

Application of Scientific Decision Supporting Tool to Optimize Energy Consumption in way of Greening the Existing Buildings

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ABSTRACT: Optimizing Energy Consumption or energy conservation refers to different methods and processes that have the main purpose in reducing the total amount of energy that is currently being used by industry, households and various other sectors of our society, to minimize the cost. The currently dominant fossil fuels are finite energy resources that will in due course become minimal and in this sense energy conservation is of vital importance to ensure reliability of future energy delivery [1]. Energy demand in buildings, driven by population growth and the addition of new energy-using equipment, is promptly increasing due to the rapid urbanization in India [2]. Retrofitting an existing building for energy efficiency can persistently be more cost-effective than building a new facility. Hence, by designing major renovations and retrofits for existing buildings to include sustainability initiatives will reduce the operation costs and environmental impacts, and can increase building adaptability, durability and resiliency [3]. In this paper, an implementation of a scientific tool, namely AHP (Analytical Hierarchy Process) has been found to be useful to decision makers of respective institution in a MCDM (Multi Criteria Decision Making) environment. The tool helps to rank different energy efficient/saving alternatives to be implemented in such institutions. Viewing the outcome/ranking of AHP, the decision makers of respective institution can conclusively disburse their finance in appropriate projects of greening buildings by retrofitting. Thus AHP has been applied as a decision supporting tool for optimization of Energy Consumption in this study.

KEYWORDS: Energy Conservation, Scientific Decision Making Process, Analytical Hierarchy Process, Multi Criteria Decision Making, Retrofitting, Greening Buildings.

I. INTRODUCTION

The major source of energy comes from fossil fuels, and the leading fossil fuels used today by most industrialized and developing countries are oil, coal, and natural gas. Among these fossil fuels, oil is the most consumed for energy conversion, followed by coal and natural gas. The burning of fossil fuels in the conversion to energy creates waste of H₂O and CO₂. While CO₂ is a natural greenhouse gas, too much of it in the atmosphere has been proven to cause global warming. The solution to the problems of limited fossil fuels and their impact on the environment is to have renewable resources of energy [4]. Renewable energy is energy that is generated from natural processes that are continuously replenished. This includes sunlight, geothermal heat, wind, tides, water, and various forms of biomass. This energy cannot be exhausted and is constantly renewed [5]. The Indian Green Building Council (IGBC) has launched IGBC green new buildings rating system to deal with the national priorities. This rating programme is a tool which enables the designer to apply green concepts and reduce the environmental impacts by buildings. Green new buildings can have wonderful benefits, like energy savings ranging from 20 - 30 % [6]. ECBC (Energy Conservation Building Codes) encourage energy efficient design or retrofit of buildings so that, it does not limit the building function, comfort, health or the productivity of the occupants and the lifecycle costs (construction + energy costs) of

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buildings by retrofitting are minimized [7]. EE (Energy Efficiency) measures should be undertaken for existing buildings and retrofitting should be done in order to reduce their global GHG (Green House Gas) footprint and make them more sustainable [8].

II. LITERATURE REVIEW

Cengel (2011) states that “Energy efficiency is to reduce energy use to the minimum level, but to do so without reducing the standard of living, the production quality, and the profitability” (Saldanha, Costa, Lima, 2016). Mukherjee (2008) uses Data Envelopment Analysis (DEA) to measure energy efficiency in different states of India, and learn how the Indian manufacturing sector is handling energy efficiency in different parts of the country (Saldanha, Costa, Lima, 2016). A ‘whole-building’ approach to residential design and construction combines sustainable site design, water conservation, energy efficiency, environmentally preferable materials and superior indoor environmental quality to achieve a green end product that meets basic human needs for shelter without compromising safety, security and health needs (Environmental Protection Agency, 2010) (Shodhganga, 2015). One study (Enkvist et al., 2007) pointed out that investment in energy-efficient lighting is one of the most cost-effective ways for improving energy efficiency in buildings and reduce CO₂ emissions (Dubois, Bisegna, Gentile, Knoop, Matusiak, Osterhaus, Tetri, 2015). According to Zhenjun et al. (2012), retrofitting should be considered as one of the main approaches to achieve sustainability in the built environment at relatively low cost and high uptake rates (Dubois, Bisegna, Gentile, Knoop, Matusiak, Osterhaus, Tetri, 2015). May et al. (2015) and Zhang and Chiong (2015) use a genetic algorithm (GA) to improve energy efficiency on the performances of a job-shop (Saldanha, Costa, Lima, 2016).

III. OBJECTIVE OF THE STUDY

1. To create a sustainable research infrastructure for energy efficiency in historic buildings by involving more researchers and creating new research environments.
2. To develop methods and technical solutions for energy efficiency, that combines old and new technologies.
3. To study retrofitting of a heritage building, keeping it undamaged while introducing the changes for green building.
4. Keeping in mind that retrofitting had to be done preferably through non-structural renovations or changes.
5. Significant time was spent on making users understand its importance and repeat the good practices.

IV. PROBLEM STATEMENT/ TESTING OF HYPOTHESIS

The present study is required for testing the following hypothesis:-

Null Hypothesis (H₀):

Green buildings do not offer any significant operational cost savings compared with traditional buildings against Alternative Hypothesis (H₁):

Green buildings always offer economically viable solutions through significant operational cost savings compared with traditional buildings.

V. METHODOLOGY

1. Questionnaires distributed among financial experts of Nabo Jibon MC Brothers & ISKCON, Mayapurdam.
2. A scientific tool AHP has been applied in the present study and Pairwise Comparison Matrix, Relative Indexes of individual financial parameters and the Final Judgement Matrix have been constructed for the two case studies discussed, using the responses given in the questionnaires by the institutional experts.
3. A statistical software, IBM-SPSS (Version 20), has also been used to draw the graphs in the study (Fig. 1, 2 & 3).

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VI. STUDIES ON SOME SELECTED RETROFITTED CASES ALONG WITH THEIR FINANCIAL PARAMETERS

A. Case-I: Ramakrishna Mission Vivekananda Centenary College (RKMVCC), Rahara [9]

TABLE I
FINANCIAL PARAMETERS FOR DIFFERENT ENERGY SAVING ALTERNATIVES AT RKMVCC, RAHARA

Sl. No.	Energy Saving Measures	Investment in Rs.	Annual Savings in Rs. /Year	Annual Savings in kWh /Year	Payback Period (Yrs.)
1.	T12 is Replaced with LEDs (20 W) (Philips)	701.60	604.8	100.8	1 yrs. 2 months
2.	T12 is Replaced with CFLs (30 W)	51.84	432	72	1.4 months
3.	T12 is Replaced with T5 (33 W)	300.34	380.16	63.36	9.5 months
4.	Ordinary Fan (75 W) is replaced with BEE Star Rated Fan (55 W)	600.65	380.16	63.36	1 yrs.7 months
5.	Ordinary Fan (75 W) is replaced with Super Fan (35 W)	1596.67	691.2	115.2	2 yrs.4 months
6.	30 kW rooftop SPV	3000000	243000	40500	12 yrs.

B. Case-II: Indian Institute of Social Welfare & Business Management, Kolkata [9]

TABLE II
FINANCIAL PARAMETERS FOR DIFFERENT ENERGY SAVING ALTERNATIVES AT IISWBM

Sl. No.	Measure/ Proposal	Present Situation	New Situation	Annual Savings (Rs.)	Investment (Rs.)	Payback Period
		Electricity Bill (Rs.)	Electricity Bill (Rs.)			
1	Replacing Magnetic Choke with Electronic Choke of 200 TLs connected with new meter (Rs. 6.66/kWh)	1,35,384	86,154	49,231	36,000	9 months
2	Replacing Magnetic Choke with Electronic Choke of 200 TLs connected with old meter (Rs. 2.40/kWh)	48,787	31,046	17,741	36,000	2 years
3	Replacement of 10 nos. TL/60 W bulb – operating 8 to 10 hrs. per day–with 11/14W CFL (new meter Rs. 6.66/kWh)	8,440	1,969	6,471	1,500	3 months
4	Switching off 31 TLs in Computer Lab Room No. 115	21,606	10,803	10,802.88	NIL	Immediate
5	A/C Load Management	1,38,442	93,266	45,176	NIL	Immediate
6	Replacing an old 2 ton A/C with new Energy Efficient one in Computer Lab.	—	—	3953.60	22000	5 years 6 months

Further details with analysis of the above two case studies would be available in the paper, as reported in Issue 08, Volume 4 (August 2017) of IJIRAE.

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Moreover, a further study on retrofitted cases in India reveals the additional two case studies (Case – III & IV) along with their financial parameters as discussed in the present paper.

C. Case-III: Nabo Jibon Missionaries of Charity Brothers, Howrah [10]

TABLE III
FINANCIAL PARAMETERS FOR DIFFERENT ENERGY SAVING ALTERNATIVES AT NABO JIBON MC BROTHERS, HOWRAH

Sl No.	Energy Saving Measures	Investment in Rs.	Annual Savings in Rs./Year	Reasons for Implementing the Measures	Payback Period	Annual Energy Savings	
1	Replacement of 60 Watt incandescent lamps by 30 Watt CFL	Rs 2,600/-	Rs. 1,402/-	A 30 Watt CFL can save 50% more energy than a 60 Watt incandescent Lamp & a CFL has an average life span of 8000 hours When the incandescent lamp has an average life span of 1200 hours.	1 year 11 months	259.2 kWh	
2	Replacement of conventional Tube Lights(T8) by T5	Rs 15,980/-	Rs.7,417/-	A 28 Watt T5 can save upto50% more energy than a 40 Watt conventional Tube Light (with conventional ballast of 15 Watt) & a T5 has an average life span of 35000 hours When the conventional Tube Light has an average life span of 800 hours.	2 years 2 months	1,370.52 kWh	
3	Replacement of conventional ceiling Fan by Super Fan	Rs.1,38,000/-	Rs.49,277/-	A 35 Watt Super Fan can save more than 50% energy than an 80 Watt Conventional Ceiling Fan.	2 years 10 months	9,108 kWh	
4	Installation of Rooftop Solar Photo Voltaic System(With subsidy)	a) For Standalone System	With subsidy 4,38,900/-	Rs 20,320/-	A 3.3 kW Rooftop Solar Photo Voltaic System with battery is sufficient to fulfil minimum energy requirement.	21 years 8 months	3,756 kWh
			Without subsidy Rs 6,27,000/-			30 years 11 months	
		b) For Grid Connected System	With subsidy Rs. 3,64,000/-	Rs.44,575/-		9 years	
			Without subsidy Rs. 5,20,000/-			12 years 10 months	
5	Installation of 1No. of 15 m3 Biogas Plants	With subsidy Rs. 57,562.50/-	Rs.60,921/-	1 No. of 15 m3 Biogas Plant will save 63 no. of LPG cylinder (approx) per year.	1 year	890.6kg	
		Without subsidy Rs.87,562.50/-	Rs.60,921/-		1 year 6 months		
6	Rain water Harvesting	Rs. 62,756/-	Rs. 1175/-	This system will minimize the requirement of water through the pumping system & it will save 0.596 kWh energy per day.	53 years	217.54 kWh	
7	Installation of Solar water heating system	a) ETC Type	With subsidy Rs. 1,40,000/-	Rs.12,984/-	It will provide 500 liter hot water per day without using electrical energy.	10 years 10 months	2,400 kWh
			Without subsidy Rs 2,00,000/-			15 years 5 months	
		b) FPC Type	With subsidy Rs. 1,54,000/-			11 years 11 months	
			Without subsidy Rs 2,20,000/-			17 years	

D. Case-IV: International Society for Krishna Consciousness, Mayapurdam [11]

Sri Mayapur Dham is situated on the banks of the Ganges River, near Nabadwip, West Bengal, India and 130 km north of Kolkata. Mayapur is the headquarters of ISKCON (International Society for Krishna Consciousness) and considered as a holy place of Hinduism. The ISKCON was founded by Swami Shrila Prabhupada in the West in 1966.

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TABLE IV
FINANCIAL PARAMETERS FOR DIFFERENT ENERGY SAVING ALTERNATIVES AT ISKCON, MAYAPURDHAM

Sl. No.	Energy Saving Measures	Investment in Rs.	Annual Savings in Rs./Year	Payback Period (Yrs.)
1.	Assessment of the Potential of Biomass based Cogeneration[12]	15501750	5304562.50	2.92
2.	Potential of Rooftop Solar System	139500000	13332747	7.33
3.	Sintex Floating Type Biogas Plant in Gada Kitchen	60000	20732	2.92
4.	34 Nos. 400 W Street Lights replaced with 33 Nos. 55 W LED	479902	361328.10	1.33

VII. RESULTS & DISCUSSIONS

A. Application of AHP in the Case Study of Nabo Jibon Missionaries of Charity Brothers, Howrah

Here, we consider seven alternatives and three criteria for each of the seven alternatives.

Alternatives:

- A1: Replacement of 60 Watt Incandescent lamps by 30 Watt CFL.
- A2: Replacement of conventional Tube Lights (T8) by T5
- A3: Replacement of conventional Ceiling Fan by Super Fan.
- A4: Installation of Rooftop Solar Photo Voltaic System
- A5: Installation of 1No. of 15 m³ Biogas Plants
- A6: Rain water Harvesting &
- A7: Installation of Solar water heating system (ETC Type).

Criteria:

- C1: Investment in Rs.
- C2: Annual savings in Rs. /Year &
- C3: Payback period in Year.

TABLE V
PAIR WISE COMPARISONS MATRIX AMONG THE THREE CRITERIA OR FINANCIAL PARAMETERS FOR NABO JIBON MC BROTHERS

Criteria	Investment in Rs.	Annual Savings in Rs./Year	Payback Period (Yrs.)
Investment in Rs.	1.00	0.75	1.33
Annual savings in Rs./Year	1.33	1.00	2.00
Payback Period (Yrs.)	0.75	0.50	1.00

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TABLE VI
FINDING OUT CONSISTENCY RATIO FROM THE RESPONSES FOR NABO JIBON MC BROTHERS

Weights (w) or Priority Vector (obtained by Geometric Mean)	Consistency Measure	Ratios (Consistency Vector)	λ_{max}	Consistency Index (CI)	Consistency Ratio (CR) = CI / RI
0.322	0.965	3.002	3.109	0.055	0.06
0.446	0.965	2.164			
0.232	0.965	4.162			

The consistency ratio (C. R.) calculated for the financial parameter, i.e. C.R. obtained in above Table - VI, is less than 0.1, indicating sufficient consistency. Therefore the experimental result is validated for application of the AHP.

TABLE VII
RELEVANT VALUES OBTAINED FROM THE CASE STUDY OF NABO JIBON MC BROTHERS

Criteria Alternatives	Investment in Rs.	Annual Savings in Rs./Year	Payback Period (Yrs.)
Replacement of 60 Watt Incandescent Lamps by 30 Watt CFL	2600	1402	1.92
Replacement of conventional Tube Lights (T8) by T5	15980	7417	2.17
Replacement of conventional Ceiling Fan by Super Fan	138000	49277	2.83
Installation of Rooftop Solar Photo Voltaic System	364000	44575	9
Installation of 1No. of 15 m ³ Biogas Plants	57562.50	60921	1
Rain water Harvesting	62756	1175	53
Installation of Solar water heating system (ETC Type)	140000	12984	10.83

TABLE VIII
COMPUTATIONS FOR FINDING OUT THE RELATIVE INDEXES OF INDIVIDUAL FINANCIAL PARAMETERS CORRESPONDING TO DIFFERENT RETROFITTING ALTERNATIVES FOR NABO JIBON MC BROTHERS

Criteria Alternatives	Investment in Rs.	Relative Index (R. I.) of Investment	Annual savings in Rs./Year	Relative Index (R. I.) of Annual Savings	Payback Period (Yrs.)	Relative Index (R. I.) of Payback Period
Replacement of 60 Watt Incandescent Lamps by 30 Watt CFL	2600	0.003	1402	0.008	1.92	0.024
Replacement of conventional Tube Lights (T8) by T5	15980	0.020	7417	0.042	2.17	0.027
Replacement of conventional Ceiling Fan by Super Fan	138000	0.177	49277	0.277	2.83	0.035

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Installation of Rooftop Solar Photo Voltaic System	364000	0.466	44575	0.251	9	0.111
Installation of 1No. of 15 m ³ Biogas Plants	57562.50	0.074	60921	0.343	1	0.012
Rain water Harvesting	62756	0.080	1175	0.007	53	0.656
Installation of Solar water heating system (ETC Type)	140000	0.179	12984	0.073	10.83	0.134
TOTAL	780898.5	1.0000	177751	1.0000	80.75	1.0000

TABLE IX
FINAL COMPARISON OR JUDGMENT MATRIX SHOWING FINAL PRIORITY OF INDIVIDUAL RETROFITTING ALTERNATIVES IN THE STUDY OF NABO JIBON MC BROTHERS

Criteria Alternatives	Relative Index (R. I.) of Investment [0.322]	Relative Index (R. I.) of Annual Savings [0.446]	Relative Index (R. I.) of Payback Period [0.232]	Final Priority	Ranking
Replacement of 60 Watt Incandescent Lamps by 30 Watt CFL	0.003	0.008	0.024	0.010	7 th
Replacement of conventional Tube Lights (T8) by T5	0.020	0.042	0.027	0.031	6 th
Replacement of conventional Ceiling Fan by Super Fan	0.177	0.277	0.035	0.189	2 nd
Installation of Rooftop Solar Photo Voltaic System	0.466	0.251	0.111	0.288	1 st
Installation of 1No. of 15 m ³ Biogas Plants	0.074	0.343	0.012	0.180	4 th
Rain water Harvesting	0.080	0.007	0.656	0.181	3 rd
Installation of Solar water heating system (ETC Type)	0.179	0.073	0.134	0.121	5 th
TOTAL	1.000	1.000	1.000	1.000	-

As per the final ranking of the Alternatives shown in Table – IX above, the 4th Alternative i.e. Installation of Rooftop Solar Photo Voltaic System has achieved the highest rank followed by Alternatives - Replacement of conventional Ceiling Fan by Super Fan, Rain water Harvesting, Installation of 1No. of 15 m³ Biogas Plants, Installation of Solar water heating system (ETC Type), Replacement of conventional Tube Lights (T8) by T5 and the Replacement of 60 Watt incandescent lamps by 30 Watt CFL, respectively in the study of Nabo Jibon MC Brothers, Howrah.

Similarly, the final judgment matrix for the other case study of ISKCON Mayapurdam, is presented below and the subsequent discussions on the AHP output of rankings generated is also exposed accordingly in this paper.

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B. Application of AHP in the Case Study of ISKCON Mayapurdam

TABLE X
FINAL COMPARISON OR JUDGMENT MATRIX SHOWING FINAL PRIORITY OF INDIVIDUAL RETROFITTING ALTERNATIVES IN THE STUDY OF ISKCON

Criteria Alternatives	Relative Index (R. I.) of Investment in Rs. [0.294]	Relative Index (R. I.) of Annual Savings in Rs./Year [0.405]	Relative Index (R. I.) of Payback Period (Yrs.) [0.257]	Final Priority	Ranking
Assessment of the Potential of Biomass based Cogeneration	0.0997	0.279	0.201	0.19	2 nd
Potential of Roof Top Solar System	0.8969	0.701	0.506	0.68	1 st
Sintex Floating Type Biogas Plant in Gada Kitchen	0.0004	0.001	0.201	0.05	3 rd
34 Nos. 400 W Street Lights replaced with 33 Nos. 55 W LED	0.0031	0.019	0.092	0.03	4 th
TOTAL	1.000	1.000	1.000	1.000	-

After the four retrofitting alternatives are compared with each other and also with three criteria (financial parameters) individually, the ranking is found out according to the priorities expressed by the experts, responded in the questionnaires. As per the final ranking of the Alternatives shown in Table - X above, the 2nd Alternative i.e. Potential of Roof Top Solar System has achieved the highest rank followed by Alternatives - Assessment of the Potential of Biomass based Cogeneration, Sintex Floating Type Biogas Plant in Gada Kitchen and 34 Nos. 400 W Street Lights replaced with 33 Nos. 55 W LED, respectively in the study of ISKCON, Sri Mayapurdam.

C. Some Relevant Observations on Cost variation of Solar Modules vs. Building Materials based on Secondary Data

The scientific decision supporting tool, when applied on two cases as reported in Tables 1 and 2, ranked Roof Top Solar Photo Voltaic (RTSPV) system in top in Case I, where the option for RTSPV existed. It has been found in the present analysis also that in two new cases (Case III & Case IV), when this tool applied, again ranked the RTSPV in the top. This led to a confusion on an unbiasedness/ fairness of the decision supporting tool that encouraged the authors to carry further scientific investigations. It has been revealed that RTSPV has become more attractive in recent times because of at least the following reasons:

1. RTSPV would avoid the use of cement and steel as SPV modules would act as roof. The cost of constructing conventional roof is increasing as the price of Iron and Cement has been increasing as shown in Table XI below.
2. Cost of SPV modules has been decreasing steadily as shown in Table XII, thereby making RTSPV more economically attractive and electricity generated from such RTSPV systems has become competitive with the price of grid electricity.
3. Awareness campaign will promote people for the use of RTSPV, since this sustainable practice has reduced impact on the environment.
4. Finally, net metering facility has recently been introduced in many states including West Bengal. This facility has reduced the need for the battery storage which may cost as high as 40% of the whole system cost. This has made the RTSPV option almost maintenance free and more attractive.

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TABLE XI
PRICE SERIES FOR CONVENTIONAL BUILDING MATERIALS - IRON ORE AND STEEL OVER 2000-2010 [13]

Year	Iron Ore (Rs./ ton)	Price of Cement (Rs./ ton)
2000	1880.66	2044.2
2001	1969.25	1635.4
2002	1948.80	2044.2
2003	2139.60	2473.5
2004	2541.62	5110.5
2005	4360.96	3407.0
2006	5192.27	4361.0
2007	5682.88	5587.5
2008	9008.11	7120.6
2009	6173.48	4701.7
2010	4906.08	4769.8

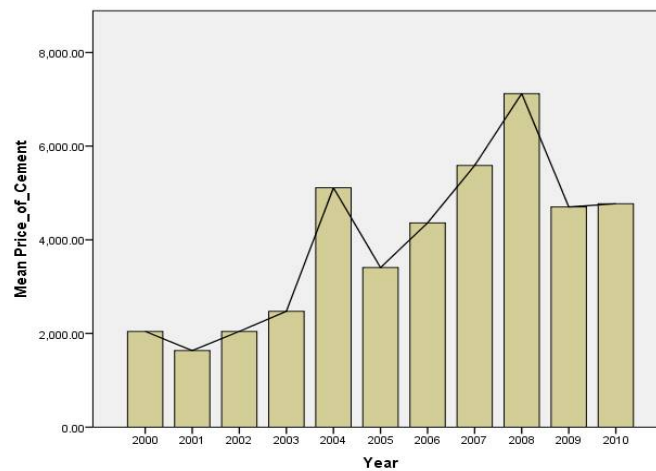


Fig. 1 Graph in SPSS software showing Rise in Mean Price of Cement over Eleven Consecutive Years

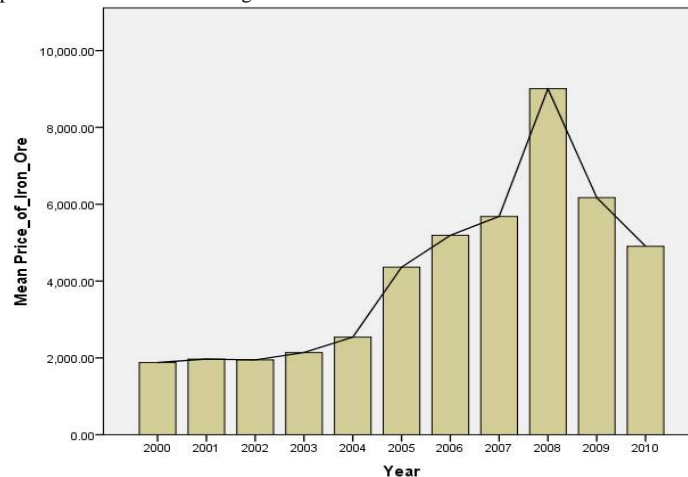


Fig. 2 Graph in SPSS software showing Rise in Mean Price of Iron Ore over Eleven Consecutive Years

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TABLE XII
TABLE SHOWING TOTAL PV MODULE COST (RS. /WATT) OVER 2010-2016 [14]

Sl. No.	Year	Production Scale of Electrical Energy by Solar (MW)	Total PV Module cost (Rs./watt)	Capital Cost Norm for Solar PV project (Rs. in Lakhs /MW)
1	2010	150	119.25	1690
2	2011	400	96.08	1530
3	2012	650	80.41	1000
4	2013	900	70.18	800
5	2014	1150	63.37	691
6	2015	1400	57.92	605.85
7	2016	2000	52	575.63

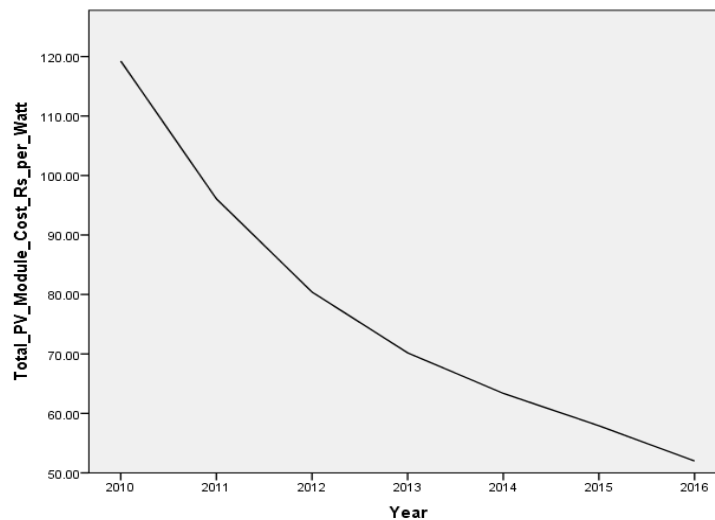


Fig. 3 Graph in SPSS software showing Fall in PV Module Cost over Seven Consecutive Years

The capital expenditure for solar power, or the cost of setting up a solar plant, will decrease gradually over each year (Fig. 3). This decrease is due to strong global learning effects (increased efficiencies due to experience gained over time), which push down the price of solar panels. We also observe local-level learning effects [16], which are not as strong, that marginally reduce non-panel costs over time and within a relatively short period of 6 years (2010 to 2016), there has been steep fall (approximately 66%) in Solar PV capital cost and tariff (from Rs. 1690 lakhs/ MW in 2010 to Rs. 575.63 lakhs/ MW in 2016).

Cost of manufacturing cement has risen over the years. The capital costs have been steadily rising (from an average of Rs. 2044.20 per tonne in 2000 to Rs. 4769.80 per tonne in 2010). Due to rapid industrialization, increased demand for steel is the common reason cited for the rise in price of iron ore. Indeed, the price of iron ore has risen from Rs. 1880.66 per tonne in the year 2000 to Rs. 4906.08 per tonne in 2010. Price of both Cement and Iron Ore in India reported highest in the period 2008 (Fig. 1 & 2).

Thus from a secondary study also, it can be concluded that application of a renewable energy device in the existing campus by means of retrofitting, is more financially reasonable than construction of a new greener building, revealed through AHP. Hence the Null Hypothesis (H_0) is rejected and the Alternative Hypothesis (H_1) is accepted.

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VIII. CONCLUSION

Solar energy being an alternative for fossil fuels and such renewable resource driven systems, where given as an option to the finance experts/decision makers of the two institution (Case III & IV), have achieved the highest rank in our present study, as per the reflection of the market. The SPV (Solar Photo Voltaic) is not only contributing as sustainable energy source but also improving the inside comfort on top floor [15]. Moreover, by accepting the option of installing rooftop solar PV module, we can economically achieve the green sustainability or can demonstrate energy efficient and sustainable technologies, avoiding the price of construction of a new green building, which incur additional land cost (land is a scarce resource in the city) and cost of miscellaneous civil works also. This trend of favourable scenario for solar energy systems has perhaps been correctly sensed through AHP, without which, chaos and conflict might have gone against solar energy systems, which are apparently less attractive because of higher initial investment. This is thus one application of scientific decision supporting tool in optimization of energy consumption and identification in the preparation of long term planning and policy for investment in rooftop solar projects (RTSPV) by retrofitting, where, AHP helps the institutional experts, without any biasness, in making decision for prioritization of energy savings alternatives, in a MCDM environment, by eliminating the conflicting opinions from the system.

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REFERENCES

- [1] Haluzan, N. (2012), "Renewables Talk: Talking and discussing renewable energy". [Online]. Available: <http://renewablestalk.blogspot.in/2012/11/energy-conservation-is-important-from.html>
- [2] Inter Academy Council, IAC. (2000), "Energy demand and efficiency". [Online]. Available: <http://www.interacademycouncil.net/File.aspx?id=24444>
- [3] Paradis, R. (2016), "Retrofitting Existing Buildings to Improve Sustainability and Energy Performance". [Online]. Available: <https://www.wbdg.org/resources/retrofitting-existing-buildings-improve-sustainability-and-energy-performance>
- [4] Riddell, A., Ronson, S., Counts, G., Spenser, K. (1999), "Towards Sustainable Energy: The current Fossil Fuel problem and the prospects of Geothermal and Nuclear power". [Online]. Available: https://web.stanford.edu/class/e297c/trade_environment/energy/hfossil.html
- [5] Ciolkosz, D. (2017), "What is Renewable Energy?". [Online]. Available: <https://extension.psu.edu/what-is-renewable-energy>
- [6] Indian Green Building Council, IGBC. (2015), "IGBC Green New Buildings". [Online]. Available: <https://igbc.in/igbc/redirectHtml.htm?redVal=showGreenNewBuildingsnsign>
- [7] Bassi, S. (2001), "Roadmap for Enhancing Energy Efficiency in New Buildings". [Online]. Available: http://www.esmap.org/sites/default/files/esmap-files/1272009111005_BEEC_Roadmap%20for%20Enhancing%20Energy%20Efficiency%20in%20New%20Building.pdf
- [8] The Energy and Resources Institute, TERI. (2013), "Roadmap for Incorporating Energy Efficiency Retrofits in Existing Buildings". [Online]. Available: http://cbs.teriin.org/pdf/Energy_Efficiency_Retrofits_in_Existing_Buildings.pdf
- [9] Majumdar, S. B., Choudhury, B. K., "Greening Buildings: Action Based on Identification of Retrofitted Parameters", International Journal of Innovative Research in Advanced Engineering (IJIRAE), ISSN: 2349-2163 Vol. 4, Issue 08, 2017.
- [10] Pratim, Dipayan, "Energy Audit Report of Nabo Jibon, Howrah", conducted by Energy Management Department, Indian Institute of Social Welfare & Business Management, 2013.
- [11] Gupta N., "Sustainable Energy Studies at Sri Mayapur Dham", conducted by Energy Management Department, Indian Institute of Social Welfare & Business Management, 2015.
- [12] Dutta P., "Assessment of the Potential of Biomass based Cogeneration at Sri Mayapur Dham", conducted by Energy Management Department, Indian Institute of Social Welfare & Business Management, 2015.
- [13] Machline, Claude, "The Global Supply Chain Pricing Dynamics", (Table 2, p-8). Paper presented in the 21st Annual Conference, Brazil, May, 2010.
- [14] Gultai, A., Manchanda, S., Kacker, R. (2016), "Harvesting Solar Power in India!", Working Paper 329 of Indian Council for Research on International Economic Relations, p- 11, Fig. 6. [Online]. Available: http://icrier.org/pdf/Working_Paper_329.pdf
- [15] Kumar, A., Chani, P. S., Deoliya, R. (2014), "Green Retrofit Potential in Existing Research Laboratories and Demonstration of Energy Efficient and Sustainable Technologies: Case Study", p-404, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 3, Issue 3.
- [16] Shrimali, G., Srinivasan, S., Goel, S., Trivedi, S., Nelson, D. (2015), "Reaching India's Renewable Energy Targets Cost-Effectively", p-5. CPI (Climate Policy Initiative) Series. [Online]. Available: <https://climatepolicyinitiative.org/wp-content/uploads/2015/04/Reaching-Indias-Renewable-Energy-Targets-Cost-Effectively.pdf>