Sustainability and the Next Phase of Business Growth

Professor Ganapati D. Yadav,

NAE (US), FNAI (US), FTWAS, FNA, FASc, FNASc, FNAE, FRSC (UK), FIChemE (UK), FICS, FIIChE

National Science Chair (Govt. of India)

Emeritus Professor of Eminence & Former Vice Chancellor

INSTITUTE OF CHEMICAL TECHNOLOGY

MUMBAI, India

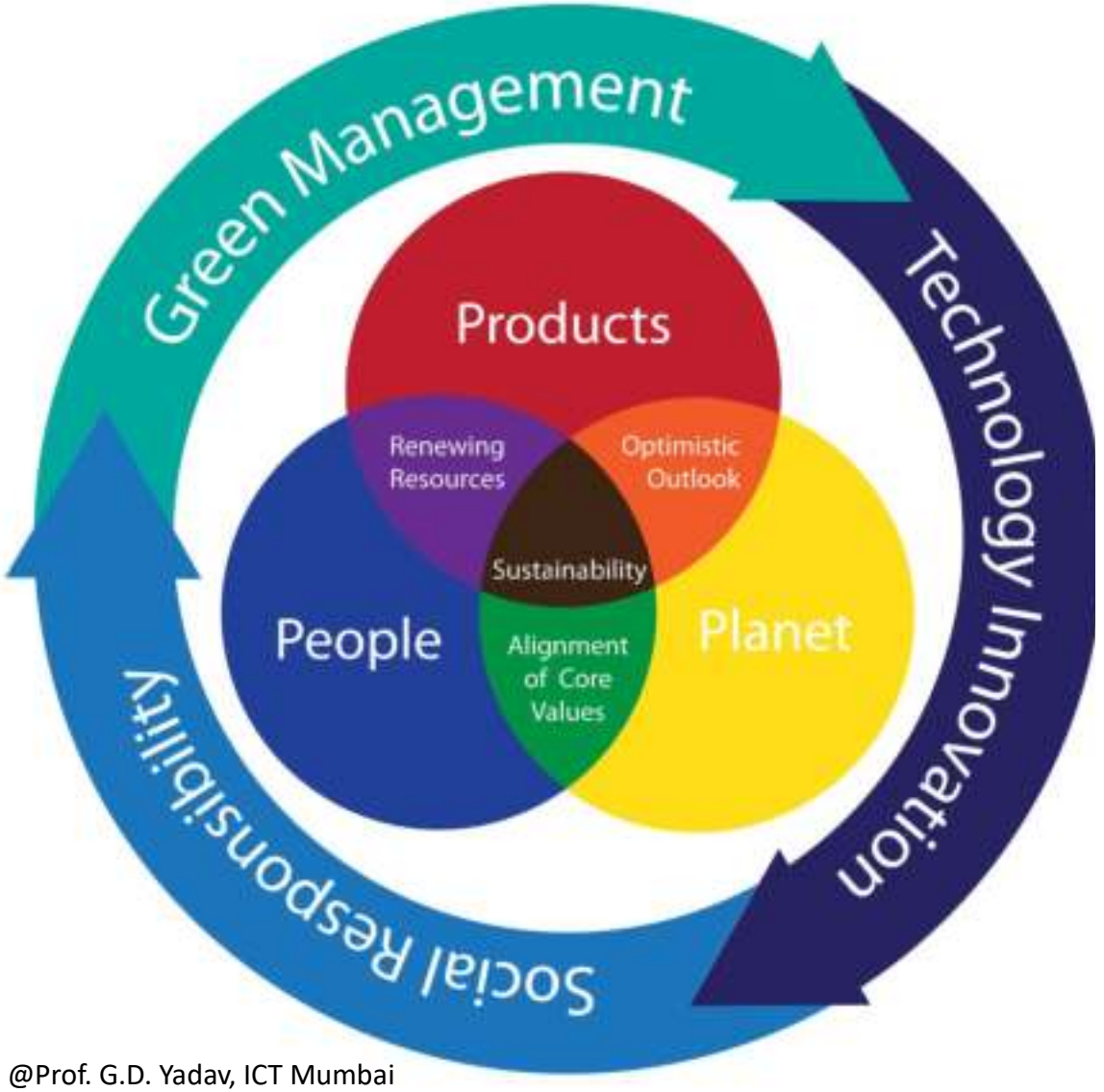
gdyadav@gmail.com; gd.yadav@@ictmumbai.edu.in

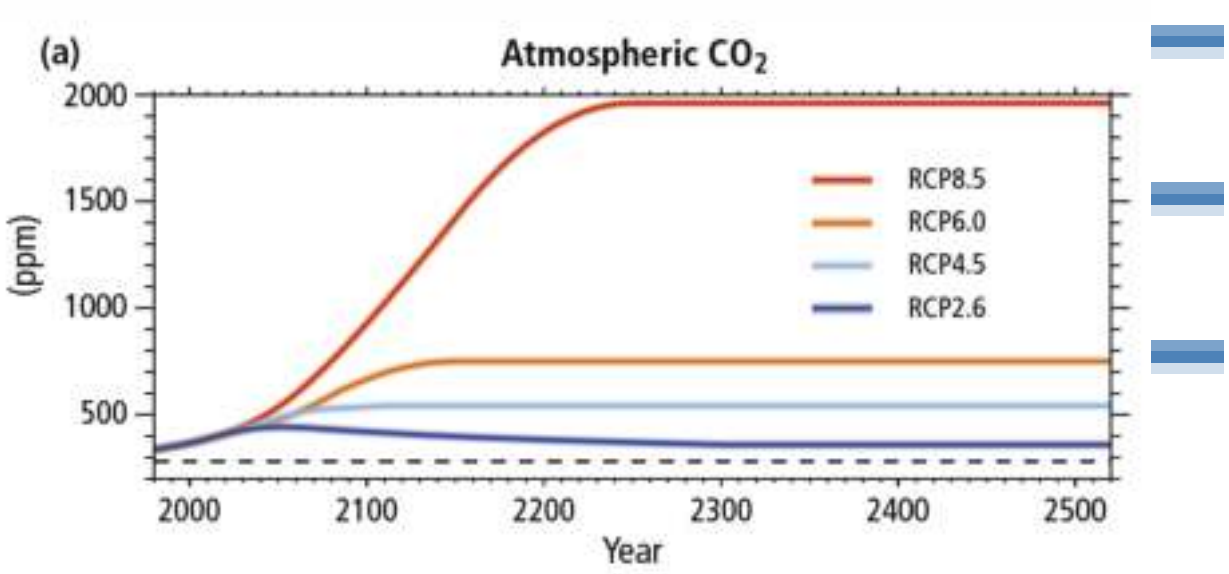
Sustainable Chemical Logistics For Future

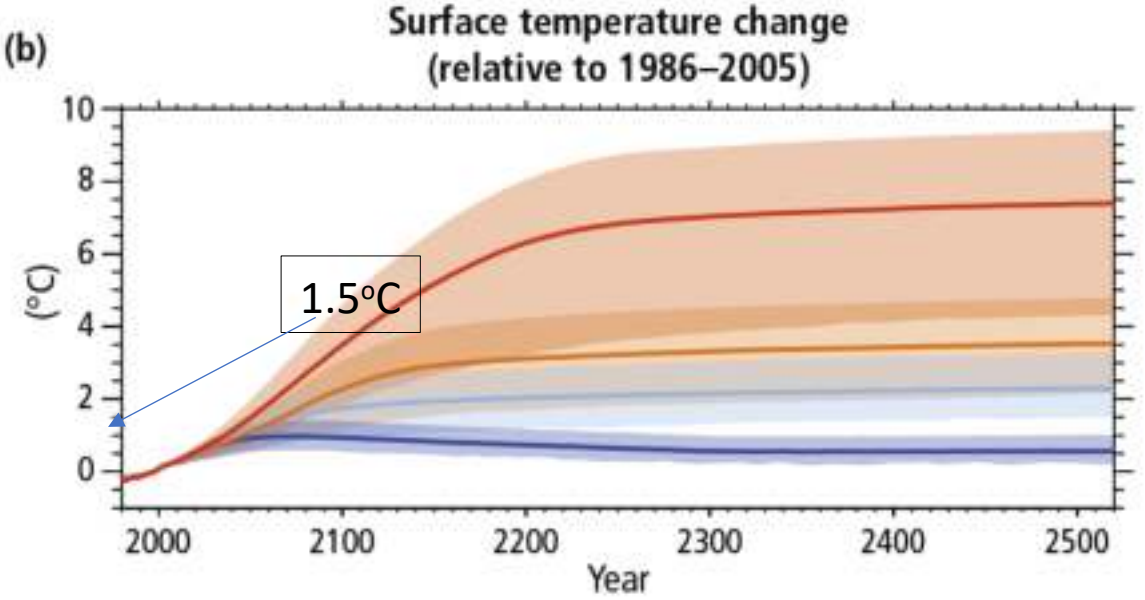
Indian Chemical News: ChemConnect 2023

October 13, 2023

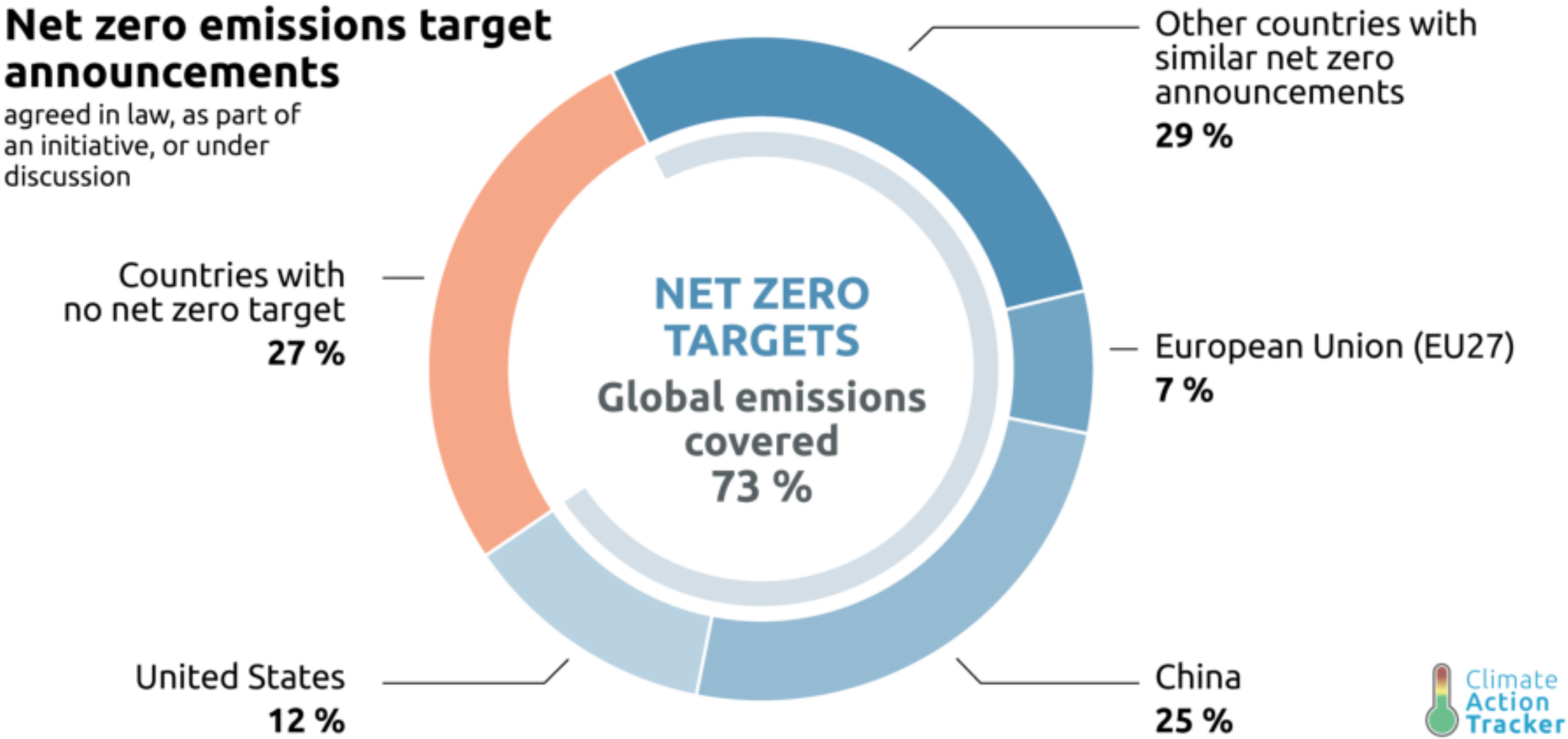
Sustainable Business







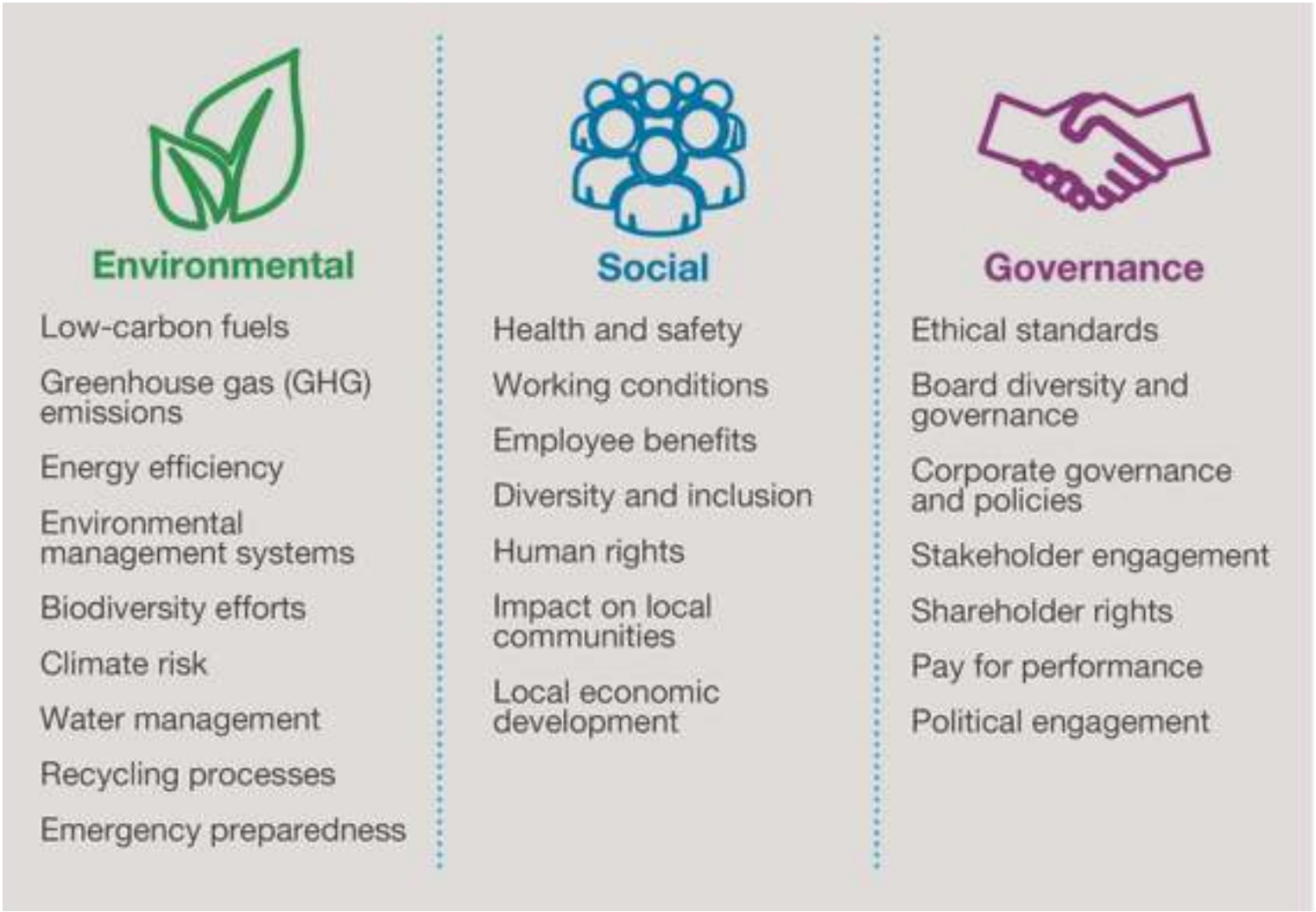
410 ppm in Jan 2020
412 ppm Jan 2021
422 ppm 19 Dec 2022



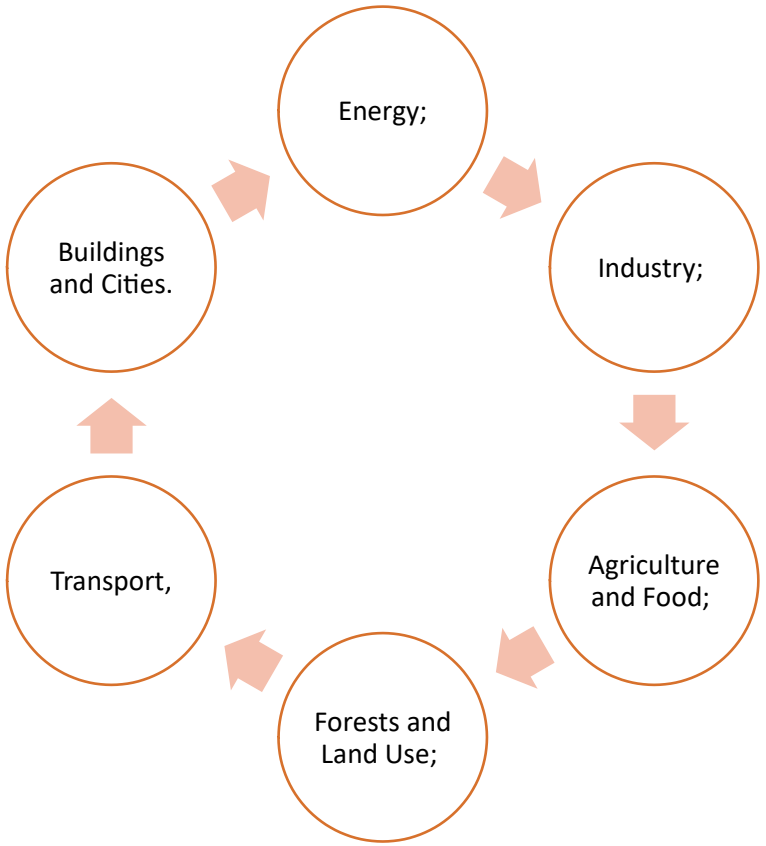
Source: World Economic Fourm

Environment, Social, and Governance Reporting

How to integrate ESG priorities ton the Organizations Value to Chain Model

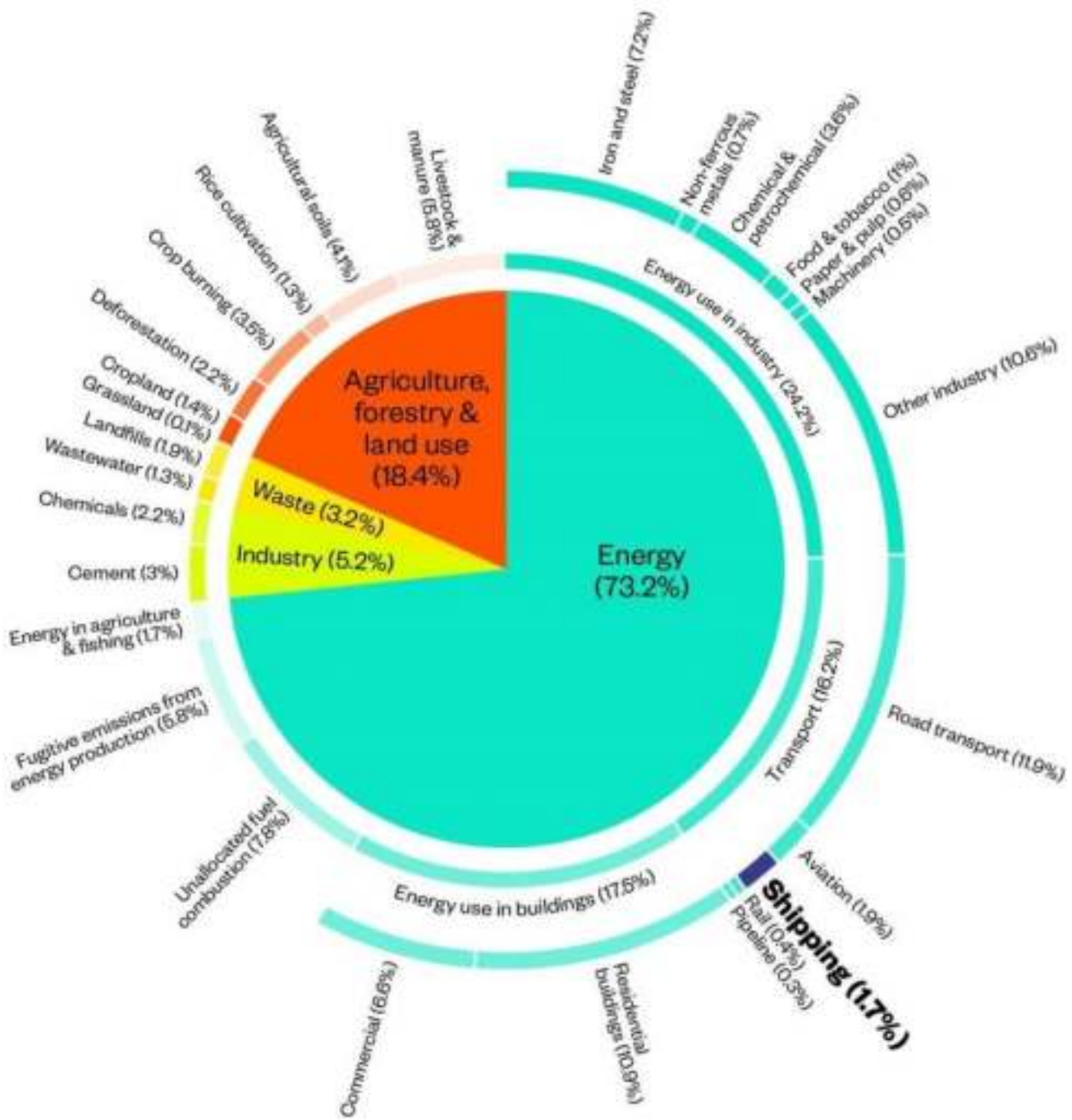


Decarbonization Sectors: UNEP



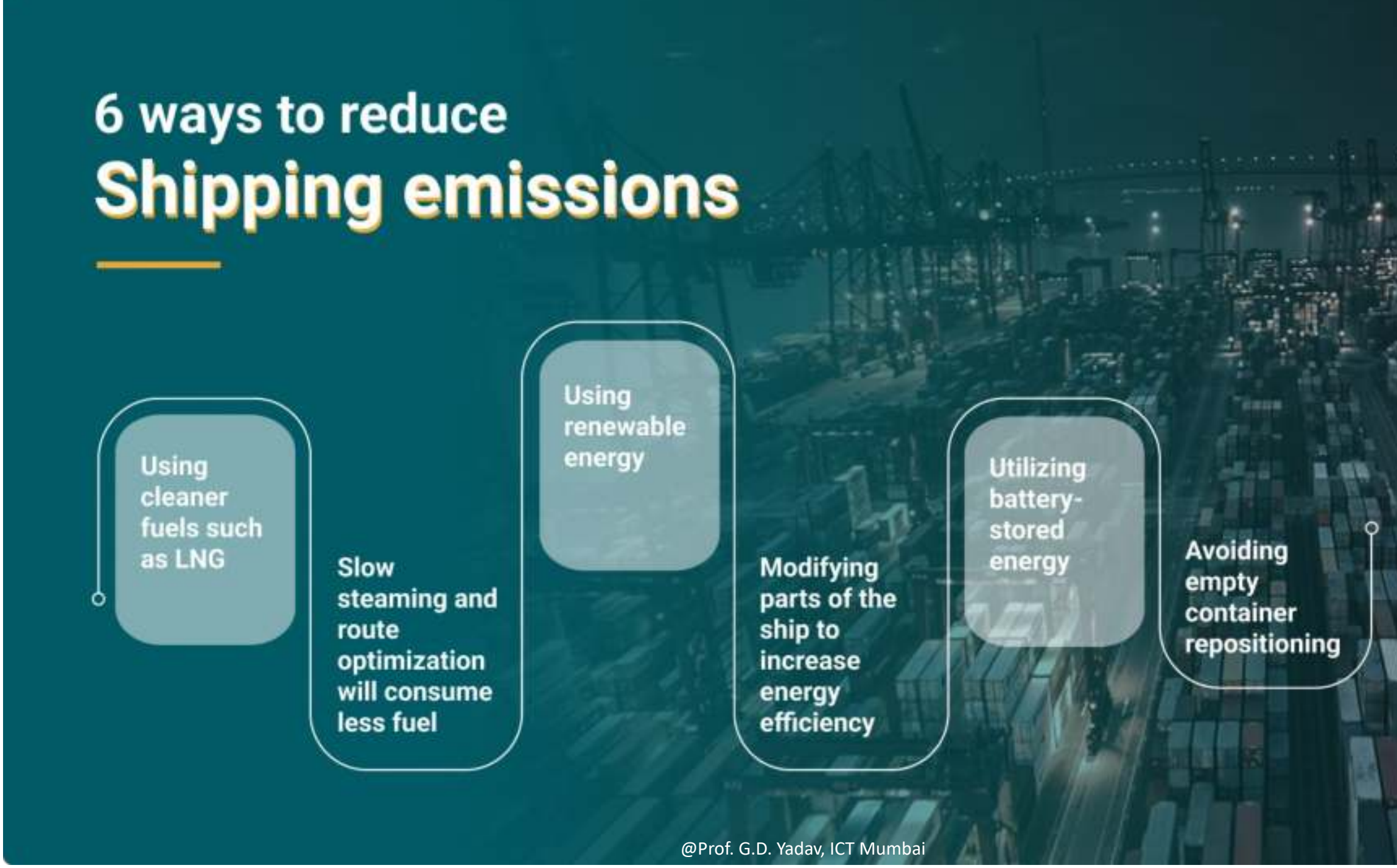
Decarbonization in Shipping industry -

- The shipping industry is probably the most challenging sectors to decarbonize—faces growing calls by shareholders, regulators, customers, and other stakeholders.
- CEOs must look at businesses from sustainability and zero emission points of view.
- Financial institute must ask for sustainability reports for any new project in all sectors.



Source: Our world in data

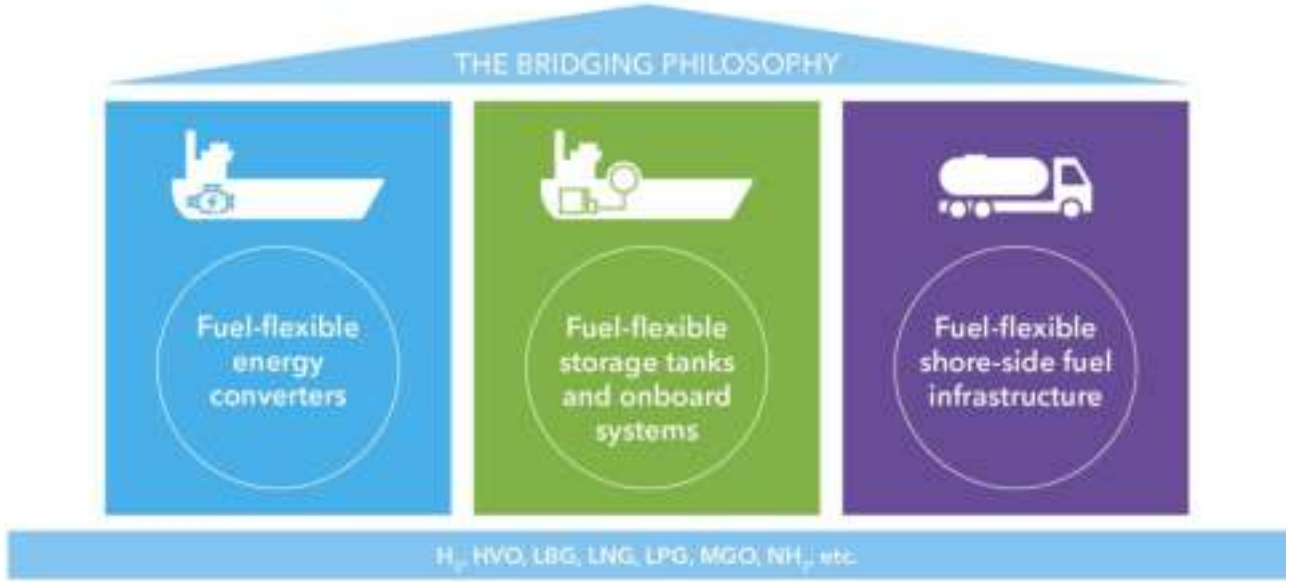
- Shipping produces just 2.2% of the world’s GHG emissions, and contributes less than 15% of global transport’s GHG emissions.
- Agriculture emits a share of over 20% according to FAOSTAT, energy almost 40 %.
- Marine pollution in the form of oil spills has been drastically reduced in the past 15 years despite the massive growth in seaborne trade.



Use of Alternative Fuels

- Avoiding empty shipping repositioning can reduce shipping emissions.
- Shipping produces 940 million tonnes of CO2 annually, which is 2.5% of global GHG.
- IMO has drafted a framework to reduce GHG emissions called Initial IMO GHG Strategy.
- EEDI promotes the use of energy-efficient engines and equipment.
- How to avoid empty shipping repositioning with Change.

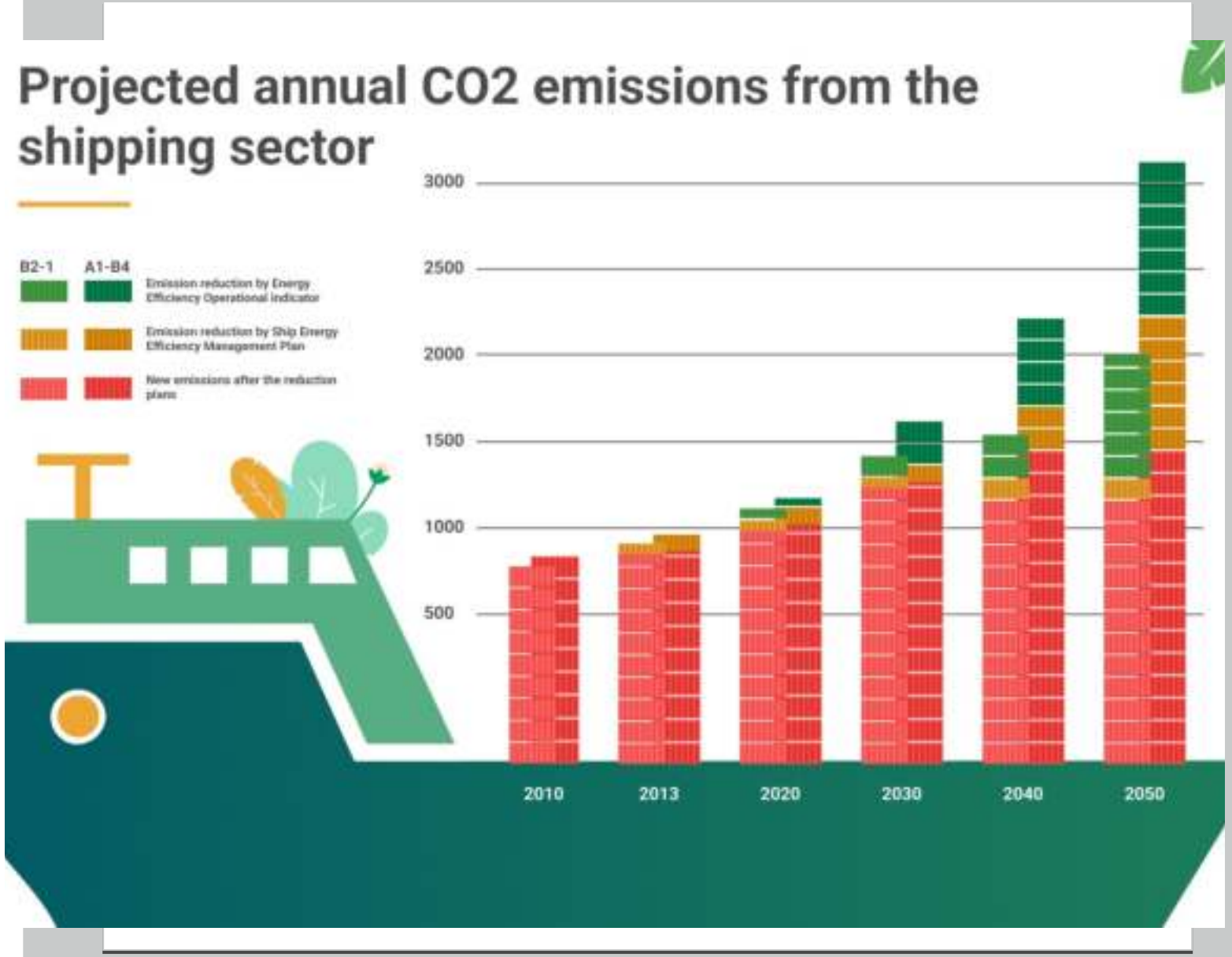
The three pillars of the bridging philosophy enabling use of alternative fuels



H_2, hydrogen; HVO, hydrotreated vegetable oil; LBG, liquefied biogas; LNG, liquefied natural gas
LPG, liquefied petroleum gas; MGO, marine gas oil; NH_3, ammonia

GHG from Shipping Industry

- International shipping accounts for about 2.5% of all global greenhouse gas emissions, according to the U.N. international maritime organisation.



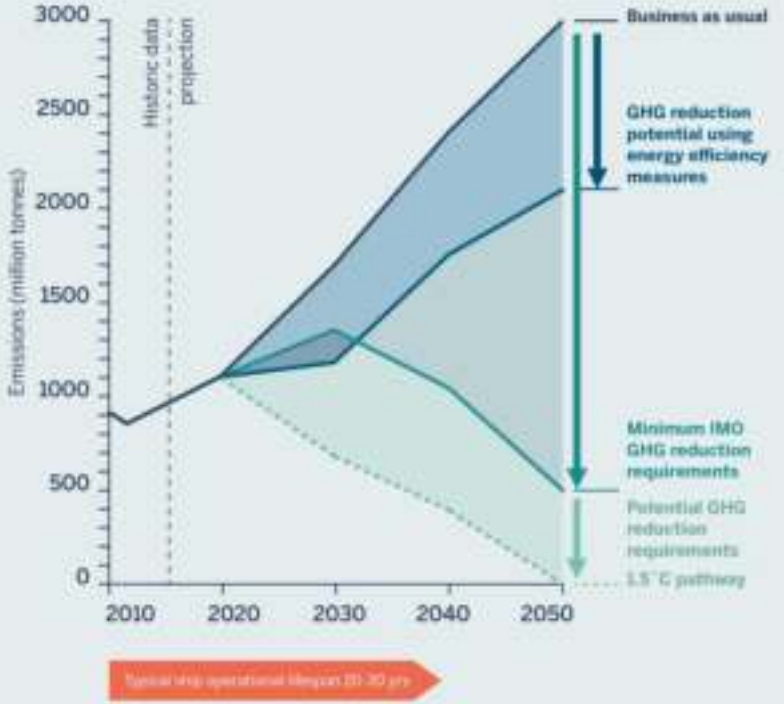
GHG in Shipping Industry

- More than 90,000 ships account for the burning of nearly 2 billion barrels of the heaviest fuel oil.
- The most-significant reductions come with a fuel switch to low sulfur content.
- According toInternational Maritime Organization’s 2020 regulation, only 0.5% sulfur can be used in commercial ship fuel globally. This sulfur cap will reduce the emission of sulfur dioxide (SO2).
- Liquified-natural gas (LNG) as one of the green fuels. Unfortunately, it’s not as green as one hoped for.
- Hydrogen driven ships and biofuels

How can shipping decarbonise?

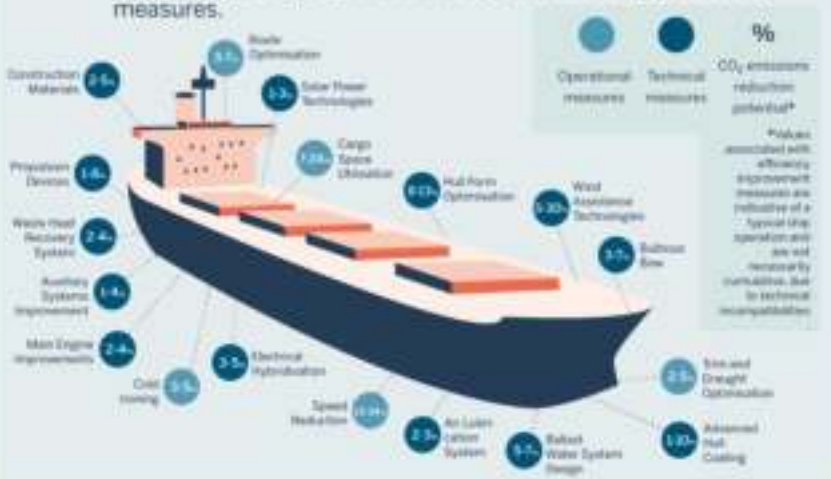
1 Pathways for international shipping emissions

The International Maritime Organization (IMO) has committed to reducing greenhouse gas (GHG) emissions from international shipping by **at least 50%** by 2050 (compared to 2008 emissions), with a strong emphasis on reaching zero emissions.



2 Efficiency measures

Some of the needed emissions reductions can be achieved immediately using technical and operational energy efficiency measures.



3 Renewable energy potential

Efficiency gains alone can't achieve the IMO's GHG reduction targets. A transition to zero-carbon fuels and electricity from renewable energy resources is needed.

International shipping will need approximately **20-40EJ of energy a year**. For example, this is about 2.5-5% of South America's total renewable energy potential or 0.4-0.7% of that of Africa.

Zero-carbon fuels for shipping

1 Using a mix of electro-fuels and electricity, both made from renewable energy, plus some limited bio-fuels, shipping can achieve the IMO GHG target and reduce its emissions further.

Renewable energy source options + products

Electro-fuels

Production of gaseous/liquid zero-carbon electro-fuels from sustainable sources.

Electrification

Production of electricity from renewable energy resources in combination with battery storage technology.

Hydrogen
Methane
Ammonia
Dimethyl Ether
Methanol
Gas Oil

Bio-fuels + limitations

1st Generation

Produced from food resources, such as wheat and sugar.

Resource competition
Life-cycle emissions

2nd Generation

Produced from bio-mass resources such as wood and organic waste.

Resource competition
Land use alteration

3rd Generation

Produced from sustainably cultivated organic materials such as algae.

Life-cycle emissions
Commercial viability

4th Generation

Produced from bio-mass resources in combination with carbon dioxide capture and storage.

Resource competition
Land use alteration

A number of limitations are associated with bio-fuels. That is why electro-fuels and electricity generated from renewable energy are likely the more sustainable option.

No one solution fits all. Different solutions suit different vessel types based on size, power and range requirements.

Short-sea or domestic shipping suitable for electrification

Relatively small tonnage and limited range requirements, including small cargo ships and tankers, barges, ferries.

Renewable energy generation

Electro-fuel production

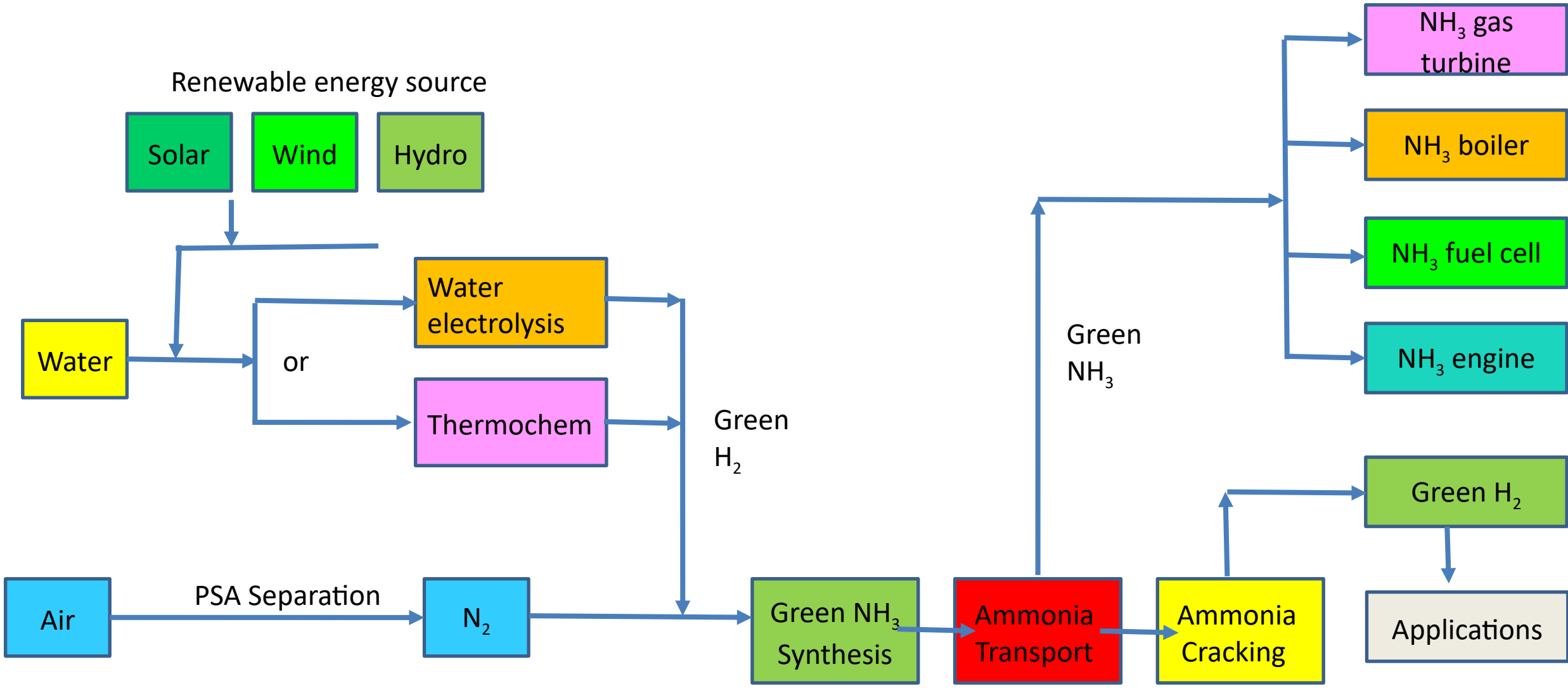
Deep-sea shipping requiring electro-fuels **2**

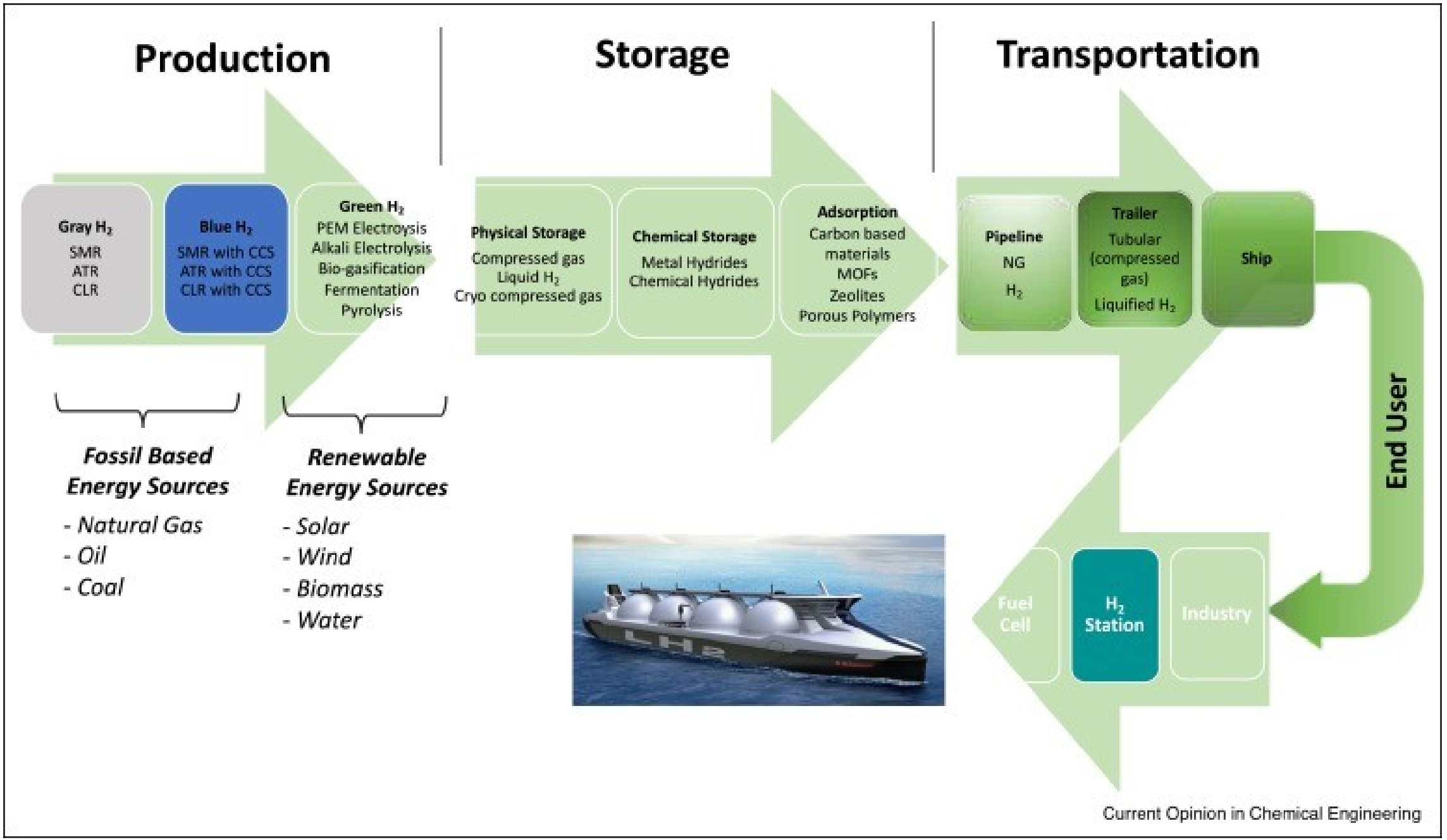
Large tonnage and considerable range requirements, including large container ships, bulk cargo and gas carriers, larger tankers, cruise ships, RoRo ferries, etc.

3 Further work is needed to transition the maritime industry to zero-carbon fuels.

- **Infrastructure**
  - Scale up production of renewable energy production & zero-carbon fuels
  - Improve availability and reduce costs
- **Ship level**
  - Scale up deployment of zero- emission vessels
- **Regulations**
  - Develop supportive policy, standards and rules

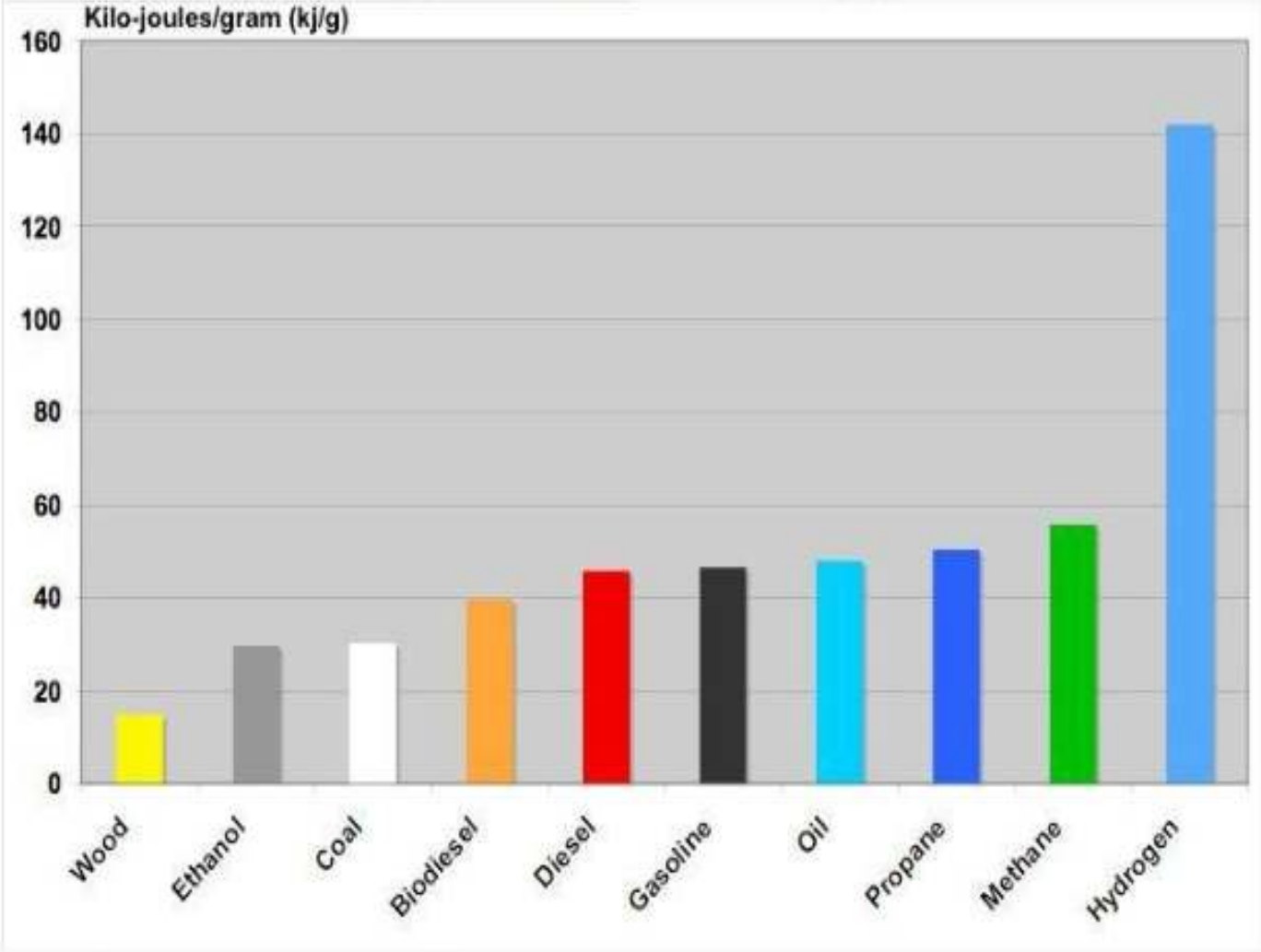
Synthesis and applications of green ammonia




Production
Storage
Transportation
Gray H_2
SMR
ATR
CLR
Blue H_2
SMR with CCS
ATR with CCS
CLR with CCS
Green H_2
PEM Electroysis
Alkali Electrolysis
Bio-gasification
Fermentation
Pyrolysis
Physical Storage
Compressed gas
Liquid H_2
Cryo compressed gas
Chemical Storage
Metal Hydrides
Chemical Hydrides
Adsorption
Carbon based materials
MOFs
Zeolites
Porous Polymers
Pipeline
NG
H_2
Trailer
Tubular (compressed gas)
Liquified H_2
Ship
End User
Fuel Cell
H_2 Station
Industry
Fossil Based Energy Sources
- Natural Gas
- Oil
- Coal
Renewable Energy Sources
- Solar
- Wind
- Biomass
- Water
Current Opinion in Chemical Engineering

- Green Power generation
- Transportation (2,3,4 wheelers, IC engines)
- Synthetic fuels from CO_2
- Upgrading of bio-oil
- Hydrogenation of biomass
- Green ammonia & fertilizers
- Green metal (steel, Ni)
- Chemical & allied industry
- Waste plastic chemical recycling
- Heat & distributed power

Specific Energy



Source: DOE, Green Econometrics research

The Hydrogen-fuelled container feeder vessel

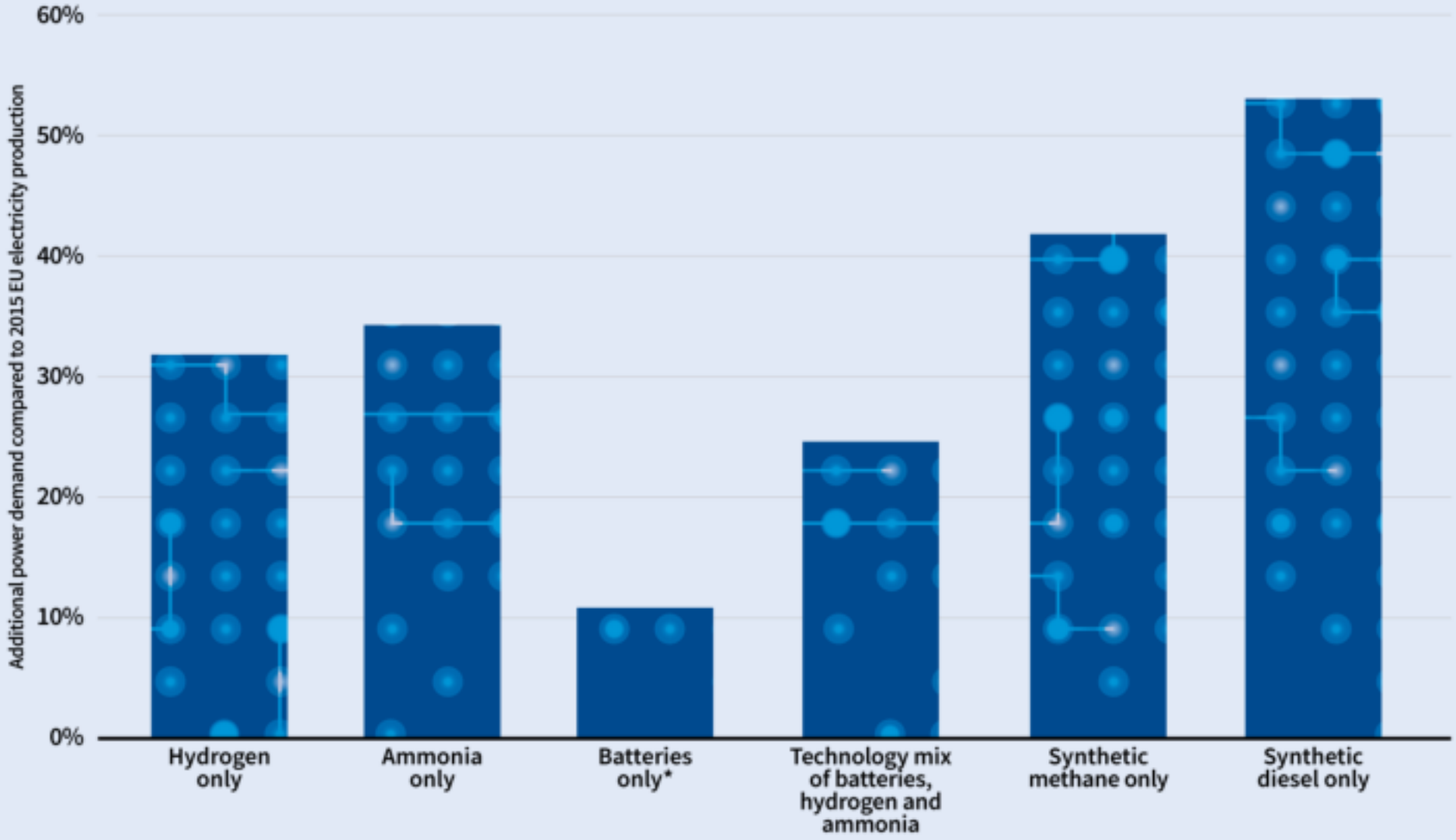
The new container feeder vessel targets traditional trades.

- full open-top 1000 TEU intake with 150 reefer slots, 700 TEU @14t
- service speed of 15 knots

The new container feeder vessel runs on liquid Hydrogen.

- two power generation rooms, forward and aft
- 5 MW fuel cell systems, with 3 MWh battery systems to provide peak power
- multiple type C tanks with 920 m^3 to hold liquid Hydrogen for a ten-day roundtrip

What's the most efficient way to power European shipping over short and long voyages?



TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

@Prof. G.D. Yadav, ICT Mumbai

*Batteries are only viable for ships on shorter distances

Source: Transport & Environment (2018)

Scope 3 emissions

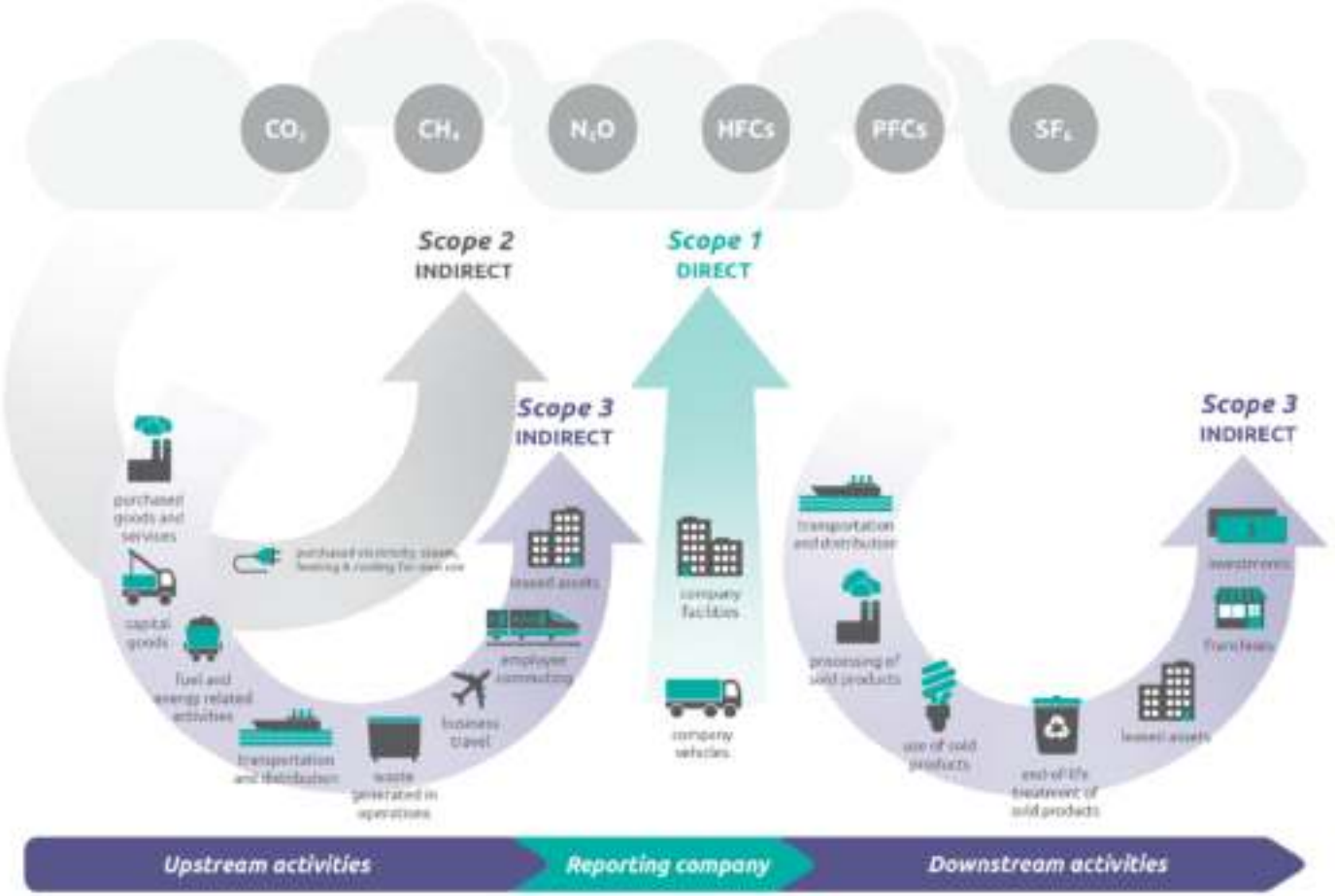
- Scope 3 emissions, also known as value chain emissions, are indirect GHG emissions both upstream and downstream of an organisation's main operations.
- This usually means all of the emissions a company is responsible for outside of its own operations—from the goods it purchases to the disposal of the products it sells.
- It is often the case that scope 3 emissions are by far the largest proportion of an organisations' carbon footprint. However, they are also the area over which businesses have the least control and have the most difficulty quantifying.

The environmental case for measuring scope 3

With time running out to make the drastic global emissions cuts required under the Paris Agreement, scope 3 offers an opportunity to drive rapid environmental engagement through supply chains, global and local businesses, local and national governments and consumers.

Whilst reducing the emissions associated with the organisation's operational or equity boundary ensures that its own sustainability performance improves, tackling scope 3 requires engaging with many other businesses and stakeholders throughout the value chain.

Scope 3 Emissions



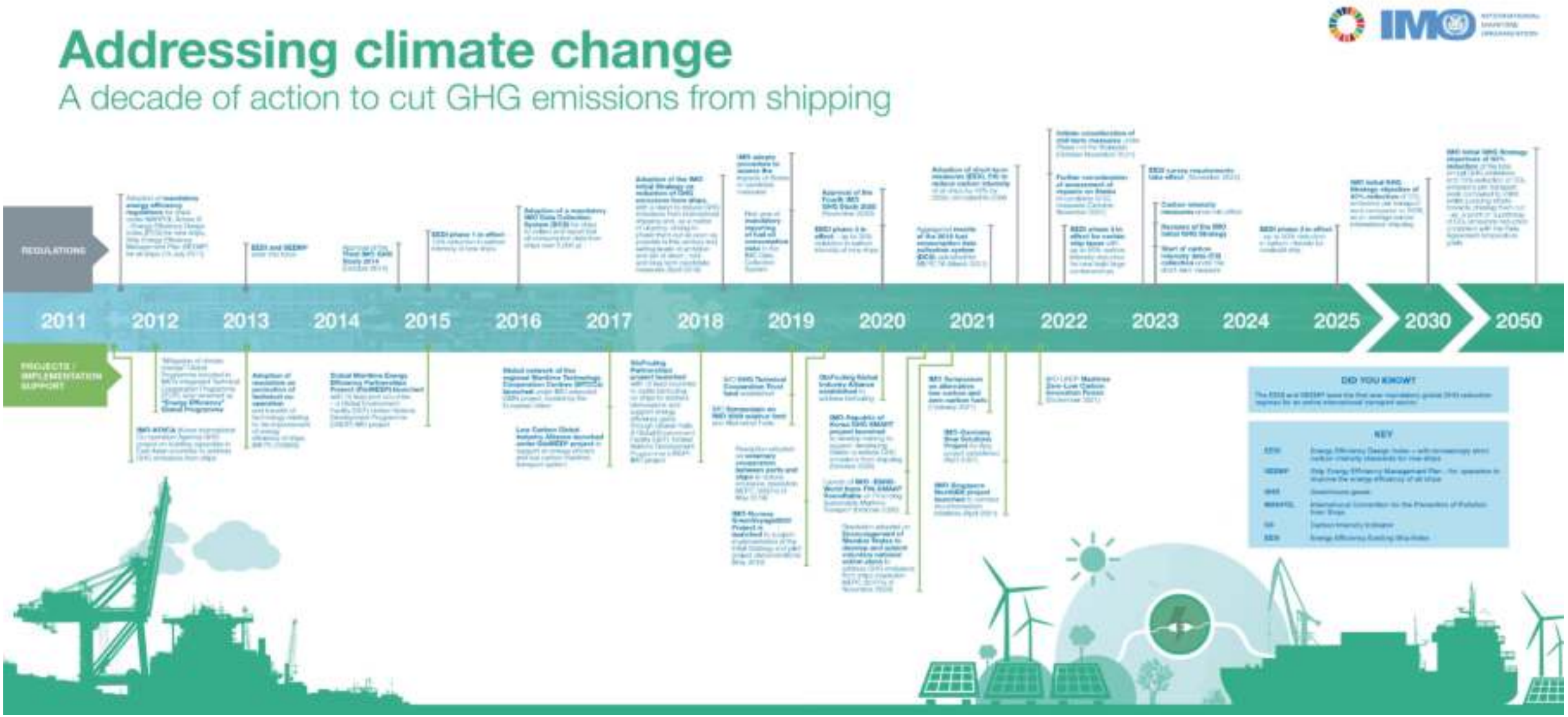
Net Zero

Net zero equation – It is not a single equation but a sum of many equations like labour skills, demand supply of goods and energy, economic development inclusive of growth.

Many countries are in the race to be Net Zero by year 2050.

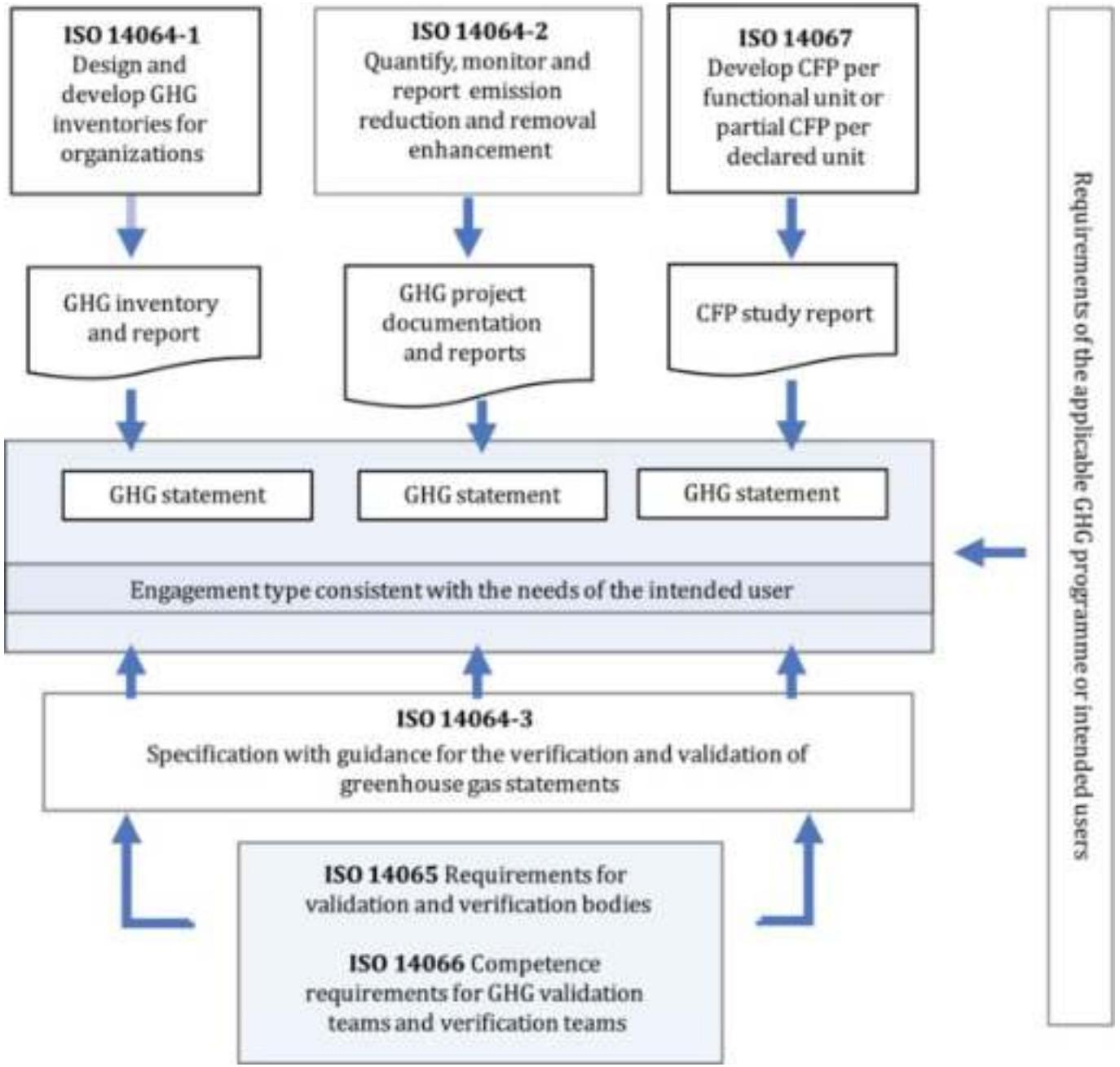
Is there a standard way to measure CO2 and GHG emissions? And which Governing body will verify these norms?

IPCC Methodology for Greenhouse Gas Inventories



ISO 14064

- **ISO 14064** is an international standard for quantifying and reporting greenhouse gas emissions.
- Part 1 guides development of a GHG inventory that can be compared to other inventories of other organizations regardless of sector or national origin.
- Part 3 establishes a process for verifying GHG inventory reports.


ISO 14064-1
Design and develop GHG inventories for organizations
ISO 14064-2
Quantify, monitor and report emission reduction and removal enhancement
ISO 14067
Develop CFP per functional unit or partial CFP per declared unit
GHG inventory and report
GHG project documentation and reports
CFP study report
GHG statement
GHG statement
GHG statement
Engagement type consistent with the needs of the intended user
ISO 14064-3
Specification with guidance for the verification and validation of greenhouse gas statements
ISO 14065 Requirements for validation and verification bodies
ISO 14066 Competence requirements for GHG validation teams and verification teams
Requirements of the applicable GHG programme or intended users

How do countries calculate their emissions?

Countries report their emissions through what is known as a ‘bottom up’ approach, where national emissions are estimated by combining data on types of activity with the emissions typically produced by those activities.

So, if one know how much carbon dioxide steelmaking produces, and how much steel is produced in that country, the total quantity of emissions from the steel sector can be estimated.

e.g. 2.38 tons CO_2/ton steel

Conclusion

- It is possible to decarbonize any industry if the targets are set and technologies developed accordingly.
- GH2 and GNH3 can help the shipping industry.