

From production to application. Downstream transport approaches for hydrogen derivates

11. Branchentag Wasserstoff Wien | 08/04/2025

RAMBOLL

Bright ideas.
Sustainable change.



Themen- übersicht

1. Kurzvorstellung Ramboll
2. Venergi
3. Energieträger als Energiespeicher
4. Modes and Means of Transport
5. Transportkosten
6. Lessons learned

Our Markets

Revenue share 2023
FTEE Employees 2023



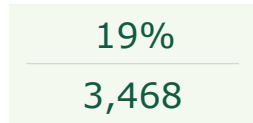
Buildings



- Aviation
- Arts & Culture
- Commercial
- Social Housing
- Healthcare
- Higher/Further Education
- Hotels & Leisure
- Industrial & Science
- Government & Public
- Residential
- Retail
- Schools
- Sports



Transport



- Bridges, Tunnels & Major Crossings
- Smart Mobility
- Rail Systems
- Aviation
- Roads and Highways
- Ports, Marine and Waterways



Environment & Health



- Air Quality
- Compliance Assurance Ecological Services
- Expert Services
- Impact Assessment
- Occupational & Building Health
- Product Safety & Stewardship
- Risk Assessment & Community Health
- Sciences for Regulatory Support
- Site Solutions
- Sustainability
- Due Diligence
- Waste & Resource Management



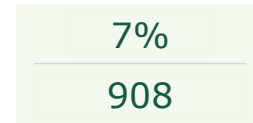
Energy



- Wind & Solar
- Green Hydrogen and Power-to-X
- Carbon Capture Utilisation & Storage
- Energy Infrastructure
- District Energy
- Bioenergy
- Waste-to-Energy
- Energy-Intensive Industries



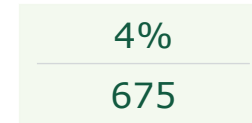
Water



- Water Supply & Treatment
- Water Resources Management
- Wastewater Treatment & Resource Recovery
- Water & Wastewater Networks
- Urban Climate Resiliency
- Storm-surge Protection & Liveable Coastlines



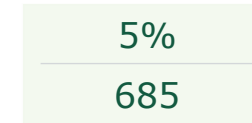
Management Consulting



- Social & Economic Impacts
- Stakeholder Intelligence
- Strategic Sustainability Consulting
- People & Change
- Digital & Technology
- Legal & Contract Management



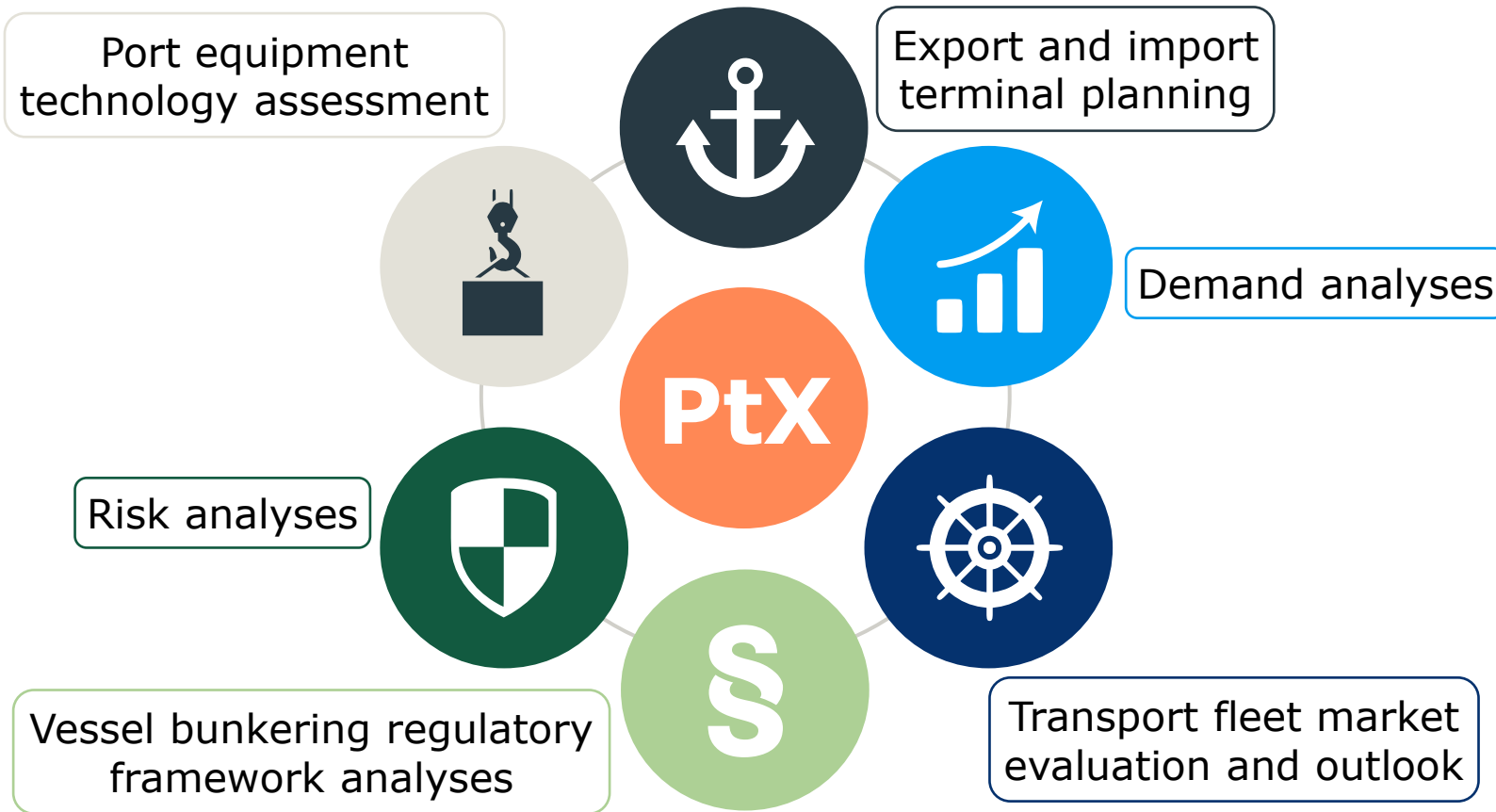
Architecture & Landscape



- Architecture
- Landscape Architecture
- Urbanism
- Interiors, Graphics & Lighting Design

Strategic Port Planning and Logistics

Selected services in maritime energy transition



Like entire Ramboll, 'Strategic Port Planning and Logistics' is interdisciplinary thinking green energies from the cradle to the grave!



Powered by Wien Energie and Ramboll

... is driving and empowering Vienna's green energy transition, achieved through integrated, sustainable solutions.

We are key to Vienna being the most resilient and livable city and society of the future by providing **planning and engineering services** in the circular economy, renewable energy and decarbonization

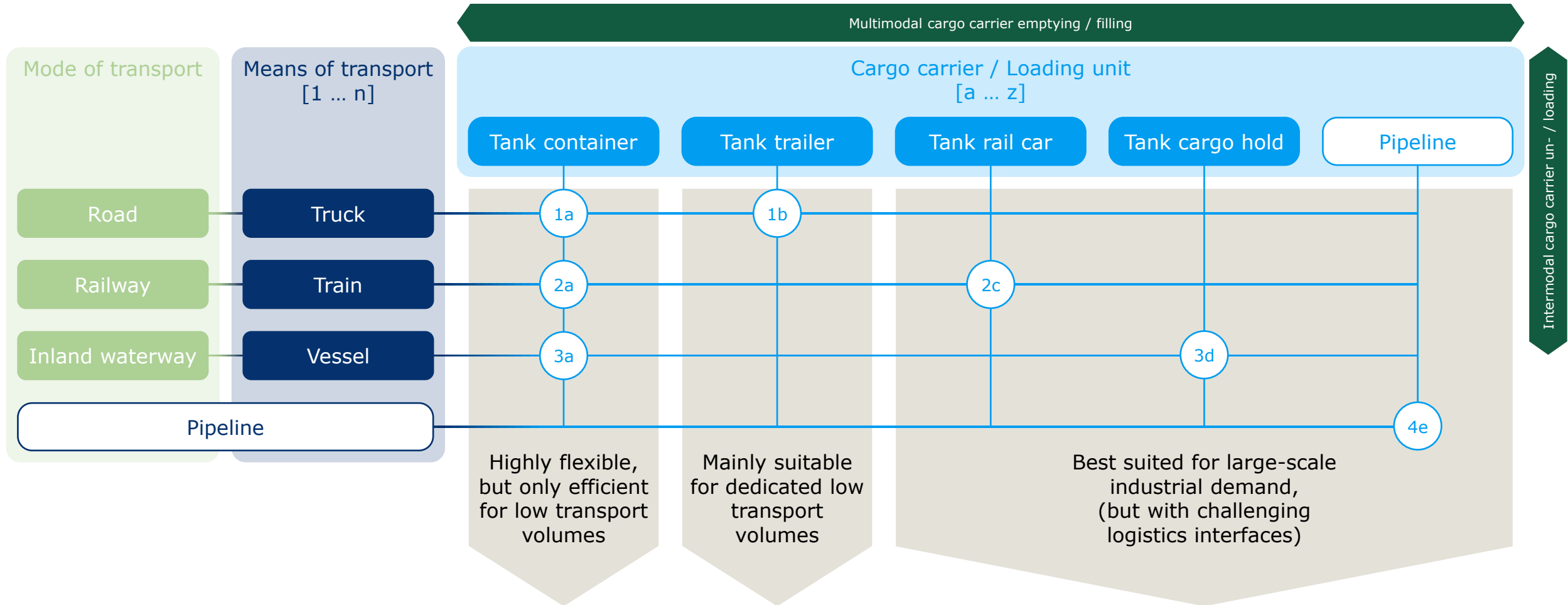


Eignung ausgewählter Energieträger als Energiespeicher

| | Wasserstoff | | | Ammoniak | | | Methanol | LOHC (Benzyltoluol) | Methan | ... The story continues |
|-------------------------------------|---|---------------------------------|-------------------------|--|-------------------------|----------------------|---|-------------------------|-------------------------|--|
| Eigenschaften | Tief-kalt verflüssigt (L-H ₂) | Komprimiert (C-H ₂) | Umgebungsbedingungen | Tief-kalt verflüssigt (L-NH ₃) | Umgebungsbedingungen | Umgebungsbedingungen | Umgebungsbedingungen (CH ₃ OH) | Umgebungsbedingungen | Umgebungsbedingungen | Tief-kalt verflüssigt (L-CH ₄) |
| Aggregatzustand | Flüssig (1bar, -252 °C) | Gasförmig (250 bar, 15°C) | Gasförmig (1 bar, 20°C) | Flüssig (1bar, -33 °C) | Gasförmig (1 bar, 25°C) | Flüssig (1bar, 25°C) | Flüssig (1bar, 25 °C) | Gasförmig (1 bar, 25°C) | Flüssig (1bar, -163 °C) | |
| Energiedichte [MWh/m ³] | 2,37 | 1,4 | <0,01 | 6,62 | <0,01 | 4,38 | 1,90 (H₂) | <0,01 | 6,25 | |
| Heizwert [MWh/t] | 33,33 | 33,33 | 33,33 | 5,17 | 5,17 | 5,53 | 1,91 (H ₂) | 13,89 | 13,89 | |
| Dichte [t/m ³] | 0,07 | 0,02 | <0,01 | 0,70 | <0,01 | 0,79 | 0,99 | <0,01 | 0,45 | |
| GHS-Kennzeichnungen | | | | | | | | | | |
| | Leicht entzündlich | Verdichtete Gase | Akut toxisch | schädlich | ätzend | umweltgefährlich | reizend | | | |

Die komplexen logistischen Kombinationsentscheidungen

Anwendbar auf H₂ und jedes Derivat



Grundlagen der Logistik

Direkt- vs. Hub-and-Spoke-Verkehre

| | 1 customer | n customer(s) |
|---------------|------------|---------------|
| 1 producer | | |
| n producer(s) | | |

- Direct delivery to customer is the most efficient way
 - No additional cargo handling
 - No change of transport mode
- But it bears challenges with increasing transport distance and volume
- Managing transport chain risks, resilience and reliability on long distance transports required

| | 1 customer | n customer(s) |
|---------------|------------|---------------|
| 1 producer | | |
| n producer(s) | | |

- Differentiating between pre-, main- and on-carriage
- Using hubs as intermediate storage for cargo carriers with
 - Un- / loading op. or
 - Emptying / filling op.
- “absorbing” transport chain disruptions by
 - Technical breakdowns
 - Strikes
 - Production and consumption volatility/imbalance
 - ...

Vergleich der Verkehrsträger im Hauptlauf

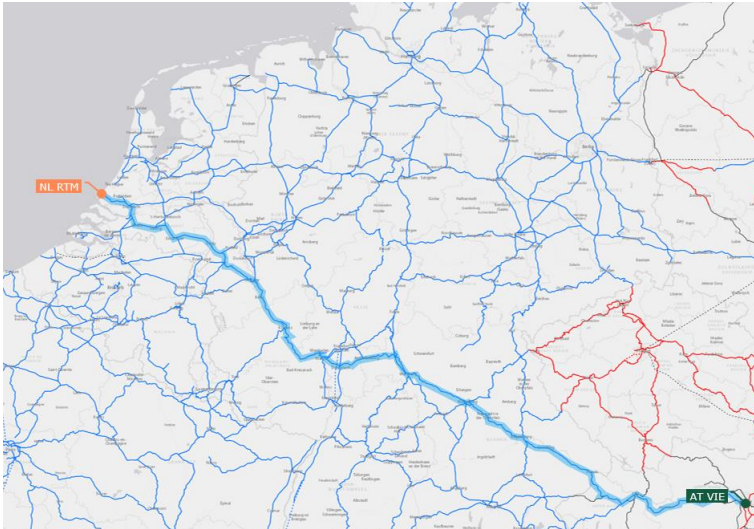
Indikative Streckenführung und Logistikkosten (Direktverkehr) ***

Road transport*



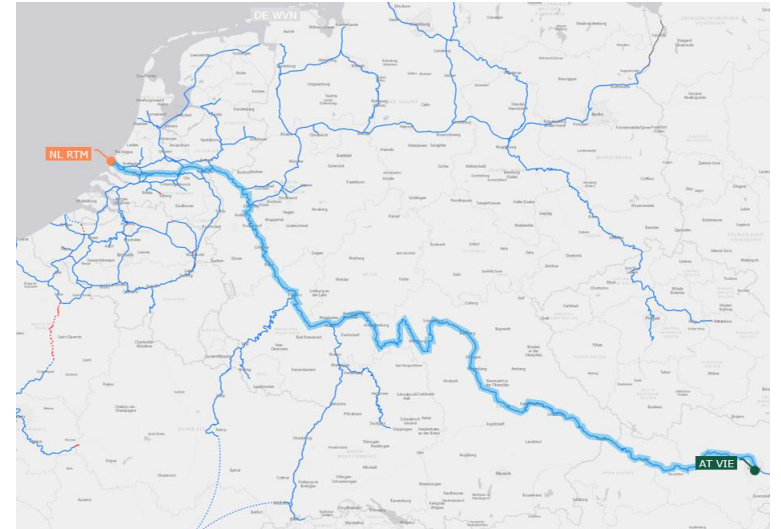
| Transportstückkosten | | |
|----------------------|----------------|---------------------|
| Produkt | Produkt [€/kg] | H2-Prod.-äq. [€/kg] |
| Wasserstoff (1a) | - | ~ 5,40 |
| Ammoniak (1b) | ~ 0,30 | ~ 1,50 |
| Methanol (1b) | ~ 0,30 | ~ 1,50 |

Rail transport*



| Transportstückkosten | | |
|----------------------|----------------|---------------------|
| Produkt | Produkt [€/kg] | H2-Prod.-äq. [€/kg] |
| Wasserstoff (2a) | - | ~ 1,50 |
| Ammoniak (2c) | < 0,10 | ~ 0,20 |
| Methanol (2c) | < 0,10 | ~ 0,20 |

IWW transport **



| Transportstückkosten | | |
|----------------------|----------------|---------------------|
| Produkt | Produkt [€/kg] | H2-Prod.-äq. [€/kg] |
| Wasserstoff | - | - |
| Ammoniak (3d) | ~ 0,10 | ~ 0,60 |
| Methanol (3d) | ~ 0,10 | ~ 0,60 |

* Operative Routenwahl obliegt dem Transportunternehmen unter direkter Berücksichtigung der zeitpunktgenauen Infrastrukturauslastung

** Das Binnenwasserstraßennetz bietet keine (signifikanten) Möglichkeiten zur operativen Anpassung der Routenwahl

*** Round-trip transport incl. equipment leasing, excl. handling

Key findings (Auswahl)

1. Transportkosten (1/2): Straße > Binnenwasserstraße > Schiene
2. Transportkosten (2/2): L-H₂ > L-NH₃ ≈ CH₃OH
3. Derivate-Direktverwendung/-verkehre vs. Dezentrale "Aufspaltung"
4. Dezentrale "Aufspaltung" = Hub-and-Spoke-Verkehre
5. Wo "aufspalten" und wohin mit dem "C" bei z. B. CH₃OH?

“On your mark. Get set. Go! The market ramp-up for the supply of H₂ from PtX to the hinterland is a marathon that will be won via the pipeline. But we must get out of the starting blocks with the logistical tools we have at our hands now!”

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