

# VALUE ENGINEERING FOR PERFORMANCE IMPROVEMENT OF SUSTAINABLE CONSTRUCTION PROJECT

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## Abstract

The technology of value engineering (VE) can be used to provide project owners with the required optimum value that is characterized by the project being delivered at the lowest cost and at a greater level of performance and quality. Providing this value can be challenging or near impossible at certain instances that could eventually impair some basic and important principles of VE that are key in arriving at the required goals of a project. This paper assessed the available conventional VE standard(s) with the aim of improving its ability to provide the best value to project owners especially in sustainability or green building projects. A critical review of the available VE tools and their uses in construction projects led to a discovery that project owners always emphasized reducing the cost of projects at the initial stages and sometimes during the whole life cycle of projects. This was identified as a limiting characteristic of the conventional VE that could hinder the project and VE team from performing VE exercises that meet the value requirements of projects. Performance worth (PW) VE approach was used to address this limitation in the function identification and analysis phase of the VE methodology. Construction industry VE practitioners were provided with a presentation and then surveyed about the conventional VE and PW approaches, and their feedback used to validate the PW idea relative to sustainable design and construction. The results of data analysis showed that PW was better than conventional VE approach and thus, it was concluded that its inclusion in the VE job plan would benefit project owners by providing better value or improved project outcomes.

**Keywords:** construction project, function analysis, performance worth, sustainable construction, value engineering.

## 1. Introduction

Value engineering (VE) originated from General Electric, a defence contractor, as a strategic tool used by multidisciplinary team of professionals focusing on functions to deliver projects or systems at the lowest cost (Wao, 2015). L.D. Miles who initiated the VE idea at General Electric after World War II in the 1950s was faced with scarcity of resources and envisioned that items could only be bought for what they could do best or needed for. So the focus on function was key and a distinguishing factor in VE.

The Society of American Value Engineers (SAVE)-International Value Management Body of Knowledge (VM Bok) of 2019 and Wao (2015) defined VE as a systematic application of strategic techniques that identify function of systems where good teamwork, specific creativity approaches and good communication by multidisciplinary team of professionals are integrated to develop strategic systems that are aimed at meeting the project requirements at the lowest overall cost and highest performance and quality levels. Great team effort and understanding, high level of performance and optimal cost are vital goals in the VE process. Alternative systems must be carefully understood in terms of their functions or what they do best in a project before selecting those that are most preferred for the project. Selecting the needed alternative require creativity from VE team members and free flow of ideas without any form of hindrance. The VE team leader who steers the team has to ensure that the VE team focuses on greater level of analysis of systems while considering the functions and project requirements before incorporating suitable evaluation techniques to arrive at the most preferred alternatives. Using a method that is flawed or one that overemphasize some parameters such as performance, quality or cost may result in a decision that does not meet the project owner's overall requirements and possibly lead to project demise and owner dissatisfaction. VE employing appropriate method would ensure that the goals are met satisfactorily especially when focusing on better sustainable design and construction outcomes.

With sustainable construction, the goal is to meet the needs of the present population without threatening the ability of the future generation to meet their own needs in the built environment (Wao et

al., 2016). This needs performance assessment of systems, ensuring that commissioning is well done, and that the performance level of systems is exceeding the goals over the life cycle of a project.

There are varied tools that can be used to assess the performance level of systems in projects but VE stands out to be a potential tool that can be used to develop desired systems that are geared towards better sustainability outcomes. However, close analysis of some of the conventional VE processes show limitations in the VE job plan, especially when the goal is to improve sustainability outcomes (Wao, 2014). Therefore, this research was centred on refocusing the conventional VE process to improve building sustainability outcomes especially the performance improvement of systems. The objective was to identify the possible limitation in the function identification and analysis phase of the VE methodology and then find possible ways to address it by developing a new VE method for performance improvement. The hypothesis was that the new approach would result in better building sustainability outcomes. The significance of the study was to provide project owners and construction industry professionals with a value-focused tool to improve performance of systems.

## 2. Literature Review

### 2.1. Value Engineering and Sustainable Construction

The success of a VE process depends on the success of the functions analysis of systems using Function Analysis System Technique (FAST) in addition to a multidisciplinary team of professionals who have good relationship and better communication amongst themselves. Function analysis helps in understanding the items by moving the team from a general understanding to specific inner detailing that could lead to improved end-value. Focusing on functions make the VE process unique and different from other problem solving techniques (SAVE International VMBOK, 2019, Wao et al., 2016). Specifically, function analysis identifies necessary functions and potentially unnecessary costs of a specific aspect of a project. Thus, it is important to spend a lot of time on function analysis using FAST. This is because the most important function leading may not be visible and that an unsound choice from a range of options can lead to a different solution leading to high cost. Figure 1 shows FAST diagramming details.

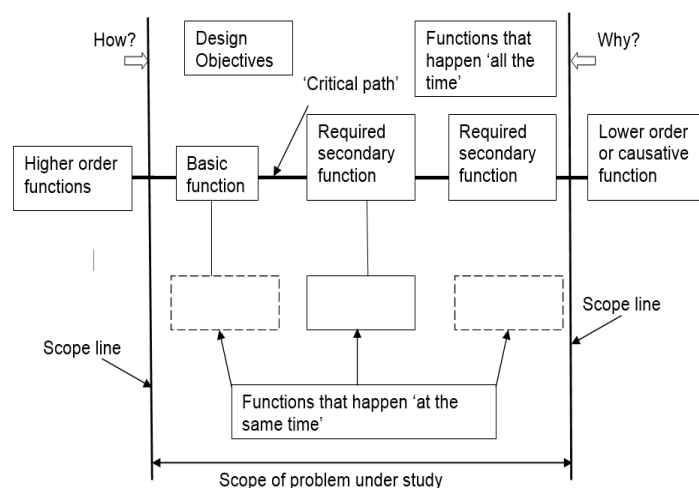


Figure 1. Technical FAST or function logic diagram (ASTM E2013-12).

The purpose in a project or system is in the higher order functions of FAST (Figure 1). Asking 'Why' determines the relationship between a higher order function and lower order function. The answer constitutes the higher order function. A logic check must be completed by asking 'How' the higher order function is realized. The answer must be the lower order function. The basic function is to the right of the left hand scope line and the secondary functions are to the right hand of the basic function and continue to the lower order function by asking 'How' questions (ASTM E2013-12; Wao, 2014). Overall, the main goal of function analysis is to develop a full understanding of the project systems. Once there

is complete understanding of the functions, the project team members can then select areas for maximum return on the value study resources that are available for the project (Wao, 2014).

Both sustainable construction and VE can be used to ensure better performance and quality of project over the life cycle (Mahadik, 2015). To achieve this, sustainability principles are integrated in projects to improve on their value, and VE can be used to achieve this value improvement goal by providing avenues to select better options for inclusion in sustainable construction projects (Wao et al., 2016).

Researchers have proposed integrating VE with sustainable construction principles so as to deliver projects with enhanced value where the main goal is to have sustainability principles and cost effective systems over the life cycle of project (Wao, 2018; Gunarathne et al., 2022). This is hoped to benefit project owners largely as it will provide them with better value for their money spent in projects while at the same time have tangible benefits in terms of socio-economic and environmental sustainability otherwise called triple bottom-line approach to sustainability (Wao et al. 2016; Senarathne et al., 2014).

Research has shown that limitations in time, lack of guidance on proper integration of sustainability principles, lack of knowledge of and awareness on sustainability and conflicting perceptions on sustainability are some of the barriers for integrating sustainability with VE (Gunarathne et al., 2022; Abidin and Pasquire, 2007). However, as stated by Yu et al. (2018), a systematic VE Job Plan can effectively guide the inclusion of sustainability principles during project life cycle. This job plan must not have limitations if it is to be effective. However, critical look at it shows some limitations.

## *2.2. Limitations of the Function Analysis Phase of the Value Engineering Job Plan*

Since VE focuses on saving the overall cost, it is often found that project owners tend to focus on reducing first cost and so they may over-emphasize the cost reduction aspect, thereby downgrading other key objectives such as improving quality or performance attributes. Over-emphasis on cost comes from ASTM E1699-14 standard that discusses cost. The standard, also called the conventional VE tool, has sections and subsections that discuss the cost-worth (CW) process in VE. Section 7.3.2 of the ASTM E1699-14 describes the importance of relating function to cost and has improvement methods in the event of cost escalation. In addition, ASTM E2013-12 standard describes value using cost reduction approach. Therefore, it is evident that sustainability or performance goals may be overlooked during VE study as attention is on the cost of systems rather than on performance or quality improvements (Wao, 2016). Thus, systems options for evaluation during the VE process are selected based on cost-to-worth ratios and not performance-to-worth basis. This could introduce bias in the end.

## *2.3. Alleviating the Limitation in the Function Identification and Analysis Phase of the VE Job Plan*

Looking at the conventional VE process, the CW approach is first-cost driven. CW ratio identifies the systems that may need improvement by considering their CW ratios. Meeting the sustainability goals require refocusing the conventional VE process since there is a tendency to over-emphasize cost reduction at the expense of performance/quality improvement. Since, the CW analysis is conducted in the function analysis phase, improving the performance or quality outcome will be achieved by improving the guiding standard. This can be seen in ASTM E2013-12 standard which states that the FAST data help in identifying system's alternatives with respect to their function costs.

ASTM E1699-14 subsection 7.3.2.5 defines worth as the VE team's estimation of the least costs, and this is the initial or first cost which is presented in the cost estimate needed to perform a specific system function. Subsection 7.3.2.6 stipulates that the CW ratio is calculated by dividing the design professional's cost for each system or functional group by the basic worth (the VE team's cost estimation). If the resulting ratio is greater than 1:1 (cost is higher in the estimate than the VE team's estimate), then there is potential opportunity for cost improvement. This means that greater ratio implies greater chance for improvement using first-cost approach.

Worth can also mean the VE team's best or highest estimation of quality or performance as defined by the selected quality and performance indicators for the project system. The performance-worth (PW)

maybe calculated by dividing the projected performance indicators by the VE team's target worth as represented by quality and performance indicators. Ratio less than 1:1, i.e., less performance realized from the design than the VE team's estimate implies a potential/ opportunity for improvement.

Integrating these changes in the VE job plan will consider all the VE objectives (cost, performance and quality improvements) in project. The VE team will discuss PW in addition to CW. The project owner can therefore obtain the best value for the lowest economic investment over the life cycle of a project.

### 3. Research Methods

The aim of this research was to refocus the conventional VE process to improve project sustainability outcomes. The objectives were to 1) identify limitation in the function analysis phase and find ways to alleviate the limitation, 2) evaluate the impact of the new VE method to sustainability. The hypothesis was that the new method would result in better building sustainability outcomes. The significance of the study was to provide owners and construction industry practitioners with a value-focused tool to improve performance of systems. Industry personnel were used in assessing the VE methods.

#### 3.1. VE Practitioners and Survey Questionnaire

In order to provide a conclusive validation of the new or alternative VE approach, a group of VE practitioners (N = 15) were purposely selected to take part in this research requiring them to offer their opinions about the alternative VE approach aimed at improving sustainability outcomes. They were certified in value engineering (certified value specialists also called CVS) and were experienced in conducting VE in projects. A presentation was given showcasing the change in the conventional VE.

Prior to presenting to them, their consent to participate in the research through this presentation and subsequent survey was sought through the assistance of the Institution Review Board (IRB) which approved the presentation and the survey protocol. The presentation was then provided to the VE practitioners and it detailed out the limitations of the conventional VE method and the avenues that were proposed to counter the limitations relative to improving sustainable design and construction outcomes. They were given time to discuss it through questions and comment section of the presentation. Immediately after the presentation, the VE practitioners were sent the online survey questionnaire via Qualtrics software so as to gather their opinions about the limitations of conventional VE method and the proposed new approach to VE. The survey questionnaire entailed collection of the VE practitioners' demographic data such as number of years in construction industry, number of years involved with VE and sustainability assessment tool. Emphasis was placed on the VE specific questions as shown in Table 1.

Table 1. Survey questions specific to VE and sustainable or green construction outcome

Number	Type of question	Coding
Q.9	Whether or not to accept the various limitations in conventional VE process.	Yes = 1, No = 0
Q.10	Degree of agreement with the various limitations in conventional VE process in negatively impacting green building outcomes.	Strongly disagree = 1, Disagree = 2, Neither agree or Disagree = 3, Agree = 4, and Strongly agree = 5
Q.11	Level of satisfaction with the VE methods in meeting or improving building sustainability outcomes.	Very dissatisfied = 1, Dissatisfied = 2, Somewhat dissatisfied = 3, Neutral = 4, Somewhat satisfied = 5, Satisfied = 6, and Very satisfied = 7
Q.12	Additional thoughts or comments on VE and green building.	NA

#### 4. Results and Discussion

The data from the survey of VE practitioners were analysed. The data were both quantitative and qualitative types (mixed method). Data analysis using SAS studio (2023) was mainly focused on the limitations of the conventional VE and the ability of the VE method to improve sustainability outcomes. The descriptive statistics results of the conventional VE and alternative VE were presented. The statistics mostly reported percentage scores and mean measures as part of the descriptive statistics because this was believed to provide good presentation of the data in a simplified format.

Those who completed the survey were Certified Value Specialists (CVS), university professors, directors and presidents of companies, construction managers, and civil engineers from all over the globe.

About 72% of the respondents had over 20 years of experience working in construction industry while 14% of them were 6-10 years and 11-15 years of experience respectively. For their experiences, 100% of them had used VE in their projects while 57% had used LEED or other green building rating systems. Of those who had used VE in their projects, about 72% of them were over 20 years of experience working with VE while 14% of them had 11-15 years and 16-20 years of experience respectively. For those who had worked with green building assessment tools like LEED, approximately 50% of them had 6-10 years of experience working with it while 25% had 2-5 years and 16-20 years respectively in working with it. This, in overall, depicted the high level of engagement in the construction industry and many years of using VE in projects which would imply greater reliability in the data or information they would provide because the many years meant experience and knowledge in their respective fields.

The respondents were also asked about the description of their respective construction companies. A complete 100% of the respondents reported that their companies specialized in VE while construction management and cost engineering areas of specialization accounted for 29% of the respondents respectively. About 14% were involved in general contracting while about 29% were in business management and risk management field. Their projects were mainly commercial (57%) and industrial (57%). Others were heavy civil (29%), manufacturing and mining (29%), and residential projects (14%). Their full engagement in VE means that the data were mostly in VE and would provide reliable interpretation for eventual accurate research generalizability.

They were also asked whether or not they accepted the limitations identified in the conventional VE process as actual or true limitations based on their VE experiences. Also, they were asked whether or not the identified limitations would negatively impact green building outcomes based on their opinions from the presentations and field experiences. Green buildings, sustainable buildings, energy efficient buildings, net zero energy buildings, high performance buildings and resource efficient projects were terms that were used interchangeably in the field of sustainable construction during the presentation.

Considering the responses to the limitations on whether or not they were true or actual limitations, more than half of the respondents (57.1%) believed that over-emphasis on cost was indeed a limitation. Considering the negative impact of the limitations to green building outcomes, about half of the respondents (42.9%) disagreed with the limitation pertaining to over-emphasis on cost while about 28.6% strongly agreed that it was actually a limitation relative to negatively impacting green building outcomes (Mean = 3.29). This feedback posed a potential venue for proposing a new method to VE whereby it was clearly feasible to discuss potential application of PW method to VE especially for performance improvement in sustainable construction projects.

The qualitative data also showed that value planning (VP) and value management (VM) were more encouraged as opposed to VE. Some respondents held that VE had for a long time been focused on reducing or cutting cost. Therefore, VP and VM would be preferred concepts to improve performance of systems using function analysis as the basis for value analysis (VA). The performance goal is where a respondent held that the biggest optimization in the VE process could be achieved through the use of performance based attributes weighted by the client prior to the start of the VE workshop. Function analysis stimulates creativity and would be easy to understand where teams use it in defining items rather than as an activity like in critical path method in project scheduling.

Some respondents held that VE, VM, and VA are terms used by many practitioners and are applied in different project stages. For example, VM is typically applied as early as possible in the project with the aim of optimizing costs, VE is applicable in all project stages and may be used for assessment of project alternatives or refinement of systems, while VA may be applied at design stages. Noteworthy is that they are all aimed at refining, reducing cost, and improving performance and quality of systems.

## 5. Conclusion

This research investigated the conventional VE method, identified some limitations in the function analysis VE phase and then proposed a potential approach that could be integrated in the VE methodology to improve its outcomes especially for sustainable projects where performance is always held in high regard. It determined and assessed the PW method in the function analysis phase of the VE job plan in comparison to the conventional VE method. VE practitioners were involved in the validation of VE PW approach whereby they were presented to and then provided their candid feedback through anonymous survey questionnaire. Analysis of the VE practitioners' feedback showed that the majority of them were in support of the PW idea, and that it could be a better approach in achieving sustainability goals in projects than conventional VE method. Thus, the hypothesis of the new VE approach being better and providing improved performance outcomes was supported. The PW idea could be a worthwhile inclusion in the VE function analysis phase to re-orient the VE teams, construction professionals, project owners and stakeholders from the routine thinking of cost reduction to inclusion of performance improvement ideas. The VE goals would be met while utilizing life cycle (and cost) analysis approach to attain the project goals. This research contributes to the VE studies body of knowledge especially those focusing on improving sustainable construction project outcomes.

Future research may delve into applying the new VE method in a case study building to investigate its overall impact in providing value to project owners. The greater value may show in 'platinum' certification in LEED or earning the 'restorative' achievement level in Envision for sustainable infrastructure projects.

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