Draft

Glass Selection & LCC Report

QUARKCITY

MOHALI

Prepared By

GLOBAL EVOLUTIONARY ENERGY DESIGN

(Low Carbon Consultant)

Global Evolutionary Energy Design,

Nadvis, D-15 Abul Fazal Enclave

Jamia Nagar New Delhi – 110025,

M +91 9873588571,

E – Mail: smhadil@gmail.com,

http://geed-india.blogspot.com

Disclaimer: The entire report is based on certain assumptions which are listed in the different sections of the report; standard procedures have been employed for calculation of different information entities. These methodologies can be referred from internationally approved documents. Large data handling and complex mathematical calculation leave space for probable errors of which the consultant takes no warranty, though efforts have been made to minimize errors and anomalies.

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Preface

This report was prepared by Global Evolutionary Energy Design “GEED India” to assist in the best case energy design of F3 building’s northern façade, in Mohali Punjab. The report contains results, recommendations and methodology followed in energy analysis of the proposed building – Report is primarily based on information provided by Architect and consultants and glass vendor of china and India.

The proposed building was analyzed using Dynamic Thermal Modeling and hourly energy simulation to explore opportunities for energy savings in HVAC, and to enhance the thermal comfort of the occupants. The proposed building comprises of 12+2 half floors and 2 basements and a stilt level

The aim of the study is to analyze and support the decision to select best suitable glazing product by optimizing the initial capital with operational losses. The report presents analysis of several different types of available glass ranges from poorest to the best available or least to very expensive options. This is a Draft Report and several points need discussion before they are finally included in the Proposed Building design.

1 Questions Addressed in the Report

Following question would be addressed in the current report.

1. What is the best and the poorest glazing option available? And how far are they in terms of relative operational efficiencies.
2. Why not to use an inexpensive glass and what will be the financial consequences of operation.
3. What is the philosophy behind the analysis and how is it worth understanding while taking the decision.
4. What percent operational efficiencies would we get if we use a better glass compare to a notional building façade (like Quark media's glass)
5. What are the figure of relative saving in $, INR for all the ten façade options?
6. What is the total electricity bill for F3 building with all the ten façade options?
7. What are the losses associated with the operations of building in KWh/m^2.Yr considering all the ten façade options?
8. What are the individual breakup of energy component acting on the building like solar gain, glazing heat transfer and HVAC cooling etc with all the ten options?
9. What kind of weather really represent the weather that act on the subject building. ASHARE guidelines.
10. Is the Chinese product better and suits our requirement?
11. From the freeze thermo physical requirements, which glass to select? What exactly is left for the architect to see in finalization of the glass?
12. What are the life cycle cost (**LCC**)for the different option compared with notional option
13. What is the pay back with 3% to 4% energy inflation over the period of 25 year?

2 Executive Summary

- We have taken cost and thermal properties of vendors from china and India.
- There is 25% cost differential for the product of same performance from China and India
- The Notional building was modeled by considering single clear glass, which is the cheapest option. Taking this as a base line other options and saving realized were calculated.
- It clearly appears that quadruple glass and is best in terms of operational cost but not very attractive due to its capital investment. It is paying back its worth in 13.3 years of operation. This makes it not a very suitable candidate for selection.
- it was also observed that the performance of triple glazed units can also be achievable by double glazed unit which makes it again not an option which justify the investments
- There has been a lot of variance in the double glazed unit considering thermal performance. This makes our selection more critical.
- If we purchase glass from India the pay back would vary from 9 to 11 year, where as due to less capital investment Chinese product are paying back there worth in 5 to 7 year.
- The only thing which has to be looked before taking any decision is the freight and transportation cost with the Chinese option.

3 Introduction

This report presents the results of an analysis of energy efficiency consequences for F3 building in QuarkCity situated in Mohali Chandigarh, India. It is a 50000 m^2 office consisting of 12 floors and about 5400 m^2 of façade.

The objective of this study is to assess the energy and cost benefits associated with energy-efficient design features focusing on the design and envelope specifications. The study primarily asses the cost benefit of using different type of high performance glazing for efficient façade design.

This analysis determine the energy use impact of several energy efficiency measures (EEM) and recommends enhancements to the proposed design budget case model.

Estimates for occupancy and schedules were obtained from the standard practice, design team and incorporated into the analysis.

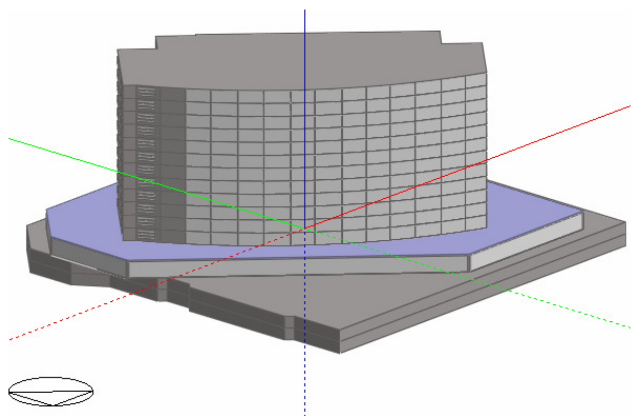


Chart 1. North view of the building envelop model

4 Analysis Methodology

Building performance for all measures was evaluated using Energy Plus software program. This program uses the discrete event simulation technique for evaluating energy-use and peak demand on an hourly or sub hourly basis. The subject building was divided as per the zone depicted in Figure 2a, 2b and 2c.

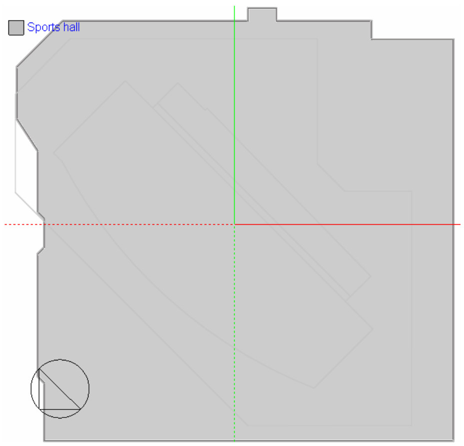


Figure 2a. *Zoning Plans of the Basements*

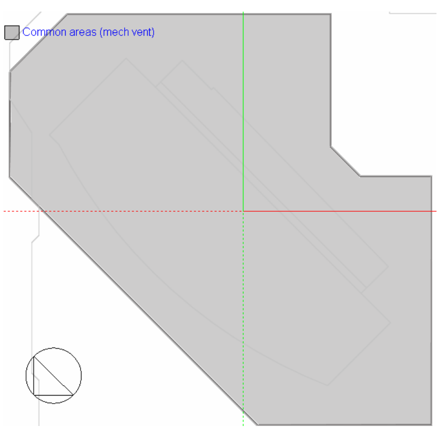


Figure 2b. *Zoning Plans of the Stilt*

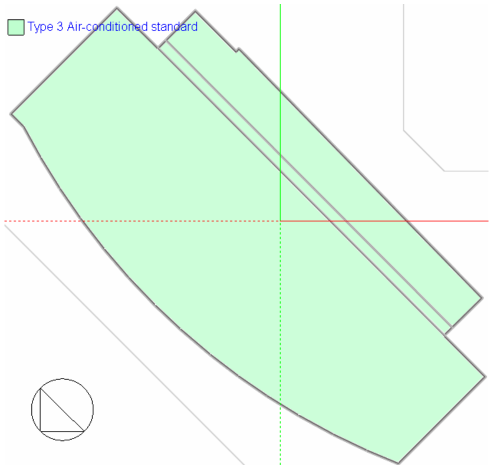


Figure 2c. *Zoning Plans of the Typical Office Floor*

Whole building simulations were carried out with all the ten cases, the notional building case (EEM0) was taken as a reference case for creating a comparative/rating analysis for other product including Indian and Chinese vendors. The notional building case is a reference case in which as per the guide line of ASHARE 90.1 and IBC 2005, an ideal building is created and simulated with the recommended parameters.

In our case a 6mm single clear glass was used in the northern façade to represent a notional building performance of the building. In the subsequent whole building simulation building component i.e. wall, roof, HVAC system and schedule remained unchanged in all 9 case except the glazing part, to see what the energy consequences are and how much they cost relatively for each individual case compare to notional building operation.

The results of the analysis in the form of graphs are depicted in Appendix I, II, III, IV, V, VI, VII, VIII and IX. The tabulated results which include the relative cost and thermo physical properties of all the 10 cases are depicted in the Appendix V.

In section seven, approximate life cycle costing (LCC) for building life of 25 years and return on investment (ROI) have been calculated. This will give further insight into the financials of the energy efficiency option over the period.

5 Weather Data and Design Conditions

Location	**:**	Mohali
Latitude (°N)	**:**	30°34'
Longitude (°E)	**:**	77° 11'
Altitude (m)	**:**	300
WMO Station	**:**	421820

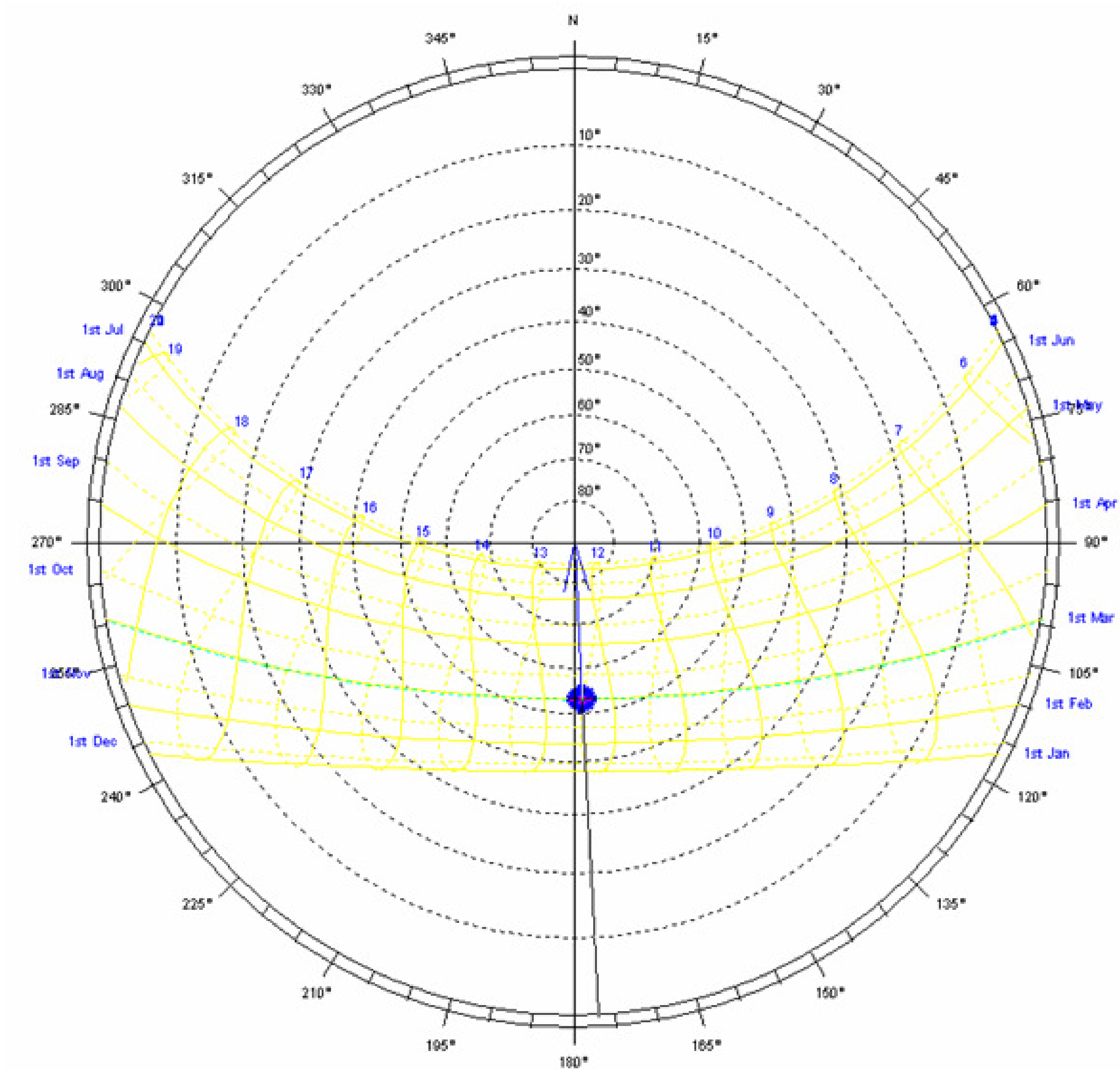


Chart 2. Sun Path Diagram for Mohali

Indra Gandhi International Airport weather file in the TMY2 (see Table A-2) format was used in simulation model. Following table shows the ISHRAE design dry bulb and wet bulb conditions for Mohali.

Table 1 ISHRAE Design Temperatures for Mohali

I	Design Temperatures	
	Dry Bulb	Mean Coincident Wet Bulb
0.4%	42	22.1
1%	40.6	22.6
2%	39.3	22.8

Chart 3. Design Temperature for Mohali (Chandigarh)

The climate type for the location of subject house is "4B" (ASHRAE Standards 90.1-2004 and 90.2-2004 Climate Zone) Mixed Dry, Probable Köppen classification=BSk/BWh/H, Semiarid Mid Latitude/Arid Subtropical/Highlands with 2721 annual cooling degree-days (18°C baseline) and 278 annual heating degree-days (18°C baseline). This kind of climate has to be designed for efficient cooling.

For energy savings and cooling calculation a wide range of individual energy conservation measures (ECM) such as envelope (Insulation for walls, roof, floors), windows shadings, were observed. To arrive at the recommended package of measures, total electrical energy consumption for each ECM was compared to the normal and budget case and net energy savings in KWh and cost associated with each of the measures is evaluated.

Estimates for occupancy and schedules were obtained from the design team and incorporated into the analysis. Following are different occupancy assigned to various areas. See Appendix for details of the schedules used

6 Case Description and Parameters

Ten cases ranging from the best practice quadruple glazed (QG) to poorest practice single glazed (SG) were considered. Base case was created from notional building considering a single glazed façade. All the other variants in the simulation except the glazing were kept fixed in all the ten cases so as to get relative difference in each case with notional building case. Thermo physical properties of all the option considered are listed in Appendix V at the end of the document.

Building Envelope

Building Envelop includes wall, ceilings, roofing material, door and window glazing etc

Lighting & Equipment

It includes a ranges of possible equipments to be used in a standard office, like photo copier printer, fax machines and computers etc. Lighting was considered to be Florescent tubes lights or CFL

Cooling System

Standard Raised floor, UFAD system is considered. The building is fed by a chilled water **plant**; AHUs dedicated to zone will be responsible for maintaining the temperature.

6.1 SG-6LowE (EEM1)

This is a single low emissive glass of 6 mm thickness

6.2 DG-6LowE-13Argon-6Clear (EEM2)

A double glazed low E glass of 6 mm thickness with 13mm argon gap with 6 mm clear glass.

6.3 TG-6LowE-13Argon-6Clear-6Air-6Clear (EEM3)

Triple glass with out side Low E glass with 13 mm Argon and then two more glass with 6 mm air gaps

6.4 QG-6LowE-13Argon-6Clear-6Air- 6Clear-6Argon-6Clear (EEM4)

This is Quadruple glass with Low E and 13 mm argon filled, 6 mm clear,, 6 argon, and again 6 clear. This is considered to be the best combination of glass which will have a very low thermal response in terms of heat transfer.

6.5 DG-6Clear-13Air-6Clear (EEM5)

This is a simple standard and a low cost combination which is generally used in buildings. This combination consists of two clear glasses with 13 mm air gap.

6.6 SG-6Clear (Notional Building Case) (EEM0)

This is a base case combination; this will form a reference case for further comparison with other cost intensive option. This case is considering a clear single 6mm glass as façade.

6.7 DG-6LowE-13Air-6Clear (EEM6)

This is again a standard option where 6mm Low E with 13 mm air gap and 6mm clear glass on inner side form the DGU (double glazed unit).

6.8 DG-6LowE-20Air-6Clear (EEM7)

This is a special option where the 13mm air gap in the Double glazed unit has been replaced with 20 mm Air gap and rest of the thing remains unchanged. This measure has been introduced to see whether this increasing gap in gas or Air do have some effect on the conductivity part or not?

6.9 DG-6LowE-6Argon-6Clear (EEM8)

In this option we have only 6mm argon gap with out glass as 6mm Low E and inner glass is 6mm clear.

6.10 DG-6LowE-13Argon-6Clear-China-Blue Green (EEM9)

This is an option which represents the performance level of the product from Chinese vendor. The double glazed unit is composed of 6mm Low E, 13 mm Argon and 6 mm Clear glass.

7 Life Cycle Cost Analysis

Life cycle cost calculations were performed assuming a reference case. This reference case is known as the notional building scenario.. It can be explained as if the building is operating with a glass which is normally used or simply a results of no energy conscious decision. After establishing this Notional building case, life cycle cost calculation were done by performing whole building energy simulations.

Other option were then calculated by changing the glass type from poorest to the best in an iterative way and considering an inflation of 3% in fuel charges life cycle cost has been calculated for the period of building life (25 years)

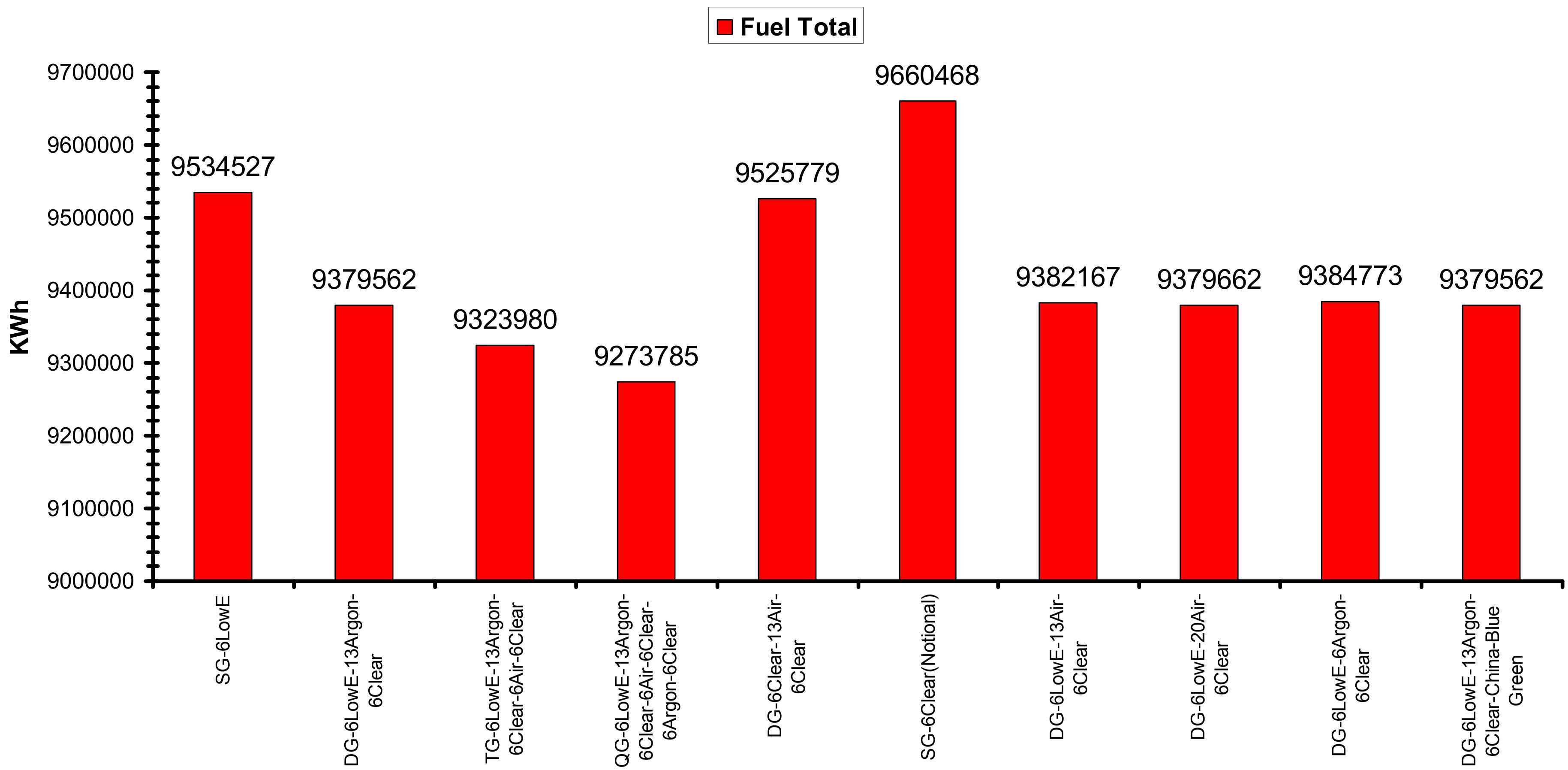
The capital investment of purchasing the different glass and there corresponding operating cost were then plotted on graphs for calculating the time which is required to nullify the capital expenditure with operational saving achieved.

8 Results and Conclusion

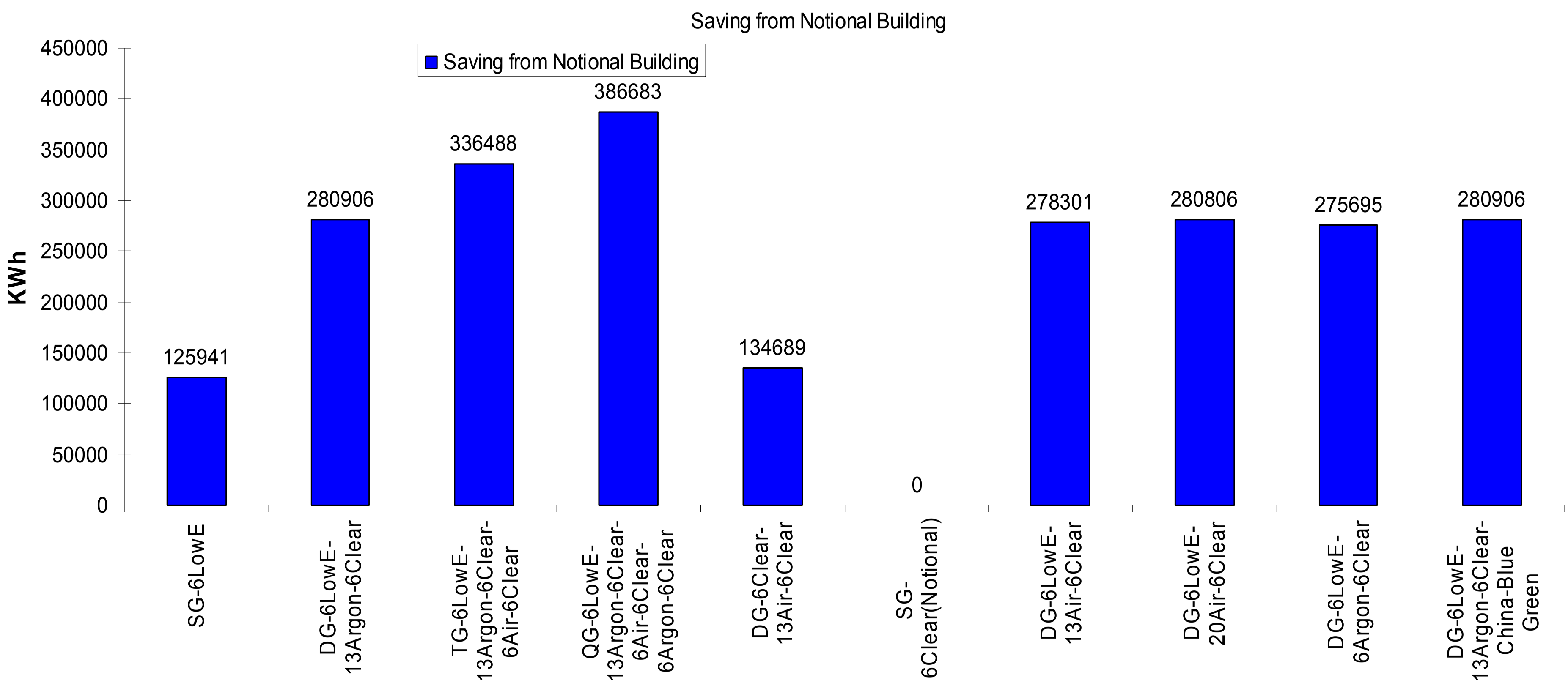
The Appendixes 1 to IX are depicting tables and graphs which illustrates the energy and cost implications aspects of using different option of glass in the façade.

1. In the Appendix I , simulation have shown that poorest glass usage would consume 9660 MWh of electrical energy annually where as the best possible option would consume 9273 MWh of electrical energy.
2. it is also showing straight annual cost of not selecting best option if compared to the poorest (notional building) façade option. 387 MWh or about INR 20 Lakh
3. The highest operational saving is 387 MWh which is attributed to quadruple glazing. But the LCC analysis does not recommend this glazing due to its huge initial capital.
4. Appendix III is depicting the operational cost difference if compared with the notional building façade, which ranges from 6 to 20 Lakhs
5. Out of total 210 KWh/m^2.yr. Building annual energy use, from 2.5 KWh/m^2.yr to 7.7 KWh/m^2.yr is the range of operational cost saving which can be achieved from using poorest and the best façade option respectively.
6. Considering building life of 25 yr. and an inflation in energy price till 2015 as 4% and after that a constant 3 % evaluated LCC has been displayed in Appendix VII. Which indicates that highest LCC come out to be of the poorest option that is clear single glazed units which is about (INR +3240,000)
7. Similarly the LCC of china Blue green option whose U value is 1.24 W/m^2.C, acceptable SHGC and VT, is coming out to be very less due to its low initial capital and high performance compared to other in this investment range.
8. Primary estimate depicts that using china glass for 25 yr would be saving about (INR -4.38 Cr.) where as other Double glazed façade options are showing a saving of (INR -1.4 to INR -3.0 Cr.)
9. The study also show that highly efficient option like quadruple and triple glazed façade are not likely to fall in the quarks 5 yr. pay back policy due to there initial capital investment.
10. Appendix VIII is showing pay back and return of investment year if saving is calculated considering notional building as a baseline for comparison.
11. If we purchase glass from India the pay back would vary from 9 to 11 year, where as due to less capital investment Chinese product are paying back there worth in 5 to 7 year only. See appendix VIII for exact year of payback.

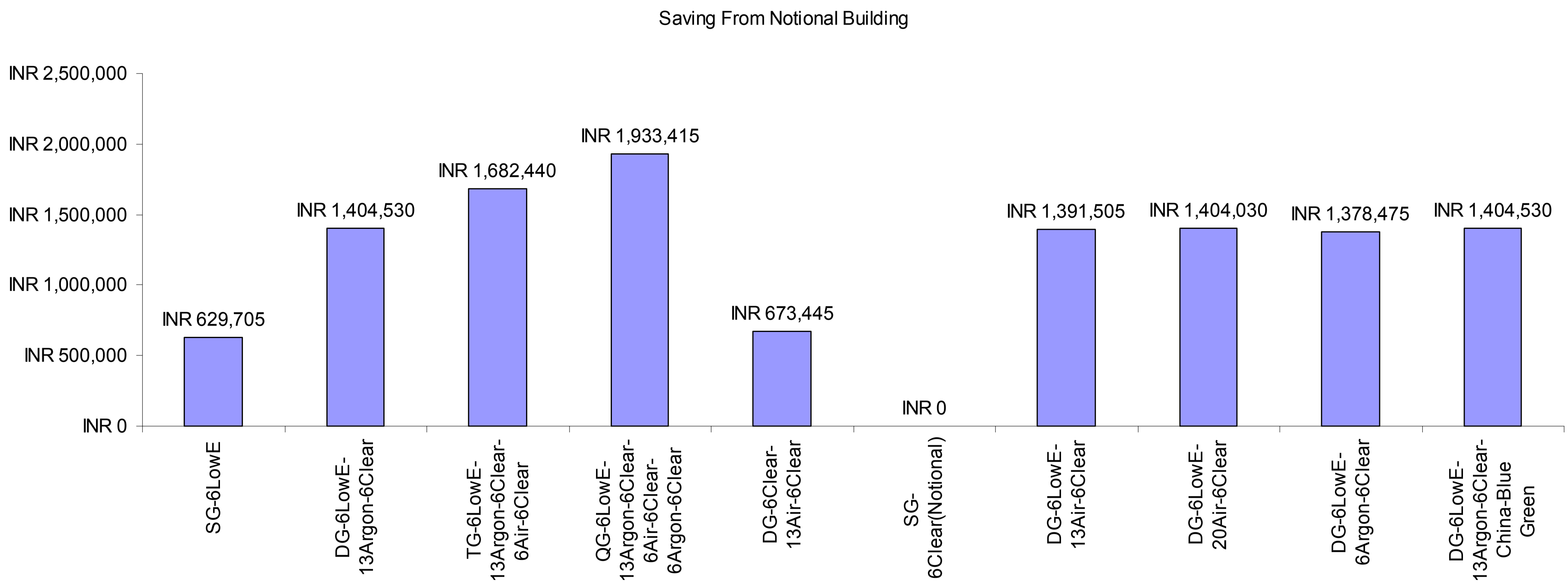
9 Appendix I – Total Annual Fuel Usage with Standard Operation for Different Glass Options



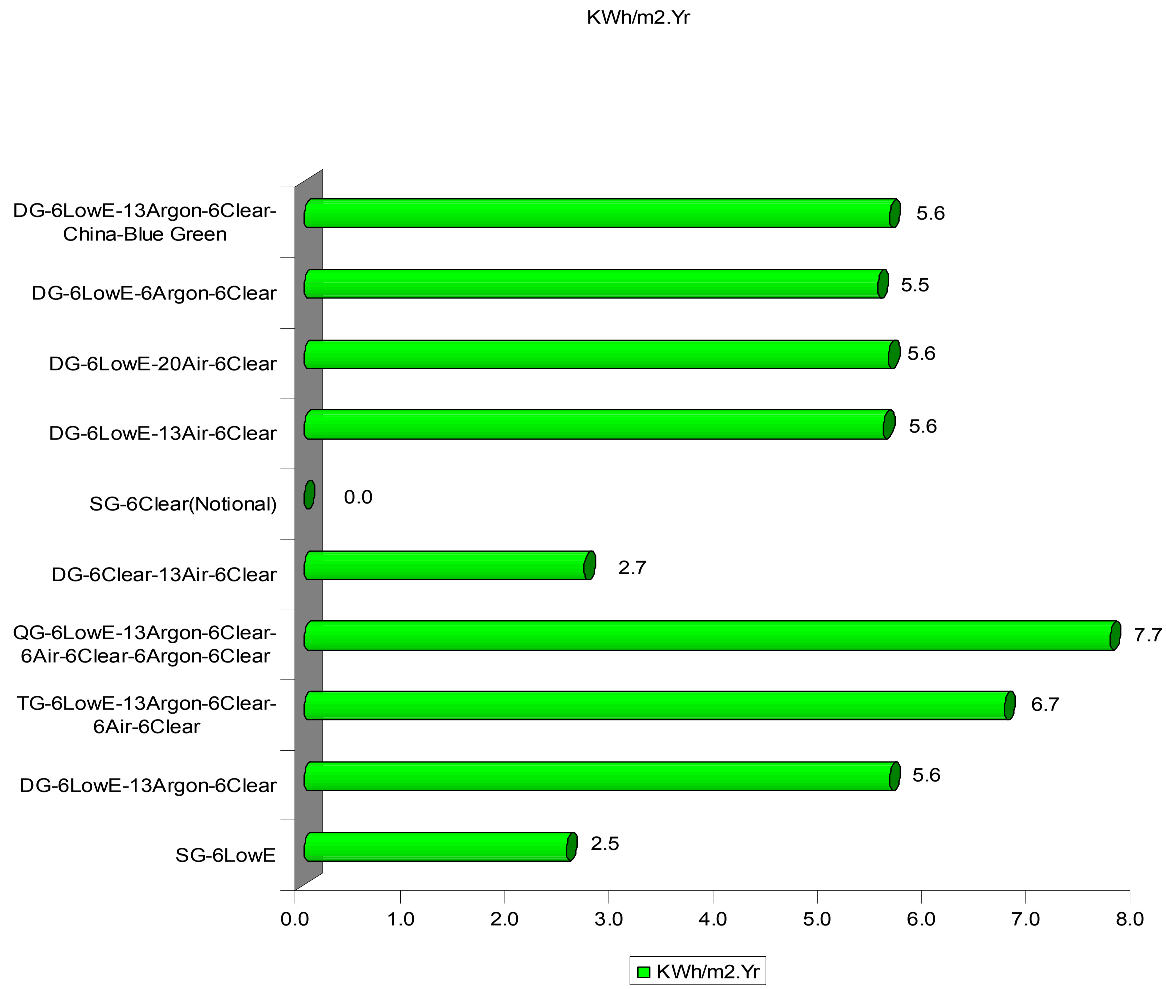
10 Appendix II – Relative Annual Saving in KWh Compared from Notional Building Energy Use



11 Appendix III- Relative Annual Saving for Each Glass Option in (INR) From Notional Building Energy Use



12 Appendix IV- Relative Annual Saving in KWh/m^2.yr Compared to Notional Building



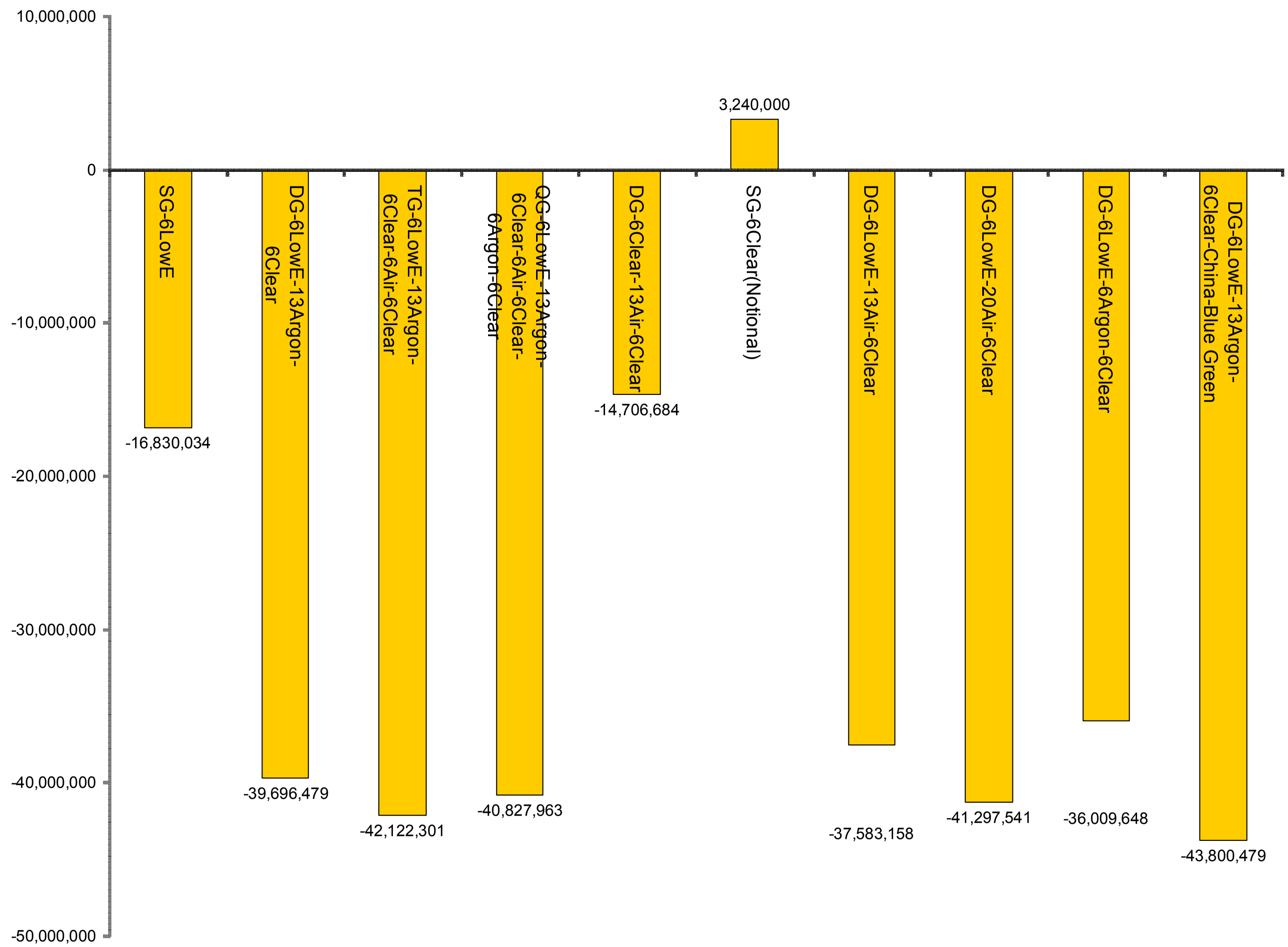
13 Appendix V- Whole Building Simulation Results and Thermal Properties of Glass

		Glass ThermoPhysical Properties				Simulation Results with Break up of Heat Balance					Analysis					
		%	%	%	W/Sqm.C	kWh	kWh	kWh	kg	kWh	KWh	KWh	%	INR	$	
S. No	Decision Support Center for Glass Selection	SHGC	DST	VLT	U-Value	Glazing	Transmitted Solar Gains	HVAC cooling	CO2	Chiller 1	Fuel Total	Saving from Notional Building	Saving from Notional Building	Saving Cost	Saving Cost	KWh/m2.Yr
1	SG-6LowE	0.628	0.602	0.841	3.99	-354951.4	2893514	-5936525	6531151	3554805	9534527	125941	1.30	INR 629,705	$ 14,311	2.5
2	DG-6LowE-13Argon-6Clear	0.564	0.474	0.745	1.499	260969.3	2109118	-5677732	6424999	3399840	9379562	280906	2.91	INR 1,404,530	$ 31,921	5.6
3	TG-6LowE-13Argon-6Clear-6Air-6Clear	0.511	0.375	0.664	1.201	637947.9	1553236	-5584911	6386926	3344258	9323980	336488	3.48	INR 1,682,440	$ 38,237	6.7
4	QG-6LowE-13Argon-6Clear-6Air-6Clear-6Argon-6Clear	0.464	0.293	0.594	0.978	871582.9	1151985	-5501085	6352542	3294063	9273785	386683	4.00	INR 1,933,415	$ 43,941	7.7
5	DG-6Clear-13Air-6Clear	0.697	0.604	0.781	2.713	-86053.2	2744528	-5921914	6525158	3546057	9525779	134689	1.39	INR 673,445	$ 15,306	2.7
6	**SG-6Clear(Notional)**	**0.81**	**0.775**	**0.881**	**6.121**	**-1036140**	**3830407**	**-6146845**	**6617420**	**3680746**	**9660468**	**0**	**0.00**	**INR 0**	**$ -**	**0.0**
7	DG-6LowE-13Air-6Clear	0.563	0.474	0.745	1.772	199433.6	2109118	-5682083	6426784	3402445	9382167	278301	2.88	INR 1,391,505	$ 31,625	5.6
8	DG-6LowE-20Air-6Clear	0.565	0.474	0.745	1.912	246915.4	2109118	-5677899	6425068	3399940	9379662	280806	2.91	INR 1,404,030	$ 31,910	5.6
9	DG-6LowE-6Argon-6Clear	0.563	0.474	0.745	1.95	145626.2	2109118	-5686436	6428570	3405051	9384773	275695	2.85	INR 1,378,475	$ 31,329	5.5
10	**DG-6LowE-13Argon-6Clear-China-Blue Green**	**0.564**	**0.32**	**0.57**	**1.249**	**260969.3**	**2109118**	**-5677732**	**6424999**	**3399840**	**9379562**	**280906**	**2.91**	**INR 1,404,530**	**$ 31,921**	**5.6**

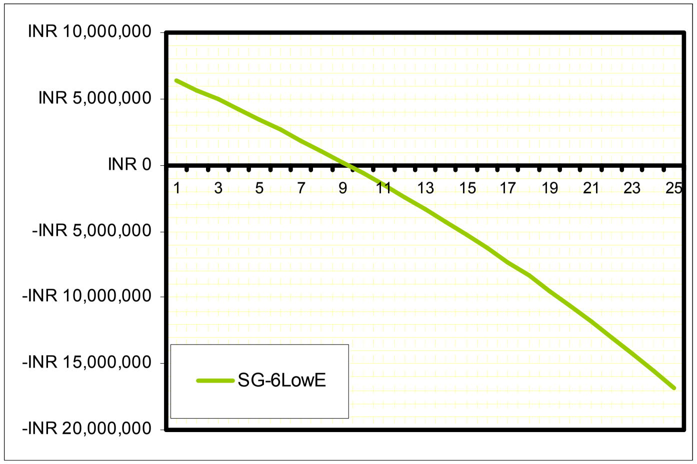
14 Appendix VI – Life Cycle Cost Assessment for different Glazing Options

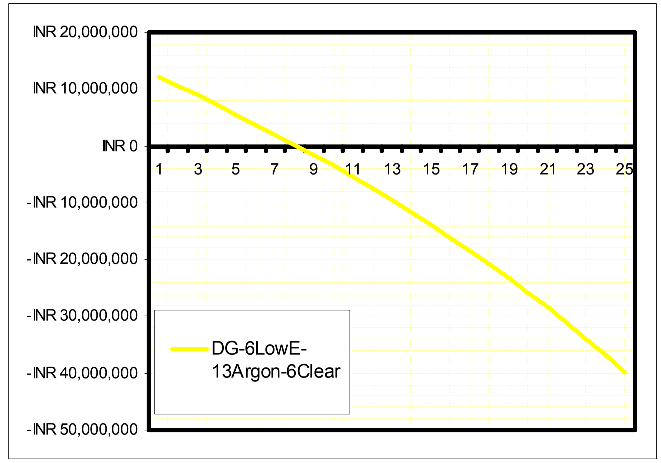
Year	Energy Price Escalation Rate for the years	Capital Cost/ Investment Year	SG-6LowE	DG-6LowE-13Argon-6Clear	TG-6LowE-13Argon-6Clear-6Air-6Clear	QG-6LowE-13Argon-6Clear-6Air-6Clear-6Argon-6Clear	DG-6Clear-13Air-6Clear	SG-6Clear(Notional)	DG-6LowE-13Air-6Clear	DG-6LowE-20Air-6Clear	DG-6LowE-6Argon-6Clear	DG-6LowE-13Argon-6Clear-China-Blue Green
2008	%/100	Capital➔	7020000	13500000	21600000	32400000	10800000	3240000	15120000	11880000	16200000	9396000
2009	0.04	1	-654893	-1460711	-1749738	-2010752	-700383	0	-1447165	-1460191	-1433614	-1460711
2010	0.04	2	-681089	-1519140	-1819727	-2091182	-728398	0	-1505052	-1518599	-1490959	-1519140
2011	0.04	3	-708332	-1579905	-1892516	-2174829	-757534	0	-1565254	-1579343	-1550597	-1579905
2012	0.04	4	-736666	-1643101	-1968217	-2261822	-787835	0	-1627864	-1642517	-1612621	-1643101
2013	0.04	5	-766132	-1708826	-2046946	-2352295	-819349	0	-1692979	-1708217	-1677126	-1708826
2014	0.04	6	-796778	-1777179	-2128823	-2446387	-852123	0	-1760698	-1776546	-1744211	-1777179
2015	0.04	7	-828649	-1848266	-2213976	-2544242	-886208	0	-1831126	-1847608	-1813979	-1848266
2016	0.03	8	-797691	-1779217	-2131265	-2449192	-853100	0	-1762717	-1778583	-1746211	-1779217
2017	0.03	9	-821622	-1832593	-2195203	-2522668	-878693	0	-1815598	-1831941	-1798597	-1832593
2018	0.03	10	-846271	-1887571	-2261059	-2598348	-905054	0	-1870066	-1886899	-1852555	-1887571
2019	0.03	11	-871659	-1944198	-2328890	-2676299	-932205	0	-1926168	-1943506	-1908132	-1944198
2020	0.03	12	-897809	-2002524	-2398757	-2756587	-960172	0	-1983953	-2001811	-1965376	-2002524
2021	0.03	13	-924743	-2062600	-2470720	-2839285	-988977	0	-2043472	-2061865	-2024337	-2062600
2022	0.03	14	-952485	-2124478	-2544841	-2924464	-1018646	0	-2104776	-2123721	-2085067	-2124478
2023	0.03	15	-981060	-2188212	-2621187	-3012198	-1049205	0	-2167919	-2187433	-2147619	-2188212
2024	0.03	16	-1010492	-2253858	-2699822	-3102563	-1080682	0	-2232957	-2253056	-2212048	-2253858
2025	0.03	17	-1040806	-2321474	-2780817	-3195640	-1113102	0	-2299946	-2320648	-2278409	-2321474
2026	0.03	18	-1072031	-2391118	-2864241	-3291510	-1146495	0	-2368944	-2390267	-2346761	-2391118
2027	0.03	19	-1104192	-2462852	-2950169	-3390255	-1180890	0	-2440012	-2461975	-2417164	-2462852
2028	0.03	20	-1137317	-2536737	-3038674	-3491963	-1216317	0	-2513213	-2535834	-2489679	-2536737
2029	0.03	21	-1171437	-2612840	-3129834	-3596721	-1252806	0	-2588609	-2611909	-2564370	-2612840
2030	0.03	22	-1206580	-2691225	-3223729	-3704623	-1290390	0	-2666267	-2690267	-2641301	-2691225
2031	0.03	23	-1242777	-2771961	-3320441	-3815762	-1329102	0	-2746255	-2770975	-2720540	-2771961
2032	0.03	24	-1280061	-2855120	-3420054	-3930235	-1368975	0	-2828643	-2854104	-2802156	-2855120
2033	0.03	25	-1318462	-2940774	-3522656	-4048142	-1410044	0	-2913502	-2939727	-2886221	-2940774
LCC Saving			-16,830,034	-39,696,479	-42,122,301	-40,827,963	-14,706,684	3,240,000	-37,583,158	-41,297,541	-36,009,648	-43,800,479
Façade Area			5400	Sqm								

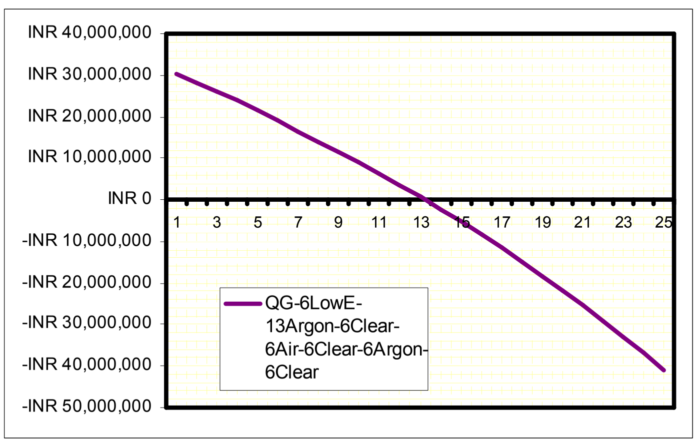
15 Appendix VII- 25 Year Life Cycle Cost Saving Compared to Notional Building

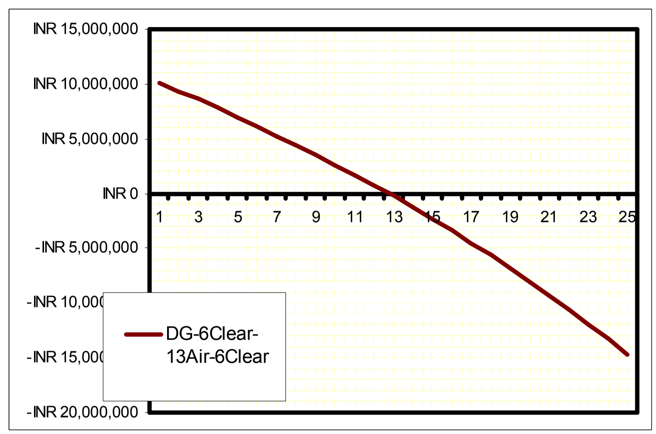


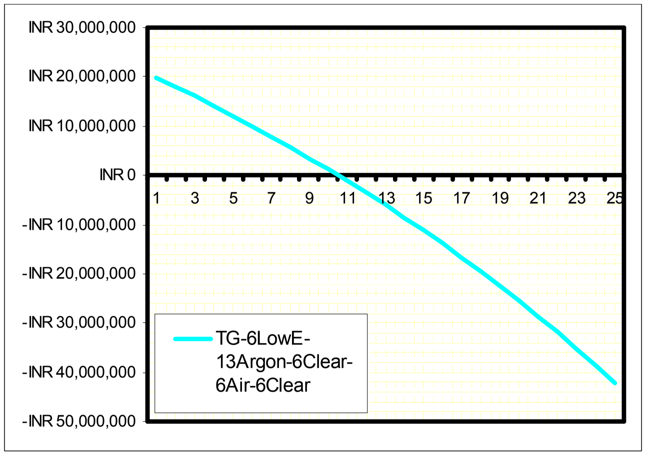
16 Appendix VIII- Pay Back Options

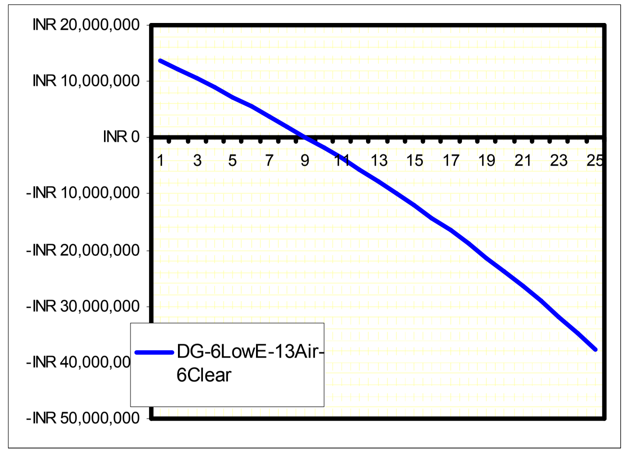









INR 30,000,000
INR 20,000,000
INR 10,000,000
INR 0
-INR 10,000,000
-INR 20,000,000
-INR 30,000,000
-INR 40,000,000
-INR 50,000,000
1 3 5 7 9 11 13 15 17 19 21 23 25
TG-6LowE-13Argon-6Clear-6Air-6Clear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-INR 50,000,000
1 3 5 7 9 11 13 15 17 19 21 23 25
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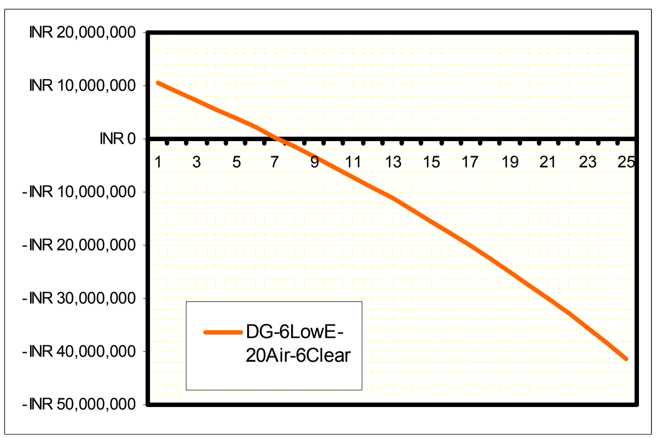
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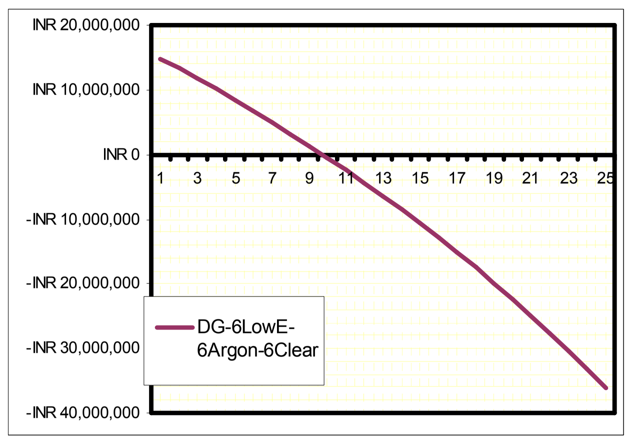
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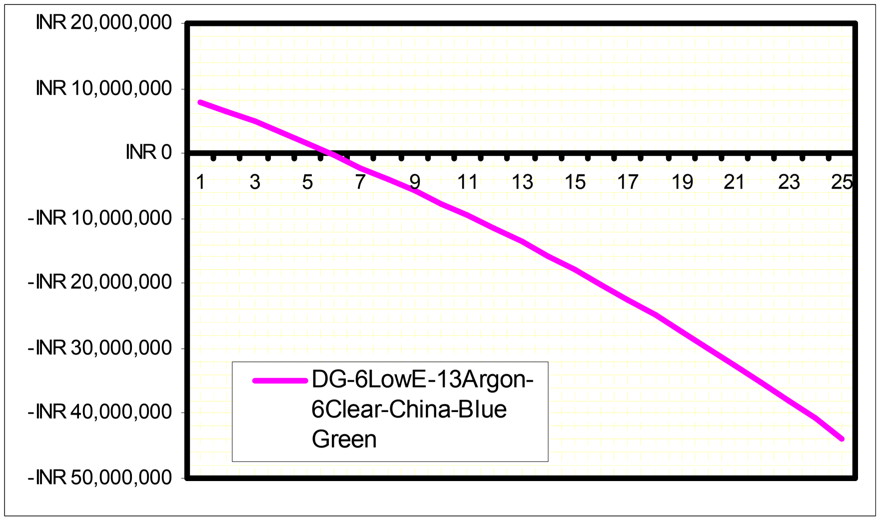
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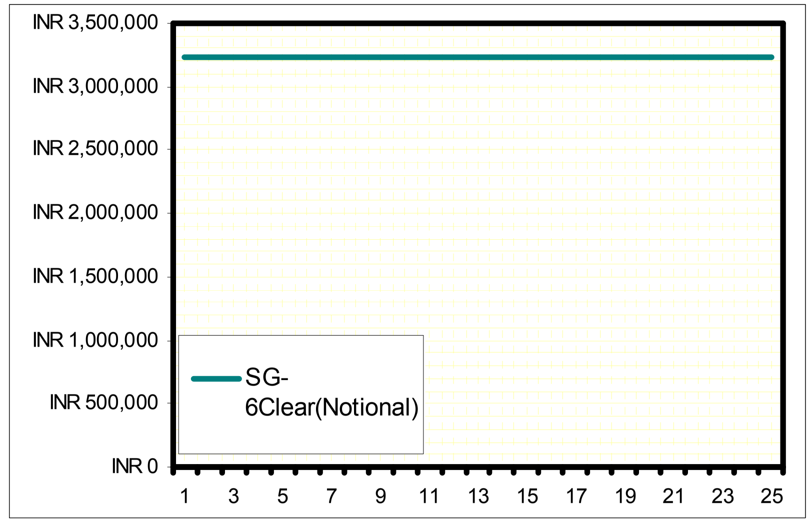
DG-6LowE-13Argon-6Clear-China-Blue Green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SG-6Clear(Notional)

17 Appendix IX- Annual Operational Cost Saving for 25 yrs. When Compared to Notional Building