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NEW ZEALAND
AGRICULTURAL GREENHOUSE GAS
Research Centre

National Infrastructure Plan

Client: Ministry for Primary Industries

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EXECUTIVE SUMMARY

This National Infrastructure Plan has been developed to support management and prioritisation of New Zealand's GHG measurement infrastructure. Investment in infrastructure is critical for advancing the search for tools and technologies that will effectively mitigate agricultural greenhouse gas (GHG) emissions, including the three main gases: methane, nitrous oxide, and carbon dioxide from soils.

The plan includes:

- An approach to assessing GHG measurement infrastructure to determine if it is critical or secondary regarding the national research priorities
- Guidance on operating models for infrastructure (purchase, management, and prioritisation)
- A new 'custodian' role for the NZAGRC to maintain a centralised hub of information and knowledge of dedicated agricultural GHG infrastructure, covering all aspects of utilisation, maintenance and strategic planning.
- An assessment of current infrastructure and of needs for additional infrastructure

The main findings following the GHG measurement infrastructure assessment is as follows:

- Cattle Respiration Chambers – the current facility will reach its capacity if demand increases by approximately 11% beyond the 2025 preliminary bookings.
- Sheep Respiration Chambers - current utilization and forecast demand indicate that no additional sheep chambers are needed.
- Greenfeeds – analysis indicates there will be a deficit of two large Greenfeed units by 2026 and that eight new Greenfeeds will need to be purchased to replace the eight units whose useful life ends in 2028.
- Eddy Covariance Towers - the current stock of eddy covariance towers is sufficient to meet anticipated demand.
- Soil Chambers - the current stock of soil chambers is sufficient to meet anticipated demand.
- Mobile Sheep PAC - A total of 36 mobile sheep PACs are currently operational, with 8 units expected to reach their end-of-life by 2030. The existing number is sufficient for the sheep genetic programme until these units reach the end of their useful life.
- Mobile Cattle PAC – successful validation of this equipment could result in an increased demand for cattle PACs and supporting infrastructure.
- Lysimeters - the current stock is sufficient to meet anticipated demand.

Feed intake measurement facilities – availability and capacity are currently limited and further demand is expected. Expanding availability of these facilities is necessary.An analysis of the supply, demand and location of infrastructure deemed to be of importance for research and development (R&D) consistent with national priorities for GHG mitigation, has resulted in the following recommendations regarding the purchase of new infrastructure:

- Expansion of the cattle respiration chamber facility at the New Zealand Ruminant Methane Measurement Centre (NZRMMC) in Palmerston North to ensure maximum capacity can be achieved [adaptation pens, critical supporting infrastructure (e.g., electrical, effluent, water, and feed management) and enhanced ability to safely undertake trials with lactating animals].
- Procurement of two new Greenfeeds in 2025 and 10 new Greenfeeds in 2027, to meet demand, and replace some of the current units when they reach the end of service.

- Establish a facility for the measurement of individual feed intake in Palmerston North to support future trial requirements and support the aim of the national GHG measurement hubs having a full suite of capabilities for GHG measurement.
- Expand the GHG measurement infrastructure capability in Lincoln, Canterbury to include the infrastructure for methane measurement both indoors and at grazing using Greenfeeds, providing an accessible hub for the central South Island. This investment would complement the existing nitrous oxide and soil carbon capabilities to create a measurement hub suitable for measuring multiple GHGs.
- Increase the capacity of existing feed intake facilities at DairyNZ, Hamilton, to allow better utilisation of existing methane measurement infrastructure.
- Subject to successful validation against Greenfeed units in 2024 revisit the need for procurement of additional cattle PAC chambers to support the ranking of cattle in low emissions breeding programmes.

Recommendations are also made with respect to some individual purchase requests received as part of the development of this infrastructure plan.

It is also recommended that this National Infrastructure Plan becomes a living document, with a comprehensive annual review of utilisation, demand, new technologies and replacement needs.

1. INTRODUCTION

Dedicated, robust and effective infrastructure is critical for supporting New Zealand's drive to develop tools and technologies that enable farmers to reduce their greenhouse gas emissions. This National Infrastructure Plan (NIP) assesses the adequacy of current infrastructure and identifies where the provision of additional infrastructure would help accelerate the development of agricultural greenhouse gas mitigation solutions. It also includes recommendations on how this additional infrastructure should be owned, managed, and operated to ensure it is used in a way that maximises its utility for New Zealand. The aim of the plan is to help ensure that the absence or the lack of capacity of agricultural GHG infrastructure does not constrain the accelerated development of solutions.

The approach adopted in compiling the Plan was to:

1. Use the information from two previous infrastructure needs assessments[1];
2. Undertake a comprehensive stocktake of the current infrastructure owned in New Zealand by research providers and other domestic organisations involved in the search for ways to reduce agricultural GHG emissions;
3. Seek views from funders, research providers and industry on where a lack of infrastructure is restricting progress and solicit requests or recommendations for new/additional infrastructure that would address this gap;
4. Define the features that identify infrastructure as 'Critical', or 'Secondary' in relation to the national goals;
5. Develop an assessment process to guide the evaluation and prioritisation of infrastructure demands or requests;
6. Analyse current and anticipated demand for infrastructure to objectively identify current and future constraints and help prioritise what and when new infrastructure will be needed;
7. Consider different ownership, procurement and management models and highlight key factors that influence how infrastructure should be best owned and managed;
8. Provide specific recommendations for additional / replacement infrastructure; and
9. Outline the next steps for ensuring the plan is kept up to date, including regular monitoring of infrastructure needs and utilisation.

[1] "Research Infrastructure and associated Skills, Capacity and Capability Needs and Challenges associated with Agricultural Greenhouse Gas Emission Mitigation Research undertaken in New Zealand", a report for the New Zealand Agricultural Greenhouse Gas Research Centre. (Rowarth 2022)

"A National Infrastructure Plan for reducing agricultural emissions", a report for the New Zealand Agricultural Greenhouse Gas Research Centre. (Sapere 2023)

2. INFRASTRUCTURE CLASSIFICATION AND ASSESSMENT

Having a transparent and thorough process for classifying infrastructure, assessing demand and prioritising its use will assist in ensuring fair and consistent decision-making. A proposed infrastructure classification and assessment framework and workflow diagram to aid decision-making are described below in sections 2.1.1 and 2.1.2.

The proposed assessment process applies to new infrastructure purchases designed to enhance the utility of current infrastructure and/or expand current infrastructure to better meet national needs. It excludes individual components within existing facilities which need to be replaced due to normal 'wear and tear'. Such components are expected to be part of maintenance programmes undertaken by the owners/operators of these facilities. However, individual components within a system could be considered for assessment if there is a strong justification that replacement will lead to significant enhancements in capacity, accuracy and/or precision.

2.1 Infrastructure classification

The first step in this assessment process is the classification of infrastructure in terms of its importance for the development of solutions to support New Zealand achieving its GHG reduction commitments. It assesses the infrastructure against a set of criteria (Table 1) to determine whether it is deemed **Critical** national GHG infrastructure (hereafter referred to as Critical Infrastructure) or **Secondary** (hereafter referred to as Secondary Infrastructure). Secondary Infrastructure plays a supporting role or fulfils a specific or narrower need e.g. for a single research programme.

Infrastructure Classification	Classification Criteria
Critical	• Needed for R&D consistent with national priorities; **and**
	• Sufficiently validated to be able to provide support for research, inventory, and regulatory purposes; **and**
	• Only used for GHG measurement fluxes (emissions over time); **and**
	• Expected to have continuous demand from multiple users over the next 5+ years.
Secondary	• Needed for R&D consistent with national priorities; **and**
	• Used to measure or support the measurement of GHG emissions and/or is critical for developing mitigation solutions; **and**
	• Not sufficiently validated to be able to provide support for research, inventory and regulatory purposes; **or**
	• Single or multiple users and may be for a shorter period.

Table 1 – Definition of Critical and Secondary Infrastructure

In this document, Critical infrastructure should be interpreted not only as the single piece of equipment involved in the direct measurement of GHG (e.g., a gas analyser, a respiration chamber). It includes the supporting equipment and facilities that form a complete system needed for the intended purpose. For example, respiration chambers cannot function without various other components such as handling facilities, animal yards, ventilation systems, etc.

2.2 Demand, need and eligibility assessment

The next stage in the assessment process involves the evaluation of the demand or need for new/additional infrastructure and whether from a national outcomes perspective there may be a case for total- or co-investment by Government (directly or via the NZAGRC). The criteria for this step are described in **Table *2*** below and presented as a flow diagram in **Figure 1**.

Assessment Criteria	Criteria Description
Available for use in New Zealand?	Is the desired infrastructure already available within New Zealand, potentially eliminating the need for acquisition.
Any alternative options?	Are there other infrastructure options available within New Zealand that could achieve the same outcome?
Does demand exceed supply?	Is existing infrastructure sufficient to meet current and anticipated demand?
Will it be used by more than one organisation or programme?	Is the infrastructure needed by a wide range of programmes/organisations and will it have high levels of utilisation.
Cost Prohibitive for a single organization? OR Negative cost benefit?	Is the purchase and running cost of the infrastructure a roadblock for organisations to proceed with procurement and therefore impede progress to solutions?

Table 2 – Criteria for assessing the need for new/additional infrastructure

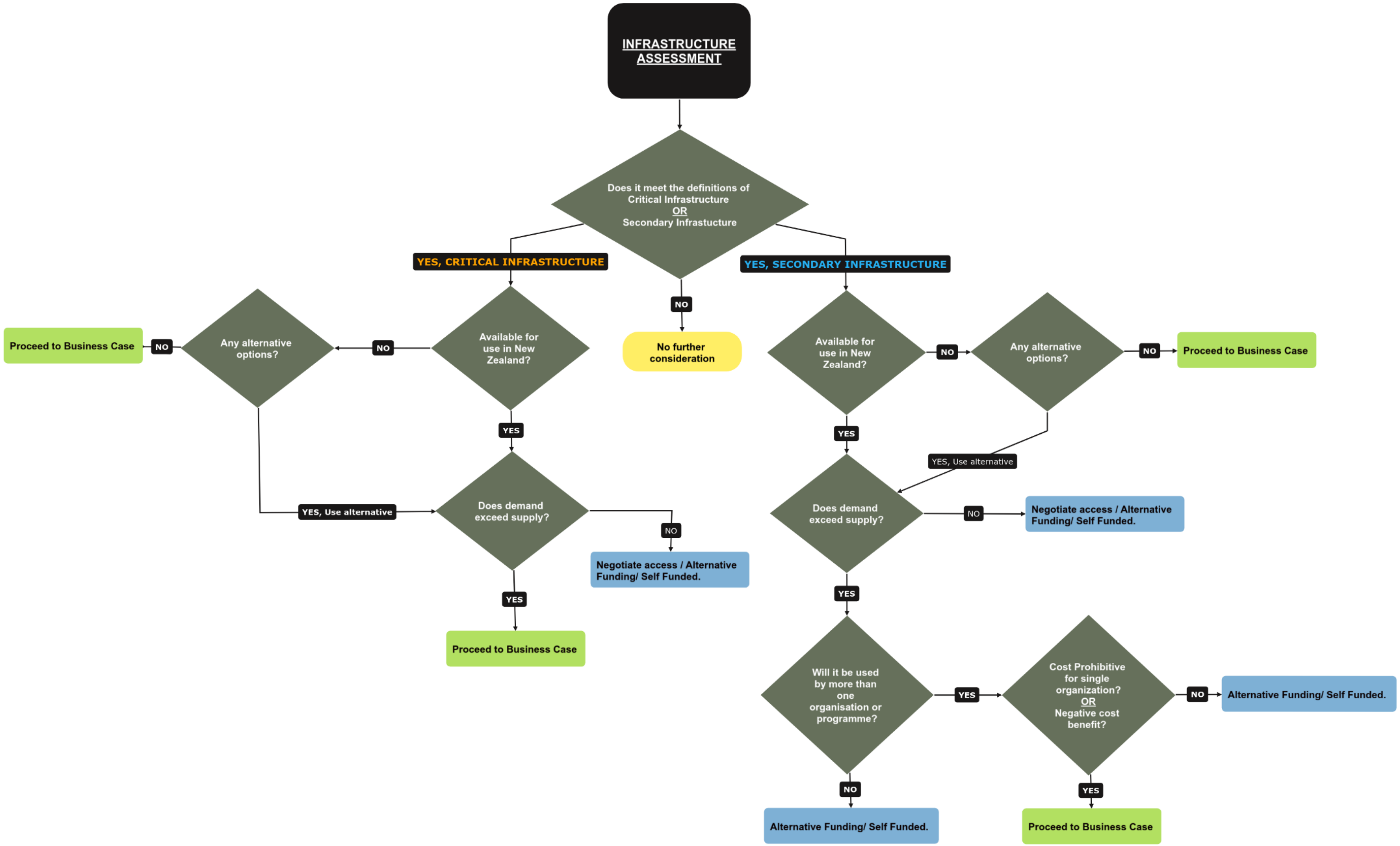

Figure 1 – Workflow to assess GHG measurement infrastructure, leading to determination of funding pathways. In this table "Business case" refers to the case for government funding or co-funding (see section 4.1 for business case considerations)

2.3 Overview of measurement techniques

When assessing requests for measurement infrastructure, it is important that they are considered in the context of the advantages/disadvantages of the range of existing measurement methods. Understanding their features and capabilities is an important input into the assessment. In national R&D programmes, there is a need to obtain precise and accurate measurements of emissions, from validated techniques across different scales (e.g., animal, paddock, farm, region, etc). Validated techniques are required not only for publication of research programmes, but also for supporting the inclusion of measurements within accounting and regulatory frameworks. **Table *3*** outlines the different techniques currently available for measuring (or estimating) agricultural GHG emissions, providing a brief description of the key features that inform the assessment process described in this plan, note that this is not an exhaustive list.

Greenhouse Gas Measurement Technique	GHG	Target	Environment	Advantages	Disadvantages
Respiration Chambers	Methane	Animal/ manure	Controlled, artificial environment	- Measures gas fluxes - Highly accurate and precise, controlled environment - Measurements on individual animals - Include emissions from hindgut fermentation - Allow accurate measurements of intake	- Results are different from free-range animals - configurations still vary from one research group to another - an animal adaptation period is required - every 2–3 h accumulation chambers must release CO2 that builds up - need calibration and gas recovery tests
Accumulation Chambers	Methane	Animal	Grazing/ pasture, indoors free stall or tie stall	- Measures gas fluxes - High throughput (measurements take only ~30 minutes per animal) - Some mobility	- Still to be validated
Hood and/ or headbox systems	Methane	Animal	Grazing/ pasture, indoors free stall or tie stall	- Measures gas fluxes - Portable and less expensive than a chamber - require less space	- Do not measure hindgut emissions - an animal adaptation period is required - some may be designed for grazing situations - recovery test needed - some systems only measure concentrations
Tracers	Methane	Animal	Animal	- Accurate if implemented correctly - few interferences by other gases - the animal can free-range	- Currently not implemented in New Zealand - Relies on SF6, which is a greenhouse gas itself - does not completely capture all tracers and, therefore, relies on spot concentration measurements - high contact with animal, which can disrupt normal behaviour - highly laborious, both in the field and laboratory analysis - limited use for intraday measurements, as it takes a daily integrated sample
Gas sensor capsules	Methane	Animal	Animal	- Compatible with new electronic technologies - relies on small, low-cost sensors - continuous measurements	- Currently not implemented in New Zealand - Information about the relation between concentration and flux (emission) - still under development and not validated.
In vitro techniques	Methane, nitrous oxide	*In vitro*	Rumen/soil simulations	- High reproducibility but used to rank interventions for mitigation potential rather than measurements of flux - allows different rumen microbial environments to be evaluated, but only for short-term responses to interventions	- Outcomes can be different from actual measurements - method relies on donor animals for rumen environment - standardization can be difficult
Micro-meteorological techniques	Methane (this could be multiple gases, depending on the sensors)	Paddock/ pasture	Herd-based measurements, whole farm measurements	- Information about many animals - data produced in a natural grazing environment	- Require expensive and accurate measurement approaches - data processing heavily influenced by microclimatic conditions - loss of data can be high.
Satellite	Methane	Basin/ region	Paddock, farm, catchment measurements, depending on resolution		- Only CH4 concentration measurements.
Computer models	Methane, nitrous oxide	Diverse		- Estimate the distribution of production - not limited to any configuration	- They can be different from real scenarios - still rely on input data made from respiration and accumulation chambers measurements as well as tracer methods. - it can only predict based on input variables or mechanisms described.
Soil Chambers	Nitrous Oxide	Soil		- Measures gas fluxes - measure nitrous oxide from a point source – the urine patch, but also from soil without (or with different) urine treatment to see the difference	- time consuming, requires specialised equipment (GCs, etc)

Table 3 – Selected characteristics of different techniques used to measure/estimate GHGs[2], with emphasis on characteristics used in the assessment process outlined in Figure 1.

Applying the infrastructure definitions from section 2.1 to the measurement techniques listed in **Table *3***, enables the classification of each technique as either Critical or Secondary **(Table 4)**. This classification will be used throughout this report.

[2] Modified table sourced from Table 1, 2023. Methane emissions in livestock and rice systems – Sources, quantification, mitigation and metrics. Rome. https://doi.org/10.4060/cc7607en

Greenhouse Gas Measurement Technique	Infrastructure Classification	Comment
Respiration Chambers	Critical	Respiration chambers are available in NZ for both sheep and cattle
Hood and/ or headbox systems	Critical	Includes Greenfeeds
Tracers	Critical	Refers to the sulfur hexafluoride (SF6) technique
Micro-meteorological techniques	Critical	Includes Eddy-Covariance Towers
Soil Chambers	Critical	-
Accumulation Chambers	Secondary	Cattle portable accumulation chambers - must be validated Sheep portable accumulation chambers - validated for animal ranking
In vitro techniques	Secondary	Suitable for early-stage research, with emphasis on rumen microbial processes (enteric methane)
Satellite	Secondary	-

Table 4 – Infrastructure classification of measurement techniques

3. OVERSIGHT OF NATIONAL INFRASTRUCTURE

In addition to a clear classification and assessment approach for the provision of new infrastructure it is important that comprehensive information is kept on both existing and new infrastructure to underpin the ongoing examination of national needs. We recommended that a strategic oversight or 'custodian' role is agreed as part of the functions of the NZAGRC. This would create a centralised hub of information and knowledge of Critical and selected Secondary Infrastructure. This would include preparing and/or supporting the preparation of information for infrastructure purchases, requests, business cases and decisions.

The Custodian would also have a role in coordinating/developing/overseeing a transparent booking, prioritisation and pricing process for assets purchased wholly or partly with government funds. Where an asset is purchased without government funds the owner may also wish to voluntarily participate in this proposed national system.

Consistently tracking the demand vs. supply of all Critical and Secondary Infrastructure is necessary for ensuring a well utilised asset pool. This system would at a minimum include the following functions:

- Implementation and oversight of a national booking system for Critical Infrastructure.
- Systematic evaluation of existing Critical and Secondary Infrastructure
    - If demand exceeds supply on a frequent basis, then the assessment process outlined in Section 2.1 should be used to determine if there is a case for additional supply.
    - If demand exceeds supply infrequently then the prioritisation process must be implemented.

- If demand is continuously or frequently below supply, determine whether the infrastructure is still needed and/or whether it is underutilised for other reasons e.g. price, lack of availability of supporting infrastructure.
- Development of a network of contributors/organisations to understand demand, supply and future investment opportunities.

The Custodian will play a key role in monitoring and assessing emerging global GHG measurement technologies. This will include identification of how new technologies could complement- or replace existing infrastructure so future funding decisions (new or replacement) can be made with this information to hand.

The Custodian will work closely with critical funding- and research partners to determine national priorities and future infrastructure purchases/needs.

The Custodian should be the key conduit for the process of receiving and supporting equipment requests where the asset has national significance, or the need is to support national research priorities.

The Custodian would work in partnership with infrastructure owners/operators to communicate needs, understand and resolve ongoing issues and undertake planning for upgrading, replacement, or retirement of Critical Infrastructure and selected Secondary Infrastructure. The development of the network of contributors/organisations ensure more open lines of communication and help New Zealand organisations, and the government, make more informed decisions around infrastructure provision and utilisation.

For critical and secondary infrastructure, the following information would be monitored by the Custodian:

- Utilisation of infrastructure (reported quarterly): ensuring a clear understanding of demand vs. capacity and including tracking any bookings denied or delayed due to lack of availability.
- Maintenance of infrastructure (reported quarterly): Ensuring that a maintenance plan exists and implemented, ensuring that equipment is well maintained and kept in good working order.
- Infrastructure end-of-life (reported annually): a record of replacement dates for all Critical Infrastructure. This will ensure that a process is initiated in a timely manner to determine whether replacement is necessary based on demand and support the development of a business case as appropriate.

4. INFRASTRUCTURE FUNDING AND OPERATION

A clear plan for funding (and associated purchase and procurement), ownership, management and monitoring of New Zealand's Critical- and Secondary Infrastructure will help ensure access to infrastructure is not an impediment to progress. There are a range of end-to-end options, with no single best option. Each infrastructure asset must be evaluated individually, and a clear decision made on how it will be funded, owned, managed, costed for use, and replaced at the end of its life.

The plan for future replacement of an asset may change over time (technology may advance, research may no longer require a certain technique, etc) but a view from the outset is essential since the approach to replacement will influence the price to, and potentially demand from, users. This aspect is covered in more detail in Section 4.2.4.

A full picture through the life of the asset is a critical part of a business case that helps inform the best funding, ownership and management model.

4.1 Business case

A business case should be developed for all proposed new or replacement assets. Development should include all parties involved in ownership, management and operation of the asset over its life. If a group are pooling funds for the purchase of an asset, the ongoing roles and responsibilities of the funders are important to get right. The Custodian can help construct the business case.

A comprehensive business plan should cover the following:

- Demand analysis and justification
- Funding
- Purchase
- Ownership
- Management (including prioritisation of use)
- Contracting needed for management/operation/servicing and maintenance
- Pricing
- Replacement

It should outline the procurement/purchase timeframe, all costs involved including freight and commissioning and make allowance for currency fluctuations and contingencies.

4.2 Funding, Ownership and Pricing

An overview of funding and ownership options covered in this section can be seen in **Figure 2**. Each funding scenario has similar options for ownership. The main difference is how much visibility and support the Custodian provides. See section 3 for more information on the role of the Custodian.

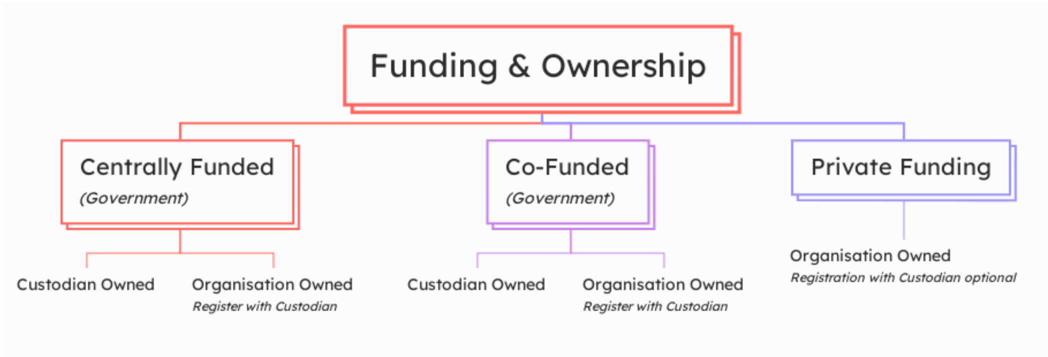

Figure 2 – Funding and ownership options

4.2.1 Funding

Table 5 outlines three funding options for Critical- and Secondary Infrastructure. All funding decisions need to be made within the context of how the asset will be procured/purchased, owned, maintained and managed through its life.

Following a funding decision, a plan for procurement and purchase will be agreed, which is usually with the ongoing owner of the asset. This should already be documented in the original business case presented as part of justification for purchase.

Funding Options	Description
Centrally Funded	Central government may provide **full** funding directly, or via the Custodian, to an organisation to undertake the purchase and commissioning of the asset.
Co-Funded	Central government may partner with other organisation(s) either directly, or via the Custodian, to **co-fund** the purchase and commissioning of the asset.
Private	An organisation or group of organisations may choose to invest in an asset.

Table 5 – Infrastructure funding options

4.2.2 Ownership

Ownership should be determined prior to procurement and purchase. The total cost of ownership must be carefully considered when making decisions including management, maintenance, operating and pricing.

There are two main ownership options when funding is provided fully or in part by the government: Custodian or organisation owned. The pros and cons for these two ownership options are listed in Table 6.

	Custodian Owned	**Organisation Owned**
Pros	Centralised view on utilisation and booking requests	Assets are managed by subject matter experts (SMEs)
	Single point of information for Central Government	Assets located closer to management
	Consistent- maintenance and servicing	Local accountability
	Consistent approach to pricing and replacement cost	Maintenance of secondary & supporting infrastructure
	Consistent approach to prioritisation of access	
	Portable asset can be relocated to suit new priority/research	
Cons	Assets are geographically distant from the Custodian, making it difficult to manage	Limited visibility on how assets are managed and maintained
	Limited visibility of the additional resources required for asset utilisations	Inconsistent approach to repairs and maintenance
	Lack of local accountability	Organisational (internal) priority mismatch
	Assets not managed by SMEs	More difficult to have a coordinated approach to asset utilisation
		Assets not managed by SMEs

Table 6 – Pros and cons of ownership options

Unless otherwise agreed, the owner is responsible for the maintenance, daily management and upkeep of the infrastructure. Ongoing operating may include cost such as servicing, spare parts, labour, and some trial costs (labour, consumables).

There is no single 'best' ownership model and each business case should include a recommendation on ownership. An important part of the assessment of new asset requests should be that all parties involved in ownership, management and operation of the asset are aware of their obligations from the outset. The Custodian will be able to assist with the evaluating the implications of ownership, and subsequent management and operating obligations, in cases where it is not owner.

4.2.3 Pricing for research use

How an asset is priced to users is a crucial consideration; prohibitive costs may result in underutilised assets and impede the timely development of solutions for New Zealand farmers. On the other hand, under-pricing could result in the asset owner incurring unsustainable financial losses.

Table *7* outlines two pricing scenarios, and the considerations needed when adopting one or the other option. Pricing decisions, particularly any justification for a subsidised approach, should be outlined in the initial business case to help ensure a balance between high utilisation and sustainable costs to the owner.

Cost recovery Options	Description
Subsidised	Where an asset is designated as Critical- or Secondary Infrastructure, there may be a case for its ongoing operational costs to be subsidised by another party. The subsidised model may be applicable irrespective of who purchases, owns, or manages the asset. However, any subsidised non-government wholly or partly purchased asset would need to be registered with the Custodian and be available for general use via a transparent booking, prioritisation and pricing system.
Commercial	An asset may be run on a full commercial basis where the user pays the full cost. If this model is adopted the consequences for the progress to solutions and likely level of utilisation must be carefully considered.

Table 7 – Infrastructure cost recovery options

4.2.4 Pricing for replacement

In addition to covering operating costs when pricing for research use, consideration of whether an asset replacement cost should be included is important. While including full replacement cost in the price factors in the need for future replacement of the asset, it may make the price to users prohibitive.

How and whether replacement costs can/should be included in the price to users interacts with the ownership model. If a replacement cost is not built into the price to users, what obligations are placed on the owner with respect to replacement at the end of life of the asset? Alternatively, if the owner collects a replacement cost for a government purchased asset, who holds this money and who decides on its future use?

If the owner received full- or partial funding from central government/Custodian to purchase the asset, central government may choose not to charge replacement costs to users on the understanding that it will pay the owner the replacement costs annually or make provisions for replacing the asset at the end of its life. Recommendations on how replacement costs are handled will be outlined in the asset purchase business case.

Replacement costs need to be monitored continuously by the Custodian/owner as in some cases there may be an intention to charge full replacement costs for an asset but the level of utilisation is ultimately too low for the owner to fully recoup replacement costs. Alternatively, a subsidy approach is adopted but it proves to be unnecessary.

If an asset has been purchased by an entity without government funding the owner will normally decide how it approaches pricing, including replacement costs. However, there may be instances where privately owned and purchased assets may help accelerate the national research effort if they are included in a national booking, prioritisation and pricing system. In this case if a fully commercial pricing model is prohibitive for users, some type of subsidy could be considered.

Regular reporting to/by the Custodian on utilisation, future demand, and, as appropriate, revenue will ensure the replacement options can be continuously monitored and evaluated.

5. CURRENT STATUS OF NATIONAL INFRASTRUCTURE

5.1 GHG Measurement Infrastructure Stocktake

New Zealand already has considerable infrastructure dedicated to agricultural greenhouse gas research and development. However, increased demand from both government and industry means that it is unlikely to be sufficient to meet future needs. To assess the adequacy of current infrastructure a comprehensive stocktake was undertaken and key existing infrastructure categorised as Critical and Secondary (Table 8). The stocktake includes infrastructure to be commissioned in 2024 (i.e., assets that have been purchased or are in purchasing phase).

The information presented in Table 8 has been collated from the following sources:

- "Research Infrastructure and associated Skills, Capacity and Capability Needs and Challenges associated with Agricultural Greenhouse Gas Emission Mitigation Research undertaken in New Zealand", a report for the New Zealand Agricultural Greenhouse Gas Research Centre. (Rowarth 2022)
- "A National Infrastructure Plan for reducing agricultural emissions", a report for the New Zealand Agricultural Greenhouse Gas Research Centre. (Sapere 2023)
- Independent interviews with various stakeholders.

Asset	Classification	In Use/ Expected in 2024	Notes on Assets
Sheep Respiration Chambers	Critical	24	AgResearch, Manawatu
Cattle Respiration Chambers	Critical	8	AgResearch, Manawatu
Greenfeeds Large - Portable	Critical	33	1 at Five Star Beef 8 at Ruminant Biotech (Excluded from calculations) 8 at LIC (owned by AgResearch) 10 at AgResearch (4x Lincoln, 6x Palmerston North) 4 at DairyNZ (2x owned by DairyNZ, 2x owned by AgResearch) 2 at Pāmu (owned by AgResearch)
Greenfeeds Large - In-Situ	Critical	12	8 at LIC (owned by AgResearch) 4 at DairyNZ (owned by AgResearch)
Greenfeeds Small - Portable	Critical	4	1 at AgResearch, Manawatu 3 at DairyNZ (owned by AgResearch)
Soil Chamber (static)	Critical	706	300 AgResearch 80 Plant & Food 326 Landcare
Soil Chamber (automatic)	Critical	21	1 system & 12 units AgResearch 1 Waikato University 8 Landcare
Soil Chamber (portable)	Critical	170	Massey University
Eddy Covariance Tower	Critical	19	6 Waikato University 1 Plant & Food 3 Landcare 9 Being commissioned at Waikato University (Owned by AgResearch)
Sheep PAC - Static	Secondary	12	AgResearch, Mosgiel
Sheep PAC - Mobile	Secondary	36	AgResearch, Mosgiel - Trailered
Cattle PAC	Secondary	10	6 at AgResearch, Mosgiel 4 at LIC (Owned by AgResearch)
Lysimeter	Secondary	450	48 Plant & Food 12 Landcare 60 Massey Uni 150 Lincoln University 180 AgResearch

Table 8 – Summary of current asset inventory[3] Unless otherwise indicated, the assets are owned by the organisation named in the 'Notes on Assets' column

5.2 National Accessibility – Locations

In addition to having Critical and Secondary Infrastructure available nationally it is also important to consider where it is located as this may influence its level of utilisation and ability to accelerate the search for solutions. A breakdown of main locations, the infrastructure available at each location, the main field of focus and the agricultural sectors served are given in **Table 9**. A geographical map of their locations is shown in (**Figure 3**).

[3] GreenFeeds owned by Ruminant Biotech has been excluded from the capacity and demand calculations, since it is unlikely that these GreenFeeds will be available for other organisations

	Asset Type	Waikato	Manawatu	Canterbury	Otago
Field(s) of focus		Field Studies at scale Soil Carbon Nitrous Oxide measurement Methane measurement Genetics/Breeding (Cattle)	Detailed rumen metabolism & microbiology Early stage research on methane mitigation options Small scale nitrous oxide measurements	Nitrous oxide Soil Carbon	Genetics/Breeding
Agriculture Sector		Dairy Airable	All ruminants	Sheep Beef	Sheep Beef
Greenfeeds (Main locations) *Units are portable	Critical	X	X	X	-
Sheep Respiration Chambers	Critical	-	X	-	-
Cattle Respiration Chambers	Critical	-	X	-	-
Automated batch culture and continuous flow rumen in-vitro systems	Critical	-	X	-	-
Lab-based rapid in vitro screening nitrous oxide system	Critical	-	X	-	-
Eddy Covariance Towers	Critical	X	-	X	-
Soil chambers for field measurement of nitrous oxide	Critical	X	X	X	X
Cattle PAC	Secondary	X	-	-	X
Sheep PAC (Main locations) *Units are portable	Secondary	-	-	-	X
Feed intake facility	Secondary	X	-	-	X

Table 9 - Current national infrastructure locations

Figure 3 - National infrastructure distribution

In addition to influencing levels of utilisation, locating Critical Infrastructure in various parts of the country helps to mitigate the risk associated with natural disasters that could severely compromise research and development activities if infrastructure is clustered in a single location. Mitigation of this risk needs to be balanced with costs and demand as replicating all Critical Infrastructure at multiple locations would incur large upfront and operating costs and is likely to result in considerable underutilisation.

Currently, there are two well-established Critical Infrastructure hubs.

In Hamilton (LIC-CRV/DairyNZ), comprehensive cattle methane measurement using Greenfeeds and feed intake facilities have been in place for >5 years. Both organisations have well-trained staff for maintaining and servicing these facilities. The facilities at DairyNZ are in high demand and utilised by a range of users. DairyNZ own the land and physical buildings that house the equipment, whilst the Greenfeeds are owned by AgResearch. As some of the equipment at DairyNZ is coming to the end of its useful life there is a need to provide replacements and to consider whether the current facilities are adequate for future needs. The facilities at LIC are devoted to the low-emissions dairy breeding programme and are utilised by that programme for 6-9 months a year. Use by other users is limited by quarantine restrictions. These facilities are assessed as being adequate for now.

Palmerston North hosts the New Zealand Ruminant Methane Measurement Centre (NZRMMC) facility at AgResearch's Grasslands campus. It is also home to 22 mobile Greenfeeds which are available for external hire on a user pays basis. The NZRMMC currently comprises 24 sheep and 8 cattle respiration chambers along with accompanying animal holding, handling and waste disposal facilities. Further expansion to these accompanying facilities is required for the respiration chambers to be utilised to their full potential. Well-trained staff are present for maintenance and servicing of the Greenfeeds and respiration chamber facilities.

There is currently no established hub for methane measurement in the South Island although Lincoln University and AgResearch have expressed a strong desire to have methane measurement and feed intake facilities located in Lincoln. In the South Island, Canterbury has the potential to serve a wider range of sectors, given their arable, beef, sheep and dairy focus. Expansion of the current GHG measurement capabilities in Lincoln (nitrous oxide and soil carbon) to include methane measurement infrastructure would turn Lincoln into an ideal South Island hub for studies on farm where concurrent measurements of the three main agricultural GHG could take place. Four Greenfeeds are now located in Lincoln to service demand in the South Island. The provision of feed intake facilities and other supporting infrastructure is needed for these Greenfeeds to meet the needs of a range of likely users.

Having Critical Infrastructure centred on three hubs, two in the North Island and one in the South Island with each hub have a particular area of expertise will provide a lower risk dispersed approach to infrastructure. It will also improve access and minimise both project costs and equipment waiting times.

6. ANALYSIS OF INFRASTRUCTURE DEMAND & CAPACITY

Future demand, (particularly long term) is uncertain and difficult to predict as it is highly dependent upon levels of investment from government and non-government entities and, where appropriate, upon successful progression of products along technology development pipelines.

In addition, technological developments in measurement infrastructure may strongly influence the future demand for particular types of existing measurement infrastructure. To manage this uncertainty we recommend that demand and capacity is reviewed annually and updated forecasts of Critical and Secondary infrastructure needs compiled.

6.1 Critical Infrastructure

An assessment of future demand for existing Critical Infrastructure was made based on current demand and interviews conducted with multiple stakeholders. This is summarised in **Figure 4** for everything except cattle- and sheep respiration chambers which are considered separately in Sections 6.1.1 &6.1.2. Based on the data in Figure 4, which considers demand and supply for Critical Infrastructure out to 2028, demand is only forecast to exceed supply for Greenfeed methane measurement units. This is analysed in more detail in 6.1.3.

There is considerable uncertainty when forecasting future demand as it is heavily dependent on results and progress in current research and development programmes. Infrastructure demand and levels of utilisation therefore need to be kept under review (See Section 3, role of the Custodian).

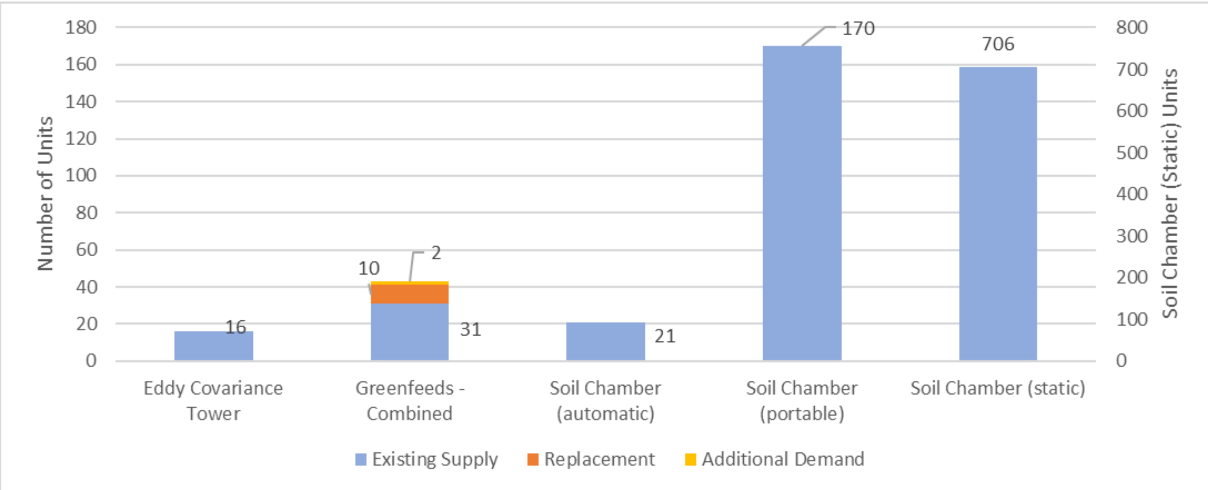

Figure 4 – Demand for selected Critical Infrastructure until 2028[4]

6.1.1 Sheep Respiration Chambers

A total of twenty-four sheep respiration chambers are operational and located at the AgResearch Grasslands campus in Palmerston North, within the NZRMMC. Given the dimensions of these chambers, they are only used for sheep emission measurements. The expected end of useful life is 2030.

Current utilization and forecast demand indicate that no additional chambers are needed. However, a plan needs to be developed for replacement, ideally by 2028. The chambers are owned by AgResearch with funding for their construction and commissioning being provided jointly by AgResearch and the government.

[4] Demand for Respiration Chambers are covered in their respective sections.
Units for static soil chambers are measured on the secondary axis.

6.1.2 Cattle Respiration Chambers

Demand for cattle respiration chambers is currently highly dependent on the research needs for methane inhibitors and an anti-methanogen vaccine programmes. This demand is dependent on results from initial experiments conducted in sheep because of the lower cost of sheep trials; successful evaluation in sheep is often a precondition for evaluation in cattle. By September 2024, 8 cattle respiration chambers will be operational at the NZRMMC in Palmerston North. This facility, with its current design will be sufficient to meet demand until the end of 2025. This assessment assumes that the supporting infrastructure (i.e., cattle yards, handling pens, feed storage, effluent management) remain as they are currently.

To determine future demand, the preliminary bookings for 2025 were used as a baseline. Then a nominal 75% linear increase in demand was assumed until 2028 (i.e., 25% per annum).

Two scenarios are considered to compare capacity vs. demand (**Figure 5**). These scenarios are (1) 8 chambers with the current supporting infrastructure and (2) 8 chambers with supporting infrastructure upgraded to allow increased chamber throughput.

6.1.2.1 Grasslands facility – 8 Chambers with existing supporting infrastructure

Currently, the cattle facility comprises 8 cattle respiration chambers and a handling area with 8 adaptation crates and 4 animal pens. The absence of extra yard space for animal adaptation and handling hampers the facility's efficiency and its ability to operate at full capacity. Existing capacity will be exceeded in this scenario if demand increases by 11% (5 additional trial weeks) beyond the 2025 preliminary bookings. For context, a typical study with cattle at the NZRMMC is ~4-8 weeks in duration. This means that the demand created by a single additional study would result in existing capacity being exceeded.

6.1.2.2 Grasslands facility – 8 Chambers + yard expansion + facilities for feed intake measurement

To maximise the utilisation of the 8 cattle respiration chambers additional yard handling/adaptation areas would be needed. This expansion substantially increases the number and types of experiments that can be accommodated. For example, additional handling or adaptation spaces will allow concurrent trials to be run. These enhancements are projected to boost the facility's capacity by at least 50%. Being able to run concurrent experiments translates into having an additional 23 cattle respiration facility weeks available per calendar year (Figure 4). With this additional capacity, demand would only exceed capacity if there is a >70% increase in demand between 2025 and 2028.

When evaluating future chamber demand, some existing additional constraints need to be considered. In some situations, feed intake needs to be measured accurately for individual animals for extended periods. Currently, this cannot be done at the NZRMMC. AgResearch has indicated that a lack of this infrastructure is a constraint on full utilisation of the cattle respiration chambers, and they are currently turning work away from commercial entities developing products for the New Zealand market. A major booking from the NZAGRC for 2025 is contingent on individual feed intake facilities for housed animals being available in the Palmerston North area.

When considering upgrades to the cattle respiration chambers to meet future demand, both upgrades of existing supporting infrastructure and additional infrastructure need to be factored in. The additional feed intake infrastructure will itself be a determinant of future demand, without it the scenario of an increased demand of 75% by 2028 may not be realistic.

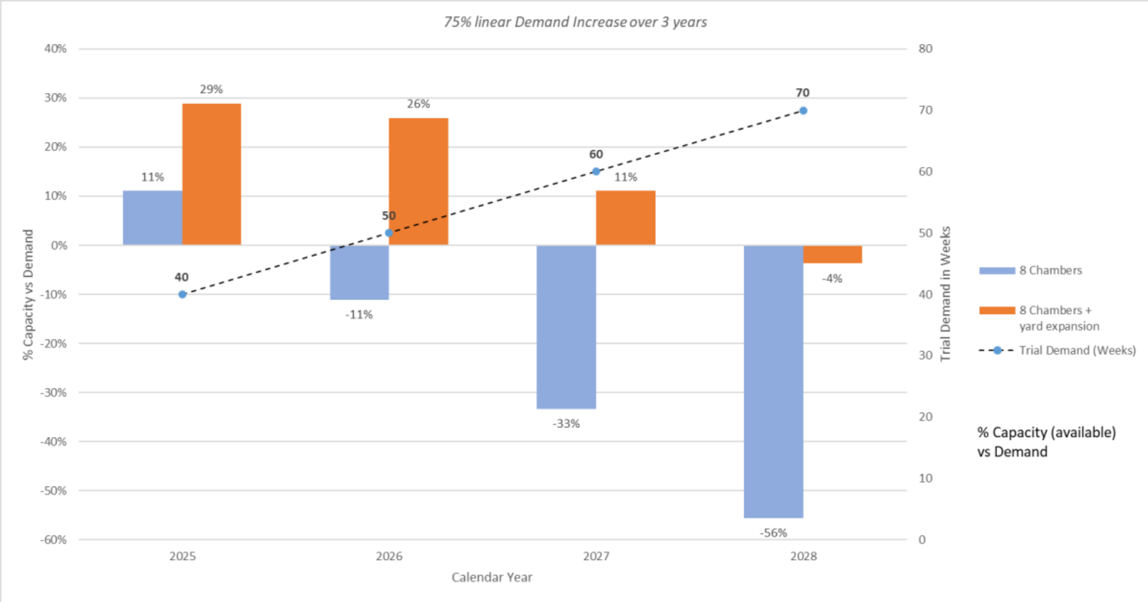

Figure 5 – Demand vs. capacity of cattle respiration chambers at the NZ Ruminant Methane Measurement Centre using two infrastructure scenarios (see text for full description) and an increase in demand of 75% between 2025 and 2028. The blue bars are scenario 1, orange bars scenario 2. Positive values indicate supply exceeding demand. Negative values demand exceeds supply.

6.1.3 Greenfeeds

Greenfeeds can be classified into three categories, large portable, large in-situ and small portable. Portable units are more versatile and can be used indoors and outdoors. Small Greenfeed units are dedicated to sheep and young cattle but updated technology in the methane sensor now enables trials with smaller animals to use newer large Greenfeed units (24 of the current Greenfeeds can be used for smaller animal trials). This potentially reduces the demand for the smaller portable units.

Eleven Greenfeed units are privately purchased and managed (8 Ruminant Biotech, 1 Fivestar Beef, 2 DairyNZ). The rest (38) were purchased with central government funds.

	Large Portable	Large in-situ	Small Portable
Greenfeed Overview	A turn-key system measuring gas fluxes of Methane (CH4) & Carbon Dioxide (CO2) from individual animals. It has optional additonal sensors to measure Oxygen (O2) and Hydrogen (H2).		
Description	Large Greenfeed mounted on a trailer or trolley	Large Greenfeed permanantly installed indoors	Designed to measure lower emmisions from individual small animals.
Animals	Large Ruminants (Cattle) Greenfeed units with serial number 500 or greater can also be used for methane measurements from small ruminants (sheep) and young cattle.		Small ruminants (sheep) Young ruminants (calves)
Photo(s)	 		

Table 10 – Greenfeed Categories

To allow for seasonality downtime, maintenance and overlapping bookings, each Greenfeed unit is assumed to be available for 26 weeks per year. The overall supply and demand for the Greenfeeds are shown in **Figure 6**.[5]

This analysis indicates there will be a deficit of 2 large Greenfeed units by 2026 driven by increased demand from low methane cattle breeding programmes and the assessment of new feeds and inhibitory compounds. The useful life of 8 in-situ Greenfeed units currently permanently located at LIC in Hamilton for the low emitting dairy cattle programme will be reached in 2028. These units will have to be replaced in a timely manner to ensure that demand requirements are not affected. A plan needs to be developed for their replacement.

Demand for Greenfeeds suitable for smaller animals is forecast to increase from 2025 onwards. This is for use by cattle and sheep. This is not anticipated to result in additional demand for the small Greenfeed units as 20 of the latest Greenfeed units are suitable for conducting measurements in small animals (e.g., sheep or calves). When the small units reach the end of their useful life (2028 & 2029), consideration should be given to them being replaced with the more versatile large Greenfeed units.

[5] GreenFeeds owned by Ruminant Biotech has been excluded from the capacity and demand calculations, since it is unlikely that these GreenFeeds will be available for external use.

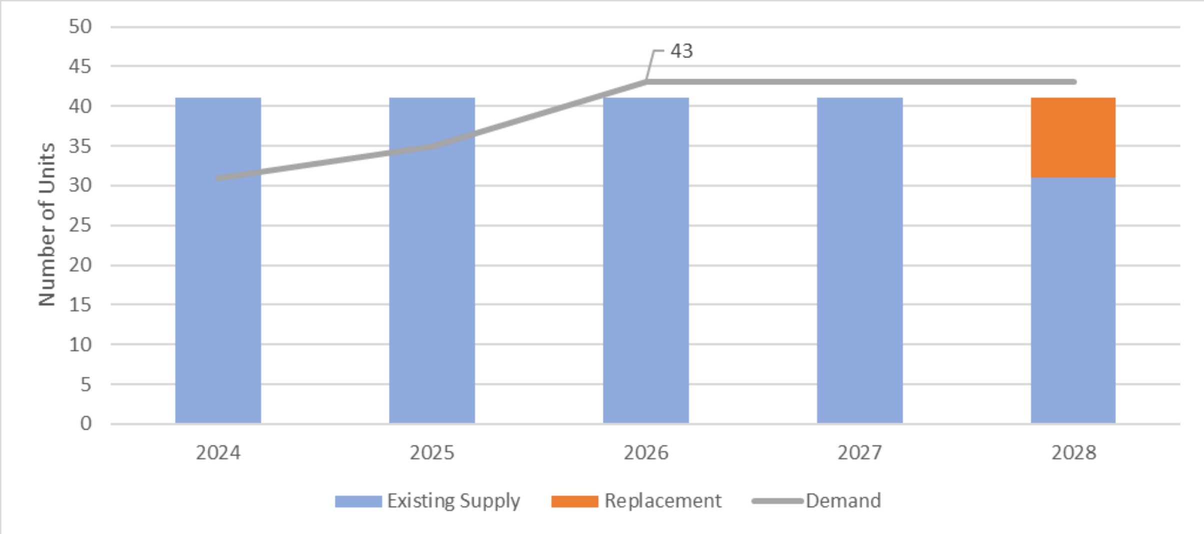

Figure 6 – Demand for Greenfeeds up to 2028

To maximise the utilisation of Greenfeeds appropriate supporting infrastructure is needed, particularly the ability to measure and control feed intake in individual animals. As with respiration chambers, having feed intake facilities alongside methane measurement facilities will accommodate a greater range of trial designs.

Currently, DairyNZ has 4 Greenfeeds located in situ in a dedicated facility which has feed intake facilities (Calan Gates) etc. The Calan Gate facility can handle 40 animals, which restricts the size and type of trials that DairyNZ can undertake. Primarily these are dairy cattle related studies. Utilisation of the Greenfeeds would increase if these feed intake facilities were expanded.

There are currently four large Greenfeeds located in Lincoln. They are portable to allow measurements both indoors and outside. Currently, feed intake facilities are not available in Lincoln to complement the Greenfeeds; consideration should be given to installing these facilities to help ensure that the South Island has a better range of facilities for conducting critical agricultural GHG research and development.

The current number of in situ (permanent indoor) Greenfeeds is 12 (8 at LIC, 4 at DairyNZ). Additional demand for indoor Greenfeeds from LIC, DairyNZ & Focus Genetics from 2025 onwards can be met by the fleet of portable units.

6.1.4 Eddy Covariance Towers

The existing number of operational units is 10, with three reaching their end of useful life in 2024. An additional nine units will become operational in 2024, increasing the total number of operational units to 16 once the three end-of-life units are decommissioned.

The current stock of eddy covariance towers is assessed as meeting immediate needs. To accommodate shifting research priorities, the nine new towers will be fitted with the instrumentation needed to quantify emissions from peat soils.

6.1.5 Soil Chambers

Our analysis indicates that the current soil chamber infrastructure capacity is not impeding New Zealand's research progress.

6.2 Secondary Infrastructure

This section outlines the forecast demand for Secondary infrastructure as defined in section 2.1.

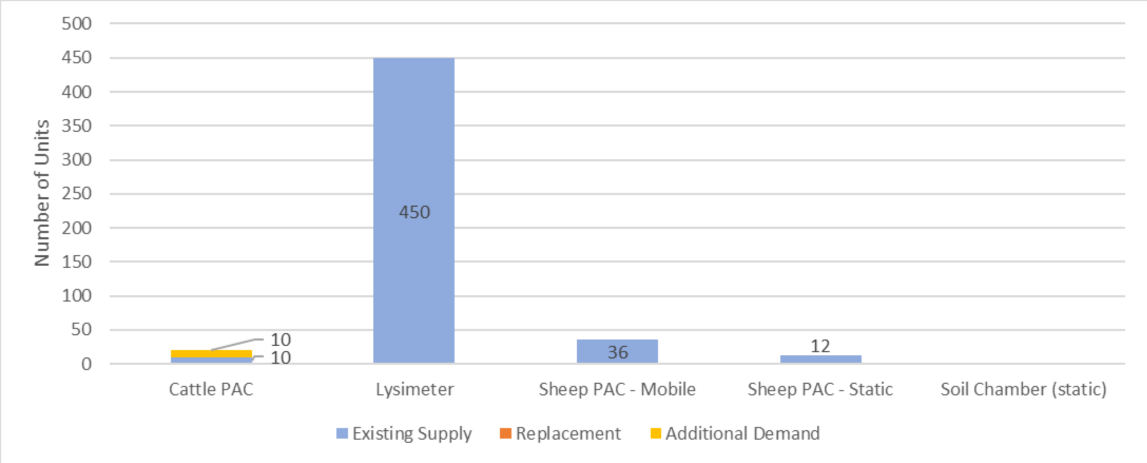

Figure 7 - Demand for secondary assets until 2028

6.2.1 Mobile Sheep Portable Accumulation Chambers (PAC)

A total of 36 mobile sheep PACs are currently operational, with 8 units expected to reach their end-of-life by 2030. The existing number is sufficient for the sheep genetic programme until these units reach the end of their useful life. Due to the weight and size of the trailers used for towing the PACS a Class 2 driver's license is required and this can restrict full utilisation at some times. Seeking alternative staffing arrangements (e.g. hiring a driver) could overcome this challenge. If not, consideration could to be given to upgrading/redesigning the existing trailers to enable greater utilisation.

6.2.2 Cattle Portable Accumulation Chambers

AgResearch owns 10 cattle PACs. In a similar manner to sheep PACs, the short measurement periods required to rank animals in cattle breeding programmes relative to using Greenfeeds or respiration chambers makes them an attractive alternative option. Cattle PACs are currently being evaluated against Greenfeeds in the LIC low emitting dairy cattle programme. Results are expected by the end of 2024. If this validation is successful it could result in an increased demand for use of cattle PACs and supporting infrastructure such as concrete pads and even buildings.

6.2.3 Lysimeters

Reviewing the current lysimeter infrastructure, there is no indication that the current infrastructure capacity (or lack thereof) is impeding New Zealand's progress to reach its GHG reduction targets.

7. SPECIFIC INFRASTRUCTURE REQUESTS

In addition to the analysis conducted on the existing Critical- and Secondary Infrastructure, some specific infrastructure requests were received from several organisations. These are detailed and analysed below against national priorities. NZAGRC's recommendations and responses to these requests are included in section 8.4.

7.1.1 Soil Chambers, Lysimeters & Greenfeeds - Northland Dairy Development Trust

Studies proposed by the Northland Dairy Development Trust on nitrous oxide mitigation includes a request for 60 static soil chambers and 60 lysimeters. Their methane mitigation studies are focused on new feeds, creating a demand for three outdoor GreenFeed units, which has been included in the demand analysis in section 6.1.3.

7.1.2 Lincoln University – Gas Chromatography Tandem Mass Spectrometry (GCMSMS)

The current nitrification inhibitor program managed by Lincoln University has progressed to the stage where there is a focus on quantifying residues in animal tissues/products, critical information for any products to achieve ACVM registration. Lincoln University has indicated that the purchase of a GCMSMS will greatly assist their research programme.

7.1.3 Massey University – Li-Cor Gas Analyser

Massey University currently use static soil chambers to measure emissions from pasture in its regenerative agricultural programme. This method restricts measurements to plots from which animals are excluded. Researchers from Massey University have proposed that purchasing a portable Li-Cor Gas Analyser System would enable measurements to be made greenhouse gas soil fluxes in a wider range of environments.

7.1.4 Feed intake measurement facility – Invermay, AgResearch

The existing sheep intake facility located at AgResearch Invermay (Mosgiel) is due for an upgrade/renovation within the next year. A capital plan is currently being developed, investigating either a new build or upgrading the existing facility. The aim would be to have a facility suitable for cattle and sheep. The feed intake facility would complement the existing cattle and sheep PAC facilities.

7.1.5 Feed intake measurement facility – North Island, Pāmu

Pāmu is currently funding the upgrade/conversion of an existing facility in Taupō so that they can measure both feed intake and methane emissions in cattle. Feed bin systems and scales have already been purchased and two NZAGRC Greenfeed units, rented for an extended period. The upgraded facility will suffice for upcoming trials, but is not large enough for the future when they plan to benchmark 1000+ animals in their genetic programmes. Pāmu have requested support for this facility expansion.

8. RECOMMENDATIONS

This section provides specific recommendations for national infrastructure investment using the process outlined in section 2.2. It includes assessment of all requests/demands identified by and/or provided to the NZAGRC during the development of the plan.

For additional information on estimated costs, see Appendix-A.

8.1 Critical Infrastructure

Evaluating the demand for Critical Infrastructure, the two infrastructure types listed in **Table *11*** are deemed to be of national significance and will have a substantial negative impact on the ability to develop tools that help New Zealand to meet GHG targets if not procured.

We recommend that two business cases are prepared. One is for funding the supporting infrastructure needed for full utilisation of the cattle respiration chamber facility at Grasslands, Palmerston North (see 8.1.1 for more details). The other is for the two additional Greenfeeds needed in 2026 and the 8 replacement Greenfeed units that reach the end of useful life in 2028 (See 8.1.2).

The expansion of the cattle respiration chambers should be the immediate priority.

Asset	Asset Class	GHG	Available for use in New Zealand?	Any alternative options?	Does demand exceed supply?	Outcome
Cattle Respiration Chambers Expansion	Critical	CH_4	Yes	-	Yes	Proceed to Business Case
Greenfeeds	Critical	CH_4	Yes	-	Yes	Proceed to Business Case

Table 11 – Evaluation of Critical Infrastructure

8.1.1 Expansion of the Cattle Respiration facility

As outlined in section 6.1.2, the current cattle respiration chamber facility will reach its capacity if demand increases by approximately 11%. It is therefore crucial that the necessary yard and holding pen area is expanded to give additional capacity. Further details are provided below.

Immediate Priority (complete in next 12 months)

- Build a new adaptation building housing 8 to 10 pens for a minimum of 16 animals.
    - Variable pen widths would be preferrable to ensure flexibility of the facility and ability to adapt to various trial requirements.
- Upgrade of the infrastructure utilities including effluent management, water and electrics. This is required and non-negotiable to cater for additional animals on site.

It is critical that expansion be actioned as soon as possible, as demand is likely to exceed in the next 18 months, leaving a short window for permitting, building and commissioning of this new infrastructure.

Medium term (complete within 24 months)

- Upgrade the feed facilities to handle the additional animals, including feed storage, mixing facilities and access to fresh forage.

8.1.2 Greenfeeds

There will be a deficit of two Greenfeed by 2026 and 10 units will reach their end-of-life by 2028. It is recommended that:

- two new large Greenfeed units are added to the NZAGRC fleet in 2025.
- 10 AgResearch-owned units are replaced in 2027 to ensure that they are operational by 2028.

8.2 Expansion of infrastructure hubs

It is recommended that a business case is developed to assess the supply of dedicated feed intake facilities and supporting infrastructure against anticipated demand. It is recommended that feed intake facilities should be available for research purposes in both the North and South islands.

In Palmerston North, AgResearch have indicated that having a dedicated feed intake facility will improve the utility of the respiration chambers available at the NZRMMC and utilisation of existing Greenfeed units.

At DairyNZ, Hamilton, feed intake facilities exist but the recent increase in the number of Greenfeeds available means that the adequacy of the existing facilities need to be re-assessed, as they are placing a restriction of the size and type of trials that can be undertaken.

In Lincoln, Canterbury, feed intake facilities (and allied supporting infrastructure e.g. waste handling are not currently available) but will be needed for Lincoln to become a fully functioning South Island GHG measurement infrastructure hub.

8.3 Secondary Infrastructure

Our analysis of the demand and needs, plus individual organisational requests for supporting/secondary infrastructure were evaluated, using the assessment process as described in section 2.2. The evaluation and outcomes following the assessment process are described in the section below.

8.3.1 Cattle Portable Accumulation Chambers (PAC)

- The cattle PACs while promising need to undergo a process of evaluation and validation against other established measurement techniques to determine their need with regards to national R&D priorities. Once this validation process is completed, demand needs to be reassessed and if required a new business case developed to justify the need for additional purchases.

8.4 Specific Infrastructure Requests

8.4.1 Gas Chromatography Tandem Mass Spectrometry (GCMSMS) - Lincoln University

- A GCMSMS will mainly be used for a fixed period of time to focus on residue detection in their studies on nitrous oxide inhibitors.
- Due to the singular, but important focus, the first recommended action is to explore whether this work can be sub-contracted to another organisation who is already in

possession of a GCMSMS and can undertake the required accredited analysis. If this alternative is shown to be unfeasible, then a business case should be developed to justify the purchase of a dedicated GCMSMS.

8.4.2 Li-Cor Gas Analyser – Massey University

- Massey University currently have the necessary equipment to measure nitrous oxide in their current programme of work. The Li-Cor Gas Analyser would appear to add versatility but its likely use beyond the current programme is unclear. It is also unclear if they have explored other options e.g. leasing/borrowing from another organisation. If options other than purchase do not exist then a full business case for purchase should be constructed.

8.4.3 Lysimeters, Soil Chambers & Greenfeeds – Northland Dairy Development Trust

- This request is for equipment to serve a single organisation and to be used, to our understanding, in a single project.
- It is recommended that the Northland Dairy Development Trust considers leasing the lysimeters and soil chambers from another organisation who is in possession of this infrastructure or purchase this themselves.
- The demand for 3 Greenfeed units has been included in the demand analysis in section 6.1.3, and these can be leased from the NZAGRC as the current supply can meet their need.

8.4.4 Feed intake facility – Invermay, AgResearch

- As a sheep feed intake facility already exists, any like for like replacement should be the primary responsibility of AgResearch as owner. However, if an upgrade increases its utility i.e. greater focus on GHG measurements and expanded to include cattle, there maybe a case for a government contribution to any upgrade, but this needs to be considered within the broader national context (8.4.5).

8.4.5 Additional methane and feed intake measurement facilities

- There has been requests for methane and feed intake measurement facilities from several organisations, e.g. PAMU & AgResearch Invermay.
- Our understanding is that these facilities are to be used primarily for low emissions breeding. These requests need to be considered from a national perspective with a clear understanding of future work and therefore demand. Our recommendations is that these requests are re-evaluated once the proposed national low-methane beef cattle breeding approach has been agreed.
- If a clear national need is demonstrated then a business case(s) should be developed.

Appendix-A Infrastructure Capex Costs

The table below indicates the demand and capital costs and the proposed year of procurement, according to the stakeholders interviewed or information obtained, for the assets covered in this report.

Asset	Asset Classification	Status	2024	2025	2026	2027
Cattle Respiration Chambers	Critical	Proceed to business case	To be determined	To be determined	-	-
Greenfeeds	Critical	Proceed to business case	-	2 new GFs ($375k)	-	10 GF Replacements ($1.88m)
Methane & feed intake measurement facility - Manawatu	Critical (Support)	Proceed to business case	1 facility ($2.5m)[6]	-	-	-
Expand methane & feed intake measurement facility - DairyNZ	Critical (Support)	Proceed to business case	To be determined			
Expand the GHG measurement infrastructure capability in Lincoln	Critical (Support)	Proceed to business case	To be determined	To be determined	-	-
PAC (cattle)	Secondary	Further analysis needed[7]	-	10 units ($500k)	-	-
Gas Chromatography Tandem Mass Spectrometry - Lincoln University	Secondary	Further analysis needed[7]	1 Unit ($350k)	-	-	-
Li-Cor Gas Analyser - Massey University	Secondary	Further analysis needed[7]	1 Unit ($195k)	-	-	-
Methane & feed intake measurement facilities	Secondary	Further analysis needed[7]	-	1 facility ($2.5m)[6]	1 facility ($2.5m)[6]	-

[6] Exact cost for a Methane & feed intake measurement facility will have to be determined per project. The $2.5m estimate cost listed was taken from costing Sapere gathered.
[7] A decision on funding for assets with status as “Further analysis needed” will be reviewed in future.