Australia's National
Science Agency

GISERA | Gas Industry Social and Environmental Research Alliance

Project Order

Short Project Title

Sources of methane emissions from the Western Downs Region

Long Project Title	Using carbon and hydrogen isotopes to fingerprint sources of methane emissions from the Western Downs Region in the Surat Basin, Queensland
GISERA Project Number	G.12
Start Date	1/11/2023
End Date	1/12/2025
Project Leader	Mohinudeen Faiz/Stephen Sestak

GISERA State/Territory

- ☒ **Queensland**
- ☐ New South Wales
- ☐ Northern Territory
- ☐ South Australia
- ☐ Western Australia
- ☐ Victoria
- ☐ National scale project

Basin(s)

- ☐ Adavale
- ☐ Amadeus
- ☐ Beetaloo
- ☐ Canning
- ☐ Western Australia
- ☐ Carnarvon
- ☐ Clarence-Morton
- ☐ Cooper
- ☐ Eromanga
- ☐ Galilee
- ☐ Gippsland
- ☐ Gloucester
- ☐ Gunnedah
- ☐ Maryborough
- ☐ McArthur
- ☐ North Bowen
- ☐ Otway
- ☐ Perth
- ☐ South Nicholson
- ☒ **Surat**
- ☐ Other (please specify)

GISERA Research Program

- ☐ Water Research
- ☐ Health Research
- ☐ Biodiversity Research
- ☐ Social & Economic Research
- ☒ **Greenhouse Gas Research**
- ☐ Agricultural Land Management Research
- ☐ Land and Infrastructure Management Research
- ☐ Other (please specify)

1. Project Summary

Methane (CH_4) is an important greenhouse gas with a global warming potential over 30 times greater than carbon dioxide (CO_2) over a 100-year period. As methane is the main component of coal seam gas, knowing that methane emissions from this industry are quantified and managed is important to a broad range of stakeholders including regional communities and, more broadly, regulators and CSG operators.

This project will apply innovative sampling and analytical methods developed by CSIRO to determine sources of methane in air samples collected in the Western Downs Region of Queensland.

Methane is generated by a range of sources, including anthropogenic (from human activity e.g., from the gas industry, agriculture, landfill systems) and natural sources (e.g., swamps, natural seeps). Attributing methane emissions to their source can be challenging. However, the isotopic signature (a fingerprint of different forms of the same element) of methane differs depending on its origin and the means through which it is produced. For example, thermogenic methane is derived from the effects of heat and pressure on organic matter in the subsurface, while biological methane results from a range of biological processes. Methane produced by these varying processes have different and distinct carbon and hydrogen isotope ratios, which can be used to determine the source.

Measuring methane in the field is typically undertaken using portable technologies, which can detect atmospheric concentrations of methane, but are limited in their ability to measure isotopic compositions. This project will use a front-end, custom-built instrument (the Atmospheric Concentrator), to concentrate methane from air and facilitate high-accuracy carbon and hydrogen isotopic measurements.

This project will be conducted in the study area bounded by the towns of Chinchilla, Condamine and Tara in Queensland, and will conduct isotopic fingerprinting of methane at selected sites in the study area. Sites will be selected (including gas industry, agricultural, wastewater treatment, swamps, natural seeps, landfills) through community and industry consultation, and guided by results from an atmospheric methane survey.

2. Project description

Introduction

Of the known greenhouse gases (GHG), methane is the second most abundant in Earth's atmosphere after carbon dioxide, however, it is around 30 times more potent as a GHG than carbon dioxide over a

100-year period (IPCC Climate Change 2021; Holmes et al. 2013). Both the United States and the European Union have recognised the significance of methane to climate change and have led a push through the Global Methane Pledge to reduce methane emissions by 30% from 2020 levels by 2030 (https://www.globalmethanepledge.org), and the Australian Government is a signatory to the pledge. Achieving these goals in Australia requires significant effort in identifying hot spots of methane emissions and understanding sources. Globally there is a focus on measuring and mitigating the emission of GHG from a range of anthropogenic activities. Within anthropogenic sources, considerable debates on apportionment between agriculture versus gas resource activities exist (Rice et al. 2016; Rigby et al. 2017; Turner et al. 2017; Nisbet et al. 2019, 2020; Jackson et al. 2020).

The Western Downs Region includes a mosaic of industries, though the largest contributors by economic output are resource-based activities including mining or coal seam gas (CSG) extraction, along with agricultural activities including cattle feedlots and cropping (cotton and grain). Cattle grazing land and feedlots are often located near CSG facilities which complicates source apportionment of elevated atmospheric methane, especially in cases when measurements are recorded at a distance from the source. Carbon and hydrogen isotopic composition can be used to assist with identifying the source of methane, in conjunction with atmospheric and geolocation information (Townsend-Small et al. 2016; Fries et al. 2019; Lu et al. 2021). Previous studies on atmospheric methane related to the proposed region in this study had various limitations in terms of sampling location, sampling technique, location coverage and sample analysis for fingerprinting the methane sources. This project aims to provide an improved scientific understanding of methane emission source apportionment through a comprehensive sampling strategy coupled with methane isotopic fingerprinting. The outcomes from this project will be communicated to community stakeholders to address concerns regarding methane emissions and its environmental impacts. This project will also provide data that will allow reinterpretation of some of the data collected during previous studies.

Measuring methane in the field is often undertaken using portable technologies such as Cavity Ring Down Spectroscopy (CRDS), which can detect atmospheric concentrations of methane (ppb to ppm range). In addition, CRDS can, to some extent, determine carbon isotope but cannot analyse the corresponding hydrogen isotopes. Carbon and hydrogen isotope measurements from dilute sources are constrained by the requirement of significant sample volumes needed to obtain adequate signal-to-noise ratios in a Gas Chromatography-Isotope Ratio Mass Spectrometer (GC-IRMS) instrument. There is currently no commercial approach for measuring isotopes of dilute gases for both carbon and hydrogen isotopes outside of dedicated global clean air monitoring stations. The primary way of determining isotopic fingerprints is using laboratory-based GC-IRMS instruments.

The current proposal seeks to leverage analytical innovations developed in CSIRO Energy for the concentration of dilute gases from environmental air samples. The project will use a front-end instrument (hereafter, referred to as the Atmospheric Concentrator) that will be attached to a GC-IRMS, to concentrate methane from air and facilitate high accuracy carbon and hydrogen isotopic measurements. This technique will allow methane isotopic fingerprinting of environmental air samples leading to a greater understanding of contributors to methane emissions in the Western Downs Region of Queensland.

Prior Research

A number of atmospheric methane surveys have been conducted in the Surat Basin using various methods of concentration measurement and sampling methods for isotopic fingerprinting. Only one study has used both carbon and hydrogen isotopes for source discrimination and possible apportionment. These studies are summarised below:

- Atmospheric methane concentration and carbon isotope data from two Australian CSG fields, one in production in Tara, QLD, and the other an exploration field in Casino, NSW, were investigated, along with other sources of methane from wetlands, sewage treatment plants, landfills, urban area, and bushfires (Maher et al., 2014). Methane surveys were carried out using a CRDS approach providing infield concentration and caron isotope data of methane, however, hydrogen isotopes were not measured. The carbon isotope data that was measured was of poor quality (low signal to noise ratio) due to the poor counting statistics of the Picarro CRDS in mobile survey mode. Had they re-circulated the same grab sample of air for 1 hour of spectral isotope measurement, the precision and accuracy of the measured carbon isotopes would have been greatly improved but with significant progress reductions in the speed of the survey programme.
- A continuous atmospheric methane survey in the Condamine Catchment used methane concentration and carbon isotope of methane to determine the source of methane derived from Walloon Coal Measures (Iverach et al. 2015). An elevated methane plume was detected within 50 m downwind of a CSG holding pond with a peak methane concentration of 2.107 ppm which is 0.333 ppm higher than the background level. Air samples were collected using Tedlar bags for carbon isotope measurements. Tedlar bags are the cheapest sampling container for gases but also the worst in terms of high diffusion rates and rapid stable isotope fractionation. Unless the samples were analysed within an hour of collection, compositional and stable isotope data is strongly skewed due to rapid diffusional exchange between the internal gas sample and the external atmosphere surrounding the Tedlar bag.
- Mobile surveys done in the Condamine region (south-eastern Surat Basin) by Lu et al. (2021) investigated major methane sources in CSG fields and adjacent agricultural districts previously identified by Luhar et al. (2018, 2020). Source apportionment was determined through carbon and hydrogen isotopic signatures from 16 plumes including CSG infrastructure, coal mine, ground and river seeps, abattoir, feedlot and grazing cattle, piggery, landfill, and wastewater treatment plants. Air samples were collected using 3 L SKC FlexFoil PLUS© sample bags. The multilayer Flexfoil bags are better than the Tedlar bags as they incorporate a composite of

polymer layers and a ~1µm deposition of evaporated aluminium to slow gas diffusion and gas absorption, but manufacturers recommendations are that samples need to be analysed within 24 hours to preserve gas sample integrity; something that is rarely possible with remote fieldwork locations and a distal analytical laboratory. The limited air samples that were analysed for carbon and hydrogen isotopes necessitated shipping to Royal Holloway (UK) and Utrecht University (Netherlands) and as such required long sample storage times in Flexfoil bags prior to analysis, which raises questions as to the amount of isotope fractionation that occurred. It should also be noted that methane measurements in these surveys were recorded at a distance from the source as sampling sites were limited to publicly accessible locations and no private landholdings or industrial sites were accessed.

- Kelly et al. (2022) used methane carbon isotope signatures of in-flight atmospheric air (IFAA) samples from the Condamine region of south-eastern Surat Basin to assess the bottom-up (BU) inventory developed specifically for the region by Neininger et al. (2021). IFAA samples in this study were collected between 100 to 300 m above ground level using 3 L SKC FlexFoil Plus© sample bags. Kelly et al. (2022) identified missing methane sources from the BU inventory (Neininger et al. 2021), including termites, as potential and significant contributors towards regional methane emissions. Isotope measurement in this study was limited to carbon isotopes only.
- Day et al. (2014) used a vehicle-mounted gas analyser to estimate methane emissions from 37 CSG well pads in Queensland. This study examined facilities at the well pads using a probe attached to the gas analyser, isolated and quantified emissions from well heads, vents, pneumatic device operation, and engine exhaust. Day et al. (2017) measured methane emissions at nine well completions and one well workover at two CSG fields in the Surat Basin during 2015 to 2016 using two gas analysers on the well sites and a lab-based gas chromatograph for collected gas bag samples. This study also measured ambient methane using a Picarro CRDS mounted on a vehicle. These two studies only measured methane concentrations and did not determine isotope compositions.
- Luhar et al. (2020) have used monitoring stations setup 80 km apart in the main coal seam gas belt of the Surat Basin. Using this extensive field data (1.5 years data overlap), they then were able to quantify methane emissions using inventory data and a regional Bayesian inversion modelling approach. Continuous high-frequency measurements (~0.3 Hz) were made of methane, carbon dioxide, water and carbon monoxide (Burncluith site) using Picarro cavity ring down spectrometers (G2301 and G2401) with gas inlets placed on masts at a height of 10 m. Although the forward transport modelling with the bottom-up emissions yielded a credible simulation of the suitably filtered observed methane concentrations, about 15 % of the higher-end concentrations observations were underestimated. The inverse methodology used in the study could not distinguish between different source categories, mainly because the

concentration of methane alone was monitored and not tracers specific to methane source types. To do source discrimination and attribution, monitoring of tracer species such as methane isotopes ($^{12}C^1H_4$, $^{13}C^1H_4$, $^{12}C^1H_3{}^2H$, $^{14}C^1H_4$, etc…), carbon dioxide species ($^{12}C^{16}O_2$, $^{12}C^{17}O^{16}O$, $^{12}C^{18}O^{16}O$, $^{13}C^{16}O_2$, $^{14}C^{16}O_2$, etc…) or other hydrocarbons in cases where they are associated with the gas source were not available with remote field equipment at that time. (Note: the radioactive Carbon-14 (^{14}C) normally used for carbon dating and mentioned above is formed by natural processes in our atmosphere when cosmic rays interact with our atmosphere through spallation reactions to form radioactive ^{14}C that gets incorporated into living things by ^{14}C carbon dioxide ($^{14}C^{16}O_2$). Our study cannot analyse radioactive ^{14}C but is used as an example to highlight the multitude of isotopomers available, both stable and radioactive).

- The use of the Atmospheric Concentrator is novel technology but has its origins in a previous CSIRO instrument that was developed by the researchers involved in this proposed study. The previous instrument was designed for the crushing and analysis of microscopic gas inclusions for trapped gas hydrocarbons in sand grains (methane, ethane, propane, butanes, pentanes) and carbon dioxide for GC-IRMS analyses. The micro-gram quantities of released hydrocarbons were successfully analysed for carbon and hydrogen isotopes while the CO_2 was analysed only for carbon isotopes. The research instrument (MK I) utilised only one cryogenic trap and at the end of the project, air samples were analysed to test whether it could feasibly analyse methane in air. It was found that methane was able to be selectively concentrated, but the carbon isotope values had a large statistical variance due to large amounts of co-trapped nitrogen (N_2), oxygen (O_2) and argon (Ar) from air. The large excess of nitrogen formed nitrogen oxides (NO_x) in the combustion reactor and produced a mass fragment at mass-to-charge 45 atomic mass units (m/z = 45 amu) that is crucial to normal carbon isotope analyses. It was determined that any future atmospheric work would require a new more complicated instrument with at least two cryogenic traps that could cryo-distil and vent the excess and unwanted N_2, O_2 and Ar but retain the CH_4 species. This previous MK I Concentrator and subsequently modified MK II instruments served as pathfinders to focus future research on a next generation Concentrator MK III instrument focussed on methane in air.
- The study participants have 25$^+$ years of experience in previous petroleum hydrocarbon research programs that focussed on organic geochemistry and gas (molecular and isotope) geochemistry. With the more recent shift to renewable energy, current research directions have re-focussed on natural gas as a transition gas to a net-zero emissions future and the use of other renewable gases such as biogas and green hydrogen. The team has gas chromatography (GC) based natural gas analysers (NGA) that can analyse gas samples from ~100 ppm to 100 % components in air and a Micro-GC NGA that has lower precision. In addition to the NGA instruments, we have a GC-IRMS instrument that can analyse carbon and

hydrogen isotopes, specifically setup for gas samples. For carbon isotopes, the lower analysis limit of hydrocarbon gases and carbon dioxide gas is ~200 ppm (0.02 %). For hydrogen isotope analyses of hydrocarbon gases, the lower analysis limit is ~2000 ppm (0.20 %) due to the mass sensitivity reduction in analysing hydrogen (m/z = 2 and 3) compared to analysing combusted CO_2 for carbon isotopes (m/z = 44, 45 and 46). Hence the capability to analyse normal hydrocarbon gas samples and CO_2 in air (~ 400^+ ppm) is proven and existing. The Atmospheric Concentrator is an add-on module that connects to the front of our GC-IRMS and allows methane in air at ~ 1.8 ppm to be enriched to a level that our GC-IRMS can then reproducibly and accurately measure its carbon and hydrogen isotope values.

- Agilent Technologies GC-NGA for bulk gas composition

- Thermo Scientific Delta Series GC-IRMS

- The current Atmospheric Concentrator (MK III) instrument is built upon a proven technology platform that has in the past successfully run contracted research samples for micro-gram quantities of hydrocarbon gases. No research ever exists in isolation and does draw inspiration from the World Meteorological Organisations (WMO) air monitoring stations that have at key remote sites automated detector systems for in-situ measurements of atmospheric trace halocarbons, hydrocarbons and sulphur compounds, in their instrument system called Medusa (Miller et al. (2008), Anal. Chem). Cape Grim, on Tasmania's west coast (managed by CSIRO-BOM) is one of the three premier baseline air pollution stations in the WMO global tracking network and uses Medusa. Approaches were made to research scientists attached to Cape Grim to analyse our urban/industrial air samples, but we were resolutely denied citing the risk our "contaminated air samples" would ruin their pristine system, which is understandable. The use of the new instrument and analysis methods do pose a potential risk in terms of delivering the project to the specifications required, but is a low risk given its previous commercial use. Our atmospheric Concentrator system has very strong parallels with the decades proven Medusa system which should ensure the greatest possibility of success.
- Atmospheric Concentrator (MK III) instrument

Throughout the studies summarised above, there have been limitations in terms of methods utilised, limited access to sampling near source emitters, access to high precision analytical instrumentation, lack of high stability (electropolished, passivated) stainless steel air sample canisters for grab sampling (as used in air monitoring studies) and exclusion of certain types of difficult methane source emitters (e.g., termites). The proposed data in this study will add to the existing data already measured in these studies to firm up our understanding and help clarify previous extrapolations and possibly even allow re-interpretation of the conclusions drawn in the previous work.

Need & Scope

An important gap in our current knowledge concerns the contribution of different sources (both anthropogenic and natural) to the observed methane emissions from the Western Downs Region. This knowledge is a prerequisite to addressing community stakeholder concerns regarding methane emissions and its environmental impacts. Carbon and hydrogen isotopic fingerprinting will provide accurate methane source apportionment and robust estimates of methane emissions from the Western Downs Region, as well as increase the community and government's awareness of potential risks.

This project addresses various limitations identified in previous studies conducted in the south-eastern Surat Basin investigating methane emissions and its isotopic signatures.

Sampling

- Several previous studies collected samples at a distance from the methane emission source. This project will collect samples at or close to the methane source by liaising with the CSG industry and landowners to get access. Additionally, a distal air sample will be collected for comparison of isotopic signatures.
- Gas collection methods used by previous studies for laboratory analyses have been shown to fractionate methane (van Holst et al. 2010). This project will collect atmospheric air samples using canisters specifically designed for guaranteeing the integrity of collected air samples.

Analysis

- Only one previous study used carbon and hydrogen isotopes for source apportionment (Lu et al. 2021) and found that for the limited samples that were analysed for both carbon and hydrogen isotopes overseas, critical insights into determining the sources of the mapped plumes was invaluable. This previous study somewhat confirms the intended strategy that methane samples have to be analysed for both the carbon and hydrogen isotopomers (isotopic isomers) in order to allow enough discrimination between methane sources; i.e., methane concentrations and carbon isotopes of methane are not enough for source discrimination, particularly in the intended QLD study area. This project will determine isotopic fingerprints of methane for all atmospheric air samples collected allowing greater accuracy of determining origin of methane source.

Sources

- Previous studies in the study area have primarily focused on anthropogenic sources. Natural sources such as rice paddies, ruminant livestock, termites, small waterbodies, wetlands and swamps are also hotspots for methane emissions (Holgerson and Raymond 2016; Grinham et al. 2018). Assessing both anthropogenic and natural sources of methane by carbon and hydrogen isotope signatures will more accurately discriminate and possibly attribute methane in air from different sources and provide a better understanding of methane emissions from the Western Downs Region.

Objectives

This study aims to determine carbon and hydrogen isotopic fingerprints of methane from air samples collected in the Western Downs Region with the Surat Basin. These data will provide accurate methane source discrimination and possible attribution to address community stakeholder concerns regarding methane emissions and its environmental impacts. Additionally, the project will conduct a methane emissions survey in the Western Downs Region and address limitations from previous studies.

In brief, this project seeks to:

1) Obtain accurate carbon and hydrogen isotopic signatures of methane from different anthropogenic and natural sources in the Western Downs Region using a cutting-edge custom built gas concentrator (Atmospheric Concentrator) interfaced with a GC-IRMS instrument. Air samples will be collected at selected sites and facilities in the study area using high integrity stainless-steel air canisters or stainless-steel sample cylinders from Swagelok for high concentration gas samples (i.e., % level methane from landfill gas).

2) Conduct a methane concentration survey in the study area with measurements made close to the source. The project aims to pinpoint not only the methane sources reported in the literature but also other sources such as termites, or other previously unidentified sources.

3) Improve the sampling strategies to eliminate sampling limitations from the previous studies by combining ground-based mobile survey (bottom-up data) plus aerial (drone) sampling (top-down data) using air canisters for gas sampling.

Methods

Logistics and field sampling campaign

Consultation with industry representatives and local communities will guide the selection of different methane emitting sites and facilities in the study area (Task 1) and provide information for planning the field survey and sampling campaign, planning for which will commence late-November 2023. The selection of prospective representatives will be narrowed down using a local consulting agronomist based in the study area to help identify sites, properties and willing landowners prepared to participate in such a study. Other representatives will be easier to select due to direct local authority for certain facilities or areas, such as local council officers, wastewater operators, landfill site operators, National Parks staff, etc. The pre-identified participants will then be asked to join a meeting in a local facility such as a council reception room to explain the study and gain their commitment to the project study.

Two CSIRO staff will conduct a field survey of the Western Downs Region using a vehicle fitted with a CRDS instrument to monitor methane concentrations in the field in real time at the selected sites or facilities. Additionally, where methane plumes are detected, air samples will be collected in canisters at ground level and at 30 m above ground level (Task 2).

Carbon and hydrogen isotope measurement using the Atmospheric Concentrator

The Atmospheric Concentrator will use collected air samples by first cryo-trapping methane from the air sample, then reducing interfering oxygen, argon and nitrogen components by cryo-distillation by variable cryogenic temperature programming and then cryo-focusing methane onto a smaller second cryo-trap to then replicate injection like sample of concentrated atmospheric methane for both carbon and hydrogen isotope analyses on a GCIRMS instrument in the CSIRO Energy laboratories located at Lindfield, NSW (Task 3). The analysis system selectively targets a minor component (methane in air ~1.8 ppm), removes the other >99.99 % of air components (water, carbon dioxide, oxygen, argon and nitrogen) to end up with the methane to residual air components in the ratio of 10:1 for successful analysis by GC-IRMS. Two separate runs of the same gas sample will be required since the carbon isotopes are carried out using high temperature catalytic oxidation of the methane to form carbon dioxide and water vapour; whereas hydrogen isotopes are analysed by high temperature thermal decomposition in a totally separate reactor system under reducing conditions to form solid pyrolytic carbon and hydrogen gas.

Communication and engagement with community stakeholders

In addition to the initial stakeholder consultation to identify suitable local participants to guide the selection of sites for the study, the project will undertake two additional workshops in Chinchilla to inform and engage community stakeholders throughout the project. The first workshop will be conducted at the early stages of the project to communicate the project's aims, scope, methods, timing and expected outcomes. The second workshop will be conducted at the end of the project to communicate project outcomes (Task 5). An assessment of the success of these workshops will be provided in the final report.

3. Project Inputs

Resources and collaborations

Researcher	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Mohinudeen Faiz	45 days	Isotopes and coal geology	+25 years	CSIRO
Stephen Sestak	96 days	Analytical chemistry and engineering	+25 years	CSIRO
Tania Vergara	35 days	Analytical chemistry and biomolecular	+12 years	CSIRO
Adrian Element	25 days	Design engineer and field sampling expertise	+20 years	CSIRO
Michael Camilleri	20 days	Design Engineer	+25 years	CSIRO
Carla Mariani	10 days	Organic chemistry and molecular biology	+5 years	CSIRO
Se Gong	15 days	Organic and biogeochemistry	+16 years	CSIRO
David Midgley	2 days	Microbial ecologist	+20 years	CSIRO

Subcontractors (clause 9.5(a)(i))	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
N/A				

Technical Reference Group

The project will establish a Technical Reference Group (TRG) aimed at seeking peer-to-peer technical advice on contextual matters and to discuss research needs as well as outputs as the project progresses. The TRG will include the project leader, key task leads and a group of different stakeholders as appropriate, which may include a range of subject matter experts from government and industry. The group will have significant experiences on local contextual contacts in the study region, emissions, and emissions quantification. To assist in facilitating access to sites, the TRG members may include staff from local councils, Queensland National Parks, local graziers and horticultural organisations.

Budget Summary

Source of Cash Contributions	2022/23	2023/24	2024/25	2025/26	% of Contribution	Total
GISERA	$0	$88,904	$178,488	$116,918	80%	$384,310
- Federal Government	$0	$62,233	$124,942	$81,843	56%	$269,017
- APLNG	$0	$12,224	$24,542	$16,076	11%	$52,843
- Origin Energy	$0	$12,224	$24,542	$16,076	11%	$52,843
- QGC	$0	$2,223	$4,462	$2,923	2%	$9,608
Total Cash Contributions	**$0**	**$88,904**	**$178,488**	**$116,918**	**80%**	**$384,310**

Source of In-Kind Contribution	2022/23	2023/24	2024/25	2025/26	% of Contribution	Total
CSIRO	$0	$22,226	$44,622	$29,230	20%	$96,078
Total In-Kind Contribution	**$0**	**$22,226**	**$44,622**	**$29,230**	**20%**	**$96,078**

TOTAL PROJECT BUDGET	2022/23	2023/24	2024/25	2025/26	-	TOTAL
All contributions	$0	$111,130	$223,110	$146,148	-	$480,388
TOTAL PROJECT BUDGET	**$0**	**$111,130**	**$223,110**	**$146,148**	**-**	**$480,388**

4. Communications Plan

Stakeholder	Objective	Channel (e.g. meetings/media/factsheets)	Timeframe (Before, during at completion)
Regional community stakeholders: landholders, traditional owners and wider public	To communicate project objectives, get input into site selection and communicate final results of the project.	A fact sheet at commencement of the project that explains in plain English the objective of the project.	At project commencement
		An initial stakeholder consultation will be undertaken to identify suitable local participants to guide the selection of sites for the study, it will involve a limited set of participants pre-identified.	At project commencement
		Local government and community groups invited to a community workshop (face-to-face) to discuss the intentions of the study and obtain community and stakeholder input into the site and facility selection for the field survey and sampling campaign.	At project commencement
		Project progress reported on GISERA website to ensure transparency for all stakeholders including regional communities.	Ongoing
		Local government and community groups invited to a community workshop (face-to-face) to communicate the project outcomes.	At project completion
		Public release of final report. Plain English fact sheet summarising the outcomes of the research.	At project completion
Gas Industry & Government	To get input into site selection (industry) and communicate the final results of the project	Fact sheet that explains the objective of the project.	At project commencement
		Industry representatives involved in site and facility selection for the field survey and sampling campaign.	At project commencement
		Project progress reporting (on GISERA website).	Ongoing
		Final project report and fact sheet.	At project completion
		Presentation of findings at joint Gas Industry/Government Knowledge Transfer Session.	At project completion
Scientific Community	Provide scientific insight into the sources of methane emissions in the Western Downs region.	Peer-reviewed scientific publication (optional). Dataset(s) available through CSIRO’s data repository.	After completion of project

In addition to project specific communications activities, CSIRO’s GISERA has a broader communications strategy. This strategy incorporates activities such as webinars, roadshows, newsletters and development of other communication products.

5. Project Impact Pathway

<table>
<tr><th>Activities</th><th>Outputs</th><th>Short term Outcomes</th><th>Long term outcomes</th><th>Impact</th></tr>
<tr><td>Logistics</td><td>• A series of documents describing the sampling sites, contacts, relevant permissions, sampling equipment and HSE considerations for this project.
• Identification of any permits or travel documents required to allow this travel to occur.
• HSE documents to ensure safe work practices during this time.</td><td rowspan="5">This project will provide detailed methane concentration, and isotopic fingerprinting (carbon and hydrogen) data of methane in collected air samples. This information will allow us to pinpoint different sources of methane and understand their attribution in the study area.</td><td rowspan="5">• Assist in informing governments, regulators, as well as policymakers on different sources of methane emissions in the Western Downs region, which will help future regional methane budget accounting.
• Improve the community’s awareness about methane emissions from different sources in the Western Downs region and the impact of methane emissions on the environment.
• Improve industry’s comprehension on sources of methane emissions from their facilities and importance of deploying both carbon and hydrogen isotope of methane to pinpoint the source of methane plumes.</td><td rowspan="5">The impact of this research extends to communities, government and industry. All communities in the Western Downs Region, as well as industry, will benefit from the outcomes of this research, through increased understanding and awareness of different sources of methane emissions in the Western Downs Region.</td></tr>
<tr><td>Field sampling campaign</td><td>Methane measurements and collection of gas samples</td></tr>
<tr><td>Data and sample analyses</td><td>Provision of gas composition, carbon and hydrogen isotopes of methane in collected air samples.</td></tr>
<tr><td>Information sharing with the community stakeholders</td><td>A pre-study initial stakeholder consultation will be undertaken to identify suitable local participants to guide the selection of sites for the study, it will involve a limited set of participants pre-identified. Following successful recruitment of willing participants, two workshops will be organised:
• The first at early stages of the project to discuss intentions/aims of the study and to obtain community and stakeholder input into site selection for the field campaign.
• The second at project completion to present research outcomes</td></tr>
<tr><td>Communication and Engagement</td><td>• The GISERA Communication team will develop a plain-English factsheet at project commencement.
• Completed fact sheet(s) with key findings for distribution via the GISERA website and at community engagement events.
• Progress and final reports with detailed outcomes will be prepared.
• Manuscripts will be prepared for submission to scientific journals (optional).</td></tr>
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6. Project Plan

Project Schedule

ID	Activities / Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Sampling logistics, industry, and community consultation	Stephen Sestak	1 November 2023	30 June 2024	
Task 2	Field survey and sampling campaign	Stephen Sestak	1 July 2024	28 February 2025	Task 1
Task 3	Isotopic fingerprinting and data analyses	Stephen Sestak	1 March 2025	31 August 2025	Task 2
Task 4	Project leadership and reporting	Mohinudeen Faiz and Stephen Sestak	1 November 2023	30 December 2025	Tasks 1, 2, 3 and 4
Task 5	Communicate findings to stakeholders	Mohinudeen Faiz and Stephen Sestak	1 November 2023	30 December 2025	Task 1-5

Task description

Task 1: Sampling logistics, industry and community consultation

OVERALL TIMEFRAME: November 2023 – June 2024

BACKGROUND**:** During this task, the project team will consult with representatives from industry and local communities in the Western Downs Region within the Surat Basin, Queensland to select sites and facilities which potentially represent different sources of methane emissions. This task will prepare the field survey vehicle fitted with a CRDS instrument for monitoring methane plumes and develop safe and environmentally sensitive plans for the provisioning and logistics of the field survey and sampling campaign.

TASK OBJECTIVES**:**

1. Establish contact with representatives from industry and local communities to guide the selection of representative sites and facilities for the field survey and sampling campaign.
2. Select sites and facilities which potentially represent different sources of methane emissions in the Western Downs Region within the Surat Basin.
3. Identify the accessibility of the selected sites / facilities and seek required permits.
4. Prepare ground-based mobile survey vehicle fitted with a CRDS instrument.
5. Establish sampling requirements, e.g., volume, numbers, locations.
6. Prepare for remote sampling fieldwork including accommodation, vehicle hire and HSE considerations.
7. Establish logistics of transporting equipment and samples between CSIRO laboratory in Sydney and collection sites in Queensland.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: This task will yield a series of documents describing sampling equipment, sampling details, field trip details and HSE considerations.

Task 2: Field survey and sampling campaign

OVERALL TIMEFRAME: July 2024 – February 2025

BACKGROUND: This task will involve two staff travelling to Queensland with the purpose of carrying out the ground-based mobile survey and drone survey at the selected sites and facilities, monitoring methane plumes and collecting air and gas samples for isotope analyses.

TASK OBJECTIVES:

1. Ground-based mobile survey at the selected sites and facilities identified in Task 1 and monitoring methane plumes.

2. Collect air samples at ground level and at 30 m above ground level by drone from locations with methane plumes.
3. Compile methane measurement data from past CSIRO surveys conducted in the study area.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Methane measurements from field survey. Collection of air samples from selected sites and facilities in the study area.

Task 3: Isotopic fingerprinting and data analyses

OVERALL TIMEFRAME: March 2025-August 2025

BACKGROUND: This task will analyse the collected air samples (Task 2) using the Atmospheric Concentrator interfaced with a GCIRMS to determine carbon and hydrogen isotope data. Additionally, gas composition of samples will be analysed.

TASK OBJECTIVES:

1. Perform carbon and hydrogen isotope analysis of collected air samples using the Atmospheric Concentrator interfaced with a GCIRMS.
2. Perform gas composition of collected air samples using a natural gas analyser.
3. Data analysis of methane concentrations measured during the field survey.

TASK OUTPUTS AND SPECIFIC DELIVERABLES**:** This task will provide isotopic fingerprinting of methane (carbon and hydrogen) in air samples collected in Task 2, as well as gas composition and will analyse methane concentrations measured during the field survey.

Task 4: Project leadership and reporting

OVERALL TIMEFRAME: November 2023-December 2025

BACKGROUND: Information from this project is to be made publicly available after completion of standard CSIRO publication and review processes.

TASK OBJECTIVES: To ensure that the information generated by this project is documented and published after thorough CSIRO internal review.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

1. Provide 6 monthly progress updates to GISERA office.
2. Preparation of a final report outlining the scope, methodology, and findings of the project.
3. Following CSIRO Internal review, the report will be submitted to the GISERA Director for final approval.
4. Provide 6 monthly progress updates to GISERA office.

Task 5: Communicate project objectives, progress and findings to stakeholders

OVERALL TIMEFRAME: Full duration of project

BACKGROUND: Communication of GISERA's research is an important component of all research projects. The dissemination of project objectives, key findings and deliverables to relevant and diverse audiences allows discourse and decision making within and across multiple stakeholder groups.

TASK OBJECTIVES: Communicate findings to stakeholders through meetings, a Knowledge Transfer Session, fact sheets, project reports and journal article/s, in collaboration with the GISERA Communication team.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Communicate results to GISERA stakeholders according to standard GISERA project procedures, which will include but are not limited to:

1. Knowledge Transfer Session with relevant government/ gas industry representatives.
2. Presentation of findings to community members/groups with two workshops held in Chinchilla (one in the early stage of the project and one at the end of the project).
3. Two project fact sheets: one developed at the commencement of the project, and another that will include peer-reviewed results and implications at completion of the project. Both will be hosted on the GISERA website.
4. Project reporting.
5. Preparation of an article for the GISERA newsletter.
6. Peer-reviewed scientific manuscript ready for submission to relevant journal (optional).

Project Gantt Chart

		2023/24								2024/25													2025/26				
Task	**Task Description**	**Nov 23**	**Dec 23**	**Jan 24**	**Feb 24**	**Mar 24**	**Apr 24**	**May 24**	**Jun 24**	**Jul 24**	**Aug 24**	**Sep 24**	**Oct 24**	**Nov 24**	**Dec 24**	**Jan 25**	**Feb 25**	**Mar 25**	**Apr 25**	**May 25**	**Jun 25**	**Jul 25**	**Aug 25**	**Sep 25**	**Oct 25**	**Nov 25**	**Dec 25**
1	Sampling logistics, industry, and community consultation	■	■	■	■	■	■	■	■																		
2	Field survey and sampling campaign									■	■	■	■	■	■	■	■										
3	Isotopic fingerprinting and data analyses																	■	■	■	■	■	■				
4	Project leadership and reporting	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5	Communicate findings to stakeholders	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

7. Budget Summary

Expenditure	2022/23	2023/24	2024/25	2025/26	Total
Labour	$0	$73,530	$194,010	$142,548	$410,088
Operating	$0	$37,600	$29,100	$3,600	$70,300
Subcontractors	$0	$0	$0	$0	$0
Total Expenditure	**$0**	**$111,130**	**$223,110**	**$146,148**	**$480,388**

Expenditure per task	2022/23	2023/24	2024/25	2025/26	Total
Task 1	$0	$78,038	$0	$0	$78,038
Task 2	$0	$0	$124,962	$0	$124,962
Task 3	$0	$0	$72,933	$29,305	$102,238
Task 4	$0	$9,649	$9,972	$95,675	$115,296
Task 5	$0	$23,443	$15,243	$21,168	$59,854
Total Expenditure	**$0**	**$111,130**	**$223,110**	**$146,148**	**$480,388**

Source of Cash Contributions	2022/23	2023/24	2024/25	2025/26	Total
Federal Govt (56%)	$0	$62,233	$124,942	$81,843	$269,017
APLNG (11%)	$0	$12,224	$24,542	$16,076	$52,843
Origin Energy (11%)	$0	$12,224	$24,542	$16,076	$52,843
QGC (2%)	$0	$2,223	$4,462	$2,923	$9,608
Total Cash Contributions	**$0**	**$88,904**	**$178,488**	**$116,918**	**$384,310**

In-Kind Contributions	2022/23	2023/24	2024/25	2025/26	Total
CSIRO (20%)	$0	$22,226	$44,622	$29,230	$96,078
Total In-Kind Contributions	**$0**	**$22,226**	**$44,622**	**$29,230**	**$96,078**

	Total funding over all years	Percentage of Total Budget
Federal Government investment	$269,017	56%
APLNG investment	$52,843	11%
Origin Energy investment	$52,843	11%
QGC investment	$9,608	2%
CSIRO investment	$96,078	20%
Total Expenditure	**$480,388**	**100%**

Task	Milestone Number	Milestone Description	Funded by	Start Date (mm-yy)	Delivery Date (mm-yy)	Fiscal Year Completed	Payment $ (excluding CSIRO contribution)
Task 1	1.1	Sampling logistics	GISERA	Nov-23	Jun-24	2023/24	$62,430
Task 2	2.1	Field sampling campaign	GISERA	July 2024	Feb-25	2024/25	$99,970
Task 3	3.1	Sample and data analyses	GISERA	Mar-25	Aug-25	2025/26	$81,790
Task 4	4.1	Project leadership and reporting	GISERA	Nov-23	Dec-25	2025/26	$92,237
Task 5	5.1	Communicate findings to stakeholders	GISERA	Nov-23	Dec-25	2025/26	$47,883

8. Intellectual Property and Confidentiality

<table>
<tr><td rowspan="3">Background IP
(clause 11.1, 11.2)</td><td>Party</td><td>Description of Background IP</td><td>Restrictions on use (if any)</td><td>Value</td></tr>
<tr><td></td><td></td><td></td><td>$</td></tr>
<tr><td></td><td></td><td></td><td>$</td></tr>
<tr><td>Ownership of Non-Derivative IP
(clause 12.3)</td><td colspan="4">CSIRO</td></tr>
<tr><td>Confidentiality of Project Results
(clause 15.6)</td><td colspan="4">Project Results are not confidential.</td></tr>
<tr><td>Additional Commercialisation requirements
(clause 13.1)</td><td colspan="4">Not Applicable</td></tr>
<tr><td>Distribution of Commercialisation Income
(clause 13.4)</td><td colspan="4">Not applicable</td></tr>
<tr><td rowspan="5">Commercialisation Interest
(clause 13.1)</td><td colspan="2">Party</td><td colspan="2">Commercialisation Interest</td></tr>
<tr><td colspan="2">CSIRO</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">APLNG</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">Origin Energy</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">QGC</td><td colspan="2">N/A</td></tr>
</table>

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