FUTURECOAL

The Global Alliance for Sustainable Coal

SCS Projects and Messages (June 2026)

Sustainable Coal Stewardship (SCS) proves that coal's future is not just about energy—it's about innovation, value, and responsible use.

- **SCS shows proven technologies:** The SCS roadmap showcases proven technologies that enable coal to be mined, processed, and used responsibly, delivering both environmental and economic benefits.

Pre-Combustion

- Describes the abatement opportunities available to the upstream sector in the coal value chain. This includes efficient mining practices, digitalisation, waste management, renewable power, methane control, management of surface subsidence, land disturbance and rehabilitation, among others.

Digitalisation

- The coal mining industry is undergoing a major transformation as digital technologies are being adopted to improve efficiency, safety and productivity. Digitalisation refers to the use of data, analytics, automation, artificial intelligence and other digital tools to enhance the performance of mining operations.
- Advanced data analytics can drastically increase efficiency and reduce maintenance costs.

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- Digitalisation not only enhances operational efficiency but also prioritises the safety and well-being of workforces. Wearable devices ensure real-time monitoring of employee safety, while drones and robotics effectively navigate hazardous environments, reducing injuries by 10-20%.
- Automation helps to attract the next generation of diverse, engaged employees.

Mine Subsidence

- The coal mining industry uses a range of engineering techniques to design the layout and dimensions of an underground mine workings so that surface subsidence can be anticipated and controlled.

Dust & Noise

- During mining operations, the impact of air and noise pollution on workers and local communities can be minimised by modern mine planning techniques and specialised equipment.

Land Rehabilitation

- Land rehabilitation is crucial for FutureCoal's SCS, ensuring the restoration and preservation of ecosystems affected by coal mining activities.

Mining Projects

- **China's** Shanxi province has 369 intelligent coal mines already operating, accounting for more than a third of the national total. AI-enabled systems, 5G connectivity, autonomous trucks and robotic mining are reducing labour intensity, improving safety and transforming coal production from the ground up.

- **Coal India** has launched "Project Digicoal." Across seven major mines, fully integrated command-and-control centres use Internet of Technologies or IoT devices and real-time analytics to monitor operations. This reduces downtime, improves fuel efficiency, and enhances worker safety.

- **Komatsu** is pioneering the deployment of autonomous vehicles and electric-drive trucks, reshaping mining operations with innovations that increase productivity while prioritising safety and sustainability.

- **Peabody** has implemented an automated production management system that integrates entire mining and processing operations.

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- **SUEK's** advanced production management system is delivering tangible results—cutting idle time, optimising haulage routes, and significantly reducing both fuel consumption and emissions.
- **Seriti Resources** have implemented a safety strategy that is built upon four foundational pillars: people, systems, learning, and stratified.
    - It begins with people — training, engaging, and building a culture of safety. It is supported by strong systems and protocols to manage risk. It is strengthened by learning — from incidents, near misses, and best practice. And it is focused through stratification — prioritising the greatest risks so that resources go where they matter most.
    - Together, these initiatives reflect a shared vision of a future where coal mining is smarter, safer, and more sustainable.

Combustion

- This describes the range of efficient technologies which when combined support power and heat utilities to abate and capture up to 99% of emissions.

Carbon Capture and Storage

CCUS is proven and scaling fast, with 50 projects already operating worldwide, 44 more under construction, and a total global pipeline of 628 projects with 416 Mtpa capacity.

Coal-based CCUS has been in operation for nearly two decades, beginning with China's first facility ahead of the 2008 Beijing Olympics.

- **China**'s Huaneng has started operating the largest coalfired power generation capture plant in the world, capturing 1.5 million tonnes of CO_2 annually at under US$30 per tonne (Source: LETA).
- **CCS Makes Economic Sense** – Capturing CO_2 from coal plants is cost-effective, with China achieving $20/tonne—far lower than Europe's price CO2 trading at US $89/tonne. Advanced technologies are making CCS more viable and accessible.
- The Taizhou CCS Project, operational since June 2023, is one of Asia's largest coal-fired power sector CCUS facility and the third-largest in the world, with a designed capture capacity of 0.5 Mtpa (Source: LETA).
- **North America** operates two successful coal-based carbon capture and storage (CCS) plants.

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- **Boundary Dam** in Canada proves that coal with CCS works, supplying electricity to 100,000 homes while capturing up to 90% of CO_2 and eliminating sulphur dioxide entirely, with more than 4.5 million tonnes of CO_2 stored since 2014.

- **Petra Nova** in the U.S. is one of the world's largest carbon capture projects, designed to remove over 90% of CO_2 from a 240-MW slipstream. Since 2016, it has consistently captured around 92% of emissions, with capacity to capture 1.4 million tonnes annually, proving the viability of large-scale CCS.

High Efficiency Low Emissions

High-Efficiency, Low-Emissions (HELE) plants raise efficiency from the global average of 37.5% to nearly 50%, with the potential to cut global CO_2 emissions by up to 2 gigatonnes, making them essential to achieving near-zero emissions from coal.

- Over 1,000 GW of Supercritical and Ultra-Supercritical coal power is already operating worldwide—equal to the EU's total electricity capacity—with hundreds more plants under construction or planned.
  - Over 233 GW under construction (159 plants) — equivalent to the entire installed capacity of Brazil, the largest economy in Latin America.
  - Over 277 GW in pipeline (129 plants) — equivalent to the installed capacity of Germany, Europe's largest economy.

- Replacing older coal plants with ultra-supercritical technology could cut over 1 billion tonnes of CO_2 each year—the same as removing up to 560 million SUVs from the road. With efficiencies above 50%, USC plants are a proven, scalable solution for cleaner energy.

- **South Africa** already operates 9,000 MW of supercritical coal capacity, more than anywhere else in Africa (Source: FutureCoal). Raising average fleet efficiency from ~33% to above 44% could cut emissions by over 30% without rebuilding plants (Source: FutureCoal, 2025).
- **China's** Beilun Power Station has become China's largest thermal plant, generating enough electricity each day to power 20 million homes. Its latest units run at record efficiency, using just 257g of coal per kWh, setting a new benchmark for modern thermal technology.

- FutureCoal's joint report with the ASEAN Centre for Energy (Clean Coal Technology in ASEAN Balancing Equity, Security & Sustainability), we found that if investment of US $26 billion was used to upgrade existing subcritical coal power plants with ultra-Supercritical technology this would

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reduce annual emissions by 60 million tCO_2, the equivalent of removing 31.5 million cars per year.
    - Whereas if US $26 billion investment was allocated to offshore wind, it would only displace 7 GW of subcritical coal capacity, reducing annual emissions by 35.8 million tCO_2, the equivalent of removing 19 million cars per year.

Coal Gasification

Coal gasification strengthens energy security for nations with coal but limited oil and gas, converting coal into hydrogen-rich syngas for fuels, chemicals, and power. With IGCC technology reaching over 50% efficiency, countries like India are making it central to their self-reliance strategy, targeting 100 million tonnes of coal gasified annually by 2030.

- **Indonesia:** Indonesia is building a US$2.3 billion coal gasification plant to cut LPG imports, converting 6 Mt of low-rank coal into 1.4 Mt of DME annually and reducing LPG imports by 1 Mt each year.

- **India:** Coal India and partners are advancing four major coal gasification projects, alongside NLC India, targeting 100 Mt of coal gasified by 2030 and creating over 20,000 jobs.

- **India:** Investing heavily in coal gasification, with a US$1 billion incentive scheme to produce ethanol, hydrogen, and fertilisers while capturing CO_2 as part of its self-reliance strategy.

- **Japan** Nakoso IGCC plant, in operation since 2021, achieves 48% efficiency and aims to cut emissions to 0.7 $kgCO_2/kWh$, well below the global average of 0.9, while making CO_2 capture easier than conventional plants.

Co-firing Biomass and Ammonia

Co-firing biomass with coal reduces greenhouse gas emissions, sulphur dioxide (SOx), and nitrogen oxide (NOx).

Biomass—organic material like wood, crops, or waste—can be burned directly or converted into fuels like ethanol or biogas. When combined with coal, it offers a lower-emission power generation option.

- **Japan's** largest power generator, JERA, successfully completed a trial co-firing 20% ammonia with coal at its Hekinan power station, proving the potential for cleaner coal generation.

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- **Indonesia** is scaling up biomass co-firing with coal, with 43 power plants using 1 million tonnes of biomass in 2023, reducing over 1 million tonnes of CO_2e. PLN targets 10.2 million tonnes of biomass use by 2025, making all 52 of its coal plants co-fire ready.

Beyond Combustion

- This is our vision of the novel business opportunities that transform coal into high-value products. These include Coal-to-Liquids (CTL), synthetic liquid hydrocarbons, hydrogen, methanol, steel, cement, critical minerals for our digitised and electrified future, and advanced materials like graphene and carbon fibre.

Heavy Industries

- **Steel:** Coal fuels approximately 70% of global steel production, serving as its primary energy source.
- **Cement:** Coal fly ash and coal power play a crucial role in producing about 80% of the world's cement.
- **Aluminium:** Coal serves as the primary energy source for producing 55% of the world's aluminium.

Hydrogen

- **Coal can produce the cleanest form of hydrogen:** Utilising advanced abatement technologies like High-Efficiency Low Emissions (HELE) and Carbon Capture and Storage (CCS), coal can generate hydrogen while slashing CO2 emissions by up to 90%, establishing it as a leading low-carbon method for producing blue hydrogen, a form of clean hydrogen.

- **Coal produces the cheapest form of hydrogen:** Coal stands out as the most economical source of hydrogen, with production costs ranging from $1.9 to $2.4 per kg H2 when employing coal gasification with CCS. In regions like China, costs can be as low as $1.6 per kg.

Critical Minerals

- **Coal and coal waste can produce essential critical minerals:** Coal and coal waste are rich sources of critical heavy metals that are indispensable in modern life. This includes aluminium, cobalt, copper, iron, lead, silver, nickel, and zinc.

- **Critical minerals for the future:** Coal and coal waste contain copper, cobalt, nickel, and rare earth elements—resources the UN predicts will see

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demand surge by 1,500% or more by 2050. Responsible recovery can reduce import dependence and support battery and renewable supply chains.

- **Produces high-value carbon products:** Developments in material science are unlocking coal's potential for producing high-value carbon products. Carbon nanomaterials like graphene has many extraordinary properties that make it valuable for various applications in science, technology, engineering and medicine. This includes computer memory devices, LED lighting, solar cells, batteries, medical imaging, and more.

- **Creates job opportunities:** Embracing these innovative uses for coal and its waste not only creates local job opportunities across industries but also propels countries towards a net-zero economy.

- **Research:** University of Texas research shows U.S. coal ash contains nearly 11 million tonnes of rare earth elements (REEs), eight times current domestic reserves — valued at $8.4 billion and reducing reliance on imports, 75% of which come from China.

Agriculture

- Coal offers a low-cost and sustainable path for agriculture by Implementing methods like humates, farmers can decrease their dependency on nitrogen fertilisers, resulting in cost savings, waste reduction, and pollution mitigation while enhancing food production.
- This innovative application offers an environmentally friendly alternative, particularly for low-rank coal, ensuring a sustainable path forward for agriculture.
    - This environmentally friendly practice is gaining popularity in Asia, where the demand for humic products increases by 10% annually.
    - In the United States, regions like North Dakota extract lignite and ship it to India for processing into humic products used as fertilisers.

Graphene

- Which can be harvested from coal, is 200 times stronger than steel yet lighter than paper. It strengthens building materials, powers lithium batteries, and boosts performance in electronics beyond silicon-based alternatives.
    - The global graphene market is set to grow from US$0.19 billion in 2022 to US$1.43 billion by 2030, underscoring coal's role as a source of one of the world's fastest-growing high-value materials.

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Carbon fibre

- Derived from coal, this advanced material is stronger and lighter than aluminium and steel, making it essential for aerospace, defence and automotive industries.

For more information, read our report: https://www.futurecoal.org/coals-future-new-report-charts-path-to-sustainability/

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