GFI Asia Pacific | Hawkwood

Where to Build:

site selection and competitiveness in APAC fermentation manufacturing

Evaluating site selection drivers and regional opportunities for fermentation-derived food ingredient scale-up

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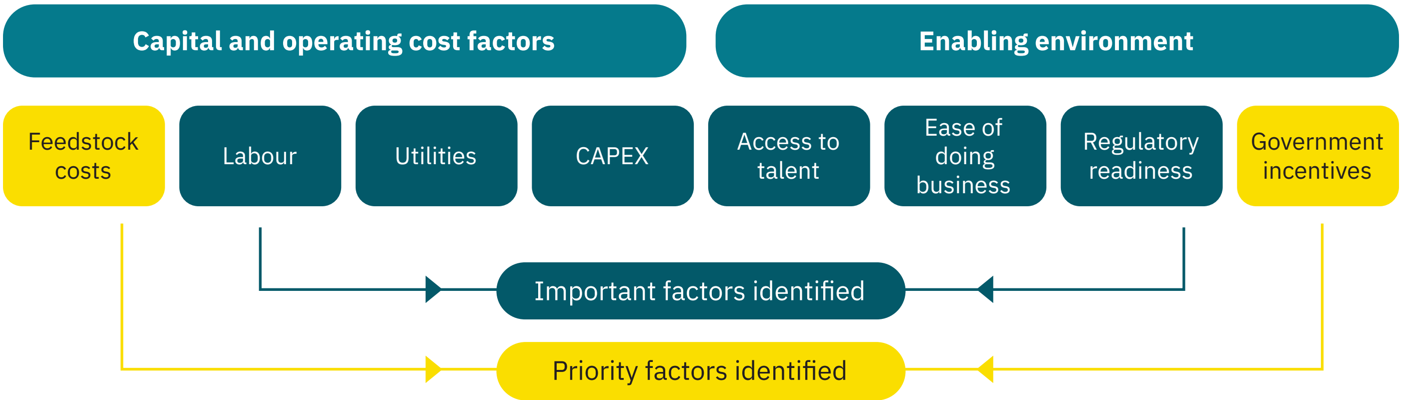
Executive summary

Biomanufacturing as an alternative method of protein production is a promising pathway to advance the global food system. This report evaluates the competitiveness of nine APAC countries as potential hosts for fermentation-derived food ingredient manufacturing.

Competitiveness drivers for biomanufacturing

Drawing from executive interviews and technoeconomic modelling, the analysis identifies eight drivers of site selection for fermentation-derived ingredient biomanufacturing. Government incentives and feedstock costs emerged as the two most critical drivers of site selection.

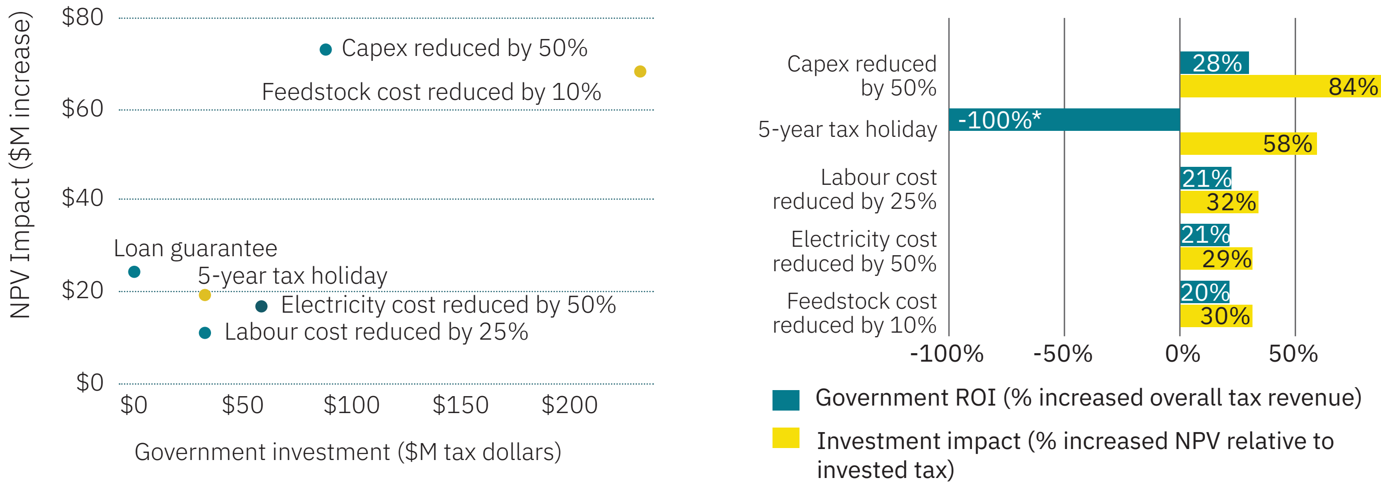
Figure 1: Summary of key factors identified for biomanufacturing site selection



Government incentives

The value of a biomanufacturing project can be dramatically influenced by government incentives. Quantitative analysis on the impact of a range of incentive types on a biomanufacturing facility found that non-dilutive capital support (e.g. capital expenditure grants, loans, or guarantees) delivered the highest Return on Investment (ROI)—both for companies, measured by projected net present value (NPV), and for governments, measured by projected tax revenue.

Figure 2: Summary of incentive impact on company and government ROI



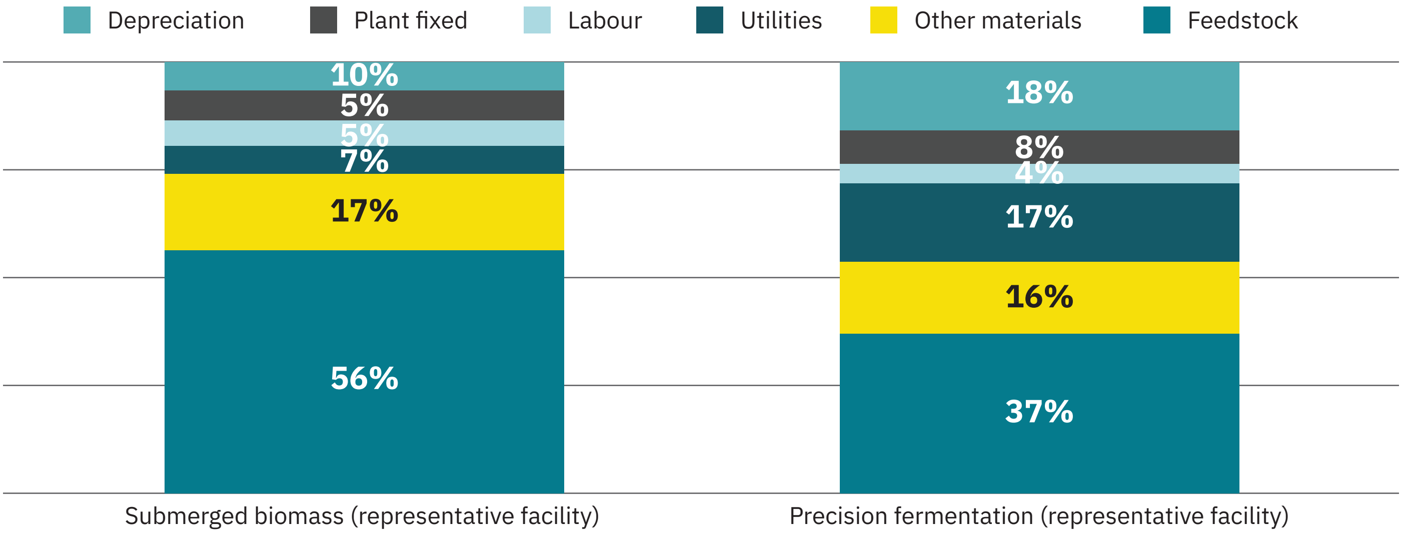
*Source: Hawkwood analysis based on technoeconomic modelling of a biomanufacturing facility. Notes: Values represent changes from the base case scenario which is assumed here as a 20 percent corporate income tax (CIT) rate, an NPV of $119 million, and $144 million in tax revenue. *Actual ROI may be higher if firms reach profitability and pay taxes after the incentive ends.*

All monetary values are expressed in U.S. dollars (USD) unless otherwise specified.

Feedstock costs

Feedstock is the largest production cost driver **(Figure 3)**. The most cost-effective manufacturing environments can be achieved when fermentation sites are co-located with sugar production, minimising feedstock and logistics costs.

Figure 3: Breakdown of production costs for fermentation across two facility models



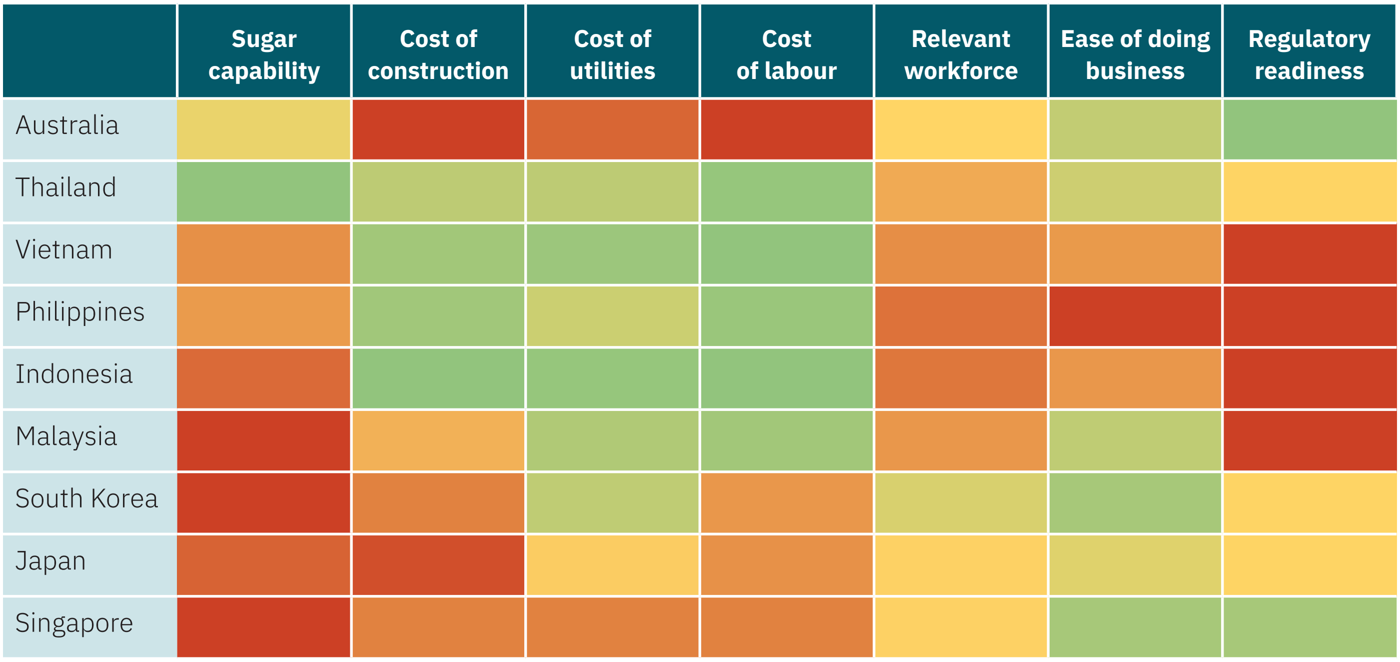
Source: Representative facility models are from proprietary Hawkwood data.

APAC biomanufacturing strengths and gaps

Using a normalised competitiveness index, nine APAC countries were assessed across key site selection drivers. This index serves as a directional tool to highlight markets with promising cost structures and enabling environments for the manufacturing of fermentation-derived food ingredients.

Figure 4: Overview of biomanufacturing competitiveness index results

Colours reflect scoring based on relative position across the country group, normalised using proportional (min-max) normalisation, where 100 (green) reflects the best observed value across countries.



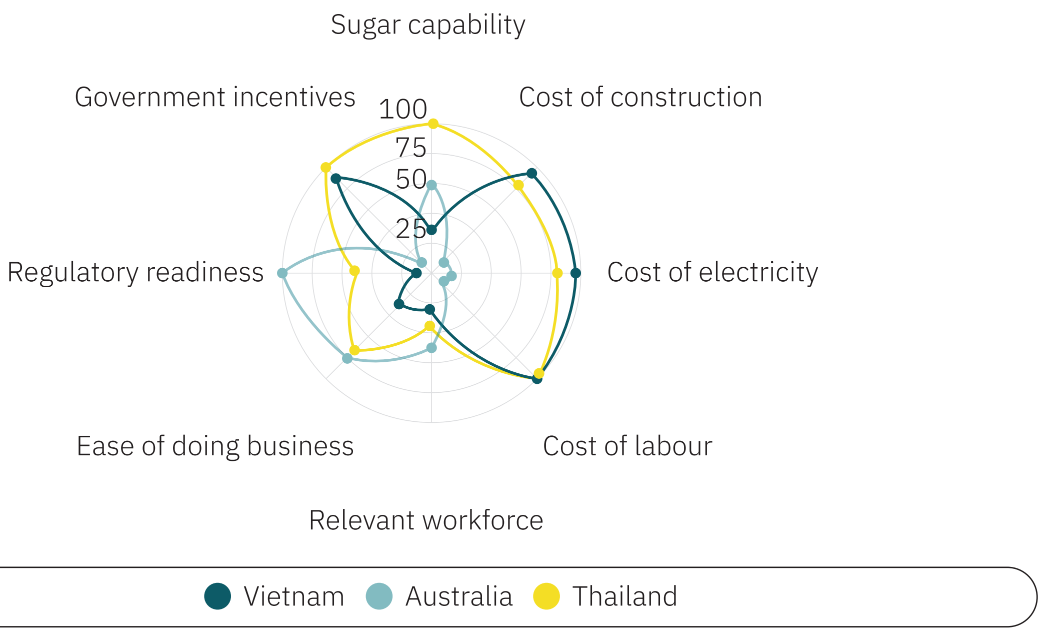
Source: See Appendix for details. Note: Government incentives are omitted here and only evaluated for three spotlighted countries.

Based on their relative strengths—and to demonstrate diverse policy contexts—**Thailand, Australia, and Vietnam** were selected for deeper evaluation. For these countries, an additional layer of analysis was added to assess the role of government incentives, which can significantly influence site selection decision-making. Incentives function as force multipliers which can either strengthen existing advantages or help to offset structural weaknesses.

Thailand	Australia	Vietnam
Thailand has one of the strongest feedstock positions in APAC and a relatively balanced profile across the competitiveness indicators. Critically, Thailand stands out for its generous government incentive. Its potential as a biomanufacturing location is diluted by uncertainty in the regulatory environment.	Australia is a leader in the region on regulatory clarity and feedstock potential. However, it is a comparatively high cost environment, and a lack of government incentive support to offset these high costs leaves its advantages underleveraged.	Vietnam's government incentives and bioeconomy strategy signal strong intent to establish the country as an emerging strong biomanufacturing location. Clear follow-through will be essential to compensate for Vietnam's feedstock limitations and regulatory immaturity.

Figure 5: Spider chart of index results for Thailand, Australia, and Vietnam

Scores reflect relative position across the country group (nine countries in APAC), normalised using proportional (min-max) normalisation, where 100 reflects the best observed value across countries.



Source: See Appendix for details. Note: Government incentives are normalised only among these three spotlighted countries.

Report overview

Goals

This report aims to answer the following questions:

1. What are the key factors influencing commercial-scale site selection for submerged fermentation facilities producing food ingredients?
2. How do selected APAC countries perform against these factors, and what steps could strengthen their competitiveness?

The APAC countries included in this analysis were Australia, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Thailand, and Vietnam. The selected countries present diverse but underexplored opportunities for biomanufacturing development.

Out of scope

This report focuses on site selection considerations for biomanufacturing facilities relevant for large-scale fermentation-derived food ingredient production. The following areas are outside the scope of this analysis as they involve distinct considerations that differ from those evaluated here:

Solid-state fermentation (SSF), as its process conditions, feedstock, scale-up challenges, and commercial maturity differ substantially from submerged fermentation. SSF typically relies on surface-limited growth with lower levels of automation and process control, meaning it has unique competitive site selection criteria.

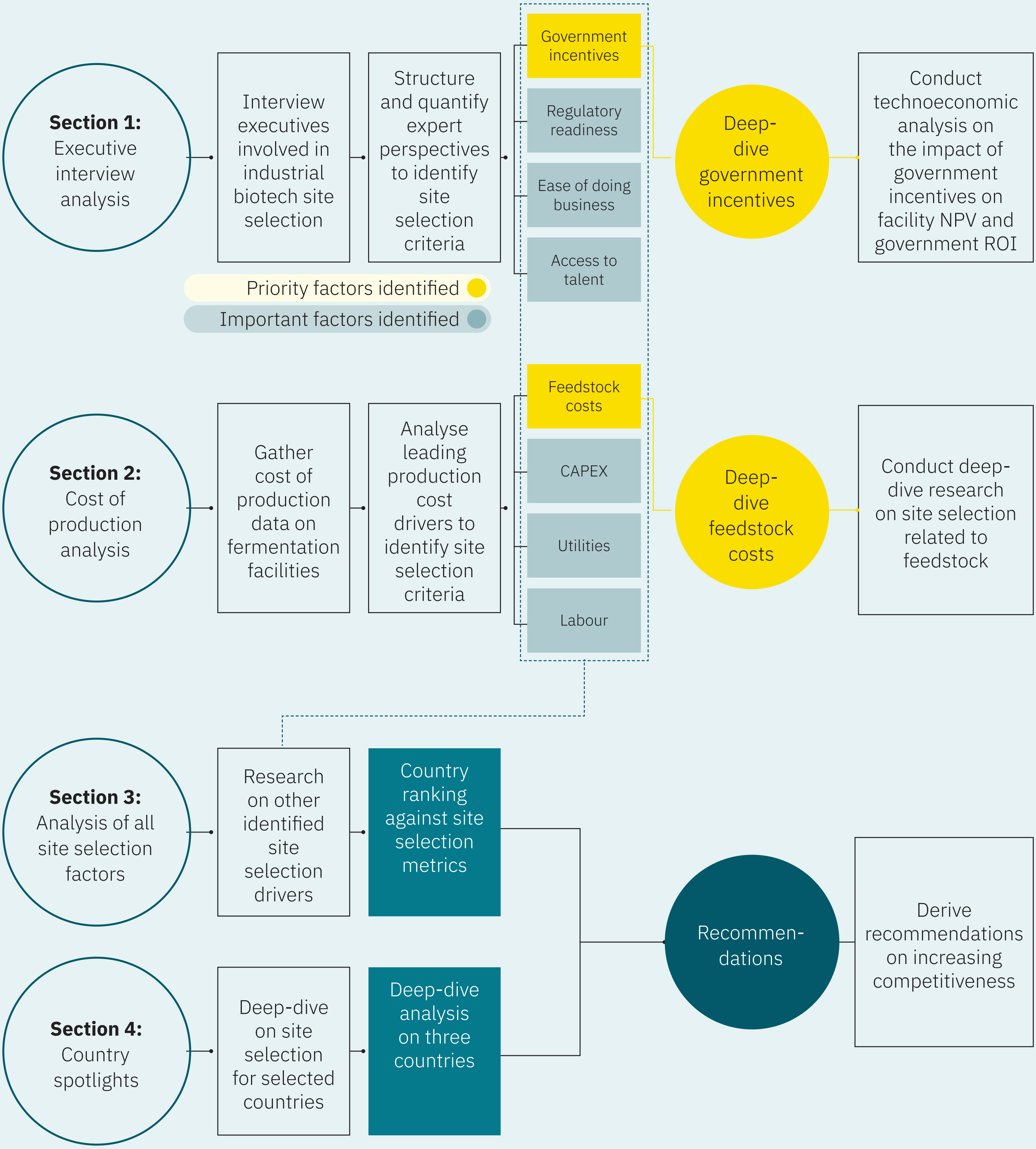
Contract (development) manufacturing organisations (CMOs/ CDMOs), as they operate under distinct business models and cost structures. In general, CMOs are optimised to provide flexibility and service to multiple clients, which means the cost dynamics and operational priorities differ from dedicated, purpose-built facilities.

China and India were excluded from the scope of this analysis due to their established biomanufacturing ecosystems as well as the complexity of their markets, which warrants dedicated, in-depth country-specific studies.

Report structure

The report is organised into the following sections:

Figure 6: Graphical representation of report structure



Background

Fermentation-derived food ingredients offer the potential to match animal-derived counterparts in both taste and price, while reducing environmental impact in a sector responsible for roughly 20 percent of annual global greenhouse gas (GHG) emissions. In the APAC region, many countries have strong agricultural bases, growing demand for protein, and ambitions to lead in biotechnology, but their readiness to host commercial-scale fermentation infrastructure is unclear. Where companies choose to invest will determine which countries emerge as leaders in fermentation-derived ingredient production, and which ones capture the associated jobs, trade benefits, and climate gains linked to biomanufacturing leadership.

Introduction to protein production using fermentation

Fermentation is a broad category of biotechnological processes that harness microorganisms such as bacteria, yeast, or fungi to produce valuable ingredients and products **(Figure 7).** This report focuses on two types of submerged fermentation (a method where microorganisms are cultivated in liquid media within bioreactors): biomass and precision fermentation. Both offer different but promising pathways as production methods for food ingredients.

Figure 7: Overview of biomass fermentation and precision fermentation processes

Biomass fermentation process

INPUT	PRODUCTION	PROCESSING	FOOD/INGREDIENTS
Microorganisms are selected for high-protein biomass fermentation.	Microorganism produces biomass content by rapid growth on carbon and nitrogen feedstocks.	Harvesting, heat inactivation and/or dewatering.	Formulate ingredient into food product or use for other alternative protein production.

Biomass fermentation involves growing microorganisms in a liquid medium and harvesting the entire microbial mass as a high-protein ingredient. As microorganisms themselves become the food product, this is generally a more cost-effective process due to simpler downstream requirements. This approach is well-suited for producing protein-rich ingredients that can provide texture and structure, such as for alternative meat and seafood products.

Precision fermentation process

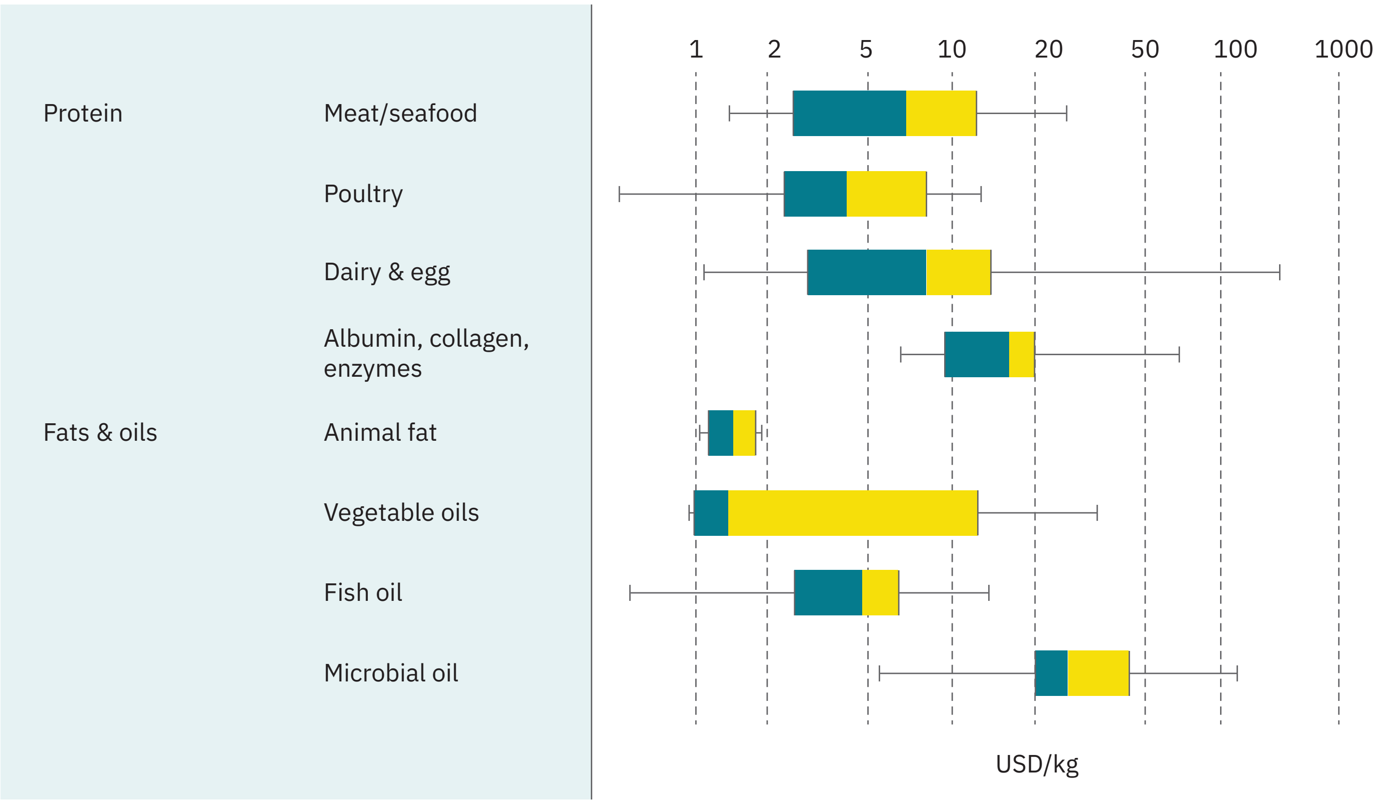
INPUT	PRODUCTION	PROCESSING	FOOD/INGREDIENTS
Microorganism expresses endogenous or introduced DNA for food-ingredient target molecule.	Microorganism produces food-specific ingredient using carbon and nitrogen feedstocks.	Extraction and filtration of food-specific ingredient from fermentation substrate or from harvested cells.	Formulate ingredients into food products or use for other alternative protein applications.

Precision fermentation involves inserting the molecular sequence of a target ingredient into a microorganism, which gives it instructions on how to produce specific functional molecules such as egg or milk proteins. After fermentation, the desired molecule is separated and purified, making this approach well-suited to creating high-value, functional ingredients used in a wide range of food applications. Precision fermentation generally has higher production costs than biomass fermentation, partly because of its more extensive downstream processing requirements.

The importance of cost-competitiveness

To gain market share, fermentation-derived food ingredients must achieve price competitiveness with their conventional equivalents. The most widely consumed animal proteins are typically sold at commodity price points (below $20 USD/kg, see **Figure 8**), leaving little room for premium pricing. Unlike high-value sectors such as nutraceuticals, where higher prices can offset production costs, success in food biomanufacturing will depend on the industry's ability to bring production costs to significantly lower levels.

Figure 8: Overview of U.S. market prices of incumbent proteins and oils



Source: Good Food Institute (2025). "Driving down costs: Insights and recommendations from a meta-analysis of techno-economic models of fermentation-derived ingredients"; downloadable database available at link. Note: The dividing line represents the median, box limits indicate the interquartile range, and whiskers show the full data range.

Achieving competitive production costs is not solely a matter of R&D. Costs are heavily influenced by the choice of production location. To close the premium gap and pinpoint the most competitive sites for large-scale production, it's essential to understand how APAC countries compare across key factors that influence site selection.

Section 1

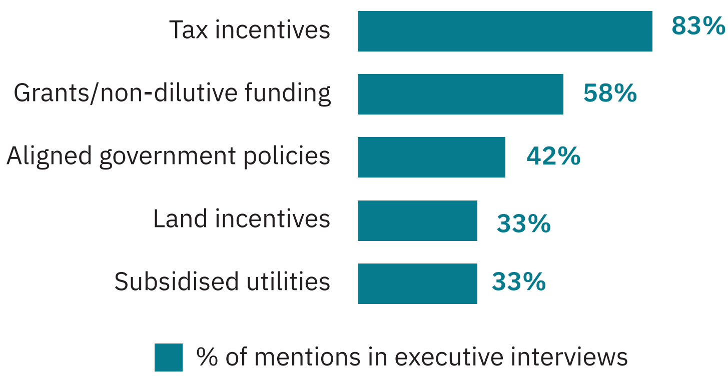
Industry perspectives on biomanufacturing site selection drivers

This section draws on interviews with executives from Fortune 500 bioscience firms and CEOs of industrial biotechnology companies to assess which factors drive site selection decisions.

Drivers of site selection

Once basic feasibility conditions allowing them to do business had been met, executives consistently cited government incentives as the most influential factor in site selection. **Figure 9** aggregates the most frequently mentioned incentives, led by tax incentives, and followed by non-dilutive funding.

Figure 9: Aggregated interview data on top five mentioned factors important to site selection



Source: Hawkwood analysis of executive interviews.

Box 1 highlights the categories and most commonly offered types of government incentives to attract private sector manufacturing to a country or region. These can be variably offered to offset local disadvantages or enhance strengths, within the bounds of local policy restrictions.

Box 1: Categories of governmental incentives

Financial incentives

Reduce capital or operational costs through direct or indirect funding.

- Discounted land (e.g. free or long-term below-market lease)
- Import/export tariff reductions
- Tax holidays and abatements (e.g. 5- or 10-year tax holiday)
- Reduced corporate tax rates
- Capital grants (e.g. direct financial assistance or rebates)
- Salary support or tax reductions to attract talent
- Investment tax credits (e.g. credits on 20% of the capital investment; possible for credits to be fungible and sold)
- Subsidised utilities or feedstocks
- Below-market loans or loan guarantees (enables project financing at lower interest rates)

Administrative incentives

Ease regulatory burden, accelerate project timelines; applicable for both construction and operating phases.

- Expedited permitting and zoning
- Fast-track visas, relocation support, and tax benefits to facilitate access to skilled labour
- Government liaison access
- Partnerships with universities and training providers

Ecosystem incentives

Enhance long-term regional appeal by investing in infrastructure, talent, and networks to drive innovation, collaboration, and workforce growth.

- Biohubs with shared utilities and logistics
- Co-location with other biomanufacturers
- Government-supported infrastructure
- Talent attraction programmes
- Anchor tenant-driven cluster development

Quantitative evaluation of government incentives

To assess the real-world financial impact of different incentive types, a technoeconomic model was used to assess how different incentives affect the financial performance of a biomanufacturing facility. The model is based on a U.S. Midwest location and a product with an average selling price of $2.58 USD per kg,[1] but includes two corporate tax rates (20 and 30 percent) to reflect conditions in the APAC region.[2] While proprietary information prevents full disclosure of the technoeconomic model, it is based on a facility with 2,500 m^3 of fermentation capacity, staffed by 100 full-time employees, and assumes a 20-year depreciation period.

Six incentives were modelled, including the incentives that were top-ranked by industry experts.[3] The incentives modelled were:

- 5-year tax holiday (0 percent corporate income tax for five years)
- CAPEX reduced by 50 percent (non-dilutive funding covering half the facility cost)
- A loan guarantee in support of loans funding construction of the facility (interest rate reduced by 50 percent)
- Subsidised electricity (reduced by 50 percent)
- Subsidised feedstock (reduced by 10 percent)
- Subsidised labour (reduced by 25 percent)

Box 2: Factors used to evaluate the impact of government incentives

Facility Net Present Value (NPV)

The net present value of the biomanufacturing facility from the company's perspective, capturing the long-term financial benefit after applying a given incentive.

Government investment

The estimated fiscal cost to the government associated with each incentive—either through direct spending (e.g. capital grants, subsidies) or forgone revenue (e.g. tax holidays). This serves as the baseline for assessing public financial return.

Government Return on Investment (ROI)

The return on public investment, calculated as the increase in direct corporate tax revenue relative to the cost of the incentive.

Ignores secondary effects such as the so-called Keynesian multiplier impact.

Investment impact

The efficiency of each incentive, measured as the increase in facility NPV per dollar of government support. This indicates how effectively public capital unlocks private sector value.

1 While a higher sales price would be more representative of precision fermentation, changing this assumption does not materially affect the conclusions.

2 A U.S. Midwest location was used due to limitations in data and modelling capacity; future models should ideally reflect local cost structures. It is important to note that utility and water treatment costs in many parts of Asia are likely higher than in the Midwest, particularly due to the need for additional cooling infrastructure (e.g. chillers, air compressors) to maintain process temperatures. As a result, the cost per kg in APAC settings may be underestimated.

3 Land incentives were identified by industry experts as important, but they are excluded here as the technoeconomic models used in this analysis do not typically include land costs. Depending on whether land is leased or purchased, such incentives would most often reduce capital expenditures (e.g. through discounted or free land) or, in some cases, lower fixed operating costs if ongoing lease payments are subsidised.

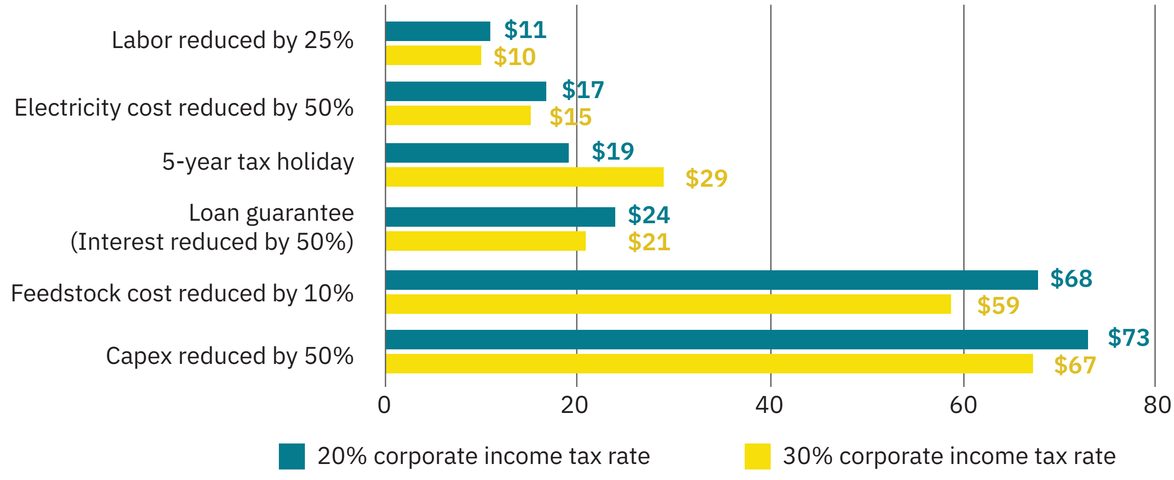
Impact on NPV for companies

NPV is a financial metric that represents the total value of a project or business in today's dollars. It is calculated by discounting all expected future cash flows to their present value and subtracting the initial investment. NPV helps compare projects by indicating which option creates more net value over time. All else being equal, a company would locate a facility at a site where the offered incentives collectively increase the NPV by the greatest amount.

While this analysis is limited to the assumptions of the facility modelled, it offers directional insights about the role of incentives in shaping biomanufacturing competitiveness. The base financial case of the modelled facility yields an NPV of $94 million USD and tax revenue of $217 million USD under a 30 percent corporate income tax (CIT) scenario, or $119 million USD and $144 million USD, respectively, under a 20 percent CIT scenario. The following results describe the facility's financial performance after applying each incentive to the base case model:

- **Non-dilutive funding to offset CAPEX delivered the largest increase in project NPV, adding up to $73 million USD (a 61-78 percent increase depending on the CIT scenario) compared to the base case.** Non-dilutive funding refers to funding mechanisms through which governments provide capital without taking equity, profit-sharing, or other ownership stakes in return. Non-dilutive contributions to CAPEX were ranked as the second most important incentive in executive interviews.
- **Feedstock incentives were not prioritised by executives, despite showing strong potential in the NPV analysis.** This may reflect concerns about their long-term fiscal sustainability—once subsidies expire, production costs may rise to uncompetitive levels. This highlights the need to evaluate incentives not only by their impact on company economics and NPV, but also by their ability to deliver durable public value from a government perspective. By comparison, reducing the cost of labour and electricity had a more modest impact.
- **Tax incentives received the highest priority during interviews, yet their modelled impact on NPV was about two to four times smaller than the most effective incentives**. While tax incentives can improve short-term profitability metrics—making them appealing to boards and investors—non-dilutive capital has a significantly greater effect on long-term project economics.
- In all cases, larger increases in NPV were realised in the lower-taxed countries, except for where a tax holiday was offered.

Figure 10: Change in NPV as a result of applied incentives (in USD millions)



Source: Hawkwood analysis based on technoeconomic modelling of a biomanufacturing facility. Notes: Figures show changes relative to the base case (an NPV of $94 million USD and tax revenue of $217 million USD under a 30 percent CIT scenario, or $119 million USD and $144 million USD, respectively, under a 20 percent CIT scenario).

Figure 11: Executive interview prioritisation of incentives compared with their impact on NPV

Incentive area	Interview priority	NPV-ranked priority
5-year tax holiday	1	4*
Capex reduced by 50%	2	1
Loan guarantee (interest reduced by 50%)	3	3*
Electricity cost reduced by 50%	4	5
Labor cost reduced by 25%	5	6
Feedstock cost reduced by 10%	NA	2

*Source: Hawkwood analysis. Notes: Interview responses were not as specific as listed here (e.g. tax breaks were mentioned but not specifically for five years). *Rankings are shown for low corporate income tax (CIT) countries; these two incentives are in reverse order for high CIT countries.*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ROI for governments

Financial ROI

Public incentives come at a cost, whether through direct spending or forgone revenue. However, these investments can yield returns in the form of increased economic activity and tax revenue. To assess financial ROI from a government perspective, this analysis uses the same technoeconomic model to compare the cost of each incentive to economic outcomes, considering projected corporate income tax (CIT) revenue alongside firm-level NPV. This provides a measure of how efficiently public capital is converted into fiscal return and private sector value creation. Figures 12-13 report the impact of each incentive relative to base case scenarios.

- **Non-dilutive support for CAPEX outperformed other incentives across all metrics.** It generates the largest increase in NPV, the highest government ROI, and the most efficient investment impact (NPV increase per dollar forgone). This reflects the value of public support for de-risking large upfront investments.
- **Feedstock subsidies are an outlier.** Though the NPV impact is high, the cost to the government is also very high. Despite being the most costly among all the incentives to cover just 10 percent of the feedstock cost, the government ROI is comparable to far less costly interventions.
- **Tax holidays increase company returns, but often yield negative government ROI in the short to medium term.** If firms fail to reach profitability or exit before generating taxable income, the forgone revenue becomes a permanent loss rather than a deferred gain. This trade-off is especially risky in a startup-heavy sector like alternative protein biomanufacturing. While tax holidays yield a relatively high investment impact, the public return depends on long-term tax receipts and whether the incentive contributes to broader strategic spillovers that justify the upfront fiscal cost.
- **Loan guarantees deliver a moderate NPV benefit that is comparable to other incentives.** However, because guarantees involve no upfront government outlay unless triggered by a default, they do not register in ROI calculations. In practice, governments assess them based on expected risk exposure, not immediate cost—so while absent from ROI figures, they may represent a high-leverage, low-cost tool for de-risking investment.
- **Electricity cost reductions produce modest NPV gains and offer a moderate government ROI.** While not as impactful as some other incentives, they are relatively low-cost for governments and could be a pragmatic tool in energy-intensive manufacturing contexts. If structured to specifically incentivise the use of renewable electricity, such as through preferential tariffs, they could also reinforce broader decarbonisation objectives and enhance the strategic value of the incentive.

- **Labour cost reductions yield the lowest NPV impact and government ROI among all incentives considered.** Labour makes up a relatively small portion of total production costs in fermentation facilities, limiting the leverage of these subsidies.

Figure 12: Evaluation of incentives according to government expenditure and facility NPV

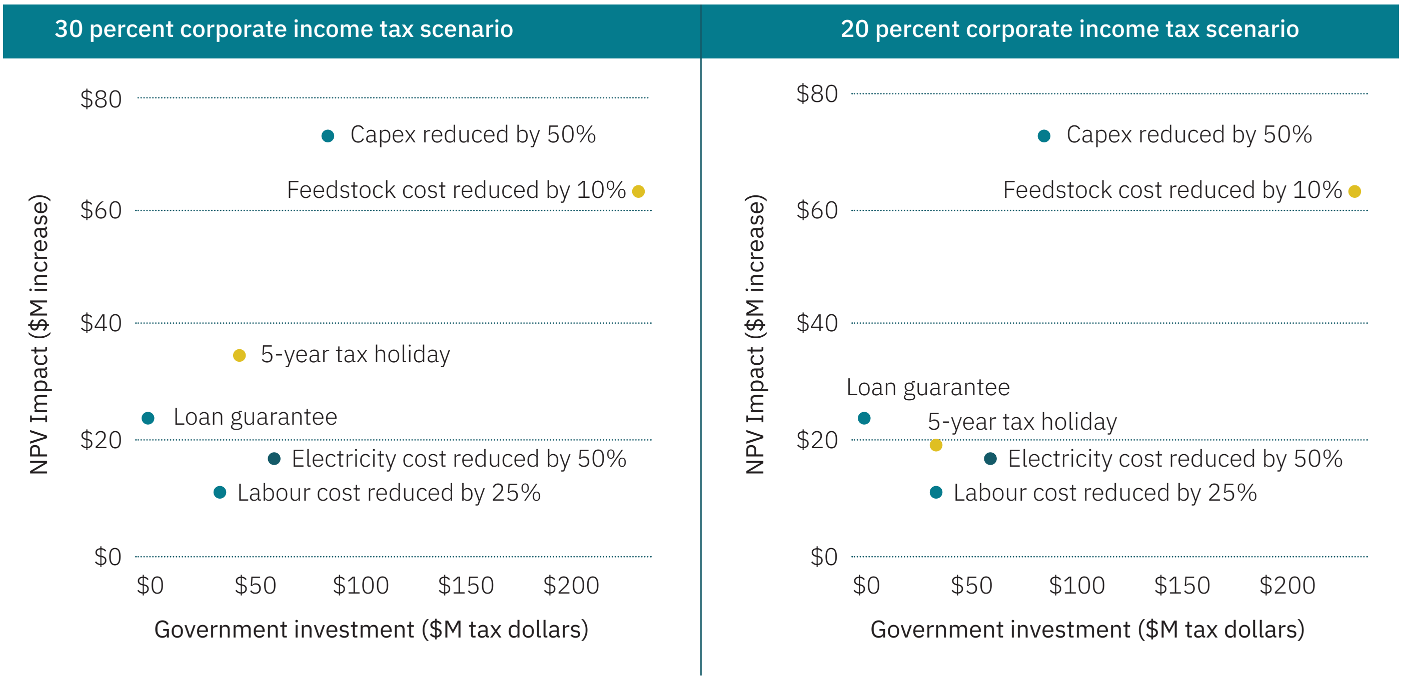
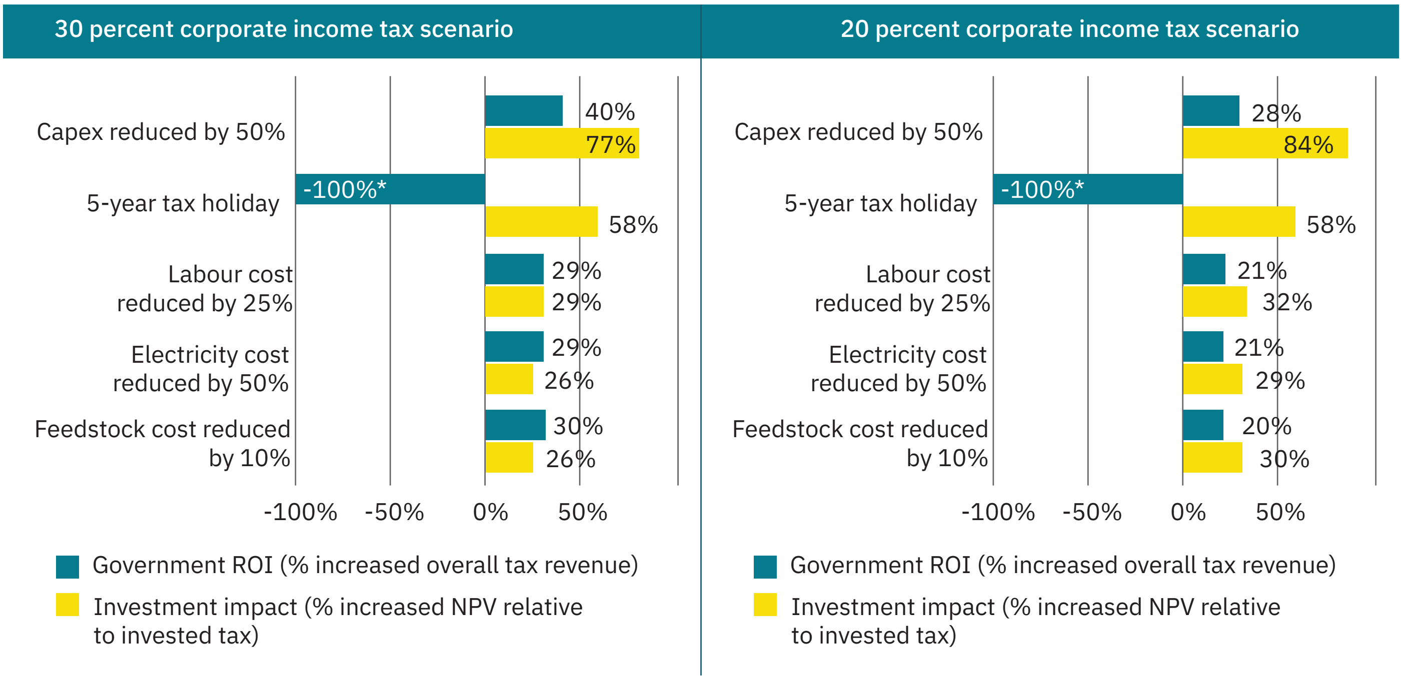


Figure 13: Evaluation of incentives according to government ROI and overall investment impact



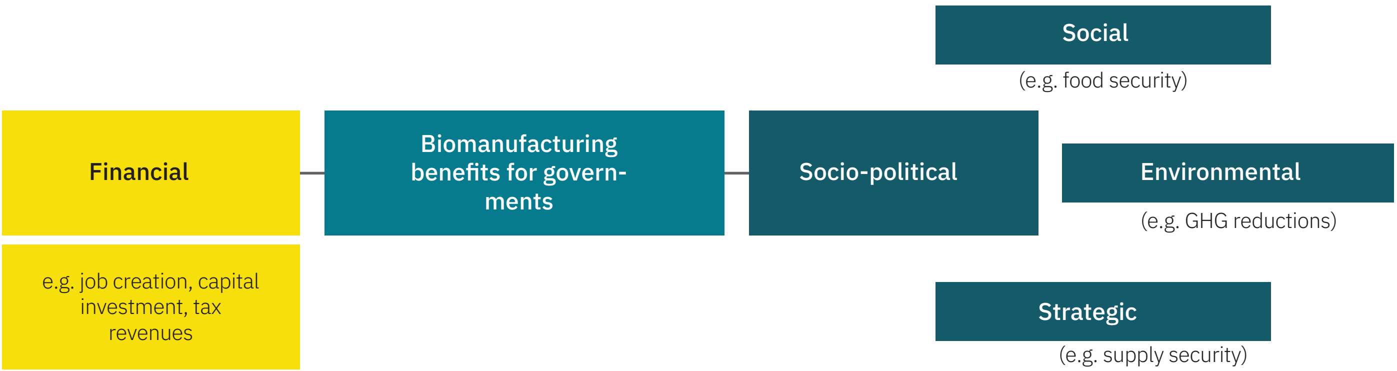
*Source: Hawkwood analysis based on technoeconomic modelling of a biomanufacturing facility. Notes: Figures show changes relative to the base case (an NPV of $94 million USD and tax revenue of $217 million USD under a 30 percent CIT scenario, or $119 million USD and $144 million USD, respectively, under a 20 percent CIT scenario). *Actual ROI may be higher if firms reach profitability and pay taxes after the incentive ends.*

Socio-political ROI

While government interests may be expressed in purely financial terms such as ROI, governments may also support policies that are quantitative but not directly financial. Building a biomanufacturing facility creates jobs, both while constructing and subsequently running them. Moreover, biomanufacturing can provide environmental and social benefits, such as a reduction in GHG emissions and reduced use of resources relative to conventional farming.

Advancement in biomanufacturing may bring additional benefits to other industries, such as the bio-based production of chemical ingredients that reduce reliance on petrochemicals. It may also enable localised production, increasing supply chain security. Governmental agencies can also consider and quantify additional benefits of biomanufacturing facilities via life cycle analyses (LCAs). The specific socio-political priorities of a government will affect the weighting of these various non-financial or indirect benefits.

Figure 14: Factors affecting government interest in biomanufacturing



Taken together, well-targeted incentives play a critical role in improving the financial viability of fermentation-derived ingredient production. While tax breaks were mentioned by more of the industry stakeholders than others, quantitative modelling shows that non-dilutive support for CAPEX delivers the greatest impact for companies and governments alike. Understanding which incentives offer the strongest ROI for both governments and producers is essential for crafting policies that create mutual benefits, accelerate scale-up, and enable competitive production costs.

Section 2

Role of production cost drivers on biomanufacturing site selection

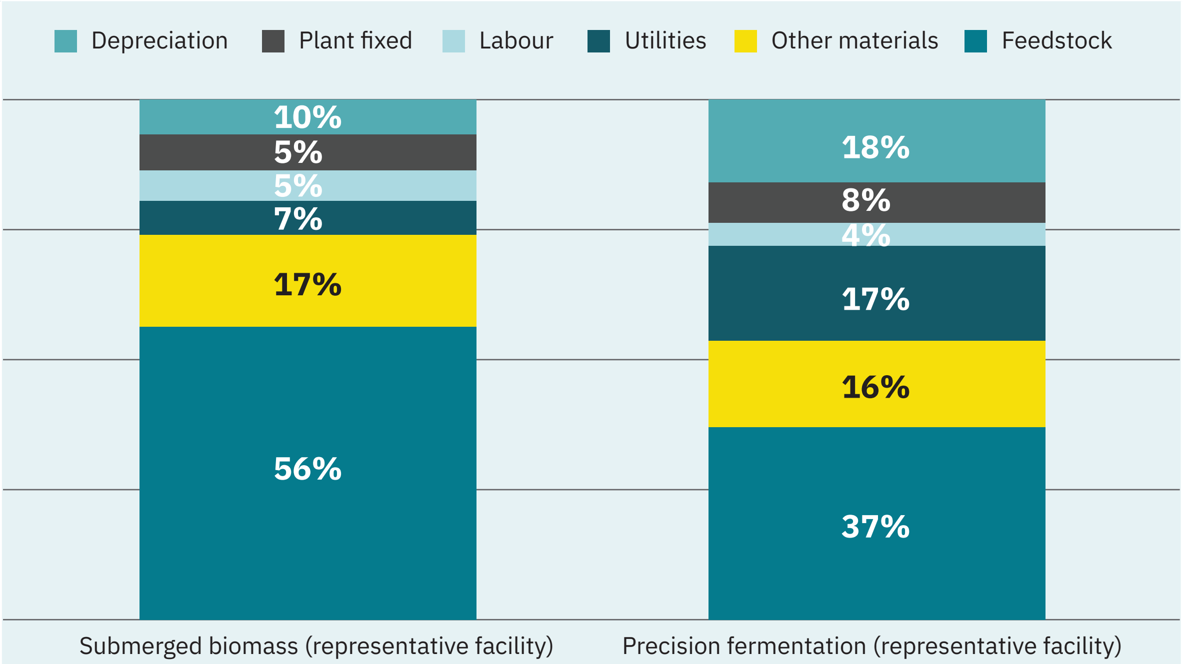
While supportive policies and incentives help create favourable conditions for fermentation-derived food ingredient manufacturing, long-term competitiveness ultimately depends on production costs. Identifying key cost drivers is essential to understanding how different locations perform relative to those drivers and where there might be opportunities to reduce overall expenses.

Analysing production costs

The cost of producing fermentation-derived food ingredients is determined by a range of capital and operational cost drivers. This analysis draws on two models based on proprietary Hawkwood studies of representative facilities. Although these facilities are modelled in a U.S. Midwest context, their assumptions align with technoeconomic analyses Hawkwood has conducted for sites in other global regions.

Figure 15: Overview of Cost of Production (CoP) model assumptions

Models analysed



Source	• Assuming 80,000 MT per year nameplate capacity • Representative submerged biomass facility from Hawkwood proprietary data	• Assuming 10,000 MT per year nameplate capacity • Representative precision fermentation facility from Hawkwood proprietary data
Methodology	All the cost models use FEL-1 CAPEX estimates (Front End Loaded). These models are used to determine project feasibility, and assume a Midwest U.S. location using corn glucose (dextrose 95/DE95) as the carbon source.	
Approach	Representative (anonymised) breakdown of COGS from a technoeconomic model for a submerged biomass/precision fermentation facility.	
Cost factors included	• Feedstock costs • Other materials (e.g. media components and chemicals used in processing) • Depreciation • Utilities • Labour • Other fixed costs (maintenance, property taxes, insurance)	

The role of feedstock in production costs

As shown in the above cost driver analysis, feedstock costs are the dominant driver of production costs for both fermentation types. The observed contribution of feedstock varies from ~30–45 percent for a precision fermentation-derived process, and ~35-65 percent for a submerged biomass fermentation process.[4]

Fermentation feedstocks are usually either sucrose, derived from sugarcane or sugar beets, or dextrose, derived from corn or cassava. In the short and medium term, viable feedstocks for both precision and biomass fermentation production will likely be limited to sugar (sucrose or dextrose). Sugar has been the mainstay of fermentation technology for more than fifty years, it is produced at large scale using established technology, and it has pricing mechanisms, including hedging mechanisms, which are well established. Below is an overview of the different types of sugar feedstock sources.

Box 3: Overview of sugar feedstocks

Dextrose	Dextrose, a monosaccharide, is broadly compatible with most microorganisms and does not require enzymatic pre-processing, unlike sucrose, a disaccharide. Strains that cannot naturally metabolise sucrose must rely on added or genetically encoded invertase, which is an important consideration when assessing feedstock simplicity and cost. Dextrose is typically produced via starch hydrolysis. In the U.S., this process uses corn, whereas in Southeast Asia, cassava is a major starch source. Cassava-based dextrose is chemically equivalent to its corn-derived counterpart and can be supplied directly when fermentation facilities are co-located with sugar mills. Its cost structure is generally tied to the price of the underlying starch and is expected to be comparable to other dextrose sources and sucrose-based feedstocks.
Sucrose	Sucrose, primarily from sugar cane or sugar beet, is also widely used. Sugar beet-derived syrups are often unsuitable due to fermentation-inhibiting toxins. If sugar cane sucrose is processed to a syrup, it can be supplied “over-the-fence” to a fermentation facility, potentially at a lower cost. It can also be further processed and sold as crystalline or No. 11 raw sugar as a traded commodity, which may require additional infrastructure to be used as a feedstock due to the need for storage and dissolution. This can be further treated to produce refined sugar.
Molasses	Molasses, a byproduct of sugar production, is rich in sugar but contains inhibitory compounds that accumulate during fermentation, limiting its utility in fermentation-derived ingredient production. While molasses is used in some established fermentation processes where the microbe is resistant to the toxins, including for ethanol, lactic acid, citric acid, and MSG, its variability and downstream processing challenges make it a less attractive option for biomanufacturing fermentation-derived ingredients.

The use of alternative feedstocks (such as cellulosics) adds additional technology risk to still-nascent fermentation approaches to protein production. Alternative feedstocks will also require the development of infrastructure to collect, process, and distribute at scale, as well as robust pricing mechanisms to help mitigate price and supply risks over the >20-year lifespan of a fermentation facility.

Optimising sugar feedstock costs: Co-location

The availability of low-cost sugar is a major consideration for site selection of commercial manufacturing facilities. Based on long-term commodity price averages, sugar prices are about $360 USD per tonne (Figure 16).[5]

4 These ranges are based on multiple technoeconomic models in Hawkwood Biotech’s database, with the detailed breakdowns included above being derived from representative facilities near the midpoint of these ranges.

5 This is based on long-term averages for commodity sugar of $400 USD/tonne, but actual costs can be significantly higher in some regions due to geopolitical factors (e.g. trade restrictions, export bans) which drive sharp price increases. For example, U.S. prices for dextrose 95—the starch-derived feedstock used in the technoeconomic models above—have experienced high inflation over the past two decades, with spot prices more than doubling from the early 2000s to the early 2020s and spiking further up to 2025 (see USDA Sugar and Sweeteners Yearbook Tables).

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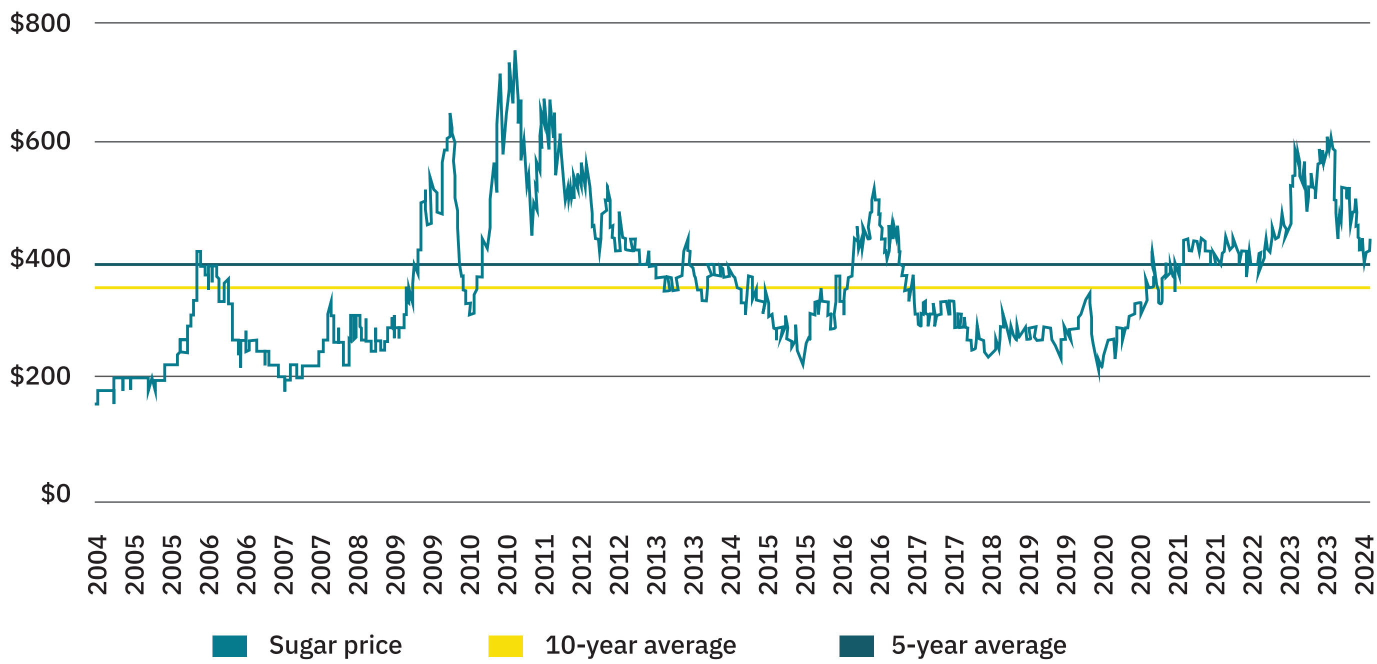
If sugar feedstocks are not readily available in a given region, logistics costs must be added to the cost of manufacturing. This can represent a significant cost increase in a fermentation production set-up. Shipping can increase the cost of sugar at the factory by up to 50 percent. This is as much a function of handling (loading and unloading) as of distance shipped. Handling bulk sugars also requires increased costs for conversion of crystalline sugar into syrup. This can include dissolution tanks with associated stirring and heating, syrup storage tanks, and costs associated with keeping the syrup contamination-free during storage.

Though there may be unique circumstances in which co-location is not required (e.g. location-specific subsidies and particularly advantaged infrastructure), "over-the-fence" or co-location of a fermentation facility with a sugar production facility is generally the most optimised way to reliably access low-cost sugar.

Figure 16: Commodity sugar prices over a 20-year period (USD/tonne)



Source: Sugar No.11 contract from Trading Economics.

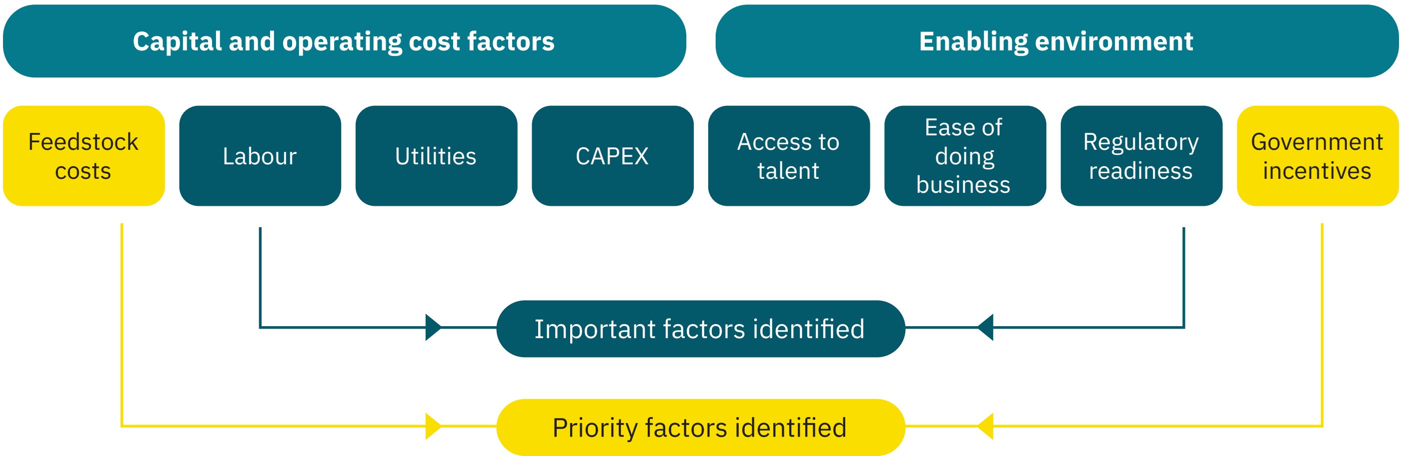
Countries able to offer competitively priced sugar have a clear advantage as potential locations for fermentation-derived food ingredient manufacturing. The following section looks at how APAC countries perform on this critical driver of feedstock capabilities and, alongside other site selection factors, assesses which locations are best placed for large-scale, cost-effective production.

Section 3

Country analysis of site selection

This section compares all the key site selection factors identified through executive interviews and technoeconomic data across nine APAC countries (Figure 17). To evaluate the relative strengths of countries, a normalised index was created which benchmarks countries on capital and operational cost drivers as well as enabling environment factors. Government incentives—while decisive—are excluded from the cross-country index due to data limitations, but are assessed in detail for three spotlighted countries in the following section.

Figure 17: Key site selection drivers for fermentation-derived protein production



Capital and operational cost factors

Four primary cost-related factors are considered: feedstock, CAPEX, utilities, and labour. As explored in Section 2, advantaged feedstock access is the dominant cost driver for fermentation-derived food ingredient production, while the other three have a meaningful but secondary impact on cost competitiveness.

Figure 18: Overview of index results for capital and operating cost factors

Scores reflect relative position across the country group, normalised using proportional (min-max) normalisation, where 100 reflects the best observed value across countries.

Capital and operating cost factors											
	Feedstock				CAPEX		Utilities			Labour	
	Sugar capability				Cost of construction		Cost of utilities			Cost of labour	
	Index	2024 sugar exports (000 MT)	2024 sugar production (000 MT)	2024 sugar imports (000 MT)	Index	Average construction cost (USD/ m2)	Index	Business rates (2023-25 av. USD/ kWh)	Average utility water tariff (USD/ 15m³/month)	Index	Average manufac-turing wages (USD/month)
Vietnam	26	0	1,350	110	93	1,672	97	0.08	0.31	100	342
Philippines	31	91	1,850	0	94	1,633	75	0.15	0.59	97	555
Australia	60	2,700	3,850	3	0	4,142	13	0.23	2.83	0	6,652
Thailand	100	5,300	10,040	0	81	1,992	84	0.13	0.38	99	431
Indonesia	14	0	2,400	5,000	100	1,487	99	0.07	0.26	100	350
Malaysia	0	0	0	1,920	38	3,134	87	0.13	0.21	93	797
South Korea	0	0	0	1,510	22	3,547	80	0.12	0.70	29	4,791
Japan	11	0	750	1,250	5	4,012	47	0.21	1.34	27	4,962
Singapore	0	3	0	6	25	3,486	27	0.29	1.44	26	5,016

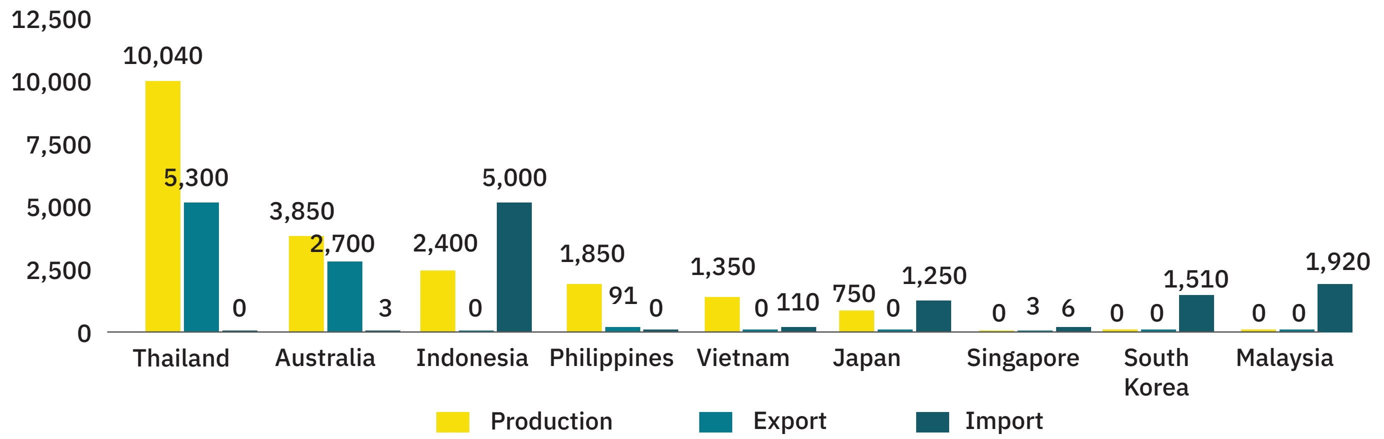
Source: See Appendix for details.

Feedstock costs

Feedstock availability was evaluated using sugar export, production, and import reliance as proxies for cost and domestic production capacity. Production volumes indicate the absolute scale of domestic supply. An exportable surplus of sugar tends to indicate production costs are low enough to compete in global commodity markets, while high import dependence signals insufficient domestic capacity of sugar or higher cost structures. Securing access to co-located sugar feedstocks represents the most favourable cost scenario for achieving competitive biomanufacturing.

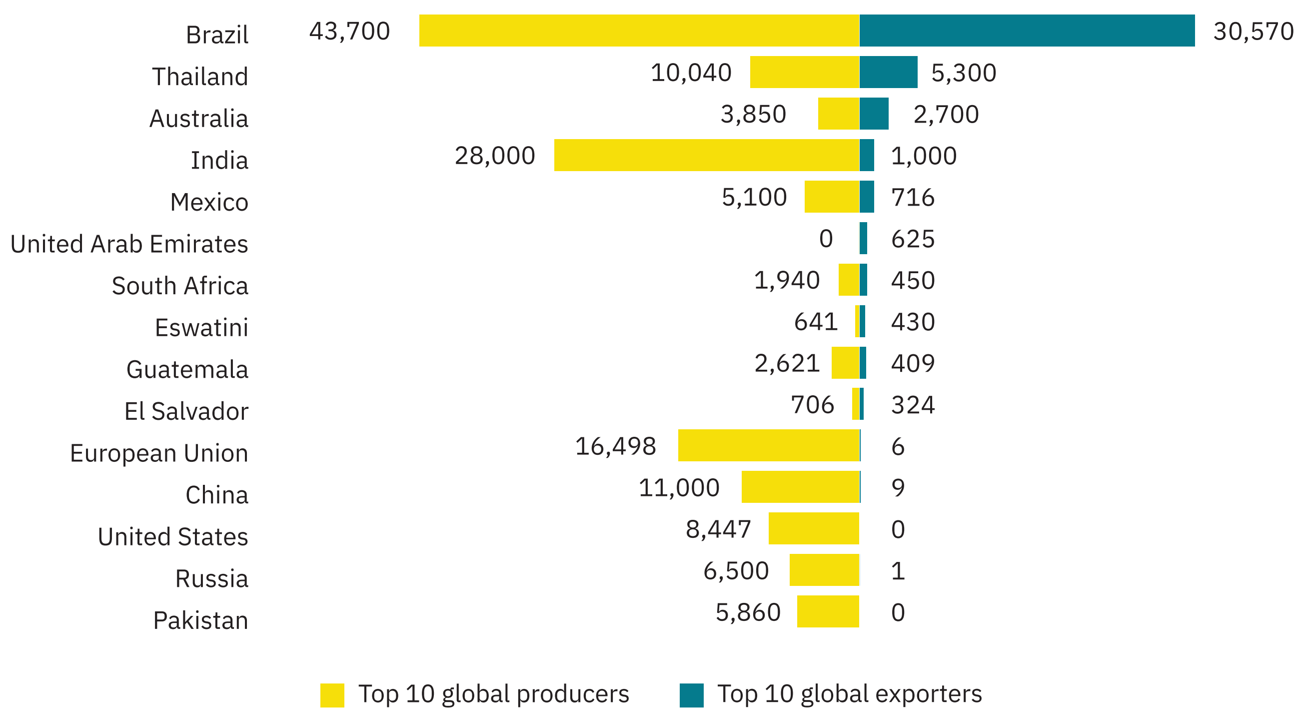
- **Thailand and Australia** emerge as leading candidates for competitive feedstock capability, reflecting their status as major sugar producers and exporters in the region **(Figure 18)**. As the world's second- and third-largest raw sugar exporters, respectively, both countries offer strong feedstock availability for industrial-scale fermentation **(Figure 19)**.
- **The Philippines and Vietnam** produce sugar domestically, but their limited export volumes suggest a lack of surplus or internationally cost-competitive production, indicating limited supply at scale.
- **Indonesia** also produces notable volumes of sugar, but its substantial import requirements highlight structural shortfalls in domestic supply.

Figure 18: APAC overview of raw sugar production, imports, and exports in 2024 (in '000 MT)



Source: USDA Production, Supply and Distribution database

Figure 19: Top global producers and exporters of raw sugar in 2024 (in '000 MT)



Source: USDA Production, Supply and Distribution database

While some fermentation facilities operate in APAC's non-sugar-exporting countries, these are typically legacy or highly specialised plants that do not offer generalisable models for scale-up. For example, a methionine facility established in Malaysia in 2013 as part of a joint venture between South Korea's CJ Bio and France's Arkema was co-located with a chemical plant due to specific chemical transformations required beyond fermentation which are specific to methionine. The facility is supported by government incentives and relies on imported sugar. In Indonesia, several world-leading producers historically built monosodium glutamate (MSG) plants, but the long-term decline of the domestic sugar industry has rendered the current environment unfavourable for new fermentation-based projects. In general, access to sugar remains a gating factor for cost-competitive fermentation at scale.

CAPEX, Utilities, and Labour

While feedstock is the most important production cost driver, high overall CAPEX and operating costs can be prohibitive. Facility and capital-related expenses (realised as depreciation and fixed plant costs), labour costs, and utility costs[6] can significantly shape a project's financial feasibility. CAPEX competitiveness was evaluated using the average construction cost per square metre for advanced manufacturing or industrial facilities; utilities costs were based on average business electricity rates for industrial users and average utility water tariffs; and labour costs were assessed using average monthly wages for manufacturing workers in each country.

- **Indonesia, Vietnam, and Thailand** offer the most competitive cost environments across these dimensions.
- **Japan, South Korea, Singapore, and Australia** face significantly higher costs across these drivers. Although these countries offer strong infrastructure and favourable business environments, their elevated operating costs can make new large-scale fermentation facilities economically unviable without significant government incentives, particularly if they also lack low-cost feedstock access. This is reflected in the strategic decisions of major regional fermentation companies, such as CJ Bio (South Korea) and Ajinomoto (Japan), which have chosen to build manufacturing facilities abroad.

Enabling environment factors

Alongside government incentives, executive interviews highlighted three additional factors that shape long-term viability and investment attraction–regulatory readiness, the business environment, and access to talent.

Figure 21: Overview of index results for enabling environment factors

Scores reflect relative position across the country group, normalised using proportional (min-max) normalisation, where 100 reflects the best observed value across countries.

Enabling environment									
	Access to talent				Business environment		Regulatory readiness		
	Relevant education and employment				Ease of doing business		Framework and approvals		
	Index	EMC graduates (%)	VOC enrollment (%)	R&D researchers per million	Index	World Bank index (2021)	Index	Novel precision or biomass fermentation-derived food ingredient approval	Novel food regulatory guidance available
Vietnam	26	20%	25%	779	30	70	0	None	No
Philippines	17	13%	29%	172	0	80	0	None	No
Australia	50	8%	53%	4,594	79	70	100	Yes	Yes
Thailand	36	23%	26%	1,699	74	63	50	None	Yes
Indonesia	18	8%	39%	400	29	70	0	None	No
Malaysia	29	29%	13%	726	80	82	0	None	No
South Korea	68	21%	16%	9,082	91	84	50	None	Yes
Japan	49	18%	21%	5,638	65	78	50	None	Yes
Singapore	55	21%	11%	7,225	100	86	100	Yes	Yes

Source: See Appendix for details. Notes: EMC = Engineering, Manufacturing, and Construction; VOC = vocational programmes for upper secondary.

6 While a proxy is used here, utility costs are often dependent on a particular biomanufacturing set-up rather than utility costs at the country-level. For example, sugar mills generate their own electricity by burning bagasse, and excess may be sold to the biomanufacturing facility much below standard cost, particularly if there is no option to sell it back to the grid. In such cases, utility costs may be less influential to country-level manufacturing decisions.

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Access to Talent and Business Environment

Access to talent was evaluated using three indicators: the share of graduates in engineering, manufacturing, and construction (EMC) disciplines; enrolment rates in vocational education (VOC) programmes; and the number of R&D researchers per million, with these metrics used as proxies to capture current workforce capacity and the pipeline of skilled workers. The business environment metric uses the World Bank's Ease of Doing Business score, which reflects regulatory efficiency and administrative burden across factors such as starting a business, obtaining permits, and enforcing contracts.

- **South Korea and Singapore** have high researcher density, strong engineering graduate output, and top business environment scores, but low vocational enrolment is a constraint to large-scale manufacturing.
- **Australia** performs well on vocational enrolment (53 percent) and research capacity, but has the lowest share of engineering graduates across all countries.
- **Malaysia and the Philippines** each perform well on one education metric—Malaysia on engineering graduates (29 percent), and the Philippines on vocational enrolment (29 percent)—but both have relatively low researcher density, limiting innovation-readiness.
- **Japan** shows a balanced profile across education, research, and business conditions, while Thailand is balanced across education indicators but has a weaker business environment score.
- **Vietnam** shows moderate technical education levels but limited research capacity (779 researchers per million), suggesting a supportive environment for manufacturing but less alignment with innovation-led scale-up.
- Indonesia faces broader constraints, with low engineering graduate output, modest vocational enrolment, and low researcher density (400 per million), signalling limited near-term readiness across both workforce and business dimensions.

Regulatory readiness

While a full regulatory assessment would include multiple factors, this index uses two proxy indicators to gauge regulatory readiness: the existence of a novel food pre-market approval framework, and the current status of approvals for precision fermentation-derived ingredients.

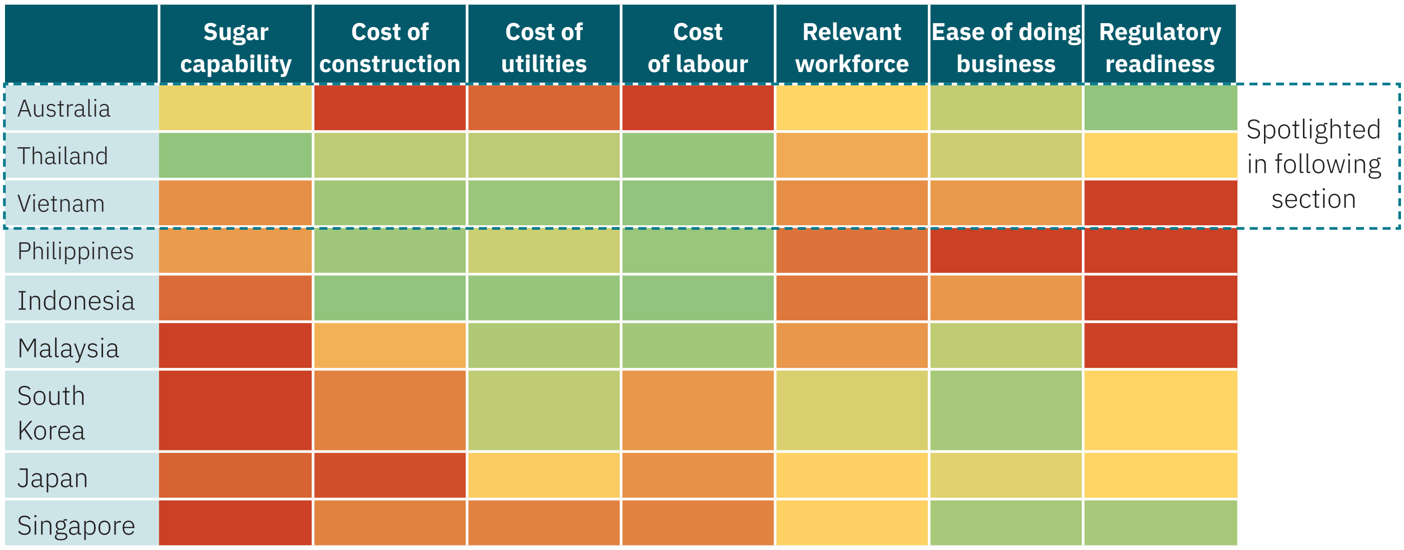
- **Singapore and Australia** score highest, having established novel food guidance and pathways that cover fermentation-derived ingredients. Australia has approved a food ingredient (Impossible Foods' soy leghemoglobin) while Singapore has granted multiple precision fermentation ingredient approvals (Perfect Day and Remilk for beta-lactoglobulin, Impossible Foods' soy leghemoglobin) and a novel biomass fermentation ingredient (Solar Foods' microbial protein powder). Their environments offer the clearest pathways for regulatory approval, advancing them as frontrunners for commercial deployment.
- **Thailand, South Korea, and Japan** have novel food frameworks in place, reflecting moderate regulatory readiness, but they lack safety assessment guidelines specifically relevant to fermentation-derived food ingredient production. They also have not approved any precision or biomass fermentation-derived novel food ingredients to demonstrate their ability to assess and approve such products.
- **Vietnam, the Philippines, Malaysia, and Indonesia** currently lack a novel food framework or relevant guidance.

Summary of index results

Taken together, the index highlights that while no country leads across all dimensions, several demonstrate clear competitive potential that could be unlocked through targeted policy support. Australia, Thailand, and Vietnam were selected for deeper analysis based on their distinct profiles: Thailand combines world-class feedstock with relatively low-cost conditions; Australia offers strong sugar production and regulatory maturity but faces high capital and operating costs; and Vietnam presents one of the region's most cost-competitive environments, though with limited feedstock surplus and an immature regulatory system. The next section outlines how each government is deploying incentives and assesses their potential to influence competitiveness by mitigating weaknesses or leveraging advantages.

Figure 4: Overview of biomanufacturing competitiveness index results

Colours reflect scoring based on relative position across the country group, normalised using proportional (min-max) normalisation, where 100 (green) reflects the best observed value across countries.



Source: See Appendix for details. Note: Government incentives are omitted here and only evaluated for three spotlighted countries.

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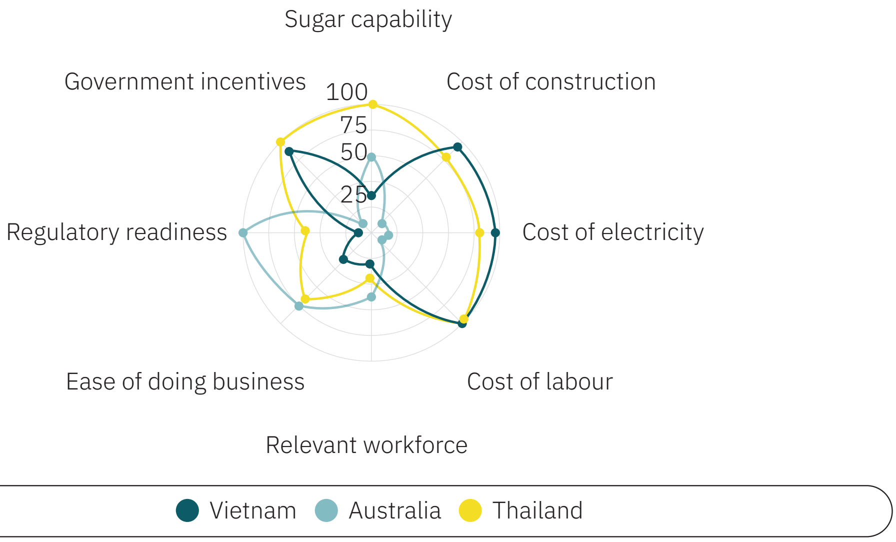
Section 4

Incentive spotlight: Australia, Thailand, and Vietnam

Incentives are a highly responsive policy tool for governments seeking to attract and compete as production locations for fermentation-based manufacturing. While infrastructure, feedstock, and labour costs are often slow to change, incentives can have an immediate impact on investment decisions. This section examines how Australia, Thailand, and Vietnam are using incentives to amplify existing advantages or offset structural limitations. The analysis reveals three distinct models: Thailand as a strong performer on incentives; Australia as a high potential market but with limited incentive deployment; and Vietnam as an emerging case where strong policy intent could help mitigate its more pronounced structural challenges.

Figure 22: Spider chart of index results for Australia, Vietnam, and Thailand

Scores reflect relative position across the country group (nine countries in APAC), normalised using proportional (min-max) normalisation, where 100 reflects the best observed value across countries.



Source: See Appendix for details. Note: Government incentives are normalised only among these three spotlighted countries.

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Figure 23: Comparison of biomanufacturing incentives in Thailand, Australia, and Vietnam

Rankings reflect results of incentive ranking from executive interviews and NPV analysis of incentive effectiveness.

☑ = widely available; ○ = incentive exists but not biomanufacturing-specific or selectively applied; ✗ = not available

Incentive	Rank interview	Rank NPV	Australia	Thailand	Vietnam
Tax incentives	1	4*	✗	☑ CIT holiday (5–8 years; extendable to 11 with merit incentives, and up to 13 years in the EEC)	☑ CIT holiday and reductions for priority sectors/locations (4-year holiday, 9 years at 50%, 10% preferential CIT for 15 years)
Grants/non-dilutive funding	2 (CAPEX grant) 3 (loan guarantee)	1 (CAPEX grant) 3* (loan guarantee)	○ Some non-dilutive financing programmes; additional support may be available on a project-specific basis for strategic investments.	○ Some non-dilutive financing programmes for export-oriented manufacturing; additional support may be available on a project-specific basis for strategic investments.	☑ ISF: Training (≤50% of costs); R&D (≤30%); production expense support (0.5–3% of realised revenue); CAPEX support (≤0.5% of total investment); additional on project-specific basis
Subsidised utilities	4	5	✗	✗ No tariff subsidies, but double deduction of utility costs available	✗
Labour	5	6	✗	☑ Workforce development and skill training deductions and programmes through BOI/EEC; personal income tax reductions for foreign experts in the EEC	☑ ISF: Training (50%), employee infrastructure (e.g. housing, healthcare) at up to 25%
Land incentives	Other incentives offered beyond those included in NPV analysis		✗	☑ BOI/EEC allow foreign land ownership for promoted projects	☑ Land rent/levy exemption 3–15 years depending on zone/area
Free trade/low duties			○ Numerous FTAs, but no biomanufacturing-specific exemptions	☑ BOI import duty exemptions on machinery and raw materials for promoted projects	☑ Import duty exemptions for qualifying high-tech/ encouraged projects
Alignment with government policies			○ Limited targeted incentives	☑ BOI one-stop service (permits, approvals, visas, import/export facilitation)	☑ Streamlined approvals in special zones/high-tech parks; import duty exemptions as above
R&D tax credits			○ National R&D tax credit (refundable for small firms, non-refundable for large)	☑ 200% deductions on R&D expenditure	☑ ISF grants (not a tax credit): up to 30% of R&D costs

*Notes:*Ranks are reversed for the high CIT rate (30 percent). BOI = Board of Investment; EEC = Eastern Economic Corridor; FTA = free trade agreement; ISF = Investment Support Fund*

Australia: Strong fundamentals but few incentives

Australia is one of the world's largest sugar exporters. Its food safety and regulatory frameworks are among the most advanced in APAC, providing clarity for companies pursuing regulatory approvals for fermentation. However, these advantages are offset by high costs, and a lack of targeted incentives to improve the investment case for biomanufacturing. As it stands, government support for the sector remains fragmented, and Australia offers few of the incentives that the executive interviews and NPV analysis identified as enablers of investment.

While several federal programmes exist, interviews with industry and policy experts pointed to a lack of biomanufacturing-specific funding. Existing programmes tend to favour projects with shorter timelines and quicker returns, often directing support to legacy sectors such as mining, energy, and conventional agriculture. Within biomanufacturing, attention remains focused on biofuels, limiting the relevance of these mechanisms for food-grade or fermentation-derived food ingredients **(Figure 24)**. This gap may reflect not only a policy preference for incumbent industries, but also the fact that the distinct value proposition of the food biomanufacturing sector has yet to be fully articulated to government stakeholders.

However, there are signs of progress at the subnational level. Queensland has pursued efforts to attract commercial biomanufacturing since the mid-2000s, and is supporting targeted projects in biomanufacturing. Most notably, Cauldron Ferm, backed by the Queensland Industry Partnership Program, is planning to construct the APAC region's first and largest industrial-scale precision fermentation contract manufacturing facility in Mackay. The plant is expected to produce over 1,000 tonnes annually of bioproducts for food, materials, and biofuels.

These efforts indicate growing strategic interest and momentum at the state level, but fall short in catalysing large-scale investment in the absence of a coordinated national strategy and targeted incentives. Without a national strategy and biomanufacturing-specific incentives, Australia risks underleveraging its feedstock advantage and losing early investment.

Figure 24: Summary of incentive programmes offered in Australia

Programme	Funding and structure	Food biomanufacturing relevance	Limitations
Northern Australia Infrastructure Facility (NAIF)	$7B AUD; loans, guarantees; can finance 100% of project debt	Supports infrastructure for sustainable development; food biomanufacturing eligible in principle	Competes with mining, energy, and transport; lacks biomanufacturing prioritisation
Future Made in Australia Plan (FMAP)	$22.7B AUD over 10 years	Aims to boost domestic manufacturing; food biomanufacturing not identified as a priority sector	Biomanufacturing excluded from priority areas
Modern Manufacturing Initiative (MMI)	$1.3B AUD; includes streams with up to $200M grants	Food biomanufacturing could fit under "food and beverage" stream	Biomanufacturing not specifically targeted; funds mostly disbursed
National Reconstruction Fund (NRF)	$15B AUD via debt, equity, and loan guarantees	Food biomanufacturing could fit under "enabling capabilities"	Broad sector focus; lacks specificity for biomanufacturing
Industry Growth Program (IGP)	$392M AUD; ≤$5M AUD grants for startups and SMEs	Focused on priority areas of NRF, so potential fit under "enabling capabilities"	Small grants; focus on early-stage companies rather than facility-scale projects
Queensland Industry Partnership Program (IPP)	$415M AUD; grants, loans, tax relief, and infrastructure access	Food biomanufacturing fits under the "bioeconomy" priority area	Bioeconomy emphasis on fuels (e.g. biofuels)
New South Wales Regional Job Creation Fund (NSWJCF)	$240M AUD; grants from $100K to $10M	Supports regional expansion; not tailored to biomanufacturing	Modest funding; limited relevance due to low sugar cane presence in NSW

Thailand: Incentive leader but lacking regulatory clarity

Thailand offers one of the most comprehensive biomanufacturing incentive packages in the region. Three key vehicles provide a range of mechanisms designed to attract investment across a range of high-priority sectors, with biotechnology and biomanufacturing clearly in scope:

- **The Bio-Circular-Green (BCG) Economy Model** provides the policy foundation for integrating biotechnology, biofuels, and circular resource use into Thailand's broader development agenda. This model emphasises Thailand's ambition to become a leading hub for sustainable bioproduction. The BCG model has been accompanied by support mechanisms including corporate income tax exemptions, import duty exemptions on machinery and R&D materials, and special incentives for advanced biotechnology projects.
- **The Thailand Board of Investment (BOI)** is the central mechanism for delivering investment incentives, streamlining regulatory processes, and managing eligibility criteria for firms entering the bioeconomy space. BOI support includes tax exemptions, simplified licensing, and sector-specific requirements for biomanufacturing.
- **The Eastern Economic Corridor (EEC)** is a designated zone aimed at concentrating investment in high-tech industries including biotechnology. It builds on BOI mechanisms by offering additional incentives, including geographically targeted benefits, extended tax holidays, R&D subsidies, infrastructure support, and incentives for firms co-locating within biotech clusters.

Two bodies underpin Thailand's R&D ecosystem in support of its bioeconomy strategy:

- **The National Science and Technology Development Agency (NSTDA)**, which provides R&D infrastructure, technology transfer services, and co-funding mechanisms for applied innovation.
- **The National Center for Genetic Engineering and Biotechnology (BIOTEC)**, which sits within NSTDA and supports microbial strain development, industrial biotech applications, and public-private partnerships across food, agriculture, and health.

Thailand offers a range of incentives, though notably does not offer significant non-dilutive financing:

- CIT exemptions of up to eight years, plus a 50 percent reduction for five additional years for eligible companies.
- Full or partial import duty exemptions on machinery and R&D inputs.
- Enhanced, location-specific benefits in the EEC—such as tax double deductions for transportation, electricity, and water costs, write-offs of facility construction costs against taxable income, and infrastructure cost deductions.
- Enhanced deductions on employee training programmes (up to 200 percent).

Despite its incentive strengths, Thailand lacks a clear regulatory pathway for novel fermentation-derived food ingredients and is yet to approve this type of food ingredient for local production or sale. This deters investors seeking predictable timelines and streamlined product approval processes. It also highlights the absence of a vertically integrated strategy that combines regulatory enablement with fiscal support to attract commercial-scale fermentation projects.

Vietnam: Emerging opportunity with supportive policy

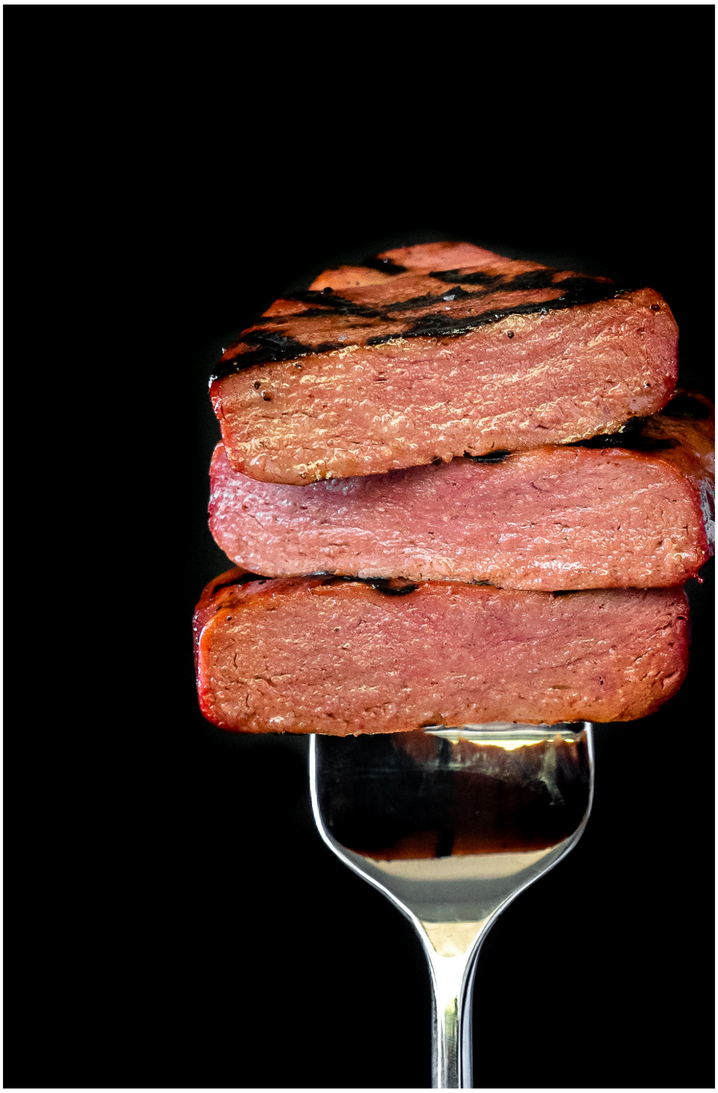
The government of Vietnam is explicitly working to improve the attractiveness of the country for biotechnology and biomanufacturing. The recent adoption of Resolution 36-NQ/TW exemplifies Vietnam's outlook and interest in developing the country with a focus on the bioeconomy. The resolution, adopted in 2023, establishes biotechnology as a "priority solution" for achieving sustainable socio-economic growth. This resolution is the umbrella for an integrated combination of policy reforms, financial incentives, and international collaborations designed to position Vietnam as a regional hub for biotechnology and biomanufacturing, and includes targets for developing and applying biomanufacturing in agriculture.

Strategies outlined by the resolution to achieve these goals include infrastructure investment, human capital development, regulatory framework development, and attracting foreign investment and technology transfer. Along with this biotechnology strategy, the announcement of a significant investment in a large-scale biomanufacturing facility are strong signs of emerging biomanufacturing potential in Vietnam.

Currently, financial incentives available for biomanufacturing facilities in Vietnam appear to be in line with several of the incentives ranked most highly in the incentive analysis. For example, large-scale biomanufacturing projects may qualify for:

- Cash support of up to 10 percent of new fixed asset investments.
- A preferential CIT rate of 10 percent for 15 years.
- A four-year tax holiday, followed by a 50 percent CIT reduction for nine more years.
- Import duty exemptions and possible fast-tracked approvals.

These provisions indicate progress, but Vietnam still faces important hurdles. A key gap is feedstock capability: while the country lags in domestic production, efforts to modernise the sugar industry are noteworthy—in 2024, Vietnam recorded the region's highest sugar yield per hectare, surpassing even Thailand, the world's fifth-largest producer. Still, constraints in feedstock supply, the absence of a clear regulatory pathway for novel foods, and limited experience with industrial-scale fermentation remain obstacles. Vietnam nevertheless presents a potential first-mover opportunity for investors, but the realisation of this potential will require continued policy momentum and implementation capacity to match the ambition of recent plans.



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Recommendations

Biomanufacturing siting decisions hinge on a set of high-impact factors: access to low-cost feedstocks, a favourable cost and business environment, clear and efficient regulatory pathways, and compelling government incentives. Countries that align their strategies around these levers are best positioned to capture the early wave of commercial-scale fermentation-derived food ingredient manufacturing.

While the sector is still emerging, it aligns closely with goals already prioritised by many APAC governments, such as building domestic manufacturing capacity, reducing reliance on imports, enabling higher-value agri-processing, and addressing climate-related risks. For countries with sugar, starch, or workforce advantages, fermentation offers a pathway to extract more value per tonne of feedstock, catalyse advanced manufacturing ecosystems, and participate early in a strategically significant growth sector.

Cross-cutting recommendations

Countries aiming to position themselves as attractive sites for fermentation-derived food ingredient manufacturing can focus on a set of interlocking policy levers.

1) Prioritise non-dilutive capital support

CAPEX remains the largest barrier to scaling new fermentation infrastructure. Tools that reduce upfront CAPEX, such as grants, guarantees, and concessional loans, deliver the highest ROI for both governments and companies. Strategic investment in shared infrastructure, including pilot facilities and co-manufacturing hubs, can further lower investment barriers.

2) Establish clear and consistent regulatory pathways

Unclear regulatory requirements increase investor risk and delay commercialisation. Governments should establish clear approval pathways for fermentation-derived food ingredients, with clear timelines and guidance for safety, labelling, and novel ingredient approvals.

3) Support infrastructure and co-location strategies

Feedstock costs are the single largest operating expense for most industrial fermentation platforms. Governments can improve cost structures by enabling co-location with sugar processing facilities, and investing in fermentation-ready industrial clusters.

4) Create a national bioeconomy strategy with coordinated implementation

Disjointed policies and unclear institutional mandates reduce the effectiveness of national bioeconomy efforts. Countries that adopt integrated strategies—anchored by clear implementation mechanisms such as inter-ministerial taskforces, lead agencies, or dedicated funds—will be better positioned to align investment attraction, regulatory approvals, and commercialisation efforts.

Country-specific recommendations: Australia, Thailand, and Vietnam

While each country faces distinct challenges, all three have significant latent potential that could be unlocked through better designed incentives and clearer policy integration.

Australia: Activate latent advantage through targeted support

With exceptional feedstock resources and a strong enabling environment, Australia has the fundamentals to lead in fermentation-derived food ingredient biomanufacturing. But without federal support to mitigate high capital and operating costs, investment will remain constrained. Supporting biomanufacturing for food ingredients is an opportunity to capture value from domestic sugar production and onshore high-value biomanufacturing as part of broader industrial diversification goals under the National Reconstruction Fund and Future Made in Australia Plan. But without targeted incentives to overcome high capital and operating costs, Australia risks losing this opportunity to lower-cost markets.

Policy priorities:

- Develop and articulate the value proposition needed to prioritise fermentation-derived food ingredient biomanufacturing in existing programmes.
- Introduce targeted CAPEX support for fermentation infrastructure.
- Establish a national-level coordinating body for food ingredient biomanufacturing to align policy, funding, and regulatory pathways across agencies, and to ensure state-level efforts are reinforced by federal leadership.
- Further streamline food ingredient approvals to match regulatory clarity in other domains with regard to the safety assessment and labelling resulting from the use of gene technology.

Thailand: Match financial incentives with regulatory clarity

Thailand already has many of the enabling conditions needed to lead in fermentation manufacturing: strong domestic sugar production, and one of the strongest biomanufacturing incentive systems in APAC. Prioritising this sector could allow Thailand to position itself as a regional export hub for fermentation-derived food ingredients. To fully capitalise on the investment incentives it already has in place, Thailand must ensure regulatory pathways are equally well developed and predictable.

Policy priorities:

- Create a coordinated national vision and strategy for biomanufacturing, including for food ingredients, that integrates incentives, regulation, and enabling infrastructure.
- Issue guidance for how biomanufacturing projects align with incentive eligibility criteria.
- Develop clear, fast-track regulatory pathways for fermentation-derived food ingredients.

Vietnam: Convert intent into investable opportunity

Vietnam has an opportunity to use fermentation manufacturing to realise its industrial policy ambitions. With strong political backing for the bioeconomy (via Resolution 36), low-cost operating conditions, and improving sugar capacity, Vietnam could become a cost-competitive site for fermentation-derived ingredient manufacturing for domestic and regional use. Doing so would support industrial diversification, reduce dependence on imported products and ingredients, and embed the country early in an emerging strategic sector.

Policy priorities:

- Operationalise Resolution 36 via funded programs with specific agency mandates.
- Clarify incentive eligibility criteria, timelines, and application processes for biomanufacturing sites.
- Publish regulatory procedures and statutory timelines for novel food approvals.

Looking forward

The window to attract early investment in fermentation-derived ingredient manufacturing is limited. Global capital will favour jurisdictions that minimise uncertainty, reduce risk, and provide strong incentive support. By introducing competitive incentives and addressing gaps, governments can position themselves to advance not only protein innovation, but also broader goals for sustainable and resilient food systems.

Appendix: Index methodology

The biomanufacturing site selection index compares nine APAC countries across eight drivers identified as critical to the competitiveness of fermentation-derived food ingredient manufacturing facilities.

Scoring and normalisation

The data was normalised using min-max scaling so that the best-performing country received a score of 100 and the lowest a score of 0, with other countries scaled proportionally in between. Scores are inverted for metrics where lower values indicate better performance (e.g. costs). Where direct data for specific metrics was unavailable for certain countries, reasonable estimates were generated using relative multipliers based on comparable values.

Sources

A. Operational and capital cost drivers

1. Feedstock costs

- Measured using three indicators:
  - Raw sugar export volumes (1,000 metric tons)
  - Raw sugar production volumes (1,000 metric tons)
  - Import reliance ratio calculated as imports / (production + imports)
- Sourced from the USDA Foreign Agricultural Service Production, Supply and Distribution (PSD) database: USDA PSD Online
- Exports are double weighted; production and import reliance are weighted equally

2. Labour costs

- Based on average monthly wages (USD) for manufacturing workers
- Sourced from ASEAN Briefing – Manufacturing Tracker and complemented with national labour statistics for Australia using Australia Jobs and Skills Data

3. Utilities costs

- Measured using two indicators:
  - Average business electricity rates (USD/kWh), sourced from Global Petrol Prices – Electricity Prices
  - Average water utility rates (USD/15m^3/month), (sourced from IB-Net)
- Both metrics are averaged together and weighted equally

4. Construction costs (CAPEX)

- Estimated via average cost per square metre (USD/m^2) for advanced manufacturing facilities
- Sourced from Turner & Townsend ICMS 2024, complemented with additional data sources where necessary using DLS Construction Cost Data

B. Enabling environment factors

1. Access to talent

- Measured using an average of three indicators:
  - Share of graduates in engineering, manufacturing, and construction (EMC), sourced from UNESCO UIS Data Browser and OECD Data Explorer
  - Enrollment in vocational programmes, sourced from UNESCO UIS Data Browser
  - Number of R&D researchers per million, sourced from Our World In Data
- The first two indicators (EMC graduates and vocational enrolment) are averaged together and contribute 50 percent of the composite score. The third indicator (R&D researchers per million) contributes the remaining 50 percent.

2. Business environment

- Represented by the World Bank's Ease of Doing Business scores, sourced from the World Bank

3. Regulatory environment

- Assessed qualitatively using national regulatory documents, relevant food ingredient product approvals and expert interviews, converted into numerical scores for comparative analysis

4. Government incentives

- Due to the complexity of incentive schemes, detailed analysis was conducted only for the three spotlight countries of Australia, Thailand, and Vietnam
- Assessed qualitatively using national government websites and expert interviews, converted into numerical scores for comparative analysis
- Incentives were scored based on the availability and targeting of incentives (2 = incentive is available and targeted to biomanufacturing/widely available; 1 = incentive is available but not targeted to biomanufacturing/widely available; 0 = not available)
- The incentives were weighted based on a multiplier calculated based on the incentive ranking from executive interviews and the NPV analysis (average of the two ranks)

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