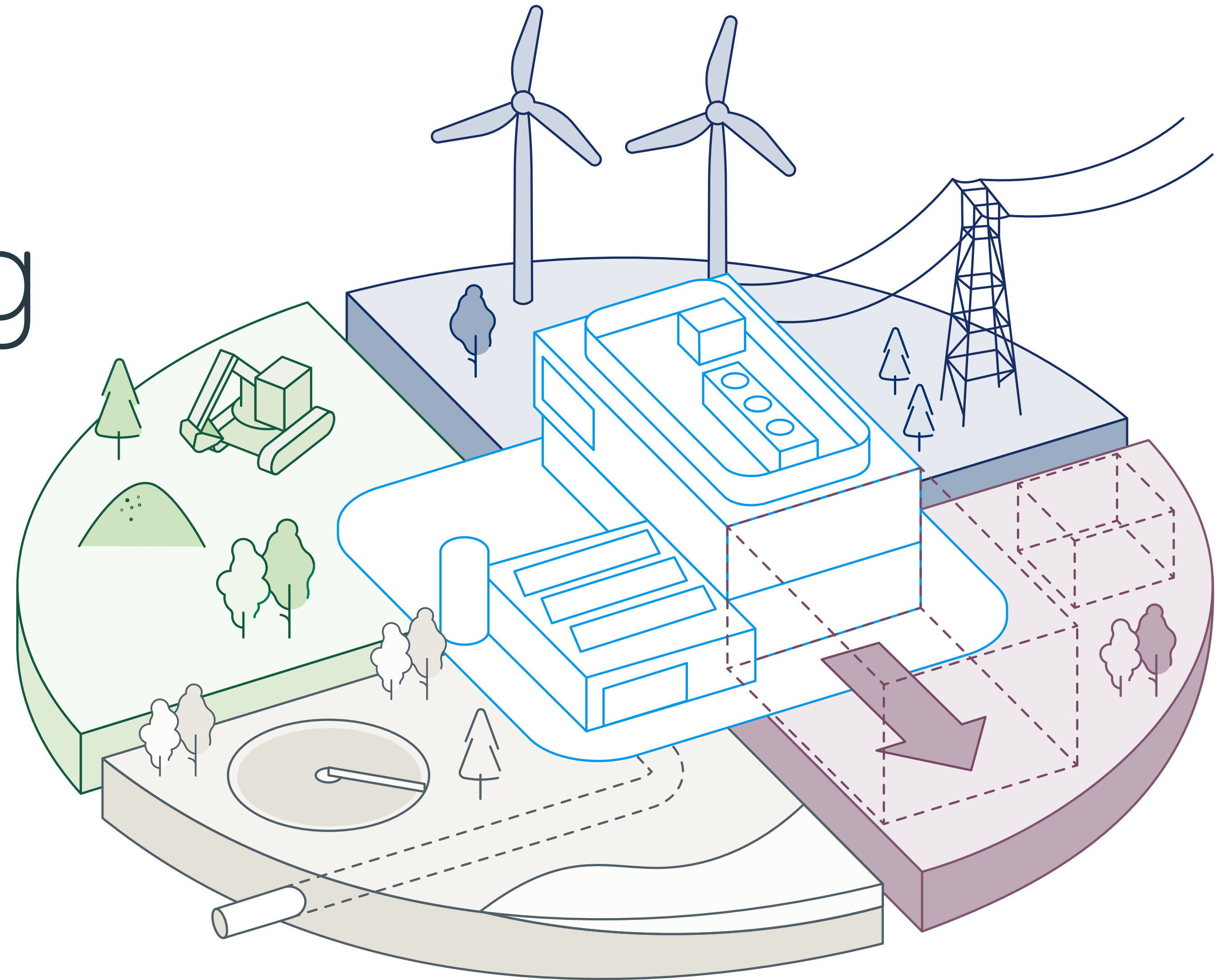


Behind every breakthrough

Future-proofing your life science site

A practical guide to what it takes to keep
your life science and pharma facilities
resilient and competitive



Foreword

When planning to build or expand your life science manufacturing facility, read this before the site is chosen, the grid and water connections are secured, and the construction plans are fixed. That is the point of this guide.

Production plants can take years to plan, build, and bring into operation. Once the final ready-to-execute decisions are made, they are difficult to undo. Some of them will determine what the site can and cannot do ten or fifteen years from now.

That is when early planning decisions start to show their true cost. A facility may be planned for one kind of product, one demand forecast, and one energy setup. Then circumstances change. Demand rises. Demand falls. A new product brings different requirements. The grid cannot deliver enough power. Water treatment and discharge become more regulated than expected. A site needs to expand, and there is insufficient space to develop.

None of this is theoretical. You may even recognise most of these challenges. And if you do, you are far from alone. These are the kinds of problems that appear when early decisions are made too narrowly, even with the best intentions.

For life science companies, production site development planning has become much harder than it used to be. Yes, speed still

matters. Cost still matters. Compliance still matters. But the facility also has to keep working when the assumptions behind it start to change.

That is why this guide focuses on four key decisions that carry long-term consequences: where to locate, how to secure energy, how to manage water, and how to design operations that can adapt to evolving needs.

At Ramboll, we see these factors coming together across the projects we support for some of the world's largest life science organisations. Working across site selection, energy, water, cleanroom design, permitting and implementation, and across diverse regulatory, energy and economic contexts, we bring a broad perspective to complex investment decisions. This experience helps us understand how decisions in one area can create risks and costly consequences in another, and how to navigate these interdependencies from the outset. That perspective is at the core of what you are about to read.

A future-fit life science facility needs to work as one connected system. Choices about site configuration, utilities, cleanrooms and digital infrastructure are interdependent and therefore should be considered together as they collectively influence the facility's efficiency, resilience, and ability to adapt.

This guide is written for project owners, investors, site leaders, engineers, and sustainability teams who need to ask the right questions before the most important choices are locked in. For

investors and capital decision-makers, it also points to the issues that deserve priority before major capital is committed. Because in facility planning, the most expensive question is often the one that arrives too late.



Anders Hummer

Global Life Sciences and Pharma
Sector Lead Director



Bjarne J. Rasmussen

Global Service Line Director,
Life Sciences & Pharma

Executive brief

What is suddenly making life science facilities harder to plan?

A life science manufacturing facility is planned before the future is known. That has always been true. The problem is that the gap between the planning reality and the operating reality is getting wider.

A facility planned today may take years to design, build, and bring into operation. By the time production lines start running, demand may have changed. Regulation may have tightened. Grid access may be harder to secure. The product mix may look different from the one behind the original business case. That is why facility planning must look further ahead.

If decisions around the site design, utilities strategy, cleanroom concept, digital infrastructure, or building layout are made too narrowly, the facility can live with the consequences for many years.

Many of these risks are not unique to one project. They are patterns that recur across complex life science facility programmes: assumptions fixed too early, interface risks discovered too late, utilities scoped for the first production phase

rather than future demand, and compliance or permitting issues underestimated. This is where experienced project delivery partners can add value. By bringing lessons from comparable projects, they help client teams test assumptions, apply best practice, identify risks across disciplines, and make better decisions before cost and schedule pressure start building.

Below are some of the main reasons that planning has become more challenging in recent years, which form the basis for the four areas this guide explores where early choices can protect future options: site selection, energy strategy and resilience, water management, and planning and designing for future-fit operations.



1. The decisions last longer than the assumptions behind them

A new pharmaceutical manufacturing facility can cost up to USD 2 billion and take five to ten years before it is operational¹. That is the first reason to take planning seriously.

A facility is often designed around a business case that makes sense today: a product, a forecast, a timeline, a budget, a site option, and a set of technical assumptions.

Then time passes and conditions change. Demand rises or falls faster than expected. A new product needs different process conditions. The company needs to decarbonise faster. Wastewater discharge limits become tougher. The site needs to expand, but the space, utilities, or permits are not in place.

And that is when the consequences of all those early decisions become real. **The question is therefore simple: Will this facility still work when the business no longer looks exactly like it does today?**

2. The building can be finished but still not be ready

Life science and pharma projects are under pressure from the beginning. Speed matters. Cost matters. Every delay can affect market access, supply, revenue, and patients. But speed without enough early clarity can become very expensive. One analysis of large pharmaceutical construction projects above USD 100 million found that 70 percent finished over budget, by an average

of 15 percent, with a typical delay of four months². Among the projects that exceeded budget, 90 percent of the overrun occurred in process equipment, clean utilities, and mechanical, electrical, and plumbing systems.

The pressure is therefore often in the systems that make a facility function and should not be treated as details at the end of a project. They are the difference between a building and a manufacturing facility.

The same industry analysis reveals that 70% of large pharmaceutical construction projects finished over budget. For project owners and capital decision makers, one implication is that the most expensive problems often appear late, even though their causes were created much earlier.

The practical lesson is clear: the earlier the operating reality is tested, the more room there is to make good decisions.

3. The power grid may not move at life sciences speed

Energy used to be treated as something that could be solved as the project moved forward. That is becoming a dangerous assumption.

More than 2,500 GW of renewable, large-load, and storage projects are currently waiting in grid connection queues worldwide³. New grid infrastructure can take five to fifteen years to plan, permit, and commission. A life science facility cannot

simply assume that the power will be there when the business needs it.

Manufacturing sites need reliable energy from day one. Many also need to electrify, decarbonise, add backup capacity, prepare for future production, and support more energy-intensive equipment. All of that can turn grid access into a serious project risk.

It can affect which site is viable, when the facility can open, whether expansion is possible, and whether the site can support the next production phase. **The right question is therefore: can we power the site we may need in ten years?**

4. Water can stop a project even when there is water

Water has always mattered in life sciences manufacturing. It is used in production, cleaning, sterilisation, cooling, and product quality.

The risk is that companies sometimes look at water too narrowly. They ask whether the site can source enough water without adequately considering what happens to the water before, during, and after use.

Where does it come from? What quality is needed? Which streams can be separated? What has to be treated? What can be reused? What can be discharged? What permits are needed? What happens if regulations tighten? What happens if local infrastructure cannot take the load?

Under new EU wastewater rules, the pharmaceutical and cosmetics industries will be required to pay at least 80 percent of the cost of removing micropollutants from wastewater. This means that water is no longer only an operational input. It is also a permitting issue, a treatment issue, a cost issue, a compliance issue, and a reputational issue.

A facility may have access to water and still run into trouble if discharge capacity, sewer access, treatment requirements, or future regulations have been underestimated. For new sites, water risk belongs in site selection and master planning. For existing sites, it belongs in resilience planning.

The practical question is: can the site support a reliable water supply, treatment, and wastewater setup that meets both present and future needs?

5. Future-fit does not mean flexibility everywhere

Future-fit planning is often misunderstood. It is not about keeping every door open or designing for every possible future, which can become expensive very quickly. The real discipline is prioritisation.

Some decisions become difficult to change once they are made such as building dimensions, structural grids, shafts, utility corridors, site access, and the main cleanroom strategy. Other decisions can often be phased or adapted later: selected equipment, local utilities, secondary systems, modular fit-out,

digital tools, and some production configurations. That distinction matters for new facilities and existing assets.

For greenfield projects, the question is how to modernise, expand, decarbonise, or improve resilience without disrupting production or spending capital in the wrong places.

A low-cost decision can become expensive if it closes off future expansion. At the same time, capital can be wasted if invested in high specification solutions that incorporate flexibility where it will never be used.

The strongest facility planning protects the options that are most likely to matter. That is why the four areas in this guide should not be read as separate topics. Site selection, energy strategy, water management, and future-fit operations are connected decisions. Each one can either support the others or create constraints that become expensive later.

The following sections look at each decision in turn, with practical actions, project examples, and questions site teams can use before the most important choices are locked in.

Five signs your next facility development decision needs a second look



The site looks suitable, but grid capacity has not been fully tested against future production scenarios.



Water intake has been assessed, but discharge constraints are still unclear.



The building envelope is being fixed before process needs are fully understood.



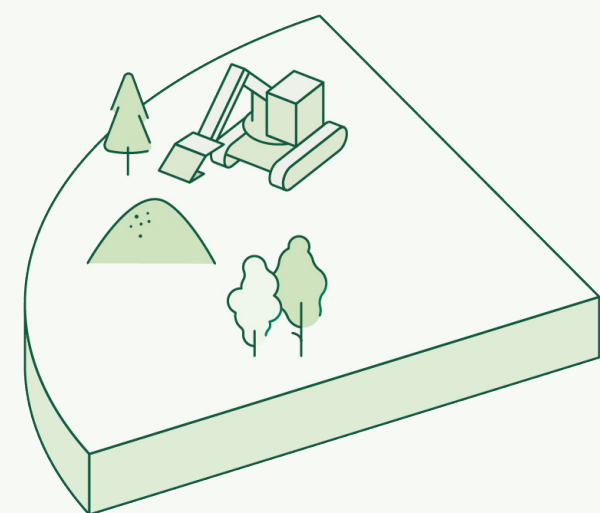
The CapEx case assumes one production scenario.



Expansion is planned, but utility routes, cleanrooms, shafts, and permitting paths have not been tested together.

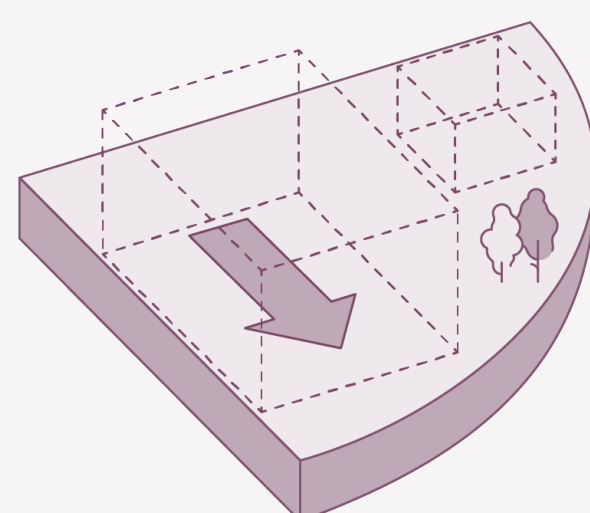
Life science facilities success factors

01



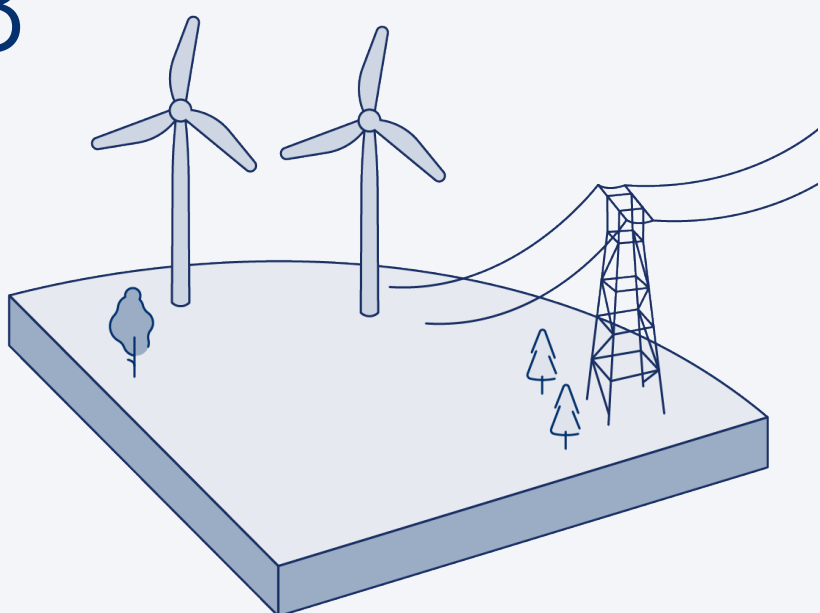
Site
selection

02



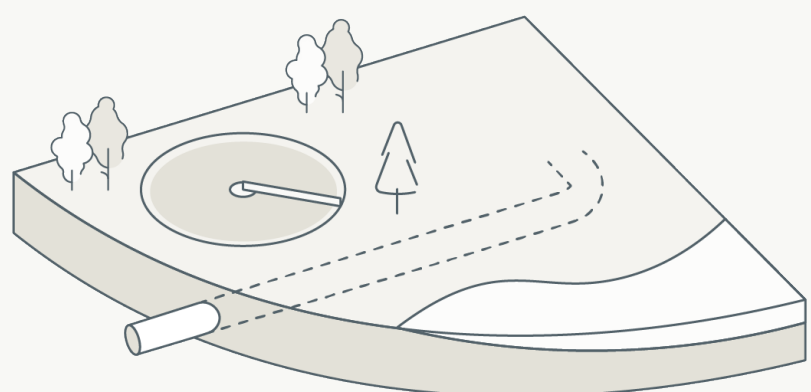
Future fit
design

03



Energy strategy
& resilience

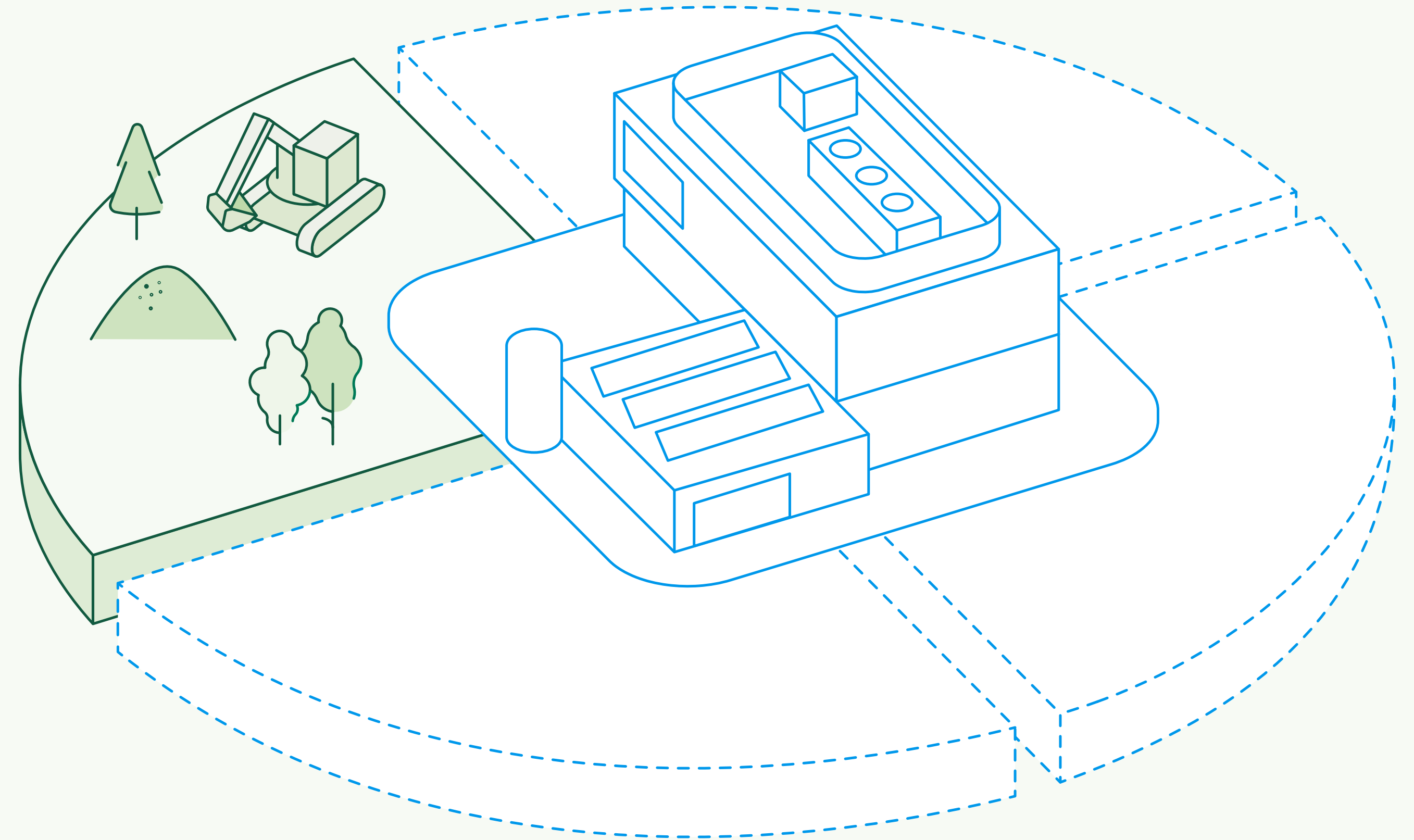
04



Water
management

Site selection

01



Site selection

Can this site still operate, expand, and secure access to utilities in ten years?

Poor site selection can create expensive constraints long after the land has been chosen.



Choosing a site is one of the first decisions in a life science facility project. It is also one of the hardest to undo.

A site may look right because the location is available, the business case is strong, and the first production phase can be accommodated. But the real test comes later. Can the site still support operations when demand changes, regulation tightens, and the next production line needs to be added?

This often requires difficult trade-offs. The site that supports the fastest delivery may not offer the greatest expansion flexibility. A location with attractive incentives may be subject to long-term utility constraints. A brownfield site can provide permitting certainty and workforce availability, while greenfield development may offer more freedom for future growth and decarbonisation.

For life science facilities, site selection used to be driven primarily by land availability, logistics, and cost. Today, access to utilities, regulatory predictability, and future expansion flexibility are increasingly becoming the decisive factors. It is also about understanding constraints that are often discovered too late: available electrical capacity, wastewater discharge limits, utility routing, zoning restrictions, climate exposure, security requirements, biodiversity considerations, and local stakeholder expectations.

A poor site decision can make later CapEx work harder than it should. It can force expensive upgrades, limit expansion, delay production, or make resilience measures more difficult to build in later.



Site selection should take its point of departure in a company’s strategy and needs and be aligned with its sustainability and biodiversity goals.



Martin Stener Breinholt
Senior Market Manager, Life Science & Pharma, Ramboll

The best site is not simply the one that works for the initial facility. It is the one that leaves enough room, capacity, and regulatory headroom for the facility the business may need later.

What a future fit site needs to prove

A future fit site should be tested against both current operations and credible future scenarios, which challenge assumptions about production growth, electrification, water demand, decarbonisation requirements, supply chain resilience, and changing regulatory expectations.

The objective is not to predict the future exactly, but to understand which constraints are most likely to limit future business options. This requires an integrated view of technical, regulatory, environmental, and social factors.

Technical considerations include grid capacity, future electrical demand, access to clean and black utilities, transport links, security, logistics, and the possibility of connecting to wider industrial systems. Increasingly, companies must also assess whether utility infrastructure can support future electrification, heat recovery, renewable energy integration, and production expansion without requiring major updates.

Regulatory and environmental considerations include zoning, permitting, water intake, wastewater discharge, hazardous materials, biosafety, emissions, climate risk, biodiversity, nature-based solutions, and compliance with Good Manufacturing

Practice (GMP) and other applicable requirements. Social considerations include early engagement with authorities, utilities, communities, and other stakeholders whose support may be needed to secure approvals and avoid delays.

Lesson learned:

Early site decisions should protect future options, not inhibit them. Site expansion may depend less on available space than on utility capacity and infrastructure integration.

 QUICK FACT

2,500 GW

More than 2,500GW of energy, storage, and large-load projects are currently waiting in grid connection queues worldwide, making access to electrical infrastructure a major factor in site selection (IEA).

 WHAT RAMBOLL SEES IN PROJECTS

What looks like a suitable site on paper can become constrained when grid capacity, wastewater discharge, zoning, utility routes, climate exposure, and expansion space are not assessed together.

Best practices for identifying the optimal site for pharma facilities



Geospatial analyses: Use advanced GIS tools to identify optimal locations for your life science facility.



Sustainability assessments: Evaluate environmental impacts and align with sustainability goals to ensure long term resilience.



Due diligence assessments: Conduct thorough evaluations covering environmental, social, power and technical aspects to inform decision-making.



Navigate compliance requirements: Understand local zoning regulations, permitting processes, and adherence to relevant environmental and regulatory standards.



Cost-benefit analyses: Analyse construction, operational, and energy expenses to determine the most cost-effective options.



Stakeholder engagement: Facilitate transparent communication and collaboration with local authorities and communities to secure approvals.



Key actions

- Test the site against future production, energy, water, decarbonisation, and expansion scenarios.
- Assess grid capacity, water availability, discharge constraints, climate exposure, zoning, biodiversity, and permitting early.
- Protect space for future utilities, production, logistics, technical infrastructure, and climate adaptation.
- Engage early with grid operators, water utilities, regulators, and local stakeholders.
- Use geospatial analysis, due diligence, and cost-benefit assessment to compare sites on long-term resilience, not only initial feasibility.

CASE STUDY

Identifying the real constraints on future expansion at a live pharma site

The following case shows why site-related decisions do not stop at the site boundary. Utility demand, cleanroom requirements, routing, compliance, and future production needs must all be understood early.

Challenge

A global pharmaceutical manufacturer needed to expand and existing production site with a new Wash & Sterilisation area to support two new filling lines. The project required GMP-compliant cleanrooms, HVAC, electrical systems, building utilities, clean utilities, black utilities, and integration with existing infrastructure.

The challenge was therefore not only whether the site had available building space. It was whether the existing utility infrastructure, routing, compliance requirements, cost assumptions, and operational continuity needs could support future production in a live pharmaceutical environment.

Action

Ramboll supported the early project phases by defining utility demand and infrastructure needs, qualifying the project basis, and developing the facility design.

The work included assessment of HVAC, building utilities, electrical loads, clean and black utilities, layout requirements, stakeholder input, sustainability goals, and future operational needs. The process brought technical disciplines together early so that utility capacity, cleanroom requirements, cost estimates, and integration with the existing site could be planned as one connected facility challenge.

Result

The work demonstrated that utility capacity and infrastructure integration, rather than available building space, were likely to become the primary constraints on future expansion.

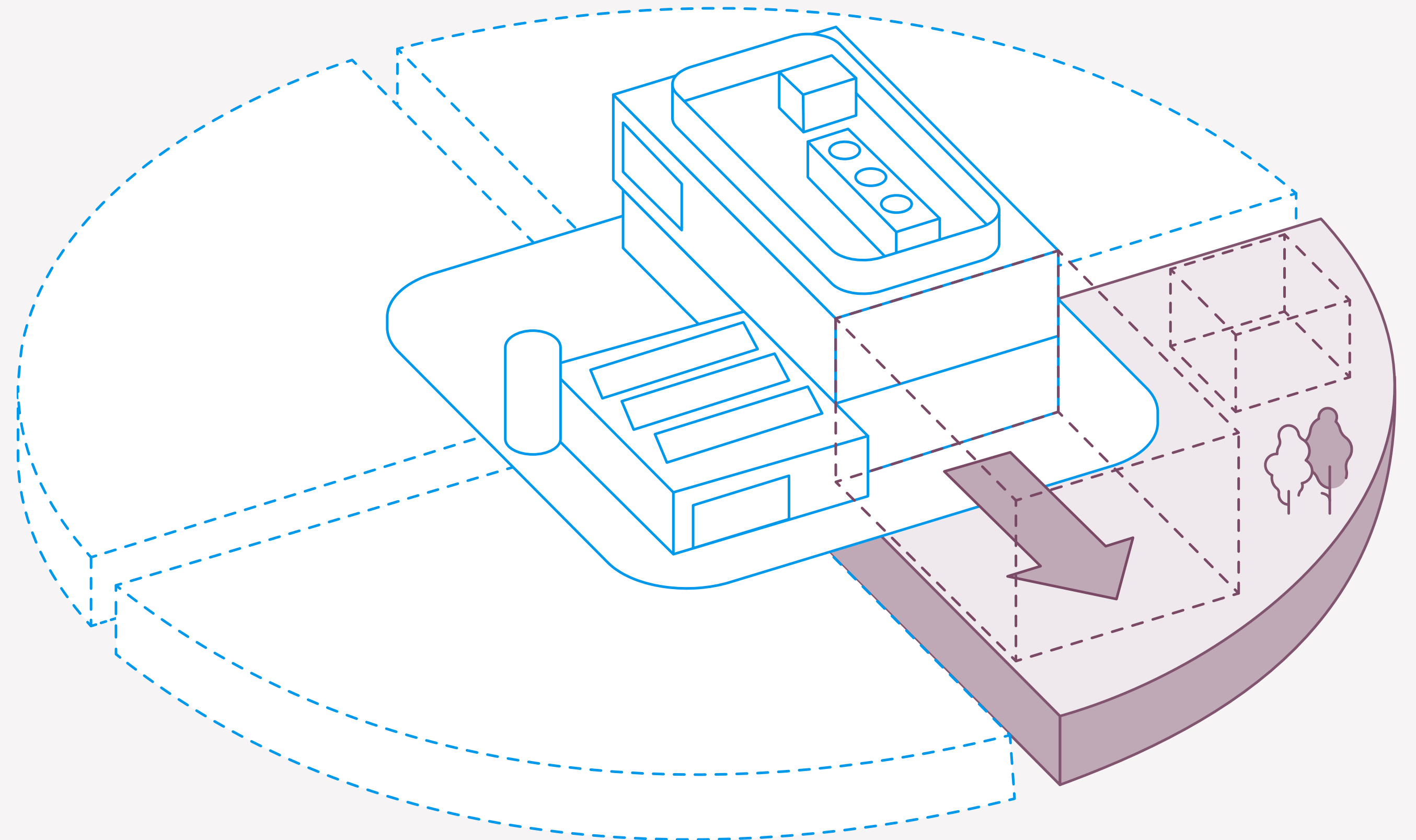
By identifying this before detailed design commenced, the project team could address these risks early and establish a stronger basis for detailed design, procurement, execution planning, and supervision.

The case shows why site-related decisions do not stop at the site boundary. For life science facilities, future expansion can depend as much on utilities, routing, cleanroom requirements, and infrastructure integration as it does on physical space.



Future fit design

02



Planning and designing for future-fit operations

Which decisions must be fixed early, and which options should stay open?

Flexibility is valuable only where it protects options the business is most likely to need.



Pharmaceutical facilities are often designed around a single demand forecast and a lead product. In practice, demand changes, product pipelines evolve, new production technology trends emerge, and regulatory requirements may be tightened before a facility is even operational. The result is a familiar pattern: late design changes, costly rework, and assets that are either constrained or underutilised from day one. Facilities take years to deliver, while the business moves much faster.

For capital projects, the risk goes both ways: a facility can become expensive because it is too rigid, but it can also waste capital if it builds flexibility where the business will never use it.

The core challenge is not poor design but planning in a context that keeps changing. When designing life sciences facilities, the production process normally defines the building envelope. In fast-track projects, however, parts of the building envelope may need to be fixed before every process requirement is fully defined and understood. That makes it critical to clarify overall scope strategies including GMP and production process strategies early and to build targeted flexibility into the elements that would be hardest to change later.

At the same time, certain elements cannot be altered down the line. Building dimensions, modularity, location of shafts and main routing, and the overall layout dispositions define the long-term flexibility of the facility. If these different building typologies are undersized or wrongly fixed too early, they might become permanent constraints instead of creating a future-fit facility.

! QUICK FACT

20% – 50%

Modular designs can cut the construction schedule for biopharmaceutical facilities by 20–50% compared with traditional methods ([Bioprocess Online](#))



WHAT RAMBOLL SEES IN PROJECTS

Flexibility becomes expensive when everything is designed to be adaptable. The value lies in knowing which decisions must be fixed early, which can be phased, and which future options must be protected.

Designing for flexibility, scalability, and control

Future-fit facilities are designed for change across products, capacities, and technologies. The aim is not to design for one expected peak scenario, but to protect the options that are most likely to matter later.

Instead of locking in a single configuration, companies define multiple demand and production scenarios and size the fixed elements for future needs, while keeping the rest of the facility flexible. Structural grids, ceiling heights, and primary utility corridors are designed with additional capacity to accommodate future expansion, while cleanroom fit-out, equipment, and secondary systems such as secondary piping, local utilities, and control systems are phased and modular.

Modular design and scalable utilities play a central role. Standardised production units, prefabricated systems, and expandable utility networks allow capacity to be added incrementally rather than through large, fixed investments. The same principles also support the growing trend towards replicating production concepts across sites, enabling more consistent operations and easier scaling within global manufacturing networks.

However, full replication is rarely possible, and 100 percent replication can introduce its own risks. Facilities must still adapt to local regulations, site conditions, utility constraints, workforce needs, and operational requirements.

At the same time, closed processing, supported by barrier technologies such as isolators and RABS (Restricted Access Barrier System), reduces dependence on stringent cleanroom environments and enables more flexible layouts.

Digital simulations are critical early in the process, before layouts are fixed, and changes become expensive. Modelling of flows, capacity, and operations helps ensure facilities are appropriately sized and avoid both underbuilt solutions and unnecessary excess capacity. Computational Fluid Dynamics (CFD) can be used to model and validate airflow, contamination control, and pressure cascades, while also enabling demand-controlled HVAC systems that reduce energy use without compromising compliance. 3D Virtual Reality or 1:1 mock-up testing of critical operational workflows, and the human factor interface supports the layout development process to secure safe and future-fit work environments.

The result is not maximum flexibility but targeted flexibility where it matters most whilst enabling facilities to evolve over time.

Lesson learned:

The most resilient facilities are not those designed for every possible future, but those that incorporate targeted flexibility where change is most likely and lock in only what cannot be changed later.



Key actions

- Define multiple demand and production scenarios and design for optionality rather than peak capacity
- Identify and fix only irreversible elements early, including layout, structural dimensions, and primary utility corridors
- Use modular design and scalable utilities to enable phased expansion and incremental capacity growth
- Apply simulation early to validate layouts, flows, and system performance before design is frozen
- Design facilities as adaptable systems that can accommodate future products, technologies, and regulatory changes

CASE STUDY

Designing future ready cleanrooms with system wide airflow modelling

Challenge

Future fit pharma manufacturing sites need cleanrooms that perform reliably under real operating conditions not just in static design scenarios. Traditional cleanroom design often focuses on individual rooms and fixed parameters such as air change rates or pressure cascades. In practice, however, cleanrooms behave as interconnected systems where doors opening, people moving, and changing pressure conditions continuously influence airflow and contamination control.

Action

In the Cellerator project at the Technical University of Denmark (DTU), Ramboll applied system wide Computational Fluid Dynamics (CFD) modelling to simulate how an entire cleanroom setup performs during real operational transitions. The modelling showed how airflow patterns, pressure responses, and human movement interact across the facility, which are insights that are difficult to capture using conventional design methods.

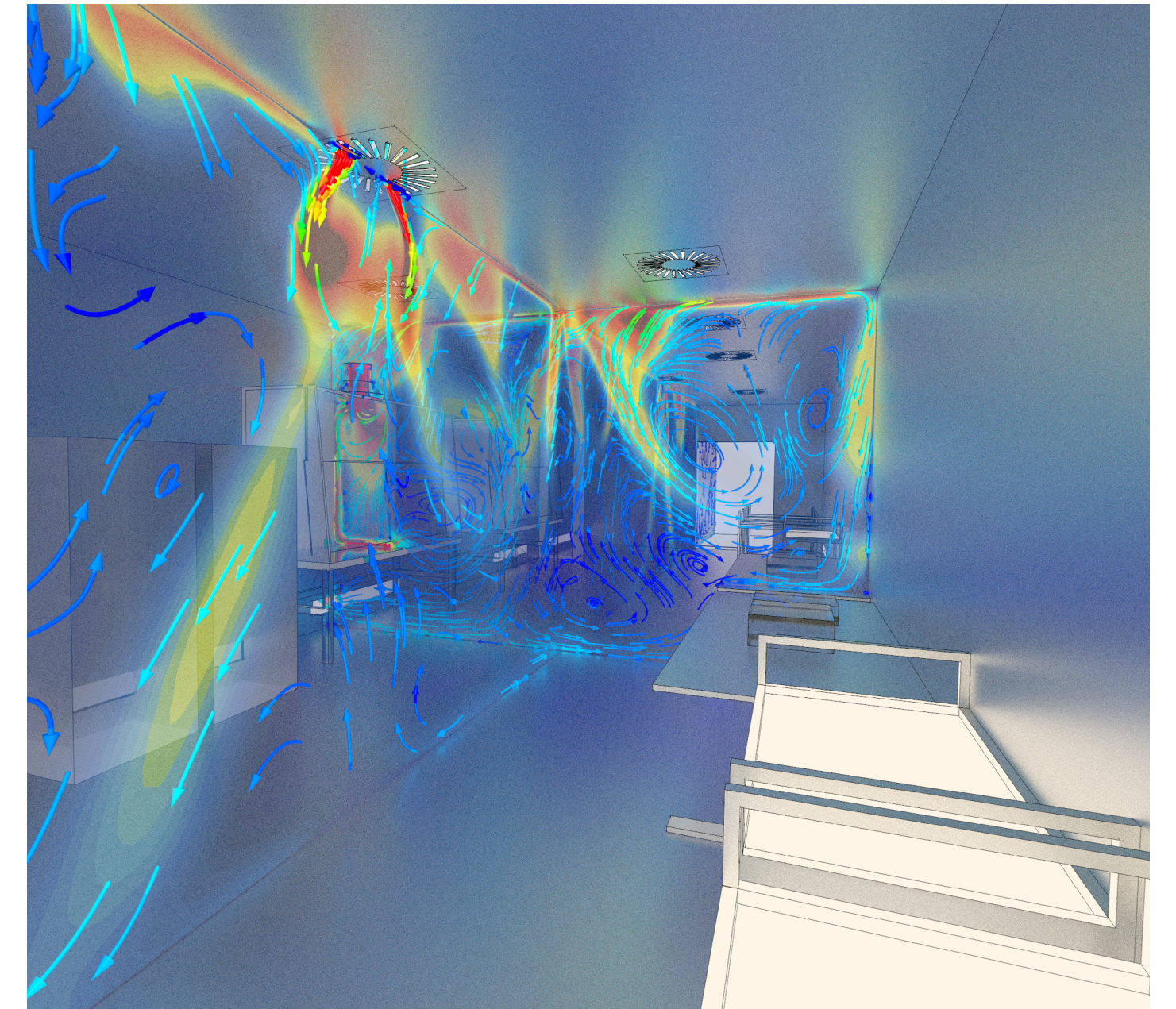
Result

The analysis demonstrated that increasing airflow alone does not necessarily improve performance. While higher air change rates reduced particle concentrations, excessive airflow also created turbulence and unnecessary energy use. By optimising airflow distribution and diffuser placement instead of simply increasing volumes, the design achieved better contamination control with lower energy demand.

The modelling also significantly reduced recovery times after disturbances, enabling faster movement of people and materials through the facility and improving operational efficiency.

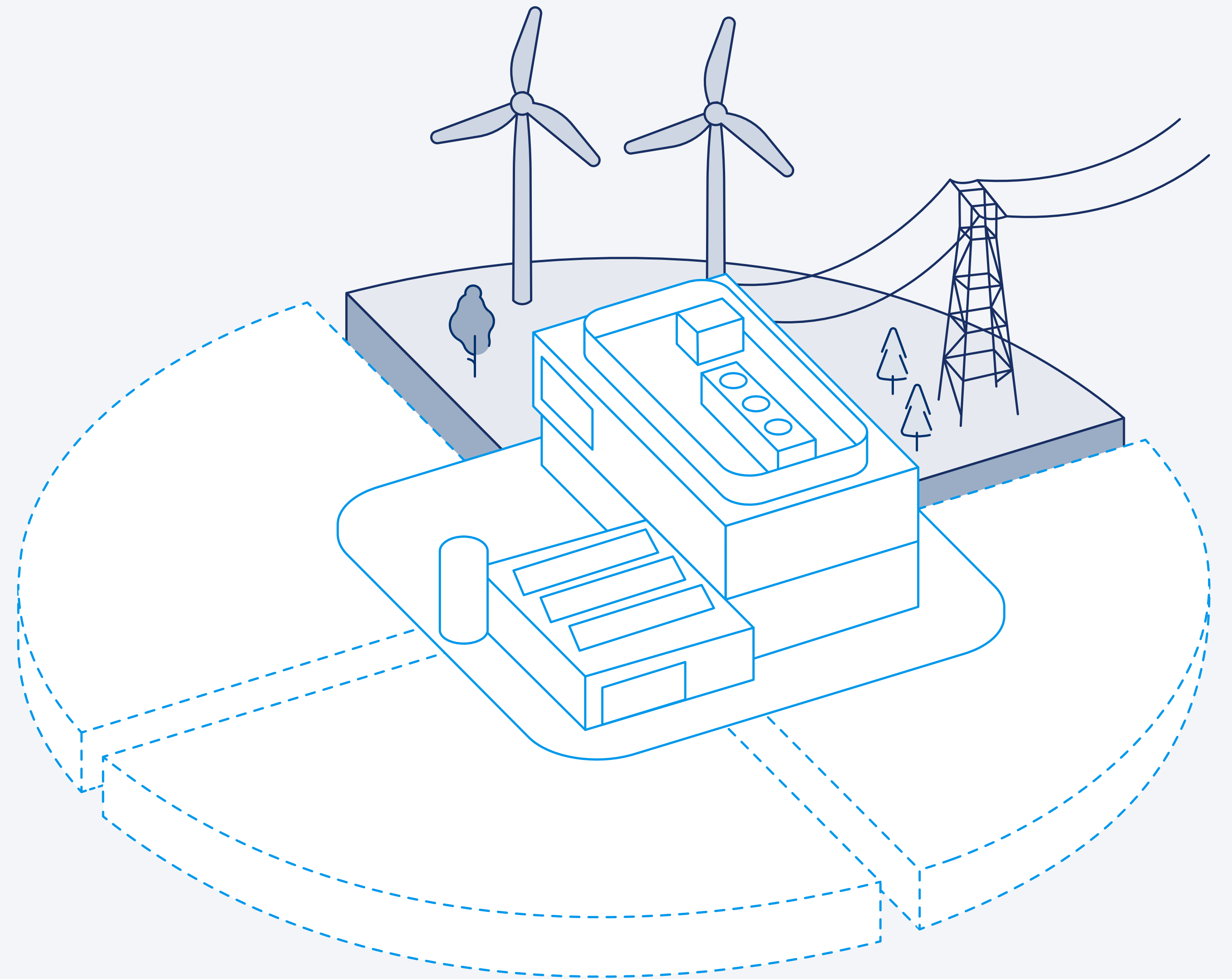
Most importantly, the system-level approach enables critical design decisions to be validated before construction. This helped reduce commissioning complexity, minimise the risk of costly late-stage modifications, and improve confidence that the facility would operate as intended from day one.

[Read more](#) 



Energy strategy and resilience

03



Energy strategy and resilience

Can the facility scale production without waiting for the grid to catch up?

Energy assumptions that look sufficient in phase one can become major cost and schedule risks when production expands.



Energy typically accounts for around 1% of pharmaceutical gross production value⁴ but is now becoming a critical consideration due to rising price volatility, security of supply risks, grid constraints, and decarbonisation pressures. This makes energy a strategic planning issue, not only an operational utility.

Life science manufacturing depends on continuous, reliable energy supply and energy has become a strategic risk, directly affecting production continuity, costs, and long-term resilience. It also presents an opportunity to enhance competitiveness and sustainability if the right solutions are implemented. These include improving energy efficiency to reduce consumption and costs, introducing flexibility to adapt to fluctuating demand or supply, and embedding redundancy to ensure backup capacity and mitigate disruptions.

Securing supply in an evolving energy system

Many facilities still rely on natural gas for process heat, but this dependency is increasingly under pressure due to geopolitical uncertainty and cost instability. This is driving the transition from gas to electrified systems where feasible. Electrification provides clear potential to address resilience and decarbonisation needs, but it also presents a new set of challenges.

Electricity use is best managed actively as both grid capacity constraints and the variability of renewable generation shape when and how electricity can be used. This means shifting

demand to periods with high renewable output and relying on storage or alternative (non-electric) supply when the system is constrained or prices are high.

Rapid expansion in production, together with electrification, can significantly increase electricity demand. This makes early planning critical and can require companies to invest in grid expansion, storage, or production behind the meter to fast-track implementation.

For capital projects, the risk is clear: an energy solution that looks sufficient for the first phase can become expensive if it limits expansion, delays electrification, or requires major upgrades later.

Lesson learned:

Energy infrastructure should be planned around future production, not only current needs.



Centralise energy production where it makes sense economically with a view to harvesting economy of scale whilst enabling cost-efficient storage and centralised redundancy options



Anna Ekdahl

Director for the Decarbonisation of Energy Intensive Industries
Ramboll

Expert view

Building resilience through integrated energy strategies

Anna Ekdahl, Ramboll's Director for the Decarbonisation of Energy Intensive Industries, explains how life science companies can embed energy resilience into manufacturing sites.

Best practices include mapping all options available for meeting energy demand and employing a hierarchical approach starting with the most impactful, feasible, and cost-effective solutions:

- Reduce overall energy demand through energy and resource efficiency measures and digitisation.
- Map energy uses on the site in relation to heating, cooling, and electricity use. Categorise them in high and low temperature levels and identify how they are connected.
- Focus on low hanging fruits, starting out with lower temperature energy uses.
- Recycle energy streams where possible, such as heat recovery from one part of the production process to another.
- Explore paths to supply energy needs using diverse strategies including sourcing from the grid, on-site production, energy storage, and procurement mechanisms such as Power Purchase Agreements (PPAs).
- Centralise energy production where it makes sense economically, with a view to harvesting economies of scale.



Key actions

- Assess current and future energy demand across production scenarios
- Engage early with grid operators on capacity and timelines
- Prioritise energy efficiency as a foundation
- Develop a diversified energy mix where possible, including grid supply, on-site production, and storage
- Build in appropriate redundancy for critical systems
- Consider phased investment and reuse of existing assets where this can reduce unnecessary CapEx without compromising resilience



! QUICK FACT

5-15 years

New grid infrastructure can take 5–15 years to plan, permit, and build, significantly longer than the typical development timeline for a pharmaceutical manufacturing facility.

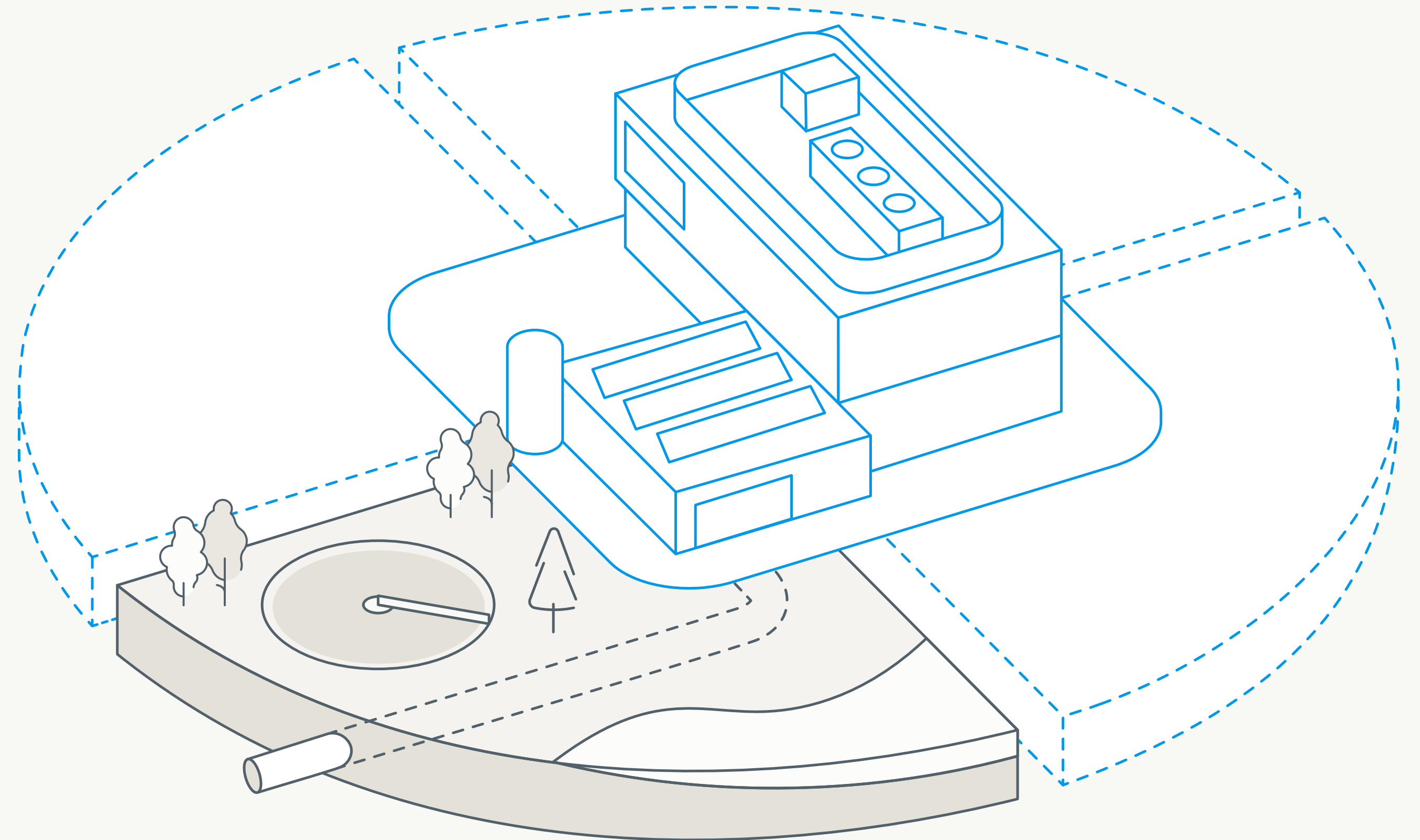


WHAT RAMBOLL SEES
IN PROJECTS

In fast growing life science projects, grid timing can become as important as construction timing. Energy resilience starts when future demand, site capacity, redundancy, decarbonisation, and phased investment are planned together.

Water management

04



Water management

Can the site support a reliable water supply, treatment, and wastewater setup that meets present and future needs?

Water risks often become expensive when intake, discharge, and permitting are assessed too late.



Life science facilities rely on consistent access to high-quality water across production, including API (Active Pharmaceutical Ingredient) synthesis, cleaning, sterilisation, and cooling. At the same time, water availability is becoming less predictable due to increasing scarcity and pressure on public supply systems.

In some cases, this is driving a change towards more closed and self-sufficient systems. Water is therefore not only a utility, but a critical factor in operational resilience.

A key risk is that water is often assessed too narrowly. Companies focus on supply but underestimate the regulatory and permitting requirements linked to both intake and discharge.

These requirements vary across countries and are becoming more stringent, particularly in Europe, where local authorities impose stricter conditions on wastewater and sewer access. If not addressed early, this can become a showstopper, delaying or even preventing operations.

For capital projects, the risk is that water constraints are discovered after site, layout, treatment, or capacity assumptions have already been fixed. That can force costly redesign, permit delays, or limits on future production.



Life science companies are increasingly implementing stricter in-house standards and exploring reuse and recycling to reduce water consumption, strengthen resilience, and accommodate future tightening of regulations.



Johann van Aartsen
Managing Consultant, Water & Wastewater Treatment,
Ramboll



Key actions

- Conduct a full water risk assessment covering supply, infrastructure, sewer systems, and regulatory requirements
- Secure permits early and assess discharge constraints alongside water intake
- Test wastewater streams and apply segregation to match treatment levels to actual contamination and compliance needs
- Design for future regulation by implementing stricter internal standards
- Assess opportunities for reuse and recycling to improve efficiency and resilience

Designing for control, compliance, and resilience

Wastewater is where challenges most often emerge. Pharmaceutical processes involve a wide range of chemicals and compounds, making treatment complex. Companies frequently underestimate contamination levels and are then forced to add treatment capacity late in the project. A more robust approach is to start early with a full water risk assessment covering supply sources, infrastructure, sewer systems, regulatory requirements, and operational risks.

Testing and segregation are critical. Rather than treating all wastewater equally, facilities should identify different wastewater streams and match treatment to actual composition, risk, and compliance requirements.

Lesson learned:

Addressing future water resilience requires a consistent way to compare site risks and prioritise investment across the manufacturing network.



QUICK FACT

40%

With global freshwater demand projected to exceed supply by 40% by 2030 ([The Guardian](#)), life science facilities are increasingly evaluating reuse, recycling, and alternative supply strategies to reduce dependence on external water systems.



WHAT RAMBOLL SEES IN PROJECTS

Water risks often appear late because supply, treatment, reuse, discharge, and permitting are handled separately. In reality, they together decide whether a site can operate, expand, and stay compliant.

CASE STUDY

Strengthening water resilience for a global healthcare manufacturer

Challenge

In close collaboration with a global healthcare manufacturer, Ramboll strengthened the client's water resilience by identifying site-level vulnerabilities and measures to support the continuity of critical, water-dependent production worldwide.

Reliable water supply is essential for life sciences manufacturers to ensure patient safety, regulatory compliance, and uninterrupted delivery of life-saving products. At the same time, production sites are increasingly exposed to water-related risks such as extreme weather, water scarcity, ageing infrastructure, and dependence on single water sources. For the client, understanding and preparing for these risks became a strategic priority.

Action

Ramboll partnered with the client to assess water-related risks across 21 production facilities in the Americas, Europe, and Asia Pacific, supporting the company's broader ESG strategy. Using the J-100 methodology from the American Water Works Association (AWWA), adapted for industrial operations, Ramboll conducted a structured resilience assessment focused on

operational continuity rather than traditional water efficiency audits. Following successful pilot assessments at two sites, the methodology was expanded globally.

Result

The assessments evaluated natural hazards, dependency and infrastructure threats, proximity risks, and malevolent threats, considering both likelihood and operational impact. Based on the findings, Ramboll developed site-specific mitigation measures, including infrastructure redundancy, enhanced security, diversified water supply strategies, and logistics resilience improvements.

The project provided the client with a clear, actionable pathway to secure reliable water, with mitigation measures already successfully implemented at several production sites. It also showed that addressing future water risks is not only a local site issue. For global manufacturers, it requires a consistent way to compare risks, prioritise investment, and protect critical production across the manufacturing network.

[Read more](#) 



Expert perspective

The decisions you cannot easily buy your way out of later

[Bjarke Møller Nielsen, Director in Pharma and Life Sciences at Ramboll with over 30 years of life sciences experience.](#)

When clients ask us what makes a life science facility future fit, my answer is usually quite simple: It's not one single brilliant decision. It's a set of early decisions that do not conflict with each other down the line.

That may sound obvious, but in real projects, it is often the hardest part.

A site can look just right until the next production phase needs more power. An energy strategy can look robust until electrification or expansion changes the load profile. A cleanroom concept can look safe until a new product changes the way people, materials, pressure, airflow, and utilities have to work together.

These are not separate problems. They are connected decisions. That is where many facility projects become difficult. Not because people failed to plan, but because decisions were made one discipline at a time. For example, site suitability did

not adequately consider power and water infrastructure. Utility systems were not fully aligned with manufacturing processes. Cleanrooms were optimised separately from energy performance.

At Ramboll, we work across the full facility journey: site selection, energy, water, cleanroom design, permitting, engineering, implementation, and optimisation. That matters because many of the most expensive risks do not belong to one discipline. They appear between disciplines.

For investors, product owners, and capital decision-makers, this is important. A life science facility investment does not only buy production capacity. It buys room to grow, utility certainty, regulatory headroom, operational resilience. And it buys the ability to keep producing when conditions change.

However, it should not buy flexibility everywhere. That is where prioritisation becomes critical. Some decisions must be made early because they become difficult, slow, or expensive to change later. Others can be phased, modularised, or adapted when the business need becomes clearer. The strongest facility planning understands the difference.

For a new site, that may mean protecting space, grid capacity, water routes, permitting options, and expansion logic before the first phase is built. For an existing facility, it may mean reusing assets where it makes sense, upgrading utilities without disrupting production, or avoiding investments that solve today's problem but create tomorrow's constraint.

Future fit planning is therefore not about spending more everywhere. It is about spending wisely where changes later would be costly, disruptive, or even impossible.

This guide is designed to help you ask those questions earlier. Before the site is chosen. Before the utility concept is fixed. Before the cleanroom strategy is set. And before the CapEx case is approved. Because once the facility has been mapped out on paper, some of the future has already been decided.



Bjarke Møller Nielsen
Pharma & Life Science
Director

CapEx

What to consider before capital is committed

A life science facility investment is more than a building decision. It determines how much flexibility, resilience, and opportunity the business retains as conditions change.

Can the site expand when the business needs it? Can the grid support the next production phase? Can water supply and discharge be secured under tighter conditions? Can the facility take a new kind of product, a new process, or a new regulatory requirement without forcing expensive workarounds? Can operations continue when something outside the fence changes?

These are core questions that decide whether a facility remains valuable after the initial business case has done its job.

That is why CapEx decisions in life sciences manufacturing need a different kind of discipline. Whether the project is a new facility, an expansion, or the modernisation of an existing asset, the CapEx question is the same: which decisions protect long-term value, and which could create constraints later?

The aim is not to solve every possible future issue on day one. That would be extremely expensive and most often quite unnecessary. The aim is to protect the choices that will be difficult, slow, or even impossible to recover later.

Some things are worth deciding early because they become hard to change: site access, expansion space, grid capacity, water intake and discharge, primary utility routes, structural dimensions, shafts, cleanroom strategy, and the main permitting path.

Other things may be better phased: selected equipment, secondary systems, modular fit-out, local utilities, digital tools, storage, and additional production capacity.

The strongest CapEx case understands the difference between what must be protected now and what can be phased later.

A low cost facility can become expensive if it leaves no room for future scenarios. The wrong decision can increase capital outlay, but it can also lock in higher operating cost for years.

That is where prioritisation begins. Before a major facility decision is approved, project owners, investors, site leaders, engineers, and sustainability teams should be able to answer twelve questions.



Twelve questions before you commit capital

- 01 Can this site still operate, expand, remain compliant, and secure the utilities it needs in ten years?
- 02 Have grid availability and resilience been tested against the highest credible future production scenario and critical production loads?
- 03 Are water supply, quality, treatment, and discharge constraints fully understood?
- 04 Which permitting, qualification, validation, or compliance requirements could delay construction, commissioning, or operation?
- 05 Which scope and design decisions become difficult to change once the building envelope and operating concept are fixed?
- 06 Which utilities and systems must be redundant from day one to protect product quality, compliance, and production continuity?
- 07 Which systems can be reused, phased, expanded, or modularised later without compromising quality, compliance, or resilience?
- 08 What happens if demand rises, falls, or the production mix changes significantly?
- 09 Have cost, scope, and quality been tested together before capital is committed?
- 10 What happens if the next product requires different process conditions, utilities, cleanroom requirements, or flows?
- 11 Have cleanroom requirements, operational flows, and GMP-critical conditions been tested before design freeze?
- 12 What could make this site difficult to operate, remain compliant, or adapt in ten years?

These questions do not remove uncertainty. They make it visible early enough to act on it. The future fit life science facility does not try to predict everything. It protects the right options, supports compliant operations, and gives the business room to move when reality changes.

In the end, the most important decisions may be the ones that still make sense years later, when the product mix has changed, regulations have tightened, the grid is under pressure, water is more contested, and the site must remain compliant while doing more than it was originally built for.

That is when early planning proves its worth. And that is why this guide ends where every major facility investment should begin: What should we decide now? What can we phase? Which future options must we protect before capital is committed?

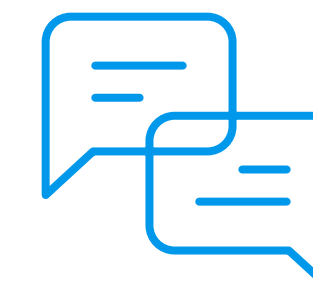
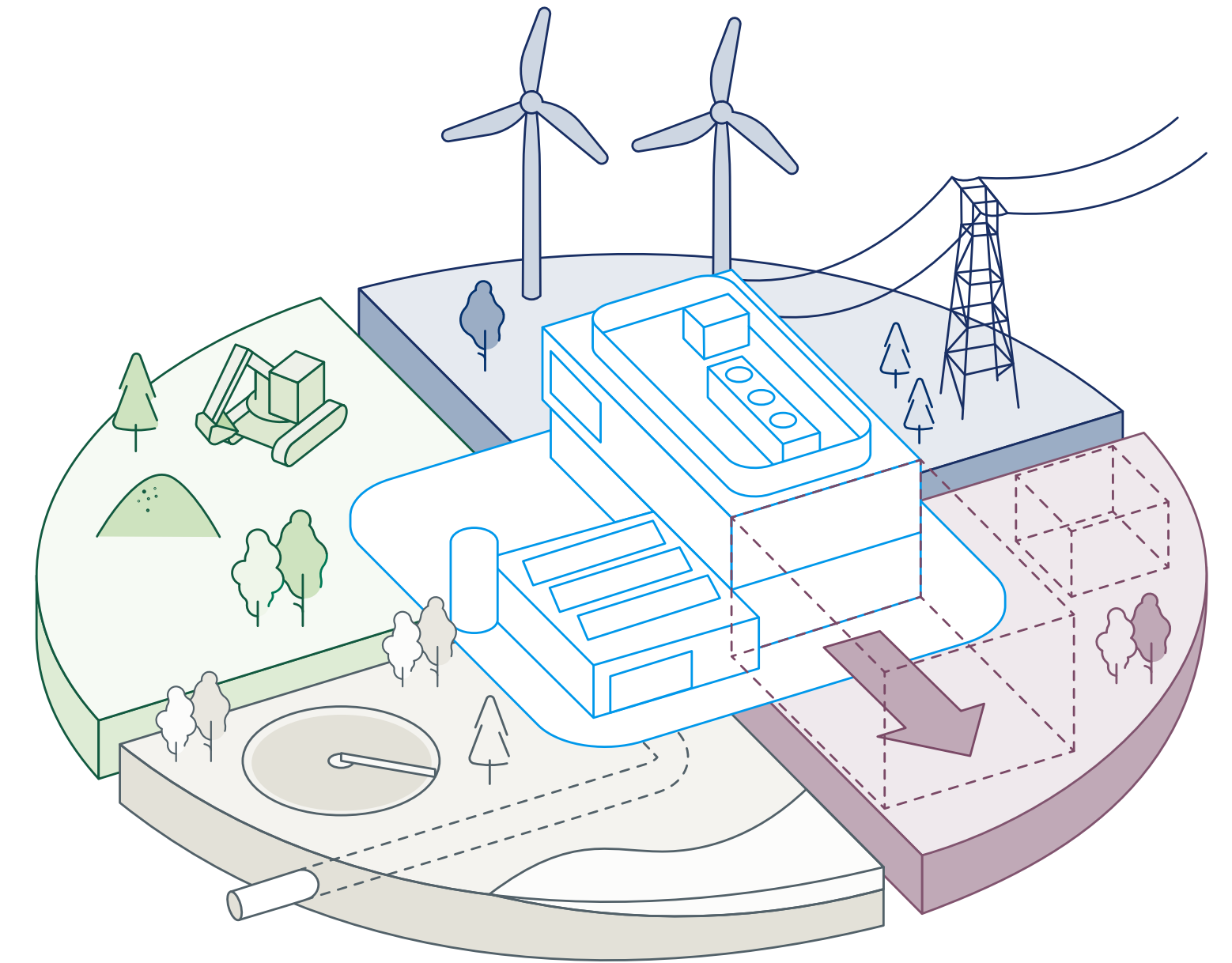
Answer those questions well, and CapEx becomes more than a cost decision. It becomes a way to balance cost, scope, and quality while protecting compliant production, resilience, competitiveness, and long-term value.

Ready to test your next site development decision?

The questions in this guide are designed to be used before major choices are locked in. Ramboll can help project owners, investors, site leaders, engineering teams, and sustainability teams test the assumptions behind a new facility, expansion, or existing asset upgrade.

A focused discussion can help clarify:

- whether the site can support future production, utilities, and permitting needs
- whether the energy strategy can support growth, resilience, and decarbonisation
- whether water intake, discharge, reuse, and treatment risks have been addressed early enough
- which facility decisions should be fixed now, phased later, or kept open
- whether the CapEx case protects long-term value or creates future constraints



Get in touch to discuss an early-stage facility review, an existing asset resilience review, or a CapEx decision workshop.

About Ramboll

For over 30 years, Ramboll has helped pharma and biopharma organisations develop advanced manufacturing sites that enhance market readiness and shorten time to market for new therapies. Working across the site lifecycle from planning through to design, delivery, and optimisation, Ramboll creates client value with advanced capabilities in engineering design, energy strategy, EPC and compliance management, digital services, and biodiversity advisory. Read more about our [Life Sciences and Pharma services](#).

Ramboll is a global architecture, engineering and consultancy company founded in Denmark in 1945. Ramboll’s more than 18,000 employees create sustainable solutions across Buildings, Transport, Architecture & Landscape, Water, Environment & Health, Energy, and Management Consulting. Across the world, Ramboll combines local experience with a global knowledge base to create sustainable societies. Read more on [ramboll.com](#)

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Get in touch



Anders Hummer

Global Life Sciences and Pharma
Sector Lead Director
anhu@ramboll.dk
+45 60 36 17 67



Bjarne J. Rasmussen

Global Service Line Director
Life Sciences & Pharma
bra@ramboll.dk
+45 51 61 64 64



Matt Foste

Americas Director,
Strategy & Growth
mfoste@ramboll.com



Anna Ekdahl

Business Development Director
aekl@ramboll.com
+45 51 61 37 41



Thomas Nowlan

Regional Director, US
thomas.nowlan@ramboll.com
+1 484-804-7213



Redding Thompson

Pharmaceutical Sector Lead
redding.thompson@ramboll.co.uk
+44 7890 659365

For more information please visit
ramboll.com/pharma



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