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HYDROGEN LOGISTICS ARCHITECTURE STANDARD Version 1.11(HLASv1.11)

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A Hydrogen Logistics System Architecture and Assurance Standard

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FOREWORD

The transition toward a hydrogen-based economy requires infrastructure systems capable of supporting production, transportation, storage, distribution, and export over investment horizons measured in decades. Unlike conventional industrial projects, hydrogen infrastructure is expected to develop progressively through numerous independent investments undertaken by producers, infrastructure developers, industrial users, logistics providers, governments, financiers, and other stakeholders operating across different regions and at different points in time.

While individual hydrogen projects may be technically and commercially successful, independent development alone does not ensure that they collectively form a coherent, scalable, or interoperable hydrogen logistics system. Without a common architectural framework, infrastructure may gradually become fragmented, duplicative, incompatible, or increasingly difficult to expand, thereby reducing long-term utilisation, increasing stranded asset risk, and diminishing investment value.

The Hydrogen Logistics Architecture Standard (HLAS) was developed in recognition of this challenge.

HLAS establishes a common architectural framework through which independently developed hydrogen infrastructure can evolve as components of a coherent regional and national hydrogen logistics ecosystem. It defines standardized Architecture Classes, governing architectural principles, infrastructure building blocks, topology rules, system boundaries, and stakeholder responsibilities that collectively preserve the structural characteristics necessary for scalable, interoperable, and resilient hydrogen infrastructure.

During the development of HLAS, it became evident that defining an architecture alone was insufficient to preserve its long-term value.

Hydrogen logistics infrastructure is inherently an **open architecture**. Production Hubs, Regional Aggregation Hubs, logistics corridors, industrial users, storage facilities, export infrastructure, Backbone Pipelines, and supporting systems are expected to evolve continuously as hydrogen markets mature. New participants enter the system, existing infrastructure expands, technologies evolve, commercial relationships change, and regional priorities adapt over time.

This capacity for continuous evolution is one of the principal strengths of hydrogen infrastructure. However, it also creates the conditions under which the defining characteristics of the architecture may gradually erode through a sequence of individually rational but collectively uncoordinated decisions.

HLAS refers to this phenomenon as **Architectural Drift**.

Architectural Drift rarely occurs through a single decision. Rather, it emerges incrementally as infrastructure evolves without continuous evaluation against the governing architectural principles. Over time, the accumulation of seemingly minor deviations may fundamentally alter the architecture, reducing interoperability, weakening diversification, constraining future expansion, increasing systemic risk, and ultimately diminishing the long-term value of the infrastructure itself.

This recognition fundamentally shaped the philosophy of HLAS.

Rather than treating compliance as an activity performed only during planning, approval, or initial implementation, HLAS establishes **Dynamic Compliance** as an inherent characteristic of every Architecture Class defined by this Standard.

Dynamic Compliance continuously preserves the defining architectural characteristics through which hydrogen logistics infrastructure delivers its intended benefits. It recognizes that the value of an architecture lies not merely in its initial design, but in the continued preservation of the structural relationships through which it mitigates infrastructure risk and enables long-term evolution.

Accordingly, HLAS establishes a family of **Dynamically Preserved Hydrogen Logistics Architectures (DPHAs)**. Every Architecture Class defined by this Standard derives its continuing architectural identity not only from its initial implementation, but from the ongoing preservation of its governing principles, structural relationships, and risk-mitigating characteristics throughout the operational lifecycle of the infrastructure.

HLAS is therefore more than an architecture standard.

It is a standard for preserving architecture.

By combining standardized hydrogen logistics architectures with Dynamic Compliance, Real-Time Stewardship, and continuous architectural assurance, HLAS provides a living architectural framework capable of supporting the orderly development of hydrogen infrastructure while preserving the defining characteristics that enable long-term scalability, interoperability, resilience, and investment confidence.

It is intended that HLAS will continue to evolve alongside the hydrogen economy. Future editions may introduce additional Architecture Classes, new infrastructure building blocks, emerging logistics models, enhanced stewardship mechanisms, and further guidance informed by implementation experience and technological advancement. Such evolution, however, shall continue to preserve the fundamental architectural principles upon which HLAS is founded, ensuring that the Standard remains relevant, rigorous, and capable of supporting the long-term development of hydrogen logistics infrastructure.

EXECUTIVE SUMMARY

The **Hydrogen Logistics Architecture Standard (HLAS)** establishes a comprehensive architecture and assurance framework for the planning, development, operation, expansion, and long-term stewardship of hydrogen logistics infrastructure.

HLAS provides a common architectural foundation for regional hydrogen systems by defining standardized Architecture Classes, governing architectural principles, infrastructure building blocks, topology rules, system boundaries, and stakeholder responsibilities for hydrogen production, aggregation, transportation, storage, distribution, and export infrastructure.

Hydrogen logistics infrastructure is expected to evolve over many decades through the continuous addition, expansion, modification, and reconfiguration of production hubs, logistics corridors, aggregation hubs, industrial users, storage facilities, export infrastructure, and supporting assets. HLAS recognizes that this continuous evolution is an inherent characteristic of hydrogen infrastructure and a prerequisite for developing scalable regional and national hydrogen ecosystems.

Because hydrogen logistics is an open architecture, infrastructure evolution inevitably creates the risk of **Architectural Drift**, whereby individually rational decisions progressively erode the defining characteristics through which the architecture delivers interoperability, scalability, resilience, diversification, network coherence, and long-term investment value.

HLAS therefore establishes **Dynamic Compliance** as the mandatory architectural mechanism through which the defining characteristics of every Architecture Class are continuously preserved throughout the infrastructure lifecycle.

Rather than treating compliance as a one-time event, HLAS recognizes that architectural integrity exists only while it is continuously maintained. Accordingly, HLAS defines a family of **Dynamically Preserved Hydrogen Logistics Architectures (DPHAs)** whose architectural identity is preserved through the continuous application of Dynamic Compliance.

Through **Real-Time Stewardship**, HLAS continuously evaluates architecturally significant infrastructure evolution against the governing principles of the applicable Architecture Class, ensuring that hydrogen infrastructure may expand, adapt, and mature without compromising the architectural characteristics upon which its long-term value depends.

HLAS does not prescribe engineering design, production technologies, pipeline specifications, storage technologies, commercial arrangements, or regulatory frameworks. Instead, it establishes the architectural relationships and governing principles within which

such decisions are made, enabling independently developed infrastructure to function collectively as coherent, interoperable, and scalable hydrogen logistics systems.

By combining standardized hydrogen logistics architectures with continuous architectural preservation, HLAS provides a living architectural framework that supports long-term infrastructure development, reduces systemic infrastructure risk, preserves architectural integrity, and enables hydrogen ecosystems to evolve while maintaining the defining characteristics that justify their adoption.

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ASSURANCE STATEMENT

(Informative — Non-Normative)

HLAS provides architectural assurance by defining mandatory Architecture Classes whose defining characteristics are continuously preserved through Dynamic Compliance.

Unlike conventional architecture standards, which primarily assess conformance at a particular point in time, HLAS recognizes that hydrogen logistics infrastructure is an open architecture that evolves continuously throughout its operational life. Production assets, logistics corridors, aggregation hubs, storage facilities, industrial users, export infrastructure, and supporting systems may be added, expanded, modified, reconfigured, or retired as hydrogen markets develop.

Accordingly, architectural assurance cannot be established solely through initial conformance or periodic evaluation. Assurance depends upon the continuous preservation of the governing architectural principles, topology rules, system boundaries, and defining characteristics of the applicable Architecture Class as infrastructure evolves.

HLAS therefore provides assurance that an architecture continues to operate as the applicable Dynamically Preserved Hydrogen Logistics Architecture (DPHA) through the ongoing application of Dynamic Compliance.

The purpose of assurance under HLAS is not to preserve individual infrastructure assets or commercial arrangements. Rather, it is to preserve the architectural integrity, interoperability, scalability, resilience, and risk-mitigating characteristics that collectively define the applicable Architecture Class.

By continuously preserving these defining architectural characteristics, HLAS enables hydrogen logistics infrastructure to evolve while maintaining its architectural identity and long-term strategic value.

Accordingly, assurance under HLAS is founded upon Dynamic Compliance, the prevention of Architectural Drift, and the continuous preservation of the defining characteristics of every Dynamically Preserved Hydrogen Logistics Architecture established by this Standard.

CONTACT INFORMATION

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This document constitutes **Version 1.11** of the **Hydrogen Logistics Architecture Standard (HLAS)**.

HLAS establishes a standardized architectural framework for hydrogen production, aggregation, transportation, storage, distribution, and export infrastructure, together with a Dynamic Compliance framework for the continuous preservation of architectural integrity throughout the infrastructure lifecycle.

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- Issuing official interpretations, clarifications, and guidance relating to the application of this Standard;
- Establishing and administering the Dynamic Compliance framework and associated architectural assurance mechanisms;
- Defining and maintaining the criteria governing Dynamically Preserved Hydrogen Logistics Architectures (DPHAs);
- Maintaining the official HLAS Architecture Registry and associated architectural records, where applicable;
- Managing version control, revisions, and future editions of the Standard; and
- Preserving the integrity, consistency, and long-term evolution of the HLAS framework.

HLAS is intended to support the development of interoperable, scalable, and resilient hydrogen logistics infrastructure across jurisdictions and markets.

Governments, regional authorities, infrastructure developers, hydrogen producers, logistics providers, industrial users, financiers, insurers, regulators, standards organizations, and other stakeholders are encouraged to adopt, reference, and implement the architectural principles, Architecture Classes, and Dynamic Compliance framework established by HLAS in the planning, development, operation, expansion, and stewardship of hydrogen logistics infrastructure.

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This governance model ensures that HLAS remains a consistent, interoperable, and continuously evolving architectural framework whose defining characteristics are preserved across all implementations through the application of Dynamic Compliance and Real-Time Stewardship.

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This document constitutes the **Hydrogen Logistics Architecture Standard (HLAS)**.

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The Standard is published to enable the planning, evaluation, design, implementation, operation, expansion, and continuous evaluation of hydrogen logistics infrastructure in accordance with the architectural principles established by HLAS.

HLAS establishes stakeholder objectives, Architecture Principles, System Boundaries, Architecture Building Blocks, Architecture Rules, Dynamic Compliance Evaluation requirements, and the Architectural Risk Mitigation Framework governing Hydrogen Logistics Architectures.

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- Develop engineering methods, software tools, analytical models, and planning methodologies supporting implementation of HLAS; and
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Because the deployment of a Hydrogen Logistics Architecture is a multi-billion-dollar sovereign-scale infrastructure endeavor involving complex, multi-decade macro-coordination across independent production hubs, logistics corridors, backbone pipelines, industrial users, storage facilities, and export infrastructure, a physical HLAS deployment cannot execute in a regulatory or administrative vacuum.

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HYDROGEN LOGISTICS ARCHITECTURE STANDARD (HLAS) - CONCEPT OVERVIEW

(Informative — Non-Normative)

1. Purpose of This Overview

This section provides a concise, non-normative introduction to the **Hydrogen Logistics Architecture Standard (HLAS)** for readers encountering the framework for the first time. It explains what HLAS is, why it has been developed, and how it fundamentally differs from conventional hydrogen infrastructure planning approaches.

This overview is intended to provide architectural context and does not establish requirements, constraints, or compliance obligations. Normative requirements are defined in the subsequent provisions of this Standard.

2. What is HLAS?

The **Hydrogen Logistics Architecture Standard (HLAS)** is a comprehensive architecture and assurance standard for regional hydrogen infrastructure.

HLAS establishes standardized Architecture Classes, governing architectural principles, infrastructure building blocks, topology rules, system boundaries, stakeholder responsibilities, and Dynamic Compliance requirements for hydrogen production, aggregation, transportation, storage, distribution, and export systems.

Rather than defining individual infrastructure projects, HLAS defines how hydrogen infrastructure should be architected as coherent regional logistics systems capable of evolving over multiple decades while preserving their intended architectural characteristics.

HLAS recognizes that hydrogen infrastructure is inherently a long-life, capital-intensive system expected to expand incrementally as production capacity, demand, logistics networks, and market participation evolve. Accordingly, the Standard is designed not only to define architecture, but also to preserve its long-term integrity throughout continuous infrastructure evolution.

3. Why is HLAS Needed?

Hydrogen infrastructure is expected to develop through numerous independent projects undertaken by producers, industrial users, logistics providers, infrastructure developers, governments, financiers, and other stakeholders over extended time horizons.

Without a common architectural framework, infrastructure development may progressively result in:

- Fragmented production ecosystems;
- Isolated logistics corridors;
- Duplicated infrastructure;
- Incompatible regional networks;
- Excessive dependence on individual counterparties;
- Reduced scalability;
- Stranded infrastructure assets; and
- Diminished long-term investment value.

HLAS addresses these challenges by establishing a common architectural framework that enables independently developed infrastructure to function collectively as coherent, scalable, interoperable, and economically resilient hydrogen logistics systems.

4. Architecture Rather Than Individual Projects

HLAS does not prescribe the engineering design of individual facilities, pipelines, storage assets, production technologies, or transport modes.

Instead, HLAS governs the relationships between infrastructure components.

The Standard defines how Production Hubs, Regional Aggregation Hubs, Large Users, Small Users, Export Hubs, logistics pathways, Backbone Pipelines, storage systems, and supporting infrastructure shall be organized to preserve the defining characteristics of the applicable Architecture Class.

Accordingly, HLAS is an architecture standard rather than an engineering design standard.

5. Hydrogen Infrastructure as an Open Architecture

Hydrogen infrastructure is not constructed as a single project.

It evolves continuously through the addition, modification, expansion, retirement, and reconfiguration of production assets, logistics pathways, demand centers, aggregation hubs, storage facilities, export infrastructure, and supporting systems.

- New participants enter the system.
- Existing participants expand or contract.
- Demand patterns evolve.
- Infrastructure ownership changes.
- Technologies mature.

- Regional priorities shift.

HLAS recognizes this continuous evolution as an inherent characteristic of hydrogen logistics infrastructure.

Accordingly, every Architecture Class defined by HLAS is treated as an **Open Architecture** whose defining characteristics must remain preserved throughout its operational life despite continuous infrastructure evolution.

6. From Architecture to Living Architecture

Defining an architecture is only the first step.

The long-term value of an architecture depends upon preserving the characteristics through which it mitigates infrastructure risk.

Although an architecture may fully conform to its governing principles when initially implemented, subsequent infrastructure evolution may gradually erode those characteristics through a sequence of individually reasonable decisions.

HLAS refers to this progressive erosion of architectural integrity as **Architectural Drift**.

Because Architectural Drift is an inherent consequence of infrastructure evolution, HLAS establishes **Dynamic Compliance** as the governing mechanism through which every Architecture Class continuously preserves its defining architectural characteristics.

Accordingly, HLAS is not merely an architecture standard.

It is a standard for **living architectures** whose integrity is continuously maintained throughout the infrastructure lifecycle.

7. Relationship to the Rest of this Standard

This overview explains the philosophy and purpose of HLAS.

The normative sections that follow define:

- Governing architectural principles;
- Dynamic compliance requirements;
- Architecture classes;
- Infrastructure building blocks;
- Topology rules;
- System boundaries;
- Stakeholder responsibilities;

- Real-time stewardship;
- Architecture registry requirements; and
- Assurance and conformance provisions.

Together, these provisions establish HLAS as a comprehensive architecture and assurance framework for hydrogen logistics infrastructure.

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OPEN ARCHITECTURES, ARCHITECTURAL DRIFT AND DYNAMIC COMPLIANCE

(Informative — Non-Normative)

1. Architecture as a System of Risk Mitigation

Every architecture exists because it mitigates one or more categories of system-level risk. The architectural principles embodied within an infrastructure system are not arbitrary design choices; rather, they represent deliberate mechanisms for reducing complexity, improving resilience, enabling scalability, preserving interoperability, strengthening long-term investment value, and preventing undesirable system behaviour.

Within hydrogen infrastructure, architectural principles mitigate risks associated with fragmented infrastructure development, isolated production ecosystems, duplicated logistics assets, stranded infrastructure investment, excessive dependence on individual counterparties, incompatible regional expansion, and long-term loss of network coherence.

These risk-mitigating characteristics collectively constitute the architectural integrity of a Hydrogen Logistics Architecture.

An architecture derives its value not from its physical assets alone, but from the continued preservation of the structural relationships through which those assets collectively mitigate infrastructure risk.

2. Open Hydrogen Logistics Architectures

Hydrogen logistics infrastructure is inherently an open architecture.

Unlike infrastructure systems constructed as a single, fixed project, hydrogen logistics systems evolve continuously over many decades through the addition, modification, expansion, retirement, and reconfiguration of production facilities, logistics corridors, aggregation hubs, storage assets, export facilities, industrial users, and supporting infrastructure.

- New market participants enter the system.
- Existing participants expand production.
- Demand patterns evolve.
- Technologies mature.
- Ownership changes.
- Regional priorities shift.

Infrastructure therefore exists in a state of continuous evolution rather than static completion.

This continuous adaptability is one of the principal strengths of hydrogen logistics architecture. It enables infrastructure to respond to changing markets without requiring wholesale reconstruction of the underlying logistics system.

However, the same flexibility that enables long-term scalability also creates the conditions under which architectural integrity may gradually erode.

3. Architectural Drift

Although an architecture may fully conform to its governing principles when initially implemented, infrastructure rarely remains unchanged throughout its operational life.

Hydrogen infrastructure evolves through thousands of individual investment decisions undertaken by independent stakeholders over extended periods of time.

Each decision may appear technically justified and commercially beneficial when evaluated in isolation.

Collectively, however, these incremental changes may progressively alter the defining characteristics of the architecture itself.

HLAS refers to this gradual erosion of architectural integrity as **Architectural Drift**.

Architectural Drift is not the result of a single failure or isolated non-conformance.

Rather, it is the cumulative consequence of unmanaged infrastructure evolution.

Architectural Drift may occur even where every individual project appears locally rational and independently successful.

Without coordinated architectural governance, Architectural Drift may result in:

- fragmented hydrogen logistics systems;
- duplicated production and transportation infrastructure;
- excessive dependence upon individual demand centres;
- declining interoperability between independently developed infrastructure;
- reduced scalability;
- increasing stranded asset risk;
- diminished long-term bankability; and
- loss of the architectural characteristics that originally justified adoption of the applicable Architecture Class.

4. Why Architectural Drift is Inevitable

Architectural Drift is an inherent characteristic of every open infrastructure architecture.

Within hydrogen logistics systems, drift naturally arises through factors including:

- Commercial pressure to optimise individual projects rather than regional systems;
- Incremental project-by-project infrastructure development;
- Changing production technologies and market demand;
- Phased infrastructure expansion over multiple decades;
- Participation by numerous independent stakeholders with differing objectives;
- Evolving regulatory and commercial environments; and
- Gradual loss of institutional knowledge regarding the original architectural intent.

These forces are neither exceptional nor undesirable.

They are the natural consequence of infrastructure systems that remain economically active throughout long operational lifecycles.

Accordingly, Architectural Drift should be regarded as inevitable unless continuously managed.

5. Dynamic Compliance

Because hydrogen logistics architecture continuously evolves, architectural compliance cannot be determined solely at the time of initial implementation.

An architecture that satisfied every requirement when first deployed may gradually lose the defining characteristics through which it mitigates infrastructure risk.

HLAS therefore establishes **Dynamic Compliance** as the governing architectural mechanism through which the defining characteristics of each Architecture Class are continuously preserved throughout the planning, development, operation, expansion, modification, and long-term evolution of hydrogen logistics infrastructure.

Dynamic Compliance is the continuous evaluation and preservation of architectural integrity as infrastructure evolves.

Its purpose is not to preserve individual assets.

Its purpose is to preserve the architecture itself.

6. Dynamic Compliance as an Architectural Requirement

HLAS recognizes that architectural value depends not only upon initial conformance, but upon continued preservation.

Accordingly, Dynamic Compliance is not an optional governance activity.

It is an inherent architectural requirement.

Every architecturally significant change affecting topology, infrastructure relationships, production ecosystems, logistics pathways, aggregation structures, or regional network formation should preserve the governing characteristics of the applicable HLAS Architecture Class.

Compliance is therefore maintained continuously throughout the lifecycle of the architecture rather than verified only at isolated points in time.

7. Purpose within HLAS

The purpose of HLAS is not merely to define Hydrogen Logistics Architecture.

Its purpose is to ensure that the defining architectural characteristics remain continuously preserved throughout the lifecycle of an open and evolving hydrogen infrastructure system.

This objective is achieved through Dynamic Compliance, Real-Time Stewardship, Architecture Classes, and the assurance mechanisms established elsewhere within this Standard.

Together, these mechanisms preserve the architectural integrity, interoperability, scalability, resilience, and long-term investment value of hydrogen logistics infrastructure as it evolves.

An architecture that is no longer dynamically compliant has not merely become non-conforming; it has progressively ceased to be the architecture that HLAS defines. Dynamic Compliance therefore preserves not only compliance, but the architectural identity itself.

DYNAMICALLY PRESERVED HYDROGEN LOGISTICS ARCHITECTURES (DPHAs)

(Normative)

The Hydrogen Logistics Architecture Standard (HLAS) establishes a family of Architecture Classes that collectively define standardized hydrogen logistics architectures for the production, aggregation, transportation, storage, distribution, and export of hydrogen.

Every Architecture Class defined by HLAS shall, by definition, constitute a **Dynamically Preserved Hydrogen Logistics Architecture (DPHA)**.

A Dynamically Preserved Hydrogen Logistics Architecture is an Architecture Class whose defining architectural characteristics shall be continuously preserved throughout the operational life of the infrastructure system through Dynamic Compliance.

The architectural value of a DPHA derives not solely from its initial design or implementation, but from the continued preservation of the structural relationships, governing architectural principles, and system characteristics through which the architecture mitigates infrastructure risk, preserves interoperability, enables scalable expansion, supports long-term bankability, and maintains regional network coherence.

Hydrogen logistics infrastructure is an open architecture in which production assets, logistics corridors, aggregation hubs, storage facilities, industrial users, export infrastructure, and supporting systems may be added, modified, expanded, retired, or reconfigured throughout the lifecycle of the infrastructure. This continuous evolution is an inherent characteristic of hydrogen logistics systems.

However, unmanaged infrastructure evolution will inevitably result in **Architectural Drift**, progressively eroding the defining characteristics and risk-mitigating properties of the applicable Architecture Class.

Accordingly, every Architecture Class defined by HLAS shall be maintained through **Dynamic Compliance**.

Dynamic Compliance shall continuously evaluate architecturally significant changes against the governing principles, system boundaries, topology rules, mandatory architectural characteristics, and other applicable requirements of the relevant Architecture Class to ensure that infrastructure evolution preserves its architectural identity, integrity, and intended risk-mitigation properties.

An implementation that is no longer maintained through Dynamic Compliance shall no longer be regarded as operating as a Dynamically Preserved Hydrogen Logistics

Architecture, irrespective of whether its original implementation conformed to the applicable Architecture Class.

Initial conformance alone shall not preserve architectural status where subsequent infrastructure evolution results in Architectural Drift.

Dynamic Compliance is therefore an inherent and mandatory characteristic of every Dynamically Preserved Hydrogen Logistics Architecture defined by HLAS.

Together, the Architecture Classes established by this Standard and the Dynamic Compliance requirements governing their evolution ensure that HLAS functions as a living architectural framework whose defining characteristics are continuously preserved throughout the lifecycle of evolving hydrogen logistics infrastructure.

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THE PRINCIPLE OF CONTINUOUS ARCHITECTURAL PRESERVATION

(Informative — Non-Normative)

Hydrogen logistics infrastructure is expected to operate and evolve over many decades.

Throughout its operational lifecycle, new production facilities may be commissioned, additional hydrogen users may connect to the network, transportation infrastructure may expand, storage capacity may increase, export facilities may be developed, and regional hydrogen markets may evolve in response to changing economic, technological, regulatory, and societal conditions.

Such evolution is not exceptional; it is an inherent characteristic of hydrogen logistics infrastructure.

The long-term value of a Hydrogen Logistics Architecture therefore depends not only upon the quality of its initial design, but upon its ability to preserve the architectural characteristics through which it delivers interoperability, scalability, resilience, diversified market participation, efficient infrastructure utilisation, and long-term investment confidence.

HLAS recognizes that these architectural characteristics are not permanent properties established solely through initial implementation.

Rather, they are emergent properties of an architecture whose governing principles, structural relationships, system boundaries, and Architecture Rules continue to be preserved as the infrastructure evolves.

Where these architectural characteristics are no longer preserved, the architecture may progressively experience **Architectural Drift**, resulting in the erosion of the stakeholder outcomes and architectural risk mitigation characteristics that originally justified its adoption.

Accordingly, HLAS is founded upon a single governing principle:

The value of a Hydrogen Logistics Architecture exists only while its defining architectural characteristics continue to be preserved.

For this reason, HLAS establishes **Dynamic Compliance** as an inherent characteristic of the Standard rather than as a conventional conformity assessment process.

Dynamic Compliance continuously evaluates whether the Hydrogen Logistics Architecture continues to preserve the Architecture Principles, System Boundaries, Architecture Building Blocks, and Architecture Rules established by this Standard.

Only through this continuous preservation can the stakeholder outcomes, architectural integrity, and risk mitigation characteristics established by HLAS be expected to endure throughout the operational lifecycle of the hydrogen logistics system.

Accordingly, Dynamic Compliance is not an administrative function appended to the Standard.

It is the architectural mechanism through which the value of the Hydrogen Logistics Architecture itself is preserved.

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REAL-TIME STEWARDSHIP AND DYNAMIC COMPLIANCE

(Informative — Non-Normative)

HLAS establishes **Dynamic Compliance** as the mandatory mechanism through which the defining characteristics of every Dynamically Preserved Hydrogen Logistics Architecture (DPHA) are continuously preserved throughout the lifecycle of an evolving hydrogen infrastructure system.

Because hydrogen logistics infrastructure is an open architecture, production assets, logistics corridors, aggregation hubs, industrial users, storage facilities, export infrastructure, and supporting systems may evolve continuously in response to changing market conditions, technological developments, commercial decisions, regulatory requirements, and regional infrastructure expansion. Such evolution is an inherent characteristic of hydrogen logistics systems and is essential to their long-term development.

Continuous infrastructure evolution, however, creates the conditions under which Architectural Drift may progressively erode the defining characteristics of the applicable Architecture Class. Dynamic Compliance is therefore implemented through **Real-Time Stewardship**, the operational framework responsible for continuously evaluating architecturally significant changes against the governing principles, system boundaries, topology rules, and mandatory requirements established by HLAS.

The purpose of Real-Time Stewardship is to preserve the architecture rather than to manage the infrastructure itself.

Accordingly, Real-Time Stewardship is limited to architectural oversight. It continuously evaluates whether infrastructure evolution remains consistent with the applicable Architecture Class while respecting the independence of infrastructure owners, operators, developers, financiers, regulators, and other stakeholders.

Real-Time Stewardship does not direct engineering design, operational control, commercial arrangements, investment decisions, regulatory functions, or asset ownership. Responsibility for those matters remains entirely with the respective stakeholders.

Its sole purpose is to preserve the architectural integrity, identity, interoperability, scalability, resilience, and risk-mitigating characteristics of the applicable Dynamically Preserved Hydrogen Logistics Architecture as infrastructure evolves.

Together, Dynamic Compliance and Real-Time Stewardship enable HLAS to function as a living architectural framework in which operational flexibility, phased infrastructure

development, technological advancement, and market evolution can occur without compromising the defining architectural characteristics established by this Standard.

The detailed requirements governing Dynamic Compliance, Real-Time Stewardship, architectural evaluation, and ongoing preservation of Architecture Classes are defined in the normative provisions of this Standard.

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READER'S GUIDE — STRUCTURE AND USE OF THIS STANDARD

(Informative — Non-Normative)

This document contains both **normative** and **informative** material.

Normative sections establish the mandatory architectural principles, requirements, constraints, system boundaries, Architecture Classes, infrastructure rules, stakeholder responsibilities, and Dynamic Compliance obligations that define conformance with the **Hydrogen Logistics Architecture Standard (HLAS)**.

Informative sections provide architectural context, explanatory rationale, implementation guidance, background information, and the conceptual foundations supporting the normative requirements. Informative material is intended to assist understanding and implementation and does not, by itself, establish compliance with this Standard.

HLAS should be read as both an **architecture definition standard** and an **architecture preservation standard**.

The early sections explain the architectural concepts underlying hydrogen logistics systems, the nature of open architectures, the inevitability of Architectural Drift, and the role of Dynamic Compliance in preserving architectural integrity throughout the infrastructure lifecycle.

The subsequent normative sections establish the mandatory Architecture Principles, Architecture Classes, infrastructure building blocks, topology rules, Dynamic Compliance requirements, and governance provisions that collectively define and preserve Hydrogen Logistics Architectures.

Unlike conventional infrastructure standards, HLAS recognizes that architecture is not preserved by initial implementation alone. Hydrogen infrastructure evolves continuously through the addition, expansion, modification, retirement, and reconfiguration of infrastructure assets. Accordingly, HLAS should be understood as a **living architecture standard** in which the defining characteristics of every Architecture Class are continuously preserved through Dynamic Compliance.

The Standard is organized to guide the reader through the logical development of the HLAS framework:

- The introductory sections explain the purpose, philosophy, and architectural concepts underlying Hydrogen Logistics Architecture.

- The foundational technical sections establish Dynamic Compliance as the governing mechanism through which Architecture Classes are continuously preserved.
- The Architecture Principles define the mandatory characteristics upon which every HLAS Architecture Class is founded.
- The infrastructure building block, system boundary, and topology sections define the permissible structure, relationships, and operation of hydrogen logistics systems.
- The Architecture Class provisions establish the standardized hydrogen logistics architectures recognized by HLAS.
- The Dynamic Compliance and Real-Time Stewardship provisions establish how the defining characteristics of each Architecture Class are continuously preserved throughout the infrastructure lifecycle.
- The remaining normative sections define the detailed requirements governing implementation, evaluation, evolution, assurance, and long-term stewardship of hydrogen logistics infrastructure.

Readers seeking to understand the architectural philosophy should begin with the informative sections before progressing to the normative requirements.

Readers planning, designing, implementing, operating, evaluating, financing, regulating, or assessing hydrogen logistics infrastructure should apply the normative provisions of this Standard in their entirety, recognizing that conformance depends not only upon initial implementation but also upon maintaining Dynamic Compliance throughout the operational life of the applicable Architecture Class.

Accordingly, HLAS should be applied as a framework for the continuous preservation of architecture rather than as a standard whose requirements are satisfied solely through initial design or implementation.

HOW TO USE THIS STANDARD

(Informative — Non-Normative)

The **Hydrogen Logistics Architecture Standard (HLAS)** is intended to be applied throughout the complete lifecycle of hydrogen logistics infrastructure, from early strategic planning through long-term operation, expansion, and continuous architectural stewardship.

Unlike conventional infrastructure standards that are applied primarily during planning, design, or construction, HLAS is intended to support the continuous preservation of architecture throughout the operational life of an evolving hydrogen logistics system.

Accordingly, users of this Standard should apply its provisions in the sequence described below.

1. Understand the Architectural Philosophy

Before applying the technical provisions of HLAS, readers should become familiar with the architectural concepts presented in the informative sections of this Standard.

These sections explain:

- the purpose of Hydrogen Logistics Architecture;
- the characteristics of open hydrogen logistics systems;
- the nature of Architectural Drift;
- the role of Dynamic Compliance;
- the concept of Dynamically Preserved Hydrogen Logistics Architectures (DPHAs); and
- the assurance philosophy established by HLAS.

Understanding these concepts provides the context necessary for the correct interpretation and application of the normative provisions.

2. Identify the Applicable Architecture Class

Every hydrogen logistics implementation should be evaluated to determine the Architecture Class that most appropriately represents the intended hydrogen logistics system.

The selected Architecture Class establishes the governing architectural principles, infrastructure relationships, topology requirements, system boundaries, and Dynamic Compliance obligations applicable to the implementation.

All subsequent evaluation and implementation activities should be performed with reference to the applicable Architecture Class.

3. Apply the Normative Requirements

The normative provisions of HLAS define the mandatory requirements governing Hydrogen Logistics Architectures.

These include, as applicable:

- Architecture Principles;
- infrastructure building blocks;
- system boundaries;
- topology rules;
- Architecture Classes;
- stakeholder responsibilities;
- Dynamic Compliance requirements;
- Real-Time Stewardship provisions; and
- architectural assurance requirements.

These provisions should be applied collectively rather than in isolation.

Compliance with selected requirements does not, by itself, constitute conformity with HLAS.

4. Plan Infrastructure Within the Architectural Framework

HLAS governs the architecture of hydrogen logistics systems rather than the engineering design of individual infrastructure assets.

Engineering decisions relating to hydrogen production technologies, pipelines, storage facilities, compression systems, transportation methods, export facilities, safety systems, commercial arrangements, regulatory approvals, financing structures, and operational procedures remain the responsibility of the respective stakeholders.

Such decisions should, however, preserve the governing architectural characteristics established by the applicable Architecture Class.

5. Maintain Dynamic Compliance Throughout the Infrastructure Lifecycle

Hydrogen logistics infrastructure is expected to evolve continuously.

Production assets may expand.

New logistics corridors may be established.

Additional aggregation hubs may be constructed.

Industrial users may connect or disconnect.

Storage infrastructure may increase.

Export facilities may be developed.

Because these changes may affect the defining characteristics of the applicable Architecture Class, HLAS should be applied continuously rather than only during initial implementation.

Dynamic Compliance should therefore be maintained throughout the planning, development, operation, modification, expansion, and long-term evolution of the hydrogen logistics system.

6. Preserve Architectural Integrity

The objective of HLAS is not simply to demonstrate initial conformity with an Architecture Class.

Its purpose is to preserve the architectural integrity, identity, interoperability, scalability, resilience, and risk-mitigating characteristics that collectively define the applicable Hydrogen Logistics Architecture.

Infrastructure should therefore be evaluated not only for technical or commercial suitability, but also for its continuing consistency with the governing architectural principles established by this Standard.

7. Use HLAS as a Living Architectural Framework

HLAS should be applied as a living architectural framework rather than as a static design specification.

Its provisions are intended to support hydrogen logistics systems that continue to evolve over many decades while preserving the defining characteristics through which they achieve long-term scalability, interoperability, resilience, investment confidence, and regional network coherence.

Accordingly, successful application of HLAS is demonstrated not solely by initial implementation, but by the continuous preservation of the applicable Architecture Class through Dynamic Compliance.

Normative Sections

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SECTION 1

WHAT HYDROGEN INFRASTRUCTURE STAKEHOLDERS ARE SEEKING

(Normative)

The stakeholder outcomes identified in this section represent the intended characteristics of a Hydrogen Logistics Architecture established in accordance with the Hydrogen Logistics Architecture Standard (HLAS).

These outcomes shall not be presumed to persist solely by virtue of the initial planning, design, or implementation of a Hydrogen Logistics Architecture. They are dependent upon the continued preservation of the Architecture Principles, System Boundaries, Architecture Building Blocks, and Architecture Rules established by this Standard.

Accordingly, the continued realization of the stakeholder outcomes identified in this section is contingent upon the ongoing maintenance of Dynamic Compliance throughout the operational lifecycle of the Hydrogen Logistics Architecture.

Where Dynamic Compliance is not maintained, the architecture may progressively lose one or more of the stakeholder outcomes identified in this section through the effects of Architectural Drift.

1.1 General

Hydrogen logistics infrastructure represents long-life strategic infrastructure expected to operate and evolve over multiple decades. Such infrastructure is developed, financed, owned, regulated, operated, and expanded by numerous independent stakeholders whose individual objectives collectively determine the long-term success of the hydrogen ecosystem.

Although stakeholders perform different roles within the hydrogen value chain, they share a common expectation that hydrogen infrastructure should remain technically robust, commercially viable, scalable, interoperable, resilient, and capable of adapting to changing market conditions without compromising its long-term architectural integrity.

The Hydrogen Logistics Architecture Standard (HLAS) establishes Architecture Classes and governing architectural principles intended to satisfy these common objectives.

Accordingly, every Architecture Class defined by HLAS shall preserve the stakeholder objectives established in this section throughout the operational lifecycle of the infrastructure through Dynamic Compliance.

1.2 Long-Term Bankability

Hydrogen logistics infrastructure shall support long-term investment confidence by providing an architecture capable of preserving infrastructure value throughout its operational life.

The architecture shall promote characteristics that reduce systemic infrastructure risk, facilitate phased investment, support efficient infrastructure utilisation, and minimise the likelihood of stranded assets resulting from unmanaged infrastructure evolution.

1.3 Infrastructure Scalability

Hydrogen logistics infrastructure shall support incremental expansion without requiring fundamental redesign of the underlying architecture.

The architecture shall accommodate the orderly addition of new production facilities, logistics corridors, aggregation infrastructure, storage assets, industrial users, export facilities, and supporting infrastructure while preserving the defining characteristics of the applicable Architecture Class.

1.4 Network Interoperability

Hydrogen logistics infrastructure shall enable independently developed infrastructure components to operate collectively as an integrated logistics system.

The architecture shall preserve compatibility between infrastructure developed by different organizations, jurisdictions, technologies, and commercial participants, thereby enabling efficient regional and national hydrogen networks.

1.5 Supply Diversification

Hydrogen logistics infrastructure shall support diversified hydrogen production, transportation, storage, and utilisation pathways.

The architecture shall minimize unnecessary dependence upon individual infrastructure assets, production centers, logistics pathways, or market participants wherever practical, thereby improving long-term system resilience and market flexibility.

1.6 Infrastructure Resilience

Hydrogen logistics infrastructure shall be capable of maintaining acceptable levels of service despite infrastructure failures, operational disruptions, changing market conditions, evolving technologies, or regional expansion.

The architecture shall support the continued operation and adaptation of the hydrogen logistics system while preserving its governing architectural characteristics.

1.7 Open Market Participation

Hydrogen logistics infrastructure shall facilitate participation by multiple independent producers, logistics providers, infrastructure owners, industrial users, storage operators, export participants, and other stakeholders.

The architecture shall support equitable expansion of the hydrogen ecosystem without creating unnecessary architectural barriers to future participation.

1.8 Regional Integration

Hydrogen logistics infrastructure shall support the development of coherent regional, national, and cross-regional hydrogen logistics systems.

The architecture shall facilitate the orderly integration of independently developed infrastructure into larger hydrogen networks while preserving interoperability, scalability, and architectural consistency.

1.9 Infrastructure Evolution

Hydrogen logistics infrastructure shall be capable of continuous evolution throughout its operational lifecycle.

The architecture shall accommodate technological advancement, infrastructure expansion, changing market demand, regulatory developments, new commercial participants, and evolving operational requirements without compromising the governing characteristics of the applicable Architecture Class.

1.10 Preservation of Architectural Integrity

The defining characteristics established by the applicable HLAS Architecture Class shall be continuously preserved throughout the lifecycle of the hydrogen logistics system.

Architecturally significant changes shall not progressively erode the structural relationships, governing principles, topology rules, system boundaries, or other characteristics through which the architecture delivers interoperability, scalability, resilience, diversification, and long-term infrastructure value.

The continuous preservation of these characteristics shall be achieved through the application of Dynamic Compliance in accordance with the requirements established elsewhere in this Standard.

1.11 Relationship to the Remaining Provisions of this Standard

The stakeholder objectives established in this section constitute the architectural outcomes that HLAS is intended to achieve.

The subsequent sections of this Standard define the governing architectural principles, infrastructure building blocks, system boundaries, topology rules, Architecture Classes, Dynamic Compliance requirements, and Real-Time Stewardship mechanisms through which these objectives are established, maintained, and continuously preserved throughout the lifecycle of hydrogen logistics infrastructure.

Accordingly, every normative requirement contained within HLAS shall be interpreted as contributing to one or more of the stakeholder objectives established in this section.

SECTION 2

SYSTEM BOUNDARIES

(Normative)

2.1 General

The Hydrogen Logistics Architecture Standard (HLAS) establishes the architectural boundaries within which Hydrogen Logistics Architectures are defined, implemented, evaluated, and dynamically preserved.

System Boundaries distinguish those elements that constitute the Hydrogen Logistics Architecture from those that remain subject to engineering design, operational management, commercial arrangements, regulatory oversight, or other disciplines outside the scope of this Standard.

Accordingly, HLAS governs the **architectural relationships** between infrastructure components rather than the detailed design or operation of the individual components themselves.

2.2 Scope of the Hydrogen Logistics Architecture

An HLAS Architecture encompasses the regional hydrogen logistics system responsible for the production, aggregation, transportation, storage, distribution, and export of hydrogen.

Within HLAS, the architectural system includes:

- Production Hubs;
- Regional Aggregation Hubs;
- Large Users;
- Small Users;
- Export Hubs;
- Backbone Pipelines;
- Hydrogen Corridors;
- Corridor Cracking Facilities, where applicable;
- Supporting architectural relationships between these building blocks; and
- The topology, connectivity, and structural organisation of the hydrogen logistics network.

These elements collectively constitute the Hydrogen Logistics Architecture governed by this Standard.

2.3 Architectural Boundary

HLAS governs the relationships between architectural building blocks rather than their internal engineering implementation.

Accordingly, this Standard establishes requirements governing:

- Architectural topology;
- Infrastructure connectivity;
- Node relationships;
- Logistics pathways;
- Architecture classes;
- System expansion;
- Regional integration;
- Dynamic compliance; and
- Real-time stewardship.

The detailed engineering design of individual infrastructure assets remains outside the architectural boundary.

2.4 Engineering Boundary

The following matters remain outside the scope of HLAS:

- Hydrogen production technologies;
- Electrolyser selection;
- Reforming technologies;
- Carbon capture technologies;
- Pipeline materials;
- Pipeline mechanical design;
- Compressor design;
- Storage vessel design;
- Geological storage engineering;
- Pressure management systems;
- Process control systems;
- Instrumentation;
- Electrical systems;
- Civil engineering;
- Structural engineering;
- Safety engineering;
- Environmental engineering; and
- Detailed engineering specifications.

These matters shall be governed by the applicable engineering standards, regulations, and project-specific design requirements.

2.5 Operational Boundary

HLAS does not govern the operational management of hydrogen infrastructure.

Operational matters outside the scope of this Standard include:

- Facility operation;
- Maintenance;
- Dispatch;
- Scheduling;
- Asset management;
- Production optimisation;
- Logistics optimisation;
- Inventory management;
- Emergency response;
- Operational control; and
- Maintenance planning.

HLAS governs only the architectural framework within which such operational activities occur.

2.6 Commercial Boundary

HLAS does not prescribe commercial relationships between participants.

Commercial matters outside the scope of this Standard include:

- Hydrogen pricing;
- Contractual arrangements;
- Commercial negotiations;
- Financing structures;
- Ownership models;
- Investment decisions;
- Tariff methodologies;
- Commercial risk allocation;
- Procurement; and
- Market participation agreements.

These matters remain the responsibility of the respective stakeholders.

2.7 Regulatory Boundary

HLAS does not replace applicable legislation or regulatory requirements.

Nothing within this Standard shall supersede:

- National legislation;
- Regional regulations;
- Environmental approvals;
- Safety regulations;
- Pipeline licensing;
- Planning approvals;
- Export regulations;
- Market regulations; or
- Any other statutory obligations.

Compliance with HLAS does not constitute compliance with regulatory requirements.

Similarly, regulatory compliance alone does not constitute compliance with HLAS.

2.8 Technology Neutrality

HLAS is technology neutral.

The Architecture Classes established by this Standard apply irrespective of the hydrogen production technology, transportation medium, storage technology, or conversion process employed.

Accordingly, HLAS may be applied to hydrogen produced using, including but not limited to:

- Electrolysis;
- Steam methane reforming;
- Autothermal reforming;
- Biomass conversion;
- Thermochemical processes;
- Natural hydrogen;
- Or other production technologies.

Similarly, hydrogen may be transported as:

- Gaseous hydrogen;
- Liquid hydrogen;

- Ammonia;
- Liquid Organic Hydrogen Carriers (LOHCs);
- Methanol; or
- Other hydrogen carriers,

provided that the applicable Architecture Class continues to satisfy the governing architectural principles established by this Standard.

2.9 Infrastructure Evolution

The System Boundary established by HLAS shall remain valid throughout the continuous evolution of hydrogen infrastructure.

The addition, expansion, modification, retirement, or replacement of infrastructure assets shall not alter the architectural boundary, provided that the implementation continues to preserve the defining characteristics of the applicable Architecture Class through Dynamic Compliance.

Infrastructure evolution shall therefore be regarded as occurring within the architectural boundary rather than redefining it.

2.10 Boundary Preservation

The System Boundaries established by this Standard define the extent of the Hydrogen Logistics Architecture subject to Dynamic Compliance.

Architecturally significant changes occurring within these boundaries shall be evaluated in accordance with the Dynamic Compliance requirements established by HLAS.

Changes occurring outside these architectural boundaries shall not affect the conformity of the Hydrogen Logistics Architecture unless they materially alter the governing architectural principles, topology, structural relationships, or defining characteristics of the applicable Architecture Class.

The System Boundaries established by this section shall apply to every Architecture Class defined by HLAS and shall remain continuously preserved throughout the operational lifecycle of the hydrogen logistics system.

SECTION 3

ARCHITECTURE PRINCIPLES

(Normative)

3.1 General

The Architecture Principles established in this section define the fundamental principles upon which every Hydrogen Logistics Architecture (HLAS) Architecture Class is founded.

These principles translate the long-term objectives of hydrogen infrastructure stakeholders into mandatory architectural requirements that govern the planning, development, operation, expansion, and stewardship of hydrogen logistics systems.

The Architecture Principles are intended to mitigate the principal architectural risks associated with hydrogen infrastructure development, including demand fragmentation, infrastructure fragmentation, stranded asset risk, single off-taker dependency, scalability constraints, interoperability challenges, network incompatibility, and long-term bankability concerns.

Every Architecture Class defined by HLAS shall conform to these Architecture Principles.

The Architecture Rules, Architecture Classes, and Dynamic Compliance requirements established elsewhere in this Standard shall be interpreted as mechanisms through which these principles are implemented and continuously preserved.

3.2 Principle 1 — Aggregated Demand

Hydrogen logistics infrastructure shall be developed around **aggregated regional demand** rather than isolated individual consumers.

Regional demand aggregation improves infrastructure utilisation, strengthens investment viability, supports efficient capital deployment, and reduces dependence upon individual demand centres.

Accordingly, hydrogen infrastructure shall preferentially serve diversified regional demand ecosystems capable of supporting long-term infrastructure utilisation.

This principle mitigates:

- Demand Fragmentation Risk;
- Under-utilisation Risk;

- Premature Infrastructure Development Risk; and
- Stranded Asset Risk.

3.3 Principle 2 — Diversified Offtake

Hydrogen logistics infrastructure shall not depend upon a single customer or a limited number of counterparties for its long-term economic viability.

The architecture shall encourage diversified hydrogen demand through multiple independent industrial users, regional demand aggregation, and expanding hydrogen markets.

Diversification reduces concentration risk, improves resilience against changing market conditions, and strengthens long-term infrastructure bankability.

This principle mitigates:

- Single Off-Taker Dependency Risk;
- Stranded Asset Risk; and
- Long-Term Bankability Risk.

3.4 Principle 3 — Shared Infrastructure

Hydrogen logistics infrastructure shall maximize the use of shared infrastructure wherever practical.

Production facilities, transportation systems, storage infrastructure, aggregation hubs, and supporting logistics assets should be capable of serving multiple independent participants rather than dedicated single-purpose applications.

Shared infrastructure improves utilisation, increases capital efficiency, reduces duplication of assets, and strengthens the long-term economic performance of the hydrogen logistics system.

This principle mitigates:

- Corridor Inefficiency Risk;
- Under-utilisation Risk; and
- Capital Allocation Risk.

3.5 Principle 4 — Production Consolidation

Hydrogen production should be organised around strategically located Production Hubs capable of supporting multiple demand centres and logistics pathways.

Consolidated production improves economies of scale, enables efficient infrastructure deployment, simplifies future network expansion, and strengthens regional supply ecosystems.

This principle mitigates:

- Distributed Production Risk;
- Infrastructure Fragmentation Risk; and
- Cost Competitiveness Risk.

3.6 Principle 5 — Scalability

Hydrogen logistics infrastructure shall support incremental expansion without requiring fundamental redesign of the underlying Architecture Class.

The architecture shall accommodate additional production capacity, transportation infrastructure, aggregation hubs, industrial users, storage systems, export facilities, and supporting infrastructure while preserving its defining architectural characteristics.

This principle mitigates:

- Scalability Risk;
- Expansion Compatibility Risk; and
- Architectural Drift Risk.

3.7 Principle 6 — Interoperability

Hydrogen logistics infrastructure shall be developed using common architectural principles that enable independently developed infrastructure to operate as coherent regional and national hydrogen logistics systems.

Infrastructure developed by different organizations, at different times, or using different technologies shall remain capable of integration within the applicable HLAS Architecture Class.

This principle mitigates:

- Network Incompatibility Risk;
- Interoperability Risk; and
- Expansion Compatibility Risk.

3.8 Principle 7 — Export Optionality

Hydrogen logistics infrastructure shall preserve the ability to support both domestic and export-oriented hydrogen markets wherever appropriate.

Architecture should maintain strategic flexibility so that future market evolution does not require fundamental architectural redesign.

The architecture shall therefore preserve optionality for domestic utilisation, regional distribution, international trade, and export development.

This principle mitigates:

- Export Integration Risk; and
- Market Evolution Risk.

3.9 Principle 8 — Network Formation

Hydrogen infrastructure shall be developed as components of future regional and national hydrogen logistics networks rather than as isolated infrastructure projects.

Every implementation should contribute toward the progressive formation of larger interoperable hydrogen ecosystems capable of supporting multiple producers, multiple users, multiple logistics pathways, and multiple markets.

This principle mitigates:

- Infrastructure Fragmentation Risk;
- Backbone Misalignment Risk;
- Architectural Drift Risk; and
- Network Incompatibility Risk.

3.10 Principle 9 — Long-Term Bankability

Hydrogen logistics infrastructure shall preserve its long-term economic relevance, interoperability, scalability, resilience, and adaptability throughout its operational life.

Architectural decisions shall prioritize long-term infrastructure value over short-term optimisation.

Every Architecture Class shall support investment confidence by preserving the structural characteristics that enable efficient expansion, diversified utilisation, and sustained economic performance.

This principle mitigates:

- Long-Term Bankability Risk;
- Stranded Asset Risk; and
- Capital Allocation Risk.

3.11 Principle 10 — Architectural Preservation

The defining characteristics of every HLAS Architecture Class shall be continuously preserved throughout the operational lifecycle of the hydrogen logistics system.

Hydrogen logistics infrastructure is an open architecture that continuously evolves through the addition, expansion, modification, and reconfiguration of infrastructure assets and market participants.

Accordingly, architecturally significant changes shall preserve the governing architectural principles, topology rules, system boundaries, infrastructure relationships, and defining characteristics established by this Standard.

The continued preservation of these characteristics shall be achieved through **Dynamic Compliance**.

An implementation that no longer preserves the defining characteristics of its applicable Architecture Class shall no longer be regarded as operating as a Dynamically Preserved Hydrogen Logistics Architecture (DPHA), irrespective of its original implementation.

This principle mitigates:

- Architectural Drift Risk;
- Loss of Architectural Identity;
- Infrastructure Fragmentation Risk; and
- Long-Term Loss of Architectural Integrity.

3.12 Relationship to the Remaining Provisions of this Standard

The Architecture Principles established in this section constitute the normative foundation of the Hydrogen Logistics Architecture Standard.

The Architecture Rules establish how these principles are implemented.

The Architecture Classes define standardized hydrogen logistics architectures that embody these principles.

Dynamic Compliance continuously evaluates and preserves these principles as hydrogen infrastructure evolves.

Accordingly, every normative provision contained within HLAS shall be interpreted in a manner that preserves and advances the Architecture Principles established in this section.

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SECTION 4

DYNAMIC COMPLIANCE

(Normative)

4.1 General

Hydrogen logistics infrastructure is an open and continuously evolving system. Throughout its operational lifecycle, production assets, aggregation hubs, storage facilities, transportation infrastructure, distribution networks, export facilities, and industrial users may be added, expanded, modified, reconfigured, or retired in response to changing market conditions, technological developments, regulatory requirements, commercial opportunities, and regional infrastructure growth.

Such evolution is an inherent characteristic of hydrogen logistics infrastructure and is essential for the development of scalable regional and national hydrogen ecosystems.

Accordingly, HLAS recognizes that the defining characteristics of an Architecture Class cannot be preserved solely through initial implementation. They shall be continuously maintained throughout the lifecycle of the infrastructure through Dynamic Compliance.

4.2 Open Hydrogen Logistics Architecture

Every Architecture Class established by HLAS shall be regarded as an **Open Hydrogen Logistics Architecture**.

An Open Hydrogen Logistics Architecture is an infrastructure architecture that is expected to evolve continuously while preserving its governing architectural principles.

Continuous infrastructure evolution includes, but is not limited to:

- Commissioning of new hydrogen production facilities;
- Establishment of additional regional aggregation hubs;
- Expansion of backbone pipeline infrastructure;
- Development of new storage facilities;
- Connection of additional industrial users;
- Construction of export terminals;
- Retirement or replacement of infrastructure assets;
- Changes in ownership or operational responsibility; and
- Integration of emerging hydrogen technologies.

Such evolution shall not invalidate the applicable Architecture Class provided the governing architectural characteristics continue to be preserved.

4.3 Architectural Drift

Architectural Drift is the progressive loss of the defining characteristics of an Architecture Class resulting from unmanaged infrastructure evolution.

Architectural Drift may occur through the cumulative effect of individually reasonable infrastructure decisions that, collectively, alter the structural relationships upon which the Architecture Class depends.

Architectural Drift is not necessarily associated with engineering failure, operational failure, or regulatory non-compliance.

Rather, it occurs when infrastructure evolution progressively departs from the governing architectural principles established by this Standard.

Examples of Architectural Drift include:

- Progressive fragmentation of hydrogen logistics networks;
- Erosion of infrastructure interoperability;
- Increasing dependence upon individual infrastructure assets or market participants;
- Degradation of network scalability;
- Reduction in architectural resilience;
- Increasing stranded asset risk; and
- Loss of the defining characteristics of the applicable architecture class.

Architectural Drift shall be regarded as an inherent risk associated with all open hydrogen logistics architectures.

4.4 Dynamic Compliance

Dynamic Compliance is the continuous process through which the defining characteristics of an HLAS Architecture Class are preserved throughout the lifecycle of an evolving hydrogen logistics system.

Dynamic Compliance shall continuously evaluate architecturally significant infrastructure changes to determine whether the applicable Architecture Class continues to satisfy the governing principles, mandatory requirements, system boundaries, topology rules, and architectural characteristics established by this Standard.

Dynamic Compliance shall apply throughout the planning, development, implementation, operation, expansion, modification, and long-term evolution of hydrogen logistics infrastructure.

Compliance with HLAS shall therefore be regarded as a continuous architectural state rather than a one-time assessment.

4.5 Architectural Identity

Each HLAS Architecture Class possesses an **Architectural Identity** established by its governing architectural principles, mandatory structural relationships, topology rules, infrastructure building blocks, and defining characteristics.

Architectural Identity distinguishes one Architecture Class from another and preserves the functional, operational, and strategic characteristics through which the architecture achieves its intended objectives.

An implementation shall retain its Architectural Identity only while the defining characteristics of the applicable Architecture Class continue to be preserved.

Where Architectural Drift materially alters those defining characteristics, the implementation shall no longer be regarded as operating as the applicable HLAS Architecture Class.

4.6 Architecture Lifecycle

The lifecycle of a Hydrogen Logistics Architecture extends beyond initial planning and implementation.

For the purposes of HLAS, the architecture lifecycle includes:

- Strategic planning;
- Architectural design;
- Infrastructure development;
- Commissioning;
- Operation;
- Phased expansion;
- Infrastructure modification;
- Integration of new participants;
- Technological evolution;
- Long-term stewardship; and
- Eventual decommissioning or replacement.

Dynamic Compliance shall apply throughout every stage of this lifecycle.

4.7 Dynamically Preserved Hydrogen Logistics Architectures

Every Architecture Class established by HLAS shall operate as a **Dynamically Preserved Hydrogen Logistics Architecture (DPHA)**.

A DPHA is an Architecture Class whose Architectural Identity is continuously preserved through Dynamic Compliance despite ongoing infrastructure evolution.

The continued recognition of an implementation as a DPHA depends upon the preservation of its governing architectural characteristics rather than the historical fact that it originally conformed to the applicable Architecture Class.

Accordingly, initial implementation alone shall not preserve DPHA status where Architectural Drift subsequently occurs.

4.8 Dynamic Compliance Requirements

Every implementation claiming conformity with an HLAS Architecture Class shall maintain Dynamic Compliance throughout its operational lifecycle.

Dynamic Compliance shall require continuous evaluation of architecturally significant changes affecting, but not limited to:

- Infrastructure topology;
- System boundaries;
- Connectivity between infrastructure components;
- Architecture building blocks;
- Hydrogen logistics pathways;
- Stakeholder relationships that influence architectural behaviour; and
- Any other changes capable of affecting the defining characteristics of the applicable architecture class.

The detailed procedures, evaluation methodologies, governance mechanisms, and stewardship responsibilities governing Dynamic Compliance are established in subsequent sections of this Standard.

4.9 Fundamental Principle

The stakeholder objectives established in Section 1 can be achieved only while the defining characteristics of the applicable HLAS Architecture Class are continuously preserved.

Accordingly, Dynamic Compliance is an inherent and mandatory characteristic of every Architecture Class defined by this Standard.

An implementation that does not maintain Dynamic Compliance shall not be regarded as operating as a Dynamically Preserved Hydrogen Logistics Architecture, irrespective of its original conformance.

Dynamic Compliance therefore preserves not only architectural conformity, but the Architectural Identity, integrity, and long-term value of the hydrogen logistics system itself.

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SECTION 5

ARCHITECTURE BUILDING BLOCKS

(Normative)

5.1 General

The Hydrogen Logistics Architecture Standard (HLAS) establishes a standardized set of Architecture Building Blocks that collectively define the structure of every Hydrogen Logistics Architecture.

Each Architecture Building Block performs a distinct architectural function within the hydrogen logistics system. Together, these building blocks provide a common architectural language through which hydrogen infrastructure can be planned, implemented, expanded, evaluated, and continuously preserved through Dynamic Compliance.

The Architecture Building Blocks defined by this Standard are strategic architectural elements. They define the role and relationships of infrastructure within the hydrogen logistics system rather than the engineering design of individual facilities or assets.

Every HLAS Architecture Class shall be composed exclusively of the Architecture Building Blocks defined in this section.

5.2 Architecture Building Blocks

HLAS establishes the following Architecture Building Blocks:

Primary Architecture Nodes

- Production Hub (PH)
- Regional Aggregation Hub (RAH)
- Large User (LU)
- Small User (SU)
- Export Hub (EH)

Conditional Architecture Node

- Corridor Cracking Facility (CCF)

Architecture Links

- Hydrogen Corridor

- Backbone Pipeline

These building blocks collectively define the architectural structure of every Hydrogen Logistics Architecture.

5.3 Production Hub (PH)

Definition

A **Production Hub (PH)** is a geographically defined hydrogen production ecosystem comprising one or more hydrogen production facilities and associated infrastructure that collectively serve as the origin of a Hydrogen Corridor.

A Production Hub represents the principal supply node within an HLAS Architecture and forms the architectural origin of hydrogen logistics flows.

Architectural Purpose

The Production Hub shall:

- consolidate hydrogen production;
- support multiple production facilities;
- accommodate multiple production technologies;
- enable phased expansion of production capacity;
- support interconnection with Backbone Pipelines; and
- establish the origin of a Hydrogen Corridor.

Mandatory Characteristics

Every Production Hub shall:

- occupy **End 1** of a Hydrogen Corridor;
- serve as the unique origin of that Corridor;
- support incremental expansion without altering its architectural identity;
- preserve compatibility with the applicable HLAS Architecture Class.

Infrastructure Constituents

A Production Hub may include:

- one or more hydrogen production plants;
- multiple production technologies;
- multiple independent producers;
- hydrogen compression facilities;

- hydrogen storage;
- carrier conversion or synthesis facilities;
- shared utilities;
- processing facilities;
- interconnections to Backbone Pipelines; and
- supporting operational infrastructure.

The internal engineering configuration of these facilities does not alter the architectural identity of the Production Hub.

5.4 Regional Aggregation Hub (RAH)

Definition

A **Regional Aggregation Hub (RAH)** is a regional demand aggregation node that consolidates hydrogen demand from multiple Small Users.

The Regional Aggregation Hub represents the principal architectural mechanism through which fragmented regional demand is transformed into economically sustainable hydrogen logistics demand.

Architectural Purpose

The Regional Aggregation Hub shall:

- aggregate regional hydrogen demand;
- reduce dependence upon individual counterparties;
- support diversified infrastructure utilisation;
- improve corridor viability;
- enable regional hydrogen distribution.

Mandatory Characteristics

Every Regional Aggregation Hub shall:

- aggregate demand from at least two Small Users;
- not aggregate another Regional Aggregation Hub;
- remain an independent aggregation node;
- preserve diversified regional demand.

Infrastructure Constituents

A Regional Aggregation Hub may include:

- local distribution manifolds;
- hydrogen storage;
- compression facilities;
- pressure management infrastructure;
- carrier regeneration facilities where applicable;
- distribution infrastructure;
- supporting operational facilities.

5.5 Large User (LU)

Definition

A **Large User (LU)** is a significant hydrogen consumer directly connected to a Hydrogen Corridor.

Large Users contribute to corridor utilisation but do not determine corridor viability.

Architectural Purpose

The Large User shall:

- improve infrastructure utilisation;
- increase hydrogen demand;
- support industrial decarbonisation;
- enhance corridor economics.

Mandatory Characteristics

A Large User:

- shall occupy intermediate positions only;
- shall not define corridor termination;
- may occur multiple times within a Corridor;
- shall remain an optional architectural node.

5.6 Small User (SU)

Definition

A **Small User (SU)** is a hydrogen consumer whose individual demand is insufficient to justify direct connection to a Hydrogen Corridor.

Small Users participate in the hydrogen ecosystem through a Regional Aggregation Hub rather than through direct corridor connection.

Architectural Purpose

The Small User enables:

- regional demand diversification;
- distributed hydrogen adoption;
- efficient utilisation of aggregation infrastructure.

Mandatory Characteristics

Every Small User:

- shall connect through one Regional Aggregation Hub;
- shall not connect directly to a Hydrogen Corridor;
- shall not constitute a Corridor node.

5.7 Export Hub (EH)

Definition

An **Export Hub (EH)** is a terminal architectural node representing international or inter-regional hydrogen export infrastructure.

It forms the terminal destination of export-oriented Hydrogen Corridors.

Architectural Purpose

The Export Hub shall:

- support hydrogen export;
- preserve export optionality;
- provide access to international hydrogen markets.

Mandatory Characteristics

Every Export Hub:

- shall occupy End 2 only;
- shall not occupy intermediate positions;
- shall be unique within a Corridor.

5.8 Corridor Cracking Facility (CCF)

Definition

A **Corridor Cracking Facility (CCF)** is a conditional architectural node deployed exclusively on Hydrogen Corridors transporting hydrogen as a chemical carrier.

Its purpose is to regenerate pure gaseous hydrogen for intermediate Large Users requiring gaseous hydrogen delivery.

Architectural Purpose

The Corridor Cracking Facility shall:

- regenerate hydrogen from chemical carriers;
- support intermediate gaseous hydrogen delivery;
- preserve architectural continuity for carrier-based corridors.

Mandatory Characteristics

A Corridor Cracking Facility:

- shall only be deployed on chemical carrier corridors;
- shall occupy intermediate positions only;
- shall not alter the identity of the Hydrogen Corridor.

5.9 Hydrogen Corridor

Definition

A **Hydrogen Corridor** is the primary architectural logistics pathway connecting a Production Hub with regional demand and, where applicable, export infrastructure.

A Hydrogen Corridor may represent:

- pipeline infrastructure;
- virtual pipeline systems;
- rail logistics;
- road transport;
- inland waterways;
- maritime logistics; or
- combinations thereof.

The Corridor is an architectural logistics pathway rather than a specific transportation technology.

Architectural Purpose

The Hydrogen Corridor shall:

- transport hydrogen between architectural nodes;
- support regional hydrogen logistics;
- preserve corridor integrity;
- enable scalable expansion.

5.10 Backbone Pipeline

Definition

A **Backbone Pipeline** is a high-capacity architectural interconnection linking Production Hubs.

Backbone Pipelines establish regional supply connectivity by interconnecting independent production ecosystems without altering the identity of individual Hydrogen Corridors.

Architectural Purpose

The Backbone Pipeline shall:

- interconnect Production Hubs;
- improve regional supply resilience;
- support network formation;
- enable future hydrogen market expansion.

Mandatory Characteristics

A Backbone Pipeline:

- shall connect Production Hub to Production Hub;
- shall not terminate at Regional Aggregation Hubs;
- shall not terminate at Large Users;
- shall not terminate at Small Users;
- shall not terminate at Export Hubs.

5.11 Supporting Infrastructure

HLAS recognizes that Architecture Building Blocks may contain engineering infrastructure necessary for their operation.

Such infrastructure supports the architectural function of the Building Block but does not constitute independent Architecture Building Blocks.

Supporting infrastructure may include:

- Geological hydrogen storage;
- Compression facilities;
- Pressure management systems;
- Metering stations;
- Process equipment;
- Virtual pipeline infrastructure;
- Multimodal distribution facilities;
- Carrier conversion facilities;
- Carrier regeneration facilities;
- Network cross-over infrastructure;
- Utilities;
- Control systems; and
- Other engineering assets necessary to support the architectural role of the building block.

The presence, absence, or engineering configuration of supporting infrastructure shall not, by itself, alter the architectural identity of the applicable Building Block.

5.12 Relationship to Dynamic Compliance

The Architecture Building Blocks established in this section constitute the fundamental structural elements of every HLAS Architecture Class.

The permissible relationships between these Building Blocks are defined by the Architecture Rules established elsewhere in this Standard.

Dynamic Compliance shall continuously preserve the architectural relationships, functions, and governing characteristics of these Building Blocks throughout the operational lifecycle of the Hydrogen Logistics Architecture.

SECTION 6

ARCHITECTURE RULES

(Normative)

6.1 General

The Architecture Rules established in this section define the mandatory relationships between the Architecture Building Blocks of the Hydrogen Logistics Architecture Standard (HLAS).

These rules ensure that Hydrogen Logistics Architectures preserve the Architecture Principles established by this Standard while mitigating the principal architectural risks associated with hydrogen infrastructure development.

Every HLAS Architecture Class shall conform to the Architecture Rules defined in this section.

6.2 Corridor Structure

Every Hydrogen Corridor shall comprise three architectural regions:

- **End 1**
- **Intermediate Length**
- **End 2**

Every Architecture Building Block shall occupy only those positions permitted by this Standard.

6.3 End 1 Rule

End 1 of every Hydrogen Corridor shall contain exactly one **Production Hub (PH)**.

No other Architecture Building Block shall occupy End 1.

The Production Hub shall constitute the architectural origin of the Hydrogen Corridor.

6.4 End 2 Rule

End 2 of every Hydrogen Corridor shall contain exactly one of the following:

- Regional Aggregation Hub (RAH); or
- Export Hub (EH).

Large Users shall not occupy End 2.

Production Hubs shall not occupy End 2.

Small Users shall not occupy End 2.

Corridor Cracking Facilities shall not occupy End 2.

6.5 Intermediate Position Rule

Intermediate positions within a Hydrogen Corridor may contain:

- one or more Large Users;
- one or more Regional Aggregation Hubs;
- one or more Corridor Cracking Facilities where the Corridor transports hydrogen as a chemical carrier.

Export Hubs shall not occupy Intermediate positions.

Production Hubs shall not occupy Intermediate positions.

Small Users shall not occupy Intermediate positions.

6.6 Regional Demand Rule

Every Hydrogen Corridor shall contain at least one Regional Aggregation Hub.

A Hydrogen Corridor that does not contain a Regional Aggregation Hub shall not constitute a valid HLAS Architecture.

The Regional Aggregation Hub may occupy:

- an Intermediate position; or
- End 2.

This requirement ensures that every Hydrogen Corridor serves aggregated regional demand rather than functioning solely as a dedicated point-to-point transportation link.

6.7 Demand Aggregation Rule

Every Regional Aggregation Hub shall aggregate demand from not fewer than two Small Users.

Regional Aggregation Hubs shall not aggregate other Regional Aggregation Hubs.

Each Regional Aggregation Hub shall function as an independent regional demand aggregation node.

6.8 Small User Connectivity Rule

Every Small User shall connect to exactly one Regional Aggregation Hub.

Small Users shall not connect directly to:

- Hydrogen Corridors;
- Production Hubs;
- Export Hubs;
- Backbone Pipelines; or
- Large Users.

6.9 Large User Rule

Large Users are optional Architecture Building Blocks.

Large Users improve corridor utilisation but shall not determine corridor viability.

The continued architectural validity of a Hydrogen Corridor shall not depend upon the presence of one or more Large Users.

6.10 Backbone Pipeline Rule

Backbone Pipelines shall connect Production Hubs.

Permitted connection:

PH ↔ PH

Backbone Pipelines shall not terminate at:

- Regional Aggregation Hubs;
- Large Users;
- Small Users; or
- Export Hubs.

Backbone Pipelines preserve regional supply connectivity without altering the identity of individual Hydrogen Corridors.

6.11 Production Hub Rule

Each Hydrogen Corridor shall originate from one unique Production Hub.

A Production Hub shall serve one Hydrogen Corridor.

Production Hubs may subsequently be interconnected through Backbone Pipelines as part of a regional hydrogen network.

6.12 Export Rule

Where hydrogen export forms part of the applicable Architecture Class, the Hydrogen Corridor shall terminate at one Export Hub.

Only one Export Hub shall be permitted within a Hydrogen Corridor.

6.13 Chemical Carrier Rule

Where hydrogen is transported as:

- Ammonia;
- Liquid Organic Hydrogen Carrier (LOHC);
- Methanol; or
- another approved hydrogen carrier,

Corridor Cracking Facilities may be deployed along the Intermediate Length of the Hydrogen Corridor to regenerate gaseous hydrogen for intermediate Large Users.

Regional Aggregation Hubs receiving hydrogen via chemical carriers shall include appropriate carrier regeneration capability where gaseous hydrogen distribution is required.

6.14 Corridor Integrity Rule

Every Hydrogen Corridor shall preserve the defining characteristics of the applicable Architecture Class.

The addition, removal, or modification of Architecture Building Blocks shall not invalidate the Hydrogen Corridor provided the Architecture Rules established by this Standard continue to be satisfied.

Architecturally significant changes shall be evaluated through Dynamic Compliance.

6.15 Regional Architecture Rule

A Hydrogen Logistics Region may contain:

- one or more Hydrogen Corridors;
- one or more Production Hubs;
- one or more Regional Aggregation Hubs;
- one or more Export Hubs; and
- one or more Backbone Pipelines interconnecting Production Hubs.

The Region shall represent the highest architectural entity governed by HLAS.

6.16 Architecture Conformance

A Hydrogen Logistics Architecture shall conform to this section only where all mandatory Architecture Rules applicable to the selected Architecture Class are satisfied.

Conformance with individual Architecture Rules shall not, by itself, constitute conformity with HLAS.

Architectural conformity shall be determined by the collective application of the Architecture Principles, Architecture Building Blocks, Architecture Rules, Architecture Classes, and the continued maintenance of Dynamic Compliance in accordance with this Standard.

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SECTION 7

DYNAMIC COMPLIANCE EVALUATION

(Normative)

The purpose of Dynamic Compliance is to ensure that HLAS implementations continuously preserve the system-level risk mitigation characteristics established by this Standard throughout their entire lifecycle.

HLAS establishes an architectural framework specifically designed to achieve defined system-level risk mitigation characteristics. These risk mitigation characteristics arise from the preservation of the architectural principles, Architecture Classes, relationships, interfaces, and other architecturally significant requirements established by this Standard.

HLAS implementations are inherently evolutionary. Throughout their lifecycle, hydrogen logistics infrastructure may be expanded, modified, or integrated with additional Production Hubs, Regional Aggregation Hubs, Export Hubs, Backbone Pipelines, logistics corridors, storage facilities, industrial users, and other architecturally significant infrastructure. Similarly, planning decisions, engineering designs, procurement activities, supplier proposals, technology selections, construction modifications, operational changes, and infrastructure expansion may progressively influence the architectural characteristics of the implementation.

Without continuous architectural oversight, such changes may introduce Architectural Drift, resulting in the progressive degradation of the system-level risk mitigation characteristics embodied within the applicable HLAS Architecture Class.

Accordingly, Dynamic Compliance has been incorporated into HLAS as the mechanism by which architecturally significant decisions and infrastructure changes are continuously evaluated throughout planning, design, procurement, construction, commissioning, operation, expansion, modification, and long-term stewardship to ensure that the applicable Architecture Class, and the associated system-level risk mitigation characteristics established by this Standard, are continuously preserved.

Dynamic Compliance is therefore fundamental to the effective implementation of HLAS and is necessary to ensure that the Standard continues to deliver its intended system-level risk mitigation outcomes throughout the entire lifecycle of an HLAS implementation.

7.1 General

The Hydrogen Logistics Architecture Standard (HLAS) does not establish a conventional certification or one-time conformity assessment process.

HLAS recognizes that hydrogen logistics infrastructure is an open architecture that evolves continuously throughout its operational lifecycle. Production assets, transportation infrastructure, aggregation hubs, storage facilities, industrial users, export infrastructure, and supporting systems may be added, expanded, modified, reconfigured, or retired over time.

Accordingly, architectural conformity cannot be established solely through an assessment performed at a single point in time.

Instead, HLAS establishes **Dynamic Compliance Evaluation** as the mechanism through which the defining characteristics of a Hydrogen Logistics Architecture are continuously evaluated and preserved throughout its lifecycle.

7.2 Purpose

The purpose of Dynamic Compliance Evaluation is to determine whether an evolving Hydrogen Logistics Architecture continues to satisfy the Architecture Principles, Architecture Building Blocks, System Boundaries, and Architecture Rules established by this Standard.

Dynamic Compliance Evaluation preserves the architectural integrity of the hydrogen logistics system by identifying Architectural Drift before it materially alters the defining characteristics of the architecture.

Accordingly, Dynamic Compliance Evaluation provides continuous architectural assurance rather than one-time certification.

7.3 Authority to Perform Dynamic Compliance Evaluation

Official Dynamic Compliance Evaluations conducted under the **Hydrogen Logistics Architecture Standard (HLAS)** shall be performed exclusively by **Novonanmek Material Sciences Private Limited** ("Novonanmek") or by organizations expressly authorized in writing by Novonanmek for that purpose.

No person or organization shall represent, issue, publish, or otherwise claim that a Hydrogen Logistics Architecture has been determined to be **Dynamically Compliant** under HLAS unless such determination has been made by Novonanmek or by an organization expressly authorized by Novonanmek.

Organizations may perform internal architectural assessments, design reviews, or self-evaluations using the principles and requirements established by this Standard. However, such assessments shall not be represented as official **Dynamic Compliance Evaluations** or as constituting official recognition under the HLAS framework.

For the purposes of this Standard, **Dynamic Compliance** is an official architectural assurance determination reserved exclusively to Novonanmek and its expressly authorized representatives.

7.4 Continuous Evaluation of Dynamic Compliance

Dynamic Compliance shall apply continuously throughout the lifecycle of an HLAS implementation and shall not be limited to operational infrastructure.

Architecturally significant activities undertaken during strategic planning, master planning, architecture development, engineering design, procurement, construction, commissioning, infrastructure expansion, modification, operation, and long-term stewardship shall be subject to Dynamic Compliance evaluation where such activities may influence the defining characteristics of the applicable HLAS Architecture Class.

Accordingly, Dynamic Compliance provides continuous architectural oversight from the initial conception of an HLAS implementation through its entire operational lifecycle, ensuring that architecturally significant decisions remain consistent with the governing principles and requirements of this Standard.

7.5 Evaluation Scope

Dynamic Compliance Evaluation shall evaluate the continued preservation of:

- the stakeholder objectives established by this Standard;
- the Architecture Principles;
- the System Boundaries;
- the Architecture Building Blocks;
- the Architecture Rules;
- the structural relationships between Building Blocks;
- regional demand aggregation;
- hydrogen logistics connectivity;
- network interoperability;
- scalability;
- architectural integrity; and
- architectural identity.

Evaluation shall consider the hydrogen logistics architecture as an integrated system rather than assessing individual infrastructure assets in isolation.

7.6 Architectural Drift

Dynamic Compliance Evaluation shall identify whether infrastructure evolution has resulted in Architectural Drift.

Architectural Drift occurs where cumulative infrastructure changes progressively alter the defining characteristics of the Hydrogen Logistics Architecture such that it no longer satisfies the governing Architecture Principles or Architecture Rules established by this Standard.

Architectural Drift may result from numerous individually acceptable changes that collectively compromise the architecture.

Accordingly, Dynamic Compliance Evaluation shall consider both the cumulative and systemic effects of infrastructure evolution.

7.7 Evaluation Triggers

Dynamic Compliance Evaluation should be undertaken whenever architecturally significant changes occur, including but not limited to:

- Establishment of new Production Hubs;
- Development of new Hydrogen Corridors;
- Modification of Corridor topology;
- Addition or removal of Regional Aggregation Hubs;
- Introduction of new Backbone Pipelines;
- Modification of hydrogen logistics pathways;
- Integration of new regional infrastructure;
- Retirement of significant infrastructure assets;
- Changes affecting regional demand aggregation; or
- Any other modification capable of altering the architectural characteristics established by HLAS.

Routine operational activities that do not affect the Hydrogen Logistics Architecture do not require Dynamic Compliance Evaluation.

7.8 Dynamic Compliance Status

Following Dynamic Compliance Evaluation, a Hydrogen Logistics Architecture shall be determined to be either:

Dynamically Compliant

The Hydrogen Logistics Architecture continues to satisfy the Architecture Principles, System Boundaries, Architecture Building Blocks, and Architecture Rules established by this Standard.

or

Architectural Drift Detected

Infrastructure evolution has materially altered one or more defining architectural characteristics established by this Standard.

Where Architectural Drift is detected, the implementation shall not be regarded as dynamically compliant until the architectural integrity of the Hydrogen Logistics Architecture has been restored.

7.9 Restoration of Dynamic Compliance

Detection of Architectural Drift does not necessarily require replacement of existing infrastructure.

Dynamic Compliance may be restored through architectural modifications that re-establish conformity with the Architecture Principles and Architecture Rules defined by this Standard.

The objective of restoration is to preserve the architecture rather than to preserve historical infrastructure configurations.

7.10 Dynamic Compliance as Continuous Architectural Assurance

Dynamic Compliance Evaluation provides continuous assurance that a Hydrogen Logistics Architecture continues to preserve the defining characteristics through which it delivers interoperability, scalability, resilience, regional integration, demand diversification, and long-term investment value.

Accordingly, Dynamic Compliance shall not be interpreted as a certification, accreditation, approval, licence, or regulatory authorization.

It is a continuous architectural evaluation process that determines whether an evolving Hydrogen Logistics Architecture continues to conform to the requirements established by this Standard.

7.11 Fundamental Principle

HLAS recognizes that the value of a Hydrogen Logistics Architecture is derived not solely from its initial implementation but from the continuous preservation of its defining architectural characteristics.

Accordingly, Dynamic Compliance Evaluation replaces conventional one-time certification with continuous architectural assurance.

An implementation shall be regarded as conforming to HLAS only while it remains dynamically compliant.

Loss of Dynamic Compliance signifies that the architecture has undergone Architectural Drift and no longer preserves the defining characteristics established by this Standard until such time as Dynamic Compliance has been restored.

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SECTION 8

HLAS CERTIFICATION FRAMEWORK

(Normative)

8.1 Purpose

The Hydrogen Logistics Architecture Standard (HLAS) establishes a comprehensive certification framework for evaluating, recognizing, and maintaining conformity with the architectural principles, Architecture Classes, and Dynamic Compliance requirements defined by this Standard.

Certification under HLAS is intended to provide independent architectural assurance to governments, regulators, project developers, financiers, insurers, infrastructure owners, engineering organizations, industrial participants, and other stakeholders that a proposed or implemented hydrogen logistics system conforms to the applicable requirements of the Hydrogen Logistics Architecture Standard.

Certification addresses different stages of the infrastructure lifecycle and shall be applied in accordance with the provisions of this Standard.

8.2 Scope of Certification

Certification under HLAS may apply to one or more of the following:

- Regional or national hydrogen logistics master plans;
- Infrastructure blueprints and conceptual architectures;
- Front-End Engineering Design (FEED) and project designs;
- Constructed infrastructure systems;
- Operating HLAS implementations;
- Infrastructure expansion and modification proposals;
- Infrastructure portfolios; and
- Other architecturally significant implementations determined by the governing authority of HLAS.

Certification under this Standard evaluates architectural conformity only.

Unless expressly stated otherwise, certification does not constitute approval of engineering design, construction quality, safety performance, operational performance, environmental compliance, financial viability, or regulatory authorization.

8.3 Infrastructure Risk Benchmarking

Typical Stage: *Concept Development, Strategic Planning, Investment Screening and Pre-Feasibility*

Infrastructure Risk Benchmarking evaluates a proposed or existing hydrogen logistics architecture against the HLAS architectural benchmark to assess exposure to recognized system-level infrastructure risks and identify opportunities for architectural improvement.

Benchmarking may be performed irrespective of whether the assessed infrastructure seeks certification under HLAS.

Typical beneficiaries include governments, regulators, investors, infrastructure funds, commercial banks, insurance companies, infrastructure owners, and project developers requiring an independent architectural assessment to support planning, investment, financing, underwriting, or strategic decision-making.

Infrastructure Risk Benchmarking provides an independent architectural assessment but does not constitute certification under HLAS.

8.4 Architecture Blueprint Certification

Typical Stage: *Master Planning, Conceptual Design, Feasibility Study and Front-End Architecture Design (FEAD), prior to Front-End Engineering Design (FEED).*

Architecture Blueprint Certification confirms that a proposed hydrogen logistics architecture, infrastructure blueprint, or master plan conforms to the applicable HLAS Architecture Class and governing architectural principles prior to implementation.

This certification may be used to support government planning, regional hydrogen logistics master plans, investment evaluation, infrastructure financing, project feasibility studies, Front-End Architecture Design, and strategic infrastructure planning.

Typical beneficiaries include governments, Industrial Development Corporations, infrastructure planners, project developers, investors, lenders, infrastructure funds, and regulators evaluating proposed hydrogen logistics infrastructure.

Architecture Blueprint Certification evaluates the proposed architecture only and does not certify future implementation.

8.5 Architecture Design Certification

Typical Stage: *Front-End Engineering Design (FEED), Detailed Engineering and Procurement, prior to construction*

Architecture Design Certification confirms that the Front-End Engineering Design (FEED), conceptual engineering, or detailed engineering design of a proposed implementation remains consistent with the certified architectural blueprint and the applicable HLAS Architecture Class.

This certification may be performed during project development, Front-End Engineering Design (FEED), or detailed engineering.

Typical beneficiaries include EPC contractors, engineering consultants, project developers, Hydrogen infrastructure developers, infrastructure owners, and government procurement agencies.

This certification evaluates architectural conformity rather than detailed engineering adequacy. Engineering solutions remain the responsibility of the implementing organization.

8.6 Infrastructure Conformance Certification

Typical Stage: *Construction Completion, Commissioning and Operational Readiness.*

Infrastructure Conformance Certification confirms that an implemented hydrogen logistics system conforms to the applicable HLAS Architecture Class following construction or commissioning.

Assessment may include verification of:

- Architectural topology;
- System boundaries;
- Required interfaces;
- Stakeholder responsibilities;
- Permitted infrastructure relationships; and
- Other architecturally significant characteristics defined by this Standard.

Typical beneficiaries include infrastructure owners, hydrogen infrastructure operators, backbone pipeline operators, logistics operators, storage operators, regulators, financiers, insurance companies, and industrial participants requiring confirmation that implemented infrastructure conforms to HLAS.

8.7 Dynamic Compliance Certification

Typical Stage:*Operational Lifecycle, including routine operation, infrastructure evolution and periodic compliance review.*

Dynamic Compliance Certification confirms that an operational hydrogen logistics implementation continues to preserve the defining characteristics of its applicable Architecture Class throughout its operational lifecycle.

Unlike point-in-time certifications, Dynamic Compliance Certification requires continued demonstration that architecturally significant changes remain consistent with the governing principles of HLAS.

Typical beneficiaries include infrastructure owners, hydrogen infrastructure operators, governments, regulators, investors, long-term infrastructure funds, asset managers, and insurance companies requiring continuing architectural assurance throughout the operational life of the infrastructure.

Maintenance of Dynamic Compliance Certification shall be subject to the Dynamic Compliance and Real-Time Stewardship requirements defined elsewhere in this Standard.

8.8 Expansion and Evolution Certification

Typical Stage:*Prior to implementation of infrastructure expansion, modification, network reconfiguration or integration of new infrastructure.*

Expansion and Evolution Certification evaluates proposed additions, modifications, or reconfiguration of hydrogen logistics infrastructure to determine whether such changes preserve the defining characteristics of the applicable Architecture Class.

Evaluation may include:

- Addition of Production Hubs, Regional Aggregation Hubs, Export Hubs, storage facilities, logistics corridors, Backbone Pipelines, industrial users, and other hydrogen logistics infrastructure components, as applicable.
- Changes in logistics connectivity;
- Expansion of pipeline networks;
- Integration of storage facilities, export infrastructure or major industrial users;and
- Other architecturally significant infrastructure changes.

Typical beneficiaries include governments, infrastructure owners, hub operators, pipeline operators, storage operators, and project developers planning phased expansion of hydrogen logistics infrastructure.

Certification shall confirm that proposed evolution does not result in Architectural Drift.

8.9 Infrastructure Portfolio Certification

Typical Stage:*Portfolio Planning, Portfolio Acquisition, Multi-Project Governance and Periodic Portfolio Review.*

Infrastructure Portfolio Certification evaluates multiple related hydrogen logistics projects, regional developments, or infrastructure assets collectively to determine whether the portfolio maintains architectural consistency with HLAS and supports coherent long-term infrastructure development.

Typical beneficiaries include national and regional governments, Industrial Development Corporations, sovereign wealth funds, infrastructure investment funds, large infrastructure owners, and multi-project developers managing portfolios of hydrogen logistics assets.

Portfolio Certification provides a common architectural benchmark across multiple projects and supports consistent long-term investment and infrastructure planning.

8.10 Architectural Assurance

Applicability:*Applies to all benchmarking assessments and certifications issued under HLAS.*

Each certification issued under HLAS provides architectural assurance only.

Certification confirms conformity with the architectural requirements established by this Standard and shall not be interpreted as certifying:

- Engineering adequacy;
- Safety;
- Construction quality;
- Operational performance;
- Regulatory compliance;
- Commercial viability;
- Environmental performance; or
- Patent licensing.

8.11 Relationship Between Certifications

The benchmarking and certifications established by HLAS address different phases of the infrastructure lifecycle.

Benchmarking may be undertaken independently of certification and does not require implementation of HLAS.

Certification at one stage does not automatically confer certification at any subsequent stage.

Where applicable, assessment may progress from Infrastructure Risk Benchmarking through Architecture Blueprint Certification, Architecture Design Certification, Infrastructure Conformance Certification, Dynamic Compliance Certification, and Expansion and Evolution Certification as infrastructure evolves throughout its lifecycle.

8.12 Certification Authority

Official benchmarking and certification under HLAS shall be issued only by Novonanmek Material Sciences Private Limited or by certification bodies expressly authorized by Novonanmek.

Requirements governing benchmarking, certification administration, interpretation, certification marks, registry participation, suspension, withdrawal, renewal, and related administrative matters shall be established by the governing authority of HLAS.

SECTION 9

ARCHITECTURAL RISK MITIGATION FRAMEWORK

(Normative)

The architectural risk mitigation characteristics established by the Hydrogen Logistics Architecture Standard (HLAS) are inherent properties of a Hydrogen Logistics Architecture that remains Dynamically Compliant with this Standard.

The architectural outcomes and risk mitigation characteristics identified in this section shall not be presumed to persist solely by virtue of an initial implementation. They depend upon the continued preservation of the Architecture Principles, System Boundaries, Architecture Building Blocks, and Architecture Rules established by HLAS.

Accordingly, the continued mitigation of the architectural risks identified in this section is contingent upon the ongoing maintenance of Dynamic Compliance throughout the operational lifecycle of the Hydrogen Logistics Architecture.

Where Dynamic Compliance is not maintained, the architecture may progressively lose one or more of the risk mitigation characteristics established by this Standard through the effects of Architectural Drift.

9.1 General

The Hydrogen Logistics Architecture Standard (HLAS) is founded upon the principle that architecture exists to mitigate infrastructure risk.

The Architecture Principles and Architecture Rules established by this Standard are not arbitrary design requirements. Each has been developed to address one or more recurring architectural risks observed in the planning, development, financing, expansion, and long-term operation of hydrogen logistics infrastructure.

Accordingly, every normative requirement contained within HLAS shall be interpreted in the context of the architectural risks it is intended to mitigate and the long-term stakeholder objectives it is intended to preserve.

9.2 Purpose

The purpose of this section is to establish traceability between:

- Recurring architectural risks;

- Stakeholder concerns;
- The architecture principles established by HLAS;
- The architecture rules implementing those principles; and
- The architectural outcomes expected from their application.

This traceability demonstrates that HLAS is a risk-informed architecture standard intended to improve the long-term resilience, scalability, interoperability, and bankability of hydrogen logistics infrastructure.

9.3 Architectural Risk Mitigation Matrix

Architectural Risk	Why Stakeholders Care	HLAS Architecture Principle(s)	HLAS Architecture Rule(s)	Expected Architectural Outcome
Infrastructure Fragmentation Risk	Independently developed hydrogen projects may evolve as isolated systems incapable of forming integrated regional hydrogen networks.	Network Formation, Interoperability, Shared Infrastructure	Regional Architecture Rule, Backbone Pipeline Rule	Infrastructure remains compatible with future regional and national hydrogen network development.
Distributed Production Risk	Numerous isolated production facilities duplicate infrastructure, reduce economies of scale, and increase capital costs.	Production Consolidation	Production Hub Rule, End 1 Rule	Production capacity is consolidated into scalable Production Hubs serving regional hydrogen systems.
Demand Fragmentation Risk	Small isolated demand centers rarely justify efficient hydrogen logistics infrastructure.	Aggregated Demand	Regional Demand Rule, Demand Aggregation Rule, Small User Connectivity Rule	Corridors serve aggregated regional demand rather than isolated consumers.

Single Off-Taker Dependency Risk	Infrastructure dependent upon one or a few industrial users may become economically impaired if demand declines.	Diversified Offtake	Large User Rule, Regional Demand Rule	Diversified demand improves resilience and reduces concentration risk.
Stranded Asset Risk	Infrastructure developed around individual customers or fixed demand profiles may lose long-term economic value.	Aggregated Demand, Diversified Offtake, Long-Term Bankability	Regional Demand Rule, Demand Aggregation Rule	Infrastructure remains economically relevant despite changing market conditions.
Premature Infrastructure Development Risk	Hydrogen transport infrastructure may be developed before sufficient regional demand exists.	Aggregated Demand	Demand Aggregation Rule, Regional Demand Rule	Infrastructure development follows demonstrable regional demand.
Transport Selection Risk	Selection of inappropriate transport infrastructure may permanently increase hydrogen delivery costs.	Shared Infrastructure, Scalability	Corridor Structure Rule, Architecture Building Blocks	Hydrogen transport develops within a consistent and scalable architectural framework.
Under-utilisation Risk	Dedicated infrastructure frequently operates below its economic capacity.	Shared Infrastructure, Diversified Offtake	Large User Rule, Regional Demand Rule	Shared infrastructure improves utilisation and economic efficiency.
Corridor Inefficiency Risk	Dedicated corridors serving individual users duplicate investment and reduce capital efficiency.	Shared Infrastructure	Corridor Structure Rule, Regional Demand Rule	Corridor infrastructure serves multiple participants and demand centres.
Scalability Risk	Infrastructure may require extensive redesign as hydrogen markets expand.	Scalability	Regional Architecture Rule, Backbone Pipeline Rule	Hydrogen logistics systems expand through repeatable architectural building blocks.

Expansion Compatibility Risk	Future infrastructure may not integrate efficiently with existing hydrogen systems.	Scalability, Interoperability	Architecture Building Blocks, Architecture Rules	New infrastructure integrates without architectural redesign.
Network Incompatibility Risk	Independently developed infrastructure may be technically or operationally incompatible.	Interoperability	Architecture Building Blocks, Architecture Rules	Hydrogen infrastructure remains interoperable across regions and stakeholders.
Export Integration Risk	Domestic hydrogen systems may require significant modification to support future exports.	Export Optionality	End 2 Rule, Export Rule	Export capability is preserved as an inherent architectural option.
Backbone Misalignment Risk	Backbone infrastructure may develop in locations inconsistent with long-term regional supply evolution.	Network Formation	Backbone Pipeline Rule	Backbone infrastructure remains aligned with regional production ecosystems.
Architectural Drift Risk	Incremental infrastructure changes may progressively erode the defining characteristics of the Hydrogen Logistics Architecture.	Architectural Preservation	All Architecture Rules; Dynamic Compliance Evaluation	Long-term architectural integrity is continuously preserved throughout infrastructure evolution.
Capital Allocation Risk	Investors require a consistent framework for comparing hydrogen infrastructure opportunities.	Shared Infrastructure, Long-Term Bankability	Entire HLAS Architecture Framework	Infrastructure projects become more comparable, transparent, and investable.

Long-Term Bankability Risk	Lenders require confidence that infrastructure will remain relevant, scalable, and economically useful over multi-decade investment horizons.	Long-Term Bankability	Entire HLAS Architecture Framework together with Dynamic Compliance Evaluation	Infrastructure preserves long-term strategic value, investment confidence, and financing attractiveness.
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9.4 Relationship to Dynamic Compliance Evaluation

The Architecture Principles and Architecture Rules established by this Standard mitigate the architectural risks identified in this section only while they continue to be preserved throughout the lifecycle of the Hydrogen Logistics Architecture.

Accordingly, **Dynamic Compliance Evaluation** shall continuously assess whether infrastructure evolution has altered the Architecture Principles or Architecture Rules in a manner that increases the architectural risks identified in this section.

Where Dynamic Compliance Evaluation identifies Architectural Drift, the corresponding increase in architectural risk shall be regarded as an indication that the Hydrogen Logistics Architecture no longer preserves the intended architectural outcomes established by HLAS.

9.5 Fundamental Principle

HLAS is a risk-informed architecture standard.

Its Architecture Principles, Architecture Building Blocks, Architecture Rules, and Dynamic Compliance Evaluation framework collectively establish a coherent architectural methodology through which the principal risks associated with hydrogen logistics infrastructure are systematically mitigated.

The long-term value of a Hydrogen Logistics Architecture therefore derives not only from its initial implementation, but from the continuous preservation of the risk-mitigating architectural characteristics established by this Standard.

SECTION 10

ARCHITECTURE EXAMPLE (INFORMATIVE)

10.1 General

This section provides an illustrative example of a regional hydrogen logistics architecture developed using the Hydrogen Logistics Architecture Standard (HLAS).

The example is provided for explanatory purposes only and does not prescribe a specific implementation.

The architecture shown has been developed by applying the HLAS Rules to the standardized Hydrogen Logistics Corridors defined in this standard, thereby determining the placement of the standardized Architecture Building Blocks.

10.2 Illustrative Regional Hydrogen Logistics Architecture

The example shown in **Figure 1** illustrates a regional hydrogen logistics system comprising multiple standardized Hydrogen Logistics Corridors interconnected through a Backbone Pipeline.

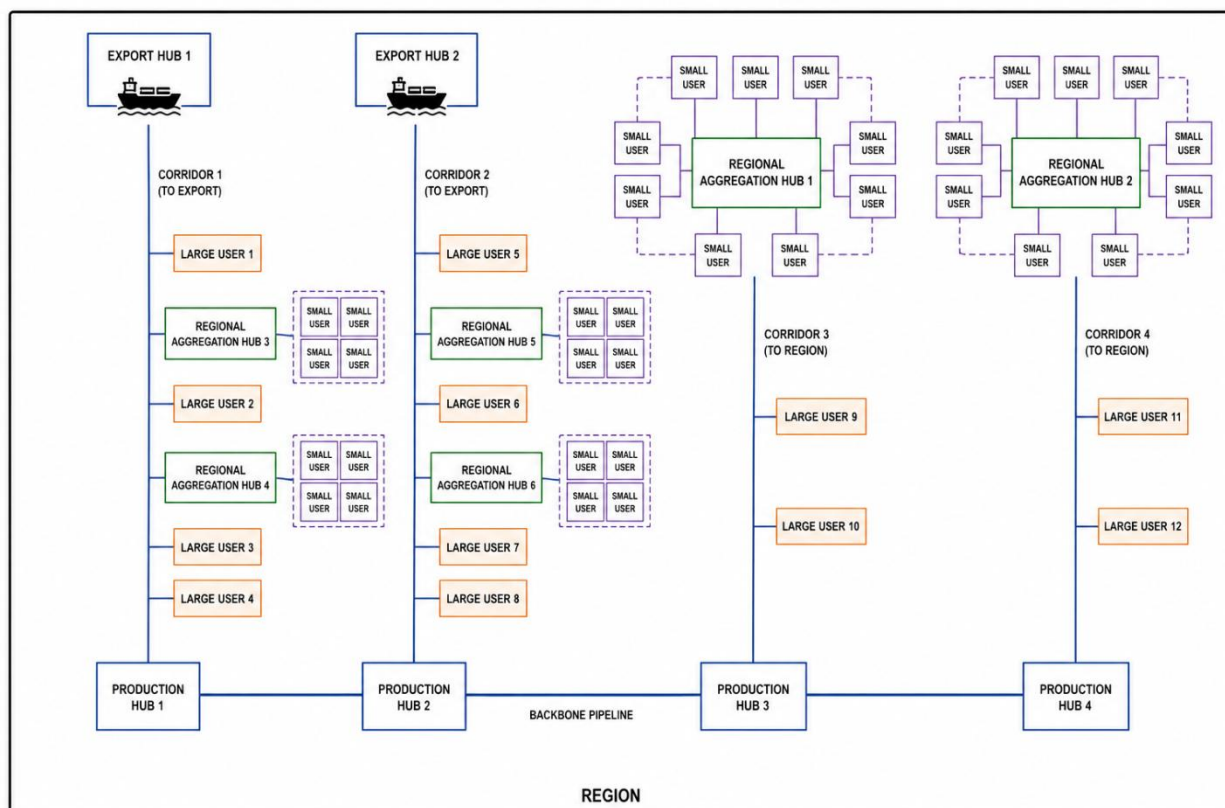
The architecture includes:

- Four **Production Hubs** serving as regional hydrogen supply centers.
- Four standardized **Hydrogen Logistics Corridors**.
- Two **Export Hubs** supporting international hydrogen export.
- Six **Regional Aggregation Hubs** serving regional demand.
- Twelve **Large Users** connected directly to the Hydrogen Logistics Corridors.
- Multiple **Small Users** supplied through the Regional Aggregation Hubs.
- A **Backbone Pipeline** interconnecting the Production Hubs to improve regional supply flexibility and network resilience.

Each Hydrogen Logistics Corridor is organized in accordance with the standardized corridor structure established by HLAS, while the placement of the Architecture Building Blocks is determined by the HLAS Rules.

The combination of these standardized corridors forms a complete regional hydrogen logistics architecture capable of simultaneously supporting domestic hydrogen demand and hydrogen export.

Figure 1 — Illustrative Regional Hydrogen Logistics Architecture



10.3 Discussion

This example demonstrates how standardized Architecture Building Blocks are assembled into standardized Hydrogen Logistics Corridors and subsequently combined to form a complete regional hydrogen logistics system.

While the arrangement of building blocks shown in Figure 1 is illustrative, alternative configurations may be developed provided they preserve the standardized corridor architecture established by HLAS and comply with the applicable HLAS Rules.

GLOSSARY

(Normative)

The following terms and definitions apply throughout the **Hydrogen Logistics Architecture Standard (HLAS)**.

Aggregated Demand

The combined hydrogen demand of multiple independent consumers that collectively supports economically viable hydrogen logistics infrastructure.

Aggregated Demand is a foundational architectural principle intended to improve infrastructure utilisation, reduce counterparty concentration, and strengthen long-term investment viability.

Architectural Drift

The progressive erosion of the defining characteristics of a Hydrogen Logistics Architecture resulting from unmanaged infrastructure evolution.

Architectural Drift may occur through the cumulative effect of individually reasonable infrastructure changes that collectively alter the governing Architecture Principles, Architecture Building Blocks, or Architecture Rules established by HLAS.

Architectural Integrity

The condition in which a Hydrogen Logistics Architecture continues to preserve its governing Architecture Principles, Architecture Building Blocks, Architecture Rules, and intended architectural characteristics throughout its operational lifecycle.

Architectural Principle

A fundamental governing principle established by HLAS that defines the desired characteristics of Hydrogen Logistics Architecture and forms the basis for the Architecture Rules.

Architecture Building Block

A standardized architectural element defined by HLAS that performs a specific function within a Hydrogen Logistics Architecture.

Architecture Building Blocks include Production Hubs, Regional Aggregation Hubs, Large Users, Small Users, Export Hubs, Corridor Cracking Facilities, Hydrogen Corridors, and Backbone Pipelines.

Architecture Rule

A mandatory requirement governing the permissible relationships, connectivity, topology, and organization of Architecture Building Blocks within a Hydrogen Logistics Architecture.

Backbone Pipeline

A high-capacity hydrogen transportation link connecting one Production Hub to another Production Hub.

Backbone Pipelines enable regional integration of hydrogen production ecosystems and support the formation of larger hydrogen logistics networks.

Chemical Carrier

A substance used to transport hydrogen in a chemically bound form.

Examples include ammonia, liquid organic hydrogen carriers (LOHCs), methanol, or other approved hydrogen carrier systems.

Corridor Cracking Facility (CCF)

A conditional architectural building block deployed on Hydrogen Corridors transporting hydrogen as a chemical carrier.

A Corridor Cracking Facility regenerates gaseous hydrogen for downstream hydrogen users requiring gaseous hydrogen supply.

Dynamic Compliance

The continuous architectural evaluation process through which a Hydrogen Logistics Architecture is determined to preserve the Architecture Principles, Architecture Building Blocks, System Boundaries, and Architecture Rules established by HLAS throughout its operational lifecycle.

Dynamic Compliance replaces conventional one-time certification within the HLAS framework.

Dynamic Compliance Evaluation

The official architectural evaluation performed to determine whether a Hydrogen Logistics Architecture remains Dynamically Compliant with HLAS.

Official Dynamic Compliance Evaluations may be performed only by Novonanmek Material Sciences Private Limited or organizations expressly authorized by Novonanmek.

End 1

The mandatory origin of a Hydrogen Corridor.

End 1 shall contain one Production Hub.

End 2

The mandatory terminal position of a Hydrogen Corridor.

End 2 shall contain either a Regional Aggregation Hub or an Export Hub.

Export Hub (EH)

A terminal architectural building block representing infrastructure supporting international or inter-regional hydrogen export.

An Export Hub may occupy End 2 of a Hydrogen Corridor.

Hydrogen Corridor

A directional hydrogen logistics pathway connecting a Production Hub with Regional Aggregation Hubs, Large Users, and, where applicable, an Export Hub.

A Hydrogen Corridor may be implemented using pipelines, virtual pipelines, rail, road, inland waterways, maritime transport, or combinations thereof.

Hydrogen Logistics Architecture (HLA)

A structured regional hydrogen production, aggregation, transportation, storage, distribution, and export system established in accordance with the Architecture Principles, Architecture Building Blocks, and Architecture Rules defined by HLAS.

Hydrogen Logistics Architecture Standard (HLAS)

The Hydrogen Logistics Architecture Standard developed and maintained by Novonanmek Material Sciences Private Limited.

HLAS establishes the Architecture Principles, Architecture Building Blocks, Architecture Rules, Dynamic Compliance framework, and Architectural Risk Mitigation Framework governing Hydrogen Logistics Architectures.

Infrastructure Evolution

The continuous addition, expansion, modification, replacement, retirement, or reconfiguration of infrastructure assets, logistics pathways, participants, and supporting systems throughout the operational lifecycle of a Hydrogen Logistics Architecture.

Intermediate Position

Any position within a Hydrogen Corridor located between End 1 and End 2.

Intermediate positions may contain Large Users, Regional Aggregation Hubs, and, where applicable, Corridor Cracking Facilities.

Large User (LU)

A significant hydrogen consumer directly connected to a Hydrogen Corridor.

Large Users improve corridor utilisation but do not determine corridor viability.

Licensed Project Initiator (LPI)

An independent, commercially self-sufficient franchise entity or specialized individual explicitly chosen, authorized, and granted a formal commercial license by Novonanmek to activate, coordinate, and register a multi-party infrastructure cluster under the HLAS framework at its own expenditure and risk

Open Hydrogen Logistics Architecture

A Hydrogen Logistics Architecture that is intended to evolve continuously while preserving its defining architectural characteristics through Dynamic Compliance.

Production Hub (PH)

A geographically defined hydrogen production ecosystem comprising one or more hydrogen production facilities and associated infrastructure serving as the origin of a Hydrogen Corridor.

A Production Hub occupies End 1 of every Hydrogen Corridor.

Regional Aggregation Hub (RAH)

A regional demand aggregation node that consolidates hydrogen demand from multiple Small Users. Regional Aggregation Hubs provide diversified regional demand and constitute the primary architectural mechanism for mitigating demand fragmentation.

Regional Hydrogen Logistics System

A hydrogen logistics system comprising one or more Hydrogen Corridors, Production Hubs, Regional Aggregation Hubs, Backbone Pipelines, and associated infrastructure operating collectively within a defined geographic region.

Shared Infrastructure

Infrastructure intended to serve multiple independent producers, users, logistics providers, or other stakeholders rather than dedicated single-purpose applications.

Shared Infrastructure is a fundamental Architecture Principle established by HLAS.

Small User (SU)

A hydrogen consumer whose individual demand is insufficient to justify direct connection to a Hydrogen Corridor.

Small Users shall connect through a Regional Aggregation Hub.

Stakeholder Objectives

The long-term infrastructure outcomes sought by governments, investors, financiers, developers, hydrogen producers, industrial users, regulators, logistics providers, and other participants within the hydrogen ecosystem.

Stakeholder Objectives form the foundation upon which the HLAS Architecture Principles are established.

System Boundary

The architectural scope within which HLAS governs the relationships between Architecture Building Blocks.

System Boundaries distinguish architectural governance from engineering design, operational management, commercial arrangements, and regulatory oversight.

Topology

The structural arrangement and connectivity of Architecture Building Blocks within a Hydrogen Logistics Architecture. Topology determines how Production Hubs, Hydrogen Corridors, Regional Aggregation Hubs, Large Users, Export Hubs, and Backbone Pipelines are organized to satisfy the Architecture Rules established by HLAS.

Underutilisation Risk

The risk that hydrogen infrastructure operates significantly below its intended capacity because of insufficient demand, dedicated infrastructure development, or ineffective architectural planning.

HLAS mitigates this risk through Aggregated Demand, Shared Infrastructure, and Diversified Offtake.

Valid Hydrogen Logistics Architecture

A Hydrogen Logistics Architecture that satisfies the applicable Architecture Principles, Architecture Building Blocks, Architecture Rules, and Dynamic Compliance Evaluation requirements established by HLAS.

Version of Record

The officially published edition of HLAS maintained by Novonanmek Material Sciences Private Limited.

Only the Version of Record shall be regarded as the authoritative version of the Standard for the purposes of Dynamic Compliance Evaluation and official interpretation.

-----End of Standard-----

Annex A— Implementation Pathway through the Energy Infrastructure Implementation Program (EIIP)

A.1 Purpose of this Annexure

This annexure describes the **Energy Infrastructure Implementation Program (EIIP)** as a practical implementation pathway through which the principles of the **Hydrogen Logistics Architecture Standard (HLAS)** may be translated into real-world industrial development, infrastructure readiness, and phased ecosystem growth.

HLAS provides the strategic architecture framework.
EIIP provides the structured pathway for implementation.

This annexure is informative only and does not create mandatory compliance obligations under HLAS.

A.2 Relationship Between HLAS and EIIP

HLAS

Provides a planning and architecture standard for:

- hydrogen hubs
- logistics hierarchy
- regional aggregation systems
- corridor continuity
- scalable network evolution
- coherent infrastructure formation

EIIP

Provides a structured implementation mechanism for:

- land readiness
- institutional coordination
- investor attraction
- project alignment
- phased execution
- ecosystem expansion

Accordingly, HLAS defines *what a coherent system may look like*, while EIIP supports *how regions may move toward such systems in practice*.

A.3 Why an Implementation Pathway Is Often Needed

Many regions may possess industrial potential but face practical barriers such as:

- fragmented planning responsibilities
- unprepared land banks
- absence of future corridor reservation
- uncertain investor signaling
- uncoordinated project proposals
- short-term project-by-project decision making
- lack of long-range infrastructure sequencing

EIIP is designed to help address such barriers through structured implementation support.

A.4 Four Phases of EIIP

Phase I — Planning and Readiness

Typical activities may include:

- identification of suitable hydrogen / CCUS development zones
- demand cluster mapping
- strategic land assessment
- indicative corridor identification
- hub opportunity mapping
- phased roadmap preparation
- investor-readiness documentation

Indicative Outcomes

- clearer development roadmap
- stronger investment readiness
- better land utilization
- improved policy preparation

Phase II — Stakeholder Coordination and Project Preparation

Typical activities may include:

- engagement with developers, producers, investors, users, and institutions
- alignment of proposals with territorial strategy
- coordination support across agencies
- preservation of future strategic corridors

- refinement of phased development priorities

Indicative Outcomes

- faster project progression
- stronger proposal quality
- reduced coordination friction
- clearer investment pipeline

Phase III — Implementation Support

Typical activities may include:

- review of incoming project alignment with long-term architecture objectives
- location suitability support
- sequencing support for hubs and corridors
- avoidance of conflicting infrastructure layouts
- continuity support for strategic logistics systems

Indicative Outcomes

- improved execution quality
- reduced stranded asset risk
- more coherent infrastructure growth
- stronger long-term efficiency

Phase IV — Growth and Expansion Support

Typical activities may include:

1. onboarding of new ecosystem participants
2. roadmap updates as demand evolves
3. expansion corridor planning
4. integration of new hubs and users
5. support for export-oriented growth opportunities

Indicative Outcomes

- scalable industrial ecosystem growth
- better utilization of existing assets
- continued investment attraction
- future-ready territorial development

A.5 Typical Users of EIIP

EIIP may be relevant to:

- State Governments
- Industrial Development Corporations
- Ports and Maritime Authorities
- Special Economic Zones
- Industrial Park Developers
- National Planning Agencies
- Sovereign / Strategic Investment Zones

A.6 Nature of Engagement

EIIP may be delivered as a professional advisory, planning, program management, or implementation-support engagement.

Use of EIIP does not imply transfer of proprietary analytical tools, decision-support systems, or internal methodologies used by implementation entities unless separately agreed in writing.

A.7 Relationship to HLAS Assessments

Where used together, EIIP may support:

- HLAS-aligned planning processes
- readiness improvement for future assessments
- structured remediation of identified gaps
- phased progression toward higher architecture coherence

A.8 Important Interpretation Note

EIIP is one possible implementation pathway associated with HLAS-aligned development. Other entities may independently pursue HLAS-aligned projects through their own lawful planning and implementation processes.

This annexure does not grant exclusive rights unless separately established by contract.

A.9 Conclusion

The Hydrogen Logistics Architecture Standard provides a strategic destination. EIIP provides a practical pathway through which regions may move toward that destination through phased planning, coordination, implementation support, and long-term ecosystem growth.