

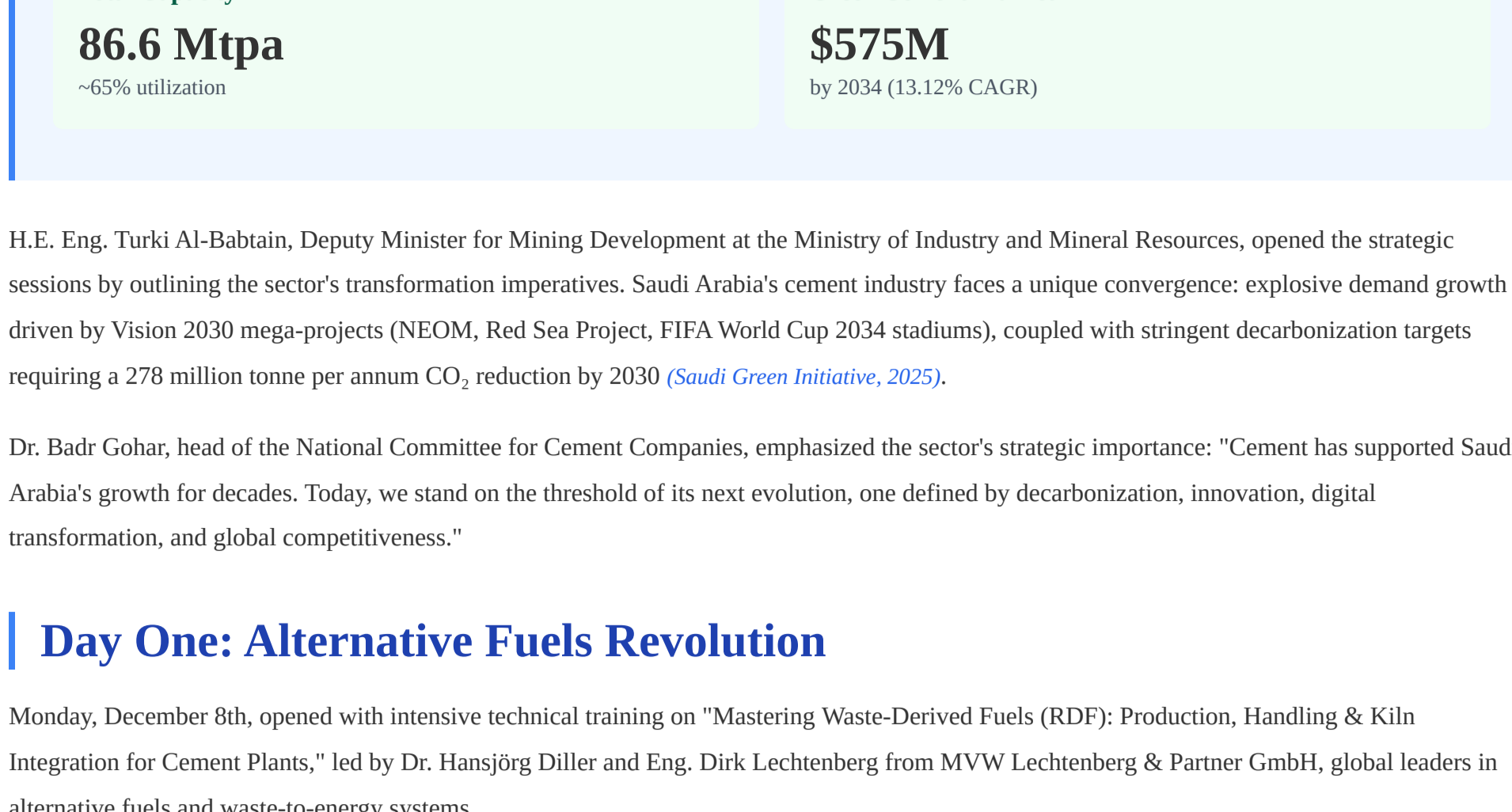
Future Cement Initiative Workshop: Saudi Arabia's Multi-Pathway Cement Transformation

Comprehensive coverage of the December 8-9, 2025 KAUST workshop integrating strategic policy, technical innovations, and market opportunities across Saudi Arabia's cement decarbonization journey

When over 200 cement industry leaders, researchers, and government officials gathered at King Abdullah University of Science and Technology (KAUST) this December, they weren't just discussing sustainability—they were architecting Saudi Arabia's cement sector transformation through an unprecedented multi-pathway approach.

The Future Cement Initiative (FCI) Workshop held December 8-9, 2025, marked a watershed moment for the Middle East's cement industry. With Saudi Arabia's cement demand projected to reach 73 million tonnes by 2030—up from 49 million tonnes in 2024—and the Kingdom's commitment to carbon neutrality by 2060, the two-day workshop unveiled a comprehensive strategy spanning carbon capture and methanol production, alternative fuels, innovative materials, 3D printing technologies, and advanced concrete formulations (Hobec Consulting, 2025).

Strategic Context: Saudi Arabia's Cement Sector at a Crossroads



H.E. Eng. Turki Al-Babtain, Deputy Minister for Mining Development at the Ministry of Industry and Mineral Resources, opened the strategic sessions by outlining the sector's transformation imperatives. Saudi Arabia's cement industry faces a unique convergence: explosive demand growth driven by Vision 2030 mega-projects (NEOM, Red Sea Project, FIFA World Cup 2034 stadiums), coupled with stringent decarbonization targets requiring a 278 million tonne per annum CO₂ reduction by 2030 (Saudi Green Initiative, 2025).

Dr. Badr Gohar, head of the National Committee for Cement Companies, emphasized the sector's strategic importance: "Cement has supported Saudi Arabia's growth for decades. Today, we stand on the threshold of its next evolution, one defined by decarbonization, innovation, digital transformation, and global competitiveness."

Day One: Alternative Fuels Revolution

Monday, December 8th, opened with intensive technical training on "Mastering Waste-Derived Fuels (RDF): Production, Handling & Kiln Integration for Cement Plants," led by Dr. Hansjörg Diller and Eng. Dirk Lechtenberg from MVW Lechtenberg & Partner GmbH, global leaders in alternative fuels and waste-to-energy systems.

The Waste-to-Fuel Opportunity

Saudi Arabia generates approximately 20 million tons of municipal solid waste annually. The workshop revealed that roughly 40%—or 7.8 million tons—can be processed into alternative fuels, potentially reducing heavy fuel oil (HFO) consumption by 18 million barrels oil equivalent (MWW Lechtenberg, 2025).

Economic Impact:

If Saudi Arabia sells recovered oil at world market prices instead of subsidized rates—assuming only a \$30/barrel differential—this could generate approximately **\$540 million annually**, sufficient to develop a comprehensive sustainable waste management system.

The technical sessions covered the complete value chain: waste assessment and contracting, RDF production technologies (pre-separation, screening, optical sorting, shredding), storage and dosing systems, kiln integration strategies, quality management protocols, and environmental considerations. Plant managers from across the Kingdom shared real-world implementation experiences, discussing both successes and challenges in integrating waste-derived fuels into existing operations.

Day Two: Strategic Vision and Innovation Portfolio

Tuesday's plenary sessions elevated discussions to strategic planning and breakthrough innovations. Professor Bassam Dally, FCI Chair and KAUST professor, articulated the initiative's vision: "Cement will remain essential to the Kingdom's development. Our challenge is to make it cleaner, more efficient, and globally competitive. Through research, training, and collaboration, we are building the scientific and industrial capabilities needed to shape the future of this vital sector" (KAUST, 2025).

Carbon Capture and Methanol Production

Transforming CO₂ into Industrial Feedstock

Eng. Mohamed Sarathy from KAUST's Clean Energy Research Platform presented on "Potential of Carbon Capture and Utilization in Saudi Cement Plants," demonstrating how cement plant CO₂ emissions could become feedstock for methanol production when combined with green hydrogen from Saudi Arabia's abundant solar resources.

Using Reversible Solid Oxide Electrolysis Cell (rSOEC) technology, the presentation showed that industrial-scale projects could capture 40,000+ tonnes of CO₂ annually to produce approximately 25,000 tonnes of methanol—transforming emissions into valuable chemical products (CarbonClean, 2025).

Saudi Solar Advantage:

Saudi Arabia experiences intense sunlight for much of the year, routinely achieving 6+ kWh/m²/day across many regions—significantly above global averages. This natural advantage positions the Kingdom uniquely for solar-powered green hydrogen production integrated with cement plant carbon capture.

Key technology: Oxygen combustion emerged as the most economically viable CO₂ capture method, with estimated costs of \$70-80 million for a 500 gpd brownfield testing facility.

Breakthrough Materials and Sustainable Concrete

NovusCrete: Seawater Concrete

Presented by Abdullah Alqahtani (PIF)

Innovative concrete solution utilizing seawater, Saudi sand dunes, petcoke aggregates, and recycled materials. Critical for water-scarce Saudi Arabia, which is becoming one of the largest construction material consumers globally.

- ICC-ES Acceptance Criteria AC3084 approved
- First demonstration pilot at NEOM Innovation Hub: >60 MPa strength
- Reduces freshwater consumption and virgin aggregate extraction

UHPC & LC3 Concrete

Presented by Eng. Hussam Nazareddin (NEOM)

Ultra-High Performance Concrete with up to 45% clinker replacement, achieving 120+ MPa compressive strength, designed for 120-year service life using local basaltic aggregates, natural pozzolan, and fly ash.

- Mean cover requirement: 20-40mm for 120-year design life
- LC3 (Limestone Calcined Clay): 50% clinker, 30% calcined clay, 15% limestone
- Leverages abundant Saudi kaolinite deposits in Asir region

KanCem: Local Clay for Supplementary Cement Materials

Presented by Prof. Abdulkader Afifi (KAUST)

Comprehensive investigation of Saudi clay deposits for supplementary cement materials. Field studies covered over 11,000 km, visiting 65 sites and collecting 100 samples (300 kg) across the Kingdom.

Key Findings:

- Largest deposits: residual laterites below and within Wasia Formation (Riyadh to Zabtiyah)
- Cenozoic laterites under basalt lava flows (Harrat As-Sirat, Asir region)
- Hydrothermal kaolinite near Yanbu (limited extent)
- Calcined kaolinite (metakaolin) can replace 5-40% of Portland cement by mass

Next steps include calcination trials at 600-800°C, reactivity testing, and techno-economic assessment for industrial integration.

3D Printing and Advanced Construction

BuildService: Layer-by-Layer Construction

Presented by Eng. Yasim Barkvi

→ **Construction Speed:** 100 m² printed in 100 hours
→ **Cost Reduction:** 30-40% overall construction cost savings
→ **Sustainability:** 60-70% less waste, 50% lower carbon footprint

→ **Labor:** 2-3 workers vs. 15-20 in traditional construction
→ **Planning:** to localize production of two 3D printer models in Saudi Arabia by end of 2025, with adapted mixes for Saudi climate conditions.

Aramco's Sustainable 3D Printing

Presented by Dr. Bandar Fadhel

Patented technology incorporating CO₂ injection and steam during 3D printing process:

- Achieved ~30% CO₂ reduction (12% avoidance + 20% uptake)
- Successfully printed 1.5m tall structure with 10mm aggregates
- Up to 47 layers printed with CO₂ injection at 2 bar pressure
- Demonstrated outdoor printing capabilities

Industry Applications and Commercial Scale

Saudi Readymix: R&D-Driven Decarbonization

Presented by Chris Leporkaridis (Technical and Strategy Director)

Comprehensive approach to decarbonizing Saudi Arabia's ready-mix concrete industry through clinker reduction, SCM usage, and innovative materials:

SCM Deployment:

- **GGFBs:** 20-70% replacement, 30% CO₂ reduction
- **Natural Pozzolan:** 15-35% rates, 25% CO₂ savings
- **Limestone Filler:** 10-15% replacement, 10-12% reduction
- **Target:** 60% cementitious materials by 2030 (30% in-house, 30% sourced)

Advanced Materials:

- **Geophene & CNTs:** 15% strength gain, 15-20% CO₂ savings
- **Geopolymer:** 100% OPC replacement for mass concrete
- **ECC (Aramco Project):** Superior ductility for infrastructure
- **Recycled Aggregates:** 25% replacement in concrete, 100% in blocks

Saudi Readymix published 50+ EPDs (2024-2025) for major projects including ARAMCO Stadium, SEVEN, Qalifa, and NEOM—first Saudi ready-mix supplier to issue EPDs since 2018.

Circular Economy and Waste Management Strategies

TerraFuel: Waste-to-Alternative Fuels

Presented by Eng. Sultan Alsaf

Strategic entity focused on converting diverse waste streams into certified, high-quality alternative fuels for cement industry:

Riyadh Flagship Facility:

- Treatment capacity: ~1 million tons MSW per year (world's largest)
- Projected to divert 100,000+ tons MSW annually
- Emissions reduction: 50,000+ tons CO₂
- Phase 2: Expansion to 3.5 million tons per year across multiple regions

RDF provides combined low NOx and GHG emissions compared to HFO, making it sustainable solution for cement kilns, especially in regions lacking gas supply infrastructure.

MWAN: National Waste Management Strategy

Presented by Mr. Sami Alrabadi (National Center of Waste Management)

Comprehensive national framework for waste management supporting cement sector decarbonization:

90%

Landfill diversion target by 2040

~848

Treatment facilities required

37 Mtpa

CO₂e reduction by 2040

Regulatory Sandbox Success: MWAN and Riyadh Cement Company completed Saudi Arabia's first regulatory-supervised pilot using steel slag (1,273.88 tons) in OPC, achieving 1-2 MPa strength increase and improved concrete slump.

Advanced Materials and Chemical Innovations

UHMWPE for High-Performance Cementing

Presented by Dr. Sara Alkhalaf (KAUST)

Tailored Ultra-High Molecular Weight Polyethylene (UHMWPE) for cementing applications, addressing the 15% annual failure rate in oil and gas well cementing (costing \$450 million in remedial work):

Polymer Engineering:

- Copolymerization to reduce melting point (140°C to 108°C)
- Young's modulus reduction (1.5 GPa to 0.15 GPa)
- Functionalization for hydrophilicity (contact angle 137° to 84.5°)

Cement Performance:

- Easy mixability with zero free fluid
- Rheology: 20-30 cP (acceptable pumping range)
- Thickening time: ~5 hours to 100 BC
- Enhanced energy dissipation and crack prevention

Policy Framework and Decarbonization Roadmap

Saudi Green Initiative Targets

Short-Term (By 2027):

- Conversion of all HFO-fired kilns to natural gas (27-30% CO₂ reduction)
- Government-funded conversion with 10-15% OPEX reduction
- 10% thermal substitution rate with alternative fuels

Long-Term (By 2060):

- Net-zero emissions across cement sector
- Commercial-scale CCUS deployment
- Solar energy integration in cement production
- Circular economy fully integrated

Mid-Term (By 2030):

- National CO₂ reduction: 278 million tpa
- Waste-heat recovery systems at all major plants
- Increased SCM usage and blended cement adoption
- 50% renewable energy in power capacity

Key Policy Measures:

- Performance-based material standards
- Low-carbon procurement mandates
- Carbon pricing mechanisms
- Green financing incentives

The workshop emphasized that successful transformation requires unprecedented collaboration between government, industry, and academia. Clear policy frameworks emerged as critical enablers: government procurement rules must embrace SCMs and blended cements, building codes need updating for low-carbon materials, carbon pricing must provide predictable market signals, and CCUS projects require financing clarity and infrastructure support.

Global Context and Competitive Positioning

Saudi Arabia's initiative emerges within a broader context of accelerating global cement industry decarbonization. The Global Cement and Concrete Association (GCCA) reports that the industry has achieved a 23% reduction in CO₂ emissions per ton of cementitious material since 1990, with a 2.2% drop in 2022 indicating accelerating progress (GCCA, 2024/25).



However, the sector faces significant challenges in scaling technologies to meet 2050 net-zero targets. The workshop positioned Saudi Arabia as uniquely capable of accelerating this transition through its combination of: abundant waste streams for alternative fuels, substantial local mineral resources (clay, pozzolan), world-leading solar energy potential for green hydrogen production, strong government commitment through Vision 2030, and significant capital availability for technology deployment.

Implementation Roadmap and Next Steps

Near-Term Actions (2025-2027)

Technical Deployment:

- Pilot waste-derived fuel systems at 3-5 plants
- Complete natural gas conversion across sector
- Deploy first commercial LC3 cement production
- Launch kaolinite clay processing facilities
- Install waste-heat recovery systems

Policy & Standards:

- Update building codes for blended cements
- Establish EPD requirements for major projects
- Implement performance-based specifications
- Create green cement certification framework
- Develop carbon pricing mechanisms

Medium-Term Goals (2027-2030)

Alternative Fuels: Scale TerraFuel operations to 3.5 million tpa treatment capacity across multiple regions

CCU/Methanol: Deploy first commercial cement-to-methanol facility with 40,000 tpa CO₂ capture

Materials Innovation: Achieve 60% SCM usage at Saudi Readymix; commercialize CNT-enhanced concrete

3D Printing: Local production of 3D printers and adapted mixes operational

UHPC Deployment: UHPC and LC3 specified for major giga-projects (NEOM, Red Sea, Qiddiya)

Capacity Optimization: Planned 12 Mtpa capacity additions operational with integrated sustainability features

Industry Perspectives and Success Factors

Industry veterans consistently highlighted two critical success factors throughout the workshop: execution speed and collaboration depth.

"We've got the roadmap," noted one plant manager with 25 years' experience. *"Now we need pilot projects moving from PowerPoint to production lines within 12-18 months. That requires unprecedented coordination between research institutions, government agencies, and private companies."*

Professor Bassam Dally emphasized: *"This isn't about finding one silver bullet. It's about creating an ecosystem of solutions that can work together to transform our cement sector while maintaining operational competitiveness."*

H.E. Eng. Turki Al-Babtain concluded: *"The cement sector has supported Saudi Arabia's growth for decades. Today, we stand on the threshold of its next evolution. This workshop is an opportunity for us to collaborate and innovate together, as I am confident that the discussions ahead will lay the foundation for a stronger, more competitive, and sustainable cement industry in Saudi Arabia."*

Economic and Competitive Advantages

The workshop revealed that Saudi Arabia's cement sector transformation represents not only environmental necessity but also significant economic opportunity. Beyond the \$540 million potential from waste-to-fuel conversion, workshop participants identified multiple value creation pathways:

Cost Reduction Opportunities:

- 10-15% OPEX reduction through natural gas conversion
- 140 SAR/ton savings with limestone filler vs. OPC
- 30-40% construction cost savings via 3D printing
- 200 SAR/m² savings using recycled aggregates

New Revenue Streams:

- Methanol production from captured CO₂
- Premium pricing for green cement in mega-projects
- Export opportunities with certified low-carbon products
- Carbon credits from CCUS deployment

The green cement market alone is projected to grow from \$189.7 million in 2025 to \$575.1 million by 2034, representing a 13.12% CAGR (IMARC Group, 2025). This growth is driven by Vision 2030 infrastructure projects, regulatory pressure, and increasing customer demand for sustainable construction materials.

Challenges and Risk Mitigation Strategies

Workshop discussions candidly addressed implementation challenges and proposed risk mitigation strategies:

Technical Challenges:

- **Alternative Fuels:** Waste quality consistency, preprocessing infrastructure
- **CCUS:** High capital costs (\$70-90M per facility), oxygen supply costs
- **rSOEC:** Durability under harsh Saudi conditions, scaling economics
- **SCMs:** Limited fly ash availability, clay processing capacity
- **3D Printing:** Climate adaptation of mixes, microcracking in high temperatures

Mitigation Strategies:

- **Phased Deployment:** Start with pilot projects, scale based on learnings
- **Technology Partnerships:** Collaborate with proven international suppliers
- **Local Adaptation:** Customize technologies for Saudi climate/resources
- **Diversified Portfolio:** Pursue multiple pathways simultaneously
- **Regulatory Sandbox:** Test innovations under temporary frameworks

Regional Leadership and Global Impact

By Wednesday afternoon, as the workshop concluded, a consensus had emerged: Saudi Arabia is uniquely positioned to become a regional catalyst and potentially a global model for cement sector transformation in rapidly developing economies.

Saudi Arabia's Unique Advantages:

- ✓ Abundant waste streams for alternatives (20M tpa MSW)
- ✓ Extensive local mineral resources (kaolinite, pozzolan)
- ✓ World-leading solar energy potential (6+ kWh/m²/day)
- ✓ Strong government commitment through Vision 2030

- ✓ Significant capital availability for technology deployment
- ✓ Large domestic market with 73 Mt demand by 2030
- ✓ Research infrastructure (KAUST, industry R&D centers)
- ✓ Strategic geographic position for regional export

Workshop participants noted that success in Saudi Arabia could provide a blueprint for other GCC nations and developing economies facing similar challenges: balancing rapid construction demand with decarbonization commitments, managing waste streams, and leveraging natural resources for sustainable development.

Conclusion: From Vision to Implementation

The Future Cement Initiative Workshop represented far more than a conference—it marked a comprehensive strategic blueprint for transforming Saudi Arabia's cement sector. The combination of technical training, research breakthroughs, strategic planning, and policy development created a holistic framework for action.

What distinguished this workshop from typical industry gatherings was its multi-pathway approach. Rather than advocating a single technological solution, the FCI recognized that transformation requires a portfolio of complementary strategies: alternative fuels reducing fossil fuel dependence, innovative materials cutting clinker consumption, carbon capture transforming emissions into valuable products, advanced construction methods improving efficiency, and circular economy principles eliminating waste.

As one workshop participant reflected: "It's like we've been given a perfect storm of opportunities. Waste problems? Check. Economic incentives? Check. Technology solutions? Check. Policy momentum? Check. The question becomes: can we execute fast enough?"

The answer to that question will determine whether Saudi Arabia's cement sector transformation becomes a local success story or a global template for sustainable industrial development. With cement demand projected to reach 73 million tonnes by 2030 and Vision 2030 mega-projects accelerating, the urgency is clear. The workshop demonstrated that the technical solutions exist, economic incentives align, and industry commitment is present.

Success depends on maintaining the collaborative momentum generated at KAUST. As the workshop concluded, participants committed to specific near-term actions: launching pilot projects, updating regulatory frameworks, scaling proven technologies, and creating the market conditions for sustainable cement to become the default rather than the exception.

Professor Bassam Dally's closing remarks captured the workshop's spirit: "Through research, training, and collaboration, we are building the scientific and industrial capabilities needed to shape the future of this vital sector. Cement will remain essential to the Kingdom's development—our challenge is to make it cleaner, more efficient, and globally competitive."

The Future Cement Initiative Workshop proved that Saudi Arabia's cement sector transformation is not a distant aspiration but an achievable reality. With comprehensive strategies spanning the entire value chain—from carbon capture to construction methods, from alternative fuels to advanced materials—the Kingdom is positioning itself as a leader in sustainable cement production. Whether this potential translates into concrete reality will shape not only Saudi Arabia's industrial future but potentially provide a model for cement sustainability across the entire Middle East and beyond.

Workshop Key Takeaways

Technical Achievements:

- 200+ participants across government, industry, academia
- 11 major innovation presentations
- Multiple pathways to 30-50% CO₂ reduction identified
- Local resources mapped for sustainable cement production

Strategic Outcomes:

- Clear decarbonization roadmap through 2030 and 2060
- Policy framework recommendations developed
- Public-private collaboration model established
- Regional leadership positioning confirmed

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About this Report: This article is based on comprehensive coverage of the Future Cement Initiative Workshop held at King Abdullah University of Science and Technology, December 8-9, 2025, including presentations from government officials, industry leaders, and research scientists. All data and findings are derived from official presentations, strategic reports, and published research cited throughout.