Hydrogen safety in ports: from risk to routine

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As ports and the wider maritime sector move toward decarbonization, hydrogen is emerging as a cornerstone of the transition. But one condition outweighs all others: safety. Without strong safety practices, projects will face delays in permitting, struggle to gain stakeholder trust, and fall short of the scale required for Europe's energy transition. Drawing from insights from the panel members at the session organised by the NSH2V Ports project at the offshore experience in Den Helder, Netherlands, the article examines the safety challenge from four perspectives:

1. Lessons from Biogas and LNG: Why Safe Design Alone Is Not Enough
2. Detection Systems: Embedding Readiness into Hydrogen Port Operations
3. Permitting Hydrogen in Ports: Why Collaboration Is the Key to Speed and Safety
4. Managing Uncertainty: Building a Culture of Safety in Hydrogen Deployment

Taken together, these insights point to a holistic approach, where hydrogen in ports is no longer viewed as a risky experiment but established as a safe, dependable, and routine energy carrier.

Lessons from biogas and LNG: why safe design alone is not enough

Hydrogen is not the first "new molecule" to demand fresh safety paradigms. The biogas and LNG industries provide valuable lessons in how to approach emerging fuels. The key insight is clear: safety cannot rely on design alone, safe operation is equally critical.

In the case of biogas, the greatest hazards often came from operational drift, deviations from procedures caused by inadequate training or delayed maintenance—rather than from the nature of the gas or flaws in engineering design. LNG terminals reinforced this lesson. Practices such as cryogenic fuel handling, boil-off gas management, and large-scale fire safety exercises only became standard after accidents and near-misses exposed weaknesses in operational readiness.

As René van der Kloet safety consultant at Vicoma observes, "safe design does not guarantee safe operation. Operators and end users must be fully integrated into the safety process from the start, and kept engaged throughout, to prevent gaps from opening between design intent and real-world practice."

This becomes even more important as hydrogen projects scale. Uncertainty is inevitable, but it must be managed - not avoided - through continuous supervision, adaptation, and proportionate "no-regret" measures, as highlighted by Wim Derksen, senior advisor in industrial and spatial safety at North Sea Canal Area Environmental Service.

European case studies underline this point. In Rotterdam and Hamburg, lessons from LNG are being applied to hydrogen pilots, but adjustments are necessary: hydrogen's invisible flames and rapid dispersion demand different emergency procedures than LNG fires.

The overarching lesson is clear: for hydrogen, safety must extend beyond engineering to encompass culture, operations, and adaptive management.

Detection systems: embedding readiness into hydrogen port operations

A key enabler of operational readiness in hydrogen port infrastructure is the deployment of advanced detection systems. Here, there is an opportunity to leverage proven technologies from other sectors. For example, detection systems originally developed for offshore energy now deliver parts-per-million sensitivity for hydrogen leaks. When combined with digital twins, ports can simulate dispersion scenarios across terminals, providing a powerful training tool for emergency services. Robotic platforms further extend monitoring to confined or high-risk spaces.

Yet, the effectiveness of these tools depends on how they are applied. Too often they are used reactively, switched on only when a leak is suspected. Ports such as Antwerp-Bruges demonstrate a different approach, embedding continuous monitoring into the permit conditions for hydrogen facilities, thereby integrating readiness into the regulatory framework.

As Martin Koelman, Cofounder at Seekable an offshore engineering company, reminds us: "Every molecule carries risk, but innovation provides the tools to manage it." The step change now is to move from reactive to preventive safety, embedding detection and monitoring into the design basis of hydrogen infrastructure and making it a standard requirement within permitting processes.

Permitting hydrogen in ports: why collaboration is the key to speed and safety

Permitting for hydrogen projects remains complex, especially where project-level safety systems must align with evolving standards. As Saša Marinić, Business Development Manager Benelux at TEAL Mobility, emphasizes, internal safety requirements and regulatory frameworks sometimes can diverge, and unless coordinated, the different requirements can impact the progress of the project realization. The goal is to achieve a process that safeguards people and assets without stalling innovation.

Collaboration between regulators and developers is emerging as the most effective solution. In the Netherlands and Germany, "permitting tables" now convene developers, regulators, emergency services, and local stakeholders from the earliest project stages. This parallel approach shortens approval timelines and builds mutual trust. As Wim Derksen notes, "fast permitting starts with fast collaboration," meaning that transparency, trust, and engagement must be cultivated as carefully as technical safety plans.

The challenge grows for international projects requiring permits across multiple jurisdictions. Marinić points to structured dialogue with partners across Europe as a route to common standards, reducing complexity and accelerating deployment. At the European level, the North Sea Hydrogen Valley Ports project demonstrates this potential: ports in Den Helder, Esbjerg, Bremen, and Brest are working toward shared permitting frameworks, while pilots in Valencia and Marseille pursue similar goals.

These efforts highlight a central lesson: harmonized permitting, underpinned by collaboration, will be decisive in making hydrogen bunkering scalable across Europe.

Managing uncertainty: building a culture of safety in hydrogen deployment

Scaling hydrogen will inevitably introduce unknowns, ranging from material behavior over long operating cycles to human-factor issues in new settings, and interactions with legacy assets. Addressing these risks requires a disciplined balance of minimization, transparency, and proportionate control. Where uncertainty hides potentially severe consequences, the precautionary principle is justified. Yet blanket measures that overshoot real risks can misallocate resources and undermine credibility. Evidence-based guidance, consistent inspections, and robust safety management, treating maintenance and training as non-negotiable, are essential.

Beyond technical controls, safety must be embedded as a culture, not just hardware. As Wim Derksen observes, some industries naturally treat safety as a core value, while others need time and structure to build this mindset. Success depends on making expectations explicit, especially for parties less familiar with hydrogen, and clarifying the commitments required. More experienced operators may be given greater flexibility, but only where responsibilities and boundaries are crystal clear.

Conclusion

Hydrogen safety in ports is not a barrier to progress; it is the platform that makes progress possible. The knowledge exists. The task now is real-world implementation: aligning design and operation, embedding preventive technology, agreeing on proportionate standards, and collaborating early and often. Do that well, and ports, at the frontline of the energy transition, can bring hydrogen into daily use in a way that is trusted by operators, regulators, and communities alike. Collaboration turns ambition into practice; readiness turns risk into routine.

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NS H2V Ports

The NS H2V Ports project aims to decarbonize heavy industries and the maritime sector by producing and using hydrogen (H2) at key North Sea ports — Brest, Esbjerg, Bremen and Den Helder. It develops road-maps to optimize hydrogen production, storage, and transport, collaborating with local stakeholders to create sustainable maritime hydrogen ecosystems.

In doing so, NS H2V Ports develops standardized designs and shares best practices to enhance cooperation and accelerate the development of Maritime H2 Valleys.

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