European Ports:
Reflection on policies & strategies for the energy transition

Prof. Dr. Gordon Wilmsmeier

Director Hapag-Lloyd Center for Shipping and Global Logistics (CSGL)
Professor in Shipping and Global Logistics
Kühne Logistics University (KLU), Hamburg / Germany

Director Kühne Professorial Chair in Logistics
Universidad de los Andes, Bogotá / Colombia

Jean Monnet Lecture 2026
28th April 2026, Piraeus, Greece


"Which picture best characterises your outlook for the European port system over the next decade(s)?"

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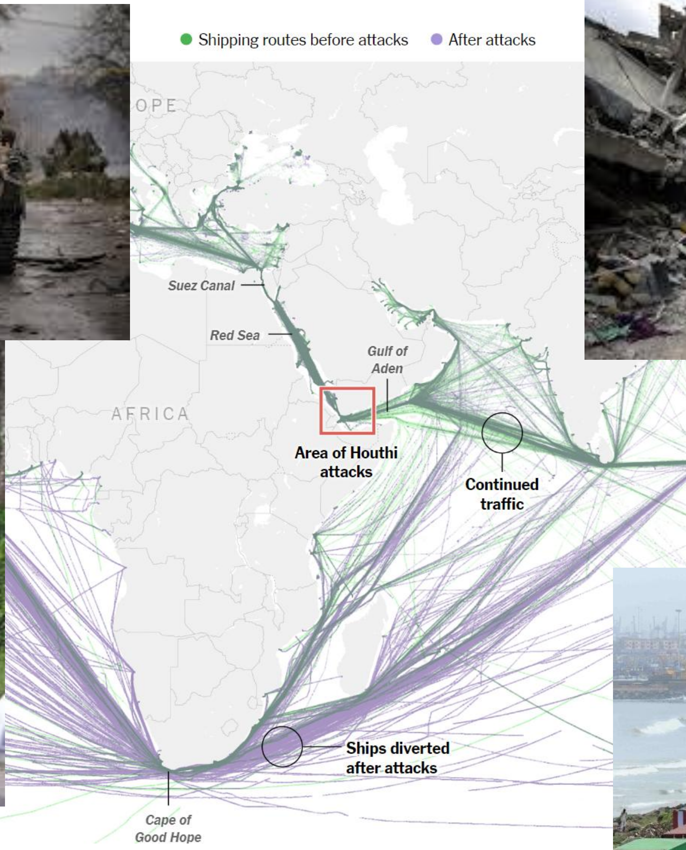
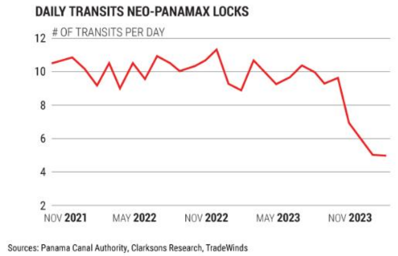
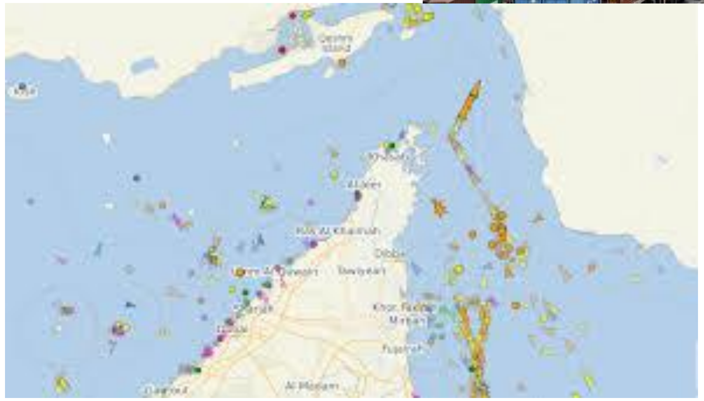
The logistics environment







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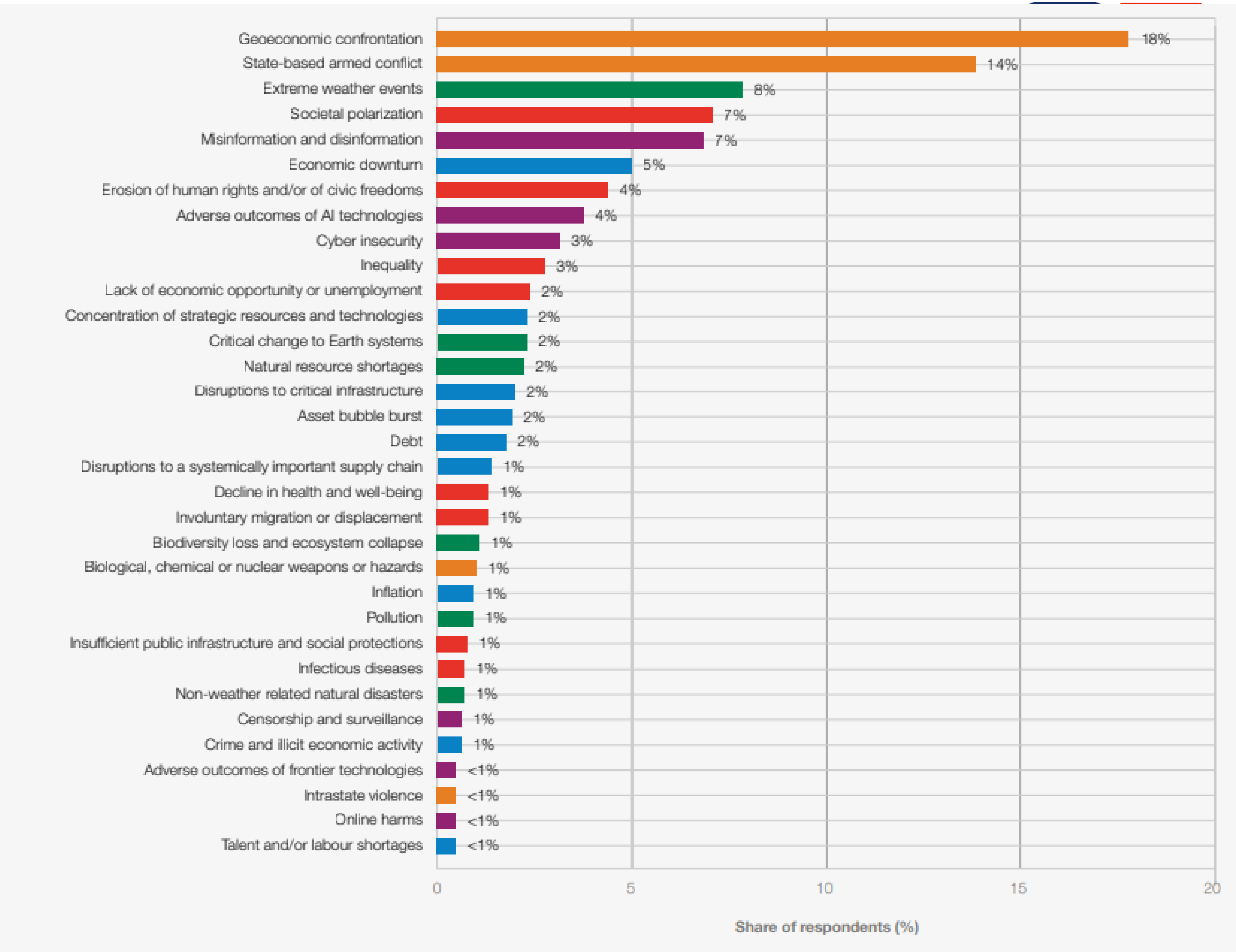
Current Risk Landscape – likelihood



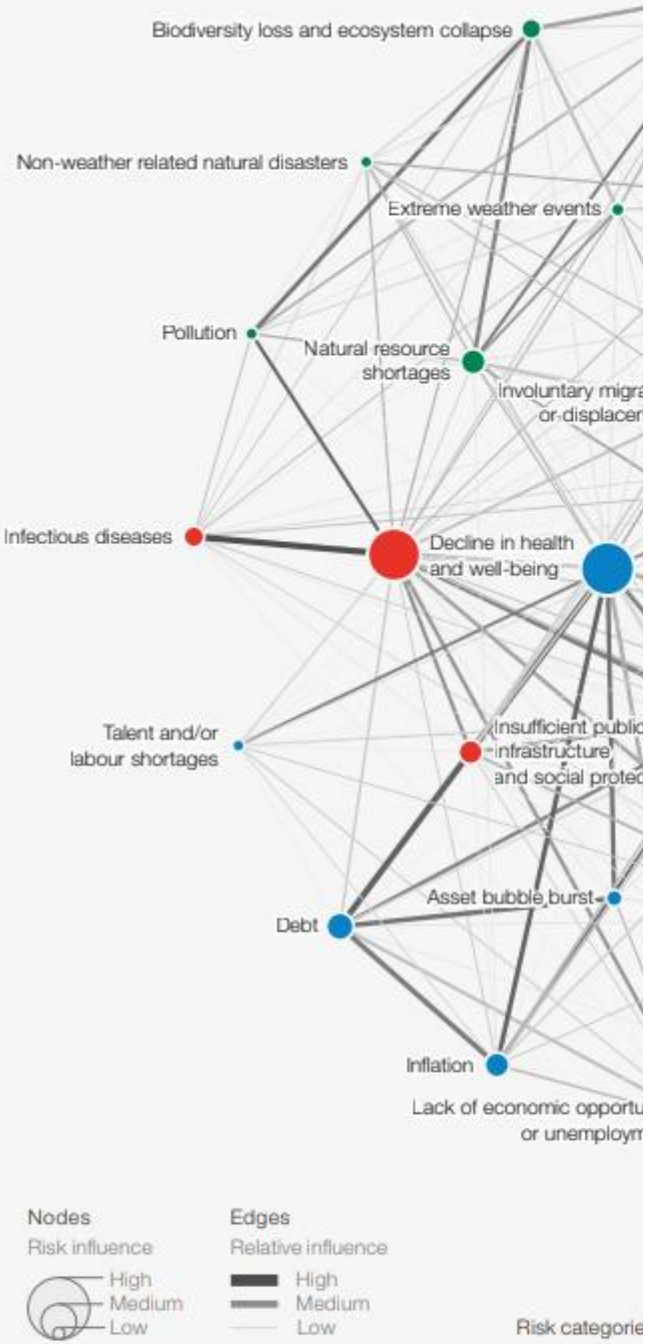
Source: World Economic Forum 2026, Global Risks Reports.

Global risks ranked by severity (2026)

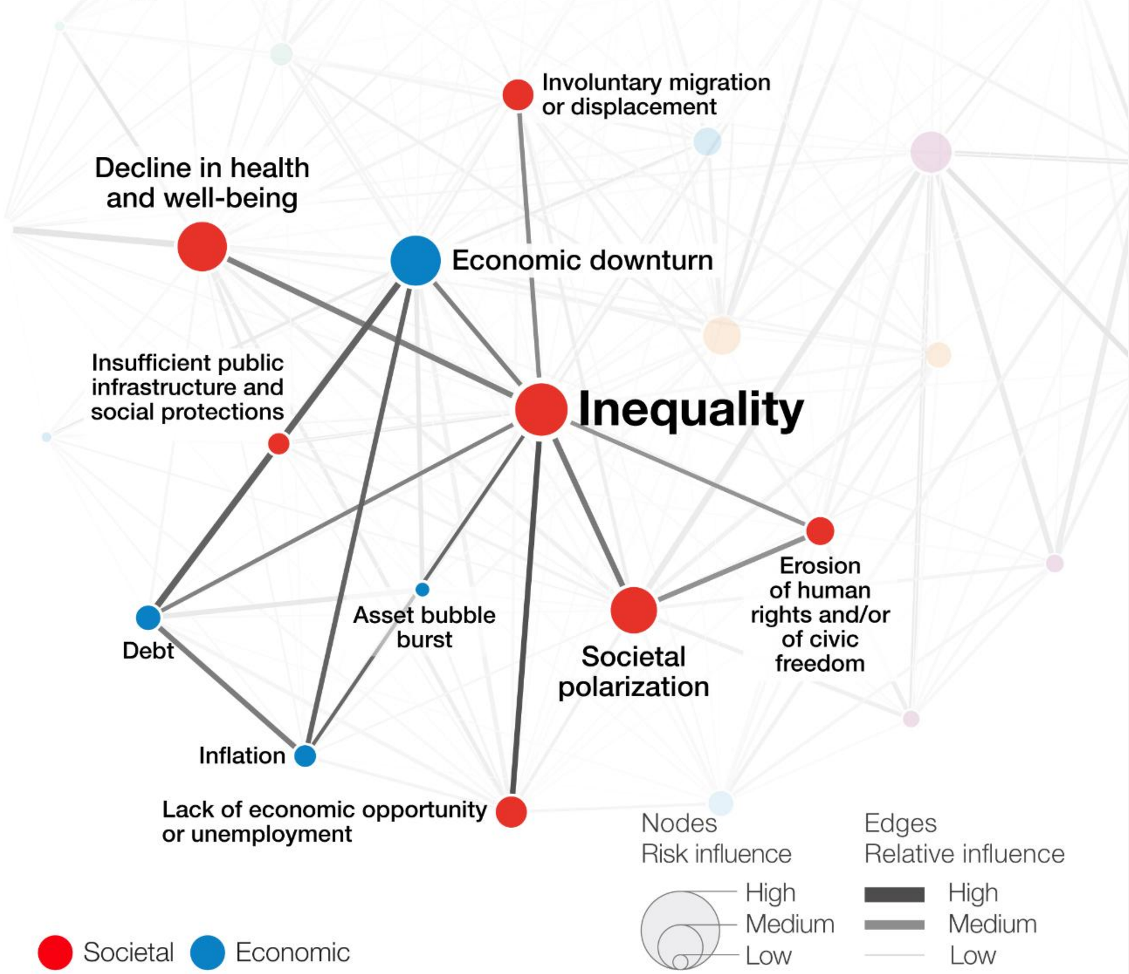
Short term (2 years)		Long term (10 years)	
1.	Geoeconomic confrontation	1.	Extreme weather events
2.	Misinformation and disinformation	2.	Biodiversity loss and ecosystem collapse
3.	Societal polarization	3.	Critical change to Earth systems
4.	Extreme weather events	4.	Misinformation and disinformation
5.	State-based armed conflict	5.	Adverse outcomes of AI technologies
6.	Cyber insecurity	6.	Natural resource shortages
7.	Inequality	7.	Inequality
8.	Erosion of human rights and/or of civic freedoms	8.	Cyber insecurity
9.	Pollution	9.	Societal polarization
10.	Involuntary migration or displacement	10.	Pollution

Source: World Economic Forum 2026, Global Risks Reports.

Global risks landscape: an interconnections map

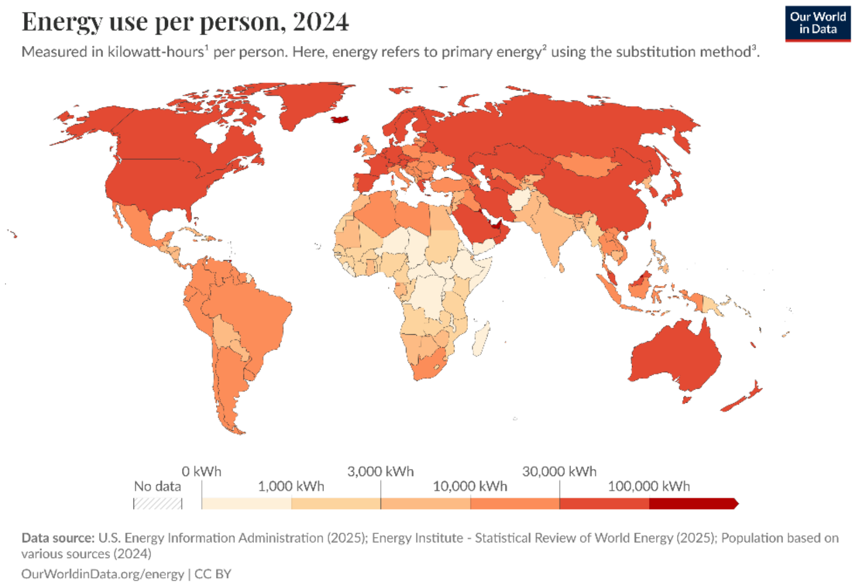


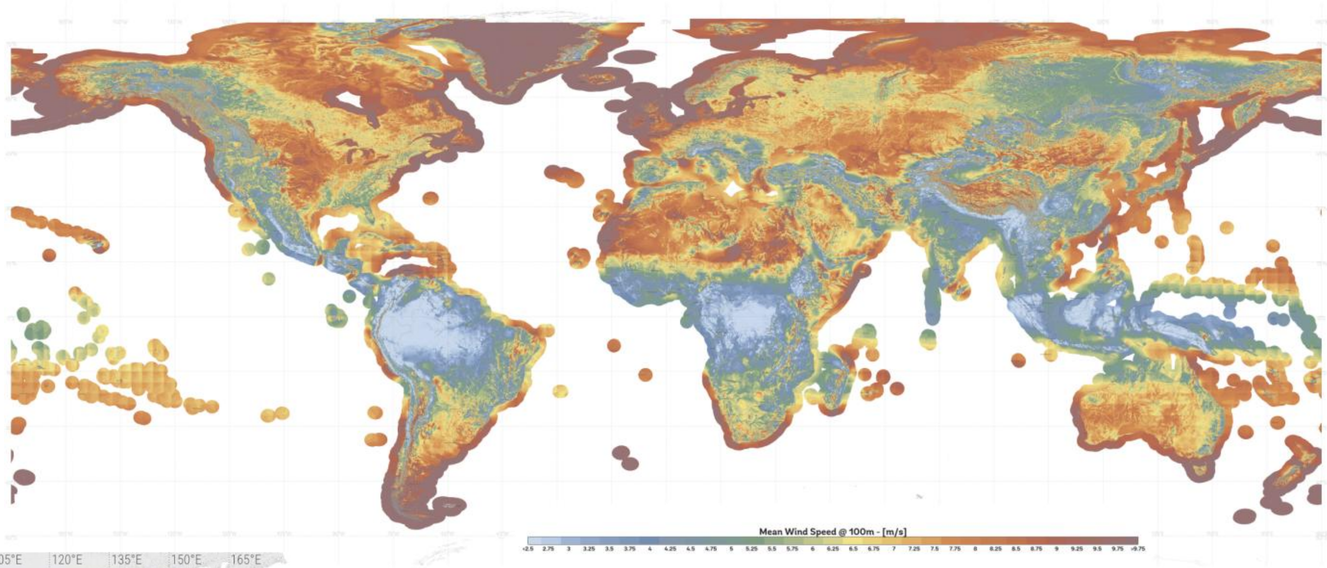
The world has entered an age of competition, defined by the accelerating scale, interconnectedness and speed of global risks, with inequality being the most interconnected risk.

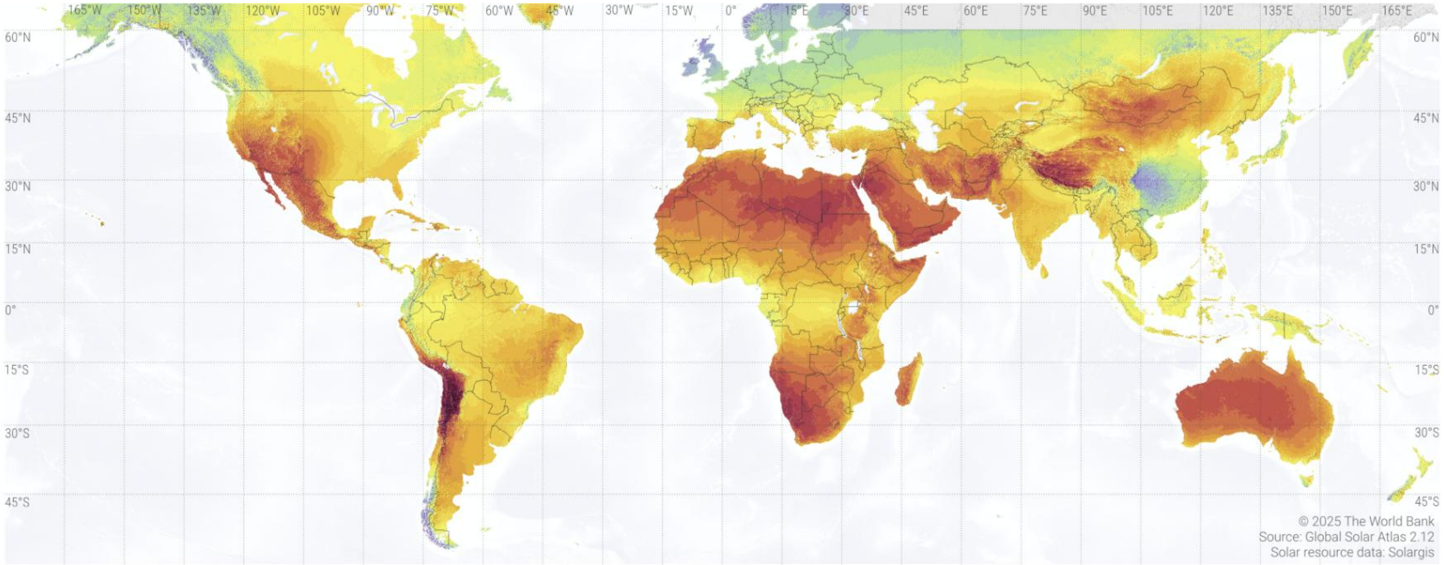


Source: World Economic Forum Global Risks Perception Survey 2025-2026.

How is this related to energy transition, ports and policy?







Sources: Wind Atlas, Solar Atlas 2026

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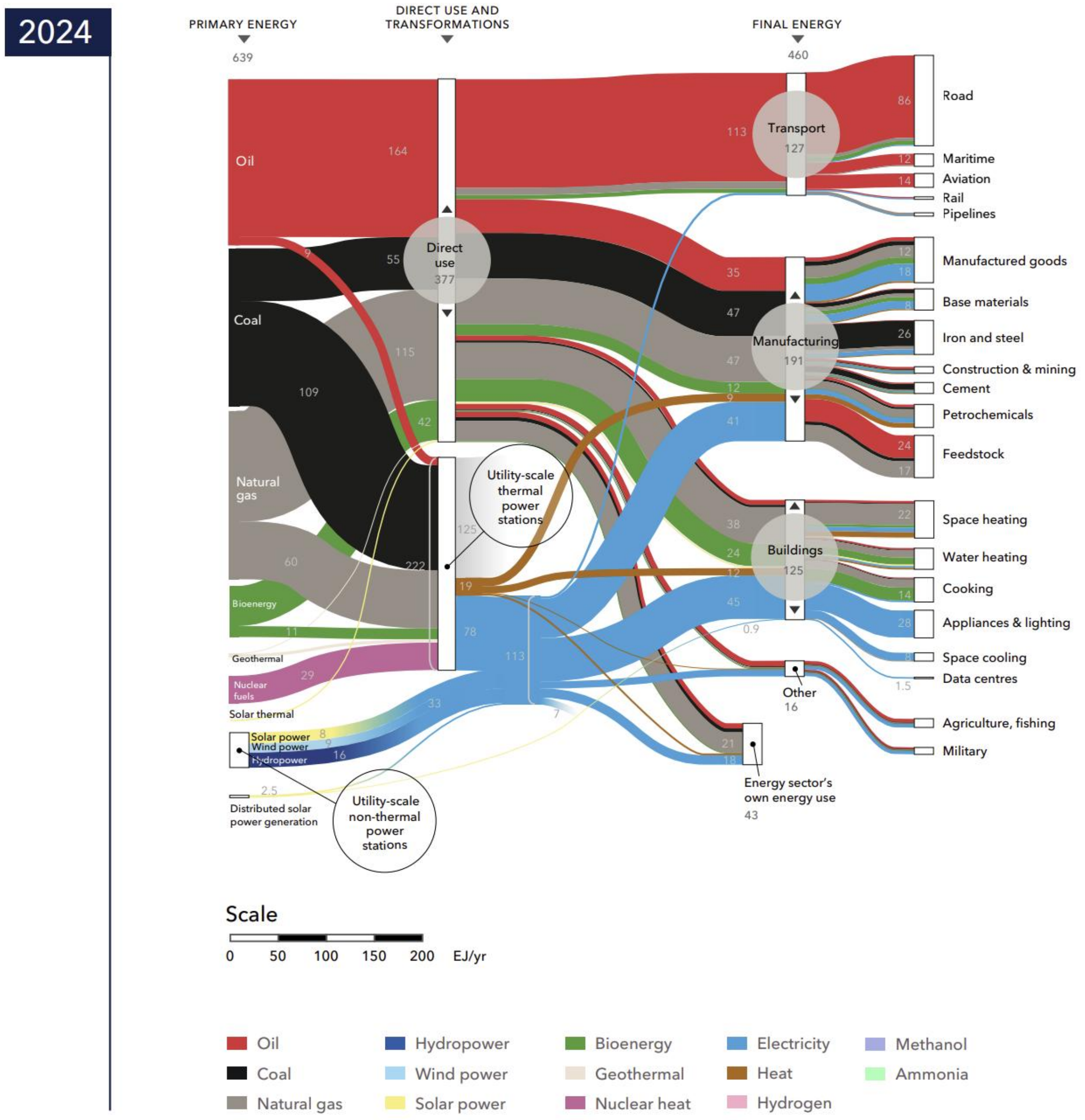
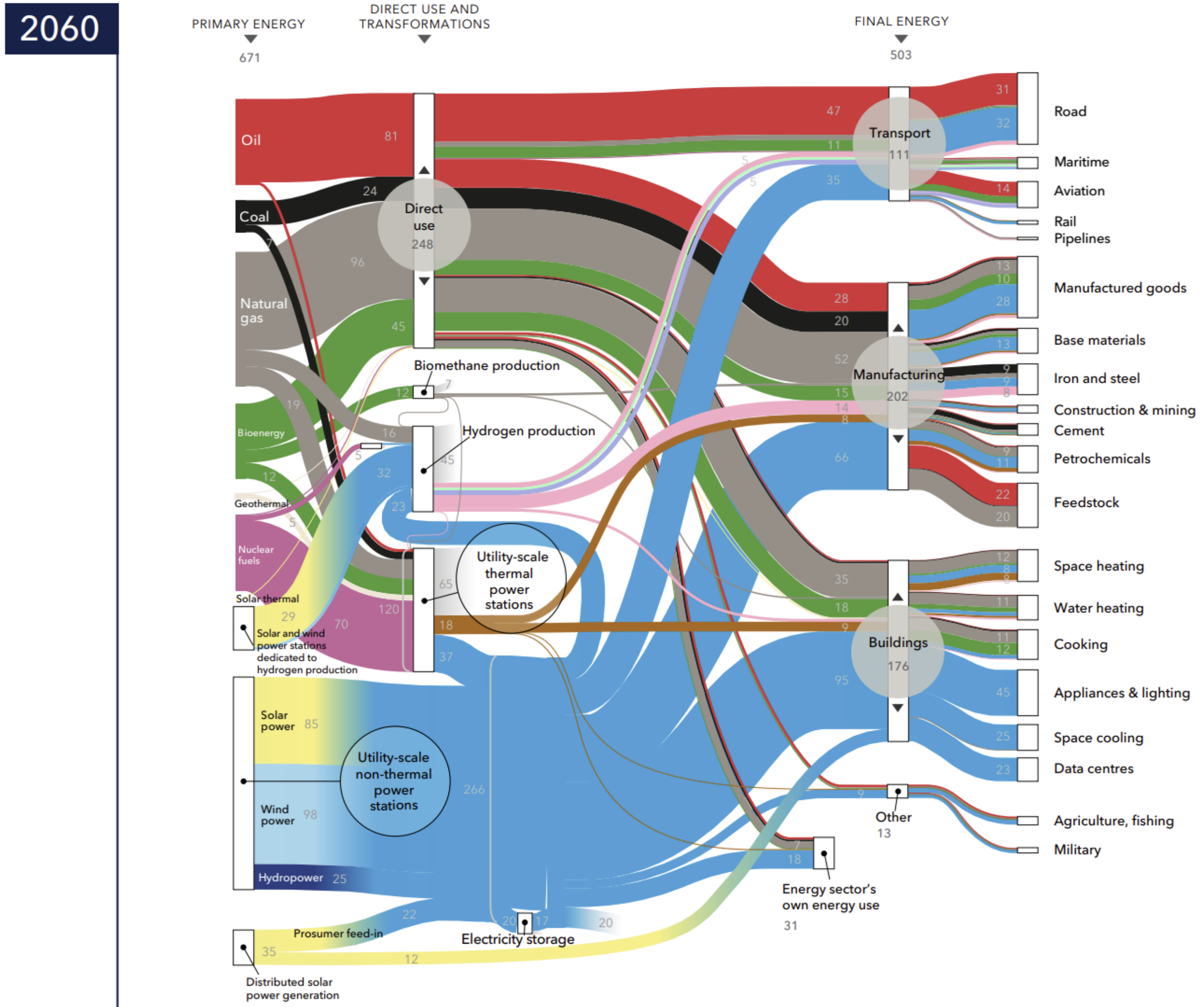
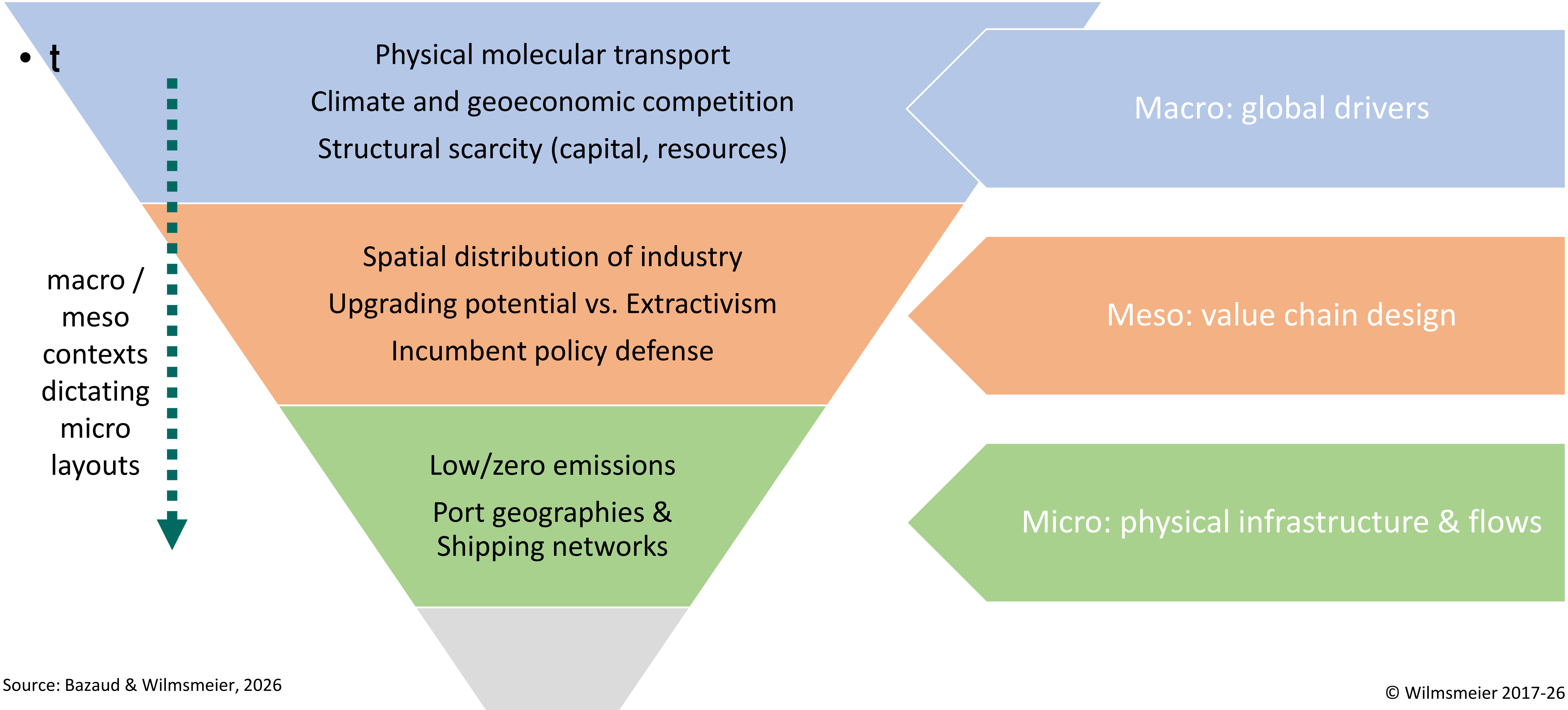




Source: DNV, Energy Outlook 2025

Ports are contextual

Physical infrastructures and flows are the downstream manifestation of upstream geoeconomic forces.

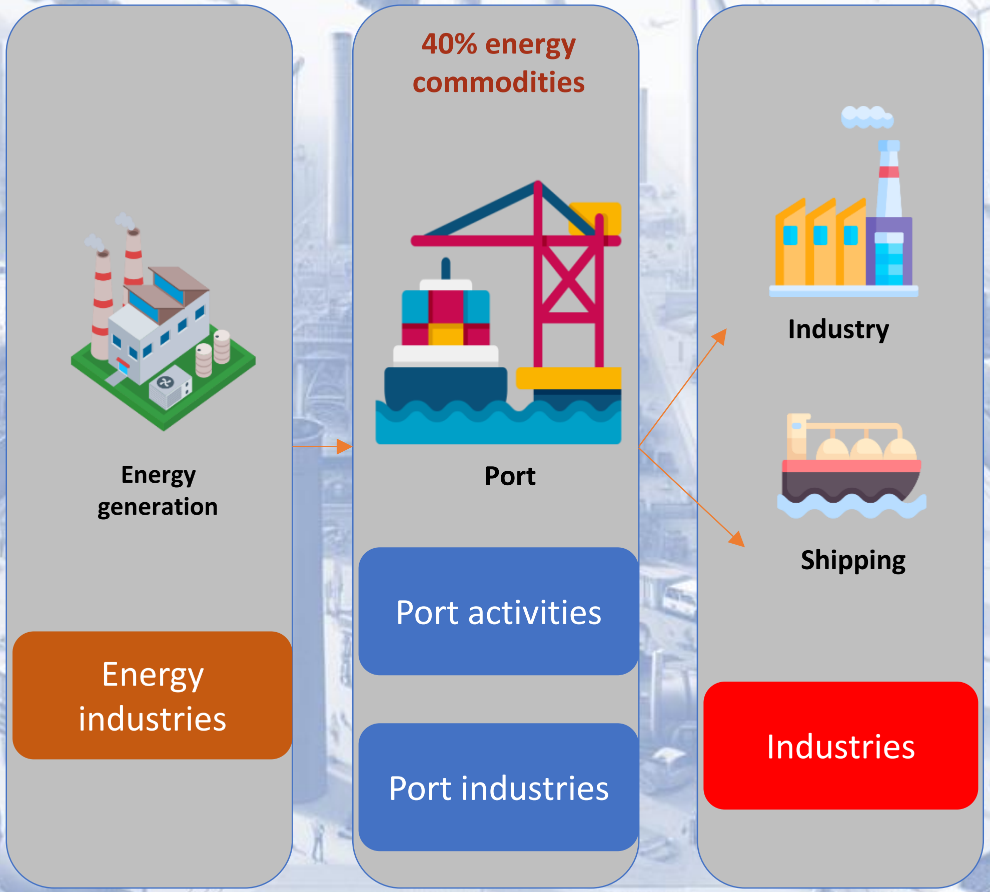


Source: Bazaud & Wilmsmeier, 2026

In a nutshell

Understanding the drivers of the spatial configuration of low-carbon fuels value chains and the consequences of changing distribution of industrial activities on local economies, socio-political dynamics, and the transformation of ports and shipping networks.

How can energy transition be enabled?



Source: Pomaska, Wilmsmeier & Meuer, based on Adapted from De Langen (2020)

The role of ports in energy transition

Decarbonising of port operations

Facilitating the decarbonisation of the shipping industry by:

providing the necessary storage and supply infrastructure to provide green bunkering fuel & electricity (cold ironing)

Facilitating the transition of national energy systems by importing, exporting, or storing green energy sources, and/or having energy industry clusters in the vicinity of ports

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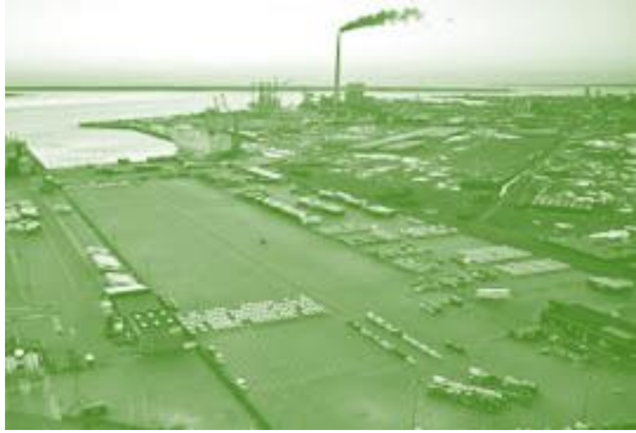
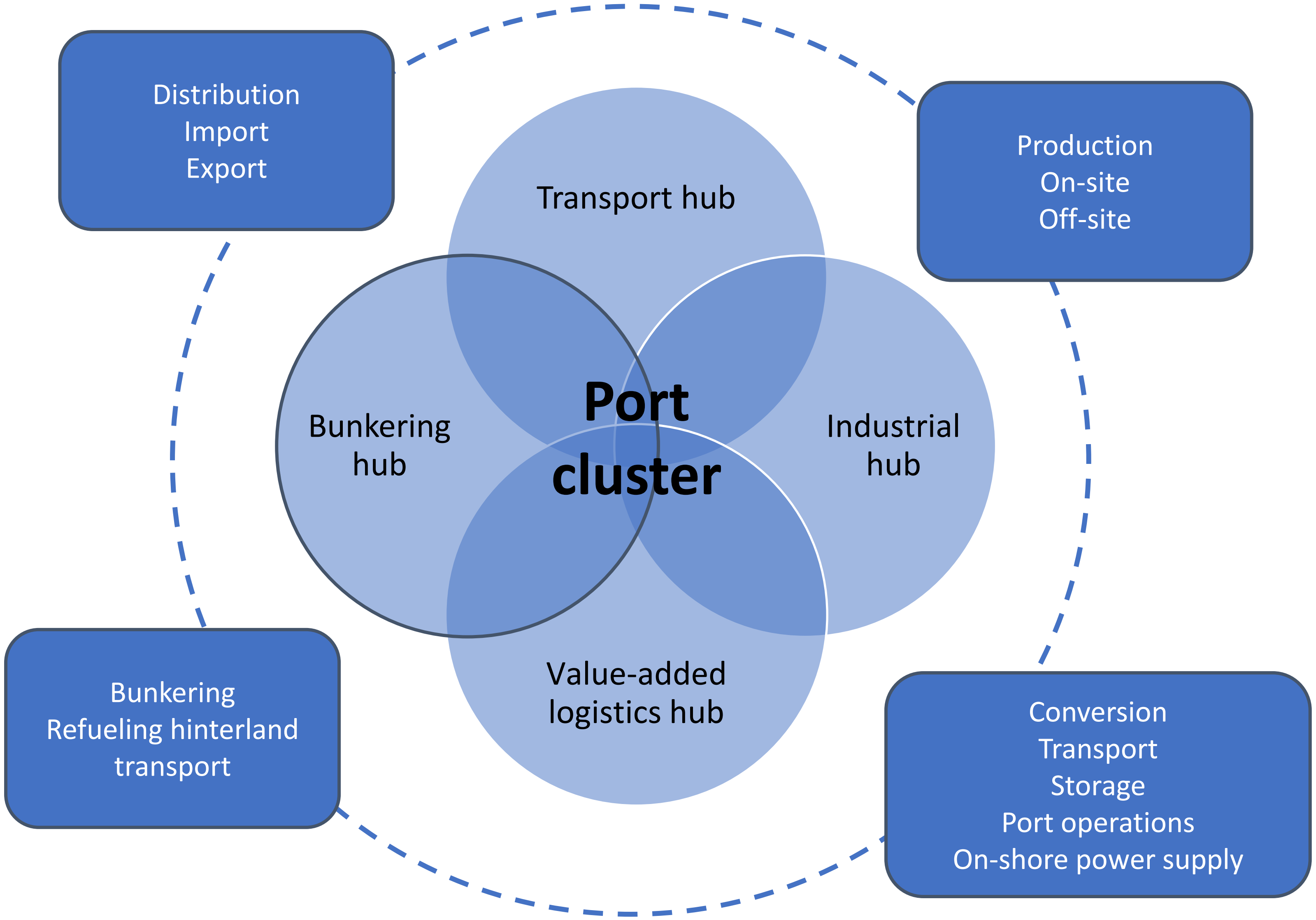
Ports are diverse and play different roles in their regions and local communities



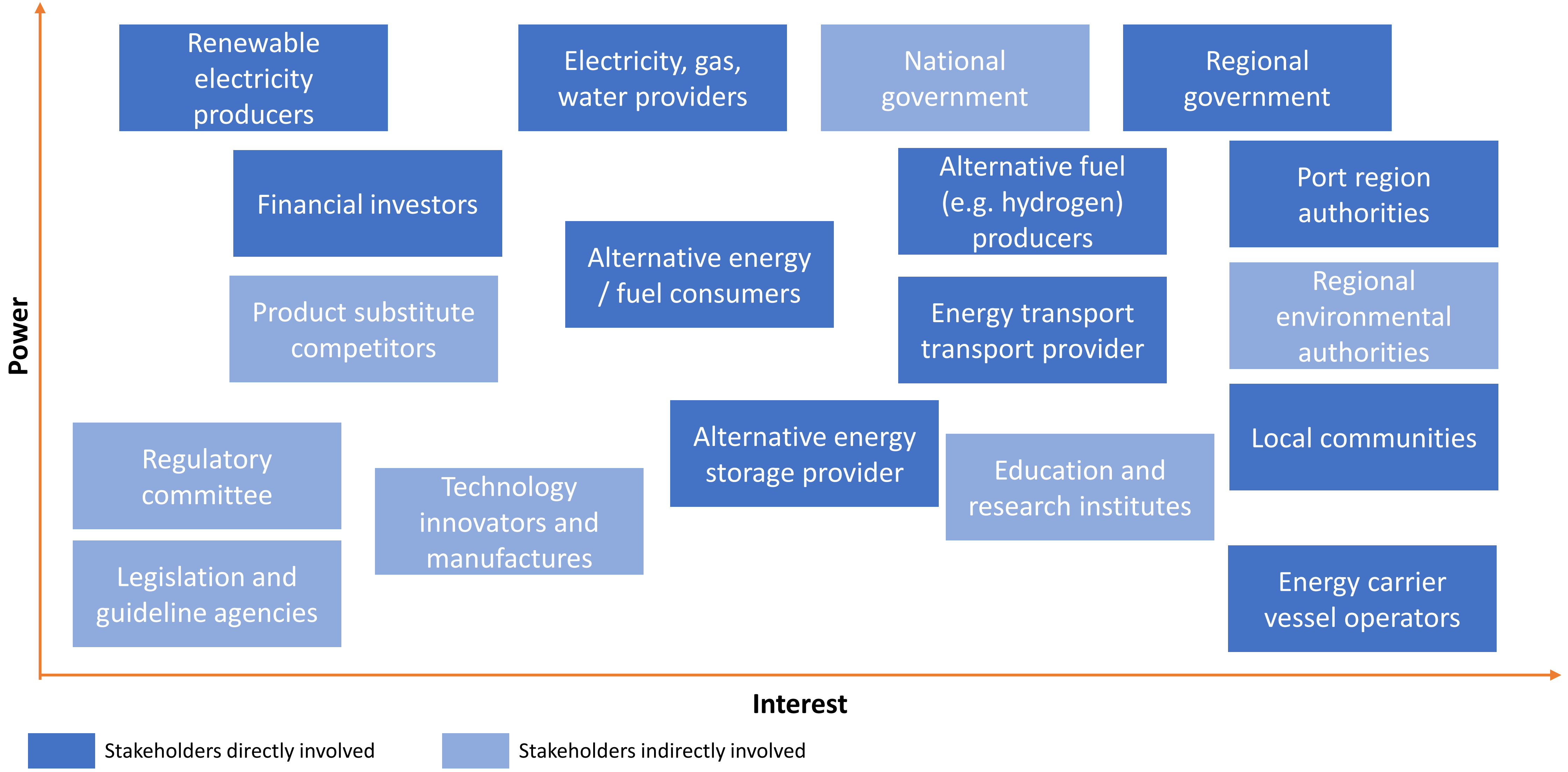



Our Energy Hub framework



Source: Pomaska, Wilmsmeier & Meuer, based on Adapted from De Langen (2020)

How do energy transitions and multi-sector collaboration function effectively?



Source: Pomaska, Wilmsmeier & Meuer Adapted from Clean Hydrogen Partnership (2023) & Jepma et al., 2020)

Why should we transition our port operations?

Image

Economic impact

Responsibility

Risk management

Competitiveness

How to weather the “storm”?

Strategy…

…a thought construct that details how one or several actors intend to bring about systemic change towards a desired end state.

When applied in practice,

a strategy serves as a flexible mental map that links an analysis of the status quo to a vision of a desirable end state by detailing different ways of achieving (intermediate) goals on the journey towards that envisioned future as well as certain means to potentially be employed along these ways

Source: Schulken et al., 2022

Policy…

… is a course of action for tackling a political problem.

Policymaking is itself a process; it is conceived by public or private groups who formulate strategy with regard to a political issue,

and carried out by government officials who implement policies as concrete programs and actions.

Policymaking thus refers not only to the end result of policies, but more generally to the analysis of government decisions and the way in which different groups attempt to get government policymakers to act in a particular way.

Source: Harvard Law School, 2026

The problem is that all that we have are targets.
Anyone can set targets

Anyone who sets precise targets risks failure because the goal already looks like the solution.
What matters is how to arrive at the target.

5 hypotheses for successful transition

There are no new beginnings

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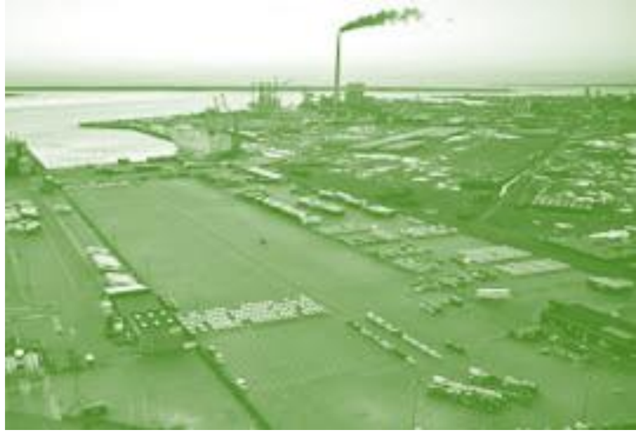


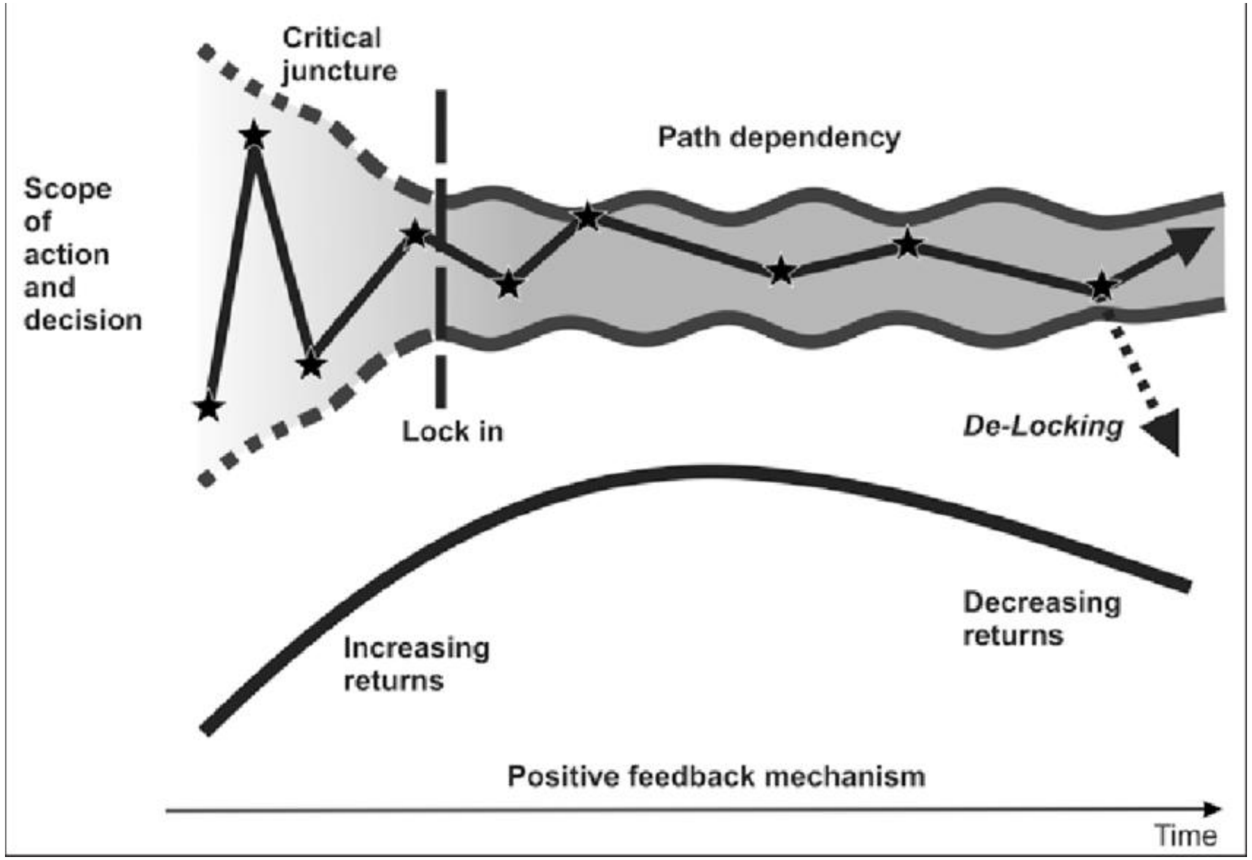
Society is currently facing a "Minsky moment":

the stability of recent times leads to the taking of greater risks in the belief that this stability will continue, ignoring the increasing evidence to the contrary…

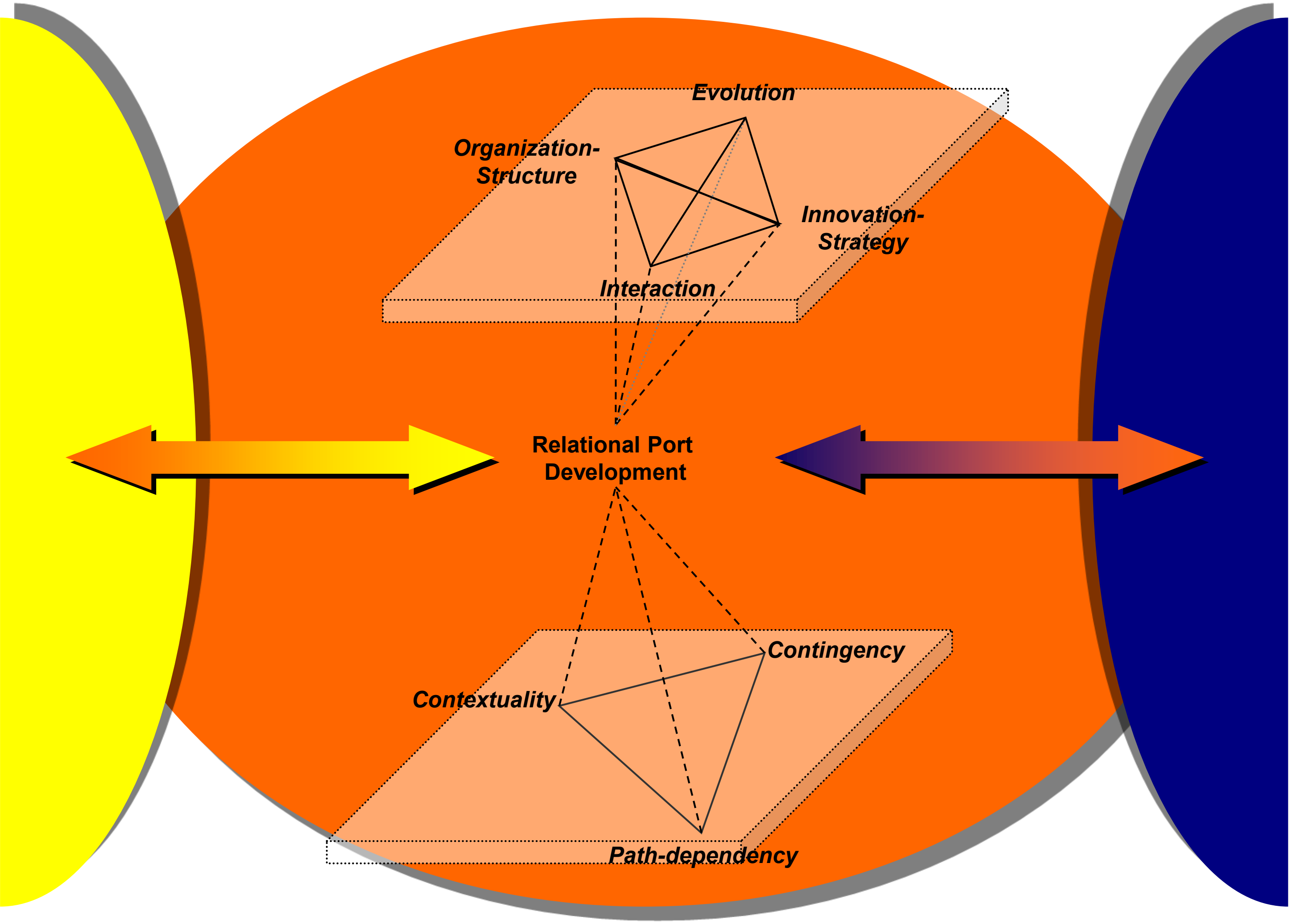
Source: WEF, 2020; US National Intelligence Council, 2021

“Port development is path dependent to the extent that future action is reliant on past decisions, structures, processes and institutional contexts, but it is also contingent and open-ended as decisions may deviate from an existing development path. Numerous factors influence which path a port follows, but isolating the effects of individual influences is difficult in such a multifaceted and interdependent system.”
(Monios & Wilmsmeier, 2016)

Path dependency



Source: Röhring, A., Gailing, L. (2010)



Source: Wilmsmeier & Sánchez (2012)


Ports are inert

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Inertia is a structural feature, not a character flaw

Inertia is not simply a lack of will, a "program," or a removable character trait of individuals. Instead, it is a **structural protection mechanism** inherent to modern society.

- **Costs exist**: While inertia protects the system from collapse and allows it to function, it also has "costs" (e.g., in the context of the climate crisis, where urgent change is needed).
- **Urgency triggers defense**: The more "disruptive urgency" and catastrophic semantics are used to describe a problem (like climate change), the more actors react with **defensive mechanisms** rather than rapid change. People can morally be criticized for this, but it should first be understood as a structural reaction.
- **Routine of crisis**: Paradoxically, the constant announcement of emergencies becomes routine itself, leading to "transformation fatigue" rather than action.

Example: strategies to overcome inertia

Success of Mitigation measures

1 impacts of any mitigation measure should be evaluated in terms of the tons of CO2e reduced in comparison to the baseline year, and its contribution to the NDCs of the country and the overall global target of net-zero GHG emissions by 2050.

2 the efficiency of any mitigation effort should also be measured in terms of cost (investment) per ton of GHG emissions reduction.

Should also account for positive effects on the overall operation affected (e.g., lower energy use and thereby lower operating costs), and the social cost of carbon.

Over the medium and long term, a positive result should be expected, particularly as the valuation of the social cost of carbon will increase as climate change progresses.

3 the efficiency of the mitigation action needs to be measured in terms of return of investment, which in most cases will determine the financial viability of the proposed solution.

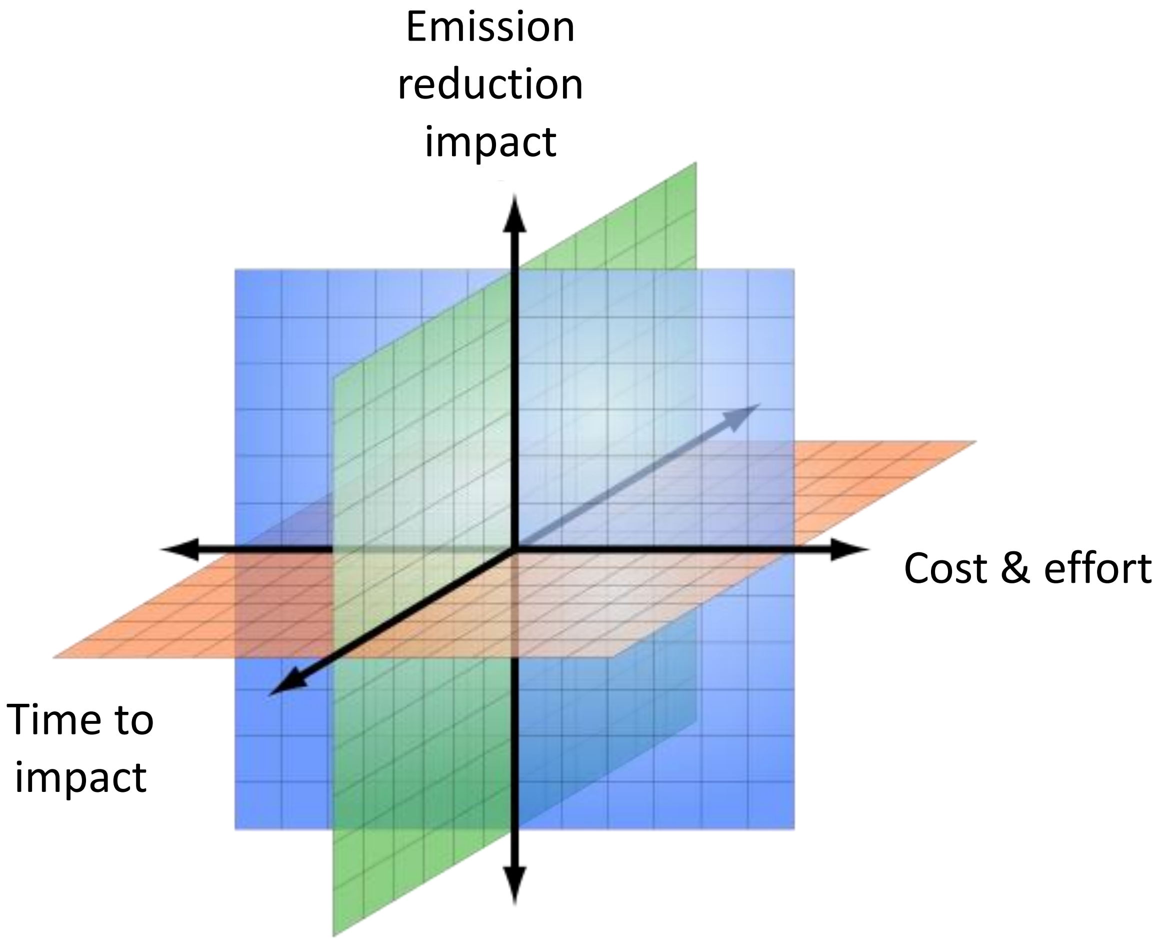
The monetary value that society places on one tonne of carbon dioxide equivalent.
For details on the social cost of carbon see: https://www.brookings.edu/bpea-articles/the-social-cost-of-carbon/

Developing an effort impact matrix

- **The first axis** depicts how much climate mitigation impact the measures will have in terms of GHG emissions reduction. Reduction in terms of percentages, from different studies, proposes the following classification. Any measure with a reduction of more than 20% (>20%) - high, between 10 and 20% (10-20%) – medium, less than 10% (<10%) - low.
- **The second axis** measures the cost to reduce one ton of CO_2e. This is based on the upfront capital expenditures and operating costs of the solution divided by the number of tons of CO_2e emissions reduced over the implementation period. The range of estimated cost/GHG emissions reduction is proposed as follows: low (less than 50 US$/ton CO_2); medium (50 -300 US$/ton CO_2); high (More than 300 US$/ton CO_2).
- **The third axis** is the implementation time required from taking the decision to the implementation, which will define the period until the impact becomes directly measurable. Three main categories are defined: short term - 1-2 years, medium term - 3-6 years, long term - > 6 years.

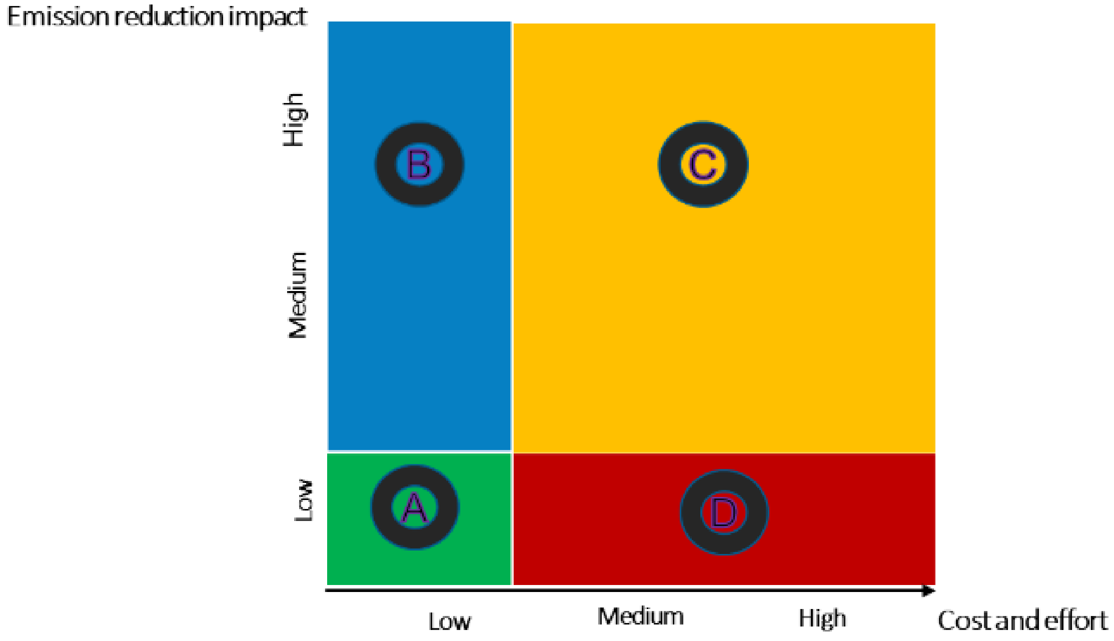
Four impact categories:

- A: Quick wins – low cost with limited emission reduction impact.
- B: Priority projects – yield the best return given relatively low costs and have a significant GHG emissions reduction impact.
- C: High-cost projects – provide significant GHG emission reductions but may be more complex and costly to execute.
- D: Hidden traps – medium and high cost and effort-consuming activities with low impact that should be managed carefully.



Source: Wilmsmeier et al. (2025)

Effort matrix and time to impact of mitigation measures in ports.



Source: Wilmsmeier et al. (2025)

Measure	Matrix cat.	Time to impact
MMGS: Measure, monitor and goals setting	B	S
ECO: Eco-driving	B	S
FM: Fleet management	A	S
PGPD: Pricing green port dues	A	S
LEE: Low electricity lighting	A	S
SS: Slow steaming in port area	A	S
STD: program to implement international relevant standards	A/B	S
TTTEE: Technological transition terminal equipment (electric)	B	M
AG: Automate gates and appointment systems	D	M
OM: Operational measures (storage optimization in terminals)	D	M
GP: Green procurement strategies	A	M
PSM: Promote sustainable mobility and community awareness	B	M
RPDFF: Review port development of fossil fuel specialized terminals	C	M
CI: Onshore power supply or cold ironing	C	M
TTTEH: Technological transition technical equipment (hydrogen or other energy fuel)	C	L
TTT: Technological transition trucks (hydrogen)	C	L
TTBT: Technological transition barges and trains (electric)	C	L
DP: Dry Ports	C	L
MS: Modal Split	C	L
PE: Produce electricity	D	L
PAF: Provide / procure alternative fuels for port users	C	L

Who wants (to) change needs to adapt

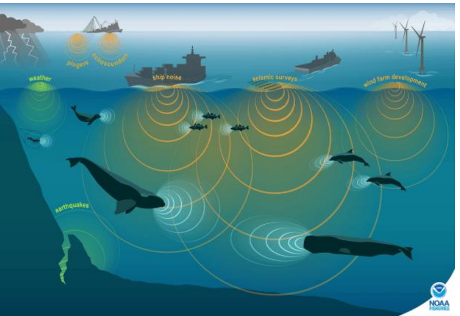
An example

Underwater noise stresses fish and disturbs the orientation of whales leading to the disruption of development in sea animals

Thus, companies should change vessel construction, engines and propellers to reduce noise.

Impossible with a World fleet of several thousand ships.

- Principle:
  - Most underwater noise from ships comes from propeller cavitation: bubbles forming and collapsing as the propeller rotates fast, creating intense sound.
  - Cavitation is strongly speed-dependent: lower speed reduces pressure differences on the propeller blades, lessening cavitation and thus noise.



A relatively small reduction in ship speed—around 5% across the EU fleet—would immediately decrease underwater noise pollution by approximately 40% due to the exponential relationship between speed and underwater radiated noise.

The measure is technically simple, requires no major redesign of ships or propellers, and can be implemented immediately via operational changes (slower transit speeds).

However

- voluntary measures are insufficient in the long term.
- need for mandatory speed limits and fixed underwater noise thresholds, with individual countries setting specific limits, as a step toward international regulation of underwater noise.

5% speed reduction is a practical entry point that can be scaled up and institutionalised.

Source: https://westernindependent.com.au/2025/11/05/swimming-in-the-speakers/ (2025)

Success finds imitators

Solutions to address climate change are already the subject of hard work outside of the political sphere: in research, in laboratories, in companies, in ports, in shipping companies, but much of it remains surprisingly invisible.

Let´s make a comparison

Data & reporting

Who delivers the most detailed and verifiable information on sustainable performance?

Hamburger Hafen und Logistik AG (HHLA)

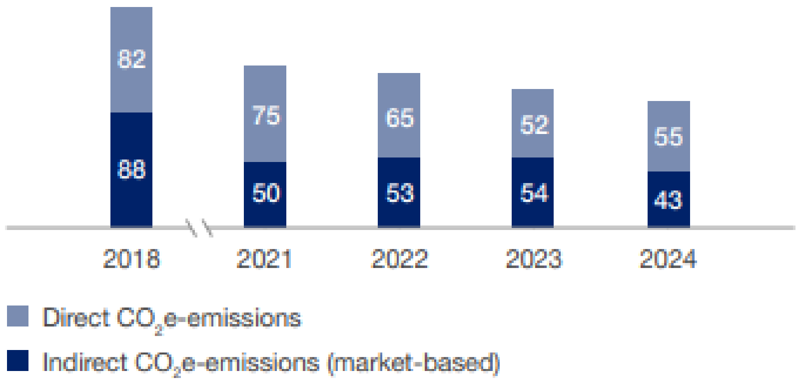
Puerto de Cartagena, Colombia

SAGT Port of Colombo, Sri Lanka

Excerpt from Hamburger Hafen und Logistik AG (HHLA) Annual Report – Ecology 2024

Direct and indirect CO_2e emissions

in thousand tonnes, base year 2018



Until 2021: CO_2 emissions, from 2022: CO_2 e emissions

Ecology

	2024	2023	Change
CO_2e emissions market-based in thousand tonnes	98.6	105.5	- 6.5 %
Direct CO_2e emissions (Scope 1 emissions)	55.3	51.7	6.9 %
Indirect CO_2e emissions (Scope 2 emissions) market-based	43.3	53.7	- 19.4 %
Diesel, petrol and heating oil in million l	19.3	18.3	5.8 %
Natural[1] gas in million m^3	1.4	1.5	- 2.9 %
Electricity in million kWh	386.4	352.9	9.5 %
of which electricity from renewables in million kWh	271.3	207.4	30.8 %
District heating in million kWh	3.0	3.3	- 10.7 %
District heating from renewable energy in million kWh	2.1	2.4	- 12.9 %
Water consumption in m^3	110,938	95,613	16.0 %
Volumes of waste[2] in tonnes	7,769	8,543	- 9.1 %
thereof non-hazardous waste	6,509	7,171	- 9.2 %
thereof hazardous waste	1,260	1,372	- 8.2 %

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Excerpt from the SAGT sustainability reports 2023/24 and 2024/25

	2022/2023	2023/2024	Difference %	
Material Usage				
RTG Tyres in kg	14,400	24,360	69.2%	🔴
PM Tyres in kg	46,560	37,680	-19.1%	🟢
Lubricants in Litres	64,926	49,823	-23.3%	🟢
Rope in kg	48,522	76,981	58.7%	🔴
A4 Paper and Letterheads in kg	3,133	2,863	-8.6%	🟢
Waste Management				
Waste Generated (Kg)*	799,403	1,006,496	25.9%	🔴
Waste Recycled, Recovered, or Reused %*	777,203	981,130	26.2%	🔴
Total Waste Sent to Landfill (Kg)*	0	0	0.0%	🟢
Total Hazardous Waste (Kg)*	60,887	64,423	5.8%	🔴
Total Non-Hazardous Waste (Kg)*	738,517	942,073	27.6%	🔴
Energy and Emissions				
Total Electricity Used (kWh)	9,378,644	9,757,125	4.0%	🔴
Electricity kWh Per Box Moved	9.32	8.91	-4.4%	🟢
Total Diesel Consumed (Litres)	3,585,902.32	4,108,570	14.6%	🔴
Diesel Usage (L) Per Box Moved	3.6	3.8	5.3%	🔴
Total Petrol Consumed (Litres)	363	306	-15.7%	🟢
Petrol Usage (L) Per Box Moved	0.00036	0.00028	-22.6%	🟢
Total LPG Usage (Kg)	22,725	23,063	1.5%	🔴
Total Energy Consumed in GJ	150,066	168,230	12.1%	🔴
Energy Intensity (GJ per box moved)	0.1	0.2	3.0%	🔴
Scope 1 Carbon Footprint MT CO_2eq	9,136	10,201	11.7%	🔴
Scope 2 Carbon Footprint MT CO_2eq	6,644	6,912	4.0%	🔴
Total Carbon Footprint MT CO_2eq	15,780	17,113	8.4%	🔴
GHG Intensity (kg CO_2eq/ box move)	15.68	15.66	-0.1%	🟢
Emissions of Nox, Sox, and other air emissions	Within CEA tolerance limits	Within CEA tolerance limits		🟢
Water Management				
Water Withdrawn (m^3) from non-water stressed areas	60,168	70,819	17.7%	🔴
Water Withdrawn (L) Per Box Moved	59.8	64.7	8.2%	🔴
Discharge Quality of Effluent	Within CEA tolerance limits	Within CEA tolerance limits		🟢

Material Usage and Waste Management			
RTG Tyres in No.s	57	52	-8.8%
PM Tyres in No.s	477	579	21.4%
Lubricants in Litres	49,824	66,439	33.3%
Rope in Kgs	76,981	111,003	44.2%
A4 Paper and Letterheads (No.s of 500-Page Reams)	1,145	962	-16.0%
Waste Generated (Kg)	1,006,490	1,384,637	37.6%
Waste Recycled, Recovered, or Reused (kg)	981,130	1,351,204	37.7%
Total Waste Sent to Landfill (Kg)*	0	0	0.0%
Total Hazardous Waste (Kg)	64,423	86,805	34.7%
Total Non-Hazardous Waste (Kg)*	942,073	1,297,832	37.8%
Total Electricity Used (kWh)	9,757,125	10,360,817	6.2%
Electricity kWh Per Box Moved	8.91	8.00	-10.2%
Total Diesel Consumed (Litres)	4,110,518	5,044,180	22.7%
Diesel Usage (L) Per Box Moved	3.8	3.9	3.7%
Total Petrol Consumed (Litres) **	306	345	12.9%
Petrol Usage (L) Per Box Moved	0.00028	0.00027	-4.6%
Total LPG Usage (Kg)	23,063	24,113	4.6%
Total Energy Consumed in GJ	184,694	220,647	19.5%
Total Energy in GJ Per Box Moved	0.169	0.170	1.0%
Scope 1 Carbon Footprint (MT CO_2eq) ***	11,491	14,261	24.1%
Scope 2 Carbon Footprint (MT CO_2eq)	3,963	4,209	6.2%
Total Carbon Footprint (MT CO_2eq) ****	15,454	18,649	19.5%
Total Carbon Intensity (kg CO_2eq per box moved) **** & ****	14.11	14.26	1.0%
Emissions of Nox, Sox, and other air emissions	Within CEA tolerance limits	Within CEA tolerance limits	
Water Withdrawn (m^3) from non-water stressed areas	70,819	52,488	-25.9%
Water Withdrawn (L) Per Box Moved	64.7	40.5	-37.3%
Discharge Quality of Effluent	Within CEA tolerance limits	Within CEA tolerance limits	
Total Significant Fines Paid (LKR) ******	0	0	0.0%
No. of Significant Spills ******	0	1	100.0%

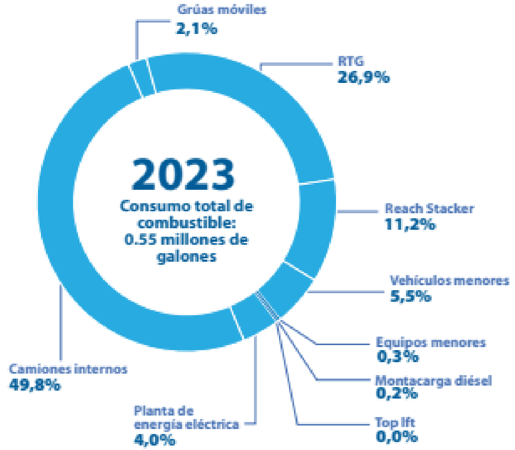
Environmental Responsibility Report Cartagena Port, Colombia

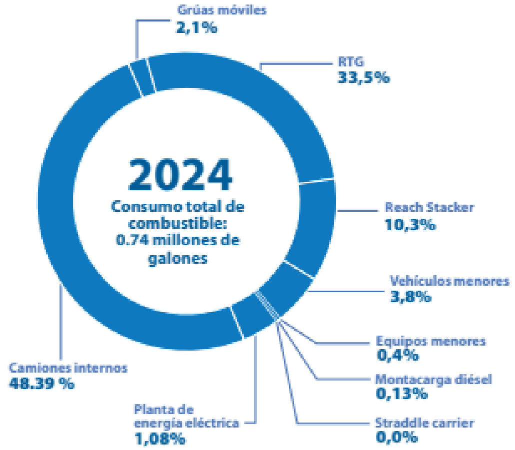
- The Port of Cartagena in the SPRC terminal implemented the electrification of RTG cranes to reduce not only fuel consumption and costs but also GHG emissions.
- Technological change:
  - Share of total diesel consumption of RTG cranes in the terminal from 53% (2015) to 29.1% (2022), equiv. to a reduction from 848 to 200.4 thousand gallons.
  - Electricity-powered RTG (e-RTG) cranes consumed 0.38 MWh (2015) and 2.3 MWh (2022), respectively.
  - Led to a net GHG emissions reduction from 4595 tons CO_{2e} to 2138 tons CO_{2e} (2022) from this type of equipment.
- The sustainability reports of the Port of Cartagena at terminal level have continuously improved over time and are an excellent reference for other terminals. Reports have been available online since 2014.

Puerto de Cartagena

SPRC, ALCANCE 1

DISTRIBUCIÓN DEL CONSUMO DE COMBUSTIBLE





Calculadora FECOC

Factor de emisión diésel marino (Embarcaciones)
8,86 kg CO_2/GI

Factor de emisión diésel B2 (Vehículos)
10,15 kg CO_2/GI

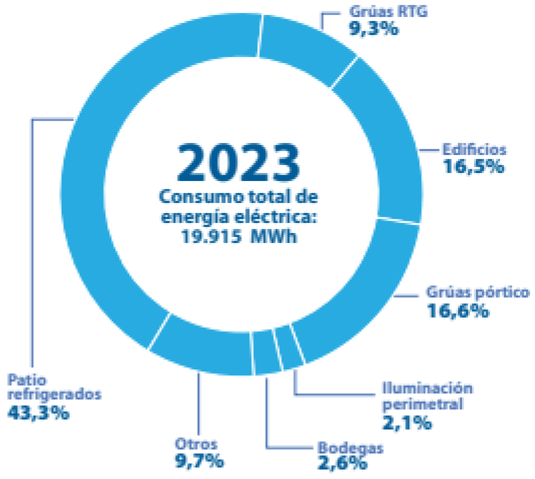
Factor de emisión gasolina
8,81 kg CO_2/GI

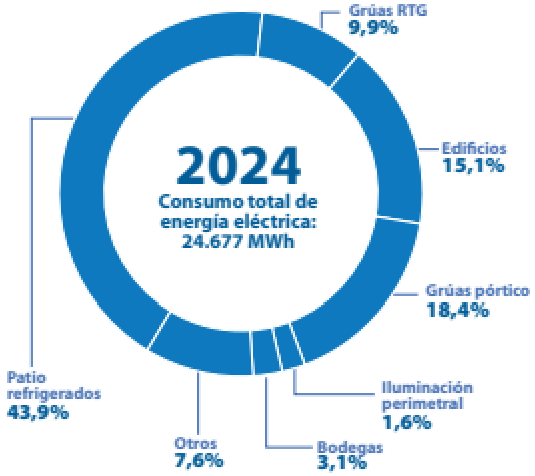
Emisiones (kg CO_2 e)= ∑(Consumo de combustible×Factor emisión combustible)

Factores de emisión fuente UPME: app.upme.gov.co/Calculadora_Emisiones1/new/calculadora.html

SPRC, ALCANCE 2

DISTRIBUCIÓN DEL CONSUMO DE ENERGÍA ELÉCTRICA





Factor de emisión energía
0,177 kg CO_2/kWh

Emisiones (kg CO_2 e)= ∑(Consumo de Energía Electrica×Factor emisión)

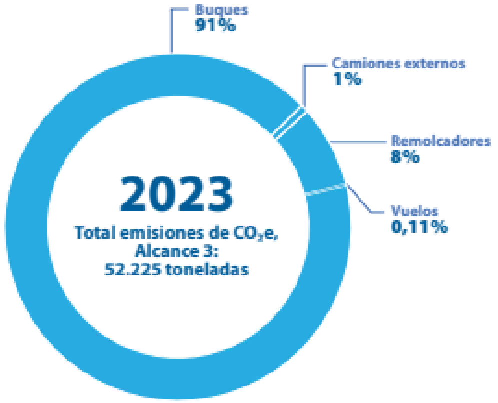
Puerto de Cartagena

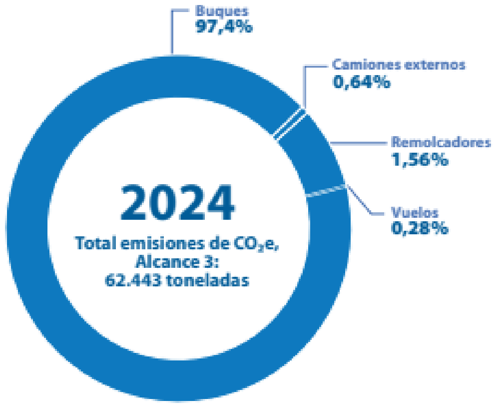
SPRC, ALCANCE 3
DISTRIBUCIÓN EMISIONES CO_2 EQUIVALENTE

Las emisiones de CO_2 equivalente del Alcance 3 corresponden a emisiones de buques, camiones externos, remolcadores y vuelos. Estas emisiones no son controladas directamente por la terminal.

Para el año 2024 las emisiones de CO_2 equivalente de este Alcance se incrementarán en 19,55% respecto al año 2023.

El aumento de las emisiones de buques que arribaron a la terminal principalmente se da por un incremento del 19,23 % en 2024 ascendiendo a 1,141 recaladas, frente a las 957 registradas en 2023.





Factor de emisión diesel (Embarcaciones)
8,86 kg CO_2/GI

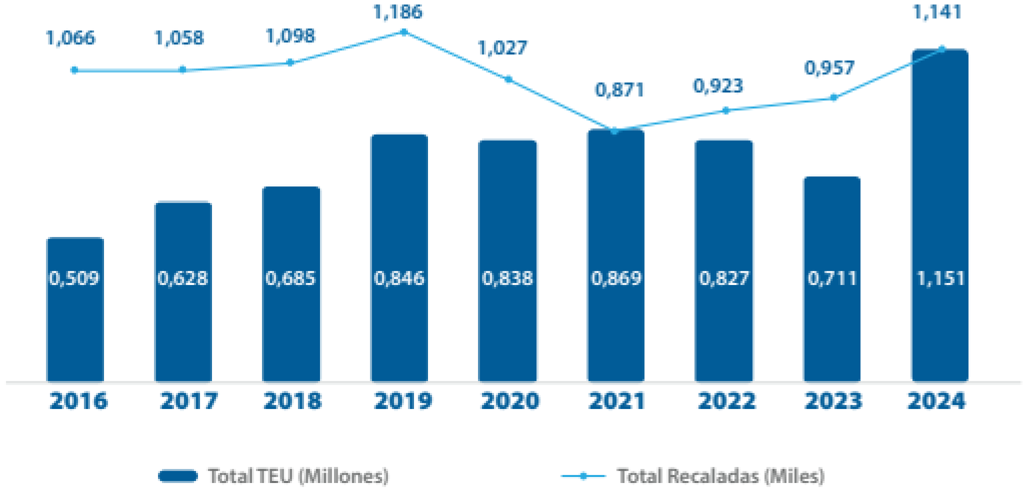
Emisiones Buques (kg CO_2 e)= ∑(Potencia Motor×Tiempo Operación ×Factor Emisión)

Emisiones Remolcadores (kg CO_2 e)= ∑(Consumo de Galones Diesel Marino ×Factor emisión

Emisiones Camiones(kg CO_2 e)= ∑(Cantidad de camiones×Tiempo real promedio×Factor consumo galones×Factor emisión)

SPRC, ALCANCES 1 + 2
EMISIONES DE CO_2 EQUIVALENTE Y KILOGRAMOS DE CO_2/TEU

TEU Y RECALADAS - SPRC




Radical ideas are indispensable

"A port system might evolve in a reactive manner to such forces but can equally change as a result of proactive strategies of various stakeholders. Arguably the most difficult aspect of port planning, however, is recognising and dimensioning (spatial and temporal) new challenges yet to be faced."
(Monios & Wilmsmeier, 2016)

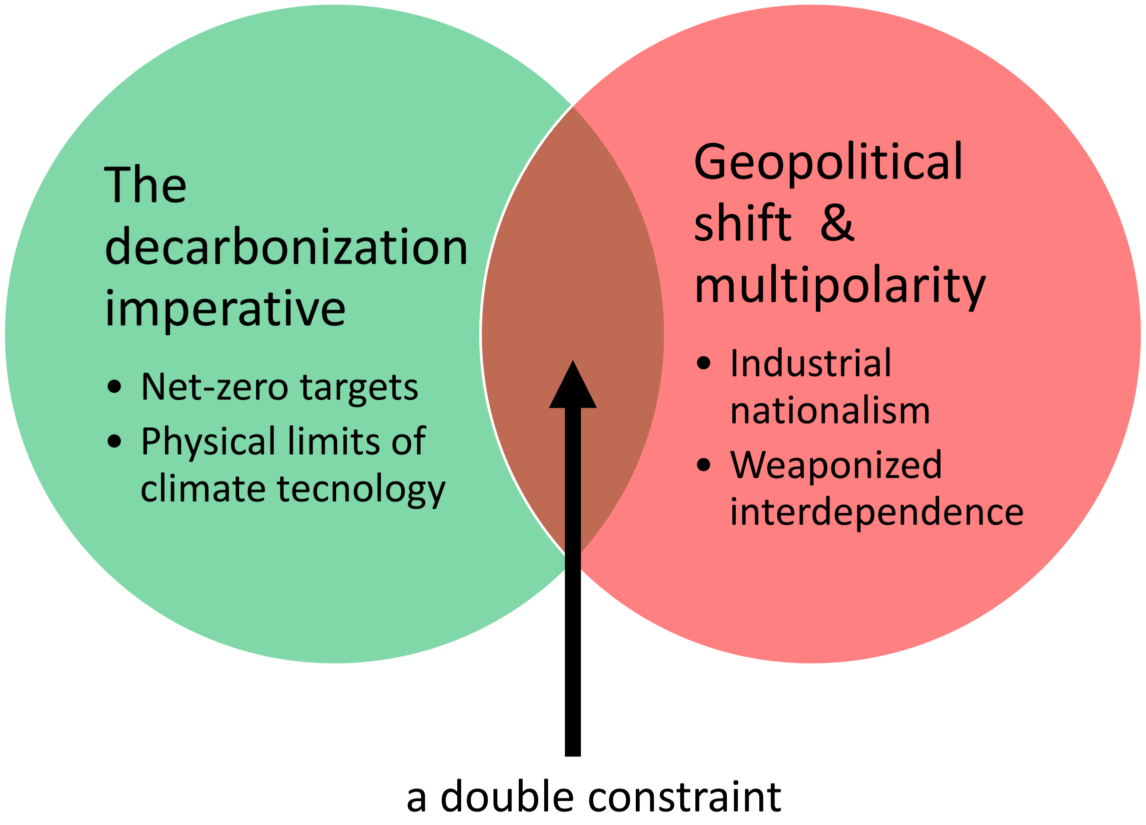
Universidad de los Andes Colombia

CSGL Hapag Lloyd Center for Shipping and Global Logistics

KLU

What if the traditional options are questioned?

Energy transition in a multipolar world



The obsolete paradigm

Traditional techno-economic assessment frameworks seeking purely optimal design (best-case scenarios) are dead. They implicitly assume a unipolar, friction-free global infrastructure

The new reality

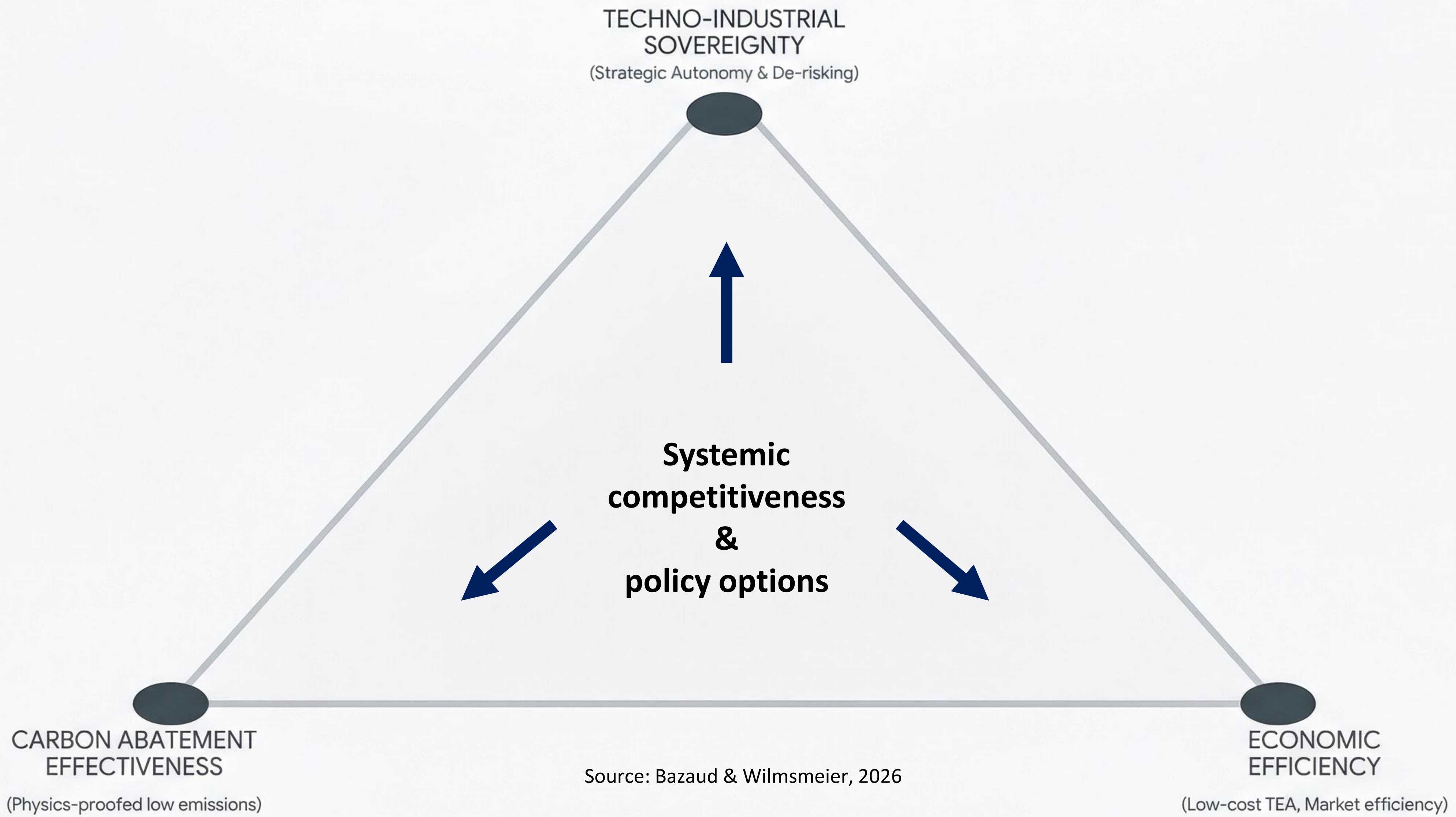
We have entered an era of techno-industrial darwinism. The energy transition is a geoeconomic arena where states and lead-firms compete to secure advantageous positions within a new techno-politcal architecture

The strategic imperative

Decision-making must shift from optimal design to systemic robustness – the ability to endure supply shocks, manage weaponized interdependence and maintain relative industrial power under deep uncertainty (the survival case)

Source: Bazaud & Wilmsmeier, 2026

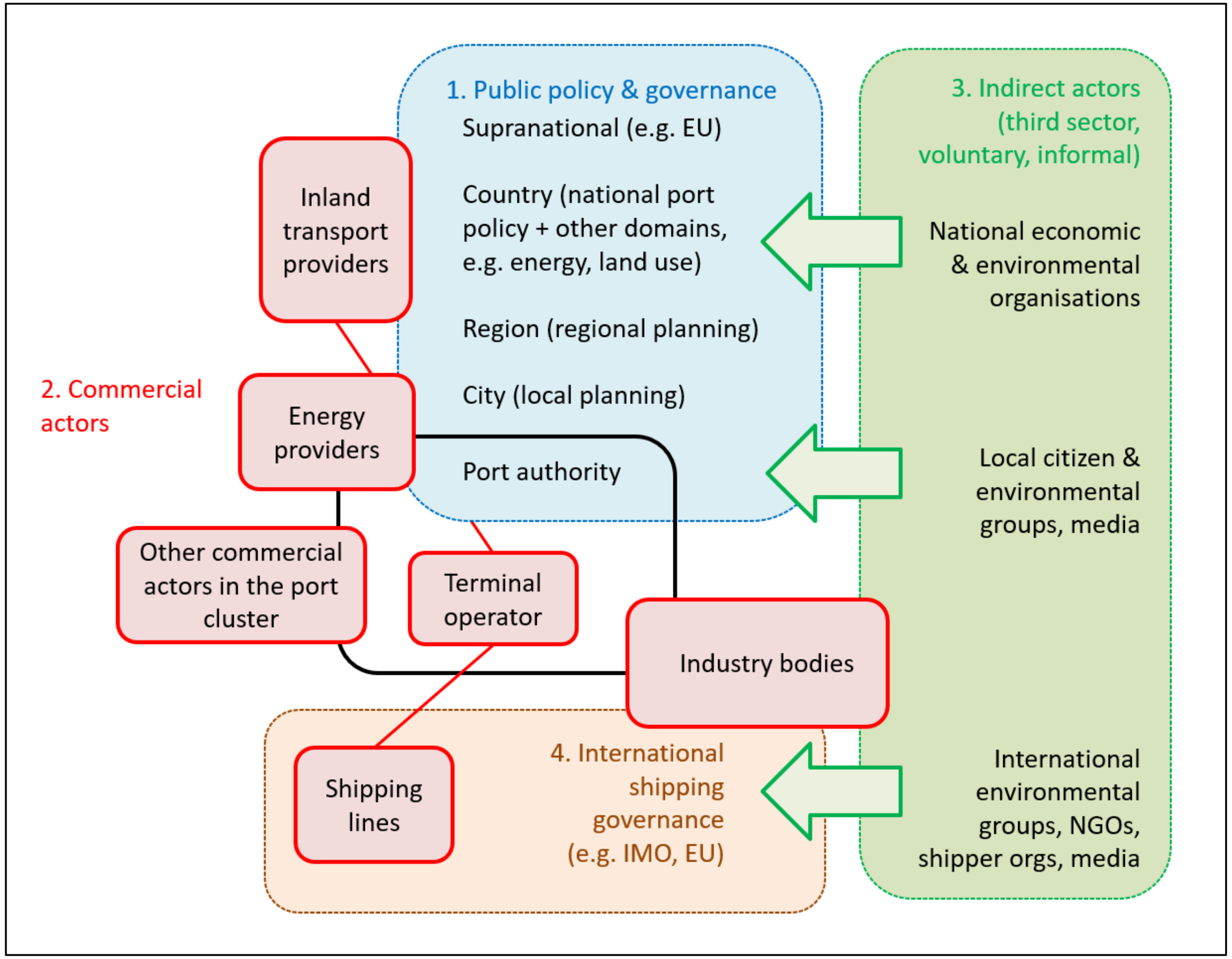
A geoeconomic trilemma of low-carbon industrial policy



Source: Bazaud & Wilmsmeier, 2026

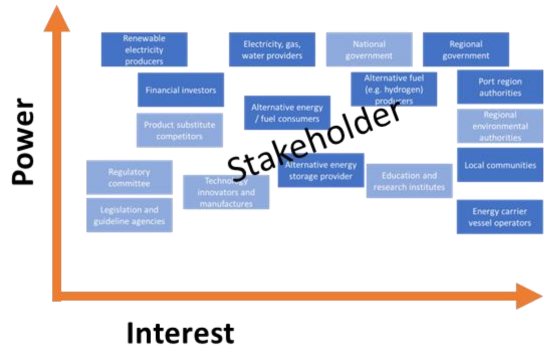
Final reflections

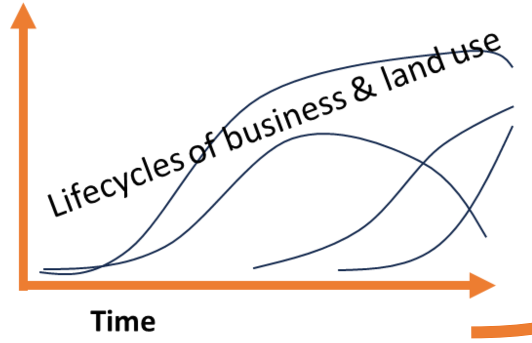
A changing environment – key actor groups to drive transitions in ports
a port governance perspective

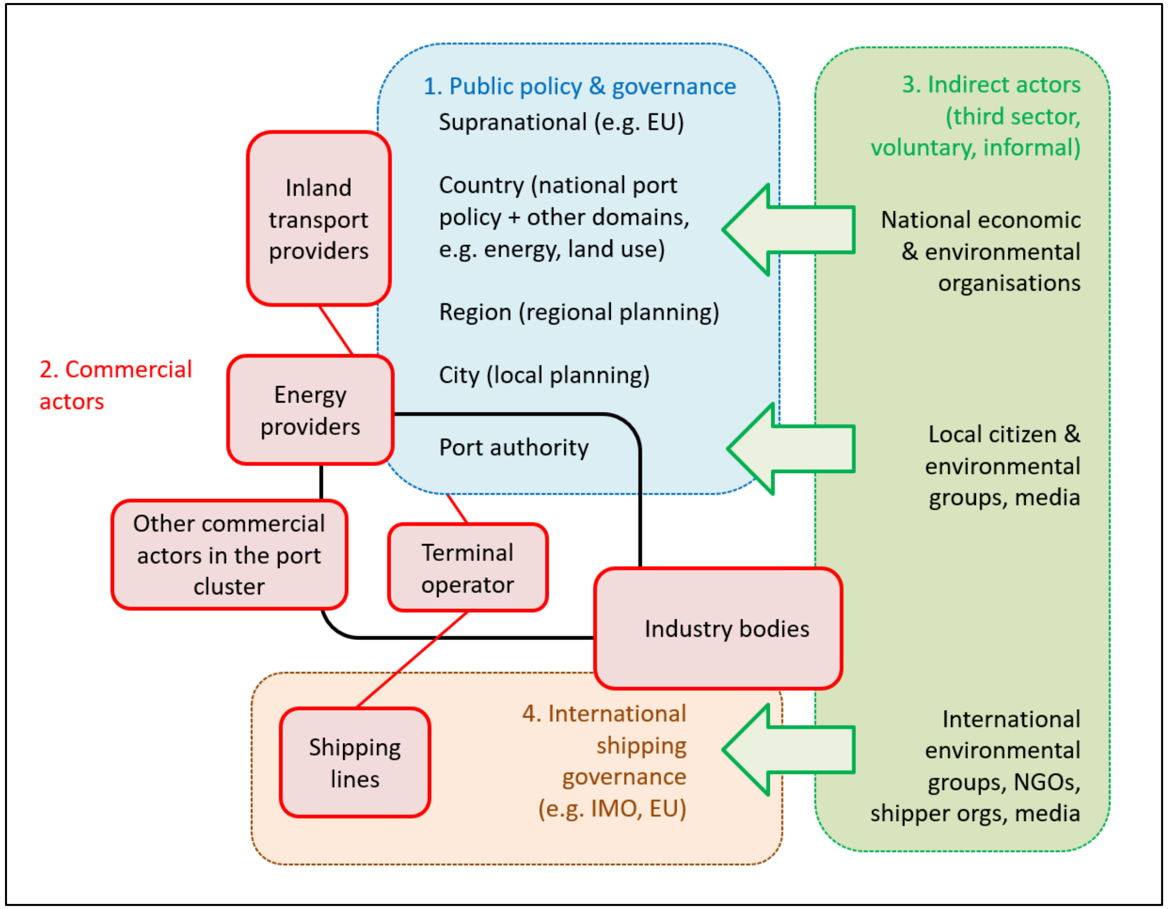


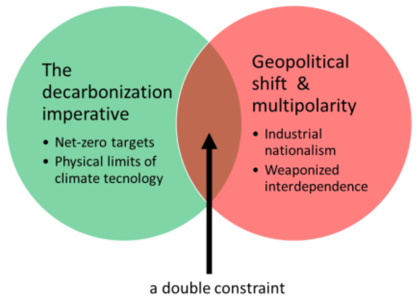
Source: Monios, Wilmsmeier, Martinez & Pomaska, 2024

A changing environment -
How do transitions and multi-sector collaboration function effectively?









Source: Monios, Wilmsmeier, Martinez & Pomaska, 2024

Final thoughts

The port sector is critical for a country´s economic development, competitiveness, and role in energy value chains.

Ports are increasingly differentiated not only by their ability to handle the latest generation of ships and the productivity levels they achieve, but also by their institutional efficiency and effectiveness in responding to transition challenges.

Projects are challenged by the multitude of stakeholders and fragmented responsibilities, which weaken the mandate of public actors, their ability to manage the distribution of costs and benefits, and their capacity to delegate actions to achieve transitions.

Policies and strategies must be crafted accordingly

Let´s discuss…

Contact:

Prof. Dr. Gordon Wilmsmeier
Director Hapag-Lloyd Center for Shipping and Global Logistics (CSGL)
Associate Professor for Shipping and Global Logistics,
Kühne Logistics University – KLU, Hamburg, Germany
Email: gordon.Wilmsmeier@the-klu.org

Kühne Professorial Chair in Logistics
School of Management, Universidad de los Andes, Colombia
Email: g.wilmsmeier@uniandes.edu.co

Recommended Material

Recent Publications:

- Monios, J., Wilmsmeier, G., Martínez Tello, G., Pomaska. L. 2024. *A new conception of port governance under climate change*. https://www.sciencedirect.com/science/article/pii/S0966692324001972
- World Bank (2025) *Port Reform Toolkit : Module 8 - Environmental Sustainability (English).* Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/099073025114570099
- Kerstin Dobers, K.,Perotti, S, Wilmsmeier, G., Mauer, G., Jarmer, J.J., Spaggiari, L., Hering, M., Romano, S., Skalski, M. 2023. Sustainable logistics hubs: greenhouse gas emissions as one sustainability key performance indicator. Transportation Research Procedia. https://www.sciencedirect.com/science/article/pii/S2352146523008700
- Spengler, T., Wilmsmeier, G. 2019. Chapter 7 - Sustainable Performance and Benchmarking in Container Terminals—The Energy Dimension. In: Green Ports. https://www.sciencedirect.com/science/chapter/edited-volume/abs/pii/B9780128140543000074 (institutional access)

Tools:

- Port and shipping activity in Latin America: https://nexusenergiamovilidad.uniandes.edu.co/dashboardses/
- Freight Transport and Logistics Observatory – port citis in the Valparaiso Region, Chile: https://www.observatoriopuertos.cl/