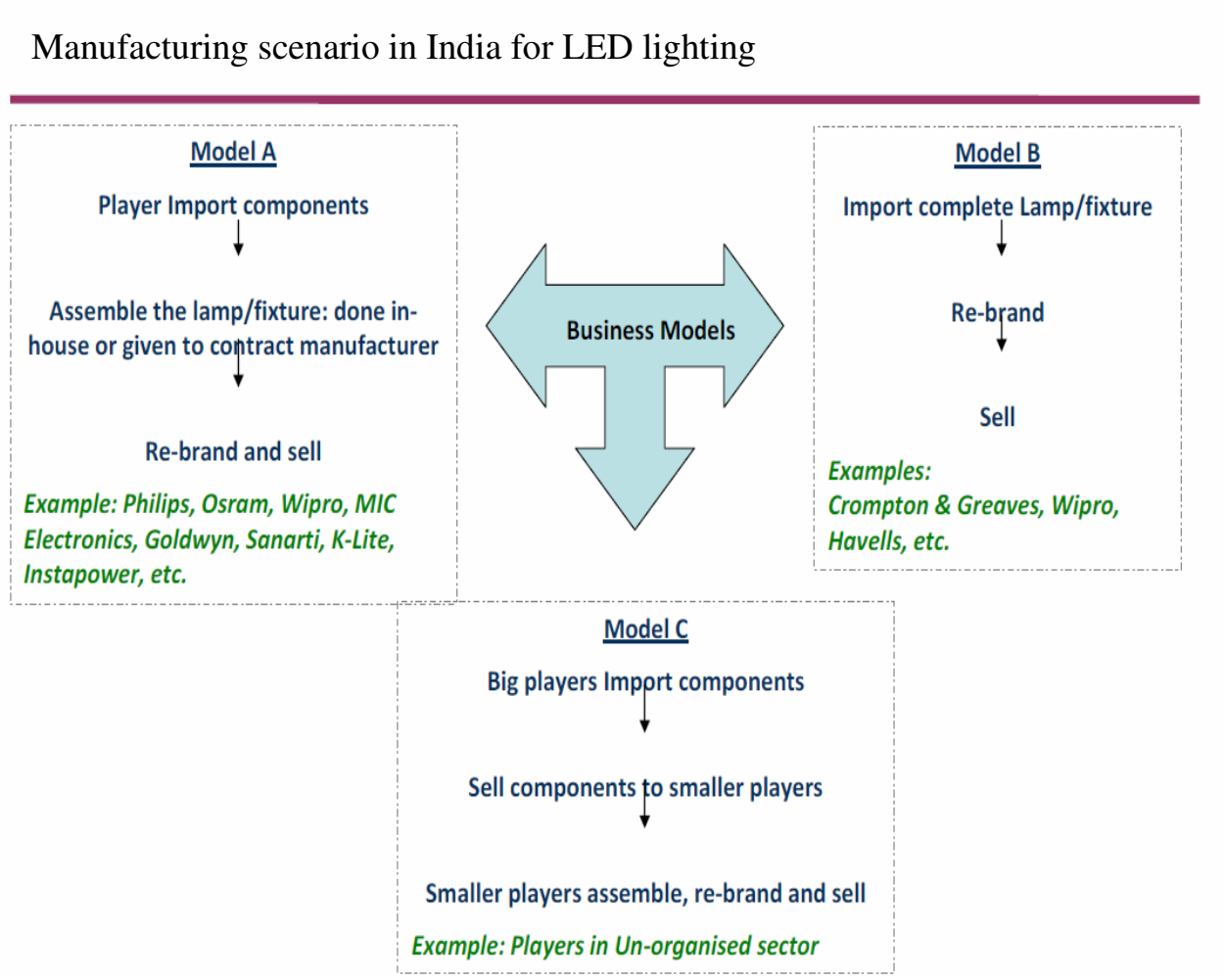
Refined set of expectations but not limited to following list

- Low power consumption
- Longer life
- Low maintenance
- Early return on initial investment
- Better lighting in terms of luminance
- Comfortable light to eye
- Better service and spare parts availability
- Low initial investment

4. Competitor analysis and de-risking methods

4.1 Competitor analysis

Major players in the Indian lighting market are Philips, Bajaj Electricals, Havells, CG, Wipro, Surya etc. All these major players and many new entrants are into LED lighting. Philips is the dominant player in Indian lighting with around 30% market share as on 2011. Profit margins for these players vary from 6% to 20% as shown in figure 4.1. Havells India has posted lighting division profits around 20% for the last three years. Philips sales data contains the global lighting data and does not specify Indian sales. Its profits are around 8% globally.

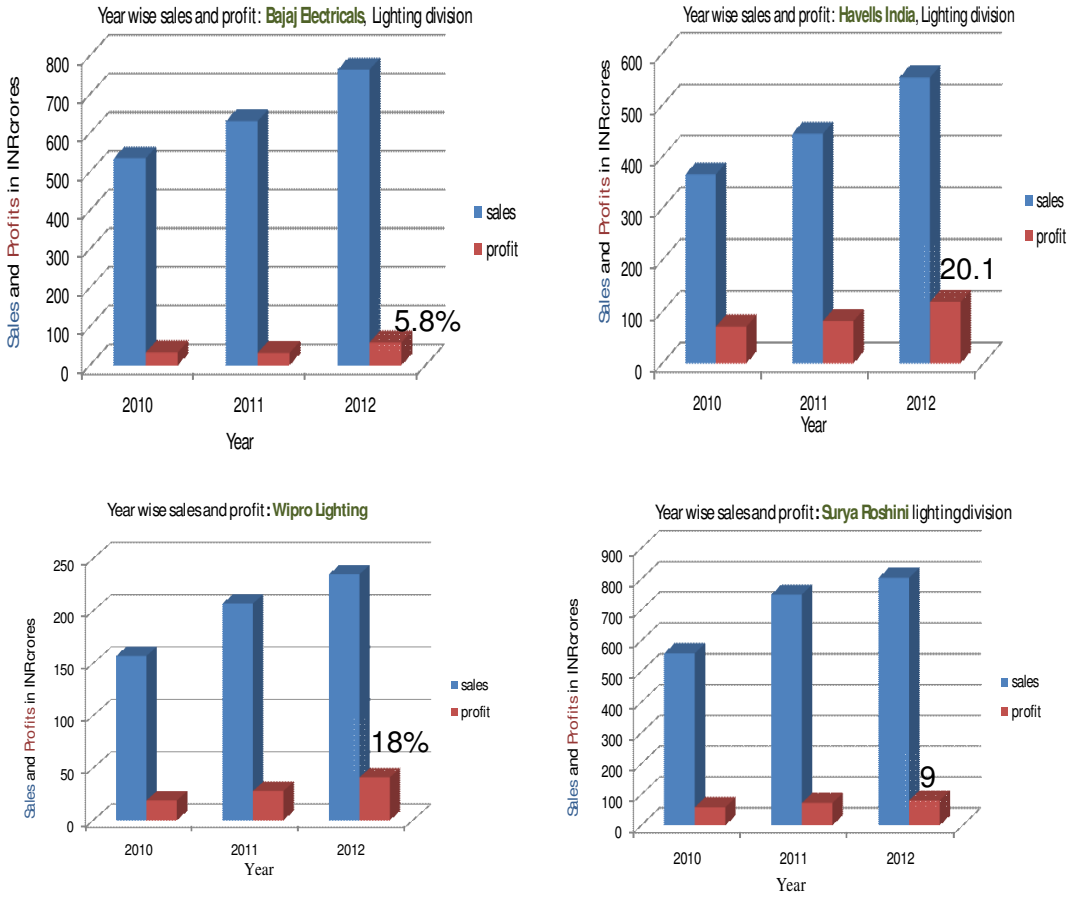


Supplier Matrix for different segments

Company Name	Segments catered to							
	Street Lighting	Industrial	Signals	Automotive & Transport	Indoor	Outdoor	Signage/displays	Others
MIC Electronics	●	●			●	●	●	●
Sanarti Group	●	●	●	●	●	●		●
Osram India	●	●		●	●	●	●	●
C&G	●	●			●	●		●
Philips Electronics	●	●		●	●	●	●	●
Surya Roshini					●	●		
Goldwyn Ltd	●	●		●	●	●		●
Wipro Lighting	●	●			●	●	●	●
Havels		●			●	●	●	●
Bajaj Electricals	●	●			●	●		●
Avni Energy	●				●			●

Figure 4.1: Lighting division Sales and profits for Havells, Bajaj, Wipro and Surya

INR crores Source: Respective company annual reports



Bajaj Electricals's lighting division has posted profit margin only 5.8% where as Havells and Wipro margin are above 18%. Bajaj electrical is spending around 74% of income on material consumption and the same is around 61% for Havells.

4.2 Porter's five force analysis

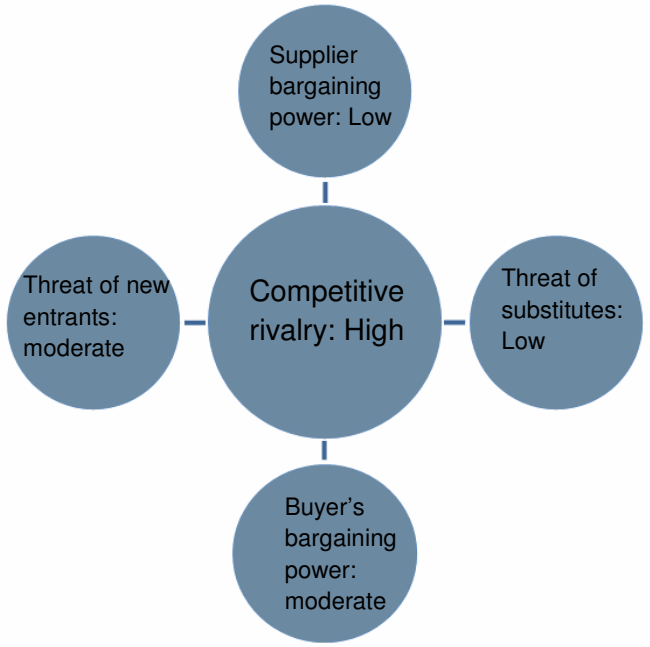
4.2.1 Threat of new entrants: LED being a relatively new revolution in lighting technology and being semiconductor based, it is possible for new players to enter the LED lighting market. However, it is essential to have a strong brand name as well as experience of dealing with the corporate and governments to secure contracts. Overall, the threat of new entrants is moderate.

4.2.2 Threat of substitute products: The latest innovation in the lighting space has been that of Organic LEDs. Organic LEDs have begun to be used in television screens, computer displays, cell phones and PDAs. However their use for general purpose illumination has been very limited. Also the lifetime of OLED is around one-fifth that of LED. While this may not cause any issue for electronic items like monitors and cell phones (since these tend to get replaced pretty soon), using OLED for general space lighting becomes very expensive. Hence threat of substitute products is low.

4.2.3 Supplier's bargaining power: The primary suppliers are the organizations supplying the semiconductor chips for the LEDs. Since there are numerous such fabrication units in Taiwan and China – which manufacture chipsets on demand, and the technology is standardized, supplier's bargaining power is low.

4.2.4 Buyer's bargaining power: Since the primary buyer for LED based street lamps are the city municipalities, who float tenders and award contracts based on price, they have good bargaining power. The other customers are townships, academic institutions, malls (parking area illumination) etc. Since the number of players in the market is also increasing, buyer's bargaining power is high.

4.2.5 Competitive rivalry: The major players in the lighting market are Osram, Philips, Bajaj, CGL and Havell's. The competitive rivalry in this segment is high. A comparison of the strengths and weaknesses of each is done below:



	Osram	**Philips**	**Havell's**	**CGL**
Strengths	Part of the Siemens group. Strong technical knowhow and innovation in LED lighting	World leader in lighting business. Acquired Color Kinetics and Genlyte in 2008, thereby strengthening its position in Solid state lighting market	Indian company. Great understanding of Indian market. Acquired Sylvania in 2008 giving it a strong foothold in lighting business	Strong presence in services. Fast moving towards a complete solutions provider
Weakness	A weaker brand name as compared to other players in the Indian market	No visible weakness. High expectations by all stakeholders	Integration of Sylvania with its existing operations expected to take some time.	Relatively new player in the LED lighting segment. More focused on CFL business
Future Outlook	Plans to develop production capacity in India for Slim FTL's and CFLs	Focus on growth driven by acquisitions. Strengthening position in emerging markets	Launching Havell's product in world markets. Increased R&D on energy efficient products	Converting consumer products division into a truly consumer-brand-marketing driven enterprise.
Presence in LED Lighting	Yes	Yes	Yes	Yes

The largest player in the Indian LED market is Philips, which enjoys a strong brand reputation for its quality products. Philips introduced LED based products in India in late 2007. Philips has also announced that it will shortly begin manufacturing LED based lighting products in India itself, thus further cutting its costs. Philips however hasn't been able to make serious inroads into the street lighting market. The other major players (Osram, Havell's and CGL) are still seriously focusing on CFLs. LED based lighting systems form a very small part of their portfolio and most of their marketing efforts are directed at the CFL market. The unorganized market in this sector is developing, with many small scale players assembling LED lighting solutions for customers. They are highly popular in the office lighting segment. However without a strong brand name, they are unlikely to secure large contracts for the street lighting segment.

4.3 Internal Environment Analysis

Strengths:

TVS has around 100 years experience in automotive field and more than 30 years in many other businesses. TVS understand and knows how to manage the supplier value chain and is a very strong brand. TVS group has a strong distribution network and service franchises spread across the country for its various products. Many existing facilities can be utilized for developing LED related electronics, packaging. From the group companies, TVS could gather the resources in terms of finance and human resources. Since the initial investment is around 25 to 30 crores, it may not be difficult for TVS to establish business. TVS has the competence in electronics, fabrication and optics to develop the LED lighting system by sourcing the LED chips.

TVS group companies have access to international markets through various products. This will help the lighting division to setup business outside India in later stages.

Weaknesses:

TVS does not have a consumer product portfolio for any electronic or domestic appliance. This limited its network and service centers. TVS needs to establish the dealer network or needs to have agreements with multi brand selling dealers. TVS is not seen as a brand for lighting solutions provider.

4.4 External environment analysis

4.4.1 Political

Government initiatives to promote energy efficient LED lighting:

- Reduced the customs duty from 10% to 4% on LED components.
- Fiscal benefits like exemption to R&D and capital items
- Ministry of Power:
    - Proposed to distribute one LED light under the Rajiv Gandhi Gramin Vidyut Vikram Yojana
    - Designated following agencies for LED lighting market development in India:
        - ❖ BIS-Responsible for setting up nation wise standards
        - ❖ DIT-Responsible for technology
        - ❖ BEE-Responsible for creating market demand
- Ministry of commerce:
    - proposed to bring guidelines for use LED in all common areas, including street lights
    - Traffic lights, blinkers, direction signage, based on LED should be powered by solar
- Ministry of Railways:
    - Already installed LED in displays, traffic signals, sign board and coach lights
    - Proposed to install LED lighting in trains and upgrade signals to LED, under Railways vision 2020

4.4.2 Economical:

- To meet the ever rising demand for electricity, generation has to go up. Addition of generating capacity means more ecological imbalance. Lighting at present constitutes to about 17-20% of power consumption. Changing the lighting solutions to more energy efficient system would relieve the demand on generation capacity addition.
- Owing to the fluctuating market conditions worldwide, demand for LED lighting solutions may get affected during slow market conditions. This is because of present high initial investment on LED lighting. By 2020, it is expected that LED chips price would

fall by more than three folds. This brings down the initial cost on LED lighting and makes it comparable to other lighting solutions in terms of pricing.

4.4.3 Socio-cultural:

- With growing importance of CSR activities and a realization among companies that investors view CSR activities favorably, any means taken to reduce energy consumption or benefit the environment could be portrayed as a CSR activity to investors.

4.4.4 Technological:

- LED lighting is the latest innovation in the lighting industry space. The technological advantages have already been discussed earlier.
- Future technologies are being developed based on LED, such as Organic LED – however these are not suitable for large scale lighting systems.

4.4.5 Ecological:

- Going green is the current corporate buzzword.
- In addition to savings from energy efficient solutions, they can also claim for carbon credits, which can be traded in the market.

4.4.6 Legal:

- Under the Energy Conservation Act (2001), BEEs (Bureau of Energy Efficiency) were established to promote energy efficiency products.
- The Indian National Action Plan on Climate Change (NAPCC), released in 2008, also proposes to incentivize energy savings.
- As of now, there is no law mandating energy efficient products.

Based on the internal and external analysis, we can refine the operating conditions for TVS as follows:

- TVS does have the relevant technological background to provide solutions in LED lighting.

- Since TVS would import LED chips and would be setting up a plant for design and assembly of finished LED lighting products, its costs can be reduced to some extent.
- TVS needs to focus on enhancing the sales and service networks.
- Considering the short term and long term plans, TVS would focus on all the LED lighting segments.

4.5 Benefits

With the help of lighting division, TVS can obtain brand extension. Since the market segments aimed at includes domestic lighting, there will be positive effect on brand strengthening. Since it is a low investment and high revenue product, TVS could increase its revenues and profits.

4.6 Risks

Initial investment is around INR 25 to 30 crores for software, infrastructure and lab facilities. In house manufacturing of light fixture and PCB assembling will need additional INR 10crore investment. Based on the market conditions, breakeven can happen in the worst case in less than 4 years time from start of sales. Several unexpected market conditions may delay the breakeven further more.

TVS needs to select the quality LED chip manufacturer like Nichia (Japan) to provide good quality lighting systems. TVS needs to have qualified engineers in the fields of optics, electronics and mechanical engineering. LED lighting is set to rise mainly because of quality and longer life. TVS or suppliers may be sources for quality problems. If the product quality is not up to the mark, business will get affected.

Though there are robust growth forecasts for LED lighting, there might be a case where the growth of LED is affected. This scenario could seriously hamper TVS in continuing only LED based products in lighting market.

4.7 Threats

TVS is trying to enter LED lighting which is yet to make a mark in lighting market. Presently there are several national and multinational players in overall lighting market. All these players are now focusing on LED lighting and some of them have already marketing. Unless TVS leverages its brand value, and quality products to promote its entry into the lighting market, it is difficult to convince the customers to purchase TVS lighting systems.

4.8 De risking methodologies

TVS will have to work with suppliers collaboratively to arrive at products with highest profit margin and better quality at the design phase itself. TVS will have agreements for sourcing quality LED chips from identified supplier so that no technological problems arise in this field. Risk of competition reducing prices has to be addressed in all stages of project from design to testing by aiming at very high operating margins. Some of the initial investments like fixture and PCB manufacturing facilities can be outsourced initially and can be added in TVS fold once the surplus funds are available.

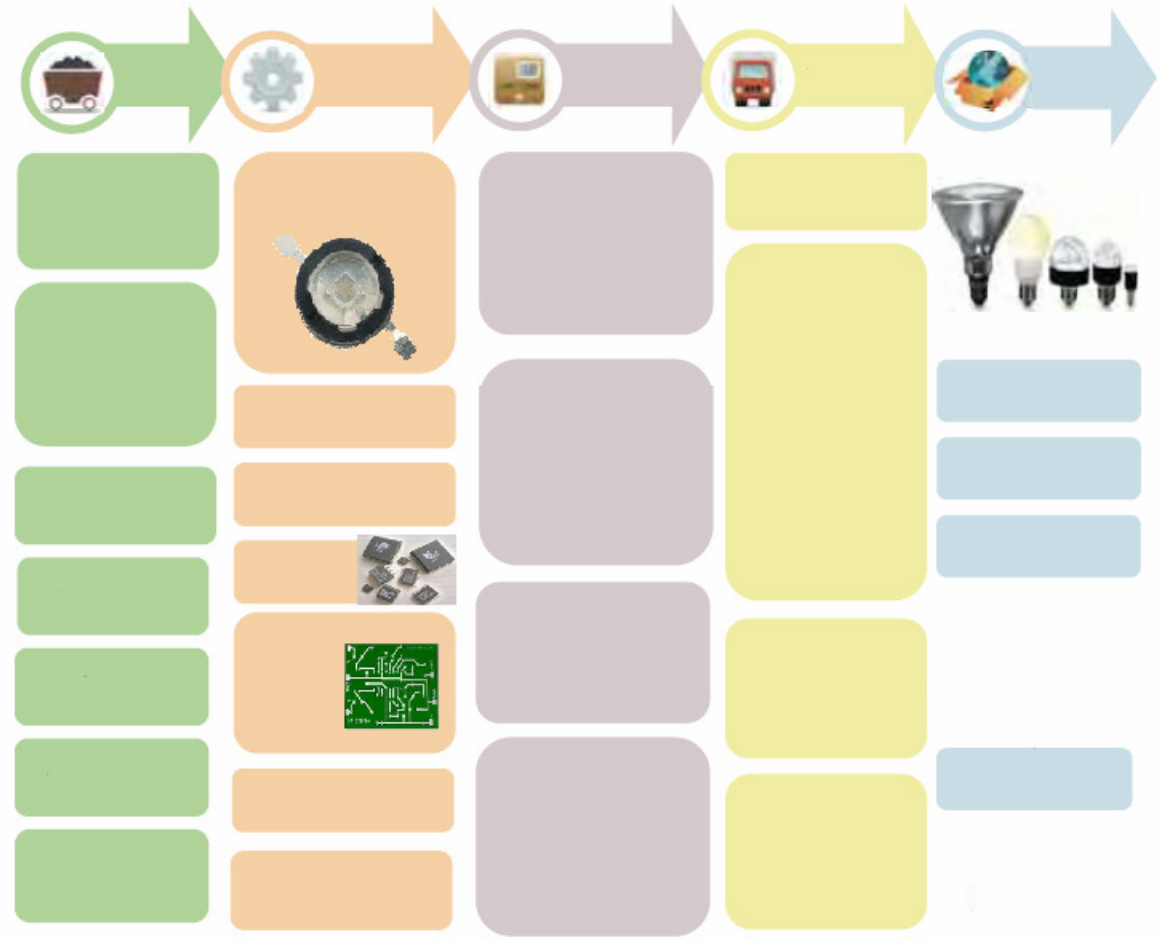
LED lighting technology is not a complex design and the focus could be more on quality of power supply design and assembling process. LED lighting designed for office at TVS motors proves the same. During the initial phase, the new business unit can utilize the experience of other TVS group companies in the areas of mechanical, thermal and electronics instead of going to consultants.

5. Technology development/Acquisition and supplier creation Strategy

Lighting technology has been more dynamic lately due to the changes occurring with the increased level of technology and relatively free trade across the nations. Environmental consciousness and rising electricity bills are driving the technology towards more energy efficient lighting using LED. The lighting market is continually increasing in a high growth Indian economy. Office, industrial and street lighting are the products with highest potential. LED street lighting will get the business from both replacement and new installations. LED technology has already evolved and is relatively slow changing with performance enhancement as the main subject. Risk is lower to invest in the LED market.

5.1 LED value chain and Technology

Figure 5.1: LED Light value chain



TVS could follow the following steps in the development of LED lighting systems:

1) TVS would import the LED chip

2) Design the Power supply/driver or could import from china if quality and cost targets are met. TVS needs to have qualified electronic engineers to design and test the power supply.

3) TVS will develop the optics related to diffuser and lighting standards. Optics needs optical engineers to solve light related issues.

4) TVS assembles the unit and market them

Above mentioned points are considered because of the following reasons:

- TVS has no competence in manufacturing LED chips
- Commissioning in-house R&D division to work around the patents would not be possible for TVS for LED chips
- Setting up a fabrication laboratory would be prohibitively costly at TVS for LED chips
- TVS could develop the electronics related to power supply. In case TVS finds a better quality and cheaper power supply driver, it could import the power supply unit.
  At TVSM, design of LED lighting unit is carried out as a mini project to reduce the office lighting energy consumption. With this project, feasibility analysis of the project and performance are carried out and it is found that the performance of the 60 Units placed in the office area is to the satisfaction. This indicates that TVS has the capability to develop the unit by only importing the LED chips and developing the rest other parts.
- TVS can create the optics, wiring, and heat dissipating components itself as it is close to its existing line of work.
- Assembly technologies are patented and may affect performance, so licensing is the best way for lighting if required.
- TVS would design the fixtures and thermal managing moulds and transfer the same to its suppliers. This reduces the initial investment. TVS has to make sure that the quality of supplier parts are within its specified levels.

Figure 5.2: LED lighting unit developed in AEG, and the same lighting the office area

5.2 Supplier Selection

Globally, LED market has many established players and major chip manufacture details are given below.

Company	Country	Sales in USD Millions(2010-11)
Nichia Corporation	Japan	2100
Cree	CA	811
Seoul semiconductor	S Korea	790
Philips Lumileds	Netherlands	717
Osram Opto Semi	Germany	570
SemiLEDs	Taiwan	42

TVS could buy LED chips from Nichia because –

- It has the technological capability to produce good quality products
- They are into LED chip manufacturing but not into finished Lighting products
- Nichia is world leader in LED chips for general lighting and offers the best price. TVS for its mini project has Nichia components based on competitive pricing of LED chips.

Different types of metal fixtures are required for LED lights to cater different segment. Plastic, metal and aluminium fixtures need suppliers to manufacture. TVS needs to find suppliers locally or from China for making these parts

5.3 IPR for design &Assembly

IPR issues

Core areas in LED light	Field/ *(IP activity)*	IPR issues	TVS handling the IPRs
LED chip	Semiconductor *(very active)*	All the IP issues will be taken care of chip manufacturer	------
LED driver (Power supply)	Power electronics *(considerably old field & very less IP activity)*	This is a very old area connected to power electronics. Although there are patents in this area, there are many expired patents that could be considered for design.	TVS is processing a patent application related to LED driver
Assembling process	& thermal management packing *(Considerably old field but for compact LED bulb that replaces incandescent bulb, they are plenty of active patents)*	Many patents in assembling of LED bulb that goes into incandescent fitting Street lighting and office lighting are open to make since they are generic assembling	TVS would licence this IPR for incandescent fittings. TVS could find the best method after studying and benchmarking the existing products

For the LED chipsets, the suppliers will be responsible for any IPR issues – this will be clearly specified in the contract. TVS may not need to license any patent related to technology on power supply and assembly for LED lights. This is an exception to the bulbs that go into the incandescent bulb fitting. TVS would license the assembly process of putting together heat sink, optics and LED chip into a malp for LED bulb that goes into standard incandescent fitting. It may license the relevant patents. For example, following patent falls in this category:

- US patent application number: US8207660B2
- Inventor: R Fabien, Osram AG, Munich
- Title: Luminaries with eccentric channel design
- Granted on: June 26th, 2012

5.4 Market Segments to target

It is proposed to have multiple product segments: Street lighting, Office lighting, industrial lighting and domestic lighting. Since all the segments in LED lighting share the same design approach, there can be a common platform to design and test. With this, resources can be optimally utilized with the reduced investment for all the segments.

Forecast for LED lighting market shows Street lighting, office lighting and railways are the focus segments in immediate future and other segments take some time to evolve. Focus can be on these three segments initially for TVS. For segments which are estimated to rise after 2016, TVS could leverage its brand and capabilities to compete and achieve the decent market share.

5.5 Differentiation and Positioning

Following are the USPs and attractive features

- Recyclability: Exchanging option for at the end of life and for the LED technology advancements.
- Light quality indication: it indicates the customer to decide when to change the light.
- Retrofit: TVS can offer retrofitting to the existing old technology light fixtures. TVS can offer the changeover to new technology at reduced price to customer without compromising on its business. Street lights are the major contributor to LED lighting at

present and all the existing suppliers are offering solutions that need replacement and no scope for retrofit. Retrofitting the existing lights would reduce the initial investment and boost the sales.

- Aesthetic look: Offering products that enhance the ambience aesthetics.

TVS will differentiate its LED lights based on performance quality and reliability. Unlike the smaller players who import entire fixtures from Taiwan/China, TVS will be carrying out assembly in India – with reduction in import duty for components and lower VAT for energy efficient products, this is expected to cut down costs. Hence TVS can also price its LED lamps lower than most competitors.

5.6 Design for Recycling and Reusability:

LED lighting systems require good quantity of Aluminum for heat dissipation. Light fixture and heat sinking aluminum can be designed for recycling. When light fails, it is primarily because of electronics. Design of lighting unit can be focused on reusability of material such that in the event of failures, only electronics are replaced and rest can be maintained. This will also ensure that customer could replace the light unit at affordable rate at the end of its life. Recycling process and best method to recycle for each part and assembly in the light unit has to be clearly defined at the time of design.

5.7 Marketing strategy

Indian lighting has many established players. TVS needs to establish its presence in the market through multiple channels.

5.7.1. Advertising:

This method can get the company's messages to large audiences efficiently through such avenues as radio, Magazines, Newspapers, Internet, Billboards, Televisions and other mobile technological communication devices. Television will be used in a very limited manner as the costs are high.

5.7.2. Sales Promotion:

This method is used through samples, demonstrations or displays. It is used to accelerate short-term sales, by building brand awareness and encouraging repeat buying. TVS is a new entrant

into the lighting. It is essential to demonstrate the product quality. TVS must provide free samples to prospective corporate customers initially. Once the products are successfully installed at different customer locations, TVS could stop giving free samples.

5.7.3. Public Relations:

A product can be advertised through public appearances, news/press releases or event sponsorships, to build trust and goodwill by presenting the product. Some of the prime places can be lighted using TVS LED to show credible performance.

5.7.4. Direct Marketing:

This method will utilized email, mail, catalogues, encourage direct responses to radio and TV, in order to reach targeted audiences to increase sales and test new products and alternate marketing tactics.

5.7.5. Personal Selling:

Setting sales appointments and meetings, making presentations and any type of one-to-one communication, to reach your customers and strengthen your relationship with your clients would help the business.

6 Exit Strategy

In the event of TVS finding the LED lighting business not so interesting in terms of future plans after the investment has all been made, TVS can very well sell the infrastructure, IPRs, brand value to new market entrants from outside India. Some of these manufacturers have only assembly units in India, and some import fully assembled lighting units to be delivered to customers and local dealers. A business unit equipped with design, manufacture, and testing facilities for lighting systems will be highly lucrative offer for international players as this could be their chance to establish Indian subsidiary with lowest efforts. TVS could exit the business with profitable numbers in such case.

Alternatively, TVS can offer its facilities to an international lighting manufacturer intending to enter Indian market for manufacturing, and assembling. Resources will still be with TVS while earning income from the usage by others. This helps TVS not forgo any money spent on such facilities. In such cases, TVS can offer its engineering and design services for companies in need by offering them design consultancy.

7 Conclusion

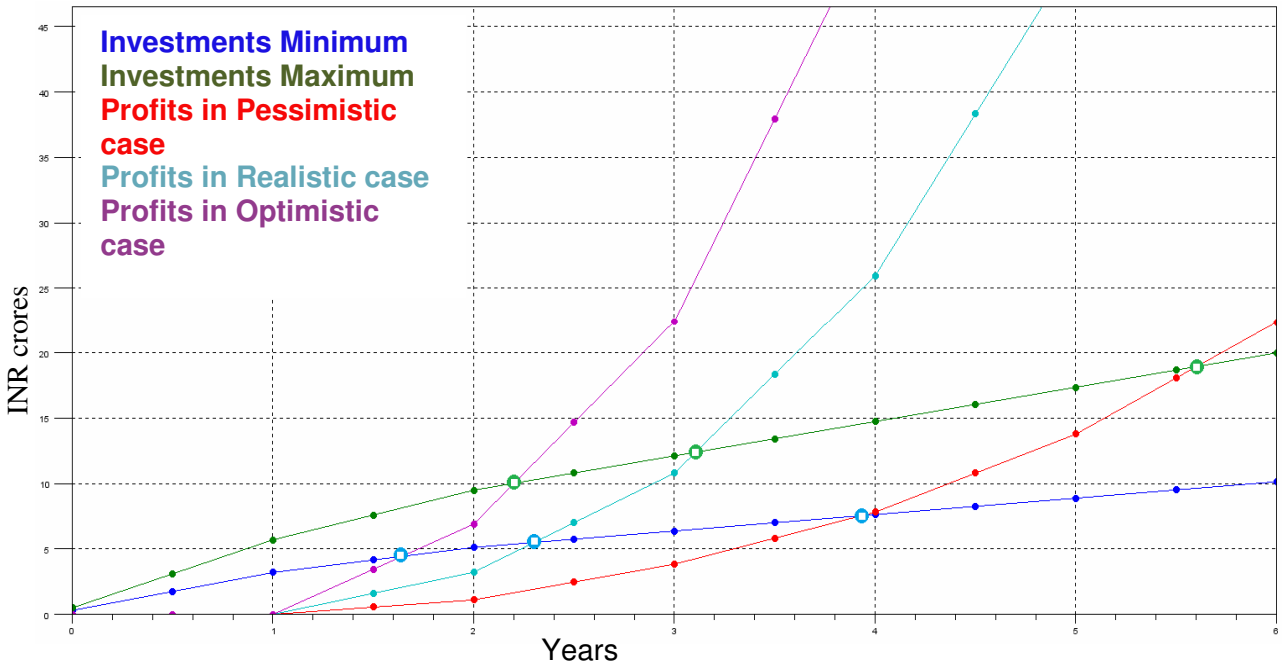
As mentioned in sections earlier, it can be seen that LED lighting market is a highly promising segment that TVS can surely think of investing in. As mentioned in section 2, it may be noticed that breakeven occurs under all realistic circumstances within reason. Realistic cases proposed in section 2 have breakeven sales happening in around 2 years of start of sales and gross profits up to INR 15 Cr.

Technology and engineering knowledge gained via this business opportunity will help TVS explore new areas in the product engineering. Addition of architectural lighting into lighting products, will build brand image for any future expansion into highly profitable markets. Expanding the business unit into domestic electrical equipments like some competitors helps in diversification of business. This helps TVS in brand extension and also builds goodwill for extending the future product portfolio.

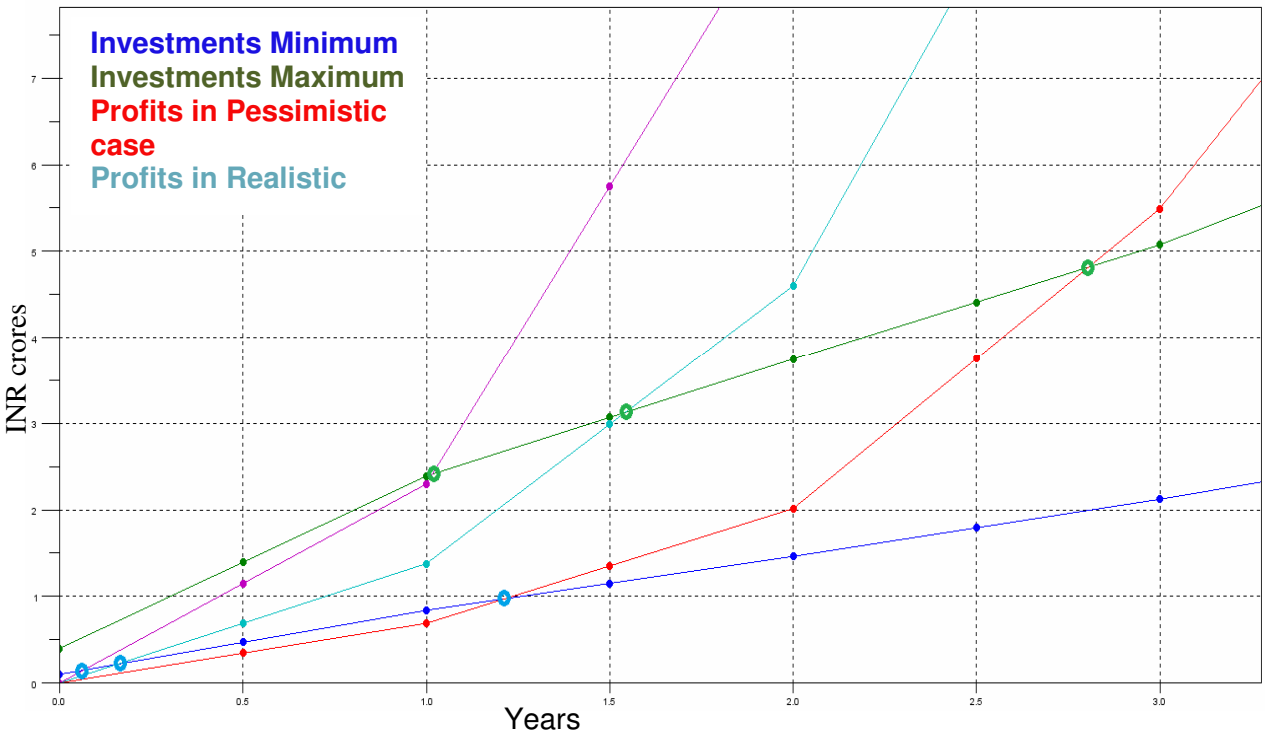
Overall, LED lighting is a revolution and is set to dominate the lighting industry. This is the right time to enter LED lighting market, a future lighting business which will be highly profitable for TVS.

Annexure 1:

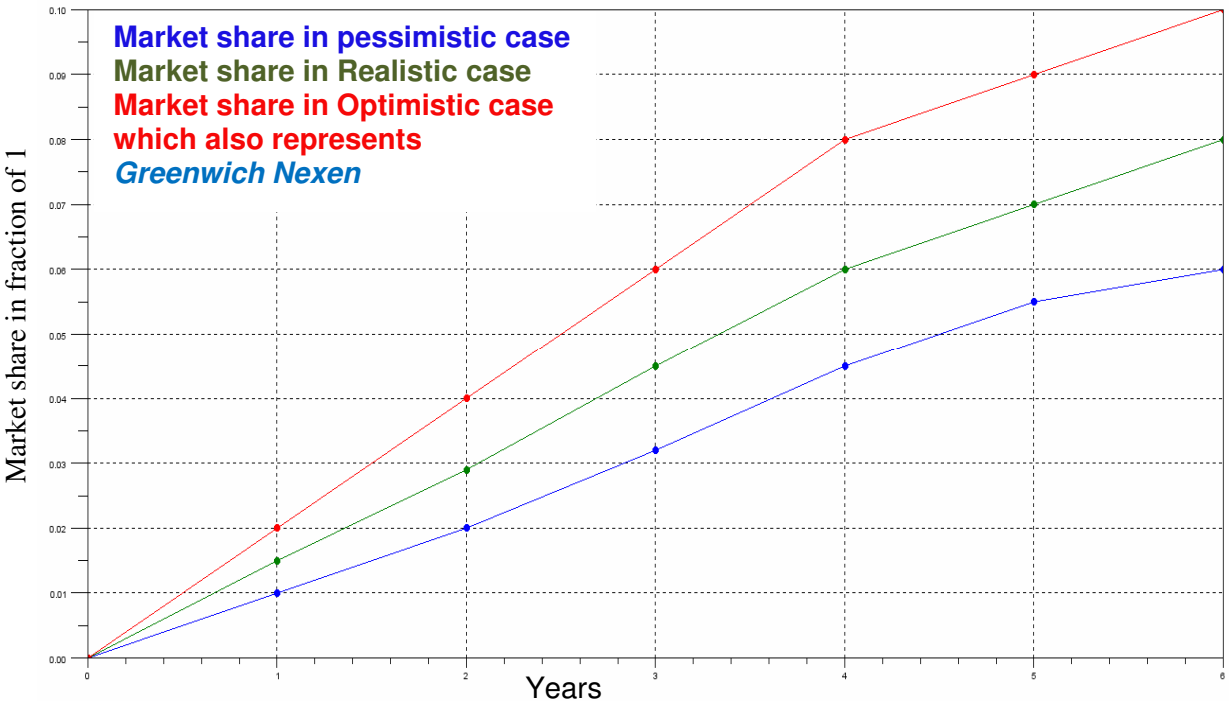
A1.1 Breakeven chart for Business case 1



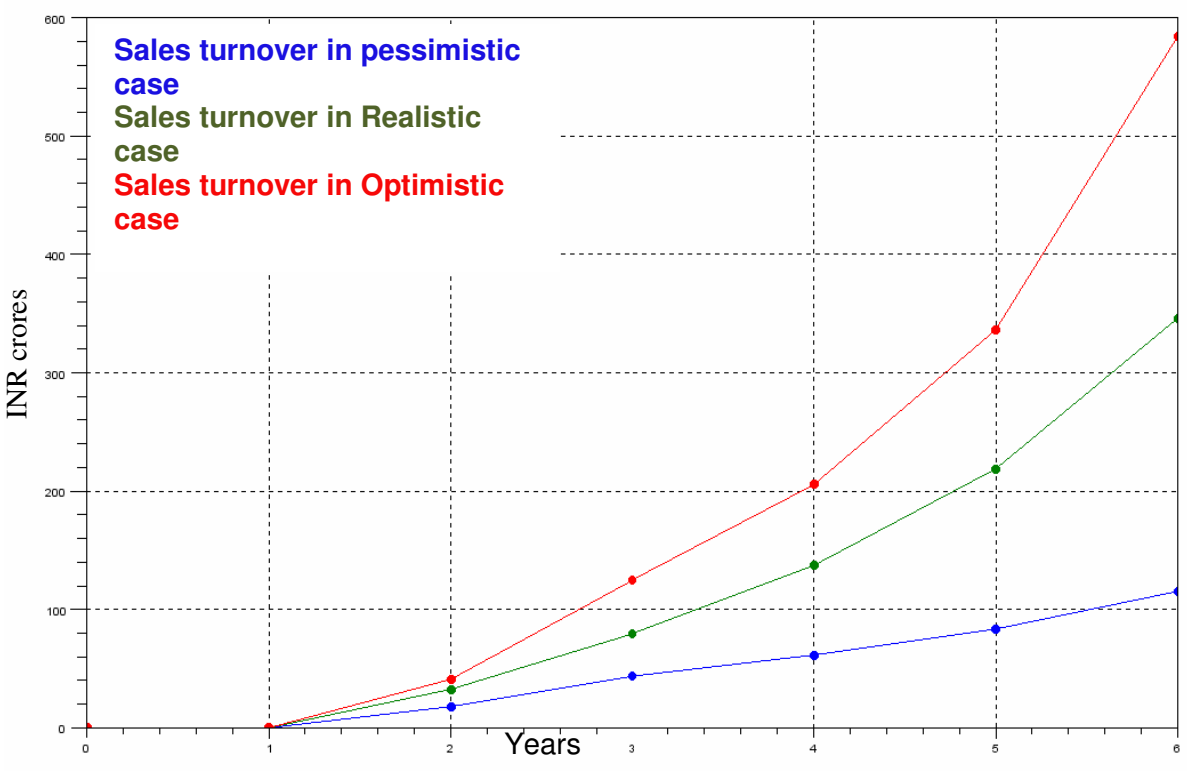
A1.2 Breakeven chart for Business case 2



A1.4 Market share projections for TVS



A1.5 Sales projection for TVS in INR crores



Annexure 2:

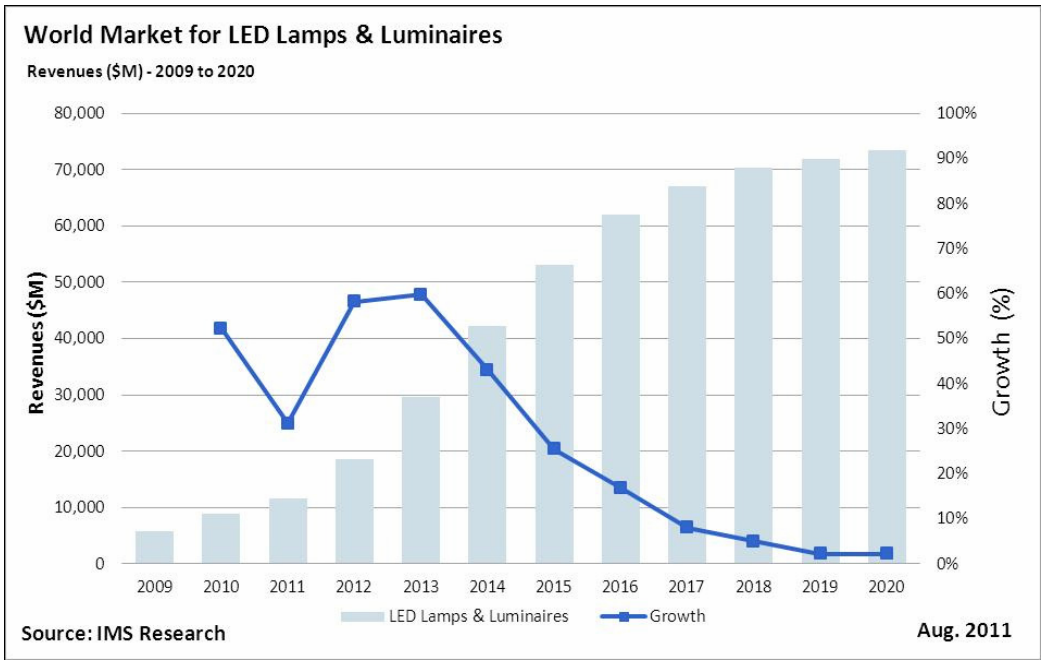
Chart 2.1: Comparison of cost to consumer for different lighting systems for same light output.

	CFL	**T5**	**LED**
Per hour power consumption	80Wh	60Wh	30Wh
Per day power consumption at 12 hours/day	960Wh	720Wh	360Wh
Per year consumption	350KWh	262KWh	131kwh
Electricity bill per yr	2275	1710	851
Installation +Replacement cost per 5 yrs	Rs 3500	Rs 4700	Rs 5500
Total cost/5yrs	Rs 14,875	Rs 13,250	Rs 9,755

Figure A2.2: Stripped down pricing details of Philips 2ftx2ft, 40W LED office light

item	Philips	Alternative	Cost saving in Rs
Driver controller IC	HV9910BD Specific LED driver IC (0.6 $)	UC3845 General purpose PWM IC (0.15$)	25
LED component	1W Osram (0.85$) Total 30 LED pieces (25.5$)	0.6W Nichia (0.23$) Total 49 LED pieces (11.2$)	760
LED PCB	Metal core PCB (Rs 420)	FR4 PCB with copper pour (Rs 185)	235
Light diffuser plate	Glass coated with iridium(Rs 400)	Poly carbonate sheet (Rs 120)	280
Total material cost	Rs 3400	Rs 2100	1300

Figure A2.2: Global LED lighting market forecast in USD Billions
Source: IMS Research, Aug 2011



List of Abbreviations

LED	Light Emitting Diode
HID	High-intensity discharge lamps
IPR	Intellectual Property Rights
CAGR	Compound Annual Growth Rate
CFL	Compact Fluorescent Lamp
TFL	Tubular Fluorescent Lamp

Annexure-3:

References:

1. Presentations from Frost & Sullivan's 2nd Annual Executive Congress on LED Lighting, Delhi November 16th 2011.

2. Link: http://www.constructionupdate.com/News.aspx?nId=z5r4XJwVNTUdVKaUv96Sbw== last referred on 09/07/2012.

3. Annual reports from Wipro, Surya Roshini, CG, Havells, Bajaj electrical

4. Lighting industry data from Intecos-CIER

5. Case study of IIM Lucknow on street lighting in August 2009.

6. www.bee-india.nic.in/mudsm/SurveyReport.pdf

7. www.isle-karnataka.org

8. www.lednyc.com/products.php

9. www1.eere.energy.gov/buildings/ssl/cri.html

10. www.ledsmagazine.com/buyers/473-474
http://techon.nikkeibp.co.jp/article/HONSHI/20091126/178024/?P=2. Last referred on 09/06/2012

11. www.elcomaindia.com/home.asp

12. www.ledinside.com

13. www.ledindia.com

14.http://imsresearch.com/tiny_mce/plugins/imagemanager/files/World_Market_for_LED_Lamps__Luminaires_Extended_Forecast.jpg. Last referred on 08/06/2012

Annexure-4: Considering the lower complexity in LED light design and manufacturing, it is proposed to have two business case scenarios.

A4.1 Business Case1 (Design, manufacture and assembling):

This business case considered that technology consultation has been sought for initial know how and fee is paid up front. TVS also employs designers and work on designs. TSV shares some of the softwares available, manpower available, test facilities available, assembly area available to reduce initial investment costs. Expenses ranging from minimum to maximum are considered. Report also assumes that the investments for certain resources are done in phases over few years depending on need.

For the sales data, a forecast market share growth and forecasted market conditions are considered for three different conditions, namely optimistic, realistic and pessimistic. Gross profits for the project are calculated for all the cases.

A4.2 Business case 2: (Sourcing from the qualified suppliers and assembling them at third party)

This business case is considered for identifying the qualified suppliers to supply sub assembly parts. TVS also finds an assembler to assemble these sourced parts. TVS does not own the designs for individual parts but for integration and assembling. Expenses ranging from minimum to maximum are considered. Report also assumes that the investments for certain resources are done in phases over few years depending on need.

For the sales data, a forecast market share growth and forecasted market conditions are considered for three different conditions, namely optimistic, realistic and pessimistic. Gross profits for the project are calculated for all the cases.

A4.3 Project expenses considered

The following table lists the expenses considered during the business cases preparation for the first six years of project.

This may not be a complete list and the numbers assumed are only indicative and may not represent the actual expenses.

Expenses	**Business case 1**	**Business case 2**
	20 Crores	**11 crores**
Designer's CTC	2.5 Crores	1.6 Crores
Tester's CTC	1.2 crores	0.6 Crores
Design SW investments	0.6 crores	0.4 Crores
Assembler's CTC	4 crores	0
Test Rig Investments	0.5 crores	0.2 crores
Prototyping Investments	0.8 crores	0.6 crores
Tooling Investments	1 crores	0.3 Crores
Consultancy charges	1 crores	0.2 Crores
Supplier Identification investment	0.5 crores	0.2 Crores
Assembler's training investment	0.2 crores	0.1 Crores
Assembly line setup investment	1 crores	0
Project management cost	2.5 crores	1.6 Crores
Marketing investment-one time and recurring	2 crores	2 crores
Technology licensing charges-recurring	Volume based (0.5% of sales)	Volume based (0.2% of sales)

Business Case details

In this plan, TVS develops all the the technology related to power supply & Assembling

TVS seeks consultantancy from the approproate technical body

Three cases of future are proposed, namely optimistic, realistic and pessimistic

critical factors determining future are defined under all these three conditions. All the financial numbers in INR crores

MarketGrowthRate_P := 1.2 MarketGrowthRate_R := 1.4 MarketGrowthRate_O := 1.50

TVSMarketShareT0_P := 0 TVSMarketShareT0_R := 0 TVSMarketShareT0_O := 0

TVSMarketShareT1_P := 0 TVSMarketShareT1_R := 0 TVSMarketShareT1_O := 0

TVSMarketShareT2_P := 0.016 TVSMarketShareT2_R := 0.025 TVSMarketShareT2_O := 0.04

TVSMarketShareT3_P := 0.033 TVSMarketShareT3_R := 0.042 TVSMarketShareT3_O := 0.06

TVSMarketShareT4_P := 0.04 TVSMarketShareT4_R := 0.06 TVSMarketShareT4_O := 0.08

TVSMarketShareT5_P := 0.05 TVSMarketShareT5_R := 0.07 TVSMarketShareT5_O := 0.09

TVSMarketShareT6_P := 0.06 TVSMarketShareT6_R := 0.08 TVSMarketShareT6_O := 0.1

Per year in INR crores

ProfitMarginFraction_P := 0.05 ProfitMarginFraction_R := 0.08 ProfitMarginFraction_O := 0.1

MarketingInvestmentCr_min := 0.3 MarketingInvestmentCr_max := 0.6

DesignSWInvestmentCr_min := 0.3 DesignSWInvestmentCr_max := 0.5

SaleLED := 1150

$$y := \begin{pmatrix} TVSMarketShareT0\_P & TVSMarketShareT0\_R & TVSMarketShareT0\_O \\ TVSMarketShareT1\_P & TVSMarketShareT1\_R & TVSMarketShareT1\_O \\ TVSMarketShareT2\_P & TVSMarketShareT2\_R & TVSMarketShareT2\_O \\ TVSMarketShareT3\_P & TVSMarketShareT3\_R & TVSMarketShareT3\_O \\ TVSMarketShareT4\_P & TVSMarketShareT4\_R & TVSMarketShareT4\_O \\ TVSMarketShareT5\_P & TVSMarketShareT5\_R & TVSMarketShareT5\_O \\ TVSMarketShareT6\_P & TVSMarketShareT6\_R & TVSMarketShareT6\_O \end{pmatrix} \qquad x := (0\ 1\ 2\ 3\ 4\ 5\ 6)$$

TestRigInvestmentCr_min := 0.1 TestRigInvestmentCr_max := 0.5

PrototypeInvestmentCr_min := 0.5 PrototypeInvestmentCr_max := 0.8

ToolingInvestmentCr_min := 0.5 ToolingInvestmentCr_max := 1

ConsultancyChargesCr_min := 0.5 ConsultancyChargesCr_max := 1

SupplierIdentificationInvestmentCr_min := 0.2 SupplierIdentificationInvestmentCr_max := 0.5

AssemblersTrainingInvestmentCr_min := 0.1 AssemblersTrainingInvestmentCr_max := 0.2

AssemblingLineSetupInvestmentCr_min := 1.5 AssemblingLineSetupInvestmentCr_max := 2

Office space and infrastructre costs are inlcuded in Prototyping cost. An area of 40x100 sqft is considered for design and testing.

$OneCr := 10000000$

$DesignersCount := 5$

$TestersCount := 5$

$DesignersChargePday\_min := 1000$ $DesignersChargePday\_max := 2000$

$TestersChargePday\_min := 1000$ $TestersChargePday\_max := 1500$

$AssemblerChargePday\_min := 600$ $AssemblerChargePday\_max := 1000$

$DesignResource := DesignersCount \cdot 12 \cdot 25 = 1.5 \times 10^{3}$ man days

$TestResource := TestersCount \cdot 12 \cdot 25 = 1.5 \times 10^{3}$ man days

$$DesignCostInvestmentCr\_min := DesignResource \cdot \frac{DesignersChargePday\_min}{OneCr} = 0.15$$

$$DesignCostInvestmentCr\_max := DesignResource \cdot \frac{DesignersChargePday\_max}{OneCr} = 0.3$$

$$TestCostInvestmentCr\_min := TestResource \cdot \frac{TestersChargePday\_min}{OneCr} = 0.15$$

$$TestCostInvestmentCr\_max := TestResource \cdot \frac{TestersChargePday\_max}{OneCr} = 0.225$$

$$ProjectManagementCostPACr\_min := \left(120000 \cdot 0.5 + 100000 \cdot 0.65 + 2 \cdot 60000 \cdot 0.9\right) \cdot \frac{12}{OneCr} = 0.28$$

$$ProjectManagementCostPACr\_max := \left(120000 \cdot 0.6 + 2 \cdot 100000 \cdot 0.75 + 3 \cdot 60000\right) \cdot \frac{12}{OneCr} = 0.482$$

$$AssemblyCostPACr\_min := 15 \cdot \frac{AssemblerChargePday\_min \cdot 25 \cdot 12}{OneCr} = 0.27$$

$$AssemblyCostPACr\_max := 30 \cdot \frac{AssemblerChargePday\_max \cdot 25 \cdot 12}{OneCr} = 0.9$$

start
time
Investments
Annually

TVSinvestT0_min := DesignSWInvestmentCr_min = 0.3

TVSinvestT0_max := DesignSWInvestmentCr_max = 0.5

TVSinvestT1_min := DesignCostInvestmentCr_min + ConsultancyChargesCr_min·0.5 ... = 2.9
+ PrototypeInvestmentCr_min·0.5 + ProjectManagementCostPACr_min ...
+ SupplierIdentificationInvestmentCr_min·0.5 + TestCostInvestmentCr_min·0.3 ...
+ ToolingInvestmentCr_min·0.8 + AssemblersTrainingInvestmentCr_min·0.5 ...
+ TestRigInvestmentCr_min + MarketingInvestmentCr_min·0.5 ...
+ AssemblingLineSetupInvestmentCr_min·.75

TVSinvestT1_max := DesignCostInvestmentCr_max + ConsultancyChargesCr_max·0.5 ... = 5.2
+ PrototypeInvestmentCr_max·0.5 + ProjectManagementCostPACr_max ...
+ SupplierIdentificationInvestmentCr_max·0.5 + ToolingInvestmentCr_max·0.8 ...
+ TestCostInvestmentCr_max·0.3 + AssemblersTrainingInvestmentCr_max·0.5 ...
+ TestRigInvestmentCr_max + MarketingInvestmentCr_max·0.5 ...
+ AssemblingLineSetupInvestmentCr_max·0.75

TVSinvestT2_min := DesignCostInvestmentCr_min + ConsultancyChargesCr_min·0.5 ... = 1.92
+ TestCostInvestmentCr_min + TestRigInvestmentCr_min·0.05 ...
+ ProjectManagementCostPACr_min ...
+ AssemblyCostPACr_min ...
+ MarketingInvestmentCr_min·0.5 ...
+ AssemblingLineSetupInvestmentCr_min·0.25 ...
+ PrototypeInvestmentCr_min·0.2 ...
+ AssemblersTrainingInvestmentCr_min·0.5 ...
+ SupplierIdentificationInvestmentCr_min·0.2 + ToolingInvestmentCr_min·0.2

TVSinvestT2_max := DesignCostInvestmentCr_max + ConsultancyChargesCr_max·0.5 ... = 3.792
+ TestCostInvestmentCr_max + TestRigInvestmentCr_max·0.05 ...
+ ProjectManagementCostPACr_max ...
+ AssemblyCostPACr_max ...
+ MarketingInvestmentCr_max·0.5 ...
+ AssemblingLineSetupInvestmentCr_max·0.25 ...
+ PrototypeInvestmentCr_max·0.2 ...
+ AssemblersTrainingInvestmentCr_max·0.5 ...
+ SupplierIdentificationInvestmentCr_max·0.2 + ToolingInvestmentCr_max·0.2

TVSinvestT3_min := DesignCostInvestmentCr_min ... = 1.255
+ TestCostInvestmentCr_min + TestRigInvestmentCr_min·0.05 ...
+ ProjectManagementCostPACr_min ...
+ AssemblyCostPACr_min ...
+ MarketingInvestmentCr_min·0.4 ...
+ AssemblingLineSetupInvestmentCr_min·0.1 ...
+ PrototypeInvestmentCr_min·0.1 ...
+ AssemblersTrainingInvestmentCr_min·0.1 ...
+ SupplierIdentificationInvestmentCr_min·0.1 + ToolingInvestmentCr_min·0.1

TVSinvestT3_max := DesignCostInvestmentCr_max ... = 2.622
+ TestCostInvestmentCr_max + TestRigInvestmentCr_max·0.05 ...
+ ProjectManagementCostPACr_max ...
+ AssemblyCostPACr_max ...
+ MarketingInvestmentCr_max·0.4 ...
+ AssemblingLineSetupInvestmentCr_max·0.1 ...
+ PrototypeInvestmentCr_max·0.1 ...
+ AssemblersTrainingInvestmentCr_max·0.1 ...
+ SupplierIdentificationInvestmentCr_max·0.1 + ToolingInvestmentCr_max·0.1

TVSinvestT4_min := DesignCostInvestmentCr_min ... = 1.255
+ TestCostInvestmentCr_min + TestRigInvestmentCr_min·0.05 ...
+ ProjectManagementCostPACr_min ...
+ AssemblyCostPACr_min ...
+ MarketingInvestmentCr_min·0.4 ...
+ AssemblingLineSetupInvestmentCr_min·0.1 ...
+ PrototypeInvestmentCr_min·0.1 ...
+ AssemblersTrainingInvestmentCr_min·0.1 ...
+ SupplierIdentificationInvestmentCr_min·0.1 + ToolingInvestmentCr_min·0.1

TVSinvestT4_max := DesignCostInvestmentCr_max ... = 2.622
+ TestCostInvestmentCr_max + TestRigInvestmentCr_max·0.05 ...
+ ProjectManagementCostPACr_max ...
+ AssemblyCostPACr_max ...
+ MarketingInvestmentCr_max·0.4 ...
+ AssemblingLineSetupInvestmentCr_max·0.1 ...
+ PrototypeInvestmentCr_max·0.1 ...
+ AssemblersTrainingInvestmentCr_max·0.1 ...
+ SupplierIdentificationInvestmentCr_max·0.1 + ToolingInvestmentCr_max·0.1

TVSinvestT5_min := DesignCostInvestmentCr_min ... = 1.255
+ TestCostInvestmentCr_min + TestRigInvestmentCr_min·0.05 ...
+ ProjectManagementCostPACr_min ...
+ AssemblyCostPACr_min ...
+ MarketingInvestmentCr_min·0.4 ...
+ AssemblingLineSetupInvestmentCr_min·0.1 ...
+ PrototypeInvestmentCr_min·0.1 ...
+ AssemblersTrainingInvestmentCr_min·0.1 ...
+ SupplierIdentificationInvestmentCr_min·0.1 + ToolingInvestmentCr_min·0.1

TVSinvestT5_max := DesignCostInvestmentCr_max ... = 2.622
+ TestCostInvestmentCr_max + TestRigInvestmentCr_max·0.05 ...
+ ProjectManagementCostPACr_max ...
+ AssemblyCostPACr_max ...
+ MarketingInvestmentCr_max·0.4 ...
+ AssemblingLineSetupInvestmentCr_max·0.1 ...
+ PrototypeInvestmentCr_max·0.1 ...
+ AssemblersTrainingInvestmentCr_max·0.1 ...
+ SupplierIdentificationInvestmentCr_max·0.1 + ToolingInvestmentCr_max·0.1

TVSinvestT6_min := DesignCostInvestmentCr_min ... = 1.255
+ TestCostInvestmentCr_min + TestRigInvestmentCr_min·0.05 ...
+ ProjectManagementCostPACr_min ...
+ AssemblyCostPACr_min ...
+ MarketingInvestmentCr_min·0.4 ...
+ AssemblingLineSetupInvestmentCr_min·0.1 ...
+ PrototypeInvestmentCr_min·0.1 ...
+ AssemblersTrainingInvestmentCr_min·0.1 ...
+ SupplierIdentificationInvestmentCr_min·0.1 + ToolingInvestmentCr_min·0.1

TVSinvestT6_max := DesignCostInvestmentCr_max ... = 2.622
+ TestCostInvestmentCr_max + TestRigInvestmentCr_max·0.05 ...
+ ProjectManagementCostPACr_max ...
+ AssemblyCostPACr_max ...
+ MarketingInvestmentCr_max·0.4 ...
+ AssemblingLineSetupInvestmentCr_max·0.1 ...
+ PrototypeInvestmentCr_max·0.1 ...
+ AssemblersTrainingInvestmentCr_max·0.1 ...
+ SupplierIdentificationInvestmentCr_max·0.1 + ToolingInvestmentCr_max·0.1

Accumulated investments annually

TotalTVSInvestmentT0Cr_min := TVSinvestT0_min = 0.3

TotalTVSInvestmentT0Cr_max := TVSinvestT0_max = 0.5

TotalTVSInvestmentT1Cr_min := TotalTVSInvestmentT0Cr_min + TVSinvestT1_min = 3.2

TotalTVSInvestmentT1Cr_max := TotalTVSInvestmentT0Cr_max + TVSinvestT1_max = 5.7

TotalTVSInvestmentT2Cr_min := TotalTVSInvestmentT1Cr_min + TVSinvestT2_min = 5.119

TotalTVSInvestmentT2Cr_max := TotalTVSInvestmentT1Cr_max + TVSinvestT2_max = 9.492

TotalTVSInvestmentT3Cr_min := TotalTVSInvestmentT2Cr_min + TVSinvestT3_min = 6.374

TotalTVSInvestmentT3Cr_max := TotalTVSInvestmentT2Cr_max + TVSinvestT3_max = 12.115

TotalTVSInvestmentT4Cr_min := TotalTVSInvestmentT3Cr_min + TVSinvestT4_min = 7.628

TotalTVSInvestmentT4Cr_max := TotalTVSInvestmentT3Cr_max + TVSinvestT4_max = 14.737

TotalTVSInvestmentT5Cr_min := TotalTVSInvestmentT4Cr_min + TVSinvestT5_min = 8.883

TotalTVSInvestmentT5Cr_max := TotalTVSInvestmentT4Cr_max + TVSinvestT5_max = 17.359

TotalTVSInvestmentT6Cr_min := TotalTVSInvestmentT5Cr_min + TVSinvestT6_min = 10.138

TotalTVSInvestmentT6Cr_max := TotalTVSInvestmentT5Cr_max + TVSinvestT6_max = 19.982

Per annum LED lighting sales

SaleLEDT2_P := SaleLED·MarketGrowthRate_P = 1.38×10^3

SaleLEDT2_R := SaleLED·MarketGrowthRate_R = 1.61×10^3

SaleLEDT2_O := SaleLED·MarketGrowthRate_O = 1.725×10^3

SaleLEDT3_P := SaleLEDT2_P·MarketGrowthRate_P = 1.656×10^3

SaleLEDT3_R := SaleLEDT2_R·MarketGrowthRate_R = 2.254×10^3

SaleLEDT3_O := SaleLEDT2_O·MarketGrowthRate_O = 2.587×10^3

SaleLEDT4 P := SaleLEDT3 P·MarketGrowthRate P = 1.987×10^3

SaleLEDT4 R := SaleLEDT3 R·MarketGrowthRate R = 3.156×10^3

SaleLEDT4_O := SaleLEDT3_O·MarketGrowthRate_O = 3.881×10^3

SaleLEDT5 P := SaleLEDT4 P·MarketGrowthRate P = 2.385×10^3

SaleLEDT5 R := SaleLEDT4 R·MarketGrowthRate R = 4.418×10^3

SaleLEDT5 O := SaleLEDT4 O·MarketGrowthRate O = 5.822×10^3

SaleLEDT6 P := SaleLEDT5 P·MarketGrowthRate P = 2.862×10^3

SaleLEDT6 R := SaleLEDT5 R·MarketGrowthRate R = 6.185×10^3

SaleLEDT6_O := SaleLEDT5_O·MarketGrowthRate_O = 8.733×10^3

Per Annum TVS sales

TVSSalesT0_P := 0 = 0

TVSSalesT0_R := 0 = 0

TVSSalesT0_O := 0 = 0

TVSSalesT1_P := 0 = 0

TVSSalesT1_R := 0 = 0

TVSSalesT1_O := 0 = 0

SalesStartTime is in 2nd year,i.e after T1

$TVSSalesT2\_P := TVSMarketShareT2\_P \cdot SaleLEDT2\_P = 22.08$

$TVSSalesT2\_R := TVSMarketShareT2\_R \cdot SaleLEDT2\_R = 40.25$

$TVSSalesT2\_O := TVSMarketShareT2\_O \cdot SaleLEDT2\_O = 69$

$TVSSalesT3\_P := TVSMarketShareT3\_P \cdot SaleLEDT3\_P = 54.648$

$TVSSalesT3\_R := TVSMarketShareT3\_R \cdot SaleLEDT3\_R = 94.668$

$TVSSalesT3\_O := TVSMarketShareT3\_O \cdot SaleLEDT3\_O = 155.25$

$TVSSalesT4\_P := TVSMarketShareT4\_P \cdot SaleLEDT4\_P = 79.488$

$TVSSalesT4\_R := TVSMarketShareT4\_R \cdot SaleLEDT4\_R = 189.336$

$TVSSalesT4\_O := TVSMarketShareT4\_O \cdot SaleLEDT4\_O = 310.5$

$TVSSalesT5\_P := TVSMarketShareT5\_P \cdot SaleLEDT5\_P = 119.232$

$TVSSalesT5\_R := TVSMarketShareT5\_R \cdot SaleLEDT5\_R = 309.249$

$TVSSalesT5\_O := TVSMarketShareT5\_O \cdot SaleLEDT5\_O = 523.969$

$TVSSalesT6\_P := TVSMarketShareT6\_P \cdot SaleLEDT6\_P = 171.694$

$TVSSalesT6\_R := TVSMarketShareT6\_R \cdot SaleLEDT6\_R = 494.798$

$TVSSalesT6\_O := TVSMarketShareT6\_O \cdot SaleLEDT6\_O = 873.281$

Accumulated TVS sales

$TotalTVSSalesT0\_P := 0 = 0$

$TotalTVSSalesT0\_R := 0 = 0$

$TotalTVSSalesT0\_O := 0 = 0$

$TotalTVSSalesT1\_P := 0 = 0$

$TotalTVSSalesT1\_R := 0 = 0$

$TotalTVSSalesT1\_O := 0 = 0$

$TotalTVSSalesT2\_P := TVSSalesT2\_P = 22.08$

$TotalTVSSalesT2\_R := TVSSalesT2\_R = 40.25$

$TotalTVSSalesT2\_O := TVSSalesT2\_O = 69$

$TotalTVSSalesT3\_P := TotalTVSSalesT2\_P + TVSSalesT3\_P = 76.728$

$TotalTVSSalesT3\_R := TotalTVSSalesT2\_R + TVSSalesT3\_R = 134.918$

$TotalTVSSalesT3\_O := TotalTVSSalesT2\_O + TVSSalesT3\_O = 224.25$

$TotalTVSSalesT4\_P := TotalTVSSalesT3\_P + TVSSalesT4\_P = 156.216$

$TotalTVSSalesT4\_R := TotalTVSSalesT3\_R + TVSSalesT4\_R = 324.254$

$TotalTVSSalesT4\_O := TotalTVSSalesT3\_O + TVSSalesT4\_O = 534.75$

$TotalTVSSalesT5\_P := TotalTVSSalesT4\_P + TVSSalesT5\_P = 275.448$

$TotalTVSSalesT5\ R := TotalTVSSalesT4\ R + TVSSalesT5\ R = 633.503$

$TotalTVSSalesT5\_O := TotalTVSSalesT4\_O + TVSSalesT5\_O = 1.059 \times 10^{3}$

$TotalTVSSalesT6\ P := TotalTVSSalesT5\ P + TVSSalesT6\ P = 447.142$

$TotalTVSSalesT6\ R := TotalTVSSalesT5\ R + TVSSalesT6\ R = 1.128 \times 10^{3}$

$TotalTVSSalesT6\_O := TotalTVSSalesT5\_O + TVSSalesT6\_O = 1.932 \times 10^{3}$

TVSprofits per annum

TVSprofitsT2_P := TVSSalesT2_P·ProfitMarginFraction_P = 1.104

TVSprofitsT2_R := TVSSalesT2_R·ProfitMarginFraction_R = 3.22

TVSprofitsT2_O := TVSSalesT2_O·ProfitMarginFraction_O = 6.9

TVSprofitsT3_P := TVSSalesT3_P·ProfitMarginFraction_P = 2.732

TVSprofitsT3_R := TVSSalesT3_R·ProfitMarginFraction_R = 7.573

TVSprofitsT3_O := TVSSalesT3_O·ProfitMarginFraction_O = 15.525

TVSprofitsT4_P := TVSSalesT4_P·ProfitMarginFraction_P = 3.974

TVSprofitsT4_R := TVSSalesT4_R·ProfitMarginFraction_R = 15.147

TVSprofitsT4_O := TVSSalesT4_O·ProfitMarginFraction_O = 31.05

TVSprofitsT5_P := TVSSalesT5_P·ProfitMarginFraction_P = 5.962

TVSprofitsT5_R := TVSSalesT5_R·ProfitMarginFraction_R = 24.74

TVSprofitsT5_O := TVSSalesT5_O·ProfitMarginFraction_O = 52.397

TVSprofitsT6_P := TVSSalesT6_P·ProfitMarginFraction_P = 8.585

TVSprofitsT6_R := TVSSalesT6_R·ProfitMarginFraction_R = 39.584

TVSprofitsT6_O := TVSSalesT6_O·ProfitMarginFraction_O = 87.328

Accumulated TVS profits

TotalTVSprofitsT0_P := 0 = 0

TotalTVSprofitsT0_R := 0 = 0

TotalTVSprofitsT0_O := 0 = 0

TotalTVSprofitsT1_P := 0 = 0

TotalTVSprofitsT1_R := 0 = 0

TotalTVSprofitsT1_O := 0 = 0

TotalTVSprofitsT2_P := TVSprofitsT2_P = 1.104

TotalTVSprofitsT2_R := TVSprofitsT2_R = 3.22

TotalTVSprofitsT2_O := TVSprofitsT2_O = 6.9

TotalTVSprofitsT3_P := TotalTVSprofitsT2_P + TVSprofitsT3_P = 3.836

TotalTVSprofitsT3_R := TotalTVSprofitsT2_R + TVSprofitsT3_R = 10.793

TotalTVSprofitsT3_O := TotalTVSprofitsT2_O + TVSprofitsT3_O = 22.425

TotalTVSprofitsT4_P := TotalTVSprofitsT3_P + TVSprofitsT4_P = 7.811

TotalTVSprofitsT4_R := TotalTVSprofitsT3_R + TVSprofitsT4_R = 25.94

TotalTVSprofitsT4_O := TotalTVSprofitsT3_O + TVSprofitsT4_O = 53.475

TotalTVSprofitsT5_P := TotalTVSprofitsT4_P + TVSprofitsT5_P = 13.772

TotalTVSprofitsT5_R := TotalTVSprofitsT4_R + TVSprofitsT5_R = 50.68

TotalTVSprofitsT5_O := TotalTVSprofitsT4_O + TVSprofitsT5_O = 105.872

TotalTVSprofitsT6_P := TotalTVSprofitsT5_P + TVSprofitsT6_P = 22.357

TotalTVSprofitsT6_R := TotalTVSprofitsT5_R + TVSprofitsT6_R = 90.264

TotalTVSprofitsT6_O := TotalTVSprofitsT5_O + TVSprofitsT6_O = 193.2

$$B := \begin{pmatrix} TotalTVSInvestmentT0Cr\_min & TotalTVSInvestmentT0Cr\_max & TotalTVSprofitsT0\_P & TotalTVSprofitsT0\_R & TotalTVSprofitsT0\_O \\ TotalTVSInvestmentT1Cr\_min & TotalTVSInvestmentT1Cr\_max & TotalTVSprofitsT1\_P & TotalTVSprofitsT1\_R & TotalTVSprofitsT1\_O \\ TotalTVSInvestmentT2Cr\_min & TotalTVSInvestmentT2Cr\_max & TotalTVSprofitsT2\_P & TotalTVSprofitsT2\_R & TotalTVSprofitsT2\_O \\ TotalTVSInvestmentT3Cr\_min & TotalTVSInvestmentT3Cr\_max & TotalTVSprofitsT3\_P & TotalTVSprofitsT3\_R & TotalTVSprofitsT3\_O \\ TotalTVSInvestmentT4Cr\_min & TotalTVSInvestmentT4Cr\_max & TotalTVSprofitsT4\_P & TotalTVSprofitsT4\_R & TotalTVSprofitsT4\_O \\ TotalTVSInvestmentT5Cr\_min & TotalTVSInvestmentT5Cr\_max & TotalTVSprofitsT5\_P & TotalTVSprofitsT5\_R & TotalTVSprofitsT5\_O \\ TotalTVSInvestmentT6Cr\_min & TotalTVSInvestmentT6Cr\_max & TotalTVSprofitsT6\_P & TotalTVSprofitsT6\_R & TotalTVSprofitsT6\_O \end{pmatrix}$$

$$B = \begin{pmatrix} 0.3 & 0.5 & 0 & 0 & 0 \\ 3.2 & 5.7 & 0 & 0 & 0 \\ 5.119 & 9.492 & 1.104 & 3.22 & 6.9 \\ 6.374 & 12.115 & 3.836 & 10.793 & 22.425 \\ 7.628 & 14.737 & 7.811 & 25.94 & 53.475 \\ 8.883 & 17.359 & 13.772 & 50.68 & 105.872 \\ 10.138 & 19.982 & 22.357 & 90.264 & 193.2 \end{pmatrix}$$

B contains the investment min, investment max, Accumulated profits on pessimistic, realistic and optimistic cases financial data

Business Case details

In this plan, TVS identifies the suppliers for supplying components & for Assembling the final product. TVS takes care of fixture designs, LED selection, LED PCB design, LED driver selection, fixture manufacturer and assembler selection and sales & marketing. TVS pays for parts and assembling. TVS may need to pay rayalty for assembly related patents.
Three cases of future are proposed, namely optimistic, realistic and pessimistic

critical factors determining future are defined under all these three conditions. All the financial numbers in INR crores

MarketGrowthRate_P := 1.2 MarketGrowthRate_R := 1.4 MarketGrowthRate_O := 1.50

TVSMarketShareT0_P := 0 TVSMarketShareT0_R := 0 TVSMarketShareT0_O := 0

TVSMarketShareT1_P := 0.01 TVSMarketShareT1_R := 0.015 TVSMarketShareT1_O := 0.02

TVSMarketShareT2_P := 0.016 TVSMarketShareT2_R := 0.025 TVSMarketShareT2_O := 0.04

TVSMarketShareT3_P := 0.035 TVSMarketShareT3_R := 0.042 TVSMarketShareT3_O := 0.06

TVSMarketShareT4_P := 0.045 TVSMarketShareT4_R := 0.06 TVSMarketShareT4_O := 0.08

TVSMarketShareT5_P := 0.055 TVSMarketShareT5_R := 0.07 TVSMarketShareT5_O := 0.09

TVSMarketShareT6_P := 0.06 TVSMarketShareT6_R := 0.08 TVSMarketShareT6_O := 0.1

Per year in INR crores

ProfitMarginFraction_P := 0.06 ProfitMarginFraction_R := 0.08 ProfitMarginFraction_O := 0.1

MarketingInvestmentCr_min := 0.3 MarketingInvestmentCr_max := 0.6

DesignSWInvestmentCr_min := 0.1 DesignSWInvestmentCr_max := 0.4

SaleLED := 1150

$$y := \begin{pmatrix} TVSMarketShareT0\_P & TVSMarketShareT0\_R & TVSMarketShareT0\_O \\ TVSMarketShareT1\_P & TVSMarketShareT1\_R & TVSMarketShareT1\_O \\ TVSMarketShareT2\_P & TVSMarketShareT2\_R & TVSMarketShareT2\_O \\ TVSMarketShareT3\_P & TVSMarketShareT3\_R & TVSMarketShareT3\_O \\ TVSMarketShareT4\_P & TVSMarketShareT4\_R & TVSMarketShareT4\_O \\ TVSMarketShareT5\_P & TVSMarketShareT5\_R & TVSMarketShareT5\_O \\ TVSMarketShareT6\_P & TVSMarketShareT6\_R & TVSMarketShareT6\_O \end{pmatrix} \qquad x := (0\ 1\ 2\ 3\ 4\ 5\ 6)$$

TestRigInvestmentCr_min := 0 TestRigInvestmentCr_max := 0.2

PrototypeInvestmentCr_min := 0.3 PrototypeInvestmentCr_max := 0.6

ToolingInvestmentCr_min := 0.1 ToolingInvestmentCr_max := 0.3

ConsultancyChargesCr_min := 0 ConsultancyChargesCr_max := 0.2

SupplierIdentificationInvestmentCr_min := 0.1 SupplierIdentificationInvestmentCr_max := 0.2

AssemblersTrainingInvestmentCr_min := 0 AssemblersTrainingInvestmentCr_max := 0.1

AssemblingLineSetupInvestmentCr_min := 0 AssemblingLineSetupInvestmentCr_max := 0.2

Office space and infrastructre costs are inlcuded in Prototyping cost. An area of 40x100 sqft is considered for design and testing.

$OneCr := 10000000$

$DesignersCount := 4$

$TestersCount := 3$

$DesignersChargePday\_min := 1000$ $DesignersChargePday\_max := 2000$

$TestersChargePday\_min := 1000$ $TestersChargePday\_max := 1200$

$AssemblerChargePday\_min := 0$ $AssemblerChargePday\_max := 0$

$DesignResource := DesignersCount \cdot 12 \cdot 25 = 1.2 \times 10^{3}$ man days

$TestResource := TestersCount \cdot 12 \cdot 25 = 900$ man days

$$DesignCostInvestmentCr\_min := DesignResource \cdot \frac{DesignersChargePday\_min}{OneCr} = 0.12$$

$$DesignCostInvestmentCr\_max := DesignResource \cdot \frac{DesignersChargePday\_max}{OneCr} = 0.24$$

$$TestCostInvestmentCr\_min := TestResource \cdot \frac{TestersChargePday\_min}{OneCr} = 0.09$$

$$TestCostInvestmentCr\_max := TestResource \cdot \frac{TestersChargePday\_max}{OneCr} = 0.108$$

$$ProjectManagementCostPACr\_min := \left(120000 \cdot 0.3 + 100000 \cdot 0.4 + 2 \cdot 60000 \cdot 0.5\right) \cdot \frac{12}{OneCr} = 0.163$$

$$ProjectManagementCostPACr\_max := \left(120000 \cdot 0.4 + 2 \cdot 100000 \cdot 0.5 + 2 \cdot 60000 \cdot 0.7\right) \cdot \frac{12}{OneCr} = 0.278$$

$$AssemblyCostPACr\_min := 15 \cdot \frac{AssemblerChargePday\_min \cdot 25 \cdot 12}{OneCr} = 0$$

$$AssemblyCostPACr\_max := 30 \cdot \frac{AssemblerChargePday\_max \cdot 25 \cdot 12}{OneCr} = 0$$

start time Investments Annually

TVSinvestT0_min := DesignSWInvestmentCr_min = 0.1

TVSinvestT0_max := DesignSWInvestmentCr_max = 0.4

TVSinvestT1_min := DesignCostInvestmentCr_min + ConsultancyChargesCr_min·0.5 ... = 0.74
+ PrototypeInvestmentCr_min·0.5 + ProjectManagementCostPACr_min ...
+ SupplierIdentificationInvestmentCr_min·0.5 + TestCostInvestmentCr_min·0.3 ...
+ ToolingInvestmentCr_min·0.8 + AssemblersTrainingInvestmentCr_min·0.5 ...
+ TestRigInvestmentCr_min + MarketingInvestmentCr_min·0.5 ...
+ AssemblingLineSetupInvestmentCr_min·.75

TVSinvestT1_max := DesignCostInvestmentCr_max + ConsultancyChargesCr_max·0.5 ... = 1.991
+ PrototypeInvestmentCr_max·0.5 + ProjectManagementCostPACr_max ...
+ SupplierIdentificationInvestmentCr_max·0.5 + ToolingInvestmentCr_max·0.8 ...
+ TestCostInvestmentCr_max·0.3 + AssemblersTrainingInvestmentCr_max·0.5 ...
+ TestRigInvestmentCr_max + MarketingInvestmentCr_max·0.5 ...
+ AssemblingLineSetupInvestmentCr_max·0.75

TVSinvestT2_min := DesignCostInvestmentCr_min + ConsultancyChargesCr_min·0.5 ... = 0.623
+ TestCostInvestmentCr_min + TestRigInvestmentCr_min·0.05 ...
+ ProjectManagementCostPACr_min ...
+ AssemblyCostPACr_min ...
+ MarketingInvestmentCr_min·0.5 ...
+ AssemblingLineSetupInvestmentCr_min·0.25 ...
+ PrototypeInvestmentCr_min·0.2 ...
+ AssemblersTrainingInvestmentCr_min·0.5 ...
+ SupplierIdentificationInvestmentCr_min·0.2 + ToolingInvestmentCr_min·0.2

TVSinvestT2_max := DesignCostInvestmentCr_max + ConsultancyChargesCr_max·0.5 ... = 1.356
+ TestCostInvestmentCr_max + TestRigInvestmentCr_max·0.05 ...
+ ProjectManagementCostPACr_max ...
+ AssemblyCostPACr_max ...
+ MarketingInvestmentCr_max·0.5 ...
+ AssemblingLineSetupInvestmentCr_max·0.25 ...
+ PrototypeInvestmentCr_max·0.2 ...
+ AssemblersTrainingInvestmentCr_max·0.5 ...
+ SupplierIdentificationInvestmentCr_max·0.2 + ToolingInvestmentCr_max·0.2

TVSinvestT3_min := DesignCostInvestmentCr_min ... = 0.543
+ TestCostInvestmentCr_min + TestRigInvestmentCr_min·0.05 ...
+ ProjectManagementCostPACr_min ...
+ AssemblyCostPACr_min ...
+ MarketingInvestmentCr_min·0.4 ...
+ AssemblingLineSetupInvestmentCr_min·0.1 ...
+ PrototypeInvestmentCr_min·0.1 ...
+ AssemblersTrainingInvestmentCr_min·0.1 ...
+ SupplierIdentificationInvestmentCr_min·0.1 + ToolingInvestmentCr_min·0.1

TVSinvestT3_max := DesignCostInvestmentCr_max ... = 1.016
+ TestCostInvestmentCr_max + TestRigInvestmentCr_max·0.05 ...
+ ProjectManagementCostPACr_max ...
+ AssemblyCostPACr_max ...
+ MarketingInvestmentCr_max·0.4 ...
+ AssemblingLineSetupInvestmentCr_max·0.1 ...
+ PrototypeInvestmentCr_max·0.1 ...
+ AssemblersTrainingInvestmentCr_max·0.1 ...
+ SupplierIdentificationInvestmentCr_max·0.1 + ToolingInvestmentCr_max·0.1

$$TVSinvestT4\_min := DesignCostInvestmentCr\_min + TestCostInvestmentCr\_min + TestRigInvestmentCr\_min \cdot 0.05 + ProjectManagementCostPACr\_min + AssemblyCostPACr\_min + MarketingInvestmentCr\_min \cdot 0.4 + AssemblingLineSetupInvestmentCr\_min \cdot 0.1 + PrototypeInvestmentCr\_min \cdot 0.1 + AssemblersTrainingInvestmentCr\_min \cdot 0.1 + SupplierIdentificationInvestmentCr\_min \cdot 0.1 + ToolingInvestmentCr\_min \cdot 0.1 = 0.543$$

$$TVSinvestT4\_max := DesignCostInvestmentCr\_max + TestCostInvestmentCr\_max + TestRigInvestmentCr\_max \cdot 0.05 + ProjectManagementCostPACr\_max + AssemblyCostPACr\_max + MarketingInvestmentCr\_max \cdot 0.4 + AssemblingLineSetupInvestmentCr\_max \cdot 0.1 + PrototypeInvestmentCr\_max \cdot 0.1 + AssemblersTrainingInvestmentCr\_max \cdot 0.1 + SupplierIdentificationInvestmentCr\_max \cdot 0.1 + ToolingInvestmentCr\_max \cdot 0.1 = 1.016$$

$$TVSinvestT5\_min := DesignCostInvestmentCr\_min + TestCostInvestmentCr\_min + TestRigInvestmentCr\_min \cdot 0.05 + ProjectManagementCostPACr\_min + AssemblyCostPACr\_min + MarketingInvestmentCr\_min \cdot 0.4 + AssemblingLineSetupInvestmentCr\_min \cdot 0.1 + PrototypeInvestmentCr\_min \cdot 0.1 + AssemblersTrainingInvestmentCr\_min \cdot 0.1 + SupplierIdentificationInvestmentCr\_min \cdot 0.1 + ToolingInvestmentCr\_min \cdot 0.1 = 0.543$$

$$TVSinvestT5\_max := DesignCostInvestmentCr\_max + TestCostInvestmentCr\_max + TestRigInvestmentCr\_max \cdot 0.05 + ProjectManagementCostPACr\_max + AssemblyCostPACr\_max + MarketingInvestmentCr\_max \cdot 0.4 + AssemblingLineSetupInvestmentCr\_max \cdot 0.1 + PrototypeInvestmentCr\_max \cdot 0.1 + AssemblersTrainingInvestmentCr\_max \cdot 0.1 + SupplierIdentificationInvestmentCr\_max \cdot 0.1 + ToolingInvestmentCr\_max \cdot 0.1 = 1.016$$

$$TVSinvestT6\_min := DesignCostInvestmentCr\_min + TestCostInvestmentCr\_min + TestRigInvestmentCr\_min \cdot 0.05 + ProjectManagementCostPACr\_min + AssemblyCostPACr\_min + MarketingInvestmentCr\_min \cdot 0.4 + AssemblingLineSetupInvestmentCr\_min \cdot 0.1 + PrototypeInvestmentCr\_min \cdot 0.1 + AssemblersTrainingInvestmentCr\_min \cdot 0.1 + SupplierIdentificationInvestmentCr\_min \cdot 0.1 + ToolingInvestmentCr\_min \cdot 0.1 = 0.543$$

$$TVSinvestT6\_max := DesignCostInvestmentCr\_max + TestCostInvestmentCr\_max + TestRigInvestmentCr\_max \cdot 0.05 + ProjectManagementCostPACr\_max + AssemblyCostPACr\_max + MarketingInvestmentCr\_max \cdot 0.4 + AssemblingLineSetupInvestmentCr\_max \cdot 0.1 + PrototypeInvestmentCr\_max \cdot 0.1 + AssemblersTrainingInvestmentCr\_max \cdot 0.1 + SupplierIdentificationInvestmentCr\_max \cdot 0.1 + ToolingInvestmentCr\_max \cdot 0.1 = 1.016$$

Per annum LED lighting sales

$SaleLEDT1\_P := SaleLED = 1.15 \times 10^3$

$SaleLEDT1\_R := SaleLED = 1.15 \times 10^3$

$SaleLEDT1\_O := SaleLED = 1.15 \times 10^3$

$SaleLEDT2\_P := SaleLED \cdot MarketGrowthRate\_P = 1.38 \times 10^3$

$SaleLEDT2\_R := SaleLED \cdot MarketGrowthRate\_R = 1.61 \times 10^3$

$SaleLEDT2\_O := SaleLED \cdot MarketGrowthRate\_O = 1.725 \times 10^3$

$SaleLEDT3\_P := SaleLEDT2\_P \cdot MarketGrowthRate\_P = 1.656 \times 10^3$

$SaleLEDT3\_R := SaleLEDT2\_R \cdot MarketGrowthRate\_R = 2.254 \times 10^3$

$SaleLEDT3\_O := SaleLEDT2\_O \cdot MarketGrowthRate\_O = 2.587 \times 10^3$

$SaleLEDT4\_P := SaleLEDT3\_P \cdot MarketGrowthRate\_P = 1.987 \times 10^3$

$SaleLEDT4\_R := SaleLEDT3\_R \cdot MarketGrowthRate\_R = 3.156 \times 10^3$

$SaleLEDT4\_O := SaleLEDT3\_O \cdot MarketGrowthRate\_O = 3.881 \times 10^3$

$SaleLEDT5\_P := SaleLEDT4\_P \cdot MarketGrowthRate\_P = 2.385 \times 10^3$

$SaleLEDT5\_R := SaleLEDT4\_R \cdot MarketGrowthRate\_R = 4.418 \times 10^3$

$SaleLEDT5\_O := SaleLEDT4\_O \cdot MarketGrowthRate\_O = 5.822 \times 10^3$

$SaleLEDT6\_P := SaleLEDT5\_P \cdot MarketGrowthRate\_P = 2.862 \times 10^3$

$SaleLEDT6\_R := SaleLEDT5\_R \cdot MarketGrowthRate\_R = 6.185 \times 10^3$

$SaleLEDT6\_O := SaleLEDT5\_O \cdot MarketGrowthRate\_O = 8.733 \times 10^3$

Per Annum TVS sales

$TVSSalesT0\_P := 0 = 0$ sales start in the first yr itself

$TVSSalesT0\_R := 0 = 0$

$TVSSalesT0\_O := 0 = 0$

$TVSSalesT1\_P := TVSMarketShareT1\_P \cdot SaleLED = 11.5$

$TVSSalesT1\_R := TVSMarketShareT1\_R \cdot SaleLED = 17.25$

$TVSSalesT1\_O := TVSMarketShareT1\_O \cdot SaleLED = 23$

$TVSSalesT2\_P := TVSMarketShareT2\_P \cdot SaleLEDT2\_P = 22.08$

$TVSSalesT2\_R := TVSMarketShareT2\_R \cdot SaleLEDT2\_R = 40.25$

$TVSSalesT2\_O := TVSMarketShareT2\_O \cdot SaleLEDT2\_O = 69$

$TVSSalesT3\_P := TVSMarketShareT3\_P \cdot SaleLEDT3\_P = 57.96$

$TVSSalesT3\_R := TVSMarketShareT3\_R \cdot SaleLEDT3\_R = 94.668$

$TVSSalesT3\_O := TVSMarketShareT3\_O \cdot SaleLEDT3\_O = 155.25$

$TVSSalesT4\_P := TVSMarketShareT4\_P \cdot SaleLEDT4\_P = 89.424$

$TVSSalesT4\_R := TVSMarketShareT4\_R \cdot SaleLEDT4\_R = 189.336$

$TVSSalesT4\_O := TVSMarketShareT4\_O \cdot SaleLEDT4\_O = 310.5$

$TVSSalesT5\_P := TVSMarketShareT5\_P \cdot SaleLEDT5\_P = 131.155$

$TVSSalesT5\_R := TVSMarketShareT5\_R \cdot SaleLEDT5\_R = 309.249$

$TVSSalesT5\_O := TVSMarketShareT5\_O \cdot SaleLEDT5\_O = 523.969$

$TVSSalesT6\_P := TVSMarketShareT6\_P \cdot SaleLEDT6\_P = 171.694$

$TVSSalesT6\_R := TVSMarketShareT6\_R \cdot SaleLEDT6\_R = 494.798$

$TVSSalesT6\_O := TVSMarketShareT6\_O \cdot SaleLEDT6\_O = 873.281$

Accumulated TVS sales

TotalTVSSalesT0_P := 0 = 0

TotalTVSSalesT0_R := 0 = 0

TotalTVSSalesT0_O := 0 = 0

TotalTVSSalesT1_P := TVSSalesT1_P = 11.5

TotalTVSSalesT1_R := TVSSalesT1_R = 17.25

TotalTVSSalesT1_O := TVSSalesT1_O = 23

TotalTVSSalesT2_P := TVSSalesT1_P + TVSSalesT2_P = 33.58

TotalTVSSalesT2_R := TVSSalesT1_R + TVSSalesT2_R = 57.5

TotalTVSSalesT2_O := TVSSalesT2_O + TVSSalesT2_O = 138

TotalTVSSalesT3_P := TotalTVSSalesT2_P + TVSSalesT3_P = 91.54

TotalTVSSalesT3_R := TotalTVSSalesT2_R + TVSSalesT3_R = 152.168

TotalTVSSalesT3_O := TotalTVSSalesT2_O + TVSSalesT3_O = 293.25

TotalTVSSalesT4_P := TotalTVSSalesT3_P + TVSSalesT4_P = 180.964

TotalTVSSalesT4_R := TotalTVSSalesT3_R + TVSSalesT4_R = 341.504

TotalTVSSalesT4_O := TotalTVSSalesT3_O + TVSSalesT4_O = 603.75

TotalTVSSalesT5_P := TotalTVSSalesT4_P + TVSSalesT5_P = 312.119

TotalTVSSalesT5_R := TotalTVSSalesT4_R + TVSSalesT5_R = 650.753

TotalTVSSalesT5_O := TotalTVSSalesT4_O + TVSSalesT5_O = 1.128×10^3

TotalTVSSalesT6_P := TotalTVSSalesT5_P + TVSSalesT6_P = 483.813

TotalTVSSalesT6_R := TotalTVSSalesT5_R + TVSSalesT6_R = 1.146×10^3

TotalTVSSalesT6_O := TotalTVSSalesT5_O + TVSSalesT6_O = 2.001×10^3

Accumulated investments annually

TotalTVSInvestmentT0Cr_min := TVSinvestT0_min = 0.1

TotalTVSInvestmentT0Cr_max := TVSinvestT0_max = 0.4

TotalTVSInvestmentT1Cr_min := TotalTVSInvestmentT0Cr_min + TVSinvestT1_min = 0.84

TotalTVSInvestmentT1Cr_max := TotalTVSInvestmentT0Cr_max + TVSinvestT1_max = 2.391

TotalTVSInvestmentT2Cr_min := TotalTVSInvestmentT1Cr_min + TVSinvestT2_min = 1.463

TotalTVSInvestmentT2Cr_max := TotalTVSInvestmentT1Cr_max + TVSinvestT2_max = 3.747

TotalTVSInvestmentT3Cr_min := TotalTVSInvestmentT2Cr_min + TVSinvestT3_min + TVSSalesT3_P·0.002 = 2.123

TotalTVSInvestmentT3Cr_max := TotalTVSInvestmentT2Cr_max + TVSinvestT3_max + TVSSalesT3_O·0.002 = 5.074

TotalTVSInvestmentT4Cr_min := TotalTVSInvestmentT3Cr_min + TVSinvestT4_min + TVSSalesT4_P·0.002 = 2.845

TotalTVSInvestmentT4Cr_max := TotalTVSInvestmentT3Cr_max + TVSinvestT4_max + TVSSalesT4_O·0.002 = 6.712

TotalTVSInvestmentT5Cr_min := TotalTVSInvestmentT4Cr_min + TVSinvestT5_min + TVSSalesT5_P·0.002 = 3.65

TotalTVSInvestmentT5Cr_max := TotalTVSInvestmentT4Cr_max + TVSinvestT5_max + TVSSalesT5_O·0.002 = 8.776

TotalTVSInvestmentT6Cr_min := TotalTVSInvestmentT5Cr_min + TVSinvestT6_min + TVSSalesT6_P·0.002 = 4.537

TotalTVSInvestmentT6Cr_max := TotalTVSInvestmentT5Cr_max + TVSinvestT6_max + TVSSalesT6_O·0.002 = 11.539

TVSprofits per annum

TVSprofitsT1_P := TVSSalesT1_P·ProfitMarginFraction_P = 0.69

TVSprofitsT1_R := TVSSalesT1_R·ProfitMarginFraction_R = 1.38

TVSprofitsT1_O := TVSSalesT1_O·ProfitMarginFraction_O = 2.3

TVSprofitsT2_P := TVSSalesT2_P·ProfitMarginFraction_P = 1.325

TVSprofitsT2_R := TVSSalesT2_R·ProfitMarginFraction_R = 3.22

TVSprofitsT2_O := TVSSalesT2_O·ProfitMarginFraction_O = 6.9

TVSprofitsT3_P := TVSSalesT3_P·ProfitMarginFraction_P = 3.478

TVSprofitsT3_R := TVSSalesT3_R·ProfitMarginFraction_R = 7.573

TVSprofitsT3_O := TVSSalesT3_O·ProfitMarginFraction_O = 15.525

TVSprofitsT4_P := TVSSalesT4_P·ProfitMarginFraction_P = 5.365

TVSprofitsT4_R := TVSSalesT4_R·ProfitMarginFraction_R = 15.147

TVSprofitsT4_O := TVSSalesT4_O·ProfitMarginFraction_O = 31.05

TVSprofitsT5_P := TVSSalesT5_P·ProfitMarginFraction_P = 7.869

TVSprofitsT5_R := TVSSalesT5_R·ProfitMarginFraction_R = 24.74

TVSprofitsT5_O := TVSSalesT5_O·ProfitMarginFraction_O = 52.397

TVSprofitsT6_P := TVSSalesT6_P·ProfitMarginFraction_P = 10.302

TVSprofitsT6_R := TVSSalesT6_R·ProfitMarginFraction_R = 39.584

TVSprofitsT6_O := TVSSalesT6_O·ProfitMarginFraction_O = 87.328

Accumulated TVS profits

TotalTVSprofitsT0_P := 0 = 0

TotalTVSprofitsT0_R := 0 = 0

TotalTVSprofitsT0_O := 0 = 0

TotalTVSprofitsT1_P := TVSprofitsT1_P = 0.69

TotalTVSprofitsT1_R := TVSprofitsT1_R = 1.38

TotalTVSprofitsT1_O := TVSprofitsT1_O = 2.3

TotalTVSprofitsT2_P := TVSprofitsT1_P + TVSprofitsT2_P = 2.015

TotalTVSprofitsT2_R := TVSprofitsT1_R + TVSprofitsT2_R = 4.6

TotalTVSprofitsT2_O := TVSprofitsT1_O + TVSprofitsT2_O = 9.2

TotalTVSprofitsT3_P := TotalTVSprofitsT2_P + TVSprofitsT3_P = 5.492

TotalTVSprofitsT3_R := TotalTVSprofitsT2_R + TVSprofitsT3_R = 12.173

TotalTVSprofitsT3_O := TotalTVSprofitsT2_O + TVSprofitsT3_O = 24.725

TotalTVSprofitsT4_P := TotalTVSprofitsT3_P + TVSprofitsT4_P = 10.858

TotalTVSprofitsT4_R := TotalTVSprofitsT3_R + TVSprofitsT4_R = 27.32

TotalTVSprofitsT4_O := TotalTVSprofitsT3_O + TVSprofitsT4_O = 55.775

TotalTVSprofitsT5_P := TotalTVSprofitsT4_P + TVSprofitsT5_P = 18.727

TotalTVSprofitsT5_R := TotalTVSprofitsT4_R + TVSprofitsT5_R = 52.06

TotalTVSprofitsT5_O := TotalTVSprofitsT4_O + TVSprofitsT5_O = 108.172

TotalTVSprofitsT6_P := TotalTVSprofitsT5_P + TVSprofitsT6_P = 29.029

TotalTVSprofitsT6_R := TotalTVSprofitsT5_R + TVSprofitsT6_R = 91.644

TotalTVSprofitsT6_O := TotalTVSprofitsT5_O + TVSprofitsT6_O = 195.5

$$B := \begin{pmatrix} \text{TotalTVSInvestmentT0Cr\_min} & \text{TotalTVSInvestmentT0Cr\_max} & \text{TotalTVSprofitsT0\_P} & \text{TotalTVSprofitsT0\_R} & \text{TotalTVSprofitsT0\_O} \\ \text{TotalTVSInvestmentT1Cr\_min} & \text{TotalTVSInvestmentT1Cr\_max} & \text{TotalTVSprofitsT1\_P} & \text{TotalTVSprofitsT1\_R} & \text{TotalTVSprofitsT1\_O} \\ \text{TotalTVSInvestmentT2Cr\_min} & \text{TotalTVSInvestmentT2Cr\_max} & \text{TotalTVSprofitsT2\_P} & \text{TotalTVSprofitsT2\_R} & \text{TotalTVSprofitsT2\_O} \\ \text{TotalTVSInvestmentT3Cr\_min} & \text{TotalTVSInvestmentT3Cr\_max} & \text{TotalTVSprofitsT3\_P} & \text{TotalTVSprofitsT3\_R} & \text{TotalTVSprofitsT3\_O} \\ \text{TotalTVSInvestmentT4Cr\_min} & \text{TotalTVSInvestmentT4Cr\_max} & \text{TotalTVSprofitsT4\_P} & \text{TotalTVSprofitsT4\_R} & \text{TotalTVSprofitsT4\_O} \\ \text{TotalTVSInvestmentT5Cr\_min} & \text{TotalTVSInvestmentT5Cr\_max} & \text{TotalTVSprofitsT5\_P} & \text{TotalTVSprofitsT5\_R} & \text{TotalTVSprofitsT5\_O} \\ \text{TotalTVSInvestmentT6Cr\_min} & \text{TotalTVSInvestmentT6Cr\_max} & \text{TotalTVSprofitsT6\_P} & \text{TotalTVSprofitsT6\_R} & \text{TotalTVSprofitsT6\_O} \end{pmatrix}$$

$$B = \begin{pmatrix} 0.1 & 0.4 & 0 & 0 & 0 \\ 0.84 & 2.391 & 0.69 & 1.38 & 2.3 \\ 1.463 & 3.747 & 2.015 & 4.6 & 9.2 \\ 2.123 & 5.074 & 5.492 & 12.173 & 24.725 \\ 2.845 & 6.712 & 10.858 & 27.32 & 55.775 \\ 3.65 & 8.776 & 18.727 & 52.06 & 108.172 \\ 4.537 & 11.539 & 29.029 & 91.644 & 195.5 \end{pmatrix}$$

B contains the investment min, investment max, Accumulated profits on pessimistic, realistic and optimistic cases financial data

$$y = \begin{pmatrix} 0 & 0 & 0 \\ 0.01 & 0.015 & 0.02 \\ 0.016 & 0.025 & 0.04 \\ 0.035 & 0.042 & 0.06 \\ 0.045 & 0.06 & 0.08 \\ 0.055 & 0.07 & 0.09 \\ 0.06 & 0.08 & 0.1 \end{pmatrix}$$

Y contains market share for optimistic, realistic and pessimistic

$$z := \begin{pmatrix} \text{TVSSalesT0\_P} & \text{TVSSalesT0\_R} & \text{TVSSalesT0\_O} \\ \text{TVSSalesT1\_P} & \text{TVSSalesT1\_R} & \text{TVSSalesT1\_O} \\ \text{TVSSalesT2\_P} & \text{TVSSalesT2\_R} & \text{TVSSalesT2\_O} \\ \text{TVSSalesT3\_P} & \text{TVSSalesT3\_R} & \text{TVSSalesT3\_O} \\ \text{TVSSalesT4\_P} & \text{TVSSalesT4\_R} & \text{TVSSalesT4\_O} \\ \text{TVSSalesT5\_P} & \text{TVSSalesT5\_R} & \text{TVSSalesT5\_O} \\ \text{TVSSalesT6\_P} & \text{TVSSalesT6\_R} & \text{TVSSalesT6\_O} \end{pmatrix}$$

$$z = \begin{pmatrix} 0 & 0 & 0 \\ 11.5 & 17.25 & 23 \\ 22.08 & 40.25 & 69 \\ 57.96 & 94.668 & 155.25 \\ 89.424 & 189.336 & 310.5 \\ 131.155 & 309.249 & 523.969 \\ 171.694 & 494.798 & 873.281 \end{pmatrix}$$