

A Review of Green Value Management Strategies for Sustainable Project Delivery

Dr. Felix Bauer

International Production Engineering and Management, Universität Siegen, Paul-Bonatz-Str. 9-11, Siegen, 57076, Germany

Prof. Dr. James Holland

Department of Civil Engineering, Faculty of Engineering, Monash University, 23 College Walk, Clayton campus,, 3800, Australia.

Abstract

As sustainability increases in significance for the project management sector, the need to apply management techniques to sustainability objectives grows. However, generic tools to measure the performance of sustainability objectives and initiatives are scarce.

Traditional project performance measurement uses the Earned Value Management (EVM) method to measure time, cost and scope. The objective of this paper is to investigate whether EVM can be adapted to measure the performance of sustainability goals in projects.

By means of two Systematic Literature Reviews (SLR), this paper investigates the bodies of knowledge of 'sustainability in Project Management' and 'Earned Value Management'. A total of 2.232 publications from 6 databases from both fields were identified through the two SLM and analysed via two-stage screening process.

The review found that the project control method EVM has not yet been used to track the performance of sustainability in projects. We therefore developed the conceptual framework for 'Earned Green Value Management'. Thus concluding, by incorporating sustainability in the business case (instead of scope), extending monitoring into the product life cycle, addressing the triple bottom line, and translating generic sustainability indicators into monetary terms to express value created through improved resource performance (instead of expenses), EVM can be translated and applied to the measurement of project sustainability and performance.

The conceptual framework presented herein lays the theoretical groundwork for a new project management tool to track the attainment of sustainability goals in projects. It contributes to the current research in sustainable project management by bridging a gap between traditional tools and normative topics on an operational level.

Keywords: Earned Value Management, Earned Green Value Management, Project Control, Sustainable Project Management, Project Management.

Abbreviations

AC(WP) Actual Cost (of Work Performed)
AE Apportioned Effort
BAC Budget at Completion
BCWS Budgeted Cost of Work Scheduled
BCWP Budgeted Cost of Work Performed
C/SCSC Cost/Schedule Control Systems Criteria
CA(M) Control Account (Manager)
CF Carbon Footprint
CPI Cost Performance Index
CPM Critical Path Method
EAC Estimate At Completion
ES Earned Schedule
ETC Estimate to complete
EV(A) Earned Value (Analysis)
EVM(S) Earned Value Management (System)
LOE Level of Effort
NVA Net Value Added
OBS Organisational Breakdown Structure
PMB Performance Measurement Baseline
PV Planned Value
RAM Responsibility Assignment Matrix
SPI Schedule Performance Index
TCPI To-Complete Performance Index
VAC Variance at Completion
WBS Work Breakdown Structure

1. Introduction

Companies worldwide increasingly address changing market requirements generated by technological advances, competition, regulation, social pressure or economic demands through projects (de Magalhães, Danilevycz, and Palazzo, 2018). These temporary organisations act as “vehicle for change” (APM, 2006a, p. xiv) and agencies for resource utilisation (Turner and Müller, 2003). The perception of projects and project management has transformed from project manager as accidental profession (Pinto and Kharbanda, 1995), to systemic organisational restructuring towards project-based work (Midler, 1995) towards multi-project levels, i.e. programs and portfolios (Maylor et al., 2006).

Project management scholars, too, have engaged in the discourse, Marcelino-Sádaba et al. (2015) assessed sustainability in various applications of project management

recognized sustainability as a challenge in the new product development, mining, energy, construction, and infrastructure sector. This became even clearer in Silvius (2017) analysis, demonstrating a growing concern for sustainability in these industries over the past 15 years, advocating sustainable project management as a new school of thought of project management (Turner et al., 2010). Huemann and Silvius (2017) echo, 'project management has a vital role in contributing to sustainable development of organizations and society' (p. 1066) raising the societal responsibility of the project management profession.

However, despite the growing awareness of the importance of the role of project management for sustainable development it seems partially ill prepared to deal with sustainability (Moehler et al., 2018). Silvius (2017) laments that integrating sustainability is a stretch for project management. According to Martens and Carvalho (2016a: 24) there is a gap between perception of importance and the actual use of sustainability in project management (SPM) practice' with similarly observations for the potential to embrace measurements and techniques that allow the PM to report and influence positively the project (Silvius and Graaf, 2019) and stakeholders i.e. shared-value (Uribe et al., 2018). Marcelino-Sádaba et al. add that a study to identify and characterize 'a set of sustainability competences that project managers must acquire, is also lacking' (2015: 14).

To further highlight the growing importance of Project Management, as a management innovation, from the management theory perspective (Markard, 2017), Sankaran et al. (2018) recognised the drive of social-technological needs with the development of tools e.g. Earned Value System, Work Breakdown Structure (WBS), Cost Schedule System Criteria, etc. Browning (2014) notes that "all project work should add value in terms of both the resources consumed and the benefits provided (e.g., scope, quality, technical performance, features, and functions)" (Browning, 2014: 583). Project management literature provides a tool to manage value of work created during a project, and it does so by integrating the dimensions of cost, schedule and scope. This tool is known as Earned Value Management, or simply EVM (PMI, 2013). Through staffing, procuring, reporting, and the managing of the project itself, EVM overlaps with every knowledge area of the Project Management Body of Knowledge (PMI, 2013). While both PMI and the Association of Project Management (APM) recognise the urgency of Sustainability (APM, 2006b; PMI, 2011b), these standards currently fail to address the issue of sustainability explicitly (Eid, 2009; Silvius and Schipper, 2014a).

EVM has proven to be a useful tool when it comes to backing up a company's balance sheet (Fleming and Koppelman, 2003) and EVM has the potential to back up a company's Corporate Responsibility Reports. As of now, no formalism unifies EVM and

sustainability in Project Management (Willems and Vanhoucke, 2015). Thus, this paper is providing the theoretical ground for changing existing techniques of project management into suitable techniques to address the challenge of sustainability. This paper devises a conceptual framework through two systematic literature reviews to lay the ground for a complete and sophisticated tool.

The remainder of this article is structured as follows: section 2 provides an overview of the terminology relevant to the paper. Section 3 describes the systematic review procedure. Section 4 provides descriptive results of the performed literature analysis. The translation of EVM concepts to suit sustainability objectives section 5. Lastly, concluding remarks and an outlook are in section 6.

2. Background and terminology

2.1. Earned Value Management

Earned Value Management is a commonly used tool which integrates the baselines of scope, schedule and cost to enable the project team to objectively assess project health in a visual manner (Bryde et al., 2018) and provide informed performance forecasts (Laird, 2013; PMI, 2011a, 2013). As opposed to traditional cost and schedule management methods, EVM can make statements of the value of the work done in relation to the expenses incurred and time passed (Fleming and Koppelman, 1997, 2003). Thus, EVM is an early warning indicator (Fleming and Koppelman, 2010), providing management with a lever for replanning, resource reallocation, and risk mitigation and protocols can be used to trigger payments in alignment with Clients value perception (Chipulu et al., 2014). Additional agency related characteristics for EVM to be successful are; low level of goal conflict, opportunistic behaviour, information asymmetry, concealment of negative outcomes; high degree of trust, organisational justice; and complete information (Bryde et al., 2018). EVM has become the gold standard for project performance measurement (PMI, 2011a). While there are doubts about the use of EVM in small and medium-sized enterprises, due to the implementation being perceived as too administrative (Turner et al., 2009; Turner et al., 2012), others suggest that the method can equally be applied in projects with short timeframes (Becker and Kunz, 2009) or small budgets (Adamczyk, 1989).

For EVM to function properly, a range of requirements need to be fulfilled. EVM implementation requires top management and stakeholder support (Chen, 2008), as it will not only require additional time, budget and staff (Chen, 2008) but possibly even changes in organisational structure and culture (Chen, 2008; Hofrichter, 1999). Furthermore, mechanisms must be in place to support report generation and data processing (Chen, 2008). Achievable benefits include EVM being an integrative system to track budget, scope and time performance to obtain project benchmarks in portfolios

and to generate valuable historical data (Christensen, 1998; Hope and Moehler, 2014; Laird, 2013). The method relies on facts to measure actual progress, thus yielding an accurate account of the project health, as well as tendencies for future performance (Christensen, 1998;). When reasonably employed, EVM can bestow additional rigour upon the project management profession (Christensen, 1998; Laird, 2013). This is mirrored by recent extensions with various emphases in the EVM and Project Control literature; e.g. separation of cost-based (EVM) and time-based duration - Earned Duration Management) (Khamooshi and Golafshani, 2014); remodelled EVM to monitor project quality in the Brazilian agriculture industry (Dodson et al., 2015), also applied to the Construction Industry (Ong et al., 2018); integrated carbon dioxide, cost and schedule management system for building projects (Lee and Kim, 2017); and most recently greenhouse gas emissions, only, as an additional control for environmental performance in the Construction Industry (Abdi et al., 2018a, 2018b).

EVM is often perceived to be overly prescriptive for the use in most commercial projects (Fleming and Koppelman, 2010) because of the usage of an “arcane and ponderous terminology” (Rose, 2003: 54) that requires special training to use a foreign language in order to be a member of the team (Bryde et al., 2018; Fleming and Koppelman, 1994). Consequently, a number of authors have proposed simplified implementation models, which are summarised in Figure 1 below (PMI, 2011a).

1	Define work to be done (Project Scope)
2	Establish Work Breakdown Structure
3	Establish Organizational Breakdown Structure
4	Set up Control Accounts
5	Plan and schedule the work
6	Create and authorize time-phased budget baseline
7	Define performance metrics (Earning rules)
8	Record all incurred costs
9	Measure performance, i.e. progress
10	Calculate Project performance
11	Forecast future performance

Fig. 1: Outline of EVM procedure.

2.1.1. Project Planning

EVM is not a magic tool that automatically yields project success (Bryde et al., 2018; Laird, 2013; PMI, 2011a). Instead of focusing on the measurement side of performance, what constitutes performance must be laid out in the first place (Hofrichter, 1999). EVM requires a solid and sound definition of the project scope in order to know what is required, what is not, and when work is due (Fleming and Koppelman, 2010). It is important to capture 100% of the scope and to be mindful of changes to the scope, as they do not solely affect the planned work, but also scheduling and budgeting (Fleming and Koppelman, 2010).

A common way to obtain a proper scope definition is via a Work Breakdown Structure (WBS), a hierarchical breakdown of work from highest project-level down to activity level, where the planned work is expressed as work packages (PMI, 2013). It should be deliverable- oriented, i.e. begin on the highest levels and then break down into

manageable, mutually exclusive elements based on a parent-child-relationship (PMI, 2011a). Moreover, care is to be taken for adequate work package sizing (Brandon, 1998; Ruskin, 2004).

The project as a temporary organisation is to be broken down in the same fashion, resulting in the Organisational Breakdown Structure (OBS). Integrating OBS with the WBS forms the Responsibility Assignment Matrix (RAM) (PMI, 2011a) that clearly identifies points of responsibility (Control Accounts, CA) (Fleming and Koppelman, 2010). Any CA holds its respective work packages, information about schedule, assigned budget and information about account responsibility (Control Account Manager, CAM) (Fleming and Koppelman, 2010). Duration and budget information are then to be obtained for each work package. In order to generate an integrated master schedule, all tasks must be sequenced in a logical manner that shows interdependencies between work packages, which is usually achieved with techniques such as the Critical Path Method. The schedule represents the time dimension of EVM, onto which cost estimates allocated to the work packages are mapped as second dimension. Each CA now contains sufficient project information to form an integrated time-phased performance baseline, called Budgeted Cost of Work Scheduled (BCWS). Other terms include Planned Value (PV), and Performance Measurement Baseline (PMB). It is defined as the total sum of individual, measurable CA budgets commonly referred to as Budget at Completion (BAC) (Fleming and Koppelman, 2010).

2.1.2. Obtain project metrics

Over the course of the project execution, project data are gathered periodically. The first metric to be captured is the actual expenses incurred within each control account, called the Actual Cost of Work Performed (ACWP), or Actual Cost (AC). It is vital that the reporting for incurred costs and the Earned Value (see below) are suitably synchronised, since deferred collection of cost information distorts the performance measurement and impairs result reliability (PMI, 2011a). Recording of ACWP includes all direct and indirect costs as indirect costs embody a large portion of expenses (Fleming and Koppelman, 1994) which in turn is meaningful for the “organisation’s efficiency, profitability, and competitiveness” (PMI, 2011a: 51).

Comparing ACWP to BCWS is insufficient to provide informational statements as to the project’s health. CA managers therefore have to report a third metric that covers the dimension of the scope which is known as Budgeted Cost of Work Performed (BCWP) or Earned Value (EV). In order to determine EV, each work package needs to be assigned an earning rule which can be classified as discrete (i.e. fixed formula, weighted milestone, percent complete, physical measurement) or non-discrete (apportioned effort,

level of effort) methods (Fleming and Koppelman, 2010). The choice of measurement method correlates with the duration and inherent nature of the task (see Figure 2).

Total EV is expressed as the cumulative sum of individual work packages' EV at the report date. Individual EVs, in turn, are calculated as degree of realisation ($\%_{C,i}$) multiplied with the work package's BAC:

$$EV = \sum EV_i = \sum \%_{C,i} * BAC_i \quad (EQ. 1)$$

Type of Work/Tasks		Characteristics	
		Tangible (Measurable)	Intangible (Immeasurable)
Duration	Short (1-2 periods)	Fixed Formula	Apportioned Effort Level of Effort
	Longer (Exceeds 2 periods)	Weighted Milestone Percent Complete Physical Measurement	

Fig. 2: Guidelines for selecting a measurement method (PMI, 2011a: 42).

The actual project health check happens through comparison of the three metrics. The performance indicators, as they are described by the PMI (2011a), are shown in Figure 3.

Table 1:

Calculation and interpretation of Performance Indicators (PMI, 2011a).

Type	Performance Indicator	Formula	Interpretation		
			Ahead	On plan	Delay/Overrun
Variances	Cost Variance (CV)	$CV = EV - AC$	> 0	$= 0$	< 0
	Schedule Variance (SV)	$SV = EV - PV$	> 0	$= 0$	< 0
Indices	Cost Performance Index (CPI)	$CPI = EV / AC$	> 1	$= 1$	< 1
	Schedule Performance Index (SPI)	$SPI = EV / PV$	> 1	$= 1$	< 1
	Critical Ratio (CR)	$CR = SPI * CPI$	> 1	$= 1$	< 1

2.1.3. Forecast future performance

The performances indices can be adduced to infer expected future outcomes. A variety of forecasting formulas are available (Table 2).

Over the past years, the issue of forecasting has been much-noticed in research (see section 3.1.5). It is worthwhile noting that Fleming and Koppelman (2010) claimed CPI in conjunction with TCPI to be the most valuable indices, because CPI shows to which degree a project has sunk cost without adding value, and TCPI indicates how (im-)possible it is to put the project back on track.

Table 2:

Summary over forecasting methods (PMI, 2011a).

Forecast Method	Formula	Assumption
Estimate to Completion (ETC)	$ETC = (BAC - EV) / CPI$	Cost needed to complete remaining work
Estimate at Completion (EAC)	$EAC = AC + (BAC - EV)$	Future cost performance will be performed at the budgeted rate
	$EAC = AC + [(BAC - EV) / CPI] = BAC / CPI$	Future cost performance will be the same as all past cost performances
	$EAC = AC + [BAV - EV] / (EV_i + EV_j + EV_k) / (AC_i + AC_j + AC_k)$	Future cost performances will be the same as the last three measurement periodes (i, j, k)
	$EAC = AC + [(BAC - EV) / (CPI * SPI)]$	Future cost performance will be influenced additionally by past schedule performance
	$EAC = AC + [(BAC - EV) / (0.8 * CPI + 0.2 * SPI)]$	Future cost performance will be influenced jointly in some proportion by both schedule and cost indices
Variance at Completion (VAC)	$VAC = BAC - EAC$	Amount of budget deficit or surplus at the end of the project
	$VAC (\%) = BAC / EAC$	Amount of budget deficit or surplus of at the end of the project as percentage
To-Complete Performance Index (TCPI)	$TCPI_{EAC} = (BAC - EV) / (EAC - AC)$	CPI must improve to the TCPI calculated in order to terminate the project on EAC
	$TCPI_{BAC} = (BAC - EV) / (BAC - AC)$	CPI must improve to the TCPI calculated in order to terminate the project on initial BAC

2.2. Sustainability

Few scholars or professionals today doubt that attaining sustainable development is amid the most pressing challenges of our time (Goedknecht and Silvius, 2012). A widely accepted definition of sustainability, or sustainable development, has been developed by the World Commission on Environment and Development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WECD, 1987: 41). While this definition is vague in nature, Elkington

(1997) describes the concept of sustainability as consisting of three pillars, namely economic prosperity, social well-being and prudent use of natural resources, and labelled it the “triple bottom line” or “3P (People, Planet, Profit)”, which is represented in Figure 3. The posture that all three components are mutually dependent (Elkington, 1997; General Assembly resolution 60/1, 2005), and that they need to be abided by simultaneously (Dyllick and Hockerts, 2002) is widely accepted as well.

Business organisations as the third pillar of society (Wartick et al., 1998) are increasingly urged to respond for a number of reasons. Governments become aware of climate issues and react with stricter regulations (Epstein, 2008). Employees choose workplaces according to how they account for social and environmental responsibilities (Keeble et al., 2003). Shareholders regard sustainability as an indicator of financial accomplishment (Lynelle, 2001) and good corporate citizenship (Keeble et al., 2003). Governments, non-governmental organisations and customers emphasise responsibility reporting and inquire the origins of products (Keeble et al., 2003).

On the company-level, sustainability is often adapted in form of Corporate Social Responsibility (CSR). According to Russell (2008), committing to and investing in a CSR strategy yields more benefit than it bears risk. Among such benefits are image improvement, increased performance, reduced cost and increased employee motivation (Hope and Moehler, 2014); effective and flexible internal organisational coherence; as well as risk mitigation, better social competence and stakeholder trust (Schieg, 2009).

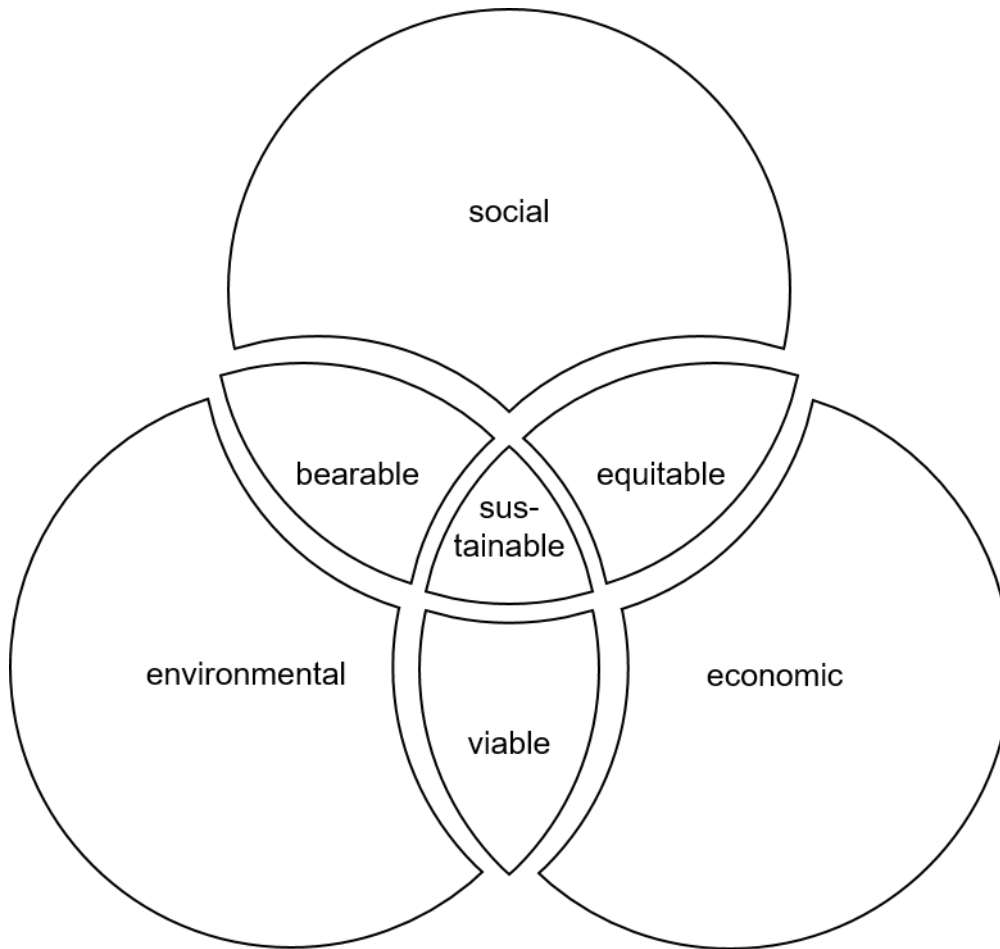


Fig. 3: Graphical representation of the triple bottom line (Elkington, 1997).

2.3. Sustainability in Project Management

It has been suggested that project management is pivotally positioned inside an organisation to deal with the challenge of sustainability (Hope and Moehler, 2014). Projects can be conceived of as organisations as well, albeit of temporary nature (Turner and Müller, 2003). They are instruments of change, and their managers are change agents (Maltzman and Shirley, 2013; Silvius and Schipper, 2014a) operating at the forefront of executing organisational strategies (Russell, 2008). As such, it is probable that project managers are more aware of local or regional social issues and can assure for these to be brought up appropriately (Russell, 2008). For companies that lack sustainability related elements in company strategy, project management is in the position to advocate their implementation by highlighting adverse effects to a high carbon footprint and impaired reputation (Crawford, 2013). Silvius et al. (2012) derive six principles of sustainability in project management, which are briefly summarised below:

1. Balancing or harmonising social, environmental and economic interests:

A company must satisfy the triple bottom line as presented by Elkington (1997). However, Labuschagne and Brent (2005) claim that current project management frameworks fail to address all three pillars of sustainability.

2. Short-term and long-term orientation:

Any business should shift their mindset slightly away from short-term financial performance towards the long-term effects of their actions, because environmental and social impacts, whether positive or negative, take time to manifest themselves (Hope and Moehler, 2015). For that reason, Labuschagne and Brent (2005) back the employment of a life-cycle perspective taking into account not only the project life-cycle, but also those of the resulting product and accompanying assets.

3. Local and global orientation:

Due to the globalisation, the amount of actors affected by an organisation's operations is increasing. Stakeholders can be a larger audience of customers, internationally acting suppliers, foreign governments, as well as competitors. It is imperative to reflect behaviours and requirements of stakeholders on all levels to realize sustainable development as a coordinated process between the parties involved (Gareis et al., 2011).

4. Values and ethics:

Sustainability is a normative concept, and systemic change is important for its realisation. An important part of achieving sustainability will therefore be the presence of a strong and dedicated set of ethics and values in leaders and consumers, to lead and guide the right behaviours and attitude (Hope and Moehler, 2015).

5. Transparency and accountability:

Transparency and accountability form part of Good Governance (Johnston, 2015). Transparency means for organisations to be open about "its policies, decisions and actions, including the environmental and social effects of those actions and policies" (Silvius et al., 2012: 18), including the provision of clear and relevant information to their stakeholders in due time. Accountability supplements the transparency principle with clear and direct responsibility for aforementioned decisions and actions, and their resulting effects.

6. Consuming income instead of capital:

In the context of sustainability, the economic principle to keep expenses below earnings is extended to environmental and social income. With respect to Earth's source and sink functions, natural resources should not be depleted faster than they are provided, and

their resultant waste must not exceed the natural absorptive capacity (Gilbert et al., 1996). The same idea applies to human resource, meaning that labour practices must avoid employees' exhaustion and provide room for recovery.

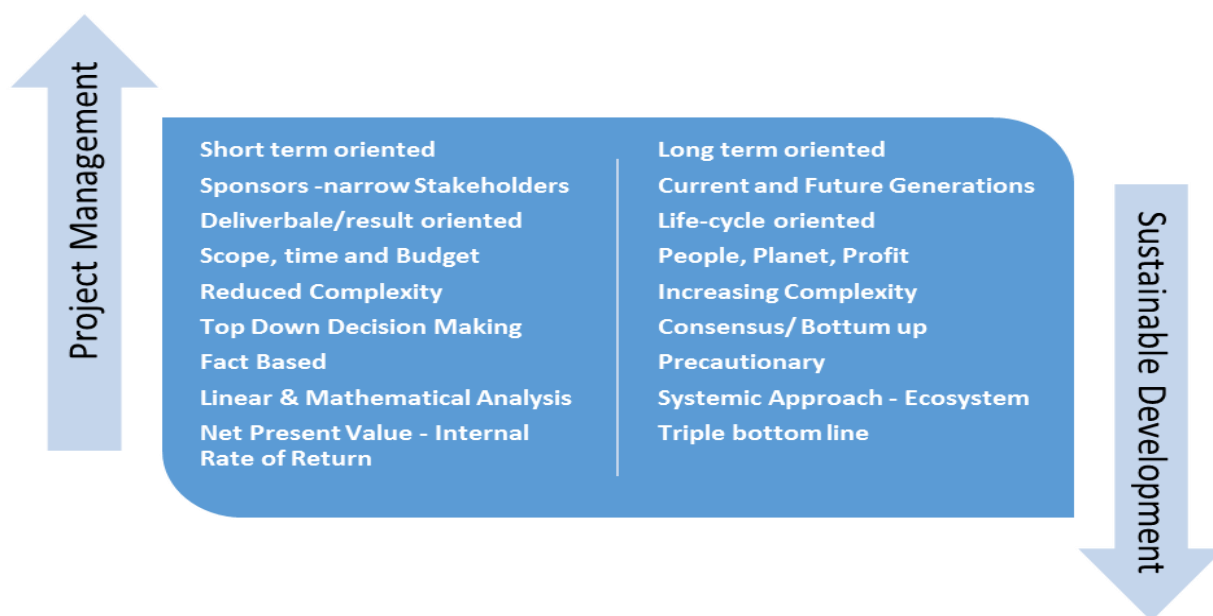


Fig. 4: Contrasts between the concepts of sustainable development and projects (Moehler et al., 2018; Silvius et al., 2012).

These principles often seem to be immediate proponents to traditional project management, as the comparison shown in Figure 4 shows (Adopted from (Moehler et al., 2018; Silvius et al., 2012)). Indeed, transforming an entire methodology that has evolved over decades, in order to turn it to advantages like the creation of economic benefits and competitive advantage, mastering complexity and dynamics of projects, promoting sustainable project results, improved risk management that reduces project trouble, and more retention of key project staff (Gareis et al., 2011) will be challenging. It is not by mere chance that Silvius et al. (2012) conclude that integrating sustainability holds the potential to change the project management profession.

Project managers will need to make use of all expertise available in order to become experts in sustainability, to be able to communicate the relating issues effectively; they have to lead by example and get all key players involved; and must redirect their ways of thinking towards incorporating the whole chain instead of only its links (Goedknecht and Silvius, 2012). This implies that project managers need to become aware of their responsibility, allowing them to form their set of professional ethics. They further need to engage with their work much more creatively and collaboratively, and change the way

they “perceive the world around them” (Silvius et al., 2012: xiv). This also implies, however, that incorporating sustainability principles in project management cannot be a quick fix. Brent and Labuschagne (2007) recommend to introduce sustainability to project management in phases. In line with this statement, research using multiple case studies could show that perceived impact and project success increase when importance is given to include sustainability in project management (Martens and Carvalho, 2016b). LaBrosse (2010: 90) concluded that “it doesn’t matter where you begin, as long as you begin somewhere”. More importantly, zeroing in on the purpose of this paper, Silvius et al. (2012) state that a change in the project management profession will entail the need to develop new tools, as well as “new performance indicators to measure the achievement of the project’s sustainability goals” (Silvius et al., 2012: xiv).

2.4. Previous systematic reviews

Although sustainable development has traditionally received less attention in project and program management than in companies (Gareis, 2013), the increasing number of publications on the subject speaks for itself: a bibliographic research conducted by (Martens and Monteiro de Carvalho, 2014) reported that almost half of the publications had been published within the past seven years (2009-2015). For the systematic review done by Silvius and Schipper (2014b) this figure increases to 76%. As a result of sustainability being a normative concept (Gareis, 2013), most studies approach sustainability in project management from a “conceptual, logical, or moral point of view” (Silvius et al., 2013: 213). One study demonstrated that consideration of sustainability integration in Project Management is presently characterised by an approach of damage control rather than seeking modern social responsibility (Silvius, 2017). Based on a literature review consisting of 42 papers that address “project management” and “eco-design”, Brunes et al. (2014) report that project management concepts and practices have only been applied sparsely to considering environmental sustainability in product development in research. Yet, although the topic of sustainability in project management is still in an early stage of development, it is concluded that regard to it will grow in the near future (Silvius et al., 2013). In their review, Martens and Carvalho (2017) identify a number of publications that highlight the lack of and need for measurement systems for performance in operational practice, especially some that extend measurement beyond environmental factors. These include, by and large, publications examined in the previous section of this paper.

3. Method

Sustainability is becoming a key theme in business nowadays. As a result, its significance for projects and the profession of project management has been acknowledged. Previous studies have examined the penetration of the sustainability

concept in project management, showing that although the importance of incorporating sustainability is steadily gaining momentum, keeping track of the performance of sustainability initiatives in projects falls short at present. Project management itself, however, offers integrative methodologies of performance measurement, namely Earned Value Management, which may serve as powerful starting points to address this shortcoming. The purpose of this paper is to investigate whether the existing concepts of EVM (see section 2.1) can be used for measuring sustainability or, if not, how they need to be modified. Therefore, two separate research questions have to be addressed:

RQ1: Has EVM to date been used to measure Sustainability?

RQ2: How has Sustainability in projects been measured to date?

To answer the above research questions in a comprehensive matter, two independent systematic literature reviews were conducted. The findings from both reviews have been synthesised into a conceptual framework that will be presented in section 5.

3.1. Review methodology

A systematic review is “a review of research literature using systematic and explicit, accountable methods” (Gough et al., 2012: 2), serving as “a method of making sense of large bodies of information, and a means to contributing to the answers to questions about what works and what does not” (Petticrew and Roberts, 2006). Regardless of discipline, systematic reviews have become the gold standard to “synthesise the findings of several studies investigating the same question (Boland et al., 2014). Systematic reviews usually have very narrow research questions, which, combined with strict quality criteria, result in a reasonable amount of studies to be included in the review whose results add up to answering the research question. This type of review is considered aggregative (Gough et al., 2012). The procedure followed for this review is adapted from the key phases presented by (Boland et al., 2014) and shown in Fig. 5.

Step	Content
1	Perform scoping search (refine research question, set inclusion criteria)
2	Search literature (includes removal of duplicates)
3	Screen titles and abstracts ("Stage 1 Screening"), apply inclusion criteria
4	Obtain papers
5	Select full-texts ("Stage 2 Screening"), apply inclusion criteria
6	Quality assessment
7	Data extraction
8	Analysis and synthesis
9	Write-up

Fig. 5: Systematic review procedure according to Boland et al. (2014).

Conducting a systematic review in this context qualifies as conceptual research, which is “related to the development of new concepts or innovations and interpretations of new ideas for existing methods” (Pilbeam, 2013: 7). One key feature of a systematic review is that all evidence pertinent to answering the research question needs to be identified Boland et al. (2014). With regards to quality assessments to be made in step 6, it must be noted that strict quality assessment is necessary for identifying studies for narrow research questions (Jesson et al., 2013). Both bodies of knowledge in this thesis need to be accessed broadly, in order to obtain a degree of saturation that is sufficient for answering the research question. Therefore, quality assessment is carried out with less rigor, and every piece of literature that could provide any insight has been considered for inclusion.

3.1.1. Systematic review for Earned Value Management

In order to address RQ1, the body of knowledge on EVM was limited to the databases Sciondirect, Scopus, Web of Science, GoogleScholar, JSTOR, ProQuest and Emerald Insight. The authors followed the selection logic by Boland et al. (2014) under the caption multi-disciplinary. All references found were downloaded including their full-texts to the bibliographic software EndNote (version X7). The lists of references was then searched for the removal of duplications. Note that the search engine Google Scholar has been precluded

from further examination in both reviews because the number of hits was considered too large to be handled reasonably.

The search for literature about Earned Value Management was performed on January 19, 2015 and repeated for publications after 2014 to 2019 on January 5, 2019. The results for all searches is shown in Table 3 and divided by search (note duplications between the two searches have been removed).

For Stage 1 screening, three criteria were introduced. Reference entries for which no abstract could be retrieved were excluded. Publications which were too similar to other publications (e.g. same article published as journal article and conference paper) were excluded due to redundancy. Lastly, papers where EVM is merely a side-remark in the paper and not topic of the research itself were not included in the review. A total of 346 + 78 (2019 search added) publications was excluded in the Stage 1 Screening. 357 + 132 (2019 search added) references remained, of which 262 + 132 (2019 search added) full-texts could be obtained.

In Stage 2 Screening, a total of 37 + 37 (2019 search added) papers, which met the exclusion criteria outlined for Stage 1 Screening were excluded. Of the remaining 225 + 121 (2019 search added) citations, 128 + 90 (2019 search added) were of empirical nature, 97 + 15 (2019 search added) were conceptual. Table 4 below shows the distribution of types of the references.

Table 3:

Results of Stage 1 Screening for EVM.

Database	Search Terms	Search Range	Number of references	
			2015	2019
Sciencedirect	"Earned Value"	Title-Abstract-Keywods; all years	59	222
Scopus	"Earned Value"	Title-Abstract-Keywods; all years	480	210
Web of Knowledge/ Science (now)	"Earned Value"	Topic; all years	252	189
JSTOR	"Earned Value"	Full-text; all years	83	33
ProQuest	"Earned Value"	All fields except full-text; all years	167	138
Emerald Insight	"Earned Value"	In: 'anywhere'; all years	108	35
Sum			1149	827
Minus Duplicates			(446)	(617)
Final Sum			703	210

Table 4:

Distribution of EVM review results by type of reference.

Type of reference	2015 Number of results 2019	
Journal Article (and review for 2019)	133	46
Conference Paper	68	16
Magazine Article	8	17
Book Chapter	7	10
Blog/Website	4	9
Book	2	2
Thesis	2	4
Report	1	1

3.1.2. Systematic review for sustainability in Project Management

The literature search for answering RQ2 follows the same basic outline. The searches herein were performed in the same databases. To find all relevant terms, i.e. “sustainability”, “sustainable” etc., the wildcard “sustain*” was used as search term, where possible. Furthermore, since project management and sustainability are two different topics in general, their combined search was ensured by searching for both terms appearing within a distinct number of words from each other, where applicable. A first quick search testing several numbers showed that an accepted range of 25 words yields satisfactory results in terms of number of references found, and this number has been applied for all searches. The search for literature about sustainability in project management was performed on January 10, 2015 and repeated on the January 5, 2019 for publications since 2014 (note duplications between the two searches have been removed). The result for all searches is shown in Table 5.

After removing duplicates, 847 + 1004 (2019 search added) results remained for Stage 1 Screening, under application of the quality criterion “Does the publication actually deal with Sustainability in Project Management?” Answers to this question were tabulated in Excel. The question could not be answered affirmatively for 628 + 689 (2019 search added) publications, leaving a total of 223 + 315 (2019 search added) publications addressing sustainability in project management, of which 150 + 232 (2019 search added) full-texts could be obtained. The remaining publications were then subjected to the following three relevance criteria:

“Does the publication deal with sustainability in Project Management?” (double-check initial inclusion criterion, decision now based on full-text)

“Does the publication deal with assessing sustainability (indicators, values etc.)?”

“Does the publication deal with measuring the progress of sustainability?”

Five references were excluded during Stage 2 Screening. Eight references were book reviews (Kodukula, 2012), 57 references were similar or equal to other publications that were already included (Goedknegt, 2013), and nine references were compilations whose articles were already included individually in the sample. Out of the final 145 + 169 (2019 search added) full-texts, 65 + 117 (2019 search added) were conceptual, 70 + 55 (2019 search added) were empirical and 10 + 2 (2019 search added) could not be discerned unambiguously. Table 6 shows the distribution of types of the references.

Table 5:

Results of Stage 1 screening for Sustainability in Project Management.

Database	Search Terms	Search Range	Number references	
			2015	2019
Science-direct	Sustain* w/25 "Project Management"	Title-Abstract-Keywords; all years	49	854
Scopus	"sustain*" W/25 "Project Management"	Title-Abstract; all years	236	232
Web of Knowledge/ Scinece	sustain* NEAR/25 "Project Management"	Search in topic; all years	149	157
JSTOR	"Project Management sustain#" ~25	Full-text; all years	94	163
ProQuest	all(sustain* N/25 "Project Management")	All; all years	302	298
Emerald Insight	general: sustain* AND "Project Management"	All fields; all year	187	1028
Sum			1017	2732
Minus Duplicates			(327)	(1545)
Final Sum			690	1187

Table 6:

Distribution of Sustainability in Project Management review results by type of reference.

Type of reference	Number of results	
	2015	2019
Journal Article/ Review	81	131
Book Section	24	17
Conference Paper	18	75
Book	9	7
Unpublished Work	5	
Thesis	5	8
Magazine Article	2	87
Newspaper Article	1	7

4. Results of the descriptive analysis

4.1. Earned Value Management

The final sample of 314 publications for Earned Value Management has been assessed regarding their research focus within the EVM procedure. Table 7 below shows the distribution of research topics. In addition, the categories “quality management”, “procurement management”, and “other” were added. “Other” comprises publications that discuss the general implementation of EVM, portray application examples (such as Scrum, Agile, etc.), deal with EVM on a general level (such as the PMI standard) or which mention EVM on a side-note, but could still provide enough information to not be excluded right away.

Table 7:

Results of distribution of EVM research topics.

Research topic	Amount 2015	Amount 2019
Work definition (Project Scope)	0	0
Work Breakdown Structure (WBS)	3	0
Organisational Breakdown Structure (OBS)	0	0
Control Accounts (CA)	0	0
Scheduling	1	1
Establish Baseline (BCWS)	5	4
Budgeting	1	1
Definition of Performance Metrics (Earning Rules)	3	10
Measure Performance (BCWP)	5	11
Record Actual Costs (ACWP)	0	0
Determine Project Performance (CV, SV, CPI, SPI)	41	20
Forecasting (EAC, ETC)	48	27
Procurement Management	2	1
Quality Management	10	6
Other	95	51
Sum	223	132

Excluding all publications in the cohort “other”, the above figure shows that most focus in research has been on performance measurement and forecasting. In general, EVM researchers and scholars have been concerned with increasing reliability and accuracy of these two issues. The imbalance between studies about cost and time performance may stem from the fact that (Christensen and Payne, 1992) have concluded more than 20 years ago that forecasting can be predicted to about 10% from CPI as early as when

a project is 20 percent complete, which has become a widely generalized notion (Fleming and Koppelman, 2010) and has only been contested rather recently (Lipke et al., 2009). This stability of performance indices has been a focus of research recently (Kim, 2015). A larger school of thought developed based on the findings that SV and SPI show false performance towards the end of a project, because SV will always equal 1, as the Earned Value will ultimately always be the Planned Value (Lipke et al., 2009; Vandevorode and Vanhoucke, 2006). To overcome this limitation Lipke et al. (2009) have developed the Earned Schedule (ES) method, and later enhanced it with a factor for schedule adherence and rework. The ES method and its resulting forecast metrics have shown to outperform other methods such as the Planned Value method (Anbari, 2003) or Earned Duration in several studies (Vandevorode and Vanhoucke, 2006; Vanhoucke and Vandevorode, 2007).

A big portion of research on progress tracking comes from the construction industry. As scheduling and measuring progress with traditional earning rules proves to be complicated, the use of optical recognition to measure Earned tons of steel or Earned cubic meters of concrete (Turkan et al., 2013), GPS and GIS (Buell, 2008), time-lapse photography (Fard et al., 2007) and Scan-to-BIM (Bosché et al., 2015) have been investigated in order to replace the traditional tracking of percent complete based on work-hours. Another approach is to replace the subjective and often inaccurate Percent Complete by linguistic fuzzy numbers in order to reduce uncertainty in the measure (Moslemi Naeni et al., 2014; Naeni and Salehipour, 2011; Salari et al., 2013). One further article proposed a quantification model for incorporating Level of Effort (LOE) tasks into the measurement (Townsend et al., 2014).

Another research trend that has seen some minor attention dealt with including the aspect of quality into EVM. This has been attempted to achieve through measuring the achievement of technical requirements (Solomon and Young, 2007), adjusting the EV by including quality and failure cost (Gao and Ye, 2011) which often represent a fracture of a task's total budget and can be assessed linguistically through fuzzy numbers (Xu et al., 2010). The mentioned methods range under names such as Quality Earned Value (Jianmu et al., 2012) or Earned Quality Value (Ong et al., 2018).

Another point worth mentioning here is concerned with the so-called S-Curve, i.e. the graphical representation of EV, PV and AC over time. Many publications in the sample obtained describe S-curves as a means of their own, and some research has been done on their mathematical representation and parameterization (Chen, 2014; Cioffi, 2005; Warburton, 2011). The idea is to fit the curve to the project data, for example by adjusting the curve parameters, to detect variations and trends, and make forecasts. What is often understated in these papers is that the S-curve represents the resource-

loaded schedule over the project life-cycle, which assumes that more resources are needed during execution than during initiation and closing (Evensmo and Karlsen, 2005; PMI, 2013). Some others describe the resource load as (bell-shaped) normal distribution (Cass, 1994; Murmis, 1997). In any case, the project shapes the S-curve, and not the other way round. Using a fitted curve to forecast project cost and duration detaches the information from the schedule, thus the meaningfulness of such a forecast is questionable.

As pointed out earlier, the category “Other” encompasses a variety of publications which advocate for the implementation of EVM in a specific industry sector, such as in R&D (Banerjee, 2005), , Construction (Alvarado et al., 2004; Czemplik, 2017; Hanna, 2012; Marco and Narbaev, 2013), Aviation (Locksley and Rice, 2000), Energy (Mudau and Pretorius, 2009) and IT (Efe et al., 2018; Erdogmus, 2010; Fowler and Chen, 2017; Luo, 2005). Conversely, it has also been argued that traditional project management methods like EVM are far less important for product development projects (Bergman et al., 2011). The opinions about the use of EVM in the IT industry, however, differ. Becker and Kunz (2009) explain that the use of EVM can prove to be problematic in dynamic projects as the baseline can change repeatedly. While the APM notes that there is a trend towards agile approaches in time-critical projects with flexible scope (APM, 2012), and it has been proposed that the concept of EVM can be applied within Agile reporting (Alleman et al., 2003; Cabri and Griffiths, 2006), other authors claim that agile methods are a means to escape the “undisciplined rut of traditional ‘Earned Value’” (Ambler, 2007: 60).

Lastly, other includes publications which describe implementation scenarios for EVM. A portion of papers utilizes the EVM methodology and applies it to different contexts, e.g. in Wireless Sensor Networks (Suenaga et al., 2017), for solving multi-period multi-product production planning problems (Bagherpour and Noori, 2012; Feylizadeh and Bagherpour, 2018; Noori et al., 2008), creative projects (Šviráková, 2017), or interfacing EVM with lean principles (Novinsky et al., 2018; Raid, 2012; Zhang et al., 2014).

To this end, this study did not identify a single publication that explicitly employs EVM for measuring sustainability in a holistic way. Thus, RQ1 cannot be answered positively. However, the sample holds exceptions that address the tracking of EVM. Vittorio et al. (2009) derive variables from EVM called Estimated Cost, Actual Cost and Budgeted Cost, as well as indicators, whose calculations resemble the ones for traditional Earned Value. Here, cost are not developed according to material and man-hours, but to energy consumption in kilowatt-hours of an industrial plant. Dwaikat and Ali (2016) use EVM in the context of building operating phase, to measure the actual end use energy cost performance of green buildings. They baseline the life cycle energy consumption cost of buildings according to typical benchmark figures. The key metric collected is the energy

consumption, while the earning rules is the energy tariff. The Earned Life Cycle Value of energy is the value of the consumed energy in reference to the total estimated life cycle budget of energy. In a similar fashion, Du et al. (2017) adopt EVM as real-time measurement for water consumption as a method to inform water resource management systems. BCWS and ACWP turn into planned and actual water consumption, while the Earned Value is endowed with the meaning of irrigation. The performance metrics thus indicate the amount of water consumption in relation to resources made available through rain. Memarzadeh and Golparvar-Fard (2012) introduce the metrics budgeted Carbon Footprint (CF) of the work performed (BCFWP), budgeted CF of the work scheduled (BCFWS), and the actual CF of the work performed (ACFWP). They employ BIM to measure and calculate these metrics and colour code the carbon-related progress of the construction site. Based on these information, they further calculate the amount of trees needed to be planted in order to compensate the created carbon footprint. Kim et al. (2015) use similar metrics, namely Budgeted CO₂ of Work Scheduled (BCO₂WS), Budgeted CO₂ of Work Performed (BCO₂WP) and Actual CO₂ of Work Performed (ACO₂WP) integrated in the traditional EV metrics. The unit of analysis sits at activity level, by adding a CO₂ package to the cost and schedule information. Lastly, Abdi et al. (2018a, 2018b) allocate greenhouse gas (GHG) emissions to work packages and use EVM to measure and track project-related emissions. They define GHG accounts as proxies to Control Accounts and provide reference tables for the emissions of certain construction activities. They equate the total GHG budget to the BAC and define all emission undercuts as Earned Greenhouse Gas Emissions.

4.2. Measuring sustainability performance in project and programs

The PMI takes up the dictum presented at the outset: “What’s measured is managed – and sustainability is no exception. Define specific, measurable, sustainability goals within each project (...) and then track those metrics as part of the project review process” (PMI, 2011b: 1). Similarly, Haanaes et al. (2011) argue that measurement is one way to step up to the sustainability embracers, even if that implies that these ways of measuring need to be invented first.

Although studies have shown that the opportunities for including sustainable principles in the PMBoK Project Control and Monitoring process groups (i.e. those in which performance measurements takes place) are significantly lower (Eid, 2009; Eid, 2013), the same studies show that the perceived level of ability to incorporate sustainability in project management is highest for the project content. Therefore, sustainability will play a major role in the project progress reports (Silvius, 2013) as they provide follow-up information regarding scope, objectives, critical success factors and more from the initial project planning processes (Silvius and Schipper, 2014b). Accordingly, many strongly

advocate for the use of sustainability indicators. Taylor (2010) recommends environmental indicators to be included in the regular project or program KPIs, because reasonably chosen indicators are a means to provide better understanding of a project's sustainability aspects (Silvius et al., 2010). Other authors who champion the employment of sustainability indicators and measuring performance of these include, but are not limited to, Russell (2008), Perrini and Tencati (2006), Keeble et al. (2003) and Bal et al. (2013).

Concerning sustainability indicators, a great deal of effort has been dedicated to producing frameworks for their selection. While Talbot and Venkataraman (2013) indicate that there is no standard for project reporting or management of sustainability, a fair amount of publications invoke the indicators devised by the Global Reporting Initiative (GRI) (for example Carboni et al. (2013), Crawford (2013), Epstein and Buhovac (2014), Labuschagne et al. (2005a), Perrini and Tencati (2006), Silvius et al. (2010), Silvius et al. (2012), Talbot and Venkataraman (2011)), which has been accepted as the global standard for reporting corporate sustainability (Talbot and Venkataraman, 2013). Generally, the identification of suitable indicators to measure the impact of an operational initiative depends on the following three essentials: data availability, the methodology to translate the operational initiative information, and the choice between qualitative methods or translating the measures into financial terms (Labuschagne and Brent, 2005).

The literature examined in the systematic review returned only a few publications, usually with a strong contextual emphasis, that identified assessment or measurement of sustainability within projects, presented below.

Based on a general framework developed by Labuschagne et al. (2005b), Brent et al. (2011a) introduce the Sustainability Cost Accounting (SCA) method. The procedure assesses environmental and social impacts of a new technology in financial terms following a four-step methodology. For SCA, the authors adopted published externality cost values based on cost approaches (estimate actual or hypothetical expenditures of reducing or eliminating impacts) and benefit approaches (analyse effect of income generation on environmental and social quality). The authors conclude that the approach sufficiently addresses the TBL approach, and that "Through the common denominator, the externalities can be incorporated with a typical internal (financial) evaluation of the performance of a technology" (Brent et al., 2011a: 49). However, the authors further infer that the practicality of SCA can be significantly impaired by uncertain externality cost data, as well as the fact that not all criteria can be quantified in financial terms (Brent et al., 2011b).

The procedure employed by Heuberger et al. (2007) based on Multi-Attribute Utility Theory calculates a single value (Utility) which represents the project's estimated contribution to sustainable development of the country the project will be implemented in. Relevant criteria were selected from various literature sources and through expert interviews. The criteria are then linked to indicators, which in turn can be quantitative, qualitative or semi-quantitative. Individual sustainability criteria for each project are calculated, weighted and added up. All results for the indicators are converted to a single utility value ranging from -1 and 1, via absolute utility functions that should be adjusted through baseline cases and best practice projects (Sutter, 2003).

Keeble et al. (2003) describe a tool for an energy company which consists of 69 (undisclosed) indicators that are assessed against four questions relating to impacts on economy, society, environment and natural resources. The indicators are ranked from 1 to 5, and the results aggregated in a summary scoring sheet. According to the authors, the tool can be used several times throughout the project life cycle, thus enabling it to be applied to performance measurement.

The evaluation tool presented by Martens and Carvalho (2013) works in a similar way: relevant actions are identified along the five project phases, such as "Identify and document lessons learnt" and "Release the product or services for the company's operation". The actions are linked to evaluation conditions for all three TBL dimensions, and compliance of the actions with the conditions are evaluated based on a 5-point Likert scale. Subsequently, averages for each TBL dimension, as well as total average for each phase are calculated and displayed on a radar diagram.

The GPM Reference Guide to sustainability in project management (Carboni et al., 2013) points to the P5 (People-Planet-Profit-Process-Products) impact analysis described in the P5 Standard (GPM Global, 2014). According to the standard, sustainability objectives are translated to project objectives by scoring GRI indicators relevant to the project on a scale from -3 (lowest impact = best score) to +3 (highest impact = worst score) and collecting amendment strategies in a Sustainability Management Plan.

Maltzman and Shirley (2012) propose Earned Environmental Value Management as a tool to be included in an Environmental Management Plan, which is supplemental to the traditional Project Management Plan. However, they do not provide insight or guidance on functionality or use of said tool, either.

Sánchez (2015) proposes a framework for portfolio selection by evaluation projects that address the triple bottom line in strategy definition. The approach uses traditional

management tools like stakeholder analysis and balanced scorecard as well as data envelopment analysis. With the latter, working with different units thus addressing the criterion multi-variable problem formulation.

Kivilä et al., (2017) conducted a case study in an infrastructure project to identify the control practices that a project organization uses for sustainable project management. Their findings reveal the use of a control package in managing sustainability during project execution. While they acknowledge that indicator sets for all three pillars of the triple bottom line were monitored and measured, they do not provide more specific details as to their measurement. Plus, the authors point out that sustainability control needs to be integrated as part of general project management.

Lastly, Barnard et al. (2011) explicitly recommend the application of Earned Value Analysis to compare planned sustainability work with actual work in program management and to detect any deviations. This proposal, again, falls short of any explanation as to how this could be achieved.

In terms of the assessment of these indicators, and the opportunity of unifying these, it has to be noted that the method proposed by Martens and Carvalho (2013) relies on subjective assessment, and the results are on a scale from 1 to 5, which renders them complicated to unify in a meaningful manner. The same applies to the tool described by Keeble et al. (2003). Although both authors claim otherwise, their procedures appear to be suitable for post-project benchmarking rather than performance measurement. The P5 model created by GPM Global (2014), on the other hand, provides a means to unify the results in one figure against which the project performance can be assessed. Here, too, the qualitative scoring renders it complicated to assign an objective monetary value to the results. The frameworks introduced by Heuberger et al. (2007), Sánchez (2015) and Labuschagne et al. (2005b) use unifying approaches as well. The former is, however, explicitly designed for pre-project evaluation, and using it for performance measurement seems complicated. The indicator framework of Labuschagne et al. (2005b) is interesting because it converts indicator data to monetary expressions. Unfortunately, the conversion relies on data that are uncertain, unstable, and possibly unavailable. While evaluating project KPIs for strategic goals, the framework proposed by Sánchez (2015) operates on a higher and presumably more abstract level than is relevant to this paper's scope. The selected method, however, may prove to be adequate for handling data acquired in the project.

5. Conceptual Framework to integrate EVM and Sustainability in Project Management

The results presented in section 4.2 reflect the following situation: the topic of sustainability inclusion in project management is steadily gaining ground. While most

publications continue to focus on normative aspects, i.e. outlines of necessities and guidelines of the approach, little work is done on the prescriptive front. The need to not only address sustainability through projects, but to also measure and track effectiveness of such initiatives as well. The techniques and tools to accomplish this, as presented in the previous chapter, are often qualitative (subjective, that is). Project management is a profession that is rich in tools as it is. Instead of designing a completely new methodology, the following chapter will attempt to bridge the gap between existing project progress management tools (EVM) and sustainability by introducing a conceptual framework which translates principles of EVM to performance measurement of sustainability indicators if and where necessary.

5.1. Scope

It has been pointed out earlier that a proper work definition is most likely the step of the highest importance, because mistakes made here invariably propagate through the entire performance measurement process. Silvius concludes that “Integrating Sustainability stretches the scope of the project and Project Management” (Silvius, 2017: 6) which stresses the importance of performing this step thoroughly. Sustainability must focus on the project context and has to yield benefit to the executing organisation. Thus, *sustainability has to be included in the project’s business case*. There is a difference in the level of consideration, with focus on either the delivery and management of a project (internal scope) or its results and end product (external scope) (Schipper and Nedeski, 2013). Either way, the scope definition uses a project charter as process input (PMI, 2013) and Sustainability principles should be anchored in it (Tharp, 2013), for example by explicitly including green statements and environmentally responsible (“SMARTER”) objectives (Maltzman and Shirley, 2012). Examining the project context requires the project executives to identify the indicators which are indeed relevant to the project and hence to the organisational strategy, and therefore ought to be *included explicitly in the business case* (Carboni et al., 2013; GPM Global, 2014).

5.2. Work Breakdown Structure

Several ways to include sustainability principles in the WBS could be identified. First, one approach proposes to detach sustainability from the regular project work and add it to the WBS separately (Mochal and Krasnoff, 2013). The second tactic works in a similar way: Haner (2013) recommends the use of a Sustainability Breakdown Structure as part of a Sustainability Program Management Plan (SPMP). Fernández-Sánchez and Rodríguez-López (2010) employ the similar term Sustainable Breakdown Structure that can follow the sustainable development pillars, for their methodology to identify sustainability indicators in construction. Consequently, their lowest level packages contain indicators, rather than tasks. Third, sustainability can be considered on the

lowest work package level. For instance, Kim et al. (2015) and Terouhid et al. (2012) use lowest level CO₂ information for carbon budgeting purposes. Similarly, the GPM P5 standard proposes to examine each work package to address sustainability. This standard recommends the use of a Sustainability Management Plan (SMP) with clear sustainability objectives (GPM Global, 2014). In conclusion, the following proposal is derived: driven by the organisational sustainability, or CSR, strategy, a Sustainability Management Plan should be employed for the project. Objectives defined herein should be broken down in a *Sustainability Breakdown Structure* (SBS) to hold indicators relevant to the strategy at the lowest level. Since the objectives are tied to project deliverables rather than work packages, lowest level SBS units can be expected to intersect with higher level WBS elements. Nonetheless, data collection and reporting will continuously occur on work package level. There is a compelling reason to not adapt the approach on lowest WBS level: intersection at this level risks disregarding the criteria of mutual exclusiveness in traditional WBS, because changes to one indicator may have immediate or postponed effects on other ones. This makes unambiguous usage complicated, not least for the creation of control accounts.

5.3. Organisational Breakdown Structure, Responsibility Assignment Matrix and Control Accounts

EVM works better on lower WBS levels than higher ones, Talbot and Venkataraman point out that “the level at which indicator sets are tracked cannot contain too many indicators or the indicator set will be too difficult to track in a project setting” (Talbot and Venkataraman, 2013: 197). Following the above notion to tie sustainability objectives to deliverables induces interfacing the SBS lowest level indicators with the WBS instead of the OBS. Indicators/objectives identified for any given deliverable then apply to all WPs that build a deliverable. *Sustainability Accounts* (SA) are mapped to higher WBS levels, and accountability trickles down to work package CAs. Another consideration regarding indicators and SAs must be made here however: it should be scrutinized thoroughly whether indicators that are not measurable as direct effects during the project work (i.e. lagging indicators) should rather be assigned to entities of the permanent organisation. Mochal and Krasnoff (2013) offer a solution to this by pointing out that a Project Management Office as appropriate entity to assist in collection and consolidation of performance data.

5.4. Work planning and scheduling

Since it has been shown that sustainability deliverables will reflect in the actual work, this results in the project being scheduled as usual with sufficient time and budget for addressing sustainability objectives being accounted for. Since estimating and measuring relevant indicators is a surplus in effort, the work required needs to be *added*

to indirect project cost and schedule. Many authors argue in favour of a life cycle perspective which exceeds the delivery of the project (Labuschagne and Brent, 2005; Maltzman and Shirley, 2012; Silvius et al., 2012). Hope (2012) refers to this as Project Legacy. As presented in section 2.3, long-term orientation is critical for implementing sustainability in projects (Silvius et al., 2012). The effects and impacts of the project deliverables are the paramount aspect and should be given precedence over the project processes. Merely focusing on the process of project delivery would be the wrong direction for research.

To address post-project benefit realization, the performance baseline needs to extend (indefinitely) beyond the traditional at-completion-point of EVM. Therefore, estimating and extrapolating the estimated value of benefits over the entire project and product life cycle can be considered. Following project handover, measurements will then not be continued by the project team, but by an entity within the primary organisation. This is in line with the idea of Mochal and Krasnoff (2013) to have a Project Management Office responsible for the project sustainability data, and benefit realization management is ultimately a key responsibility of organisational management Carboni et al. (2013).

5.5. Budgeting and Baseline establishment

5.5.1. Indicator selection

There are a lot of indicator sets available, and a few of them were presented in section 4.2. Berring and Ung (2003) suggest that stakeholders need a decision-making tool based on unified analysis. This point is even more significant given that EVM expresses data from three dimensions in monetary terms. Additionally, it is recommended to not stick too closely to set standards, as the choice of indicators should be influenced by the organisation's values, culture, and its business realities (Keeble et al., 2003). At the same, it can be observed that many frameworks utilize the reporting indicators developed by the GRI, as it has also been outlined earlier. It can therefore be recommended to apply the GRI as basis for measuring sustainability with the conceptual framework described herein. Nonetheless, the selection of appropriate sustainability indicators should be guided by the project's business case for sustainability and the organisational strategy (GPM Global, 2014) and is therefore at the discretion of the organisation itself.

5.5.2. The concept of value

The EVM concept expresses material usage and man-hours spent in terms of their respective price-tag. It has already been pointed out that monetizing environmental and social value is utterly intricate. Berring and Ung (2003) explain that quantification and monetization of environmental aspects takes an entire body of referenced literature and empirical data to estimate monetary outcomes for each project position. Availability and

quality of this type of data poses severe constraints to the feasibility of the procedure. Epstein and Buhovac (2014) highlight willingness-to-pay and willingness-to-accept methods, that rely on extensive surveys among all stakeholders involved. Needless to say that this monetization is purely subjective, hence will be the value created, and the cost and time consumption of the approach might as well outweigh the benefits.

A simple approach is proposed here: the Sustainable Value (SV) approach developed by Figge and Hahn (2005). The approach relates a company's financial return (i.e. its Net Value Added (NVA)) to its resource usage and compares it to a benchmark, usually the economy that the company operates in. According to Figge and Hahn, "Value is created whenever benefits exceed costs" (Figge and Hahn, 2004: 173). SV measures the value added that is generated by a company using a portion of resources or materials instead of a benchmark. The validity of the approach is determined by the selection of the benchmark and the earnings figures (Figge et al., 2006). The SV methodology has some significant advantages: the variables are also given in the GRI reporting guidelines; it addresses the need for unified metrics; and the calculations require data which should be available in a company from financial and responsibility reporting. While the SV method primarily builds on eco-efficiency representing only a subset of sustainability, every indicator which expresses a scarcity and is linkable to added value can be adduced for the calculation, data availability provided. However, SV alone cannot express every indicator in monetary terms and thus has to be supplemented by other mechanisms. It has been pointed out earlier that "Managers must quantify how one variable drives another until the link to profit is clear" (Epstein and Buhovac, 2014: 42). For some (primarily lagging) indicators, this is relatively simple: for instance, reduced cases of corruption mean less illegal relocation of budget, decreased employee turnover reduces recruitment cost, and improved product quality or safety lead to less product recalls, which are costly as well. Other indicators like child labour and trained professional emigration are by far less straightforward.

The rationale is that SV is being created when return on capital is greater than opportunity cost of capital. This means that the SV baseline, as opposed to traditional Earned Value, does not display the cumulative value of cost spent on work done, but rather the value of cost avoided through resources saved. When comparing the company with its benchmark economy, the company has to perform better than the economy to add value. The economy hence is a point of reference to compare against. For use in projects, the method needs some modification. Carboni and Hodgkinson (2013) argue that sustainability takes place at portfolio level. In order to avoid over- and understatement of resource-efficiency, resource metrics must relate to the appropriate entities (Müller et al., 2012). Therefore, it is proposed that the project under

consideration is not benchmarked against the economy, but rather against its primary organisation. In SV, the company's net contribution is analysed in relation to the economy. Accordingly, the project must be analysed in relation to its contribution to the firm (see Fig. 6). The project benefits management plan holds financial targets as derived from the project's business plan, where the financial value is expressed as net present value (NPV).

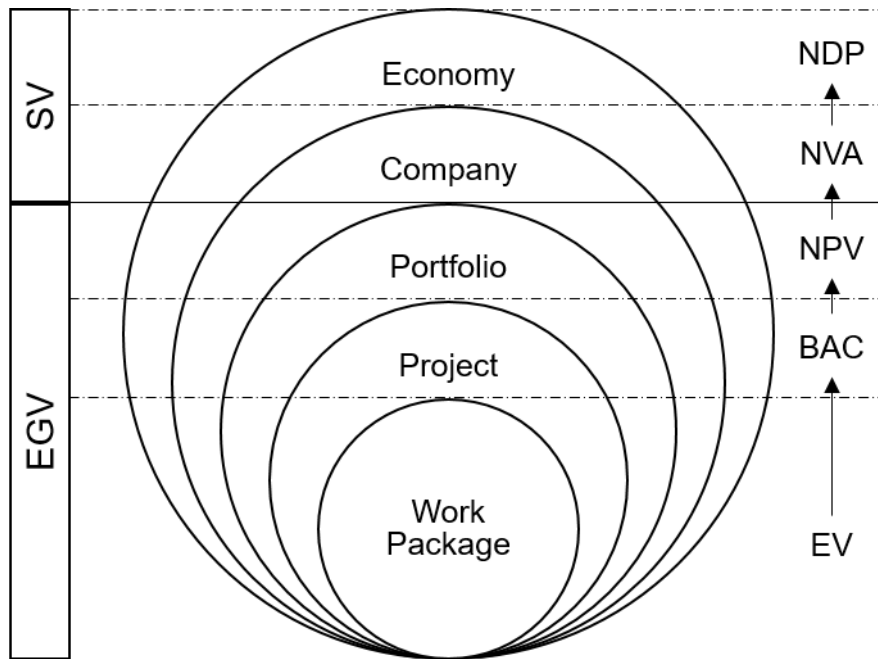


Fig. 6: Relationship between metrics on different hierarchical levels

5.5.3. Terminology

While this chapter introduces SV as method for monetizing Sustainability indicators, the proposed framework provides the option for the practitioner to select whichever monetization is considered appropriate. Furthermore, “Earned Sustainable Value Management” is a very attractive expression for verbal use. Thus, although SV has been employed here a more general formulation is favoured, as well as to avoid confusion in case that monetization is performed following other methodologies. Terminology should be guided by standard EVM expressions. Earned Sustainability appears unfit as its acronym ES can easily be confused with Earned Schedule which is already in use. Furthermore, Earned Sustainability fails to reflect the notion of value, which is a crucial component of the approach proposed herein. Instead, it is proposed to follow the formulation denoted by (Maltzman and Shirley, 2012). They use the term “greenality” interchangeably for Sustainability. Plus, as noted previously, they also employ the term “Earned Environmental Value Management”. While the term ‘green’ is deeply ingrained in people’s heads as merely reflecting environmental aspects, “green” should address all three aspects of Sustainability. Further, “green” can invoke a positive image rather than

a mere association of the term with reducing negative impact rather. Although “green” has also been portrayed negatively through terms like ‘greenwashing’, the notion of green in this context should be expanded to apply to social and economic aspects as well. Moreover, one cornerstone of this methodology is to express a project’s (and thus ultimately an organisation’s) performance in terms of resource efficiency (i.e. reduce negative impact) and to express it in an understandable language, i.e. in monetary terms. Green often being the colour associated with money further bestows a double-barrelled meaning upon the term ‘Green Value’. To conclude, this framework will merge Earned Value Management with the word “Green” as holistically considered approach to sustainability, thus leading to the term *Earned Green Value Management (EGVM)*. Consequently, Planned Value (PV) in EVM is translated to Planned Green Value (PGV).

5.5.4. Baselining the cumulative Sustainable Value

Apart from regular project data like duration and budget estimates, each work package now contains SV information, representing the monetary contribution of each work package in terms of resource efficiency compared to the organisation’s portfolio of projects, and/or past project operations. Note that the cumulative result is expected to be positive, since improved sustainability results should be targeted during work definition. This implies, however, that contrary to traditional PV, the cumulative SV baseline can take negative values or equal zero. The latter, $PVG = 0$, would indicate that no improvement in sustainability compared to previous projects or the selected benchmark ($PGV > 0$) are being planned into the project goals. In line with the existing terminology, the target measure shall be referred to as *Green Value at Completion (GVAC)*, regardless of positive or negative face value.

5.6. Record actual costs

As shown in section 5.5.2, resource usage will be compared to NPV. In other words, the project budget drives the use of resources in terms of procured material, energy usage, employee commute and travel, etc. That means, when the Actual Cost exceeds the baseline, this may have been caused by additional workforce deployed (and thus more resources were used). Alternatively, a decision could have been made to increase expenses on sustainably sourced materials, thus having positive effect on the Sustainability performance. The bottom line is that Actual Cost (AC) can also be used for measurements and calculations in this method.

5.7. Measure progress

The Sustainability baseline is established through planned indicator values for each work package, e.g. planned CO₂ emissions during any work package. For performance measurement, each indicator must be measured in the respective unit, and then

converted to SV as described earlier. Depending on the approach, the SV calculation can be simplified to formulas with either NVA or BAC as reference.

Definition of earning rules

Environmental indicators are recorded in absolute numbers (m³, tons, etc.). Most indicators of economic sustainability already come as monetary expressions. Some thought, however, has to be given to indicators, which are not directly quantifiable/monetizable, such as employee satisfaction and customer retention. In these cases, a company should make use of past experiences. For instance, every organisation should be able to determine the per-unit opportunity cost for product recalls, or the recruiting cost per employee. These metrics serve as appropriate monetary proxies for inclusion into a Sustainability baseline. Another aspect is much more unwieldy: the issue of unsynchronized accrual has been brought up already in the literature review of EVM. Epstein and Buhovac (2014) discuss that Sustainability performance measurement should make use of leading and lagging indicators as well. While this addresses the principle of long-term perspective, it presents in-project performance measurement with a problem, because benefits such as customer retention might not manifest itself until in a further project, and other benefits might even take years to unfold. Three ideas come to mind. First, Epstein and Buhovac express that “Managers must quantify how one variable drives another until the link to profit is clear” (Epstein and Buhovac, 2014: 42). Thus, an attempt can be made to express lagging/leading indicators through variables which are measurable during the project life cycle.

Furthermore, it has been pointed out earlier that Level-of-Effort (section 2.1.2) tasks can accrue Earned Value with no Actual Cost being incurred. Sustainable Value can often be earned through management processes without added expenses. Other examples relate to sustainable procurement or reducing other resource-intensive activities. Therefore, a good share of Sustainable Value can be accounted for based on Level-of-Effort (LOE). To this end, a positive appropriation can be provided to LOE, whose usage is otherwise explicitly discouraged (Fleming and Koppelman, 2010). With all data readily acquired, EGV can be determined following the computations as described in section 5.5.2 and Figge and Hahn (2005).

5.8. Determine Sustainability performance

The calculation of performance indices and variances can proceed following the traditional EVM procedure. Their interpretation changes accordingly: negative/positive variances between planned and achieved Sustainability indicate that to date, less/more resources have been saved than planned. Negative variances between planned Sustainability and incurred costs indicate that more money has been spent on

Sustainability than sustainable benefits could be achieved from it. This is important, because it can sharpen the project team's wits. For instance, Maltzman and Shirley (2012) show an example where deleting screensavers saved 1.9 million kilowatts of energy and 266,000 dollars per year – for free. The same amount of energy can be saved by replacing 20,879,121 100W-bulbs with 9W-LEDs. At a cost of 7 € per LED that amounts to almost 146.2 million euros. The re-definition of the project metrics is shown in Table 7.

Table 7:

Re-definition of EVM project metrics.

EVM metric	EGVM metric	Formula
Cost Variance (CV)	Net Green Value (NGV)	$= EGV - AC$
Schedule Variance (SV)	Variance of Green Value (VGV)	$= EGV - PGV$
Cost Performance Index (CPI)	Cost of Green Value (CGV)	$= EGV/AC$
Schedule Performance Index (SPI)	Rate of Green Value (RGV)	$= EGV/PGV^*$

**) Note that for RGV, PGV must be greater than 0.*

5.9. Forecasting

These steps work according to regular EVM methodology. Arguments in the formulas need to be replaced, the calculations remain the same. The interpretations reads: "How much time will it take until we saved the resources we were supposed to have saved by today" and "How much more (or less) do we need to spend in order to achieve our Sustainability goals".

5.10. Summary of the proposed conceptual framework

Figure 8 shows the EGVM framework. The process-steps on the left correspond to the amended EVM process steps and thus follow the structure of this paper. Each process-step contains sub-steps as identified and explained in section 5 and can therefore be employed as checklist for the EGVM methodology. The same concepts are represented as a graphical workflow on the right-hand side of the figure. Green process-steps indicate new or altered concepts while blue blocks represent concepts that have been adapted without changes from the original EVM methodology.

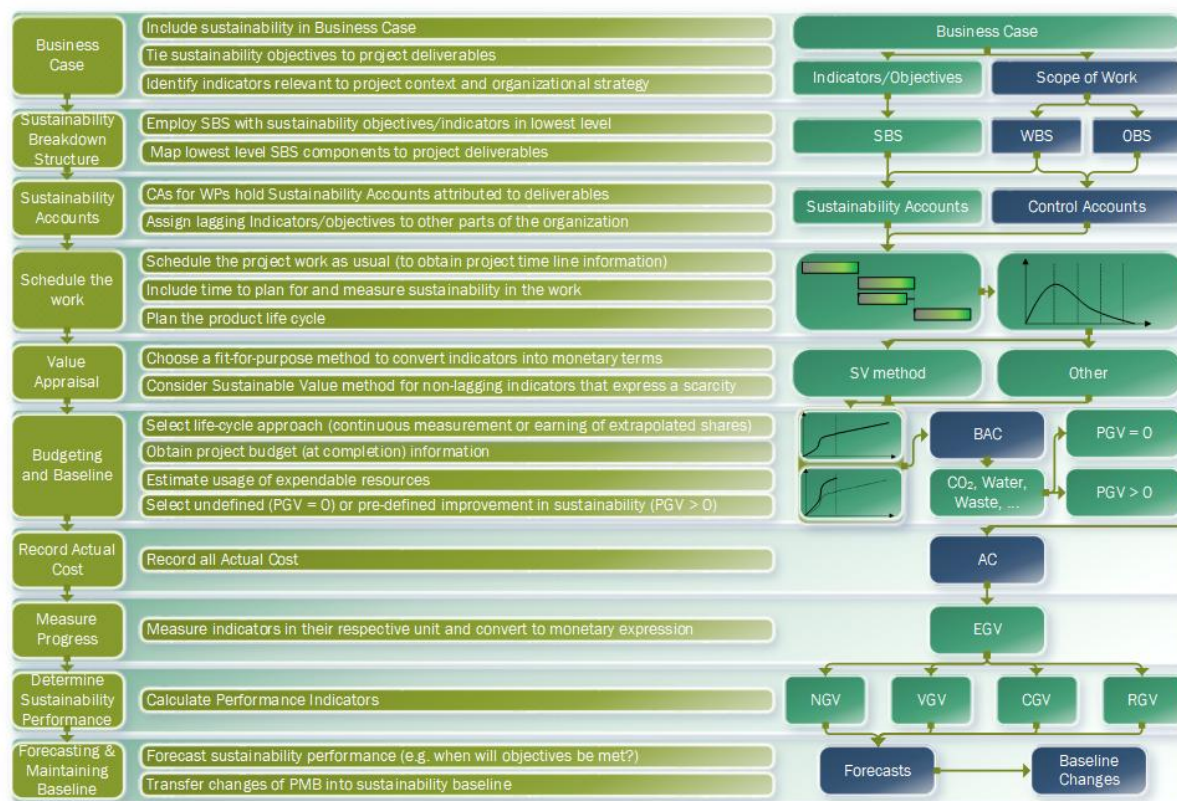


Fig. 8: EGVM conceptual framework.

6. Conclusion

Sustainability has become a trending topic in project management practice and research. The focus of past considerations of this subject has mostly been normative. Effective implementation of sustainability objectives in projects requires proper tracking and control effort as well. Project management literature already provides a sophisticated tool for multidimensional project controlling - Earned Value Management. As literature on operationalization of sustainability in projects is scarce, this paper aims to investigate existing conceptual and methodological overlap between the bodies of knowledge Earned Value Management and sustainability in project management. Using a systematic review methodology, a total number of 696 full-text references was examined to answer the research questions "Has EVM to date been used to measure Sustainability?" and "How has Sustainability in projects been measured to date?" respectively.

The results of the review showed that EVM has been used for carbon emission budgeting, but not for sustainability in a holistic way. By contrast, literature on sustainability in project management referred to EVM as a potential tool for sustainability performance measurement but without application. Subsequently, both bodies were merged into one comprehensive conceptual framework that integrates sustainability with EVM methodology to apply to sustainability, thus answering the research question.

The resulting framework **Earned Green Value Management** (EGVM) differs from the traditional methodology in some key characteristics. While most activities within project planning, i.e. using a WBS, OBS and control accounts, can be adapted to EGVM, relevant indicators need to be identified through a Sustainable Breakdown Structure. Additional time must be accounted for in project scheduling, in particular for increased measurement effort. Major differences in methodologies prevail in life-cycle and value considerations: first, to ensure effective benefits management, EGVM should be applied on portfolio instead of project level. Second, the project life-cycle must be extended past the project closure and consider the effects of the product life-cycle. Third, the methodology focuses on the triple bottom line of sustainability rather than the traditional iron triangle. Lastly, the perception of value creation shifts from a sunk cost perspective towards an opportunity cost based view, i.e. saved cost through increased efficiency of ecological and human capital resources. While this framework proposes a resource efficiency based approach relying on the Sustainable Value method, other monetization methods are possible as well.

In essence, EGVM is a first-of-its-kind tool that bridges the gap between sustainable project management and traditional project management practices. At the same time, EGVM does not replace, but **supplement** EVM. One major limitation of the framework is that it does not overcome a critical impediment to sustainability in general: to produce a marked effect, sustainability management requires thorough measurement of key indicators, which has often been stated to be one inhibitor to engaging in sustainability.

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