Pathways to Fossil-Fuel-Free Construction: Equipment, Awareness, and Barriers

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Fossil-fuel-free Construction

The construction sector is under increasing pressure to reduce carbon emissions across the full project lifecycle. While much attention has focused on embodied carbon in construction materials and operational emissions from completed buildings, emissions generated during the construction process itself also require urgent attention (Lendlease & The University of Queensland, 2022). Construction sites continue to rely heavily on diesel, petrol and LPG to power plant, machinery, generators, temporary site facilities and internal transport. These fuel sources contribute directly to greenhouse gas emissions, local air pollution, noise, fuel spill risks, and broader dependence on fossil fuel supply chains.

Fossil-fuel-free construction provides a practical pathway for reducing direct emissions from construction-site activities. A fossil-fuel-free construction site is one that avoids the use of fossil fuels for on-site construction activities, including tools, plant, temporary accommodation, and internal site transport. (New Zealand Green Building Council, 2023). In practice, this transition is achieved through a combination of electric and battery-powered equipment, renewable electricity, battery energy storage, improved site-energy planning, and transitional low-carbon fuels where full electrification is not yet feasible.

This study investigates how the construction industry can move towards fossil-fuel-free construction through practical and staged actions. Rather than treating the transition as a single technology-replacement exercise, the study examines the current power sources used by construction tools and machinery, the availability of cleaner alternatives in New Zealand, the extent to which these alternatives are used or hired, and the barriers to wider adoption. The findings are based on equipment and barrier

data collected from participating construction organisations, including subcontractors, contractor yards and a plant hire company.

The central argument of this report is that fossil-fuel-free construction is achievable, but it requires leadership, coordination and commitment across the whole construction value chain. Immediate progress can be made by targeting light tools and small equipment, where electric and battery-powered alternatives are already widely available. Greater challenges remain for heavy plant and specialist machinery, where barriers include limited equipment availability, performance concerns, battery capacity, high capital costs, higher hire rates, site-power constraints and uncertain demand. By identifying where change is already possible and where further support is needed, this report provides a staged pathway for reducing fossil-fuel use during construction.

Leadership is essential because no single organisation can deliver fossil-fuel-free construction alone. Clients and government agencies can create demand through procurement requirements and willingness to support low-emission options. Main contractors can coordinate site-energy planning, emissions tracking and subcontractor requirements. Subcontractors can transition tools and request fossil-fuel-free hire options where available. Plant hire companies and suppliers can expand access to low-emission plant when demand is clear. Policymakers can support the transition through standards, incentives and infrastructure planning. This report therefore positions fossil-fuel-free construction not only as a technical challenge, but as a transformation in how construction sites are planned, powered, procured and supplied.

Research method

To examine the possibility of transitioning to fossil-fuel-free construction sites, a qualitative study was conducted through semi-structured interviews with 15 participating construction companies, comprising 12 subcontractors, 2 plant yards and 1 plant hire company. The interviews first aimed to map the participants' current equipment inventories, specifically categorising their assets as heavy or light plant machinery and documenting their existing power sources. Participants were then asked to assess their awareness of the availability of alternative, non-fossil-fuel-powered machinery and tools in the New Zealand market. Finally, to systematically evaluate the impediments to adopting these sustainable alternatives, the researchers explicitly prompted participants to consider and discuss potential barriers across five categories: technical limitations, infrastructure deficits, commercial constraints, and operational challenges.

Key Findings

This report summarises the findings on the implementation of fossil-fuel-free construction sites. The dataset contains 278 tools, plant and equipment items used to physically construct building elements. The analysis examined whether tools and equipment were light or heavy plant, their current power sources, the availability of fossil-fuel-free alternatives in New Zealand, whether alternatives had been used or hired, and the barriers preventing replacement.

1. Characteristics of tools and machinery

The dataset is dominated by light plant/tools, as shown in Table 1, but the main fossil-fuel challenge sits with heavy plant. Light tools are generally easier to electrify because many battery-powered or corded options are already available in tool sheds. Heavy plant is more difficult because it often requires higher power output, longer operating times, charging infrastructure, or the availability of specialist machinery.

Category	Count	Share of total
Light plant/tools	217	78%
Heavy plant/equipment	61	22%
Total	278	100%

Table 1: Composition of tools and equipment by plant type

Overall, Table 2 shows that two-thirds of all tools/equipment were already electric or battery-powered, indicating that electrification is relatively mature for many construction tools. However, almost one-third of all equipment remains fossil-fuel-powered, indicating that eliminating fossil fuels entirely will require targeted action rather than general encouragement alone.

Power source	Count	Share of total
Electric/battery	185	66.5%
Fossil Fuel	91	32.7%
Hybrid	2	0.7%
Total	278	100%

Table 2: Power source profiles

The highest fossil-fuel exposure occurs in Concrete, Demolition, Piling, and Insulation, with 100%, 100%, 85.7%, and 80% of fossil- and hybrid-tool shares, respectively. These trades/companies should be priority areas for future fossil-fuel-free site pilots. By contrast, Carpentry and Joinery had no fossil-fuel items recorded, suggesting that some trades have already largely transitioned to electric or battery-powered tools.

2. Availability of fossil-fuel-free alternatives

The analysis indicates that 91 assets in the dataset are fossil-containing or mixed fossil/electric assets requiring transition. Of these, 60 assets have a clearly identified fossil-fuel-free or reduced-fossil alternative available in New Zealand, representing approximately 65.9% of fossil-containing equipment. The remaining 31 assets, or 34.1%, have either no available alternative or unclear alternative status. Battery-electric alternatives dominate the transition pathway, accounting for 52 of the 60 clearly available alternatives. This is a significant finding because the main problem is not always the absence of alternatives. In many cases, alternatives exist but are not being adopted due to cost, hiring rates, performance concerns, site suitability, or infrastructure limitations. Reported alternative availability was high for both heavy and light plant. Although alternatives were often available, actual use and hiring were much lower.

Figure 1 Availability of fossil-fuel-free alternatives across all 15 firms. Green bars represent fossil-containing assets with a clearly identified fossil-fuel-free alternative, while red bars represent assets with no available or unclear alternative. The results show that availability gaps are concentrated in Demolition, Piling, Acoustics and Insulation, whereas several tool-based or mixed-equipment firms report high availability of alternatives.

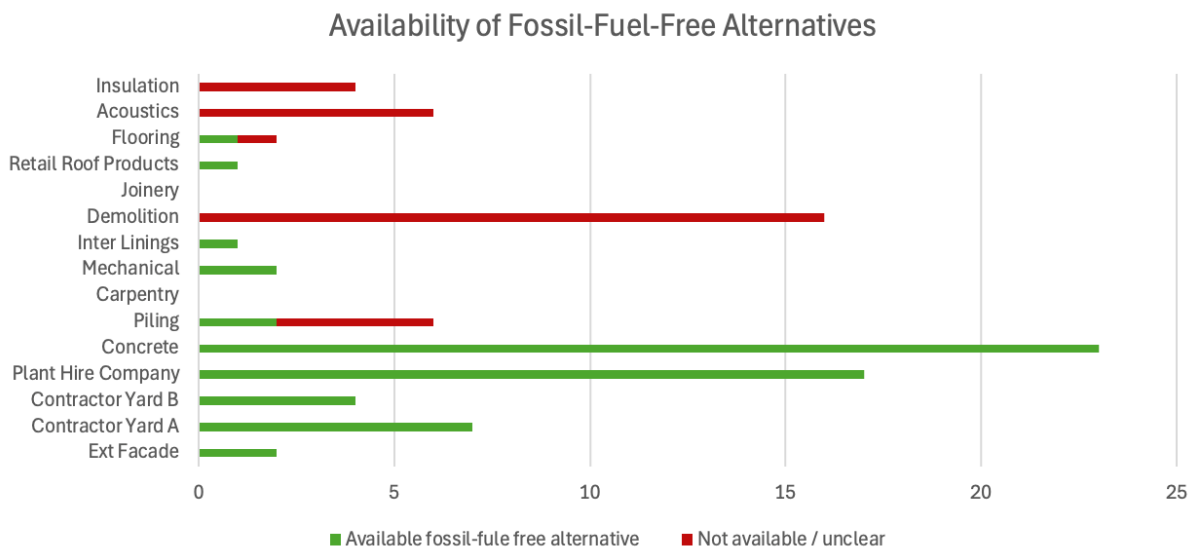

Figure 1: Availability of fossil-fuel-free alternatives for each firm

3. Barriers to adapting to fossil-fuel-free construction

The analysis identified 91 recorded barrier selections for fossil/hybrid items. These were grouped into technical, commercial, market/industry, infrastructure and operational barriers. As shown in Table 3, the most significant barrier group was technical barriers, followed by commercial barriers and market/industry barriers. Infrastructure barriers were recorded less often, although qualitative comments in the workbook suggest that

charging capacity, three-phase power and site power distribution may still be important practical issues.

Barrier category	Count	Share
Technical	39	42.9%
Commercial	26	28.6%
Market / industry	22	24.2%
Infrastructure	4	4.4%
Operational	0	0.0%

Table 3: Barrier categories

As Figure 2 illustrates, the most common specific barrier was performance limitations, particularly concerns about whether electric or battery equipment can provide sufficient power, torque and reliability for demanding site tasks. The second most common barrier was no alternative electric/battery plant, which was especially relevant to specialist or heavy equipment. For light plant, the dominant issues were technical and market-related, especially for specialist gas tools and trade-specific tools where electric/battery replacements may not exist. For heavy plant, commercial barriers were much more prominent, particularly higher hire rates and capital costs. This indicates that heavy-plant decarbonisation is not only a technical issue. It is also a business-model issue involving hire companies, procurement policies, asset replacement cycles and client willingness to pay for low-emission alternatives.

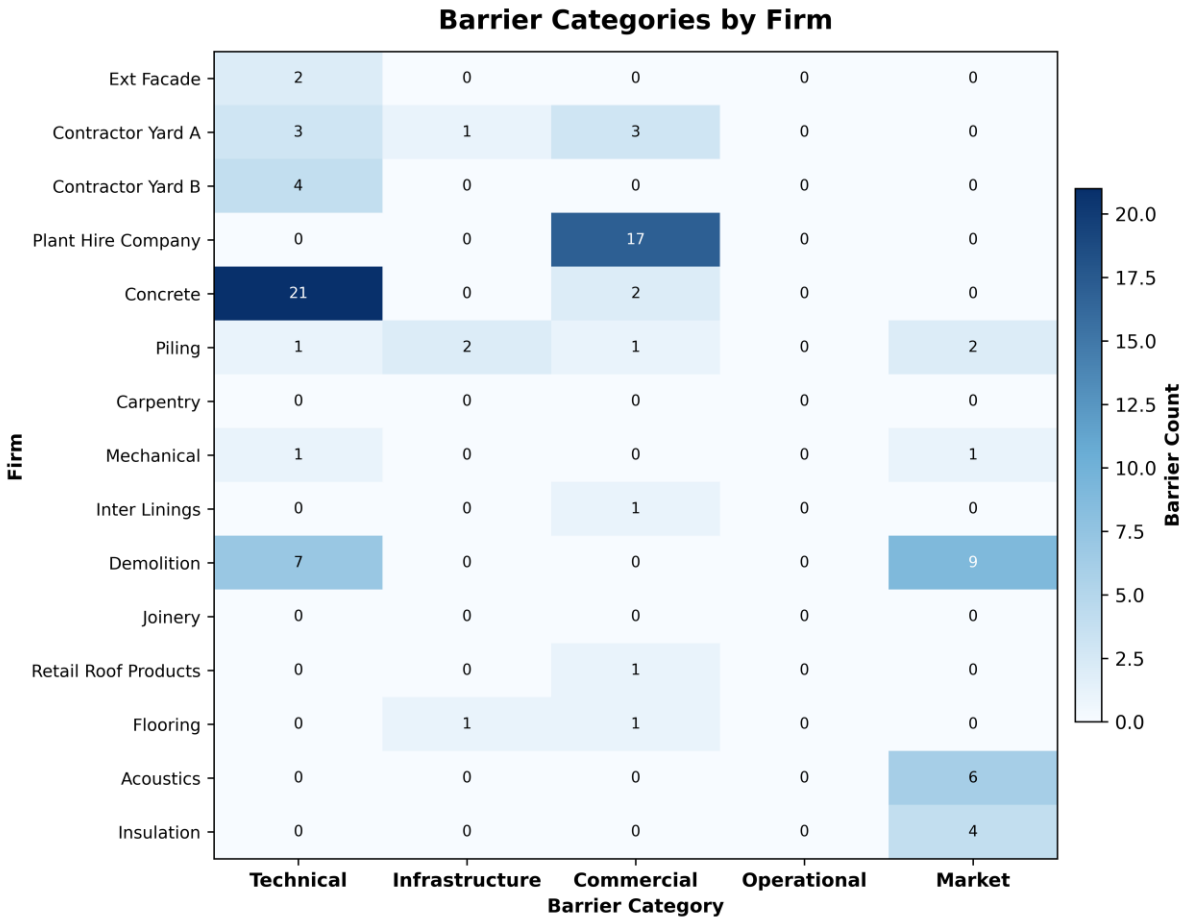

Figure 2: Heatmap of barrier category by firm

The findings show that the fossil-fuel-free construction sites is not merely a single-technology substitution problem. Instead, it is a combined transformation of technology, procurement, infrastructure, and site operations. For light tools, the transition is already well advanced. Many trades already rely heavily on battery or corded electric tools. This suggests that the industry could move relatively quickly toward a requirement that all common handheld tools be electric or battery-powered. For heavy plant, the transition is more challenging. The dataset shows that heavy plant is still overwhelmingly fossil-fuel-powered, and barriers include cost, hire rates, performance, battery life, availability of alternatives, and infrastructure. This means heavy plant will need a staged strategy involving trials, supplier engagement, site-power upgrades and procurement incentives

Ways forward

The findings suggest that the move toward fossil-fuel-free construction should not be understood simply as replacing one piece of equipment with another. While some equipment categories can be easily replaced with electric or battery-powered alternatives, other categories require broader changes to procurement, site planning, infrastructure, supplier relationships, and asset management. The transition is therefore best understood as a system-level change rather than a straightforward technology swap.

The transition should be framed around equipment readiness. Equipment that already has proven electric or battery-powered alternatives should be prioritised for early replacement. Equipment that does not yet have suitable alternatives should be addressed through trials, supplier engagement, temporary bridging fuels, redesign of construction methods, or longer-term technology development. This staged framing allows the industry to make immediate progress while recognising the practical limits of current market availability.

The more difficult transition challenge lies with heavy plant and high-demand equipment. These items often operate for longer periods, require greater torque or hydraulic power, and perform tasks central to construction productivity. Replacing these machines with low-emission alternatives is therefore more complex than replacing handheld tools. The issue is not only whether an alternative exists, but whether the alternative can perform reliably under site conditions, operate for the required duration, and be supported by appropriate charging or refuelling infrastructure. Heavy plant also raises a commercial challenge. Much of this equipment is hired, shared, or supplied through external plant providers. Individual subcontractors may not have direct control over the availability of low-emission plant, and hire companies may be reluctant to invest in new equipment without clear demand from clients and main contractors. This creates a supply chain dependency in which each party waits for stronger signals from the others.

One of the most important implications from the study is the distinction between availability and adoption. The presence of an alternative in the market does not mean that firms will automatically use it. Adoption depends on confidence, cost, productivity, site suitability, supplier support, and the timing of asset replacement cycles. To nurture adoption confidence, demonstration projects and pilot sites could play an important role. By documenting performance, charging needs, downtime, cost and user feedback, pilot projects can reduce uncertainty and build confidence in low-emission equipment.

A practical issue raised through the study is the quality of asset information held by firms and subcontractors. Many organisations do not appear to maintain detailed equipment registers that capture power source, ownership, utilisation, age, condition, depreciation or replacement timing. This limits the ability to plan a structured transition. Without accurate asset data, firms may struggle to identify which equipment should be replaced first, when replacement is financially realistic, or how much investment is required.

A fossil-fuel-free site requires a shift from fuel logistics to energy logistics. Instead of planning only for diesel deliveries and fuel storage, project teams will need to plan electricity demand, charging locations, charging schedules, peak loads, battery storage, temporary power distribution and the needs of multiple subcontractors. If this planning is not done early, electric equipment may be available but impractical to use on the site. Site-energy planning should therefore be integrated into project planning before mobilisation. This is particularly important for larger projects or projects involving multiple subcontractors with electric tools and battery-powered plant. Future work should model practical site-energy requirements, including charging demand, three-phase power requirements, battery energy storage, generator substitution and peak-load management. Such modelling would help translate the concept of fossil-fuel-free construction into practical site design and temporary works planning.

Conclusion

The overall implication is that fossil-fuel-free construction is feasible, but it requires a staged, coordinated pathway. Immediate progress can be made by focusing on light tools and small equipment for which alternatives are mature. The next stage should target small fossil-fuel-powered equipment where alternatives are available but not yet widely adopted. Heavy plant and specialist tools will require longer-term strategies involving supplier engagement, procurement incentives, site trials, improved asset data, and site energy planning.

The most important message for the industry is that fossil-fuel-free construction is not only a technical transition. It is also a transformation in how construction sites are planned, powered, procured and supplied. Achieving this transition will require coordinated action across all players, including clients, main contractors, subcontractors, plant hire companies, equipment suppliers and project teams.

Reference:

Lendlease, & The University of Queensland. (2022). Stepping up the pace: Fossil fuel free construction.

New Zealand Green Building Council. (2023). Fossil fuel free construction site.

Special Thank you to the trade contractors engaged in completing the data collection.