




From Green Corridor Pilots to Scalable Nordic Transport Networks

A Leg-Based Approach to
Multimodal Decarbonization
and Digital Collaboration



Executive Summary

“Building on the strong momentum around green transport corridors, the Nordic transition now depends on connecting these and other Nordic initiatives into networked systems that can match transport demand and supply across modes, value chains, and borders. This report brings these elements together and outlines how coordinated, system-level approaches can be developed and scaled in practice.”

Sindre Bornstein, CEO, Nordic Innovation

Green corridors have emerged as an important approach to accelerating freight decarbonization. Initiatives such as the Clydebank Declaration have mobilized collaboration around zero-emission deployment along strategic shipping routes (Clydebank Declaration, 2021; Svendsen et al., 2023). However, in Nordic freight systems, corridor framing alone does not fully capture how freight moves in practice through interconnected networks of ports, terminals, ferry services, rail corridors, and road distribution systems.

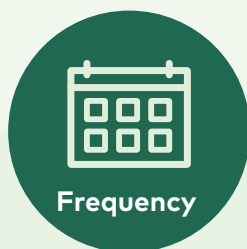
This report shifts the focus from corridor-based thinking to scalable networks built on reusable transport legs.

The key insight of this report is that scalable multimodal freight systems are built around qualified transport legs – recurring service connections between logistics nodes such as ferry routes, rail segments, or road links. Nordic sustainable transport networks emerge when such qualified legs are reused across multiple freight flows.

A transport leg becomes a scalable building block when it satisfies three criteria:



Sufficient anchored demand to justify deployment



Regular service availability that supports logistics planning



Predictable operational performance that shippers can depend on



Executive Summary

Scaling requires shared performance governance, based on transparent and comparable KPIs across cost, delivery time, and emissions.

The report introduces a scenario-based method for comparing alternative network configurations. Digital collaboration strengthens coordination across multimodal logistics systems and supports credible emissions accounting (Maritime and Port Authority of Singapore, 2025). The Virtual Watch Tower is highlighted as an example of public-good digital infrastructure supporting end-to-end collaborative decision making, disruption management, and leg-level emissions transparency.

Finally, the report emphasizes that sustainable transport networks cannot scale within the transport system alone. Decarbonization requires coordinated transformation across interconnected value chains, including sustainable fuel supply, logistics operations, and carrier asset transitions (Petersen and Renken, 2023). Parallel Nordic initiatives such as the Nordic Roadmap for the Introduction of Sustainable Zero-Carbon Fuels in Shipping focus on green shipping corridors and the associated maritime energy ecosystem across the corridor value chain. The present report complements this work by introducing a shipper-driven logistics perspective focused on how transport buyers adopt and scale sustainable freight solutions across multimodal logistics networks.

The Nordic opportunity therefore lies in prioritizing high-impact transport legs, equipping shared nodes with interoperable digital collaboration mechanisms, applying shared KPI frameworks, and aligning transport networks with sustainable energy ecosystems. In this way, existing green corridor initiatives can be extended into scalable multimodal Nordic freight systems.

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Key Concepts and Definitions

This report introduces several concepts used to explain how sustainable transport networks can scale beyond individual corridor pilots. The table below summarizes the key terms used throughout the report.

Concept	Definition
Green Corridor	A transport route where stakeholders collaborate to deploy low- or zero-emission transport solutions, often supported by coordinated infrastructure, fuel supply, and regulatory alignment. Early green corridor initiatives have primarily focused on maritime shipping routes between ports.
Sustainable Transport Network	An interconnected system of transport legs and nodes that together enable efficient, reliable, and low-emission freight transport across multiple modes. In this report, sustainable networks emerge through combinations of reusable transport legs supported by digital collaboration and energy-system integration.
Transport Leg	A recurring service or infrastructure connection between two nodes in a freight transport system, such as a ferry route, rail segment, port-terminal interchange, or road distribution segment. Transport legs function as the fundamental building blocks of scalable transport networks.
Qualified Transport Leg	A transport leg that meets the operational criteria required for scaling within sustainable transport networks. In this report, qualification is determined through the Volume-Frequency-Reliability (VFR) framework.
Volume-Frequency-Reliability (VFR)	The operational framework used to assess whether a transport leg can function as a scalable network component: Volume (anchored demand), Frequency (regular service availability), and Reliability (predictable operational performance).
Cost-Time-Emissions (CTE)	The three primary performance dimensions used by shippers when evaluating logistics options: Cost (transport cost), Time (lead time, delivery performance, and predictability), and Emissions (greenhouse gas footprint).
Dual-Layer Scaling Framework	A framework linking infrastructure readiness and shipper adoption. VFR determines which legs can scale as infrastructure components, while CTE determines which transport solutions are adopted in practice.
End-to-End Collaborative Decision Making (e2eCDM)	A digital collaboration approach enabling multiple actors in a transport chain to share situational awareness and coordinate operational decisions across interconnected transport legs and nodes.
Virtual Watch Tower (VWT)	A digital collaboration infrastructure designed to support shared situational awareness, coordinated disruption management, and emissions transparency across multimodal transport networks.
Transport-Energy Ecosystem	The integrated system linking transport operations with sustainable fuel supply, energy infrastructure, and carrier asset transitions. Decarbonization requires coordination across these interconnected value chains.

Introduction

The Nordic countries have long held a prominent position in sustainable transport and logistics. Ambitious climate targets, extensive multimodal infrastructure, and globally connected supply chains position the region as a testbed for sustainable freight system transformation (Nordic Council of Ministers, 2023; European Commission, 2020). At the same time, national strategies across the Nordic countries differ in their approaches to decarbonization, reflecting variations in energy resources, industrial structures, and transport system characteristics. Freight flows are highly interconnected across Nordic borders through maritime links and multimodal transport systems connecting ports, industrial regions, and international markets. This creates both challenges and opportunities for coordinated Nordic transport development.

In international policy and industry discourse, the concept of green corridors emerged to accelerate decarbonization in strategic transport flows. The Clydebank Declaration from COP26 called on nations to establish green shipping corridors between ports where zero-emission solutions can be deployed through public-private collaboration (Clydebank Declaration, 2021; Svendsen et al., 2023). Recent green and digital corridor initiatives integrate digital collaboration with environmental performance to improve maritime supply chain efficiency and resilience (Maritime and Port Authority of Singapore, 2025; Australian Government Department of Foreign Affairs and Trade, 2025). Similar perspectives have also been articulated in discussions on the Nordic maritime energy transition, emphasizing the need to coordinate transport systems, fuel ecosystems, and logistics networks (Lind et al., 2025).

However, several observations arise when corridor initiatives are viewed in the context of multimodal Nordic freight systems:

1. The Clydebank framing – and much of the early literature – is explicitly maritime in scope, focusing on shipping routes and port dyads.
2. The addition of “digital” reflects an early recognition that information integration and operational transparency are essential enablers of low-carbon logistics – not optional add-ons.
3. When applied to multimodal freight systems, the corridor framing alone does not fully capture how freight flows operate through interconnected logistics networks.

This report extends existing corridor perspectives by examining how scalable multimodal transport networks emerge from reusable transport legs. Rather than focusing on static route definitions, ***sustainable logistics are understood as networks of qualified transport legs that can be reused across modes, nodes, and freight flows.***

In this report, the term “sustainable transport networks” primarily refers to freight systems that reduce transport-related emissions while maintaining competitive logistics performance. Broader sustainability dimensions extend beyond the scope of the present analysis.

1.1 From Corridors to Network Legs

Early green corridor initiatives were often defined geographically (e.g., Rotterdam–Singapore or Gothenburg–Rotterdam). However, freight systems operate as interconnected logistics networks where ports, rail links, ferry services, and terminals support multiple flows simultaneously. This report, therefore, shifts the analytical focus from corridors to transport legs – recurring service connections between logistics nodes that can be reused across many freight flows (UNESCAP, 2022; UNECE, 2021).

In this report, the focus is on how individual transport legs—such as ferry connections, rail segments, port interchanges, and road links—can be qualified and combined into Nordic sustainable networks that support large freight volumes through repeatable service patterns.

For a leg to be considered a scalable building block of such a network, it must meet the following criteria:

- **Volume** – anchored and recurring demand that justifies investment
- **Frequency** – regular and reliable service availability
- **Reliability** – predictable performance that shippers can depend on

1.2 Networks and Value Chain Integration

The transition to sustainable logistics networks requires integrating transport systems with energy systems and broader industrial value chains. Decarbonization depends on the coordinated development of sustainable fuel supply, carrier technologies, and operational logistics systems across interconnected value chains (Lind et al., 2025; Petersen and Renken, 2023). This systemic perspective is particularly relevant in the Nordic region, where maritime transport, rail freight, and road distribution are strongly interconnected across national borders. Many freight flows are intra-Nordic or connect to nearby European markets, creating opportunities to coordinate infrastructure development, fuel deployment, and operational standards across countries. Extending these insights across modes reinforces the need to treat logistics as integrated transport–energy systems (Lind et al., 2025).

1.3 Purpose and Contribution of This Report

The purpose of this report is threefold:

1. To synthesize lessons from green and digital corridor initiatives for freight decarbonization.
2. To reframe the corridor concept as a network of qualified transport legs across maritime, rail, and road freight.
3. To provide a practical scaling logic for moving from corridor pilots to interoperable Nordic sustainable transport networks.

This report is guided by three research questions:

1. How can sustainable freight decarbonization move beyond corridor pilots toward scalable transport networks?
2. What operational criteria determine whether transport legs can function as reusable building blocks in such networks?
3. How can digital collaboration and shared performance frameworks support adoption and scaling across Nordic logistics systems?

The following sections address these questions by examining qualification criteria for transport legs, measurement frameworks, and methods for evaluating network configurations.

This reframing addresses the limitations of static corridor definitions and aligns with emerging value-chain approaches to systemic decarbonization in transport and energy ecosystems.

1.4 Report Structure

The remainder of this report is structured as follows:

- **Section 2** defines sustainable transport networks in terms of qualified legs and nodes.
- **Section 3** elaborates the qualification criteria (volume, frequency, reliability).
- **Section 4** discusses what needs to be measured, including predictability and emissions transparency.
- **Section 5** introduces a method for balancing cost, delivery time, and emissions across network configurations.
- **Section 6** positions collaborative digital infrastructure - particularly end-to-end collaborative decision making - as an enabler of network performance.
- **Section 7** outlines how qualified legs combine into Nordic sustainable logistics networks.
- **Section 8** reviews earlier Nordic work, including the Nordic Roadmap and relevant fuel and decarbonization assessments.
- **Section 9** concludes with strategic insights for Nordic scaling.

Green and Digital Sustainable Networks Defined

Green corridors have gained prominence as a mechanism to accelerate freight decarbonization, particularly in maritime shipping. Early initiatives associated with the Clydebank Declaration focused on establishing shipping routes between ports where zero-emission technologies and fuels could be deployed through coordinated public–private collaboration (Clydebank Declaration, 2021). More recent initiatives increasingly integrate decarbonization with digital collaboration to improve operational transparency and coordination across logistics systems (Maritime and Port Authority of Singapore, 2025).

In multimodal Nordic freight systems, the corridor concept has limitations. Freight transport operates through interconnected networks of shared infrastructure and recurring service legs rather than isolated linear routes. This report, therefore, adopts a broader framing: ***Green and digital sustainable transport networks emerge from combinations of qualified transport legs and nodes, enabled by digital collaboration and coordinated transport–energy ecosystems.***

2.1 From Route-Based Corridors to Network-Based Systems

While green corridor initiatives have accelerated attention to freight decarbonization, freight systems operate through interconnected networks rather than isolated linear routes. Ports, rail segments, ferry services, and terminals support multiple flows simultaneously. Sustainable transport systems, therefore, scale through reusable transport legs rather than fixed corridor routes.

2.2 Transport Legs as the Building Blocks of Nordic Networks

In this report, a transport leg refers to a recurring operational connection between two logistics nodes within a freight transport system, such as:

- A ferry route between two ports
- A rail trunk line connecting terminals
- A port-to-terminal interchange leg
- A road-based first/last-mile distribution segment

A transport leg becomes scalable when it satisfies the operational qualification criteria elaborated in Section 3. The same qualified ferry leg or rail segment can serve multiple network configurations and cargo flows.

2.3 Digitalization as an Enabler of Network Collaboration

The addition of “digital” to green corridor initiatives reflects growing recognition that digital coordination mechanisms can improve operational transparency and system efficiency in decarbonizing logistics systems.

Digitalization enables (Lind et al., 2021):

- Shared situational awareness
- Collaborative disruption management
- End-to-end performance monitoring
- Operational-data-based emissions accounting

Initiatives such as the Singapore-Rotterdam green and digital shipping corridor (Maritime and Port Authority of Singapore, 2025) illustrate how digital collaboration can support coordination and operational transparency within corridor initiatives, even if such initiatives remain early experiments in large-scale implementation.

In the Nordic context, this implies that sustainable networks require interoperable digital coordination mechanisms operating across multiple legs and nodes as shared network infrastructure, enabling coordination, transparency, and end-to-end collaborative decision making across transport legs rather than corridor-specific platforms.

2.4 Integration of Transport and Energy Ecosystems

Sustainable transport networks emerge from combinations of qualified transport legs interconnected through shared nodes and coordinated transport–energy ecosystems. A transport–energy ecosystem links transport operations with fuel production, energy infrastructure, and carrier technologies required to deliver low-carbon transport services.

Decarbonization requires coordination across three interconnected value chains:

1. Sustainable fuel supply and energy infrastructure
2. Operational logistics and transport services
3. Carrier asset transitions (vessels, vehicles, rail traction)

Decarbonization must be approached through a value-chain lens: fuel production, operational optimization, and asset investment are interdependent and must be coordinated rather than treated separately (Lind et al., 2022; Petersen and Renken, 2023).

This is reinforced in Nordic Roadmap work on sustainable zero-carbon fuels, which highlights the need to align fuel supply, bunkering infrastructure, demand aggregation, and regulatory frameworks across actors (Nordic Energy Research, 2023).

Thus, sustainable networks must be understood as part of broader transport–energy ecosystems rather than isolated transport corridors.

2.5 Illustrative Nordic Network Route Configurations

To illustrate the network perspective, several recurring Nordic transport configurations can be identified based on combinations of qualified transport legs:

- **Nordic–Continental Trade Network:** Gothenburg – Malmö – Copenhagen – Hamburg (rail, road, and port gateway legs).
- **Bothnian Industrial Network:** Umeå – Luleå – Haparanda/Tornio – Oulu (shared rail and port legs supporting forestry and industry).
- **Mid-Nordic East–West Resilience Network:** Trondheim – Östersund – Sundsvall – Umeå – Vaasa (rail/road legs combined with the Vaasa–Umeå ferry leg).
- **Baltic Ferry Shuttle Network:** Turku – Stockholm – Helsinki (high-frequency maritime legs functioning as floating bridges).
- **Icelandic Gateway Leg:** Reykjavík connected via maritime services to Norway/Denmark hubs.

These examples illustrate recurring Nordic logistics structures where reusable transport legs combine across modes and borders. Several align with established European priorities such as the Scandinavian–Mediterranean (ScanMed) corridor linking Nordic gateways to continental Europe (European Commission, 2020) and the TEN-T framework guiding Nordic infrastructure development. In this context, the Helsinki–Tallinn connection should be recognized as a critical southern gateway for Finland and one of its most important and frequent links to continental Europe.

The Bothnian Industrial Network reflects the strategic north–south freight axis supporting forestry, mining, and industrial value chains (Ramboll Finland Oy, 2023), while the Mid-Nordic East–West configuration highlights the resilience role of cross-border connections linking Atlantic and Bothnian systems, consistent with UNECE’s emphasis on multimodal corridors as networks of interoperable legs (UNECE, 2021). The Baltic Ferry Shuttle Network illustrates high-frequency maritime legs functioning as “floating bridges” within Nordic logistics systems (OECD, 2021), while the Icelandic Gateway Leg highlights the role of maritime connectivity for integrating island economies into regional supply chains (Nordic Council of Ministers, 2023). Together, these examples illustrate where qualified transport legs converge and where coordinated investments can generate strong scaling effects.

Qualification Criteria for Scalable Transport Legs: Volume, Frequency, Reliability

The transition from corridor pilots toward scalable Nordic sustainable transport networks requires shifting the analytical focus from routes to reusable transport legs. Sustainable networks emerge when individual legs function as reliable building blocks that can support multiple logistics flows.

Across Nordic freight systems, three operational criteria determine whether a transport leg can scale (**Figure 1**): volume, frequency, and reliability. These criteria align with international supply chain performance frameworks emphasizing that modal shift and decarbonization depend fundamentally on service competitiveness and predictability (UNECE, 2021; OECD, 2021).

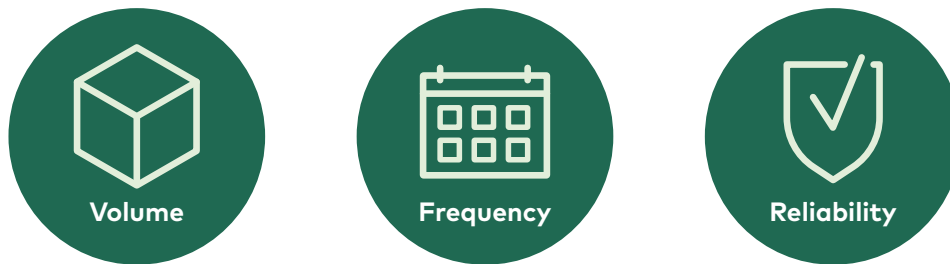


Figure 1: Three Qualification Criteria for Nordic Freight Networks

3.1 Volume: Anchored Demand as the Foundation for Scaling

The first qualification criterion is volume. A transport leg must serve sufficient recurring demand to justify stable operations and infrastructure investment. Anchored demand across multiple shippers enables the same leg to support several logistics flows. **Volume represents:**

- recurring cargo flows
- sufficient demand aggregation
- economic justification for service investment
- potential for emissions impact at scale

The Maersk Mc-Kinney Møller Center emphasizes that demand-side concentration is an important enabler of green corridor development, where cargo owners and operators jointly commit volumes that can support fuel transition and infrastructure deployment (Global Maritime Forum, 2024).

Similarly, Menon Economics highlights that the feasibility of future fuel uptake in shipping depends on predictable demand clusters that justify supply-side investment (Basso et al., 2022). From a network perspective, legs where demand concentration and strategic connectivity converge should be prioritized, as they create the strongest scaling effects.

Examples include major ferry legs, trunk rail segments, and port gateways that serve multiple industries simultaneously.

3.2 Frequency: Service Availability and Network Usability

Volume alone is insufficient. Services must also operate with adequate frequency. Frequency refers to the regular availability of transport services that allow shippers to integrate a transport leg into their logistics planning. **Frequency determines:**

- whether a leg can function as a regular logistics option
- whether shippers can plan reliably
- whether buffer capacity and inventory needs can be reduced
- whether intermodal transfers become operationally feasible

UNECE notes that corridor performance depends not only on infrastructure availability, but on the regularity and stability of service offerings across modal interfaces (UNECE, 2021).

In practice, frequency is particularly important for:

- ferry-based maritime shuttle legs
- rail intermodal services
- cross-border connections with timetable constraints

Higher service frequency increases network usability by enabling more flexible routing options and reducing dependency on single departures.

For example, Baltic ferry connections between Finland and Sweden function not as one-off corridor links, but as recurring maritime legs that support multiple Nordic network configurations. **Thus, frequency transforms infrastructure into a service leg, and service legs into scalable network building blocks.**

3.3 Reliability: Predictability as the Threshold for Adoption

The third and often most decisive qualification criterion is reliability, meaning predictable and consistent transport performance. **Reliability reflects:**

- punctuality
- variance in lead time
- disruption recovery capacity
- trustworthiness for industrial supply chains

For shippers, reliability represents the threshold for operational adoption: even high-volume and frequent services will not be integrated into logistics planning if delivery performance is unpredictable.

OECD emphasizes that resilience and competitiveness increasingly depend on predictable and coordinated logistics systems, where disruptions are managed collaboratively across actors (OECD, 2021).

Reliability is particularly critical in multimodal contexts where delays propagate across legs and interfaces:

- a ferry delay affects rail departure windows
- port congestion disrupts inland distribution
- border crossing uncertainty reduces service attractiveness

A low-emission option will not scale unless it is operationally dependable, making reliability both a performance requirement and a governance requirement that drives the need for shared situational awareness and collaborative disruption management.

3.4 The Combined Qualification Logic

A transport leg becomes a scalable network component only when volume, frequency, and reliability are satisfied simultaneously. Together, they define whether a leg can serve as a reusable component of a Nordic sustainable transport network.

This qualification logic provides a practical prioritization framework: ***Prioritize first the legs where volume, frequency, and reliability converge, as these offer the strongest network effects.***

3.5 From Qualified Legs to Shipper Adoption: A Dual-Layer Scaling Framework

Infrastructure readiness alone is insufficient. Even when transport legs satisfy Volume–Frequency–Reliability criteria, adoption depends on whether service configurations are competitive for shippers. Even a highly qualified leg will not generate emissions impact unless it is actively used in logistics decisions. Nordic scaling, therefore, requires alignment between two evaluation layers.

The relationship between infrastructure readiness and shipper adoption can be understood as a two-layer decision logic. The Volume–Frequency–Reliability (VFR) framework identifies whether a transport leg can function as a scalable infrastructure component. The Cost–Time–Emissions (CTE) framework then evaluates whether logistics solutions built on that infrastructure are competitive for shippers. Only when both conditions are satisfied – strong VFR and competitive CTE–can a transport leg scale as a sustainable network component. When infrastructure is strong, but shipment competitiveness is weak, improvements in cost, delivery time, or emissions are required; when infrastructure readiness is weak, initiatives remain pilot cases rather than scalable network services.

Layer 1: Network Qualification (VFR)

At the level of reusable transport infrastructure, Volume–Frequency–Reliability determines whether a leg can function as a scalable Nordic network component.

Layer 2: Shipment-Level Competitiveness (CTE)

At the level of actual shipper decisions, **adoption depends on competitiveness across:**

- Cost
- Delivery time
- Emissions performance

VFR defines what can scale, while CTE defines what will be used.

Scaling fails if either layer is missing. A leg may be operationally mature, but if cost or emissions performance is weak, shippers will not adopt it. Conversely, a low-emission routing may appear attractive in a single shipment case, but without sufficient volume and repeatability, it will not scale into Nordic network infrastructure (**Figure 2**).

Scaling thus requires alignment between leg readiness and shipper uptake.

This dual-layer framework provides the missing bridge between network-level scaling priorities and shipment-level decision realities, linking qualified transport legs to adopted sustainable network services.

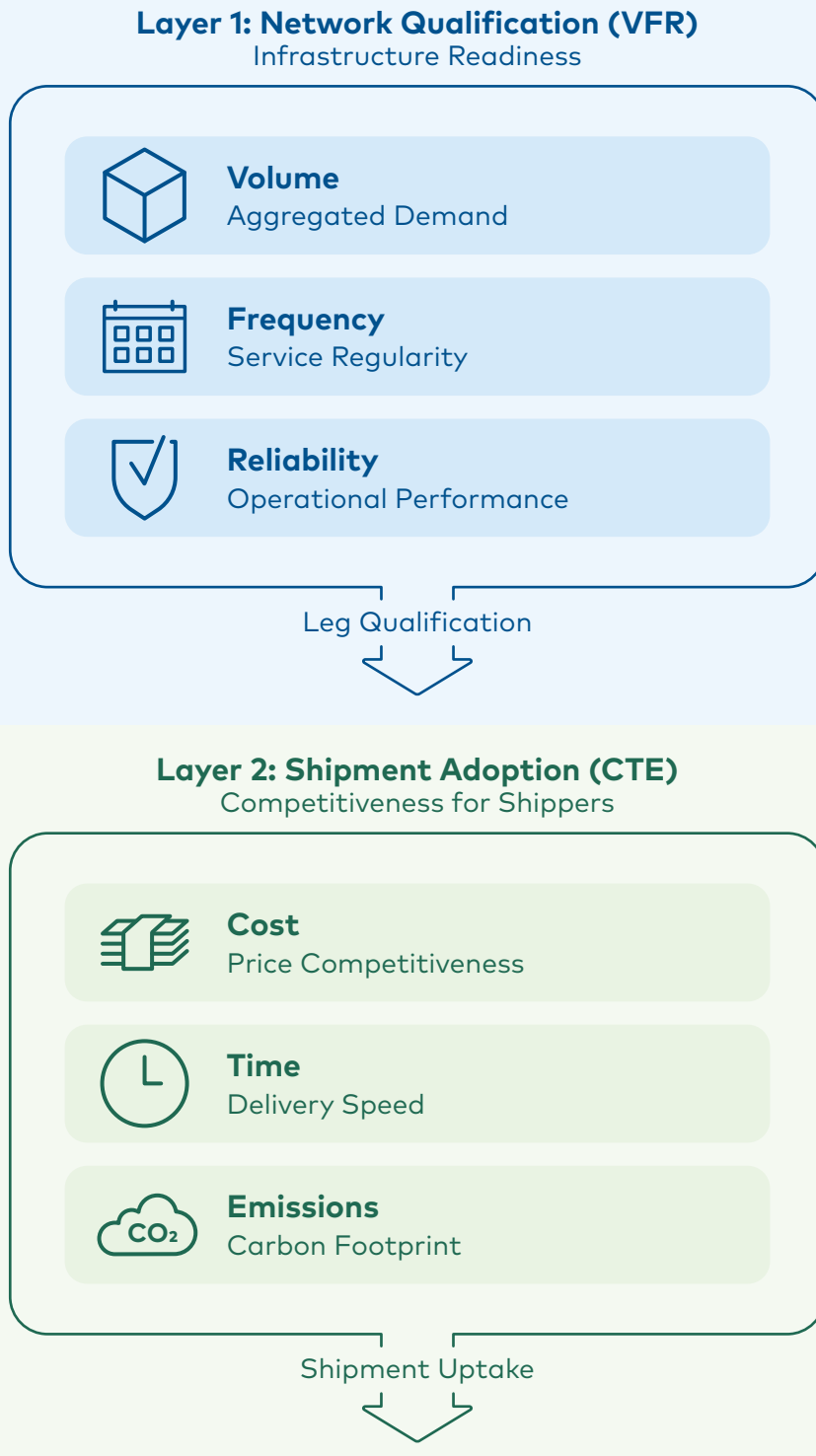


Figure 2: Dual-Layer Scaling Framework for Nordic Sustainable Transport Networks

3.6 Implications for Nordic Network Scaling

Applying these criteria suggests that scaling should focus on:

- high-volume gateway legs linking Nordic trade to continental Europe
- frequent ferry shuttle legs functioning as maritime bridges
- reliable rail trunk segments connecting industrial regions
- multimodal nodes where multiple qualified legs converge

Because many Nordic freight flows are cross-border and multimodal, qualifying shared legs across maritime, rail, and road systems becomes particularly important for achieving regional network effects.

Such an approach also aligns with the Nordic Roadmap emphasis on demand aggregation and coordinated fuel supply investment:

"Qualified legs provide the demand anchors needed for sustainable fuel ecosystems to emerge."

Nordic Energy Research, 2023



What Needs to Be Measured?

Predictability, Emissions Transparency, and Shared KPIs

Scaling sustainable transport networks requires shared measurement frameworks. Even when transport legs satisfy the Volume–Frequency–Reliability criteria, scaling depends on whether their performance can be measured, compared, and governed across actors and modes, including predictability, cost competitiveness, and emissions performance across alternative combinations of reusable transport legs.

International experience shows that corridor initiatives succeed only when end-to-end performance can be measured and compared (OECD, 2021; Global Maritime Forum, 2024).

Three measurement domains are critical:

- Predictability and punctuality
- Emissions accounting and transparency
- Shared KPI frameworks enabling trade-off governance

4.1 Predictability and Punctuality Across Network Legs

For shippers, predictability is often the decisive operational requirement because it determines whether service chains can be integrated into logistics planning and compete with direct trucking.

UNECE emphasizes that multimodal performance depends less on nominal travel time and more on the stability of interfaces and the reliability of operations across nodes and legs (UNECE, 2021).

From a network perspective, predictability must be measured not only end-to-end, but also at the level of individual legs, including (UNECE, 2021; OECD, 2021):

- ferry departure and arrival reliability
- rail service punctuality
- terminal dwell time variance
- border crossing stability
- disruption recovery time

Because legs are reused across multiple flows, improvements in predictability generate network effects: one reliable leg supports many sustainable network configurations simultaneously.

4.2 Emissions Accounting: Challenges in Multimodal Networks

While predictability drives adoption, emissions performance is central to decarbonization strategies. However, emissions accounting becomes complex in multimodal logistics systems where different actors operate different legs. **Key difficulties include:**

- inconsistent calculation methods across modes
- limited availability of primary operational data
- challenges in allocating emissions across shared multimodal chains

Sustainable network scaling therefore requires shared baselines and transparent emissions signals that allow actors to coordinate fuel transition and demand aggregation across value chains (Svendsen et al., 2023).

The need for shared emissions signals can be further illustrated through the double-trinity model (**Figure 3**), which highlights that scalable digital collaboration depends on trustworthy shared signals across cargo owners, transport operators, and transport nodes. As transport decarbonizes, these signals must expand beyond operational readiness to include carbon integrity and energy-system alignment, linking transport execution directly to sustainable fuel supply and verified emissions performance (Lind et al., 2026).

Many initiatives still rely on generic emission factors rather than operational data, limiting accuracy and credibility. **For Nordic sustainable networks, this implies that emissions measurement must evolve toward:**

- primary-data-based accounting
- leg-level emissions transparency
- comparability across multimodal configurations

Only with such measurement maturity can reusable transport legs become trusted building blocks for scalable Nordic sustainable transport networks.

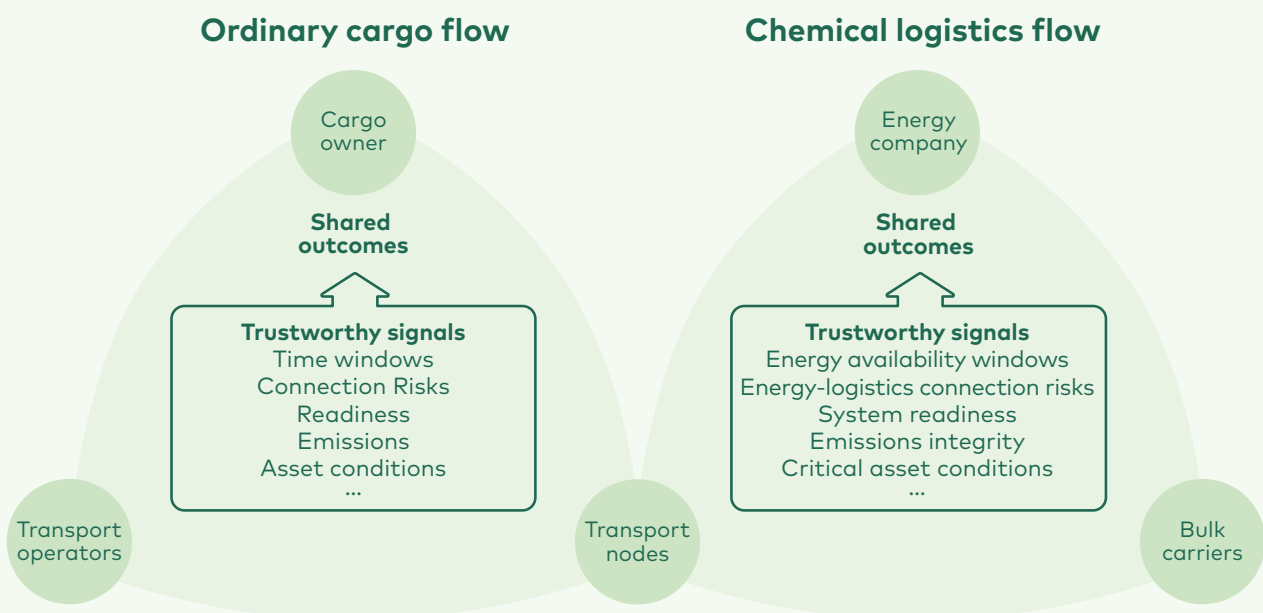


Figure 3: The Double-Trinity Model for Digital Collaboration in Decarbonizing Transport Systems (Lind et al., 2026)

4.3 Shared KPI Frameworks Across Cost, Time, and Emissions

Shared KPI frameworks enable comparison of transport solutions across cost, delivery time, and emissions. OECD notes that resilient freight systems increasingly depend on coordinated performance management across actors, enabled through shared situational awareness and common metrics (OECD, 2021).

The Maersk Mc-Kinney Møller Center similarly highlights that scalable green corridor initiatives require measurable performance frameworks that align stakeholders around shared objectives (Global Maritime Forum, 2024).

From the leg-based network perspective introduced in this report, KPI frameworks must operate at two levels:

1. Leg-level performance

- reliability of ferry legs
- rail punctuality
- port turnaround times

2. Network-level performance

- end-to-end service competitiveness
- emissions impact across multimodal chains
- resilience across alternative routing options

Sustainable networks therefore require KPI governance across reusable transport legs serving multiple flows.

4.4 Measurement as the Basis for Trade-Off Governance

A central scaling challenge is that emissions reductions alone are insufficient; transport solutions must remain competitive across multiple performance dimensions.

Shippers continuously balance:

- cost
- delivery time
- emissions

A low-emission alternative will not scale unless it remains competitive in service reliability and cost.

This implies that Nordic sustainable networks must be governed through transparent trade-off frameworks rather than single-objective optimization.

These trade-offs become visible when alternative leg combinations are compared:

- direct trucking vs. ferry + rail
- faster options vs. lower-emission options
- higher-frequency legs vs. lower-cost legs

within multimodal network configurations.

This implies that shared KPI frameworks are not only analytical tools, but critical enablers of coordinated decision-making and investment prioritization across Nordic transport systems.

Method to Balance Cost, Delivery Time, and Emissions Across Network Configurations

Once transport legs are qualified through the Volume–Frequency–Reliability (VFR) framework, the next step is to evaluate how combinations of these legs perform in real logistics decisions. This section introduces a scenario-based evaluation method that translates network-level transport leg qualification into shipment-level decision support. The method compares alternative end-to-end service chains constructed from qualified transport legs across cost, delivery time, and emissions.

Freight transport decisions rarely optimize a single objective. Instead, logistics actors must balance cost efficiency, delivery performance, and environmental impact simultaneously. The scenario-based method therefore evaluates alternative logistics configurations across these three KPIs to reveal the trade-offs between operational performance and emissions reduction (Global Maritime Forum, 2024; UNECE, 2021).

In multimodal freight systems, multiple routing options often exist between origin and destination. These routes may combine ferry services, rail connections, terminals, and road distribution legs in different ways. By evaluating these alternative service chains across cost, delivery time, and emissions, the method operationalizes the dual-layer scaling framework introduced earlier in the report: VFR qualifies the legs that can scale, CTE evaluates the solutions that shippers will adopt, and digital collaboration improves the predictability and transparency required for both layers to function in practice.

5.1 Core KPIs: Cost, Delivery Time, and Emissions

The scenario-based evaluation method compares alternative transport configurations using three core key performance indicators (KPIs): transport cost, delivery time, and greenhouse gas emissions. Together these indicators capture the operational trade-offs faced by logistics actors when selecting among alternative transport options.

- **Cost:** Transport cost reflects the direct and indirect expenses associated with a transport configuration. It includes transport rates, terminal and handling charges, and potential buffer costs related to service variability or disruption.
- **Delivery Time:** Delivery performance captures both the nominal transit time and the predictability of transport services. It includes total lead time, punctuality, and variability, all of which influence inventory levels and supply chain planning.
- **Emissions:** Emissions represent the greenhouse gas (GHG) footprint associated with a transport chain. Emissions depend on the transport modes used, fuel types, and operational efficiency across the sequence of transport legs.

While the qualification of transport legs determines the infrastructure readiness of the network, these KPIs determine whether specific network configurations will be adopted by shippers.

5.2 Scenario-Based Comparison of Network Configurations

To compare alternative logistics solutions, the method constructs a set of scenarios, where each scenario represents a complete transport chain linking origin and destination. Each scenario consists of a sequence of transport legs - for example road transport, ferry services, rail segments, and terminal transfers. For each scenario, the three KPIs (cost, delivery time, emissions) are calculated and compared across scenarios.

By evaluating these scenarios using shared KPIs, actors can identify which network configurations provide the most favorable balance between cost, delivery time, and emissions. **Typical scenarios include:**

- road-only configuration
- ferry + road configuration
- ferry + rail + road configuration
- alternative port/terminal routing options

The method is not limited to maritime corridors, but applies across multimodal Nordic networks by comparing alternative leg combinations.

5.3 Operationalizing the Method

Operationalizing the method requires combining shipment data, transport service characteristics, and emissions factors for each scenario. The method involves five practical steps:

Step 1: Identify Qualified Legs

Select legs that meet minimum thresholds of volume, frequency, and reliability.

Step 2: Construct Alternative Network Configurations

Combine legs into plausible end-to-end service chains.

Step 3: Collect KPI Data

- lead time distributions
- cost components
- emissions estimates, increasingly based on operational data

Step 4: Compare Trade-Offs

Compare how scenarios differ across cost, time, and emissions.

Step 5: Support Decision Making

Enable shippers and operators to identify **configurations offering:**

- acceptable competitiveness
- measurable emissions reduction
- sufficient reliability for adoption

Such evaluations can be conducted by shippers, freight forwarders, and logistics planners assessing multimodal routing decisions.

5.4 Illustrative Application: A Swedish BCO Case Based on 300 Real Shipments

To illustrate the practical application of the method, the report analyses approximately 300 shipments handled by a Swedish beneficial cargo owner (BCO) transporting goods from Umeå in northern Sweden to multiple destinations in Finland (**Figure 4**). Developed within the Green Node in a Green Corridor project, the method supports scenario-based evaluation of multimodal leg combinations across cost, delivery time, and emissions performance (Haraldson & Lind, 2026; Lind et al., 2025).¹ The dataset enables comparison of alternative network configurations.

Scenario Construction

For the BCO, three alternative transport scenarios were constructed, representing different end-to-end configurations between Sweden and Finland:

- **Scenario 1: Road-only transport**
Direct trucking from origin to destination.
- **Scenario 2: Ferry-enabled multimodal configuration - Liquefied Natural Gas (LNG)**
Road transport combined with the Vaasa–Umeå ferry leg powered by Liquefied Natural Gas (LNG), reducing road distance while introducing maritime integration.
- **Scenario 3: Ferry-enabled multimodal configuration – Liquefied Biogas (LBG)**
Road transport combined with the Vaasa–Umeå ferry leg powered by liquefied biogas (LBG), reducing road distance while introducing maritime integration.

Each scenario represents a different combination of reusable transport legs. **Figure 4** makes the trade-offs across cost, delivery time, and emissions explicit and shows how the same ferry leg can yield different outcomes depending on fuel pathway and service configuration.

¹ Importantly, this evaluation method was developed and tested within the Vinnova-funded *Green Node in a Green Corridor* project. The objective has been to make emissions visible across the full set of activities involved in moving goods through a transport node-covering upstream transport to the node, operational activities at the node itself, and downstream transport onward to the next node in the chain.

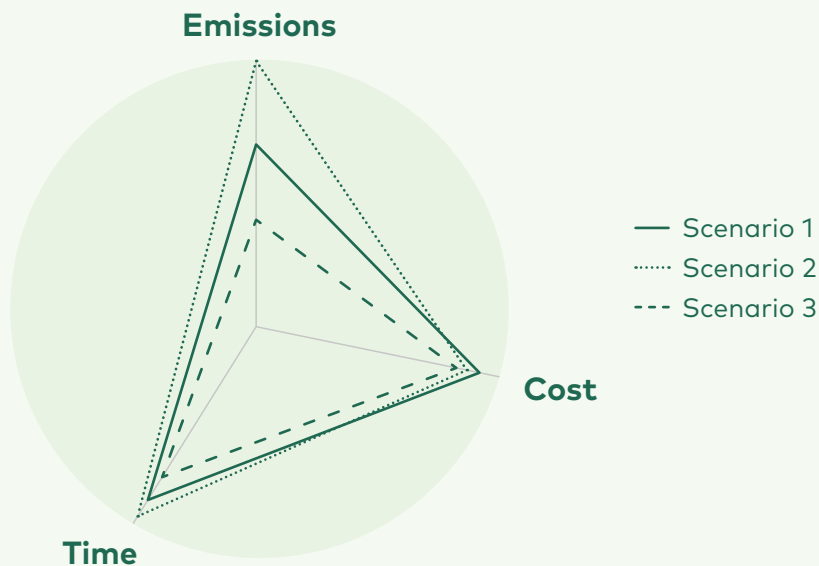


Figure 4: Trade-off between Cost, Time, and Emissions across Transport Scenarios (Haraldson & Lind, 2026)

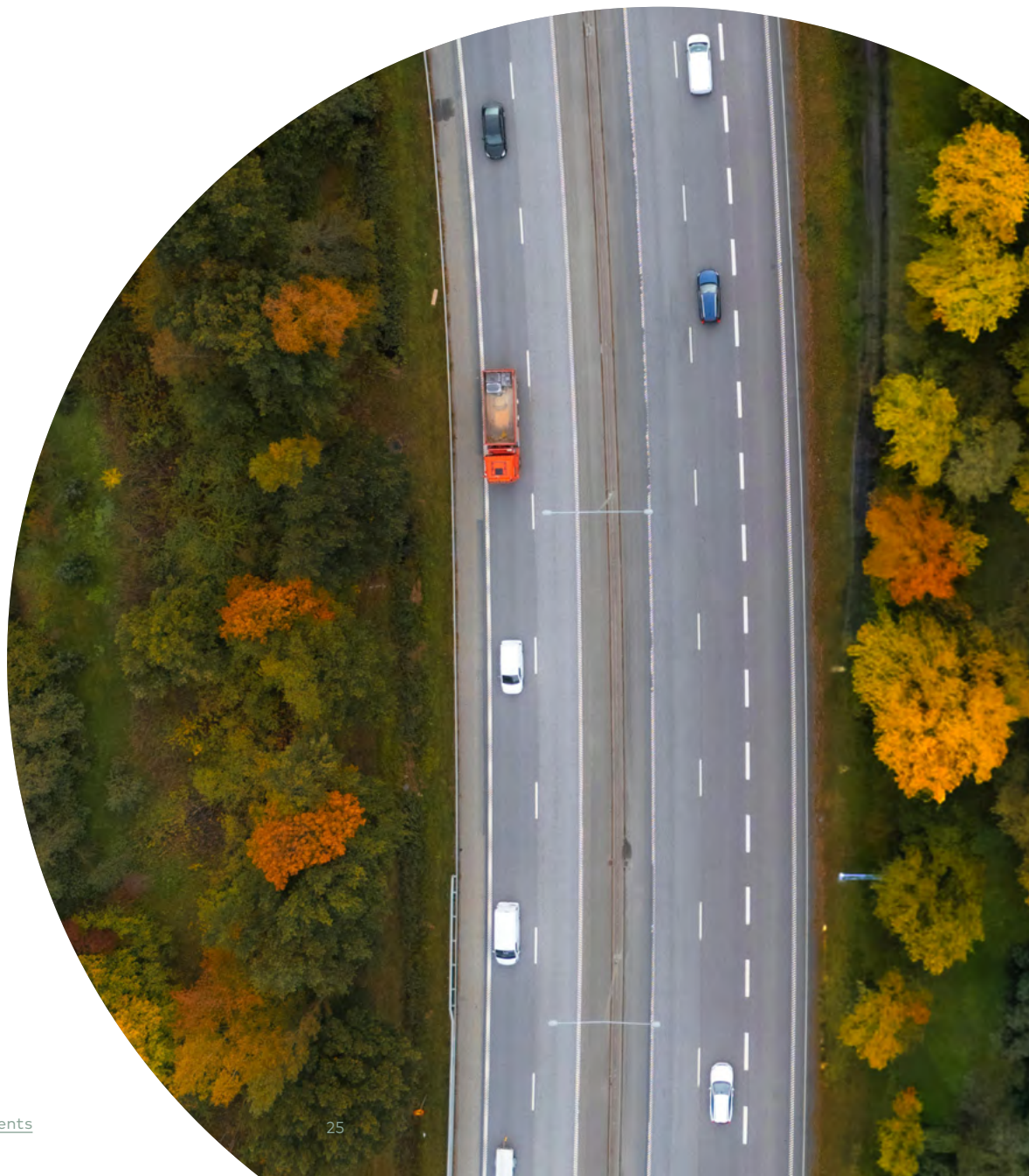
5.5 Scaling Value: From Corridor Pilots to Network Services

While corridor pilots provide valuable learning opportunities, scalable sustainable logistics require solutions that operate across transport networks. By evaluating alternative combinations of qualified transport legs, the method supports the transition from isolated corridor experiments to reusable network services.

Its key scaling value is that it supports:

- reuse across multiple network instances
- comparison of alternative leg combinations
- prioritization of high-impact interventions

Rather than optimizing one fixed corridor, the method enables optimization across a network of shared legs.



Digital Collaboration and End-to-End Collaborative Decision Making (e2eCDM)

Scaling sustainable transport networks requires more than qualified legs and KPI evaluation. Even when legs meet the criteria of volume, frequency, and reliability, network performance ultimately depends on the ability of multiple actors to coordinate operations across shared legs and nodes.

Because transport legs are reused across multiple logistics flows, coordination across actors becomes essential for maintaining reliability and enabling scalable network services. This coordination challenge becomes even more important as logistics systems decarbonize, since alternative fuels, multimodal configurations, and tighter operational margins increase the need for shared situational awareness and coordinated disruption management.

International experience confirms that successful green corridor initiatives depend not only on fuel transitions but also on governance mechanisms that enable coordination across value chains (Global Maritime Forum, 2024; Svendsen et al., 2023). Digital collaboration therefore becomes a core scaling infrastructure for Nordic sustainable transport networks.

6.1 From Data Sharing to Digital Collaboration

Digitalization is often presented as a key enabler of sustainable logistics systems, but many initiatives remain limited to data sharing rather than operational coordination. In multimodal freight systems, data exchange improves visibility, but sustainable network performance depends on digital collaboration that enables actors to coordinate decisions across interconnected transport legs and nodes.

Traditional digitalization initiatives have often focused on data exchange between individual actors. While such data sharing improves visibility, it does not automatically translate into coordinated operations. Digital collaboration instead focuses on synchronizing operational decisions across actors and transport legs, allowing disruptions, delays, and capacity constraints to be managed collectively rather than locally.

Digital collaboration, therefore, transforms fragmented operational data into shared network coordination capability.

6.2 End-to-End Collaborative Decision Making as a Network Capability

End-to-end collaborative decision making (e2eCDM) is a structured digital collaboration approach enabling actors across the transport chain to coordinate operational decisions through shared situational awareness. From the leg-based perspective developed in this report, e2eCDM functions as a coordination mechanism across reusable transport legs.

It enables actors responsible for different legs - ports, rail operators, ferry services, and logistics providers - to align operational decisions in real time, thereby improving predictability and reliability across the overall transport chain.

e2eCDM, among other use cases, supports:

- shared situational awareness
- collaborative disruption response
- aligned operational timelines
- emissions transparency across multimodal chains

6.3 Virtual Watch Tower (VWT): e2eCDM as Public-Good Digital Infrastructure

One example of digital collaboration infrastructure supporting end-to-end coordination is the Virtual Watch Tower (VWT). Rather than functioning as a proprietary platform for a single corridor or actor, VWT illustrates how shared digital infrastructure can enable situational awareness, disruption management, and emissions transparency across interconnected transport legs.

Based on its capability to gather and distribute primary operational data, **the VWT addresses three core scaling opportunities:**

- **Shared situational awareness**, providing a real-time common operational picture across legs and nodes
- **Disruption management**, enabling coordinated recovery when delays propagate across multimodal chains
- **Emissions calculation and transparency**, supporting primary-data-based accounting at leg level and comparability across alternative network configurations

This illustrates how digital collaboration becomes a governance mechanism for sustainable networks rather than an isolated IT solution.

The VWT concept has been described through the use of a **metro-map representation (Figure 5)**, where transport legs and nodes are visualized as shared network lines rather than fixed corridor routes. This representation highlights that value is generated through interoperability and reuse across multiple flows, rather than through isolated pilot corridors (Lind et al., 2023).

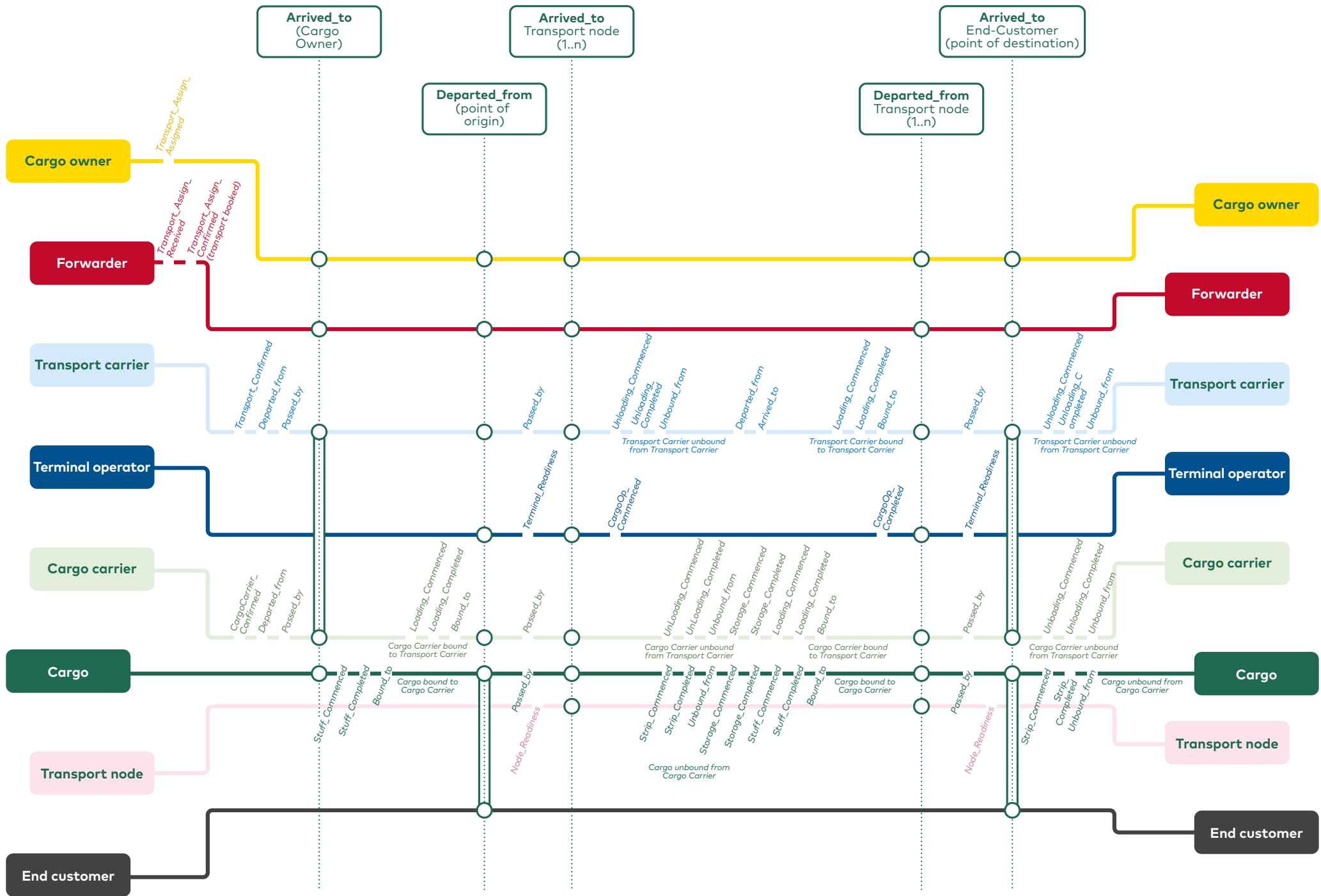


Figure 5: The metromap for end-to-end CDM underlying the VWT network approach (Illustration by Sandra Haraldson; Lind et al., 2023)

6.4 Empirical Network Visibility: Monitoring Nordic Shipper Flows

Empirical visibility into freight flows is essential for understanding how transport networks actually operate. Monitoring shipment patterns allows researchers and logistics actors to identify recurring transport legs, evaluate alternative network configurations, and assess the performance implications of routing decisions. The VWT approach has been applied to the monitoring of approximately **1000 real shipments** originating from Nordic shippers.

These monitored flows illustrate that Nordic logistics is simultaneously:

- globally connected through international trade lanes
- regionally dependent on well-coordinated Nordic multimodal legs and nodes

To illustrate this duality, Figure 6 provides two complementary perspectives:

- a global distribution of monitored Nordic shipments across worldwide supply chains
- a Nordic zoom-in revealing the concentration of flows and the importance of coordinated regional network performance

In the Nordic context, where freight flows frequently cross-national borders and involve multiple transport modes, such visibility is particularly valuable for identifying scalable legs and coordinating network-level improvements.

Digital collaboration is not only relevant for operational coordination but also for credible emissions accounting and integration between transport and energy systems. Because reliable emissions data requires operational information across multiple transport legs and actors, digital collaboration platforms provide the transparency needed to align logistics operations with evolving energy infrastructures and fuel supply systems. **Green network scaling requires a credible accounting of:**

- fuel pathways
- operational emissions performance
- availability of low-carbon energy infrastructure

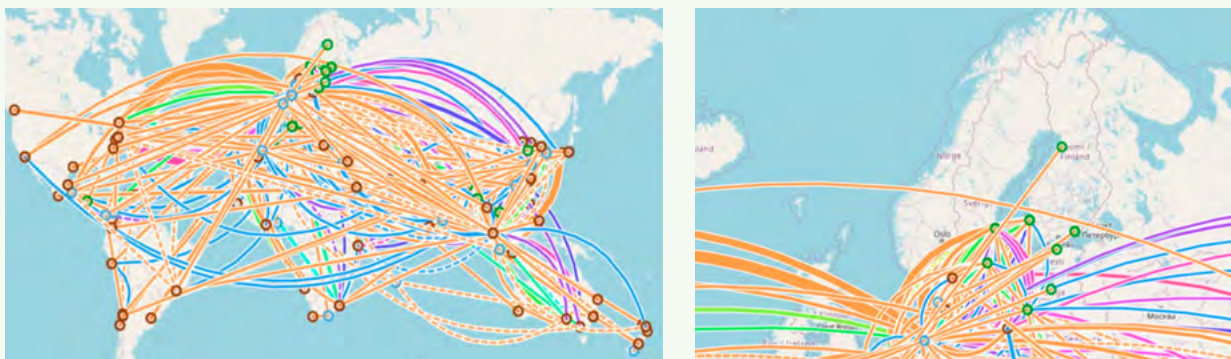


Figure 6: Shipment monitoring maps (global + Nordic zoom), side by side (Source: The VWT initiative)

The Nordic Roadmap for sustainable zero-carbon fuels emphasizes that fuel supply chains, bunkering infrastructure, and demand aggregation must be coordinated across actors and countries (Nordic Energy Research, 2023).

More broadly, decarbonization depends on integrated value chains, where fuel supply, carrier investments, and operational practices evolve together rather than independently (Petersen and Renken, 2023). **Digital collaboration mechanisms such as e2eCDM and VWT provide the operational foundation for such integration, enabling:**

- coordinated fuel uptake along shared legs
- optimization of energy use across multimodal chains
- transparent emissions baselines supporting governance

Consequently, digital collaboration becomes the bridge between transport networks and energy ecosystems.

Such empirical visibility allows actors to observe how individual shipments traverse multiple reusable transport legs, providing the operational insight required to prioritize high-impact legs and network nodes for digital coordination and emissions monitoring.

6.5 Scaling Implication: Digital Infrastructure as a Shared Network Layer

Digital collaboration infrastructure therefore functions as a shared coordination layer for sustainable transport networks, enabling actors across different transport legs to synchronize operations, manage disruptions, and generate trustworthy performance signals. Digital collaboration infrastructure acts as a network layer that connects actors operating individual transport legs and enables them to coordinate decisions across the entire logistics system. **Because legs are reused across multiple flows, digital coordination investments must function as:**

- interoperable network layers
- shared situational awareness mechanisms
- reusable governance building blocks

This aligns with broader conclusions that scaling requires shared infrastructure and governance rather than isolated pilots (Global Maritime Forum, 2024). The Nordic opportunity therefore lies in **establishing e2eCDM-enabled infrastructures such as the Virtual Watch Tower as public-good network capabilities, supporting:**

- disruption resilience
- emissions transparency
- coordinated fuel transition
- scalable sustainable logistics services

In this sense, digital collaboration becomes a foundational capability for scaling sustainable transport networks, enabling actors to coordinate complex multimodal logistics systems while maintaining operational autonomy.

Scaling from Qualified Legs to a Nordic Sustainable Transport Network

The preceding sections introduced the key elements required for scalable sustainable transport systems: qualified transport legs, shared KPI frameworks, decision-support methods, and digital collaboration mechanisms. This Section explains how these elements combine into scalable Nordic sustainable transport networks.

Three conditions enable network scaling:

1. Transport legs must be qualified through volume, frequency, and reliability.
2. Performance must be governed through shared cost–time–emissions frameworks.
3. Digital collaboration must enable coordination across reused legs and nodes.

The central scaling insight is that the qualified transport leg is the scalable unit of Nordic sustainable transport systems. Networks emerge when such legs are combined into interoperable service configurations.

7.1 Scaling Logic: From Legs to Networks

A network-based approach therefore shifts the focus from defining new corridors to equipping existing high-impact transport legs and enabling reuse across multiple end-to-end chains. Scaling is achieved when the Nordic freight system operates as a network of interoperable legs rather than a set of declared corridors.

7.2 Prioritization: Equip the Legs with the Strongest Network Effects

Because infrastructure and fuel deployment resources are limited, scaling requires prioritizing transport legs that generate the strongest network effects—legs serving multiple industries, connecting major logistics nodes, or supporting large recurring freight flows.

Leg-based scaling therefore prioritizes legs where:

- volumes are high
- services are frequent
- reliability thresholds are achievable
- nodes serve multiple flows simultaneously

OECD similarly notes that resilient freight systems depend on concentrating investments where network effects are strongest (OECD, 2021).

In the Nordic context, this suggests prioritizing:

- major gateway legs linking Nordic trade to continental Europe
- high-frequency maritime shuttle legs across the Baltic
- rail trunk legs serving industrial north–south flows
- cross-border east–west resilience legs connecting Atlantic and Bothnian systems

The VFR–CTE Scaling Matrix for Nordic Prioritization

The dual-layer framework introduced earlier can be translated into a practical governance tool by combining infrastructure readiness (VFR) and shipment competitiveness (CTE) into a scaling decision matrix (**Figure 7**).

	CTE Strong <i>Competitive</i>	CTE Weak <i>Uncompetitive</i>
VFR Strong <i>Scalable Infrastructure</i>	Priority Network Leg	Improve Cost, Time and Emissions
VFR Weak <i>Pilot/Unreliable</i>	Pilot Only Won't Scale Yet	Not a Candidate

Figure 7: VFR–CTE Scaling Matrix for Nordic Prioritization

This matrix provides actionable guidance:

- VFR identifies reusable infrastructure readiness
- CTE identifies real adoption potential
- Scaling requires that both conditions converge.

The Nordic opportunity lies in prioritizing legs and nodes where both infrastructure maturity and shipment competitiveness align. In the Nordic region, such legs frequently include ferry connections linking national markets, rail trunk lines serving industrial regions, and gateway ports connecting Nordic supply chains to continental Europe.

The relationship between VFR and CTE should be understood as dynamic (**Figure 8**). Shipper decisions generate demand signals revealing where improvements in frequency, reliability, or capacity are required. Infrastructure owners and policymakers can respond by strengthening the VFR characteristics of transport legs. As infrastructure improves, adoption increases, generating further demand signals and enabling continuous network development.

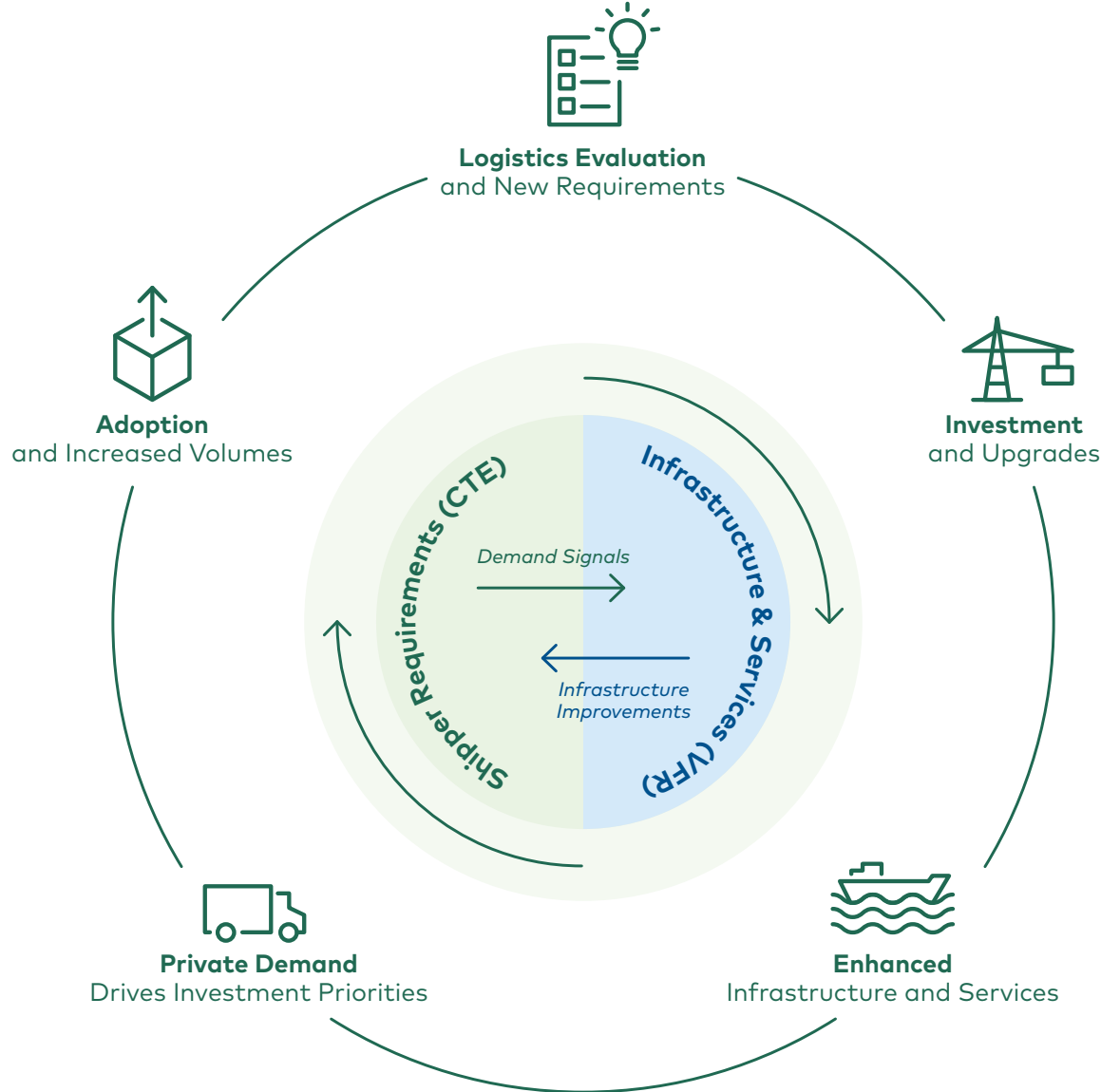


Figure 8: Continuous development of transport capacity through the interaction between shipper requirements (CTE) and infrastructure readiness (VFR)

7.3 Illustrative Nordic Network Configurations

The following examples illustrate how qualified transport legs combine into recurring Nordic logistics network structures.

- **Nordic–Continental Trade Network:** Gothenburg – Malmö – Copenhagen – Hamburg, representing the main Nordic gateway system linking Nordic trade to continental Europe.
- **Bothnian Industrial Network:** Umeå – Luleå – Haparanda/Tornio – Oulu, supporting forestry, mining, and industrial value chains.
- **Mid-Nordic East–West Resilience Network:** Trondheim – Östersund – Sundsvall – Umeå – Vaasa, illustrating cross-border resilience links between Atlantic and Bothnian systems.
- **Baltic Ferry Shuttle Network:** Turku – Stockholm – Helsinki, where high-frequency maritime legs function as floating bridges within Nordic logistics systems.
- **Icelandic Gateway Leg:** Reykjavík connected via maritime services to Nordic hubs, integrating Icelandic freight flows into regional supply chains.

Together, these examples show how reusable maritime, rail, and road legs combine into scalable Nordic logistics structures across borders.

7.4 Integration with the Energy Ecosystem

Sustainable transport networks cannot scale within the transport sector alone. Fuel availability, charging infrastructure, and bunkering systems must evolve in parallel with transport services. Value-chain coordination is therefore essential: fuel availability, vessel and vehicle investments, and operational practices evolve together rather than independently (Petersen and Renken, 2023). The Nordic Roadmap similarly highlights that zero-carbon fuel uptake requires coordinated infrastructure deployment, demand aggregation, and cross-border collaboration (Nordic Energy Research, 2023). Nordic sustainable networks must therefore be understood as transport–energy ecosystems rather than transport-only corridors.

In addition, energy preparedness and system resilience are becoming critical dimensions of transport–energy integration. Ensuring secure, flexible, and decentralised energy supply – capable of responding to disruptions, peak demand, and geopolitical uncertainties – is essential for maintaining continuity in transport operations and safeguarding critical infrastructure.

7.5 Digital Collaboration as the Scaling Infrastructure

Digital collaboration infrastructure enables actors operating individual transport legs to coordinate decisions across the broader network through shared situational awareness, disruption management, and emissions transparency. In the Nordic context, the opportunity is to extend this logic beyond maritime routes by establishing interoperable e2eCDM as a shared network capability across modes. Digital collaboration infrastructure therefore functions as the coordination layer of the transport network, linking operational decisions across ports, terminals, carriers, and logistics providers.

7.6 From Pilot Instances to Nordic Network Governance

Early green corridor initiatives have often focused on individual pilot routes. While such pilots are valuable for testing technologies and collaboration models, long-term scaling requires governance beyond single corridors. **Scalable networks require:**

- shared KPI frameworks
- interoperable digital collaboration
- aligned investment signals across fuel, operations, and assets
- institutional mechanisms for cross-border coordination

Green corridor success depends on governance models capable of aligning multiple stakeholders around shared performance and investment objectives (Global Maritime Forum, 2024). **A Nordic network perspective therefore implies governance across:**

- shared legs serving multiple flows
- nodes reused across industries
- cross-border energy and transport ecosystems

This enables policymakers and industry actors to coordinate investments, digital infrastructure, and fuel deployment across multiple transport legs simultaneously.



Other Nordic Work and State of the Art Associated with Green Corridors and Sustainable Networks

The Nordic region has been highly active in advancing sustainable transport and freight decarbonization. Significant work has already been undertaken across maritime, port, fuel, and multimodal domains in the Nordic region. This section reviews key Nordic and international initiatives relevant to green corridor development and situates the contribution of the present report. The report introduces a shipper-driven scaling perspective, reframing the discussion from static maritime corridor pilots toward leg-based, multimodal Nordic sustainable transport networks integrated with the energy ecosystem.

Parallel Nordic initiatives such as the Nordic Roadmap for the Introduction of Sustainable Zero-Carbon Fuels in Shipping focus on the development of green shipping corridors and the associated maritime energy ecosystem. This work addresses the full corridor value chain, including fuel production and distribution, bunkering infrastructure, port operations, vessel technologies, and regulatory coordination across corridor partners.

These initiatives are essential for enabling the maritime energy transition. The present report complements this foundation by shifting attention from maritime fuel pathways alone toward shipper adoption, multimodal service competitiveness, and leg-based scaling across Nordic freight systems. In this perspective, the key challenge is not only fuel availability but whether transport services achieve competitive performance across cost, delivery time, and emissions, enabling widespread adoption across supply chains.

Recent analyses emphasize that green corridors function not only as transport routes but also as collaborative platforms coordinating fuel producers, ports, cargo owners, and regulators (Global Maritime Forum, 2024).

8.1 Green Shipping Corridors as the Initial International Frame

The concept of green corridors gained international prominence through maritime initiatives aimed at accelerating the deployment of zero-emission technologies along specific shipping routes. The Clydebank Declaration launched at COP26 encouraged countries to establish zero-emission maritime routes between ports through coordinated public–private collaboration (Clydebank Declaration, 2021; Svendsen et al., 2023). While these initiatives mobilized important early collaboration and experimentation, they have largely focused on maritime port-to-port routes, often overlooking the multimodal logistics systems through which freight actually moves.

Subsequent work has expanded this agenda by emphasizing that green shipping corridors require coordinated action across fuel suppliers, ports, shipowners, regulators, and cargo owners, supported by credible baselines and aligned investment signals (Svendsen et al., 2023). Recent assessments similarly show that successful corridors function not only as transport routes but also as collaborative platforms where cargo owners, fuel providers, ports, carriers, and regulators align investments and governance mechanisms (Global Maritime Forum, 2024).

The state of the art, therefore, confirms that corridors are not merely geographic routes but governance and value-chain constructs.

8.2 Nordic Roadmap for Sustainable Zero-Carbon Fuels

A key Nordic initiative is the Nordic Roadmap for the Introduction of Sustainable Zero-Carbon Fuels in Shipping, which supports the development of green shipping corridors across the Nordic region. The program addresses the full corridor ecosystem, including fuel production and distribution, bunkering infrastructure, port readiness, vessel technologies, safety frameworks, and regulatory coordination across participating countries and industry actors (Nordic Energy Research, 2023). The program is coordinated under the Nordic Council of Ministers and brings together Nordic governments, industry actors, and research organizations to accelerate the deployment of green shipping corridors and zero-carbon fuels in the region (Nordic Energy Research, 2023). The roadmap emphasizes that transport decarbonization depends on coordinated development of energy infrastructure, fuel production capacity, and transport demand across multiple countries.

The roadmap highlights that shipping decarbonization depends fundamentally on aligning (Nordic Energy Research, 2023):

- fuel production pathways
- bunkering and port infrastructure
- demand aggregation mechanisms
- cross-border regulatory coordination

This work provides essential foundations by clarifying that fuel transition is not a vessel-level issue alone, but an ecosystem challenge involving multiple actors and coordinated investment signals. The present report complements this foundation by shifting attention from maritime fuel pathways alone toward shipper adoption, multimodal service competitiveness, and leg-based scaling across Nordic freight systems.

8.3 Future Fuels Assessments and Demand Clustering

Nordic work on future fuels and demand clustering highlights that alternative fuels scale only where demand is sufficiently concentrated and predictable to justify supply-side investment (Menon Economics, 2022; Nordic Innovation, 2024). This aligns with the present report's emphasis on anchored demand, while extending the discussion from fuel uptake toward multimodal network scaling.

8.4 Port Electrification and OPS as Enabling Infrastructure

Port electrification, OPS, and alternative fuel bunkering initiatives show that ports are critical nodes in the energy transition of freight systems (Nordic Innovation, 2022). These initiatives strengthen corridor and network readiness, but they mainly address specific infrastructure components. The present report complements them by positioning ports as shared multimodal nodes within reusable Nordic transport networks.

Other recent Nordic Council of Ministers program also reinforce the broader relevance of coordinated sustainable freight development. Co-operation on Sustainable Freight Transport highlights the need for cross-border coordination in freight policy and system development, while ChargeNordic – Heavy-Duty eTransport Alliance addresses enabling conditions for electrification of heavy-duty freight transport in the Nordic region. Together, these program underline that Nordic freight decarbonization depends not only on maritime fuel transitions, but also on coordinated development across multimodal logistics and infrastructure systems.

8.5 Green and Digital Corridor Initiatives Beyond the Nordics

Green and digital corridor initiatives beyond the Nordics, including Singapore-led collaborations and the Green Jutland Corridor, demonstrate the value of combining emissions reduction, digital collaboration, and cross-border coordination (Maritime and Port Authority of Singapore, 2025; Global Maritime Forum, 2024). The present report complements them by extending the logic from corridor-specific initiatives toward leg-based multimodal network scaling in the Nordic context. Additional Nordic Council initiatives addressing freight decarbonization include program such as the Co-operation on Sustainable Freight Transport and the ChargeNordic Heavy-Duty eTransport Alliance, which focus on policy coordination and electrification of heavy transport systems.

8.6 The Unique Contribution of This Report

While earlier Nordic initiatives have focused primarily on maritime corridor development and the energy transition in shipping, the present report introduces a complementary logistics perspective. By focusing on reusable transport legs across maritime, rail, and road systems, the report provides a scaling logic for how sustainable transport solutions can move beyond corridor pilots toward interoperable Nordic transport networks.

This report contributes a broader scaling framework by introducing qualified transport legs as the operational building blocks of sustainable freight networks. By combining the Volume–Frequency–Reliability (VFR) qualification framework with Cost–Time–Emissions (CTE) performance governance and digital collaboration mechanisms, it provides a practical approach for scaling sustainable logistics systems beyond individual corridor pilots.

A key gap nevertheless remains: most corridor work is maritime and route-centric, while Nordic freight reality is multimodal and network-based. The present report therefore contributes **a distinct scaling perspective:**

- the scalable unit is the transport leg, not the corridor
- legs must qualify through volume, frequency, and reliability
- sustainable networks emerge from combinations of reusable legs across modes
- digitalization enables end-to-end collaborative decision making across shared network components
- scaling requires integration of transport and energy ecosystems

8.7 Implications for Nordic Network Development

Taken together, these initiatives provide important foundations, while the present report contributes a complementary scaling perspective centered on qualified transport legs, shipper adoption, multimodal reuse, and transport–energy ecosystem integration.

Conclusion

The Nordic Opportunity to Scale Sustainable Transport Networks

This report has argued that the transition from green corridor pilots to scalable Nordic sustainable transport systems requires a shift from route-based thinking to leg-based network governance. With ambitious climate commitments, strong multimodal infrastructure, and globally connected supply chains, the Nordics are well positioned to demonstrate scalable decarbonization pathways (European Commission, 2020; Nordic Council of Ministers, 2023).

Green corridors have played an important role in accelerating early action, particularly in maritime shipping. In the Nordic context, the next step is to translate that experience into scalable multimodal transport networks built on reusable and qualified transport legs.

9.1 Key Conclusions

The report's conclusions can be summarized in five points:



Transport systems operate as **networks of reusable legs and nodes**.



Transport legs **must meet Volume-Frequency-Reliability criteria** to function as scalable infrastructure components.



Shipper adoption depends on performance trade-offs between Cost, Delivery Time, and Emissions.



Digital collaboration enables coordinated operations across multimodal networks.



Decarbonization requires integration between transport systems and energy ecosystems.

Leg qualification is the foundation for scaling. Transport legs become reusable building blocks only when they meet three critical criteria: volume, frequency, and reliability. These criteria determine whether sustainable alternatives can compete operationally and attract shipper adoption (OECD, 2021; UNECE, 2021).

Network performance requires shared measurement and governance. Sustainable networks cannot scale without transparent performance frameworks. Predictability, emissions accounting, and shared KPIs across cost, delivery time, and emissions are prerequisites for governance and commercialization (IMO, 2020; Global Maritime Forum, 2024).

Trade-off methods enable adoption beyond pilots. Decarbonization will not scale through emissions ambition alone. Shippers balance delivery time, cost, and emissions simultaneously. Practical scenario-based methods for comparing alternative leg combinations therefore provide essential decision support for sustainable network adoption.

Digital collaboration is the operational scaling infrastructure. For Nordic sustainable networks, digital infrastructure must enable end-to-end collaborative decision making, shared situational awareness, coordinated disruption management, and emissions transparency across multimodal chains. Initiatives such as the Virtual Watch Tower illustrate how end-to-end CDM can function as a public-good digital infrastructure for shared situational awareness, disruption management, and primary-data-based emissions transparency across Nordic freight networks.

9.2 The Nordic Scaling Opportunity

The Nordic region is well positioned to scale sustainable transport networks due to its interconnected multimodal freight systems and strong cross-border integration. While the analysis focuses primarily on transport legs as scalable building blocks, the performance of shared logistics nodes such as ports, terminals, and intermodal hubs remains equally critical. Predictability and operational efficiency at these nodes strongly influence the reliability of the overall network and represent an important area for further work.

Importantly, this perspective complements existing green corridor initiatives and aligns with broader European frameworks such as TEN-T by extending them from route-based planning toward scalable, network-based system development. Corridor pilots have played a crucial role in mobilizing collaboration, testing technologies, and demonstrating the feasibility of low- and zero-emission transport solutions. However, freight systems rarely operate as single linear routes. In practice, logistics flows move across interconnected multimodal networks where individual transport legs are reused across many supply chains. The leg-based network perspective, therefore, extends corridor thinking by showing how successful corridor components can scale beyond individual pilot routes and become part of reusable Nordic logistics infrastructure.

Moving from corridor pilots toward scalable, interoperable sustainable transport networks requires coordinated action across four strategic dimensions:

- Prioritize qualified transport legs where volume, frequency, and reliability converge.
- Equip shared nodes with interoperable digital collaboration infrastructure enabling end-to-end coordination, disruption management, and emissions transparency.
- Apply shared KPI frameworks across cost, delivery time, and emissions to support shipper adoption and transparent trade-off governance.
- Align transport development with sustainable energy ecosystems so that fuel supply, infrastructure deployment, and logistics demand evolve together.

The Nordic region is therefore uniquely positioned to demonstrate how green corridor initiatives can evolve into scalable multimodal sustainable transport networks built on qualified transport legs, shared digital infrastructure, and coordinated energy ecosystems.

This also implies a shift in focus for Nordic stakeholders—from developing individual corridor initiatives to coordinating investments, governance, and digital infrastructure at the level of interoperable transport networks.

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