Green Construction in New Commercial Buildings

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Abstract

Studies have shown that the buildings and the construction sector accounted for 36% of final energy use and 39% of energy and process-related carbon dioxide (CO2) emissions in 2018, 11% of which resulted from manufacturing building materials and products such as steel, cement, and glass (Birlol, Andersen, 2019). In a time when global warming and climate change are at the forefront of everyone's minds, this needs to change. This model addresses possible solutions on how construction companies can be more green while constructing new skyscrapers, using AHP to determine which alternative is best out of HVAC systems, Grey Water, Smart Equipment, and Green building materials. Each of these alternatives is also tied to a list of criteria, including how cost-efficient they are if people and construction companies are willing to adopt these products, how easy it is to integrate into a building, and how much they cost compared to regular material, how large of an impact these changes will make, and efficiency is there a large difference in energy savings between the two products. Through the AHP model, it determined that Green HVAC systems were the best choice out of the alternatives. Showing that switching to eco-friendly HVAC systems makes the biggest ecological impact as well as fitting all the criteria the best.

Green Construction in New Commercial Buildings

When looking for a topic to try and research the group had to look no further than directly outside. Living in Pittsburgh Pennsylvania we live in one of the worst environmental cities in the nation. Ravaged by air pollution from steel mills, airport pollution, and new construction of skyscrapers downtown. This is a pressing issue that needs to be addressed. Although the group can not go back in time and fix the decades of pollution that steel mills and airports have caused to the city we call home, fixing the buildings that are being constructed is one way that could combat the terrible environmental conditions that is Pittsburgh. That is what the AHP model is being used for, testing to find the best way to implement eco-friendly construction of new buildings. A problem that not just our city faces but the rest of the world does as well. The goal of our AHP model is to find out how construction companies could be more green while building skyscrapers and being able to possibly attain a green efficiency rating. Throughout the rest of the report, the discussion will focus on the criteria that the model uses as well as the possible alternatives that can be implemented to make the construction of these buildings to be more sustainable and green.

Method

Sustainable construction involves using renewable and recyclable materials on building projects to reduce energy consumption and toxic waste. The primary goal of this initiative is to decrease the industry's impact on the environment by utilizing sustainable construction procedures, practicing energy efficiency, and harnessing green technology.

While several companies from different business sectors are doing ways to be more environmentally responsible, many focus their attention on the construction industry since it is considered the largest user of global resources. This sector alone is responsible for approximately 50% of the worldwide consumption of raw materials and is a significant waste producer. It makes construction unique because by changing outdated practices, the industry can significantly reduce the effects of global warming. Many construction firms are now recognizing the importance of sustainable and green building methods. With the increased interest in sustainability and energy conservation, new advances in technology, materials, and practices have been developed over the past decade to enable and promote overall efficiency.

One of the best ways to implement sustainability in construction is through materials. Technological advancements have paved the way for a new generation of more robust, lighter, and renewable building materials such as insulated access doors and panels, which can help push traditional practices to be more environment-friendly. These ecological materials also help promote a cleaner Earth by reducing the carbon footprint of the buildings that utilize these elements. They have the same purpose as their non-renewable counterparts while also aesthetically pleasing and much more efficient. Ergonomic construction isn't just about using renewable materials; it's also about implementing methods that enhance sustainable efforts. Construction sustainability isn't just beneficial for the environment, but it also supports the well-being of individuals and communities. There are many proven benefits of adopting the green initiative in the building industry.

Criteria

(**Cost**, Implementation,**adoption, efficiency**, impact)

The criteria that are used in the AHP model can be stemmed from the basics of a PESTEL analysis as well as trying to run a profitable business. Using a mix of both, the criteria assesses real problems that are faced in the construction sector today.

First looking at adoption, adoption can be defined as simply if the construction companies and the tenants of the building are willing to adopt the new green building. The adoption of the new eco-friendly market for green buildings has been growing. The green building market is anticipated to be among the fastest-growing industries worldwide. The number of LEED-certified projects in the United States rose from 296 certifications in 2006 up to over 67,200 in 2018 (Statista, 2022). With that statistic, it is easy to say that most of the construction companies would be on board. The projected revenue from the construction of green buildings in 2022 is forecasted to be almost $100 billion. The global green construction market size is expected to reach a value of more than US$ 774 billion by 2030 increasing at a CAGR of more than 11.8% over the next 8 years (Wilson, 2022). Construction companies would be foolish to go against one of the largest growing industry trends. As far as tenant adoption, it is said that tenants are willing to pay up to 15% more in rent for a building that is green-certified. It looks as if both the construction company and the tenant would be happy to have green buildings. No matter what alternative is used to get there.

The next criterion that is used in the AHP model is the cost, not only the cost of the building but also the cost versus a more common building supply. While the cost of green construction has decreased over the years, it's still generally more expensive than traditional

buildings. And depending on which green features and materials you use, the payback can be relatively short or quite long. It can also cost money to have a building certified green through programs such as Leadership in Energy and Environmental Design (LEED). For example, the One World Trade Center cost 3.9 billion dollars, the most expensive building in the whole United States with that. One World Trade Center received a Leadership in Energy and Environmental Design (LEED) Gold Certification, making it one of the most environmentally sustainable skyscrapers in the world.

Implementation is the next criterion**,** which would be how they decide to build the building that has the greatest impact on the surrounding environment. That is why the builder that built the One World Trade Center used LEED to see what would suit New York the best. On page 12 is the full report for the World Trade Center and you can see that some areas are better than others but the building has the gold in terms of LEED. From that, we have the impact of building a greener building. This is two-sided on one side yes the building would be good for the environment and show that the world is moving forward to a greener time but also you have to look at does building a skyscraper make sense like for example the Burj Khalifa the world's tallest building by definition it has a gold rating with LEED but right now it uses 250,000 gallons of water per day. The other side is yes you might be building a green building but how is the building being put together with such as transportation of the materials to the job site, it would be like going something halfway. If construction companies build green buildings they have to go green themselves.

Another criterion that is being used in the model is efficiency. This can simply be explained as if the alternative that is being presented is more efficient than the thing it is

replacing. The first alternative that can be looked at is grey water. The average commercial building uses about 20 gallons of water per square foot. For a building like the freedom tower in New York which is 3.5 million square feet, it would use about 70 million gallons a year. With a grey water system installed it is said that in a commercial building it could save about 6% a year on total water usage or in the case of the freedom tower 4.2 million gallons. Through a building's life, it can be substantial. Moving onto green construction material, concrete that emits C02 can be replaced with “green” concrete that is stronger and absorbs C02 from the city producing a carbon-negative building. Other alternatives include introducing new and improved HVAC systems, HVAC systems in a building are large burners of energy. Once again the new “green” HVAC system can help reduce energy costs by 30%. Finally looking at smart equipment, smart equipment such as smart light switches helps save as much as 40% in energy consumption and costs. All of our alternatives presented help to improve the efficiency of a building substantially.

Alternatives

When it comes to designing and implementing a green construction project, there are four primary alternatives that we took into consideration for this project. These alternatives include heating, ventilation, and air conditioning (HVAC) solutions, sustainable construction materials, smart equipment, and greywater.

HVAC

For our HVAC systems solution, several new and improved “Green” systems could be implemented to help sustainability. In NYC alone 42% of the total greenhouse gasses emitted in the city come from the heating and cooling of the buildings. Worldwide however 60% of the

energy consumption is used on HVAC systems. Through new systems that have been developed, new systems can reduce energy usage by 90%, lower temperatures faster, and use 30% less water. Although these systems are slightly more expensive, in the long run, they pay for themselves through substantially lower energy usage and costs.

Materials

The materials that buildings are constructed from are another alternative to help with their overall sustainability. It is common knowledge in today's day and age that skyscrapers emit tons of harmful chemicals and increase their surrounding area's heat signature. However, with new advancements in construction technology, new types of concrete are being researched and produced that are not only stronger but safer and more environmentally friendly. Certain concretes have been shown to absorb and store co2 that is emitted into the atmosphere, making a building carbon negative.

Smart Equipment

Another option for reducing building emissions and energy consumption, Smart Equipment use of technologies such as Artificial Intelligence, Monitoring Equipment, etc. building managers can calculate the exact amount of energy consumption that is used on a routine basis and can find the most simple and cost-effective way to reduce it. Smart Equipment is less of an alternative in this sense and functions more as a complimentary piece in the quest for a greener building. The downside to this however is that smart equipment for buildings is still relatively in its infancy and can come with a rather hefty price tag. The price of between $2.50 to $7.50 per square footing of a building is an incredibly hefty price however given that in other

changes to the building you save tens of thousands of dollars per year, especially when using greywater systems, you make up the loss for monitoring by saving elsewhere. According to manufacturers, buildings using smart equipment can save up to 15% on energy bills, up to 12% on heating bills, and another 15% on cooling bills.

Greywater

Greywater is also an alternative as it helps reduce the amount of water substantially as well, instead of using fresh water to flush toilets it filters water from the handwashing station and other water sources to use to flush. The average household uses 107,000 gallons of water per year. Given that 1,000 gallons of water are the equivalent of $1.50, the average household uses $160.50 worth of water per year. The average skyscraper uses roughly 20,000,000 gallons of water per year which at the rate of $1.50 per 1,000 gallons costs $30,000 per year. Greywater systems will cost around $800 to $4,000 for installation which will result in a savings of at most $29,200 in the first year alone and at least $26,000 in the first year alone.

Results

Based on the rankings of the AHP results we will be able to determine which alternative is most viable while considering every criterion.

Alternative(s) in it:	• Alt-HVAC • Grey Water • Materials • Smart Equipment
Network Type:	Bottom level
Formula:	`Not applicable`

Clusters/Nodes	• **Alternatives:**
	  ◦ **Alt-HVAC:** *Heating, Ventilation, air conditioning, cooling that is environmentally friendly*
	  ◦ **Grey Water:** *Wastewater created in households and offices without contamination*
	  ◦ **Materials:** *What buildings are made out of is also a great way to help sustainability*
	  ◦ **Smart Equipment:** *use of technologies such as Artificial Intelligence, Monitoring Equipment, etc*
	• **Criteria:**
	  ◦ **Adoption:** *how are the construction companies willing to use the materials*
	  ◦ **Cost:** *Expense*
	  ◦ **Efficiency:** *Energy saved compared to normal skyscrapers*
	  ◦ **Impact:** *measured by less landfill waste, less energy consumption, and less impact on the environment as a whole*
	  ◦ **Integration:** *how easily the materials would be integrated into the construction sites*
	• **Goal:**
	  ◦ **Sustainable Skyscrapers:** *Skyscrapers that are eco-friendly and operational*

Alternative Rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Alt-HVAC	0.1820	0.3640	1.0000	1
	Grey Water	0.0568	0.1136	0.3119	4
	Materials	0.1263	0.2525	0.6937	3
	Smart Equipment	0.1349	0.2698	0.7412	2

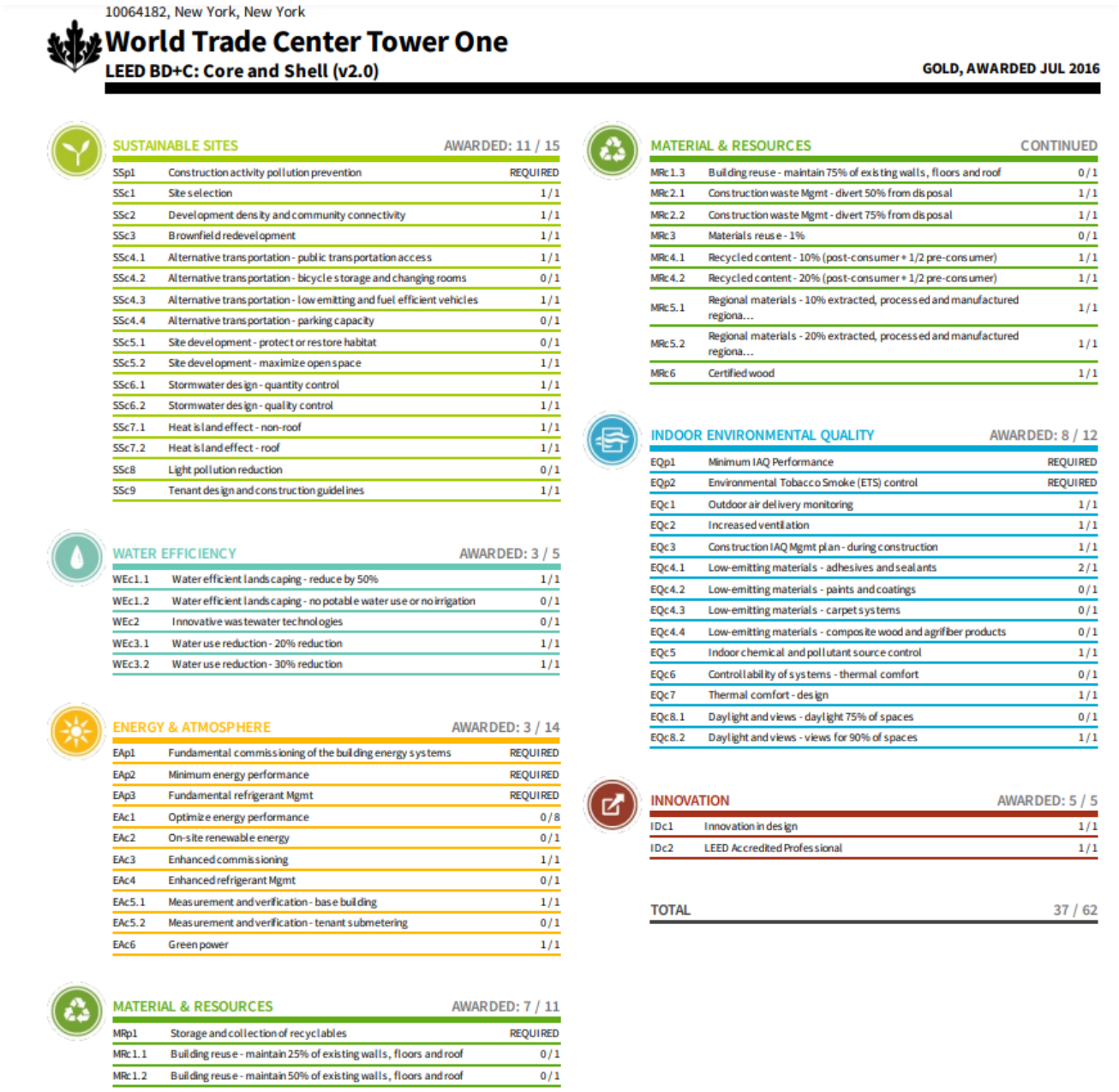
Outcome 1: Alternative HVAC

Eco-friendly HAVC systems are ranked number one in our results. It scored high in adoption, efficiency, and impact. At the same time, falling a bit short in cost and integration.

Outcome 2: Smart Equipment

Smart equipment scored high in impact, efficiency, and integration. Compared to the other alternatives, smart equipment also has a lower cost as well.

Figure 3



10064182, New York, New York

World Trade Center Tower One

LEED BD+C: Core and Shell (v2.0)

GOLD, AWARDED JUL 2016

SUSTAINABLE SITES AWARDED: 11 / 15

SSp1	Construction activity pollution prevention	REQUIRED
SSc1	Site selection	1 / 1
SSc2	Development density and community connectivity	1 / 1
SSc3	Brownfield redevelopment	1 / 1
SSc4.1	Alternative transportation - public transportation access	1 / 1
SSc4.2	Alternative transportation - bicycle storage and changing rooms	0 / 1
SSc4.3	Alternative transportation - low emitting and fuel efficient vehicles	1 / 1
SSc4.4	Alternative transportation - parking capacity	0 / 1
SSc5.1	Site development - protect or restore habitat	0 / 1
SSc5.2	Site development - maximize open space	1 / 1
SSc6.1	Stormwater design - quantity control	1 / 1
SSc6.2	Stormwater design - quality control	1 / 1
SSc7.1	Heat island effect - non-roof	1 / 1
SSc7.2	Heat island effect - roof	1 / 1
SSc8	Light pollution reduction	0 / 1
SSc9	Tenant design and construction guidelines	1 / 1

WATER EFFICIENCY AWARDED: 3 / 5

WEc1.1	Water efficient landscaping - reduce by 50%	1 / 1
WEc1.2	Water efficient landscaping - no potable water use or no irrigation	0 / 1
WEc2	Innovative wastewater technologies	0 / 1
WEc3.1	Water use reduction - 20% reduction	1 / 1
WEc3.2	Water use reduction - 30% reduction	1 / 1

ENERGY & ATMOSPHERE AWARDED: 3 / 14

EAp1	Fundamental commissioning of the building energy systems	REQUIRED
EAp2	Minimum energy performance	REQUIRED
EAp3	Fundamental refrigerant Mgmt	REQUIRED
EAc1	Optimize energy performance	0 / 8
EAc2	On-site renewable energy	0 / 1
EAc3	Enhanced commissioning	1 / 1
EAc4	Enhanced refrigerant Mgmt	0 / 1
EAc5.1	Measurement and verification - base building	1 / 1
EAc5.2	Measurement and verification - tenant submetering	0 / 1
EAc6	Green power	1 / 1

MATERIAL & RESOURCES AWARDED: 7 / 11

MRp1	Storage and collection of recyclables	REQUIRED
MRc1.1	Building reuse - maintain 25% of existing walls, floors and roof	0 / 1
MRc1.2	Building reuse - maintain 50% of existing walls, floors and roof	0 / 1

MATERIAL & RESOURCES CONTINUED

MRc1.3	Building reuse - maintain 75% of existing walls, floors and roof	0 / 1
MRc2.1	Construction waste Mgmt - divert 50% from disposal	1 / 1
MRc2.2	Construction waste Mgmt - divert 75% from disposal	1 / 1
MRc3	Materials reuse - 1%	0 / 1
MRc4.1	Recycled content - 10% (post-consumer + 1/2 pre-consumer)	1 / 1
MRc4.2	Recycled content - 20% (post-consumer + 1/2 pre-consumer)	1 / 1
MRc5.1	Regional materials - 10% extracted, processed and manufactured regiona...	1 / 1
MRc5.2	Regional materials - 20% extracted, processed and manufactured regiona...	1 / 1
MRc6	Certified wood	1 / 1

INDOOR ENVIRONMENTAL QUALITY AWARDED: 8 / 12

EQp1	Minimum IAQ Performance	REQUIRED
EQp2	Environmental Tobacco Smoke (ETS) control	REQUIRED
EQc1	Outdoor air delivery monitoring	1 / 1
EQc2	Increased ventilation	1 / 1
EQc3	Construction IAQ Mgmt plan - during construction	1 / 1
EQc4.1	Low-emitting materials - adhesives and sealants	2 / 1
EQc4.2	Low-emitting materials - paints and coatings	0 / 1
EQc4.3	Low-emitting materials - carpet systems	0 / 1
EQc4.4	Low-emitting materials - composite wood and agrifiber products	0 / 1
EQc5	Indoor chemical and pollutant source control	1 / 1
EQc6	Controllability of systems - thermal comfort	0 / 1
EQc7	Thermal comfort - design	1 / 1
EQc8.1	Daylight and views - daylight 75% of spaces	0 / 1
EQc8.2	Daylight and views - views for 90% of spaces	1 / 1

INNOVATION AWARDED: 5 / 5

IDc1	Innovation in design	1 / 1
IDc2	LEED Accredited Professional	1 / 1

TOTAL 37 / 62

This is the full breakdown of the LEED report for the World Trade Center building One.

Conclusion

Through the AHP model, it can conclude that through the testing, the ideal way to help make construct green skyscrapers is through the use of new and improved HVAC systems, followed by smart equipment, building material, and then grey water. HVAC systems relate to the criterion the best. Being cost-efficient, easy to integrate, people are willing to adopt it, and finally, easily able to integrate into the new buildings. Although all options are great ways to make a building become green and possibly get a green" efficiency rating the largest impact was through the HVAC systems.

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