IRENA INNOVATION WEEK 2023

Solutions to decarbonise the shipping and aviation sectors

In partnership with

ITS UCDAVIS Institute of Transportation Studies

26 September 2023 | 14:00

#IIW2023

IRENA INNOVATION WEEK 2023

Scene-setting Presentation

Pierpaolo Cazzola
Director – European Transport and Energy Research Center
Institute of Transportation Studies at UC Davis

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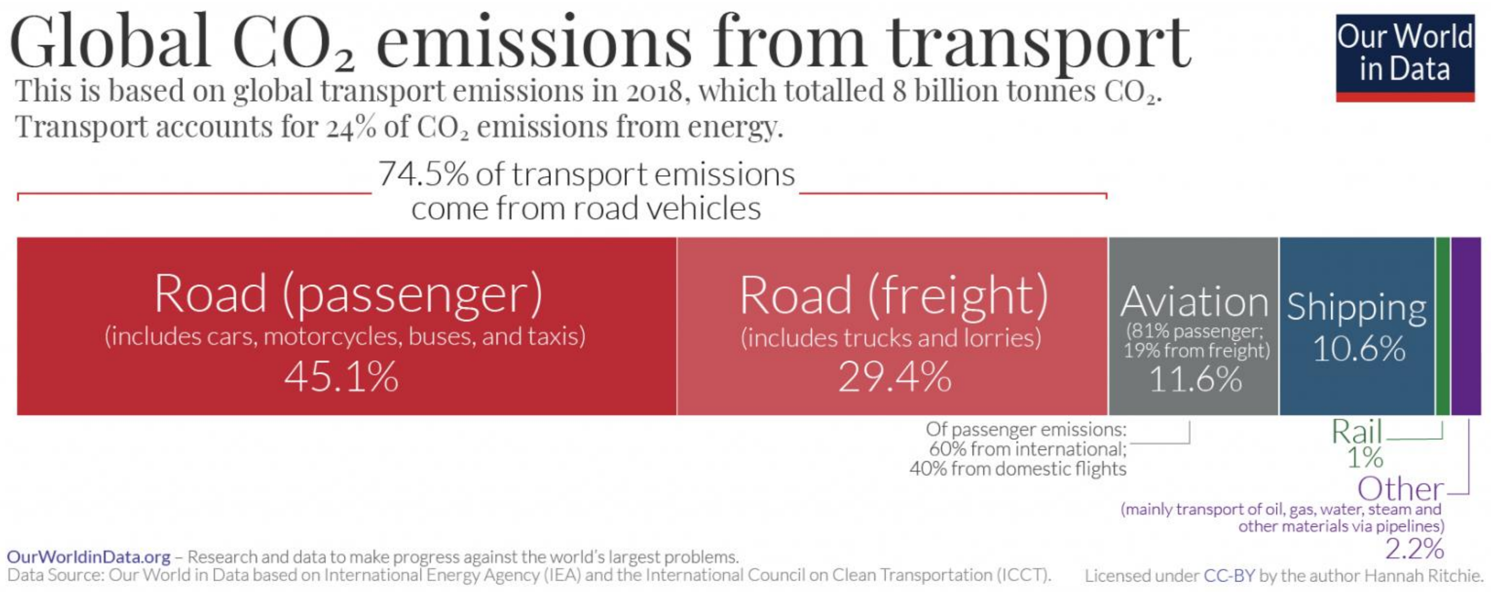
Introduction

- Transport plays a vital role in the world's economy, but it is also a major source of emissions: 23% of energy-related GHG emissions globally, and close to a third once indirect emissions (vehicle manufacture, fuel production, infrastructure construction) are included



- Energy combustion emissions from shipping and aviation currently account for over 5% of GHG emissions (fairly evenly split)
- This share will grow as road transport decarbonizes
- For aviation, it comes with important additional climate forcing pressure (due to non-CO_2 effects)

Technology options to decarbonize shipping and aviation

Important **commonalities**

- International relevance + presence of ad-hoc international "regulator" (IMO, ICAO)
- Major importance of long distance trips
- Poor track record regarding fuel taxation and meaningful carbon pricing (with few exceptions)

Decarbonisation needs to be articulated on three main areas of action

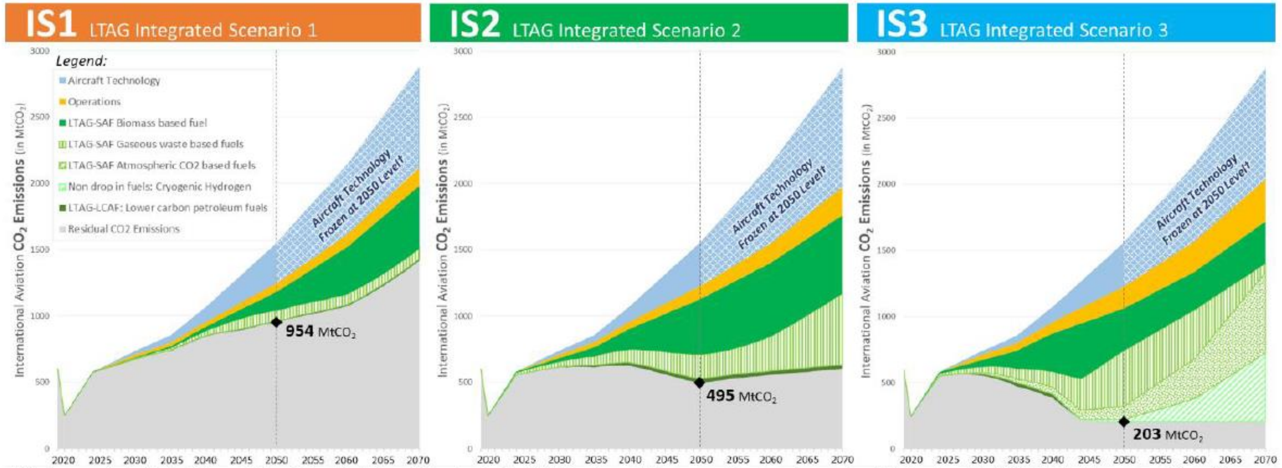
- The management of travel demand
- The enhancement of the energy efficiency

→ Operational and technical solutions

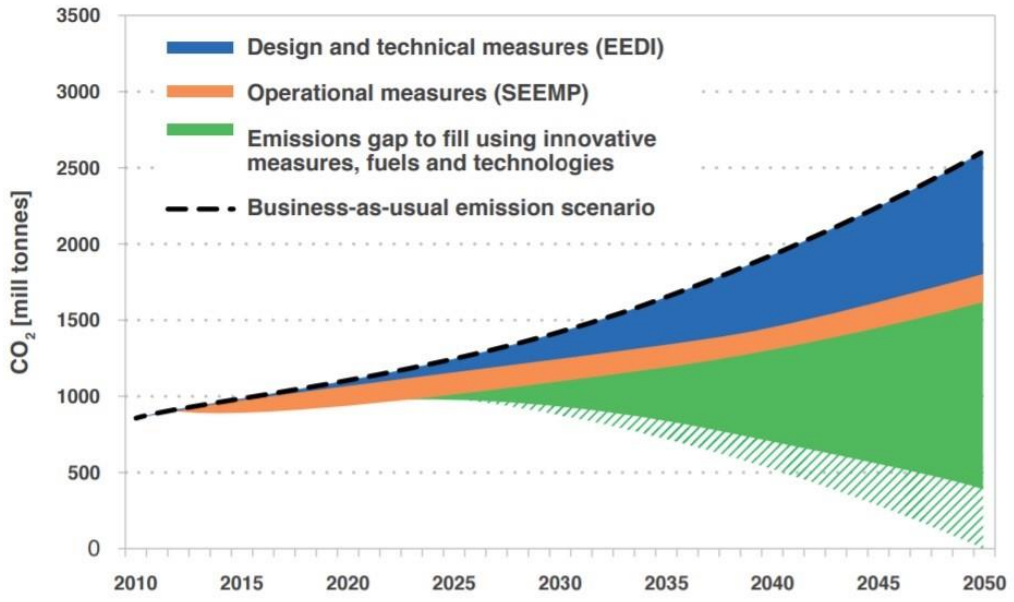
- The reduction of the fossil carbon content of energy vectors/fuels, in line with IPCC (IPCC is also clear on the fact that carbon dioxide removals are needed for complementary measures)

→ Need for coordinated action for vessels, energy/fuels & infrastructure

Technology options to decarbonize shipping and aviation



† Caution required with the interpretation of absolute CO_2 emissions levels after 2050 due to modelling assumptions e.g., frozen aircraft technology after 2050. Under these assumptions, CO_2 emissions are higher than in an alternative scenario (and modelling approach) where aircraft technology would continue to improve after 2050.



Technical solutions for efficiency improvements

Operational improvements

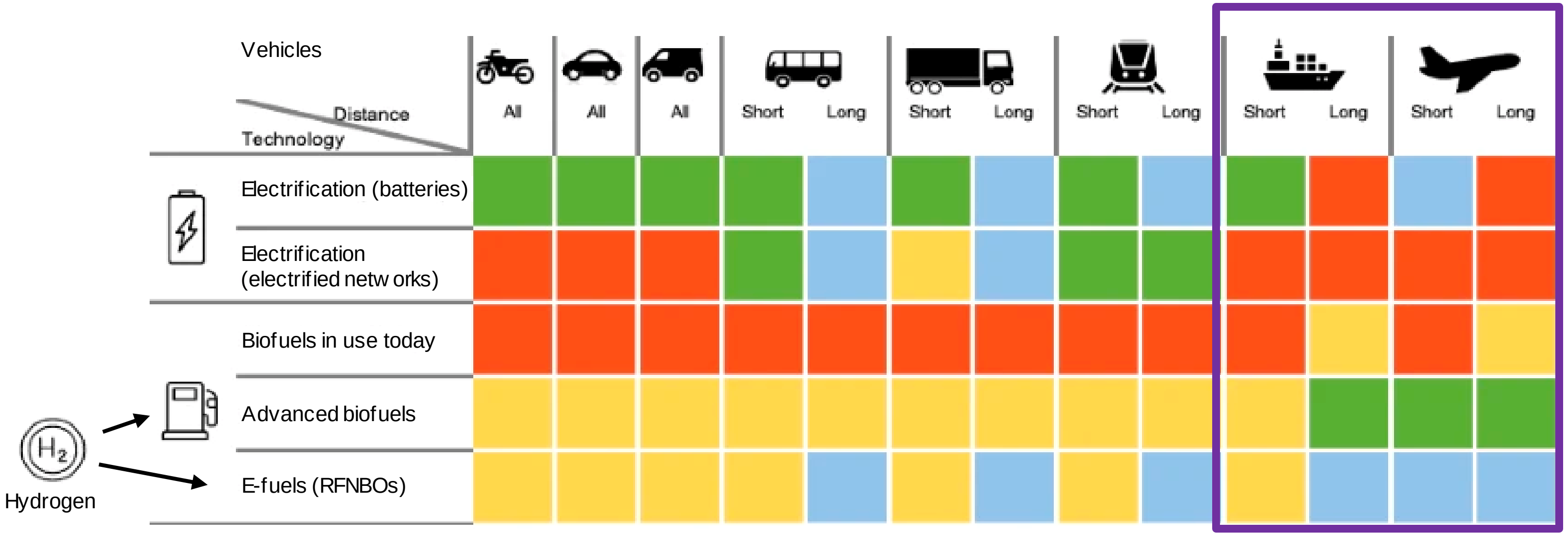
Fuel switching

Requiring carbon negative approaches (offsets)

Zoom into fuel options

Need to account for multiple needs:

- Technology readiness and technical feasibility (including safety aspects)
- Availability, at scale and in line with sustainability requirements (with respect to GHG emission abatement, on a life-cycle basis, energy efficiency, water and land use requirements)
- Cost, with a focus of total cost of ownership and operation

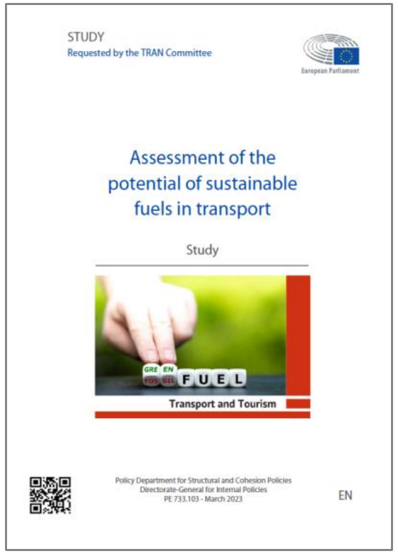


High priority (technically feasible, suitable, economically competitive)
Low priority (technically feasible but not very suitable, economically suboptimal)
Not a priority (subject to major technical restrictions, limited economic competitiveness)
Uncertain (at present, subject to technical and economic restrictions, albeit with a considerable potential, requires research and deployment support)

Source: adapted from https://www.nature.com/articles/d43978-022-00098-x

In words…

- For both cost and resource efficiency reasons, the shift to sustainable fuels should be first driven by a significant increase in **energy efficiency**
- **Direct electrification** from renewable and other low-carbon resources is the best option for the decarbonisation of **road transport and short haul shipping**, due to lower cost, better energy efficiency and – with economic circularity – resource requirements vs. competing alternatives
- **Liquid and gaseous sustainable fuels** should be primarily dedicated to transport sub-sectors that cannot be easily electrified, i.e. **aviation, shipping**, and – possibly – part of heavy-duty road transport



Sources:
https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2023)733103
https://doi.org/10.7922/G2SB442Z

With more details…

- **Biofuels** are cheaper than renewable e-liquids, but they face availability limitations and competing demand in the bio-economy and sustainability constraints with respect to land use
- **Hydrogen** could be used as an energy carrier (with storage challenges) or a feedstock for PBtL and e-fuels (RFNBOs), but it needs to be produced from low-carbon pathways (requiring very carbon electricity and very cheap forms of primary energy)
- **Renewable e-liquids** are interesting options for both aviation and shipping
  - Blendable e-hydrocarbons (drop-in) are needed for SAF; they can also be used by ships (cost/energy efficiency challenge)
  - E-ammonia and e-methanol are competitive candidates for maritime fuels, although their adoption remains uncertain: safety issues are currently a barrier for ammonia, and the sourcing of carbon can be challenge for methanol
- **Fossil fuels with emissions offsetting** (including but not limited to DACCS) may outcompete e-fuels (if also reliant on DAC), but there are scale constraints for DAC, due to volumes of air to be processed and need for large low-carbon heat inputs

Policies for transport decarbonization

- Focusing in least-cost is crucial to maximise development opportunities and/or minimize economic drawbacks
- While there is a tendency on near-term focus in policymaking, looking at structural long-term aspects (availability, modularity and its cost implications) is important to anticipate change, de-risk investments meant to seize opportunities and steer the economy towards greater competitiveness
- Carbon pricing is key for signals on efficiency and fuel switching investments, even if not sufficient (and also far from being universally adopted)
- The support of innovation and technological development (best if funded by carbon pricing) is crucial for sustainable aviation and shipping fuels that can leverage large scale feedstock availability

IRENA INNOVATION WEEK 2023

Scene-setting Presentation

Carlos Ruiz
Programme Officer, Innovation and End-use Sectors
IRENA

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IRENA
International Renewable Energy Agency

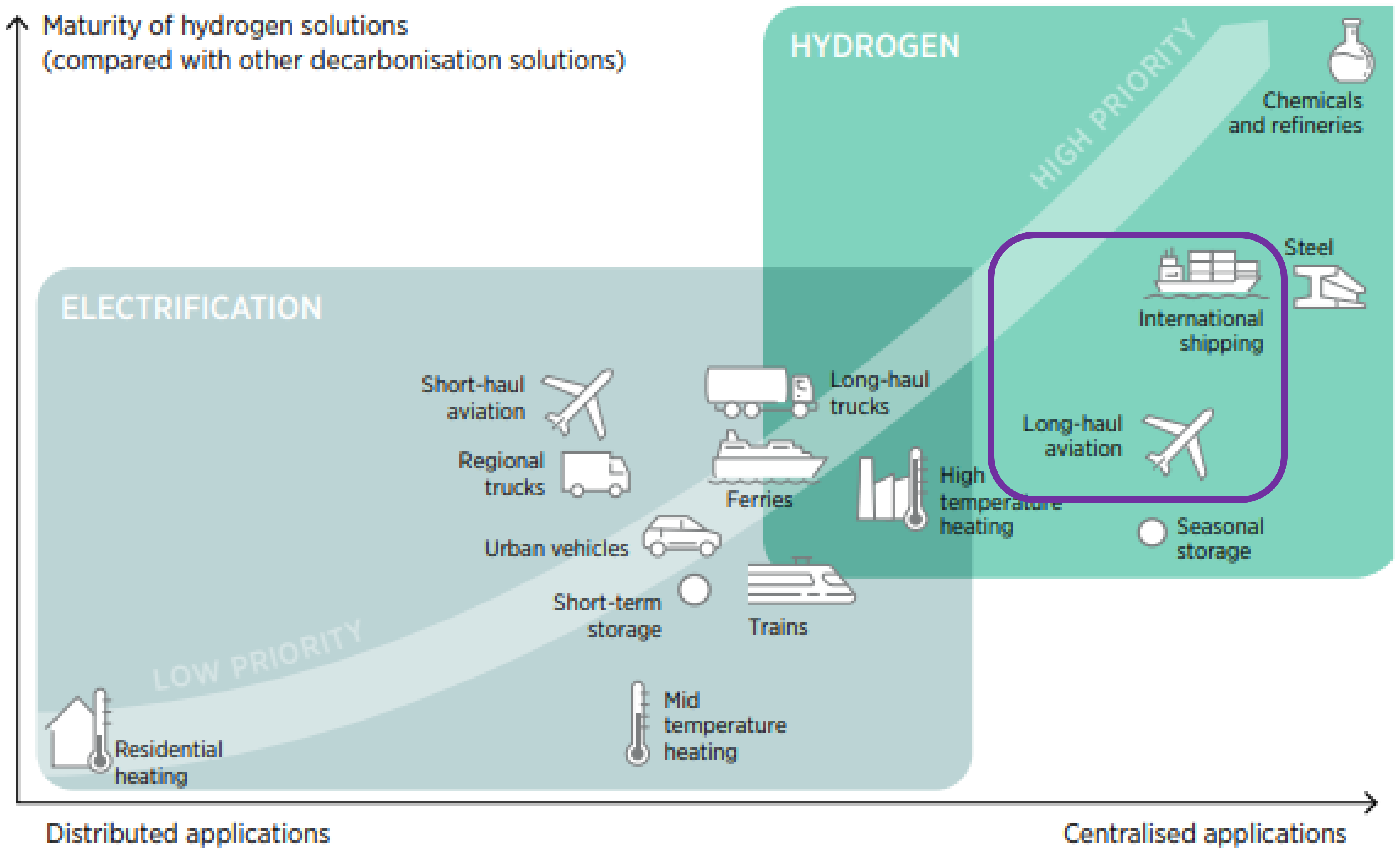
The role of renewables in decarbonising the shipping and aviation sectors

IRENA Innovation Week
Day 2 – Solutions to decarbonise the shipping and aviation sectors
26 September 2023

Carlos Ruiz
Programme Officer – Innovation and End-use Sectors

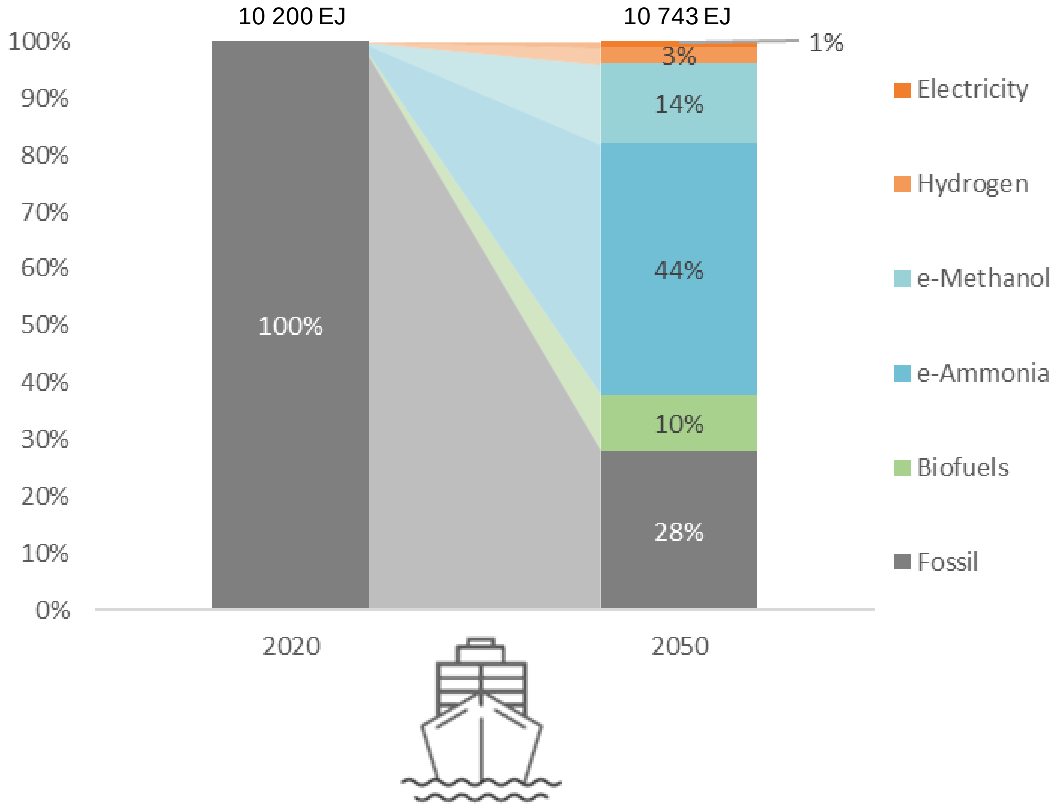
INNOVATION WEEK

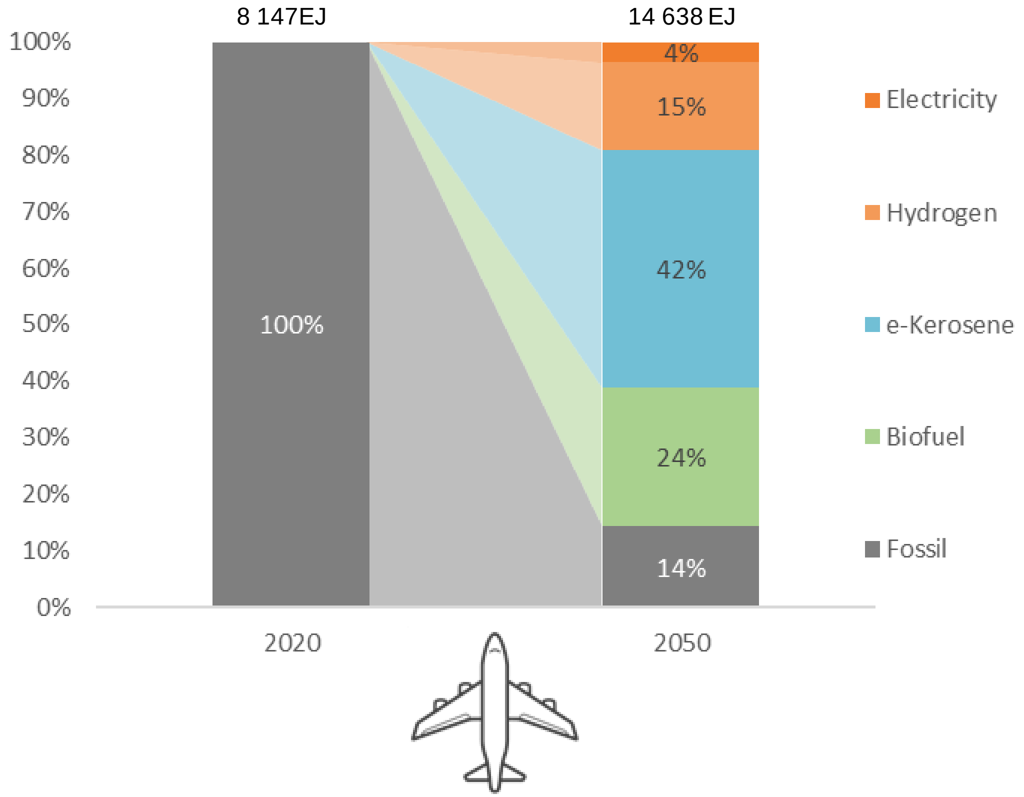
H_2 based fuels are not equally suitable for all sectors



Shipping and aviation have similar paths to net-zero

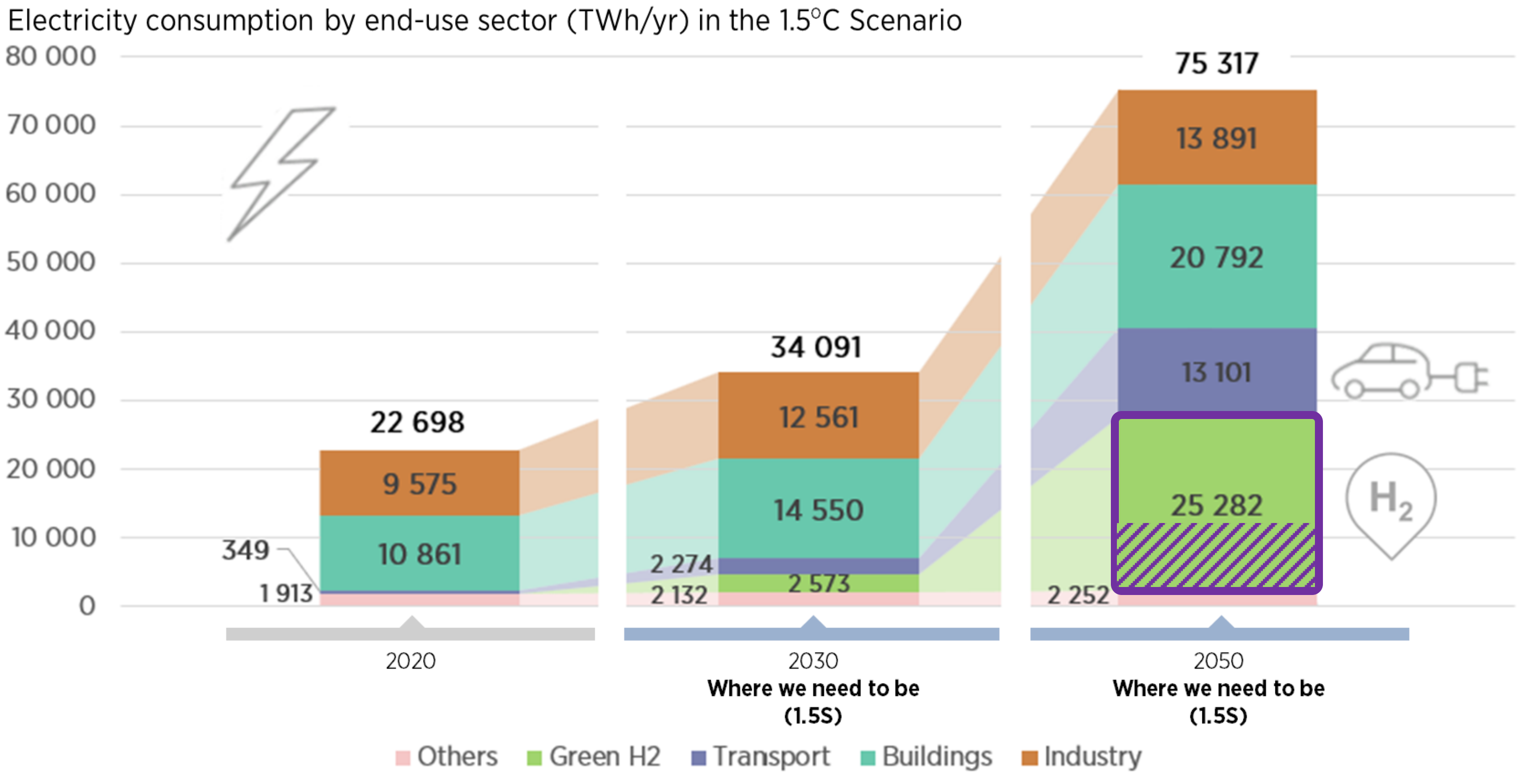
IRENA International Renewable Energy Agency





1. Reduced demand and improved energy efficiency
2. Direct use of clean electricity
3. Direct use of bioenergy
4. Indirect use of clean electricity via e-fuels

Electricity demand for e-fuel production will grow exponentially



By 2050:

- H_2 supply reaching **530 Mt/yr** (6x growth)
- **Shipping and aviation** expected to consume **~170 Mt/yr** (roughly a third)
- Electricity consumption to grow **3.3x**
- **Renewable resources are plentiful**, the key is the timely planning of their deployment.

Synthetic fuels are still in their early stages

- Supply and demand for synthetic fuels needs to be bult up in parallel across all end-use sectors.
  - The timely development of necessary infrastructure is critical.
  - Harmonised certification of green fuels and safety standards to further enable trade and investments.
- Long term clarity on policy and regulation is needed.
- International cooperation between governments is important, but also between public/private sectors and across end-use sectors.
  - Collaborative instruments, such as green corridors are emerging and helping to demonstrate and scale decarbonisation efforts.

IRENA is advancing the decarbonisation agenda with its Members

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Scene-setting Presentation

Zhang Tianfu
Chief Scientist
State Power Investment Corporation, China

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Powering tomorrow's transportation: SPIC's journey producing e-fuels

Tianfu Zhang

State Power Investment Corporation Research Institute

Bonn, Germany, September 26, 2023

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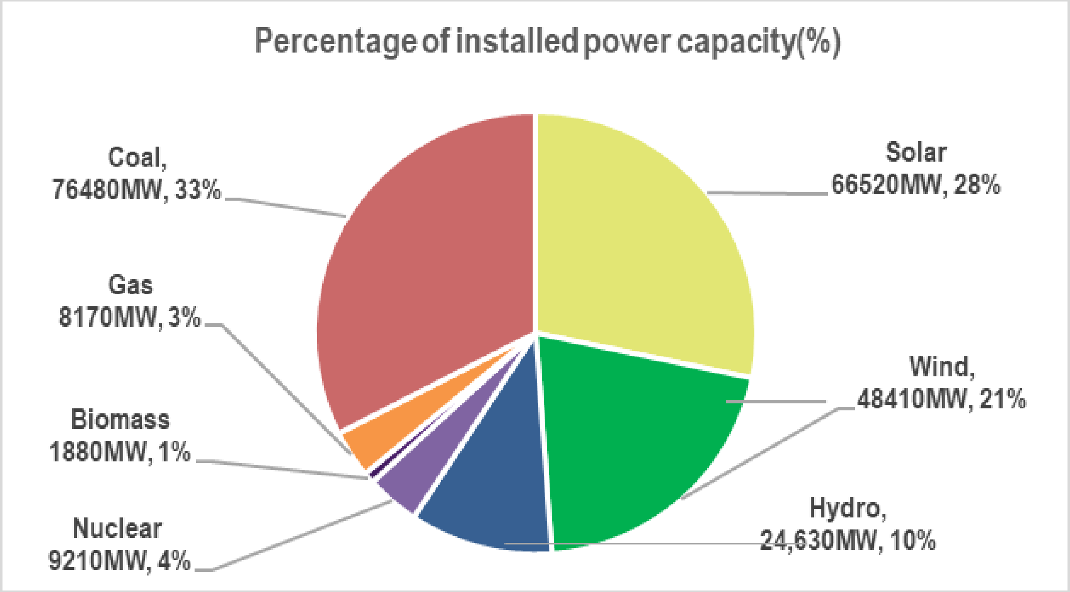
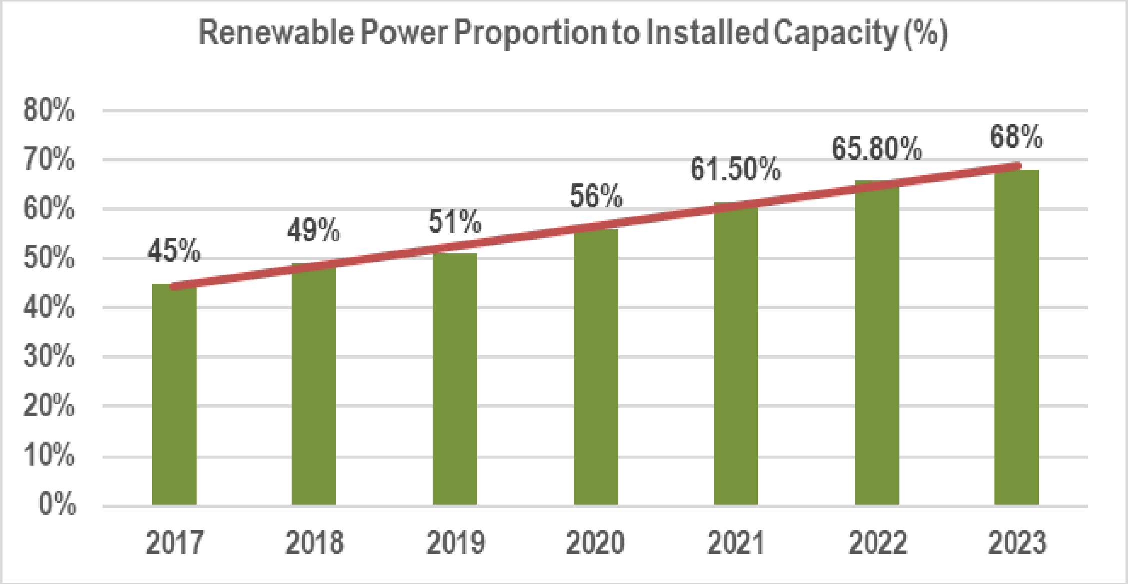
Brief on Green Power Conversion Industry in SPIC

- **State Power Investment Corporation (SPIC),** is one of China's five largest power generation groups,with over **120,000** employees and **€ 200 billion** assets.
- **SPIC** manages overall power capacity of **237 GW**, with renewable energy installed capacity of **160 GW.**





Brief on Green Power Conversion Industry in SPIC

国家电投 SPIC

SPIC establishes 'green power conversion' as one of the five pilar industries

Renewable Energy

Largest Renewable Power company globally

Solar PV installed capacity

67,810 MW

No.1 globally

Wind power installed capacity

48,410 MW

No.2 globally

Biomass

Largest Biomass power company nationally

Biomass power generation

(20 million ton/year)

44 plants

No.1 nationally

Waste power generation

21 plants

Hydrogen

Leading hydrogen energy company nationally

- Technology leader of fuel cell
- Independent development of PEM water electrolysis equipment (200Nm³/h)
- Hydrogen transport in natural gas pipelines
- Hydrogen internal combustion engine

CCUS

Leading CCUS company nationally

China's first 10000 ton/year CCS project

Coal-fired	Gas-fired
Regeneration heat $\leq$2.4GJ/tCO_2	Regeneration heat $\leq$3.0GJ/tCO_2
Solvent loss $\leq$0.8kg/tCO_2	Solvent loss $\leq$2.0kg/tCO_2

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Development of e-fuels industry

国家电投 SPIC

Shipping industry

- IMO (International Maritime Organization) plan to reduce 20% carbon emision by 2030, and achieve zero emission by 2050.
- Green NH_3 and green methanol are important solutions to achieve the goal. Many leading shipping companies are planning to equip NH_3 and methanol engines on their ships. The demand on green methanol is expected to be 3 million tons by 2025.

Aviation industry

- REDII released by European Commission requires 2% of SAF (Sustainable Aviation Fuel) blending by 2025 and 63% of SAF blending by 2050.
- IATA (International Air Transport Association) plans to achieve zero emission by 2050, meaning **350 million tons SAF** demand.

Year	EU aviation fuel demand/ Mt	SAF		RFNBOs	
		blending ratio	demand/ Mt	blending ratio	demand/ Mt
2025	6800	2%	140	-	-
2030	7150	5%	350	0.7%	50
2050	8700	63%	5500	28%	2450

Layout of green NH_3 industry

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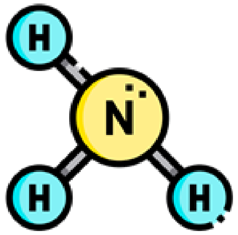
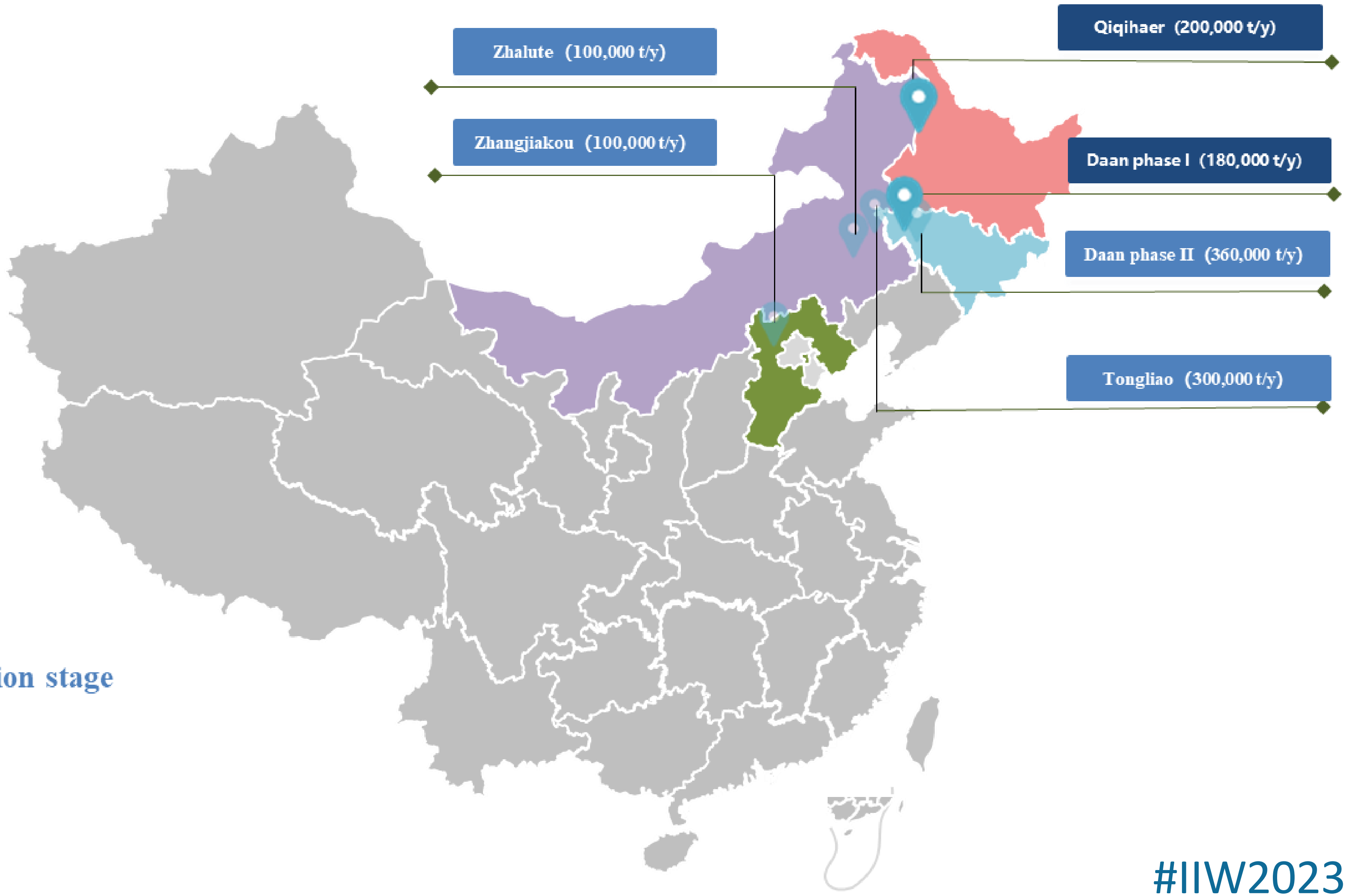


Green ammonia

Located in northeast of China

Quota granted projects (380,000 t/y)

Not granted yet, in negotiation stage (1260,000 t/y)



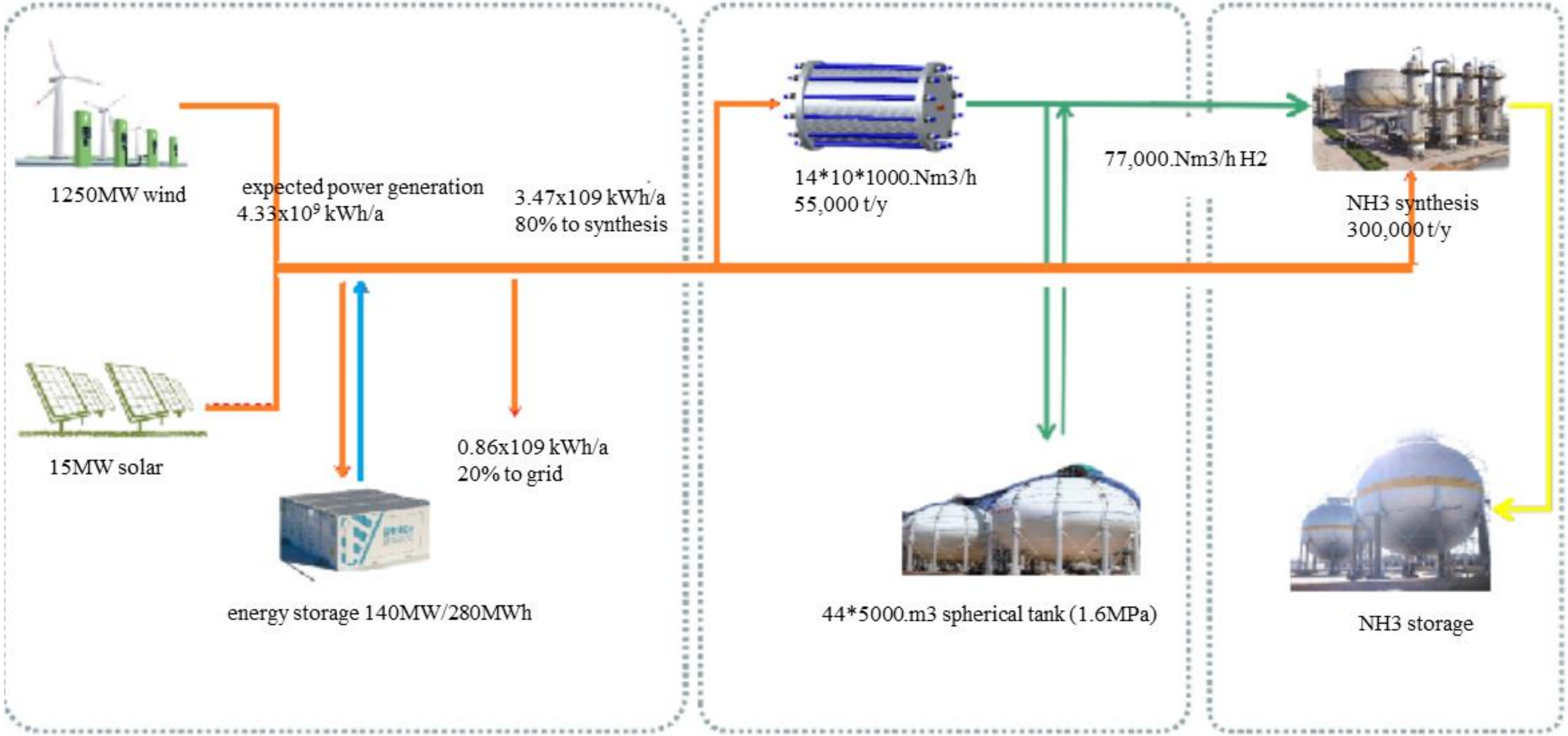
Process of green NH_3 plant

国家电投 SPIC

Power supply
1250MW wind + 15MW solar
energy storage 140MW/280MWh

H_2 production
140,000 Nm^3/h
H_2 storage 2860,000Nm^3

NH_3 synthesis
300,000 t/y



€ 0.02/kWh

H_2: € 1.95/kWh

NH_3: € 370/t

Layout of green methanol industry

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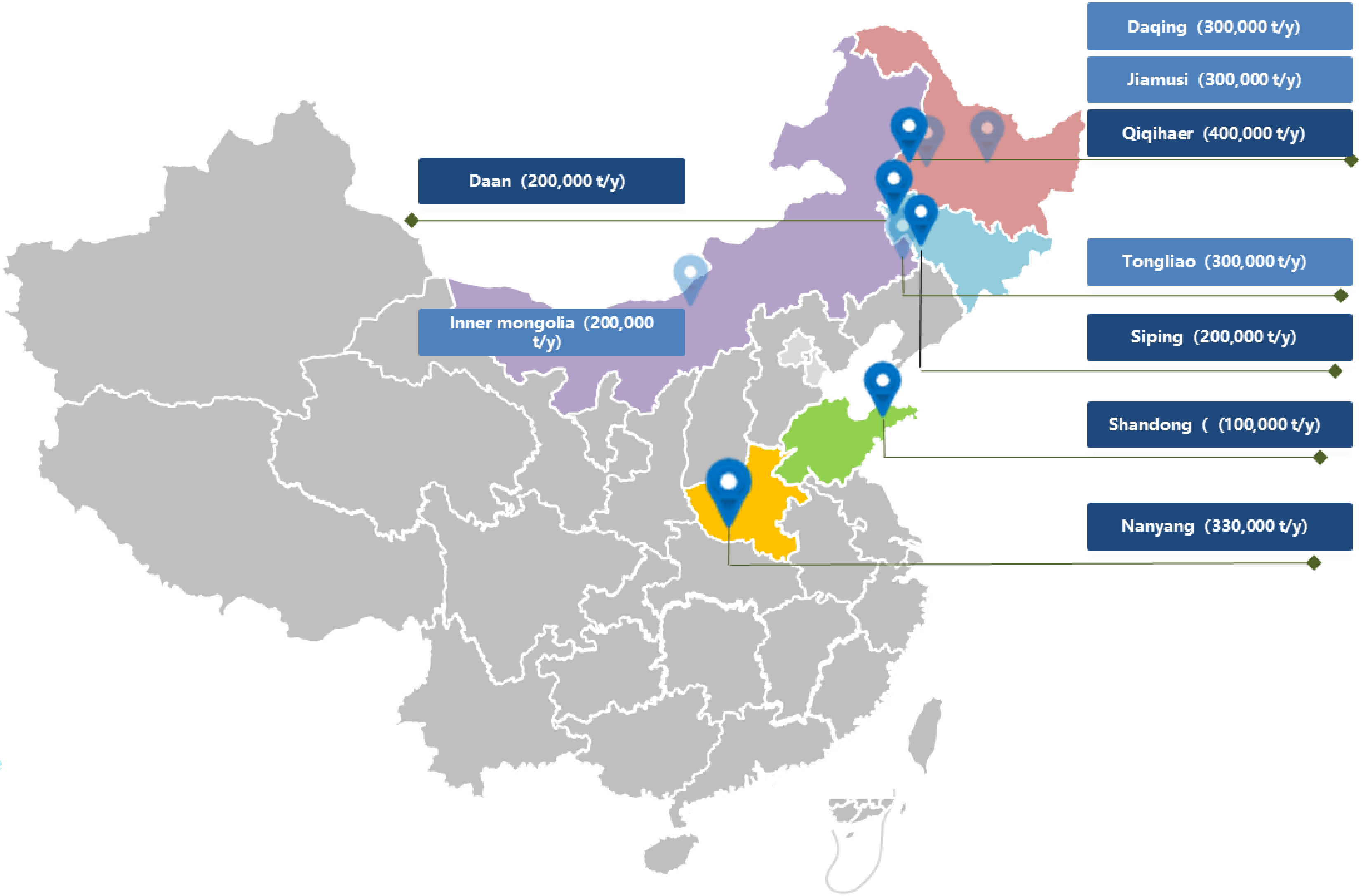
Green methanol

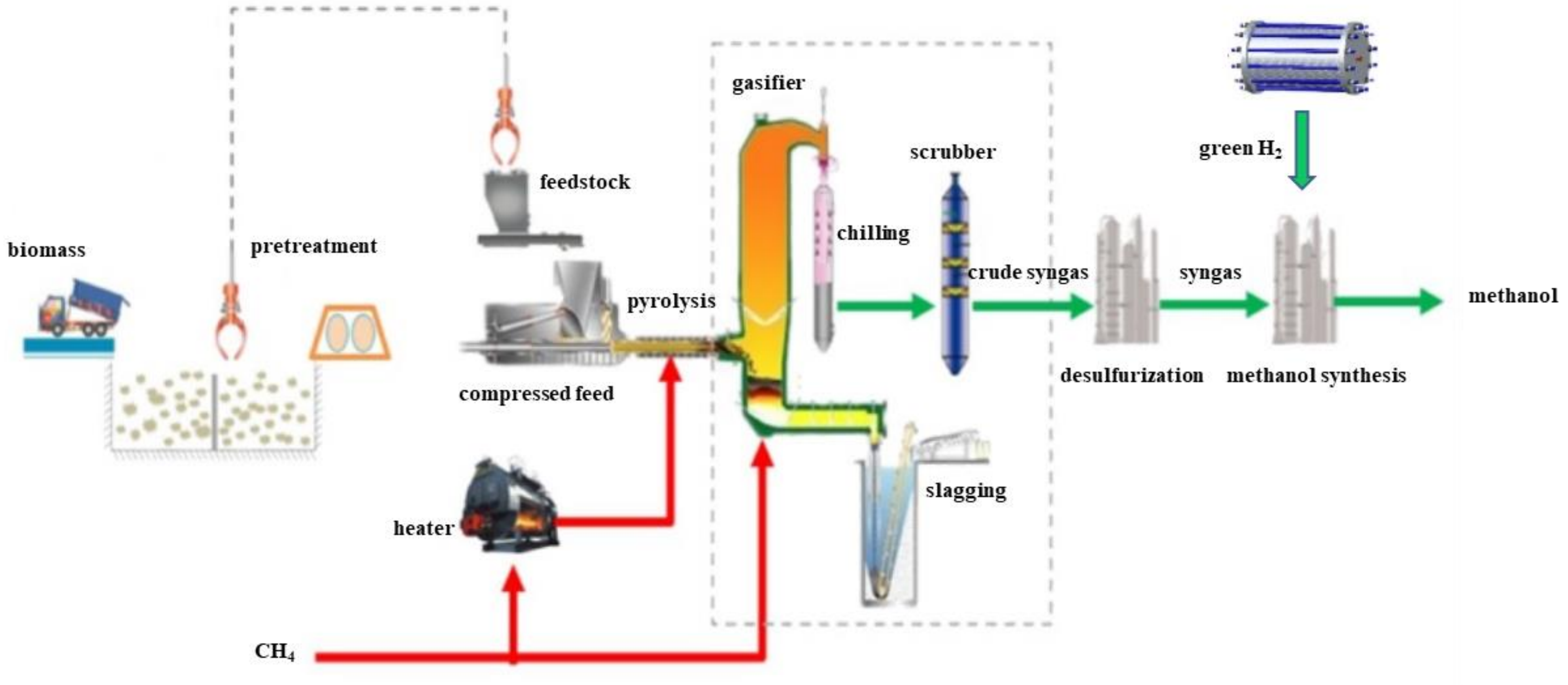
Located in northeast and east of China, with abundant biomass and wind/solar sources, and close to sea port.



Quota granted projects (1230,000 t/y, 800,000 t in 2025)

Not granted yet, in negotiation stage (1100,000 t/y)

Process of methanol plant



- 1.3t corn straw + 77 kg H_2 → 1t methanol
- Green methanol: € 420/t

Layout of SAF industry

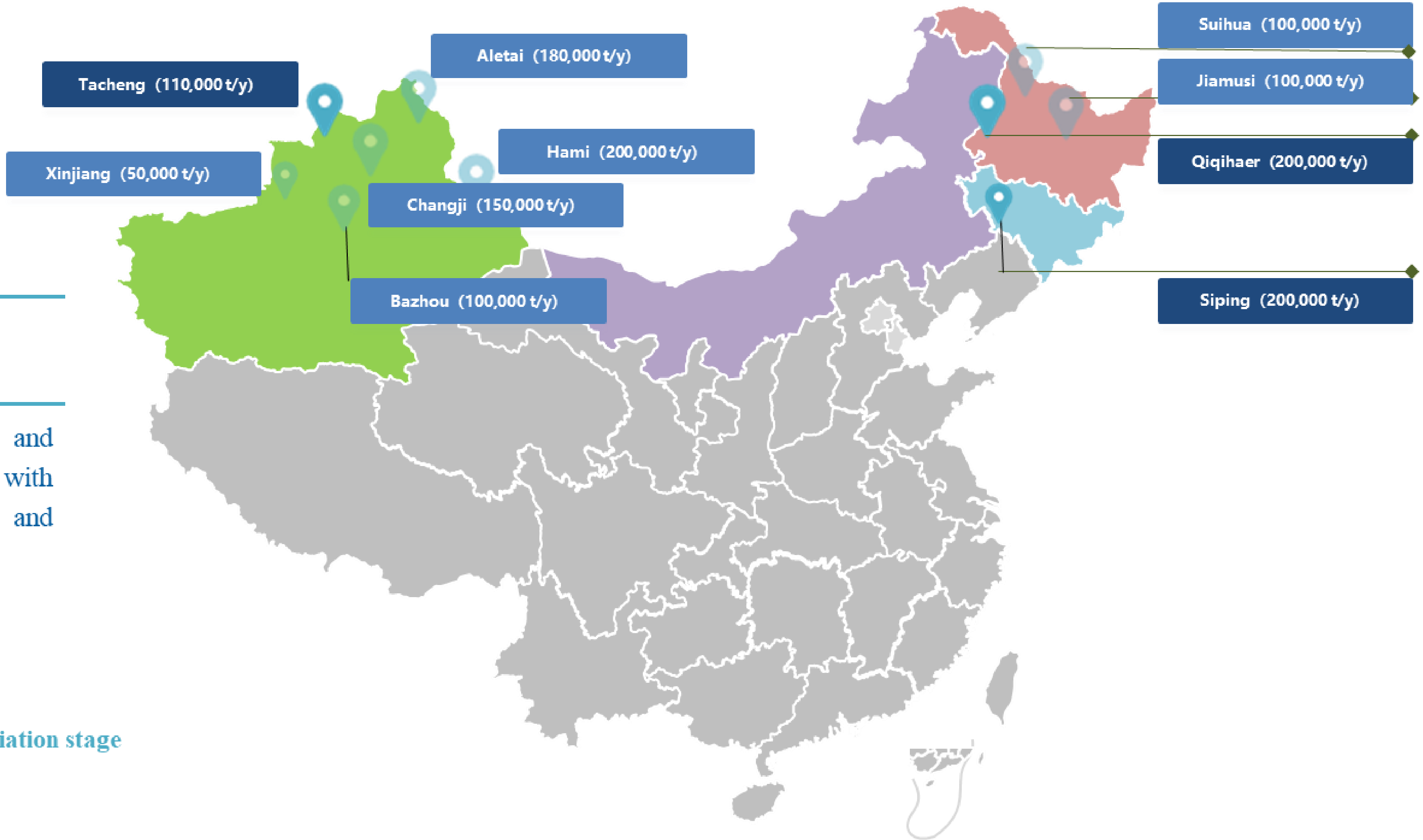
国家电投
SPIC

SAF

Located in northeast and northwest of China, with abundant biomass and wind/solar resources

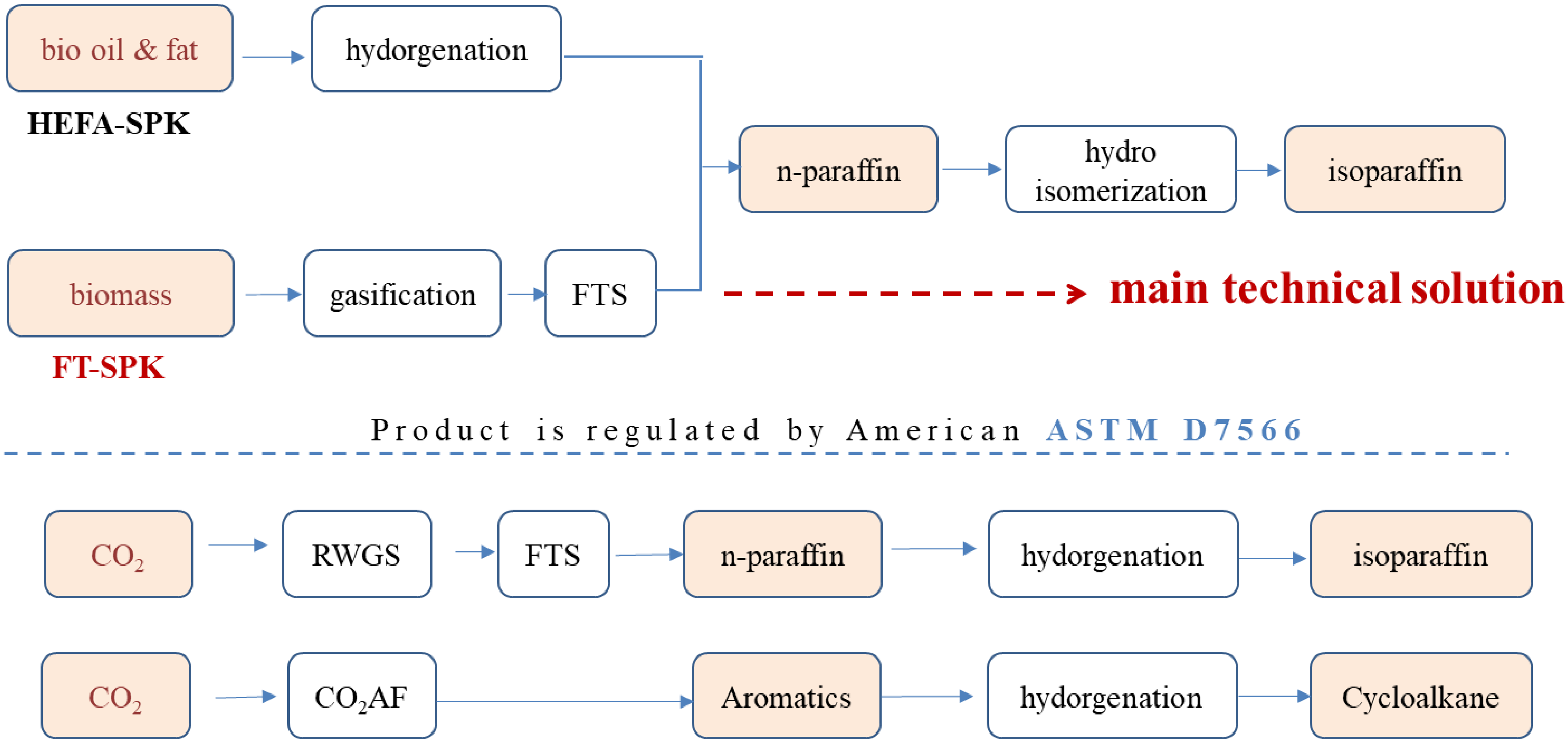
Quota granted projects (360,000 t/y)

Not granted yet, in negotiation stage (880,000 t/y)



SAF technical solutions

国家电投 SPIC



Prospect of key areas in 2030

Three 10GW industry clusters

Jilin： 10.8GW

Xinjiang： 10.7GW

Inner mongonia： 9.45GW

Several GW industry bases

Qinghai： 6.98GW

Tibet： 5.35GW

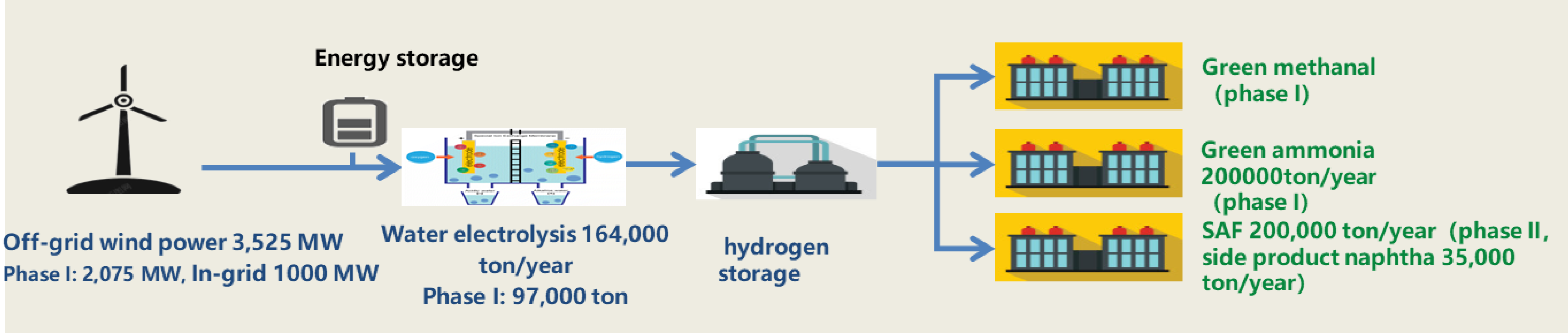
Heilongjiang： 4.6GW

Gansu： 2GW

Sichuan： 1.4GW

Comprehensive utilization of green H_2 in northeastern China

- **Overall Plan：** **3,525MW off-grid wind power**, **164,000 ton/year hydrogen** production facility， **400,000 ton/year green methanol**, **200,000 ton/year green ammonia**, **200,000 ton/year SAF**； 1,000MW wind power connect to the grid. The project is overall planned, and will be conducted in different phases.
- **Phase I：** 2,075MW off-grid wind power, 97,000ton/year hydrogen production facility， 400,000 ton/year green methanol and 200,000 ton/year green ammonia.
- **Phase II：** 1,450 MW off-grid wind power, 67,000 ton/year hydrogen production facility, 2×100,000 ton/year SAF plants.



Partnerships

清华大学 港华智慧能源 上海交大
中国石油 中国石化 中国海油
中国建材 CONCH 安徽海螺 中国建筑
中国铝业 BAOWU 宝武集团
CRTC 中国融通 CSFA 农垦系统 兵器工业
国药集团 中国通用 五粮液 中国移动 中国电信
CEEC 中国能建 中国电建 水电总院 中咨公司 电规总院
南方电网 中国华能 大唐集团 兖矿集团 淮河能源
中国一汽 上汽集团 东风汽车
明阳集团 中国一重 LONGi 隆基股份 金风科技
上海电气 CSIC 中船重工 TBEA 特变电工 远景能源

SPIC is willing to cooperate with partners all over the world and let us together contribute to develop a green and low-carbon energy world.

风光无限 国家电投

SUSTAINABLE POWER FOR AN INVALUABLE CAUSE

绿色 创新 融合，真信 真干 真成

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Airbus

Bruno James
Head
New energy business development

International Chamber of Shipping

Nelson Mojarro
Head
Innovation and partnerships

IRENA

Maisarah Abdul Kadir
Associate Programme Officer
End-uses and roadmaps

Norsk e-Fuels

Karl Hauptmeier
CEO

UNFCCC

Bernd Hackmann
Team Lead
NDC, LT-LEDS and sectoral support

Yara

Emile Herben
Director
Product mgmt. and certification

Moderator:

Pierpaolo Cazzola
Director
European Transport and Research Center
ITS-DAVIS

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Clean Energy Marine Hubs (CEM-Hubs)

CLEAN ENERGY MARINE HUBS
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

De-risking and transforming the Energy-Maritime supply chain

IMO's Strategy and Net-Zero Goals: Historic and ambitious

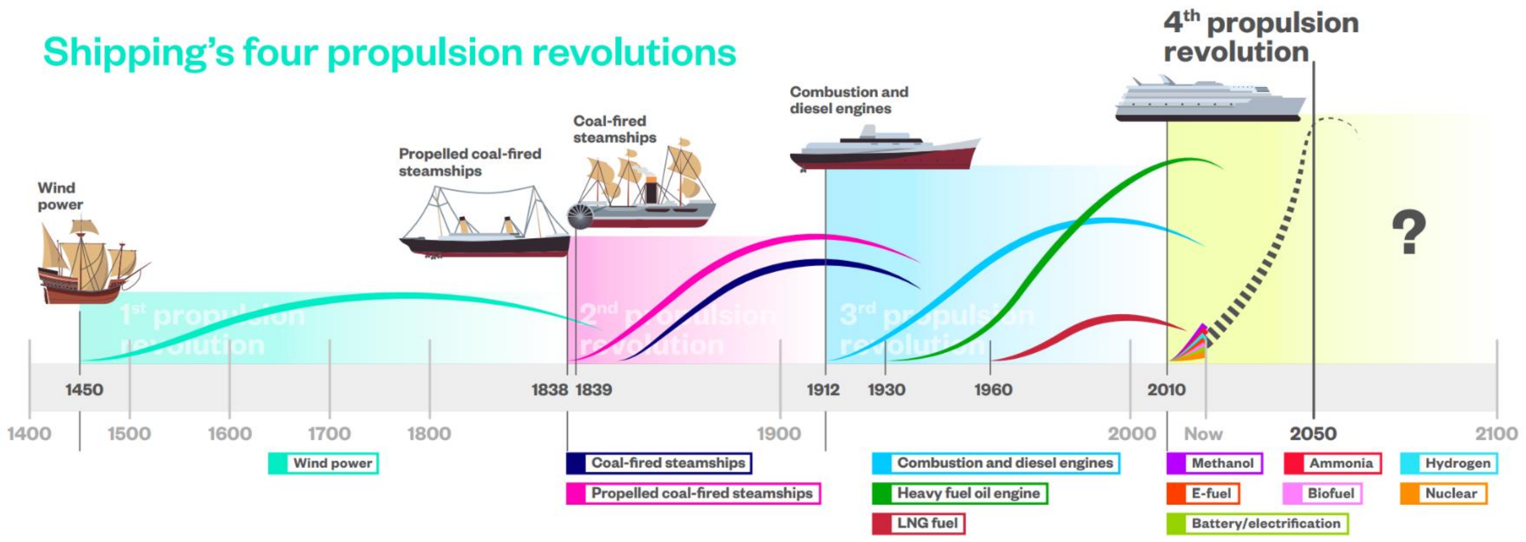
2050 goals impossible to achieve without:

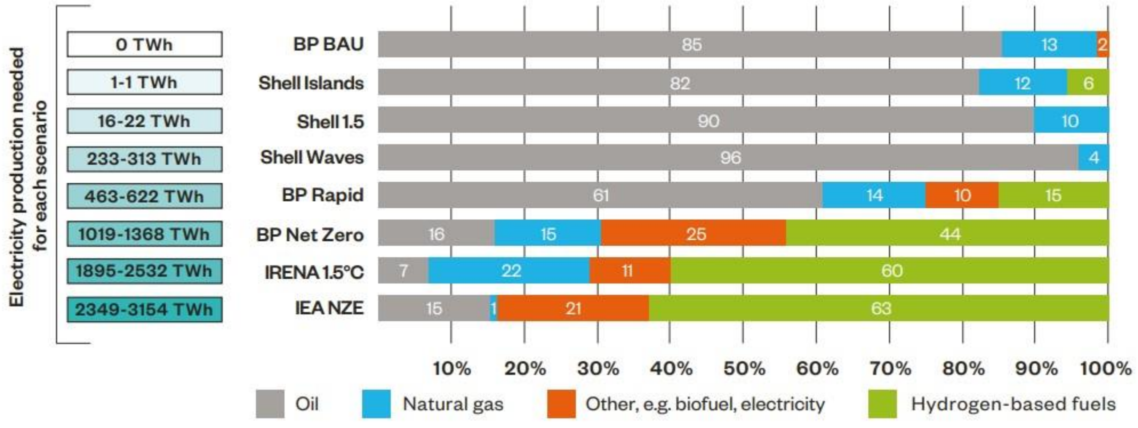
1.Production AT SCALE of low and zero carbon fuels close to the ports. Electricity requirement.

2. Global regulation and cross-sectoral collaboration.

3. Dual-Role of Shipping.

Enabler of the transition.





CLEAN ENERGY MINISTERIAL

International Chamber of Shipping

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IRENA INNOVATION WEEK 2023

Closing

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Thank you!

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