Greening of Fertilizer Production

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Plant Nutrients

Macro Nutrients

Primary Nutrients

C
H
O
N
P
K

Secondary Nutrients

Ca
Mg
S

Micro Nutrients

Cu
Zn
Fe
Cl
Mn
Mo
B

Type of Fertilisers

Straight Fertilisers

- **Containing only one of the primary nutrients**

  Urea (N), SSP, TSP (P), MOP (KCl-K)

- **Complex or Compound Fertilisers**

  Containing two or all three primary nutrients

  Di-ammonium phosphate (DAP - N&P)

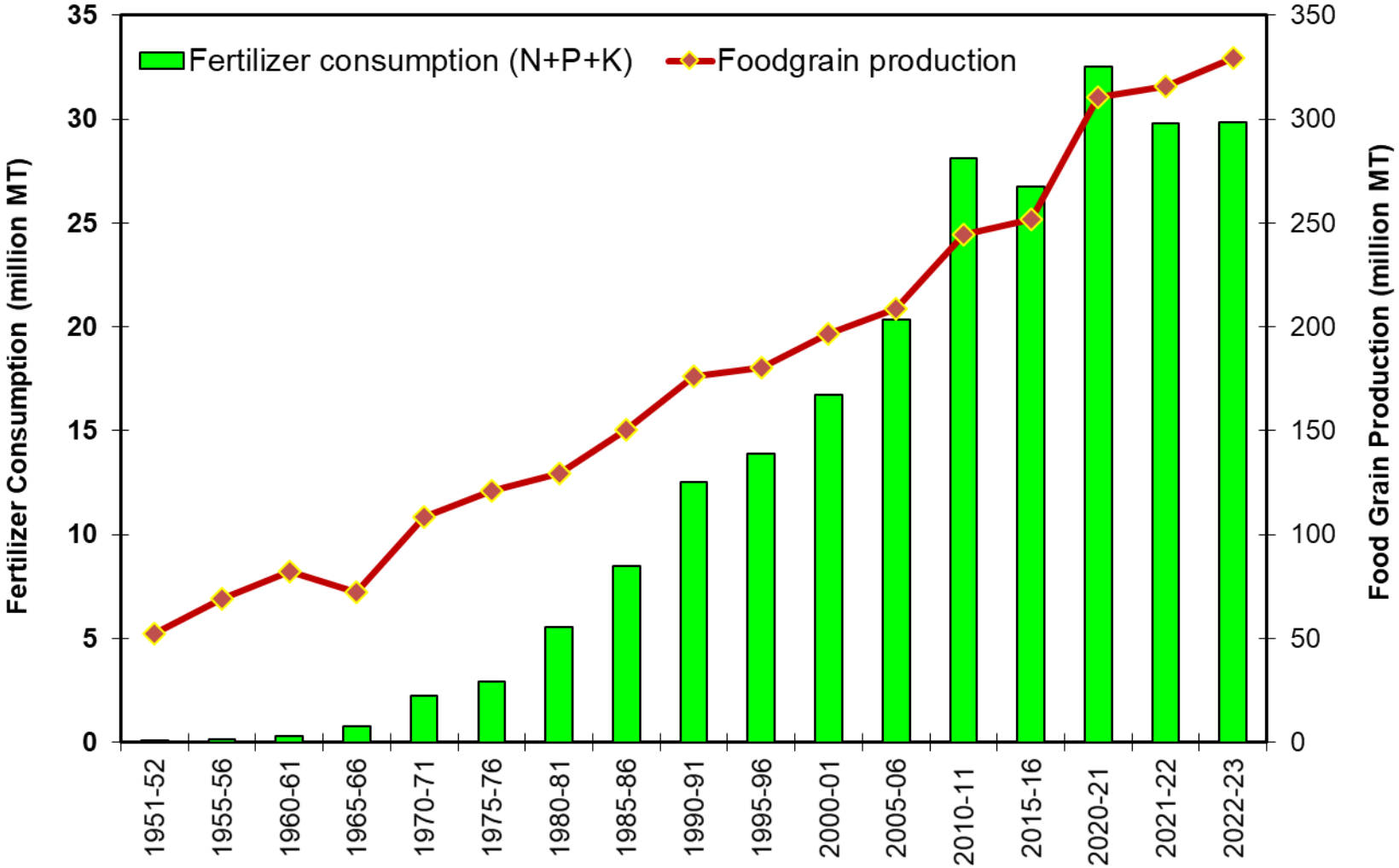
  Ammonium Phosphate + KCl (N, P & K)

Nitrogenous Fertilisers – Containing N

Phosphatic Fertilisers – Containing P

Potassic Fertilisers – Containing K

Fertilizer Consumption v/s Foodgrain Production



Source: FAI, New Delhi

Production, Import and Sale of Major Fertilizers 2022-23 (million MT)

Fertilizer	Production	Import	Sale
Urea	28.50	7.58	35.73
DAP	4.35	6.58	10.53
MOP	-	1.87	1.63*
NP/NPKs	9.29	2.75	10.07
SSP	5.65	-	5.02
Total Products**	**48.69**	**18.78**	**63.92**

* = MOP for direct application

** = Includes other products viz., Ammonium Sulphate, Ammonium Chloride, etc.

Introdouction

- Production of nitrogen fertilizers is several times more energy intensive than phosphatic and potassic fertilizers.

- Therefore, focus will be on nitrogen containing fertilizers.

Production of Nitrogenous Fertilizers

- Ammonia is required for producing any nitrogen containing fertilizer e.g. urea, ammonium sulphate, ammonium nitrate, ammonium chloride, ammonium phosphates and complex fertilizers.

- More than 80% of energy used in production of nitrogen fertilizers is taken up in production of ammonia.

Industrial Fixation of Nitrogen through Ammonia is Feeding Two-fifth of World Population

Fertilizers: A Major Scientific Breakthrough in Man’s Ability to Feed Himself

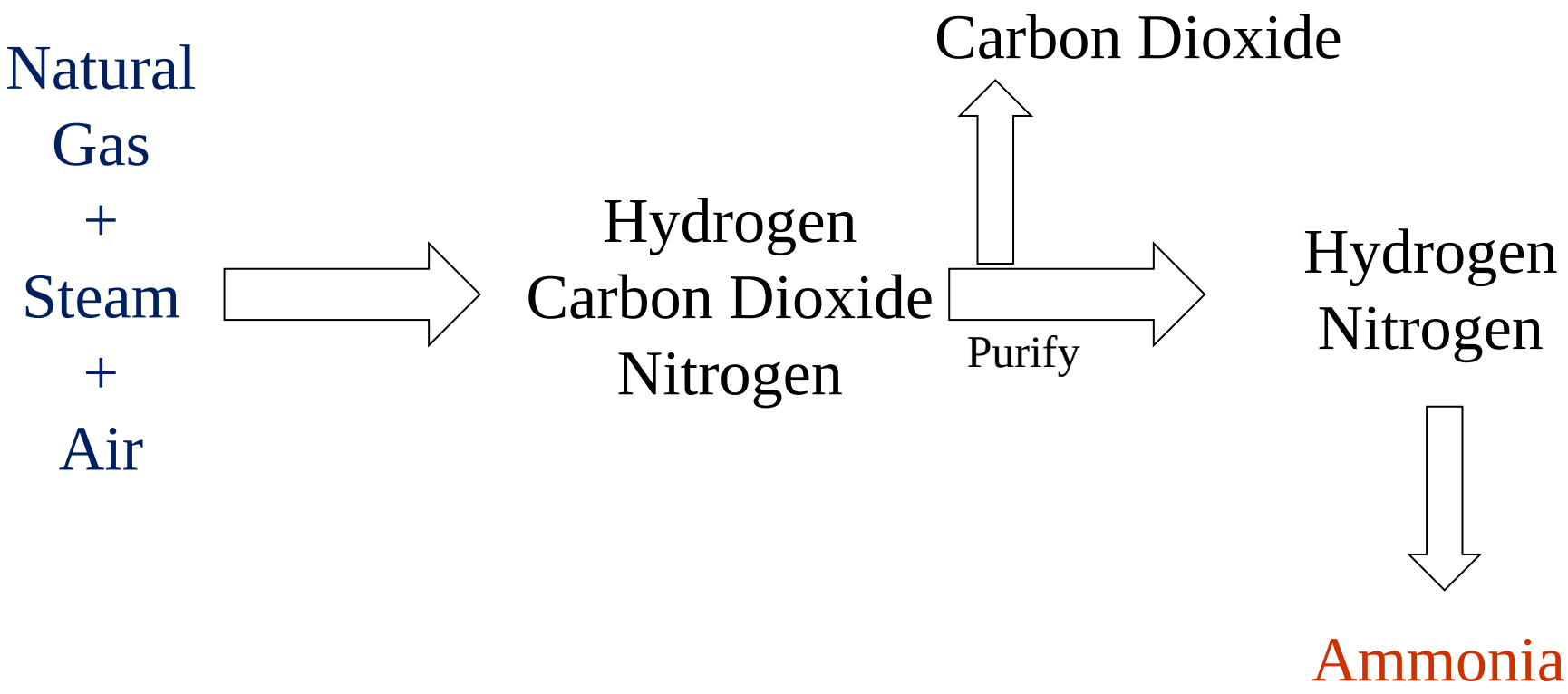
Ammonia

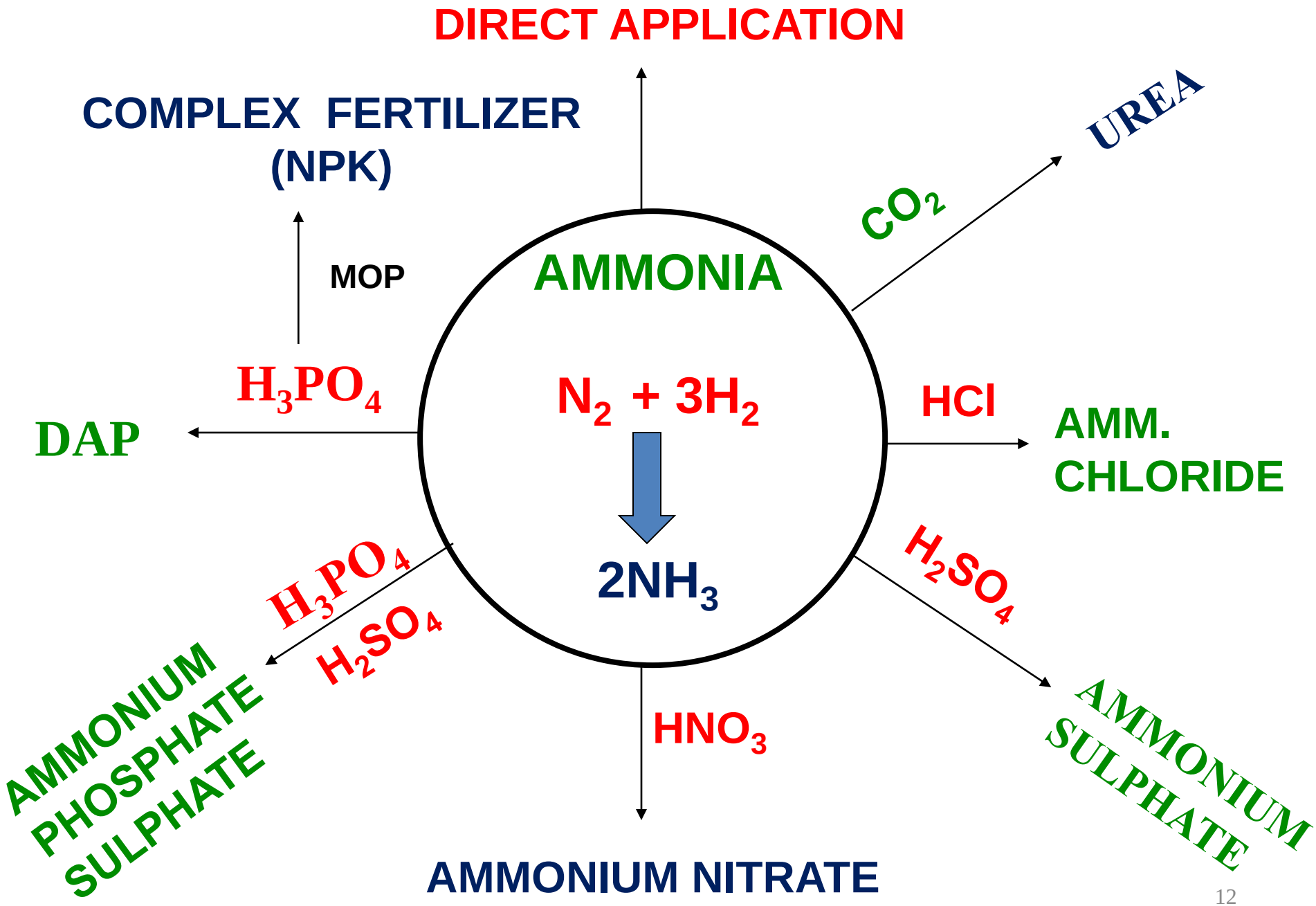
- Ammonia is the second most produced chemical worldwide.
- World ammonia production was 185 million MT in 2021.
- Projected production is 223 million MT by 2030 and 330 million MT by 2050.
- About 85% of ammonia is used to manufacture fertilizers.

Ammonia

- Use of fossil fuels to manufacture ammonia accounts for 1.3% of total GHG emissions.
- Indian ammonia plants generate less than 2.0 MT CO_2 per MT ammonia.
- Most Indian ammonia production is used to produce urea. An average of 1.3 MT CO_2 per MT ammonia is converted to urea.

Production of Ammonia




DIRECT APPLICATION
COMPLEX FERTILIZER (NPK)
MOP
UREA
CO_2
AMMONIA
$N_2 + 3H_2$
$2NH_3$
H_3PO_4
DAP
HCl
AMM. CHLORIDE
H_3PO_4
H_2SO_4
H_2SO_4
AMMONIUM PHOSPHATE SULPHATE
HNO_3
AMMONIUM SULPHATE
AMMONIUM NITRATE

Capacity Buildup of Ammonia Production

Year	Ammonia Capacity (MTPY)	No. of Plants
1980-81	5.7	29
1987-88	8.6	33
1990-91	10.4	40
2001-02	13.7	40
2009-10	14.3	37
2017-18	14.8	37
2019-20	16.4	39
2022-23	19.2	43
2023-24	19.7	44

Notes: 1. There was no new plant for almost 20 years after 1999.

2. Capacity was increased through debottlenecking existing plants.

3. Six large plants have been commissioned in last few years.

Production and Use of Ammonia in India 2022-23 (Provisional)

Sl. No.	Sources of Ammonia	Million Metric Tonnes
1.	Domestic Ammonia Production	17.4
2.	Imported Ammonia	2.3
3.	Ammonia in imported DAP, NP/NPK and Urea	6.6
4.	Total Ammonia Utilized	26.3

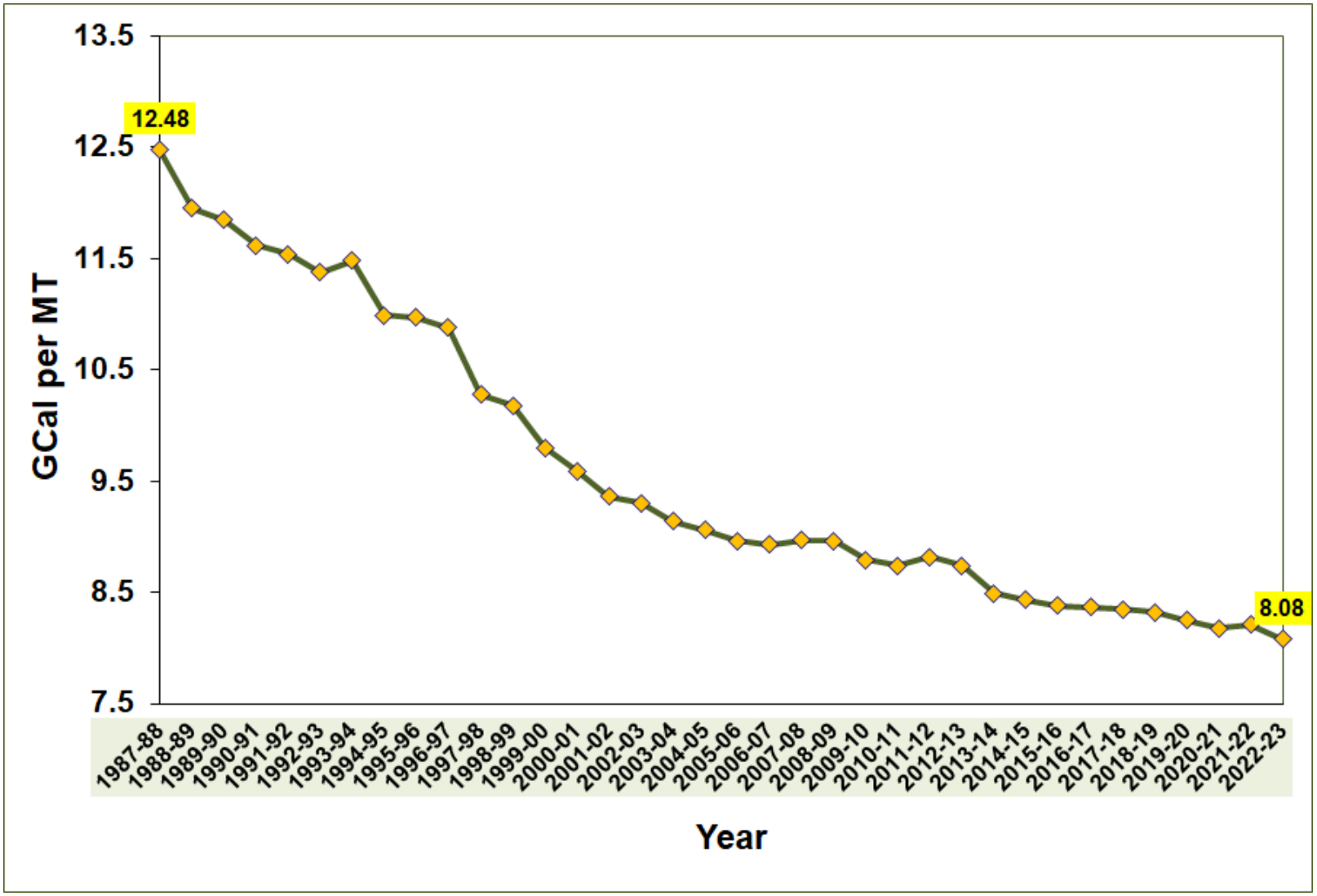
Production and Use of Ammonia in India

- Ammonia production is expected to go upto 19 million tonnes in 2023-24
- More than 95% of domestic ammonia will continue to be used to manufacture urea
- All the imported ammonia is used to manufacture complex fertilizers

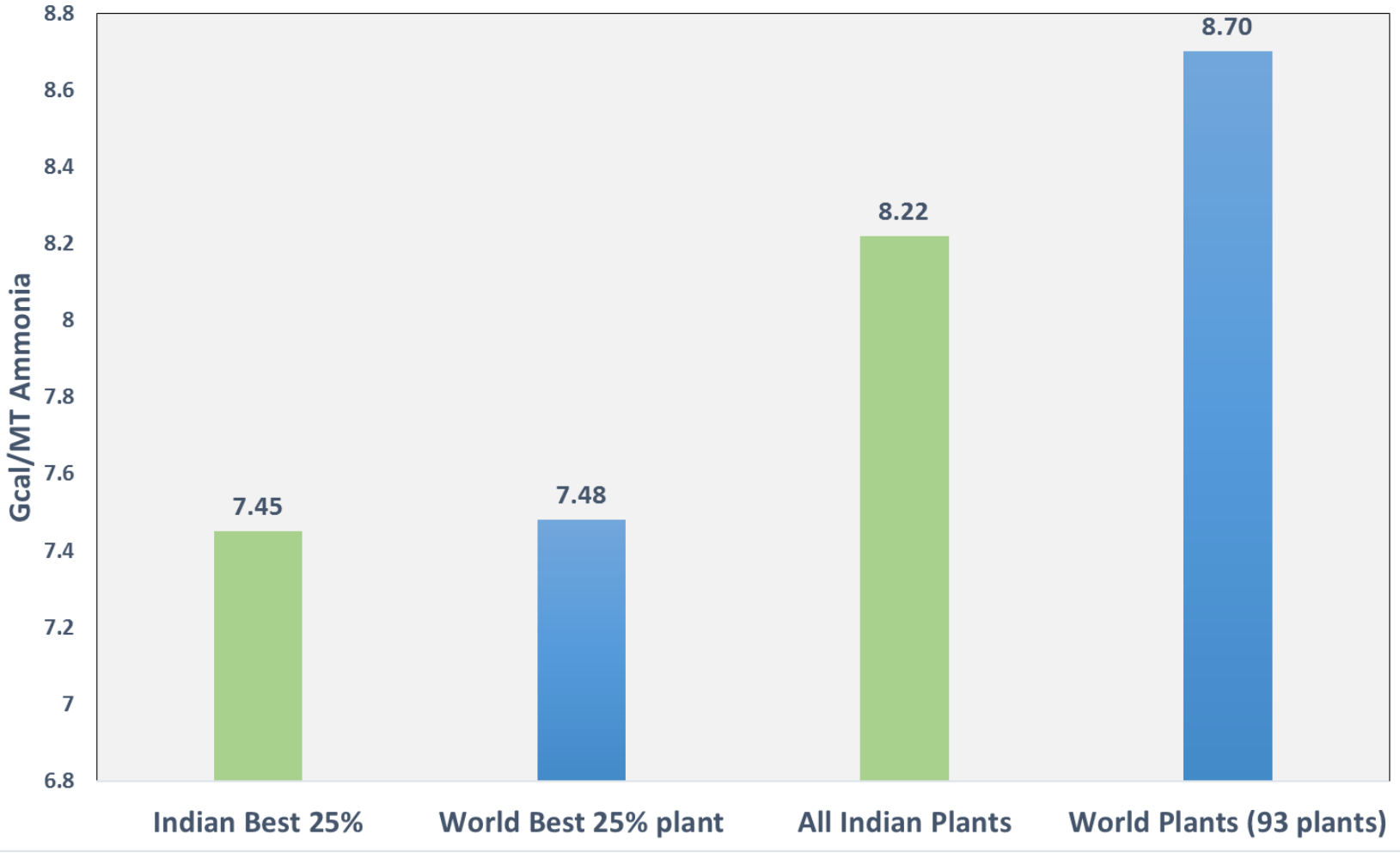
Technological Developments

- Feedstock change from fuel oil/naphtha to natural gas
- High activity catalysts
- Large single stream plants (2200 TPD ammonia, 3850 TPD urea)
- Better process technologies
- Better materials of construction
- Higher efficiency pumps and compressors
- Gas based steam and power generation
- Better design of reactors and heat exchangers
- Automation in process control and optimization of operating parameters
- Recovery and use of waste heat

Trend in Energy Consumption of Ammonia Plants



Benchmarking of Energy Efficiency of Ammonia Plants 2019-2020

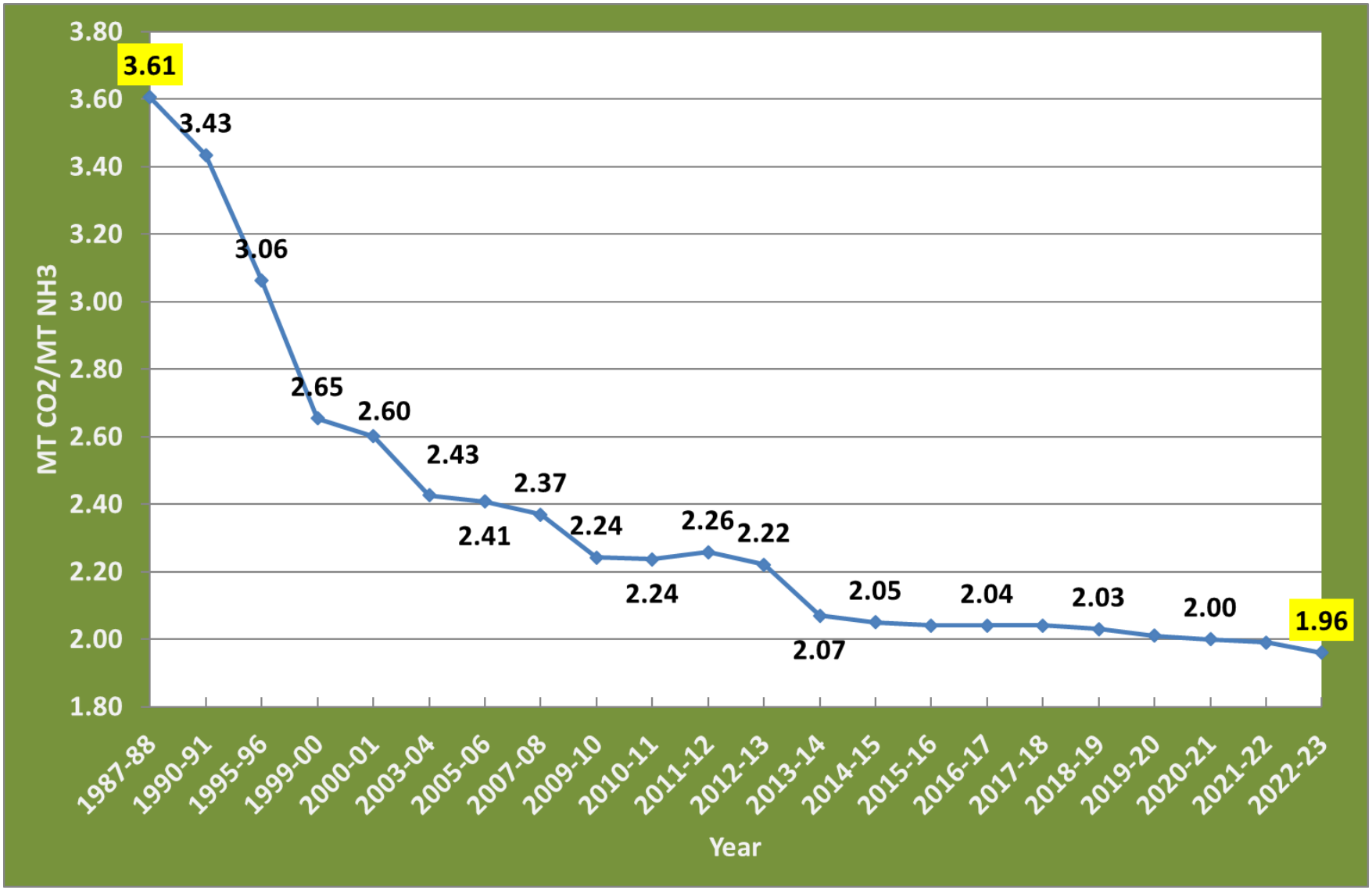


Source: IFA, Paris and FAI, New Delhi

Carbon dioxide Emission from All Indian Ammonia Plants

- Energy consumption data are also used to calculate the carbon dioxide emissions to atmosphere from ammonia plants.
- The total carbon dioxide emission from ammonia plant was reduced from 3.61 MT CO_2/MT ammonia in 1987-88 to 1.96 CO_2/MT ammonia in 2022-23.
- Thus, total CO_2 emission from 19 million Mt ammonia will be 37.2 million tonnes in 2023.
- Part of CO_2 is used for production of urea.

Total Carbon dioxide Emissions from All Indian Ammonia Plants



Note : A reduction of about 46% in CO_2 emission since 1987-88

Green Ammonia

Definitions:

Grey Ammonia : Ammonia produced using fossil fuels e.g. NG, naphtha, fuel oil, coal etc.

Blue Ammonia : Ammonia produced from fossil fuels with carbon capture.

Green Ammonia : Ammonia produced using renewable energy e.g. wind, solar, hydro, etc.

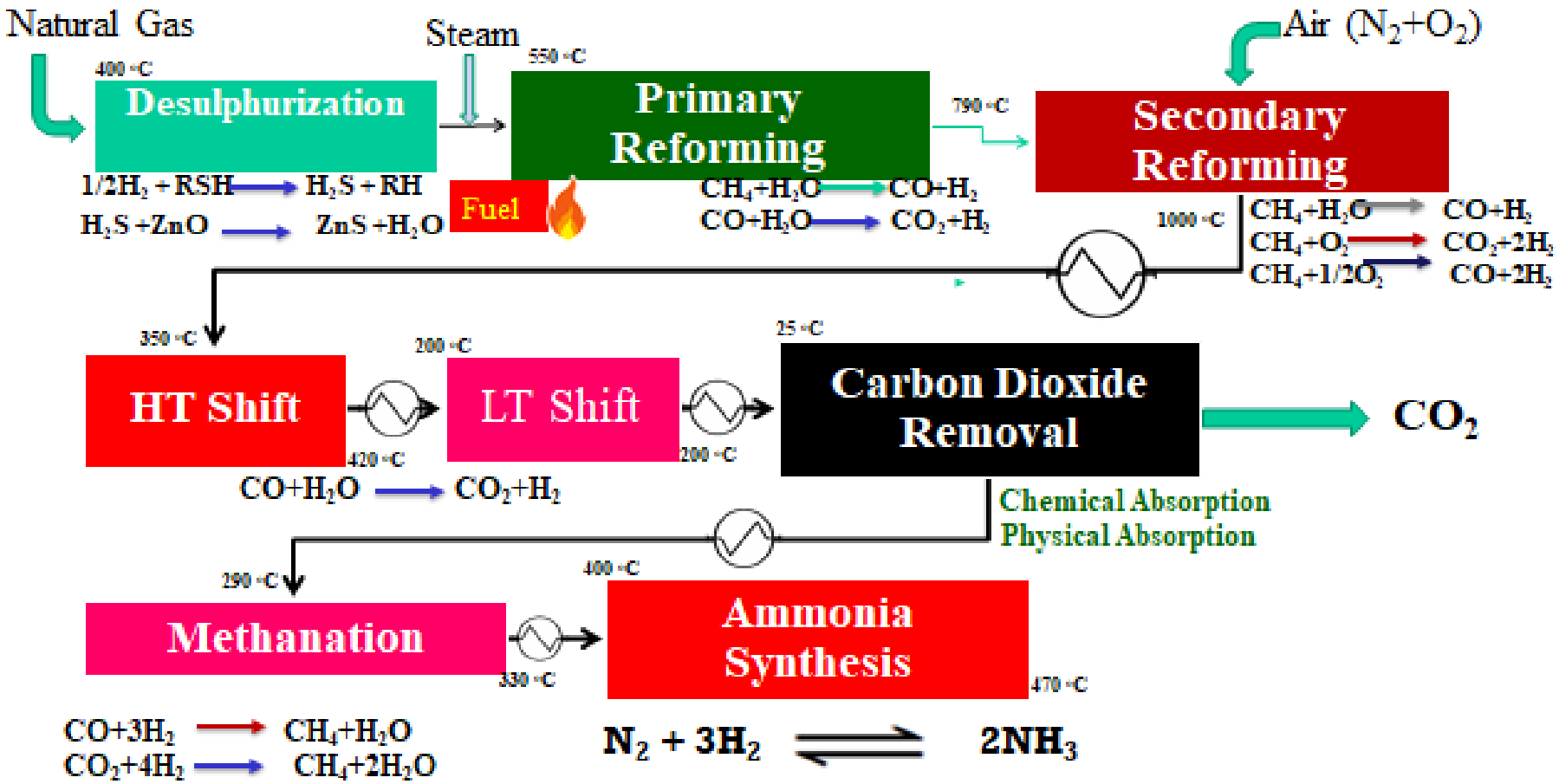
Process for Production of Green Ammonia

1. Electrolysis of water using green electricity to produce hydrogen.

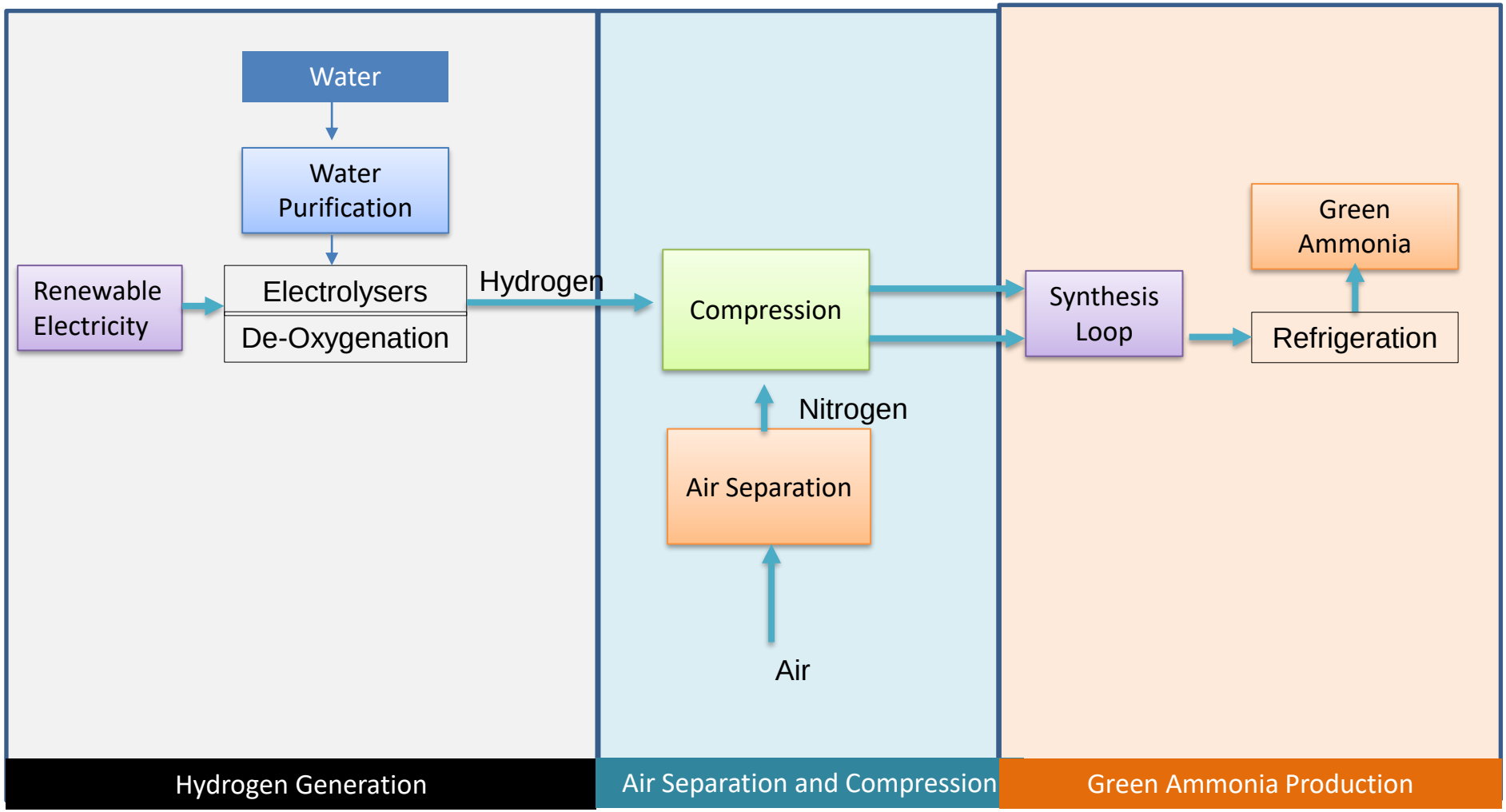
2. Separation of air into oxygen and nitrogen using green power.

3. Synthesis of ammonia using conventional synthesis loop (Haber-Bosch process)

Conventional Ammonia Production



Green Ammonia Production



National Green Hydrogen Mission

- An outlay of Rs. 19,744 crores was approved in 2023.

- It provides for amongst other things incentives for manufacturer of electrolyzers and green hydrogen producers.

Strategic Intervention for Green Hydrogen Transition

- To implement the Mission, a notification was issued on Strategic Interventions for Green Hydrogen Transition (SIGHT) Generation Based Incentive for Green Hydrogen Production on June 2023.

- It has proposed a maximum incentive of Rs. 50/kg production of green hydrogen in 2025-26 and it will be reduced to 80% in 2026-27 and 60% in 2027-28.

Demand Generation

- Under Green Hydrogen Mission, there will be obligations on consuming sectors like refinery, fertilizer and city gas distribution to use Green Hydrogen.

Issues In Transition to Green Ammonia

Technical Issues

- Green ammonia can be right away used for production of non-urea fertilizers.
- For production of urea, CO_2 is required which is produced in situ in grey ammonia production.
- A source of CO_2 will have to be near the ammonia-urea facilities.
- Technologies are available for recovery of CO_2 from flue gases wherever fossil fuels are combusted.
- Existing ammonia plants can be revamped/retrofitted to produce green ammonia partially.

Issues Transition to Green Ammonia

Financial Issues

- There is a viability gap of more than $350-400/MT between cost of green and grey ammonia.
- This gap is not fully addressed by the provisions/incentives provided under Green Hydrogen Mission.
- Carbon credits can offset at least part of the viability gap once carbon trading mechanism is established.
- There is need for large capital investment during transition period.

Issues Transition to Green Ammonia

Policy Issues

- Urea is heavily subsidized (to the extent of 80% of cost) for farmers.
- Reasonable pricing of urea can help to reduce its demand and hence need for its production.
- Pricing policy correction will also help to switch to more efficient products like slow release fertilizers, nano-urea and non-urea products like ammonium sulfate and ammonium phosphates.

Strategy for Transition to Green Ammonia

- All non-urea fertilizer products should be produced using green ammonia.
- Existing ammonia plants should be modified to produce a mix of green and grey ammonia (hybrid production).
- Vintage ammonia plants may be completely replaced with green ammonia plants.
- Viability gap should be appropriately filled either through Green Hydrogen Mission or fertilizer subsidy mechanism or both. Both these mechanism are already existing.

Reduction of CO_2 Emission from Fertilizer Production

S.No.	Action Taken/To be Taken	CO_2 Million MT per Year
1.	Total CO_2 emission for 21.5 million MT of ammonia production/use.	42.1
2.	Potential for reduction in CO_2 emission by further improvement in energy efficiency of existing plants by 2032 (7.2% reduction).	2.0
3.	Potential for reduction in CO_2 emission by replacing 25% of existing ammonia production with green ammonia by 2032	9.3
4.	Replacement of 2.5 million tonnes imported ammonia with green ammonia by 2030.	4.9
5.	Total reduction in CO_2 emission in fertilizer production by 2032 from base year 2023 – A reduction of 39%.	16.2
6.	Potential for reduction in CO_2 emission by further improvement in energy efficiency in existing plants (4%) from production of 9.5 million MT.	0.7
7.	Potential for further reduction in CO_2 emission by replacing additional 25% of existing ammonia with green ammonia by 2050.	8.7
8.	Total reduction in CO_2 emission in fertilizer production by 2050 from base year 2023 – A reduction of 62%.	25.6

Balance sheet of Carbon dioxide Emission (million tonnes)

2023		
1.	Total CO_2 emission from production/use of 21.5 MMT grey ammonia	42.1
2.	Of which CO_2 used for production of 30 MMT urea	22.2
3.	Net CO_2 emission	19.9
2050		
1.	Total CO_2 emission from production/use of 9.5 MMT of grey ammonia	16.6
2.	Of which CO_2 used for 20 MMT urea	14.8
3.	Net CO_2 emission	1.8

Assumptions:

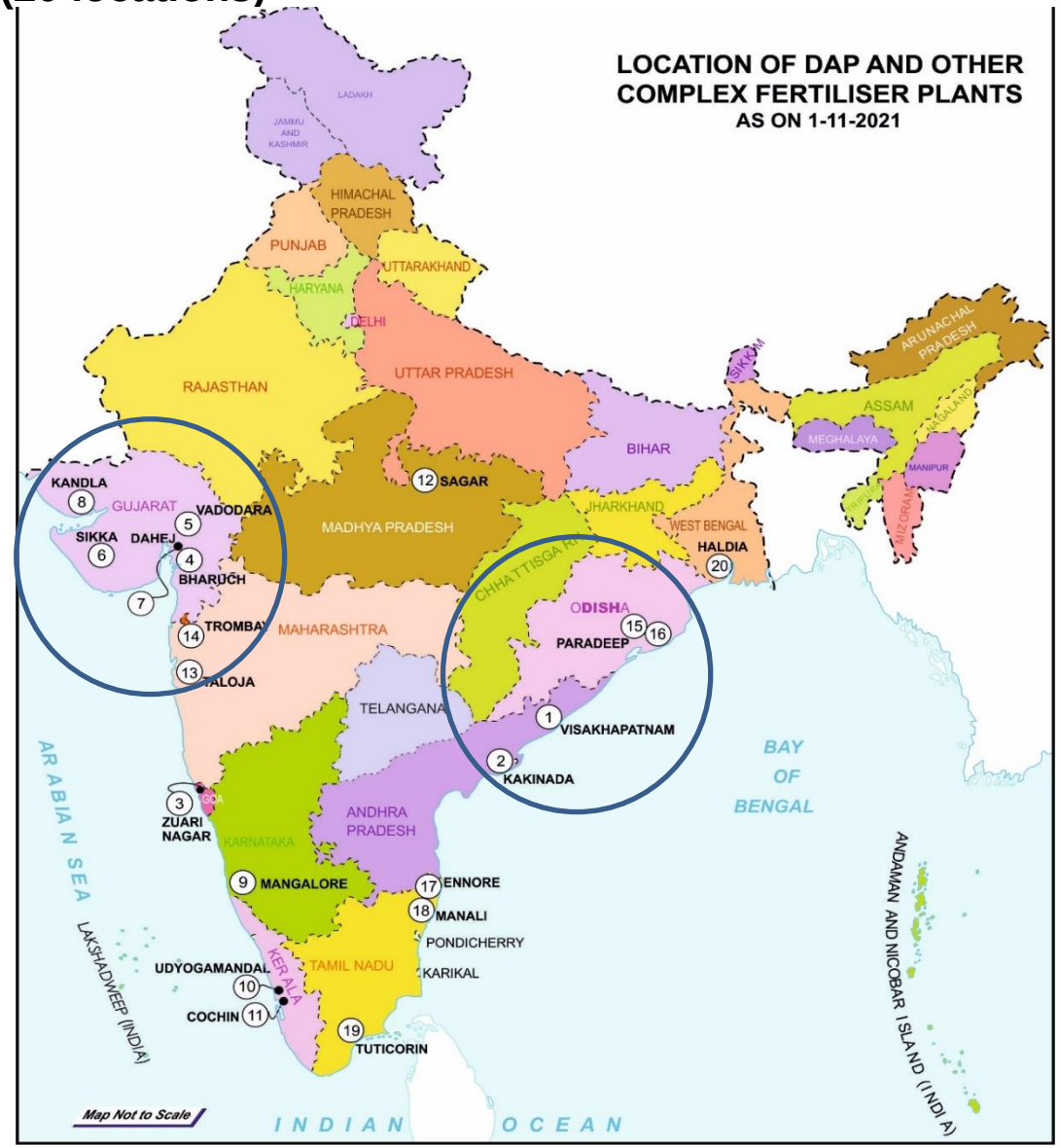
1. Urea consumption will be reduced to 20 MMT in 2050 by
   (i) Other fertilizer products manufactured from green ammonia.
   (ii) Higher nitrogen efficiency from use new and innovative products and better farm practices.

2. CO_2 emission in grey ammonia plants 1.75 MT/MT by 2050 due to improvement in energy

Location of Green Ammonia Plants

Proximity to complex fertilizer plants (20 locations)

Sl. No	Locations
1	Kandla, Gujarat
2	Sikka, Gujarat
3	Dahej, Gujarat (now closed)
4	Vadodara, Gujarat
5	Bharuch, Gujarat
6	Trombay, Maharashtra
7	Taloja, Maharashtra
8	Goa
9	Mangalore, Karnataka
10	Udyogmandal, Kerala
11	Cochin, Kerala
12	Tuticorin, T.N.
13	Manali, T.N.
14	Ennore, T.N.
15	Kakinada, A.P.
16	Vizag, A.P.
17 & 18	Pradeep, Odisha
19	Haldia, W.B.
20	Sagar, M.P.



Location of Green Ammonia Plants

- Almost all ports on west and east coast have ammonia handling facilities.
- These facilities are at present used for import of ammonia and same can be used for export of green ammonia.

Other Uses of Ammonia

- Nitric Acid – Ammonia Nitrate – Explosives
- Refrigeration
- Chemical, Pharmaceutical and other industries
- NO_x abatement
- Other Potential Uses
  - Marine Fuel
  - Fuel for Power Generation
  - Carrier of Hydrogen/Energy

Way Forward

- Several commercial plants for production of green hydrogen based on different electrolysis technologies are proposed including at coastal locations.
- Construction of Green Ammonia plants next to green hydrogen/fertilizer plants.
- Replacement of grey ammonia with green ammonia used for manufacture of fertilizer products other than urea right away.
- Replacement of 10-20% grey with green ammonia for manufacture of urea in near term.
- Realistic viability gap funding for at least initial 5 years of transition to green hydrogen/green ammonia.