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Emerging Giants: decarbonizing ammonia in China, India and the United States

Oliver Hatfield, VP Business Development

Ammonia Energy Association conference

November 2022

Market Reporting

Consulting

Events

illuminating the markets

Argus

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Argus has a global ecosystem of energy experts to provide an industry-grounded understanding of each aspect of how your firm can better navigate the journey to net zero status.

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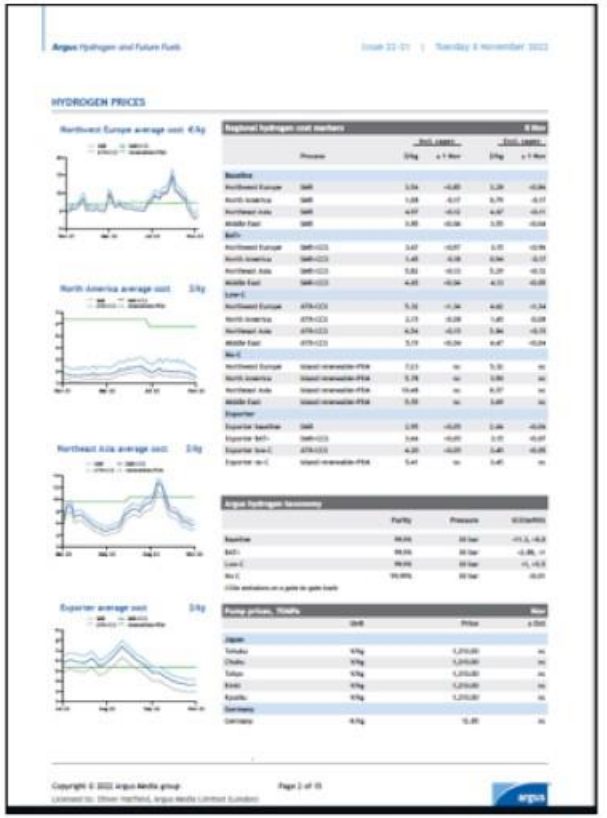
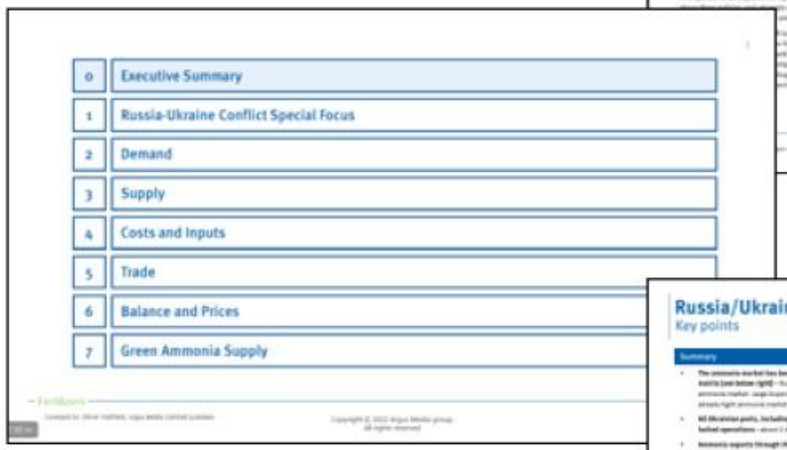
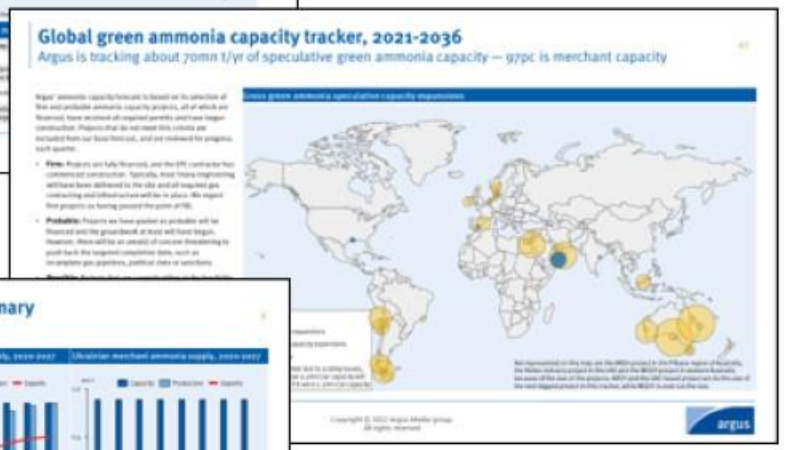
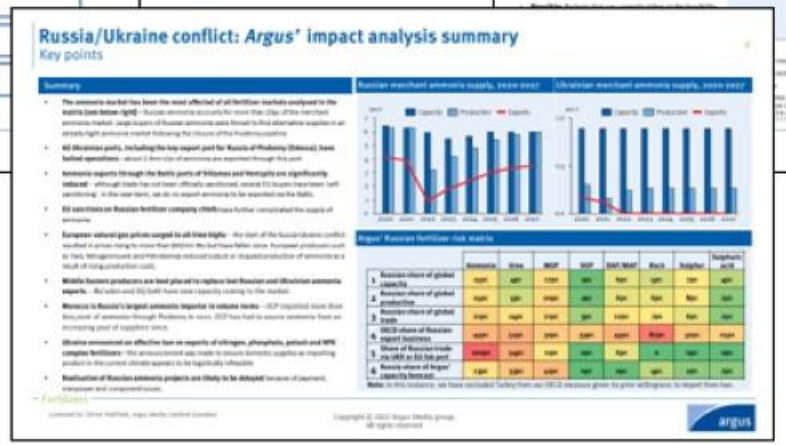


Argus clean ammonia subject matter expertise

Argus Ammonia Analytics

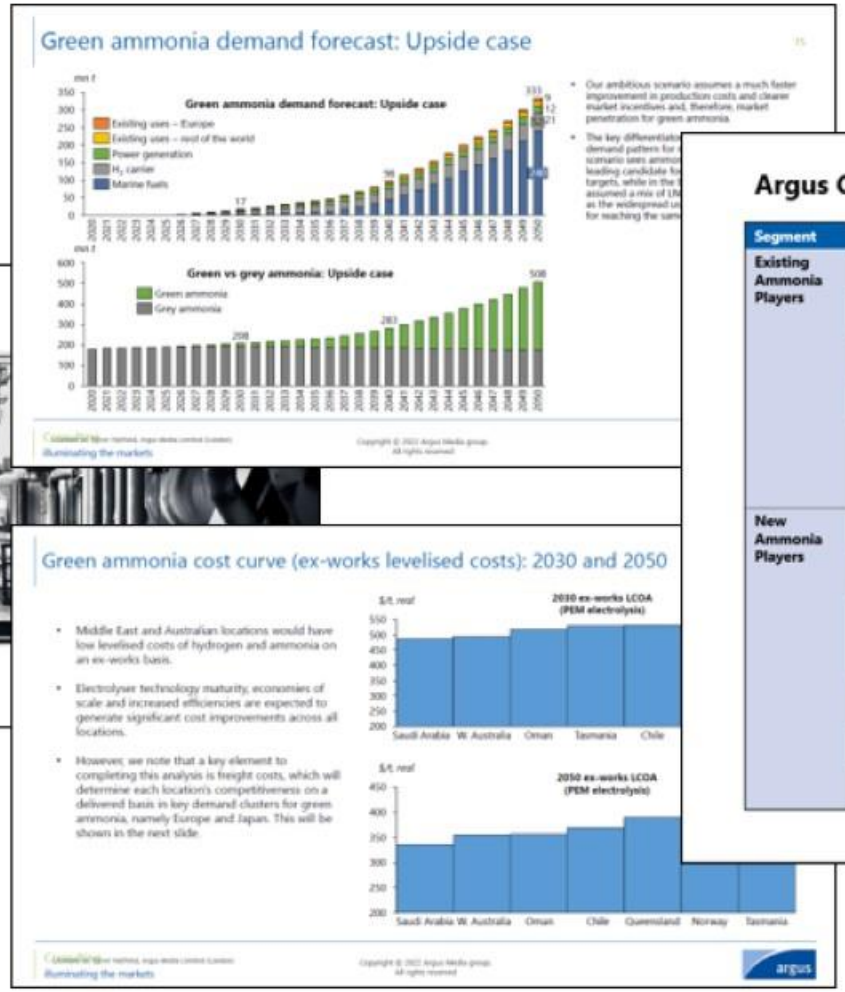






Argus clean ammonia subject matter expertise

Argus clean ammonia and net zero consulting

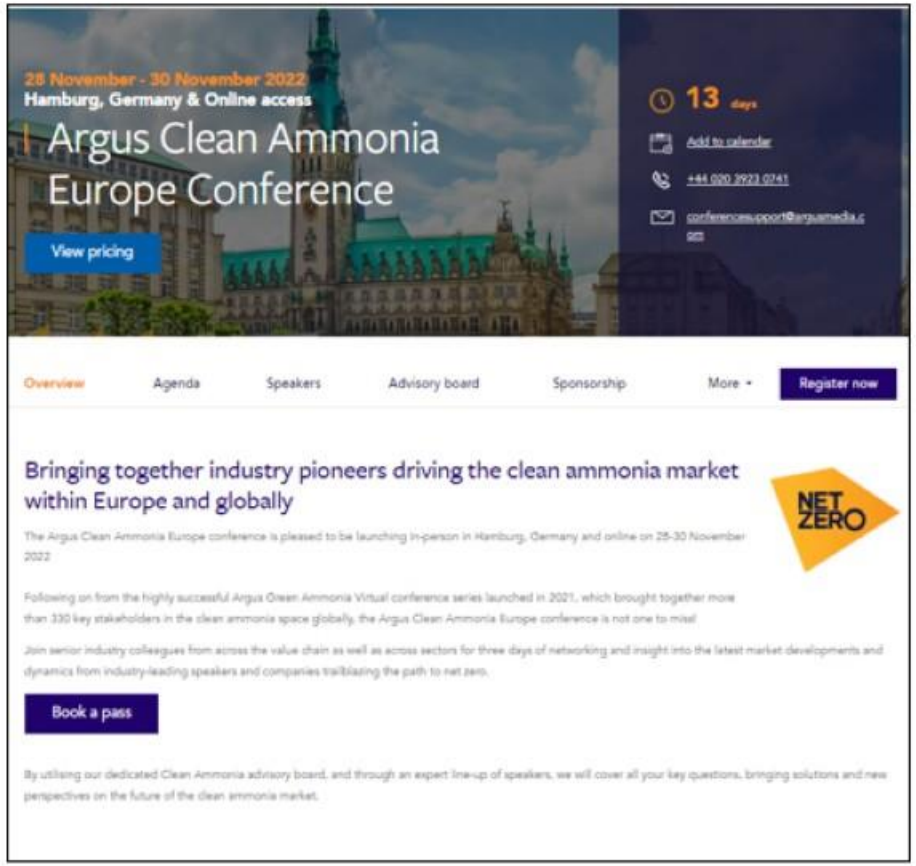


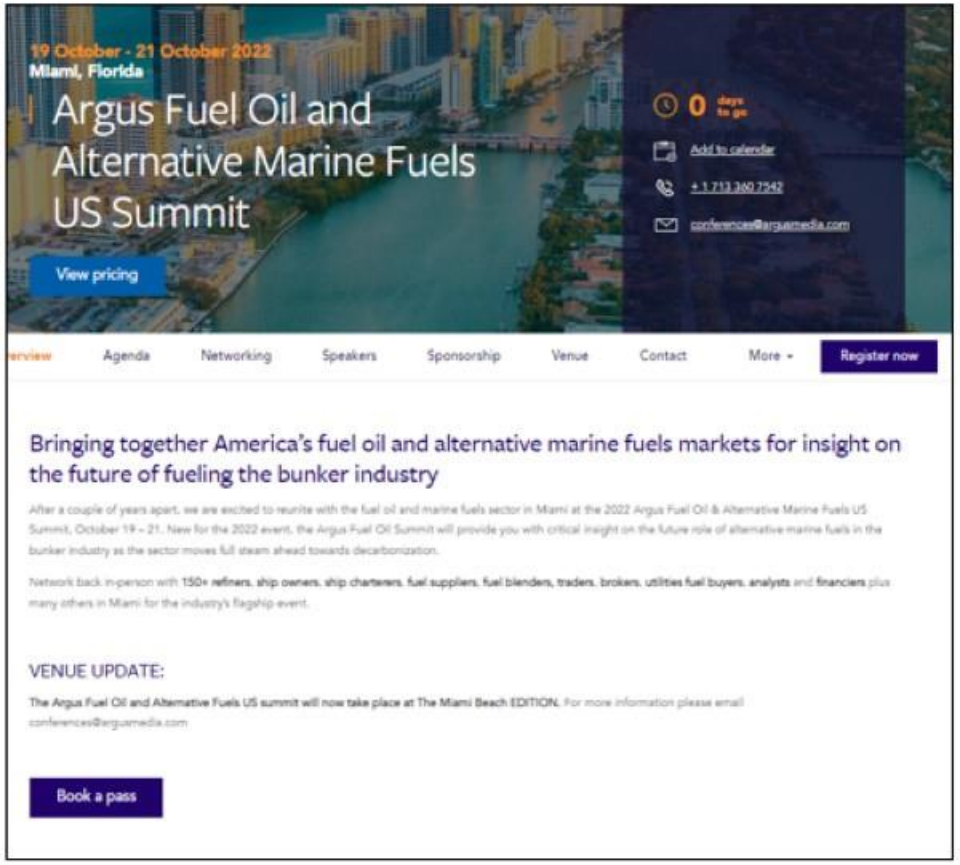
Argus Consulting – 2022 Green Hydrogen/Ammonia Project Credentials

Segment	End Client Profile	Location	Project Focus	Key Client Questions
Existing Ammonia Players	Fertilizer producer (ammonia buyer)	MENA	Impact of CBAM	• How is CBAM likely to be implemented? • What will be impact on our competitive landscape?
	Industrial producer (ammonia buyer)	Europe	Green ammonia pricing	• What price should I be paying for low-carbon ammonia? • What is the value of being first mover?
	Fertilizer industry	MENA	Decarbonization strategy	• What are the GHG emission from fertilizer in our country? • What examples of decarbonization can we observe in other regions?
	Integrated nitrogen fertilizer producer	Central Asia	Decarbonization strategy	• How should our core business adapt to decarbonization trends? • What new low-carbon business opportunities should we pursue?
	Ammonia Producer	Europe	Clean ammonia IPO support	• How can we leverage our competitive position in traded grey ammonia to develop the clean ammonia market?
			Clean ammonia bunkering	• How will low-carbon fuels affect global bunkering market? • What investments have been made in clean ammonia bunkering?
New Ammonia Players	Oil & Gas Producer	Europe	Gas diversification	• How will low-carbon developments affect current grey ammonia market? • Should we invest in LNG or ammonia as means of monetising gas?
	Oil Refinery	Europe	Decarbonization strategy	• What market trends are affecting our core business in refining and storage? • How should we position ourselves within low-carbon hydrogen economy?
	Utility	Europe	Pink ammonia review	• What are customer perceptions of ammonia colours: pink vs blue and green? • What is regulatory environment for pink hydrogen and ammonia?
			Low-carbon ammonia customer analysis	• How is low-carbon ammonia demand expected to develop in Europe? • Which customers should we be targeting for low-carbon ammonia?
	Utility	Europe	Green ammonia customer analysis	• How cost competitive is green ammonia produced in Europe? • Which customers should we be targeting for green ammonia?
	Renewable Energy Developer	Oman	Green ammonia project feasibility	• How cost competitive is project in Oman? • How suitable is proposed offtake agreement?
	Industrial Conglomerate	India	Green hydrogen commercialization	• How best should we monetize proposed green hydrogen capacity? • What is the price sensitivity of green hydrogen/ammonia demand?

Argus clean ammonia subject matter expertise

Conferences and events





Overview

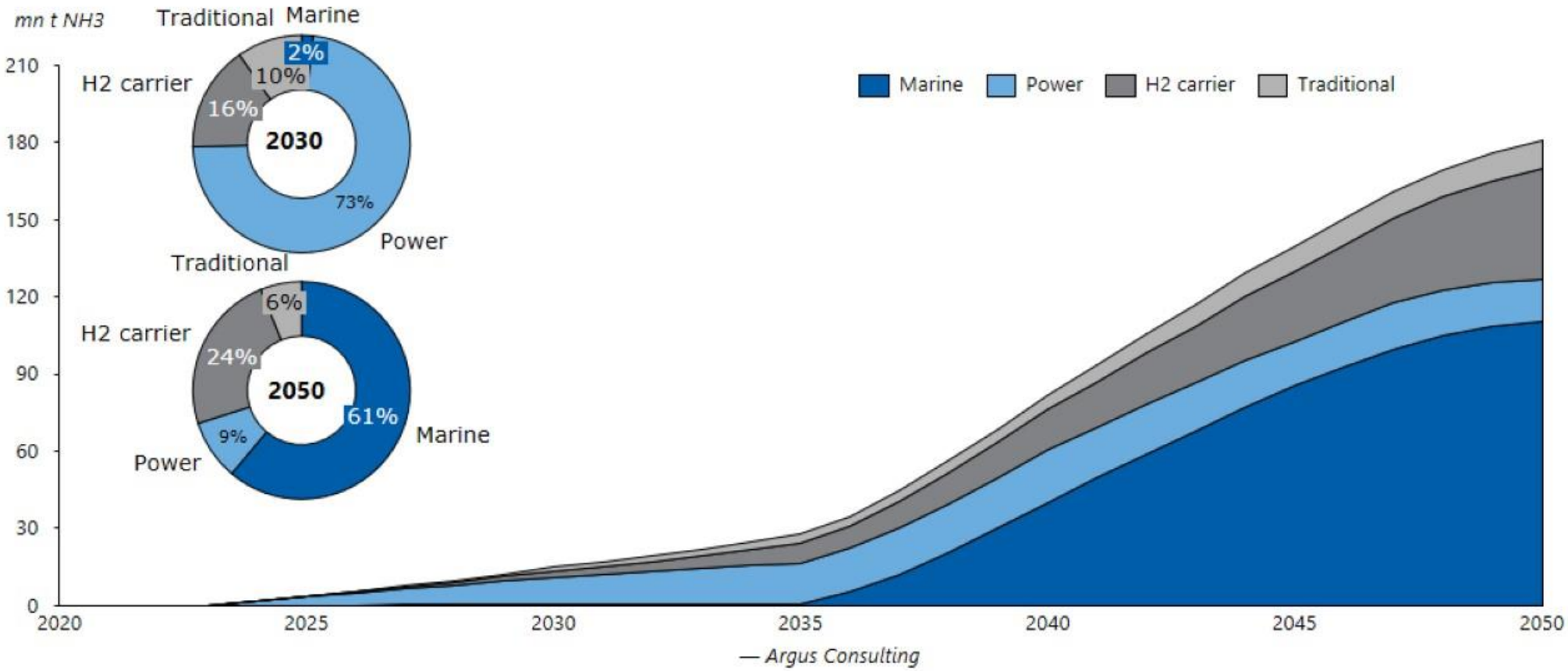
- Global perspective
- India focus

Overview

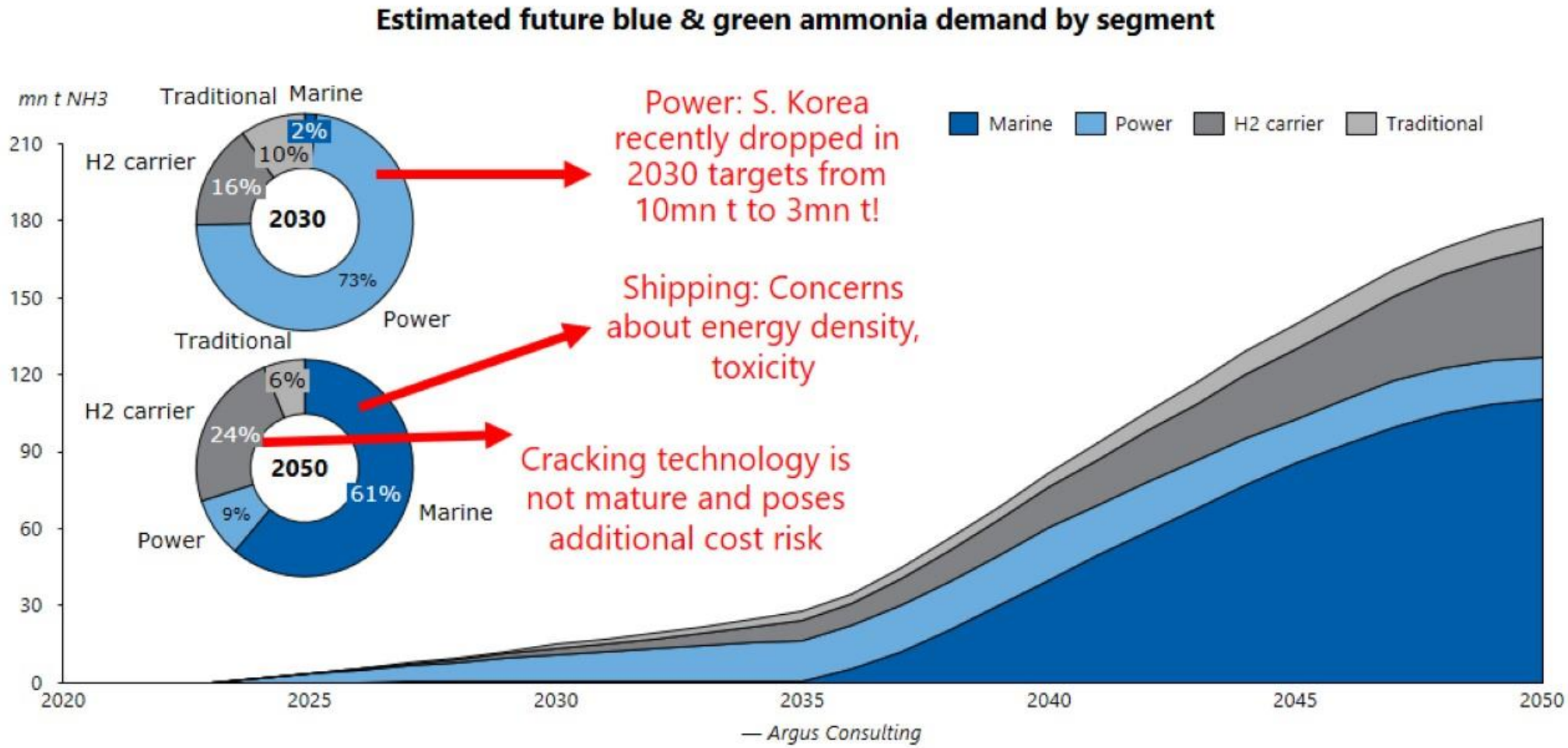
- Global perspective
  - Green ammonia potential by end use
  - Project activity
  - Pricing and production costs
- India focus

Demand outlook - Power is first major demand segment, likely overtaken by marine and H2 carrier uses in long-run

Estimated future blue & green ammonia demand by segment



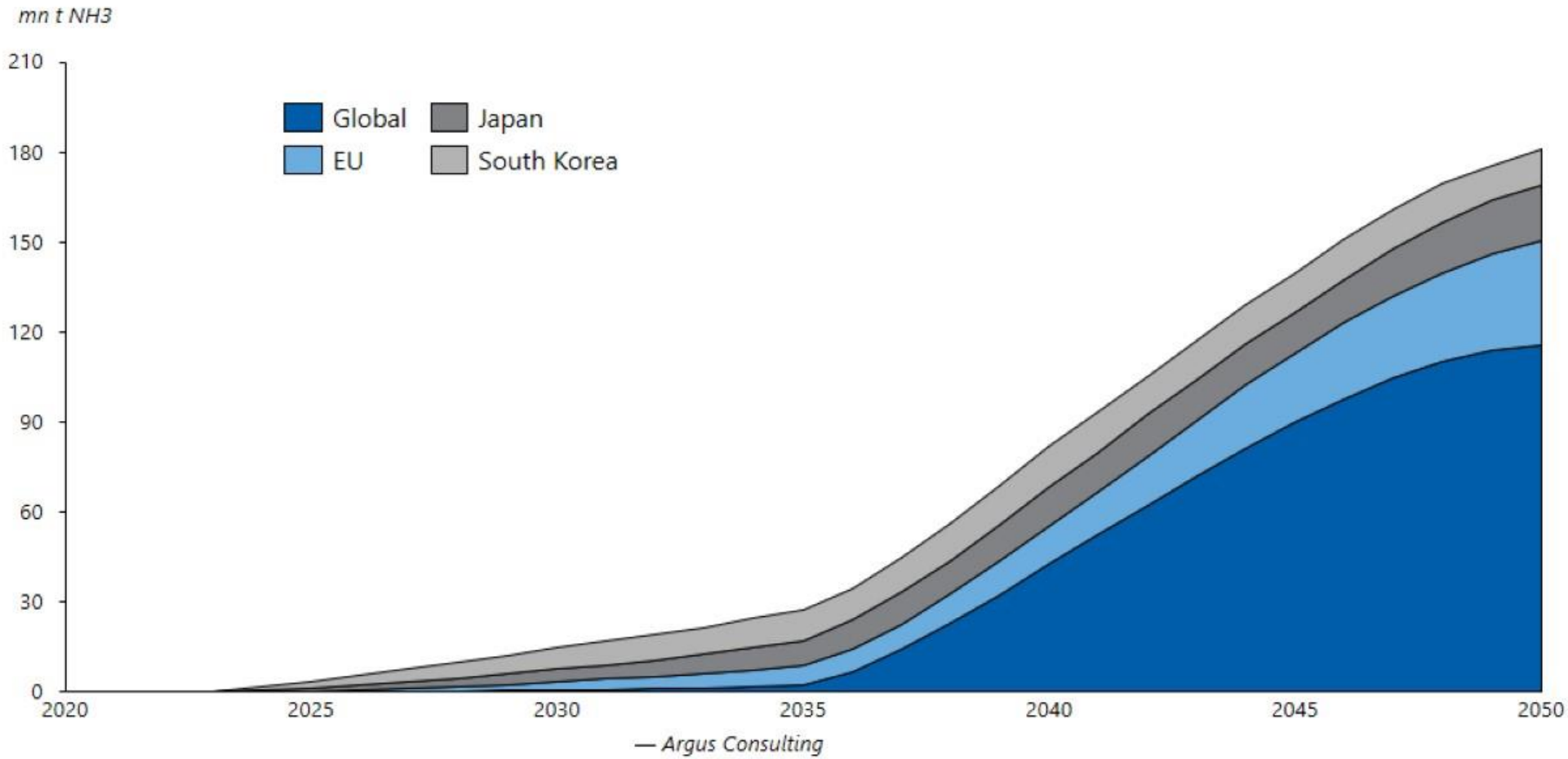
Demand outlook - Power is first major demand segment, likely overtaken by marine and H2 carrier uses in long-run, but there are risks to this outlook



Regional demand outlook: Argus base-case scenario

East Asia is a first mover, but Europe could emerge as dominant demand centre in the long-run

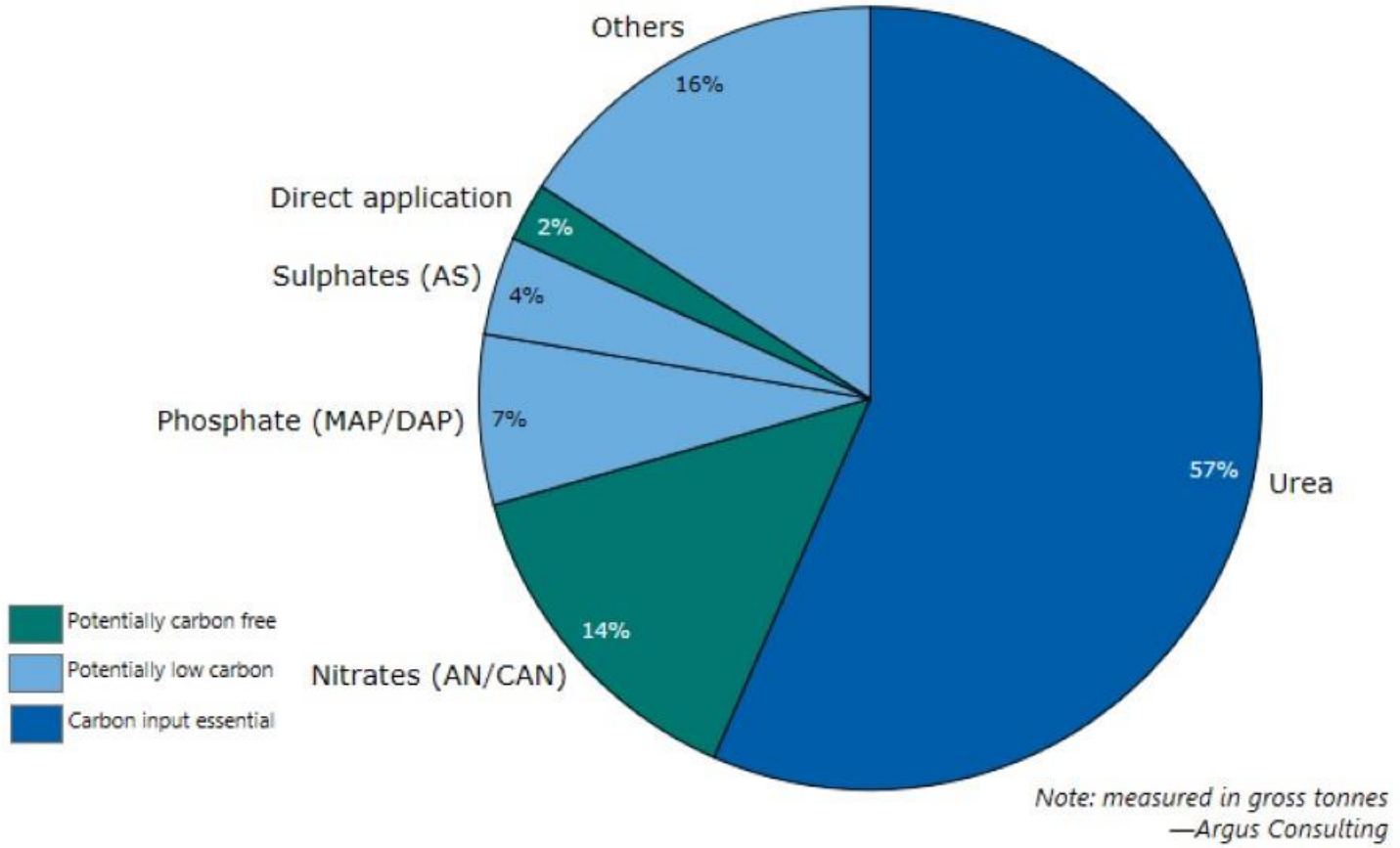
Estimated future blue & green ammonia demand by geography



Demand for traditional uses is likely to be small

As long as urea is the main nitrogen product the use of green ammonia in fertilizers could be limited

Downstream nitrogen fertilizers that require a carbon input from upstream ammonia production



Note: measured in gross tonnes
—Argus Consulting

Overview

- Global perspective
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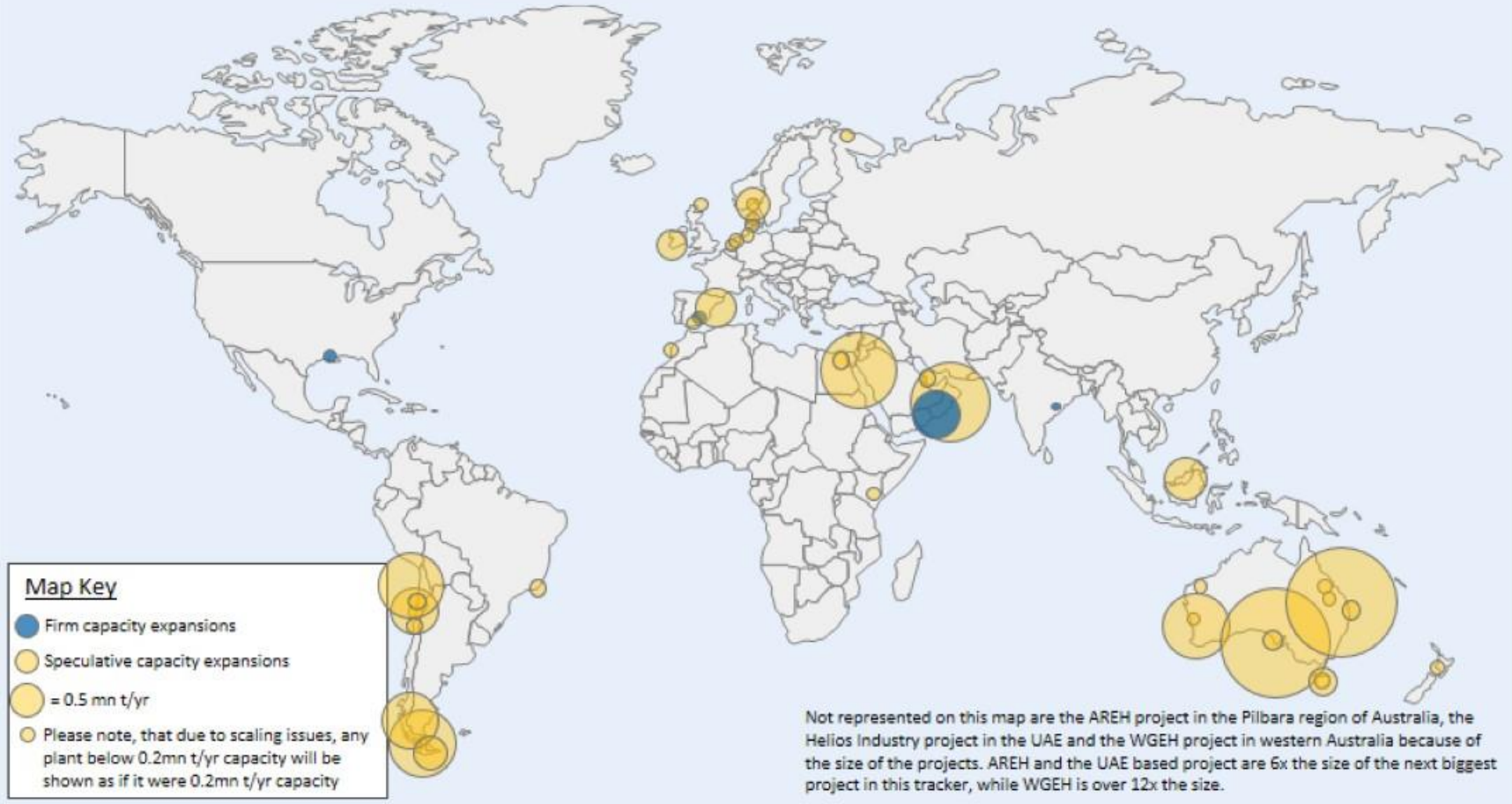
Capacity outlook for green ammonia

We are tracking around 70mn t of speculative green ammonia capacity

- **Firm:** Projects are fully financed, and the EPC contractor has commenced construction. Typically, most heavy engineering will have been delivered to the site and all required gas contracting and infrastructure will be in place. We regard firm projects as having passed the point of FID.
- **Probable:** Projects we have graded as probable will be financed and the groundwork at least will have begun. However, there will be an area/s of concern threatening to push back the targeted completion date, such as incomplete gas pipelines, political risks or sanctions. Many probable projects have passed the point of FID.
- **Possible:** Projects that are currently either at the feasibility stage or have progressed to construction but face significant delays due political or physical impediments. We believe these projects are have strong potential to proceed to, or recommence, construction over the next 18 months.
- **Speculative:** Projects that are still at the scoping stage or in early feasibility. EPC contracting and gas supplies will not have been agreed in most cases, and the financing process will be at the early stages or yet to commence.

Gross green ammonia speculative capacity expansions



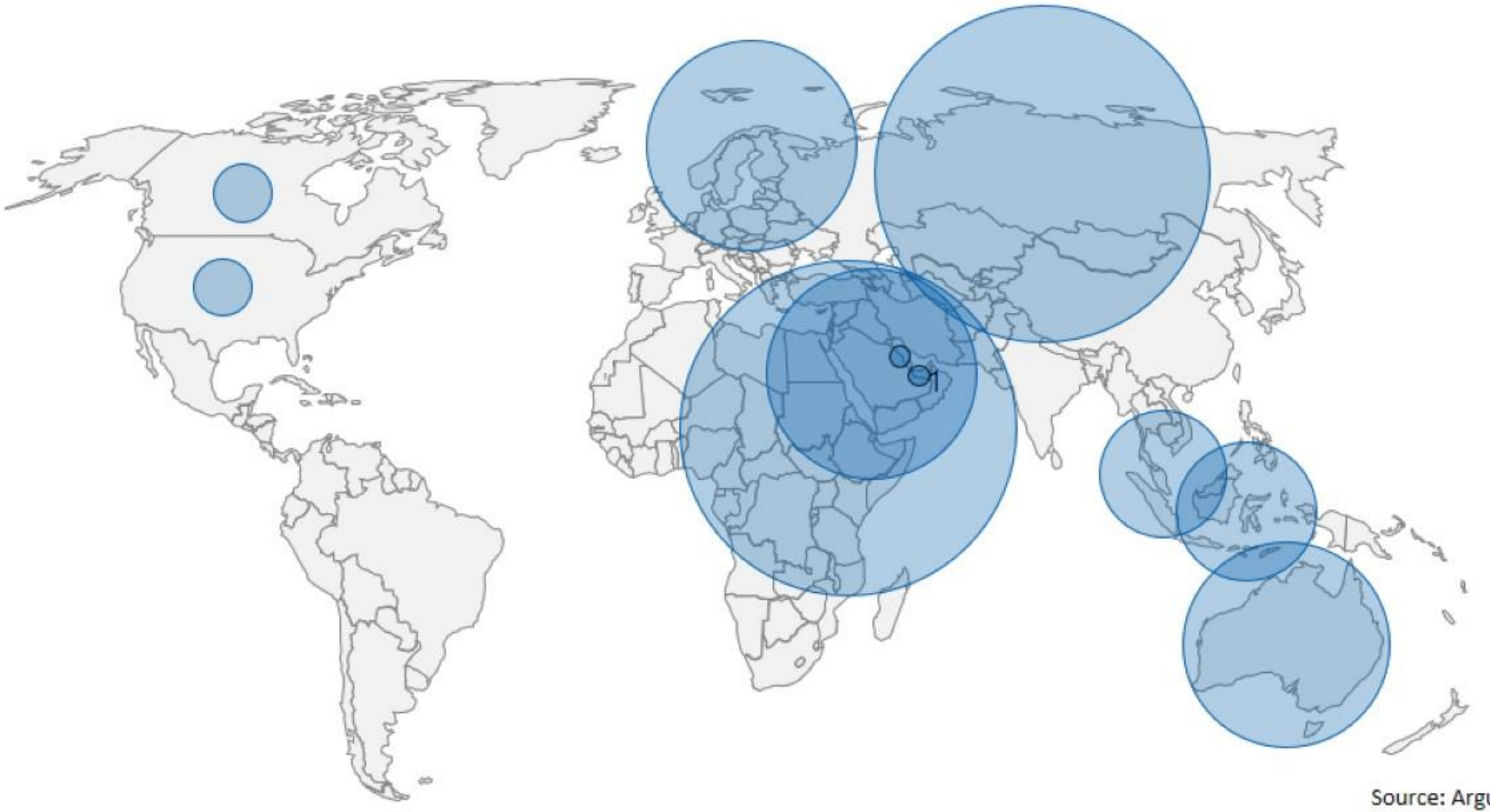
Not represented on this map are the AREH project in the Pilbara region of Australia, the Helios Industry project in the UAE and the WGEH project in western Australia because of the size of the projects. AREH and the UAE based project are 6x the size of the next biggest project in this tracker, while WGEH is over 12x the size.

Source: Argus Analytics

Planned blue ammonia projects

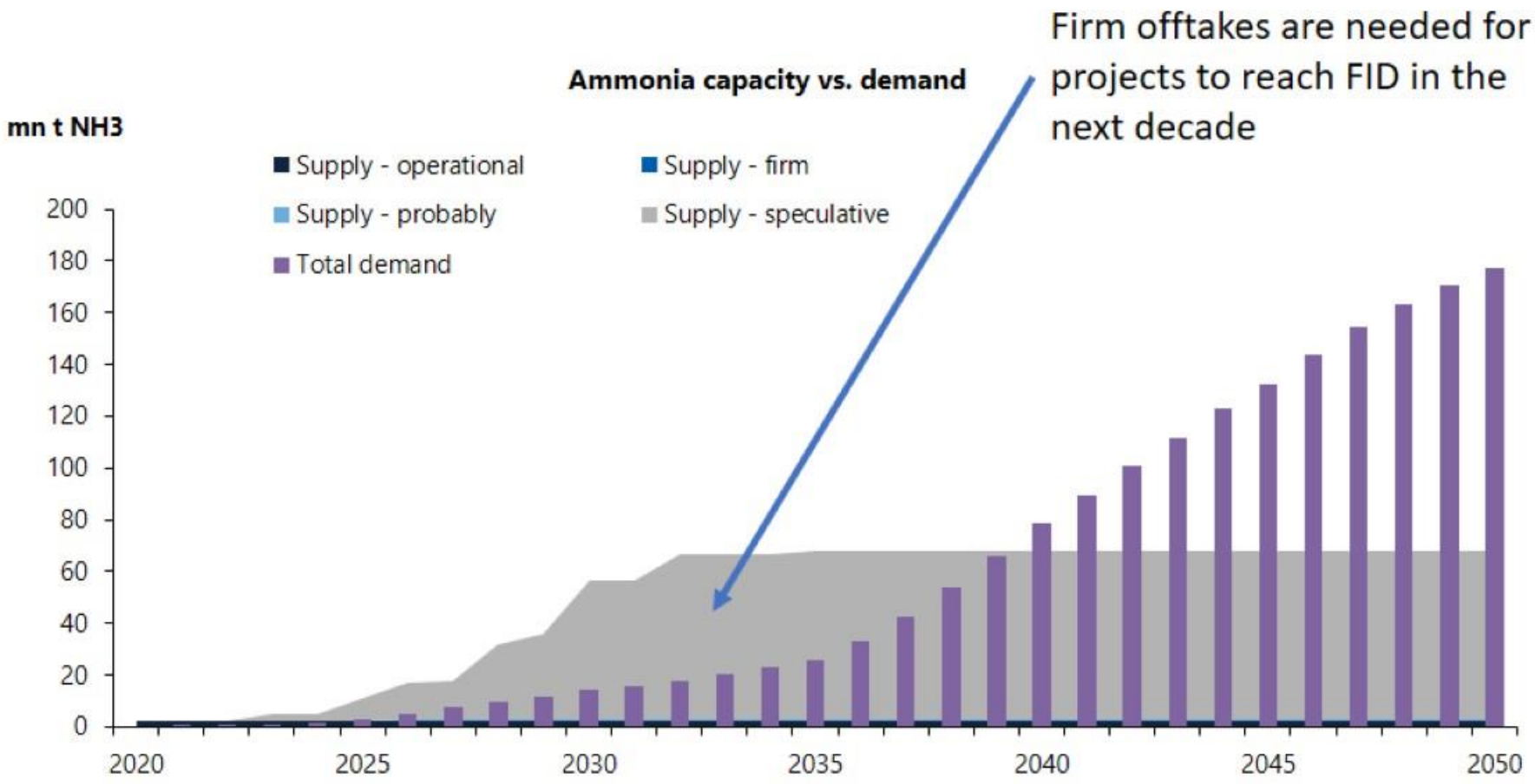
> 20mn t of blue ammonia capacity announced, a marked increase since last year

Blue ammonia project capacity overview



Source: Argus Analytics

Large number of projects and limited short-medium term demand potential means that many projects will fail to materialise



Notes: includes US blue ammonia capacity
— Argus Consulting

Overview

- Global perspective
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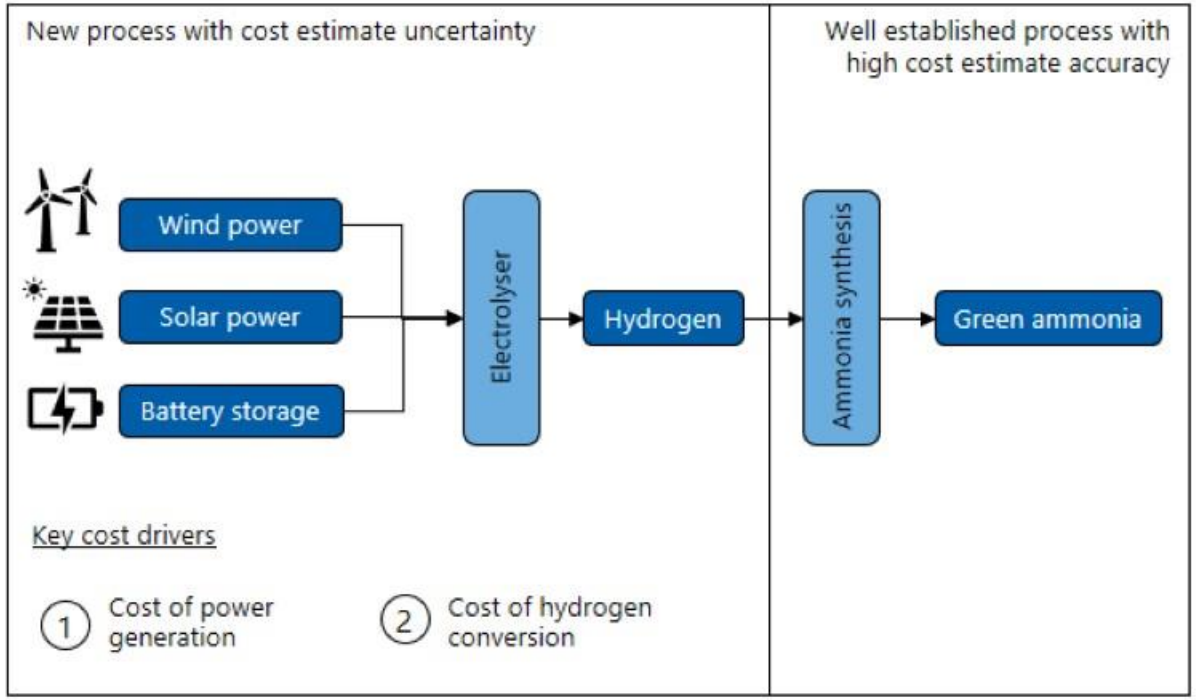
Forecasting future green ammonia prices a unique challenge

New electrolyser technology is immature, and renewable generation as a feedstock to fertilizers is rare

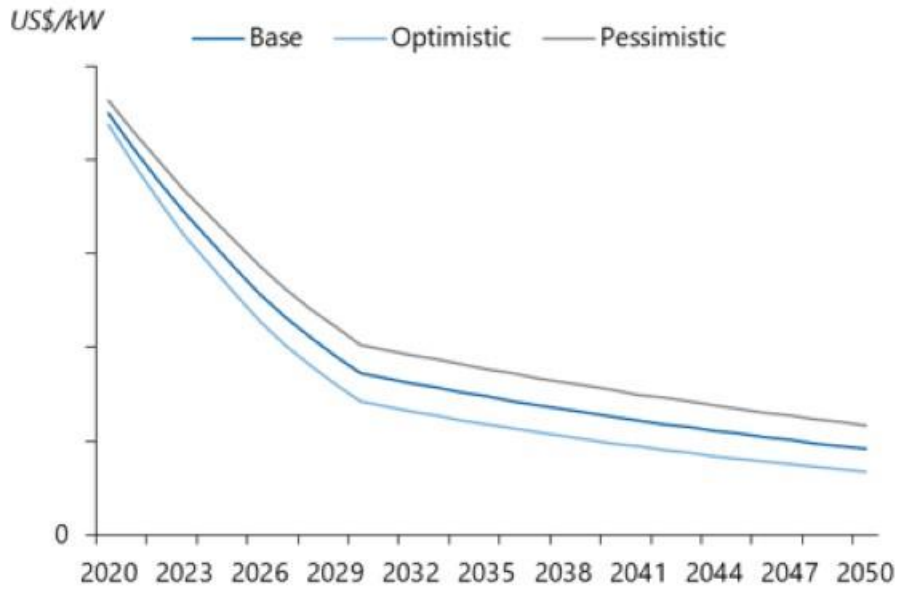


- The ammonia synthesis combining hydrogen with nitrogen using the Haber-Bosch methodology is a well established process.
- The hydrogen feedstock production however utilises novel technologies for which important technological progress is anticipated
- Given the high impact of hydrogen prices on green ammonia costs as well as the uncertainty in the speed of cost reduction, scenarios best incorporate key drivers of hydrogen generation cost:
  1. Cost of power generation
  2. Cost of hydrogen conversion (impacted by electrolyser technology)

Source: Argus Consulting

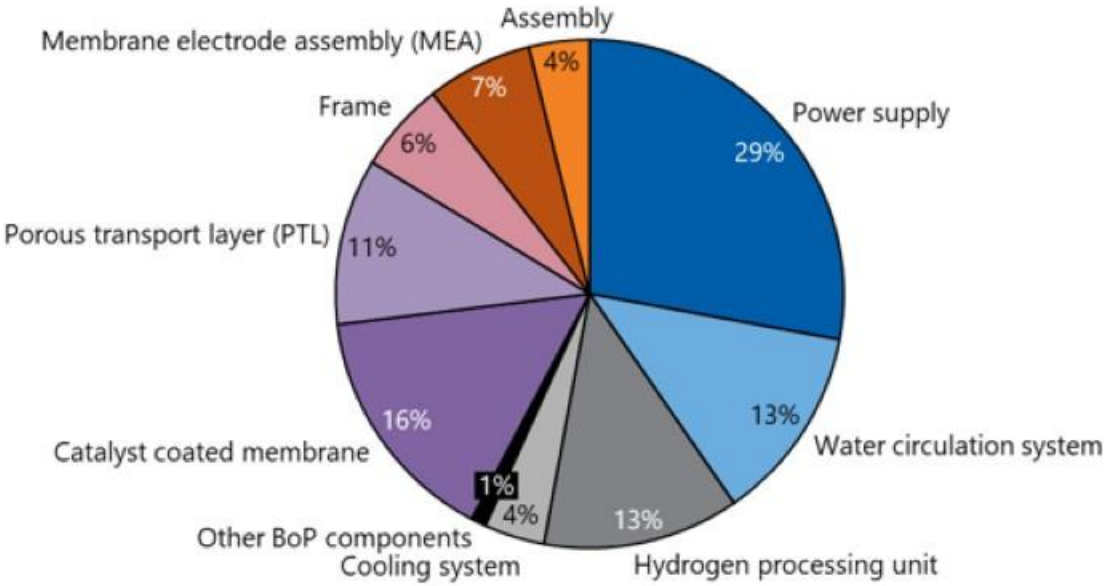
Levelized costs of green hydrogen are shaped by the power price and by electrolyser capital intensity

Electrolyser CAPEX intensity



Notes: in real 2021US$
— Argus Consulting

Electrolyser manufacturing cost components

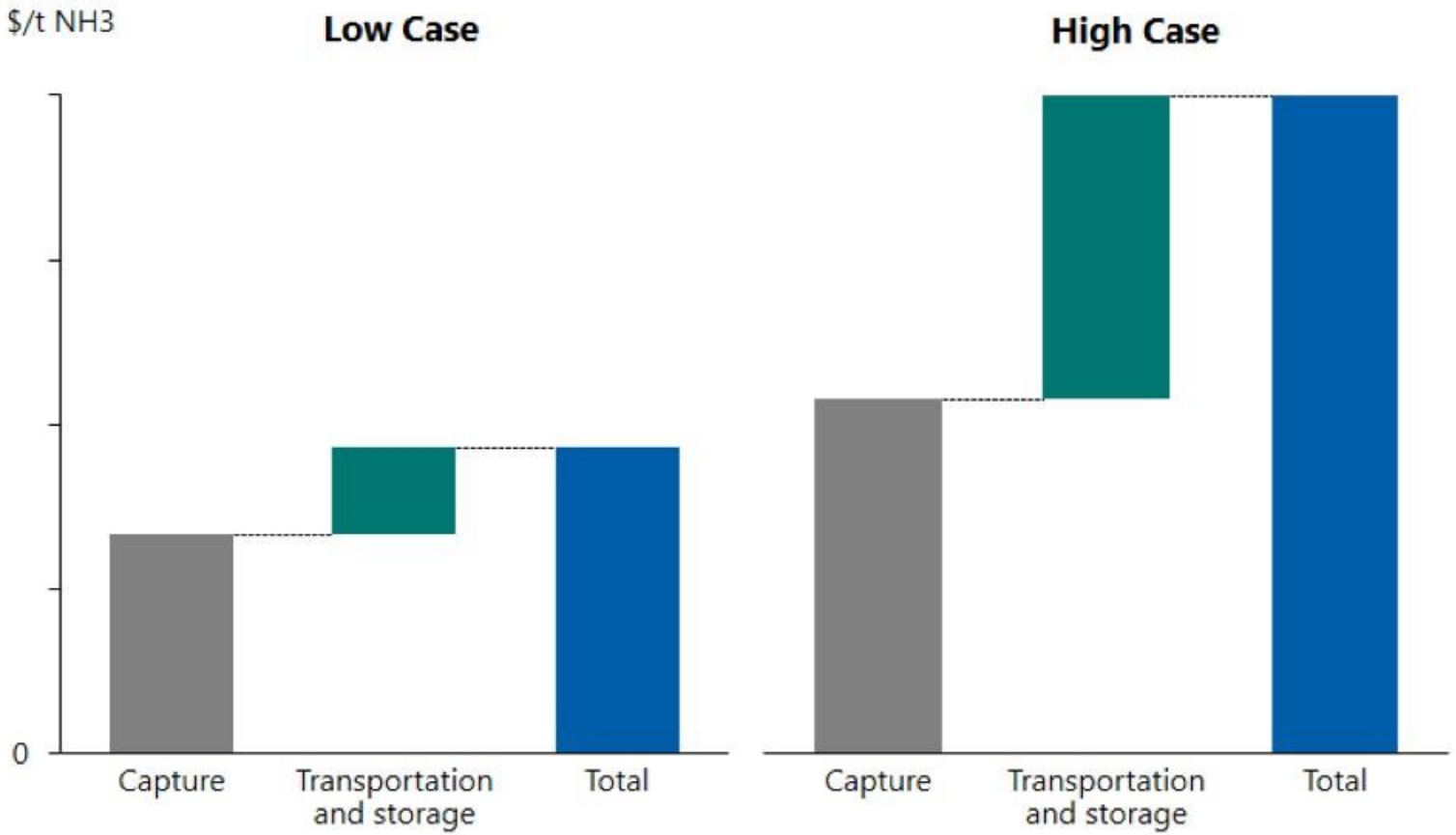


Notes: based on 10MW/year production scale
— IRENA

Green H2 economics suggest that green ammonia will be significantly more expensive vs. grey ammonia in the short and medium term

Source: Argus Analytics

Blue ammonia offers lower production costs and the opportunity for more familiar pricing arrangements, especially for retrofits of existing plants



- Most Blue Ammonia projects are being planned by existing producers
- Grey NH3 + CCS cost or Grey NH3 + carbon price would be a likely pricing strategy

Source: IEA, Argus Consulting

Overview

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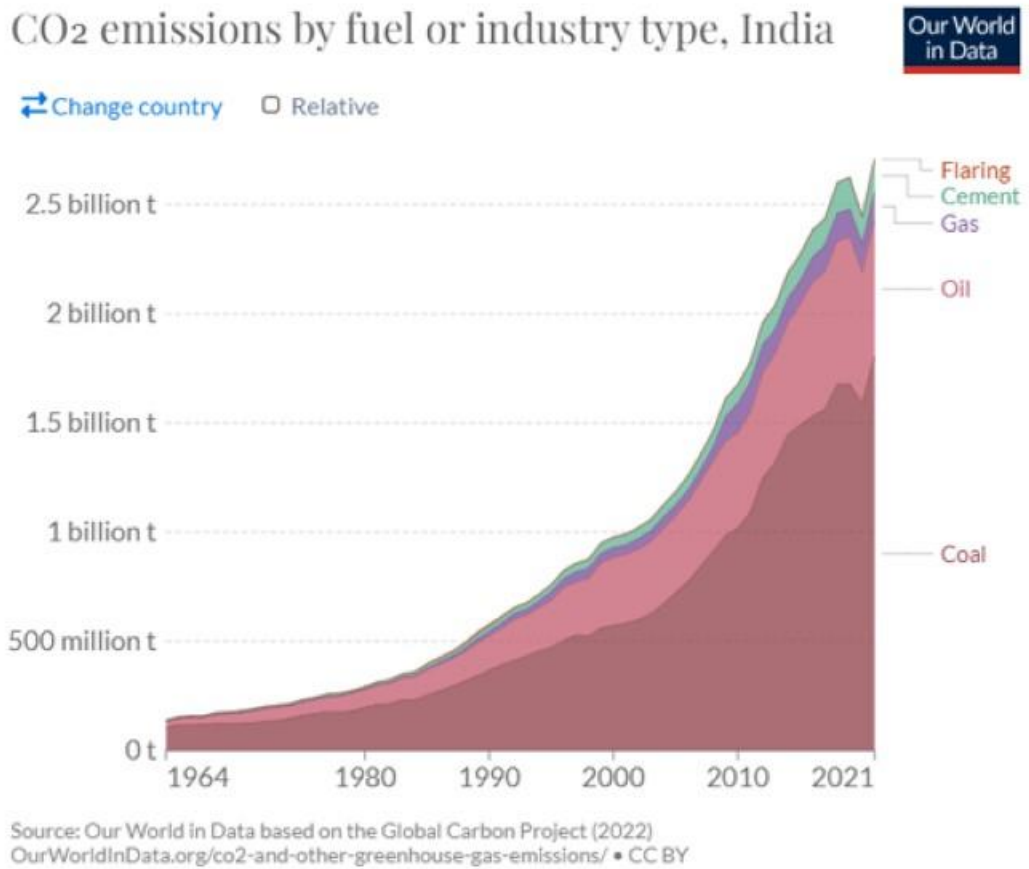
Overview

- Global perspective
- India focus
  - Background
  - Demand and addressable market
  - Supply and projects
  - Challenges

Policy Background

- India makes up around 8% of global GHGs
- It has a five-point plan to reach net zero greenhouse gas (GHG) emissions by 2070,
- The focus is largely on ramping up renewables development by 2030; reducing CO2 emissions by 1bn t from now to 2030, and cut the economy's carbon intensity by 45pc over 2005-30.



Position on ammonia and hydrogen

The country's **national hydrogen roadmap** set a production target of 5mn t/yr by 2030, ambition to make India a green hydrogen hub, including for export. Several commitments and initiatives at the draft stage

- **Demand**
  - Green hydrogen purchase obligation (GHPO) for several sectors
- **Supply**
  - Plan to introduce production-linked incentive (PLI) schemes for electrolyser manufacturing for the first 4mn-5mn t/yr of renewable hydrogen output
    - E.g. Tax rebates, export duty concessions, easier land acquisition terms
  - Power-related measures to spur project investment
    - A waiver on inter-state electricity transmission fees for green hydrogen producers (in production before mid-2025)
    - Producers will be able to bank' their surplus renewable power in the grid, with an option to use it within 30 days to address intermittency
    - Hydrogen and ammonia projects will be prioritised for grid access
- **Other**
  - Ministry for New and Renewable Energy (MNRE) has said that India's focus will be on green hydrogen using renewable capacity with no place for blue
  - Export focus: permission granted for producers to set up storage near ports to facilitate exports; other measures to stimulate export business

Overview

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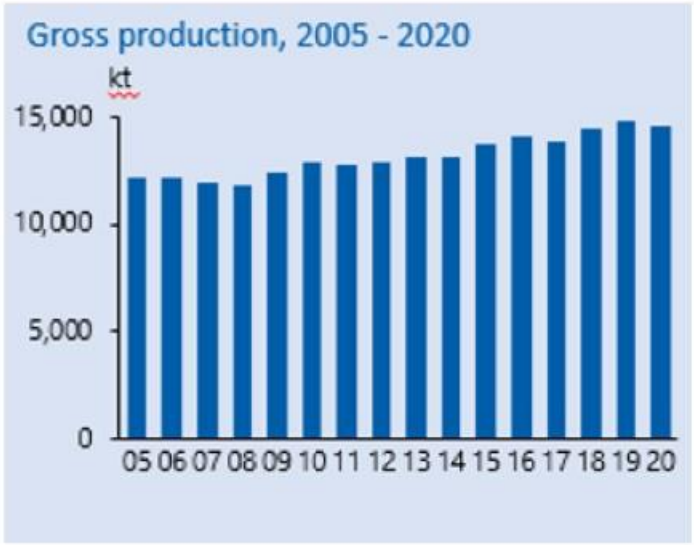
Ammonia demand

India's ammonia consumption is growing steadily, with most of the demand met by domestic production and ~13% via imports



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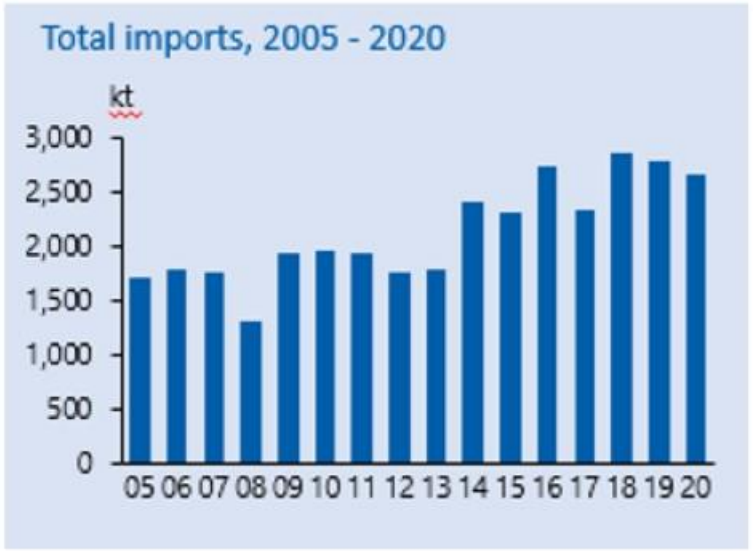

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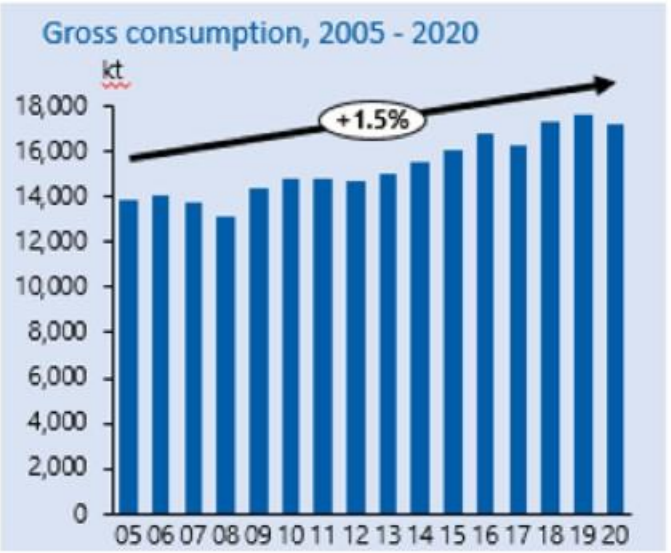
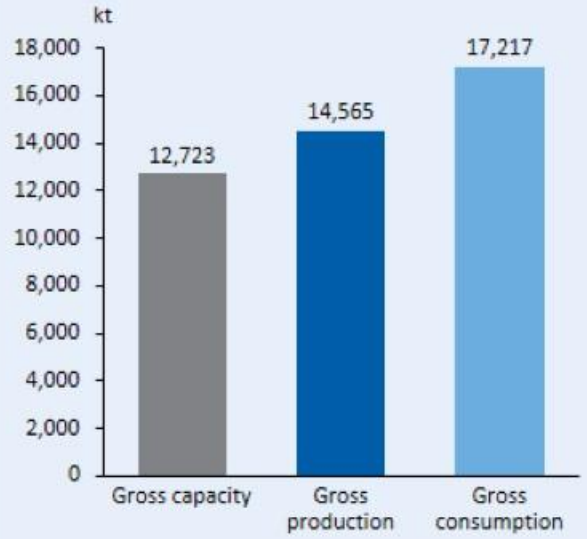


Source: Argus Analytics

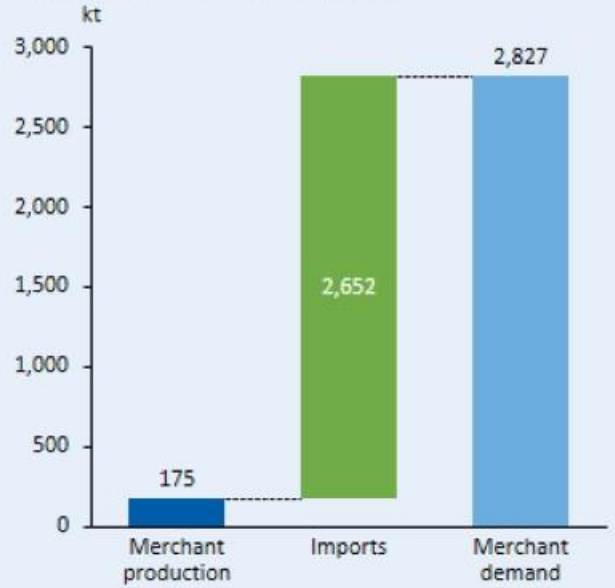
India’s merchant ammonia market, 2020

India has a 17.22 mn t ammonia market, of which merchant ammonia accounts for 2.8 mn t or just over 16%

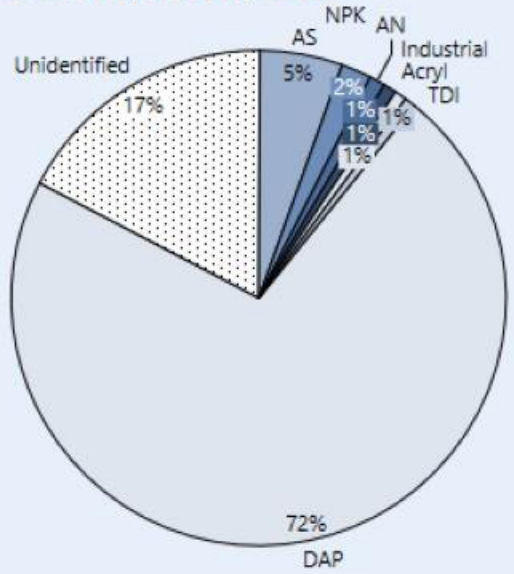
Ammonia market, 2020



Merchant Ammonia market, 2020



Merchant demand by end-use, 2020



Source: Argus Analytics

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A spate of clean NH3 project announcements over the last year or so

Initial agreements for green hydrogen, ammonia projects in Karnataka		
Company	Investment in bn USD	Ammonia output target in mn t/yr
Acme Cleantech Solutions	6.26	1.2
ReNew Power	6.03	1
ABC Cleantech	6.03	1
Avaada Energy	5.43	1
JSW Energy	5.24	-
Petronas	3.76	0.5
O2Power	2.15	-

— Karnataka state government

- **Avaada** project to build green power plant and green ammonia capacity in Rajasthan, signed an agreement with state government for 1 million tpy of ammonia. Rajasthan largest solar energy producing state. $5bn capex
- Indian state-controlled Oil and Natural Gas Corporation (**ONGC**) and renewable energy developer Greenko last month announced plans for a 1.3GW electrolyser site, which could produce 1mn t/yr of ammonia from 2026 onwards, utilising wind, solar and hydroelectric power.
- **Acme Cleantech Solutions** has also unveiled a number of planned projects in recent months.
- ABC Cleantech, a subsidiary of solar and wind energy firm Axis Energy, plans a facility that would produce 200,000 t/yr of hydrogen and 1mn t/yr of ammonia, fed by 5GW of renewable energy.
- Malaysia's state-owned **Petronas**, intends to build a plant that will eventually produce 500,000 t/yr of ammonia.
- **Acme** will set up a 1.2mn t/yr green hydrogen and green ammonia plant along with a captive solar power unit in Mangalore city between 2022 and 2027, the firm said on 6 June. The total investment in the project is 520bn rupees ($6.7bn)
- **Jakson Group** is planning a $2.8bn renewable hydrogen and ammonia project in Kota in northwest Rajasthan.Jakson plans to build the project in phases between 2023 and 2028, with the plant to produce 15,000 t/yr of renewable ammonia by 2025. Once completed, combined output of hydrogen and ammonia could reach 3.65mn t/yr, the company said.

These projects are early stage, and we need to see greater progress before we consider them firm or probable

Source: Argus Direct

And H2 project activity ramping up

- Indian state-controlled refiner **IOC** aims to produce 5pc green hydrogen out of its total hydrogen production by the 2027-28 fiscal year ending 31 March and up to 10pc by 2029-30, although it has yet to disclose actual figures. Its Mathura refinery will house a 40MW green hydrogen plant and its Panipat site will have a 16MW plant
- Indian stainless steel producer **Jindal Stainless** plans to build a green hydrogen plant in the northern Haryana state with renewables developer Hygenco India, targeting commissioning in the third quarter of calendar 2023. The solar-powered plant will house an alkaline electrolyser that has a potential to produce up to 250 t/yr but is targeting initial production of 75 t/yr, Jindal Stainless said on 14 September, describing the venture as a first for a stainless steel producer in India. It expects the plant to help it reduce CO2 emissions by 2,700 t/yr. The hydrogen produced is planned to replace ammonia in its in-house annealing of stainless steel, which is part of the heat treatment process.

Source: Argus Direct

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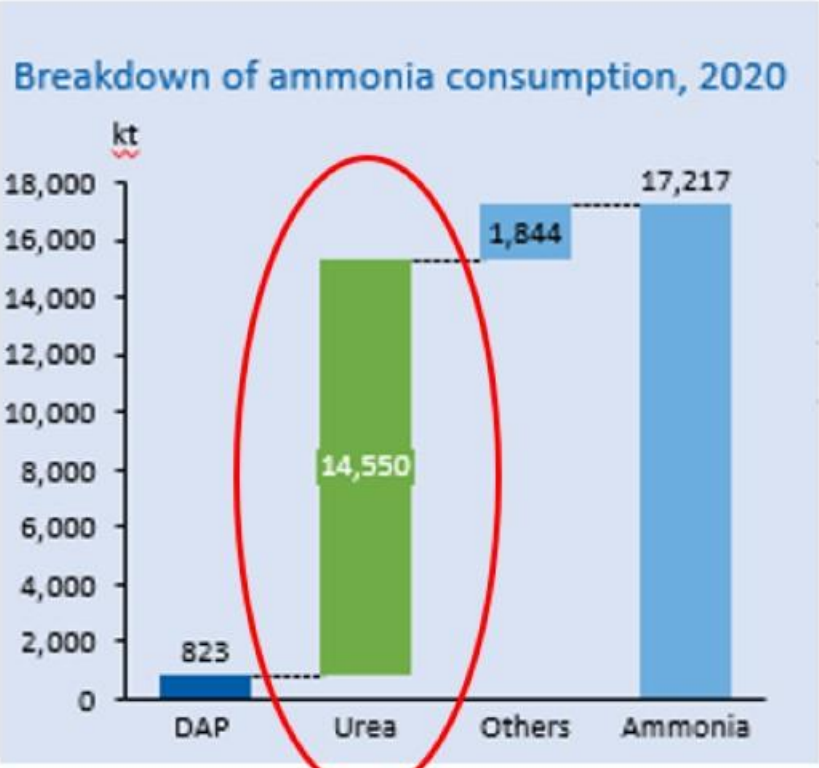
Urea is a problem



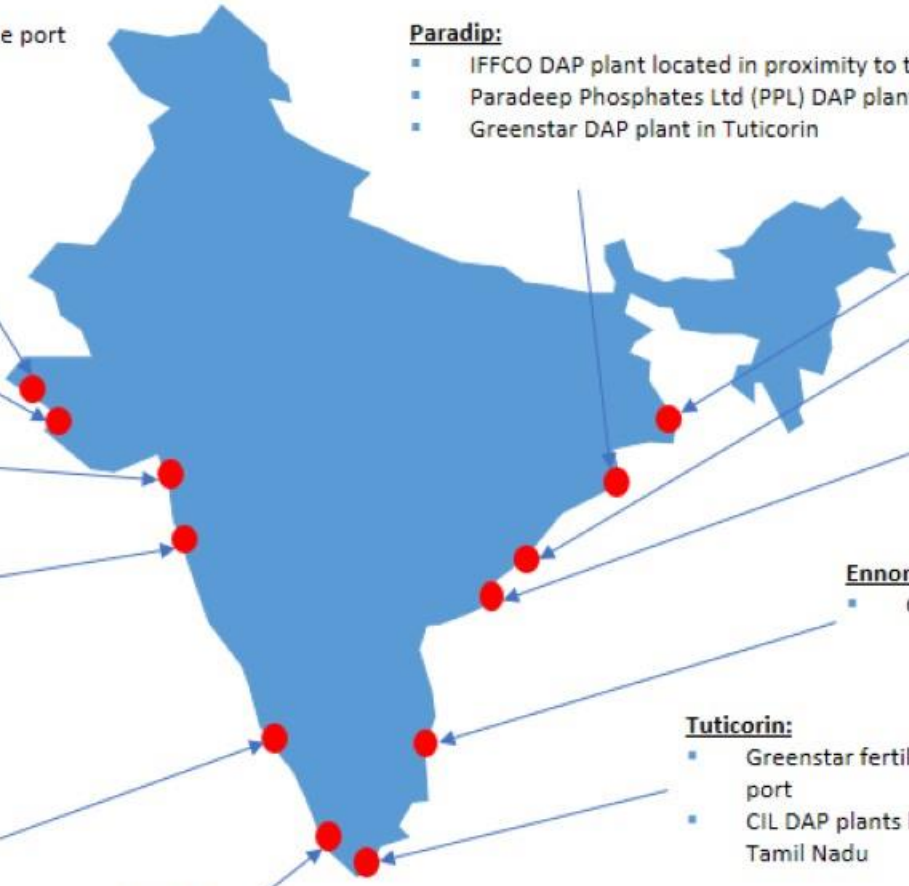
- By far the biggest use of ammonia is for urea, which cannot be decarbonized. Use of recycled/biogenic carbon would seem unlikely on a large scale.
- Existing ammonia/urea plants could switch to a 10% green H2 blend with gas. Perhaps this would allow for partial decarbonization.

- Furthermore.
  - India's fertilizer subsidy budget for 22/23 is around US$14 billion, primarily composed of urea, which is sold to farmers at a mandated Rs6 per kg (US$ 70 pt)
  - Higher priced ammonia feedstock, at least in the s-m term, would inflate the budget further

Source: Argus Analytics

Is India the logical supplier to the balance of the domestic NH3 market?

India's ammonia imports typically satisfy demand located near the port – inland ammonia transportation is minimal



Kandla:
- IFFCO DAP plant located next to the port

Sikka:
- Gujarat State Fertilizers (GSFC) DAP plant located close to the port

Dahej:
- Hidalco DAP plant located in close proximity to the port
- Sanjana DAP fertilizer

Jawaharlal Nehru Port Trust (JNPT):

Mangalore:
- Mangalore Chemicals and Fertlizers Ltd (MCFL) DAP plant located in Panambur, Mangalore.

Cochin:
- FACT Cochin DAP plant located near the port

Paradip:
- IFFCO DAP plant located in proximity to the port
- Paradeep Phosphates Ltd (PPL) DAP plant
- Greenstar DAP plant in Tuticorin

Haldia:
- IRC agrochem DAP plant located near the port

Vizag (Vishakhapatnam):
- CIL DAP plant located in Vishakhapatnam

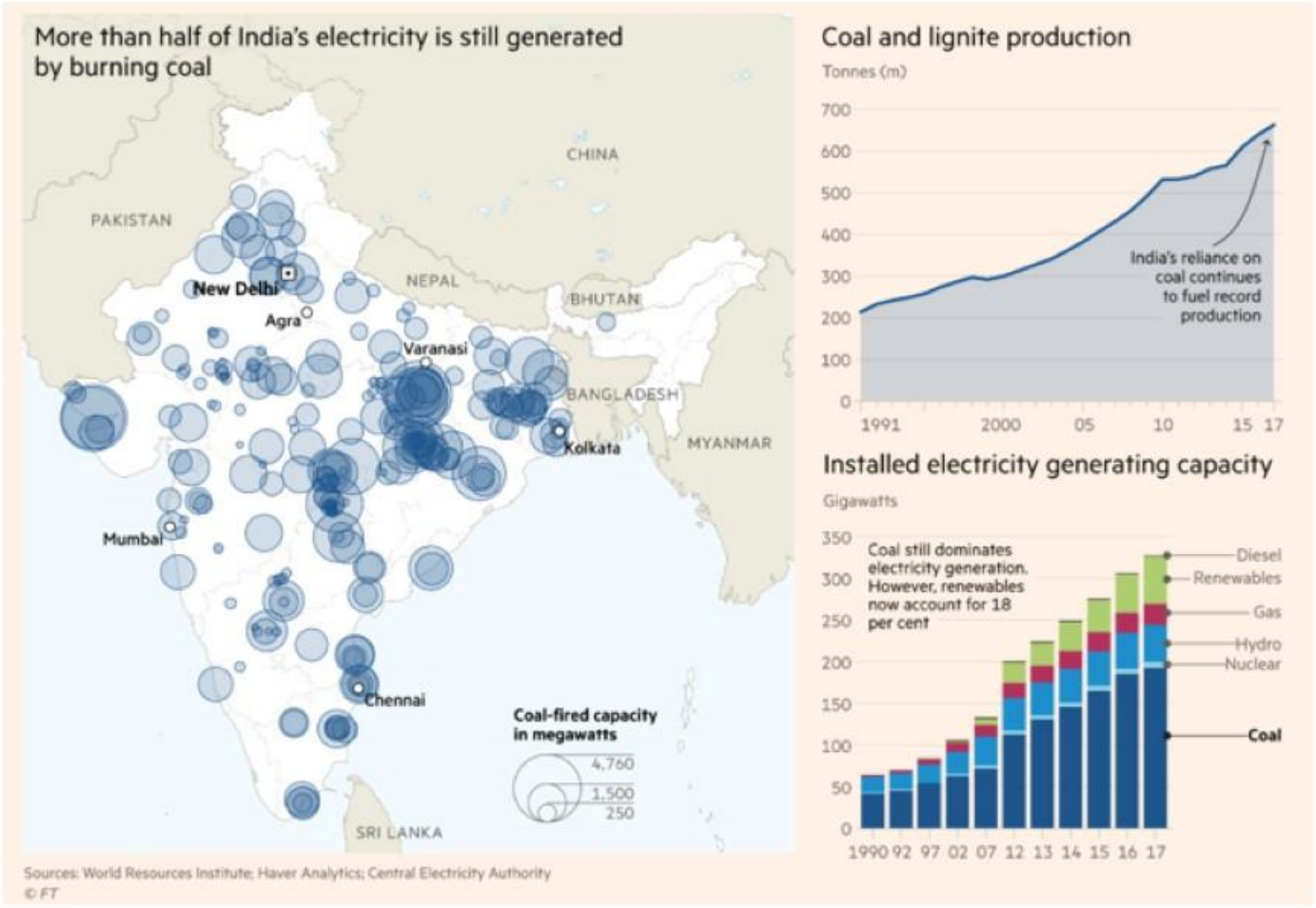
Kakinada:
- CIL DAP plant located near the port

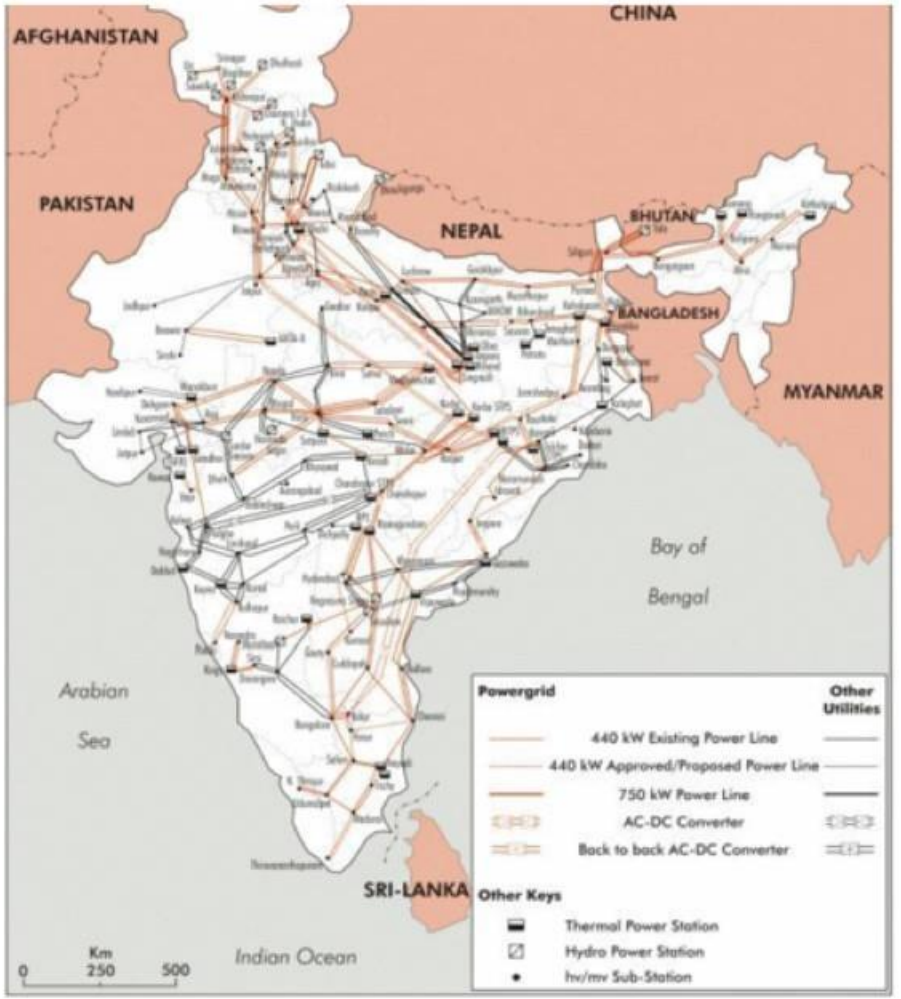
Ennore:
- CIL DAP plant located close to the port

Tuticorin:
- Greenstar fertilizer plant located in the vicinity of the port
- CIL DAP plants located in Ennore and Ranipet regions in Tamil Nadu

Source: Argus Analytics

Is green NH3 the best use of Indian clean energy resources?





Source: FT, Geni.org

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Thank You

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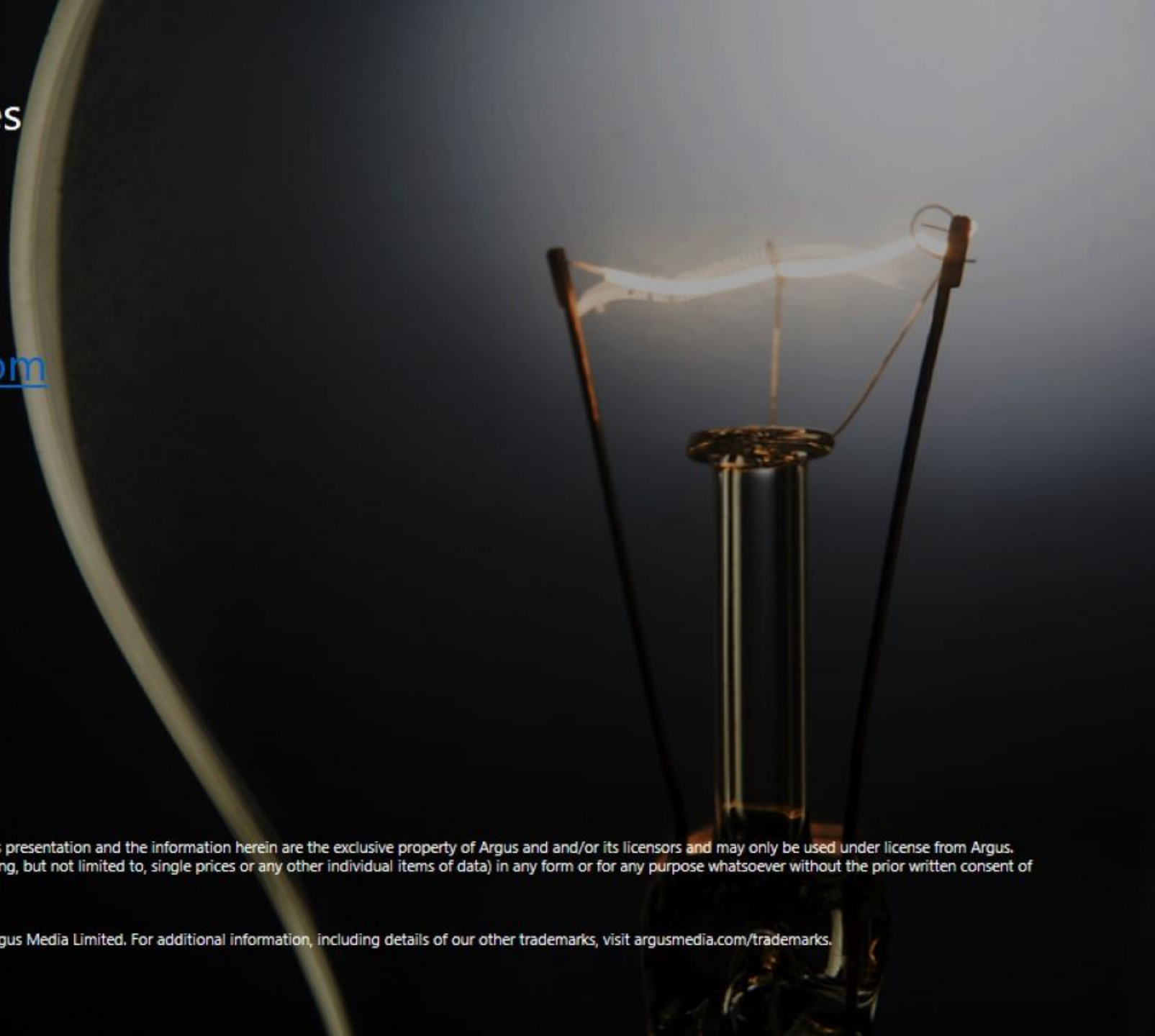

Sources
Argus Consulting Analytics Reports; Argus Monthly Outlook reports; IFA; GTT