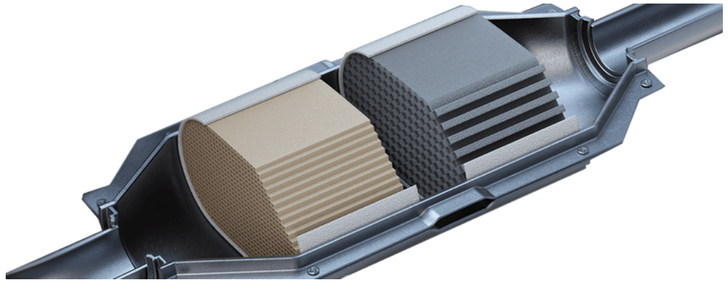
Catalysis 2.0 Project

“Decarbonization with focus on Sustainable Chemistry”

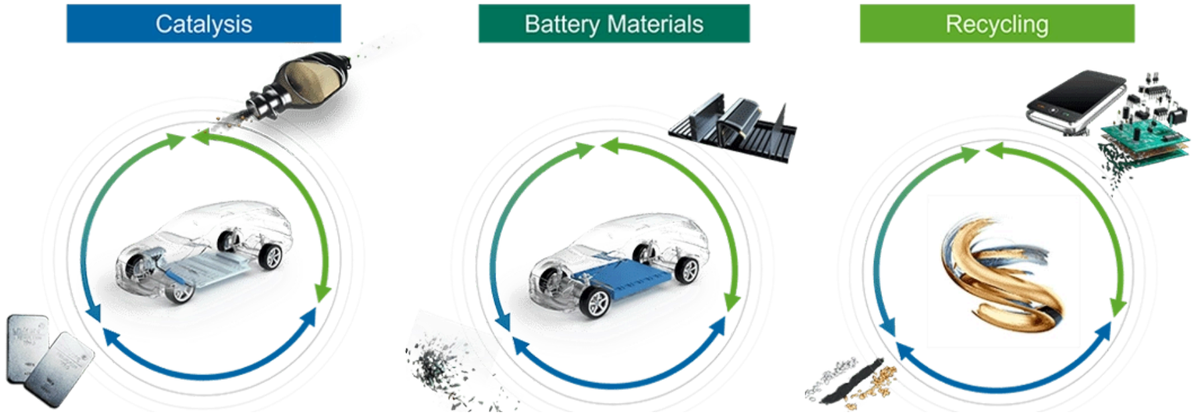
Aditya Deep, 22CH10003

About Umicore



Chemical Manufacturing Company
Headquarter: Brussels, Belgium

Circular Materials Technology:
precious metal refining, catalyst, battery material, recyling ...



Umicore Autocat Pvt. Ltd.

Shirwal, near Pune

Produces key catalysts such as three-way catalyts, particulate filters, NO2-reduction catalysts and more

Supplier to Major OEMs like TATA, Hyundai, etc

About the Role

Project Title:

Catalysis 2.0 “Decarbonisation with focus on Sustainable Chemistry”

Objective:

To map technologies and value chains, of India’s decarbonization approach relating to Sustainable chemistry market

Duration:

12-Weeks

Interface:

India and Global Team

Focus Areas:

Green Hydrogen Value Chain

Green Methanol

Point Source Capture

Direct Air Capture

Carbon Utilization

Mentors

Mr. Rajesh Maynal

Head, Product Management

Mr. Kedar Rele

Head, Business & Strategy

Goal

- Energy Independence by 2047
- Net Zero by 2070

Fossil Fuel

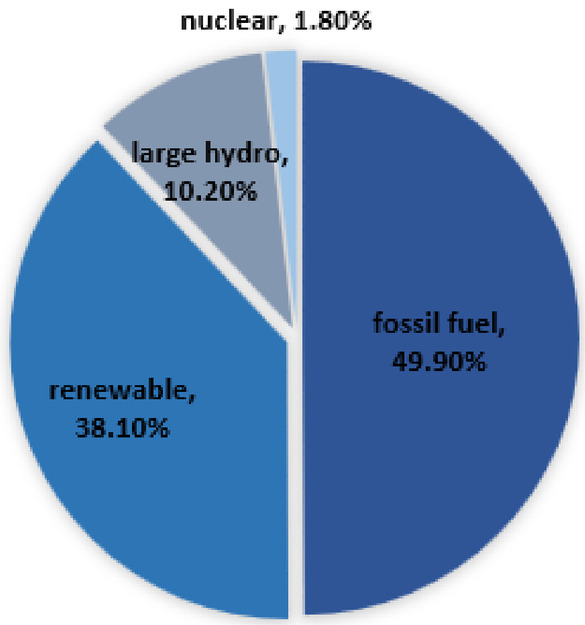
Coal	44.3%
Gas	4.1%
Lignite	1.4%
Diesel	0.1%

Renewables

Solar PV	24.0%
Wind	10.7%
Biomass	2.3%
Small Hydro	1.1%
Waste to Energy	0.2 %

Installed Electricity Generation Capacity

TOTAL: 484.8 GW



Energy Scenario

- energy use has doubled in the last 20 years
- to grow by at least another 25% by 2030
- imports 45% of primary energy requirement worth over 100 billion USD
- imports 17% coal, 85% crude oil, 44% natural gas, and 95% methanol

abundant renewable energy resources

- fastest growing renewable energy capacity in the world
- grown 2.74 times over last 10 years
- 76.37 GW in 2014 to 209.44 GW in 2024
- commitment to 500 GW by 2030

National Green Hydrogen Mission

- demand creation for domestic need and exports
- direct production linked financial incentives
- ecosystem for scaling and development

Direct financial incentive SIGHT for

- green hydrogen production
- electrolyser manufacturing

Sectors Under Focus

- Green Steel: provisions of carbon credit & barrier imposition
- FCEV buses and trucks, locomotives etc
- Shipping: green hydrogen/ammonia fuelled vessels

Financial Outlay: 2.4 billion USD

SIGHT	2.100 billion USD
Pilot Projects	0.180 billion USD
R&D	0.048 billion USD
Hubs and others	0.047 billion USD

Expected Outcomes by 2030, under National Mission

- Total 15 MMTA of green hydrogen production
  - domestic use, 5MMTA/60GW
  - aiming 10% of global market. i.e., 10 MMTA
- 50 MMTA CO_2 Avertion
- RE addition by 125 GW
- leverage total investment of 95 billion USD
- 0.6 million job creation
- by 2024-35, substiute all Ammonia based fertilizer imports

Green Hydrogen Application

- replace fossil-fuel derived/grey hydrogen feedstock in
  - petroleum refining: 2.1 MMTA
  - ammonia production: 2.7 MMTA
  - steel industry: 1 MMTA
  - equivalent to market size of USD 11 billion
- hydrogen fuelled long-haul automobiles and marine vessels
- blending green hydrogen in City Gas Distribution system
- green hydrogen derived synthetic fuels

Fertilizer Imports

- import 10 MMT Urea, 5 MMT DAP and 3 MMT Ammonia
- worth 6 billion USD

Energy Imports

- 45% of Primary Energy Resouces
- worth over 100 billion USD

Electrolysers Investment

- Electrolyser consitute 30-40% of the total cost of green hydrogen, rest is reneweable energy and storage systems
- 550 million USD for domestic electrolysers manufacturing

Electrolyser Market

- Domestic Market
  - 20 GW by 2030
  - 226 GW by 2050
- Global Market
  - 590 GW by 2030
  - 3300 GW by 2050

investment of USD 47–71 million/GW needed for electrolyser manufacturing

Electroylser Manufacturing Capacity

Domestic

- 0.5 GW in 2021 & 1.5 GW in 2023
- by 2030
  - 2.4 GW per planned projects
  - 10 GW per announced capacity

Global

- 8 GW in 2021 & 21.5 GW in 2023
- by 2030
  - 60 GW as per commitments

umicore

Electrolyser Production offers under SIGHT		
TOTAL CAPACITY: 3000 MW		
T1 B1	Any Stack	1200 MW
T1 B2	Indigenous	300 MW
T2 B1	Any Stack	1100 MW
T2 B2A	Indigenous	300 MW
T2 B2B	Indigenous Smaller Units	100 MW
base incentive USD 55/kW in 1st year & taper annually		

Non Incentivised Projects

- Besides there are Non-Sight electrolyser manufacturing projects
- Many other are importing electrolysers or working with OEMs outside India

TRANCHE 1	
Bucket 1 (MW)	
Reliance	300
John Cockerill	300
Jindal	300
Ohmium	137
Advait	100
L&T	63
Bucket 2 (MW)	
Adani	198.5
Homihydrogen	101.5

Ohminum being only one with PEM, rest Alkaline

TRANCHE 2	
Bucket 1 (MW)	
Waaree	300
Newage	300
Avaada	300
Matrix	237
Advait	200
Ohmium	137
GH2	105
Bucket 2A (MW)	
Newage	300
Adani	101.5
Bucket 2B (MW)	
Adani	30
Eastern	30
Newtrace	30
Suryashish KAI	30

PEM Production in India

- cost of a PEM electrolyser system around 359 USD/kW
- material cost 138 USD/kW, rest manufacturing and BoP
- Nafion Membrane and carbon cloth constitute 60% of stack cost

Potential Indigenisation

- Cathode PTL (carbon cloth)
- Anode PTL (gold coating)
- CCM Manufacturing

To be imported

- Anode PTL material (Titanium)
- CCM material (Nafion, Pt, Ir, ionomer, Ru)

Alkaline Production in India

- cost of a Alkaline electrolyser system around 323 USD/kW
- material cost 100 USD/kW, rest manufacturing and BoP
- Zirfon membrane is only directly brought-out
- extra cost of hydrogen compressor needed

Potential Indigenisation

- BPP manufacturing (Ni coated steel)
- PTL, anode and cathode manufacturing

To be imported

- PTL material (Ni foam)
- Cathode (Ni & Mo), anode (Ni) raw material
- Zirfon (membrane)

SOE Production in India

- cost of a SOE electrolyser system around 344 USD/kW
- material cost 104 USD/kW, rest manufacturing and BoP
- 60% stack cost for electrolyte- interconnect

Potential Indigenisation

- end plate, Ba-based sealant, Interconnect (ferritic steel)
- NiO/CGO, LSCF, SSZ (cathode, annode, electrollyte manufacturing)

To be imported

- Ba-based glass-ceramic sealant
- NiO/CGO, LSCF, SSZ (raw material)

About 60% already indigenous, potential indigenisation of 25% and materials to be imported due to limited reserves is 15%

R&D- Mission Mode Proposals (0-5 years)

- develop domestic modular electrolysers
- Type III / IV compressed hydrogen cylinders
- Proton Exchange Membrane fuel cells
- commerical biomass hydrogen generation

R&D- Grand Challenge Proposals (0-8 years)

- manufacture critical electrolyser & fuel cell compo
- MEAs, Electrocats, CCMs, GDLs, biopolar plates, etc
- improve their effectiveness and reduce cost

R&D- Blue Sky Projects (0-15 years)

- development of 3rd gen electrocat, BNS, BNCs etc
- reversible SOECs and SOFCs, thermochemical waterspliting, seawater electrolysis, therocat pyrolysis
- plasma pyrolysis, salt cavern surveys, high entropy alloys for hydrogen storage

Bhabha Atomic Research Centre

- AWE and PEM based electrolysis
- thermo-chemical splittinglike I-S process
- High-Temp Steam Electrolysis, Copper-Chlorine Cycle & Hybrid Sulphur
- photocatalytic hydrogen generation

CSIR CERI

- photochemical oxidation of water using molecular catalyst
- water oxidation by functional electro-catalysts and novel composite electrolytes
- seawater electrolysis using reduced Titania

IOCL R&D

- oxy-steam biomass gasification
- solar-powered electrolysers
- bio-CNG reforming-based generation

IIT KGP

- 10000-litre pilot scale dark fermentation from organic waste and groundnut deoiled cake

CSIR IICT

- dar fermentation from biogenic waste like vegetable waste, distillery waste etc
- pilot bioreactor with 10 m^3 capacity producing 50 m^3 per day

TERI

- 1000-litre scale dark fermentation from sugar cane blackstrap molasses
- 150-litre scale dark fermentation using microbe from woody biomass

Methanol Source

- currently produced through coal gasification and natural gas reforming
- 1 tonne of methanol requires approx 1.5 tonnes of coal or 0.69 tonnes of NG

Methanol Usecase

- feedstock in paint & pharma
- raw material in plastic industries
- energy application
- wastewater and effluent treatment

Methanol Market

- annual demand 2.97 MMTA (2022-23)
- domestic production 0.7 MMTA relying on imported NG
- rest imports worth 0.86 billion USD
- to rise to 4.1 mtpa by 2030

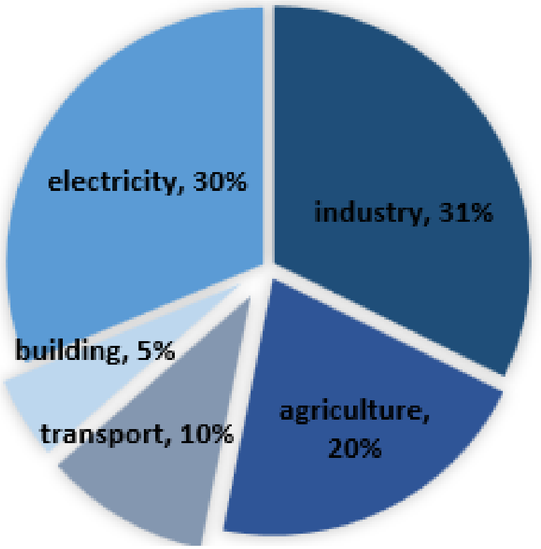
Major Projects- Green Methanol

- Vindhyahcal Thermal Power Plant
  - NTPC with Jakson Green
  - plant capacity 10 TPD
- Singareni Thermal Power Station
  - with Ohmium, PEM tech
  - plant capacity 180 kg/day (exp.)
  - planned 8000 TPD
- AM (Greenko) Green and DP World
  - 1 MTPA green methanol for export
  - GAIL supplying 350 KTPA of CO_2
- NPTC Pudimakad Hub
  - 7500 TPD derivates
- ReNew E-Fuels Private Limited
  - 500 KTPA in Malkangiri
  - 300 KTPA in Rayagada
- NTPC and GACL (GJ)
  - 75 TPD green methanol

Carbon Emission Background

- 3rd largest emitter of CO_2 after US and China
- 2.6 gtpa in 2019 and expected to cross 4 gpta by year 2030
- share of emission to increase from current 8% to 14% in 2050

Sector- Wise Contribution



Necessity

- to limit global temperature rise between 1.5 to 2^0 C according to Paris agreement
- even with increasing reneweable share, baseload demand to be mate by fossil fuels
- sustence of existing emitters with less than 15 years of age
  - 219 GW coal based power capacity
  - 144 mtpa crude based steel capacity

Market

- Indian carbon capture and storage market reached 97.08 million USD in 2024
- to reach 195.36 million USD by 2033, with CAGR of 8.08% (IMARC Group)
- India's decarbonization jouney will need 150-200 billion USD through 2050

Major Projects

JSPL Angul

- GOI Incentivised CCU Steel Project
- Carbon Capture as part of iron prod.
- Rectisol and MDEA plant
- 3000 TPD CO2 Capture Capacity
- Lurgi (Air Liquide) Cold Methanol based physical CO2 absorption
- Tertiary Amine based CO2 Recovery proces in DRI plant
- Tata Steel Jamshedpur another example

New Era Cleantech Solution

- GOI Incentivised CCU Coal Project
- Coal Gasification to produce methanol
- 3000 TPD CO2 to produce 1 MMTPA green methanol

Dalmia Cement, Tamil Nadu

- CCU Cement Plant Project
- with Carbon Clean CDRMax Tech
- Captue 0.5 MT CO2 year and Utilization

Turticorin Alkali

- CCU Fertilizer Plant Project
- JV Carbon-Clean (CycloneCC tech)
- capture 60 kTPD CO2
- to produce Green Soda Ash

NTPC Vidhyanchal

- CCU Thermal Power Plant Project
- JV Carbon-Clean (CDRMax™ tech) and Green Power Int. Pvt Ltd
- capture 20 TPD CO2 of Power Plant
- produce 10 TPD methanol through catalytic hydrogenation

Power and Industries Emissions

	2020 (mtpa)	2030 (mtpa)
Power	1004	1210
Upstream	125	177
Iron & Steel	240	450
Cement	196	325
Grey H2	56	102
Coal Gasi.	-	27
total	1621	2291

- contributes to 60% of total emissions
- to grow 1.5 times in 10 years

Coal Gasification - Sunrise Sector

- Coal Gasification Incentive Scheme
- key to energy & material security, given India's rich endowments of coal

Direct Air Capture India Market

- valued at modest 3.2 million USD in 2024
- expected to grow to 52 million USD by 2030
- India's share of Global Market being 3.3%
- CCUS market being larger and growth forecast more robust for India
- growing number of Indian and Mulitnational coperations looking for carbon credicts

DAC Tech

- In India, the Solid-Sorbent DAC being the choice
- accounts for 87.5% of market revenue in 2024

Challenges

- high capture cost barrier to commerical viability
- lack of dedicated infrastrucutre
- Nascent policity framework or financial incentive

Stakeholders

- Center of Excellence at IIT Bombay, JNCASR

Startups

- UrjanovaC
  - backed by IIT Bombay
  - recognised by Elon Musk Foundation
  - pilot plant of 3 TPD
  - aqueous-based CO2 capture tech
- GreenGine
  - backed by IIT Kanpur
  - Collab with IOCL for Point Source
  - Collab with EIL for DAC
  - Microalgae based solution
- UGreen Technology
  - tech for pre, post and DAC
  - backed by Oil India and IITs

Conclusion

- There is recognized 15% import dependency for critical materials, specifically PGM catalysts (Pt, Ir) & CCMs
  - Position as the primary supplier of high-performance catalysts and CCMs to the SIGHT scheme winners
  - Invest in a local catalyst/CCM finishing plant to align with the "Make in India" policy and secure long-term supply contracts.
  - Partner with Indian R&D hubs (IITs, CSIR) to co-develop next-generation, low-PGM electrocatalysts
- Demand for methanol synthesis and CO_2 hydrogenation catalysts
  - Act as a catalyst technology partner for major industrial players to maximize the efficiency of their CCU and methanol plants
  - Aggressively market and supply specialized catalysts for methanation and CO_2 conversion
- First-Mover Advantage in Urban Mining (Recycling)
  - Invest in a state-of-the-art recycling facility in India to recover PGMs from end-of-life clean energy hardware
  - Offer customers a "Closed-Loop" service—bundling the sale of fresh catalysts with a guaranteed buy-back

Key Learnings

Technical Exposure:

- Gained understanding of Green Hydrogen, Electrolysers, Green Methanol, CCU technologies
- Developed awareness of technology readiness levels (TRLs) and current limitations

Industrial Perspective:

- Insight into intersection of technology, policy, market dynamics
- Exposure to value chain considerations: research, procurement, production, logistics

Profesional Skills:

- Collaboarated with cross functional teams at India and Global interface
- Documentation, reporting and presentation skills
- Acquired exposure to corporate workflows

Soft Skills:

- Strenghtened communication skills while interacting with supervisors and colleagues
- Improved time management under deadlines
- Built adaptability and confidence in new environments

Thank You