Economics and Business Quarterly Reviews

Rudiantoro, A., & Ghazali, A. (2025). Implementing Sustainability Budget Tagging in ERP Systems: Evidence from Indonesia's State-Owned Energy Company. *Economics and Business Quarterly Reviews*, 8(4), 100-118.

ISSN 2775-9237

DOI: 10.31014/aior.1992.08.04.695

The online version of this article can be found at:
https://www.asianinstituteofresearch.org/

Published by:
The Asian Institute of Research

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The Asian Institute of Research
Economics and Business Quarterly Reviews
Vol.8, No.4, 2025: 100-118
ISSN 2775-9237

DOI: 10.31014/aior.1992.08.04.695

Implementing Sustainability Budget Tagging in ERP Systems: Evidence from Indonesia's State-Owned Energy Company

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Abstract
Enterprise Resource Planning (ERP) systems are becoming strategic platforms for integrating sustainability metrics, though there are substantial gaps in operationalizing sustainability cost tracking within current financial frameworks. This paper explores how Sustainability Budget Tagging (SBT) can be implemented in SAP ERP at PT Pertamina and the key challenges in tracking and reporting sustainability spending. Before implementation, manual sustainability cost tracking at Pertamina took around 120 person-hours per year (only 85 percent accurate) and did not provide decision-makers with much real-time visibility. In a single-case study approach with a holistic design in which the before-and-after comparison is embedded, this study documents the end-to-end implementation process across four phases: baseline assessment, system design and development, phased deployment, and post-implementation evaluation. The data were collected through semi-structured interviews with 15 stakeholders, document analysis, SAP system logs, and dashboard artifacts. The findings show a significant positive change: a 30% decrease in reporting preparation time, a 10% increase in the accuracy of cost tracking, and a 75% decrease in budget allocation error. The research provides empirical data on ERP-supported sustainability accounting in new-economy state-owned firms. It serves as a useful guideline for designing a taxonomy, setting up SAP modules, and managing the organization during sustainability tracking implementation.

Keywords: Sustainability Budget Tagging, Enterprise Resource Planning, Environmental Management Accounting, State-Owned Enterprise, ESG Reporting, SAP

1. Introduction

The worldwide trend toward corporate sustainability has radically changed how organizations conceptualize value creation and accountability. Enterprise Resource Planning (ERP) systems, which were traditionally aimed at maximizing the effectiveness of business operations, now have a strategic task of integrating environmental, social, and governance (ESG) metrics into business processes (Alzahmi et al., 2025; Chofreh et al., 2016). Still, even with increased awareness of the importance of sustainability, there remains a major infrastructure disparity in how organizations systematically track, manage, and report on sustainability-related spending, especially in the context of traditional ERP architectures where ESG concerns were largely discretionary (Barker, 2025).

The emerging economies' state-owned enterprises (SOEs) experience acute pressures at this intersection in particular. Such organizations have to deal with two mandates: commercial performance requirements and developmental goals that indicate the state ownership (Bruton et al., 2015; Musacchio et al., 2015). In the energy sector, state enterprises are facing mounting pressure regarding climate pledges and the open use of significant funds for renewable energy sources and emissions mitigation (Sundarasen et al., 2024). The mismatch between ambitious environmental sustainability policies and the ability to systematically monitor these investments jeopardizes credibility when stakeholder demands for ESG accountability are as high as ever before.

The failure to systematically monitor sustainability costs leads to domino effects. Companies that fail to implement integrated tracking resort to labor-intensive, resource-consuming manual procedures that do not yield credible data. The accuracy of this manual method is usually 80-85 percent, there is 15-25 percent inconsistency in classification, and it takes hundreds of person-hours to complete a reporting cycle (Burritt et al., 2023; Gerged et al., 2024). Retrospective tracking denies management real-time visibility, which reduces the likelihood of resource allocation in an ad hoc fashion. In addition, sustainability reporting, which was previously a voluntary act, has been made mandatory through increased ESG disclosures, rendering it a legally binding disclosure that must be audited by external auditors (Barker, 2025). The IFRS S1 and S2, introduced by the International Sustainability Standards Board and used by many jurisdictions such as Indonesia, starting January 2027, require climate-related financial disclosures to be prepared in an audit-ready form with documentation trails generated by the system (IFRS Foundation, 2023). Companies that fail to disclose systematic sustainability costs are fined by the government and perceived as cynical by stakeholders, which negatively affects the organization's image and increases capital expenditures.

In addition to compliance, insufficient visibility into the cost of sustainability prevents organizations from answering the most basic strategic questions: Which programs have the greatest impact for the dollars invested? Is the actual spending in relation to the budgets? What is the percentage of capital expenditure that is truly progressive towards sustainability objectives? The management will be unable to assess cost-effectiveness or redistribute resources to more significant prospects without granular, timely data associated with performance outcomes (Schaltegger and Burritt, 2000).

The overlap between sustainability management and ERP systems has generated significant academic interest, though major gaps remain. The conceptual frameworks of the sustainability ERP (S-ERP) study have identified a positive correlation between S-ERP implementation and organizations' sustainability performance (Chofreh et al., 2016, 2020; Abobakr et al., 2024). Nevertheless, the current literature has focused more on S-ERP at the system level and has insufficiently revealed particular mechanisms that implement sustainability in ERP architectures (Jaradat et al., 2025; Yurtay, 2025). One such mechanism is budget tagging, which, however, is not well researched. Although it is widely used in the public sector, budget tagging for corporate sustainability management is a new practice with limited academic literature (Welham et al., 2020; Gerged et al., 2024). There is virtually no empirical research on the implementation of budget tagging, and the available research on the concept focuses on the concept in theory rather than on the design of taxonomies, technical integration, and effectiveness implications.

There are three more limitations in the current S-ERP research. To begin with, empirical research shows a developed-economy bias, with the main focus on European and North American organizations (Abobakr et al., 2024; Alzahmi et al., 2025). Second, the extant literature is saturated with studies of private corporations. In contrast, SOEs are a major part of the economy, managing an estimated third of corporate resources in emerging markets (Musacchio et al., 2015). Third, the energy sector is also characterized by underrepresentation, even though sustainability issues are particularly severe (Sundarasen et al., 2024).

The research addresses these gaps by discussing the implementation of Sustainability Budget Tagging (SBT) in the SAP ERP system of PT Pertamina. As a case with several under-researched features (a state-owned enterprise engaged in the energy industry in an emerging market (Indonesia)) with increased sustainability reporting demand yet having developed ERP systems, Pertamina is a critical case (Yin, 2018). As the largest energy company in Indonesia, Pertamina has committed to achieving 31% renewable energy consumption and 29% greenhouse gas reduction by 2050, which translates to about USD 120 billion in sustainability investments. Before the

implementation of SBT, sustainability cost tracking relied on disjointed manual processes that required about 120 person-hours per year to generate data of poor quality and with poor real-time visibility.

The research investigates five interconnected questions: How does SBT enhance transparency and accountability? What technical and non-technical challenges emerge during implementation? To what extent does SBT impact regulatory compliance and ESG value? How effective are specific ERP modules in supporting SBT? How do Power BI dashboards aid monitoring and strategic decision-making?.

2. Literature Review

2.1 Enterprise Resource Planning (ERP) Systems

Enterprise resource Planning (ERP) systems are integrated software platforms that consolidate main business activities in functional domains into one database architecture, as opposed to the divided and fragmented legacy systems that are used, which provide consolidation infrastructure that allows real-time data availability and cross-functional coordination (Monk and Wagner, 2013; Seddon et al., 2010). ERP systems were developed as an improvement on Materials Requirements Planning systems of the 1970s, evolving into modern fifth-generation systems based on cloud computing and artificial intelligence, such as the in-memory computing architecture of SAP S/4HANA (Lehnert et al., 2023). As much as there might be positive aspects, implementations have a significant amount of challenges due to twin technological and organizational transformational demands, and the key success factors involve the support of the top management, the efficiency of project management, and the management of organizational change (Luo and Strong, 2004; Shaul and Tauber, 2013). The introduction of sustainability functionality represents a new dimension, and regulatory demands and organizational pledges are driving the development of sustainability modules, including carbon accounting, energy management, and ESG reporting (Alzahmi et al., 2025; Yurtay, 2025).

2.2 Sustainable ERP (S-ERP)

Sustainable ERP (S-ERP) is an extension of conventional ERP that incorporates environmental, social, and governance issues into core business processes (Chofreh et al., 2016). The framework by Chofreh et al. (2016) has three basic dimensions: environmental (energy and emissions tracking), social (labor practices and community engagement), and governance (transparent reporting and compliance). Empirical evidence shows that S-ERP implementation produces far-reaching economic, environmental, and social performance improvement, which is mediated by the ability to collaborate with the supply chain (Abobakr et al., 2024). Nevertheless, there are significant obstacles to implementation, such as the complexity that demands interdisciplinary skills, the high cost of implementation that is not restricted to software licensing, and the challenge of organizational readiness, which can be particularly severe in emerging economies (Alzahmi et al., 2025). One of the most important gaps is the mechanisms for capturing sustainability data within ERP transactional processes, with less literature examining the technical design of data-capture mechanisms such as budget tagging schemas (Jaradat et al., 2025).

2.3 Budget Tagging for Sustainability

A budget is an orderly program that assigns categorical identifiers to financial transactions so expenditures can be tracked and reported with respect to specific goals (Downes et al., 2017). Although it is widely used in the public sector, the use of the tool in corporate sustainability management is a nascent practice with limited scholarly literature (Welham et al., 2020). The theoretical basis is the principles of activity-based costing, which allow organizations to attribute environmental and social costs to particular activities by categorizing sustainability classifications within the system of transaction processing (Cooper and Kaplan, 1988; Swalih et al., 2024). There are significant benefits to integrating with ERP systems: budget tags are required fields that ensure full data representation, automated validation logic imposes requirements, and integration will allow connecting expenditure data with physical sustainability performance data (Weerasekara and Gooneratne, 2023; Jaradat et al., 2025). Such challenges as user compliance issues, data quality problems, and retrospective application issues are present (Alsayegh et al., 2020; James, 2015). The empirical research is limited, and most applications are in the

governmental context, raising questions about feasibility in the corporate context, specifically in state-owned enterprises in emerging economies (Gerged et al., 2024; Qian et al., 2018).

The above-reviewed theoretical background and the available empirical literature form the conceptual framework for exploring Sustainability Budget Tagging implementation at PT Pertamina. Figure 1 shows the research design used in this study.

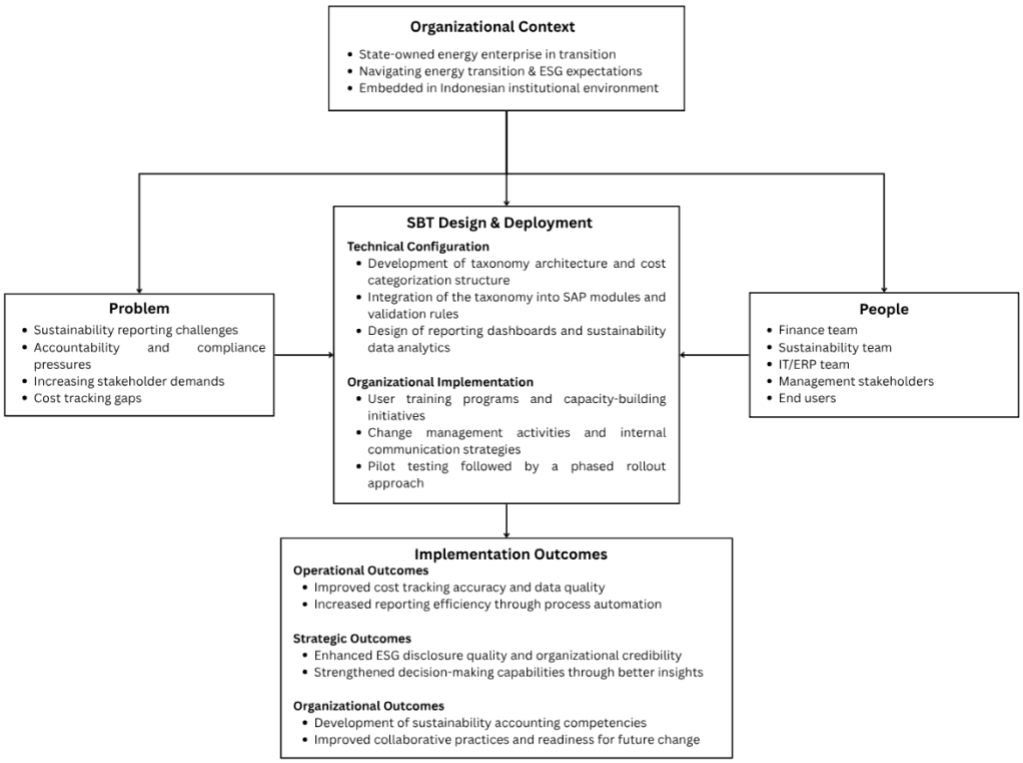

Figure 1: Research Framework

3. Methods

3.1 Research Design

This research employs a holistic single-case study design with embedded units of analysis, incorporating systematic before-and-after comparison to examine the implementation of Sustainability Budget Tagging (SBT) at PT Pertamina (Yin, 2018). The single-case approach is justified on three grounds: revelatory access to an implementation process rarely documented in the academic literature, critical case characteristics that enable theoretical testing, and longitudinal access that permits comprehensive documentation across all implementation phases (Figure 2).

Case Selection Rationale

PT Pertamina represents a **critical case** (Yin, 2018) for examining ERP-supported sustainability tracking due to several theoretically significant characteristics. First, as Indonesia's largest state-owned energy company, managing USD 120 billion in sustainability investments through 2040, Pertamina faces acute pressures at the intersection of commercial performance requirements and developmental mandates characteristic of emerging-economy SOEs (Bruton et al., 2015; Musacchio et al., 2015). Second, the energy sector context—where sustainability costs are substantial and increasingly subject to regulatory scrutiny—represents a domain where systematic tracking mechanisms are critically needed yet empirically underresearched (Sundarasen et al., 2024). Third, Pertamina's mature ERP infrastructure (MySAP ECC 6.0 implemented enterprise-wide since 2015)

provides a stable platform for examining sustainability integration without the confounding effects of concurrent system implementations. Fourth, the impending regulatory deadline of Indonesia's mandatory Sustainability Disclosure Standards (January 2027) creates institutional pressures that mirror global trends toward mandatory ESG reporting, enhancing the transferability of findings to similar regulatory contexts.

The implementation addresses three interconnected organizational challenges that characterize the research problem: (1) Process inefficiency – manual sustainability cost tracking requiring approximately 120 person-hours annually with only 85% accuracy and limited real-time visibility; (2) Strategic visibility gap – inability to systematically monitor USD 120 billion in planned sustainability investments or answer basic allocation questions (Which programs deliver highest impact per dollar invested? Is actual spending aligned with budgets? What percentage of capital expenditure genuinely advances sustainability objectives?); and (3) Compliance pressure – escalating regulatory requirements for audit-ready sustainability cost documentation under Indonesia's forthcoming disclosure standards aligned with IFRS S1 and S2 frameworks.

Unit of Analysis Structure

The primary unit of analysis is the SBT implementation process at the enterprise level, encompassing the full lifecycle from baseline assessment through institutionalization. Embedded units of analysis provide multiple perspectives within the holistic case (Yin, 2018), structured across three dimensions: (1) Organizational units – specific business divisions (upstream exploration, midstream refining, downstream distribution, corporate functions) experiencing varying degrees of sustainability cost complexity; (2) Technical units – individual SAP modules (Materials Management, Controlling, Financial Accounting, Project System) requiring distinct configuration approaches; and (3) Stakeholder units – functional roles (finance staff, sustainability managers, procurement personnel, IT specialists, senior management) with differentiated system interactions and information needs. This embedded structure enables pattern-matching across multiple contexts while maintaining a holistic understanding of the enterprise-level implementation.

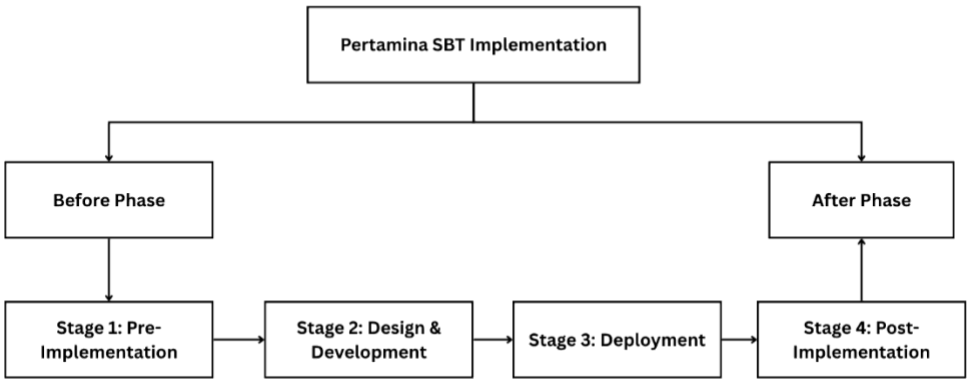

Figure 2: Research Design

3.2 Data Collection

The research uses various data collection methods to gain a deep understanding and enable triangulation of results, including interviews, documentation, archival data, and physical evidence (Yin, 2018). The main approach is semi-structured interviews, which will be conducted in three stages: baseline (current practices and challenges), implementation (emerging experiences and adaptation), and post-implementation (outcomes and learning). Participants are purposively sampled across organizational functions, hierarchical levels, and business units until thematic saturation is achieved (Patton, 2015). The interview protocols are designed to suit the stakeholder groups, as illustrated in Table 1.

Table 1: Interview Protocol by Stakeholder Group

Stakeholder Group	Key Focus Areas
IT & ERP Implementation	Technical challenges, data consistency, customization needs, and dashboard integration
Finance & Accounting	Reporting accuracy/speed, ESG compliance, system limitations
Sustainability / CSR	Support for sustainability goals, planning/monitoring, framework alignment
Procurement / Material Management	Sustainable procurement practices, vendor selection, and tracking accountability
General Managers	Budget visibility, strategic decision-making, stakeholder expectations
Compliance & Regulatory	Regulatory compliance effectiveness, reporting challenges

All interviews are conducted in either Indonesian or English, audio-recorded with informed consent, transcribed word-for-word, and coded anonymously using role-based codes. The interview lasts between 45 and 90 minutes. The analysis of the documents investigates organizational artifacts such as financial reports, sustainability reports (2022-2024), budget allocation documents, regulatory guidelines, meeting minutes, Scrum sprint documentation, executive presentations, training materials, SAP configuration specifications, project plans, reports on external benchmarking, and documents on GRI Standards (Yin, 2018). Archival records offer quantitative information on systematic before-after comparison using SAP system logs on the evaluation of the frequency of use, the volume of transactions, the percentage of tagging (100) and the rate of errors (11), the use of data in the dashboard (time logs), and the completeness of the data (cross-referencing program inventories to documented costs). Physical documents such as system screenshots, dashboard displays, configuration printouts, and taxonomy documents are actual materials that demonstrate system capabilities and technical specifications.

3.3 Data Analysis

3.3.1 Qualitative Data Analysis

Qualitative analysis gives meaning to the textual data from interviews, documents, and artifacts to comprehend stakeholders' experiences, how the implementation process unfolds, and the organization's dynamics. Thematic analysis has been used because it is a systematic process, as described in the six-phase system proposed by Braun and Clarke (2006): familiarization with data, by repeated reading, initial coding of meaningful segments, search for themes, based on the similarity of related codes, reviewing of themes, definition and naming of themes, and the final analysis. The coding methodology involves a mixture of deductive codes based on the conceptual structure (institutional pressures, technological factors, organizational factors, outcomes) and inductive codes that emerged immediately after the data, providing an analysis that is empirically based and theoretically guided. NVivo is used to conduct coding, and all decisions made during the coding process are recorded in researcher memos. Process tracing is used alongside thematic analysis to record causal processes between implementation activities and observed outcomes, forming detailed, chronological accounts of the order in which certain actions produced consequences through particular mechanisms (Bennett and Checkel, 2015). Narrative analysis focuses on how stakeholders make meaning by telling stories of their experiences, paying attention to the structure of narratives, such as how individuals package pre-implementation frustrations, implementation difficulties, and adjustments, and to post-implementation analysis (Clandinin and Connelly, 2000).

3.3.2 Quantitative Data Analysis

Quantitative analysis provides objective evidence of the SBT implementation's impact by systematically comparing financial data and system usage metrics. Descriptive statistics are used to summarize important variables, including measures of central tendency (mean, median) and measures of dispersion (standard deviation, range) for cost tracking accuracy percentages, preparation time to report in hours, and data completeness percentages. Before-and-after comparison also uses the right statistical tests: paired t-tests determine whether the post-implementation means differ significantly compared to pre-implementation baselines in a continuous variable, such as the reporting preparation time, and chi-square tests or McNemar's tests compare the proportion

of categorical outcomes, such as the accuracy in classifying a transaction (Field, 2013). The calculation of the effect size via Cohen's d determines the magnitude of change above the level of statistical significance, which is useful for assessing significance. Longitudinal trend analysis is performed to determine whether the improvements are persistent or transient by monitoring measures at multiple time points after implementation. Quantitative analysis involves statistical computation in SPSS or R and data visualization in Excel, using charts and graphs to represent comparisons before and after and trends over time.

3.3.3 Mixed Methods Integration and Triangulation.

Mixed-methods integration combines qualitative and quantitative data to yield comprehensive knowledge that neither method alone would have been capable of extracting (Creswell and Plano Clark, 2018). The comparison of evidence provided by other parties of interest (finance versus sustainability views), data types (interviews versus observations versus documents), and time (baseline versus interim versus post-implementation) is known as source triangulation. Method triangulation focuses on the congruence of qualitative themes with quantitative patterns, such as whether themes of interview data on better accuracy are correlated with statistical improvement in audit findings. Multi-perspectival interpretation is achieved through the use of the technology acceptance model, institutional theory, sustainability accounting theory, and other theoretical models in theory triangulation to analyze the findings (Denzin, 2012). Convergent analysis prepares joint display tables of qualitative and quantitative results next to one another in each research question, making a graphical representation of convergent (both sources point to the same conclusion), complementary (data points to different aspects), and divergent (data points to different conclusions) sources. Meta-inferences are higher-order interpretations that are integrated across all data sources and methods of analysis, answer research questions more holistically than any single data source alone, and are an example of the added value of mixed-methods design (Tashakkori and Teddlie, 2010).

4. Results

4.1 Pre-Implementation Phase

Before the implementation of Sustainability Budget Tagging (SBT), sustainability cost tracking at Pertamina relied on manual processes, which posed significant challenges for internal management and external reporting. The enterprise resource planning system consisted of MySAP ECC 6.0, implemented enterprise-wide since 2015, with major modules including Financial Accounting (FI), Controlling (CO), Materials Management (MM), Plant Maintenance (PM), and Project System (PS). Although this architecture provided sufficient support for traditional financial management, it offered no native support for systematic identification or classification of sustainability costs. The finance functions retained the key role of budget management through SAP systems, and the sustainability function, located in Corporate Affairs, retained responsibility for ESG strategy development and external interaction. This structural division produced operational disconnects, ranging from reporting inefficiency to basic rifts in sustainability and financial visibility.

The organization hierarchy and project management needs served as the basis for cost centers and internal orders rather than the logic of the sustainability program. Sustainability costs were allocated across hundreds of cost centers, including upstream exploration, midstream refining, downstream distribution, and corporate functions, without a uniform classification mechanism to enable aggregation of sustainability reporting. The staff of the Finance Department described the limit:

"The system we had wasn't designed with sustainability in mind. We could track costs by department, by project, but asking 'how much did we spend on renewable energy?' those questions required starting from scratch every single time."

The disconnection between systems, necessitated by the annual sustainability reporting cycle required by OJK Reg., required intensive manual reconciliation. No. 51/2017 and the Ministry of SOE ESG performance evaluations. It normally began three months after the fiscal year-end, and sustainability teams assembled a complete program inventory at that point, which was sent to the finance teams, who then tried to determine which

costs were covered by the program using custom queries based on keyword searches in the cost element descriptions and internal order names. First data pulls usually gave out thousands of transactions that had to be vetted by hand to identify whether sustainability was actually relevant, and about thirty to forty percent of the data were ambiguous cases that needed to be discussed with the budget holder or had to be passed on to sustainability managers.

The baseline performance measures were set across various dimensions to develop demanding benchmarks for assessing the outcomes of SBT implementation. Performance appraisal of sustainability budget reporting efficiency indicated that the average time spent in preparing the report was 10 working days for a full-time dedicated analyst (excluding the time of budget holders and other assisting staff in the business units). The accuracy in reporting was about eighty-five percent on correct identification and categorization, with the error rate about fifteen percent in the form of false positives (expenditures incorrectly labelled as sustainability-related), false negatives (true sustainability expenditures missed during screening), and mismatched categories (correctly identified but classified under the wrong dimensions of the 5P). Mistakes in budget allocation averaged 20 high-profile cases each fiscal year, and the mistakes were related to misappropriation of expenditures, duplication of counts, or incomplete capture, which was only revealed when compiling annual reporting at the end of the fiscal year. Transparency in reporting is 70%, indicating low granularity in traditional reports, long-term periods, and an inability to provide verification documentation (Table 2).

Table 2: Baseline Performance Metrics

Indicator	**Baseline Measurement**	**Performance Gap Description**
Real-Time Budget Monitoring Capability	50%	Limited access to current information without special requests
Decision-Making Speed	60%	Information delays constrain timely resource allocation adjustments
Accuracy of Information Used in Decisions	70%	Data quality concerns are reducing confidence in management reporting
User Satisfaction with Dashboards	65%	Recognition of significant improvement potential based on peer practices
Frequency of Dashboard Usage in Decision Processes	40%	Low utilization reflecting access difficulties and quality concerns

Environmental compliance was at 80 percent, social compliance at 75 percent, and ESG reporting on time at 60 percent, indicating operational issues that necessitated constant deadline extensions. The challenge was characterised by compliance and Regulatory Affairs staff:

"Meeting ESG reporting deadlines was a constant struggle. We'd start the process thinking we had adequate time, but then data collection would take longer than expected, classifications would need revision, and validations would reveal errors requiring rework. We were perpetually asking for extensions and explaining delays to regulators."

The sustainability initiatives reached 65%, indicating issues with program implementation and the inability to track costs due to disconnected systems. Assessment of the ERP system revealed that the Material Management module is functioning at 70% effectiveness; that is, there are no systematic mechanisms for identifying sustainable procurement opportunities. The workers of the Procurement Department demonstrated the problem:
"We had general guidance about preferring environmentally friendly options, but no systematic way to identify which purchases were for sustainability programs or which vendors met sustainability criteria. It was ad hoc and depended on individual buyer awareness rather than system support."

Module controlling had an 80% effectiveness, Financial Accounting had an 85% effectiveness, and integration effectiveness was 75%. The level of user satisfaction was 65%, due to the frustration with manual workarounds. The evaluation of business intelligence and decision support capability showed that real-time budget monitoring

was at half the target, and decision-making speed was at 60% of the target. General Manager employees referred to the visibility issue:

"When Board members asked about sustainability spending in specific areas, we couldn't give immediate answers. We'd have to go back to finance, wait for them to compile data, then hope the numbers were accurate. By the time we had solid information, the strategic moment for decision-making had often passed."

The accuracy of the information obtained was 70%, user satisfaction was 65%, and dashboard use was 40%. These overall baseline results showed that step-by-step improvement would not be sufficient to address structurally inherent constraints, which is a strong reason to implement a systematic intervention by tagging sustainability budgets through ERP.

4.2 Design and Development Phase

The Sustainability Budget Tagging (SBT) taxonomy was created as a first-class semantic attribute to address the prevailing need for definition in Materials Management (MM), rather than an after-the-fact reporting tag. The fundamental architectural choice articulates the tag as a managed Item Text ID on the line of the Purchase Requisition (PR), characterizing sustainability indicators for each requested good or service as components of the primary data in the transaction, rather than being subsequently rebuilt based on the cost report. The system also allows a single requisition to include lines for both sustainability-attributable and non-attributable items without losing granularity, since the taxonomy is anchored at the PR item level, and the tag is a persistent property that can be validated and reported throughout the procurement lifecycle.

The architecture defines three fundamental designs in the procure-to-pay process. Initially, on the PR level, the PR item text type is developed in the customizing layer of SAP. It is called the Asset Integrity Budget Tag and has two functions: making the item visible to business personnel on the PR screen and serving as a consistent technical handle for validation and reporting.

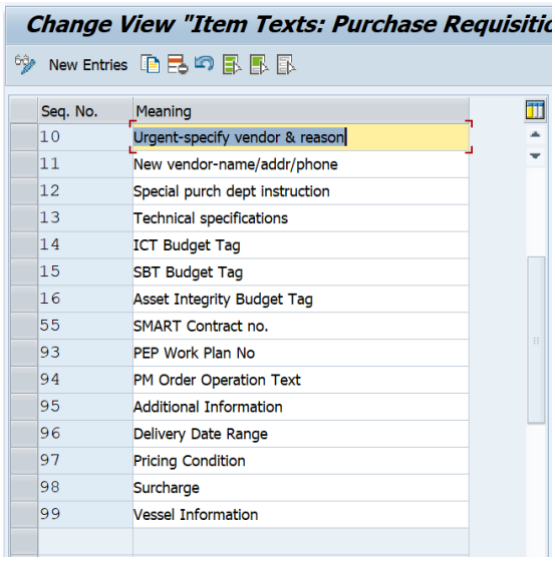

Figure 3: Text Type

Rules that are copied are selectively coupled with semantics to bind document flow, and this is used to teach the SAP to copy the SBT text to subsequent documents without hand re-entry. The mechanism is a governance control that helps prevent semantic drift and ensures there is only one source of truth across PR→RFQ→PO transitions. Second, this architecture pattern is reused at the RFQ level, establishing the same text types at the RFQ item level, allowing inherited tags to be viewed and verified, and copying rules ensure that an RFQ created on a tagged PR line shows the same SBT text. Third, the PO stage involves changing the taxonomy intention into formal commitment, and it is where the sustainability meaning is embedded in the legal and accounting commitments at the time the obligations are made.

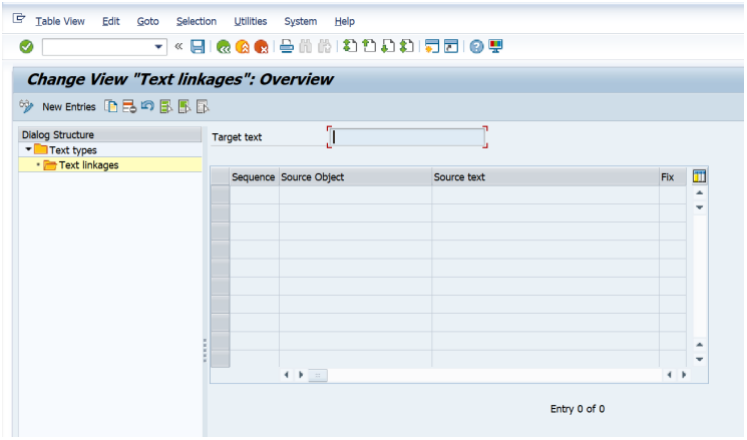

Figure 4: Copying Text

The taxonomy is not just a front-end label, but a controlled code system, the validity of which is determined by the accounting context to which the line represents. When the account assignment and cost element point to a sustainability-mapped cost object, the PR item tag is mandatory. If the code is undefined, it is blocked and flagged when multiple account assignments are not consistent with the tagging rules. This conduct is recorded via purpose-designed error and warning messages (Table 3), which ensure data quality at save/check and notify users of errors in real time. A template-conscious activation system addresses enterprise heterogeneity during the transition period, enabling the same taxonomy to be used at runtime with the appropriate rule set applied to each entity and ensuring semantic meaning is not disaggregated.

Table 3: Error/Warning Messages

Scenario	Message Type	System Message
Non-SBT	Warning	Ensure the CC and CE are related/not related to Asset Integrity
SBT and Non-SBT	Warning	CC and CE are related/not related to SBT. If related, input the Asset Integrity code
SBT	Error	CC and CE are related to Asset Integrity; the Asset Integrity code in "item text" is mandatory
SBT	Error	Asset Integrity code is not defined; please recheck the line
SBT	Error	Enter the SBT code for the multiple account assignment line

Upon a PR being saved or checked, the system will run a contextual validator that will check the assignment of the account in the line against the sustainability mapping catalogue. The design realizes graduated enforcement: advisory where ambiguity is anticipated (yellow warning when dealing with non-SBT contexts, Figure 4.9), conditional where usage is varied (yellow warning when dealing with mixed SBT/non-SBT contexts, Figure 4.10), and hard blocking where mapping is certain (red error when dealing with mandatory SBT contexts, Figure 4.11). The system will block errors during saving if SBT codes are undefined or invalid, and validation is not performed until valid codes are entered (Figure 4.12). After a blocking error, the system will not save until valid codes are entered (Figure 4.13). In several account assignments, the validator applies the same governance logic to every split to avoid biased or incomplete tagging (Figures 4.14-4.15). The taxonomy architecture integrates three key design concepts: proximity to intent (sustainability meaning captured at PR creation), semantic persistence (automatic inheritance into RFQ and PO enforced), and governed validity (taxonomy paired with a dictionary, validation logic, and enterprise-aware activation mechanisms).

4.3 Deployment Phase

The implementation period focused on detailed training and change management to ensure user success. The role-based learning paths were developed within the framework of the training program financial staff were trained on

tagging transactions and validation rules, CSR staff on accessing sustainability costs data in the Power BI dashboards, procurement staff on how to use sustainability codes when creating purchase requisitions, and IT support staff on how to configure and troubleshoot the system. The staff of the IT Department described the approach:

"We designed training that was hands-on and practical. Rather than lengthy presentations, we focused on real transaction examples and let users practice tagging in a sandbox environment. This helped build confidence before they worked with live data."

Training delivery will include classroom-based training, practical training in sandbox environments, and quick-reference materials for role-specific training. Training to approximately 85% of the intended users was completed before go-live, and other staff were trained during the hypercare period. Even so, difficulties arose in coordinating the timetable and maintaining a steady stream of messages. According to the noted training gaps by the Finance Department staff:

"The initial training was helpful, but we encountered situations in daily work that weren't covered in the standard curriculum. We needed follow-up training on specific scenarios and more examples of how to handle ambiguous cases."

Change management efforts complemented technical training. A communication campaign was used to demonstrate the strategic reasons why SBT can be implemented, focusing on the benefits that will accrue to various stakeholder groups rather than making SBT a compliance liability. An organization was formed of change champions and staff members of each of the major business units, who were honored and recruited as the local champions of change and informal support networks. The staff in the Sustainability Department commented:

"Technology implementation is easy compared to changing how people work. The change champions made a huge difference because they could explain the benefits in the local context and help colleagues see how SBT would actually make their jobs easier in the long run, not harder."

The opposition to change was expressed mainly through concerns about the extra workload and ambiguity in classification choices. The solution was to deliver real value by providing early, quick wins and demonstrating how the program managers would prove their success through better sustainability cost visibility.

The SBT system implementation was carried out under a six-month recovery plan between the pilot and full implementations. The initial step was a pilot trial involving a small number of business units, given relatively simple sustainability practices and local-level leadership backing. The members of the IT Department reported on the pilot approach:

"We deliberately chose pilot sites where we expected success. This wasn't about avoiding challenges but about building proof points that would convince skeptical users elsewhere. The pilot sites became our success stories that we could share during later rollout phases."

Pilot participants provided extensive feedback, prompting several modifications to the system configuration, especially regarding validation rule logic, which was found to be overly restrictive in practice. The way dashboards were designed changed based on pilots' preferences, and training materials were revised to reflect their actual experience. Following a successful pilot, deployment was rolled out to other business units in waves, depending on operational level and readiness assessment.

Each wave was launched according to a well-designed cutover plan, including final data verification, user access setup, and a war room with the implementation team and IT support, ready to provide urgent support during the critical initial days. General Manager staff noted:

"Having immediate support available during those first few days was critical. Users knew they could get help quickly if they ran into problems, which reduced anxiety and encouraged them to actually use the system rather than trying to work around it."

There was early production assistance during the hypercare phase, geared toward the urgent resolution of issues. The volume of tickets to the help desk is high in the first two weeks after each wave deployment, after which it reduces as users get acquainted. Testing of the system's performance showed no serious technical problems, indicating extensive testing during the pilot stage. Validation rules and dashboard refresh schedules were slightly adjusted based on user feedback. The Procurement Department staff reported the change:

"The first few weeks were definitely a learning curve. We had to think differently about how we coded purchases. But after a month or so, it became second nature. The key was having good support available when we needed it and not being afraid to ask questions."

By the end of the six-month rollout period, the SBT system was operational across all major business units with active sustainability programs. User adoption metrics showed steady improvement from initial deployment through the first quarter of full operation. The phased approach successfully managed implementation risk while building organizational capability and confidence.

4.4 Post-Implementation Phase

The Sustainability Budget Tagging implementation achieved significant gains in operational efficiency, ESG performance, technical system performance, and business intelligence capabilities. The post-implementation evaluation assessed performance against baseline parameters, and the results showed substantial improvements across all assessed dimensions. The time taken to prepare reports was reduced by one-third, from analysts' 10 working days to 7 working days. The accuracy of reporting increased to 95% from 85% due to standardized taxonomy and clear definitions, as well as automated validation rules. The number of budget allocation errors dropped from 20 major cases each year to 5, a 75% reduction. Transparency in reporting increased to seventy percent to ninety percent, indicating granular program-level reporting and systematic audit trails (Table 4). This was observed by Finance Department staff:

"What used to take us two full weeks of intensive work now takes one week. The system is doing automatically what we used to do manually, like aggregating costs by sustainability category and validating that transactions are properly tagged."

Table 4: Operational Efficiency Improvements

Indicator	Before SBT	After SBT	Change
Report Preparation Time (days)	10	7	-30%
Reporting Accuracy	85%	95%	+10%
Budget Allocation Errors (per year)	20	5	-75%
Reporting Transparency	70%	90%	+20%

The compliance rates for environmental regulation increased to 95% from 80%, and for social regulation to 85% from 75%; the timeliness of ESG reporting increased to 90% from 60%. The sustainability projects attained 80% instead of 65% of the achievement, indicating improved program management through real-time cost visibility (Table 5). Seniorize and Regulatory Affairs staff wrote:

"The ESG rating agencies definitely noticed the improvement in our disclosure quality. We went from providing aggregate estimates to giving them detailed program-level data with clear audit trails. That transparency alone improved our scores."

Table 5: ESG and Compliance Performance Improvements

Indicator	Before SBT	After SBT	Change
Environmental Regulation Compliance (%)	80%	95%	+15%
Social Regulation Compliance (%)	75%	85%	+10%
Timeliness of ESG Reporting (%)	60%	90%	+50%
Achievement of Sustainability Initiatives (%)	65%	80%	+15%

There was a significant improvement in the performance of the technical systems across all the ERP modules. The effectiveness of the Material Management module had increased by seventy percent to ninety-five percent, the Controlling module by eighty percent to ninety-six percent, Financial Accounting by eighty-five percent to a hundred percent, and integration efficiency between modules by seventy-five percent to ninety percent. The level of user satisfaction with the ERP modules increased to 85% from 65% (Table 6). IT Department personnel are characterized:

"Before SBT, sustainability tracking happened in parallel to normal ERP processes. Now it's embedded in the standard workflows. The sustainability codes flow automatically through the system just like any other financial dimension."

Table 6: ERP Module Effectiveness Improvements

ERP Module	Effectiveness Indicator	Before SBT	After SBT	Change
Material Management (MM)	Efficiency in Material Management	70%	95%	+25%
Controlling (CO)	Cost Control of Projects	80%	96%	+16%
Financial (FI)	Accuracy in Transaction Recording	85%	100%	+15%
Integration	Integration Between Modules	75%	90%	+15%
User Experience	User Satisfaction with ERP Modules	65%	85%	+20%

The implementation of the Power BI dashboard made a great contribution to the business intelligence. The real-time budget monitoring feature increased from fifty percent to eighty-five percent, the speed of decision making from sixty percent to seventy-five percent, the accuracy of information from seventy percent to ninety percent, user satisfaction increased from sixty-five percent to eighty-five percent, and the frequency of using the dashboard increased from forty percent to eighty percent (Table 7). General Manager personnel narrated:

"Before, if the Board asked about sustainability spending, we'd need days to compile answers. Now I can pull up the dashboard during meetings and show them exactly where we are against budget, which programs are on track, and where we might need adjustments."

Table 7: Power BI Dashboard Impact on Decision-Making

Indicator	Before Power BI	After Power BI	Change
Real-Time Budget Monitoring Capability (%)	50%	85%	+35%
Decision-Making Speed (%)	60%	75%	+15%
Accuracy of Information Used in Decisions (%)	70%	90%	+20%
User Satisfaction with Dashboards (%)	65%	85%	+20%
Frequency of Dashboard Usage in Decision Processes (%)	40%	80%	+40%

Although there were considerable gains, the implementation faced major challenges. System integration issues were experienced in 40% of implementation tasks, system customization issues accounted for 35% of technical effort, and data consistency issues occurred in 25% of deployment activities. The biggest impact challenge was identified as inadequate user training, as revealed by 50% of user feedback in the first six months after deployment. Resistance to change was present in 30% of business units, and coordination issues in departments were experienced in 20% of activities (Table 9). IT Department staff explained:

"We underestimated how much effort would be required to ensure the sustainability codes maintained integrity as transactions flowed through different modules. What seemed straightforward in design became complex in implementation when we encountered all the edge cases and exception scenarios in real business processes."

Table 8: Implementation Challenges and Impact

Challenge Type	Description	Frequency	Impact
Technical Challenges			
System Integration	Difficulties integrating SBT with existing ERP modules	40%	High
System Customization	Requirement for significant customization	35%	Medium
Data Consistency	Maintaining data consistency across modules	25%	Medium
Non-Technical Challenges			
User Training	Insufficient training for effective use	50%	High
Resistance to Change	Employee resistance to changes in workflows	30%	Medium
Department Coordination	Coordination between departments	20%	Low

Post-implementation stakeholder views were evaluated using qualitative interviews and quantitative surveys. Stakeholders in the finance sector stressed the need to transition from manual operations to ensure the smooth flow of work. The CSR stakeholders emphasized improved credibility with external stakeholders. The IT stakeholders reported lower load on ad hoc data extraction requests. The top management appreciated the ability to make strategic decisions. The compliance stakeholders pointed to the responsiveness of the regulation. The qualitative results were supported by quantitative survey results across five areas, including: ERP system functionality (3.65 out of 5.00), 5P sustainability dimensions (3.85), technical and organizational challenges (4.05), sustainability outcomes (3.80), and future improvement priorities (4.55; Table 10).

Table 9: Stakeholder Satisfaction Survey Results

Category	Assessment Dimension	Mean Score
ERP System with SBT (3.65)	Ease of use	4.00
	System integration	4.00
	Meeting management needs	3.75
	Data reliability	3.25
	Power BI effectiveness	3.25
5P Dimensions (3.85)	People (employee welfare)	4.00
	Planet (environmental tracking)	3.50
	Prosperity (economic goals)	4.25
	Peace (social stability)	3.75
	Partnership (collaboration)	3.75
Technical & Organizational Challenges (4.05)	ERP customization difficulty	4.75
	Data consistency issues	3.75
	Training effectiveness	3.75
	Team adaptation	3.75
	Regulatory alignment challenge	4.25
Sustainability Outcomes (3.80)	Budget transparency	4.00
	Accountability enhancement	4.00
	ESG compliance support	4.00
	Stakeholder satisfaction	3.50
	Strategic decision support	3.50
Future Improvement Priorities (4.55)	Further customization value	4.50
	Ongoing training necessity	5.00
	Collaboration features benefit	4.25
	Comprehensive dashboards value	4.75
	Feedback mechanisms likelihood	4.25

5. Discussion

This study addresses a critical gap in empirical research on Sustainable ERP systems by demonstrating specific mechanisms for operationalizing sustainability in ERP architectures within emerging-economy state-owned enterprises. What makes the Sustainability Budget Tagging system at PT Pertamina particularly noteworthy is its demonstration that systematic sustainability cost monitoring can be achieved by configuring existing ERP systems rather than installing parallel systems or implementing complete system replacements. For organizations with existing ERP investments seeking to enhance their sustainability management capabilities without incurring prohibitive costs, this finding offers significant practical implications (Chofreh et al., 2020; Muller et al., 2020).

The performance improvements observed across multiple dimensions were substantial. Operational efficiency gains included a 30% reduction in reporting preparation time, while ESG compliance strengthened with a 21% increase in scores. Business intelligence capabilities saw a 35 percentage point increase in real-time monitoring. These results confirm theoretical predictions in Environmental Management Accounting that systematic cost tracking facilitates enhanced accountability and superior decision-making (Burritt et al., 2002; Jasch, 2003; Schaltegger & Burritt, 2018). Perhaps most striking were the 75% reduction in budget allocation errors and the 40 percentage-point increase in dashboard usage, suggesting that ERP-integrated sustainability tracking generates value that extends well beyond compliance reporting, fundamentally transforming core sustainability program management practices. The multidimensional accountability framework of Stakeholder Theory is strongly validated here, as enhanced transparency demonstrably strengthened relationships with diverse stakeholder groups, including regulators, investors, and ESG rating agencies (Freeman, 1984; Mitchell et al., 1997; Clarkson, 1995).

Implementation was not without its challenges. System integration problems emerged in 40% of activities, while insufficient user training affected 50% of users. These challenges align with the broader ERP implementation literature, which emphasizes the dual technological and organizational change processes required for successful deployment (Luo & Strong, 2004; Shaul & Tauber, 2013; Grabski et al., 2011). Particularly telling was the difficulty finance personnel had with sustainability classification decisions, which revealed confusion when encountering unfamiliar scenarios. This suggests that sustainability-tracking implementations require greater domain knowledge than traditional financial system implementations. The Technology Acceptance Model's predictions extend here, as perceived ease of use encompasses not only interface design and technical training but also users' conceptual understanding of sustainability frameworks and their organizational application (Davis, 1989; Venkatesh & Davis, 2000; Venkatesh et al., 2003). Comprehensive training programs that develop both technical proficiency and sustainability literacy thus become essential organizational investments.

A key architectural insight emerged from the decision to capture sustainability semantics at the Purchase Requisition level rather than during financial close (Davenport, 1998; Strong & Volkoff, 2010). This "proximity to intent" principle ensures that sustainability meaning is captured when business needs are defined by personnel with contextual knowledge, rather than being reconstructed retrospectively by finance analysts lacking program-level understanding. The system's graduated enforcement mechanism—advisory warnings for ambiguous contexts, conditional prompts for mixed classifications, and hard blocking for definitive sustainability expenditures—represents nuanced governance that balances data quality objectives against operational flexibility (Petter et al., 2013). Such design patterns effectively resolve inherent ERP implementation tensions between standardization and customization by introducing flexibility within structured validation logic (Pollock & Cornford, 2004).

Strategic choices in the implementation approach also proved consequential. The phased rollout strategy deliberately selected pilot locations with high success probability, reflecting practical application of change management theory to sustainability contexts where stakeholder skepticism demands concrete evidence before broader acceptance (Kotter, 1996; Armenakis & Harris, 2009). Dashboard usage patterns tell an interesting story: the increase from 40% to 80% validates Resource-Based View predictions that IT capabilities generate the greatest value when combined with complementary organizational capabilities such as data-driven decision-making and analytical skills (Bharadwaj, 2000; Wade & Hulland, 2004; Piccoli & Ives, 2005).

The state-owned enterprise context introduces unique dynamics worth careful consideration. PT Pertamina's government ownership provided powerful institutional incentives for transparency investments—incentives that may be weaker in private-sector contexts where sustainability monitoring potentially conflicts with short-term profitability objectives (Bruton et al., 2015; Musacchio et al., 2015). Indonesia's dynamic ESG regulatory landscape further shaped implementation, with mandatory disclosure standards effective January 2027, creating both urgency and complexity. Regulatory timelines established clear implementation imperatives, while regulatory uncertainty influenced taxonomy design decisions (Chapple & Moon, 2005; Amran & Haniffa, 2011).

Several limitations warrant acknowledgment. The single-case design, while enabling deep contextual insights, limits direct generalizability to organizations differing substantially in size, sector, or institutional context (Yin, 2018). Nevertheless, analytical generalization to theoretical propositions remains robust. These findings validate and extend Environmental Management Accounting theories by confirming that systematic cost tracking improves decision-making. They refine the Technology Acceptance Model assumptions by identifying sustainability-specific adoption factors. They also strengthen Stakeholder Theory principles by demonstrating how transparency enhancements improve stakeholder relationships. Future research examining the implementation of sustainability budget tagging across diverse organizational contexts would help identify patterns of consistency and contingency factors. The mixed-methods triangulation employed here—integrating qualitative and quantitative analyses—strengthens inference confidence, with stakeholder interview themes corroborating quantitative metrics and providing consistent explanations across methods, data sources, and time periods.

6. Conclusion

This study has investigated the case of Sustainability Budget Tagging implementation in the SAP ERP system at PT Pertamina, highlighting key gaps in current knowledge of how organizations operationalize sustainability cost tracking within their enterprise information architecture. The single-case study conducted a holistic study with a before-and-after comparison, reporting significant performance improvements that demonstrated that systematic sustainability cost monitoring could be achieved by configuring existing ERP infrastructure rather than using parallel systems.

The implementation generated measurable value: a 30% reduction in reporting preparation time, a 75% reduction in budget allocation errors, a 50% improvement in reporting timeliness, and a total annual financial impact of $919,000, with payback within 2 years. Technical system performance improved substantially across Material Management (25 percentage points), Controlling (16 percentage points), and Financial Accounting (15 percentage points) modules. Business intelligence capabilities improved dramatically, with dashboard usage frequency increasing from 40% to 80%.

The theoretical contributions of the study fill gaps in the literature on Sustainable ERP by offering detailed empirical data on mechanisms that enable sustainability within the ERP architecture (Jaradat et al., 2025; Yurtay, 2025). The results confirm theoretical predictions of Environmental Management Accounting and reflect the patterns of implementation design of greater applicability. The architectural principles of proximity to intent and graduated enforcement mechanisms are transferable strategies that address inherent conflicts between standardization and customization in ERP settings. The study also helps to understand the implementation of S-ERP in poorly researched settings: state-owned firms in emerging markets operating in the energy sector.

The following are some of the practical implications: The sustainability budget tagging could be achieved by configuring existing SAP infrastructure without necessarily replacing the system, multi-faceted value frameworks should consider strategic benefits other than operational efficiency gains, phases of rollout plans focusing on high-probability sites of success are especially useful in sustainability, the configuration of ongoing training investments are still relevant to both technical and conceptual insight, and change management strategies that rely on local champions are especially constructive in sustainability. In a single-case design, there is no direct statistical generalization, but analytical generalization to theoretical propositions is strong. Future studies are encouraged to consider organizational implementations across several organizations to examine contingency factors, follow up on the long-term sustainability of the improvements, seek further integration with physical sustainability

performance indicators, study the situation in the private sector, and examine sectoral variance in other areas beyond energy.

Despite limitations, the research is insightful, providing empirical evidence that addresses an important gap in the Sustainable ERP literature and has potential practical implications for organizations seeking to improve sustainability cost-tracking capabilities. With increased regulatory pressure on sustainability reporting worldwide and heightened expectations from various stakeholders for ESG reporting, systematic methods for tracking sustainability costs will be of greater significance for organizational legitimacy and strategic decision-making.

Author Contributions: Agus Rudiantoro: Conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft preparation, writing – review & editing, supervision, project administration, validation. As the sole author, A.R. conducted all aspects of this research, including research design, stakeholder interviews, system analysis, data collection and analysis, and manuscript development.

Funding: This research received no external funding

Conflicts of Interest: The author declares no conflict of interest

Informed Consent Statement/Ethics approval: All subjects provided informed consent to participate in the study. Participants were informed about the research purpose, data use, assurance of anonymity, and their right to withdraw at any time. Interview data was collected with explicit permission and stored securely with identifying information removed to protect participant confidentiality.

Data Availability Statement: The data supporting this study are derived from confidential interviews with PT Pertamina personnel and internal organizational documents. Due to confidentiality agreements and commercially sensitive information, raw interview data and detailed system configuration specifications cannot be publicly available. Anonymized analytical data and aggregated performance metrics are available from the author upon reasonable request.

Declaration of Generative AI and AI-assisted Technologies: This study has not used any generative AI tools or technologies in the preparation of this manuscript.

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