

Feasibility Study on Integration of Green Technologies in Prospective Construction Projects: A Case of Vishakhapatnam

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ABSTRACT

Purpose: *The construction sector is one of the important sectors that play an important role in country's infrastructure development. The haphazard urbanization, industrialization and population explosion, have driven this sector vulnerable in terms of causing impacts on the environment. The construction process involves several stages and numerous stake holders, while this sector remains unorganised in most developing countries. These unintegrated processes in urban expansion, development and construction lead to a huge amount of emissions that cause environmental degradation. This emphasises the need to establish the use of 'Green Technologies' and 'Green Materials' in the Construction Sector at least as a beginning to bridge the gap between practices in the allied sectors as well.*

Design/Methodology/Approach: *With a view to examine this possibility, the feasibility of green technologies was considered to be studied, for Eastern Vishakhapatnam, the selected study area, which is a developing potential zone identified for potential integration of Green Technologies in construction processes. A comprehensive literature review to identify the major accomplishments and shortcomings in the chosen field, followed by a pre-feasibility analysis was conducted through an organized site visit during an academic project that included personal interaction with the concerned stakeholders and an assessable questionnaire survey. The notion of this study was to collect the details of similar category projects for the incorporation of select 'green technologies' identified from relevant literature studies in domains such as energy, material and waste management, which are known to cause maximum impact on the environment. This procedure in turn formed the very basis of the overall methodology of this study.*

Findings/Result: *The analysis of outcomes of the survey helped in developing a breakthrough understanding about the stakeholder's potential and roles in the overall feasibility of integrating the Green Technologies. Nevertheless, the comparison of the prospective projects in the study area, with the existing projects of the same category that have successfully adopted the green technologies abroad, helped to optimize the framework of integrating green technologies, using green materials based on the above-mentioned domains, for the proposed pilot project. It is inferred from the analysis that it is possible to integrate green technologies in the domains of energy, materials and waste management in prospective projects, if certain constraints and challenges related to social, administrative and economic spheres are eradicated thus encouraging Sustainable Development.*

Originality/Value: *Integrated strategy of adopting green technologies with green construction practices, in major identified domains of energy, materials and waste management will fetch new outcomes and lead towards aiding sustainable development.*

Paper Type: *Ex-Post Facto Research*

Keywords: Construction Industry, Feasibility of Green technologies, Energy, Material and Waste management, Integration of Green Technologies, Sustainable Development.

1. INTRODUCTION :

As the building activities contribute to huge amount of carbon emissions, it is high time to initiate green technology implementation. Also, as high-demand lifestyle is responsible for increasing anthropogenic carbon emissions, emission mitigation policies, regulations and fuel switching measures result in carbon emission savings up to 25%. Similarly, shifting power generation technology from conventional methods to cogeneration or hybrid technology methods, result in substantial reduction in carbon emissions [1][2][3]. It has become important to reduce the consumption of energy during construction minimizing the energy foot print [4]. Though several factors may play a significant role in selecting green materials the local environmental factors contribute crucially in selecting materials and technology for a commercial green building complex [5][6]. Despite of some basic awareness and willingness regarding the green practices, the Indian construction industry is facing several challenges and issues towards its path to sustainability. These challenges have to be essentially addressed, yet have been neglected over many years. Although a few regulatory incentives encourage the green building market, the barriers to implementing green building technology still exist. It has become highly essential to adopt sustainable technologies to reduce the carbon emissions and to adopt alternatives like renewable energy resources, waste material recycling and developing construction materials from waste. These have been regarded as effective measures in sustainable practices by many researchers [7][8]. Authors like [4] have discussed strategies such as “Energy-Savings Tool for Building Construction” which can assist contractors in estimating and recording energy consumption. Findings of researchers while associating the green building materials with energy savings and studying the sustainability index etc., reveal that green building material is the only viable option that can be adopted in achieving an effective green rating as a move towards sustainability [9][10][11][12]. Also, green technologies are being sought to be incorporated in construction processes, within the important spheres of energy, material and waste management which is predominantly evident from the literature review. Nevertheless, this study further presents an overview related to the costs trends, awareness amongst stakeholders, the state of government incentives, the approach of top management etc. and uses these research findings to enable recommendations towards more sustainable project management practices in the construction industry.

2. RELATED WORKS :

During the study, a detailed analysis of other researchers’ findings was carried out and few observations of the reviewed literature are represented in Table 1.

Table 1: Related Works of Few Notable Authors

S.No.	Findings	Reference Number
1.	Achieving green rating and green building material application will also be indirectly helpful in reducing global climate change impact at local level by achieving reduction in local surface temperature.	[13][14][15]
2.	It has been illustrated with the help of case studies from India that, utilisation of wastes such as plastic, glass, scrap and even agricultural waste such as rice and wheat husk or construction demolition waste such as recycled concrete enhance energy efficiency during building construction. Few principles of sustainability such as: Economy of material and its effects, Life Cycle Assessment, energy efficient Design that is “livable and workable for humans”, have been discussed by authors further stating that Green technologies should be used in every phase of construction starting from site selection and foundation to MEP services like HVAC and Plumbing. Nevertheless, it is propagated that, a predominant alternative to achieve sustainability in construction practices is adopting green building materials in construction activities.	[16][17][18]

3.	The study titled “Solar Energy - Review of Potential Green & Clean Energy for Coastal and Offshore Applications” aimed to find out the various offshore energy applications and potential of solar energy to substitute conventional oil and gas fuels. It has been stated that Solar PV/T technology can cater the offshore energy requirement substantially. However, Levelized Cost of Energy (LCOE) of Solar per KWh is more than that of any other renewable energy; although mobility, portability and feasibility of offshore installations are the key factors which dominate amongst the renewable energy sources. Also, since the PV module conversion efficiency 15-20% commercially, the offshore wind turbines prove to be more competent owing to availability of stronger and more consistent sea breezes. Nevertheless it becomes necessary to demarcate the sensitive and vulnerable marine regions as protected zones.	[19][20][21]
4.	In a paper titled “Tidal Energy - An overview of Indian Scenario” the author has pointed out that tidal energy can be a major source of energy in coastal regions. Thus, in this background, the focus of the research is to examine the underlying feasibility of incorporating the green technologies in some prospective projects in the study area	[22]

3. RESEARCH GAP :

The adoption of green technologies extensively in construction practices looks like a myth. Through this study however, an attempt has been made to understand the feasibility of the same in select specific domains of energy, materials and waste management. Further, this can pave way to exploration of similar technologies in these or other domains and to adapt to the perspectives of the different stake holders. These approaches could extend to Cost benefit analysis to fetch more realistic outcomes.

4. RESEARCH AGENDA :

Exploring perception amongst the stake holders in implementing the green technologies and the feasibility of the same within conventional construction framework is the main research agenda.

5. OBJECTIVE OF THE STUDY :

- (1) The main objective of this study is to carry out the preliminary feasibility analysis over a range of applications of green technologies and possibilities of integration of the green technologies in the proposed projects based within the study area of Vishakhapatnam.
- (2) To identify the challenges in implementation of the green technologies in construction projects.

6. RESEARCH METHODOLOGY :

The initial step of the research study was to identify a sample site where there was scope for employing green technologies. Next, based on the outcomes from literature review, prospective green technologies that could be incorporated in construction practices were identified. These technologies were observed to be dominant in the three spheres of Energy, Material and Waste Management, with maximum of potential of integration with conventional construction practices. To measure the feasibility thus, a study area was carefully selected where there was scope for application of these green practices. A case study approach was adopted for research, involving a descriptive comparison between projects of similar nature, to those within the study area. Further, pilot surveys to understand the scope for integration of green technologies within the projects proposed in the study area, were carried out. Most of the required primary data concerning the study area and the projects within, was obtained with the help of a survey questionnaire, apart from the sourced secondary data gathered through relevant sources. Various green technologies that had the potential to be incorporated were identified and a preliminary feasibility study on these was carried out. The green technologies under above mentioned verticals were derived from literature reviews and case studies of projects of similar nature.

6.1 Study Area Background and Description:

Vishakhapatnam, a City located along the East coast of India, in the newly formed State of Andhra Pradesh has been proposed to be planned as one of the upcoming Smart Cities under the India Smart City Mission by Govt. of India. Following the regular codes of the mission, certain areas have been

identified for Redevelopment, Retrofitting and Green field development. Nevertheless, Vishakhapatnam also recently made headlines in November 2020 as it made its headway to the final list of “World Smart City Awards”, organised as part of Smart City Expo World Congress in Barcelona. An urban vicinity Kailasagiri, a hilltop park in the city of Visakhapatnam, and a part of the Smart city proposal of Vishakhapatnam, has been selected to conduct a thorough study, for analyzing the challenges in green technology integration that could emerge in the near future. This park was developed by the Visakhapatnam Metropolitan Region Development Authority (VMRDA) and comprises 380 acres (150 ha) of land covered with flora and tropical trees. The hill, at 173 metres (568 ft.), overlooks the city of Visakhapatnam. Kailasagiri, was devastated by the cyclone ‘Hudhud’ in 2014. As per news that has been appearing in the Indian Express, it is expected that Kailasagiri would undergo rapid development now. The Visakhapatnam Metropolitan Region Development Authority (VMRDA) has prepared proposals to develop Kailasagiri, submitted for restoration and redevelopment of 380 acres of Kailasagiri Hilltop Park under the Andhra Pradesh Disaster Recovery Project. The draft proposals prepared by the consultants were submitted to the World Bank, which agreed to sanction `56 crore loan for the project. It aims to redevelop Kailasagiri Hilltop Park as a world-class tourist destination with good recreational opportunities supported by infrastructure facilities. The land use map of Greater Vishakhapatnam represented in the Figure 1 highlights the land use pattern of the study area. The reason behind picking on the hill for the study was that the proposed infrastructure here has a lot of scope for incorporation of green technologies right from the basic solar street lighting to the innovative renewable energy generation. Also the proposal of a 120 m tall Sky-tower over the hill has been the focal point of attraction for all stakeholders. Similarly, other infrastructure developments in surroundings include Kapulappada hill near Vizag-Bheemili beach road, which is competing in development at a bustling pace, as the government has planned around 80-100 companies in the area to convert the hill to the next IT hub in the state, with an area of around 1,400 acres of land.

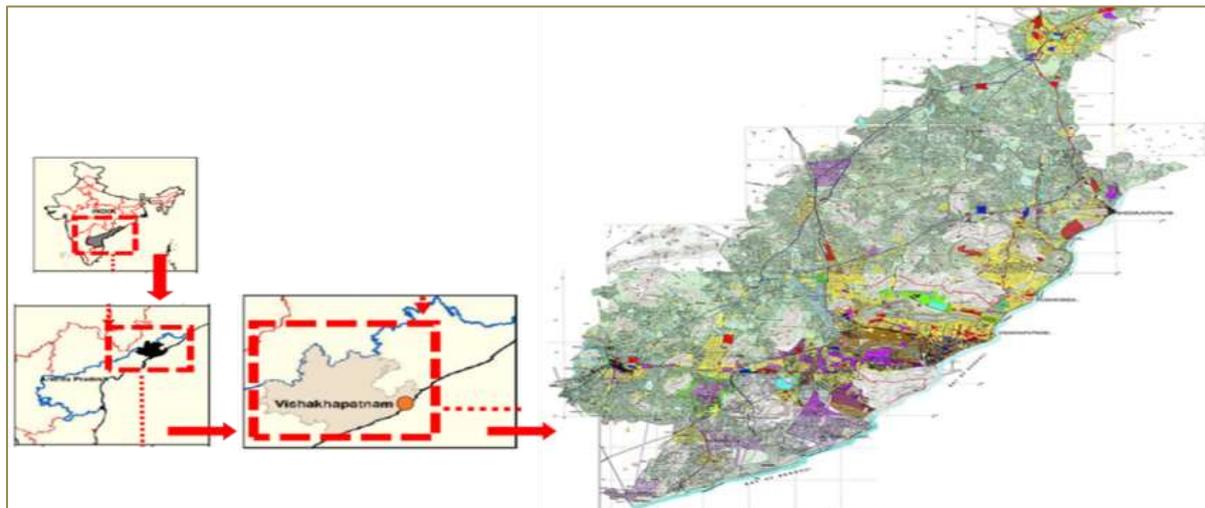


Fig. 1: Land use map of Greater Vishakhapatnam in the state of Andhra Pradesh Study area map
Source: compiled by the researchers

The proposal for redevelopment of Kailasagiri includes the following amenities like Ghat, road development, Sky tower, Amphitheatre, CCTV surveillance, Architectural lighting, Seating areas, Gaming arena, Admin building, Food courts, Kiosks, Restaurant, Children’s play area, Parking, Pathways, Viewpoints, Gardens, Toilets, Drinking water, Water fountains etc. The proposed Sky Tower atop Kailasagiri is 120 m tall. Nevertheless, it is proposed to be the tallest in the country along the lines of those in Singapore & New Zealand. It is designed to resist heavy wind loads and cyclones on the shore of the Bay of Bengal. There are proposed hotels, restaurants, amusement parks around it. The most striking of the projects, viz., the Sky Tower, the amusement park and the gaming arena have been selected for the preliminary feasibility study. Also, in order to understand various technologies that can be implemented in retrofitting of parks, a resource guide for Planning, Designing, and Implementing Green Infrastructure in parks has been referred and aided a better survey outcome for the study area and its surroundings.

7. STAKEHOLDER SURVEY AND DATA ANALYSIS :

A preliminary ground survey of the stake holders, officials and technocrats was conducted. The consolidated outcomes have been presented here, that throw some light on the awareness amongst the stakeholders, related to green rating, waste management, green materials, sustainability etc. Following is a summary of the general perspectives that emerged amongst stakeholders. Most stakeholders were of the opinion that there wasn't much difference between the construction practices in coastal regions and otherwise, except for factors such as precipitation, humidity, and salinity needed consideration in design for their implications on the structural stability. The use of green technology was largely believed by all to be limited and fragmented. Adaptation of primary technologies for solar & wind energy deployment were thought to bear some potential.

From the perspective of reducing energy consumption and dependability on conventional resources, it was noted that though conventional technologies such as solar panels had been adopted, alteration to the same, such as 'solar trees' had to be incorporated at an urban level due to the space constraints. Though there was scope for region specific strategies within tidal energy, it needed proper know-how, planning, infrastructure and framework for successful implementation. Nevertheless, the incorporation of tidal energy is believed to be challenging, as it requires a high amount of investment, technology, plant and equipment. In the material domain however, recycling of construction waste such as steel, debris (dismantled brick battens, wood, glass etc.) was explicitly believed to further improve energy efficiency. It was quoted that major part of concrete waste was however being dumped in nearby canals and lakes devoid of strict penalties or legal frameworks.

Further, in order to gain a deeper understanding, the survey focused on understanding feasibility of technologies pertaining to the following aspects:

- (1) Type of lighting fixture and kind of lighting design preferred in case of outdoor lighting for lighting optimization
- (2) Preferred turbine for utilization of the renewable wind energy
- (3) Share of Solar energy as a major source of power generation
- (4) Impact of orientation of the building on minimizing dependency on artificial lighting
- (5) Viability of tidal energy generation in study area
- (6) Optimization of energy performance of buildings with design strategies like vertical landscaping, wind towers, geo thermal heat sinks, etc.
- (7) Material preferences in construction like composite materials, Fly ash, glass, AAC blocks/hollow concrete or stone blocks, etc.
- (8) Preference and feasibility for Design strategies like cool-roofs, light-coloured facades, green roofs or walls, to combat the heat island effect
- (9) Landscape strategies to counter the surface runoffs and enhance storm water management
- (10) Substitute materials to steel for reduction in steel consumption
- (11) Effectiveness of implementation of waste management strategies like solar power compacting bins, mobile waste recyclers; optimum scale (truck scale/forklift scale/floor scale/bench scale) for accurate weighing of recycled waste, implementation of fiber sorting lines, etc.

The outcomes of the survey were classified according to the three foremost important domain verticals of Energy, Materials and waste Management. Few of the outcomes have been discussed below. Under the Energy segment, based on the data obtained for lighting fixture preferences and utilization it became clear based on the outcome of questionnaire that more people were preferring LED lights (40%) next to sodium vapour lamps (34%) followed by compact florescent lamps (29%) as represented in Fig 2.

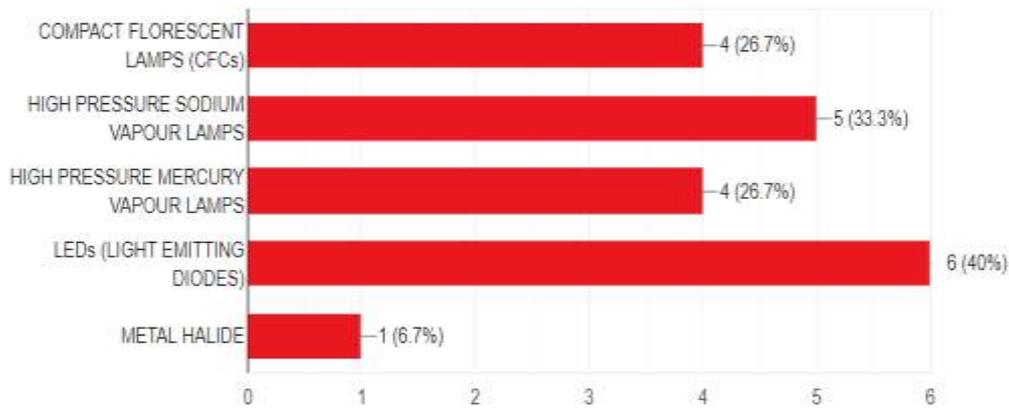


Fig. 2: Preferences of Light Fixtures map

Source: compiled by the researchers

Also, based on the data obtained for wind turbine preferences and utilization it became clear based on the outcome of the questionnaire that, the Micro Wind turbines were the most preferred ones (50%) followed by the Vertical Axis wind Turbines and Ducted wind turbines which were being given equal preference for (40% together); whereas the Horizontal axis wind turbines were least preferred as represented in Fig. 3.



Fig. 3: Preferences of type of turbine for utilization of wind energy map

Source: compiled by the researchers

Similarly, the survey also noted that 87.1 % of the stakeholders strongly believed that Solar Energy could be a major source of power generation. Renewable energy generation with the help of tidal energy was also reviewed for Vishakhapatnam, it being a strategic coastal zone. Approximately 19% of the stakeholders believed tidal energy to be a potential source of power generation for the coastal area, whereas 42 % of the stakeholders disagreed with the same at varying degrees. The remaining 39% of the stakeholders were unsure about the feasibility of application of tidal energy. Similarly, as represented in Fig. 4, the relation between the orientation of the building and its influence on day lighting has been analysed. Most stake holders agreed that orientation of building could improve day light and reduce dependency on artificial lighting, thus leading to major energy savings.

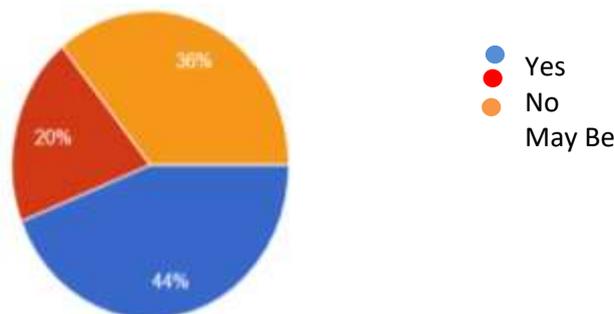


Fig.4: Orientation of building and its influence on daylighting map

Source: compiled by the researchers

Similarly, more than 67% of the stakeholders believe that design strategies like vertical landscaping improve the energy efficiency of the building; more than 61% stakeholders believe that wind towers aid in effective energy management of buildings; while more than 45% stakeholders believe that innovative strategies like geo thermal heat sinks can aid in efficient heating and cooling systems and save on energy. Next the material preference in the construction practices was studied. Many stakeholders (approximately 52%) reported to prefer composite materials as represented in Fig. 5.

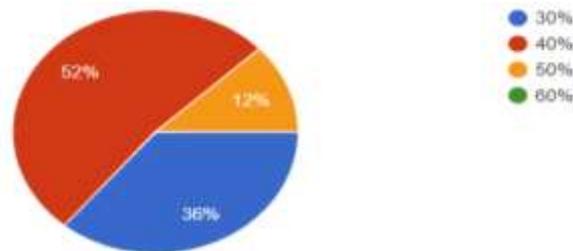


Fig. 5: Preference of composite materials in construction practice map

Source: compiled by the researchers

While glass is being considered as an alternative to steel in certain practices, sunshield and reflective glass types are the most popular ones for facades. Also, AAC blocks are the most preferred of materials followed by precast hollow concrete blocks and hollow stone blocks. Façade treatment for reducing the heat island effect is also popular invariably, the light-coloured facades and low VOC paints being most sought after and cost effective; while green roof strategies are also preferred to this effect. High Albedo Paving and Pervious paving etc., are other preferred materials for surface water runoff management. In terms of waste management techniques, solar power compacting bins are popular. It was also clear from the analysis that 51.6% stake holders and technocrats preferred utilization of fly ash in building construction in the range of 30% to 40% only, as represented in Fig 6. As evident in Fig.7, nearly 88% stakeholders agreed that this was one of the energy efficient waste management techniques; while approximately 80% people agreed that mobile waste recyclers were effective in high rise constructions. Similarly for accurate weighing of recyclable waste the truck scales and the fork lift scales were the most popular and effective of techniques; while installation of fiber sorting lines was seen as a feasible technology may as many as 76% stakeholders.



Fig. 6: Preference for utilization of Fly-Ash in construction practice map

Source: compiled by the researchers

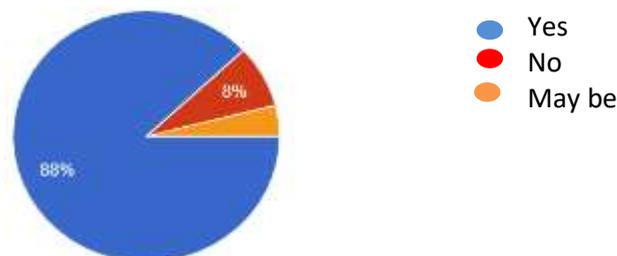


Fig.7: Preference for solar power compacting bins map

Source: compiled by the researchers

This study outcomes highlighted that there is considerable awareness prevailing amongst the stake holders and technocrats. However notable barriers included non-availability of space and materials, lack of support from the clients and few more practical difficulties. This rendered the developers incapable to implement the same in the day-to-day construction activities. It was however noticed that, in larger construction projects, considerable importance was being given to green ratings and sustainability initiatives.

8. FEASIBILITY STUDY OF GREEN TECHNOLOGIES :

Owing to the constraint of non-availability of the DPRs for the upcoming projects in the study area, a project based analysis was undertaken to determine the feasibility of green technologies within the projects in the study region.

Initially, in order to analyze the feasibility of various green technologies in the study region, a list of green technologies that can be incorporated in construction practices, was shortlisted by referring to various similar projects (termed as “Reference Projects” hereon); further, a basic survey pertaining to understanding the project-wise potential for these green technologies was undertaken.

For sake of analysis, these technologies were as well categorized under the three segments, viz. energy, materials and waste management. The overall idea was that, the projects which served as a reference for selecting green technologies, had been designed considering all the possibilities of their application. Thus, the shortlisted green technologies from several case studies became a benchmark for identifying implementation related challenges within the study area.

The following projects as represented in table 2 (hereon mentioned as “Reference Projects”) in respective categories were analysed to understand the green technologies implemented therein and to chart the feasibility of the same for similar projects proposed in the study area.

Table 2: Benchmark Green Technologies from Reference Projects map

IT Parks/Institutional campuses			
S. No.	Project/ Building	Green Practices Implemented	Green Outcome
1	IIT, Kanpur	Renewable Energy Installed: 13.86 KW Use of low energy/ green materials: Portland Pozzolona Cement with fly ash to reduce embodied energy of the building	Energy Consumption Reduction: 41% Reduction from GRIHA Benchmark 30% Annual Energy requirement for internal artificial lighting met by solar energy 100% annual energy requirement for hot water met by solar thermal hot water systems
2	Infosys Ltd., Hyderabad	Renewable Energy installed on site: 44KWp Installed capacity of solar energy: 44 KWp Use of ceramic tiles and carpets with recycled content Use of low energy material for internal partitions, paneling, false ceiling, and in-built furniture Use of low energy material for internal partitions, paneling, false ceiling, and in-built furniture	Energy Consumption reduction: 56% reduction from GRIHA benchmark
3	CII-Sohrabji Godrej Green Business Centre	Solar PV systems, indoor air quality monitoring, a high efficiency HVAC system, a passive cooling system using wind towers, high performance glass,	The building provides a 50% saving in overall energy consumption, 35 % reduction in potable water consumption and

		<p>aesthetic roof gardens, rain water harvesting, root zone treatment system, etc. Building Management system installed for real time monitoring of energy usage. 80% of materials used are from within 500 miles away from site. 20% of the building energy is from solar PV, installed with a capacity of 23.5kw. To improve the indoor air quality wind towers are being used for drawing fresh air into building and this reduces the pressure on air conditioning units.</p>	<p>usage of 80% of recycled / recyclable material. Use of aerated concrete blocks reduced the load on Air condition systems by 15-20%. Energy savings: 55% reduction, with ASHRAE 90.1 as the baseline 120,000 kWh / year. Reduction in CO 2 emissions - 100 tons / year (building is functional since January 2004).</p>
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Sports Arena

S. No.	Project/ Building	Green Practices Implemented	Green Outcome
1	National Stadium, Taiwan	World’s first solar powered arena of 8,844 solar panels. Vernacular raw materials sourced from Taiwan have been used	Generates 1.14 kwh per year, 100% self-sustainable Provides 10% energy to the surroundings Saves 660 tons of CO2 emission per year.
2	Marlins Park, U.S.A	Baseball ground with 35,000 capacity Waste energy Reduction Regionally Sourced Materials ‘Cool-roof’ technology for roofing	LEED, gold rated project Reduces Heat Island effect
3	Olympic Stadium, London	NO construction waste sent to landfills, Yet more often 98% recycled.	Zero Waste Project

Towers

S. No.	Project/ Building	Green Practices Implemented	Green Outcome
1	Menara Mesiniaga	Trusses of steel & aluminum Incorporates solar panels Vertical landscaping Naturally ventilated core	Passive Design in buildings reduces HVAC costs Used 20% less steel than normal; 80% of steel is recycled Renewable energy minimizes the costs of electricity
2	The Bahrain World Trade Centre	Uses wind turbines Accommodates 15% electrical requirements	
3	Hearst Tower, New York	Used glass & steel, contemporary design	
4	Carbon Tower, California	Used nano materials: (cross hatched lattice made of carbon fiber) which is several times stronger than steel	

Source: compiled by the researcher

Further, three different projects (termed as “representative projects” hereon) were considered from within the study region, to carry out a pre-feasibility mapping. A set of responses inferring to overall project feasibility were collected for the three representative projects (viz. Project A, B, and C). The general project feasibility outcome of these three projects came to be 61%, 25% and 14% respectively. Similarly, a separate set of responses denoting the potential of implementation of green technologies within these three projects were collected. The individual feasibilities for implementation of green

technologies in these three projects were recorded as a percentage, based on the outcomes of the survey. Next, the project feasibilities were plotted on y-axis, and potential feasibility of green technologies on the x-axis; the outcome was a Feasibility Graph, where three graph lines emerged viz. the Energy line, Material line and Waste management line.

The feasibility analysis done as shown in Fig.8, depicts three different feasibility factors in the energy, materials and waste management categories. The shaded area in this figure represents the common feasible area for integrated implementation of the shortlisted green technologies for all projects within the study area in Vishakhapatnam.

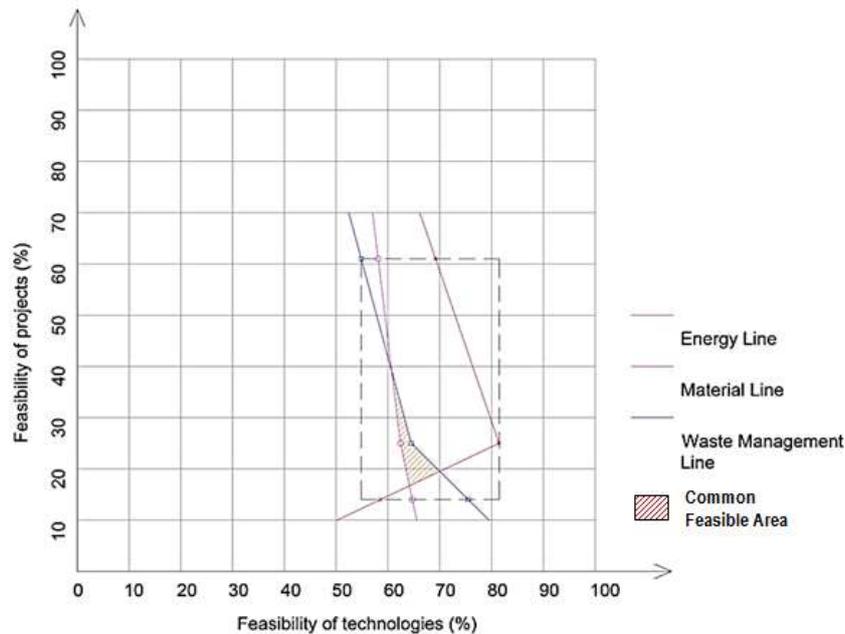


Fig. 8: Feasibility graph: Common Feasible Area for Energy, Material and Waste management related Green Technologies in study Region map

Source: compiled by the researchers

It is clear from the graph represented in Fig.8, that the projects implementing higher degree of green technologies are less viable and vice versa. Cost plays a very important role in any project. All these green technologies are costly when resulting in higher project costs. It is observed that, the capital costs are often high when various green techniques are used and thus cost control poses a major challenge. Also, the operating equipment used to implement green technologies is different from those used conventionally. Nevertheless, there is uncertainty in the performance of green technologies and unavailability of specifications for their use and low level of awareness. Nevertheless, the number of green material suppliers in the market is limited. Improper evaluation of performance of various green equipment and poor coordination between various stake holders of the project are other notable challenges.

Lastly, an attempt was made to work out the feasibility for a specific upcoming Sky Tower project in Kailasagiri. A similar kind of sky tower was considered in Auckland, New Zealand, which is already commissioned. Those technologies (from technologies involved in the survey) that were already implemented in Auckland sky city were sorted down and considered as feasible technologies for Auckland’s conditions. Now, these feasibilities were converted into Visakhapatnam’s conditions using the Feasibility Factors of the region which were obtained from the analysis. The feasibility percentage was depicted in Table 3.

Table 3: Calculation of Feasibility of Green Technologies in Kailasagiri Sky Tower map

Feasibility	Energy	Materials	Waste Management
Feasibility of Auckland sky city (%) ^(a)	55.5	42.8	61.7

Feasibility of Kailasagiri sky tower (%) (a*factor)	55*0.51 = 28%	42.8*0.49 = 21%	61.7*0.47 = 29 %
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Source: compiled by the researcher

Thus, the results obtained in Table 3, helped to infer that 28% of the assumed energy related technologies are feasible in Kailasagiri Sky Tower. Similarly, 21 % of assumed Material related technologies and 29 % of assumed Waste management related technologies are feasible in Kailasagiri Sky Tower.

9. CONCLUSION :

The various green technologies that can be implemented under the segments of energy, materials and waste management have been identified. In order to check the feasibility of the implementation of green technologies at the projects under consideration i.e., Indoor Stadium at MVP Colony, Chinna Waltair park and IT park at Kapulappada hill a pre-feasibility test was done. Since the Detailed Project Report (DPR) wasn't available, the pre-feasibility test was done considering the assumptions and case studies as reference. Based on the green technologies implemented there, feasibility as a percentage was calculated for the same technologies at the prospective projects in eastern Visakhapatnam. Nevertheless, due to the limitations faced every challenge and restriction faced by each technology could not be identified. Hence, common challenges that are faced during the implementation of the identified green technologies were examined.

This study has identified the feasibility of utilization of green technologies in existing conditions at Vishakhapatnam, based on three major aspects of energy, materials and waste management. It highlights that adopting these technologies is feasible to a considerable extent in projects like the Sky tower in Vishakhapatnam, and can be made further more feasible, if economic, societal, and management barriers are handled effectively and if there is proper planning right from the inception of such projects. Incentivizing and institutionalizing Green Technology processes in all major segments are therefore believed to be a key to mainstreaming green practices across the construction sector.

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