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Examining electricity demand profiles to inform sustainable on-site construction practices

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As the construction sector takes greater responsibility as a significant contributor to climate change, all stages of the project can deliver sustainability measures. On-site construction electricity demands are poorly understood but deserve detailed consideration in the construction life cycle. Therefore, this study aims to better understand electricity usage on construction sites. This was achieved by monitoring electricity consumption on two case study sites in Ireland. The main novelty of the work arises from the detailed submetering, which allows electricity usage to be analysed over time and across site activities. The initial key finding shows a significant baseline, or out-of-hours demand, estimated at 48% of the total electricity consumption, representing an opportunity to implement interventions to reduce demand. The first case study site presented a strong correlation ($\rho = 0.81$) between hours worked and power consumption. The peak demands were associated with the building fit out and commissioning phases of project delivery. For the second site, submetering offered additional data insights, capturing the demands of site closures and contributions of tower cranes and drying rooms. The results shows how electricity consumption patterns vary during on-site construction, and provides a benchmark for future research on sustainable construction practices.

Keywords: built environment/construction/energy conservation/energy profile/on-site consumption/sustainable construction/whole-life carbon

1. Introduction

The construction industry plays a crucial role in society by enhancing quality of life and making substantial contributions to economic growth. However, the environmental impacts of the industry are significant and it is a major contributor to climate change (Labaran *et al.*, 2022). It has been estimated that the construction industry consumes a third of global resources, 40% of all raw materials, and is responsible for more than 40% of the annual energy consumption and greenhouse gas emissions in many developed countries (Larsen *et al.*, 2022; Miller *et al.*, 2015; Rode *et al.*, 2011; Yeheyis *et al.*, 2012). In light of this, the demand for more sustainable construction practices has risen steadily over the last 25 years (Det Udomsap and Hallinger, 2020; Skillington *et al.*, 2022). The construction sector has a great responsibility to deliver on *sustainable consumption and production*, sustainable development goal 12, with governments and industry needing to take more responsibility to take action and support initiatives such as sustainable procurement, producing certified sustainable products using life cycle methodologies, or supporting a client-driven sustainability (Ball *et al.*, 2022; Secher *et al.*, 2018; Weniger *et al.*, 2023).

The term 'green building' is often used interchangeably with 'sustainable building' (Zhao *et al.*, 2019). There are many different definitions of a 'green building' (Li *et al.*, 2022); however, the Environmental Protection Agency (EPA) defines it as a '*structure that is environmentally responsible and resource-efficient during all its life-cycle designing to construction, operation, renovation and destruction while keeping the classical building concerns with the comfort, economy, utility and durability aspects*' (EPA, 2016). Environmentally responsible means that during the life cycle of the building, it consumes less water and energy, and uses more recycled resources to decrease its impact on the environment (Ding *et al.*, 2018; Uğur and Leblebici, 2018). Several green building rating systems (GBRSs) have been developed to quantify building sustainability (Sartori *et al.*, 2021). Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED) represent the two best-known UK and US rating systems, respectively (Fenner and Ryce, 2008). Other GBRSs also exist, including the EU LEVEL(S) framework (European Commission, 2019; Ferrari *et al.*, 2022). This assesses each phase of the life cycle and has three main aims: resource use and environmental performance during a building's life cycle, health and comfort and cost, and value and risk (Dodd *et al.*, 2017), which strongly align with the three pillars of sustainability (WCED SWS, 1987).

Generally, GBRSs are based on two methods, one focusing on scores for a list of sustainability indicators, and the other requiring life cycle assessments to quantify the environmental impacts of the building elements (Ferrari *et al*., 2022; Mattoni *et al*., 2018). LEVEL(S) adopts the latter life cycle–based approach (Dodd *et al*., 2017). This supports the evaluation of the climate change impacts of a construction project, with most uptake to date focusing on material declarations and embodied carbon. The most advanced reporting in the LEVEL(S) framework, a 'Level 3' evaluation, involves on-site monitoring on construction sites and operational performance (Ferrari *et al*., 2022). The latter factor has received lots of attention, as operational carbon in buildings has been assessed in detail (e.g. Geng *et al*., 2019; Santamouris and Vasilakopoulou, 2021; Xiao, 2025). This has led to various design interventions to reduce operational carbon (e.g. Feehan *et al*., 2021; Illankoon *et al*., 2020; Kadi *et al*., 2024; Najjar *et al*., 2019). The World Green Building Council refer to 'upfront carbon' as that emitted before a building is used and estimate that this will account for half of the carbon footprint of new construction between now and 2050 (World Green Building Council, 2019). This term includes carbon associated with materials and production as well as emissions from on-site construction practices, that is stage A1 to A5 of building life cycle (Kechidi and Banks, 2023). However, there is a lack of literature and accurate energy data related to on-site construction, stage A5, and its associated environmental impacts (Davies *et al*., 2015). This inhibits both the development of benchmarks to drive sustainability initiatives and the ability to accurately quantify the embodied carbon of this stage of a construction projects life cycle (De Wolf *et al*., 2017). In light of this, the construction phase and associated impacts are often omitted as they are deemed insignificant in comparison to the total project life cycle energy demands or assumed without rigour in life cycle analysis studies on construction projects (Davies *et al*., 2015).

This study considers electricity consumption in construction projects. It is important to state that electricity is not the only form of energy consumed during a construction project and is not the only source of upfront carbon. Nevertheless, it is an area where upfront carbon may be reduced and is therefore worthy of further research. There is a very limited body of academic research exploring the characteristics of on-site electricity consumption. Electricity demand is poorly understood and there is limited capacity to inform associated potential reductions in energy, economic costs, and environmental impacts. There are a relatively small number of studies that report total electricity usage for individual case study developments, including those by Hong *et al*. (2015) for a case study development in China (212.5 MWh or 18.46 kWh/m^2) and, more recently, Haddad *et al*. (2023) (204.6 MWh or 13.06 kWh/m^2) for a Brazilian development. Davies *et al*. (2013) reported total electricity and diesel usage for 24 different construction projects in the UK, and proposed simple linear equations to predict total usage based on financial turnover, number of staff, and site area. Similarly, Janssen (2014) reported total electricity usage on 14 different residential construction sites in the Netherlands, and showed that electricity usage was correlated with gross floor area, gross building volume, and construction period, but not with building height. In Ireland, Gottsche *et al*. (2016) demonstrated the possibility of saving 17.5% of the total cost of electricity in a case study educational development through straight-forward 'quick-win' energy saving measures. However, no study appears to provide a detailed breakdown of electricity usage, either over time or between various on-site activities. Such studies are needed to properly understand the nature of electricity consumption and allow informed decisions about grid connection capacity and energy saving measures to be made. From the existing literature, the extent of the savings that may be made by reducing consumption are not apparent and it is unclear as to whether it is worthwhile and economically justifiable to pursue measures to achieve such reductions. Further studies to develop an understanding of energy usage quantities and patterns during construction are required if the complete life cycle embodied energy approach, envisioned in LEVEL(S), is to be realized.

The aim of this study is to collect and analyse electricity consumption data for two construction sites in Ireland acting as case studies, to better understand consumption profiles and trends and identify potential correlations between on-site activities and the use of different machinery through the various stages of project delivery. The novelty in the work arises from the high resolution and detailed submetering employed in monitoring, which allows for a detailed breakdown of electricity usage over time or between various on-site activities in a way that has not been reported before. The findings are used to assess behavioural and technological interventions that can reduce on-site energy consumption, and the associated operational carbon produced during construction, lowering the pressures on grid networks to support infrastructure projects. The results can also improve our understanding of electricity usage patterns on construction sites and aid contractors to predict energy consumption more accurately as part of project tenders. Ultimately, this helps to provide transparency of on-site energy usage which can facilitate initiatives to address sustainability within the construction sector.

2. Methods

2.1 Case study sites

Electricity consumption for two case study sites operated by John Sisk and Son (Holdings) Ltd was recorded and analysed. Both developments were relatively large, at least in an Irish context. The size of the sites, length of recording period, and resolution of the recordings were different for the two sites, as summarised in Table 1, meaning different information can be inferred from each case study.

The first case study (Site A) was a large six-block project with a total floor area of 62 600 m^2. This was a mixed-use commercial

Table 1. Overview of case study construction sites

Project details	Site A	Site B
Project size	Large (62 600 m^2)	Medium (22 845 m^2)
Structures	Six blocks high-rise (up to 79 m)	Two blocks low-rise (up to 21.5 m)
Monitoring duration	3 years	6 months
Data resolution	15 min	1 h
Data breakdown	Gross site usage only recorded	Data recorded for 6 submeters showing demand from various activities including tower cranes, drying rooms, and outdoor lighting
Anomalies	N/A	Monitoring campaign interrupted by COVID-19 lockdown

and residential development including the one relatively tall block of 23 storeys, with the remaining blocks ranging from three to seven storeys. There were six tower cranes and six hoists, employed during construction on the site. Electricity usage for the entire site was monitored over a 30-month period, from August 2016 to February 2019. The second case study (Site B) was part of a large mixed residential, office, and retail development with a total area of over 200 000 m^2. However, the electricity usage was monitored for two residential blocks with a total floor area of 22 845 m^2. The blocks are a combination of five and six storey sections ranging from 16.8 to 21.5 m in height and construction equipment included four tower cranes and three concrete pumps. Electricity usage was monitored for a 6-month period of construction in 2020.

2.2 Data analysis

Monitoring at Site A took place over approximately 3 years, representing most of the construction period, but only gross electricity usage was recorded. In contrast, the monitoring at Site B was shorter in duration, 6 months in total, but included power consumption from various local substations, which allows the power demands of different equipment to be examined. Furthermore, different ancillary information, for example the volume of concrete delivered, and the number of personnel hours worked, were also available for each site.

For the analysis, the work hours on the three case study construction sites were taken as Monday to Friday from 7.00 a.m.−7.00 p.m., and Saturday from 08.00 a.m.−2.00 p.m. on weekends. All other hours were considered as 'out-of-hours' in which no active work took place on the construction sites.

Given the different nature of the data and ancillary information, the electricity usage from each case study site is analysed slightly differently. However, generally, the analysis involves studying the weekly and diurnal variations in electricity usage – both over the full recording periods and shorter sample subsections of interest. This helps to identify trends in power consumption on different construction sites, factors that can be used to predict electricity consumption on construction sites, and areas for potential savings of electricity on construction sites.

2.3 Limitations of study conditions

The work involved monitoring the electricity consumption on two case study construction sites in Ireland; therefore, care is needed when extrapolating beyond this. Furthermore, it is important to recognise that electricity consumption is not the same as total energy consumption, as it ignores some other systems and processes, such as transport of materials to the site, temporary generators in site setup, and the use of diesel-powered heavy machinery. Finally, it should be noted that one of the monitoring campaigns was impacted by COVID-19 enforced stoppages in construction activity, meaning that data in these cases may not be fully representative of a typical scenario.

3. Results and discussion

3.1 Site A – large-scale project

For Site A, the total electricity consumption on the site was recorded every 15 min over a 30-month period. This period corresponds to most of the on-site construction phase. Over the entire monitoring period, a total of 11.03 GWh (176 kWh/m^2) of electricity was consumed. This figure for electricity consumption per unit area over the course of an entire projects is an order of magnitude greater than values of 18.46 kWh/m^2 by and 13.06 kWh/m^2 reported by Hong *et al*. (2015) and Haddad *et al*. (2023) for projects in China and Brazil, respectively. However, it is in line with some values reported by Davies *et al*. (2013) for larger sites in the UK. In addition, for the site under consideration in this study, the number of hours worked and volume of concrete delivered to site each month were provided by the contractor. The programme of work proposed before work began was also provided.

3.1.1 Operational energy, hours worked, and concrete received

Firstly, an analysis of the monthly electricity usage was undertaken. This provides a coarse representation of data that was recorded at a 15-minute resolution; however, it allowed for a general overview of the long-term trends and energy profile. This is particularly relevant for this case study, as data were collected for the complete project duration allowing the evolution in demand over the course of a large project to be assessed. Figure 1 presents the provisional construction programme, total electricity consumption, number of hours worked,

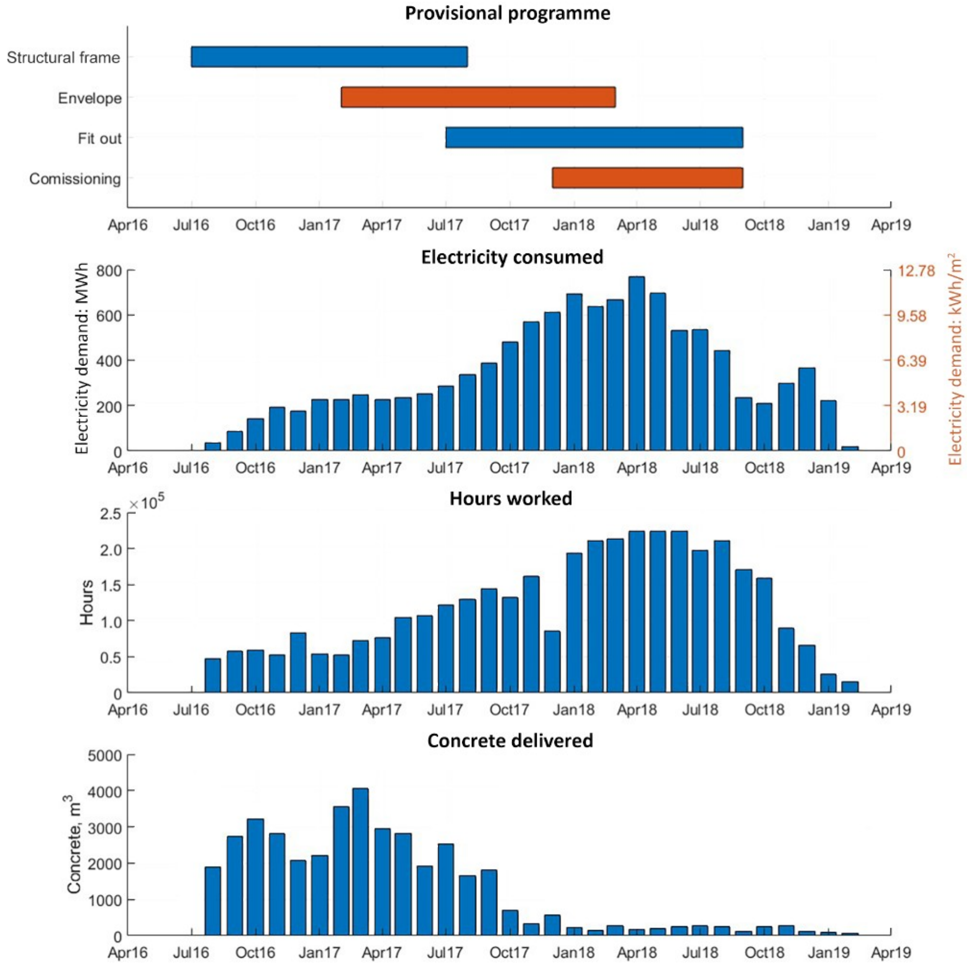

Figure 1. Provisional programme, electricity demand, hours worked and concrete deliveries at Site A during the project from August 2016 to February 2019

and the volume of concrete delivered to site for each month of the project.

It can be observed that the electricity demand peaked in the winter and spring of 2017–2018, with a maximum monthly value of 767 MWh (12.25 kWh/m^2) in April 2018. The programme of works for the project was divided into four main stages (structural core and superstructure, building envelope, fit out, and commissioning); however, the project was not delivered to the planned schedule with the commissioning phase extending beyond the initial target end date. Given the overlap between stages, electricity usage cannot be attributed directly to any one stage; however, greater electricity demands were noted to be associated with the later stages of project delivery – namely, the fit out and commissioning stages. The monthly electricity usage was quite strongly aligned with the number of hours worked on site with a correlation coefficient of $\rho = 0.81$. However, no such relationship existed between the volume of concrete delivered and electricity usage. The volume of concrete delivered peaked in the early months of 2017, when the electricity demand was still relatively low. Controlling for hours worked, the partial correlation coefficient between electricity usage and concrete delivered to site is $\rho = -0.23$ – indicating that electricity usage can be considered unrelated to concrete delivered in this case.

As expected, higher volumes of concrete are delivered for the early structural core and superstructure stages of the project. Despite the extensive use of cranes during these early stages of the project, the building fit out and commissioning phases represented the stage with greater electricity demand. However, these results do not clearly distinguish the proportion of energy used by the cranes. This highlights the need for submetering on construction sites to capture the energy demands of different infrastructure.

3.1.2 Diurnal trends

The data from Site A were also analysed in shorter time periods at a higher resolution to investigate shorter-term variation in electricity usage. Figure 2 presents hourly electricity usage from four

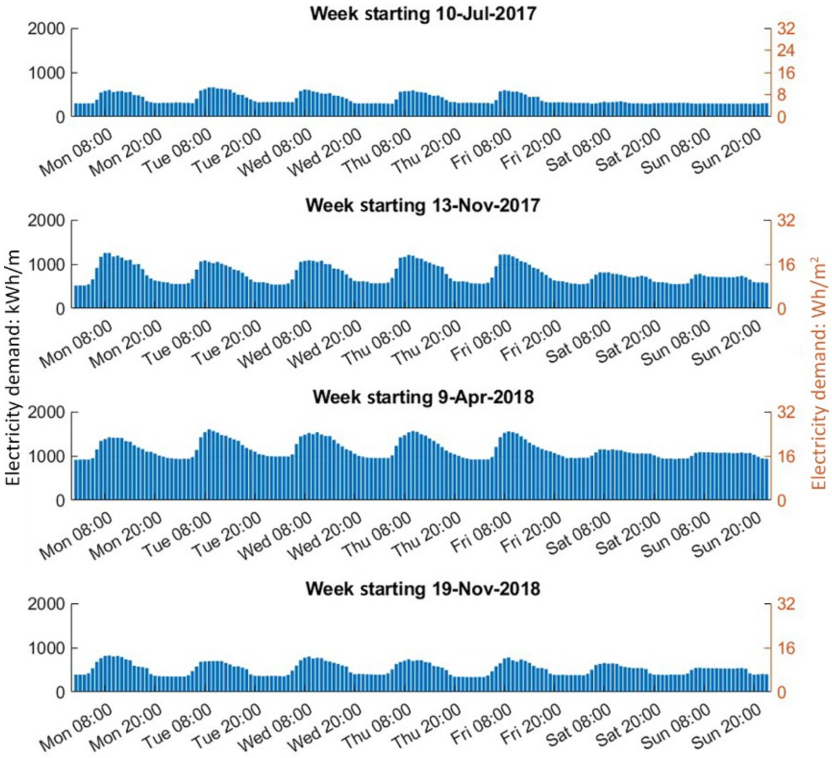

Figure 2. Hourly electricity demand over four sample weeks from Site A

sample weeks during the project, which included the 10 July 2017, 13 November 2017, 9 April 2018, and 19 November 2018, which represent different stages in the project delivery.

For all four weeks, a diurnal pattern for energy consumption was evident, with increased demand attributed to work hours on all weekdays (7.00 a.m.−7.00 p.m.) and Saturday mornings (08.00 a.m.−2.00 p.m.). This shows an expected higher electricity demand during working hours, but the proportion of energy consumed during out-of-work hours presents a constant baseline of unaccounted for energy. Reflecting the trends in monthly consumption, electricity demands were highest in the sample week in April 2018, with hourly usage peaking at 1500 kWh (24 Wh/m^2) and out-of-hours usage of approximately 1000 kWh (16 Wh/m^2), equivalent to 40% of the total energy consumption even through the weekend period has limited working hours.

Finally, an analysis of working hours and out-of-work hours consumption presented in Figure 3 showed that out-of-hours energy demands represented an average 33% (ranging from 27%–38%

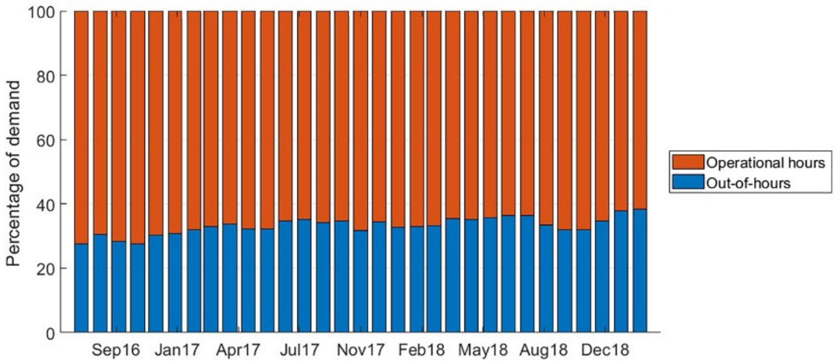

Figure 3. Breakdown of total electricity demand at Site A between weekdays only (Monday to Friday), separating operational hours (07.00 a.m.–07.00 p.m.) and out-of-hours (07.00 p.m.–07.00 a.m.)

with a standard deviation of 2.67%) of the total weekday electricity consumption during the project. This figure increased when accounting for the entire 7-day week, with out-of-hours representing an average of approximately 42% (ranging from 33%–53% with a standard deviation 4.26%). These results highlight the evident need for out-of-hours energy demands to be better understood, as it represents a baseline of electricity consumption on a site with no active work taking place.

3.2 Site B – medium-scale project

For Site B, hourly data were recorded during an approximate 6-month period of a project from December 2019 to July 2020, reflecting a much smaller dataset than for Site A. The monitoring period also took place during COVID-19 lockdowns, when construction activity was stopped for seven weeks between 28 March and 17 May (The Irish Times, 2020). As such, no on-site activity took place for several weeks during this period, and the return to work did not reflect standard procedures; thus, the data were not fully considered as representative of typical on-site conditions. However, in contrast to Site A, data submetering was undertaken with six temporary electricity meters installed to record the energy consumption across the site. Therefore, while the data from Site B do not reflect a complete project and takes place during COVID-19, it is beneficial to help understand the types of construction activities that consume energy on site.

3.2.1 Submetering data

Figure 4 presents the weekly electricity demands on Site B. Electricity usage is divided into six categories. The submeters were located to measure the energy demands of the tower crane, drying room and outdoor lighting, with three additional meters at 'sub main distribution board' (SDB) locations, which have mixed energy requirements. SDB#1 included power delivered to two other tower cranes and one building, SDB#2 also includes power delivered to a building and a sub-contractors office (using battery charging at night), and SDB#3 captured power to a building and a crane.

From observing Figure 4, the impact of the coronavirus pause in construction is immediately apparent in the week starting on 27 March 2020, with electricity demands dropping by almost 80% from the previous week and remaining at this level for the subsequent 6 weeks. This finding shows that even inactive sites can consume up to 20% of the electricity of a typical working week, also reflected by the Christmas period closure, which highlights a minimum baseline for a construction site. Reduced energy usage was evident in the 2 weeks prior to the shutdown, suggesting behavioural changes or supply chain issues were already taking place. A gradual increase in usage is observed in early May, as construction activity returned to pre-shutdown levels in the subsequent weeks.

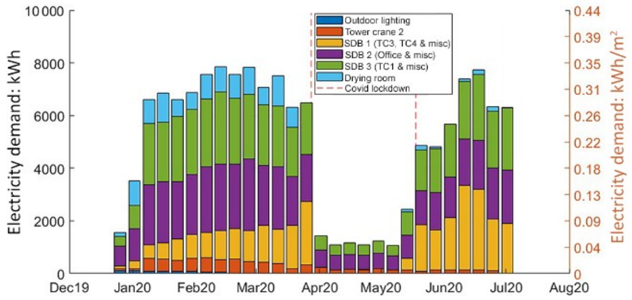

Figure 4. Breakdown of weekly electricity demands from six submetering locations at Site B between December 2019 to August 2020

During active construction, the weekly electricity usage ranged from 6603 to 7854 kWh (0.29–0.34 kWh/m^2). This was an order of magnitude smaller than at Site A, yet not clearly proportionate to the difference between total floor areas of the projects. However, Site B represented a low-rise project as compared with the high-rise structure at Site A. Figure 5 shows the hourly usage for each component on the week of 9 March 2020.

A clear diurnal pattern is evident, with electricity usage fluctuating between the baseline demand of approximately 35 kWh for out-of-work hours to approximately 60 kWh/h during working hours; thus, out-of-hours representing more than 58% of the baseline occurring throughout the day. A small peak observed on Saturday was associated with working hours, with no peak on Sunday due to inactivity on site.

3.2.2 Daily energy consumption profiles

Figure 6 presents the daily usage over a 10-week period covering the 'typical' (i.e. post-Christmas and pre-COVID-19) weeks during the recording period. This allows daily usage patterns to be appreciated. Generally, the energy demands were broadly similar on weekdays, on average consuming 1113 kWh (or 0.05 kWh/m^2) per day, with a standard deviation of 94.8 kWh. On Saturdays, which may have some work hours, average consumption reduced to 916 kWh (with a standard deviation of 60 kWh), with further reductions to an average value of 750 kWh (standard deviation 73 kWh) on Sundays.

3.2.3 Operational vs out-of-hour demands

The division between electricity consumption inside and outside operational hours is presented in Figure 7. From this, it can be appreciated in the typical weeks, after Christmas and before the coronavirus shutdown, out-of-hours usage was on average 44% (with a standard deviation of 3%) of the total value.

This is similar to values observed at Site A. As expected, out-of-hours demand became a greater portion of total demand once on-site activity was suspended for coronavirus, as operational hours in this period do not correspond to working hours. Once activity was permitted again, out-of-hours demand returned to similar levels of demand. However, as with Site A, the accuracy of analysis is impacted by the fact that some work appears to be performed on Saturdays, which is counted as outside operational hours.

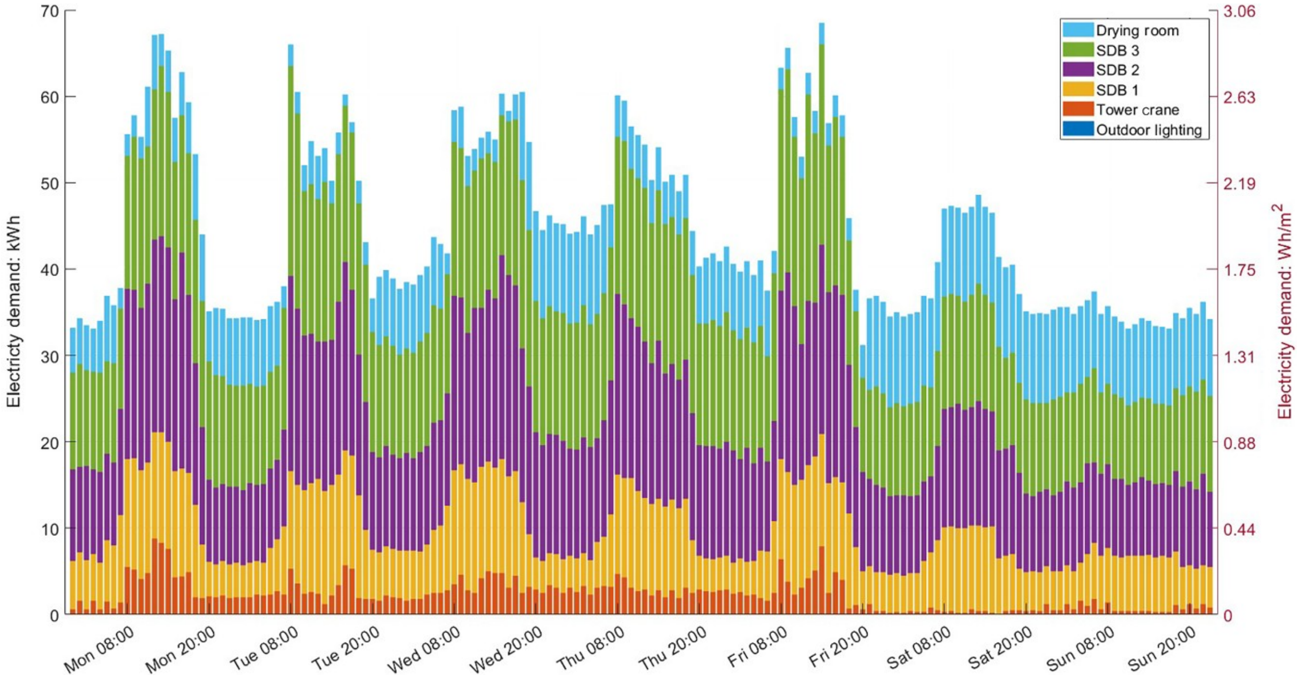

Figure 5. Hourly electricity usage at Site B for the week starting 9 March 2020

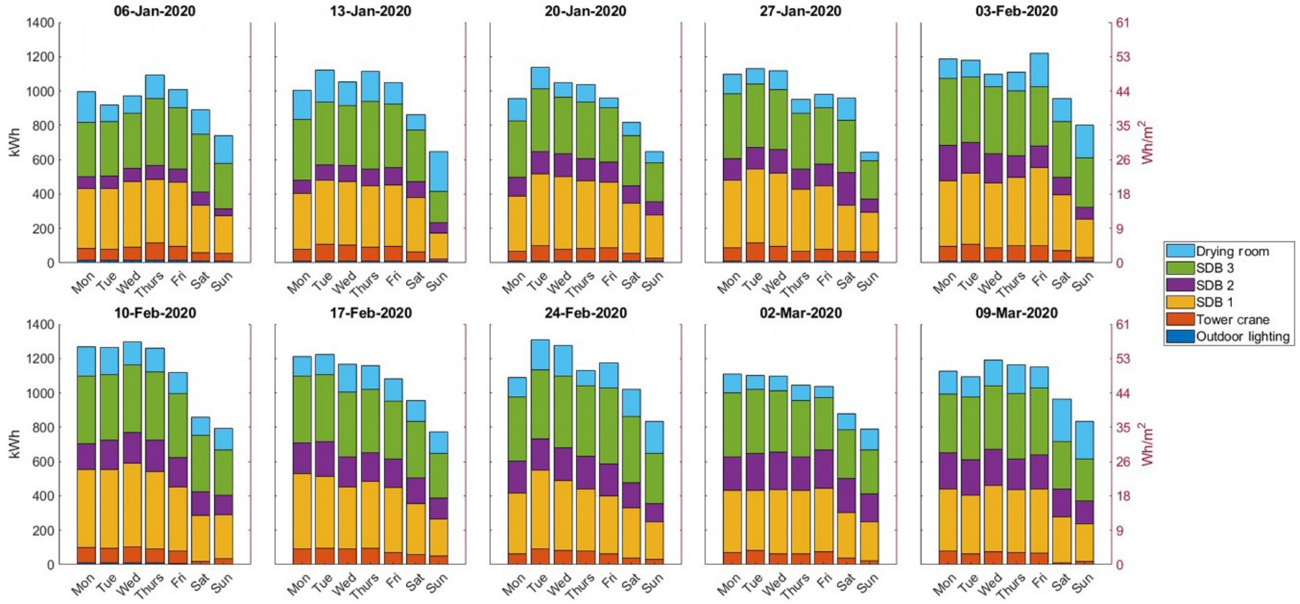

Figure 6. Daily electricity usage over a 10-week period at Site B

3.2.4 Crane and drying room consumption

3.2.4.1 Cranes

The submetering data demonstrated that the tower crane only consumed a relatively small amount of the total electricity demand (Figure 5), with an average 6% (standard deviation 1%) of the total electricity usage in the weeks prior to the COVID-19 lockdown. Extrapolating this result to the other three cranes on-site suggests an estimated one-quarter of the total on-site electricity demand is related to the cranes. This finding aligns with the results from Site A, as peaks in electricity demands did not directly

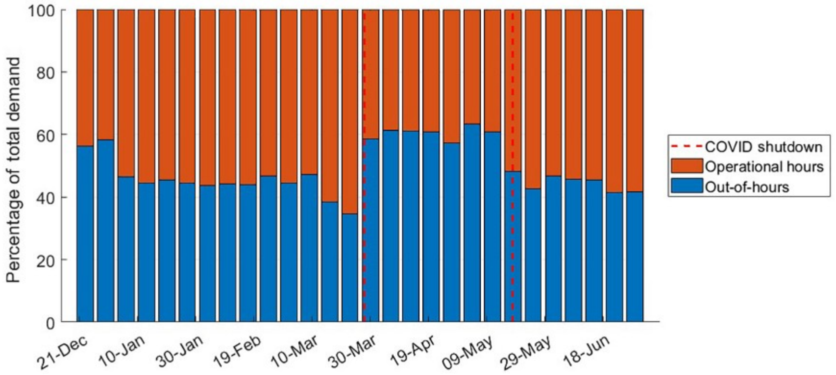

Figure 7. Breakdown of total electricity demand at Site A between weekdays only (Monday to Friday), separating operational hours (07.00 a.m.–07.00 p.m.) and out-of-hours (07.00 p.m.–07.00 a.m.)

correlate with the most intensive periods of tower crane usage during the structural phases. Figures 8 illustrates the hourly power consumed by the tower for two typical sample weeks starting on 10 February 2020 and 9 March 2020, respectively.

Firstly, an examination of electricity for the tower crane demonstrated a distinctive weekly trend that is not correlated to the overall site demands observed. For both weeks examined, while some peaks are evident during working hours, the energy demands are relatively constant from Monday evening through to Friday morning, with much lower consumption at the weekend. It is difficult to know what causes the relatively high levels of consumption outside working hours during the week, but speculatively this may be associated with equipment within the crane, such as electric heaters or lighting, left running overnight.

As the resolution of data analysed remains coarse, the amount of power used and the fact that consumption is reasonably constant on weekdays requires further investigation. Furthermore, this may not reflect the maximum and true energy patterns of the crane as its lifting loads would use large quantities of energy for short periods, of less than a minute. This highlights the importance of appropriate resolution for data collection for some infrastructure on construction sites to better capture trends in energy demands.

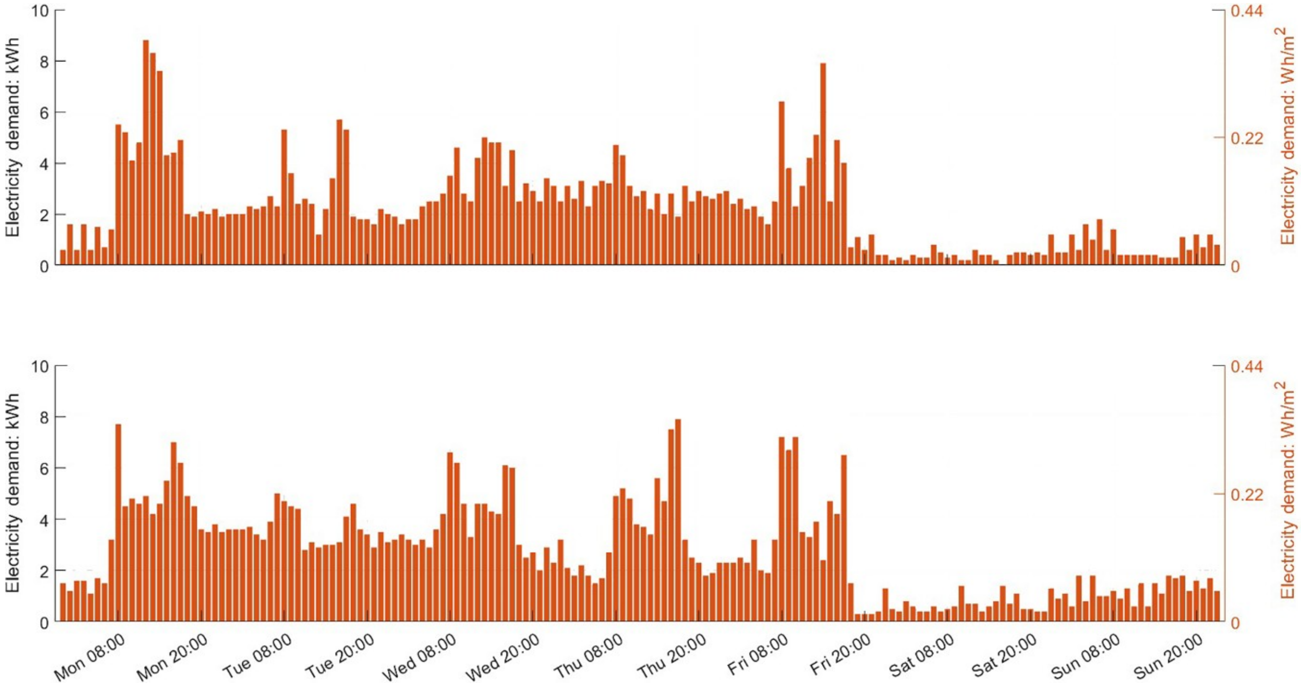

Figure 8. Weekly electricity usage for Tower Crane 2 for the weeks starting 10 February 2020 and 9 March 2020

With some rough approximations (weekly power consumed by the tower crane is 470 kWh, with the possibility of reducing from an average of 3.5 kWh/h to 1 kWh/h over the four 'out-of-hours' time periods during the week) it is estimated that electricity consumed by the tower crane can be reduced by 25% if the settings evident on the weekend state was adopted every night for the tower crane.

3.2.4.2 Drying room

The electricity demand from the drying room prior to the shutdown is on average 12% (standard deviation 2.3%) of total electricity consumption, which is over twice the demand from Tower Crane 2. Drying room electricity demand greatly reduced after the coronavirus lockdown. This is possibly attributable to drier weather in the summer months, although it is also possible that virus-related concerns about deploying air circulation systems contribute to the reduction. Therefore, the drying room represents an energy consumer that may have links to meteorological or weather conditions and can be correlated to typically seasonal changes and requirements. The energy consumed by the drying room, as illustrated in Figure 9, follows an inverse pattern to the site.

Demand is lower during working hours but increases at night. For both weeks presented, the consumption is constant throughout the weekend, suggesting the equipment may be left operating for the entire weekend. This trend of high weekend demand is particularly prominent in the week of 10th February. The usage patterns observed suggest that a smart monitoring or control system could effectively reduce consumption while ensuring sufficient drying has been achieved.

3.3 Discussion: opportunities for energy, economic, and environmental impacts

The preceding work provides an insight into the nature of electricity use on construction sites, both over short and long timeframes. There are a number of potential benefits, both financial and environmental, to developing a full understanding of electricity usage profiles over the full duration of a construction project. Understanding the amount and nature of electricity usage is necessary to connect a site to the grid in the most efficient manner and for the optimal deployment electricity saving technologies.

One way to reduce both the environmental and financial cost of the electricity required for construction is by optimally sizing the connection of the site to the wider electricity grid. Developing a comprehensive understanding the electricity usage patterns over the duration of a construction project can help a contractor to do this. Financially, the cost of a grid connection is proportional to the connection capacity. At present, where power use is not well understood, grid connection capacities may not be optimally sized. The results in this study, particularly from Case Study A, suggest that electricity requirements increase over the course of a project in line with hours worked and savings may be achievable if grid connection capacity is optimized accordingly. However, further monitoring is required to verify this. Also, from a financial

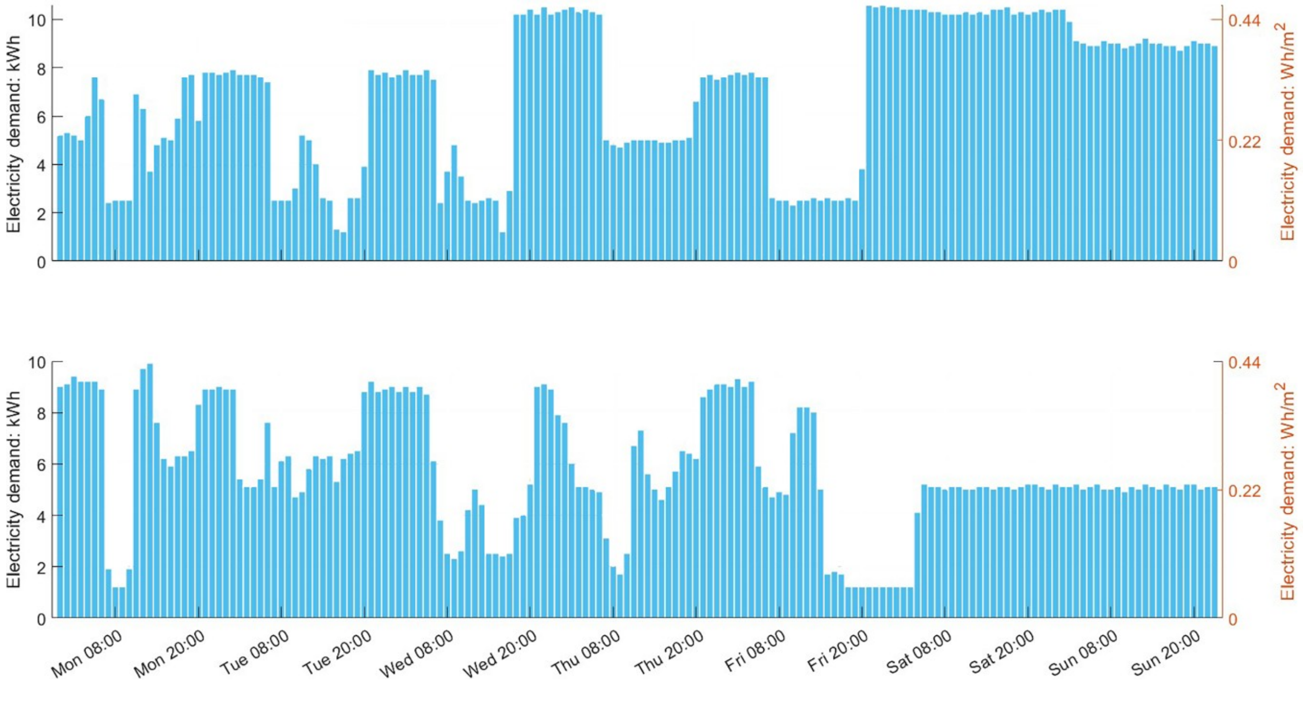

Figure 9. Weekly electricity usage for the drying room for the weeks starting 10 February 2020 and 9 March 2020

viewpoint, a full understanding electricity usage patterns may help contractors to develop more accurate tender prices.

In addition, an understanding of how electricity is consumed on construction sites allows judgements about the potential benefits of electricity saving technologies to be assessed. Examples of such technologies include battery powered tools, various remote access controls, smart lighting, and battery storage. Battery storage can be used to address the large difference between average and peak electricity demands, such as those visible in the crane demands in Figure 8, associated with the short-term high loads of lifting equipment. Using electricity from batteries to manage these peaks can also help to reduce the size of the grid connection required, again providing financial savings for the contractor. In addition, this also allows for the use of smaller step-down transformers, which experience lower no-load losses, thereby improving environmental performance. The observations from this study suggest that of out-of-hours electricity usage, demonstrated particularly by the demands of tower cranes and drying rooms observed in Case Study B, is an area where significant electricity savings may be possible. This suggests that smart control systems that allow remote monitoring and control of key systems may be particularly beneficial. In contrast, the relatively negligible amount of electricity used for outdoor lighting in Case Study B (e.g. Figure 4) suggests that the investment in smart approaches like passive infrared lighting is more difficult to justify.

4. Conclusions

4.1 Key takeaways

The study examined electricity consumption profiles for two different construction sites in Ireland. A detailed breakdown of electricity usage, both over time and between various on-site activities, is reported in a way that has not been previously presented in literature. As expected, the electricity demands were greater during working hours than at night and at weekends. However, it was observed that out-of-hour electricity demand accounted for a substantial portion, between 40% and 50%, of the total electricity consumed on site. This highlights the potential benefits of technological interventions, such as smart controls, to limit wasteful electricity usage and support more sustainable practices on construction sites.

For Site A, where monitoring covered the full duration of the project, a strong correlation was found between average monthly hours worked and power consumption. Electricity use for this site peaked during the later stages of project delivery, and was associated with the building, fit out, and commissioning phases, with substantially lower demand during the construction of the structural frame. Such insights can help to predict electricity demand over the course of a construction project, offering potential financial savings for contractors as it will allow grid connections to be optimally sized. However, further research is required to fully understand typical usage patterns. For Site B, detailed sub-monitoring was used to show how electricity usage is distributed between components. This highlights inefficiencies that may exist in the other site, and which can offer significant potential for electricity savings.

More generally, the paper addresses the fact that on-site electricity consumption deserves detailed consideration in the construction life cycle, but benchmark data are currently limited in the literature. This is especially true given that reporting electricity from the on-site construction phase is a requirement for more advanced GBRSs like LEVEL(S). This will accelerate the recognition that this area is poorly understood and encourage both further research and the adoption of mitigation measures to reduce energy, costs, and upfront carbon as a means of delivering sustainability in construction projects.

4.2 Recommendations

Further high-resolution monitoring and analysis of submetering data is required for more construction projects of different scales and sizes. These technological and behavioural solutions can be achieved by improved power demand forecasting, reductions in transformer capacity, integrating smart controls for distributions boards and lighting, and large-scale batter storage. Exploring the impact of the electricity demands of tower cranes as they require large quantities of energy in very short timeframes can help improve our understanding of on-site energy demands. This can help support piloting and assessing the impact of innovating interventions such as battery storage and methods to reduce out-of-hour and baseline energy demands. These activities can provide knowledge to the global construction sector, to help deliver improved and targeted sustainability interventions that reduce electricity consumption and the upfront carbon impacts of construction while simultaneously addressing the economic and environmental challenges that face the sector with rapidly increasing costs of energy.

Data availability

The data used in this article are proprietary to John Sisk and Son (Holdings) Ltd. Data may be provided with some restrictions upon reasonable request.

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