



# Off-Site Manufacturing Report

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# Executive summary

Off-site manufacturing has increased significantly in recent years, particularly in sectors such as data centres, life sciences, residential, leisure and healthcare. However while growth has been rapid, adoption varies considerably by country, region and sector, influenced by a variety of factors including maturity of the modular supply chain in-market. Despite the popularity of off-site manufacturing as a method of construction, there is still a lack of clarity and guidance around the key parameters that clients should evaluate to assess whether off-site or traditional is the optimal approach to meet the project objectives.

In order to assist our clients make this assessment, Linesight carried out extensive research and workshops with our global client base and team of cost and project managers, to understand and rank the importance of the key decision-making criteria involved in choosing off-site as a construction method across four primary sectors, Data Centres, Life Sciences, Residential and Healthcare.

In this report, we collate the key findings and provide guidance on the key considerations for choosing the most appropriate construction method, primarily focussing on Category 1 Off-Site Manufacturing.

# Key benefits of off-site manufacturing (OSM)

## Speed



Programme savings of up to 50%<sup>1</sup> are possible compared with traditional forms of construction. Manufacturing facilities can operate 24/7 and are not prone to weather conditions that can affect construction sites, enabling faster production times. With fewer activities on-site, scheduling of tasks such as demolition, excavation and other site works is made easier. A good example of lower site time is that demonstrated by McDonalds<sup>2</sup> fast-food chain, where site time from green field to first hamburger sold can be as low as 48 hours and on average takes less than two weeks, with a total of almost 4,000 hours for factory production.

In many cases, the investment decision is centred on an assessment of the increase in project return, based on the length of programme reduction required to cover any extra construction costs associated with use of an OSM approach. The required programme reduction to cover any increased OSM cost is dependent on a range of project assumptions and can be estimated up front.



## Cost

The repetitive nature of modular construction creates opportunities for lower costs (though these savings may not always be achieved in practice). Savings in labour costs are possible, through more efficient use of labour, or by factories

locating in lower cost areas and avoiding city wages. Standardised details and structures with a degree of repeatability can reduce overall design fees and lead to a more predictable construction programme, reducing the risk of increased costs due to delays on-site. From a financial perspective, these streamlining approaches all mean that capital employed is kept to a minimum. Transferring from trade-based delivery to a more task-trained operative scenario not only reduces cost, but also improves productivity, access to labour and can help alleviate any construction skills capacity issues in a market.

## Certainty in delivery – improved predictability



Efficiency of construction, along with a greater ability to control costs, labour, schedules and delivery means that builders benefit from fewer budget overruns by using off-site manufacturing methodologies, compared with conventional site-built construction.

## Quality



As off-site manufacturers operate in a climate-controlled production environment, they have the ability both to produce thermally-efficient modules and constantly monitor key metrics and parameters to ensure consistency and quality. In turn, this precision and commitment to quality

<sup>1</sup>Fannie Mae. "Multifamily Modular Construction Toolkit." <https://multifamily.fanniemae.com/media/13576/display>  
<sup>2</sup><https://www.portakabin.com/gb-en/case-studies/mcdonalds-200th-restaurant/#>

helps to reduce errors and delays in construction. In addition, operating costs are optimized, by increasing MTBF figures as a result of the improved quality.

## Improved whole life costs



Whole life costs are considered a better way of assessing value for money than construction costs, which can result in short term gains at the outset, but conversely may lead to higher ongoing costs over the lifetime of the asset. The importance of whole life costs when considering a construction approach is strongly linked to whether a building is going to be owner-occupied post-construction or not. When a building is immediately sold, returns are maximised when costs are minimised to the point of sale. With an owner-occupier, post-construction completion returns are maximised when the total cost of ownership is minimised – this situation may favour up front spend to reduce operational spend.

## Health and Safety



Manufacturing modules off-site means that construction itself takes place in a more controlled environment that will generate low levels of both dust and noise, while the amount of working at height will be reduced to a minimum. Coupled with the elimination of the potential dangers that poor weather can bring, these

factors all combine to make for a site with fewer potential hazards than one using traditional methods.

## Sustainability



With OSM, manufacturing takes place in a controlled environment and therefore waste is minimised and recycling of material and packaging is also comparatively easy. With the number of journeys by the various trades to / from the site lower, the carbon footprint is kept to an absolute minimum.

## Accreditation, inspection and quality assurance



Off-site manufacturing allows for the accurate tracking of modules and components from the manufacturing line through to installation on-site using electronic tagging.

In sectors such as life sciences and data centres, the benefits of off-site commissioning and qualification process can favour the use of the off-site approach as commissioning and acceptance can be completed in the factory environment and the buildings attain a level of quality beyond that normally achieved on-site.

# Barriers to adoption of off-site manufacture

While taking an OSM approach offers considerable advantages, there are also a number of issues which may mean that the approach is not the appropriate one for a particular project. The most common barriers to adopting a modular approach are:

## Reduced programme flexibility



Because production schedules and logistics are planned well in advance, speeding up or slowing down an OSM project can be difficult. The reduced flexibility also applies to the design, as once a design is in production, it cannot be changed. Late changes are clearly not desirable, but they can sometimes be required and OSM cannot always facilitate easily or cheaply.

## Compressed timing and project planning co-ordination



As the process is linear, the design and engineering phases need to be completed early. This may, potentially, lead to these phases being rushed or compressed in order to meet the schedule.

## Delivery at acceptable cost



While modular is not a totally new approach, it will inevitably take a while for a fully-formed supply chain to develop / emerge. As a result, in some localities / regions or in some specific sectors, competition may be limited, meaning that pricing may be higher than would be expected.

## Suitability of construction design



Perhaps the most important consideration, is the need to commit to the concept of modular construction early. Committing to a modular approach as early as possible ensures that all the necessary considerations such as building design, site logistics, suppliers etc. are considered from the outset and throughout.

## Supply chain limitations



Some markets have only a modest amount of off-site manufacturing capacity among a relatively small number of manufacturers. While most plants can build modules for any type of building, retooling and adapting worker skills for different types of products can be costly.

Early commitment to a particular manufacturer or system means that insolvency or inability to deliver by that particular supplier may create significant delay or additional cost for the project. For manufacturers, purchasing and setting up the facilities and processes to construct a modular building represents a large initial upfront investment; this can restrict the financial viability of undertaking smaller projects. Where there are few plants in a region that can manufacture a high volume of units, a buyer may find themselves facing limited alternatives, should something go wrong with a modular construction contract.

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## Financing and cashflow



Traditional construction methods have distinct phases and financing models are typically structured around these phases. With a modular project, the costs are typically incurred at the start

of the project as the design is finalised and the production capacity reserved. This necessitates different financing models and may result in potential challenges in cash flow. As a result, lenders may require additional security and costs may increase.

## Fire safety and building control



Fire safety is a major consideration for modular construction and in some regions where adoption is low, can cause issues with certification. The fundamental principles of fire safety must all be critically analysed at each stage from concept through design and manufacture to on-site assembly and completion. Fire testing of components and systems is a key part of demonstrating fire safety compliance of off-site construction technologies. The certification process is rigorous and typical costs and timeframes must be estimated and considered carefully.

## Proximity of suppliers



With off-site manufacturing, modules will need to be transported from the manufacturing location to site. Due to their weight and size, this can be a costly exercise and can be a barrier to adoption, if potential users of the approach cannot find a suitable supplier within easy travel distance from their site.

# Key drivers for choosing off-site manufacturing

During a detailed series of interviews and structured workshops that took place with a range of clients from different sectors and regions, including EMEA, Americas and APAC, we sought to understand and rank what was important to clients when evaluating the opportunity for using off-site techniques in their projects. Starting from the list of criteria that were defined in these workshops, a detailed tool to evaluate and screen a projects suitability for an OSM approach was developed. Clients acknowledged that business drivers vary for different types of projects in their sector, and as such, a number of typical project types were evaluated. These workshops identified eight key decision factors (plus health & safety) and their relative importance to clients in each sector.

The results are summarised below:

**Table 1 – Key client desired outcomes**

	Criteria	Definition	Measurement metric
	Schedule/Speed	Overall time taken to complete the project	Programme months, m <sup>2</sup> /week (concept to practical completion)
	Programme certainty	Certainty of construction programme that construction approach provides	Actual construction programme/ predicted construction programme, %
	Budgeted capital cost	Budgeted construction cost for the project	Total construction cost of building works, cost per metre
	Cost certainty	Certainty of cost that construction approach provides at an early stage	Final out-turn cost / initial budget cost, %
	Cost in use	Running cost when completed	Annual Opex, annual cost per metre
	Quality	Level of quality build approach can deliver beyond normal standard	Rework cost / Construction Cost, %. Emergent defects # per \$100k cost
	Adaptability	Ease of future change/ adaptation of use of building during its serviceable life	Cost to adapt as % original construction cost
	Design flexibility	Flexibility to accommodate design changes through the project	Time to design freeze, design programme overlap with on-site construction as % on-site programme
	Health & Safety	Certainty of programme that construction approach provides	Accident rate per 100,000 person-hours

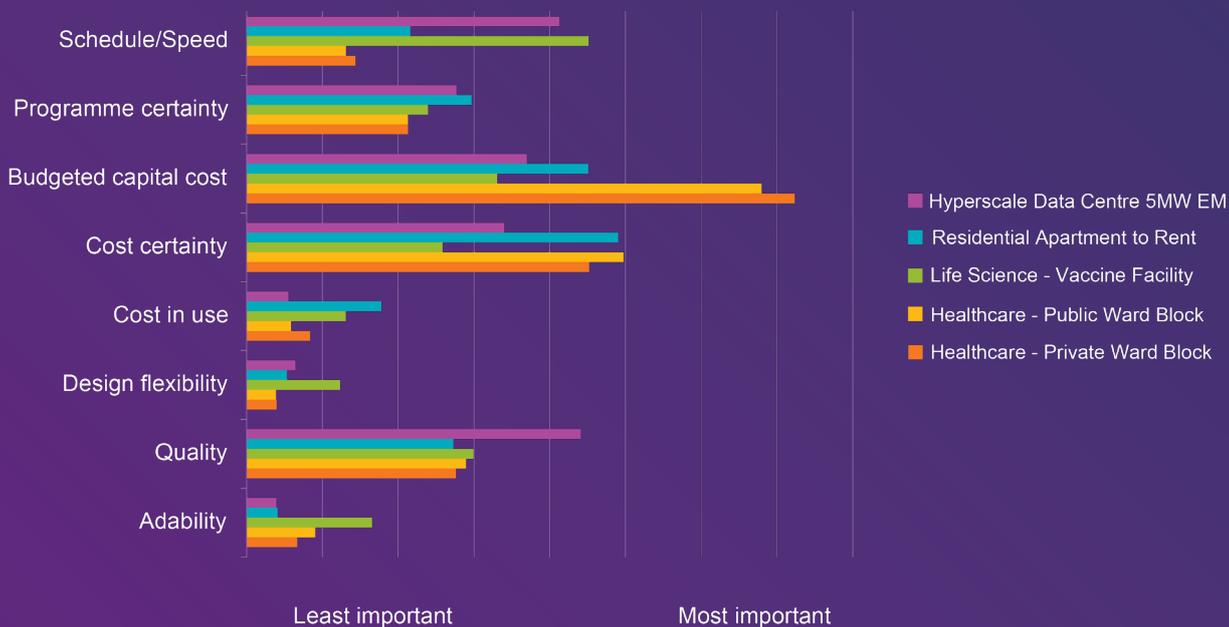
<sup>10</sup> Residential – 100 apartment build to rent building. Life Science – Vaccine production facility. Datacentre – 5MW facility. Healthcare – Hospital ward block.

# Ranking key criteria across sectors

Each criteria was assessed across the following key sectors to establish whether there was a difference in relative importance across sectors including: Data Centres, Life sciences, Residential and Healthcare

The relative importance of each desired outcome across the four sectors is summarised in Figure 1. Clients indicated that the requirement for early cost certainty is important across all sectors. Quality delivered by the construction approach is of most importance for data centre clients with design process flexibility being most important for healthcare clients where the need to allow a design to evolve is key. Budget cost is key for residential clients given their business model and affordability imperative globally, with importance also attached to the running cost of the building. Where there is a need to forecast with certainty the opening date for a facility to assist operational planning completion certainty trumps overall duration. In the data centre and pharmaceutical sectors minimising overall project duration is key as accelerating time to market clearly improves overall ROI.

**Figure 1 – Relative importance of desired client outcomes in each sector**



Note: All Clients highlight quality as a top priority. The ranking above is in relation to relative importance of OSM

# Performance benchmarking for OSM against criteria

Interestingly, when performance metrics are applied across sectors, the differences become apparent. For some sectors such as life sciences, data centres and healthcare, there is strong alignment between the important decision-making criteria and the ability of OSM to deliver against these criteria.

and construction quality in general, it performs less well in design process flexibility, adaptable building and minimizing construction costs. The importance of these criteria for the project in hand, will influence the decision whether to choose off-site manufacturing.

In the following table, we can see that while off-site manufacturing performs well on schedule, delivery date certainty, cost in use

**Figure 2 – Suitability of construction approach to deliver desired client outcomes**



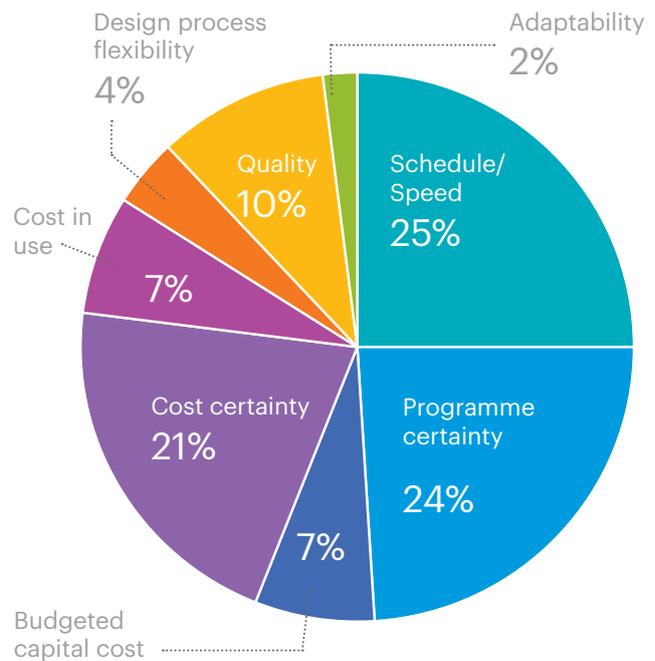
When we look at sectors in more detail, it is clear that there are sectoral trends showing a difference in the ranking of criteria, resulting in different adoption rates for off-site manufacturing.

# Data centres

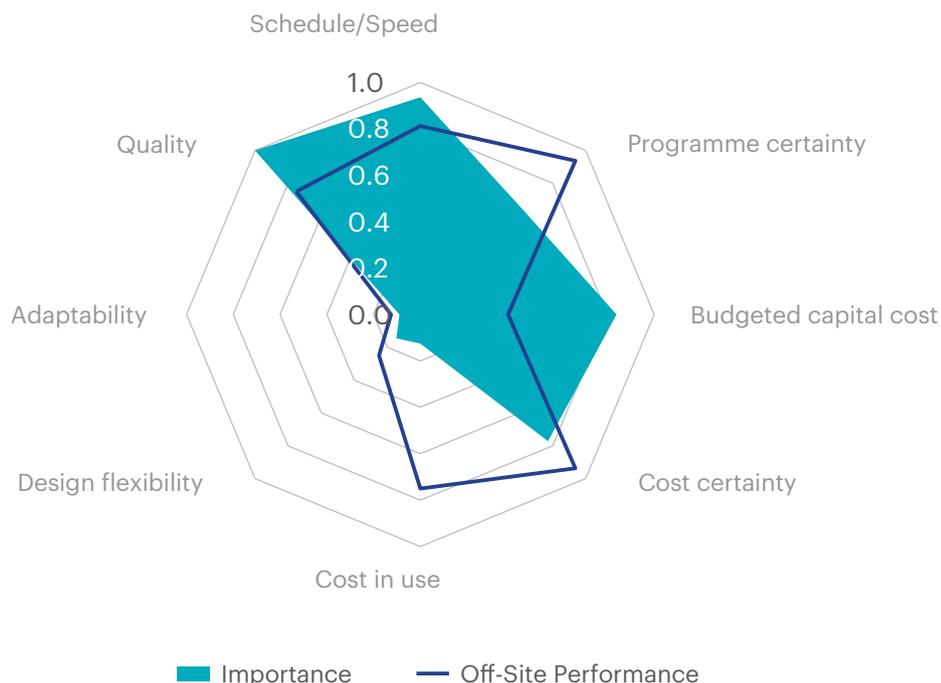
Speed is proving to be a key driver towards modular, in some countries. The sector's focus is on financial return, so the requirement is to be operating as soon as possible, with standardised and repeatable designs. OSM provides a flexible, scalable and efficient solution that can be pre-engineered, pre-fabricated, pre-tested and pre-validated. However, low labour costs in some countries make traditional builds still viable, so a hybrid, country-by-country approach is taken by most companies. On paper, clients acknowledge that the cost per sq. m./sq ft. will be pretty similar between the traditional and off-site approach but they also need to take account of the significant risk elimination from less congested sites, more controlled production environments and improved health and safety risk.

For data centre clients, the most important criteria effecting choice of construction methods are schedule speed, certainty of completion date, early cost certainty and quality of production.

**Figure 3 – Importance of project outcomes for data centre clients – 5MW data centre project**



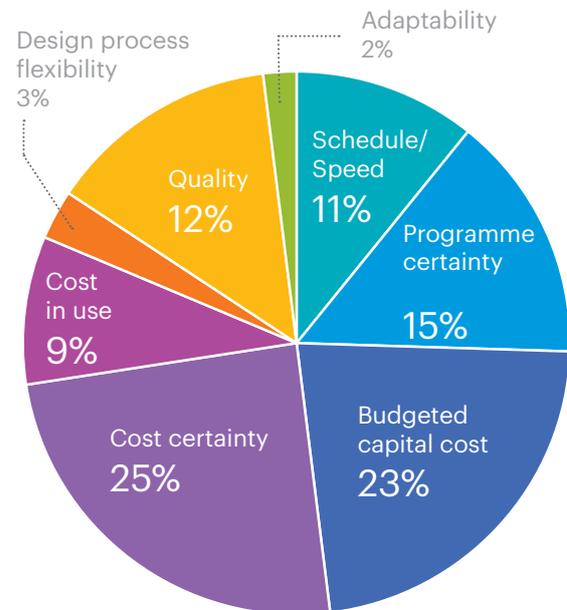
**Figure 4 – Performance of off-site construction in meeting client objectives on a 5MW data centre project**



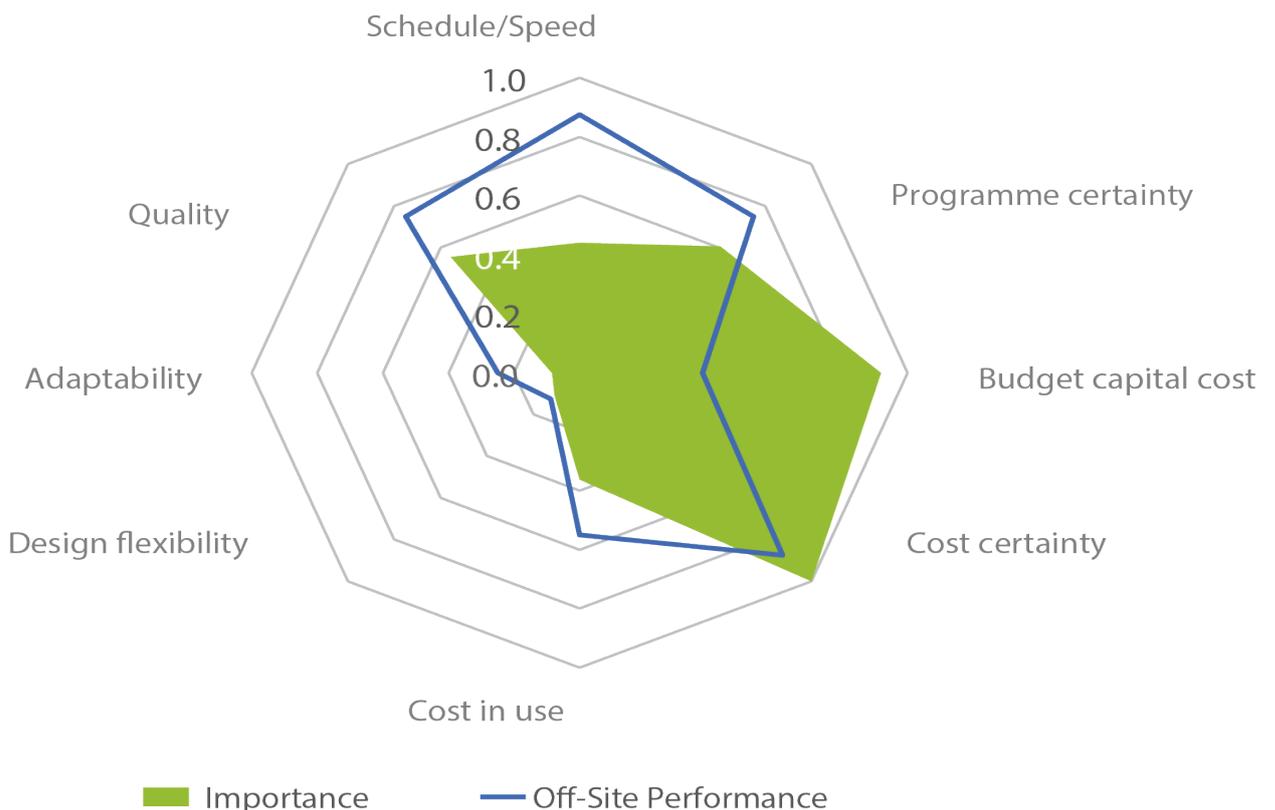
# Residential

Where there is a high volume of repeatable / standardised apartments and retained ownership, there is often a preference for OSM. In addition, areas / regions / nations with a strong demand for housing, a relatively weak supply of residential properties and high labour costs in construction will also tend to steer towards modular. Given the business model of clients in the sector, the importance of initial construction cost and knowing accurate out-turn costs up front, was indicated to be critical. Certainty of completion date for a rental product and short programmes were important given a client's need to get tenants in place as soon as possible, with cost in use reflecting retained ownership. The importance of key criteria can vary depending on the ownership model. For example, a house-builder can place high emphasis on cost base, but less on programme due to a consistent pipeline and a requirement to phase units to market. On the other hand, a build-to-rent developer can place much greater emphasis on bringing units to market quickly.

**Figure 5 – Importance of project outcomes for residential clients – 100 apartments for rent**



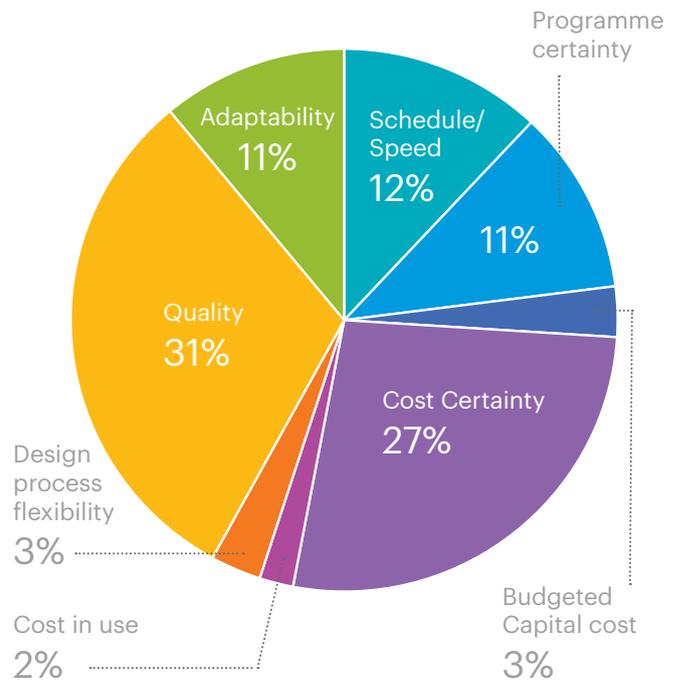
**Figure 6 – Performance of off-site construction in meeting client objectives on 100 apartment rental project**



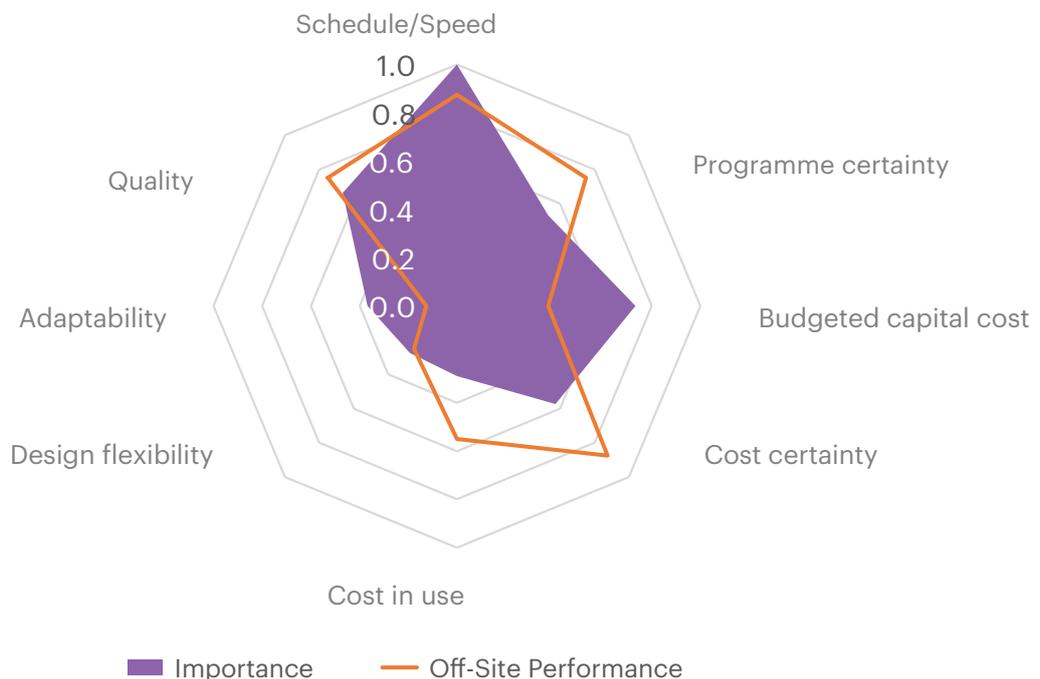
# Life Sciences

Pharmaceutical companies face challenges in developing and mass producing new products, requiring a rapid build-up of manufacturing capacity, making schedule/speed a critical decision driver. Modular provides standardised, turnkey solutions and high quality modules. While overall cost has some importance, an accurate up-front estimate, which allows clarity around the investment decision is seen to be highly important – unnecessary surprises can be minimised, resulting in more reliable budgets. With highly regulated operational sites OSM offers significant advantage around testing and troubleshooting enabling risk mitigation and time saving on-site.

**Figure 7 – Importance of project outcomes for life science clients – vaccine manufacturing facility**



**Figure 8 – Performance of off-site construction in meeting client objectives on vaccine manufacturing facility project**



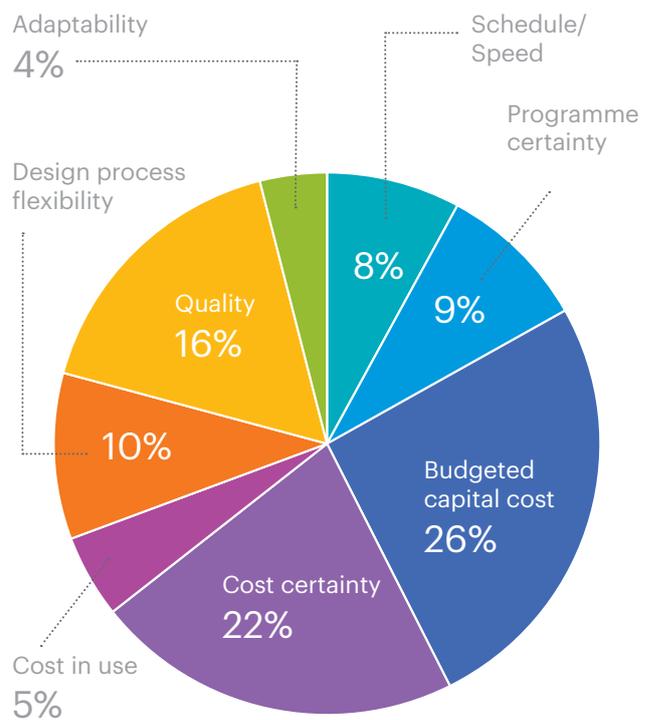
# Healthcare

Healthcare projects are characterised by a need to deliver services as soon as possible. Within live operating environments, traditional building methods can cause disruption, usually due to noise, dust and litter and the added danger of aspergilliosis. Project approaches that deliver speed to service and minimise time and disruption on-site are preferred.

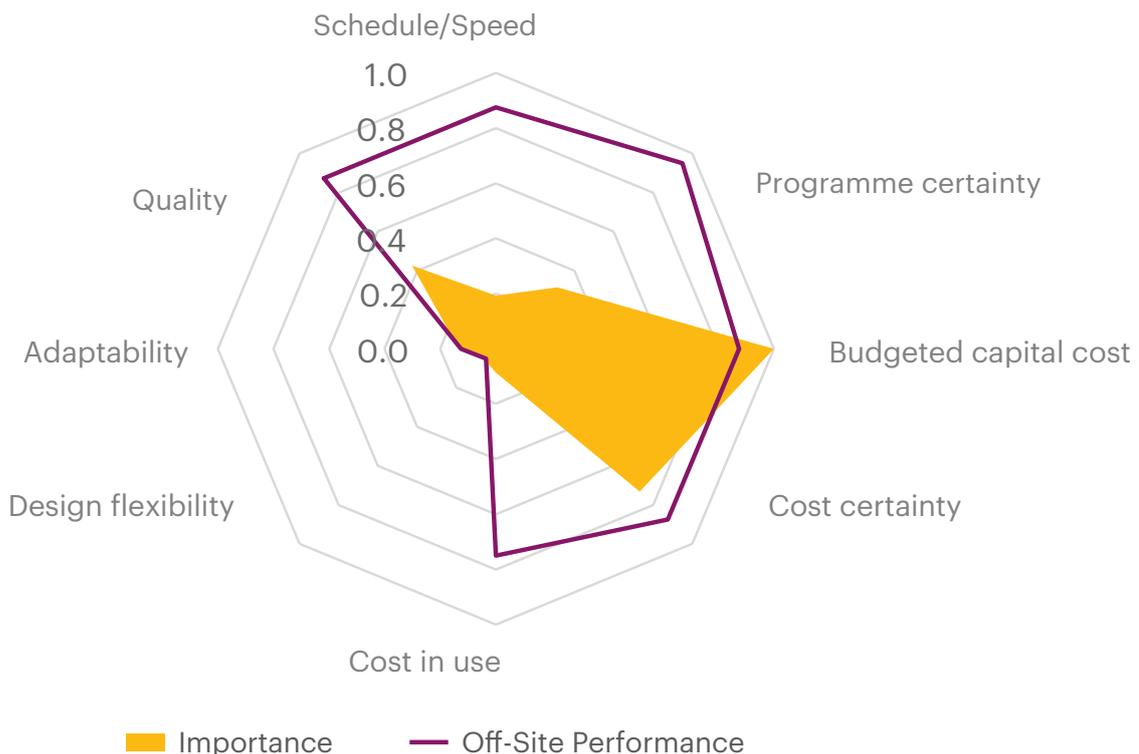
## Healthcare (Public)

Public procurement in some countries may create an obligation to accept lowest cost, rather than best value. So, programme delivery and disruption to operations are not taken into account. This enhances the importance to a client of budgeted cost when deciding which approach to take. The cost of OSM as compared with traditional methods varies by country, so the adoption of modular also varies as a consequence.

**Figure 9 – Importance of project outcomes for healthcare clients – hospital ward block**



**Figure 10 – Performance of off-site manufacturing in meeting client objectives on hospital ward block project**



# Summary of output

The consolidated output from the regional and sectoral workshops that took place is summarised in numerical format in the following tables.

**Table 3 – Comparison of relative importance of client project objectives for each sector**

Relative importance of desired outcomes	 <b>Life Science Vaccine Facility</b>	 <b>Hyperscale Data Centre 5MW EMEA</b>	 <b>Residential Apartment to Rent</b>	 <b>Healthcare - Public Ward Block</b>	 <b>Healthcare - Private Ward Block</b>
Schedule/Speed	22.6%	20.6%	10.8%	6.6%	7.2%
Programme certainty	12.0%	13.9%	14.9%	10.7%	10.7%
Budget capital costs	16.5%	18.5%	22.5%	34%	36.2%
Cost certainty	12.9%	17.0%	24.5%	24.8%	22.6%
Cost in use	6.5%	2.8%	8.9%	2.9%	4.2%
Design process flexibility	6.2%	3.2%	2.7%	2%	2%
Quality	15%	22%	13.6%	14.5%	13.8%
Adaptability	8.3%	2%	2.1%	4.5%	3.3%

**Table 4 – Performance of off-site construction approach in meeting client project objectives (1.00 = good, 0.00 = poor)**

Off-Site Construction Performance	 <b>Life Science Vaccine Facility</b>	 <b>Hyperscale Data Centre 5MW EMEA</b>	 <b>Residential Apartment to Rent</b>	 <b>Healthcare - Public Ward Block</b>	 <b>Healthcare - Private Ward Block</b>
Schedule/Speed	0.88	0.81	0.88	0.88	0.88
Programme certainty	0.75	0.94	0.75	0.95	0.88
Budgeted capital cost	0.38	0.38	0.38	0.88	0.88
Cost certainty	0.88	0.94	0.88	0.88	0.88
Cost in use	0.55	0.75	0.55	0.75	0.75
Design process flexibility	0.25	0.25	0.13	0.05	0.05
Quality	0.75	0.75	0.75	0.88	0.88
Adaptability	0.13	0.13	0.25	0.13	0.13

(1.00 = good, 0.00 = poor)



# Conclusion

It is clear that the decision to choose off-site manufacturing or traditional methods of construction is highly complex and dependent on the sector clients are operating in, the organisation's priorities, availability of competent suppliers in market, labour and regional infrastructure.

Industry sectors have evolved at a different pace, depending on their priority drivers. This report shows that clients in sectors such as life sciences and data centres have evolved quicker in their adoption of modular construction based on their need for early cost certainty, completion date certainty and quality. As demand for residential output increases in many regions, the appeal of repeatable design and fast programme makes modular an attractive choice, however up-front CAPEX can be higher. Healthcare will require positive government support to improve adoption

as the sector is restricted by the current public procurement restrictions requiring a focus on cost rather than overall value.

When considering whether to include off-site manufacturing as part of a construction development, clients need to consider a range of factors that will enable them to make an informed choice based on the market they operate in and the particular factors that are important for their industry sector and organisational requirements.

Linesight can assist clients to make an informed decision based on ranking the relative importance of desired outcomes. Our team of experts are available to assist in this decision-making process.



# Acknowledgments

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We wish to acknowledge and credit the following contributors:



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