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LAST PLANNER SYSTEM IN THE OWNER'S PERSPECTIVE: CASE STUDY IN ONSHORE WIND ENERGY PROJECTS

Marcus C.T. Fireman[1], Lucas B. Bizarro[2], Bruno G. Antonini[3], Giuliano Silva de Campos[4], Celso Denardi Junior[5] and Bernardo M.B.S. Etges[6]

ABSTRACT

The race to reduce countries' carbon footprints has increased pressure to shorten the timelines of projects related to the construction of renewable energy parks. Projects of this scale require greater involvement between the representatives of the owner, who act in project management, and companies contracted to perform different scopes of the project. This study presents, through two case studies, the adoption of a model based on the Last Planner System from the perspective of the owner in onshore wind energy projects. It discusses current challenges within the management model of these projects and addresses tools and routines to be considered by companies participating in onshore wind energy construction. Among the main contributions of the research is the highlighted importance of the owner in the dissemination of lean within contracted companies, as well as the role of rituals such as control tower meetings and lookahead planning in improving communication and collaboration between sectors.

KEYWORDS

Lean construction, Last Planner System, owner, onshore wind energy project, collaboration.

INTRODUCTION

Energy supply has always been considered a critical aspect of modern life, playing a central role in the economic landscape of most countries and serving as the primary input to enhance social well-being and global development (Lima et al., 2013). In recent decades, concerned with total Greenhouse Gas emissions, an international alliance of countries has treated the global decarbonization process as a key element in addressing climate change (Souza, 2017). This initiative has led to an increasingly growing expansion in the search for renewable energy use (Irena, 2019).

1 Founding Partner at Climb Consulting Group, PhD Candidate, M.Sc. Eng. Federal University of Rio Grande do Sul, Porto Alegre, Brazil, marcus@climbgroup.com.br, orcid.org/0000-0001-5843-4715

2 Lean Consultant at Climb Consulting Group, Graduate in Production Eng. At Pucrs, Porto Alegre, Brazil. lucas@climbgroup.com.br, orcid.org/0000-0002-0341-0879

3 M.Sc.Eng., Lean Consultant at Climbg Consulting Group, Graduate in Civil Eng. At Pucrs, Porto Alegre, Brazil, bruno@climbgroup.com.br, orcid.org/0000-0003-4437-4664

4 Planning Engineer at Engie Brazil, Graduate at Civil Engineer at Pucrs, Porto Alegre, Brazil, giuliano.campos@engie.com, orcid.org/

5 Planning Coordinator at Engie Brazil, Graduate at Electrical Engineer at Federal University of Parana, Porto Alegre, Brazil, celso.denardi@engie.com, orcid.org/

6 Founding Partner at Climb Consulting Group, PhD Candidate, M.Sc. Eng. Federal University of Rio Grande do Sul, Porto Alegre, Brazil, bernardo@climbgroup.com.br, orcid.org/ 0000-0002-3037- 5597

Regarded as clean energy in terms of its final product, wind energy has seen strong growth in Brazil in recent years. According to the Brazilian Wind Energy Association (ABEE), the first wind parks were installed in Brazilian territory in 2011, and last year, the country reached a milestone of 890 wind parks with about 25 GW of installed capacity, all produced in the onshore model. However, the current scenario presents more challenging aspects regarding the construction of new parks: (i) increased competitiveness, the global race for renewable energies has created challenges for the supply chain; (ii) tighter deadlines; (iii) parks in more inhospitable locations with significant infrastructure challenges; and (iv) complexity in the production and assembly of wind turbines, which are larger and with a generation capacity well above the initial models.

Aiming to improve their efficiency and competitiveness, companies involved in the construction of new wind parks have sought the adoption of planning methods that bring better reliability to the management of deadlines and costs (Lima et al, 2023). This movement is also identified outside Brazil, where a series of research demonstrates the advances in the adoption of methods such as the Last Planner System and Takt planning in offshore wind energy projects (Lerche et al., 2019; Lerche, 2020; Lerche et al., 2020; Lerche et al., 2022; Tommelein & Lerche, 2023). The Last Planner system (LPS) is a construction planning and control methodology that emphasizes collaboration and team commitment to improve project schedule reliability. It aims to enhance predictability and reduce waste by involving multidisciplinary teams in defining realistic work plans and proactively identifying constraints. However, it is possible to identify as a limitation of these studies the fact that the adoption of these methods from the Owner's perspective is scarcely discussed.

The construction of onshore wind parks holds great complexity and interface between different work scopes, including from obtaining licenses to the creation of road access, civil construction of tower bases and the substation, foundations, assembly of electrical transmission cables, and the assembly of wind towers and rotors (Gouveia, 2013). Normally, each work scope is the responsibility of different companies, according to competencies and expertise, which are contracted in the Engineering, Procurement and Construction (EPC) format. On a regular basis, the owner in these types of capital projects presents an in-house team responsible for contractual management, managing the owner's constraints, and supervision of issues related to service quality, occupational health and safety, and environmental aspects.

In the IGLC database, it is possible to notice the existence of articles that addressed the involvement of the owner in lean initiatives (Drysdale 2013; Knapp et al., 2014; Wirahadikusumah; Sulistyaningsih, 2013; Mota et al., 2019; Christensen et al. 2023). Knapp et al. (2014) highlighted that the owner plays a crucial role in facilitating the decision-making process in IPD projects. Toledo et al. (2014) presents a proposal for Bim-Lean implementation to improve the quality of information for project progress control and constraint management of the owner. Drysdale (2013) described the British highway agency's strategy for deploying lean improvement across the supply chain. Recently, Schöttle; Bocker (2023) proposes new integrations to the Last Planner System to increase common understanding of the project scope and goals within the owner, project teams, and stakeholders as the basis for reliable megaprojects delivery. However, there is still a gap regarding how to structure an owner planning model based on the Last Planner.

This paper presents a case study of lean construction implementation in major wind power projects in Brazil. The authors present the benefits, limitations, and opportunities identified from the development of lean construction in this case study. As the main contribution of this paper, it presents an adaptation of the Last Planner model from the owner's perspective.

METHOD

This research adopts a design science research methodology, and the artifact created is a planning method based on the Last Planner system, incorporating the perspective of the owner in a wind power project. The study was structured around three main phases: (i) diagnosis; (ii) development; (iii) evaluation. The diagnosis and development phases were conducted through two case studies within an onshore wind power project developed by Company X. The first three authors participated as consultants responsible for implementing lean concepts, and the last authors represented the company's planning sector.

Company X is an energy management firm which is responsible for managing land issues such as leasing and purchasing areas for the park's execution, monitoring environmental issues regarding fauna and flora, the approval and compatibility of engineering designs, and, finally, monitoring the execution of production through planning in collaboration with the quality and occupational safety sector, according to the norms established in contracts with contractors.

The diagnosis phase occurred in the first case study, located in the northeast region of Brazil, comprising 70 wind turbines. This phase began in September 2022 and concluded in November 2022. During this period, the authors conducted a Swimlane workshop, analyzed planning documents, performed direct observations of management routines, and interviewed representatives from Company X and its stakeholders. The purpose of the diagnosis phase was to understand the planning model utilized by Company X and identify the primary gaps.

The development phase spanned from March to December 2023 in the second case study, also situated in the northeast of Brazil and involving 188 wind turbines. For the construction of the Wind Complex, Company X hired four companies to execute the main work scopes. Contractor C was responsible for Civil and Earthmoving scopes; Contractor S handled the construction of the Power Substation and Medium Voltage Networks; Contractor O was in charge of the Transmission Lines; and Contractor V supplied and assembled the wind turbines. Figure 1 illustrates the organizational chart showing the principal responsibilities of each company.

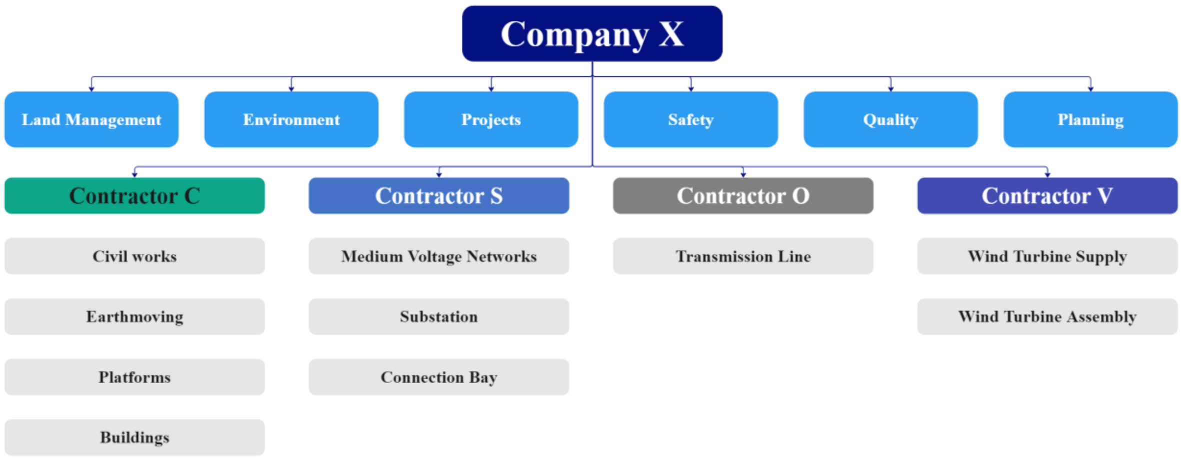

Figure 1: Organizational chart of Company X and the service scope of each company.

RESULTS

The findings are structured around the research's three phases: Diagnosis, Development, and Evaluation.

DIAGNOSIS – CASE STUDY 1

The project initiated with an in-depth diagnostic analysis of the company's current operational landscape, with the application of interviews with key department heads to identify critical issues and areas for potential enhancement. This process enabled the construction of a comprehensive swimlane diagram, delineating processes and responsibilities across various departments, including Business Development, Environmental, Land Management, Engineering, Planning, and Production, and proposed targeted improvements for each activity area. Figure 2 showcases the detailed swimlane diagram, illustrating the collaborative workflow and inter-departmental responsibilities.

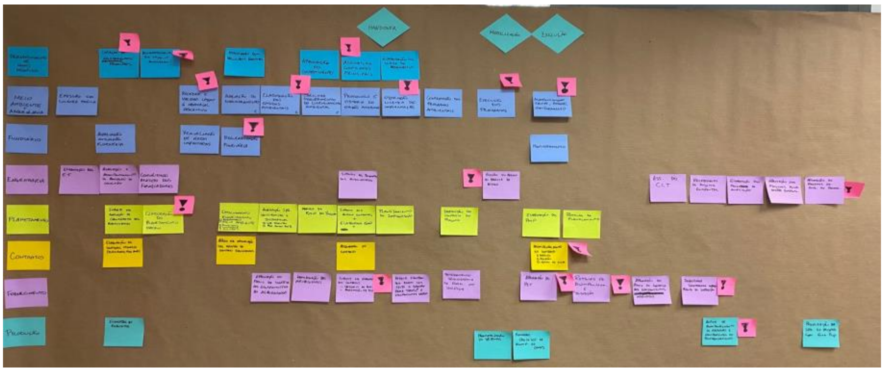

Figure 2: Project Development Flow

The consolidation of identified challenges revealed 63 areas for potential improvement, categorized by project phases. The Execution phase emerged as the most problematic, accounting for approximately 44% of the issues, followed by the Project Development phase at 35%, and the Commissioning phase at 21%.

The analysis of the execution phase pinpointed key concerns among the teams, predominantly centered around: (i) communication breakdowns with contractors; (ii) mismatches between weekly schedules and monthly replanning in the contractors' field planning; (iii) discrepancies between the agreed-upon timelines and contractors' actual scheduling efforts.

The planning department routinely faced the challenge of synthesizing progress updates from various contractors into coherent trend analysis reports. This task was complicated by the necessity to handle data from disparate sources, including MS Project, Excel, and WhatsApp, into a unified system, leading to inefficiencies and redundancies. Updated reports were then generated for executive management, providing insights into contractor performance. In instances of schedule delays, contractors were requested to submit action plans for review and incorporation into the project's master schedule, utilizing the critical path method for strategic adjustments.

Direct observation of management practices highlighted two main meetings: (i) the weekly contract meeting, focusing on contractual and procedural discussions with contractors and Company X's departmental representatives (safety, planning, environment, quality, production); and (ii) the monthly coordination meeting, serving a similar purpose but extending participation to contractors' directors and the client's executive team. These sessions, conducted separately with each contractor, were crucial for Company X to manage the interface between contractors' project scopes. Meeting minutes were meticulously prepared, encapsulating discussions and action items with each contractor.

A meticulous review of these meeting minutes revealed a dual categorization of discussion topics: operational constraints and contractual procedure adjustments. Analysis of resolution timelines for identified constraints showed a significant variance, ranging from 1 to 6.5 weeks across different areas, with outliers extending up to 18 weeks. Although data did not conclusively indicate the timeliness of constraint resolution, feedback from meeting participants suggested a reactive, firefighting approach to addressing issues, often aiming for resolution within the week.

DEVELOPMENT - CASE STUDY 2

The initial diagnostic phase provided insights into the operational dynamics of the company and identified key focus areas for development in the second case study. The development phase started with the creation of phase scheduling workshop to strategically visualize project phases and map out potential interferences and constraints with a broader anticipation horizon (12 to 21 weeks). For a more intuitive grasp of potential service scope interferences throughout the sub-parks, the Time-Location technique was employed.

The Time-Location tool, a form of location-based scheduling, utilizes the x-axis for production lots (park paths) and the y-axis for project time. This tool was instrumental in visualizing execution interferences in the field for Civil and Medium Voltage Networks activities, particularly due to the high number of rock detonations required throughout the project, which could impact nearby service executions within a 500 meters radius due to the need for temporary halts. Figure 3 illustrates the Time-location developed collaboratively with planning and production departments of the contracted companies and Company X.

Figure 3: Time-location for contractor C and S scopes.

After completing the time location chart, it was possible to pinpoint areas and times where interferences or a high volume of simultaneous services occurred. Table 1 lists the main points of concern identified in the planning.

Table 1- Time-location attention points

Id	Attention Points
1	Possible detonations for pole excavation concurrent with Base execution
2	Possible detonations for pole excavation concurrent with Platform Base execution
3	Possible detonations for pole excavation concurrent with Access Earthmoving
4	Possible detonations for pole excavation concurrent with Access Earthmoving
5	Services of RMT Suppression concurrent with Access Earthmoving

Only Contractor C was aligned with Lean culture, having embarked on their Lean journey in 2020 and adopting planning rituals based on the Last Planner system. Rounds of training and education on Lean Construction, Last Planner System, Takt Planning, and waste were conducted for both Company X employees and the other Contractors. Beyond theoretical discussions, the game Takt Planning - Wind Turbines was applied to practically implement Takt planning and develop the Time-location for a mini-park of 10 wind turbines. This activity involved 11 employees, 3 from Contractor C, 5 from Contractor S, and 3 from Contractor O (Figure 4).

Figure 4: Practical Application of Takt Planning and Time-location Concepts.

To enhance internal communication within Company X and establish a specific forum for discussing schedules and constraints, a Lookahead planning routine was implemented with a 6-week planning horizon and bi-weekly control meetings. These meetings involved planning departments of each Contractor and Company X, where Contractors were responsible for presenting their 6-week activity schedules and reporting constraints related to their scopes and those of Company X.

The constrains related to Company X were mainly due to land issues, such as land release that could impact the planned execution site or land embargoes; environmental issues, including wildlife, flora, and archaeological sites; factory inspections regarding the quality of products supplied by contractors, among other project management constrains. Additionally, constrains on the mobilization of labor and machinery by contractors were important for Company X to anticipate the necessary workforce for the swifter release of documentation. Furthermore, given the complexity of constructing a wind park, constrains related to the wind window for tower and wind turbine assembly were significant concerns, alongside the requisite training for workforce qualification in working at heights. Logistic constraints were also critical factors due to the large volume and magnitude of equipment involved.

The planning department of Company X critically evaluated the plans against the time-location, contractual items, and procedures. After these lookahead meetings, an internal session was held with the Safety, Environment, Quality, Land Management, and Production departments to review the contractors' proposed plans and identify potential sector-specific constraints (Figure 5).

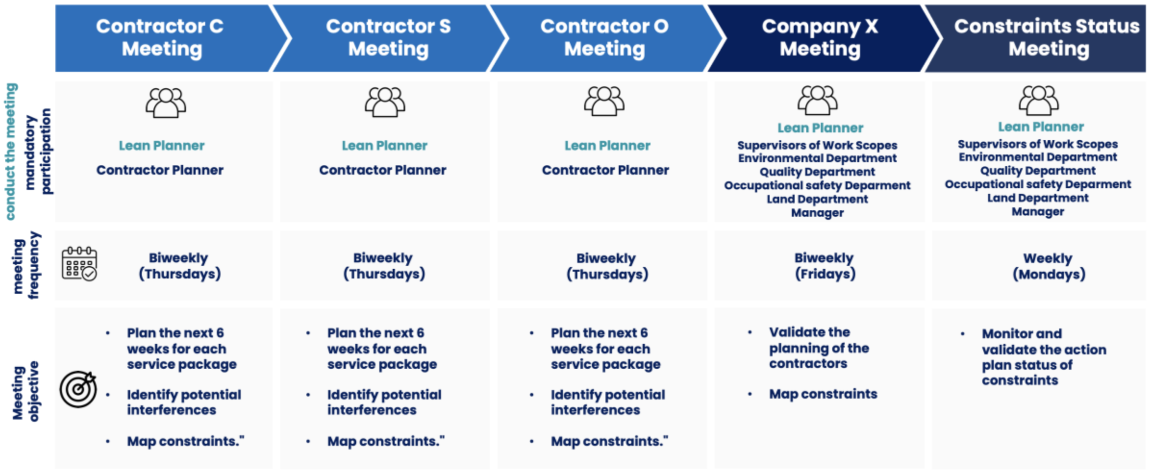

Figure 5 – Medium-term rituals workflow.

Lookahead planning meetings utilized visual management boards (Figure 6), where each contractor had a designated space for their 6-week plan. Activities were represented with post-its, and those with constraints were marked with a coded sticker indicating a constraint needing resolution. Action plans for removing identified constraints were highlighted on visual boards, specifying responsible individuals and deadlines for each Contractor. This approach emphasized constraint management, improving visibility and transparency of potential project impacts compared to the text-heavy minutes of weekly meetings.

Figure 6- Lookahead Management Panels (left) and Constraint Removal Plan (right)

The final element of the lookahead meeting was the constraint removal status routine, conducted alongside the Control Tower routine. The Control Tower was a weekly ritual involving representatives from the internal areas of Safety, Environment, Land Management, Quality, Planning, and Production, where each presented predefined indicators to the project manager and colleagues. This routine was crucial for aligning all company sectors, facilitating discussion, and presenting key elements for the project manager's decision-making. Furthermore, the weekly Control Tower meetings allowed for periodic monitoring of each department's indicators, fostering discussion and action plan formulation to achieve targets (Figure 9).

Figure 9: Control tower panels

EVALUATION

The initiative by Company X, the project owner, to implement the Lookahead planning routine along with its contractors led to the internal adoption of this practice by contractors S and O. For Company O, the adoption was voluntary, as the company's senior management and planning departments saw value in the ritual. However, Company S faced initial challenges in adopting the routine, largely because its leadership did not fully support the initiative, viewing it as beyond their contractual obligations, which affected the quality of the lookahead plans due to a lack of engagement and cooperation from support departments in creating more feasible plans.

To assess the maturity gained by the companies, analyses of key medium-term planning indicators were conducted: (i) Percentage of Constraint Removal (PCR) – evaluating the number of constraints removed on time against the total number of constraints for the period under review; (ii) Bi-weekly Adherence – assessing the number of completed packages compared to the planned work packages within a fortnight.

Figure 8 demonstrates the maturity level achieved by each contractor throughout the project, evidencing the effectiveness of the Lookahead routine in early constraint identification. The analysis covers two periods: the first from 03/07/23 to 14/08/23, and the second from 21/08/23 to 02/10/23, calculating the average Percentage of Constraint Removal (PCR) for each contractor across these periods.

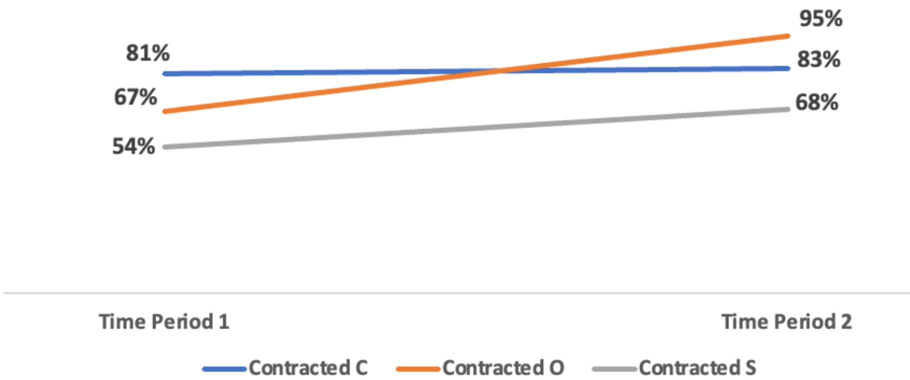

Figure 10- Evolution of Contractors' PCR Indicators

From Figure 8, it is clear that all three contractors improved in identifying and removing constraints on time. Contractor C's consistent performance was expected due to its internal adoption of the routine, leading to greater experience and maturity with the process over the project. Contractor O showed significant improvement, starting with an initial average of 67% and reaching 95% PCR in the last period analyzed. Contractor S also improved its Percentage of Constraint Removal, although it remained lower than the other contractors.

The Bi-weekly Adherence indicator for the defined medium-term plan packages showed a stable adherence rate across the project (Figure 11). Consolidating the packages from all three contractors yielded an average overall adherence of 78% for Contractor C, 77% for Contractor O, and 70% for Contractor S. A specific dip was noted in week 32, impacted by local holidays not initially accounted for, indicating a potential planning oversight for that week.

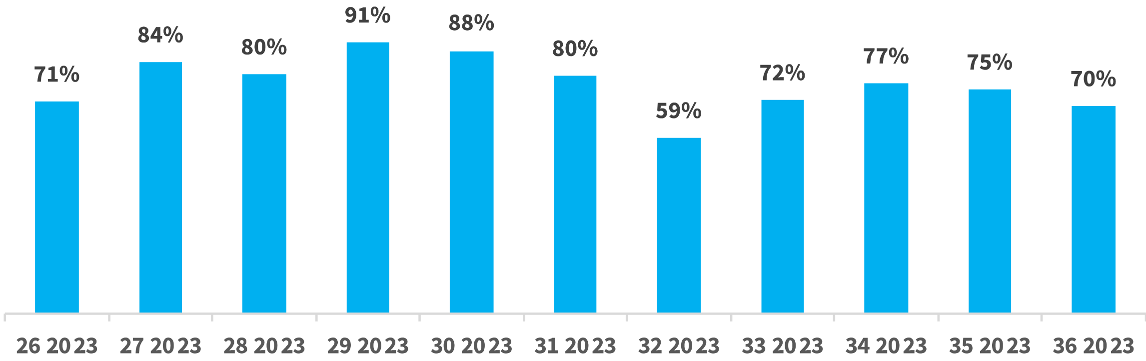

Figure 11- General Adherence Indicator

At the end of the project, in order to better understand and comprehend potential gains in the perception of those involved from Company X, a survey was developed and shared with the planning coordinator, who also was the main sponsor of the lean implementation journey. The questionnaire was designed with 6 open-ended questions, which can be viewed in Table 2.

Table 2- Post-implementation Lean Perception Questionnaire

Questions	Answers
How would you describe the effectiveness of communication between the contracted companies and the Company X team prior to the implementation of the Last Planner System?"	The communication was based on weekly meetings and highly reactive, focusing on project issues.
In your opinion, how has the Last Planner System improved planning transparency between the contracted companies and the Company X team? If so, provide examples if possible.	The LPS aided in the forward-looking view of activities, focusing on resolving problems and constraints before they impacted operations. An example is the approval of health and safety procedures and documentation prior to commencing activities.
Did the Last Planner System help identify and solve conflicts or obstacles more efficiently and with greater predictability during project execution? If so, provide an example if possible.	Yes, one example was with the contractor S, where we conducted a workshop and task force to identify issues and deviations from the planning in the final phase of the project, aiming to not impact commissioning activities.
In your experience, did the Last Planner System facilitate adaptation to unforeseen changes during project execution? If so, how?	Yes, the LPS proved to be a very useful tool for analysing scenarios and providing responses to changes and unforeseen events in the project.
What were the main perceived benefits of implementing the Last Planner System in the construction of the wind farm?	Increased predictability, greater integration between project areas, and improved communication with contractors were the main perceived benefits.
Did you notice an improvement in communication and transparency of relevant information among Engie's internal sectors for the project after the implementation of Lean? If so, provide examples if possible.	Yes, and the involvement of all areas in the lookahaed meetings greatly assisted in communication and understanding of constraints and critical points between the areas.

CONCLUSION

This study aimed to explore a planning and management model based on the Last Planner System from the owner's perspective in onshore wind energy projects through two case studies. The first case study shed light on the current challenges faced by the owner in managing onshore wind projects. One challenge stem from the traditional management and contract model, where the owner relies on an internal team for contractual management and coordination of interfaces between contractors, giving contractors full autonomy for planning and executing the project. This model has been questioned in literature and industry for not fostering collaboration among contractors, often prioritizing local optimization over global efficiency. Another challenge is the low maturity of contractors in adopting efficient planning practices based on Lean, such as the Last Planner System, and the third challenge relates to internal communication failures within the owner's team, with departments sometimes operating independently without aligning with project priorities.

The second case study showcased the adaptation of the Last Planner System from the project owner's viewpoint, implementing elements like Phase scheduling and Lookahead planning meetings. While phase scheduling aimed to identify hand-offs and potential risks to meeting deadlines using the time-location tool, the Lookahead meetings established structured sessions with contractors to proactively address constraints, whether from the contractors or the owner (Company X). This model created separate focal points for discussing each contractor's 6-week plan, followed by an internal alignment meeting to identify constraints, avoiding lengthy meetings and maintaining the quality of discussions despite varying Lean maturity levels among contractors.

A key outcome of the second case study was the enhanced Lean maturity among contractors, supported by internal training cycles and the structured Lookahead planning rituals implemented by the owner, which were disseminated among the contractors, improving their planning processes and proactive constraint management. This maturation was evidenced by indicators such as the Percentage of Constraint Removal and Bi-weekly Adherence of planned packages.

Another outcome was the implementation of the Control Tower ritual, aimed at fostering collaboration across departments, indicator-based management, and monitoring the status of departmental constraints. This ritual successfully integrated various aspects (land management, environment, safety, projects, quality) into production control.

Future research suggestions include exploring the adoption of BIM and 4D planning in onshore wind energy projects as mechanisms for identifying spatial constraints and conflicts. Another potential research area is the relationship between the implementation of integrated project delivery in onshore wind energy projects and the increased maturity in adopting Lean practices among contractors and the owner.

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