

Toolkit for Managing Sociotechnical Risk in the Energy Transition

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Foreword



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Strengthening public safety assurance through sociotechnical risk thinking

The Australian gas industry has a strong record of safe and reliable infrastructure delivery. This record reflects disciplined engineering, capable people, practical regulation, operational experience and a sustained commitment to public safety.

The energy transition now requires the industry to apply the same rigour in a more complex environment. Future fuels, new technologies, repurposed assets, evolving supply chains and changing community expectations are reshaping the context in which safety decisions are made.

This toolkit is important because it reinforces that public safety is not protected by technical compliance alone and requires a comprehensive view of the risks. Safe outcomes depend on how people, technology, systems of work, governance, knowledge and culture interact within the broader operating environment. This is the value of a sociotechnical risk lens. It helps identify factors that often sit outside traditional engineering checklists but can be critical to safety outcomes.

For the energy industry, three points are critical,

- Safety must remain the organising principle as the energy system changes.
- Safety in Design must consider the full asset lifecycle and whether the design, organisation, supply chain, workforce and operating model are collectively capable of delivering the intended safety outcome.
- Demonstrating that risks have been eliminated or minimised so far as is reasonably practicable requires duty holders to consider what is known, or ought reasonably to be known, about hazards, risks and available controls.

I welcome this toolkit as a practical contribution to industry learning and public safety assurance. I encourage industry leaders, project teams, technical specialists, assurance practitioners and regulators to use this to support better conversations, sharper questions and stronger safety decisions.

Foreword



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This sociotechnical risk management toolkit is important for industry.

My perspective stems from 30 years' experience as an upstream oil and gas regulator and from learnings gained from many incident investigations, and from extensive reviews, assessments and inspections of company performance and management systems. Over the years I've come to realise that organisations are like an iceberg, the tip above the water line is "what" you can see, their people, the return to shareholders, their housekeeping, their environmental and safety KPIs (often measured by number of LOCIs/LTIs) etc. However, it's what lies below the surface that you can't immediately see that matters most if your task is to understand "how" and "why" an organisation delivers performance and more importantly whether such performance is sustainable and a result of conscious planning and effort.

It's below the water line where the sociotechnical risk management principles detailed in this document have their place and value. They focus on the things that are not immediately obvious, matters like individuals' competencies, skills and responsibilities, management of change, past experiences and understanding of technologies an organisation has adopted or is about to adopt including their limitations and uncertainties.

The value of this toolkit extends beyond the energy transition. Its application fits perfectly into any self or external body assessment process of an organisation's financial, technical, systemic and human capability to undertake its business safely, responsibly and sustainably.

How to use this toolkit

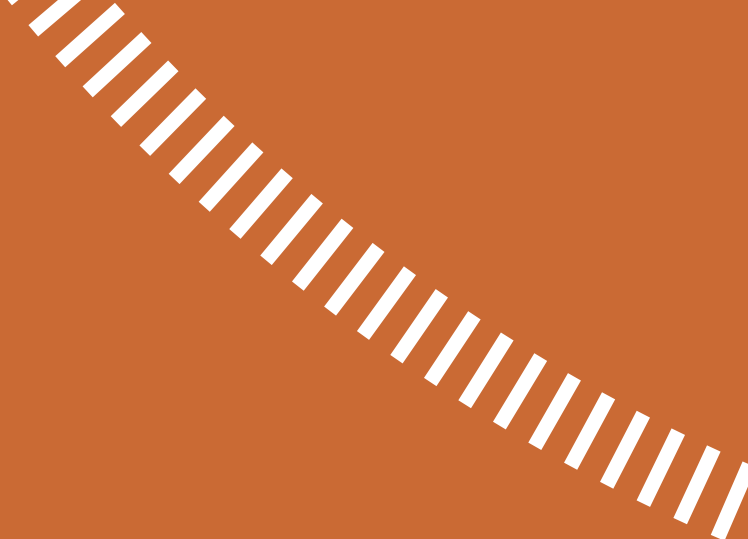
This toolkit sets out eleven principles that have been established by research for managing sociotechnical risks that have the potential to impact public safety in the context of energy transition projects. The underlying premise is that we cannot consider technology as existing in isolation. We need to think about the people and social structures involved and how they relate to the desired technological outcome. As such, successful risk management through the energy transition requires a sociotechnical view which focuses on the people who are involved in every aspect of selecting, governing, leading, designing, constructing, operating and maintaining technological systems.

The toolkit is designed to support existing company project risk management processes, particularly in the context of the novel technologies and heightened uncertainties inherent in energy transition projects. For each principle, the toolkit sets out a series of reflective questions to help projects determine relevant risks, plus two or three examples of where such risks have arisen on other transition projects. The question sets can be used informally by those involved in projects to inform decision making or as the basis of more formal reviews as part of overall project risk management processes.

In doing project work, the three primary objectives of cost, schedule and quality are all linked to each other and to long term public safety. In many cases, when issues arise during project execution a decision must be made whether to incur a cost and/or schedule penalty to fix them or defer the issue to operations, with potential long term safety implications. In seeking to encourage projects to reflect on sociotechnical risks, we have therefore not made a hard distinction regarding those that are safety-related, but rather assumed that anything that has the potential to cause schedule, cost or quality issues can also impact long term safety outcomes.

The toolkit applies to the activities of all parties working on transition projects including owners, operators, contractors and regulators. It focuses attention on identification of risks, rather than providing detailed, prescriptive advice regarding how best to manage risks. There are two reasons for this. In general, failures happen because people can't imagine them. This toolkit promotes reflection on what risks may be present in any given project. Generally speaking, mitigation is relatively straightforward once a failure mechanism is understood. In addition, the range of energy transition project activities is wide, so fit for purpose and specific risk mitigation advice is not amenable to general guidance such as contained here.

Overall, the toolkit aims to reduce the risks of unplanned outcomes and to improve the performance of all participants involved in delivery of new, safe and reliable infrastructure and technologies.



Principle

Acknowledge the uncertain environment and the impact this can have on everyone

1

Ensure individuals and organisations understand their responsibilities and have the skills to carry them out

2

Consider how different people and organisations bring different cultures to the project

3

Spend extra time on planning to achieve goals faster in the end

4

Ensure that novel technology equipment items are effectively integrated into the whole-of-plant design

5



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11 Support continuing research and standards development to capture and share new knowledge

10 Maximise learning from operating experience including sharing across the sector

9 Keep in touch with government policy shifts at all levels

8 Ensure regulatory responsibilities are understood and regulator relationships are strong

7 Consider how the built facilities will be integrated into the base business technically, financially and organisationally

6 Think about how our past experience influences our design and our way of working



Acknowledge the uncertain environment and the impact this can have on everyone

Working on innovative projects linked to energy transition is rewarding, and so they attract capable people. But uncertainty is the constant in today's evolving renewable gas landscape, with rapid scientific and technological advancements, shifting project scopes, and fluctuating market conditions. These changes can affect timelines and influence the morale of project personnel, particularly those involved in pre-FID stages and demonstration facilities.

Identifying risks linked to uncertainty

- Constantly shifting goal posts can result in change fatigue. What can we do to support our people and maintain clarity while still meeting evolving expectations?
- How do we keep the team motivated to stand up for safety and make difficult safety choices when there is so much uncertainty about the project going ahead? Do we have effective change management systems to ensure the final design is fit for purpose?
- With significant uncertainty over the basic science, how do we recognise when it is necessary to return to first principles to address remaining technical challenges? Are we allowing sufficient time and space to do this effectively?
- Financing and regulatory processes often require demonstrating best practice, but this becomes challenging when there are no existing facilities or benchmarks to draw on. What additional steps or evidence might be required to satisfy both financing requirements and regulatory expectations? How will you meet them?
- Delivery expectations may be set by political imperatives, not by engineering considerations. Are our schedule requirements realistic given the technical work required?
- In a tight employment market, securing and retaining skilled personnel is critical. What can we do to encourage project team members to stay in a competitive employment environment?
- Commercial pressures can drive optimistic assumptions regarding uncertain safety and reliability outcomes. Are our safety and reliability performance assumptions realistic and appropriately risk averse?

The strain of late-stage changes

In rapidly evolving sectors such as hydrogen, constant shifts in project scope driven by uncertainty around offtake and emerging market opportunities can create significant strain on teams. In one project, late-stage changes, such as scaling facility size in response to new potential customers, repeatedly redirected project efforts. While teams may initially respond with energy and adaptability, this becomes unsustainable over time.

One strategy to address this is limiting the time individuals spend in roles that are most exposed to constant change and rework.

When safety is extra hypothetical

A project environment always involves some degree of contestation where engineers need to be able to put a good case for what they think is the right choice. To be most effective, professionals need to be invested in the outcome of their work, but this becomes hard to maintain in the face of constantly shifting goal posts.

When teams believe a project is unlikely to proceed, safety considerations may be treated as theoretical rather than real, leading to less rigorous scrutiny of hazards and mitigations. It's hard to maintain chronic unease if you know in the back of your mind that the design will likely change next month.

Maintaining discipline in safety management, regardless of perceived project viability, is critical to ensuring preparedness and protecting future system integrity, people, and the environment.



Ensure individuals and organisations understand their responsibilities and have the skills to carry them out

To date, the pipeline industry has benefited from a strong base of technical expertise and established safety practices. With the emergence of renewable gases, the market is seeing an influx of new participants who may have limited backgrounds in process safety. This is compounded by a broader industry-wide knowledge gap, as organisations and professionals work to build understanding of safe management of renewable gases and their impacts on existing infrastructure. This shift has introduced uncertainty around capability levels and highlights a gap in knowledge development within the sector.

Identifying responsibility and skills risks

- What responsibilities sit with the operating organisation, contractors and with vendors? Are there any gaps, overlaps, or ambiguities in responsibility allocation?
- Embedding safety from concept selection is critical to achieving the best safety outcomes and regulatory approvals. Do all organisations have common expectations about safety in design processes and requirements?
- Have we defined the critical skills and capabilities required for the project? Where are our most significant capability gaps?
- Do we have a structured approach to building these capabilities? How do we ensure training content remains current with evolving technologies and standards? How effectively are we capturing and sharing lessons learned from projects across teams and organisations? Do we have a plan to keep in touch with new research? Are informal networks (communities of practice, technical forums) being leveraged effectively?
- Are we building long-term industry capability rather than just meeting immediate project needs?
- Do professionals fully understand the extent and limits of their expertise? Are individuals empowered to speak up when something falls outside their competence?
- Do all workers at all levels (management, engineers and trades) have sufficient background in process safety? What additional training is needed? How will we provide it in a timely way?

Right person, right job

Because technology is evolving rapidly, purchasing major equipment for renewable gas projects often involves major contracts for bespoke equipment.

Some companies have procurement processes that rigidly separate technical and commercial considerations in ways that don't lead to the best outcomes for projects with many technically non-conforming tenders and significant technical uncertainties.

This has led to significant issues in project execution, exacerbated by the need for early ordering of long-lead items so critical purchasing decisions must be made early.

Safety in design

The concept of safety in design has been well adopted in the gas sector and other process industries including embedding safety thinking into concept selection.

In contrast, the early stages of some projects have focussed on project economics and technical feasibility, seeing safety as a check or an add-on to be addressed later. This has led to significant cost additions at later stages of design to address possible failure modes or worst-case consequences and how to avoid them.

This can lead to costly rework or even taking projects forward only to discover later in project execution that they cannot be safely executed.



Consider how different people and organisations bring different cultures to the project

Aligning cultures, fostering collaboration, and proactively managing external relationships are key to building the collective norms and confidence needed for successful project delivery. Renewable gas project teams are often more agile and less bureaucratic than those in base business, while international vendors bring their own practices that may not align with local expectations. These cultural differences can lead to gaps, misunderstandings, or missed requirements if not actively managed. The key strategy is to use diversity effectively and compensate for different assumptions where necessary.

Identifying cultural risks

- Renewable gas projects have brought together companies with a wide range of backgrounds who may not have worked together previously. What cultural assumptions are we making about our partner organisations? How can we be sure that we have common assumptions about what's important for safety and reliability?
- Vendors' practices and concerns may not align with local expectations and requirements. How are we localising vendors' international experience? Do vendors understand this is key to success?
- Are all organisations involved familiar with safety in design principles and the benefits of frontloading safety studies? If not, are new processes needed? Do we need expert help?
- Are vendors aware of the need to meet Australian standards? Do we have plans to check key requirements at design and again in the factory?
- Specialised equipment vendors are likely to be entrepreneurs who may not be willing to share some aspects of technical intellectual property (IP). Have we made requirements for sharing safety-related performance data clear?
- Has the organisation deliberately separated its renewables teams from the base business, and if so, how is it planning to manage the transition as these activities scale? What steps are being taken to reintegrate ways of working and maintain a consistent culture?

Vendor engagement in safety processes

Vendors supplying complex technologies, such as electrolyzers, can be reluctant to participate in safety processes such as HAZOP studies. Vendors may also resist design changes arising from safety studies or local regulatory requirements, given their focus on supplying standardised packages developed for global markets. These experiences highlight the need for early alignment of expectations, stronger contractual requirements for participation in safety processes, and relationship management strategies that position vendors as long-term partners rather than transactional suppliers.

Australian Wiring Rules

Meeting the requirements of the Australian Wiring Rules (AS 3000) is an important aspect of electrical compliance. Vendors who have not supplied equipment for use in Australia in the past may assume AS and ISO wiring requirements are identical when there are significant differences. Inexperienced project teams may fail to point this out. Effective management strategies can include presenting regulators with a gap analysis or importing bare equipment to be wired locally. On some projects, discovering this issue close to project completion has caused major startup delays. Similar issues exist for functional safety and hazardous area standards.

Spend extra time on planning to achieve goals faster in the end

Strong front-end loading of projects has been shown repeatedly to produce higher quality and more cost-effective outcomes. This is particularly the case when uncertainty is high as with innovative technologies. Starting detailed work before major issues are resolved leads to expensive rework or even significant flaws in the final design if change management systems are overwhelmed.

Identifying project planning risks

- Especially at pre-concept stage, does vendor-provided technical performance data seem realistic (e.g. representative of sustainable long-term reliability, rather than theoretical peaks) and valid for Australian conditions (e.g. cooling requirements for electrolyzers)?
- Are budget constraints preventing effective planning? What can we do about this?
- Have we front end loaded key safety studies so big-ticket items are addressed as early as possible?
- Many renewable gas projects operate on a compressed schedule. Are we ordering long lead items early? What is the possible impact on safety in design or operational reliability and how can we mitigate this?
- Sometimes lack of experience leads to conservative assumptions in the interests of safety. In what ways is our design highly conservative? Are there opportunities for additional safety studies that could reduce conservatism in the design and so cost? Do we have time to do them?
- Have we defined what is needed for facility operational readiness and planned how to get there?
- Where will our operational workforce come from (e.g. in-house transfer, recruitment from other sectors)? Does our staffing plan acknowledge the likely requirements for troubleshooting in initial operations?
- Are we across all relevant research? Would our project benefit from further testing or empirical research?

Operational workforce planning

Some early renewable gas projects planned for facilities to be mostly unstaffed. In practice, they discovered they needed a continuous operational presence at site. This created unexpected worker resourcing problems, which in turn impacted facility up time. In the most extreme cases, the optimum location of the facility might have been different if actual workforce requirements had been understood earlier.

Relying on overseas data

In the early stages of project scoping, it is common to rely on vendor data for typical estimates of utilities consumption. When vendors are overseas in locations where conditions are very different to Australia, typical requirements may vary enough to impact project economics. For some hydrogen projects, water requirements for electrolyser cooling have initially been substantially underestimated for Australian conditions.

Relying on theoretical performance data

Effective project scoping also relies on realistic estimates of equipment performance. With limited operating data available, some projects have relied on vendor-supplied data representing theoretical peak performance, rather than basing project economics on performance data that is representative of sustainable long-term reliability. In some cases, this has resulted in highly optimistic early evaluations of project economics. If data seems too good to be true, it probably is.



Ensure that novel technology equipment items are effectively integrated into the whole-of-plant design

Understanding how an electrolyser or other novel equipment item functions as part of an overall plant design requires data on boundary conditions and safety and operational studies of how the entire system functions in both normal and abnormal conditions. In the renewable gas context, some vendors have not focussed strongly on this aspect of their technology development and may not fully understand the complexity and importance of system-wide studies. Inadequate management of this interface can lead to safety and reliability problems in operation.

Identifying risks linked to integration of whole-of-plant design

- An effective process safety view of a new plant requires an integrated understanding of how the entire system will operate. Are we considering safety at a system level, not just focussing on individual equipment items? Have we done a Layers of Protection Analysis (LOPA) and established Safety Integrity Levels (SIL) for instrumented risk controls? Has risk been reduced so far as is reasonably practicable (SFAIRP)?
- Do vendor contracts / relationships give us access to all the safety information we need to safely integrate each new equipment item into an overall safe system?
- Are we satisfied that operational and safety instrumented functions are separated in our design and management of change processes will ensure this is maintained in operation?
- Comprehensive safety studies require an understanding of possible failure modes which might be lacking for innovative designs with little operating track record. Do we have a good understanding of the possible failure modes of all parts of the new facility? Have we completed a comprehensive HAZOP that addresses nodes across all facilities?
- Many new facilities are bespoke, meaning that spares may not be readily available when they are needed. Have we thought about spares requirements (likely need and delivery time) and the potential impact on plant up time?
- Novel technology is rapidly evolving. How does our design take this into account?
- Does everyone clearly understand the boundaries between vendor packages and the balance of plant?

Access to vendor safety studies

HAZOP is a key safety assurance mechanism and conducting an effective HAZOP of a plant involving innovative technology requires that the entire plant is reviewed by a team that includes expertise in the new technology. Some projects have experienced difficulties in getting vendors to provide details of past HAZOP studies conducted for their equipment and/or to take part of whole of plant HAZOP studies.

This risk has been managed by ensuring contract conditions list required documents but also by building strong vendor relationships to ensure the cooperation of technical staff.

Impact on the rest of the plant

Some design contractors reported that electrolyser vendors do not always design operating and safety functions as separate within instrumentation architecture as has been standard in the oil and gas sector for decades. This becomes particularly critical when vendors retain access to operational instrumentation even after plant commissioning in order to monitor equipment performance and even make operating software updates remotely.

Managing this risk requires significant awareness on the part of design personnel including checking fundamental aspects of design that might normally be taken for granted.



Think about how our past experience influences our design and our way of working

Experience shapes how we approach design and operations, offering an important guide for new challenges. Yet these same experiences carry assumptions and practices that may no longer fit in the renewable gas context. It is important to recognise what knowledge transfers well, and where old rules of thumb may be misleading.

Identifying risks linked to past ways of working

- Some renewable gases introduce toxicity hazards as well as the more familiar issues of flammability. What are the worst case consequences of a failure of our facilities? How far could the impact extend? Have we considered this from the earliest stages of plant siting/layout and/or pipeline routing?
- Does our project impact existing systems relying on odorant injection as a key method of leak detection? Will the old system still work as intended? Is this the right option for our project?
- What aspects of this project are outside our experience (fluids, types of technologies, locations etc)? How do we know what we don't know?
- Unlike natural gas from petroleum reservoirs, feedstock may vary significantly in composition and availability. Have we considered this in plant design and operations? How does this impact existing systems?
- How are we addressing complacency? Who has the job of challenging what's normal?
- What are we assuming in regards to material and functional compatibility of a renewable gas with our existing equipment and materials? Does this need a project specific assessment? What assumptions can be safely made, or what project specific testing or monitoring may be needed?

Ammonia toxicity

Ammonia introduces acute toxicity hazards and, under some conditions, flammability hazards. Pipeline and facility design must therefore consider toxic dispersion, public exposure, leak prevention and detection, emergency response, materials compatibility, operating pressure and consequence-based controls. Detailed assessment of risks and risk controls must use methods suitable for ammonia which in many cases differ from methods used for natural gas.

Injecting Hydrogen

The injection of hydrogen into existing pipelines is a topic of active research, particularly in the context of pipeline integrity.

The topic has been the subject of extensive technical research by the Future Fuels CRC. Several projects are now up and running on gas distribution networks. A deliberately conservative approach has been adopted to manage uncertainty. Greater challenges remain for transmission pipelines due to increased susceptibility to hydrogen embrittlement at high operating pressures. There are uncertainties about the definition and the measurement of toughness, which lead to significant differences in acceptable defect size compared to natural gas service.



Consider how the built facilities will be integrated into the base business technically, financially and organisationally

The complex and uncertain nature of renewable gas projects has the potential to create difficulties at upstream and downstream interfaces with the base business. Issues can be technical or organisational as existing systems, equipment, workforce and customers are impacted by the new facilities. Effective management makes for easier startup whereas gaps can make early operations difficult.

Identifying risks linked to base business integration

- Is everyone clear on the motivation driving the project (profit, proof of concept, other)? Does everyone share the vision?
- Does our project introduce hazards that our workforce may not be familiar with (e.g. presence of H₂S, operating completely new types of equipment)? How will they be trained to manage such hazards?
- What are the key assumptions we have made in our design about facility operations? Are there any new operational monitoring requirements to confirm our assumptions regarding plant behaviour in operations?
- Is organisational ringfencing required to meet competition regulations?
- How are those working in the base business kept up to date with new projects and what these changes might mean for them?
- How do our project plans impact existing customers, both technically and commercially? Have all potential impacts been addressed?
- Are we planning to shut down old plant and/or facilities as part of the project? Have we identified and considered all interfaces, particularly utilities?
- As we move to increasing use of artificial intelligence (AI), how does this impact our plans for renewable gas projects?

When agile meets systems

Renewable gas project teams are sometimes noted as having a different culture to base businesses - more agile and less compliance focussed. While this might work well for generating concepts and ideas, at some point the project needs to be integrated with company systems. Some projects have addressed this relatively late in project execution creating confusion and delays.

Selling renewable gas to existing customers

Existing customers who buy gas under contract can also be impacted by renewable gas projects. In addition to technical questions related to the impact of changes in the heating value of the gas supplied to them, legal paperwork may also need to be updated to ensure that new gases fall into the scope of existing sales agreements.

Changes to base plant

Some renewables projects have involved shutting down parts of base plant to eliminate carbon-intensive operations. Planning for such changes is not simple. Process plant is often highly integrated, particularly when it comes to utilities such as heating, cooling, plant air and/or plant nitrogen. Planning for some projects has come unstuck when interfaces are not understood from the start.



Ensure regulatory responsibilities are understood and regulator relationships are strong

As for any project, renewable gas projects are subject to many regulatory constraints ultimately targeting the public interest. There are three key aspects that need emphasis. Given the high level of technical uncertainty, early engagement with technical regulators is key to project approval. Further adjustments to gas marketing and economic regulation are required to allow renewable gases to be successfully blended into the existing gas network. In some cases, renewable gas technologies trigger different regulatory regimes that then must be addressed.

Identifying regulatory risks

- Which Commonwealth, state, territory and local laws apply, including pipeline safety, work health and safety or occupational health and safety, dangerous goods, major hazard facility, environmental, planning, professional registration and critical infrastructure requirements?
- Have duty holders, including designers, identified their legal duties and translated them into clear project responsibilities and assurance evidence?
- Workplace health and safety legislation ascribes duties to groups beyond those who own/operate facilities. Do all organisations involved in the project understand their duties and how this translates into project responsibilities?
- Have we/are we engaging with the technical regulators at the earliest possible stage to build confidence and ensure common understanding of requirements?
- Do we understand how the wholesale gas market operates and how our gas can be sold into it?
- Does this project impact economically regulated assets? How will costs be recovered and in what timeframe?
- Does this project impact nationally critical infrastructure? Have we considered security requirements, including cybersecurity?
- What other unusual regulations might be relevant (e.g. biogas projects can run into requirements for waste processing)?
- How do state-based engineering licencing requirements impact approvals for our project?
- Are we across local government requirements (e.g. for land use planning)?

Registered Professional Engineer of Queensland

In Queensland, engineering drawings and other design documents can only be formally approved for construction by professionals who are registered with the Board of Professional Engineers of Queensland or under their direct supervision. Registration requires demonstration of appropriate experience and qualification.

Some projects have experienced delays in project approvals by technical regulators when it is discovered that documentation regarding overseas-designed and manufactured equipment does not meet these requirements. Retrospective compliance is messy and time consuming and can delay startup. Addressing these requirements during the design phase should avoid problems.

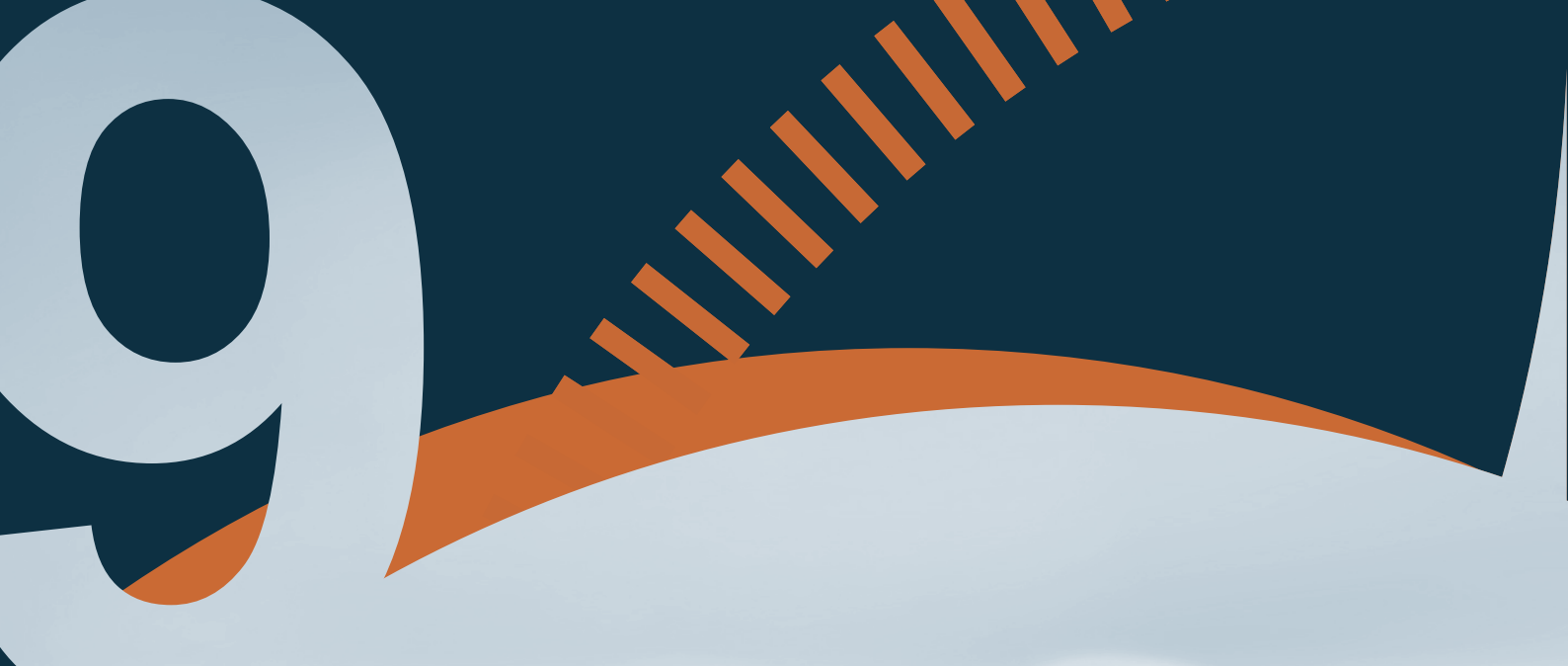
Technical regulator early engagement

Technical regulators provide an important governance function for renewable gas projects. The level of technical innovation and uncertainty involved has meant that successful projects start technical regulatory engagement early and adopt a transparent approach on technical information.

Strategies that have worked well include:

- Conducting joint research and/or open sharing of research results
- Involving regulators in scoping testing programs
- Sharing lists of technical challenges to be resolved
- Once facilities exist, inviting regulators to site

These approaches have led to both effective regulatory governance and timely project approvals.



Keep in touch with government policy shifts at all levels

Staying on top of policy developments is essential for managing renewable gas project risk in a rapidly evolving environment. Project economics turn on government policy, grant schemes, and the price of electricity. Small changes in policy settings can materially affect likely revenue and so long-term project viability, especially as organisations are looking to scale-up projects. The policy environment also affects existing gas infrastructure, with decreasing investment undermining long-term system planning.

Identifying risks linked to government policy

- Government grants are originating from multiple sources (state and commonwealth, different departments). Are we across all possible sources of project support?
- Proactive policy monitoring enables early identification of shifts that could impact project timelines or design. Do we have systems in place to anticipate future policy shifts and the opportunities they could present?
- Effective advocacy helps shape stable, supportive policy settings for renewable gas. How is our organisation advocating for, and educating stakeholders on, practical, economically viable solutions in the energy transition? Do we have a clear and compelling narrative about how our product addresses net-zero policy problems?
- Over the last few years, existing gas infrastructure has increasingly been treated as “unloved,” and exploration for new reserves discouraged. How are we continuing to maintain reliable systems during the transition?
- Delivery expectations may be set by political imperatives, not by engineering considerations. Are our schedule requirements realistic given the technical work required or overly driven by political and commercial considerations?

Biomethane as “low-hanging fruit”

Many people described biomethane as an under-supported and under-utilised opportunity, constrained by policy preferences that prioritise electrification. From an engineering perspective, the availability of feedstock, mature technology, and compatible infrastructure makes biomethane a pragmatic and immediate decarbonisation option. Despite these perceived advantages, people working in this space see a lack of government support. Rather than being defeated, these players have sought to better understand the policy environment and have become increasingly engaged in advocacy efforts. While these actions are beginning to influence policy settings, there is more work to do.

Reactive responses to hydrogen policy

Over the past five years, many companies have engaged in hydrogen projects to repurpose existing pipeline infrastructure in a changing energy landscape. This engagement has often been reactive rather than strategic. The driving factor for companies entering the hydrogen space has been government grants. These incentives helped offset high costs and uncertain returns. Yet when policy support weakened or market conditions shifted, many of the same companies scaled back or withdrew their involvement. This pattern reflects a broader recognition that, under current conditions, hydrogen economics remain difficult. Indeed, many companies were aware of these challenges from the outset. While there is an expectation that hydrogen could become more viable over time, this has not translated into continued investment. This creates both a risk and an opportunity. Companies that remain on the sidelines may once again find themselves reacting to future policy or market shifts, repeating past cycles of entry and exit. In contrast, those that invest strategically building on their existing capabilities and relationships position themselves ahead of the curve.



Maximise learning from operating experience including sharing across the sector

The pipeline sector has a strong culture of sharing lessons learned within and across organisations. In the context of the renewable gas transition, this commitment has been further strengthened, including proactive engagement with adjacent industries. Vendors play a critical role by bringing operational insights from similar facilities internationally, enabling local project teams to anticipate risks and adopt proven practices more efficiently.

Identifying learning and sharing risks

- Given the general lack of operating experience with renewables, sharing across industry is a valuable way to learn. Are we sharing technical lessons with others operating similar facilities?
- How are we embedding operating experience of others into our design? What steps are we taking to critically evaluate whether approaches apply to our case?
- Are we tapped into any relevant competency units available via the National Training Register (training.gov.au)?
- Have we considered training requirements from vendors as part of scope and contract development?
- Renewable gas technologies continue to evolve rapidly as more facilities begin operations. Do we have a way to track any failures that occur in facilities like ours and address the implications for our operations?
- Are we benchmarking our system performance against other equivalent facilities? How are we doing? Are there areas for improvement?
- How's our relationship with the community surrounding our facilities? Are we listening to their experiences and ideas, and keeping them up to date with our plans?
- Are vendors providing feedback from their other customers' experiences? How can we encourage more of this?

Learning from other sectors

Collaboration with experienced industrial gas producers has proven valuable in solving immediate technical problems, and to build workforce capability. In one case, a facility encountered a critical issue with hydrogen leak detection systems. Lacking the in-house expertise to accurately diagnose and manage the situation, operators were forced to shut down for several months to ensure safety. The situation was eventually resolved when specialists from industrial hydrogen operations stepped in. They were able to help address the problem and provide targeted training to site personnel, helping build the internal capability needed to safely manage similar issues in the future.

IP concerns inhibit sharing

Concerns over IP remain a significant barrier in some cases. Vendors tend to be highly protective of their IP, often showing reluctance to disclose details about their technologies. Project proponents are sometimes similarly cautious, only willing to share their expertise if compensated in a consulting capacity. This dynamic can create confusion, especially among those who view the work as serving a broader public good. However, such expectations overlook the commercial realities in which these organisations operate, where knowledge is closely tied to financial aspects. Where sharing is linked to funding (i.e., ARENA grants) organisations are more likely to be open.



Support continuing research and standards development to capture and share new knowledge

The progress achieved in renewable gases to date has been fundamentally research-led, reflecting a sustained global effort to address both technical and non-technical challenges alike. In parallel, regulatory frameworks and the standards that underpin them have evolved rapidly in response to this advancing knowledge base. However, this is not a solved problem: continued investment and focus remain essential. Shifts in policy risk creating the impression that the task is complete or no longer urgent, when in reality further innovation, scaling, and work to understand transitions risks are still critical to fully realise the potential of renewable gases.

Identifying research and standards risks

- Do our early career engineers understand the link between standards and engineering judgment, particularly in the context of rapid evolution of standards to reflect increasing operating experience?
- When working with standards developed in varying contexts (e.g., plant v pipelines) are we adopting a critical lens to examine the degree to which requirements are applicable?
- What changes to Australian and international standards are under development? Do we have processes in place to identify standards changes during project execution and assess their impact?
- Is our organisation continuing to support and/or advocate for work on standards relevant to renewable gases, irrespective of current projects?
- Is our operating experience with new technologies feeding into future standard revisions?
- Are we represented on all relevant standards committees? Can we do more to share lessons learned of both successes and failures?
- What are the enduring unknowns in the renewable gases space that warrant research (e.g. technical, economic, policy and regulatory, organisational)?
- Are we across research outputs as they relate to our renewable designs and operations?

Defining gas

An early challenge was the limited scope of the previous definition of natural gas in AS 4564, which is referenced within the broader Australian gas framework. AS 4564:2025 now sets gas-quality requirements for natural gas and specified natural gas equivalents, providing a clearer basis for determining whether those gases are suitable for transportation and general-purpose use.

The revised Standard reduces uncertainty about the gas-quality requirements that apply to eligible renewable gases. However, conformity with AS 4564 addresses gas quality only. Each project must separately identify and satisfy all applicable design, materials, integrity, safety, operational, market, contractual, licensing and regulatory requirements.

Designing ahead of the standard

Early projects in the energy transition faced significant uncertainty regarding standards. In many cases, designers drew on a patchwork of international standards and other guidance documents. There is now a growing body of local guidance and resources. These developments are reducing uncertainty, improving consistency, and enabling more streamlined project delivery. However, organisations must remain aware of how relevant standards may be not well-aligned with the Australian context, or out of step with the latest operating experience of new technologies.

Formalising guidance into standards

The general approach for building renewable gases into Australian Standards has been to produce guidance documents first drawing on research and early industry experience and then integrate these into revisions to existing standards as requirements crystalise. This creates a source of collective experience, reducing the chance of repeated problems but requires significant effort to stay on top of changing requirements.

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