# Roadmap for Decarbonization

# Indian Cement Industry


**HOLTEC CONSULTING PRIVATE LIMTED**

**Mr. Dinesh Satija, Head-Process**

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# ABOUT HOLTEC

- Created in year 1967
- Services firm focused on the Global Cement Industry: Advisory, Engineering, Plant Operations & Maintenance, AFR & Solutions
- Also offer services in Highways, Power & Engineering Support Services
- 4,800+ assignments for 1,000+ clients in 90+ countries
- Full fledged engineering and business consulting firm
- Strong execution processes (ISO certified)
- Total Solutions: Integrated service from concept through commissioning and operations.
- Industry expertise with 6,500 man-years experience.
- Extensive database built over 55+ years.
- Offices: 3 in India, 1 in UAE (Sharjah) and various other site offices.

**HOLTEC delivers comprehensive, end-to-end solutions tailored for the global cement industry**

# EXPERIENCE IN THE GLOBAL CEMENT

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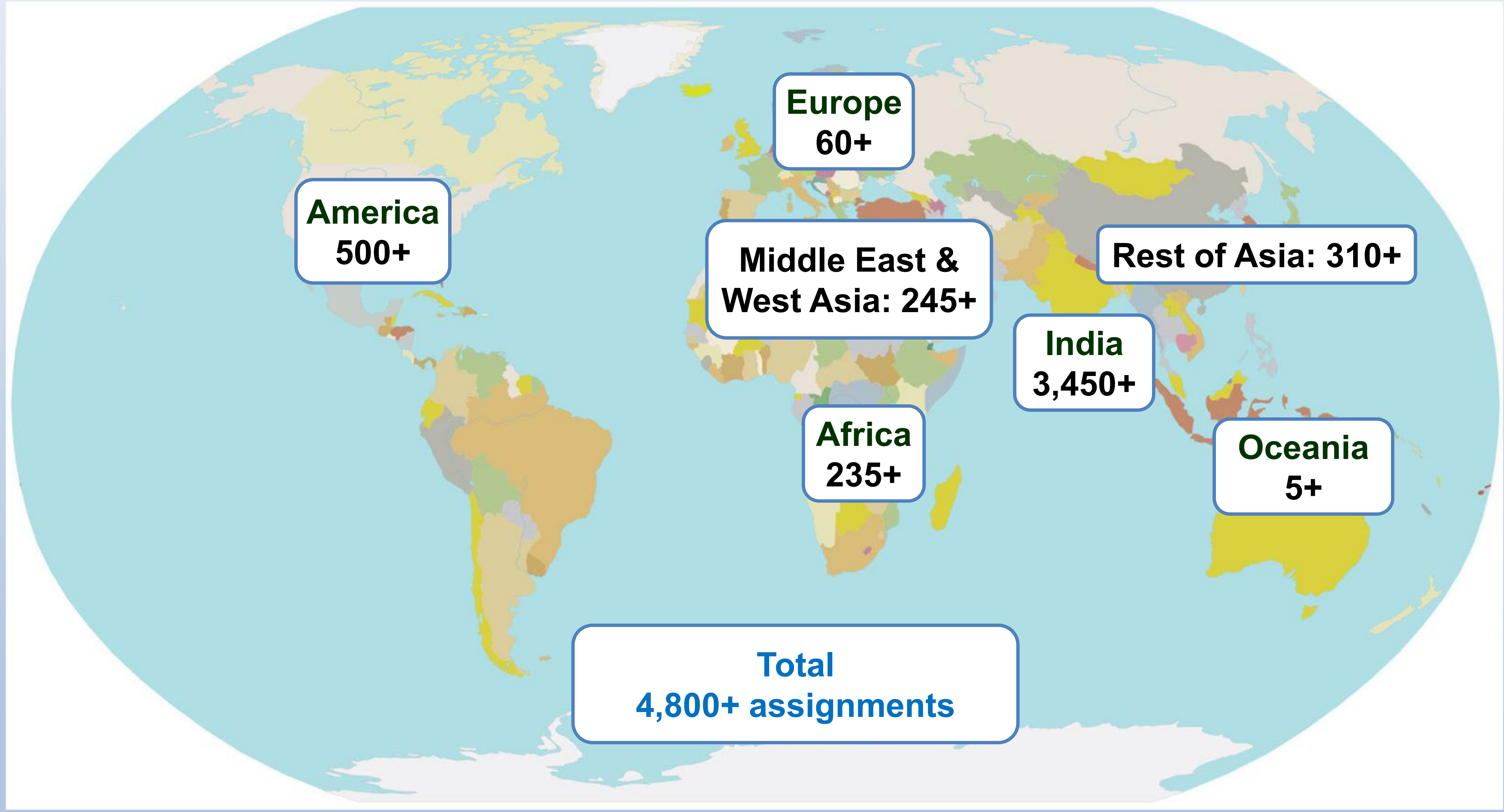
**4800+ projects in 100+ countries for 1000+ clients**

| Type of Projects | No. of Projects |
|---|---|
| Due Diligence, Valuations and Investment Studies | 190+ |
| Raw Material Studies | 750+ |
| Feasibility, Market and Strategic Studies | 1,100+ |
| Performance Enhancement and Audit Studies | 320+ |
| Project Engineering, Procurement, Field Services, etc. | 2,260+ |
| Other Miscellaneous Studies | 180+ |
| **Total** | **4,800+** |




- **Engineered over 100 large-sized projects, greenfield and brownfield; 20+ with kiln capacities of >8,000 tpd and 30+ with kiln capacities of 6,000-8,000 tpd**
- **Successfully executed 300+ Performance Enhancement, Process Advancement and Alternative Fuels projects worldwide**

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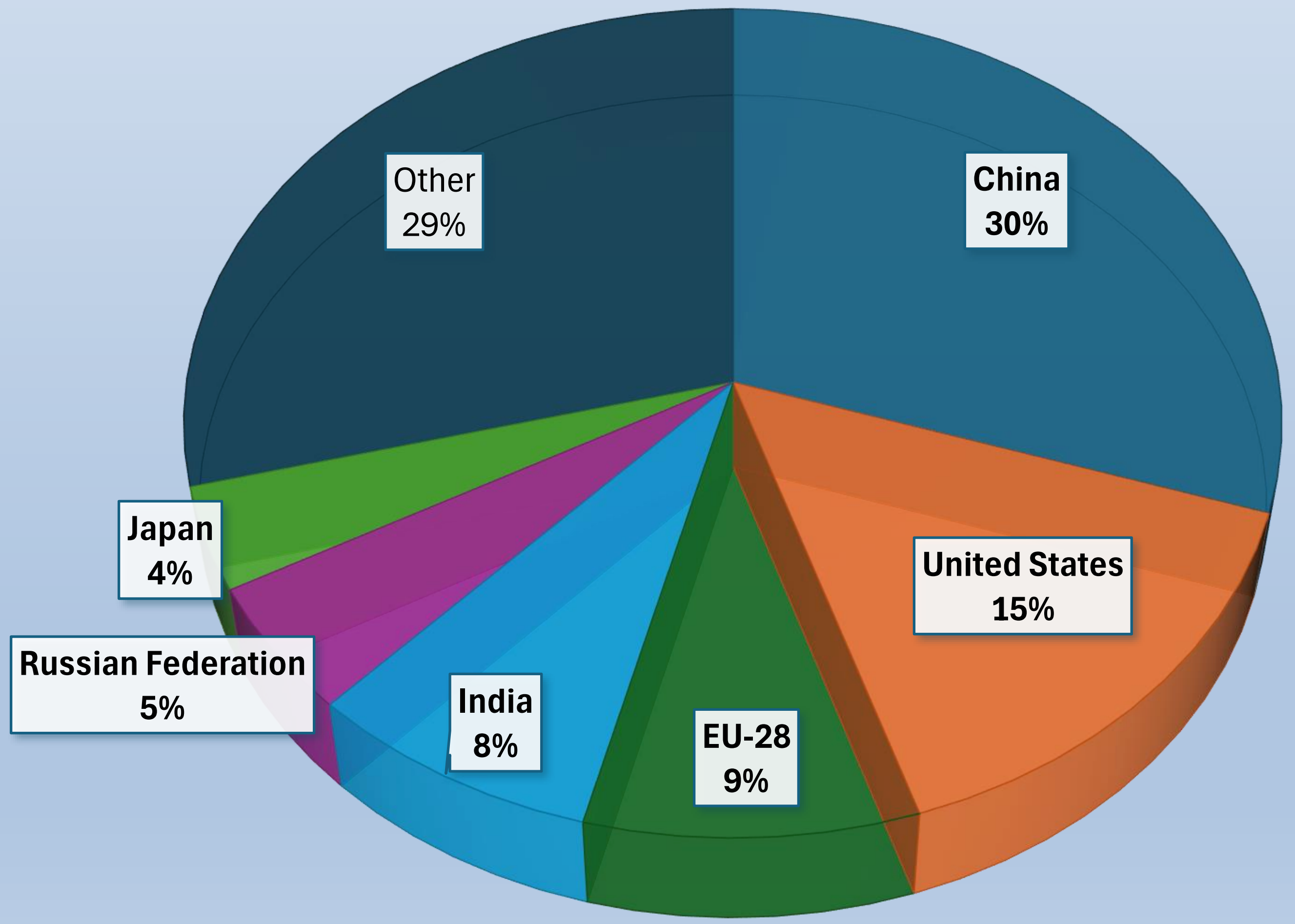
# Decarbonization

# Decarbonization ?

- The process of reducing $CO_2$ emissions from industrial, energy and transport sectors.
- Involves transitioning from fossil fuels to renewable or low-carbon alternatives.
- Includes technological shifts, process improvements to limit carbon output.

**GLOBAL CO2 EMISSION FROM FOSSIL FUEL CONSUMPTION**




**Global CO2 emissions is 41.6 Billion tones (2024)**

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# Why We Need Decarbonization

### Combat Climate Change

Reduces greenhouse gases to slow global warming

### Protect Public Health

Lowers pollution, improving air and respiratory health.

### Ensure Energy Security

Promotes stable, renewable energy over fossil fuel dependency.

### Boost Economic Growth

Encourages green jobs and clean technology investments worldwide.

# National Commitment

# Net-Zero Emissions By 2070

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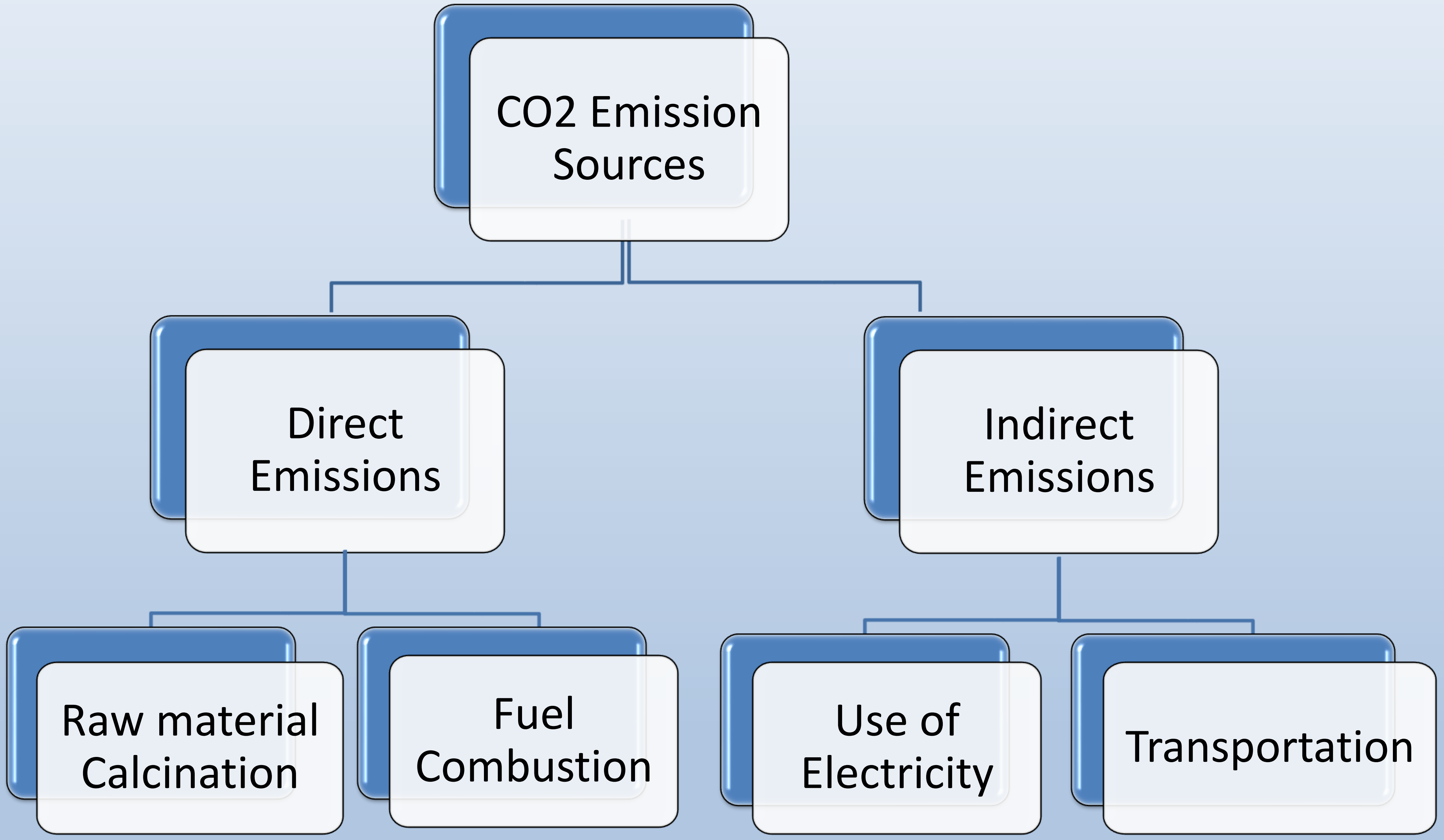
India has committed to achieving **net-zero carbon dioxide (and all greenhouse gas) emissions by 2070**. This pledge was announced at **COP26 in Glasgow on November 1, 2021**

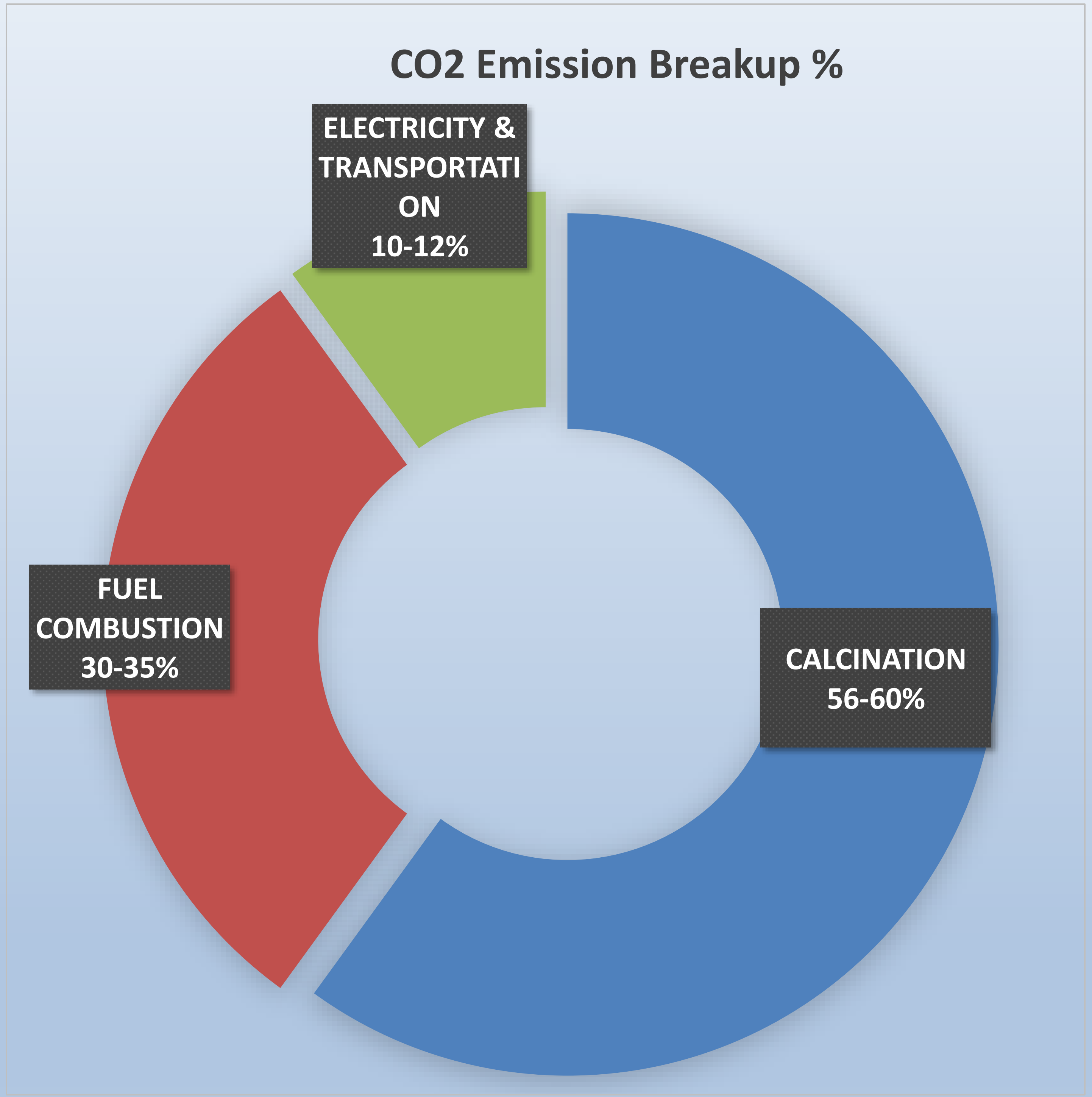
## Major Climate Commitments

1. Expand **non-fossil energy capacity to 500 GW by 2030**
2. Meet **50% of total energy requirements using renewable sources by 2030** (*Currently 50%*)
3. Reduce projected **carbon emissions by 1 billion tonnes by 2030** (*Baseline: 1.56 Billon Tons 2005*)
4. Reduce **carbon intensity** ($CO_2$ emissions per unit of GDP) by **45% by 2030** (*Baseline: 425.3 tCO2e per million $ GDP PPP in 2005*)
5. Achieve **net-zero emissions by 2070**

**Require deep Decarbonization across energy, transport, industry & buildings**

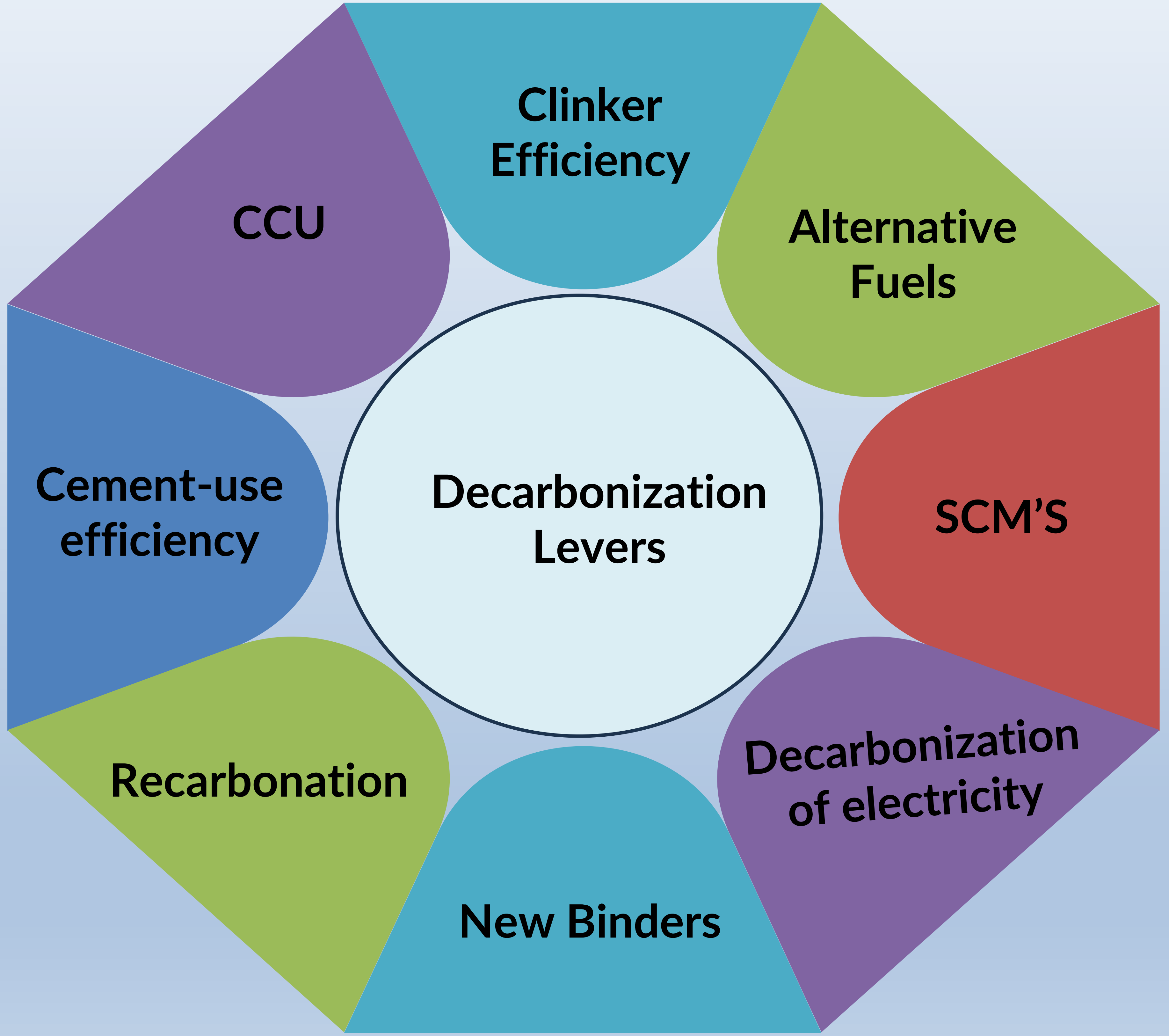
# $CO_2$ Emission Sources In Cement Production



# Decarbonisation Levers

1) Clinker Efficiency (Thermal Energy )
2) Alternative Fuels (AFR)
3) Supplementary Cementitious Materials (SCMs)
4) Decarbonisation of Electricity
5) New Binders
6) Recarbonation
7) Cement-Use Efficiency
8) **Carbon Capture, Utilization and Storage (CCUS)**



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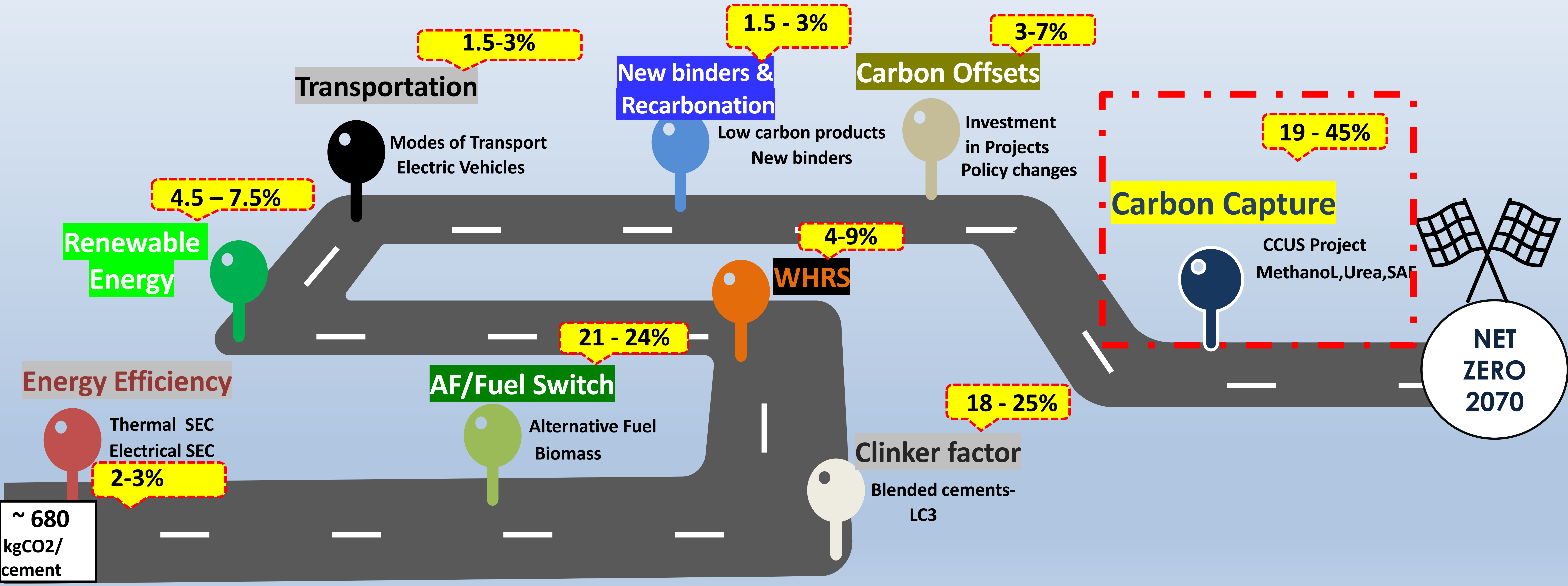
# Indian Cement Industry Decarbonization Targets

| Goal | 2030 Targets | 2050 Targets |
|---|---|---|
| **Emissions Intensity Reduction** | ~35 – 40% ($tCO_2$/ton cement) | ~55–60% |
| **Blended Cement Share** | >75% (PPC, PSC, $LC^3$) | Shift to net-zero cement ($LC^3$, geopolymer, etc.) |
| **Thermal Substitution Rate (TSR)** | 25–30% | >50% |
| **Renewable Energy Use** | >30% | Widespread use of green hydrogen, alternative fuels, biofuels |
| **Waste Heat Recovery (WHRS)** | >60% | ≥ 90% |
| **Carbon Capture & Storage (CCS)** | Pilot projects initiated | Starts Scaling |

# Decarbonization Roadmap - Indian Cement Industry



# Clinker efficiency (Thermal Energy)

**Goal:** Reduce specific thermal energy consumption in clinker production.

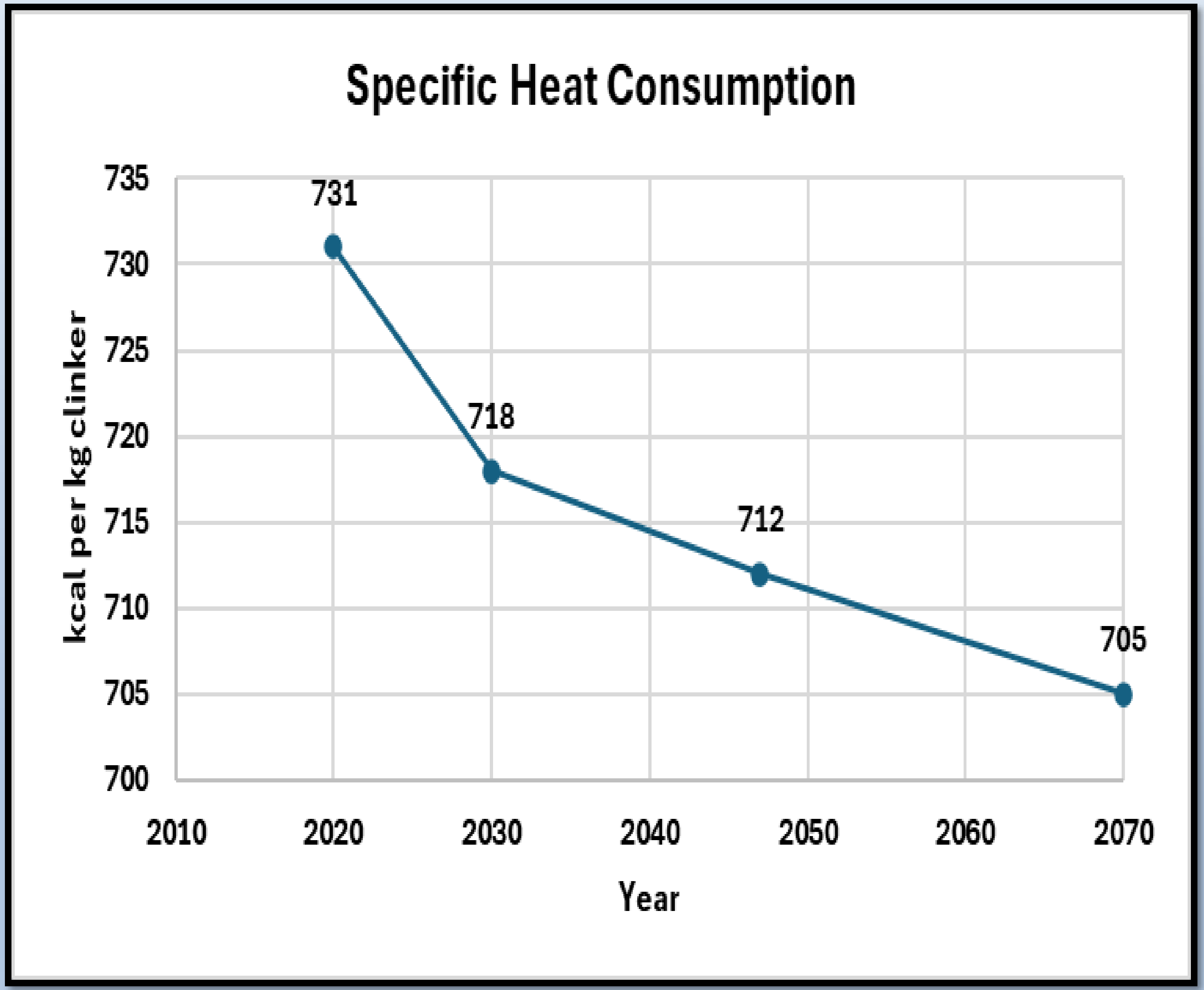
**Achievements:**

- ✓ Indian cement industry largely uses energy-efficient dry kiln processes.
- ✓ Average SHC reduced to 731 kcal/kg clinker in 2020–21.
- ✓ Target SHC by 2070: 705 kcal/kg clinker. (*taking into consideration the increase in energy consumption due to deployment of CCUS*)

**Methods:**

- ✓ Includes reduction in SEC-thermal, increased use of biomass and adoption of green fuels and technologies.

**$CO_2$ Reduction Potential by 2070: 2.5-3.5%**



# Alternative Fuels

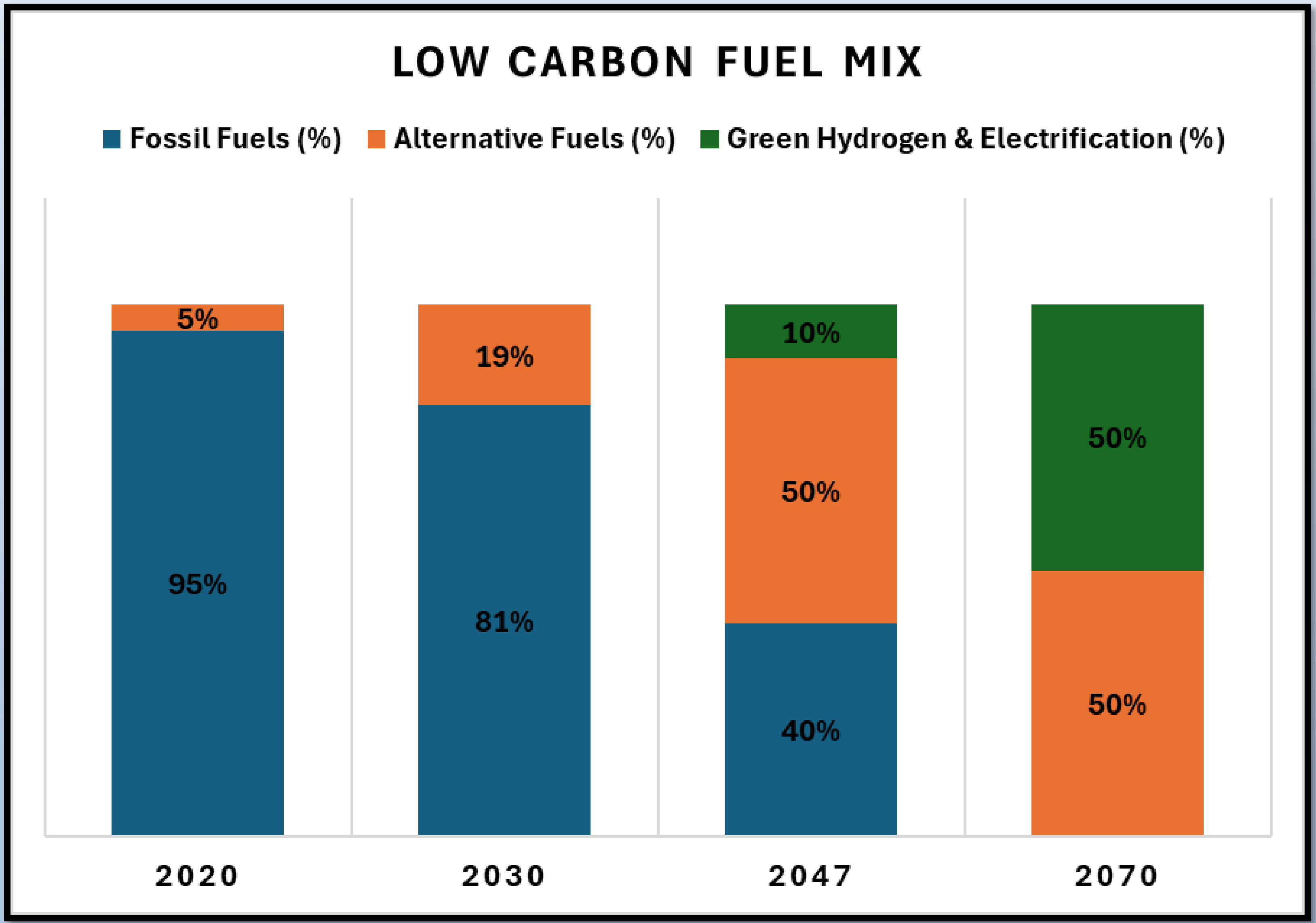
**Goal:** Replace coal and pet coke with low-carbon fuels.

Target fuel mix by 2070:

- ✓ 50% green hydrogen
- ✓ 35% waste-derived fuels
- ✓ 15% biomass

**Challenges**: Supply chain, segregation, and preprocessing.

**$CO_2$ Reduction Potential: 21-24%**



# Supplementary Cementitious Materials (SCMs)

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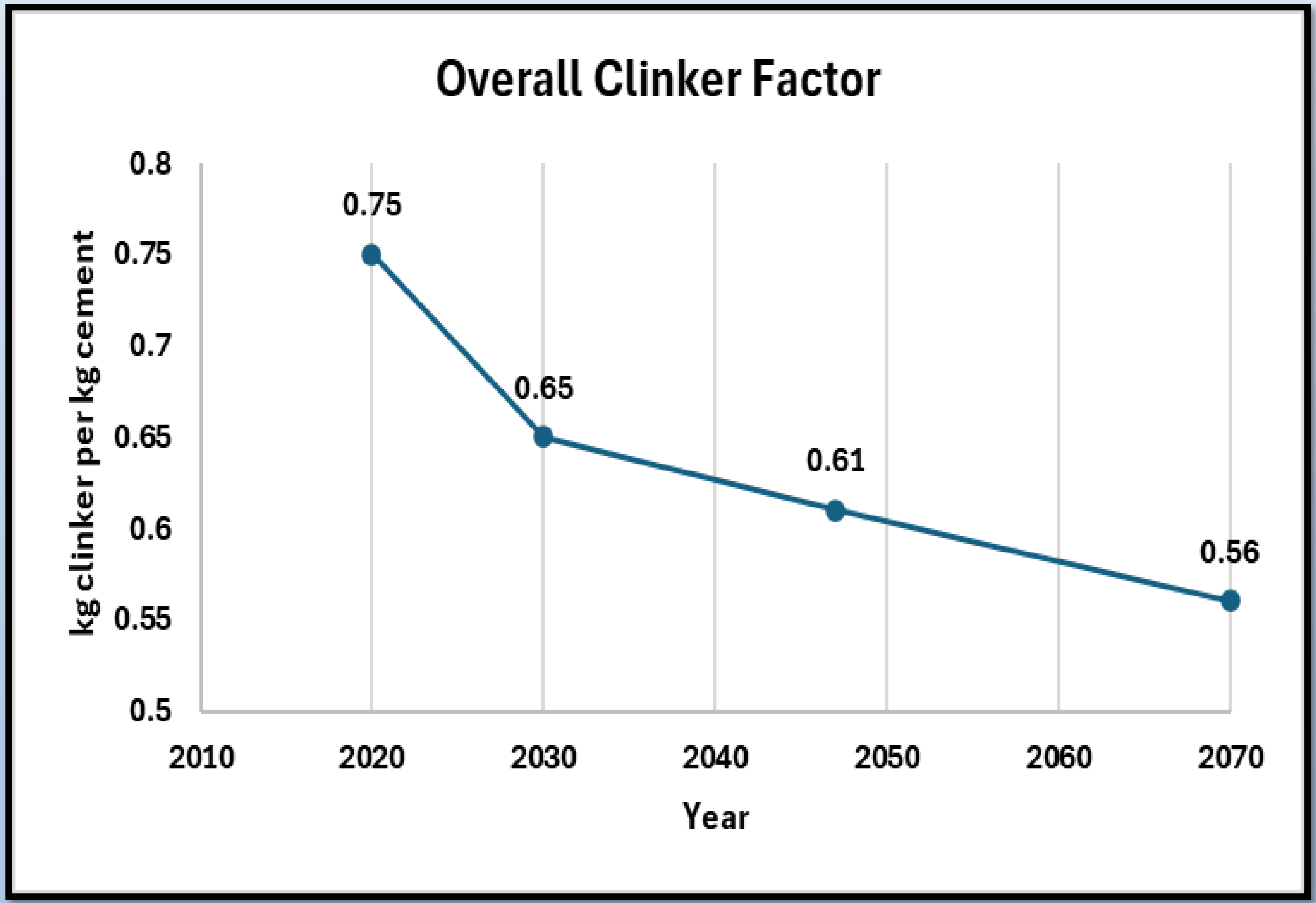
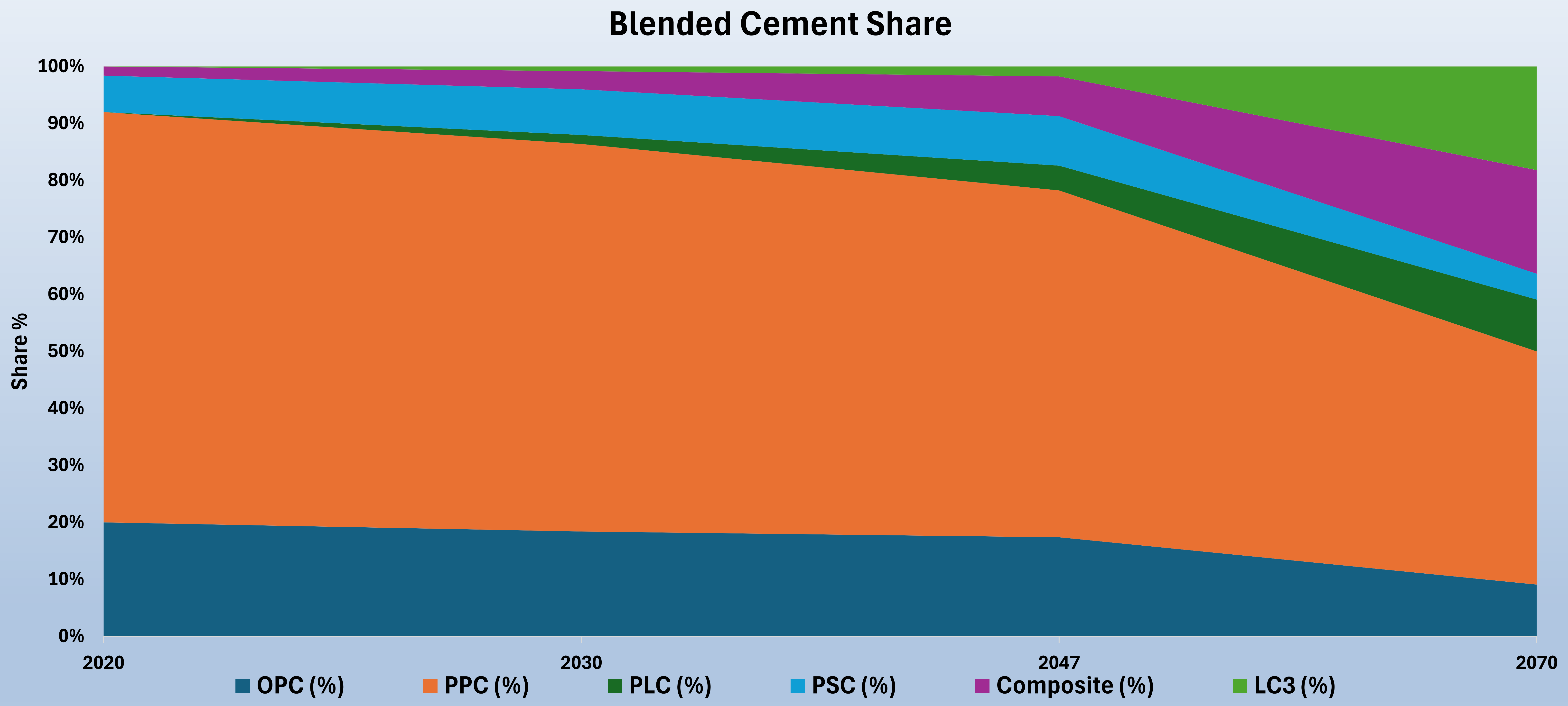
- SCMs reduce the clinker factor, which in turn reduces energy use and $CO_2$ emissions.
- Major SCMs: Fly ash, GGBS (slag), calcined clay, & limestone.
- Blended Cement Share Target by 2070:
  - ✓ 90% of cement to be blended types (PPC, PSC, PLC, PCC, LC3, etc.)
  - ✓ Clinker factor to reduce from **0.75 (2020)** → **0.56 (2070)**




**$CO_2$ Reduction Potential: 18-25%**

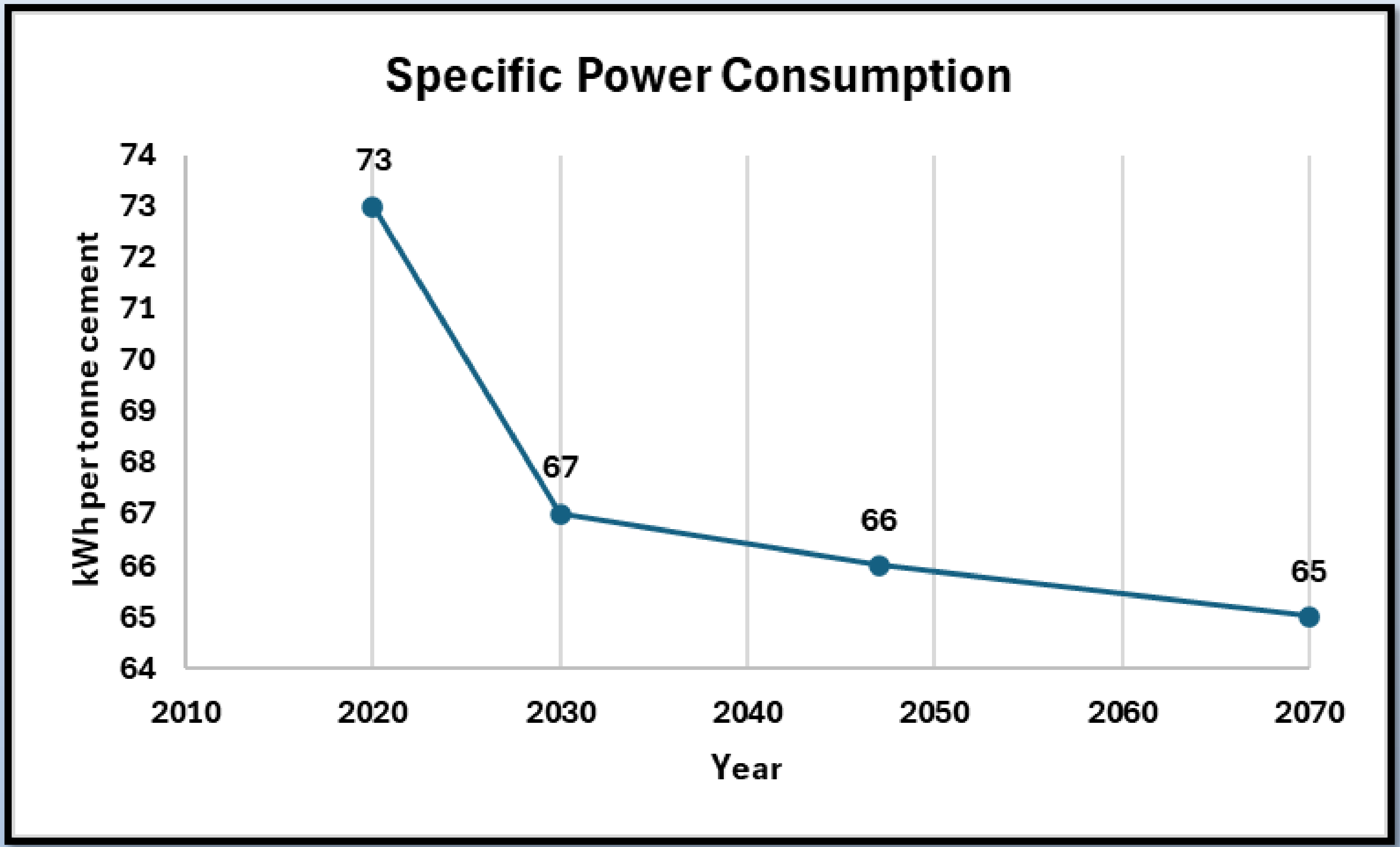
# Supplementary Cementitious Materials (SCMs)



# Decarbonization of Electricity

**Goal:**

- ✓ Improve electrical efficiency (SPC from 73 → 65 kWh/ton cement).
- ✓ Increase Waste Heat Recovery (WHR) capacity (538 MW [*achieved*] vs. ~ 1100 MW [*potential*].
- ✓ Shift to green electricity with renewable energy use




**$CO_2$ Reduction Potential: 9.5 –18.5 %**

# New Binders

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- **New Emerging Binders** that are being developed with a goal to reduce carbon emissions, improving durability & used as alternatives to traditional Portland cement

| **Binder Type** | **$CO_2$ Reduction** |
| --- | --- |
| LC3 | ~40% |
| Calcium Sulfoaluminate (CSA) Cements | 30–40% |
| Geo polymer | ~80% |
| Magnesium-based Cements | Up to 100% |
| Carbonatable | Up to 70% |
| Celitement | ~50% |

**$CO_2$Reduction Potential: 0.2-1%**

# Cement Use Efficiency

**Key Strategy**: Shift from bagged to bulk cement (e.g., Ready-Mix Concrete - RMC).

**Concrete Usage Breakdown (2020):**

→ 65% in structural applications

→ 29% via RMC; **36% mixed on-site**

→ 35% in non-structural applications

**Levers for Efficiency:**

- Improved grading of aggregates
- Use of plasticizers to lower water-cement ratio
- Quality control in RMC plants

**Advanced Practices:**

- Precast and pre-engineered building components
- Use of AAC blocks instead of clay bricks
- Replacing mortar with adhesives
- Construction & Demolition (C&D) waste recycling

**Technology Integration:**

- 3D concrete printing
- Automated concrete design systems
- Optimization of structural geometry

# Carbon Capture, Utilization & Storage (CCUS)

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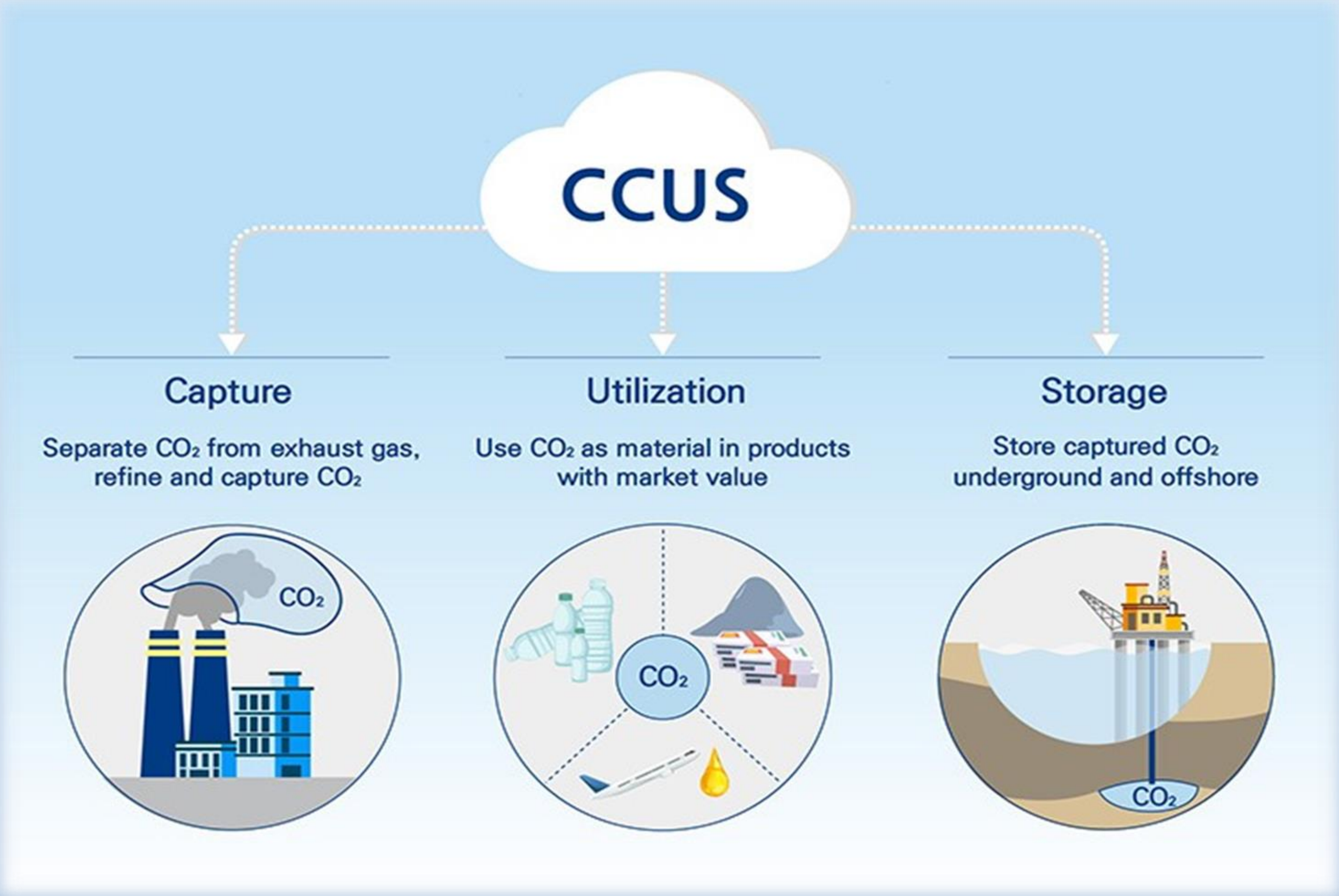
**CCUS is the process of:**

- Separating CO2 from flue gases of point sources such as stacks of cement plants, power plants, steel and iron plants etc.,
- Transporting it to a storage site or utilization site.
- Depositing it or utilizing it, thereby not letting CO2 enter the atmosphere for mitigation of global warming.




**$CO_2$ Reduction Potential: 19-45%**

# Post-combustion $CO_2$ capture

**Post-combustion $CO_2$ capture** involves removing $CO_2$ **after** fossil fuel has been burned. The $CO_2$ is separated from the flue gases before they are released into the atmosphere.

It's the most suitable method for **a cement plants**, since it doesn't require fundamental changes to the combustion system.

# Amine Scrubbing Technology

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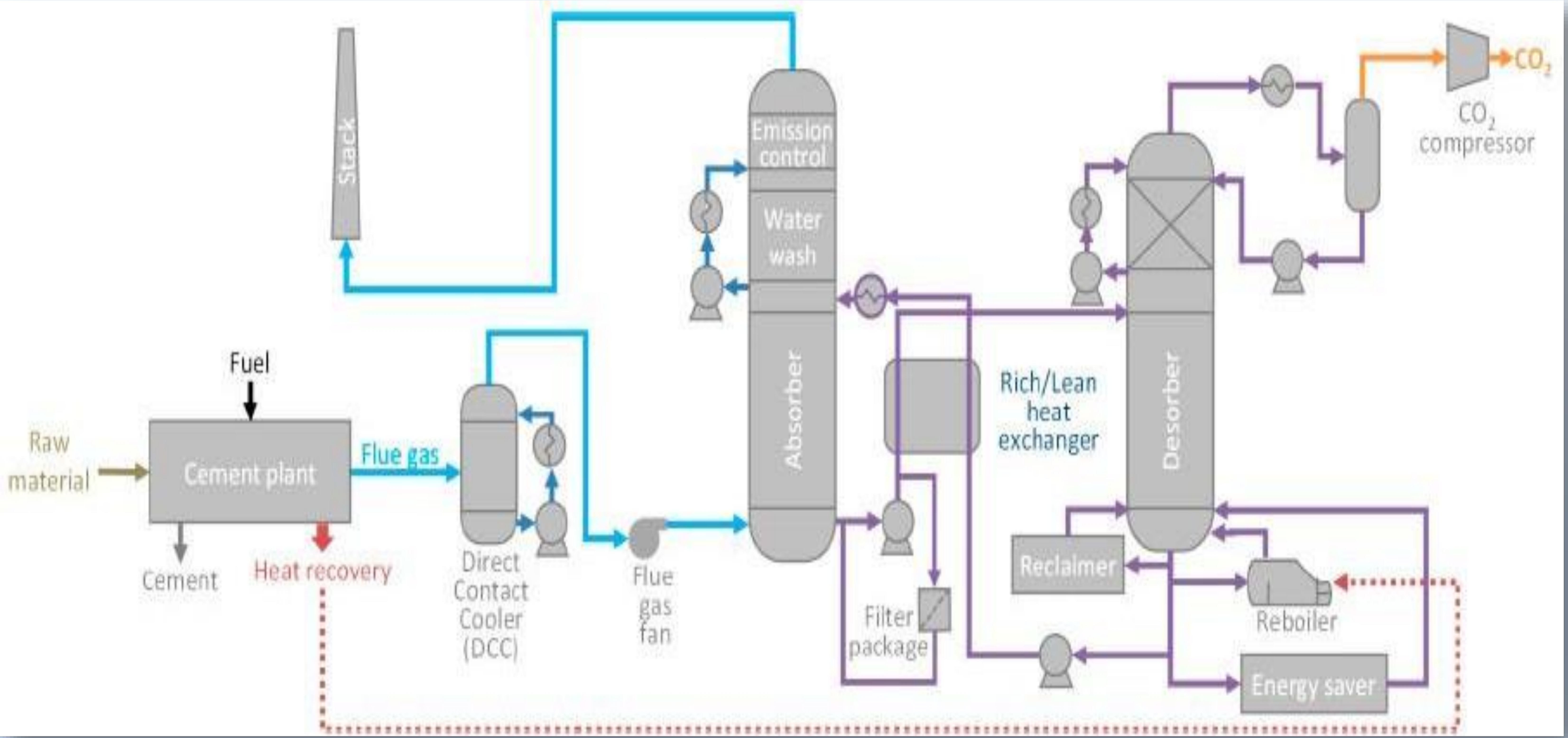
**MEA (Monoethanolamine)** is a primary amine solvent, used for post-combustion $CO_2$ capture due to its high reactivity with $CO_2$, commercial maturity, and relative simplicity in plant integration.

- Type: Chemical absorption (amine-based)
- Status: Most mature post-combustion $CO_2$ capture technology

## Key Performance Metrics

| Metric | Typical Value |
|---|---|
| $CO_2$ Capture Efficiency | **85–95%** |
| $CO_2$ Purity | **95–99%** |
| Energy Requirement | **3.5–4.0** GJ/ton $CO_2$ (with MEA) |

# Amine Scrubbing Technology



# CCU – Current Status, Initiatives & Chalenges

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## Current Status in India

- ✓ No large-scale implementation yet.
- ✓ Pioneers: A few Indian cement companies exploring pilots.
- ✓ Barriers: High costs, lack of infrastructure, and need for policy/funding support.

## Global & Indian Initiatives

- ✓ Reports: GCCA, Global CCS Institute studies on $CO_2$ hubs, storage, and financing.
- ✓ NITI Aayog Recommendation: Develop CCUS clusters (shared infrastructure for industries).

## Challenges

- ✓ Capex: High upfront costs for capture, transport, and storage.
- ✓ Infrastructure: Requires pipelines, storage sites (e.g., depleted oil fields).
- ✓ Energy Demand: Additional power needed for $CO_2$ separation.

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# Indicative Cost for 1 MMTPA CO2 Capture

| Parameter | UOM | Value | Remarks |
|---|---|---|---|
| Captured CO2 | Million tons of CO2 | 1.0 | From ~4,000 TPD Plant |
| CAPEX of $CO_2$ Capture Unit (1 MMTPA) | Million USD | ~ 450 | |
| OPEX of $CO_2$ Capture from Cement Plant | USD/ t of CO2 | ~ 25 | |

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# Utilization Pathways for Captured $CO_2$

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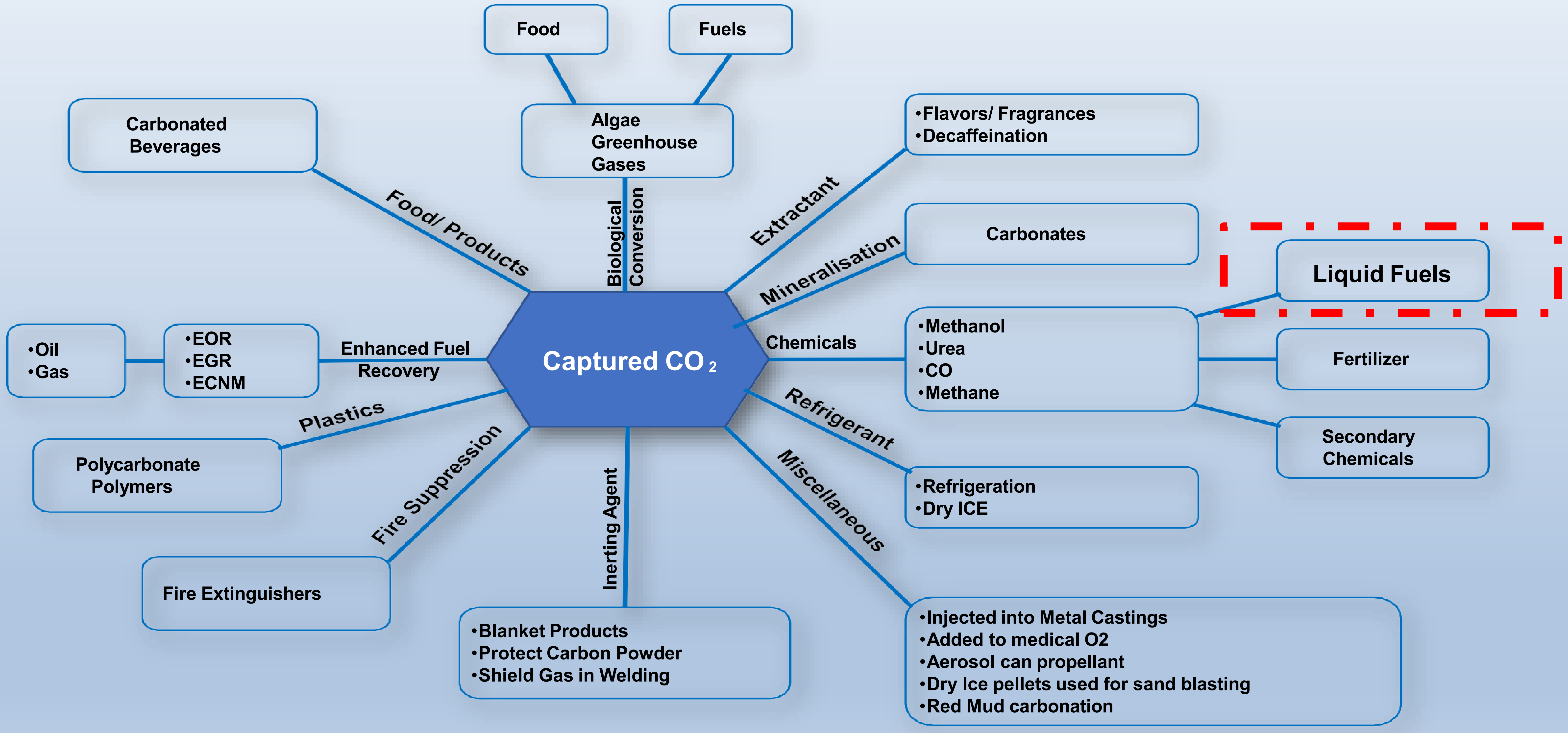

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# LIQUID FUEL: SUSTAINABLE AVIATION FUEL(SAF)

# SAF: Sustainable Aviation Fuel

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## What is SAF?

- SAF is an **alternative jet fuel** that is made from **non-petroleum (non-fossil) feedstocks**.
- Has similar chemical and physical properties to conventional jet fuel.
- **Significantly lower carbon footprint** over its entire lifecycle.

## Key Characteristics of SAF

- **Reduced Emissions**: Reduce GHG emissions by **up to 80%**
- **Drop-in Fuel**: Blended with conventional jet fuel (typically up to a 50% blend, though efforts are underway for 100% SAF flights)
- **Non-Petroleum Feedstocks**:Unlike conventional jet fuel derived from crude oil, SAF comes from a variety of sustainable sources

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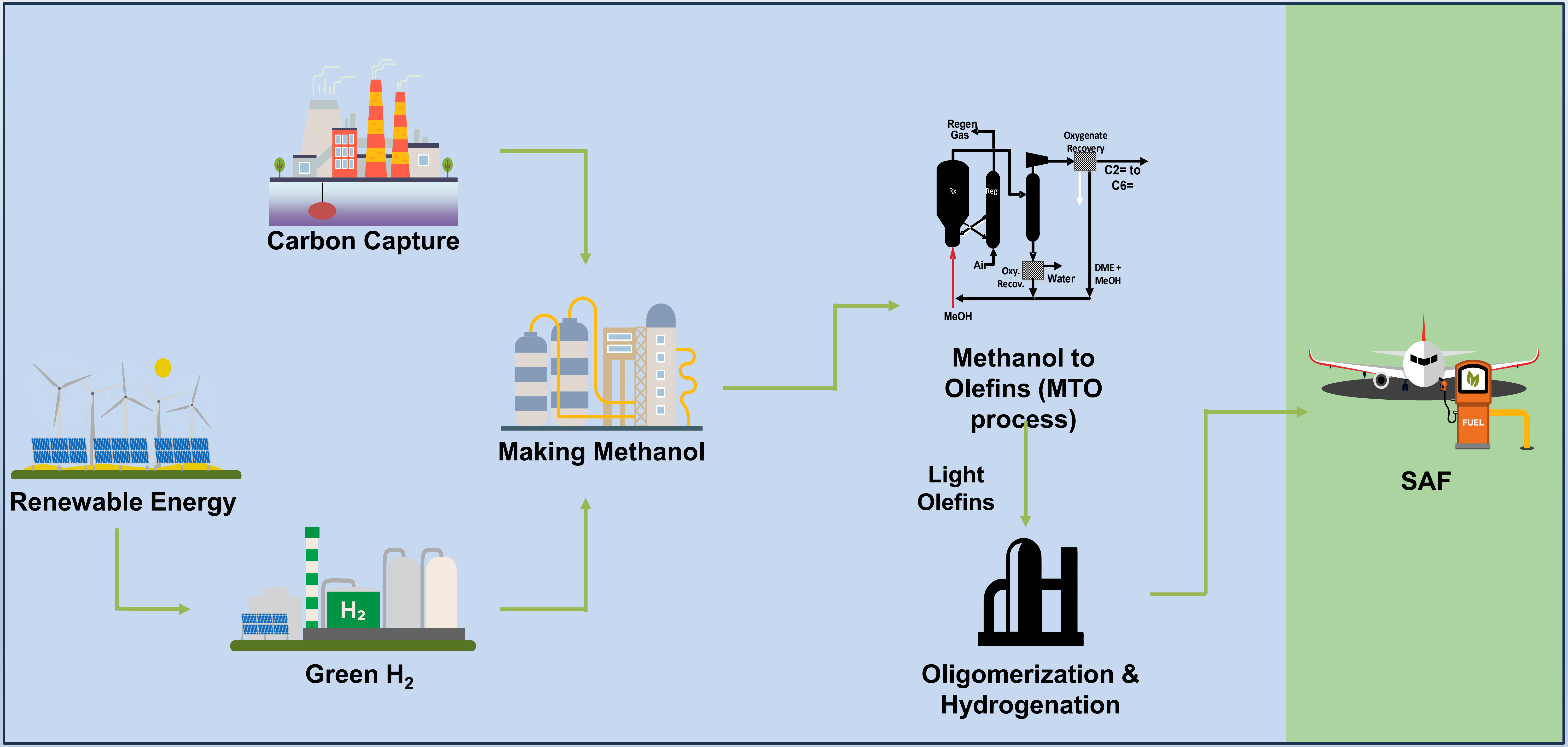
# SAF: Sustainable Aviation Fuel



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# Global Benchmarks (EU, China, USA)

## Comparative Summary (India vs. Global Benchmarks)

| Metric | India | EU | China | USA |
|---|---|---|---|---|
| **Avg. Clinker Ratio** | ~70% | ~75% | ~65-75% | ~75-80% |
| **AFR Use** | 5-10% | **40-70%** | 10-20% | **20-25%** |
| **WHR Adoption** | ~50% plants | ~90% plants | **~80% plants** | ~70% plants |
| **CCUS Progress** | Pilot stages | **Operational** | Early stages | **Scaling up** |
| **Carbon Pricing** | None | **€80-100/ton** | Pilot ETS | **$85/ton** |

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# Decarbonization Initiatives In The Indian Cement Industry

# Decarbonization Initiatives – Case Study

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| Parameter | Cement Group A | Cement Group B |
|---|---|---|
| **Installed Capacity (FY25)** | ~ 60 MTPA | ~ 184 MTPA |
| **Renewable Energy Capacity** | 300+ MW (Wind + Solar) | 150 MW (Wind + Solar) |
| **% of Total Energy from Renewables** | 40% | 25% |
| **Renewable Energy Goal (Next 5 Years)** | 50% of total energy from renewables | Increase share (specific % not stated) |
| **Energy Intensity Reduction** | 10% per tonne of cement | 7% per tonne of cement |
| **$CO_2$ Emissions Intensity Reduction** | 12% | 5% |
| **Alternative Fuels Used** | Agricultural residues, biomass, plastic waste | Biomass, industrial waste |

# Green $H_2$ and SAF Initiatives: Leading Projects & Partnerships in India

| Green Hydrogen Projects | |
|---|---|
| **Organization(s)** | **Project / Initiative** |
| NTPC Green + Honeywell UOP | SAF from NTPC's $CO_2$ + green $H_2$ (Vizag) |
| IOCL & L&T Energy Green Tech | 10,000 TPA green $H_2$ plant (Panipat Refinery in Haryana) |
| BPCL + Sembcorp | JV for large green $H_2$ production portfolio |
| AM Green (Greenko) | 4,500 MW RE from CIL to produce green ammonia/$H_2$ |
| GAIL | 10 MW Electrolyzer for green $H_2$ |
| Oil India Limited | 99.9% pure green $H_2$ pilot for fuel cell applications |
| **SAF Pilots & Developers** | |
| Honeywell UOP + NTPC Green | Exploring eFining™-based SAF from cement/power sector $CO_2$ |
| Xytel India | Pilot plant specialist developing SAF units |
| Indian Oil, BPCL, HPCL | Research & development in SAF technologies |

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# HOLTEC's ROLE IN DECARBONIZATION

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**Carry out studies related to Decarbonization for Cement Plants in the following areas**

| Area of Service | Description |
|---|---|
| Energy & Process Audit | Process debottlenecking for Capacity Upgradation and energy saving projects Identification. |
| | Reduce specific heat consumption of Pyro system |
| | Optimize electrical equipment and Reduce SPC |
| Clinker Factor Reduction | Reduce % of clinker in cement (via SCMs) |
| WHRS Integration | Capture waste heat to generate electricity |
| AFR Integration | Use of alternative fuels & Raw materials |
| Grinding Optimization | Reduction in Power consumption by Increase in production. |
| Energy Efficient Design | For Green field Cement Projects |

# EXECUTION – DECARBONIZATION PROJECTS

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## Execution:

- Basic Engineering
- Procurement Services
- Detailed Project Engineering
- Equipment Inspection
- Site Supervision Services

# THANK YOU

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