Strategic Guidelines for sustainable procurement of infrastructure capital projects in the oil and gas industry

Luciana Salvatore[1], Antônio Márcio Tavares Thomé[1[0000-0001-9751-905X]] and Adriana Leiras[1[0000-0002-6305-9662]]

[1] Pontifical Catholic University of Rio de Janeiro, Industrial Engineering Department
Rua Marquês de São Vicente, 225, Gávea
Rio de Janeiro, RJ - Brasil
CEP: 22451-900 - Cx. Postal: 38097
mt@puc-rio.br

Abstract. Sustainable development and carbon dioxide emissions have been debated in the oil and gas sector as a basis for developing plans to reduce the emission of this gas in its operations, influenced by the commitments made in the Paris Agreement by reducing the emission of greenhouse gases (GHG). Investment funds demand organisations act on this subject, urging companies to outline GHG emissions throughout their value chain. This work aims to contribute to including initiatives to decarbonise the construction phase of infrastructure capital projects using the procurement process. Through a systematic literature review (SLR) and a case study applied to a Brazilian oil and gas company, the documentation related to four contract opportunities for the construction of infrastructure and offsite areas was evaluated, applying criteria raised in the literature to identify initiatives that lead to the decarbonisation during the construction phase. The study comprised interviews with experienced professionals and direct observation of the procurement process preparation of two projects. Results showed initiatives as contractual requirements targeting energy efficiency, minimising costs, and maximising productivity associated with using GHG-emitting equipment. We deliver a strategic guide for incorporating environmental sustainability initiatives with a focus on reducing GHG emissions into the processes for procuring construction services and assembling logistics infrastructure and offsite projects.

Keywords: Sustainable procurement, Decarbonisation, Infrastructure projects

1 Introduction

The growing discussions on climate change and the commitments made by the signatory countries of the Paris Agreement to limit the increase in global temperature to 2 degrees Celsius by reducing greenhouse gas (GHG) emissions [42] led investors to direct their capital to portfolios based on sustainable projects that incorporate the Environmental, Social and Governance (ESG) aspects [18] [20]. As a result, the transition to low carbon dioxide emissions has been discussed by several companies

after that, in the services and manufacturing sectors, in particular by extractive industries (e.g., [30]). Following suit, the oil and gas (O&G) companies incorporated plans to reduce GHG emissions substantially [30].

The GHG Protocol [45] was adapted to calculate GHG emissions by companies operating in Brazil [16]. Companies in the O&G sector, including those exploring, refining and distributing petroleum products, are signatories of the GHG Protocol. The protocol segregates GHG emissions into three scopes: Scope 1 - GHG emissions generated within the company's facilities, Scope 2 - indirect GHG emissions occurring by purchasing electricity, and Scope 3 - indirect GHG emissions resulting from the activities in the supply chain [45]. Using the GHG Protocol to account for Scope 3 emissions in organisations' supply chains directly impacts the contracting of products and services, stimulating the implementation of a sustainable procurement process. In addition, the participation of the incumbent firms in sustainability initiatives generates learning processes in their supply chains that are prone to accelerate the pace of sustainability transitions [9] [39].

This paper aims to contribute to include initiatives to reduce Scope 3 GHG emissions in the processes of contracting construction and assembly services of logistics infrastructure sites of a major Brazilian O&G company. Within the infrastructure projects, the analysis focuses on the emissions generated by the machinery and transportation of materials. Other phases of the life cycle of the projects, such as the GHG emissions caused by the materials used in the implementation sites (e.g., steel, cement), are out of the scope of this paper.

Specifically, two research questions (RQ) are addressed:

RQ1: Are the GHG emission reduction initiatives included in the company's procurement process?

RQ2: How to refine and expand the inclusion of GHG emission reduction initiatives in the company's procurement process?

This paper contributes to the ongoing debate about sustainable procurement in large logistics infrastructure construction works and providing support to industrial areas (offsite activities) by looking at GHG emissions attributed to Scope 3 in the case company. In addition, it offers a Guideline encapsulating sustainable procurement strategies applied to six large projects and suggests its application in other projects. The case company recognised this contribution to the betterment of sustainable procurement in writing.

After this introduction, section 2 describes the theoretical background. Then, the research methods are presented in Section 3. Next, the results are summarised in Section 4. Finally, section 5 concludes the paper.

2 Theoretical background

Different terms are found in the literature related to environmental sustainability, among them initiatives, requirements, practices and actions [19] [33] [34]. This paper adopts the following definitions: (i) practices: conducts established and implemented by an organisation in a consolidated and systematic way, (ii) initiatives: still punctual

conducts in preliminary stages of maturity, (iii) criteria: reference items defined to identify sustainability initiatives focused on reducing GHG emissions in contractual documentation, (iv) requirements: service specifications established by the company researched in contractual documentation as mandatory for compliance by the contracted companies and (v) actions: the application of criteria and requirements to practices and initiatives during the process of sustainable procurement contracting during the construction phase of infrastructure projects. The construction phase "[starts] with construction/fabrication contracting and planning for site mobilisation, and continuing through to initial operations, final performance testing, and handover of the completed facility" [33, p.2].

The UK Sustainable Contracting Task Force suggests that sustainable contracting "should consider the environmental, social and economic consequences with respect to design, the use of non-renewable materials, manufacturing and production methods, logistics, delivery services, use or application, operation, maintenance, reuse, recycling options, the disposal and ability of suppliers to deal with these consequences throughout the supply chain" [11]. Alqadami et al. [5] see that sustainable hiring can be seen as a process that strives to achieve a higher environmental quality in addition to the normal hiring process, which at times already includes standard environmental requirements, such as environmental impact mitigation actions and compliance with standards applicable to the construction sites.

In reviewing the criteria for evaluating sustainable procurement in large infrastructure capital projects in the extant literature, two main research streams could be identified. On the one hand, there are prescriptive studies aiming at the use of the contracting process as a tool for change, with the inclusion of sustainability initiatives in the construction industry, ranging from the contractual strategy adopted to the actual content of contract requirements [1] [2] [3] [5] [6] [8] [11] [12] [14] [15] [17] [21] [22] [24] [26] [28] [29] [36] [37] [43] [44]. On the other hand, studies are focusing on the technical aspects of initiatives that can be incorporated into contracts for the reduction of GHG emissions during the construction phase [4] [10] [13] [22] [23] [25] [26] [27] [32] [33] [36] [37]. Among the authors in this second segment, there are a further subdivision of papers analysing environmental sustainability initiatives during the execution of works in a comprehensive manner [22] [36] and papers that discuss more specific initiatives during the implementation of projects [4] [10] [13] [23] [25] [26] [27] [33] [37].

Kenley et al. [27] and Sanchez et al. [37] emphasise the significant impacts of the road fleet on GHG emissions in the construction phase of a linear infrastructure project (such as in highways, bridges and pipelines). The impacts are associated with entering and exiting materials from the construction site [23] and moving land, rocks, stones or clay through fossil fuel-powered equipment. Therefore, optimising this fleet's use can bring economic gains and contribute to reducing GHG emissions [27]. However, as put forward in [27], infrastructure projects have unplanned elements concerning soil conditions, distances for the movement of loads (materials or land, for example) and their quantities, making it difficult to use typical GHG emission data during the execution of the works.

The CII published a Catalogue of 54 sustainability actions (in the environmental, economic and social dimensions) for the evaluation of schedules and costs during the planning phase of construction works and assembly of infrastructure projects [10], later summarised in [33]. The CII is a consortium of more than 140 public and private companies, including construction and engineering companies and their supply chain counterparts, based at the University of Texas at Austin. The Guide provides comprehensive and rigorous coverage of sustainable actions in construction projects serving as the basis for establishing procurement criteria for construction sites and assembly of infrastructure projects. However, as stressed in [22] [37], the actual implementation of the CII's sustainability actions remains dependent on measurement parameters of associated deliveries, which might not be feasible due to the uncertainty inherent to large infrastructure projects [23]. Furthermore, in the case of State and mixed-owned companies operating in Brazil, the companies should abide by law 13.303 [7], which specifies the contracting company's responsibilities in the different procurement process phases. The law equally details the offeror's obligations in the steps of project proposal submission and appeals.

The legal implications according to the type of procurement projects and the measurement of deliverables are paramount for selecting strategies and criteria for the strategic sustainable procurement guidelines discussed in Section 4.

3 Methods and materials

The study is a mixed-method research comprising a systematic literature review (SLR) and a thoughtful and rigorous case study application.

3.1 Systematic literature review

The SLR provided the theoretical foundation for the research and the elaboration of the Guidelines. A description of the first seven steps adopted from the SLR's eight steps proposed in [40] is provided next. Steps 1-3 refer to the planning of the SLR, selection of databases and search keywords, and data gathering. The Scopus and Web of Sciences databases were selected for the review because they are the most complete for engineering projects [31]. The following keywords (in pseudocode) were applied to titles, abstracts and keywords, with no time restrictions: (("sustainable procurement" AND "construction" AND "infrastructure") OR ("Sustainability" AND "procurement" AND "construction" AND "infrastructure")), resulting in 81 unduplicated documents. After completing the search with forward and backwards snowballing [40], nine additional papers were added. The technical reports of the following institutes (main sources for contractual guidelines in construction projects) were consulted: CII, the International Federation of Consulting Engineers (FIDIC), Independent Project Analysis (IPA), International Organization for Standardization (ISO), Project Management Institute (PMI), and the International Association for the Advancement of Cost Engineering (AACE). The consultation resulted in 3 additional reports. A concept matrix was formed with the articles listed in each line. For each article, the following exclusion criteria were applied (numbers in parenthesis are papers excluded in each

stage): (i) not sustainability-related (35); (ii) household buildings (8); (iii) applies after the completion of the project (2); (iv) sustainable materials only (1); (v) social sustainability only (7). Thirty-one papers, reports and guidelines were selected for final analysis.

Step 4 consists of quality checks: only peer-reviewed papers and indexed Conference proceedings were included. In Step 5, data were content-analysed and synthesised [38]. The consistency of the criteria for project evaluation with the research questions was applied to interpret the results (Step 6). This paper corresponds to Step 7, the presentation of results. Step 8 (update of previous literature reviews) is outside the scope of the paper and was excluded.

3.2 Case Study

The case study phases were planning, preparation for data collection, data collection, analysis of the collected data and presentation of the results [35]. The case and its units of analysis were defined during the planning phase. A single case study method was chosen to provide in-depth observation [46]. The company is the case unit, and the procurement processes within the company are the units of analysis. Four units of analysis (procurement processes) were selected for documental review and two for direct observation. Consistent with [5], the units of analysis were selected looking at the sustainability initiatives that could go beyond those already arising from legal requirements for waste management, effluent disposal and air quality. In addition, the measurement of emissions in contract deliveries was also scrutinised by [23].

A research protocol was elaborated during the preparation of data collection. Three data sources were triangulated to strengthen validity and reliability: (i) review of contractual documents of four major capital projects; (ii) semi-structured interviews with nine professionals of project management and procurement preparation with over 21 years of experience in the case company, lasting a total of over 3.5 hours; (iii) direct observation by the first author during 14 meetings for procurement preparation of two large capital projects in the initial stages.

Construct validity was reinforced by data triangulation and establishing chains of evidence during data collection [46]. External validity was ensured during the case study design and is restricted to similar projects of the same company. Reliability was strengthened by using a research protocol and constitution of a research database comprising the interviews' transcripts, the documents analysed for each project, and field notes from direct observation. Internal validity is beyond the scope of exploratory single-case research [46]. Data analysis was conducted by creating an extensive list of criteria for sustainable procurement during the construction phase of infrastructure projects, following literal replication [46] of findings derived from the SLR. The sustainability actions estimated by the company experts and the SLR as having a more significant impact on reducing GHG emissions were selected for inclusion in the Guideline. The experts from the case company validated the final strategies for implementation and monitoring, and the contribution was certified in writing.

4 Results and Discussion

4.1 Context: the case and the units of analysis

The Brazilian government controls 22.9% of the company stakes and 50% of the voting rights. The company reported an accumulated net income of over US$ 30 billion in the first three quarters of 2022. It operates 12 refineries, 48 terminals for storing and distributing oil and derivatives, and a park of 20 thermo-electric plants. Oil exploration and production are concentrated in ten basins, generating roughly 3 million barrels of oil equivalent per day on ten rigs. In the strategic plan for 2021-2025, the company subscribed to an ambitious 25% reduction of its total operational absolute GHG emissions by 2030. The 55 US$ billion 2021-2025 investment plan includes the areas of exploration and production, refining, natural gas and commercialisation, and logistics. The definition of the hiring process of supplying goods and services in these areas includes preparing documentation and monitoring compliance by Brazilian Federal Law 13.303 [7].

The four units of analysis selected for the documental review were in the opening bidding (OB) phase, with contracts still being awarded. They will be referred to as OB1-OB4. OB1 comprises expanding and improving an existing industrial area, requiring competencies in mechanical, civil, and electrical engineering (e.g., foundations, equipment bases, drainage systems). OB2 refers to the support of construction services, including earthmoving, civil construction, electromechanical assembly, and interconnections. OB3 has an assembly scope for an industrial unit, including adaptations of support areas. Finally, OB4 includes earthmoving services requiring the execution of accesses, paving and drainage systems.

The units of analysis selected for direct observation (DO) were two logistics infrastructure projects: (i) the construction and assembly of a land pipeline more than 300 km long, passing through free and urban land (DO1) and; (ii) the construction of an oil and fuel tank and storage facility in an existing operational area (DO2). The anonymity and confidentiality of the observation units are strictly ensured regarding data sources, analysis, and dissemination.

4.2 Sustainability actions for decarbonisation

Fourteen sustainability actions applicable to the contract phase of construction sites were preselected among the 54 actions extracted from the CII catalogue [33]. They are provided in the Appendix.

The documental analysis of the four contract opportunities available in the e-commerce database of the company resulted in 43 contractual requirements, observed in 29 from a universe of 152 documents, which met 12 of the 14 actions defined in the appendix, and which can be associated with GHG emission reduction initiatives during the execution of the construction and assembly works.

The concentration of the OBs in different sustainability actions varies according to the context of the construction work. OB1 (expanding and improving industrial areas) concentrates on sustainability actions associated with using machinery and equipment. OB2 (support to construction services) has a more complex scope and broader coverage

of different sustainability actions. However, OB3 (assembly for industrial areas and support services) also has a complex scope but concentrates on fewer actions impacting the use of machines and equipment. Finally, OB4 (linear earthmoving works) has a very specific scope, with a greater focus on requirements related to equipment and machines, concentrating on the first ten sustainability actions. It is inferred from the documentation reviewed that differences in the degree of inclusion of sustainability initiatives in the process of contracting construction and assembly services may be attributed to scope (which leads to the elaboration of specific requirements in the contracts), the different compositions of the teams and actors involved (which can be related to the number of documents issued for procurement process and thereby promote the detailing of sustainability initiatives) as well as the resources allocated to each project (which can inhibit or promote the discussion of new contractual requirements).

Overall, the four OBs emphasise economic reasons for contract requirements, such as higher efficiency in the use of equipment and machines, the minimisation of resources spent, and the maximisation of productivity, which can lead to the reduction of GHG emissions. However, there are indications from the analysis of the documents that the company still does not practice in its contracting processes what was raised in the scientific and grey literature as a sustainable contract with an explicit focus on reducing GHG emissions during the execution of construction services and assembly of infrastructure works. This interpretation can be based on the fact that there still needs to be incentives for the inclusion of these GHG emission reduction initiatives in the works or the existence of technical barriers to these practices.

Figure 1 shows the total number of times a sustainability action was associated with the four OBs.

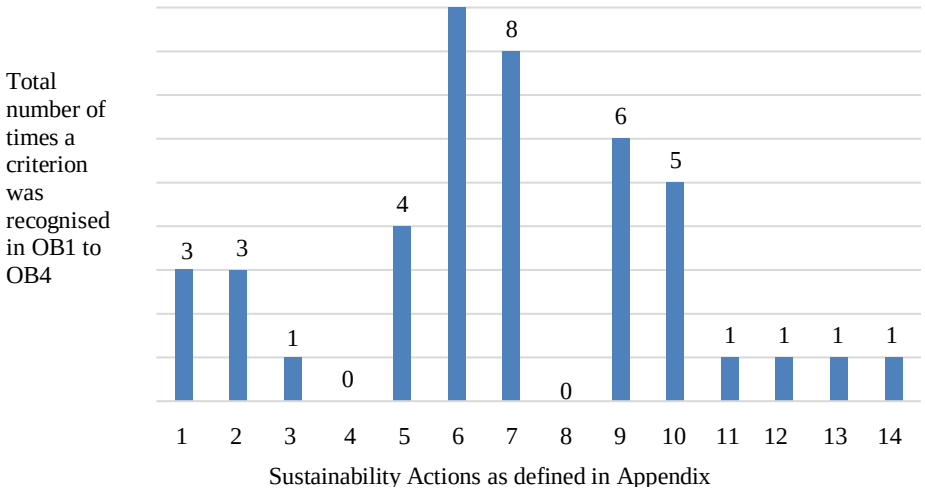

Fig. 1 Total number of times each sustainability action was recognised in the contractual documents analysed.

The ten first sustainable actions prevail except actions 4 and 8 (see Appendix). These actions are associated with fuel consumption for equipment and machines used in construction activities, as opposed to the four remaining actions, which refer to electricity consumption at construction sites. Actions 6, 7, 9, and 10 are prevalent in the four contract opportunities documentary analysis. They directly impact the time of use and the quality of equipment and machines, contributing to reducing GHG emissions at the construction site.

The prevalence of an economic view guiding the contractual requirements contrasts with the recognition by interviewees that the company can lead initiatives for sustainable transitions in the supply chain, reducing Scope 3 emissions. This is consistent with [9] [39]. As quoted during interviews: "If the company aims to become more sustainable and emit less carbon, it cannot turn a blind eye to the means of its suppliers. It [sustainability actions] has to enter the definitions and criteria." Another one quoted directly the leading role in the Supply Chain: "A company like the [company] that has a very high level of contracting of goods and services, it ends up being a benchmark that suppliers want to meet. They cannot do without providing goods and services to large companies. So, if large companies put these requirements in the contract, they will undoubtedly move to empower themselves to meet them. I think it is the best way to develop the entire company ecosystem."

The paucity of the inclusion of sustainability actions in the procurement of construction works is also clear during the direct observation of the units of analysis DO1 and DO2. Fewer sustainability actions were included (numbers 1, 2, 3 and 6). In both cases, the environmental agency requested environmental impact surveys independently of contractual clauses. DO1 resorted to a simplified certification by a third-party agency, as it is already in operation. DO2 had more time for planning, and the meetings attempted to address sustainability actions.

The triangulation of direct observation with the documentary review also confirmed the prevalent economic view of the company and that differences in the degree of inclusion of sustainability initiatives in the process of contracting construction and assembly services might be attributed to the scope, compositions of the teams, and the resources allocated.

4.3 Strategic guidelines for sustainable procurement

Consistent with [5] [23], the Guideline to strengthen and expand the inclusion of sustainability actions in the procurement process was built around two strategies referred to as GS1 and GS2. The guidelines are available in full at [47] and presented in Figures 2 and 3. GS1 reinforces existing initiatives based on elaborating contractual requirements more adherent to the criteria developed for the sustainable actions provided in the Appendix, going beyond the compliance already built in the contracts.

GS2 requests contractors to provide the inventory of GHG emissions, certified by an independent third party, for Scopes 1 and 2 of the construction works. These strategies are expected to encourage the inclusion of a greater number of sustainability initiatives in the contracting process and to encourage contractors to acquire more experience in sustainable actions.

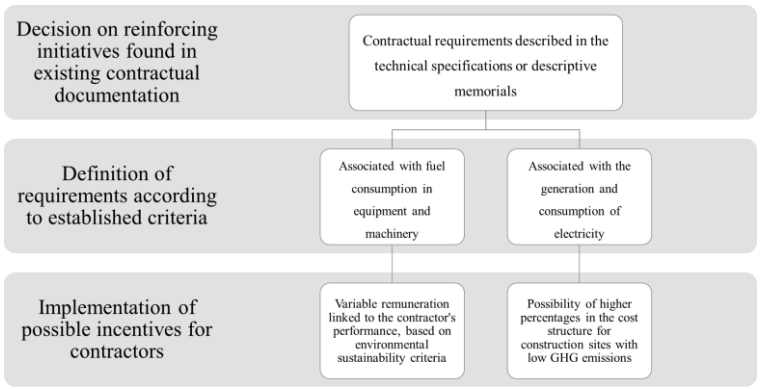

Fig. 2. GS1 - Guide for including initiatives to reduce GHG emissions in the contracting process

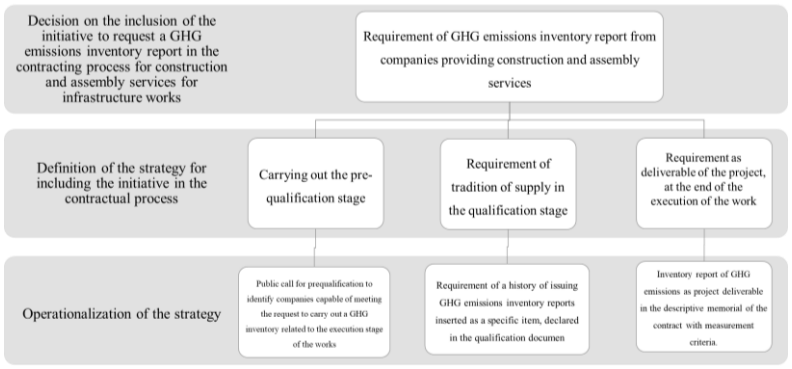

Fig. 3. GS2 - Guide for including the GHG emissions inventory in the contracting process for construction and assembly services

5 Conclusion

This paper discusses the current stage of inclusion of environmental sustainability initiatives, with a focus on reducing GHG emissions, in the process of contracting services and proposes strategic guidelines to strengthen and expand the role of a major O&G company operating in an emerging country to transition towards more sustainable procurement processes in the Supply Chain to reduce Scope 3 GHG emissions. Answering RQ1, there are economic-driven contractual clauses based on efficiency, minimisation of costs and maximisation of productivity that could result in environmental gains. Interviews with nine professionals experienced in the management and implementation of logistics infrastructure projects align with what is observed in the literature on the relevant role of contracting companies in boosting the movement to include initiatives that lead to the decarbonisation of the work environment. Direct observations corroborated with the orientation by the economic bias, also to guarantee the efficient use of resources and minimise costs. However, contracting is not sustainability-driven regarding GHG emissions. The strategic options

for adopting sustainable actions provide a road map for the expansion and refinement of sustainable procurement called for in RQ2. In this roadmap, the inclusion of environmental sustainability initiatives focused on reducing GHG emissions in the processes for contracting services of construction and assembly of logistics infrastructure projects and support for industrial areas was presented concerning: (i) the direct inclusion of requirements that express the actions discussed here as contractual requirements and (ii) the requirement of an inventory report of GHG emissions during services execution. This last request can be established directly as a deliverable at the end of the contract or by using the qualification or pre-qualification steps to promote a learning curve in the service provider market. However, results are limited by the single case method's capability of replication to other companies, calling for further research on the prominent role of major O&G companies in sustainable procurement and sustainability transitions.

References

1. Alqadami, A.; Zawawi, N. A.; Rahmawati, Y.; Alaloul, W. Challenges of implementing green procurement in public construction projects in Malaysia. In: IOP Conference Series: Materials Science and Engineering. IOP Publishing, 012047. (2020a).
2. Alqadami, A.; Zawawi, N. A. W.; Rahmawati, Y.; Alaloul, W; Alshalif, F. A. Key Success Factors of Implementing Green Procurement in Public Construction Projects in Malaysia. In: IOP Conference Series: Earth and Environmental Science. IOP Publishing, 012098. (2020b).
3. Alqadami, A.; Zawawi, N. A. W.; Rahmawati, Y.; Alaloul, W; Alshalif, F. A. Challenges of implementing green procurement in public construction projects in Malaysia. In: IOP Conference Series: Materials Science and Engineering. IOP Publishing, 012097. (2020c).
4. Anthonissen, J., Troyen, D. V., Braet, J., Bergh, W. V. Using carbon dioxide emissions as a criterion to award road construction projects: a pilot case in Flanders. Journal of Cleaner Production, 102, 96-102 (2015).
5. Arts, J.; Faith-Ell, C. New governance approaches for sustainable project delivery. Procedia-social and behavioral sciences, 48, 3239-3250. (2012).
6. Bohari, A. A. M.; Skitmore, M.; Xia, B.; Teo, M. Green oriented procurement for building projects: Preliminary findings from Malaysia. Journal of Cleaner production, 148, 690-700. (2017).
7. Brazil. Law No. 13,303 of June 30, 2016. Official Gazette of the Union, Brasília, DF, 1 Jul. 2016. Home Page <http://www.planalto.gov.br/ccivil_03/_ato2015- 2018/2016/lei/l13303.htm> last accessed 2021/01/14..
8. Brooks, A.; Rich, H. Sustainable construction and socio-technical transitions in London's mega-projects. The Geographical Journal, 182(4), 395-405. (2016).
9. Cormack, A., Thomé, A. M. T., & Silvestre, B. (2021). An integrative conceptual framework for supply chain sustainability learning: A process-based approach. Journal of Cleaner Production, 320, 128675.
10. CII. Construction Industry Institute. A Framework for Sustainability during Construction. The University of Texas at Austin. 2014.
11. DEFRA, Department for Environment, Food and Rural Affairs. Procuring the Future Sustainable Procurement National Action Plan: Recommendations from the Sustainable Procurement Task Force. Home Page

<https://www.gov.uk/government/publications/procuring-the-future>, last accessed 2021/01/18.

12. Ek, K.; Mathern, A.; Rempling, R.. Multi-criteria decision analysis methods to support sustainable infrastructure construction. In: Proceedings of IABSE Symposium 2019: Towards a Resilient Built Environment-Risk and Asset Management, March 27-29, 8. International Association for Bridge and Structural Engineering (IABSE). Guimarães. (2019).

13. FIDIC - International Federation of Consulting Engineers. Project sustainability management. Applications manual, 2nd edition, Genebra. (2013).

14. Flores, R. F., Montoliu, C. M-P; Bustamante, E. G. Life cycle engineering for roads (LCE4ROADS), the new sustainability certification system for roads from the LCE4ROADS FP7 project. Transportation Research Procedia, 14, 896-905. (2016).

15. Gao, G-X. Sustainable winner determination for public-private partnership infrastructure projects in multi-attribute reverse auctions. Sustainability, 10(11), 4129, 2018.

16. GHG Protocol. Home Page <https://ghgprotocolbrasil.com.br/membros?locale=pt-br> last accessed 2020/01/13.

17. Goel, A., Ganesh L.S., Kaur, A. Sustainability integration in the management of construction projects: A morphological analysis of over two decades' research literature. Journal of Cleaner Production, 236, 117676. (2019).

18. Goldman Sachs Research. Carbonomics: 10 Key Themes From the Inaugural Conference. Equity Research,2020. Home Page <https://www.goldmansachs.com/insights/pages/carbonomics-10-key- themes.html>, last accessed 2020/28/12.

19. GRI. Global Reporting Initiative. Consolidated set of GRI Sustainability Reporting Standards 2020. Home Page <https://www.globalreporting.org/how-to-use-the- gri-standards/gri-standards-english-language/>, last accessed 2021/01/14.

20. GSIA Global Sustainable Investment Alliance. Global Sustainable Investment Review, 2018. Home Page <Trends Report 2018 | GSIA (gsi-alliance.org)>, last accessed 2020/12/28.

21. Hartshorn, J.; Crooks, J.; Stahl, R.; Bond, Z. Creative destruction: building toward sustainability. Canadian Journal of Civil Engineering, 32(1), 170-180. (2005).

22. Hueskes, M., Verhoest, K., Block, T. Governing public–private partnerships for sustainability: An analysis of procurement and governance practices of PPP infrastructure projects. International Journal of Project Management, 35. 1184– 1195. (2017).

23. Hughes, L.; Phear, A.; Nicholson, D.; Pantelidou, H.; Soga, K.; Guthrie, P.; Kidd, A.; Fraser, N. Carbon dioxide from earthworks: a bottom-up approach. In: Proceedings of the Institution of Civil Engineers-Civil Engineering. Thomas Telford Ltd, London, 66-72. (2011).

24. Ibrahim, M. N.; Thorpe, D.; Mahmood, M. N. Risk factors affecting the ability for earned value management to accurately assess the performance of infrastructure projects in Australia. Construction Innovation, 19(4), 550-569. (2019).

25. ISO. International Organization For Standardization. ISO 15393:2019: Sustainability in buildings and civil engineering works — General principles. Genebra. (2019).

26. Karlsson, I., Rootzén, J., Johnsson, F. Reaching net-zero carbon emissions in construction supply chains – Analysis of a Swedish road construction project. Renewable and Sustainable Energy Reviews, 120, 109651. (2020).

27. Kenley, R.; Harfield, T. Greening procurement: a research agenda for optimizing mass-haul during linear infrastructure construction. In: Proceedings of the 6th International Conference on Construction in the 21st Century: Construction Challenges in the New Decade. Kuala Lumpur, Malaysia: East Carolina University, Greenville, North Carolina, USA. (2011).

28. Lenferink, S.; Tillema, T.; Arts, J. Towards sustainable infrastructure development through integrated contracts: Experiences with inclusiveness in Dutch infrastructure projects. International journal of project management, 31(4), 615- 627. (2013).
29. Li, M., Wiedmann, T., Hadjikakou, M. Enabling Full Supply Chain Corporate Responsibility: Scope 3 Emissions Targets for Ambitious Climate Change Mitigation. Environmental Science & Technology, 54, 400−411. (2020).
30. Lu, H., Guo, L., Zhang, Y. Oil and gas companies' low-carbon emission transition to integrated energy companies. Science of the Total Environment, 686, 1202– 1209. (2019).
31. Mongeon, P.; Paul-Hus, A. The journal coverage of Web of Science and Scopus: a comparative analysis. Scientometrics, 106(1),213-228. (2016).
32. Moretti, L.; Di Mascio, P.; D'andrea, A. Environmental impact assessment of road asphalt pavements. Modern Applied Science, 7(11), 1-11. (2013).
33. O'connor, J. T.; Torres., N.; Woo., J. Sustainability Actions during the Construction Phase. Journal of Construction Engineering & Management, 142(7), 04016016. (2016).
34. Pope, J., Annandale, D., Morrison-Saunders, A. Conceptualising sustainability assessment. Environmental Impact Assessment Review, 24, 595–616. (2004).
35. Runeson, P.; Höst, M. Guidelines for conducting and reporting case study research in software engineering. Empirical software engineering, 14(2), 131-164. (2009).
36. Ruparathna, R.; Hewage, K. Sustainable procurement in the Canadian construction industry: current practices, drivers and opportunities. Journal of Cleaner Production, 109, 305-314. (2015).
37. Sanchez, A. X.; Lehtiranta, L.; Hampson, K. D.; Kenley, R. Evaluation framework for green procurement in road construction. Smart and Sustainable Built Environment, 3(2),153-169. (2014).
38. Seuring, S.; Gold, S. Conducting content-analysis based literature reviews in supply chain management. Supply Chain Management, 17, 544-555. (2012).
39. Silvestre, B.S.; Silva, M.E.; Cormack, A.; Thome, A.M.T. "Supply chain sustainability trajectories: learning through sustainability initiatives", International Journal of Operations & Production Management 40(9), 1301-1337. (2020).
40. Thomé, A. M. T.; Scavarda, L. F.; Scavarda, A. J. Conducting systematic literature review in operations management. Production Planning & Control, 27(5), 408- 420 (2016).
41. UNEP. United Nations Environment Programme. Emissions Gap Report 2019. Home Page <https://www.unenvironment.org/resources/emissions-gap-report- 2019>. last accessed 2021/01/14.
42. UNFCC. United Nations for Climate Change. Paris Agreement, 2015. Home Page https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris- agreement/key-aspects-of-the-paris-agreement, last accessed 2021/12/28.
43. Willar, D.; Waney, E. V. Y.; Pangemanan, D. D. G.; Mait, R. E. G. Sustainable construction practices in the execution of infrastructure projects. Smart and Sustainable Built Environment10(1), 106-124. (2020).
44. Wondimu, P. A.; Hosseini, A.; Lohne, J.; Hailemichael, E.; Laedre, O. Early contractor involvement in public infrastructure projects. In: Proc. 24th Ann. Conf. of the Int'l. Group for Lean Construction, Boston, MA, USA, p. 13-22. (2016).
45. WRI, WBCSD. World Resources Institute And World Business Council For Sustainable Development. A Corporate Accounting and Reporting Standard. 2004. Home page <https://ghgprotocol.org/corporate-standard>, last accessed 2021/01/13.
46. Yin, R, K. Case Study - Planning and Methods. 5to ed. Porto Alegre: Bookman, (2015).
47. Salvatore, L. ; Leiras, A.; Thomé, A. M. T. Decarbonizing the supply chain in the oil and gas sector in infrastructure projects. Rio de Janeiro, 2021, 116p. Home page:

https://www.maxwell.vrac.puc-rio.br/colecao.php?strSecao=resultado&nrSeq=52304@1, last accessed 2023/03/29.

Appendix – Sustainable Actions for Project Construction Sites in infrastructure construction projects in the O&E sector (adapted from CII, 2014 and O'Connor et al., 2016)

1. Planning the use of the road fleet
2. Pre-assembly and prefabrication of items
3. Planning of land movement
4. Location of facilities for the use of construction workers
5. Management of the flow of materials
6. Selection and replacement of equipment and machines
7. Dimensioning of equipment and machines
8. Use of total capacity of equipment and machinery and support vehicles
9. Reduction of downtimes of equipment and machinery
10. Planning of inspection and maintenance of equipment and machinery
11. Own generation of energy for the facilities to support the area of construction
12. Definition of energy source for the area of execution of the activities
13. Management of the energy systems in the support facilities
14. Planning of construction activities to reduce energy consumption