Building Australia's biomanufacturing future – Lessons from international precedents

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Building Australia's biomanufacturing future – Lessons from international precedents

> *In this discussion paper, we draw on leading international precedents to demonstrate how Australia can build on its existing strengths to create a coordinated, end-to-end national capability pipeline for biomanufacturing. We illustrate how nationally coordinated policy and investment, together with shared multi-purpose scale-up infrastructure, can build the shared industrial foundation needed to translate Australia's research strengths into durable sovereign industrial capability.*

In a world marked by increasing prevalence of supply shocks and geopolitical disruptions, there is growing recognition that domestic control over industrial inputs is critical to sovereign resilience. By enabling onshore production of strategically important goods—including foods, fuels, chemicals, materials, and pharmaceuticals—biomanufacturing can strengthen supply chain resilience and reduce reliance on imported and fossil-derived inputs.

As the role of biomanufacturing as a strategic necessity and form of national resilience infrastructure becomes clearer, policy attention is shifting beyond scientific discovery towards the policy architecture, infrastructure and public investment required to translate emerging capability into large-scale commercial production and sovereign industrial capability.

Cellular Agriculture Australia's (CAA's) first discussion paper in this series, *From food to fuel: The shared industrial foundation of biomanufacturing*, identified a concerning trajectory for Australia: treating food, fuel and other biomanufacturing applications as separate industries risks failing to capture the broader economic, strategic and resilience benefits that a coordinated biomanufacturing ecosystem could deliver. It proposed that Australian policymakers should instead view biomanufacturing as a **shared industrial foundation** of technologies, processes, infrastructure and specialised workforce capabilities.

This discussion paper takes that argument from concept to implementation: drawing on international precedents as an evidence base for how Australia can put the shared-foundation model into practice and realise its potential as a leading Asia-Pacific—and potentially global—biomanufacturing hub (1, 2).

International experience shows that this model is neither abstract nor untested. Leading jurisdictions—including the United States (US), China, European Union (EU), United Kingdom (UK), Japan, Thailand, and India—are increasingly combining shared multi-purpose scale-up infrastructure with coordinated policy and investment mechanisms to translate biotechnology research into sovereign industrial biomanufacturing capability. This discussion paper focuses on the US and EU as two leading and particularly relevant examples for the Australian context, taking a deep dive into how these jurisdictions are successfully building a coordinated, connected **end-to-end biomanufacturing capability pipeline** to support companies' progression from foundational research through to commercial production.

Australia has already established important parts of this pipeline, including a strong shared scientific foundation and emerging shared scale-up capability, complemented by competitive advantages such as access to abundant high-quality feedstocks (sugarcane), renewable energy and workforce capability. However, significant gaps remain as biomanufacturing companies progress towards later-stage scale-up and commercial production, driven by siloed policy and fragmented investment.

The opportunity now is to **implement a nationally coordinated approach that connects, accelerates and extends Australia's existing capabilities into an end-to-end biomanufacturing capability pipeline**. Drawing on US and EU precedents, this discussion paper proposes **three actionable recommendations** for the Australian Government to achieve this.

1. International precedents for building the shared industrial foundation of biomanufacturing

Across global leaders in biomanufacturing, governments are increasingly treating the commercialisation of biotechnologies and biomanufacturing capability as requiring deliberate national coordination rather than relying on individual markets to develop it independently.

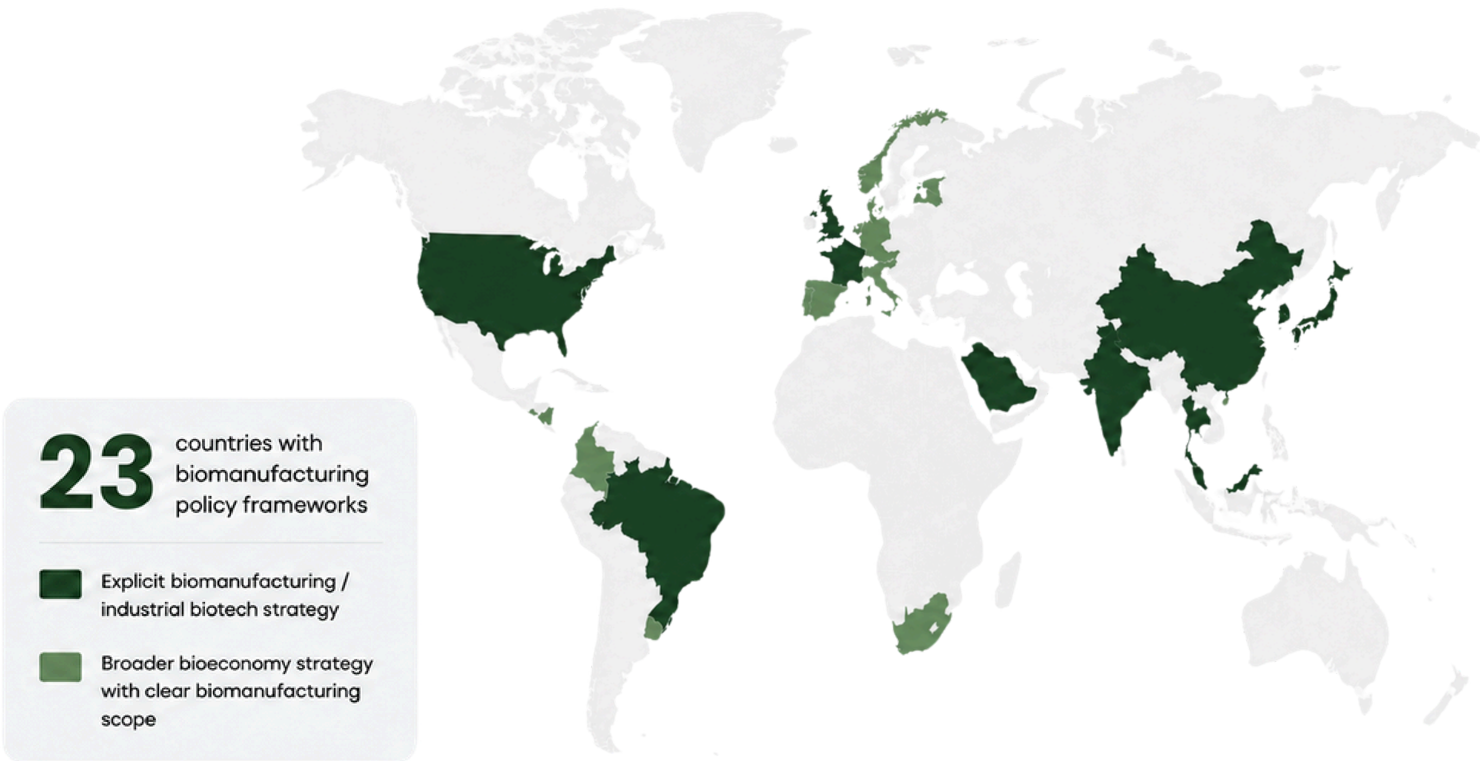
According to FAO reporting, 27 countries and 3 regions have adopted bioeconomy strategies, with an additional 17 under development. As shown in ***Figure 1***, CAA's analysis identifies 25 national and regional biomanufacturing policy frameworks across **23 countries and 2 regions**—including the EU, China, the UK, India, South Korea, and Japan—that explicitly encompass the industrial application of biological production platforms. See ***Appendix 1*** for the full list. Importantly, each of these frameworks is cross-sectoral, connecting applications across food and agriculture, fuels, chemicals, materials and pharmaceuticals.

This aptly reflects the shared-foundation logic explored in CAA's From food to fuel paper. Across the frameworks identified, economic growth and industrial competitiveness are universal drivers, while regional development and resilience also feature prominently.

This policy coordination is increasingly being matched by investment in the physical infrastructure required to translate biotechnology research into commercial-scale biomanufacturing. Alongside research infrastructure and biofoundries, governments are supporting shared-access pilot and demonstration facilities and place-based clusters that can serve multiple product categories and technology types. ***Appendix 2*** highlights notable multi-purpose shared scale-up facilities globally.

Against this broader international backdrop, this section examines biomanufacturing momentum in the US and EU in greater depth. While their policy mechanisms and institutions may not always be replicable in Australia, these case studies offer complementary examples of a common approach: coordinated policy and investment mechanisms, together with a connected network of shared multi-purpose scale-up capability.

Figure 1. *Jurisdictions with biomanufacturing policy frameworks. See Appendix 1 for full list and scope inclusions.*



1.1 Europe: building a connected pathway from research to industrial deployment

Europe provides one of the clearest international examples of the shared-foundation model being implemented across the biomanufacturing commercialisation pipeline. Over more than a decade, the EU and its Member States have combined overarching strategy with public-private deployment programs, investment in multi-purpose scale-up infrastructure, and increasingly connected facility networks.

EU Bioeconomy Strategy: The enduring coordinating mechanism

First developed in 2012 (3) and most recently updated in 2025, the EU Bioeconomy Strategy has provided an enduring framework for coordinating research, investment, regional development and industrial deployment across an otherwise fragmented policy landscape. European Commission reviews credit the strategy for mobilising research and innovation, attracting private investment, supporting new value chains, encouraging the development of national bioeconomy strategies, and bringing together previously disconnected stakeholders (4, 5). It has also provided an overarching framework (6, 7) under which instruments such as the Circular Bio-based Europe Joint Undertaking (CBE JU) could co-fund infrastructure projects. Later reviews noted that improved cooperation with Member States had helped translate this strategic direction into complementary funding programs, regional initiatives and infrastructure investment (8).

23	198
First-of-a-kind flagship biorefineries	Demonstration plants

Importantly, the strategy has evolved alongside the maturity of the sector. Its emphasis has progressively shifted from research and sustainable resource use towards industrial scale-up and reduced dependence on petrochemical inputs (9). In 2024, the European Commission further elevated biotechnology and biomanufacturing, positioning them as strategic capabilities for European competitiveness, resilience, and economic security (10). Although these efforts have not eliminated Europe's commercialisation barriers, they have provided continuity across funding cycles and a mechanism for aligning otherwise dispersed initiatives around a shared industrial objective.

Circular Bio-based Europe Joint Undertaking: De-risking industrial deployment

A central implementation mechanism of the EU Bioeconomy Strategy has been the Circular Bio-based Europe Joint Undertaking (CBE JU) and its predecessor, the Bio-based Industries Joint Undertaking. CBE JU is a €2 billion EU–industry public–private partnership under Horizon Europe (the EU's €95.5 billion flagship research and innovation funding program (11)) that co-funds collaborative projects to move bio-based innovations from research through demonstration to first-of-a-kind industrial deployment.

Because the CBE JU generally funds project-specific rather than shared-access facilities, its broader relevance lies in its institutional model. In addition to providing a grantmaking and co-investment mechanism, the CBE JU pools public and industry resources, gives industry a formal role in identifying shared research and deployment priorities and assembles consortia from across the value chain. Since 2014, CBE JU and its predecessor have supported 243 projects involving 1,860 beneficiaries across 46 countries (12). Its portfolio includes 23 first-of-a-kind flagship biorefineries and 198 demonstration plants, with SMEs accounting for approximately 38 per cent of participants (13). The predecessor program reportedly mobilised €3.65-5.20 in private investment for every €1 of EU funding (14), demonstrating the potential for public co-investment to crowd in private capital.

Bio Base Europe: Shared scale-up infrastructure in practice

The Bio Base Europe Pilot Plant (BBEPP) in Belgium is one of Europe's strongest and most mature examples of shared multi-purpose pilot and demonstration infrastructure. It combines capabilities spanning biomass pretreatment, precision fermentation, biomass and gas fermentation, biocatalysis, and green chemistry, and supports applications across chemicals, pharmaceuticals, food and feed ingredients, and energy (15). In this sense, BBEPP is a leading example of the shared-foundation model applied not just to biomanufacturing, but across the broader bioeconomy.

The BBEPP was established in 2008 through €13 million in funding from a regional Flanders–Netherlands initiative (16). Notably, whilst it predates the EU's first Bioeconomy Strategy, it represents an early regional response to the same scale-up challenge European policy would later address more systematically.

Below: *Bio Base Europe Pilot Plant. Credit: BBEPP*

BBEPP's subsequent expansions have attracted at least €40 million in additional investment through layered public co-investment from regional governments, the European Regional Development Fund (ERDF), and other public programs (17, 18). Its ongoing operating expenditure is funded by a combination of paid confidential commercial projects and participation in publicly funded collaborative consortia (19).

BBEPP's fermentation infrastructure extends from laboratory equipment through 1,500 L and 15,000 L bioreactors to a 75,000 L demonstration line for precision fermentation (20)—effectively supporting companies to progress through Technological Readiness Levels (TRLs) 4-7. One notable characteristic of BBEPP is its flexible, modular unit operations, which can be assembled into process-specific production lines, allowing companies to test complete processes rather than isolated fermentation steps (21). BBEPP also provides access to engineers and operators, meaning knowledge developed across successive projects strengthens the facility's broader capabilities, even when individual company information remains confidential.

The facility includes integrated downstream processing capabilities and operates across different product and regulatory environments, including both food-certified production capability and non-food infrastructure suitable for industrial chemical and fuel-related processes (22). For example, BBEPP supported the scale-up of dsm-firmenich- and Fonterra-backed company Vivici's precision-fermented beta-lactoglobulin through repeated 15,000-litre runs and the commissioning of its 75,000-litre food-grade line (23). For an industrial fuels application, BBEPP validated gas fermentation processes converting carbon monoxide from steel-mill gases into ethanol, helping de-risk subsequent investment in ArcelorMittal and LanzaTech's (now operational) commercial-scale ethanol facility (24). These examples provide a clear proof point that appropriately designed and operated infrastructure can successfully apply shared fermentation, process-engineering and downstream expertise across multiple end markets.

Above: *Pilots4U powered by COPILOT, current map of pilot and demonstration-scale facilities*

Cumulatively, BBEPP has completed more than 900 bilateral projects for over 270 companies, alongside numerous publicly funded collaborations (25). Reported outcomes include four collaborations contributing to investment rounds worth more than €200 million, ten leading to new facilities or product lines, and nine resulting in new products reaching market (26). Publicly documented product launches have included food and nutrition ingredients, agricultural inputs, bio-based chemicals and materials (27). These outcomes demonstrate that shared multi-purpose scale-up infrastructure is not only feasible, but has a proven record of building shared industrial capability across diverse end markets, de-risking private investment and helping companies progress from pilot validation to commercial deployment.

Connecting facilities into a European network

Europe's biomanufacturing capability is not concentrated in BBEPP alone. More than 120 shared multi-purpose pilot and demonstration facilities (28) provide complementary scales, equipment and technical specialisations. Notable multi-purpose examples include Germany's Fraunhofer Center for Chemical-Biotechnological Processes, Finland's VTT Bioruukki Pilot Centre and Sweden's RISE Processum infrastructure.

As with BBEPP, their development has commonly relied on combinations of national, regional and EU public funding, such as through the ERDF.

Recognising that full-cost fee-for-service facility access can be prohibitive for start-ups, governments have also used targeted support to subsidise access to this infrastructure. The €5.98 million Interreg/ERDF-funded BioBase4SME program, for example, provided start-ups and SMEs with vouchers of up to €100,000 for activities including process development and pilot-scale work (29), and ultimately supported 63 SMEs over 2016-19 (30).

European policy has increasingly sought to connect these distributed assets rather than replicate every capability within each region. Pilots4U mapped equipment, identified infrastructure gaps and created a searchable entry point to pilot and demonstration facilities (31). Its successor, Pilots4U powered by COPILOT, adds cross-border access, training, facility visits and matchmaking between companies and infrastructure providers. This is intended to help improve utilisation of existing assets while enabling companies to find the capabilities required for their next stage of scale-up.

Complementing these efforts, the European Commission also launched a dedicated EU Biotech and Biomanufacturing Hub in 2025, providing companies with a single entry point to regulatory guidance, finance, research and pilot infrastructure, and business networks.

Taken together, Europe's experience shows how sustained policy coordination, public–private investment, shared multi-purpose scale-up infrastructure and network coordination can progressively build a connected biomanufacturing capability pipeline. This layered approach has successfully expanded access to scale-up capability, accelerated commercialisation, mobilised private investment and contributed to Europe's broader efforts to strengthen sovereign industrial capability.

1.2 United States: from regional agricultural value-add to national strategic capability

The US provides a complementary example of the shared-foundation model for biotechnologies and biomanufacturing. Its growing capability and capacity have been underpinned by bipartisan Congressional support and an estimated US$10–15 billion in government investment over the past decade (32).

A growing national security framing has provided a particularly durable basis for bipartisan action, with biotechnology and biomanufacturing increasingly embedded in defence legislation, institutions and investment. As a result, momentum has continued despite the 2025 rescission (33) of the 2022 biotechnology and biomanufacturing Executive Order (34), which previously triggered a whole-of-government coordinating initiative and substantial federal investment under the Biden administration (35).

IBRL: Proving the shared-foundation model through agricultural value-add

The Integrated Bioprocessing Research Laboratory (IBRL) at the University of Illinois Urbana-Champaign provides another long-standing example of the shared industrial foundation of biomanufacturing put into practice.

Below: *C16 Biosciences' 'Palmless' cocoa butter, which received scale-up support at the IBRL. Credit: C16 Biosciences.*

Above: *The IBRL facility at the University of Illinois Urbana-Champaign. Credit: IBRL*

Opened in 2018 following approximately US$32 million in predominantly state economic development funding (36), the IBRL was designed to help Illinois, an agricultural region, convert biological feedstocks into high-value products. It was viewed not merely as research infrastructure but as a clear agricultural value-add and regional economic development opportunity (37).

Like BBEPP, IBRL operates as an industry-facing, shared facility, providing flexible pilot-scale infrastructure (bioreactors up to 1,200 L working volume), technical expertise, and workforce training (38). Companies can access its equipment and personnel under commercially protective agreements through its fee-for-service cost-recovery model (39). Its scope, however, is narrower than BBEPP's, centring on pilot-scale fermentation and bioprocessing across food, chemicals, fuels, materials, and other bio-based products.

By September 2025, IBRL had served more than 140 companies across thousands of projects (40), with several clients having reported launches of fermentation-derived products such as C16 Biosciences' cocoa butter substitute and Tandem Repeat's protein-based textiles (41, 42). It had also trained more than 350 people and grown to 64 in-house employees (43). An IBRL representative confirmed to CAA that:

> ***Having an in-house technical team execute client runs allows expertise to accumulate across projects, particularly in equipment operation, process execution and troubleshooting. This institutional knowledge helps streamline runs and accelerate problem-solving, which is highly valued by clients using the facility.***

Above: *Fermentation equipment at the IBRL facility. Credit: IBRL.*

Importantly, the facility has begun to anchor complementary private capability, with Boston Bioprocess relocating to the IBRL's surrounding innovation precinct and providing smaller-scale process development services that can feed projects into IBRL's larger pilot infrastructure (44).

These successes, however, exposed the next gap in the commercialisation pathway. IBRL previously reported reaching capacity (45), highlighting both the strong demand for shared biomanufacturing capability and the insufficiency of available domestic capacity. IBRL's Executive Director has described how companies completing pilot-scale development at the facility also lacked a suitable domestic demonstration-scale pathway, leading many to continue scale-up in Belgium through the BBEPP or elsewhere in Europe (46) - a bottleneck which subsequent initiatives, namely iFAB, have sought to address.

iFAB: Building a regional lab-to-line ecosystem

IBRL has since become the cornerstone of the Illinois Fermentation and Agriculture Biomanufacturing Tech Hub (iFAB). Designated through the US Economic Development Administration's (EDA's) Regional Technology and Innovation Hubs ('Tech Hubs') program in 2023, iFAB received approximately US$51 million in implementation funding in 2024 (47). This has been complemented by at least US$680M in matching investments from its 33 consortium partners (48).

The Tech Hubs program is explicitly intended to strengthen regional capacity to manufacture, commercialise and deploy critical technologies supporting job creation, US competitiveness and national security.

The iFAB Tech Hub is intended to build a connected regional biomanufacturing cluster centred around precision fermentation—a "lab-to-line" pathway encompassing research, shared pilot-, demonstration-, and commercial-scale infrastructure, coupled with services for incubation and workforce development (49). Rather than building one large-scale public facility from scratch, iFAB is upgrading, retrofitting, and integrating the infrastructure of its industrial consortium partners; effectively aiming to mitigate the sector's scale-up bottleneck post-pilot-scale (50).

iFAB's Infrastructure expansion is currently under development and will include:

- 35,000 sq ft expansion of IBRL's pilot and training capacity (total testing capacity increasing from 2,932 L to 12,312 L) (51)
- Construction of iPROOF, a 10,000 L pilot-scale facility operated by consortium partner Primient, including upstream and downstream process development and a full suite of wraparound scale-up services
- An upgrade to consortium partner ADM's BioProducts facility to provide fermentation capacity at approximately 75,000 L
- EnterpriseWorks 2.0, which will add incubation and light-manufacturing space for growing companies (52)

Building on a proven shared facility, an established user base and the region's industrial strengths, iFAB is connecting complementary capabilities into a single regional cluster. This is intended to streamline technology transfer across each phase of scale-up, creating a seamless lab-to-commercial production pipeline for biomanufacturing.

Above: *A BioMADE workforce development project. Credit: Worcester Polytechnic Institute*

BioMADE: Taking shared capability national through a coordinated institutional framework

The Bioindustrial Manufacturing Innovation Institute (BioMADE), sponsored by the US Department of Defense (DoD), provides a national model for coordinating technology development, infrastructure and workforce around a sovereign bioindustrial manufacturing agenda.

Launched in 2021 as a nonprofit public–private partnership within the Manufacturing USA network, BioMADE aims to build an end-to-end domestic bioindustrial manufacturing ecosystem and bridge the gap between university-based research and commercial production (53, 54). The Institute was established through a seven-year US$87.5 million DoD award, matched by more than US$180 million from non-Federal partners (55). Its broad pipeline-enabling model combines funding for translational research projects, workforce development programs, and shared infrastructure (56).

More specifically, its Technology and Innovation Program provides matched funding for translational research projects (MRLs 4-7) that intend to bridge the gap between scientific proof of concept and commercial production (57).

BioMADE is now complementing its research portfolio with a national network of multi-user pilot and demonstration facilities. Announced in 2023, the Pilot Plant Network is intended to address the shortage of domestic scale-up capacity to prevent US companies from moving offshore (58). Congress appropriated a total of US$400 million in the 2023 and 2024 fiscal years to support the network (59).

Three sites have been announced in California, Iowa and Minnesota, with capabilities ranging from food-grade pilot fermentation infrastructure to 25,000 L demonstration plants, although all three remain under development (60). The US$40M Iowa facility, for example, is planned to open in 2028 as a shared facility with capacity of up to 10,000 L catering to agricultural, chemical and food bioproducts (61). Like iFAB, it is explicitly framed around using agricultural resources to create higher-value products, new revenue streams for farmers and regional manufacturing jobs (62).

The BioMADE Pilot Plant Network signals that the US is moving beyond isolated pilot plants toward a distributed network differentiated by regional feedstocks, industrial strengths and technical requirements. In this sense, BioMADE extends the same shared-capability logic seen at IBRL and iFAB to the national level, and demonstrates the value of linking technology development, infrastructure and workforce initiatives through a coordinated institutional framework.

National Security Commission on Emerging Biotechnology: Embedding biomanufacturing in a coordinated national security agenda

Building on this expanding base of federal and regional investment, US biotechnology and biomanufacturing policy has increasingly been consolidated within a broader national strategic and security agenda. The White House Critical and Emerging Technologies List identified biotechnologies – specifically including novel synthetic biology, biomanufacturing and bioprocessing technologies – alongside artificial intelligence and quantum information technologies as among the critical technologies most significant to US national security (63).

This strategic framing was later consolidated and expanded by the bipartisan National Security Commission on Emerging Biotechnology (NSCEB), whose final report called for at least US$15 billion in investment in US biotechnology over five years, and has since helped catalyse substantial action across Congress, federal agencies, and defence institutions.

The Commission described biotechnology, particularly when combined with AI, as a new industrial revolution affecting how the US manufactures, feeds, cares for and defends its population (64). Its central warning was that:

Research leadership would provide limited economic or strategic advantage if companies could not scale domestically and the country remained dependent on overseas infrastructure and supply chains (65).

This framing (already evident in initiatives such as BioMADE) reflects a broader geopolitical shift: recognition that biopower—the ability to harness biotechnology into industrial and strategic advantage—is a critical source of economic influence, national resilience, and strategic autonomy (66). The NSCEB reinforced and consolidated this proposition within a more comprehensive security agenda, thereby generating renewed political urgency around biotechnologies and biomanufacturing as matters of national security and essential sovereign capability.

The scale and bipartisan nature of subsequent policy action indicate that this framing has gained substantial political traction.

US policymakers have acted on more than half of the NSCEB's 49 recommendations over the last year (67), with key elements of its agenda now embedded more durably within federal and defence institutions.

Most notably, the FY2026 National Defense Authorization Act established a DoD Biotechnology Management Office and authorised new programs to support the design and construction of bioindustrial manufacturing facilities, incentivise expansion of commercial-scale manufacturing capacity, and strengthen domestic biomanufacturing supply chains. The Act also requires a new DoD biotechnology strategy addressing development of a network of commercial biomanufacturing facilities, as well as the use of advance market commitments and offtake agreements to support their deployment. The significance of these reforms lies in their system-wide approach: coordinating intervention across research, scale-up, commercial manufacturing and market demand to keep technologies onshore.

1.2.1 Distributed Bioindustrial Manufacturing Program:

Implementation of the NSCEB agenda is also building on existing programs. NSCEB recognised the DoD's Distributed Bioindustrial Manufacturing Program's (DBIMP) valuable role in complementing shared pre-commercial infrastructure with support for company-led commercial-scale facilities (68). Its first phase awarded more than US$60 million (69)—including US$1.76 million to Australian company Cauldron Ferm—with the FY2026 DoD budget subsequently proposing a five-year US$1.3 billion program (70). While DBIMP supports company-operated rather than shared facilities, it plays an important role in completing the capability pipeline from pre-commercial validation to domestic production.

Overall, the US is assembling an emerging end-to-end biomanufacturing capability pipeline: BioMADE coordinates technology development, workforce, and shared infrastructure at the national level; and DBIMP supports the transition to domestic commercial production; NSCEB and subsequent defence initiatives increasingly connect these investments within a broader national security agenda, while adding complementary mechanisms to strengthen manufacturing capacity and market demand. In this respect, the US is converging on a layered model similar to Europe's, but through a more decentralised and security-oriented institutional framework.

2. Australia has strong foundations, but a missing scale-up middle

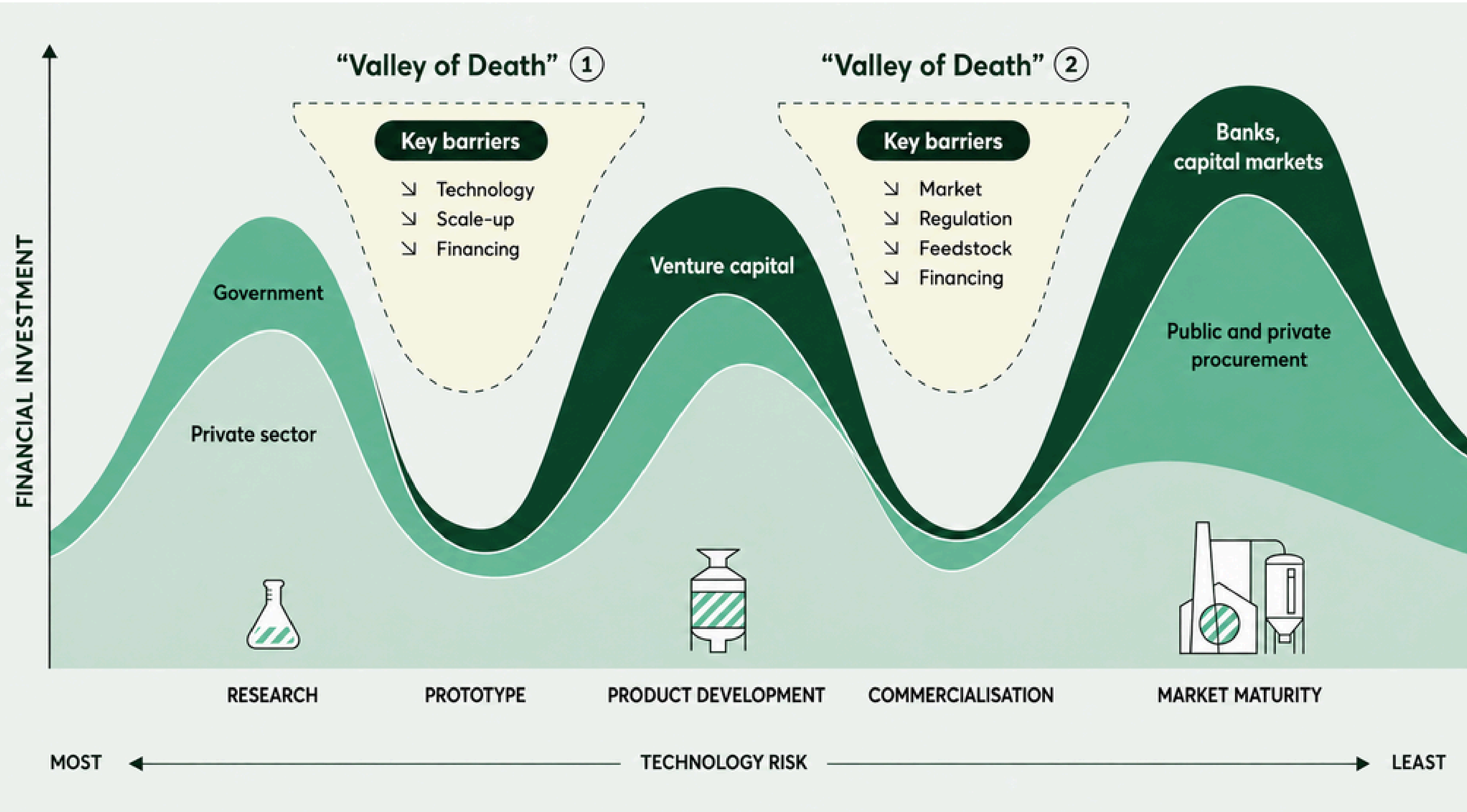
The international precedents examined above provide an evidence base which we cannot ignore and against which we can now assess the state of Australia's current biomanufacturing ecosystem and capability pipeline.

Critically, the EU, US, and other leading jurisdictions (as seen in ***Appendices 1 & 2***) demonstrate that building biomanufacturing capability is not simply a question of research strength, but of building the enabling environment for companies to progress through scale-up towards commercial production. Against this backdrop, Australia's biomanufacturing ecosystem exhibits a familiar commercialisation challenge: strong research capability is not always matched by the infrastructure, investment and coordination required to translate it into commercial readiness, and ultimately, domestic production.

One way of understanding where this bottleneck emerges is through the two 'valleys of death' identified by European Commission analysis: first, between research and prototyping, where technical feasibility must be demonstrated; and second, a 'missing middle' between initial product development and commercial-scale production, where technologies must be proven at progressively larger scales (See ***Figure 2*** below)(71).

This section will show that Australia is comparatively well equipped to help companies bridge the first of these valleys, with existing application-agnostic shared research infrastructure providing a strong scientific foundation for progressing through initial technology development. It will then examine how biomanufacturing capability becomes progressively thinner as companies move towards larger pilot and demonstration-scale production.

Figure 2. *The two valleys of death in scaling the bioeconomy. Adapted from the 2025 EU bioeconomy strategy.*



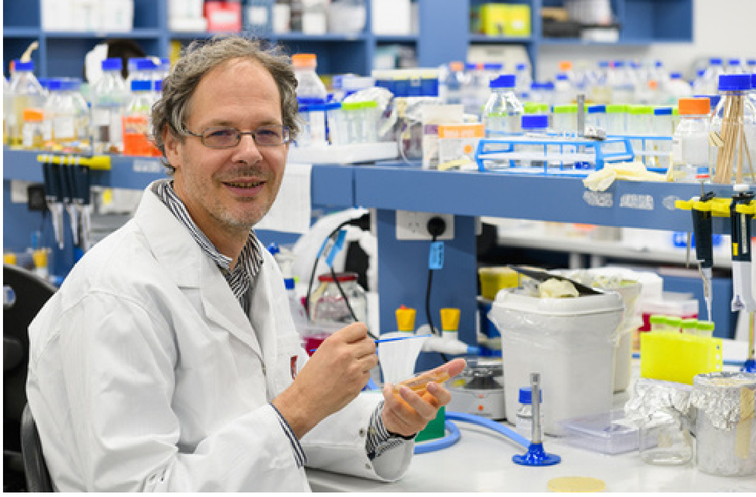
2.1 Australia has built the shared scientific foundation

Australia is not starting from scratch. Through sustained investment in research infrastructure, synthetic biology and translational capability, the Australian federal and state governments are already implementing the shared-foundation model at the scientific end of the biomanufacturing pipeline.

Bioplatforms Australia (BPA), a national research infrastructure network funded by NCRIS, provides the clearest example. In 2023, the Australian Government committed $55 million to expand national synthetic biology infrastructure through BPA, including funding for the Australian Genome Foundry (AGF) and Integrated Design Environment for Advanced Manufacturing (IDEA Bio). These facilities provide complementary shared infrastructure and expertise to researchers, start-ups and industry seeking synthetic biology capability.

Importantly, these investments are increasingly embedded in place-based clusters that bring together complementary research programs, infrastructure, and expertise. At Macquarie University, the AGF is co-located with the ARC Centre of Excellence in Synthetic Biology (CoESB), a national research collaboration comprising more than 300 researchers focused on applying synthetic biology across a range of biomanufactured products. This concentration of automated biofoundry infrastructure, research expertise and start-up activity creates a pathway through which scientific discoveries can be developed, tested and translated within a connected ecosystem.

Below: *Levur's precision-fermented palm oil, currently incubated at AGF. Credit: Levur.*



Above: *Ian Paulsen, Director of the ARC CoESB. Credti: CoESB.*

Early outcomes demonstrate the commercial potential of this model. At the time of writing, the AGF was incubating biomanufacturing companies Levur and Newera Bio (72), and was credited with a "fundamental" role supporting HydGene (73) to rapidly progress through early scale-up - which subsequently commissioned its own pilot plant. CoESB has also supported the formation of 12 start-up companies developing products across a range of industrial biotechnology applications including food, agriculture, chemicals, and materials (74). With a reported combined valuation exceeding AUD $1 billion—approximately 40 times the Centre's initial public investment (75)—these companies demonstrate the commercial value that can emerge from sustained investment in shared scientific capability.

A similar ecosystem is emerging at the University of Queensland. IDEA Bio is now housed within the UQ Biosustainability Hub, bringing shared bioprocess development infrastructure together with research programs, industry partnerships and pilot-scale capability. IDEA Bio has supported projects across fuels, chemicals, food, agriculture, therapeutics, and materials, while the broader Hub seeks to provide a 'one-stop-shop' to translate biomanufactured products across multiple end markets.

These investments affirm that, in the Australian context, application-agnostic shared infrastructure can support technologies across diverse end markets, improve access to specialised expertise, enable company formation, and generate commercial value beyond any single product category. The opportunity now is to extend this successful shared-foundation model further along the commercialisation pathway.

2.2 Scale-up infrastructure: the missing middle

Australian biomanufacturing companies encounter a persistent bottleneck between laboratory proof-of-concept (<20 L scale) and full industrial deployment. Analysis from Bioplatforms Australia (BPA), informed by interviews with fermentation-focused Australian biomanufacturing companies, identified that this gap is driven by a lack of coordinated, repeatable access to intermediate-scale infrastructure (Scaling the Bioeconomy, 2026; internal report prepared for Bioplatforms Australia).

Critically, BPA's analysis found that offshore scale-up has become the rational default under current system settings, with many companies lacking a viable domestic alternative. The consequences are already visible, with food biomanufacturing start-ups All G and Nourish Ingredients among the companies that have publicly reported accessing offshore fermentation infrastructure. Over time, gradual leakage of intellectual property, talent, manufacturing jobs, and strategic capability will continue to confine Australia to early-stage innovation. The implications also extend beyond individual companies: Australia also risks losing the opportunity to build the broader domestic supply chains that commercial biomanufacturing could support, including new sources of demand and value-add for agricultural regions and industries—for example, Australia's sugarcane industry.

Australia has made important progress in addressing this 'missing middle', including through a combination of shared and privately operated scale-up assets, which are detailed in **2.2.1-2.2.3**. However, this section will demonstrate that gaps remain in the availability, scale, and accessibility of this infrastructure, reflecting a capability base that has developed through discrete, sector-driven initiatives rather than as part of a coordinated national scale-up pathway.

2.2.1 QUT Pioneer BioPilot - Pilot-scale capacity:

The Queensland University of Technology's Pioneer BioPilot in Mackay, which completed an AUD$18M upgrade in late 2025 (76), is the leading operational example of shared biomanufacturing scale-up infrastructure in Australia. Co-funded by the Australian and Queensland governments and QUT, it provides pilot-scale fermentation capacity of up to 2,400 litres, along with downstream processing capabilities, for projects spanning food, fuels, chemicals, and other bio-based products (77). Located at the site of one of Australia's major sugar manufacturers, the facility also benefits from access to high-quality feedstocks and associated industrial infrastructure.

CAA has been informed that the Pioneer BioPilot is expected to commence projects with external partners in September 2026, with reported demand already "very high" and likely to exceed available capacity. However, despite substantial public investment in the facility's physical infrastructure, it does not receive dedicated recurrent public funding for operations and relies substantially on project-based and fee-for-service revenue. According to a Pioneer BioPilot representative, **this limits the staff and operating capacity available to fully utilise the facility, reduces the number of projects it can support, and is likely to make access prohibitive for early-stage companies**.

Right: *The QUT Pioneer BioPilot. Credit: QUT*

2.2.2 Cauldron Ferm - Demonstration-scale capacity:

Privately operated contract manufacturing capacity complements Australia's shared infrastructure ecosystem, showing how private capital—supported by targeted public co-investment—can expand domestic scale-up capability.

Established in 2022, Cauldron Ferm has built on more than 35 years of R&D through the acquisition of Agritechnology's precision fermentation IP and equipment. Since then, Cauldron has secured more than AUD $26 million in private investment (78), alongside support from the Australian and Queensland governments (79, 80).

Its Orange-based demonstration-scale facility, incorporating 10,000-litre production lines, downstream processing capability, and a total capacity of 30,000 L (81), is underpinned by its globally recognised (82) proprietary continuous fermentation platform, designed to improve productivity, capital efficiency and the cost of goods.

2.2.3 Industry Biotechnology Centre - An emerging scale-up hub:

The Industry Biotechnology Centre (IBC), currently under development in Toowoomba, Queensland, will help fill a critical gap in Australia's biomanufacturing scale-up ecosystem. The IBC is being developed as a biotechnology facility providing shared infrastructure and an operating environment that supports commercialisation pathways, technology development, industry collaboration and business growth. It is backed by $50 million in investment, including $25 million in joint Australian and Queensland government support (funded through the SEQ City Deal Innovation Economy Fund) and matched by FKG Group.

The IBC's initial facilities are planned to commence operations in 2027, and are being designed to support a broad range of biotechnology applications, including fermentation, microbial production, biomanufacturing and other biotechnology-related production and development activities. While the facility's final bioprocessing capacity and configuration have not yet been confirmed, the IBC reportedly aims to support activities across pilot, demonstration, and commercial scales through a combination of its shared infrastructure and the broader ecosystem of tenants, partners, and future expansion opportunities it is designed to foster. Strategically located within the AATLIS Precinct alongside agricultural, advanced manufacturing and innovation-focused industry activity, the approximately 4,000-square-metre core complex will combine laboratory and office space with advanced manufacturing zones.

Taken together, this broader hub model, its place within an established industrial ecosystem, and a provision for future expansion, position the IBC as a potential platform for connecting and extending Australia's biomanufacturing scale-up capability over time.

Left: *Cauldron Ferm's demonstration-scale facility in Orange, NSW. Credit: Cauldron Ferm*

Where the bottleneck remains

Taken together, the QUT Pioneer BioPilot provides shared multi-purpose pilot-scale fermentation and downstream processing capability; Cauldron Ferm adds privately operated demonstration-scale capacity; and the IBC represents an emerging translational hub with the potential to host and connect a broader range of scale-up and commercialisation capabilities. These assets are complementary, but they do not yet constitute a complete, consistently accessible pathway to commercial readiness. Our analysis above, together with the recent BPA scale-up report, identifies four principal limitations:

> **Gaps in scale and technical fit:** existing operational infrastructure does not consistently provide the required vessel volumes, fermentation modes, equipment configurations or integrated downstream processing needed across different scale-up pathways.

> **Insufficient throughput for repeatable scale-up:** companies require repeated, multi-run campaigns—often over extended periods—to demonstrate reproducibility, robustness and integrated operation. Existing facilities are not consistently configured or available to support this type of sustained industrial learning.

> **Insufficient capacity and availability:** a small number of operational facilities are servicing a growing pipeline of companies, with existing capacity frequently oversubscribed and unable to meet demand.

> **Cost and access barriers:** Shared-use facilities are costly to operate because they must accommodate diverse processes and equipment. The need to maintain commercially sustainable utilisation can result in access fees that are prohibitive for capital-constrained start-ups. CAA has heard anecdotally that as a result, access is pragmatically prioritised for high-value multinational clients over early-stage start-ups. (Source: Scaling the Bioeconomy)

A nationally coordinated approach is now needed to build on investments already underway by connecting existing assets, expanding their utilisation and accessibility, and strategically filling remaining pre-commercial scale-up gaps.

2.3 Fragmented policy and investment: a missed opportunity to complete the national capability pipeline

However, Australia's current policy and investment architecture is not yet fit-for-purpose to support the development of a nationally coordinated biomanufacturing capability pipeline.

Responsibility for Australia's biomanufacturing capability is dispersed across federal portfolios, including industry, energy, agriculture, health and climate policy. Without a single institution or policy mechanism responsible for stewarding the capability pipeline as a whole, investment has largely emerged through discrete initiatives linked to specific priority markets rather than sustained, coordinated public support.

For example, support for advanced biofuels includes the AUD $1.1 billion Cleaner Fuels Program, the Future Made in Australia Innovation Fund, dedicated finance and grant administration mechanisms, and the National Bioenergy Feedstock Strategy. This market-specific approach creates valuable momentum and is well suited to supporting individual projects and companies, but is not fit-for-purpose to enable national-level coordination nor fund capital-intensive, shared infrastructure whose benefits are distributed across multiple end markets.

Hence, Australia's remaining challenge is both technical and systemic: gaps in scale, access and capacity are compounded by fragmented policy and investment—barriers the international examples above provide clear models for addressing in concert.

3. What Australia can learn - Three steps to sovereign biomanufacturing capability

The opportunity now is to connect, accelerate and extend Australia's existing biomanufacturing capability into a complete and coordinated pathway from research through scale-up to commercial readiness.

Neither the European nor US model can, or should, be replicated wholesale in the Australian context. Europe operates across a much larger, multi-jurisdictional market and has built its ecosystem through more than a decade of layered European, national and regional investment. Nonetheless, it provides a valuable mature example of long-term ecosystem building through coordinated strategy, public-private investment and accessible shared infrastructure.

The US similarly benefits from a larger domestic market, substantially greater public investment and a defence-industrial system without a direct Australian equivalent. Yet its federal structure, strong regional agricultural and industrial economies, and growing emphasis on sovereign manufacturing, critical technologies and supply-chain resilience provide important parallels for Australia. The lessons for Australia, therefore, lie in the common policy principles these models demonstrate.

Australia's smaller economy makes these lessons more, not less, relevant. Australia cannot afford unnecessary duplication of capital-intensive specialised infrastructure across individual industries and regions. Aggregating demand across food, fuels, chemicals, agriculture and other biomanufacturing applications, while building on existing assets and regional strengths, provides a more logical, capital-efficient route to sovereign industrial capability.

Developed in close consultation with the Australian non-clinical biomanufacturing sector, we propose three sequenced actions for the Australian Government to build a complete national biomanufacturing capability pipeline and durable sovereign industrial capability. Each is grounded in international precedent provided by the US and Europe, but adapted to Australia's institutional and economic context.

Recognise the strategic imperative - Biomanufacturing as a national resilience and security priority

1. Direct the Treasury to conduct a sector assessment of biomanufacturing against the Economic Resilience and Security Stream of the Future Made in Australia (FMA) National Interest Framework

The assessment should consider biomanufacturing as a cross-sector national capability that underpins economic resilience and national security by enabling the secure domestic production of strategically important goods.

Significant public investment and policy coordination are more likely when biomanufacturing is treated not simply as an emerging technology opportunity, but as a strategic national capability. In the US, we've seen how this framing has helped embed biotechnology and biomanufacturing across bipartisan Congressional action, defence institutions, and longer-term programs, making momentum less dependent on any single policy instrument or policy moment. Viewed through this lens, addressing scale-up market failures through public investment and national coordination becomes a strategic necessity rather than discretionary support for an emerging sector.

Australia already has a mechanism to formally assess this strategic case. The FMA National Interest Framework, the Australian Government's current broad industrial policy agenda, includes an Economic Resilience and Security Stream for sectors where sovereign capability is important to resilience and security but unlikely to be delivered through private investment alone. A sector assessment would determine whether biomanufacturing meets these criteria, identify investment barriers and where government intervention may be warranted (83). Recognition of biomanufacturing as a FMA priority would firmly establish the sector as a critical enabler of supply-chain resilience, economic and national security, and help shift support from fragmented, market-specific initiatives toward more systematic consideration across government policy and investment decisions.

Establish a national strategy and coordinating mechanism

2a. Develop a National Biomanufacturing Security Strategy

The Strategy should sit alongside the National Quantum Strategy and National AI Plan and align with AUKUS Pillar II. The Strategy should:

- Set a pathway to sovereign capability across food and ingredients, fuels, fertilisers, industrial chemicals, pharmaceuticals and other biomanufactured products.
- Consolidate existing public and private investment, outline a balanced public-private investment pathway to de-risk supply chains, and consider short-term subsidies and demand-side incentives.
- Be developed in collaboration with Australia's national security agencies and explicitly address dependence on foreign technology and manufacturing capability, in alignment with Recommendation 1.

2b. Establish a cross-departmental National Biomanufacturing Taskforce with industry

The Taskforce should enable implementation of the Strategy by aligning existing portfolios, infrastructure, and investment; identifying capability gaps; and developing investable initiatives.

Once this strategic imperative is recognised, international experience shows the value of an overarching national framework to coordinate otherwise fragmented, market-specific support. Europe's Bioeconomy Strategy provides the clearest long-term precedent. It has provided an enduring and evolving policy framework within which research, regional development, infrastructure, industrial deployment, and complementary investment mechanisms could be progressively aligned alongside the sector's maturity.

Australia currently lacks an equivalent framework. Biotechnology is recognised as a Critical Technology in the National Interest, yet, unlike AI and quantum, it has no:

- dedicated national strategy;
- priority recognition in AUKUS Pillar II;
- coordinating mechanism; or
- consolidated investment pathway.

As outlined above, responsibility is instead dispersed across portfolios and programs that largely assess individual end markets separately. A National Biomanufacturing Security Strategy, complemented by a National Biomanufacturing Taskforce, is therefore needed to provide the overarching direction and implementation function to connect these activities and steward the biomanufacturing capability pipeline as a whole.

Develop shared capability through investment in National Biomanufacturing Production Hubs

3a. The Australian Government should issue a Request for Proposals (RFP) for one or more National Biomanufacturing Production Hubs

This should encompass both large-scale centralised facilities and the distributed, modular systems already commercially deployable at feedstock and end-user sites, characterised as critical infrastructure.

Long-standing facilities such as BBEPP and IBRL demonstrate that shared infrastructure can successfully aggregate demand across multiple end markets—and, in BBEPP's case, multiple technology types—with documented outcomes including accelerated scale-up, new products reaching market and subsequent private investment. BBEPP demonstrates the value of flexible, modular infrastructure, whilst IBRL's evolution into iFAB further shows how a proven shared facility can anchor a broader place-based biomanufacturing ecosystem built around regional strengths.

Consistent with these precedents, the RFP should seek to build a complementary national network of multi-purpose shared facilities by connecting and expanding Australia's existing assets, leveraging regional strengths and filling remaining capability gaps.

As outlined above, the IBC currently under development provides a compelling illustration of how prior infrastructure investment could be built on under such an RFP: its ecosystem-enabling scale-up hub model, precinct infrastructure, and capacity for expansion make it a strong foundation for potential designation as a National Biomanufacturing Production Hub and subsequent follow-on support. Moreover, Mackay provides a further example, combining existing pilot-scale capacity (through the QUT Pioneer BioPilot), established agricultural feedstocks and industrial infrastructure that could be complemented by larger-scale shared capability.

3b. Mandate the National Biomanufacturing Taskforce (Recommendation 2b) to identify, validate and accelerate defensible, credible joint ventures

The Taskforce should be assigned the role of convening technology proponents, facility operators, feedstock suppliers, commercial offtakers and capital providers to form investment-ready projects.

3c. Biomanufacturing projects should be explicitly recognised as a priority for Investor Front Door support

The RFP should operate in concert with the Commonwealth Investor Front Door, the National Reconstruction Fund Corporation and the Clean Energy Finance Corporation. Biomanufacturing projects should be explicitly recognised as a priority for Investor Front Door support. This would enable qualifying projects to access its single-point coordination function designed to support large capital expenditure projects in accessing government financing opportunities.

Europe's CBE JU is not a direct analogue for Australia, but it demonstrates the value of aligning public and private priorities, convening partners, and using public co-investment to de-risk industrial deployment. Australia can apply these principles through the proposed Taskforce and the existing Investor Front Door, which together provide a practical equivalent of CBE JU's convening and de-risking function without requiring the establishment of a new large-scale funding institution.

Additional considerations: critical enablers of an end-to-end national biomanufacturing capability pipeline

International experience highlights four complementary implementation considerations that will determine whether a national strategy and the development of shared production hubs will successfully translate into a coordinated, accessible, and ultimately commercial capability pipeline.

From individual shared assets to a functioning national network

Ensure that shared infrastructure is accessible:

European SME access schemes show the effectiveness of pairing capital investment with targeted access support. Australia has already implemented this principle through Bioplatforms Australia's matched-funding voucher scheme, which provides subsidised access to NCRIS synthetic biology infrastructure. Extending similar support to both existing and future scale-up facilities could improve access for domestic start-ups and scale-ups while increasing facility utilisation.

Establish a coordination and ecosystem-building function:

Europe's Pilots4U network demonstrates how geographically distributed facilities can be made more accessible and visible, while encouraging regional specialisation and reducing duplication. Meanwhile, BioMADE provides a useful example of national ecosystem-building by connecting technology development, infrastructure, workforce and industry - a model which various Australian sector proponents (CoESB, ANU National Security College) have previously pointed to as relevant to Australia. As Australia's biomanufacturing ecosystem matures, it may be worthwhile considering the value of comparable ecosystem-building and coordination functions.

Beyond shared capability: applying the shared-foundation lens to market-specific policy

Adopting the shared-foundation model does not mean every policy intervention must be cross-sectoral. Once technologies reach commercial readiness, market-specific interventions may still be required to enable individual end markets to reach commercial production. Importantly, applying a shared-foundation lens can strengthen the case for market-specific interventions by revealing benefits beyond the immediate end market—including flow-on effects for shared feedstocks, infrastructure, workforce and supply chains that may otherwise be overlooked under siloed policy-making.

Create a pathway from commercial readiness to domestic production:

Shared pilot and demonstration infrastructure can help companies de-risk technologies and processes to the point of commercial readiness, but does not guarantee that production will occur domestically. Companies progressing successfully through shared scale-up infrastructure need an accessible route into proprietary commercial-scale facilities (as seen through the US DBIMP program), together with the investment and market conditions required to make those facilities commercially viable—including, where appropriate, demand-side mechanisms such as advance market commitments and offtake agreements, as recommended by the NSCEB. Consideration should be given to where similar mechanisms could support commercially-ready Australian biomanufacturing technologies to progress into domestic production.

Secure near-term strategic biomanufacturing inputs through a national ethanol mandate:

Australia's sugarcane industry provides an important feedstock and industrial base for future biomanufacturing, but the sector is increasingly vulnerable due to low and variable global sugar prices, rising input costs, and declining mill viability (84). A national ethanol mandate, drawing on longstanding renewable-fuel demand mechanisms in the US and EU (85, 86), could create new, durable demand for sugarcane, helping diversify and sustain this capability whilst future-proofing its accessibility as a critical biomanufacturing input. The Australian Government's current Securing Australia's Cleaner Fuels Industry consultation on an LCLF demand mechanism provides a timely opportunity to consider these wider benefits. In this sense, short-term action to strengthen Australia's sugar industry and longer-term growth in biomanufacturing are complementary: sustaining the sugar industry now can preserve the feedstocks and industrial capability needed for future biomanufacturing, whilst the commercialisation of biomanufactured products could later add value and demand for Australian sugar.

Building the next stage of Australia's biomanufacturing capability pipeline

The central lesson from leading international jurisdictions is that building sovereign biomanufacturing capability requires a deliberate pathway from strategic recognition through national coordination, shared scale-up capability, and ultimately domestic commercial production.

We've seen how Australia has already begun building this shared foundation at the scientific end of the pipeline and through emerging scale-up assets, reflecting growing recognition across industry and state and federal governments of the need for shared biomanufacturing capability.

The task now is to connect, accelerate, and extend this capability base into a coordinated national pipeline—leveraging existing assets, regional strengths, and Commonwealth investment mechanisms wherever possible, as outlined in our three core recommendations above.

Doing so would maximise the value of investments already underway, reduce duplication across individual end markets and identify where additional capability is still required.

However, the window to convert Australia's existing competitive advantages into regional—or global—biomanufacturing leadership is narrowing. **As international investment accelerates and Australian companies increasingly scale offshore, coordinated action is becoming more urgent.**

If swift action is taken, a nationally coordinated approach to biomanufacturing would close persistent commercialisation bottlenecks, strengthen Australia's capacity to manufacture strategically important products onshore, and capture more of the economic and strategic value generated by its research and innovation strengths.

Above: *Cauldron Ferm's demonstration-scale facility in Orange, NSW. Credit: Cauldron Ferm*

Appendix 1: Cross-sector biomanufacturing and bioeconomy policy architecture

This appendix presents national and supranational policy frameworks that explicitly encompass the industrial application of biological production technologies, including biomanufacturing, industrial biotechnology, fermentation, cell or microbial cultivation, synthetic/engineering biology, bioprocessing or related biological conversion platforms. Broader bioeconomy strategies are included only where these technologies are demonstrably connected to industrial production, scale-up, commercialisation or manufacturing across multiple end markets. Sector-specific strategies focused solely on pharmaceuticals, vaccines, therapeutics or other medical applications are excluded, as are frameworks focused only on biological resources, bio-based products or research-stage biotechnology. Status is current as at 24 August 2026. This appendix was prepared with the assistance of ChatGPT for research synthesis and drafting.

Strategic framing key:
ECO = economic growth / industrial competitiveness ·
RES = sovereignty / resilience / supply chains
SEC = national security / defence
CLIM = climate / sustainability / circular economy
REG = regional development
HUM = human security (food, health, energy security)

Jurisdiction	Strategy / framework	Year / status	Technology scope	Product / sector scope	Strategic framing / VP	Key commitments / targets / funding
European Union	**A Strategic Framework for a Competitive and Sustainable EU Bioeconomy**	2025; live	Broad bioeconomy; industrial biotechnology; advanced fermentation; biorefineries; biomanufacturing	Chemicals, polymers, fibres/textiles, construction products, fertilisers, food/feed and other bio-based products	ECO; RES; CLIM	Explicit shift toward industrial deployment and market scale-up. Associated biobased-industry implementation envisages €1–2bn in public/private investment in demonstration and production capacity and €10bn in corporate procurement/offtake commitments by 2030 through the Bio-based Europe Alliance.
United Kingdom	**National Vision for Engineering Biology**	2023; live; 10-year horizon	Engineering biology; synthetic biology; fermentation and cultivation; bioprocessing; biofoundries; downstream processing	Food, chemicals, fuels, materials, medicines/health, agriculture and other industrial applications	ECO; RES; SEC; CLIM	£2bn over 10 years. Six priority areas spanning R&D, infrastructure, skills/talent, regulation and standards, adoption, and responsible innovation. Explicit commitment to infrastructure that reduces scale-up costs and supports start-ups and scale-ups.
United States†	**Department of Defense Biomanufacturing Strategy**	2023; live; Department of Defense strategy — not a whole-of-government national strategy	Bioindustrial manufacturing; primarily non-pharmaceutical biomanufacturing; microbial/biological production; process scale-up	Fuels, chemicals, materials, construction inputs and other defence-critical products; implementing programs also extend to food and nutritional products	SEC; RES; ECO	DoD announced US$1.2bn in new biomanufacturing investment in 2022, including a planned US$1bn over five years for domestic bioindustrial manufacturing infrastructure. Following subsequent program/funding changes, the FY2027 defence budget describes the Distributed Bioindustrial Manufacturing Program as a five-year US$1.3bn investment in US bioindustrial manufacturing.
Austria	**Bioeconomy – A Strategy for Austria**	2019; live to 2030	Broad bioeconomy; biotechnology; biological conversion; biorefineries; bio-based processing	Food/agriculture, forestry, chemicals/materials, industrial products and energy	CLIM; ECO; REG	Implemented through a national action-planning process covering 100+ short- and medium-term measures. No single dedicated strategy-level funding envelope identified.

Estonia	**Circular Bioeconomy Roadmap**	2023; live	Broad circular bioeconomy; biotechnology; bio-based processing	Agriculture, food, forestry, fisheries, chemicals, biotechnology, energy and bio-based products	CLIM; ECO; RES; REG	Focuses on deployment of new technologies, higher-value use of biological resources, industrial symbiosis and reducing reliance on imported/non-renewable resources. No single strategy-level funding envelope identified.
France	**National acceleration strategy: Bio-based products and industrial biotechnologies – sustainable fuels**	2021; live under France 2030	Industrial biotechnology; biomass conversion; bio-based production and scale-up	Bio-based chemicals/materials, industrial products and sustainable fuels	ECO; CLIM; RES	€420m in public support, explicitly aimed at accelerating industrial biotechnology, bio-based products and industrialisation from R&D through full-scale demonstration and industrial deployment.
Germany	**National Bioeconomy Strategy**	2020; live	Broad bioeconomy; industrial biotechnology; microorganisms; biotechnology, automation and other enabling technologies	Agriculture/food, chemicals, pharmaceuticals, industrial biotechnology, cosmetics, paper, textiles, forestry and other bio-based sectors	CLIM; ECO	Federal cross-government framework integrating research with implementation and industrial application. No single strategy-level funding envelope specified.
Italy	**Italian Bioeconomy Strategy (BIT II) + Implementation Action Plan 2025–2027**	2019 strategy; current 2025–27 implementation plan	Circular bioeconomy; industrial biotechnology; biorefineries; bio-based manufacturing	Agriculture/food, forestry, marine bioresources, chemicals/materials, energy and other bio-based industries	ECO; CLIM; REG	Current implementation plan responds to international investment in bio-based manufacturing and the need to translate Italian bioeconomy capability into industrial deployment. No single dedicated strategy-level envelope stated.
Latvia	**Latvian Bioeconomy Strategy 2030 (LIBRA)**	2017; live to 2030	Bioeconomy; biotechnology; bio-based industrial processing	Agriculture, fisheries, food, forestry/wood, chemicals, biotechnology and energy	ECO; REG; CLIM	By 2030: maintain around 128,000 bioeconomy jobs, increase value added to ≥€3.8bn, and increase bioeconomy exports to ≥€9bn.
Netherlands	**Dutch Vision on Biotechnology 2025–2040**	2025; live to 2040	Modern biotechnology; industrial biotechnology; biological production; biotechnology scale-up	Healthcare, biochemical industry, food/agriculture and other biotechnology applications	ECO; CLIM; HUM; RES	Four 2040 outcomes covering greater economic contribution, healthy life years, climate/circularity, and food security/sustainable agriculture. Includes an implementation agenda spanning economy, innovation/human capital, security and regulation. No single strategy-level envelope specified.
Norway	**The Government's Bioeconomy Strategy: Familiar Resources – Undreamt of Possibilities**	2016; current	Broad bioeconomy; biotechnology; biological conversion; cross-sector technology platforms; biorefining; fermentation	Food/feed, ingredients, health products, energy, materials, chemicals, paper, textiles and other bio-based products	ECO; CLIM; REG	Explicitly takes a cross-sector approach, promoting knowledge and technology platforms that can use biological resources from different sectors and apply across different industries. No single strategy-level funding envelope identified.
Spain	**Spanish Bioeconomy Strategy: Horizon 2030**	2015; current national instrument to 2030	Biotechnology; microorganism/algae cultivation; bio-based processing and production	Agri-food, forestry, biotechnology, bioplastics, lubricants, food ingredients, cosmetics and bioenergy	ECO; CLIM; REG	Focuses on commercial application of knowledge, industrial competitiveness and creation of markets for biological resources. No single strategy-level funding envelope stated.

India	**BioE3 Policy – Biotechnology for Economy, Environment and Employment: Fostering High-Performance Biomanufacturing**	2024; live	Explicit biomanufacturing policy; synthetic biology; genome editing; metabolic engineering; bioprocess engineering; Bio-AI; biofoundries	Bio-based chemicals, biopolymers, enzymes/APIs; smart proteins/functional food; biotherapeutics; agriculture; carbon utilisation/biofuels; marine/space biotechnology	ECO; CLIM; RES; HUM	Establishing Biomanufacturing Hubs, Biofoundries and Bio-AI Hubs; supports progress toward a US$300bn Indian bioeconomy by 2030. Eligible projects can receive government assistance of up to 70% of project cost.
Japan	**Bioeconomy Strategy**	2024; live to 2030	Biotechnology; biomanufacturing/bio-derived products; synthetic biology; microorganism/cell design; biofoundries	Industrial biomanufacturing/products; agriculture/food; forestry; biopharma; regenerative/cell/gene therapies; healthcare	ECO; RES; CLIM; HUM	Target to create ¥100tn in bioeconomy markets in Japan and overseas by 2030. Explicitly seeks broader incorporation of bioprocesses into industry and stronger supply chains.
South Korea	**Bioeconomy 2.0 Promotion Direction**	2023; live / under implementation	Broad biotechnology; biofoundries and biomanufacturing; synthetic/digital biology	Biopharmaceuticals, bio-based materials, bioenergy, digital bio and associated manufacturing	ECO; RES	Implementation architecture includes a national biofoundry and bio-material/energy initiatives. Associated national biofoundry infrastructure is being developed from 2025 to strengthen synthetic-biology-based biomanufacturing capability. No single cross-strategy funding envelope identified.
China	**14th Five-Year Plan for Bioeconomy Development (2021–2025)**	National bioeconomy plan issued 2022 for 2021–25; biomanufacturing policy direction continuing under the 15th Five-Year Plan (2026–30)	Biotechnology; synthetic biology; industrial biomanufacturing; fermentation; biological conversion; bio-based materials and processes	Chemicals, materials, pharmaceuticals, energy, agriculture/food and other industrial products	ECO; RES; CLIM; HUM	State-Council-approved bioeconomy plan identified biomanufacturing as a strategic industrial direction and promoted biological substitution of conventional feedstocks/processes. The current 15th Five-Year Plan identifies biomanufacturing as a future industry, demonstrating continuity beyond 2025.
Malaysia	**National Biotechnology Policy 2.0**	2022; live to 2030	Broad biotechnology; industrial biotechnology; bioinnovation; circular bioeconomy	Agriculture/food security; health; industrial biotechnology/circular economy	ECO; HUM; CLIM	Strategic objective for biotechnology companies to contribute 5% of Malaysian GDP by 2030; accompanied by commercialisation and company-support mechanisms including BioNexus.
Thailand	**BCG Action Plan 2021–2027**	Cabinet-approved 2022; live to 2027	Bioeconomy; biotechnology; synthetic biology; bioprocess engineering; biorefining and pilot/ demonstration-scale production, integrated with circular/green economy	Agriculture/food; medicines/health; energy; biomaterials/biochemicals; circular economy and other sectors	ECO; CLIM; REG; HUM	Approximately THB41bn Cabinet-approved action-plan budget. Targets an additional THB1tn in BCG-economy GDP by 2027, alongside development of pilot, demonstration and scale-up infrastructure and increased domestic production of high-value biobased products.
Saudi Arabia	**National Biotechnology Strategy**	2024; live; 2030/2040 horizons	Broad biotechnology; biomanufacturing and localisation; genomics; plant biotechnology	Vaccines/biologics, biomanufacturing, genomics and agriculture/plant optimisation	ECO; RES; HUM	Aim to become a leading MENA biotechnology hub by 2030 and global leader by 2040; targeted contribution of >US$34.6 bn to non-oil GDP and 55,000 jobs by 2040.

Brazil	**National Bioeconomy Strategy (ENB)**	2024; live	Broad bioeconomy; explicitly includes bioindustry and biomanufacturing	Bioindustry/biomanufacturing, biomass, terrestrial/aquatic systems and broader biodiversity-derived value chains	ECO; CLIM; REG	Establishes the National Bioeconomy Commission and National Bioeconomy Development Plan (PNDBio) as implementation mechanisms. No single strategy-level funding envelope stated in the establishing framework.
Colombia	**Mission-oriented Research and Innovation Policy – Bioeconomy and Territory Mission**	2023/24; approved 2024; live	Biotechnology and biodiversity-based production; green chemistry; biorefineries; bioprocess/value-chain innovation	Functional foods, agricultural bioinputs, biopolymers, biorefineries, health/cosmetics and other biodiversity-derived products	ECO; REG; CLIM	National mission seeks to strengthen value chains for bio-based products and services across regions. Government reporting for 2023–24 identifies 29 projects and COP40.091bn in investment under Bioeconomy and Territory.
Costa Rica	**National Bioeconomy Strategy 2020–2030**	2020; live to 2030; update work underway	Broad bioeconomy; advanced biotechnology; circular biomass utilisation; bio-based production	Agriculture/food, biodiversity, bio-based products, biorefineries and other industrial applications	CLIM; ECO; REG	Seeks to make bioeconomy a pillar of productive transformation through value addition, diversification, technological sophistication and fossil-carbon substitution. No single dedicated strategy-level funding envelope identified.
Uruguay	**National Sustainable Bioeconomy Strategy**	2024; live; horizon to 2050	Broad bioeconomy; biotechnology; biological-resource transformation; bioproduct development	Food/beverages; forestry; chemicals/pharma; waste/by-product valorisation; aquatic bioresources and other bio-based products	ECO; CLIM; REG	Horizon to 2050, with a 2024–26 Action Plan operationalising the strategy through 12 priority actions, including bioproduct markets and RDI capability. No overarching funding envelope stated.
South Africa	**Bio-economy Strategy**	2013; still active toward 2030	Biotechnology; industrial biotechnology; bio-based innovation from R&D through commercialisation	Health, agriculture/food, manufacturing/industry and environment	ECO; HUM; REG	Explicitly targets creation of biotechnology industries, sustainable industrial development and commercialisation, with a longer-term ambition for the bioeconomy to become a significant contributor to GDP.
East African regional framework	**East African Regional Bioeconomy Strategy 2021/22–2031/32**	2021/22; live regional framework to 2031/32	Broad bioeconomy; biotechnology; bioprocessing; biomass conversion; circular production	Food/agriculture, pharmaceuticals/health, chemicals, biomaterials, agricultural inputs and bioenergy/biofuels	REG; ECO; HUM; CLIM	Covers Burundi, Kenya, Rwanda, South Sudan, Tanzania and Uganda, focused on sustainable industrialisation, revitalised bioprocessing/value chains, new bio-based industries and regional market development. No single regional funding envelope specified.

† US note: Unlike the other national entries, the US framework shown is a Department of Defense strategy rather than a whole-of-government national strategy. The 2022 whole-of-government biotechnology and biomanufacturing Executive Order was rescinded in March 2025; current US policy is distributed across defence programs, legislation and other federal initiatives

Appendix 2: Selected shared multi-purpose biomanufacturing scale-up facilities globally

This table presents selected shared-access multi-purpose facilities providing meaningful pilot- and/or demonstration-scale biomanufacturing capability, intended to support external users in progressing processes beyond laboratory proof-of-concept towards commercial manufacturing. "Multi-purpose" includes facilities capable of supporting multiple product applications and/or technology platforms; it does not require every facility to support all forms of biomanufacturing. Facilities may be operational, under construction or credibly committed/planned. The table is illustrative rather than exhaustive. Vessel volumes are published working or nominal capacities and are not necessarily directly comparable between facilities. Status is current as at 24 August 2026. This appendix was prepared with the assistance of ChatGPT.

Facility / operator	Jurisdiction	Technology scope	Product / sector scope	Scale-up capability	Downstream / integrated capability	Access / operating model	Ownership / funding model	Status	Notable feature
QUT Pioneer BioPilot, Mackay / Queensland University of Technology	**Australia – Queensland**	Precision fermentation; microbial fermentation; biomass processing; biorefining; thermochemical conversion	Food ingredients and proteins; enzymes; industrial chemicals; biofuels/SAF; other bioproducts	100 L, 1,200 L and 2,400 L working-volume fermenters; batch, fed-batch, continuous and perfusion; aerobic and anaerobic operation	Extensive integrated DSP including centrifugation, filtration/TFF, homogenisation, chromatography and drying; also biomass processing, biorefining, SAF and hydrotreating capability	Industry-facing shared scale-up facility; external industry and research projects supported by QUT technical staff	QUT-operated public/university infrastructure; AUD$18.2m upgrade supported by Australian and Queensland Governments through FaBA, together with QUT	Operational; upgraded facility opened 2025	Leading Australian public/shared pilot-scale comparator; located beside a major sugar mill and integrates fermentation with broader biorefining capability
Cauldron Ferm, Orange demonstration facility	**Australia – New South Wales**	Precision fermentation; proprietary continuous "hyper-fermentation"	Food/feed ingredients; proteins; fibres/materials; industrial bioproducts and other fermentation-derived products	R&D fermenters at 2 L, 20 L, 42 L and 150 L; two 10,000 L fermentation lines for process validation and demonstration	Centrifugation, filtration and drying; food-grade and licensed for work with genetically modified microorganisms	Commercial contract scale-up through FermaFit/FermaValidate; technology transfer and customer IP protection; process validation through 10,000 L	Privately owned and venture-backed; complemented by Australian and Queensland Government support for technology and facility development	Operational	Important private/CDMO complement to public shared infrastructure; demonstrates continuous fermentation at 10,000 L in Australia
Industry Biotechnology Centre (IBC), Toowoomba / AATLIS	**Australia – Queensland**	Industrial, agricultural and environmental biotechnology; advanced bioreactor systems	Biomanufacturing; agtech; environmental biotechnology; broader industrial biotechnology	Public bioreactor volume not yet disclosed; designed to support progression through R&D, scale-up and manufacturing	Planned PC2 and PC3 laboratories; advanced manufacturing zones; scalable production capability; analytical and commercial space	Designed for external industry, startup and research users through collaborative R&D and manufacturing/scale-up access	AUD$50m project: AUD$25m joint Australian/Queensland Government support through the SEQ City Deal Innovation Economy Fund, matched by FKG Group	Under development; Stage 1 construction planned mid–late 2026; core commissioning in 2027	Emerging Australian benchmark, noteworthy broader hub model through focus on both infrastructure and operating environment for scale-up.
Bio Base Europe Pilot Plant (BBEPP), Ghent	**Belgium**	Precision and biomass fermentation; gas fermentation; biomass pretreatment; biocatalysis; green chemistry	Food/feed ingredients; chemicals; materials; fuels/energy; pharmaceuticals and other bioproducts	Scale-up from laboratory through 1,500 L and 15,000 L to an operational 75,000 L demonstration line; batch, fed-batch and continuous configurations	Extensive modular DSP and product recovery integrated with fermentation; unit operations can be assembled into complete process trains; food-grade and segregated industrial capability	Confidential bilateral commercial projects and contract scale-up/manufacturing; publicly funded collaborative projects; specialist in-house engineering and operating teams	Independent non-profit; established with €13m regional public funding and subsequently expanded through layered regional, EU and other public co-investment; operating revenue from commercial and collaborative projects	Operational and continuing to expand	Flagship mature precedent: genuinely cross-sector and multi-technology, with shared scale-up extending to 75,000 L and documented commercialisation outcomes
Changde Synthetic Biology Manufacturing Pilot Base / Changde Economic & Technological Development Zone	**China – Hunan**	Synthetic biology; microbial fermentation; biocatalysis; process scale-up	Biopharma/cosmetic ingredients; biochemicals; agricultural and food products; biomaterials; proteins, peptides, polysaccharides/nucleic-acid products and other fermentation products	Operational: 2 × 5,000 L + 2 × 20,000 L fermentation lines. Additional 1,000 L food-grade and 5,000 L non-GMP pilot lines announced	Full process chain spanning strain expansion, fermentation, product extraction, separation/purification, catalytic refining; 20-tonne/day downstream-processing line	Purpose-built public/shared pilot-service platform for research institutes and companies; provides pilot contract processing, customised scale-up/process services and joint product development.	RMB169m pilot-base investment; planned/built by Changde ETDZ with technical and operating support from Central South University's microbial-manufacturing team; government–university–industry model	Operational from June 2026; further food-grade/non-GMP capacity being added	One of the clearest current Chinese examples: large 20,000 L shared fermentation capacity explicitly intended to reduce the cost and entry barrier for startups and research organisations crossing the "last mile" into industrial production.

Chongqing Biomanufacturing Industry Pilot Platform, Bishan / Chongqing Life Science City	**China – Chongqing**	Synthetic biology; microbial fermentation; plant-cell cultivation; intelligent/digital bioprocessing	High-value chemicals; natural products; biopharmaceutical-related applications; agricultural/RNA products and broader synthetic-biology products	Phase 1 operational: 182 graded fermenters spanning 1–500 L. Phase 2 planned: eight large-scale fermentation modules spanning 3,000–30,000 L	Phase 1 integrates automated sample processing, sensing/analytics and digital-twin/process-control systems; Phase 2 adds 16 flexible separation and purification modules	Explicitly established as an open/shared public-service platform serving external research teams and companies. Target of >100 companies served annually once mature	Approximately RMB625m total investment. Built by Bishan District with East China University of Science and Technology's State Key Laboratory of Bioreactor Engineering and industrial partners including Danaher; supported by national and Chongqing development/reform authorities	Phase 1 operational since 23 June 2026; Phase 2 under development	Particularly notable for its planned scale and digitalisation: it connects 182 small/pilot fermenters to future 30,000 L modules, creating a deliberate continuous scale-up pathway rather than an isolated pilot plant.
Intelligent Bio-Manufacturing Center / Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences (CAS)	**China – Tianjin**	Microbial fermentation; synthetic biology; intelligent/digital bioprocess engineering	Broad industrial biomanufacturing: intracellular/extracellular macromolecules and small molecules, including diverse fermentation-derived products	Pilot fermentation and production lines spanning 20–2,000 L; eight digital pilot fermentation lines	Particularly extensive: centrifugation, filtration, micro/ultra/nanofiltration, chromatography, membrane separation, concentration/crystallisation, granulation, fluid-bed and spray drying, homogenisation and liquid-liquid separation; digital process sensing/control	Flexible external-access models explicitly described as "shared kitchen", "shared chef" and contract-development-style services; broader CAS technical facilities are open to domestic and international researchers	Public national-research-institute infrastructure operated by the Chinese Academy of Sciences; exact establishment/capital cost not publicly identified in sources reviewed	Operational	A genuinely shared 20–2,000 L end-to-end fermentation and DSP platform, with unusually flexible access models and strong process-digitalisation capability.
Fraunhofer Center for Chemical-Biotechnological Processes (CBP), Leuna	**Germany**	Microbial fermentation; biocatalysis; lignocellulosic fractionation; enzymatic and chemical conversion	Chemicals; enzymes/proteins; materials; fuels and other bio-based industrial products	10 L, 100 L, 300 L, 1,000 L and 10,000 L bioreactor cascade; batch, fed-batch and continuous operation; additional ATEX fermentation capability	Integrated biomass separation, cell disruption, membrane filtration and purification; chemical and physical processing; ability to assemble complete upstream/downstream process chains	Industry contracts and collaborative/public R&D; flexible pilot infrastructure and specialist Fraunhofer technical support	Fraunhofer applied-research model; publicly supported research infrastructure combined with customer and collaborative project funding	Operational	Strong example of modular integration of biological and chemical process scale-up, enabling processes to be demonstrated through to industrial maturity
National Industrial Biotechnology Facility (NIBF) / CPI, Wilton	**United Kingdom**	Precision fermentation; biomass fermentation; gas fermentation; microbial and cell-culture bioprocessing	Food/feed; chemicals; fuels; materials; proteins and other industrial biotechnology products	NIBF pilot fermentation at 100 L, 400 L and 2,000 L and demonstration at 10,000 L; the Novel Food Innovation Centre within NIBF adds food-grade scale-up through 50 L, 100 L, 400 L and two 750 L units	Plug-and-play DSP scale-up; biomass processing; purification, formulation and technology-transfer capability	Open-access facility; development and piloting projects; short- and long-term contract manufacturing; tailored access for startups, SMEs, corporates and universities	UK government-backed independent innovation organisation; NIBF is a £24m facility developed through successive public infrastructure investments	Operational; novel-food capability expanded in 2026	One of the clearest UK shared-scale-up precedents, combining 10,000 L industrial biotechnology capability with dedicated food-grade engineering-biology infrastructure
National Biorefinery Pilot Plant (NBPP), Lisheen / Irish Bioeconomy Foundation	**Ireland**	Precision and general submerged fermentation; solid-state fermentation; anaerobic digestion; photobioreactors; biomass pretreatment	Agri-food; dairy; forestry; brewing/distilling; marine products; chemicals; ingredients; energy and other bio-based products	Precision bioreactors at 25 L, 100 L, 1,000 L and 3,000 L; general-purpose vessels 500–3,000 L; 2,500 L anaerobic digestion; 1,000 L photobioreactor; supports TRL 4 through pre-commercial TRL 8	End-to-end pretreatment, hydrolysis, fermentation, clarification, centrifugation, membrane filtration, extraction, distillation, evaporation, spray/drum drying, formulation and TEA/LCA	Open access; fully managed fee-for-service projects; client-managed secure pilot zones; confidential trials and collaborative R&D	Operated by Irish Bioeconomy Foundation; developed through Enterprise Ireland/regional enterprise support and subsequent EU Just Transition Fund/BioScaleUP investment	Operational; formally launched June 2026	Very recent national precedent built specifically as an integrated open-access pathway from laboratory validation through pre-commercial deployment

Kanto Biofoundry / Green Earth Institute (GEI), Mobara	**Japan – Chiba**	Microbial fermentation; synthetic-biology production; biomass pretreatment; biorefining/process development	Amino acids, peptides, oils, enzymes, organic acids, aromatic compounds and other fermentation-derived/bio-based products	0.25 L–3,000 L fermentation scale-up; demonstrated scale-up through 300 L and 3,000 L	Integrated biomass pretreatment; fermentation optimisation; explosion-protected purification capability; process modelling/CFD; cost and CO_2/LCA assessment	External companies and universities access confidential scale-up and demonstration services, with GEI technical support; current NEDO projects largely require users to cover consumables and external costs.	GEI-operated facility established under NEDO's national bio-manufacturing/biofoundry program; developed with NEDO support, with Kyowa Hakko Bio involved in the original project; exact facility capex not identified in the public sources reviewed	Operational since 2023 under the NEDO demonstration program; transitioning to full commercial biofoundry services from FY2027	Particularly strong Japanese precedent because it was created specifically to solve the lab-to-commercial scale-up bottleneck. By mid-2025 it had undertaken eight demonstrations across several product types, with seven successfully reaching 300 or 3,000 L.
Biotechnology Fermentation Factory (BFF), Ede / NIZO Food Innovation Campus	**Netherlands**	Precision fermentation; biomass fermentation	Food ingredients; alternative proteins; functional biomolecules; enzymes; flavours and other fermentation-derived food products	10–30 L pre-pilot capability operational in 2026; planned food-grade 1,000 L and 10,000 L pilot systems supporting approximately TRL 4–7	Integrated upstream and primary recovery on BFF line; secondary DSP and wider food-product development available through NIZO's existing pilot infrastructure	Non-profit, open-access facility for food and ingredient biotechnology companies and technology providers	Supported by a €12.5m National Growth Fund grant through Cellular Agriculture Netherlands, regional support from Oost NL and in-kind/private contributions including NIZO	Pre-pilot operational; 1,000 /10,000 L installation underway in 2026; pilot operations from 2027	Highly targeted example of public investment explicitly addressing the food-grade fermentation "missing middle"
VTT Industrial Biotechnology Infrastructure, Espoo	**Finland**	Synthetic biology and cell-factory development; microbial fermentation; bioprocess engineering	Chemicals; materials; energy; food; proteins/enzymes; pharmaceutical applications	More than 60 bioreactors spanning approximately 0.25 L to 1,200 L; laboratory-to-pilot scale	Separation, filtration, cell lysis, drying and analytics integrated with strain engineering and bioprocess development	Customer-specific industry projects and collaborative R&D; support from strain engineering through pilot validation	VTT public research organisation; national research infrastructure combined with customer and collaborative project funding	Operational	Particularly strong strain-to-pilot model integrating synthetic biology, process development, analytics, fermentation and DSP in one organisation
RISE Processum / RISE Research Institutes of Sweden, Örnsköldsvik	**Sweden**	Strain development; microbial fermentation; lignocellulosic pretreatment; enzymatic hydrolysis; bioprocess engineering	Food/feed; materials/polymers; chemicals; pharmaceuticals; biofuels and other bio-based products	Bioreactor systems from millilitre scale through 10 m^3 (10,000 L); pilot/production-scale bioprocessing; newly built pilot infrastructure completed in 2024	Integrated homogenisation, centrifugation, drying, chromatography, filtration/ultrafiltration and other DSP; feedstock pretreatment and analytics	Contract R&D and collaborative projects for startups, established industry and research partners	RISE is Sweden's independent government research institute; infrastructure supported through public, EU, collaborative and customer-funded activity	Operational; major pilot facility modernised/expanded in 2024	Comprehensive "strain-to-scale" platform extending to 10,000 L across unusually broad food, material, chemical and fuel applications
Biosolutions Technology Center / Danish Technological Institute, Høje-Taastrup	**Denmark**	Microbial fermentation; biorefining; microalgae	Food ingredients; mycoproteins; omega-3 products; biochemical products; pharmaceuticals; bioplastics; biofuels and other biosolutions	Current fermentation capability at 1 L, 20 L and approximately 200 L; 2,000 L food/ATEX-compatible capacity planned for 2027	Integrated pilot biorefining and DSP including centrifugation, filtration, extraction and spray drying; expansion will add further DSP	Direct company projects, R&D collaborations and pilot testing for startups, established companies and research organisations	Danish Technological Institute applied-technology model; public/collaborative R&D and commercial project funding; further pilot investment underway	Operational at 200 L scale; 2,000 L expansion underway for 2027	Useful example of a jurisdiction deliberately expanding an existing shared facility to close a recognised laboratory-to-industrial scale-up gap
NREL Biochemical Conversion Pilot Plant / National Renewable Energy Laboratory	**United States – Colorado**	Biomass pretreatment/deconstruction; enzymatic hydrolysis; microbial fermentation/conversion	Biofuels; renewable chemicals and other biomass-derived bioproducts	30 L, 160 L and 1,500 L vessels feeding four 9,000 L main fermenters; batch, fed-batch or continuous; integrated biomass throughput up to roughly one dry tonne/day	Solid-liquid separation; centrifugation; filtration; evaporation and distillation integrated with pretreatment and hydrolysis	Industry partners and researchers can test processes using NREL equipment or compatible external/rental equipment	U.S. Department of Energy national-laboratory infrastructure	Operational	One of the strongest fuels/chemicals comparators: an integrated feedstock-to-product pilot plant combining 9,000 L fermentation with tonne/day biomass conversion
Advanced Biofuels and Bioproducts Process Development Unit (ABPDU), Lawrence Berkeley National Laboratory	**United States – California**	Microbial fermentation; biomass deconstruction; biocatalysis; integrated bioprocessing	Biofuels; chemicals; proteins/food ingredients; oils; dyes/materials and other bioproducts	Pilot fermenters at 50 L and two 300 L units; working volume up to 300 L; technologies routinely progress from bench through pilot scale	More than a dozen downstream/recovery operations plus biomass pretreatment, analytics and techno-economic analysis	External industry and research collaborations, including cost-recovery/work-for-others and publicly supported scale-up projects	U.S. Department of Energy/Berkeley Lab public scale-up infrastructure supplemented by project and partner funding	Operational	Smaller maximum vessel size but highly notable for startup access, integrated process-development expertise and documented transfer of technologies onward to demonstration/commercial manufacturing

Integrated Bioprocessing Research Laboratory (IBRL) / Illinois Fermentation and Agriculture Biomanufacturing (iFAB) Tech Hub	**United States – Illinois**	Precision fermentation; microbial bioprocessing	Food ingredients/proteins; chemicals; materials/textiles; fuels; agricultural inputs and other bioproducts	CURRENT: IBRL pilot capability up to 1,500 L; total testing capacity 2,932 L. PLANNED: IBRL 2.0 increases testing capacity to 12,312 L; iPROOF adds two 1,500 L and two 10,000 L fermenters from 2027; ADM BioProducts upgrade adds approximately 75,000 L capability	IBRL flexible pilot DSP; iPROOF will include centrifugation, micro/ultra/nanofiltration, evaporation, spray drying and HTST; linked industrial partner infrastructure extends the process pathway	IBRL industry-facing shared/fee-for-service model; iPROOF independent and industry-neutral; iFAB connects users into partner infrastructure and wraparound commercialisation/workforce services	IBRL university/state infrastructure; iFAB received approximately US$51m EDA Tech Hub implementation funding, with its proposal identifying roughly US$680m in complementary/co-investment across consortium partners	IBRL operational; IBRL expansion, iPROOF and ADM upgrades under development; iPROOF expected operational spring 2027	Perhaps the clearest U.S. "lab-to-line" regional model: expands a proven shared pilot facility and connects it to progressively larger private/partner assets rather than duplicating all scales in one facility
BioMADE California Pilot Plant, Hayward	**United States – California**	Industrial microbial fermentation / bioindustrial manufacturing	Chemicals; materials; food and other commercial/defence bioproducts	Multiple aerated stirred-tank fermenters up to 4,000 L; commensurate seed train	Harvest tanks; centrifugation; ceramic/polymeric membrane filtration; evaporation; spray drying; capacity to bring in third-party DSP skids	Nationally available multi-user facility; project-scoped commercial access under BioMADE's common Pilot Plant Network pricing/operating model	BioMADE public-private institute; conversion/acquisition of former Lygos infrastructure represents at least US$80m investment funded by U.S. Department of Defense	Under development/commissioning; current BioMADE schedule targets customer opening mid-2027	Notable example of public investment repurposing existing private pilot assets into nationally accessible shared infrastructure
BioMADE Iowa Pilot Plant, near Ames	**United States – Iowa**	Industrial microbial fermentation / bioindustrial manufacturing	Agricultural bioproducts; chemicals; animal feed; food products; materials and defence-related bioproducts	Published BioMADE sources are inconsistent: current network overview lists 1,000 L and 10,000 L; the 2025 groundbreaking announcement and 2026 facility sheet list 5,000 L and 10,000 L. Final configuration should be confirmed before publication	Planned centrifugation, homogenisation, MF/UF/NF membrane filtration, chromatography, crystallisation/separation, evaporation, spray drying, HTST, media/feed systems and analytical chemistry	National multi-user facility serving startups, industry and government users under the BioMADE network operating model	US$40m project: at least US$20m BioMADE, up to US$10m Iowa State University cost share and US$10m Iowa Economic Development Authority funding	Under construction/development; current BioMADE customer schedule is early 2028	Strong agricultural value-add and regional-development precedent, explicitly using shared biomanufacturing to create new markets for domestic agricultural feedstocks
BioMADE Minnesota Demonstration Facility, Maple Grove	**United States – Minnesota**	Industrial microbial fermentation; bioindustrial manufacturing including volatile-process capability	Chemicals; materials; fuels; defence products and broader consumer/industrial bioproducts	5,000 L and 25,000 L scale capability; two 25,000 L principal industrial fermenters planned, with smaller seed train systems	Extensive centrifugation, membrane filtration, ion exchange, crystallisation, evaporation/filtration and drying; explosion-proof/volatile-liquid capability	National multi-user CDMO-style facility for industry and U.S. Government customers; standard BioMADE network access model	US$132m project; 2026 Minnesota reporting identifies US$50m Minnesota support and US$82m federal matching investment	Under construction; completion expected late 2027 and current BioMADE customer opening target early 2028	Largest of BioMADE's first three facilities and explicitly designed to fill the demonstration-scale gap before commercial manufacturing
NRC Microbial Fermentation Pilot Plant, Montréal / National Research Council Canada	**Canada – Quebec**	Microbial fermentation with CL-1, CL-2 and CL-3 capability	Proteins; peptides; nutraceuticals; organic acids; polymers; probiotics and other microbial biotechnology products	CL-1 bioreactors up to 1,500 L; CL-2 up to 150 L; CL-3 up to 30 L	Primary recovery, cell breakage/product capture and small- to pilot-scale purification; analytical and process-monitoring laboratories	Accessible to biotechnology industry and research users for process development, optimisation, scale-up, material production and training	Federal public research infrastructure operated by National Research Council Canada	Operational; providing shared fermentation scale-up for more than 25 years	Long-running Canadian public infrastructure combining meaningful pilot scale with multiple biological containment levels
Verschuren Centre / 10X Bioprocessing Scale-up Facility, Cape Breton	**Canada – Nova Scotia**	Precision and microbial fermentation; industrial/agricultural biotechnology; wider bioresource processing	Industrial biotechnology; agritech; food/feed; green chemicals; biomaterials and marine/bioresource applications	Shared fermentation pathway at approximately 100 L, 1,000 L and 10,000 L; 10,000 L precision-fermentation line ("10X") now operational	End-to-end downstream processing; analytical laboratories; complementary 6,000 L marine extraction capability	Shared-use contracted services for SMEs and industry; AscendBio combines technical scale-up, commercialisation/investment support and full IP retention	Independent not-for-profit; 10,000 L expansion described as roughly C$10m investment assembled through stacked public/partner funding, with further federal/provincial support for capacity and training	Operational; Province confirmed operational 10,000 L line in August 2026	Excellent intermediate-scale comparator: companies can move through shared 100/1,000/10,000 L capacity before transitioning into Neptune's industrial infrastructure

Neptune BioInnovation Centre, Dartmouth	**Canada – Nova Scotia**	Industrial-scale precision fermentation / industrial biotechnology	Food and nutrition; green chemicals; agriculture; smart materials; bioplastics and other advanced bioproducts	Current Neptune facility information identifies multiple vessels ranging from 25 m³ to 150 m³ (25,000–150,000 L), with capacity for additional lines; full build-out remains underway	Industrial solids-liquid separation, concentration, solvent extraction, ion exchange and other DSP; industrial spray drying	Not-for-profit multi-user hub and CMO; contract manufacturing, shared labs/infrastructure and flexible tenant manufacturing space	Not-for-profit public-private model; C$5m non-repayable federal contribution plus C$5m Province of Nova Scotia investment announced in 2025, alongside broader private/partner investment	Opened in 2025 but being built out in phases; some resources available now and additional capacity coming online	Unusual example of shared infrastructure extending into industrial/commercial-scale production; together with Verschuren creates a deliberate pilot-to-industrial regional continuum
Callaghan Innovation Fermentation & Bioprocessing Facility	**New Zealand**	Precision fermentation; biomass fermentation; synthetic biology	Alternative proteins; probiotics; nutraceuticals; pharmaceuticals; crop and animal health; other microbial bioproducts	1 L to 1,000 L fermentation; PC2/GMO capability; aerobic and anaerobic cultivation	Integrated centrifugation, filtration, concentration, purification and drying; formulation/packaging and technology-transfer support	Commercial project/service access for innovators; process development, pilot-scale production and technology transfer to commercial manufacturers	New Zealand public/Crown innovation infrastructure supported through government funding and commercial project activity	Operational	Highly relevant small-economy comparator; described as New Zealand's only end-to-end fermentation facility linking upstream development, 1,000 L pilot production and DSP
ScaleUp Bio, Tuas	**Singapore**	Submerged microbial fermentation; precision fermentation	Primarily food-tech applications including proteins, fats/oils, enzymes, probiotics and functional food ingredients	Commercial food-grade scale-up from approximately 100 L to 10,000 L	High-speed separation and membrane processing including microfiltration, ultrafiltration and nanofiltration; associated product recovery and DSP	Commercial CDMO/fee-for-service access for external startups and established companies; process optimisation, scale-up and manufacturing support	Private joint venture between ADM and Temasek-owned Nurasa; embedded in Singapore's wider A*STAR/Nurasa food-tech ecosystem	Operational	Important Asia-Pacific comparator: dedicated food-grade shared/CDMO infrastructure allowing companies to scale from pilot through early commercial production without building proprietary capacity

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