Applying a revised six-stage value engineering job plan in Egyptian banking sector construction projects to optimize cost efficiency and improve value

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Abstract. Traditional VE frameworks often fail to address specific challenges unique to banking facilities, such as stringent security requirements, regulatory compliance, and advanced technological demands. This study explores the application of a revised six-stage value engineering (VE) job plan tailored for construction projects in the banking sector. The revised plan integrates critical factors, including enhanced security measures, economic feasibility, sustainability, safety standards, and long-term maintenance needs. A case study of a new branch for the Egyptian Export Development Bank construction demonstrates the effectiveness of this approach, highlighting innovations like reinforced security systems, sustainable energy solutions, and advanced compliance protocols. The findings illustrate how aligning VE methodologies with banking sector standards can optimize cost efficiency, enhance functionality, and foster sustainable development, offering a robust framework adaptable to similar high-security, technology-driven environments.

Keywords: Value Engineering, Construction Projects, Cost Efficiency, Sustainability, Value Index.

1. Introduction

Value Engineering (VE) was introduced during World War II as a structured approach to address material and labour shortages. During 1997, the Society of American Value Engineers International (SAVE Int.) was established as an international organization to promote the practices globally and standardize its methodologies (Chen et al., 2022). VE started in manufacturing engineering, it spread quickly to other disciplines and had made its way into the construction field by 1970. This shift into the construction industry brought two significant changes to VE: (1) it started the utilization of a 40-hour workshop to carry out a VE study; and (2) two different thought processes for the implementation VE (AbdelRaheem, 2018). The idea of VE became more widely accepted in the construction industry, it was applied to many different situations and scenarios, and the number of tools available to aid VE workshops has grown (Elhegazy, 2022). Highlights VE as a systematic and organized methodology aimed at optimizing project value by balancing functionality, quality, and cost found that this strategy saved 20-30% of costs (Rachwan et al., 2016).

Several studies highlight the significant role of Value Engineering (VE) in optimizing costs, improving quality, and enhancing functionality across construction projects. For example, AbdelRaheem(2018) identified 15 success factors in four key areas—team requirements, client influence, facilitator expertise, and departmental roles highlighting VE's growing potential in construction and encourages further research on its benefits and critical success elements. Lin et al., (2023) demonstrates how value engineering optimizes cost and performance through a structured process, including pre-study, six core stages, and post-study implementation emphasized its importance in balancing cost, time, and quality using the FAST tool in a five-phase job plan. VE has been highlighted as a systematic approach to maximizing value by balancing functionality and cost. VE offers benefits such as cost reduction, quality

improvement, resource optimization, enhanced decision-making, innovation, and sustainability (Invernizzi et al., 2019). VE's efficiency and cost-saving potential but noted limited adoption in developing countries due to expertise constraints. The integration of Lifecycle Cost Analysis (LCCA) with VE to achieve eco-friendly alternatives and cost savings. The study demonstrated VE and LCCA's role in improving cost performance, supporting green building standards, and minimizing environmental impact. Reviewed VE's global application, particularly in developing countries, highlighting tools like BIM-based Idea Banks and their integration with sustainability efforts. However, challenges such as limited expertise and regulatory barriers remain (Tom & Gowrisanker, 2015). Finally, revealed gaps in VE's practical application in Egypt due to limited awareness and resistance to change, recommending early integration for better implementation (Rane & Attarde, 2018). Revealed gaps in VE's practical application in Egypt due to limited awareness and resistance to change, recommending early integration for better implementation (Sara Atef et al., 2021). VE's efficiency and cost-saving potential but noted limited adoption in developing countries due to expertise constraints. The integration of Lifecycle Cost Analysis (LCCA) with VE to achieve eco-friendly alternatives and cost savings. The study demonstrated VE and LCCA's role in improving cost performance, supporting green building standards, and minimizing environmental impact (Ali Imron and Albert Eddy Husin., 2021). Pointed to VE's efficiency and cost-saving potential but noted limited adoption in developing countries due to expertise constraints (Rad and Yamini., 2016).
However, practical challenges such as limited awareness, regulatory constraints, and insufficient focus on main functions often hinder VE’s effective implementation and despite its advantages, there is limited research on VE’s specific application in banking sector, VE addresses distinct challenges such as stringent security requirements, regulatory compliance, and advanced technological demands. Utilizing a six-stage methodology encompassing preparation, information gathering, analysis, idea generation, evaluation, and presentation VE effectively balances cost reduction with functional enhancement, aligning with financial, operational, and environmental objectives. By focusing on sustainability through reduced energy use, optimized lifecycle costs, and environmentally friendly practices, VE incorporates corporate social responsibility into project development. This study aims to close that gap by creating a specialized framework for banking projects, fostering innovation, cost efficiency, and sustainable growth.

2. Objective

This study aims to develop a revised six-stage VE job plan tailored specifically to banking sector construction projects to address their unique challenges. The proposed framework will emphasize critical factors such as security, regulatory compliance, economic feasibility, sustainability, and long-term maintenance planning. By moving beyond traditional cost-cutting approaches, the revised methodology seeks to optimize construction processes and designs to meet the unique demands of banking facilities, fostering innovation, operational efficiency, and sustainable growth.

3. Methodology

A revised six-stage value engineering job plan applied in the banking sector construction case study of a new branch for the Egyptian Export Development Bank by addressing specific shortcomings and aligning with industry standards. Key limitations include insufficient focus on security, economic constraints, environmental impacts, safety compliance, and maintenance requirements. Enhancements to the plan should integrate robust security measures to protect sensitive data and assets, prioritize cost-efficiency without compromising quality, incorporate sustainable practices to meet environmental standards, and ensure adherence to safety regulations to protect occupants and workers. Maintenance needs to ensure long-term functionality and cost savings. The following sections will discuss two phases: (1) overview of the traditional six-stage VE job plan; and (2) revised Six-Stage VE job plan for the Banking sector.

4. Phase 1: Overview of the Traditional Six-Stage VE Job Plan.

This phase provides an overview of the traditional six-stage VE job plan, which can be summarized as follows:

- a- Information stage: gather and complete the value study data package. The team is briefed by project sponsors or designers.
- b- Function Analysis stage: Outline and classify functions using verb-noun pairs ('boil water'). Estimate the cost of each function and determine areas for improvement.
- c- Creative stage: brainstorm alternative ways to achieve each function selected for study. This phase emphasizes creativity, free from constraints.
- d- Evaluation stage: rank, rate, and synthesize ideas generated during the creative phase, selecting feasible options for further development.
- e- Development stage: prepare sketches, narratives, and technical information for the most feasible alternatives, allowing project sponsors to assess implementation potential.
- f- presentation stage: present the best alternatives to decision-makers for approval and implementation.

5. Phase 1: Revised Six-Stage VE Job Plan for Banking Sector.

The banking sector has distinct challenges such as: stringent security requirements, regulatory compliance, and advanced technological demands. There for traditional six-stage VE job plan needs to be revised to consider limited awareness, and a sharper focus on the main function while integrating regulatory standards, security constraints, environmental impact, and economic feasibility. Key considerations for enhancing awareness include: (1) Security Concerns: Prioritizing structural integrity, advanced security measures, and restricted access zones to mitigate unique risks in banking facilities; (2) Regulatory Compliance: Addressing stringent and complex banking regulations that traditional VE often overlooks; (3) Environmental Standards: Emphasizing sustainability by aligning construction practices with environmental requirements, typically underemphasized in traditional VE; (4) Cost Control and Economic Impact: Implementing robust economic analyses and cost-control measures to meet banks' cost-sensitive priorities while focusing on the main functions of systems; (5) Safety Systems: Ensuring safety standards align with modern protocols and recognizing the primary safety functions; (6) Maintenance Requirements: Addressing high maintenance standards and evolving needs to ensure long-term functionality and cost efficiency, surpassing traditional VE considerations.

There for this study provide a revised Six-Stage VE job plan to address the unique needs of the banking sector construction to ensures robust, secure, and sustainable banking facilities. The stages of this plan can be summarized as follows:

a. Information stage as the same procedure of traditional Six-Stage VE Job Plan with in-depth regulatory review ensures compliance with banking construction standards, while stakeholder identification aligns objectives with the expectations of authorities, security consultants, and environmental specialists.
b. Detailed function analysis stage prioritizes security features such as vaults, surveillance systems, and restricted access zones, complemented by a comprehensive risk assessment to address potential physical and cyber threats.
c. Focused creative stage, sustainable design solutions and advanced security systems, including biometric access and state-of-the-art surveillance, are explored to enhance functionality and environmental performance.

d. Evaluation stage as the same procedure of traditional Six-Stage VE Job Plan with assesses security, regulatory compliance, and economic feasibility, ensuring cost-effectiveness and ROI.
e. Prototyping and development stage, pilot testing of security features and mock-up rooms for critical spaces verify functionality and design efficiency.
f. Presentation stage as the same procedure of traditional Six-Stage VE Job Plan with focuses on securing compliance approvals through tailored presentations and developing a phased implementation plan with clear construction stages and cost projections.

5. Case Study

A real-life case study of the construction of a new branch in Egypt is analyzed to illustrate the use of the Revised Six-Stage VE Job Plan and highlight its unique and capabilities for: (1) solar energy system and energy conservation, both critical aspects of sustainability and improve power efficiency; and (2) Access control systems (ACS) which vital role in securing sensitive areas and assets. The project consists of 2 basement floors, in addition to the ground floor and seven repeated floors with a building footprint of 7050 square meters. Incorporated a comprehensive six-stage plan focusing on enhanced security, improving power efficiency and sustainability.

First, applying the revised six-stage job plan of value engineering to solar energy system and energy conservation. The procedure can be summarized as follows:

a. Information stage: the initial phase focused on gathering data to identify the specifications, banking regulations and clients need for the bank construction project. this included evaluating the need for solar energy system to enhance power efficiency, reduce carbon emissions and security compliance with both Egyptian and international standards.
b. Detailed function analysis stage: key functions of the PV panel system were identified, including enhanced power efficiency, reduce carbon emissions, and cut electricity costs. This system has an initial cost of 878,700 LE with no maintenance costs. The return on investment (ROI) calculations for the PV panel system are summarized in Table 1. As a result, this system can generate savings of 1,829,587 LE. In addition, a risk assessment was conducted to enhance power efficiency up to comply with power efficiency needed to security systems in banks must not be less than 98% instead of 90% power efficiency for other construction projects as shown in figure (2). This system of PV panel ensured that they addressed both functional and structural needs.
c. Focused creative stage: innovative thinking about main function were proposed to enhance power efficiency by using materials more effective by putting forward Ideas such as the use of European cables for DC current to achieve the highest efficiency, use inverter for variable folding, use aluminum mounting mounts instead of iron and photovoltaic modules for cells. These solutions aimed to balance performance, cost, and sustainability.
d. Evaluation stage: evaluating the alternative materials such as DC cables European production, double-insulated to withstand the voltage resulting from the system and operating the complexes at 25 degrees and solar radiation of 1000 W/m2 "1000 VDC. So, for solar cells photovoltaic modules-IEC 61215 & IEC - Complies with international testing standards "61730". IP with a degree of protection "68 (J.Box) and a "BYPASS DIODE" connection box enhancing inverter efficiency by using On-Grid Inverter protected from short-circuit currents, overloads, high and low voltage and

frequency above limits and aluminum mounting structures withstand stresses resulting from high wind speeds up to 150 km/h.

e. Prototyping and development stage: a prototype for system was made and it was approved by the Egyptian Renewable Energy Authority and it showed Performance Ratio 86.9%, cables for connecting photovoltaic complexes have a capacity of 125% of the maximum DC current, Solar cell efficiency warranty: 90% for 10 years - 80% for 25 year and 10-year cell warranty against manufacturing defects, which give Feedback used to refine the design and ensure optimal performance.

f. Presentation stage: findings were presented as power efficiency achieved ≥ 98% compliant with security system requirements for banks as shown in figure (1), warranty coverage: 10 years at 90% efficiency and 25 years at 80%, alignment with Egyptian and international standards. Compliance with industry standards in this stage and detailed installation and integration plans incorporate modular construction techniques, local material usage, and real-time cost-benefit analyses to ensure the project aligns with both quality standards and budgetary constraints which optimize reliability, resistance to extreme conditions, PID resistance, High mechanical stability and water resistance which means security systems have optimized power efficiency.

Table 1: ROI cost saving

Year	Electricity Generated (MW-Hr)	Electricity Tariff (LE)	Electricity Generated Price (LE)	Accumulated Revenues (LE)
1	65000.00	1.45	94,250.00	784,450.00
2	64415.00	1.60	102,741.93	681,708.08
3	63835.27	1.75	111,998.97	569,709.10
4	63260.75	1.75	110,706.31	459,002.79
5	62691.40	1.90	119,706.31	339,889.13
6	62127.18	1.90	119,113.66	221,847.49
7	61568.03	1.90	1188,041.64	104,868.23
8	61013.92	1.90	116,979.26	11,058.22
9	60464.80	1.90	115,926.45	125,941.33
10	59920.61	1.90	114,883.11	239,790.50
11	59381.33	1.90	113,849.16	352,615.02
12	58846.90	1.90	112,824.52	464,424.12
13	58317.27	1.90	111,809.10	575,226.94
14	57792.42	1.90	110,802.82	685,032.53
15	57272.29	1.90	109,805.59	793,849.88
16	56756.84	1.90	108,817.34	901,687.87
17	56246.02	1.90	107,837.99	1,008,555.31
18	55739.81	1.90	106,867.45	1,114,460.95
19	55238.15	1.90	105,905.64	1,219,413.44
20	54741.01	1.90	104,952.49	1,323,421.35
21	54248.34	1.90	104,007.92	1,426,493.20
22	53760.10	1.90	103,071.84	1,528,637.40
23	53276.26	1.90	102,224.90	1,629,862.30
24	52796.78	1.90	100,313.88	1,730,167.17
25	52321.61	1.90	99,411.05	1,829,587.22
Total			2,708,2887.22	1,829,587.22

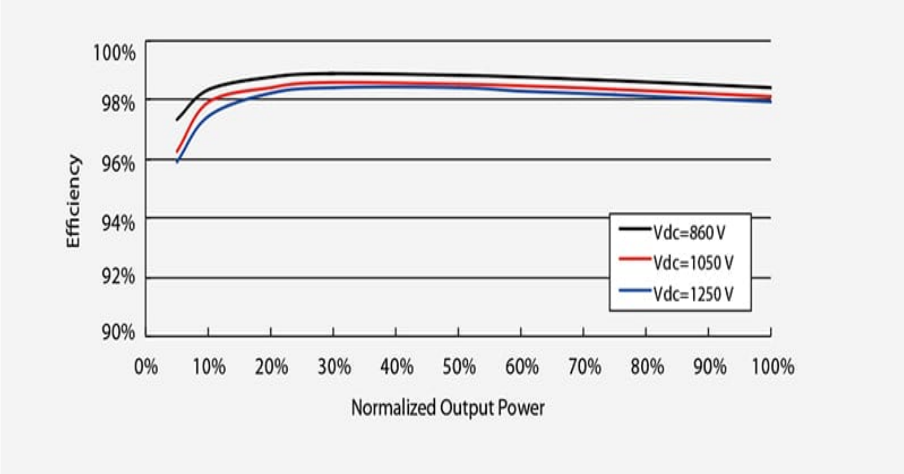

Fig.1 Power Efficiency of Solar Energy System.

Second, applying the revised six-stage job plan of value engineering to Access control systems (ACS). The procedure can be summarized as follows:

a. Information stage focused on gathering specific security requirements, talking to expertise, comply owner and consultant about to Access control systems such as Network Time Protocol (NTP) which Synchronize with IP video surveillance system, integration with Intrusion Detection system, Fire Alarm, Voice Evacuation System and security Compliance with both Egyptian and international standards.
b. Detailed function analysis stage: By assessing the risk of security threats such as fraud and theft and evaluating the functionalities of an integrated security system. The value index (VI) of the system can be calculated using Eq. (1). The value index of the system is used to optimize costs while addressing potential security threats. Given that daily transactions may reach 60 million LE, the Access Control System must be fully integrated with an Intrusion Detection System to ensure comprehensive security.

$$VI = \frac{FC}{FW} \quad (1)$$

Where:
VI: The value index of the system;
FC: the value of function cost of the system;
FW: the value of function worth of the system.

c. Focused creative stage introduces innovative security solutions for vaults, data centers, and executive offices by integrating essential elements of an Intrusion Detection System (IDS). This includes an intrusion detection panel to process alerts and coordinate responses, window intrusion detection sensors to detect unauthorized access, and an emergency/panic foot rail for discreet and immediate emergency alerts. By implementing these components, the system enhances security, ensuring proactive protection against potential threats.
d. The Evaluation Stage assesses the integration of the Access Control System with the Intrusion Detection System to ensure reliability and security. The system must comply with key performance criteria. First, the Intrusion Detection Panel must be equipped with a backup battery capable of operating the system for 8 hours in standby mode during a power outage, store at least 250 event logs in an internal non-volatile memory, and support a 20-second pre-recorded message. Second, the Window Intrusion Detection Sensor must

include hard-drawn copper break wire sensors (up to 26 AWG diameter with a strength of 17.8 N) that trigger an alarm if the wire is cut or tampered with. Finally, the Emergency/Panic Foot Rail Unit must be made of rugged cast aluminum, operate silently, be tamper-protected, and feature a DPDT switch with a maximum switching current of 100 mA to ensure a reliable and secure emergency response.

e. The Prototyping and development stage required developing a prototype of the intrusion detection system integrated with an IP Video Surveillance System, Access Control System, and IP Telephony System. To ensure continuous operation, the system is powered by two power sources government electricity and UPS source power as a backup. In the event of an intrusion, it automatically dials a pre-recorded message to security authorities. Additionally, the system comes with 3 years warranty, ensuring reliability and long-term functionality.

f. The presentation stage involves assessing the risks of fraud and theft while ensuring compliance with standards. The system is designed to handle daily transactions with total of 60 million LE, representing its function worth. Its cost was evaluated between two suppliers: the first supplier offered 59.5 million LE, while the second supplier offered 64 million LE. Using Eq. (1), the Value Index was calculated as 0.99 for the first supplier and 1.07 for the second. Based on this analysis, the first supplier was selected to optimize cost while effectively mitigating security threats.

6. Conclusion

The revised six-stage Value Engineering (VE) job plan, tailored for banking sector construction and demonstrated in the Egyptian Export Development Bank branch case study, has proven highly effective in addressing key challenges. These include: (1) enhanced security measures through the integration of biometric access controls and advanced surveillance and intrusion systems, backed by a three-year warranty and a Value Index of 0.99; (2) the use of sustainable solutions to achieve 98% power efficiency, utilizing solar panels with an 86.9% performance ratio and long-term warranties of up to 25 years, meeting both security system requirements and energy-saving goals; and (3) regulatory compliance and cost efficiency, ensuring optimized energy use, functionality, and risk minimization in the banking sector. This approach validates the plan's ability to enhance cost efficiency, promote sustainability, and meet high-security demands, providing a robust and adaptable framework for similar projects.

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