ASIA AND THE PACIFIC TRANSPORT FORUM 2024

CLEAN TRANSPORT FOR ALL

14–17 May 2024 | ADB Headquarters, Manila, Philippines

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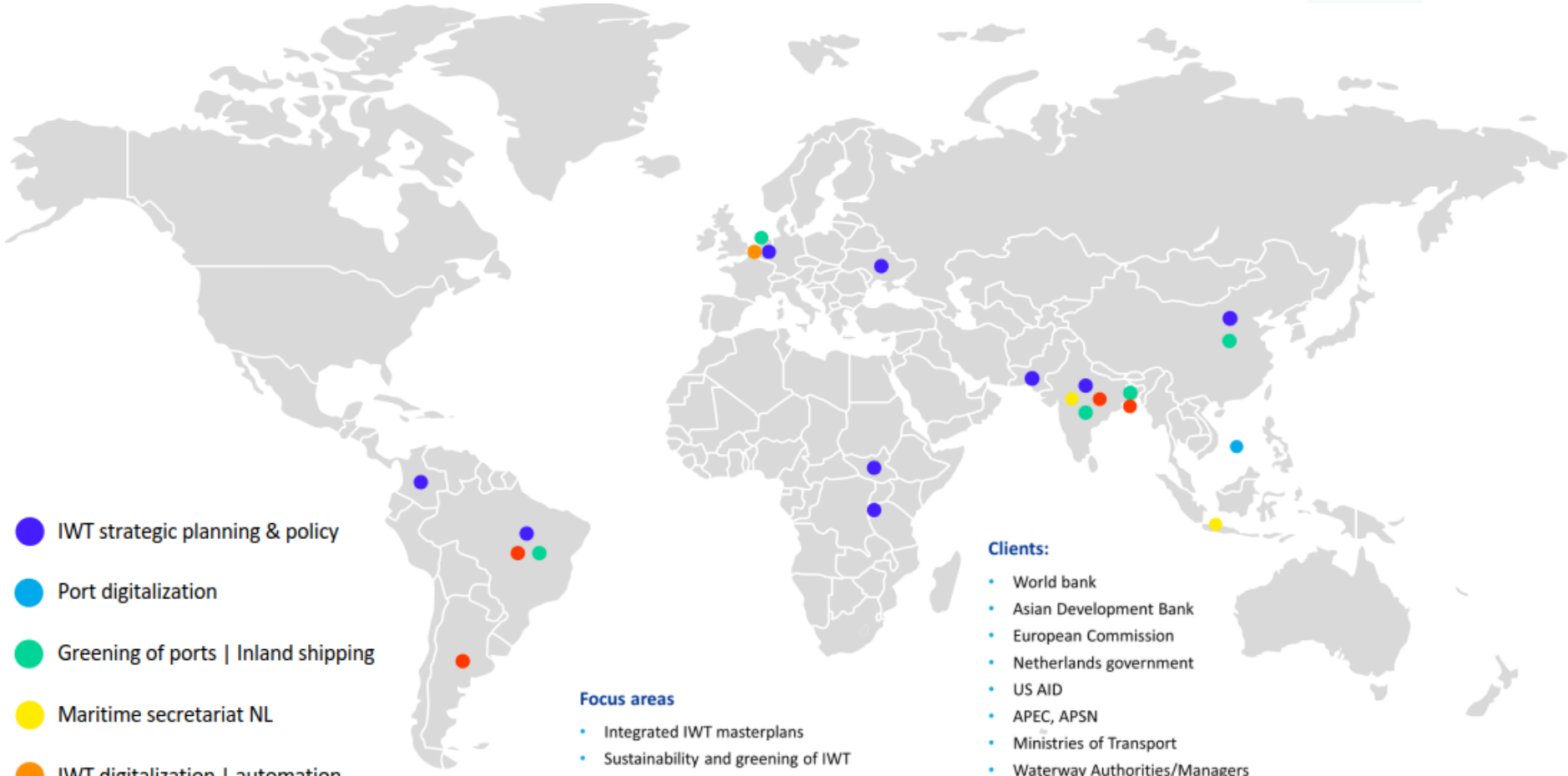
Development of New Energy Applications in Ports and Shipping

Richard van Liere, Nestra

Manilla, 17 May, 2024

Introduction Nestra



- IWT strategic planning & policy
- Port digitalization
- Greening of ports | Inland shipping
- Maritime secretariat NL
- IWT digitalization | automation
- IWT infrastructure

Focus areas

- Integrated IWT masterplans
- Sustainability and greening of IWT
- ICT applications and digitalization
- Feasibility projects
- Capacity building and training

Clients:

- World bank
- Asian Development Bank
- European Commission
- Netherlands government
- US AID
- APEC, APSN
- Ministries of Transport
- Waterway Authorities/Managers
  Port Authorities
- Private sector associations,
  Individual companies

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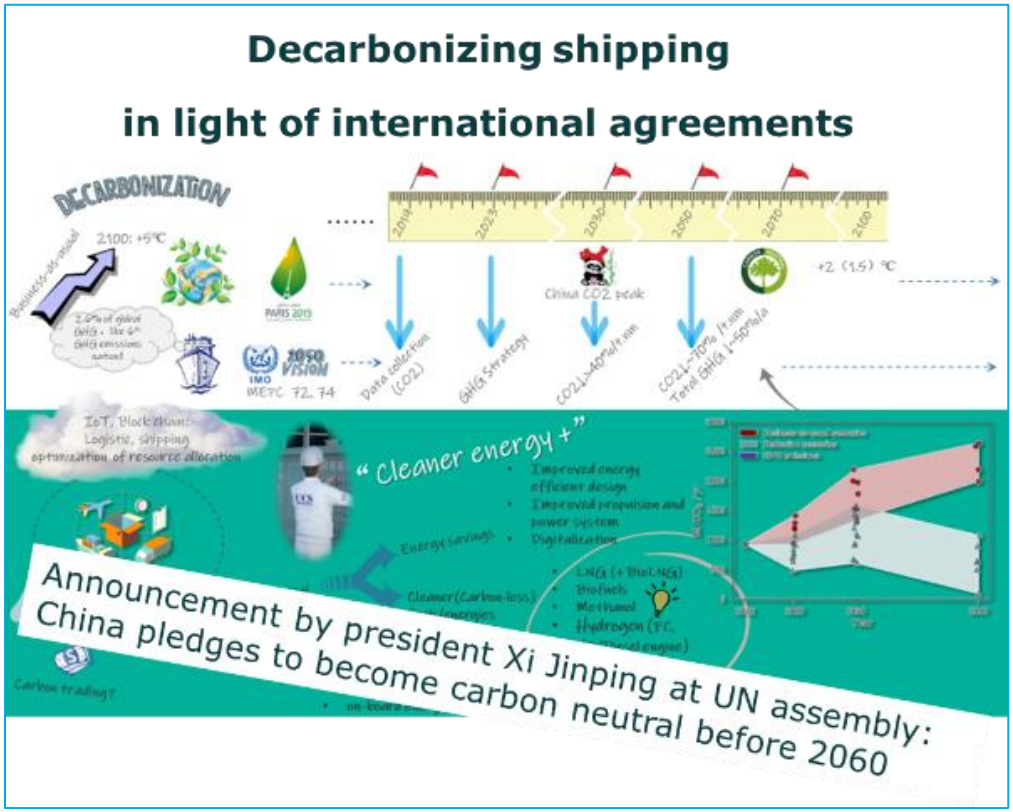
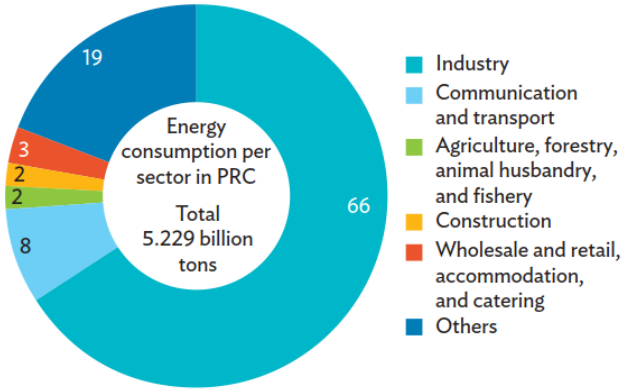
Introduction Study ADB



Proportions of Energy Consumption of Various sectors in the People's Republic of China (%)



PRC = People's Republic of China.

Notes:
1. Total energy consumption is presented in standard coal equivalent (SCE).
2. Consumption of coal, oil, natural gas and other energy source have been uniformly converted into SCE.

Source: Government of the People's Republic of China, National Bureau of Statistics. 2023. *China Energy Statistical Yearbook 2022*. Beijing: China Statistics Press.

Introduction Study ADB

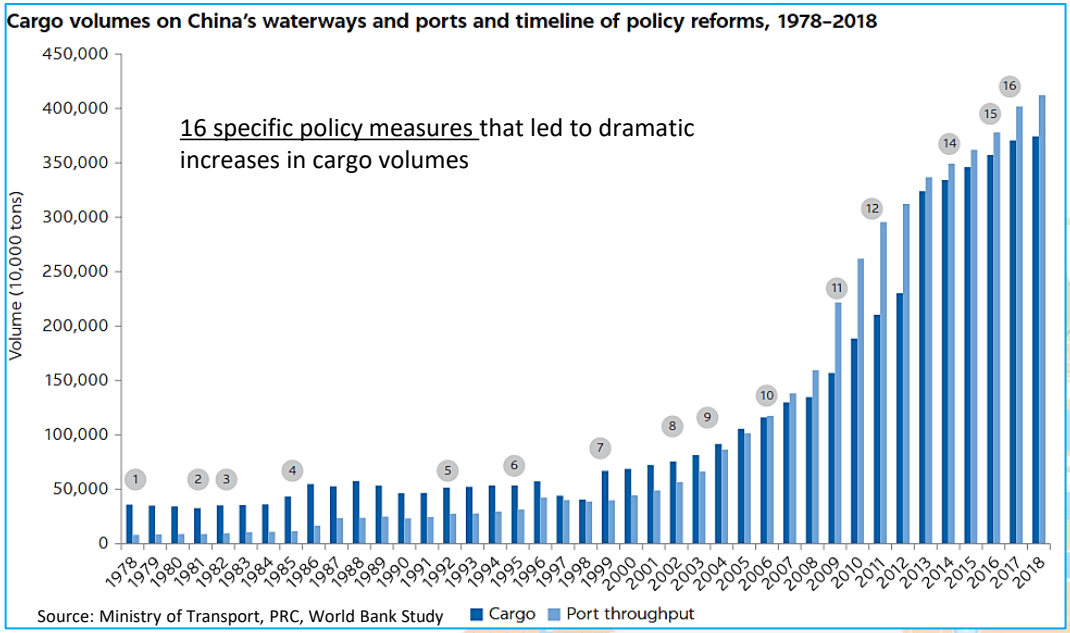
F1 Development of New Energy Applications in Ports and Shipping (55032-001) ADB - TA-6882 PRC

- Objective: develop a strategy for accelerated adoption of green solutions in ports & shipping
- Based on experiences in China (a.o. Qingdao and Huzhou) & international practices (both technical options and policies)
- Capacity building for:
  - Knowledge sharing and exchange several government bodies involved in port and IWT planning
  - International knowledge exchange; share experiences from China
- Focus on solutions for **inland shipping sector**, **applications in and for coastal and inland ports** and major seaports (from clusters) from the perspective of energy supply chains / corridors

PRC: Overview Port Sector

Some statistics on ports

- 16 out of 20 largest ports in the world in PRC
- Ningbo Zhoushan Port the world's largest port
- Total cargo throughput: 15.685 billion tons
- International trade: 4.607 billion tons
- Almost 296 million TEUs



Some views on "greening ports"

- Long-standing reliance on fossil fuel
- World-class ports: "safe and convenient, intelligent and green, cost-effective and efficient, powerful and cutting edge"
- Renewable energy is gaining momentum; 70% of demand still from thermal power plants

PRC: New Energy in Ports

- Solar, wind, hydrogen, and tidal energy, bioenergy to power port industries and operations
- Multi-energy integration based on utilization of electric energy

Renewable energy for thousands. The PRC has constructed its first combined tidal and solar power station. Located in Zhejiang Province, the station will provide electricity to 30,000 homes (photo by Guodian United Power and Zhejiang University).

Estimated Costs of Energy from Renewable Sources

Technology	Investment Cost	Transport Cost	Energy Price
	660 MW installation: CNY2,500 million	CNY0.20–0.30/1,000 km	CNY0.30–0.40/kWh
	Distributed generation CNY8.10/W	Nearby used, short transmission lines, negligible	CNY0.36/kWh
	3 MW equipment: CNY9.30 million CNY~3,100/kW	CNY0.20–0.30/1,000 km	CNY0.27–0.35/kWh
HYDROGEN	1,000 m^3/h installation: CNY13 million	CNY20 MPa: 21/500 km/kg CNY50 MPa: 9.64/500 km/kg	Gray: CNY12.80/kg Green: CNY24.40/kg CNY0.38–0.73/kWh
TIDAL ENERGY	1 MW installation: CNY33 million	Nearby used, short transmission lines, negligible	CNY0.45–1.40/kWh

h = hour, kg = kilogram, km = kilometer, kW = kilowatt, kWh = kilowatt-hour, m^3 = cubic meter, MPa = megapascal, MW = megawatt, W = watt.

Notes:
1. This figure assumes that the lower heating value of hydrogen of 33.33 kWh/kg is applied.
2. A megapascal is a unit of pressure according to the International System of Units.

Sources: J. Cao et al. 2021. Current Status of Hydrogen Production in China. *Progress in Chemistry*. 33 (12). pp. 2215–2244; Carbon Commentary. Some Rules of Thumb of the Hydrogen Economy. https://www.carboncommentary.com/blog/2021/6/11/some-rules-of-thumb-of-the-hydrogen-economy; Government of the People's Republic of China, National Energy Administration. The LCOE of Photovoltaic Power Generation in China Has Dropped by 90% in 10 Years [in Chinese]. http://www.nea.gov.cn/2018-04/13/c_137108373.htm; H. Qing. 2023. China is Putting New Energy and Investment into Tidal Power. *The Maritime Executive*. 23 February. https://maritime-executive.com/editorials/china-is-putting-new-energy-and-investment-into-tidal-power; Xiamen Mibet New Energy Co., Ltd. 2021. *What Are the Aspects of Photovoltaic Power Generation Cost Calculation? How Are Costs Assessed?* [in Chinese]. 19 May. https://www.mbt-energy.cn/news/industry/2105192.html.

PRC: New Energy Technology

- Zero-carbon terminals, electrification of (automated) port equipment, hydrogen fueled trucks and rail gantry crane, OPS

Zero-Carbon Terminal in Tianjin Port

KEY CHARACTERISTICS

Shore power
All berths equipped with shore power facilities; technically capable vessels can now be connected.

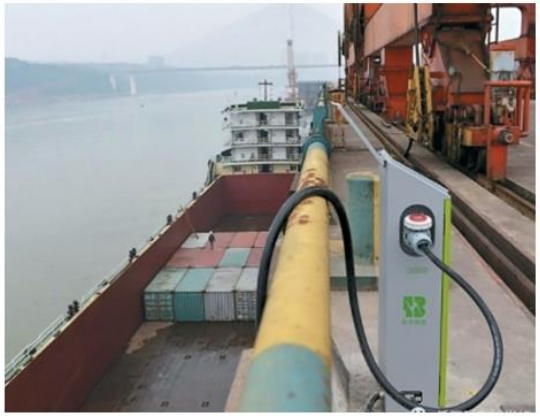
Electrification equipment
All terminal and handling equipment is electrified, with no fossil fuels or carbon emissions.

Renewable energy
Wind and solar energy sources generate 50 million kWh per year (more than the total terminal consumption of 45 million kWh), with 70% self-consumed and 30% sent to the main grid, where it is used during downtimes.

Power-generation system
New (internal) energy power-generation system avoids long-distance transmission lines, and reduces utility costs and energy loss.

Equipment electrification. Electric automated guided vehicles are already operating in Qingdao Port (photo by Nestra).

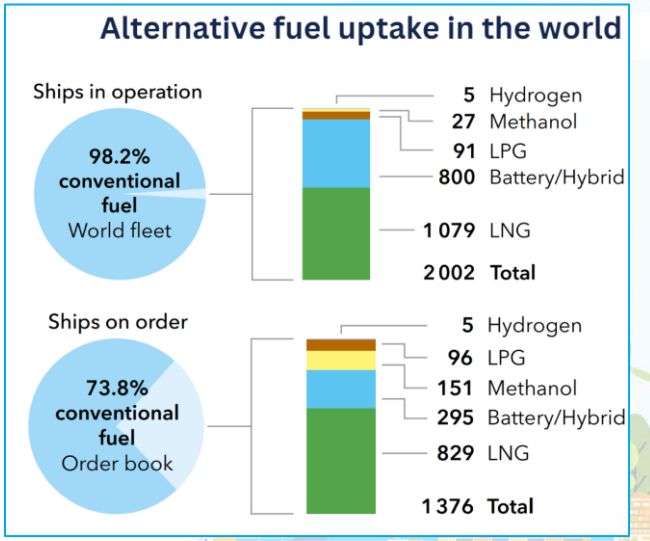
Hydrogen fuel at Qingdao Port. Pictured above are pipes for pumping the hydrogen fuel into trucks, a refueling station (photo by Nestra).



Onshore power. This is a view of the onshore power facility in Luzhou Port, the first one completed in Sichuan Province (photo by Sohu, Inc.).

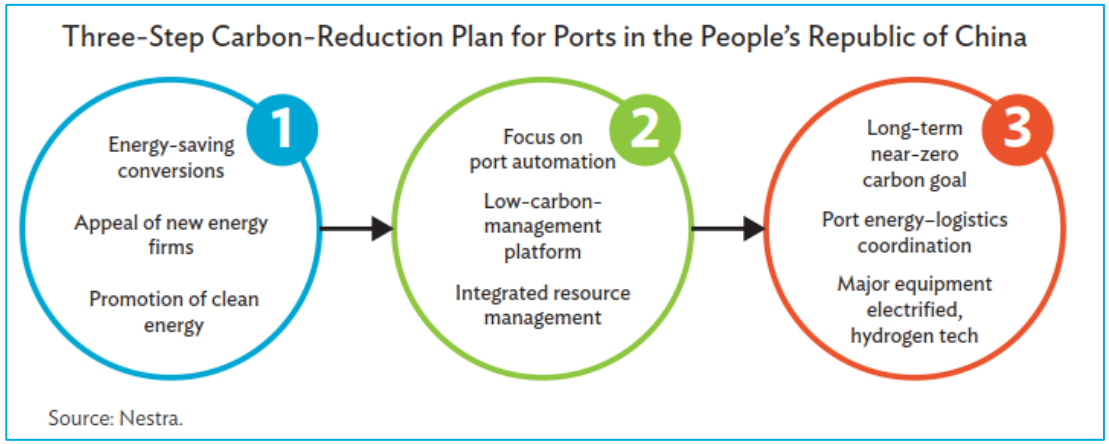
PRC: Some challenges in Ports with New Energy Application

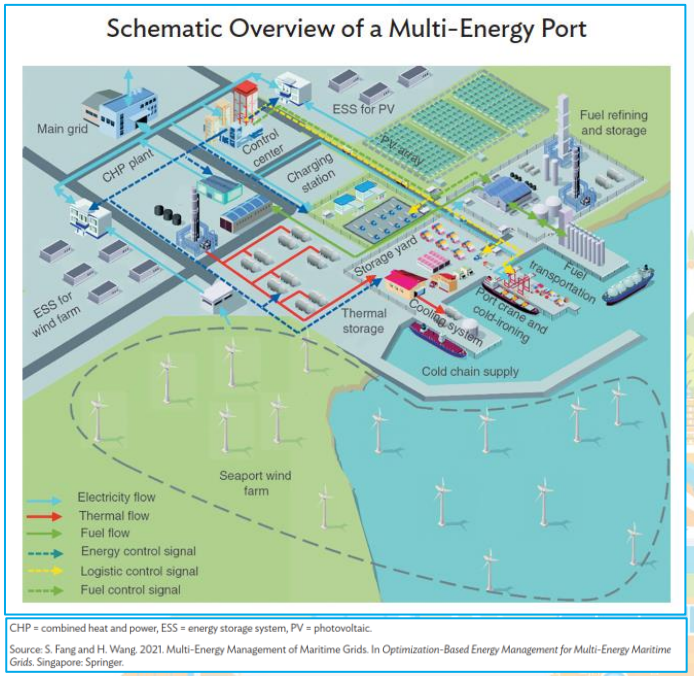
- Port integrated energy systems: optimized energy exchange in port domain (heat, natural gas, hydrogen)
- PRC sea ports and inland ports have to adapt to future energy technology for used to power vessels (LNG, Battery-Electric, Methanol, Hydrogen)
- Close to 2% of the vessels in numbers operate on an alternative fuel.
- New vessels on order, by number: 21% have alternative fuel technology.
- Onshore Power Supply challenges for further upscaling in PRC exist:
  - Safety (circuit breakers, high-voltage)
  - Power frequency not standardized for vessels
  - Older vessels not able to connect to OPS



Source: Maritime forecast 2050, Energy transition outlook 2023, DNV, also based on IHSMarkit data.

PRC: Roadmap for New Energy Application





Guiding, Organizational and Market Stimulation policies to support

- Port grid load layout optimization and new energy power system
- Promotion of green port technology in parallel with intelligent systems
- OPS and clean energy cutting direct emission of vessels
- Integrated port energy systems with hydrogen production and storage
- Microgrids in sea and inland ports

PRC: Inland Waterway Transport sector

IWT network

- "2-1-2-18 network"
- Blueprint and roadmap for the development of IWT in China
- Classification waterways was important first step, followed by synchronizing fleet and ports

Flows and Fleet (2022)

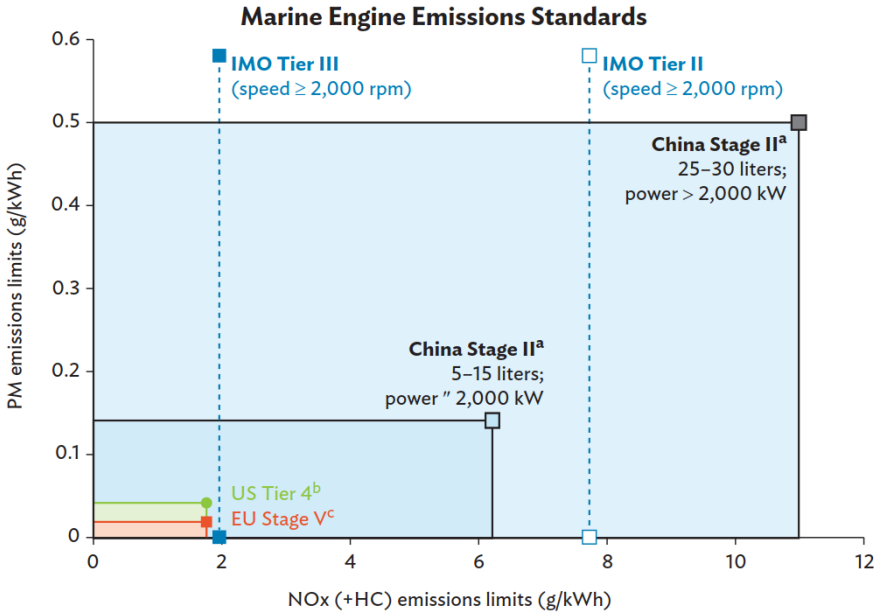
- 4.4 billion tons of cargo
- 39 million passengers
- 109,500 inland vessels
- Barge standardization

Source map: World Bank Group. 2020. Blue Routes for a New Era - Developing Inland Waterways Transportation in China

PRC: New energy application in inland shipping

- Low emission standards in view of decarbonization goals
- > 460 LNG-powered vessels, typically the larger cargo vessels
- > 80 all-electric inland waterway vessels (greater than 20 meters in length
- 20 all-electric vessels > 3,000 DWT

Comparative Overview of Global Emission Standards for Inland Vessel Engines



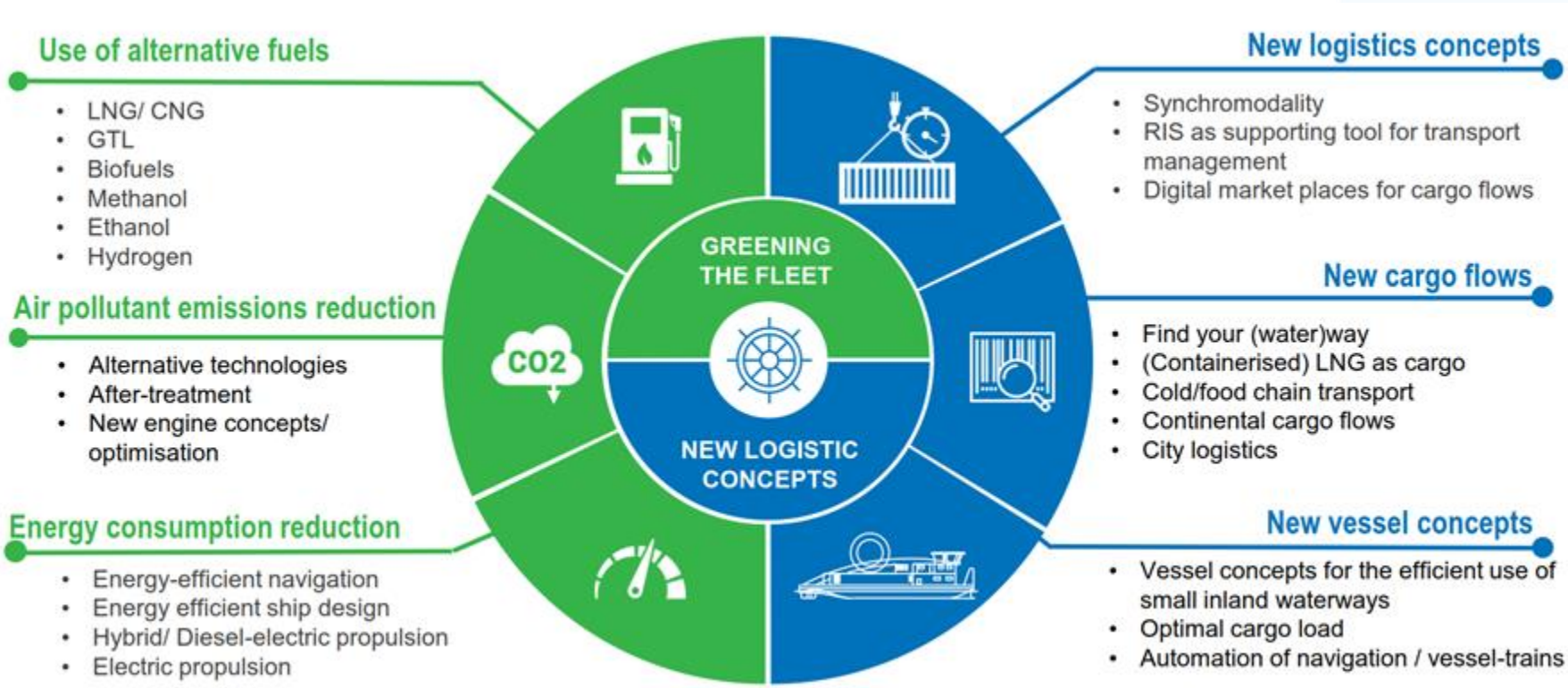
EU = European Union, g = gram, HC = hydrocarbon, IMO = International Maritime Organization, kW = kilowatt, kWh = kilowatt-hour, NOx = nitrogen oxide, PM = particulate matter, US = United States, rpm = revolutions per minute.

Note: Emission standards depend on the engine-rated speed, displacement per cylinder, or on the rated power.

[a] Standards for PM and NOx + HC, which took effect in 2021.
[b] Standards for PM and NOx, for engines with rated power ≥ 600 kW and < 3,700 kW, phased in 2014–2017.
[c] Standards for PM and NOx, for engines with rated power > 300 kW, phased in 2019–2020.

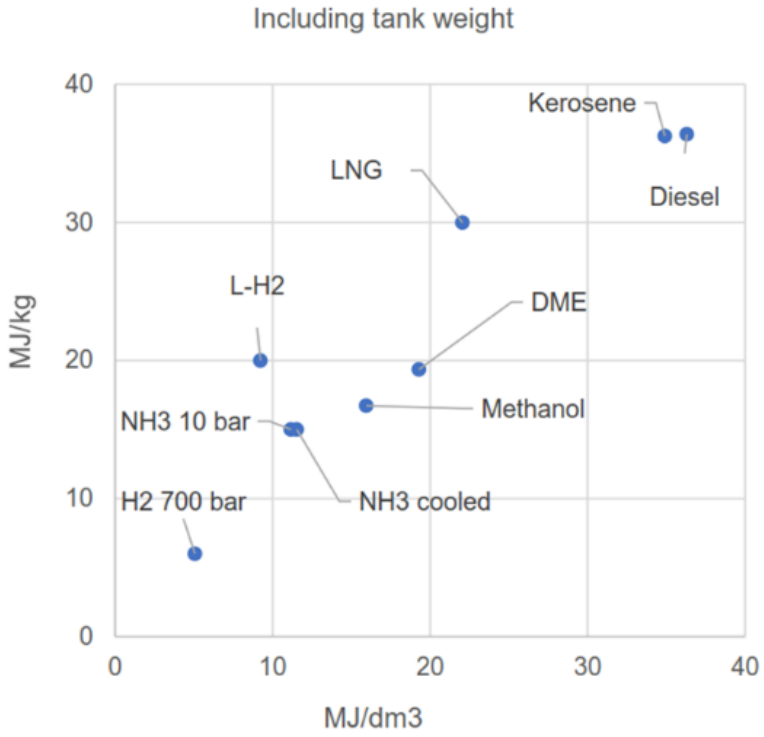
Source: National Resources Defense Council. https://www.nrdc.org/.

IWT Greening Strategy



(EIBIP, source NAIADES II Common Expert Group meeting)

IWT Greening – Implications Alternative Fuels



Factor compared to diesel fuel	Volume factor based	Packaging factor ship	Volume incl. space factor
Methanol	2,3	1	2,3
LNG	1,6	2	3,2
NH3 cooled	3,1	1.1	3,1
NH3 10 bar	3,1	2	6,3
cryogenic H2	6,3	2	12,5
comp. H2 700 bar	7,1	2,5	17,7
comp. H2 350 bar	12,5	2,5	31
Battery	50	2	100

Source: Presentation EICB + Study TNO

PRC: New energy application in inland shipping

Application

- LNG ships: 460+
- Methanol ships: 6
- Hydrogen ships: 4
- Ammonia ships: 5
- Battery ships: 280+ (incl. <20 m)

COSCO

- 119.8 x 23.6 meters
- 36 TEU battery capacity x 1.6 MWh = 57,600 kWh

Source: China Certification Society

Vessel N997 and N998: “COSCO SHIPPING Green Water 01” and “COSCO SHIPPING Green Water 02

Source photo: COSCO Shipping - Wang Weizhou/Wen Zou (on Shipping Telegraph)

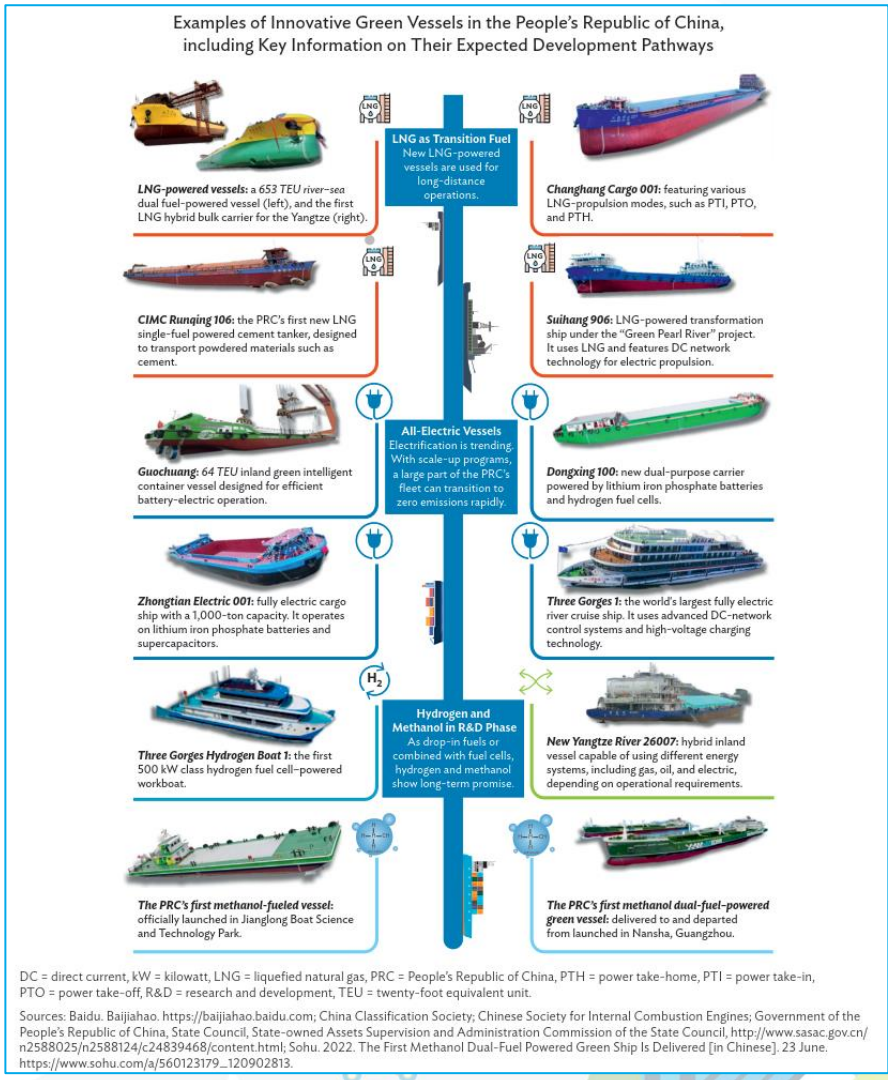
PRC: R&D inland shipping

Application - Rules and Guidelines

- LNG
- Methanol/Ethanol
- Ammonia
- Pure battery power
- Fuel cell
- LNG Bunkering
- Methanol Bunkering
- Hydrogen Bunkering (ongoing)

Application - Digitalization Solutions

- Safety assessment and simulation software for Machinery Space
- Digital Auxiliary Inspection System for Battery Powered Ships



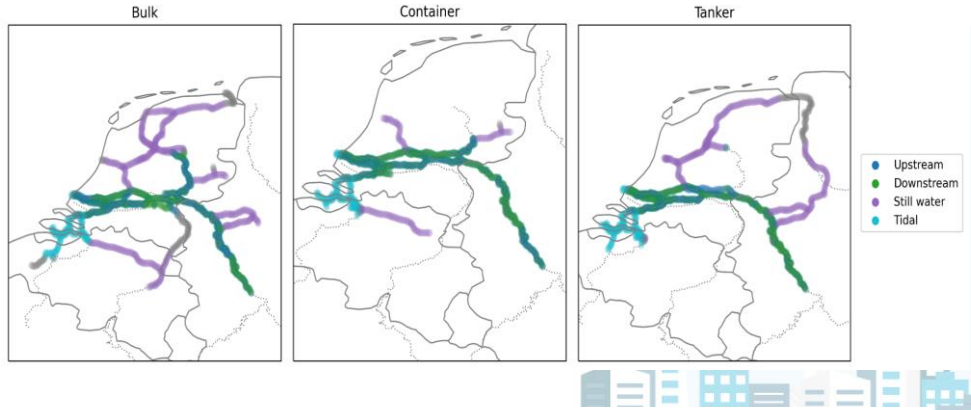
DC = direct current, kW = kilowatt, LNG = liquefied natural gas, PRC = People's Republic of China, PTH = power take-home, PTI = power take-in, PTO = power take-off, R&D = research and development, TEU = twenty-foot equivalent unit.

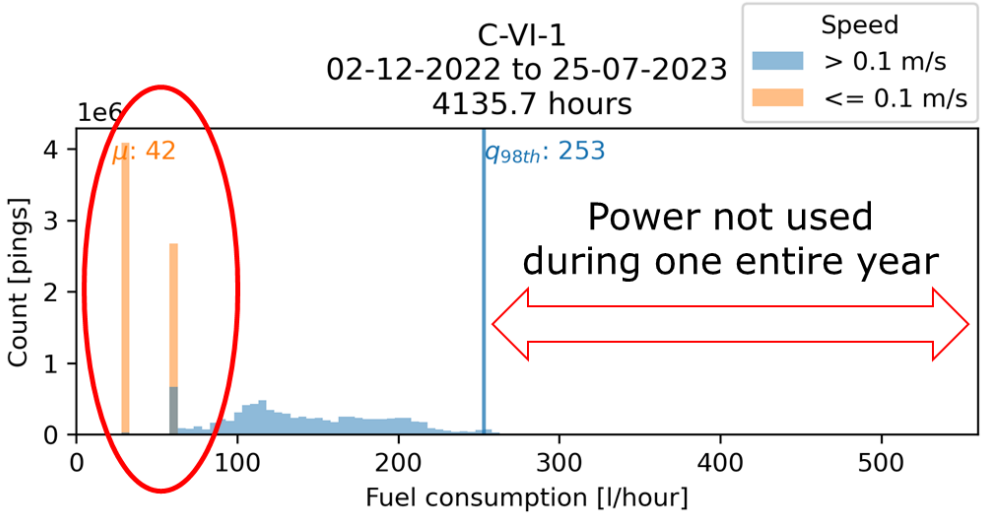
Sources: Baidu. Baijiahao. https://baijiahao.baidu.com; China Classification Society; Chinese Society for Internal Combustion Engines; Government of the People's Republic of China, State Council, State-owned Assets Supervision and Administration Commission of the State Council, http://www.sasac.gov.cn/n2588025/n2588124/c24839468/content.html; Sohu. 2022. The First Methanol Dual-Fuel Powered Green Ship Is Delivered [in Chinese]. 23 June. https://www.sohu.com/a/560123179_120902813.

EU: R&D inland shipping

Digitalization is powerful tool for greening

- Inland vessels: too much power installed
- Energy loss when running idle
- Combined energy loss 135m inland container vessel:
  - 51,000 liter of diesel fuel
  - 177,000 kg CO_2
  - 55,000 euro fuel costs
- New energy technology:
  Power <u>installed</u> vs. **Power <u>used</u>**

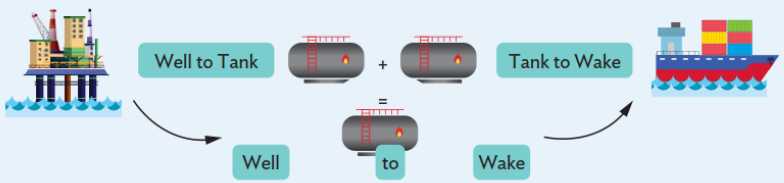




(Source: IWT footprinting project by Top Sector Logistics in the Netherlands, in which Shipping technology & Nestra provide vessel data)

PRC: New energy application in inland shipping

Power Source	WTT CO_2 Emissions (tons)	TTW CO_2 Emissions (tons)	WTW CO_2 Emissions (tons)	Savings Compared with Gas Oil
	61	288	349	
	364	0	364	+4%
	203	0	203	–42%
	0	0	0	–100%



+ = higher, – = lower, CO_2 = carbon dioxide, DC = direct current, GLEC = Global Logistics Emissions Council, h = hour, km = kilometer, kW = kilowatt, kWh = kilowatt-hour, PRC= People's Republic of China, SOx = sulfur oxide, TTW = tank-to-wheel, WTT = well-to-tank, WTW = well-to-wheel.

Notes:
1. The total life cycle of the various technologies is not included in this comparison.
2. For electricity, the well is the source of production (thermal, gas, renewable energy), the tank is the main grid or intermediate storage unit, and the "wake" refers to the batteries installed in the vessel.
3. A blank cell indicates that the column head does not apply.

Sources: Smart Freight Centre. The GLEC Framework. https://www.smartfreightcentre.org/en/our-programs/global-logistics-emissions-council/calculate-report-glec-framework; Sustainable Energy Authority of Ireland.

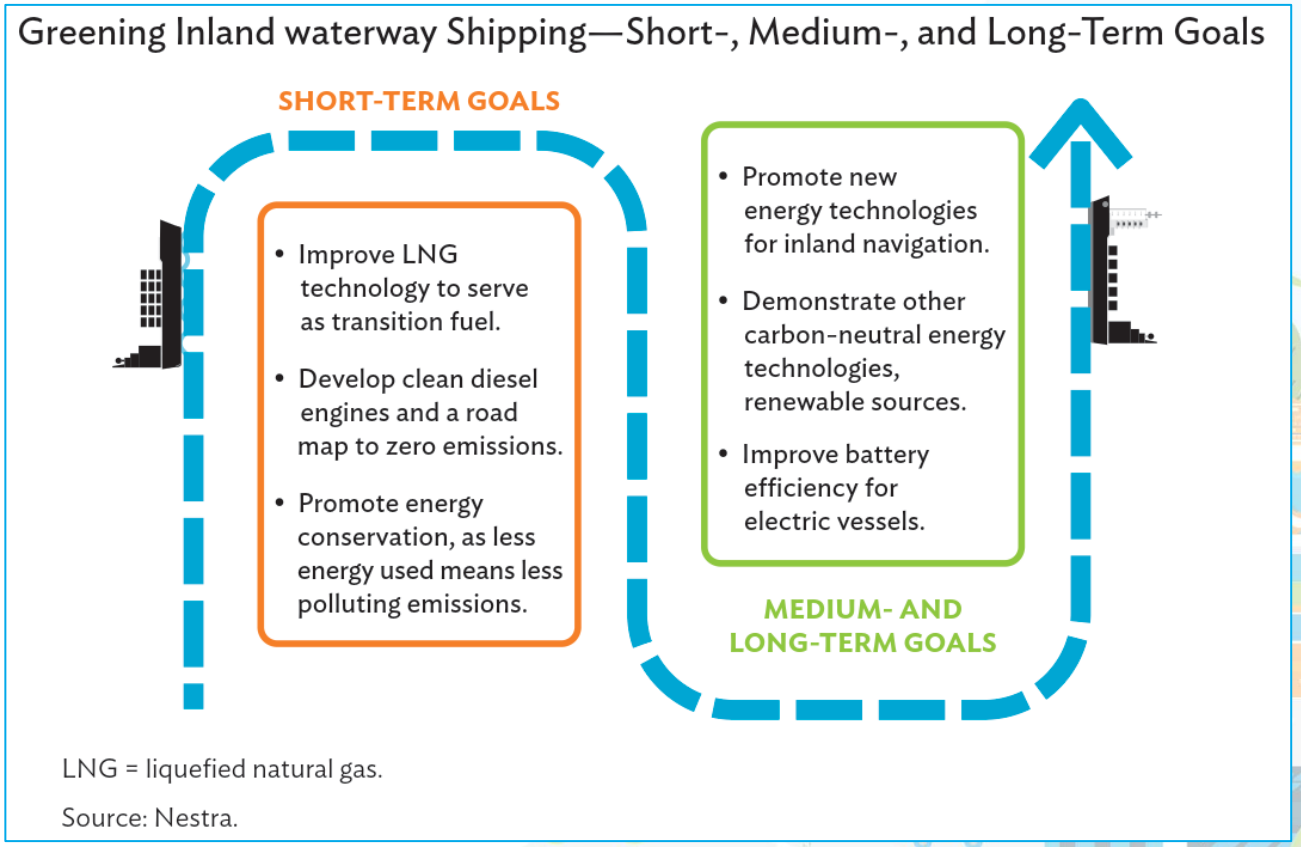
Huzhou Demonstration Zone - China

- Dongxing 100
- 62.7m x 12.4 x 4.1 = 1,800 tons capacity
- "Fixed" battery of 3,400 kWh
- Charging 4-5 hours, range 300 km

PRC: Roadmap for New Energy Application

Guiding, Organizational and Market Stimulation policies to address

- Longevity of vessels
- Bunkering infrastructure and charging
- Investment costs
- Harmonized standards
- Internalizing external costs (ETS)
- Improve LNG technology
- Accelerate all-electric
- R&D hydrogen, methanol, …



Opportunities for international & regional cooperation

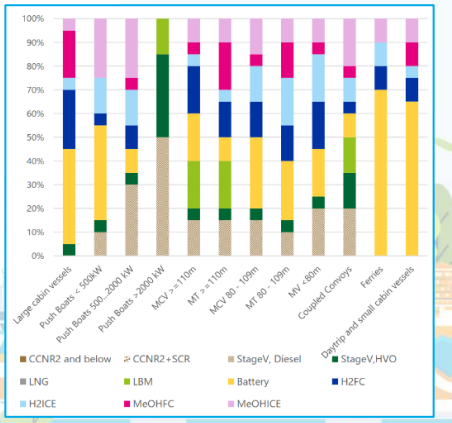
- **Make use of "Maritime Relations" in ship building, technology design**

- **Research & Consultancy:** technical assistance for knowledge exchange
  - Port & waterway infra: climate change adaptation
  - (Inland) shipping:
    - energy conservation / hull optimization
    - On-board monitoring
    - Roadmap based on operational profile
    - Common technical standards for new energy technology
    - "Supply chain thinking"

- **Benefit from scale advantage PRC**
  - PRC: fuel-cell technology @USD 500/kW

Source: China Certification Society

Source: Study on financing the energy transition towards a zero-emission EU IWT sector, CCNR



Source: RH2INE project, https://www.rh2ine.eu/

Transferability of Good Practices to Other ADB DMCs

- **PRC Good Practices, Not a Blueprint**
  - Long-term planning of sustainable growth
  - Benefits of public financing for ports and inland-waterway shipping
  - Investment in R&D infrastructure
  - Standardization as a way to reduce costs
- **A few recommendations based on the ADB - TA-6882 PRC**
  - Study and introduce multi-energy port microgrids to supply renewable energy to industries, vessels, and equipment
  - Study and introduce preferential policies for clean port and shipping operations. Green solutions usually lead to higher costs and would benefit from preferential policies or subsidies (priority berthing, free OPS, green-port or shipping-award system, carbon-pricing/emission trading, corporate sustainability reporting, etc.)
  - Technical and economic viability of new energy solutions key to accelerated uptake. A central financial guarantee system could help de-risk commercial investments in ports and (inland-waterway) shipping.

ADB

THANK YOU!

Netherlands Expert Group for Sustainable Transport and Logistics

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Personal profile

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