Umicore AutoCat India Private Limited
Satara, India

Internship Report

Title: Indian market 'decarbonization' opportunity with focus on Sustainable chemistry

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About the Company

Umicore is a Belgium-based materials technology company specializing in catalysts, battery materials, precious metal refining, and recycling. It is a global leader in automotive emission-control systems, producing technologies such as three-way catalysts, particulate filters, and NOx reduction systems that support cleaner mobility.

In India, **Umicore Autocat Pvt. Ltd**. runs a manufacturing plant at Shirwal, near Pune. The facility produces key catalysts for major OEMs like Tata and Hyundai and supports compliance with Bharat Stage emission norms.

The Shirwal plant is certified for environmental and safety standards (ISO 14001, ISO 45001) and combines Umicore’s global expertise with local demand, making it an important contributor to India’s efforts in reducing vehicular emissions.

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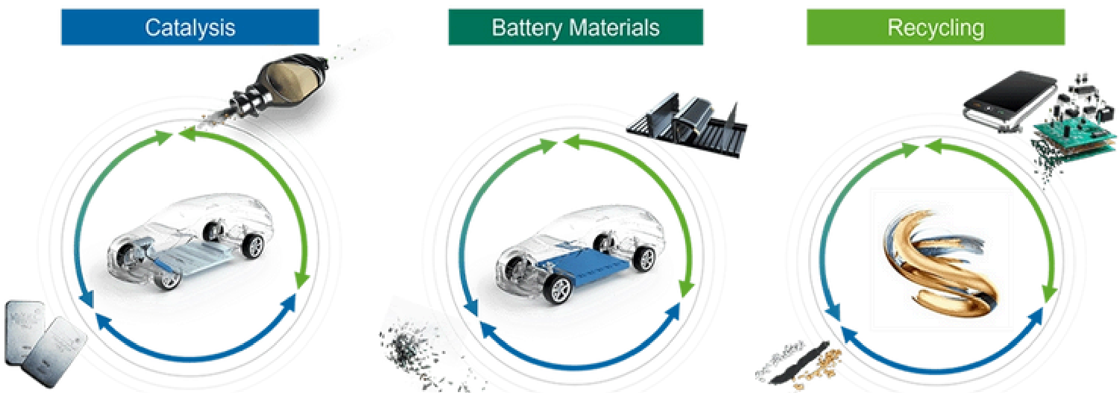

About the Project

The project titled “**Catalysis 2.0 – Decarbonisation with focus on Sustainable Chemistry”** aimed to study and map technologies and value chains relevant to India’s decarbonization efforts in the sustainable chemistry sector. The work involved close coordination with both Indian and global teams to ensure alignment with broader strategies.

The focus areas included emerging solutions such as the green hydrogen value chain, green methanol, point source capture, direct air capture, and carbon utilization, all of which are central to reducing carbon emissions and advancing sustainable industrial practices.

The project was carried out under the guidance of mentors Mr. Rajesh Maynal (Head, Product Management) and Mr. Kedar Rele (Head, Business & Strategy), providing a blend of technical and strategic perspectives.

Key Findings

Energy Scenario:

Current Energy Mix and Fossil Fuel Dominance

The nation's current installed electricity generation capacity is 484.8 GW. The energy mix is almost evenly split, with fossil fuels comprising 49.9% of the total. Within this category, coal is the dominant source, accounting for 44.3% of the entire nation's capacity.

The Challenge of Import Dependency

This heavy reliance on fossil fuels creates a significant energy security challenge. The country imports 45% of its primary energy, costing over 100 billion USD. This dependency is particularly stark for crucial resources, with imports accounting for 85% of crude oil and 44% of natural gas requirements.

The Shift to Renewables and Future Goals

In contrast, the renewable energy sector represents a growing portion of the mix at 38.1%, led by Solar PV (24.0%) and Wind (10.7%). This sector is one of the fastest-growing in the world, having expanded 2.74 times over the last decade. This rapid transition is driven by ambitious national goals to achieve energy independence by 2047 and net-zero by 2070, supported by a commitment to reach 500 GW of renewable capacity by 2030

Green Hydrogen:

Mission Overview and Financial Strategy

The National Green Hydrogen Mission is a comprehensive national strategy aimed at creating an ecosystem for the production, use, and export of green hydrogen. The initiative is supported by a total financial outlay of $2.4 billion USD. The vast majority of this funding, $2.1 billion, is dedicated to the SIGHT program, which will provide direct financial incentives to kickstart the industry.

Strategic Focus and Target Sectors
The mission's core strategy focuses on stimulating both supply and demand. On the supply side, it offers direct incentives for green hydrogen production and the domestic manufacturing of electrolysers. On the demand side, it targets the integration of green hydrogen into hard-to-abate sectors. Key focus areas include Green Steel production, deploying FCEV buses and trucks, and transitioning the shipping industry to green hydrogen and ammonia-fueled vessels.

Expected Outcomes and National Impact by 2030
By 2030, the mission is expected to yield significant environmental and economic benefits. The primary goals include establishing 15 MMTPA of green hydrogen production capacity (aiming for a 10% global market share), achieving 50 MMTA in CO2 emission reductions, and facilitating the addition of 125 GW of renewable energy. Furthermore, the mission is projected to leverage a total investment of $95 billion, create 0.6 million jobs, and fully substitute all ammonia-based fertilizer imports.

Green Hydrogen Applications and Market Potential
Green hydrogen is targeted to replace fossil-fuel-derived hydrogen in several key industrial processes, creating an immediate market opportunity estimated at $11 billion. The primary applications include petroleum refining (requiring 2.1 MMTPA), ammonia production (2.7 MMTPA), and the steel industry (1 MMTPA). Beyond these, green hydrogen is also planned for use as a fuel in long-haul automobiles and marine vessels, for blending into City Gas Distribution systems, and for creating synthetic fuels.

Strategic Importance for Import Reduction
The push for domestic green hydrogen, particularly for ammonia production, is a strategic move to reduce significant import dependency. The nation currently imports fertilizers worth $6 billion, including 3 million metric tonnes of ammonia. This is a component of the broader energy import challenge, where 45% of all primary energy resources are imported at a cost exceeding $100 billion, highlighting the economic imperative for energy self-sufficiency.

Electrolysers:

The Electrolyser Market and Investment Outlook

Electrolysers are a critical component, constituting 30-40% of the total cost of green hydrogen. The market for this technology is projected to expand dramatically, with domestic demand expected to grow from 20 GW by 2030 to 226 GW by 2050. To facilitate this growth, an investment of $47-71 million is needed for every GW of manufacturing capacity, and a dedicated fund of $550 million has been allocated for establishing domestic electrolyser manufacturing.

Scaling Up Manufacturing Capacity

To meet future demand, domestic electrolyser manufacturing capacity is set for a major expansion. From a base of 1.5 GW in 2023, announced projects are expected to increase domestic capacity to over 10 GW by 2030. This national ambition is part of a global ramp-up, with worldwide manufacturing commitments aiming for a collective capacity of 60 GW by 2030, positioning the domestic industry within a rapidly growing and competitive global market.

The SIGHT Program for Electrolyser Production

Under the Strategic Interventions for Green Hydrogen Transition (SIGHT) program, the government is directly incentivizing the production of 3000 MW of domestic electrolyser manufacturing capacity. The program provides a base financial incentive of $55 per kilowatt in the first year, which will taper down annually. This initiative is designed to build a robust and self-reliant supply chain for the critical components needed for green hydrogen production.

Structure of the Incentive Scheme

The total 3000 MW capacity is allocated across two tranches, which are further divided into buckets with specific criteria. These buckets differentiate between manufacturers using any stack technology and those developing purely indigenous technology, with a dedicated sub-category for smaller indigenous units. This tiered structure is intended to encourage both large-scale, technology-agnostic manufacturing and the growth of local innovation in the electrolyser space.

Key Awardees and Technology Focus
Several major industrial players secured capacity through the bidding process. In the first tranche, companies like Reliance, John Cockerill, and Jindal were among the largest winners. The second tranche saw firms such as Waaree, Newage, and Avaada win significant allocations. Notably, Adani secured capacity in buckets dedicated to indigenous technology. The allocations also reveal a technological trend, with the majority of awardees focusing on Alkaline electrolysers, while Ohmium stands out as a key manufacturer of PEM technology.

The Broader Market Context
The SIGHT program is a critical catalyst, but it does not encompass the entire electrolyser manufacturing landscape in the country. The infographic notes that there are non-incentivized projects operating outside of this scheme. Additionally, many companies continue to meet their requirements by importing electrolysers or collaborating with international Original Equipment Manufacturers (OEMs), indicating a diverse market with multiple avenues for sourcing technology.

Current and Potential Indigenisation Levels
An analysis of electrolyser production in India indicates a strong existing manufacturing base, with approximately 60% of the components and processes already being indigenous. There is a clear potential to increase this self-reliance by an additional 25% through targeted domestic manufacturing of specific components. However, a persistent 15% of the required materials are expected to remain import-dependent, largely due to the limited domestic reserves of essential raw minerals.

Comparative Cost and Component Breakdown
A cost comparison of the three primary electrolyser technologies reveals Alkaline systems to be the most economical at approximately $323/kW, followed by Solid Oxide Electrolysers (SOE) at $344/kW, and PEM systems at $359/kW. Across all types, direct material expenses account for only a portion of the total cost—ranging from $100 to $138 per kilowatt—with the majority of the cost stemming from manufacturing processes and the Balance of Plant (BoP).

Indigenisation Paths for PEM and Alkaline Systems
For PEM electrolysers, future indigenisation efforts can target the manufacturing of the Cathode Porous Transport Layer (PTL) and the Catalyst Coated Membrane (CCM). Despite this, the raw materials for the CCM, including titanium and platinum group metals (Pt, Ir, Ru), will likely remain imports. Similarly for Alkaline systems, components like bipolar plates and electrodes can be manufactured locally, but critical inputs such as the Zirfon membrane and raw materials like nickel foam and molybdenum will continue to be sourced from international markets.

SOE Systems and Raw Material Challenges
In the case of Solid Oxide Electrolysers, there is significant potential to domestically produce components like end plates, interconnects, and various oxides for the anode, cathode, and electrolyte. The primary import dependency for SOE technology lies in the raw materials for these oxides and specialized glass-ceramic sealants. This highlights a common challenge across all technologies: while India can develop the capability to manufacture most finished components, securing a stable supply of critical raw materials will be a persistent factor.

A Multi-Tiered National R&D Strategy
India's research and development strategy for hydrogen is structured as a comprehensive, multi-tiered plan with distinct timelines and objectives. The roadmap includes short-term "Mission Mode" projects (0-5 years) for immediate product development, medium-term "Grand Challenge" proposals (0-8 years) to achieve self-sufficiency in core components, and long-term "Blue Sky" projects (0-15 years) aimed at fostering breakthrough innovations and future technologies.

Near-Term Development and Component Indigenisation
In the near to medium term, the R&D focus is on establishing a robust domestic ecosystem. Mission Mode proposals aim to develop market-ready products like domestic modular electrolysers, Type III/IV compressed hydrogen cylinders, and commercial-scale biomass hydrogen generation. This is supported by Grand Challenge projects that target the indigenous manufacturing of critical electrolyser and fuel cell components—such as MEAs, electrocatalysts, and bipolar plates—with the explicit goal of improving their effectiveness and reducing costs.

Long-Term Vision and "Blue Sky" Innovations

The long-term vision, encapsulated in the Blue Sky projects, pursues next-generation technologies to secure future leadership in the hydrogen space. This advanced research includes the development of 3rd generation electrocatalysts, reversible solid oxide cells (SOECs/SOFCs), and novel hydrogen production methods like thermochemical water-splitting and direct seawater electrolysis. The strategy also addresses storage challenges through exploratory work on salt cavern surveys and the development of new materials like high entropy alloys.

Institutional Focus on Advanced Electrolysis

Leading national institutions are spearheading research in line with this strategy, particularly in advanced electrolysis and water-splitting technologies. The Bhabha Atomic Research Centre (BARC) is working on multiple pathways, including AWE, PEM, and high-temperature steam electrolysis. CSIR-CERI is focused on photochemical and electrochemical water splitting, while IOCL's R&D division is exploring solar-powered electrolysers and industrial-scale biomass gasification.

Research Thrust in Bio-Hydrogen Production

A significant research effort is also directed towards bio-hydrogen production from organic waste, with several institutions running large-scale pilot projects. IIT Kharagpur is developing a 10,000-litre dark fermentation process using organic and agricultural waste. Similarly, CSIR-IICT is working on fermentation from biogenic and distillery waste in a pilot bioreactor, while TERI is focused on producing hydrogen from industrial byproducts like sugarcane molasses and woody biomass.

Green Methanol:

Methanol Market and Import Dependency

India's methanol market is defined by a substantial gap between domestic demand and production, resulting in significant import dependency. For the 2022-23 period, the annual demand was 2.97 million metric tonnes (MMTPA), while domestic production, reliant on imported natural gas, stood at only 0.7 MMTPA. This shortfall required imports valued at $0.86 billion, a figure that is poised to increase as national demand is projected to grow to 4.1 MMTPA by 2030.

Traditional Production and Diverse Use Cases

Conventionally, methanol is produced through carbon-intensive methods such as coal gasification and natural gas reforming. It serves as a vital and versatile chemical across multiple sectors, used as a feedstock in the paint and pharmaceutical industries, a raw material for plastics, an energy source in various applications, and for treating wastewater and industrial effluents.

The Strategic Transition to Green Methanol

To tackle the dual challenges of a heavy import bill and the environmental impact of fossil-based production, India is initiating a strategic shift towards green methanol. A strong and diverse pipeline of major projects is now in development, aiming to utilize renewable pathways to produce methanol. This transition is set to fundamentally reshape the country's methanol sector, with the goal of reducing import reliance and establishing a sustainable domestic production base.

Major Green Methanol Projects on the Horizon

The commitment to this transition is demonstrated by the scale and number of planned green methanol projects. These range from initial pilot and small-scale plants, such as NTPC's 10 TPD facility at Vindhyachal and its 75 TPD project with GACL, to world-scale industrial hubs. Among the most ambitious are the large-scale facilities planned by ReNew E-Fuels, totaling 800 KTPA, and the massive 1 MTPA export-oriented green methanol project being developed by AM Green and DP World, signaling a clear ambition to become a major player in the global green methanol market.

Point Source Capture

India's Carbon Emission Profile
India is a significant contributor to global carbon emissions, ranking as the third-largest emitter of CO_2 after the United States and China. The nation's emissions were recorded at 2.6 gigatonnes per annum (gtpa) in 2019 and are on a trajectory to exceed 4 gtpa by 2030. This growth is projected to increase India's share of total global emissions from the current 8% to approximately 14% by the year 2050.

Sectoral Sources of Emissions
An analysis of the country's emissions by sector shows that the industrial and electricity generation sectors are the primary sources. The industrial sector is the single largest contributor, responsible for 31% of all emissions, with the electricity sector following closely at 30%. Other significant contributions come from agriculture (20%), transport (10%), and the building sector (5%).

The Imperative for Decarbonization
The need to decarbonize is driven by international climate commitments, such as the Paris Agreement's goal to limit global temperature rise, as well as pressing domestic realities. India faces the unique challenge of managing a large and relatively new fleet of high-emitting industrial assets. With 219 GW of coal-based power capacity and 144 mtpa of crude-based steel capacity being less than 15 years old, these facilities have long operational lifespans that necessitate solutions like carbon capture, as their early retirement is not feasible.

The Market and Financial Scale of the Transition
Addressing this challenge represents both a substantial financial undertaking and a nascent market opportunity. The specific market for Carbon Capture and Storage (CCS) in India was valued at $97.08 million in 2024 and is forecast to grow to $195.36 million by 2033. This is a component of a much larger investment landscape, with estimates suggesting that India's complete decarbonization journey through 2050 will require a total investment of $150 to $200 billion.

Overview of Major CCU Initiatives

India is actively pursuing several major Carbon Capture and Utilization (CCU) projects across its most carbon-intensive industries. These initiatives, often supported by government incentives, are being deployed in sectors such as steel, coal, cement, fertilizers, and thermal power. The projects highlight a broad national strategy to develop and implement technologies for mitigating industrial emissions and creating value from captured carbon.

CCU in the Steel and Coal Sectors

In the steel and coal industries, large-scale, government-incentivized projects are demonstrating significant ambition. The JSPL Angul steel project is integrating CCU directly into its iron production process, featuring a capture capacity of 3000 tonnes per day (TPD) of CO2 using advanced absorption technologies. In a project of similar scale, New Era Cleantech Solution is utilizing coal gasification to capture 3000 TPD of CO2 with the goal of producing one million tonnes per annum of green methanol.

Application in Cement and Chemical Industries

The application of CCU is also being advanced in other hard-to-abate sectors like cement and chemicals. Dalmia Cement in Tamil Nadu is implementing a landmark project to capture 0.5 million tonnes of CO2 per year from its plant for subsequent utilization. In the chemical sector, Turticorin Alkali is developing a CCU facility at its fertilizer plant to capture CO2 and use it as a feedstock to produce valuable 'Green Soda Ash', showcasing a circular economy approach.

CCU Integration in the Power Sector

The power sector is another key focus area for decarbonization, exemplified by the CCU project at the NTPC Vidhyanchal thermal power plant. This joint venture is designed to capture 20 TPD of CO2 directly from the power plant's emissions. The captured carbon is then utilized on-site to produce 10 TPD of methanol through a process of catalytic hydrogenation, providing a clear pathway from emission capture to the creation of value-added chemicals.

Direct Air Capture

The Nascent Direct Air Capture Market in India
The Direct Air Capture (DAC) market in India is currently in its early stages but is poised for significant expansion. Valued at a modest $3.2 million in 2024, the market is projected to grow substantially to $52 million by 2030, representing about 3.3% of the global market. While the broader Carbon Capture, Utilization, and Storage (CCUS) market is larger and has a more robust growth forecast, interest in DAC is increasing, driven by a growing number of Indian and multinational corporations seeking to acquire carbon credits.

Technology Landscape and Prevailing Challenges
Technologically, the Indian DAC sector is currently dominated by Solid-Sorbent based systems, which account for 87.5% of the market's revenue. Despite this technological preference, the path to widespread commercial viability for DAC faces substantial hurdles. The primary challenges hindering its adoption include the high cost of capture technology, the absence of dedicated infrastructure for CO2 transportation and storage, and a nascent policy framework that currently lacks strong and specific financial incentives.

Key Stakeholders and the Emerging Startup Ecosystem
Despite these challenges, a vibrant ecosystem of academic institutions and innovative startups is driving progress in the field. Key research hubs, such as the Center of Excellence at IIT Bombay and the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), are foundational to developing new technologies and fostering talent. This strong academic support has been instrumental in nurturing a new wave of startups focused on making DAC a viable climate solution in the Indian context.

Profiles of Prominent DAC Startups
Several promising startups are emerging as leaders in this space. UrjanovaC, which is backed by IIT Bombay and has received recognition from the Elon Musk Foundation, is already operating a 3 TPD pilot plant. GreenGine, supported by IIT Kanpur, is developing a unique microalgae-based solution and has formed strategic collaborations with major public sector units like IOCL and EIL. Furthermore, UGreen Technology, with backing from Oil India and various IITs, is developing a comprehensive suite of technologies for pre-capture, post-capture, and direct air capture applications.

Conclusion

India's state-funded energy transition presents a direct, multi-billion-dollar opportunity for Umicore, specifically targeting its core competencies in catalysis, PGM-based materials, and recycling.

1. Opportunity: Green Hydrogen & Electrolyser Supply Chain

- Market Scope:
  - A government-incentivized program (SIGHT scheme) is creating 3000 MW of domestic electrolyser manufacturing capacity.
  - The total domestic market is projected to reach 20 GW by 2030.
  - Crucially, there is a recognized 15% import dependency for critical materials, specifically the PGM catalysts (Platinum, Iridium) and CCMs that are Umicore's core products.
- Investment Options:
  - Near-Term (Supply): Position as the primary supplier of high-performance catalysts and CCMs to the SIGHT scheme winners (e.g., Reliance, Adani).
  - Mid-Term (Manufacture): Invest in a local catalyst/CCM finishing plant to align with the "Make in India" policy and secure long-term supply contracts.
  - Long-Term (Innovate): Partner with Indian R&D hubs (IITs, CSIR) to co-develop next-generation, low-PGM electrocatalysts.

2. Opportunity: CCU & Green Methanol Catalysis

- Market Scope:
  - Major Carbon Capture (CCU) projects are operationalizing in hard-to-abate sectors like steel (JSPL: 3000 TPD CO2 capture), cement (Dalmia: 0.5 MTPA CO2 capture), and power.
  - These projects feed a growing green methanol market (e.g., 1 MMTPA scale projects), creating immediate demand for methanol synthesis and CO2 hydrogenation catalysts.
- Investment Options:
  - Technology Partnership: Act as a catalyst technology partner for major industrial players to maximize the efficiency of their CCU and methanol plants.

Product Line Expansion: Aggressively market and supply specialized catalysts for methanation and CO2 conversion.

3. Opportunity: First-Mover Advantage in Urban Mining (Recycling)

- Market Scope:
  - India has zero domestic PGM reserves, making recycling a long-term strategic imperative for national resource security.
  - The deployment of a multi-gigawatt PEM electrolyser and fuel cell ecosystem will create a massive urban mine of valuable PGMs.
- Investment Options:
  - Strategic Capex: Invest in a state-of-the-art recycling facility in India to recover PGMs from end-of-life clean energy hardware.
  - Business Model Innovation: Offer customers a "Closed-Loop" service—bundling the sale of fresh catalysts with a guaranteed buy-back and recycling contract for spent materials, creating a circular and defensible business moat.

Key Learnings

On a technical level, the experience provided a foundational understanding of key green technologies, including Green Hydrogen, electrolysers, Green Methanol, and Carbon Capture & Utilization (CCU). This involved not only learning the principles behind them but also gaining a practical awareness of their Technology Readiness Levels (TRLs) and current limitations in the field.

From an industrial perspective, there was valuable insight into how technology, policy, and market dynamics intersect to shape the energy sector. This included exposure to the entire value chain, from research and procurement to production and logistics, offering a holistic view of how projects move from concept to reality.

The role also honed essential professional skills through active collaboration with diverse, cross-functional teams at both the local Indian and global levels. This practical engagement strengthened core competencies in documentation, reporting, and presentation, while providing meaningful exposure to corporate workflows and procedures.

Finally, the experience was instrumental in developing crucial soft skills. Interacting with supervisors and colleagues enhanced communication, while managing tasks under deadlines improved time management. This fostered greater adaptability and built confidence in navigating new and dynamic professional environments.

Appendices

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Thank You