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Optimizing Time Performance in Implementing Green Retrofitting on High-Rise Residential by using System Dynamics and M-PERT

Albert E. Husin [1*], Riza S. Prawina [1], Priyawan Priyawan [1], Rizkiawan Pangestu [1], Bernadette D. Kussumardianadewi [1], Lastarida Sinaga [1], Kristiyanto Kristiyanto [1]

[1] *Department of Civil Engineering, Universitas Mercu Buana, Jakarta 11650, Indonesia.*

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Abstract

Climate change is a threat and crisis that is engulfing the world today; therefore, the target of Net Zero Emission (NZE) by 2060 should be an obligation for all countries. The greenhouse effect, global warming, destruction of the ozone layer, forest destruction, uncontrolled use of CFCs, and industrial exhaust are factors that cause climate change. The consequences of climate change are dire, resulting in drought, water scarcity, land fires, rising sea levels, flash floods, melting polar ice caps, storms, and a decline in biodiversity. Green buildings (GB) are important in saving energy, water, and other resources by meeting technical construction standards and applying green building principles according to their function and classification at each stage of their implementation. Buildings with measurable performance. Expected to reduce carbon or greenhouse gas emissions. The latest Technical Guidelines for Green Building Performance Assessment Standards were developed through regulations from the Ministry of Public Works and Public Housing (PUPR) No.1 of 2022. The way to improve and find a solution to achieve a Green Building according to these regulations is by applying solar modules as an alternative energy source in the building under study, providing significant added value to the assessment process. This research aims to analyze whether the renewable energy source factor is an influencing factor in the application of the Ministry of PUPR Green Building in High-Rise Residential. This research framework is at least initiated from matters where M-PERT, which is an innovation and the latest method of continuation of the PERT method, is proven to be able to provide an accuracy of planning execution time of 99% or with an error rate of 1%. From the research results with the application of M-PERT, it is proven that it can provide an accuracy of implementation time of 98.93% in the Primary Rating, while in the Intermediate Rating, it can provide an accuracy of implementation time of 99.92% and 98.88% accuracy of implementation time for the Main Rating category.

Keywords: Green Building; SEM-PLS; System Dynamics; M-PERT; High-rise Residential; Time Accuracy.

1. Introduction

The building sector significantly influences the natural environment through numerous industrial activities. The industry exhibits significant energy and resource use, as well as substantial environmental damage [1]. Research indicates that buildings presently contribute to approximately 30% of overall energy consumption, with energy use itself being responsible for nearly 30% of CO_2 emissions. Throughout the lifespan of a structure, the majority of its energy consumption, specifically 80%, takes place during the operational phase rather than the construction phase. [2]. Hence, a prudent approach to mitigate global dioxide emissions and minimize the overall use of energy is to adapt preexisting structures in an eco-conscious manner. Green buildings are facilities that are constructed in a resource-saving manner with consideration for the environment and are considered sound facilities [3, 4]. Specifically, there are various global green building ranking tools aimed at facilitating the building process.

* Corresponding author: albert_eddy@mercubuana.ac.id

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Global green building assessment tools are geographically defined as LEED (Leadership in Energy and Environmental Design) in the US, BREEAM (BRE Environmental Assessment Method), and DGNB in the UK. Germany's CASABEE (Building Environmental Efficiency Comprehensive Evaluation System), Australia's Green Star, Malaysia's GBI (Green Building Index), Hong Kong's HK BEAM (Hong Kong Built Environment Assessment Method), PRSE (Pearl Rating System for Estidama) in the United Arab Emirates, and the Assessment Standard for Green Building in China. Three areas are very important to him as tools for assessing green buildings from a micro- and macro-perspective: environment and space, energy efficiency itself, and eco-environment [5].

The focus is on energy efficiency and its impact on the ecological environment. The operational efficiency of green buildings can be assessed based on several indicators, such as the attainment of different certification levels, including Gold, Platinum, and Silver. But it's worth noting how much this certificate refers to improved energy efficiency. In fact, according to previous research, a total of 1,446 buildings were certified in China from 2006 to the end of 2013. However, progress has been made, with only 104 buildings having an operational certificate and less than 8% using green building materials [6]. In other words, accredited buildings do not correlate with exceptional operational efficiency or improved energy performance [7]. Green building operational performance is related to the alignment of green building metrics [8, 9] and the strategy and management of these operations.

In line with Indonesia's economic growth, development in various sectors is growing very rapidly. Many private and government parties are competing to carry out development. These development activities are in the form of projects, such as business premises construction projects, warehouse projects, construction projects, infrastructure projects, product development projects, radio telecommunications projects, and others. The existence of project development is expected to increase economic progress in various sectors.

A project includes certain tasks that are specifically designed with predetermined results, time, and limited resources. With the challenges of limited time and resources that have been designed, physical activities must be completed before or exactly at the planned time with appropriate project results [10]. The existence of time constraints on project completion creates problems for implementers in the field. Because the success of physical activities is seen in the timeliness of completing these activities.

Carbon is an important indicator of the increasing global damage caused by current greenhouse gas emissions [11]. Energy consumption to operate the construction industry has increased by 35% worldwide [12]. In 2018, the International Energy Agency discovered that constructions and structures are responsible for 39% of carbon emissions related to energy and industrial processes. Out of the total, 28% may be attributable to construction activities, while 11% can be credited to materials and construction. In light of this context, it is imperative to decrease the release of greenhouse gases in the constructed environment to alleviate the effects of climate change [13]. The burgeoning urbanization in contemporary cities has enduring ramifications on ecosystems and natural resources. Based on a survey conducted by the International Energy Agency (IEA), constructions account for 32% of global energy use. [14]. The International Energy Agency (IEA) states in its publication World Energy Overview 2021 that there is a notable shift occurring in 2021. The energy sector is identified as the primary source of over 75% of worldwide greenhouse gases [15].

Sutikno et al. [16] discovered that green buildings are intentionally constructed to prioritize sustainability for both the economy and the environment. This includes considering the local climate and cultural requirements, thereby enhancing the well-being, safety, and efficiency of the occupants. According to Nguyen & Macchion [17], the green building industry has reached a level of maturity where it is possible to observe the tangible benefits of the green economy in the marketplace for real estate. This is evident through the significant rise in the adoption of energy from renewable sources and the integration of information technology and technological advancements in the construction of smart towns, eco-districts, and eco-campuses.

In Indonesia, there is a significant demand for green property, particularly in high-rise structures, making it a requirement in today's market. The Chairman of the Certification and Advocacy Board of Real Estate Indonesia (REI) made this statement during the panel discussion titled "Towards Green Indonesia" on Wednesday, June 27, 2012. According to him, property developers are led to build buildings with the concept of green buildings (Berita Satu, 2013). This is enforced by legislation designed to oversee it, especially through the Minister of Public Works and Housing (PUPR) Regulation Number 21 of 2021 and the Technical Guidelines for Green Building Performance Assessment in 2022. Indonesia has established a goal to decrease its carbon dioxide emissions by 26% by the year 2020. The information is derived from the Presidential Regulation of the Republic of Indonesia Number 61 of 2011, which pertains to the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GHG).

2. Material and Methods

The research was conducted with a literature study to collect influential factors on High-Rise Residential (X1), Green Retrofitting (X2), System Dynamics (X3), M-PERT (X4), and Time Variable (Y). By examining periodicals, literature, and legislation about linked subjects, one can acquire the influential aspects of each variable.

By defining multiple sub-factors, the study indicators were compiled. Then, from these sub-factors, several questions were made to be distributed to respondents in the form of questionnaires. The assessment of filling out the questionnaire by the respondent is given a scale of 1 to 6 for each question, with different answers for each respondent. The number of respondents needed in this study is at least 123, obtained from the calculation of determining the minimum number of respondents so that the results of filling out the questionnaire can be continued into SEM-PLS modeling. The indicators listed in the table are from the questionnaire used in this study.

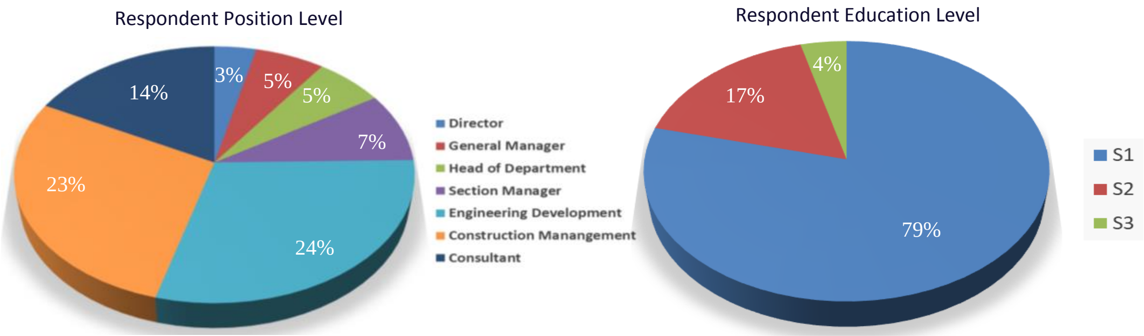

Figure 1. Respondent Data

PLS is the most suitable statistical analysis technique because it has the goal of prediction or theory development. However, if the research objective is confirmatory modeling and theory testing, covariance-based CBSEM is more appropriate. Partial Least Squares (OUTER) is a variance-based SEM. Partial Least Squares (PLS) diverge from covariance-based Structural Equation Modelling (SEM), which employs software tools like AMOS (Analysis of Moment Structures) or LSR (Linear Structural Relationship. PLS is an analytical technique that integrates confirmatory factor analysis, principal component analysis, path analysis, and structural models. PLS is a more complex method than SEM because it can be applied to both reflective models and formative models, while SEM can only be applied to reflective models [16]. The data processing diagram for SEM-PLS has been presented in Figure 2.

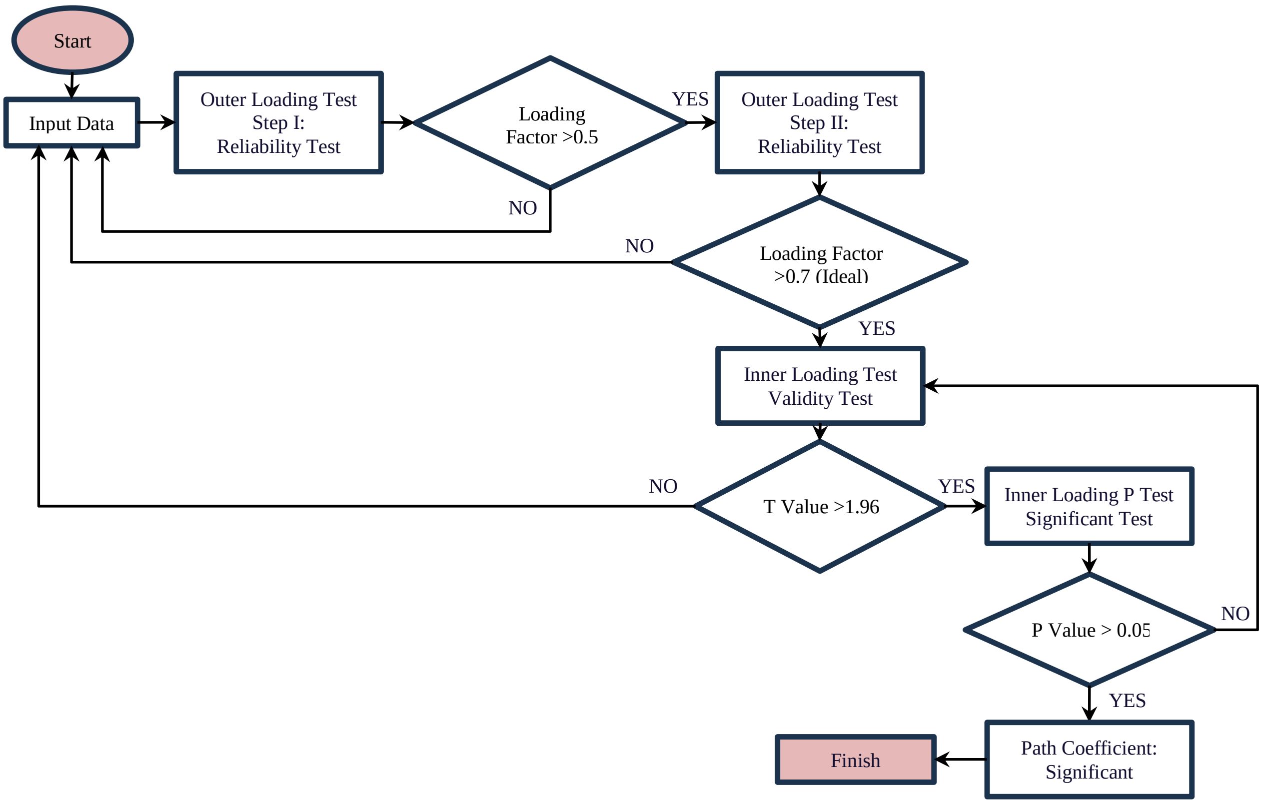

Figure 2. Data Processing Diagram for SEM-PLS

The flowchart of the research methodology that was used to achieve the study's aims is shown in Figure 3.

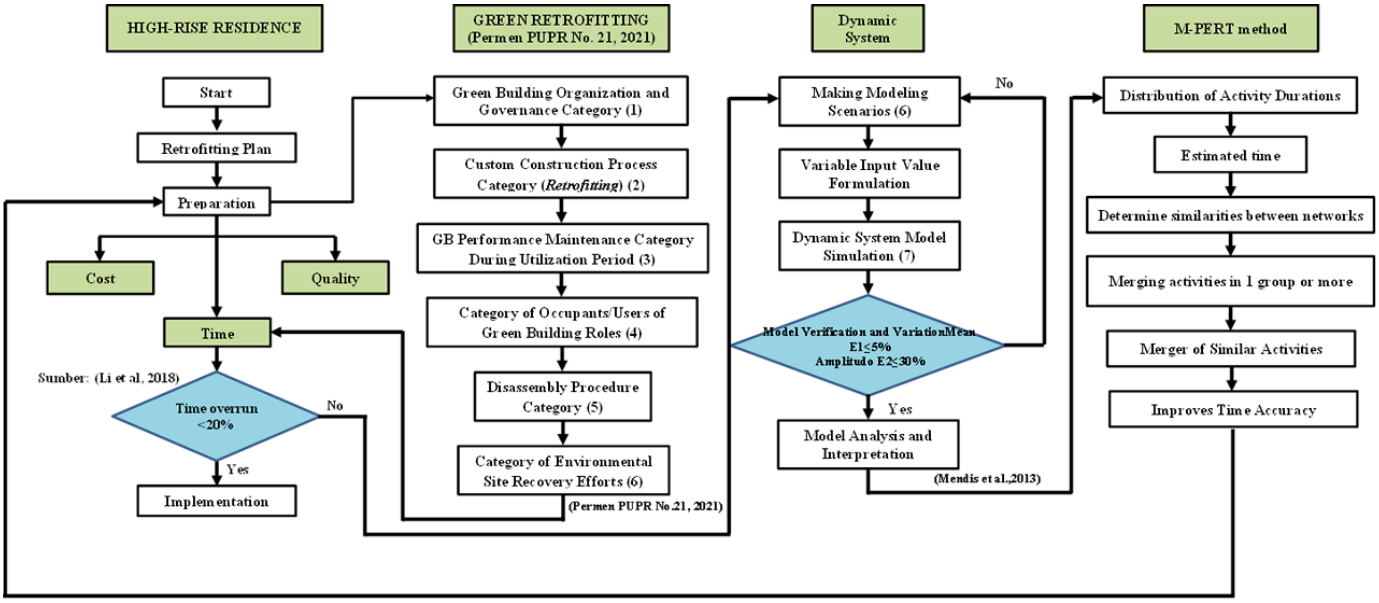

Figure 3. Flowchart of the research methodology

PERT is a time-focused method that results in probabilistic or stochastic planning [18]. Some research suggests that stopping PERT activities can speed up project execution [19]. This method is a derivative of Dr. Pablo Ballesteros-Perez's PERT method. He has the position of professor at the School of Construction Management Engineering, located at the University of Reading in the United Kingdom. Introduced in 2017, this technology has enabled him to potentially enhance the project length of bridge construction by up to 8.8%. [20]. In the next phase, individual details will be displayed.

- Developing detailed schedules or schedules for each stage of work execution.
- Calculate the duration of each phase of work execution.
- Developing schedules and analyzing project plans.
- Combining stages of work implementation.

This valuation is conducted on a high-rise residential object located in Bekasi City, West Java, Indonesia. High-rise residential building with an area of 9,426 m^2. Researchers have conducted an assessment using PUPR Technical Guidelines No. 1 of 2022 against this building so that the results obtained meet the Green Building standards. From the results of the assessment of the implementation of building utilization, a value of 69.0 points was obtained, with these results indicating that the building during the utilization period was still considered insufficient to achieve a PRATAMA rating with a minimum value of 87.0 points so that a repair/improvement process was needed in the building. Researchers propose six work items so that the Green Building Technical Standards can be met. Researchers can briefly explain some of the work items that are improvements/upgrades.

COP, or kW/TR, of air conditioning equipment following SNI 6390: 2020 has the highest value in the assessment and in the value of financing its improvement to become a green building. Researchers performed calculations by making improvements to the chiller plant work so that the OTTV value was better, namely 34.7 W/m^2, where it was originally 35.0 W/m^2.

Then PLTS as a renewable energy source that will be installed on the rooftop area of the building, the source of electricity from the solar panel unit is used as an alternative source of electrical energy and meets the Green Building Assessment Point. The utilization of this system can be used as a solution for dealing with the threat of a shortage or crisis of electrical energy so that it becomes an energy source that is friendly to the environment. The process of project duration planning commences with the stage of ascertaining the duration of each task and concludes with the determination of the overall duration of labor and its corresponding standard deviation. In summary, generate a network diagram illustrating the sequence of actions starting from the initial task and ending with the final task. Tables 1 to 6 demonstrate the sequential progression of work tasks for each activity, from initiation to completion.

Table 1. Detention Pond Work

Activity Code	Activity Description
1.1.1	Rainwater Detention Pond Work Pond 1
1.1.1.1	Detention pond excavation
1.1.1.2	Remove Excavated Soil
1.1.1.3	Working Floor Pile Cap, Tiebeam, Slab
1.1.1.4	Sandbags Pile Cap, Tiebeam, Slab
1.1.1.5	Column
1.1.1.6	Tiebeam
1.1.1.7	Slab
1.1.1.8	Retaining Wall
1.1.2	Reinforcing steel quality of BJTP 24 & BJTD 40
1.1.2.1	Column
1.1.2.2	Tiebeam
1.1.2.3	Plates
1.1.2.4	Retaining Wall
1.1.3	Plywood Formwork Work
1.1.3.1	Column
1.1.3.2	Retaining Wall
1.1.4	Brick Formwork Work
1.1.4.1	Tiebeam
1.1.5	Mortar mix (1:3) according to specifications
1.1.5.1	40 mm thick mortar, concrete deck
1.1.6	Waterproofing slurry ex. Penetron is applied to the surface of the concrete deck
1.1.6.1	Waterproofing slurry; applied to the roof floor including side walls H=20 cm

Table 2. Exhaust Lobby Work

Activity Code	Activity Description
1.1.7	Lower Ground
1.1.7.1	EF-GF.1-4
1.1.8	Ground Floor
1.1.8.1	EF-LG.1-4
1.1.9	1st Floor
1.1.9.1	EF-1st Floor 1-4
1.1.10	2nd Floor
1.1.10.1	EF-2nd Floor 1-4

Table 3. Building Façade Work

Activity Code	Activity Description
1.1.11	Façade Work
1.1.11.1	Glass Window
1.1.11.2	Automatic Glazed Doors
1.1.11.3	Glazed Doors With Aluminium Frames
1.1.11.4	Glazed Doors And Windows With Aluminium Frames

Table 4. Water Fixture Work

Activity Code	Activity Description
1.1.12	Water Fixture
1.1.12.1	Kloset
1.1.12.2	Faucet Wastafel
1.1.12.3	Faucet Dinding
1.1.12.4	Urinoir

Table 5. Solar Panel Work

Activity Code	Activity Description
1.1.17	Preparation
1.1.17.1	Survey
1.1.17.2	Preliminary design and planning
1.1.18	Main Equipment
1.1.18.1	Solar Modules
1.1.18.2	Inverter ON GRID
1.1.18.3	Inverter ON GRID
1.1.18.4	Inverter Manager
1.1.18.5	Battery
1.1.18.6	Battery Container
1.1.18.7	Weather Station
1.1.18.8	Monitoring System
1.1.18.9	Panel AC Combiner Building 1
1.1.18.10	Panel AC Combiner Building 2
1.1.18.11	Panel AC Combiner Building 3
1.1.18.12	Mounting structure (Building 1)
1.1.18.13	Mounting structure (Building 2 & 3)
1.1.18.14	DC-Cable and connector
1.1.18.15	Cable tray with cover (from PV to Inverter, Inverter to AC combiner & AC Combiner to Interconnecting)
1.1.18.16	AC-Material
1.1.18.17	Grounding Cables & Accessories

Table 6. Garbage Building Work

Activity Code	Activity Description
1.1.19	Structure
1.1.19.1	Pilecap
1.1.19.2	Tiebeam
1.1.19.3	Beams
1.1.19.4	Column
1.1.19.5	Plates
1.1.20	Inner Wall
1.1.20.1	Wall, 100mm thick
1.1.20.2	Plaster and Wall Skimcoat on light brick wall masonry
1.1.20.3	Skimcoat on concrete walls
1.1.21	Outer Wall
1.1.21.1	Wall, 100mm thick
1.1.21.2	Wall, 75mm thick
1.1.22	Iron Door
1.1.22.1	Iron door, overall size 1800 mm × 2100 mm
1.1.23	Floor Work
1.1.23.1	Mortar to receive homogeneous tile, 40 mm thick for toilet and prayer room areas.
1.1.23.2	Wet + Dry Garbage area floor
1.1.23.3	Footpath2 and dry garbage
1.1.24	Roof Work
1.1.24.1	Procurement & installation of metal roofing, including trusses according to drawings and specifications
1.1.25	OTHER
1.1.25.1	WCBR 150 Tricycle Motor Open Trash Can 1.8M
1.1.25.2	Installation of AC, wet waste room

The network provided is considered the crucial path as it consists of operations that have no idle time. The PERT network covers 209 days, with an average deviation of 64.21 days. After determining performance time based on the PERT method, proceed using the M-PERT method to balance estimated times between pessimistic, average, and optimistic times to calculate task duration. Estimated time according to the following formula:

$$\mu_i = \frac{(a+(4\times m)+b)}{6} \tag{1}$$

With the variation of each activity with the following equation:

$$\sigma^2 = \left[\frac{(b-a)}{6}\right]^2 \tag{2}$$

The calculation of the correction rate to solve the corrected standard deviation with the following equation:

$$K = \sqrt{\frac{5}{7} + \left(\frac{16}{7} \times \frac{(m-a)(b-m)}{(b-a)^2}\right)} \tag{3}$$

By using the above equation, a simplification of the PERT diagram is obtained, which is continued by using M-PERT, which is based on the equation issued or applied by the inventor. Obtained as many as five steps of implementation of customization of high-rise residential buildings. The following is a diagram of the work from Step 1 to Step 5 and the results of this method (Figure 4).

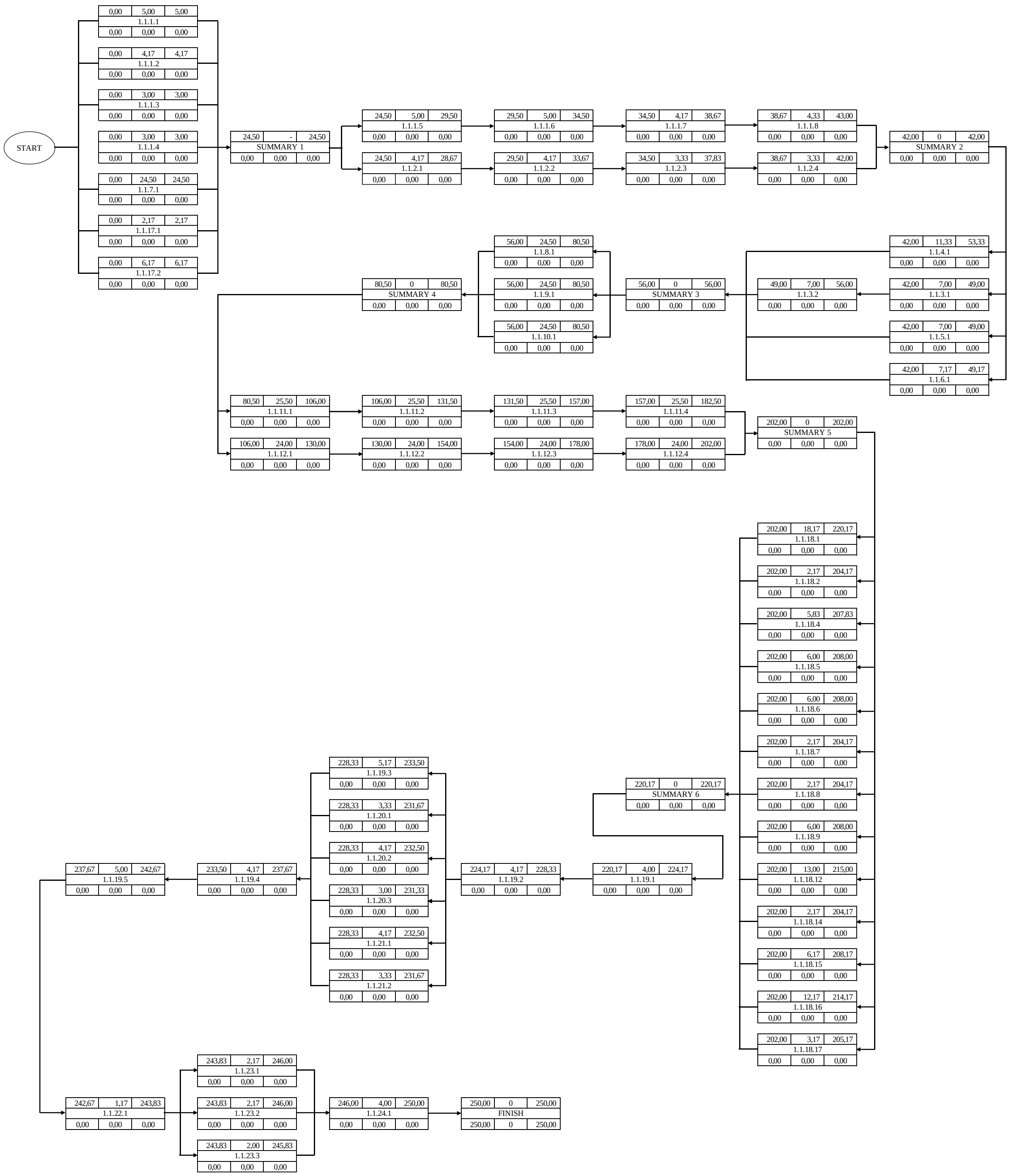

Figure 4. PERT diagram for 5 steps of implementation of customization of high-rise residential buildings

3. Results

3.1. Implementation of SEM-PLS to Get the Most Influential Factors

Questionnaire data collected by researchers as part of this research work will be processed and analyzed using "Structural Equation Modeling (SEM)". This method seems to dominate the use of path analysis and multiple regression, which have been commonly used so far. This is because this analysis is more comprehensive. This is because the values of any latent variable, factor, or procedure problem can be comprehensively analyzed as sub factors of an observed or latent variable (see Tables 7 to 12). Researchers used SEM SMART-PLS software version 3.0.

Table 7. Performance Assessment of Utilization Stage in Green Building based on Technical Guidelines of the Ministry of PUPR No.1 the Year 2022 [21]

No	Criteria (Sub Factor)	Point	No	Criteria (Sub Factor)	Point
1	Encourage public transportation	2	53	Evaluation, monitoring, and improvement mechanism	1
2	Energy saving SOP	3	54	Has integrated building data	1
3	Environmentally friendly materials	2	55	Construction method ideas & innovations	1
4	Environmentally friendly- consumables	2	56	Value-added innovation	1
5	Sustainable use of used goods	1	57	Equipment mobilization plan and realization	1
6	No use of hazardous & toxic materials	3	58	Efforts to optimize the utilization of construction equipment technology.	1
7	Plastic bag ban	1	59	Construction safety from falling materials.	1
8	Have a water-saving SOP	1	60	Calculation of reducing construction waste	1
9	Commitment to the smoking ban in BGH	1	61	Construction waste sorting	1
10	Waste management policy	1	62	Provision of hazardous waste absorbent media.	1
11	Wastewater management policy	1	63	Cooperation & monitoring of construction waste management	1
12	Manager of laws and regulations	1	64	Demonstrate 3R efforts of construction waste	1
13	Expert must have SKK	1	65	Copy shop drawings testing and commissioning	1
14	Have-an O&P SOP	1	66	Copy list of testing and commissioning support data	1
15	There are as-built drawings and other documents	1	67	Documentation of testing and commissioning	2
16	Building management performance	1	68	Documentation of equipment system operation training	1
17	Equipment operational logbook	1	69	Warranty certificate documents for major equipment from the manufacturer	1
18	Conduct periodic inspections of the building	1	70	Manufacturer's operation and maintenance manual documents	3
19	Have an emergency response SOP	1	71	Submit as-built drawing	4
20	Training (maintenance)	2	72	Environmentally friendly pest and weed control	1
21	Training to improve soft skills	2	73	Ventilation System: (2.3 m2/person).	1
22	(OTTV) and (RTTV) maximum-35 Watt/m^2	5	74	Air Conditioning System testing and commissioning results.	4
23	Window to Wall Ratio < 30%	3	75	Lighting System according to the lighting level	2
24	Optimization of natural or mechanical ventilation	2	76	Transportation System in Building meets SNI 03-6573-2001.	1
25	AC usage $\geq 25°C \pm 1°C$; Humidity 60% ± 10%	1	77	Monitoring and recording energy consumption	2
26	COP according to the latest SNI	4	78	Ensure elevator performance is up to standard	1
27	Lighting planning according to SNI	1	79	Maintain energy consumption not exceeding 10%	1
28	One switch in a room < 30 m2	1	80	Addition of 1 point (able to save 10%)	1
29	Use of lighting sensors	1	81	Re-commissioning: verification of key equipment efficiency.	3
30	Daylighting & grouping of lights	3	82	Suitability of customized water efficiency criteria	8
31	Use of photocells	1	83	No additional deep groundwater sources.	2
32	Traffic analysis lift according to the latest SNI	1	84	Suitability of water meters including their functions	2
33	VVVF Elevator Usage	1	85	Water-saving sanitary ware	4
34	Escalator: slow motion or automatic on/off	1	86	Monitoring actual water consumption	1
35	Electric energy consumption saving plan	5	87	Actual water consumption does not exceed 10%	1
36	Electric load grouping and kWh-meters	1	88	Maximum use of 20% well water source.	1
37	Use (BMS) of the Building.	2	89	Show laboratory results for water quality for the last 6 months	1
38	Plan for utilization of renewable energy sources.	1	90	Report every 6 months in the last 3 years.	1

No	Criteria (Sub Factor)	Point	No	Criteria (Sub Factor)	Point
39	Water meter installation	1	91	Appropriateness of indoor air quality criteria.	8
40	Calculation of water saving plan	1	92	Suitability of indoor air quality parameters	8
41	At least 75% of the total procurement of fixture products	4	93	There are no smoking warnings or signs.	1
42	Smoke-free commitment.	1	94	Appropriateness of waste management criteria.	8
43	Warning and no-smoking signs	2	95	Waste segregation is carried out	3
44	The room is designed not to use refrigerant.	4	96	Waste bins that match waste generation	3
45	The value of (ODP) is equal to zero	2	97	TPS following the amount of waste generated	1
46	GWP of 700 at most.	1	98	Ensure that waste does not accumulate in TPS	1
47	3R waste management at sources.	1	99	Bookkeeping of monthly waste generation weight/volume.	1
48	individual/communal waste container facilities	1	100	Checking the quality standards of treated water (WWTP)	2
49	Building temporary shelters (TPS)	2	101	There is a socialization program about BGH	2
50	Organic and Inorganic waste processing	1	102	There is an information board about the greenness of the building	2
51	Recording the weight/volume of waste generation	1	103	Building user satisfaction survey.	5
52	Project work-plan initiation document	1			
			Total		**165**

Table 8. Performance Assessment of Demolition Stage in Green Buildings based on Technical Guidelines of the Ministry of PUPR No.1 Year 2022 [21]

No.	Criteria (Sub Factor)	Points	No.	Criteria (Sub Factor)	Points
1	Documentation of identification of building facilities and infrastructure	7	8	There is an identification of hazardous materials that can damage the environment	7
2	Documentation of building material identification	7	9	Restore vegetation on the site	10
3	Management of demolition implementation is by planning and implementation.	24	10	Minimize negative impacts during demolition.	17
4	Demonstrate compatibility of plans and methods with the demolition executor.	24	11	Minimize the use of new materials.	10
5	There is an identification of materials that will be reused by at least 40%.	9	12	Evaluate the suitability of the land restoration plan.	8
6	There is an identification of materials to be recycled by at least 40%	9	13	Provide collection, separation, and storage locations for recyclable materials.	8
7	There is an identification of the material to be destroyed	8	14	Record construction materials that are disposed of, recycled, reused, and/or stored and/or reused for future use.	9
			Total		**165**

Table 9. High-rise residential variables (X1)

No.	Sub-factor	No.	Sub-factor
1	Identification of Licenses and Non-Licenses	19	Procurement of Bid Consultant
2	Master Plan	20	Whole Work Drawing Document
3	Land Acquisition	21	Engineering Specification Document
4	Environmental Studies	22	Contractor Appointment
5	Forest Area Use	23	Project Construction Control and Implementation
6	Sector Master Plan	24	Develop Security, Safety, Health, and Sustainability Standards
7	Financing Planning (Budget)	25	Work Plan (Time Schedule)
8	Translating Building Needs	26	Site Plan/Installation
9	Term of Reference (TOR)	27	Material Procurement
10	Site Survey	28	Procurement and Mobilization of equipment and personnel
11	Project Feasibility Study	29	Preparation and Measurement Work
12	Design Selection	30	Working Drawing
13	Program Selection	31	Construction Fitness Test
14	Pre-Design Stage	32	Operation and Maintenance Plan
15	Design Development	33	Completion of inventory no longer than 6 (six) months
16	Checking for technical issues	34	Handover of Work 1
17	Client Consent	35	Building Maintenance by Contractor
18	Final Design Stage		

Table 10. System Dynamics Variables (X3)

No.	Sub-factor	No.	Sub-factor
1	System Dynamics Modeling	6	Initial Data
2	System Dynamics Model Explanation	7	Modeling and Simulation
3	Objectivity of the System Dynamics Model	8	Validation
4	Identifying Problems	9	Scenario Development
5	Define Problem Limitation		

Table 11. M-PERT Variable (X4)

No.	Sub-factor	No.	Sub-factor
1	Manual calculation development	7	Qualified Leaders
2	Network Simplification	8	Availability of Labor
3	Correlation between Activities	9	Activity Duration Variance
4	Merger of Project Activities	10	Average Project Duration
5	Number of Validation Tests	11	Average Duration of External Work
6	Monitoring Job Financing	12	Duration of External Work

Table 12. Variable Time (Y)

No.	Sub-factor	No.	Sub-factor
1	Unpredictable weather	4	Delayed delivery of materials and tools
2	Material Shortage	5	Shortage of skilled labor
3	Project location restrictions	6	Inaccurate production predictions

Based on the Research Objectives and Methodology, the main modeling in this study is shown in Figure 5.

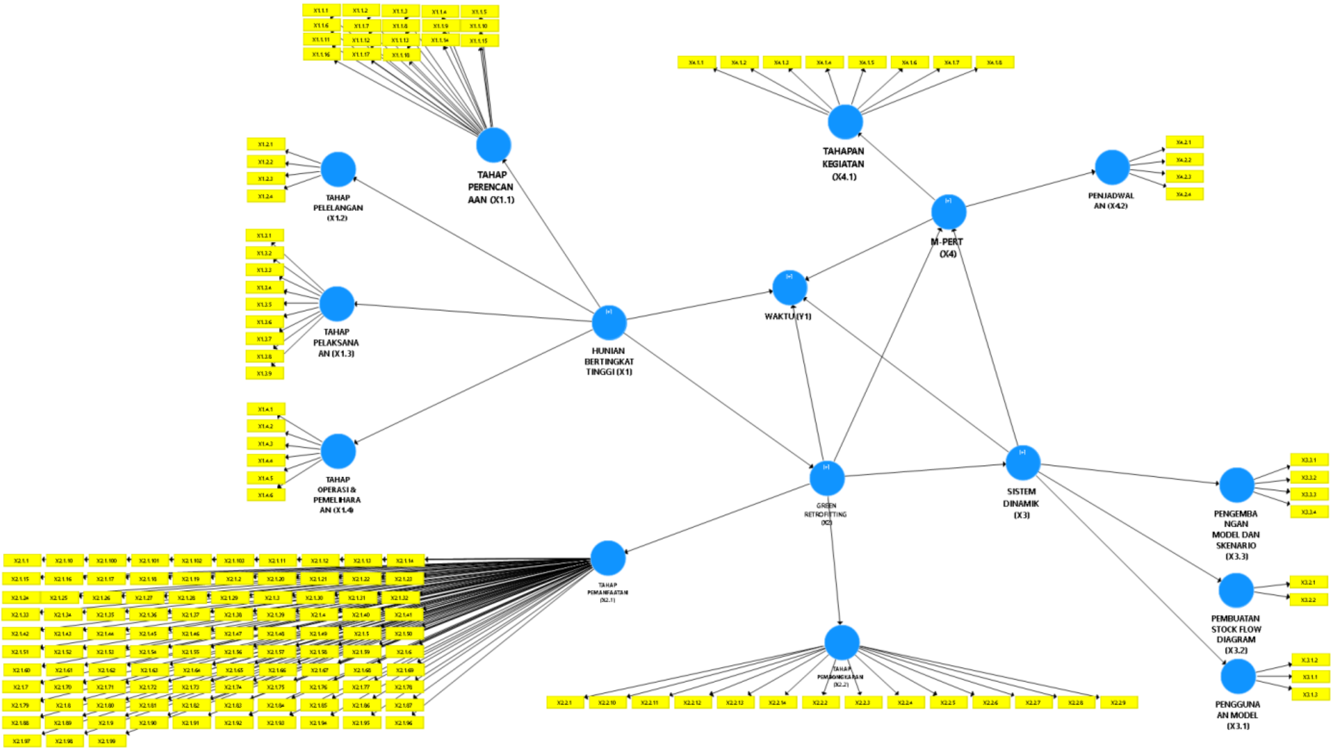

Figure 5. Modeling Diagram with SEM-PLS

The initial phase involves doing calculations via the SEM-PLS software. Convergent validity analysis examines the extent to which there is a strong correlation with other measures that assess the same construct [22]. To evaluate this, composite reliability and Cronbach's alpha are employed. When the composite reliability value falls between 0.6 and 0.7, it is regarded as possessing good reliability [23]. Cronbach's alpha value is used to assess the level of internal consistency of the scale. In this study, the reliability value derived for all variables and the entire range is found to be above 0.6 [24]. All indicators with an outer loading value greater than 0.5, as well as a valid outer loading validity value, indicate that all variables possess convergent validity, as demonstrated in Table 13.

Table 13. Convergent Validity Results Based on Convergent Validity

Main Factor	Cronbach's Alpha	Rho_A	Composite Reliability	Average Variance Extracted (AVE)
Green Retrofitting (X2)	0.993	0.993	0.993	0.539
High-rise Residential (X1)	0.996	0.996	0.996	0.863
M-Pert (X4)	0.977	0.979	0.979	0.800
Stock Flow Diagram Creation (X3.2)	0.849	0.849	0.930	0.869
Model and Scenario Development (X3.3)	0.895	0.921	0.929	0.770
Model Usage (X3.1)	0.975	0.976	0.984	0.953
Scheduling (X4.2)	0.920	0.932	0.943	0.804
System Dynamics (X3)	0.968	0.973	0.974	0.806
Operation & Maintenance Stage (X1.4)	0.987	0.987	0.989	0.938
Implementation Stage (X1.3)	0.974	0.976	0.978	0.829
Auction Stage (X1.2)	0.958	0.959	0.970	0.889
Utilization Stage (X2.1)	0.991	0.992	0.992	0.534
Disassembly Stage (X2.2)	0.977	0.979	0.979	0.773
Planning Stage (X1.1)	0.995	0.995	0.995	0.917
Activity Stages (X4.1)	0.971	0.974	0.976	0.837
Time (Y1)	0.959	0.964	0.968	0.837

The next step is to determine the T-statistical coefficient for testing the research hypothesis. The results were acquired by the utilization of the Bootstrapping function menu on SEM-PLS.

Based on the results of bootstrapping computation, if the t-statistical value is ≥ 1.96 and the p-value <0.05, it can be concluded that there is a significant relationship. Consequently, all construct-forming indications are deemed valid and can be utilized to test hypotheses on structural accurate measurements. Based on the analysis of questionnaire data, we have identified the 19 most influential factors out of the 181 factors examined. These factors significantly contribute to improving the accuracy of determining the execution time of green building customization, particularly in the context of high-rise residential buildings assessed using system dynamics and the M-PERT (Manual-Project Evaluation and Review Technique) approach. The 10 influential criteria are ranked in descending order of influence, with the utilization stage being the most influential factor. As indicated in Table 14.

Table 14. Most Influential Sub-Factors

No.	Sub-factor		Original Sample Value	Mean	T.Statistic > 1.96 (p< 0.05)	Against R Square
1	Monitoring and recording energy consumption.	(X2.1.77)	0.831	0.827	25.387	
2	Commitment to smoking ban at GB (Management Statement).	(X2.1.9)	0.821	0.822	23.050	
3	No use of hazardous and toxic materials.	(X2.1.6)	0.820	0.821	23.146	
4	Use (BMS) of the Building.	(X2.1.37)	0.820	0.819	25.865	
5	Use of environmentally friendly materials.	(X2.1.3)	0.819	0.819	23.363	
6	Individual/communal waste container facilities.	(X2.1.48)	0.817	0.818	28.110	**0.993**
7	Efforts to optimize the utilization of construction equipment technology	(X2.1.58)	0.815	0.815	26.863	
8	There is a socialization program about GB.	(X2.1.101)	0.813	0.813	23.899	
9	Smoke-free commitment.	(X2.1.42)	0.809	0.806	19.524	
10	Ban on plastic bags.	(X2.1.7)	0.803	0.803	21.474	

Monitoring electrical energy is necessary because the current utilization of electrical energy is less effective and its use is very excessive. In addition to the existing post-paid electricity in Indonesia, prepaid electricity has been implemented. This service has advantages over previous technologies because customers can control the cost of spending on electricity needs, such as topping up credit via their cell phones. The reality is that recording kWh (kilowatt-hours) cannot be controlled in real-time, often over-budgeting usage [25].

Significant quantities of data and information are produced at every phase of a development project. Comprehensive design information is produced to ensure the successful delivery of the developed asset and its intended use. Data is continuously generated during the whole lifespan of the building until it reaches the point where it is no longer functional. The majority of the data generated at this final stage pertains to energy use. Information can also be gathered regarding routine maintenance tasks performed daily. The entire performance is significantly influenced by the energy performance of the building [26].

3.2. Implementation of M-PERT to Time Performance

This research framework is at least initiated from matters where M-PERT, which is an innovation and the latest method of continuation of the PERT method (Figure 6), is proven to be able to provide an accuracy of planning execution time of 99% or with an error rate of 1% [20].

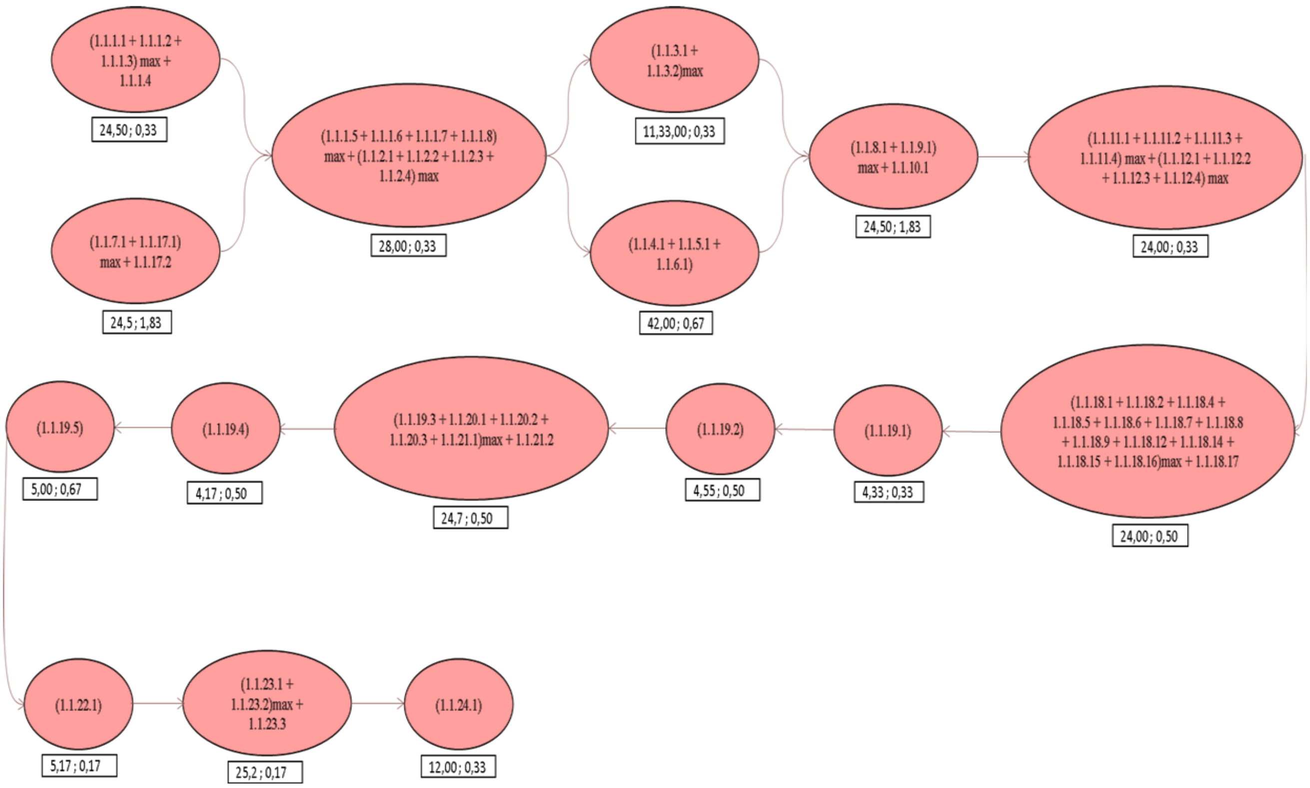

Figure 6. High-Rise Residential GB Conversion Work Diagram Step 2 (second) M-PERT Method

The Programme Evaluation and Review Technique Manual assumes that the normal distribution is a suitable approximation. This is because the majority of construction projects, albeit typically involving several tasks, do not all come together into a single unified activity. Instead, multiple lines converge towards various activities. Put simply, there is no single dominant peak of computation, but rather several peaks of computation combined with a large number of activities occurring in a sequence or peaks of activity occurring in a sequence, both of which deteriorate quickly. Within the context of a normal distribution. Furthermore, students who are engaged in M-PERT have a greater level of familiarity with the normal distribution compared to the distribution of extreme values.

M-PERT is a reduction approach where project activities are consolidated by a team of two or more individuals, leading to the creation of a new merged activity. The difficulty in utilizing M-PERT is in determining the precise method of integrating the various activities, which finally conform to the duration distribution. Therefore, based on the above justification, it is presumed that the durations of activities conform to a normal distribution. Three out of the five approaches also assume normality, even though a specific probability distribution is considered to be of little significance. CPM/PERT lightweight network elements depict the connections between activities in a project.

The last phase of the information requirements for a project involves determining the duration of every task, specifically the duration of the construction work for the Sunda Strait Suspension Bridge. In addition to determining the period of each activity, this stage also estimates the standard deviation for each of these activities [27, 28]. Computation of the duration for each task, utilizing optimistic, most likely, and pessimistic time estimates. By applying the formula mentioned in the preceding section, we can determine the duration, standard deviation, and corrected standard deviation for every activity (refer to Figures 7 to 9).

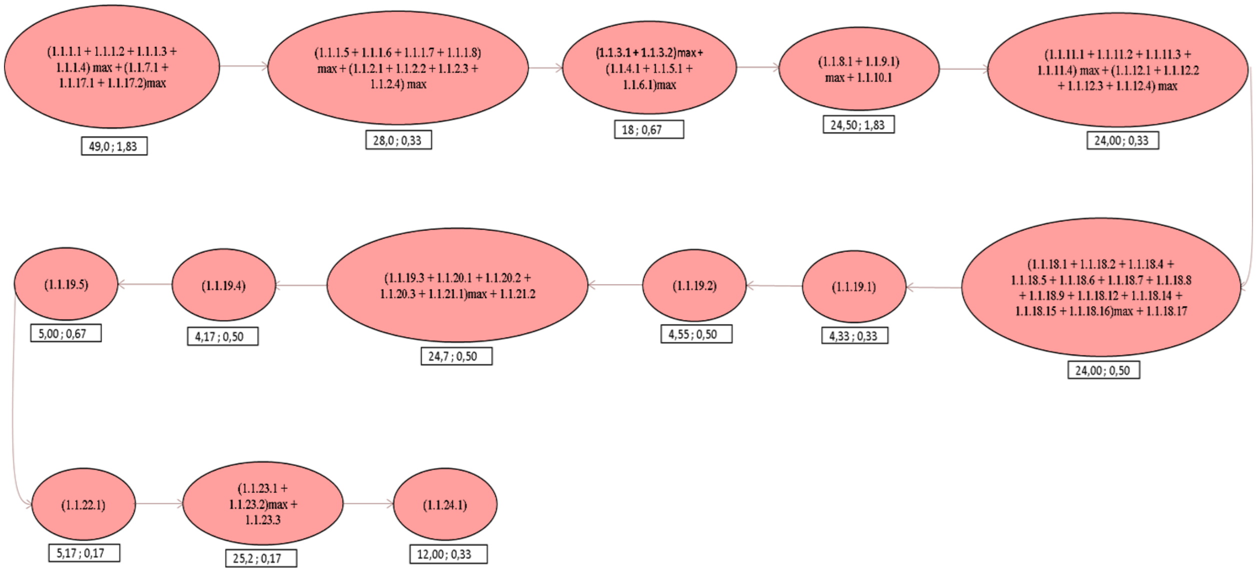

Figure 7. High-Rise Residential GB Conversion Work Diagram Step 3 (third) M-PERT

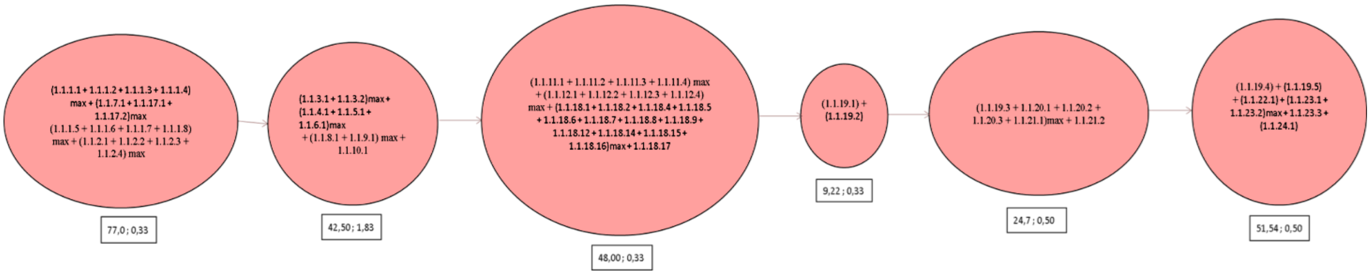

Figure 8. High-Rise Residential GB Conversion Work Diagram Step 4 (fourth) M-PERT Method

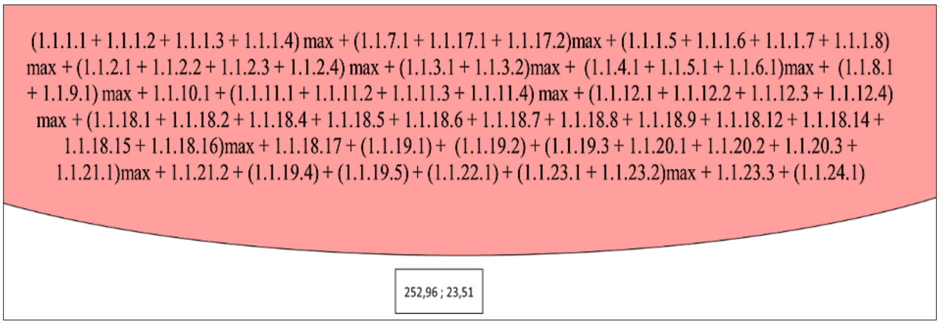

Figure 9. High-Rise Residential GB Conversion Work Diagram Step 5 (fifth) M-PERT Method

4. Conclusion

Ten factors influence green retrofitting modeling using system dynamics and M-PERT to improve time performance in high-rise residential buildings (by Tools SEM-PLS), including monitoring and recording energy consumption; Commitment to a smoking ban on GB (Management Statement); does not use hazardous and toxic materials; uses BMS in buildings; uses environmentally friendly materials; Individual/communal waste container facilities; Efforts to optimize the utilization of construction equipment technology; There is a socialization program about GB. Smoke-free commitment; prohibition of plastic bags. These factors are obtained from path analysis and have a significant effect.

The results of research on the time accuracy of green retrofitting high-rise residential buildings using M-PERT For the MAIN criteria, it is 98.88% where the Main GB Retrofit schedule is 250 days and the length of implementation after M-PERT is 252.96 days; MADYA is 99.92% where the GB Madya Retrofit schedule is 217 days and the implementation time after M-PERT is 219.57 days; and PRATAMA is 98.93% where the GB Pratama Retrofit schedule is 84 days and the implementation time after M-PERT is 84.99 days.

In this study, there are still limitations related to the possibility of differences in the results obtained for research objects, especially from the large number of objects that are being modified in high-rise residential buildings. At least by applying the M-PERT program in the customization process, it can still provide results for accuracy in implementation time.

5. Declarations

5.1. Author Contributions

Conceptualization, A.E.H. and R.S.P.; methodology, P.P.; software, R.P.; validation, B.K., R.S.P., and K.K.; formal analysis, L.S.; investigation, R.S.P.; resources, K.K.; data curation, P.P.; writing—original draft preparation, B.K.; writing—review and editing, A.E.H.; visualization, R.P.; supervision, R.S.P.; project administration, K.K.; funding acquisition, B.K. All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

5.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

5.4. Conflicts of Interest

The authors declare no conflict of interest.

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