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Article

Sustainability assessment with the green retrofitting concept for building: A study case in the Gresik regency, Indonesia

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Abstract: In green construction, sustainable resources are essential. One such material is copper, which is widely utilized in electronics, transportation, manufacturing, and residential buildings. As a very useful material, it has many beneficial impacts on human life. Observed from the recent demand spike is in line with the overall trend and the current growing smelter construction in Indonesia. Researchers intend to adapt the existing Copper Smelting Plant Building into an environmentally friendly building as a part of the production chain, in addition to reducing public and environmental concerns about the consequences of this development. We have identified a disparity in cost, where the high cost of green buildings is an obstacle to its implementation to enhance the cost performance with increased renewable energy of the Smelter Construction Building, this study investigates the application of LEED parameters to evaluate green retrofit approaches through system dynamics. The most relevant features of the participant assessments were identified using the SEM-PLS approach, which is used to build and test statistical models of causal models. We have results for this Green Retrofitting study following significant variables according to the following guidelines: innovation, low-emission materials, renewable energy, daylighting, reducing indoor water usage, rainwater management, and access to quality transit.

Keywords: renewable energy; LEED; copper smelter; system dynamics; SEM-PLS

1. Introduction

One of the biggest energy consumers in the world is the building sector. This sector provides about 30% of the country's primary energy needs, especially in the warm and humid Southeast Asian region (Ali et al., 2024), in accordance with the Indonesian Central Agency of Statistics (Statistics Indonesia, 2023) reports that the country's industrial and construction sector uses 53.4% of its total energy consumption included in the Smelter industry where this copper materials are produced there. As a result of the building industry's high potency energy usage, detrimental impacts on the natural world, and wasteful use of material, the percentage of Green Buildings (GB) is increasing globally (Atabay et al., 2020). Among other things, this construction development's significant energy consumption is a major contributor to climate change and a serious environmental danger (Dandia et al., 2021). Apart from innovation, sustainability has become a crucial factor in determining competitiveness within the construction sector (Zhang et al., 2024), renovations play a particularly important role in augmenting the energy efficiency of building materials during this period of growing emphasis on environmentally friendly buildings (Aktas and Ozorhon, 2015). Furthermore, there are ongoing efforts to create sustainable buildings (Ibrahim et al., 2023) that have low energy requirements and available Renewable Energy Sources (RES), it is critical to overcome the high energy usage in existing buildings (Birkha Mohd Ali et al., 2021; Hashempour et al., 2020; Okpalike et al., 2022). Conversely, it is generally found that retrofitting of existing buildings tends to be more costly about 1.58% (Sun et al., 2019), premium cost (Dwaikat and Ali, 2016). Sustainable development, incorporating the concept of green retrofitting, is an effective approach to address the increasing obsecration for energy-saving measures (Chel and Kaushik, 2018; El-Darwish and Gomaa, 2017; Husin and Kristiyanto et al., 2024). Through the utilization of alternative energy sources (Qin et al., 2012), costs can be decreased, and shortened construction time, thereby exceeding the requirements of the Green Building Assessment (Husin and Priyawan et al., 2023). Considering the impact and consequences of Smelter processing waste which can cause sources of pollution and impact on the environment, human health, and the biosphere (Filimonova et al., 2015; Izydorczyk et al., 2021; Zheng et al., 2021) including the absence of government support for sustainability (Darko et al., 2017). This can affect the achievement of the concept of GB with sustainable resources for the goal of conservation, including water conservation (Annisa and Maknun, 2024), land, and nature.

Numerous studies to assess sustainability (Chi et al., 2020; ElSorady and Rizk, 2020; Yamany et al., 2016) with minimizing the current expenses associated, provides a multitude of advantages in terms of economics (Maria, 2011), social influence, with the Green Building concept, particularly in the initial phase of Green Retrofitting research. In this study, the researchers utilized LEED v4 BD + C parameters as a sustainable evaluation of existing Copper Smelter Buildings to identify a disparity in high-cost GB with system dynamics as automation assessment tools to analyze the most relevant factor for implementation in Indonesian Smelter.

2. Literature review

2.1. Green building and green retrofitting concept

Green Building (GB) is an application of a concept that aims to lower greenhouse gas emissions in the world's construction segment through the improvement (He et al., 2019). The practice of GB in Indonesia still has many obstacles (Pahnael et al., 2020) especially for high initial cost, no incentive and reduced tax, the beneficial environmental impacts of GB, and stimulating the building sector to adopt GB guidelines during the scheme, development, and construction of the project phases (Jaradat et al., 2024). The advantages of implementing the Green Building concept in buildings are achieving efficiency in reducing the impact of carbon emissions by up to 38%. For this reason, a process is needed so that the contribution of carbon emissions contained during implementation stages up to building operations can be minimized (Besana and Tirelli, 2022).

Green retrofitting (GR) is a strategy to improve energy efficiency and building performance. Some countries have implemented green retrofitting including installing energy-saving equipment (Haruna et al., 2020), control technology devices, retrofitting windows and walls, installing heating and cooling technology (Sigrist et al., 2019), enhancing the thermal insulation performance of the roof system (Fan and Xia, 2017), reduce building heating load (Akram et al., 2022) and upgrading the ventilation system.

2.2. LEED (leadership in energy and environmental design)

One of the leaders in sustainability assessment, LEED-certified buildings can increase efficiency (Mapp et al., 2011), save costs, lower carbon emissions, and compose a healthier environment for people. LEED categories can also contribute towards achieving the United Nations (UN) Sustainable Development Goals (SDG), however, the analysis reveals that the main challenges to obtaining GB accreditation during operational stages are discrepancies in government laws (Karamoozian and Zhang, 2023) which is a primary SDG in the environmentally friendly building rating system (Chi et al., 2020). To achieve LEED certification, a project earns LEED certification by satisfying a series of prerequisites and credits about carbon emissions, internal environmental quality, energy consumption, water usage, waste management, transportation, materials, and human health. The (U.S. Green Building Council LEED v4.1, 2022) verifies and evaluates projects before assigning points that match LEED certification levels: Certified (40–49 points), Silver (50–59 points), Gold (60–79 points), and Platinum (80+ points). We chose the LEED compared to other certifications due to the complexity of the Smelter and the significant credit rating required in the application process.

The category credit assessment of LEED is shown in **Table 1** represents of all levels that we will create starting with Basic, Certified, Silver, Gold, and Platinum.

Table 1. Category silver of LEED v4.1 building design and construction (BDC) checklist.

Assessment Credit				Category	Possible Point
1	0	0	Credit	Integrative Process	1
11	0	0	Location and Transportation		16
0			Credit	LEED for Neighborhood Development Location	16
0			Credit	Sensitive Land Protection	1
1			Credit	High-Priority Site and Equitable Development	2
4			Credit	Surrounding Density and Diverse Uses	5
4			Credit	Access to Quality Transit	5
1			Credit	Bicycle Facilities	1
1			Credit	Reduced Parking Footprint	1
0			Credit	Electric Vehicles	1
6	0	0	Sustainable Sites		10
Y			Prereq	Construction Activity Pollution Prevention	Required
1			Credit	Site Assessment	1
0			Credit	Protect or Restore Habitat	2
1			Credit	Open Space	1
1			Credit	Rainwater Management	3
2			Credit	Heat Island Reduction	2
1			Credit	Light Pollution Reduction	1
7	0	0	Water Efficiency		11
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required

Table 1. (*Continued*).

Assessment Credit				Category	Possible Point
1	0	0	Credit	Integrative Process	1
7	0	0	Water Efficiency		11
Y			Prereq	Building-Level Water Metering	Required
1			Credit	Outdoor Water Use Reduction	2
3			Credit	Indoor Water Use Reduction	6
2			Credit	Optimize Process Water Use	2
1			Credit	Water Metering	1
19	0	0	Energy and Atmosphere		33
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
3			Credit	Enhanced Commissioning	6
10			Credit	Optimize Energy Performance	18
1			Credit	Advanced Energy Metering	1
0			Credit	Grid Harmonization	2
4			Credit	Renewable Energy	5
1			Credit	Enhanced Refrigerant Management	1
6	0	0	Materials and Resources		13
Y			Prereq	Storage and Collection of Recyclables	Required
2			Credit	Building Life-Cycle Impact Reduction	5
1			Credit	Environmental Product Declarations	2
1			Credit	Sourcing of Raw Materials	2
1			Credit	Material Ingredients	2
1			Credit	Construction and Demolition Waste Management	2
6	0	0	Indoor Environmental Quality		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
1			Credit	Enhanced Indoor Air Quality Strategies	2
1			Credit	Low-Emitting Materials	3
0			Credit	Construction Indoor Air Quality Management Plan	1
1			Credit	Indoor Air Quality Assessment	2
1			Credit	Thermal Comfort	1
1			Credit	Interior Lighting	2
1			Credit	Daylight	3
0			Credit	Quality Views	1
0			Credit	Acoustic Performance	1
2	0	0	Innovation		6
2			Credit	Innovation	5
0			Credit	LEED Accredited Professional	1

Table 1. (*Continued*).

Assessment Credit				Category	Possible Point
1	0	0	Credit	Integrative Process	1
0	0	0	Regional Priority		4
0			Credit	Regional Priority: Specific Credit	1
0			Credit	Regional Priority: Specific Credit	1
0			Credit	Regional Priority: Specific Credit	1
0			Credit	Regional Priority: Specific Credit	1
58	0	0	Total Possible Points:		110

2.3. Dynamic system modeling

A technique for assessing the cumulative computation of the number of cost flows and performance against changes in time is called system dynamics (SD) (Sahlol et al., 2021) and develop comparative financial feasibility scenarios for the project (Husin and Berawi et al., 2015). In the meantime, determining the problem formulation that will be posed by creating the dynamic system is the first step in creating a dynamic system model (Sweeney and Sterman, 2000).

3. Methodology

Through a verification method, researchers gather primary data in order to assess existing buildings that satisfy GB standards (Husin and Priyawan et al., 2023). Primary data reflects the implementation of the LEED Guidelines v4.1 at this stage, data use begins with secondary data available in the company environment, such as energy consumption data, and other existing building data. Besides that, secondary data in the form of project documents such as existing drawings, and facility operational data, and staff operations will also be utilized. During the development of the questionnaire, we take a look for those that have the most significant influence. When formulating the questionnaire, the researcher refers to the indicators that have been identified and presented by previous researchers. This questionnaire was distributed to project colleagues, especially on the existing Smelter building project, including those who were directly and indirectly involved. In analyzing the data, an instrument is needed to test the variables contained in this research by utilizing a simulation tool called Structural Equation Modeling (SEM) using SMART-PLS (Partial Least Squares) software 3.0. Apart from that, we will conduct interviews to gain a deeper understanding. According (Husin and Kristiyanto et al., 2024) using this tool, we aim to identify the main factors and dominant subfactors that influence the cost efficiency that we examine SMART-PLS is a widely used and well-known data analysis software in scientific research where we will find the sustainability assessment variable related to retrofitting existing buildings in the case study.

The aim of this research is to determine the significant effect of implementing cost efficiency on green construction retrofit of Smelter Buildings based on LEED parameters as an assessment of the green retrofitting concept based on system dynamics for Smelter building objects in Indonesia to improve cost performance. A flow diagram (**Figure 1**) which illustrates the process of finding the most influential factors. In the initial stage of this research, relevant factors and subfactors were identified. Next, data collection was carried out using research instruments. This step was completed prior to the current discussion. This research involves a literature review to determine the influencing factors related to Smelter (X1), Green Retrofitting (X2), System Dynamics (X3), Discrete Event Simulation (X4), and Cost Variable (Y).

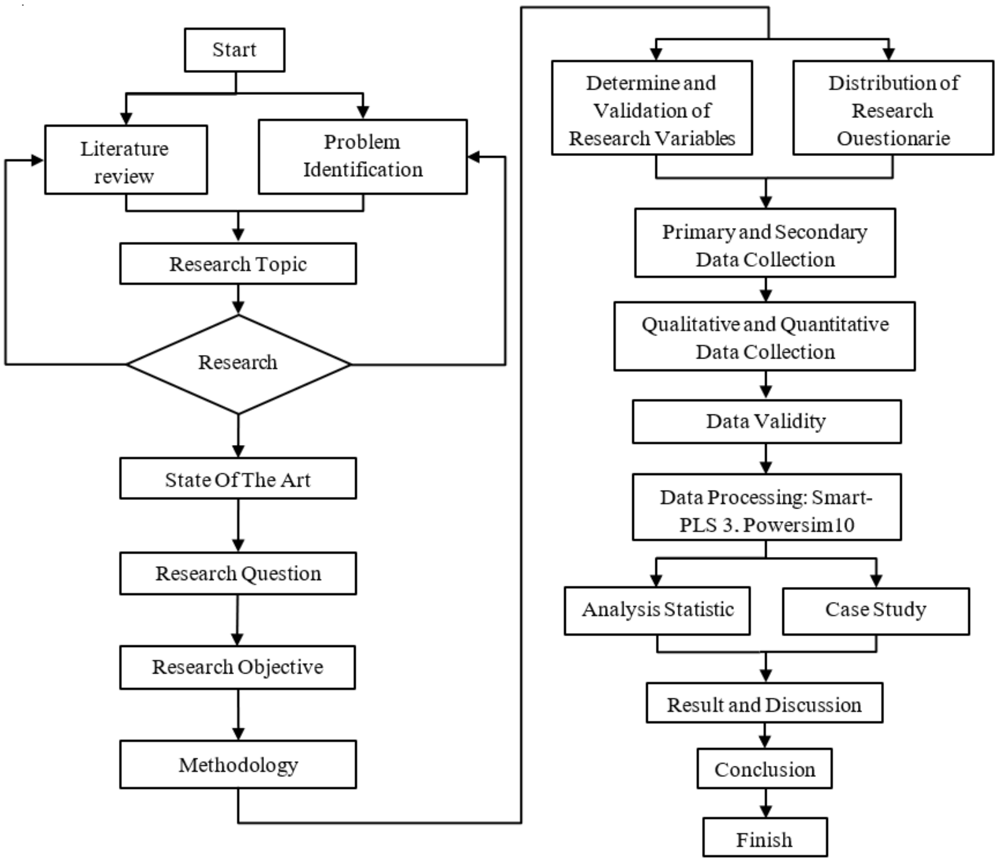


Figure 1. Process data flow diagram.

The creation of the questionnaire is based on the paired comparison method to determine the level of weight of each factor/criterion. The weight value ranges from 1 to 6, booth those weight depends on concerns. The questionnaire contains a comparison between each factor and other criteria. The scale is planned with a value of 1 indicating the least expected answer and a value of 6 indicating the most expected answer. After collecting all the information from all respondents, the data processing process continued after the data was collected and entered into tabulation using Microsoft Excel. In SEM-PLS testing, considerations include model properties, sample size, data distribution form, missing values, and measurement scales. The minimum sample size results from the path factor (p-min) and the height difference during the 80% statistical stress test (Hair et al., 2019). To achieve the research objectives, the next step the researcher took was to develop a research scheme at each step to obtain statistical analysis and steps to apply research in case studies. In one study (Vu-Ngoc et al., 2018), only half of the systematic reviews included flowcharts to provide insight into the study evaluation process where in this research we will use full of the systematic reviews. Researchers applied five main variables, which were explored and analyzed, so that the research was accurate, as shown in **Figure 2** as a concept model for the implementation of green retrofitting. In this case, the researcher explains the stages for exploration, development, and analysis of the main factors in this research to aim the objectives of the Green Building Concept.

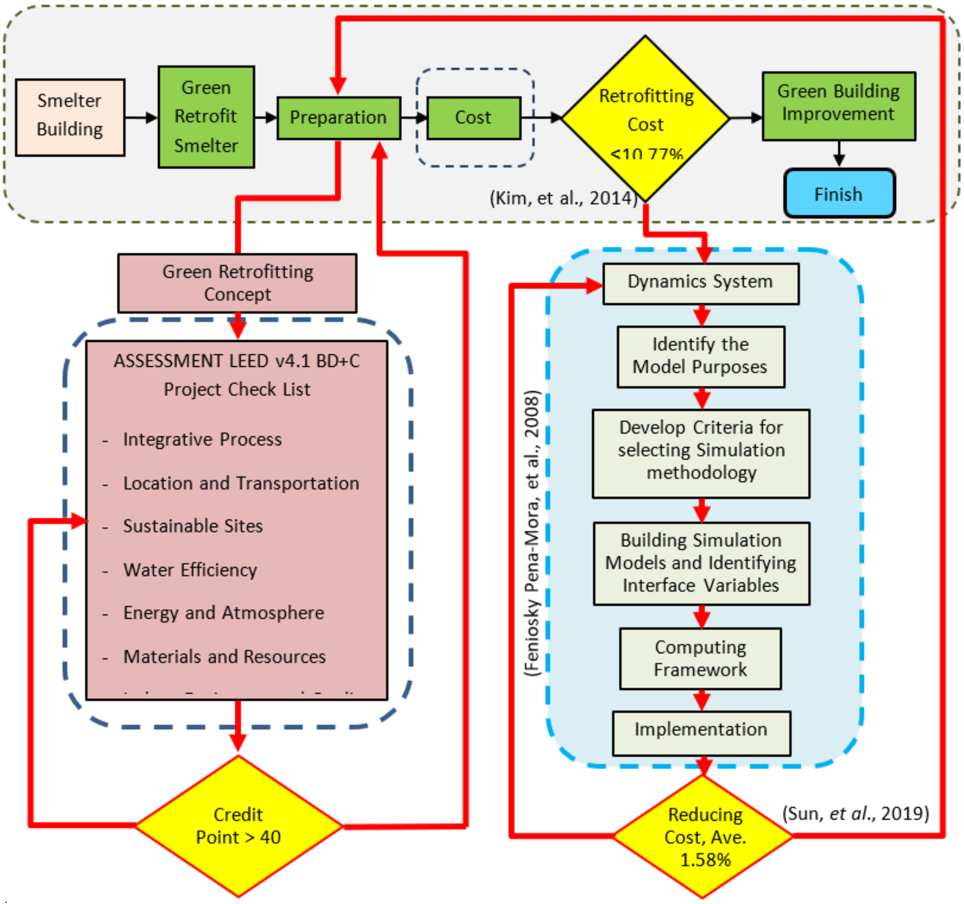


Figure 2. Concept model for the implementation of green retrofitting.

Researchers find the implementation of renewable energy potential in this project, among others: natural lighting systems and Solar PV, management of surface water reused on location, as depicted in **Figure 3** diagram of Identification of Potential Renewable Energy.

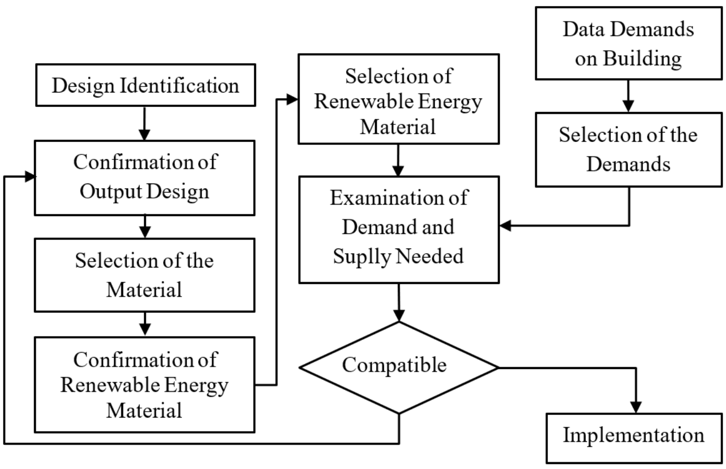


Figure 3. Diagram of identification of potential renewable energy.

4. Result and discussion

4.1. Measurement model evaluation (process data with SEM-PLS)

A total of 180 copies were distributed directly to respondents related to the renovation of the Smelter building, and 137 copies of the questionnaire were returned with a respondent rate of 76%, respondent data can be seen in **Figure 4(a)** position, **Figure 4(b)** work experience, **Figure 4(c)** respondent education.

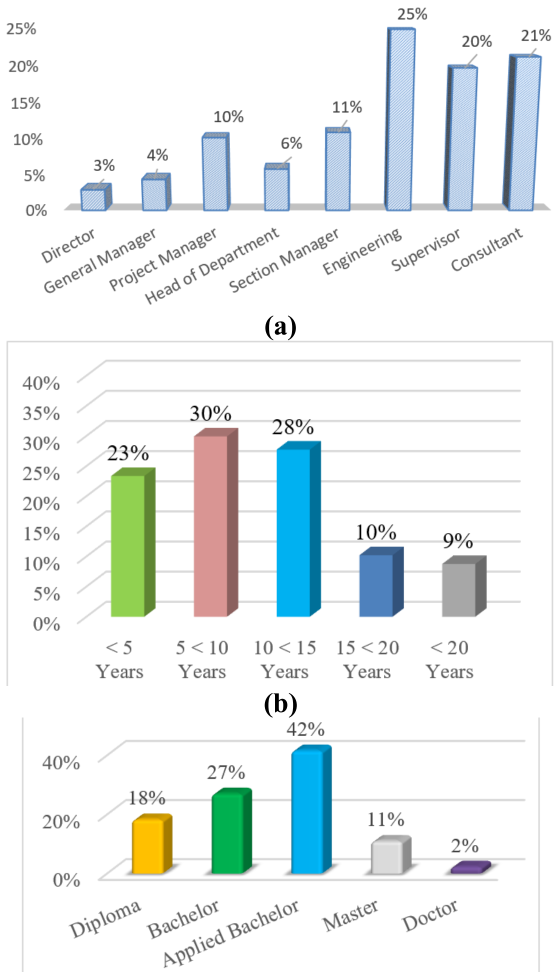


Figure 4. Respondent data; **(a)** position; **(b)** work experience; **(c)** education.

The initial stage includes running the SEM-PLS program for computing. Convergent Validity Analysis evaluates the degree to which a measure correlates with other measures of the same construct (Al-Emran et al., 2019). Composite Reliability and Cronbach's Alpha are the tools used for this assessment. A combined reliability value in the range of 0.6–0.7 indicates good reliability (Sarstedt et al., 2021). For all variables, reliability values exceeding 0.6 were determined for all scales used in the study. The validity test is considered acceptable if the Average Variance Extracted (AVE) value exceeds 0.5. An AVE value that exceeds 0.5 indicates that the latent variable construct explains more than half of the variance in the indicator (Hair et al., 2019). All indicators whose outer loading value is greater than 0.5 currently comply with the outer loading validity criteria, meaning that all indicators have convergent validity, as shown in **Table 2**. In terms of reliability, a variable is said to be reliable if Cronbach's Alpha exceeds 0.7 and Composite Reliability is greater than 0.7 which is a widely accepted standard of reliability for research instruments (Wahyudi et al., 2023). Based on the values presented in **Table 2**, it can be the following conclusions are drawn: first, The AVE value of the latent and median variables is greater than 0.5 which indicates that the convergent variable is valid and meets the required threshold, Variable X1.1 (Planning Stage) is 0.730, second, The Composite Reliability value of 0.983 and Cronbach's Alpha 0.982 exceed 0.7, which indicates that the instrument is reliable and meets acceptable standards.

Table 2. The results of construction reliability following convergent validity.

Main Factor	Cronbach's Alpha	rho_A	Composite Reliability	AVE
Smelter (X1)	0.996	0.996	0.996	0.747
Green Retrofitting (X2)	0.995	0.995	0.995	0.819
Dynamic Systems (X3)	0.989	0.989	0.989	0.739
Cost Performance (X3.3)	0.987	0.988	0.988	0.756
Renovation and Demolition Stages (X1.4)	0.986	0.987	0.987	0.807
Operation and Maintenance Stages (X1.5)	0.985	0.986	0.986	0.801
Implementation Stages (X1.3)	0.984	0.985	0.986	0.766
Indoor Environmental Quality (X2.7)	0.983	0.984	0.985	0.883
Planning Stages (X1.1)	0.982	0.983	0.983	0.730
Location and Transportation (X2.2)	0.975	0.976	0.978	0.850
Organization Model (X4.1)	0.969	0.970	0.973	0.767
Energy and Atmospheric (X2.5)	0.959	0.962	0.968	0.834
Sustainable Sites (X2.3)	0.958	0.958	0.966	0.826
Tender Stages (X1.2)	0.938	0.940	0.953	0.803
Cost (Y)	0.973	0.977	0.977	0.793
Discrete Event Simulation (X4)	0.983	0.983	0.984	0.754
Integrative Process (X2.1)	0.957	0.959	0.972	0.921
Water Efficiency (X2.4)	0.911	0.916	0.938	0.791
Materials and Resources (X2.6)	0.934	0.938	0.950	0.792
Internal Cost (Y1)	0.953	0.960	0.963	0.815
Innovation (X2.8)	0.947	0.953	0.967	0.906
Regional Priority (X2.9)	0.967	0.967	0.976	0.910
Construction Operations Improvement (X4.2)	0.958	0.959	0.964	0.748
Model Usage (X3.1)	0.860	0.863	0.915	0.782
External Cost (Y2)	0.938	0.948	0.954	0.807
Stock Flow Creation (X3.2)	0.822	0.825	0.894	0.738

The diagram in **Figure 5** illustrates the outcomes of SEM PLS data processing for conducting Cronbach Alpha reliability and validity tests. the result exceeds 0.7 are indicating good reliability.

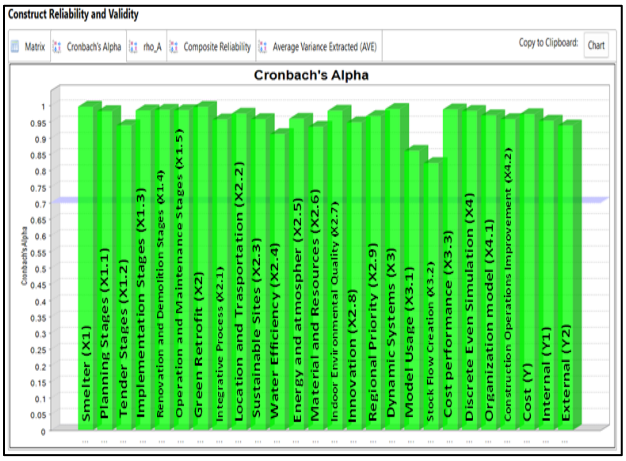
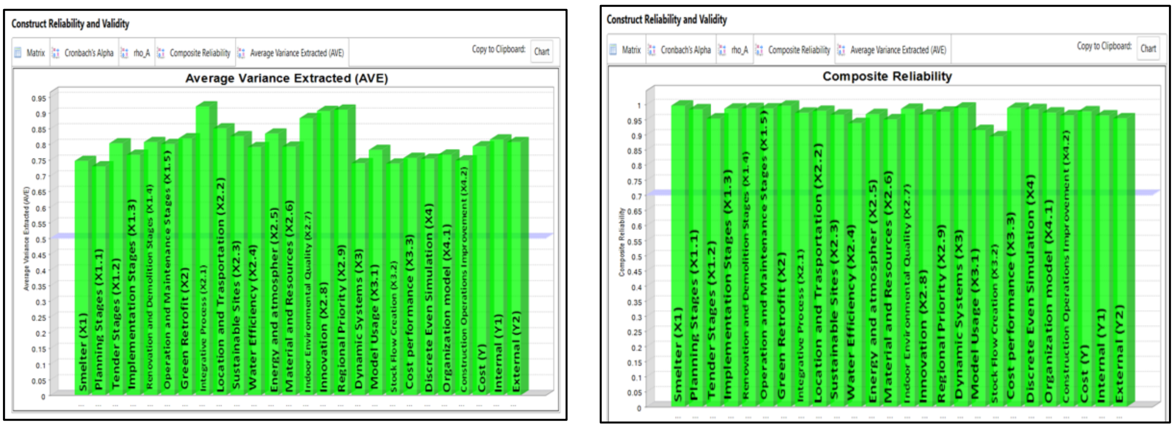


Figure 5. Outer loading of validity test-Cronbach's alpha.



(a) (b)

Figure 6. **(a)** Outer loading of validity test-composite reliability; **(b)** AVE.

Table 3. The results of *R*-Square.

Main Factor		***R*-Square**	***R*-Square Adjustment**
Cost Performance	(X3.3)	0.996	0.996
Organization Model	(X4.1)	0.995	0.995
Construction Operations Improvement	(X4.2)	0.992	0.992
Implementation Stages	(X1.3)	0.986	0.986
Internal Cost	(Y1)	0.982	0.982
Location and Transportation	(X2.2)	0.978	0.978
Cost	(Y)	0.977	0.976
Indoor Environmental Quality	(X2.7)	0.976	0.976
External Cost	(Y2)	0.974	0.974
Sustainable Sites	(X2.3)	0.903	0,973

The diagram in **Figure 6** illustrates the outcomes of SEM PLS data processing for conducting; (a) Composite reliability test and (b) Average Variance Extracted (AVE) reliability and validity tests. The result of Composite Reliability is greater than 0.7, which is passed the standard of instrument reliability, and the result of AVE is considered valid because value above 0.5 means that the latent variable constructs more than half of the variance in the indicator. Analysis was carried out using SEM PLS software as shown in **Table 3** below and from these results, it can be explained that the results of the R-square on Cost (*Y*) are 0.977 or 97.7% and the adjustment *R*-square 97.6% > 50%, so the influence of all independent variables against dependent variables.

We check the T statistical coefficient and the *P*-value as per the hypothesis, the correlation between X1, X2, X3, X4, and Y shows significance as per SEM-PLS specific indirect effects result (**Figure 7**).

Specific Indirect Effects

Mean, STDEV, T-Values, P-Values | Confidence Intervals | Confidence Intervals Bias Corrected | Samples

	Original Sa...	Sample Me...	Standard D...	T Statistics (...	P Values
X2 (GR) -> X4 (DES) -> X4.2 (POK)	0.392	0.400	0.099	3.950	0.000
X1 (S) -> X2 (GR) -> X4 (DES) -> X4.2 (POK)	0.385	0.392	0.098	3.934	0.000
X3 (SD) -> X4 (DES) -> X4.2 (POK)	0.558	0.551	0.099	5.606	0.000
X2 (GR) -> X3 (SD) -> X4 (DES) -> X4.2 (POK)	0.543	0.537	0.097	5.604	0.000
X1 (S) -> X2 (GR) -> X3 (SD) -> X4 (DES) -> X4.2 (POK)	0.532	0.526	0.095	5.620	0.000
X1 (S) -> X2 (GR) -> Y (BIA)	-0.419	-0.415	0.085	4.928	0.000
X2 (GR) -> X3 (SD) -> Y (BIA)	-0.180	-0.180	0.055	3.281	0.001
X1 (S) -> X2 (GR) -> X3 (SD) -> Y (BIA)	-0.176	-0.177	0.054	3.280	0.001
X2 (GR) -> X4 (DES) -> Y (BIA)	0.414	0.424	0.111	3.730	0.000
X1 (S) -> X2 (GR) -> X4 (DES) -> Y (BIA)	0.405	0.415	0.109	3.717	0.000
X3 (SD) -> X4 (DES) -> Y (BIA)	0.588	0.582	0.109	5.371	0.000
X2 (GR) -> X3 (SD) -> X4 (DES) -> Y (BIA)	0.573	0.567	0.107	5.371	0.000
X1 (S) -> X2 (GR) -> X3 (SD) -> X4 (DES) -> Y (BIA)	0.561	0.556	0.104	5.388	0.000
X1 (S) -> Y (BIA) -> Y1 (INT)	0.513	0.505	0.116	4.407	0.000

Figure 7. Result of *T*-statistic and *P*-value from SEM-PLS.

The estimated path coefficients in the structural model were assessed for strength and significance, with a *P*-value < 0.05 and *T*-Statistic > 1.96 considered significant various criteria such as coefficient of determination (R2), cross-validation redundancy (Q2), effect size (f2) (Kussumardianadewi et al., 2024) shows in **Figure 8**.

About 197 sub-factors have been analyzed with SEM-PLS, the most influential factors are ranked in descending order, with the most influential factor being Green Building (GB) validation, as shown in **Table 4** we analyze the ten most influential sub-factors that we will be implementing on green retrofitting in the Smelter building, following the SEM-PLS results they are innovation, low emission material, renewable energy, daylighting, reducing indoor water use, rainwater management, recognize project specifications and details, access to quality transit, operating costs, and approval design drawing.

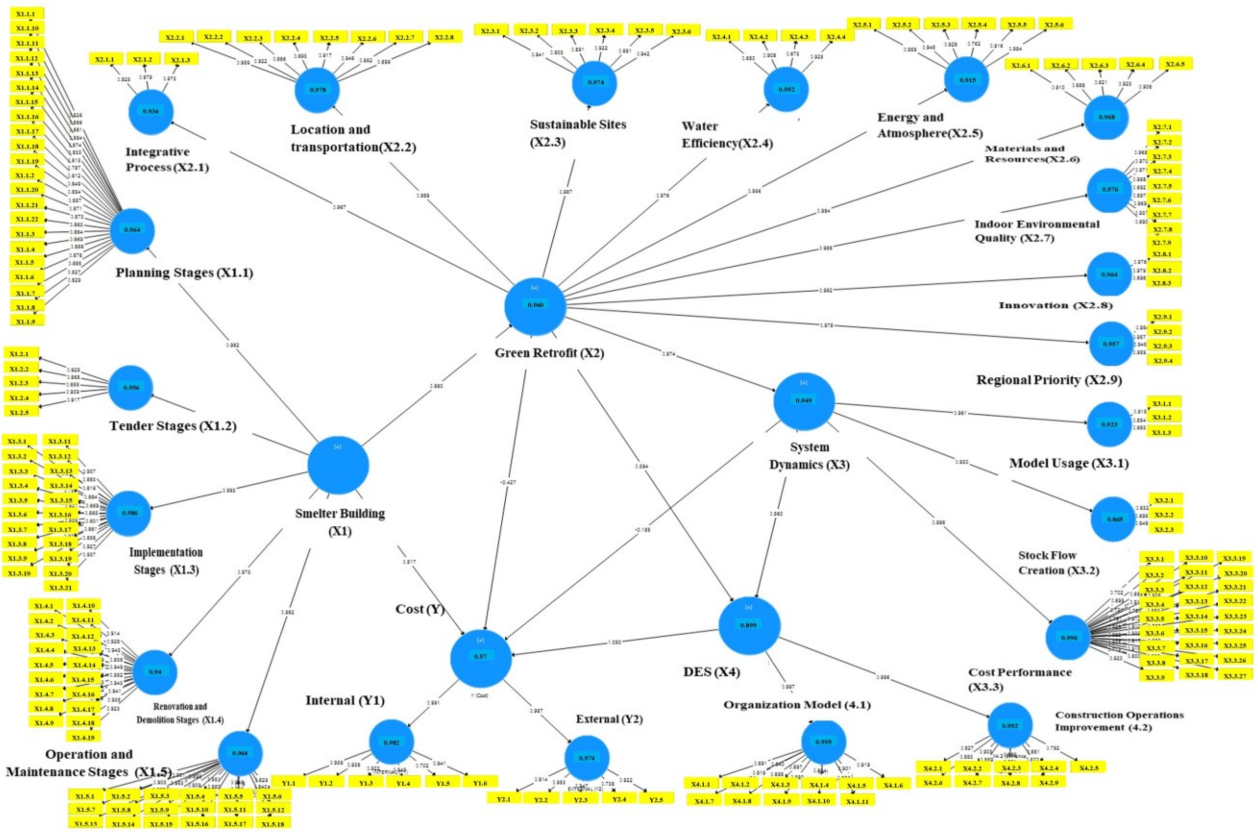


Figure 8. *T*-Value and *P*-Statistics diagram, by Smart-PLS 3.0.

Table 4. The most influential sub-factor.

Sub Factor		Origin Sample Value	Mean	T Statistic >1.96 and $p < 0.05$	R Square
Innovation	X2.8.1	0.976	0.977	240.974	0,934
Low Emission Material	X2.7.1	0.970	0.970	185.279	0.976
Renewable energy	X2.2.16	0.970	0.970	222.124	0.978
Daylighting	X2.7.7	0.969	0.969	173.814	0.976
Reducing Indoor Water Use	X2.4.2	0.939	0.939	91.309	0.952
Rainwater Management	X2.3.4	0.922	0.922	88.328	0.973
Recognize project specifications and details	X4.1.7	0.919	0.919	84.760	0.995
Access to Quality Transit	X2.2.5	0.917	0.916	81.009	0.978
Operating Costs	X3.3.2	0.895	0.895	65.363	0.996
Approval Design Drawing	X1.3.16	0.865	0.863	43.177	0.986

4.2. Sustainable assessment of the retrofitting building with LEED

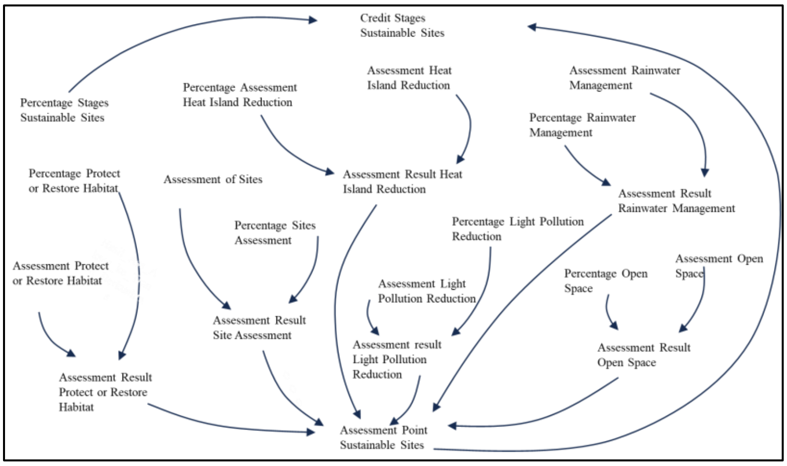


Figure 9. Clausal loop diagram of LEED parameter; sustainable sites.

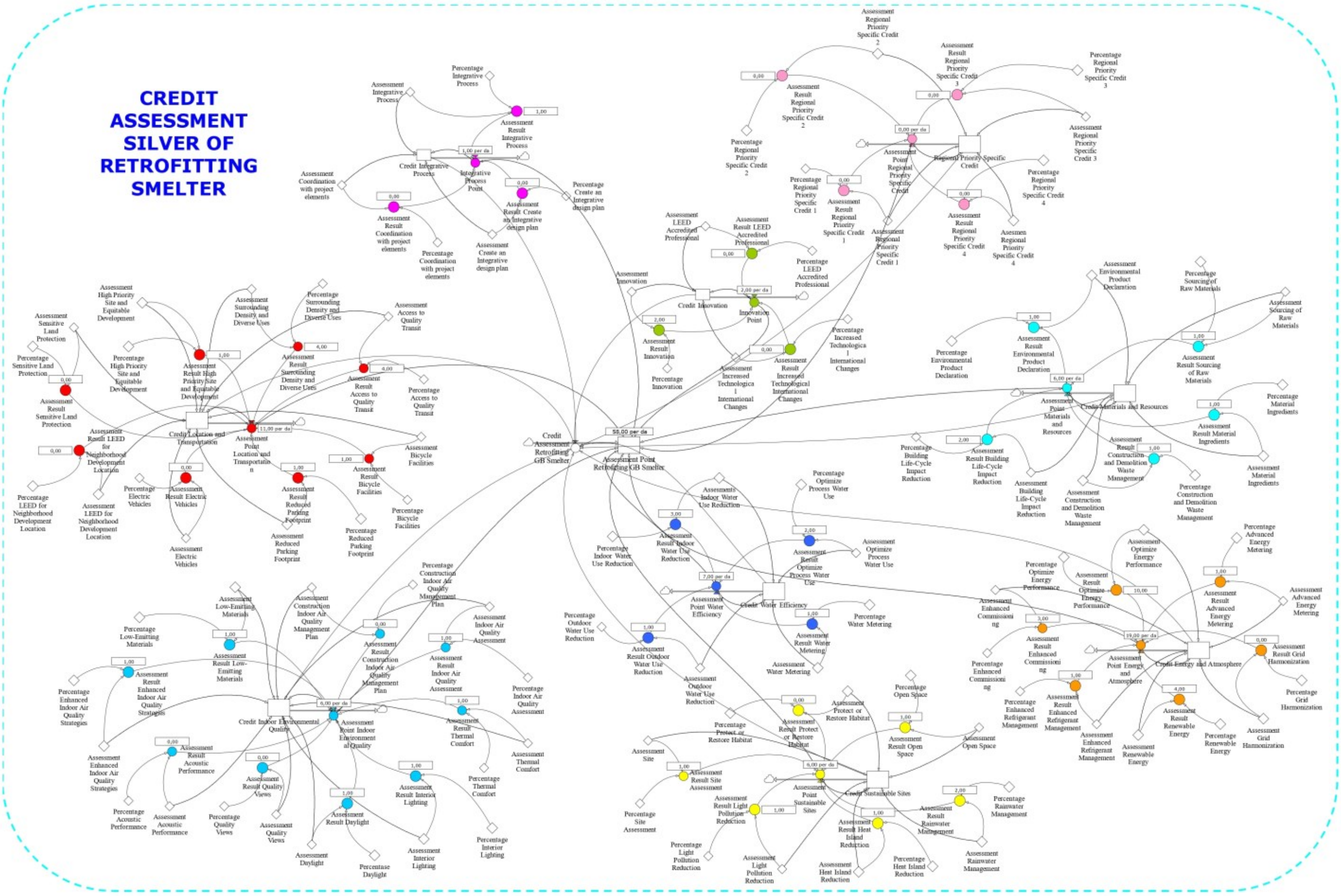


Figure 10. Shows the 58 credits point SFD model for silver assessment.

Researchers use LEED v4.1 for Building Design and guidelines Construction with a total of 110 assessment points using the dynamics system and implementing to the Smelter building. By knowing what parameters will be improved to become a Green Building, we will get points related to the retrofitting of the building, whether it is in the Basic, Silver, Gold, or Platinum category. We developed a causal loop diagram to demonstrate how the interaction between variables works. Specifically, we built a system to characterize the relationship between the determined independent variables, Smelter Building, Green Retrofitting, and Dynamics System. The Clausal Loop Diagram findings acquired from running modeling using the academic version of Powersim Studio 10 software are displayed in **Figure 9** as one of the LEED parameters we showing, due to the limited we display this clausal loop exclusively as a representation and in **Figure 10** we created the Stock Flow Diagram (SFD) simulations in dynamic system modeling too, at this stage the LEED parameters with nine categories are entered as variables. Each credit category is made into the SFD and linked to its stock assessment points for green retrofitting of Smelter buildings.

We used credit points for the constant variable, while the auxiliary variable is each parameter that is connected to the flow after the credit constant is connected to a constant percentage that is operated by a slider. The operation uses the active tools for creating a slider for this assessment to make the operation easier by binding assessment constants and playing variable percentages for each assessment level. The following is an overview of SFD assessment using LEED guidelines as seen in **Figure 11**. This step continued up to the credit assessment for the Basic, Silver, Gold, and Platinum categories. After obtaining a rating regarding the modification of existing objects we analyzed the correlation between the most sub-variable result by SEM-PLS with the assessment result from LEED Parameters using Dynamics systems. We have the LEED assessment result is as follows: 39 points for the beginning stage, 47 points for the Basic stages, 58 points for the silver stages, 75 points for the gold stages, and 86 points for the Platinum stages.

Figure 11. Shows the active tools slider of rating for silver assessment.

5. Conclusion

In this research, the author uses an assessment tool as automation. Various efforts have been made to translate this system to make it easier as an assessment tool. Therefore, for future efforts, collaboration and cooperation with the practitioners are critical to simplify and facilitate their effective implementation. Promoting the application of assessments using software tools makes automation better and improved compared to manually, this reduces the error rate when carrying out assessments and can also help prevent assessors from cheating in GR credit assessments so that green building construction costs which were initially expensive than non-green building will be more effective and efficient. Future research efforts must be able to dig deeper into the goodness of GB so that various considerations from actors and stakeholders make Green Building progress, especially the use of renewable energy. These research results confirm that using the Green Retrofitting concept with a dynamic system as an assessment of LEED parameters has resulted in the work improvement needs on GR building due to correlation with the most relevant features of the participant assessments were identified using the SEM-PLS approach, as shown in **Table 5**.

Table 5. Improvements needed towards green retrofitting building assessment based on LEED.

Work Improvement	Non-Green Retrofitting (39)	GB Assessment Level			
		Basic (47)	Silver (58)	Gold (75)	Platinum (86)
Surrounding Density and Diverse Uses	√	√	√	√	√
Access to Quality Transit	√	√	√	√	√
Rainwater Management	√	√	√	√	√
Heat Island Reduction	√	√	√	√	√
Outdoor Water Use Reduction	-	√	√	√	√
Indoor Water Use Reduction	√	√	√	√	√
Renewable Energy	√	√	√	√	√
Building Life-Cycle Impact Reduction	√	√	√	√	√
Sourcing of Raw Materials	√	√	√	√	√
Construction & Demolition Waste Management	-	√	√	√	√
Enhanced Indoor Air Quality Strategies	√	√	√	√	√
Daylight	√	√	√	√	√
Innovation	√	√	√	√	√

Due to the limited research, we propose to hold the analysis of the cost affect of the building based on this work improvement with the LEED assessed in the future, this will impact the client's investment when they develop the GR in the Smelter building.

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