Decarbonizing the Fertilizer Value Chain: Pathways from Innovation to Industrial Transformation

Objective: These **case studies** explore practical, data-driven pathways to reduce the carbon footprint of the fertilizer industry, covering the full value chain—from energy supply and feedstock production to process optimization and system integration. Participants will analyze real industrial scenarios involving green hydrogen, ammonia, Power-to-X, energy systems integration, and life-cycle assessment, with a focus on translating scientific innovation into scalable, industrial solutions.

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Case Study 1: Grid Integration & Power-to-X Pathways

Objective: Define the low-carbon electricity and energy system supplying a fertilizer plant. Outputs from this day become fixed assumptions for Case Studies 2 and 3.

Cross-cutting aspects: Grid safety, system resilience, regulatory compliance, and adoption challenges of large-scale energy infrastructure.

Selected Scenarios

CS1–A: Hybrid Renewable Energy Systems

- Optimal PV–wind–hydro mix
- Overcapacity & reliability
- Climate and regional constraints

CS1–B: Energy Storage & Flexibility

- Short-term vs long-term storage
- Batteries, hydrogen, ammonia
- Seasonal storage and cost of flexibility

CS1–C: Thermal Energy Storage & Industrial Heat

- TES for process heat
- Coupling with electrolysis & synthesis
- CO_2 reduction from heat decarbonization

Case Study 2: Hydrogen & Ammonia in the Value Chain

Objective: Translate the energy system into low-carbon molecules, quantifying costs and emissions.

Cross-cutting aspects: Hydrogen and ammonia safety, regulatory frameworks, standards, and market adoption.

Selected Scenarios

CS2–A: Green Hydrogen via Renewable Electrolysis

- Alkaline vs PEM vs SOEC
- Dynamic operation
- Water and scalability constraints

CS2–B: Green Ammonia via Green Haber–Bosch

- Integration of green H_2
- Flexible vs continuous operation
- Efficiency and heat integration

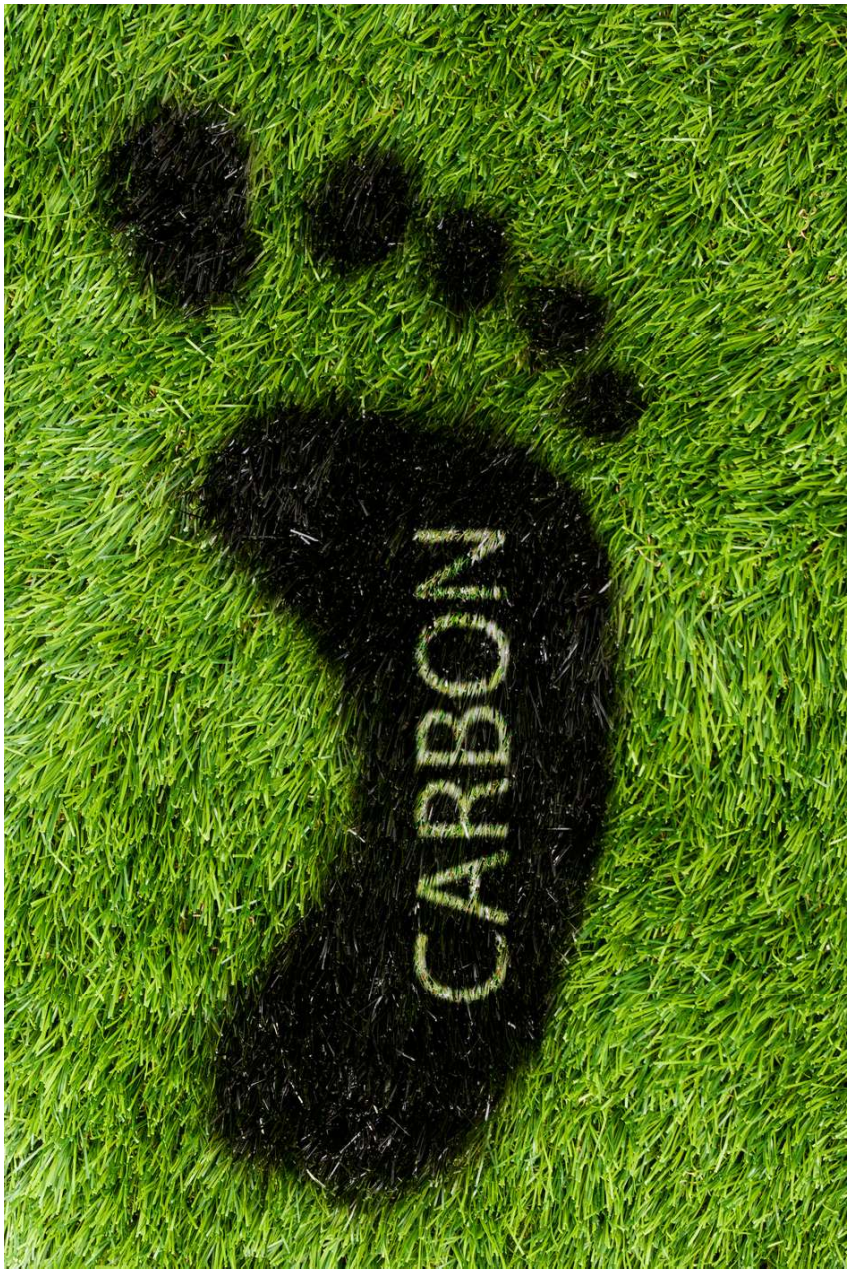
CS2–C: Blue Hydrogen & Ammonia with CCUS

- SMR + CCS
- Capture rates & methane leakage
- Residual emissions and climate robustness

Case Study 3: Reducing the Carbon Footprint of Material Extraction

Objective: Decarbonize the upstream raw material supply, closing the loop with sustainability and circularity.

Cross-cutting aspects: Occupational safety, environmental risk management, and adoption of digital and circular solutions.



Selected Scenarios

CS3–A: Electrification of Mining & Processing

- Electrified equipment and beneficiation
- Electricity and flexibility demand
- Achievable CO_2 reduction

CS3–B: Materials Innovation & Circular Economy

- Phosphogypsum valorization
- Recovery of critical elements
- Environmental and economic trade-offs

CS3–C: AI-Driven Optimization

- AI for ore quality and process efficiency
- Energy and material savings
- Implementation barriers

Group Allocation

Group	Case Study 1	Case Study 2	Case Study 3
G1	CS1–A	CS2–A	CS3–A
G2	CS1–A	CS2–B	CS3–B
G3	CS1–A	CS2–C	CS3–C
G4	CS1–B	CS2–A	CS3–B
G5	CS1–B	CS2–B	CS3–C
G6	CS1–B	CS2–C	CS3–A
G7	CS1–C	CS2–A	CS3–C
G8	CS1–C	CS2–B	CS3–A
G9	CS1–C	CS2–C	CS3–B

Group Project Presentations & Award CEREMONY

- 09:00 Group 1
- 09:20 Group 2
- 09:40 Group 3
- 10:00 Group 4
- 10:20 Group 5
- 10:40 Group 6
- 11:00 Group 7
- 11:20 Group 8
- 11:40 Group 9
- 12:20 **Award Ceremony**