



Navigating the Energy Transition Workbook

Navigating the Energy Transition

Aligning Vision | Accelerating Transformation | Leading with Purpose.

This leadership program is designed exclusively for leaders and professionals tasked to lead and contribute to steering the energy initiative. Through strategic insights, real-world case studies, and comparative global benchmarks, this course empowers participants to:

- Embrace and internalize the Kingdom's bold energy and sustainability vision.
- Translate national ambitions into policy coherence, operational excellence, and international credibility.
- Navigate the complex trade-offs between energy security, affordability, and environmental responsibility.
- Learn from global pioneers while championing Saudi-led frameworks such as the Circular Carbon Economy.

This is not just a course. It is a strategic forum—where participants refine their role to deliver on this mandate, sharpen their influence, and lead the next era of sustainable prosperity.

"We are determined to reinforce and diversify the capabilities of our economy, turning our key strengths into enabling tools for a fully diversified future. As such, we will transform Aramco from an oil producing company into a global industrial conglomerate. We will transform the Public Investment Fund into the world's largest sovereign wealth fund."

HRH Prince Mohammed bin Salman bin Abdulaziz Al Saud, Crown Prince and Prime Minister

KSA's strategy is **pragmatic and dualistic**—leveraging its oil wealth to fund a **gradual, innovation-driven clean energy transition**, while aligning with **Vision 2030** and regional leadership goals. Unlike many Western economies focused on rapid decarbonization, KSA balances **economic resilience with sustainability**, making it a **distinctive model** in the global transition landscape.

In the Saudi context, *dualism* refers to the **simultaneous pursuit of two parallel energy and economic tracks**:

- **Sustaining the traditional hydrocarbon economy** (to maintain fiscal strength, global oil leadership, and domestic stability)
- **Accelerating clean energy transformation** (to align with global net-zero goals and future-proof the economy)

This principle underpins KSA's **"And, not Or"** approach:

Oil economy + Clean economy = Strategic coexistence

"While renewable, nuclear power, and hydrogen energy sources are expanding, oil and gas will remain indispensable, especially in hard to abate sectors like heavy industry, transport, and in supporting economies of developing countries,"

HRH Prince Abdulaziz bin Salman bin Abdulaziz Al Saud, Minister of Energy said while addressing the opening session of the 9th OPEC International Seminar in Vienna.

Course objectives

1. Build a comprehensive understanding of the energy transition, including renewable energy integration into the energy mix, policy and regulation, sustainability practices, and energy security, enabling leaders to confidently contribute to key initiatives (e.g. renewable projects).
2. Strengthen critical skills required to contribute to a complex and evolving energy landscape through simulated and immersive learning experiences.
3. Review energy strategies and policies and develop actionable insights to bridge the gap between national vision and on-the-ground implementation.
4. Engage with real-world energy sector challenges and scenarios ensuring new skills result in measurable improvements in participants' contribution to energy related programs and initiatives.
5. Align efforts with the participating entities' strategic objectives to achieve intended outcomes.
6. Take accountability, identify key success metrics and follow-up to ensure identified measures of success are tracked and achieved.

Course outcomes

1. **Interpret and Anticipate Energy Trends:** Analyse global and regional energy trends (such as shifts in renewable energy, oil markets, and climate policies) and assess their implications for KSA's strategy. As a result, participants will be able to contribute proactively to energy related programs and initiatives.
2. **Navigate Policy and Regulatory Frameworks:** Navigate KSA's energy policy and regulatory environment to advance the transition. Participants will understand the policies, laws, and incentives that enable the energy transition (e.g. renewable procurement programs, efficiency standards, carbon reduction targets) and will know how to leverage these tools or contribute to their development.
3. **Understand the Energy Transition:** Contribute effectively to energy transition initiatives. This includes understanding how renewable energy and new technologies are integrated into the existing energy mix, balancing considerations of energy security and sustainability, and managing the complexities of the energy landscape.
4. **Identify opportunities for Alternative Energy Technologies and Adoption:** Analyse viable new technologies and innovative solutions for the country's energy portfolio, including emerging technologies like solar, wind, hydrogen, energy storage, and carbon capture.
5. **Build Critical Skills:** Demonstrate improved capabilities for driving the energy transition. Participants will practice techniques for engaging stakeholders, evaluating policy and regulatory frameworks, global and national drivers, and building collaborative partnerships.
6. **Prepare for Action:** With a strong understanding of Vision 2030 and their organization's strategic objectives, participants will be ready and able to connect their daily work and critical decisions to these overarching goals.

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Module 1: Global Energy Landscape | Vision 2030

Session 1: Saudi Vision 2030 and Energy Transition

1. Strategic Context

Saudi Vision 2030 is KSA's long-term blueprint to diversify its economy, reduce its dependence on oil, and position itself as a global leader in sustainable development. This transformation is an ambitious energy transition agenda that aligns national priorities with global climate and innovation goals.

As Vision 2030 marks its tenth year, KSA stands at a pivotal moment. The Kingdom is delivering on its promise of transformation – empowering its people, reshaping its economic landscape, and unlocking new opportunities at scale. The past year has delivered concrete progress across economic, social, and institutional fronts confirming the strength of the Kingdom's strategic direction and the commitment driving it.

KSA Ministry of Energy – Vision 2030 Message

Insights from the Last 6 Speeches

1. ENERGY TRANSITION AS NATIONAL TRANSFORMATION

The Ministry reaffirmed that the energy transition is a cornerstone of Vision 2030, driving economic diversification, industrial growth, and job creation. The Kingdom is building a future energy system that is sustainable, reliable, and built for generations to come.

Our transition powers the nation's future.

2. ACHIEVING NET ZERO WITH REALISTIC, RESPONSIBLE ACTION

The Ministry emphasized that Net Zero 2060 is not just a target, but a long-term commitment built on innovation, technology, and global partnerships. The approach is pragmatic, technology-neutral, and focused on real, measurable results across the entire energy value chain.

Real ambition. Real solutions. Real impact.

3. BUILDING A DIVERSE, RELIABLE AND AFFORDABLE ENERGY MIX

The speeches highlighted the importance of balancing all available energy sources – oil, gas, renewables, hydrogen and emerging technologies – to ensure energy security, affordability and reliability while enabling sustainable growth and global competitiveness.

All energies. One future.

4. INVESTING IN PEOPLE, INNOVATION AND FUTURE CAPABILITIES

The Ministry underlined that people are the greatest asset in the energy transition. Investment in talent, research, digitalization and local capabilities is essential to lead the future, create high-value jobs, and build homegrown solutions.

Empowered people. Innovative nation.

5. GROWING THE ECONOMY AND CREATING GLOBAL VALUE

The Ministry reinforced the role of energy in expanding non-oil exports, strengthening industries, attracting investment and unlocking new markets. The Kingdom is positioning itself as a global energy leader and a hub for sustainable energy solutions.

Energy for prosperity. Value for the world.

6. PARTNERSHIP, RESPONSIBILITY AND A BETTER TOMORROW

The Ministry called for stronger international collaboration and shared responsibility to address climate change and energy challenges. The Kingdom remains committed to environmental stewardship, community well-being, and building a cleaner, safer, brighter future.

Together for a sustainable tomorrow.

Vision 2030 is built on the Kingdom's core strengths: its central role in the Arab and Islamic worlds, its influence within the global economy, and its strategic geographic location. These foundations have been paired with a clear reform agenda and long-term planning to enable durable and inclusive growth. Vision 2030 has progressed in clear phases. **The first phase** established a strong foundation – introducing sweeping reforms, launching Vision Realization Programs (VRPs), and building institutional capability and capacity. This phase focused on unlocking potential and preparing for rapid transformation.

The second phase built on this foundation, accelerating impact through regional and sectoral coverage, increased private sector engagement, and a more integrated, national delivery model. The pace of change quickened – and so did the scale.

In 2026, Vision 2030 will enter its **third and final phase** of delivery: a new chapter focused on entering full delivery mode, expanding opportunity across every sector, and sustaining the impact well beyond 2030. <https://www.vision2030.gov.sa/en>

2. Vision Realisation Programs

The Vision Realization Programs (VRPs) have played a central role in delivering Vision 2030’s objectives – strengthening coordination, building capabilities across the ecosystem, breaking silos, and accelerating progress. Launched in the initial phase of Vision 2030, the VRPs were designed as the primary implementation vehicles for turning the Vision into action. As medium-term programs, the VRPs have evolved over time to remain aligned with national priorities, adapting to changing economic and developmental needs across each phase of Vision 2030. Some programs have been merged, others concluded, and new ones launched to reflect emerging priorities. There are now 10 VRP’s targeted for the third phase of Saudi Vision 2030.

SAUDI VISION 2030

10 VISION REALIZATION PROGRAMS IN OPERATION

Continuing to drive transformation and deliver the ambitions of Vision 2030

1. FINANCIAL SECTOR DEVELOPMENT PROGRAM Develops a strong, stable and inclusive financial sector that supports economic diversification, encourages savings and investment, and drives sustainable growth.	2. HUMAN CAPABILITY DEVELOPMENT PROGRAM Builds a capable, creative and empowered society by investing in education, skills, health and social development to prepare citizens for the future and a thriving economy.	3. HEALTH SECTOR TRANSFORMATION PROGRAM Improves the efficiency, accessibility and quality of healthcare services to enhance quality of life and build a sustainable and world-class health sector.	4. PILGRIM EXPERIENCE PROGRAM Enriches the experience of pilgrims and visitors to the Two Holy Mosques by improving services, infrastructure and crowd management to the highest standards.	5. QUALITY OF LIFE PROGRAM Enhances the quality of life for all by expanding opportunities in culture, entertainment, sports, tourism and urban development.
6. NATIONAL TRANSFORMATION PROGRAM Drives government transformation, digitization and operational excellence while enabling the private sector and improving the business environment.	7. PUBLIC INVESTMENT FUND PROGRAM Maximizes the impact of the Public Investment Fund by building a diversified portfolio of global investments and driving new sectors and jobs.	8. HOUSING PROGRAM Increases homeownership and improves housing supply and affordability to enhance stability and quality of life for Saudi families.	9. NATIONAL INDUSTRIAL DEVELOPMENT AND LOGISTICS PROGRAM Develops local industries and logistics capabilities across four core sectors: energy, industry, mining and logistics to diversify the economy and create jobs.	10. PRIVATIZATION PROGRAM Increases private sector participation in the economy by optimizing government assets, improving efficiency and delivering better services.

3. Key Energy Transition Objectives

KSA's national strategies – whether sectoral or regional – emerged as a core part of Vision 2030's delivery model. These strategies drive value creation across key sectors and are designed to extend their impact well beyond 2030. These strategies build on the foundation laid by VRPs. As progress accelerated and opportunities became more defined, the need for specialized national and regional strategies emerged, ensuring more targeted planning and implementation.

This is enhancing economic diversification, expanding impact across regions, and delivering tangible benefits to citizens and businesses alike. Today, sectors such as tourism, culture, renewable energy, and mining are growing at pace, powered by clear strategic direction and effective government execution. This progress positions KSA as a rising global hub for innovation and investment, and as a destination for those looking to shape and share in a future of opportunity.

Current Strategic Objectives of KSA Related to the Energy Transition

1. Energy Security Ensure a reliable, secure and diversified energy supply to support economic growth, industrial development and national resilience.	2. Renewable Energy Expansion Increase the share of renewable energy in the energy mix, develop world-class renewable projects and attract investment in clean energy technologies.	3. Carbon Emissions Reduction Reduce greenhouse gas emissions and advance towards net zero through cleaner technologies, carbon capture and circular carbon economy initiatives.	4. Energy Efficiency and Demand Management Improve energy efficiency across all sectors and implement demand-side management to optimize resource use, reduce costs and enhance grid flexibility.	5. Economic Diversification Grow new industries, create jobs and develop local supply chains through the energy transition, including green hydrogen, advanced manufacturing and clean technology.
6. Infrastructure and Grid Modernisation Build a resilient and flexible electricity grid and supporting infrastructure to integrate renewables, enable new technologies and meet future demand.	7. Innovation and Technology Leadership Accelerate research, development and innovation, adopt digital solutions and position KSA as a regional leader in energy technology and clean energy services.	8. Human Capital Development Build a skilled and future-ready workforce through education, training and capability development to support the energy transition and new industries.	9. Environmental Stewardship Protect natural resources, conserve biodiversity, manage water and waste responsibly and ensure environmental sustainability across the energy value chain.	10. Governance, Collaboration and Global Partnerships Strengthen regulatory frameworks, promote transparency and collaboration with international partners to accelerate the energy transition and achieve Vision 2030.

<https://www.vision2030.gov.sa/en/explore/programs/national-industrial-development-and-logistics-program>

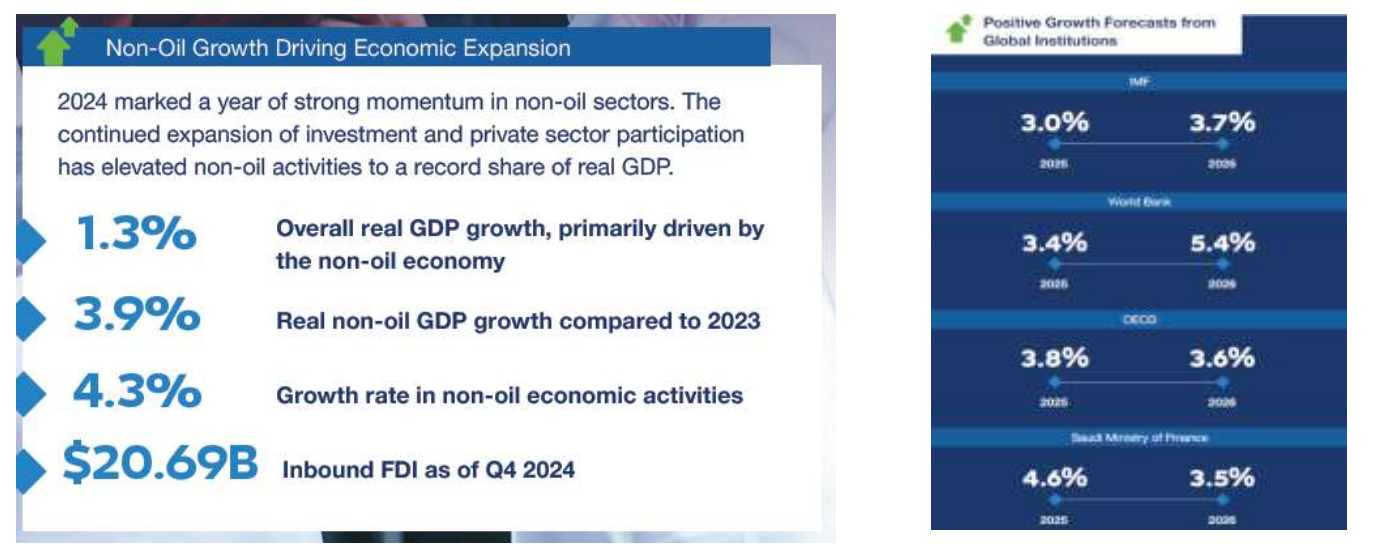
This second phase of Vision 2030 has also seen the maturation of national planning processes, financial governance, and performance management systems. These advancements reflect nine years of accumulated experience, strengthened by partnerships with global organizations, and the steady development of technical expertise across sectors. Efforts are also underway to update the Kingdom's

GDP framework in line with the System of National Accounts (SNA), to enhance economic transparency, improve data quality, and ensure more accurate measurement of KSA’s economy.

NATIONAL STRATEGIES AND INITIATIVES (2018-2025)				
01 2018	02 2020	03 2020	04 2021	05 2021
Integrated Strategy for Mining and Mineral Industries	Comprehensive Strategy for the Real Estate Sector	Labor Market Strategy	National Transport and Logistics Strategy	Asir Region Development Strategy
06 2021	07 2022	08 2022	09 2022	10 2022
National Investment Strategy	Custodian of the Two Holy Mosques Scholarship Program	Financial Technology Strategy	National Gaming and Esports Strategy	National Industry Strategy
11 2024	12 2024	13 2024	14 2025	
National Biotechnology Strategy	National Red Sea Sustainability Strategy	Transformation Strategy for the Institute of Public Administration	National Privatisation Strategy	

4. Economic Landscape

In 2024, KSA maintained macroeconomic stability while advancing structural reforms under Vision 2030. The economy continued to diversify, supported by targeted investment, policy shifts, and the gradual expansion of non-oil sectors. These developments contributed to steady growth and a favourable investment climate, reinforcing the broader trajectory of long-term transformation.



[Source: <https://www.vision2030.gov.sa/en>]

5. Vision 2030 Progress overview – end of phase 2

As delivery vehicles, the performance of VRPs and national strategies is evaluated along two main dimensions: progress in initiative execution and achievement of performance indicators.

Overall, efforts remain on track, with some deviations observed due to fast-evolving external and internal variables affecting certain programs and strategies.

Corrective actions are being implemented to accelerate delivery and realign initiatives and indicators, ensuring that Vision 2030 objectives remain within reach.



6. Vision 2030 and Its Energy Goals <https://www.vision2030.gov.sa/en/>

KSA's Vision 2030 is a strategic national roadmap launched in 2016 under the leadership of Crown Prince Mohammed bin Salman. It aims to diversify the Saudi economy, reduce dependence on oil revenues, and transform KSA into a global investment powerhouse, a vibrant society, and a thriving nation.



The three pillars of Vision 2030

A Vibrant Society, A Thriving Economy, and An Ambitious Nation—are each supported by a set of quantifiable KPIs that reflect progress, accountability, and ambition.

These indicators not only measure performance but also ensure the alignment of policy initiatives with long-term strategic outcomes. Collectively, they offer a data-driven roadmap for KSA's transformation into a globally competitive and sustainable nation.

VISION 2030 ANNUAL REPORT 2025

7. A Vibrant Society | A Leading Destination

This pillar aims to strengthen national identity, preserve cultural heritage, promote healthy lifestyles, and improve quality of life. It envisions a society deeply rooted in Islamic values and national pride, while being open to global cultures and modern lifestyles.

Strategic Objectives include:

- Enhance quality of life and urban liveability
- Promote physical and cultural activities
- Develop the Saudi arts, culture, and entertainment sectors
- Preserve Islamic and national heritage



[Source: <https://www.vision2030.gov.sa/en>]

8. A Thriving Economy

This pillar focuses on economic diversification, private sector empowerment, foreign investment, innovation, and job creation. It aims to move KSA from an oil-reliant economy to a globally competitive economic hub.

A Fast-Growing Economy

- ♦ Economic Diversification and Global Standing
- ♦ Public Investment Fund: A Catalyst for Economic Growth
- ♦ Empowering the Private Sector
- ♦ Mining: A Sustainable Resource Driving Diversification
- ♦ Industrial Development: From Foundations to Future
- ♦ Transportation and Logistics: Powering Economic Connectivity
- ♦ Financial Sector: A Thriving Hub of Investment and Innovation
- ♦ Digital Sector: Advancing Global Digital Leadership

More than 1,000 reforms and 1,200 measures have been implemented, alongside the introduction of key institutions and updated laws, including allowing 100% foreign ownership in most sectors.

Digital platforms have reduced requirements for investment licenses by 54%, while property transfers can now be completed within 60 minutes and container clearance within 24 hours.

Improvement in Global Competitiveness Rankings

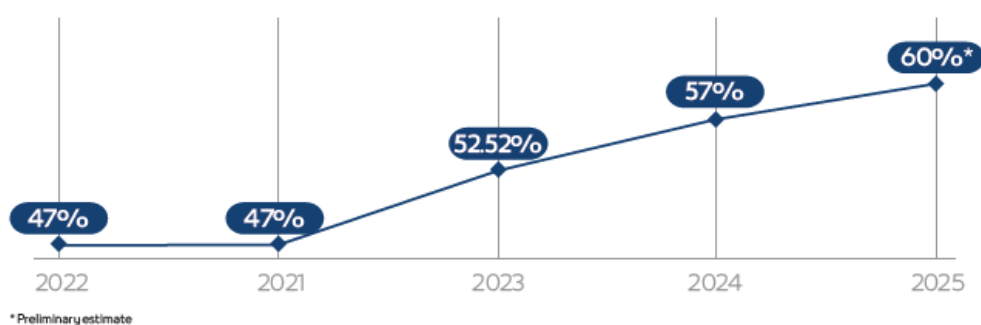
World Competitiveness Yearbook 2025



Expanding Opportunities for the Private Sector



Local Content in Projects



[Source: <https://www.vision2030.gov.sa/en>]

Regulatory Maturity Driving Investment

Mining reforms over the past decade have strengthened regulation and improved the investment environment, making the sector more competitive and easier to access.

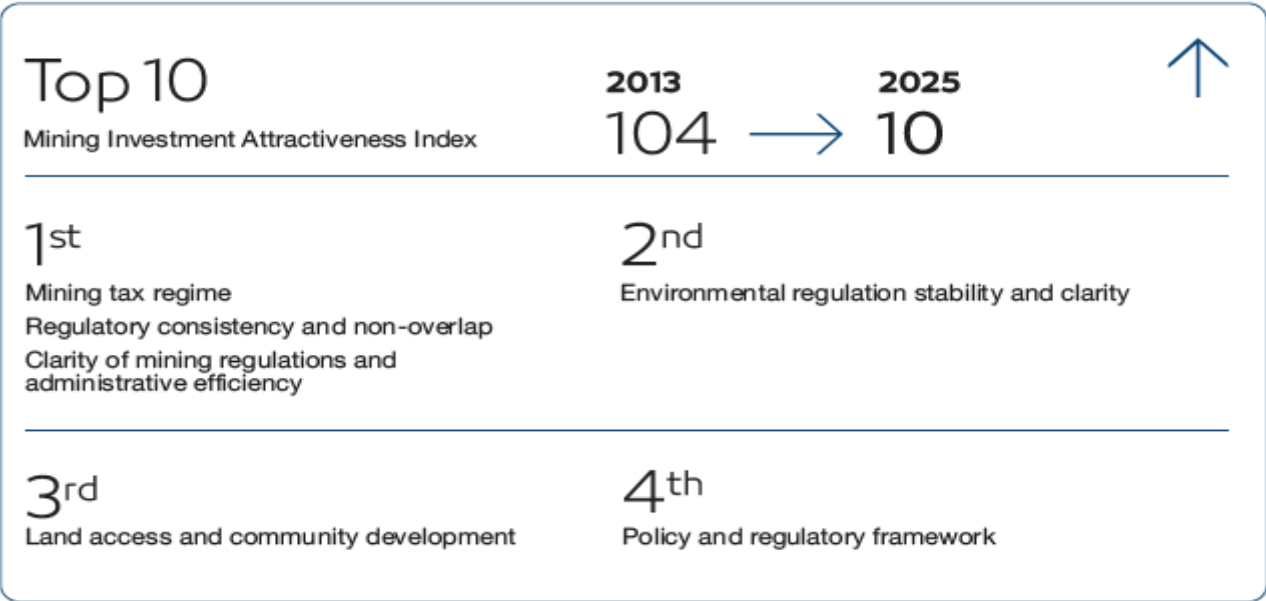
This shift is reflected in international

indicators, with Saudi Arabia advancing significantly across key mining indices. It is also visible in rising exploration activity and increased participation by mining companies, supported by clearer regulations and expanded investment opportunities.

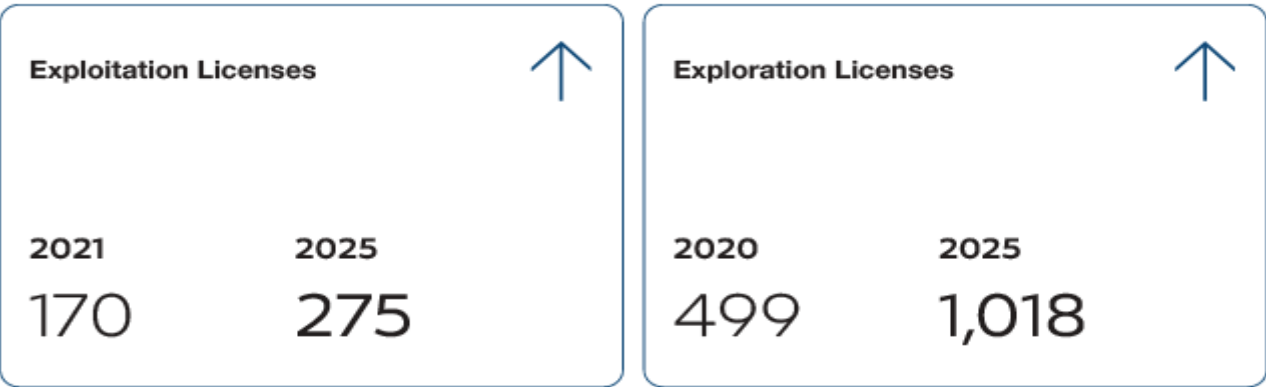
Large-scale geological survey programs have further reinforced this momentum, helping to unlock new resources and expand the sector's long-term potential.

Global Competitiveness in Mining

Fraser Institute Annual Survey of Mining Companies 2024, published in 2025



Mining Activity



[Source: <https://www.vision2030.gov.sa/en>]

An Ambitious Nation – Empowered Society

This pillar aims to strengthen governance, enhance transparency, increase public sector efficiency, and empower citizens and civil society. It seeks to build a modern state where institutions are responsive, accountable, and results oriented.

Strategic objectives include:

- Improve government performance and e-services
- Increase transparency and combat corruption
- Enhance citizen engagement
- Optimize public sector spending
- Enable civil society and non-profits



[Source: <https://www.vision2030.gov.sa/en>]

9. Cross-Pillar Integration

Each pillar has its own focus, but Vision 2030 is designed as an **integrated framework**.

- A vibrant society cannot exist without economic opportunity (Thriving Economy).
- A thriving economy requires a transparent and effective government (Ambitious Nation).
- An ambitious nation is only sustainable if it serves a cohesive, healthy, and engaged population (Vibrant Society).

A critical enabler of these ambitions is a **reformed and resilient energy sector that supports economic diversification, environmental sustainability, and technological innovation**.

10. Energy Sector Transformation under Vision 2030

Reducing Oil Dependence

Historically, KSA's economy has been heavily dependent on oil exports.

Vision 2030 seeks to shift KSA's energy profile toward a balanced energy mix and low-carbon economy, positioning energy as a driver of sustainable development rather than a limiting dependency. The pace of delivery depends on power-market reform, grid investment, demand growth and the maturity of the project pipeline

How Does the Kingdom Ensure the Sustainability of Energy Supplies?

- | | | |
|------|---|---|
| 2017 | ◆ | National Renewable Energy Program launched |
| 2018 | ◆ | Expansion into nuclear and alternative energy capabilities |
| 2019 | ◆ | First utility-scale solar project connected to the grid |
| | ◆ | Energy sector mandate expanded |
| 2020 | ◆ | Circular Carbon Economy framework adopted at the G20 |
| | ◆ | Jazan Refinery commissioned, with capacity of 400K+ barrels/day |
| 2021 | ◆ | Large-scale solar projects launched |
| 2022 | ◆ | Hydrogen and clean energy initiatives scaled |
| 2023 | ◆ | Integration into global carbon capture and storage efforts |
| 2025 | ◆ | Discovery of 14 new oil and gas fields |



[Source: <https://www.vision2030.gov.sa/en>]



11. Key Energy Goals of Vision 2030

Goal	Description
Energy Diversification	Shift from a hydrocarbon-dominated energy system to an energy mix including renewables, natural gas, and nuclear. Target: 50% of power generation from renewables by 2030.
Enhancing Energy Efficiency	Improve the efficiency of energy consumption across residential, commercial, and industrial sectors. Targeted interventions include building codes, appliance standards, and transportation reforms.
Localizing Energy Technologies	Develop local content and industrial capabilities in renewable energy technologies (e.g., solar panels, wind turbines, green hydrogen) to foster job creation and R&D.
Enabling Private Sector Participation	Open energy markets to private investment through Public-Private Partnerships (PPPs), auctions, and regulatory reforms.
Supporting Climate Action	Align energy reforms with environmental commitments such as the Paris Agreement and reduce carbon emissions through initiatives like the SGI.
Grid stability and Modernization	Upgrade national electricity grid infrastructure to accommodate intermittent renewable energy sources, smart metering, and energy storage.

12. Institutional Enablers and Governance

Key bodies driving the energy transition under Vision 2030 include:

- Ministry of Energy – Sets energy policy, including diversification and pricing reforms.
- [Public Investment Fund \(PIF\)](#) – Invests in large-scale clean energy projects like NEOM and hydrogen megaprojects.
- [Saudi Energy Co. \(SE\)](#) – Manages the national grid and power generation.
- [Saudi Energy Efficiency Centre \(SEEC\)](#) – Drives efficiency programs.
- K.A.CARE - facilitate the introduction of sustainable technologies, contributing to national strategies and implementation plans.

13. Alignment with Global Energy Trends

Vision 2030's energy strategy is designed to meet growing domestic energy demand sustainably, position KSA as a responsible global energy leader in the post-oil era and to align with the [UN Sustainable Development Goals](#) (SDGs), especially SDG 7 (**Affordable and Clean Energy**), SDG 13 (**Climate Action**), SDG 9 (**Industry, Innovation, and Infrastructure**)

14. Flagship Programs and Projects – Energy Transition

<https://www.vision2030.gov.sa/en/explore/projects>

12 MOST SUCCESSFUL FLAGSHIP ENERGY TRANSITION PROGRAMS IN KSA TO DATE

1. SAKAKA SOLAR PV IPP One of the world's largest single-site solar PV plants, establishing KSA's renewable energy procurement model.	2. DUMAT AL JANDAL WIND FARM KSA's first utility-scale wind project, setting a benchmark for large-scale renewable development.	3. NEOM GREEN HYDROGEN World-scale green hydrogen project to produce clean fuels and ammonia for domestic use and export.	4. THE RED SEA DEVELOPMENT 100% renewable energy powered destination, integrating clean energy, storage and sustainable tourism infrastructure.	5. AMAALA Renewable energy powered ultra-luxury destination with integrated clean energy and sustainability solutions.	6. DIRIYAH GATE Large-scale development powered by renewable energy and energy-efficient infrastructure.
7. ROSHN COMMUNITIES Sustainable housing developments incorporating energy efficiency, smart infrastructure and low-carbon design.	8. QIDDIYA Sustainable entertainment city powered by renewable energy and energy-efficient infrastructure.	9. KING SALMAN PARK One of the world's largest urban parks with renewable energy and sustainable infrastructure.	10. JEDDAH CENTRAL DEVELOPMENT Major urban regeneration project incorporating clean energy, smart infrastructure and sustainability solutions.	11. KING SALMAN INTERNATIONAL AIRPORT Next-generation airport designed for net-zero emissions, powered by renewable energy and advanced energy-efficiency systems.	12. RENEWABLE ENERGY LOCALISATION (NREP SUPPLY CHAIN) Development of a local renewable energy manufacturing ecosystem to support solar, wind and energy storage projects across KSA.

15. Policy Enablers and Institutions – Energy Transition

Several entities have been aligned to deliver on this mandate, and it includes the following:

12 KEY ROLE PLAYERS IN KSA ENERGY TRANSITION

1. LEAD Ministry of Energy (MoE) Leads national energy policy and strategy, oversees the energy transition and ensures energy security and sustainability.	2. THINK KAPSARC Provides independent energy research, policy analysis and modelling to support evidence-based decision making.	3. THINK KA CARE Develops atomic, renewable and emerging energy technologies, builds national capabilities and supports research and innovation.	4. GOVERN Saudi Energy Efficiency Center (SEEC) Leads national energy efficiency programmes and promotes demand-side efficiency across all sectors.	5. GOVERN Saudi Electricity Regulatory Authority (SERA) Regulates the electricity sector, ensures fair competition and protects consumers.	6. GOVERN Nuclear and Radiological Regulatory Commission (NRRC) Provides independent regulation of nuclear and radiological activities, ensuring safety, security and environmental protection.
7. OPERATE National Grid SA Operates and develops the national transmission network, integrates renewable energy and ensures grid stability and reliability.	8. OPERATE Saudi Electricity Company (SEC/SE) Generates, distributes and supplies electricity, modernises networks and implements demand-side management initiatives.	9. OPERATE Saudi Power Procurement Company (SPPC) Leads competitive procurement of power projects and manages PPAs and offtake agreements.	10. INVEST & BUILD Public Investment Fund (PIF) Mobilises strategic capital, invests in energy transition projects and accelerates economic diversification.	11. INVEST & BUILD ACWA Power Develops, invests in and operates large-scale renewable power, water and hydrogen projects locally and globally.	12. INVEST & BUILD Saudi Aramco Reduces emissions across its operations, develops CCUS and hydrogen, and invests in lower-carbon and cleaner energy solutions.

If there are other role players in the audience, their specific role should be explained accordingly. The simulator will need to be adjusted for those roles.

16. Global Alignment and Regional Leadership

KSA's energy transition is aligned with:

- Paris Agreement commitments (through nationally determined contributions)
- GCC regional cooperation on renewable integration and smart grid interconnection
- Leadership in hydrogen markets, CCUS technology, and energy innovation platforms

17. Looking Forward

Vision 2030 positions KSA not only as an energy producer but as a **clean energy innovation leader**—balancing economic resilience, environmental sustainability, and technological excellence.

Session 2: KSA's Energy Strategies

18. Introduction

This session differentiates between two completely different approaches to the Net Zero challenge. The idea is not to choose which is the best option – BUT rather to understand that there is more than one approach as a baseline for achieving the outcomes of the design of an energy strategy.

Strategy: “Reject Austerity, Embrace Dualism” vs. “Managed Transition”

Norway embraces a **cautious, state-led managed transition**, positioning oil as a “declining but dignified” asset. It prioritizes public consensus, social equity, and long-term fiscal prudence. **KSA** embraces **strategic dualism**:

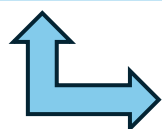
- Continue **expanding oil production and petrochemical exports** (energy security for Asia).
- Simultaneously invest in **renewables, green hydrogen, carbon capture**, and a post-oil economy (Vision 2030).
- **Reject austerity**: leverage fiscal power to lead in both energy security and sustainability. This dual track allows KSA to **retain control of fossil fuel markets** while crafting a new narrative as a **leader in pragmatic decarbonization** (Circular Carbon Economy).

Maximalist Strategy: KSA's Energy Ambition

KSA's energy strategy is **not transitional**, but **expansionary**, built on:

Oil Dominance:

Expanding capacity to 12 million barrels/day (Aramco). Maintaining Aramco's maximum sustainable capacity at 12 million barrels per day, while actual production remains shaped by market conditions and OPEC+ decisions. Targeting emerging markets, especially Asia.



Green Expansion:

NEOM, Red Sea renewables.

Vision to **export clean molecules (hydrogen, ammonia) and clean electrons (renewables)**.



CCE as Global Diplomacy:

Projecting a third path: not renunciation (like Europe), not denial (like some producers).

CCE allows oil export + carbon mitigation = balance of national interest and climate responsibility.

[Source for barrels per day: [Aramco receives directive to maintain MSC at 12 MMBD | Aramco](#)]

19. Legislative and Governance Systems

Dimension	KSA
Policy-Making Style	Top-down, visionary (Vision 2030, SGI, NREP) with clear royal mandates and institutional execution
Energy Governance Leadership	Centralized in the Ministry of Energy , which oversees policy, regulation, and long-term planning
Role of Independent Regulators	Emerging role for independent entities (e.g., NCEC , K.A.CARE , SERA) but all report to the state
Legal Enforcement & Judiciary	Regulatory enforcement typically via royal decree or ministerial directive; judiciary less engaged in policy
Climate Legislation	No standalone climate law; instead, climate action is embedded in strategic documents like SGI
Carbon Pricing & Disclosure Laws	Voluntary ESG disclosures growing (e.g., Tadawul ESG index); no carbon pricing yet implemented
Energy Market Model	Government-owned, vertically integrated model; some IPP models in renewables. Private role players like Aqua Power (global player) in renewables and conventional power.
Institutional Stability	Strong political will ensures continuity of megaprojects but exposed to global perception risks

20. Strategic forces reshaping global energy systems



21. Strategic pillars of Energy reform | Best practice examples

Energy reform is a global effort, and as such a big shift is needed to achieve the strategic goals, including the following:

Strategic pillar	Old paradigm	New paradigm	Geographic considerations	Best practice examples
Policy design	One-size-fits-all global policies	Context-aware policy design: region-specific energy strategies aligned with international goals, tailored to local capacities and industrial needs	Differentiated by industrial maturity – e.g. heavy industry hubs versus service economies (United Arab Emirates, Singapore)	Chile's <i>National Green Hydrogen Strategy</i> (2020): uses regional renewable strengths to design differentiated hydrogen hubs, targeting environmental safeguards, local jobs and exports ⁹⁴
Financing	Unequal capital access, market-led	Closing of the capital gap: blended finance, risk-sharing and international support mechanisms for emerging economies	Emerging economies (Africa, South Asia) facing highest capital costs	Sustainable Energy Fund for Africa (SEFA): provides blended capital and technical assistance for early-stage, high-risk clean energy projects across Sub-Saharan Africa ⁹⁵
Infrastructure	Centralized, uniform tech deployment	Localized innovation: context-specific infrastructure like decentralized grids, hydrogen hubs and AI tools adapted to national and regional conditions	Africa: decentralized grids; Europe: hydrogen hubs; Asia: AI-powered energy optimization	Denmark's energy islands: establishes artificial islands in the North Sea to centralize offshore wind generation, enabling local use, storage and cross-border clean energy exports ⁹⁶
Cooperation	Globalized trade and tech	Strategic sovereignty: national energy independence, balanced with global cooperation on trade, tech and investment frameworks	EU/US: tech alliances; MENA: interconnectors; Asia: supply chain coordination	Laos-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP): a regional power integration project to balance supply and improve resilience ⁹⁷
Workforce	One-size-fits-all labour strategies	Targeted workforce development: inclusive, localized strategies to build adaptable talent pipelines for diverse energy systems	Fossil-heavy regions need re-skilling e.g. Gulf Cooperation Council (GCC); youth-skewed economies need up-skilling (e.g. Saudi Arabia)	Germany's Ruhr transition model: combines re-skilling, income support and innovation hubs to repurpose a former coal region into a clean technology economy ⁹⁸
Business case	Subsidy-heavy and unstable	Market-driven transition: competitive, innovation-led conditions supported by stable policies and innovation-driven incentives to ensure a strong business case for needed energy investments and make clean energy the preferred business option	Investment hubs (US, EU, United Arab Emirates) versus markets needing de-risking (Sub-Saharan Africa, Southeast Asia)	US IRA: De-risked over \$200 billion in private clean energy investment by linking subsidies to domestic manufacturing and project bankability ⁹⁹

22. Different Strategies and Dimensions

The following comparison is illustrating two different approaches to energy reform.

Dimension	Norway	KSA – strategy highlighted
Strategic Energy Narrative	Transition state: Treats oil as a legacy enabler to fund green growth.	Oil is a permanent strategic asset , not a transitional fuel. Seeks to monetize and optimize.
Decarbonization Philosophy	Net-zero by 2050 , domestic oil phase-out is gradual, relies on electrification.	Dualism : Decarbonize <i>production</i> , not <i>consumption</i> . Export hydrocarbons while greening the economy.
Approach to Domestic Oil Demand	Managed reduction through electrification of transport and industry.	Rejects domestic oil demand reduction as economically harmful. Focus on efficiency, not cutbacks.
Hydrogen Strategy	Focus on blue hydrogen using gas + CCS; green hydrogen for export is emerging.	Large-scale green hydrogen (NEOM), also blue hydrogen to use gas assets and support exports.
Electricity Mix	~90% from hydropower , strong grid; emerging offshore wind and batteries.	2,2% from renewables [see reference below], but plans to exceed 50% by 2030 (solar, wind). Strong move toward grid reform .
Carbon Capture (CCUS)	Longship project (Norcem + Northern Lights), Equinor leadership.	Uthmaniyah (Aramco), expanding CCUS in industrial zones. Positioned as CCE pillar.
Energy Export Strategy	Net exporter of gas; oil declining slowly; positioning for EU energy security.	Maximalist strategy : Maintain market share in oil, become dominant player in hydrogen, chemicals, and green energy .
Technological Investment	R&D in CCS, marine renewables, and smart grids; high institutional trust (NVE).	Large investments in solar, green hydrogen through water splitting, AI, smart cities (NEOM) ; private-public partnerships via PIF.
Principle: Austerity vs. Dualism	Conservative spending, sovereign fund invests for future (Oljefondet).	Reject austerity : Invest in both oil dominance and clean technology (dualism).

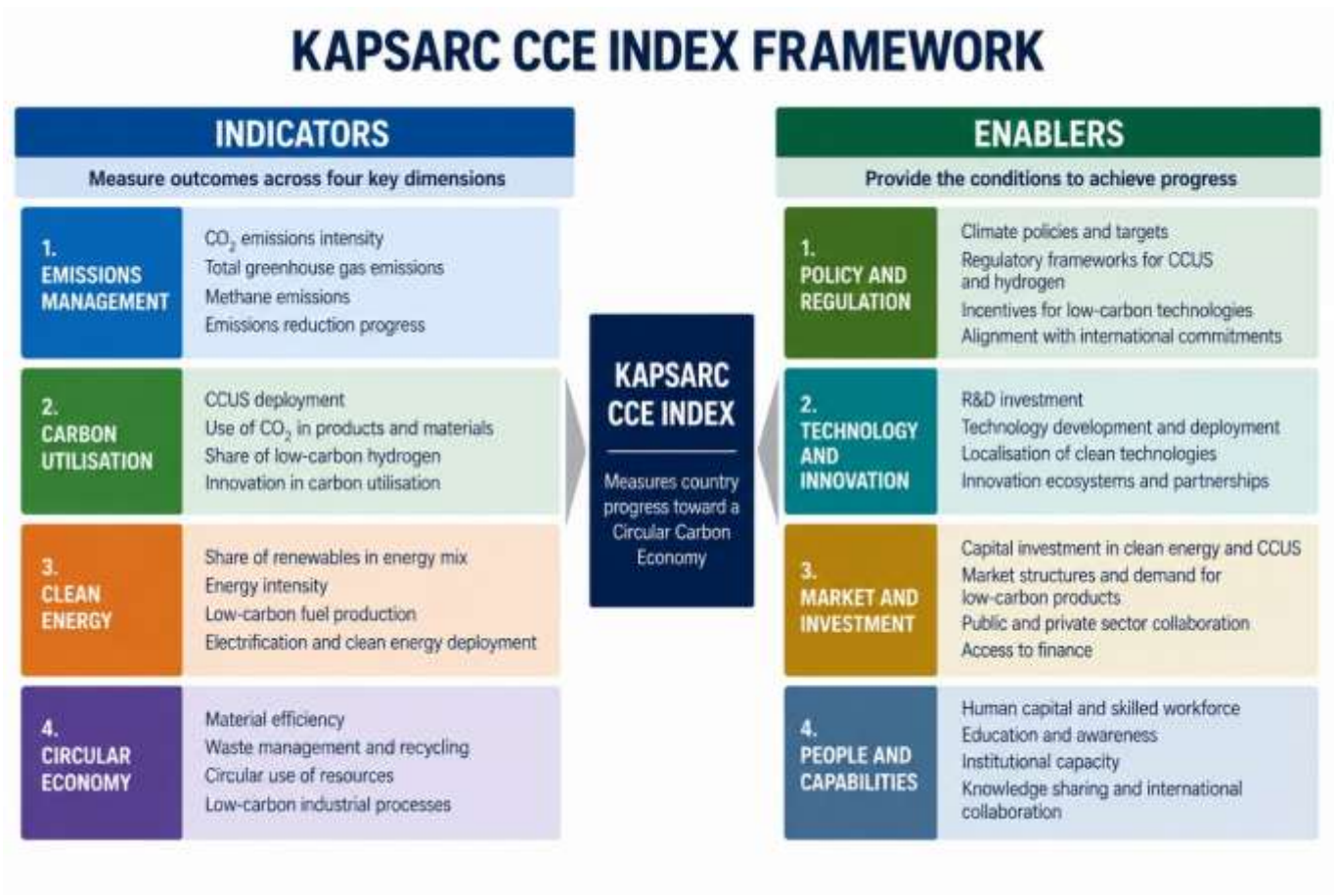
Note: The current actual share of renewable energy in Saudi Arabia's power mix is between 2% and 5%. While the country has a massive **Vision 2030 goal of reaching 50% renewable energy** in its electricity mix by 2030, its current actual grid-connected generation share stands at **roughly 2.2% as of recent data**. However, Saudi Arabia's capacity is scaling rapidly:

- **Massive Growth:** The Kingdom's operational renewable capacity jumped by **88%**, reaching **12.3 gigawatts (GW)**.
- **The Future Pipeline:** There are over **44 GW of projects under active development**, with the ultimate goal of connecting **130 GW of solar and wind energy** to the grid by the end of the decade.

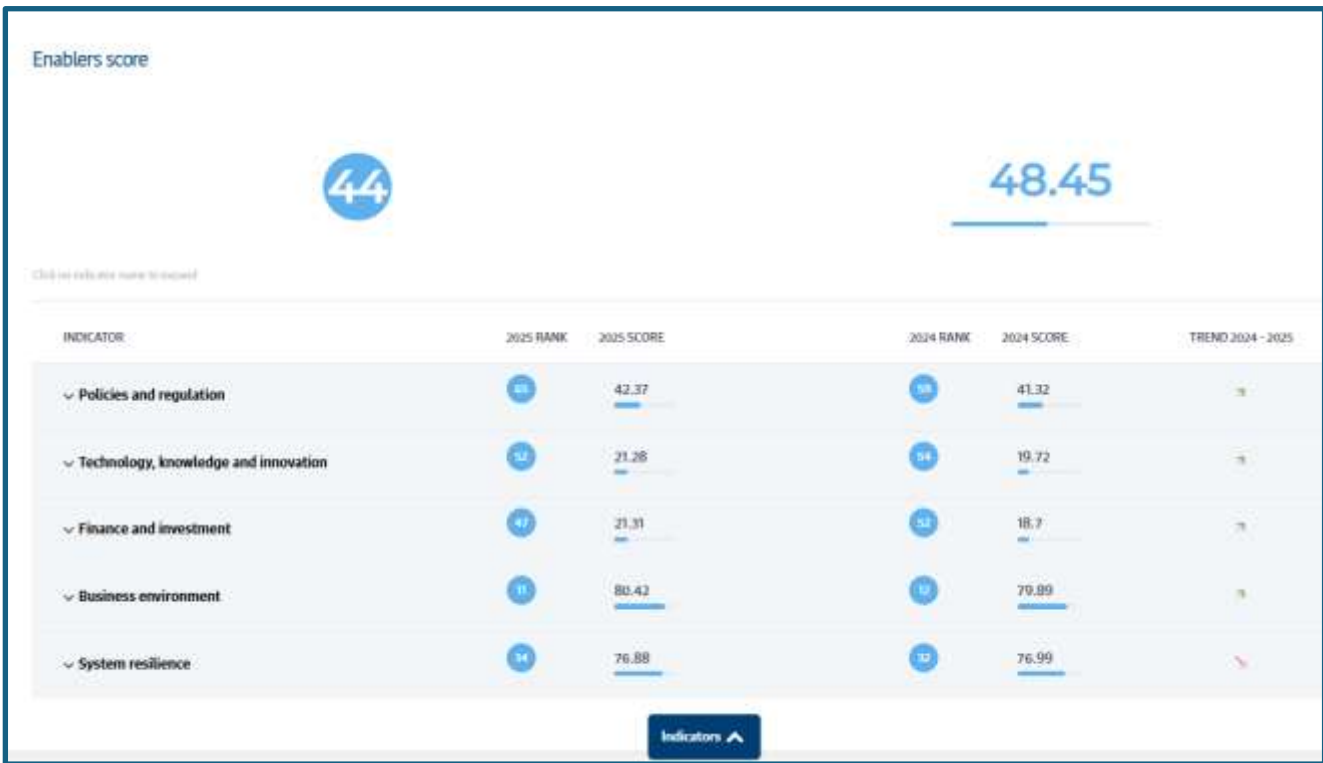
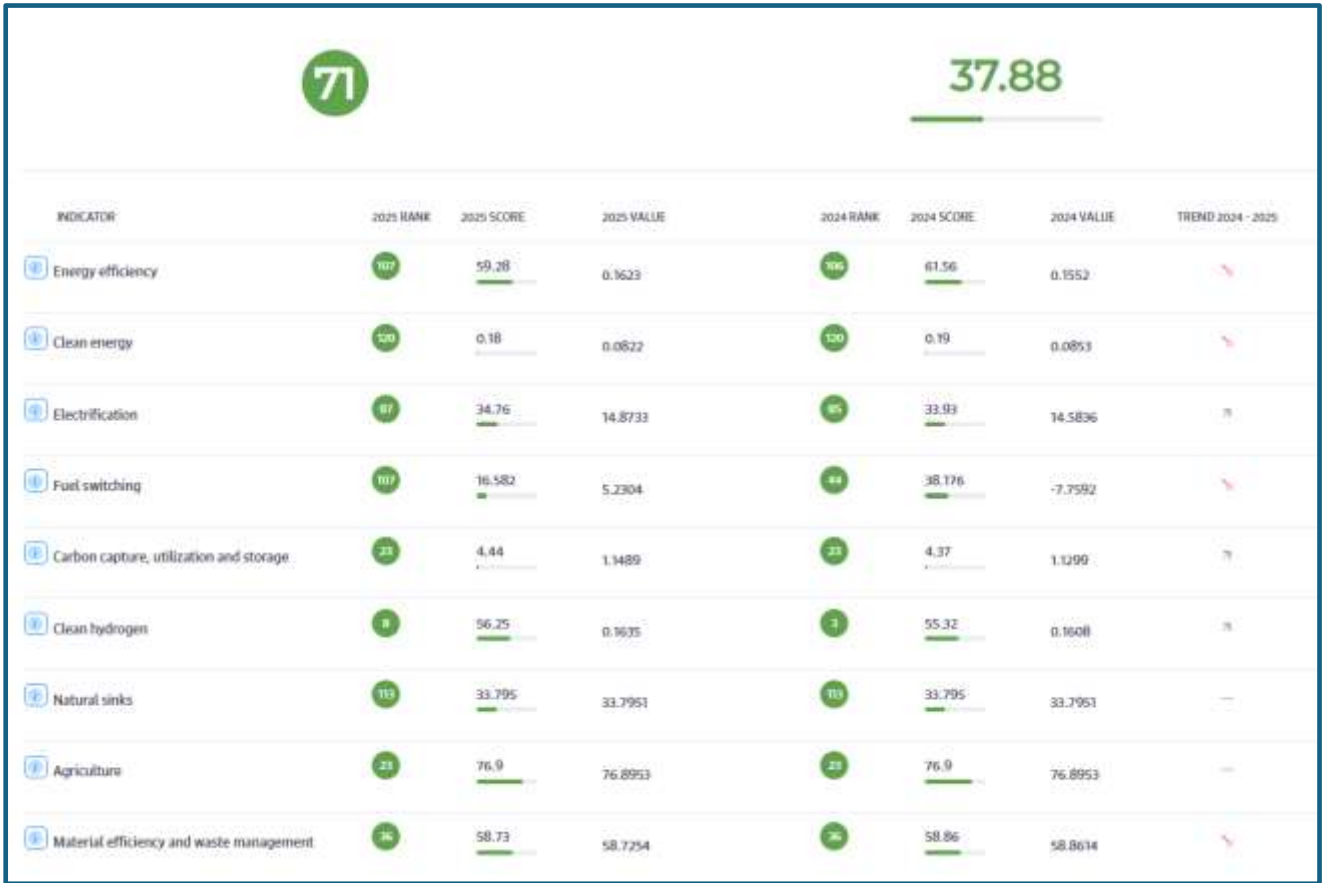
Source : <https://ember-energy.org/countries-and-regions/middle-east/>

Session 3: A scan of current measurement tools

23. KAPSARC - <https://cceindex.kapsarc.org/cceindex/profiles/SA>



24. Explore Indicators and Enablers



25. Our role in optimizing the enablers

Break into teams of four people and explore the KAPSARC enablers. Click on the individual enablers for the dropdown menu. Identify key actions that can enhance the effectiveness and efficiency of the energy transition in KSA.

Enablers	Our role – how do we contribute to the effective energy transition
Policies and regulation	
Technology, knowledge and innovation	
Finance and investment	
Business environment	
Systems resilience	

Question for discussion: Which peer practices are transferable to Saudi Arabia, which require adaptation, and which are unsuitable because of different system conditions?”

26. Net Zero Tracker – A Global Comparison

Outcome: Participants will gain hands-on experience in tracking real-time climate pledges, understand disparities between different strategies and implementation, and understand global best practices to regional contexts such as KSA and Kuwait.

Objective:

Participants will explore the **Net Zero Tracker** platform to understand how different countries commit to net-zero targets, compare their strategies, and assess the transparency, credibility, and implementation mechanisms in place.



Step 1: Introduction and Platform Familiarization

1. Open <https://zerotracker.net>
2. Review the landing dashboard: note the number of countries/entities tracked, net zero coverage by population and emissions.
3. Read the explanation of **four key elements** tracked:
Target status (e.g. in law, in policy document) | **Scope** (full economy or partial) | **Emissions coverage** | **Governance and transparency**

Step 2: Select Country Profiles

Participants work in small teams and select **four countries** for comparison:

China (large emitter, policy-based target) | **Norway** (high ambition, climate leader) | **KSA** (net zero by 2060, oil economy) | **Kuwait** (emerging climate actor, regional context)

Navigate to each country's page using the **search bar or interactive map**.

Step 3: Analyse Country Commitments - Use the provided **Country Comparison Worksheet** to fill in the following:

Indicator	China	Norway	KSA	Kuwait
Target Year				
Legal Status				
Coverage (% of total emissions)				
Inclusion of Scope 3 emissions				
Interim Targets				
Sectoral Roadmaps				
Monitoring/Review Mechanism				
Transparency Score (tracker rating)				

Step 4: Synthesis and Reflection - Reconvene as a large group and discuss:

1. What patterns emerge between **developed and oil-exporting nations**?
2. How do interim targets, legal backing, and public transparency differ?
3. What can **KSA and Kuwait** adopt from peers like Norway or China?
4. What are the Saudi strongpoints of focus?
5. How can we improve our reporting on our strategy to improve the comparative ratings of Saudi?

Step 5: Policy Insights - Each team drafts **two recommendations**:

1. One to **improve the transparency or credibility** of their selected country's plan
2. One to **enhance domestic implementation** (e.g., roadmap, legal reform, metrics)

Question for discussion: Which peer practices are transferable to Saudi Arabia, which require adaptation, and which are unsuitable because of different system conditions?"

Session 4: Climate Action Tracker

27. Introduction

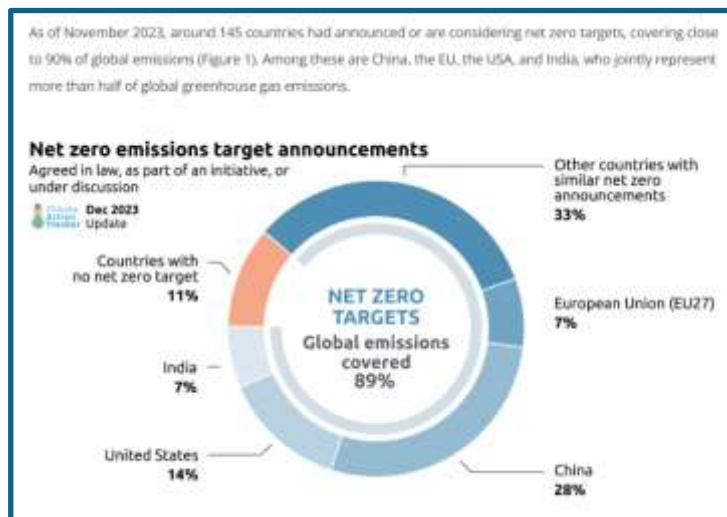
The Climate Action Tracker is an independent scientific project that tracks government climate action and measures it against the globally agreed Paris Agreement aim of "holding warming well below 2°C, and pursuing efforts to limit warming to 1.5°C." CAT quantifies and evaluates climate change mitigation targets, policies and action. It also aggregates country action to the global level, determining likely temperature increases during the 21st century using the [MAGICC climate model](#).

CAT covers all the biggest emitters and a representative sample of smaller emitters covering about 85% of global emissions and approximately 70% of global population. The national actions we track are:

- **Effect of climate policies and action on emissions:** The policies a government has implemented or enacted and how these are likely to affect national emission over the period to 2030, and where possible beyond.
- **Impact of pledges, targets and NDCs** on national emissions over the period to 2030, and where possible beyond.
- **Comparability of effort against countries' fair share and modelled domestic pathways**

28. Urgent need for transparent assessments of national net zero targets

<https://climateactiontracker.org/global/cat-thermometer/>



Navigate and interpret the Climate Action Tracker database

Compare net-zero policies of countries at different stages of energy transition

Identify gaps between target-setting and implementation

Relate findings to national planning in KSA

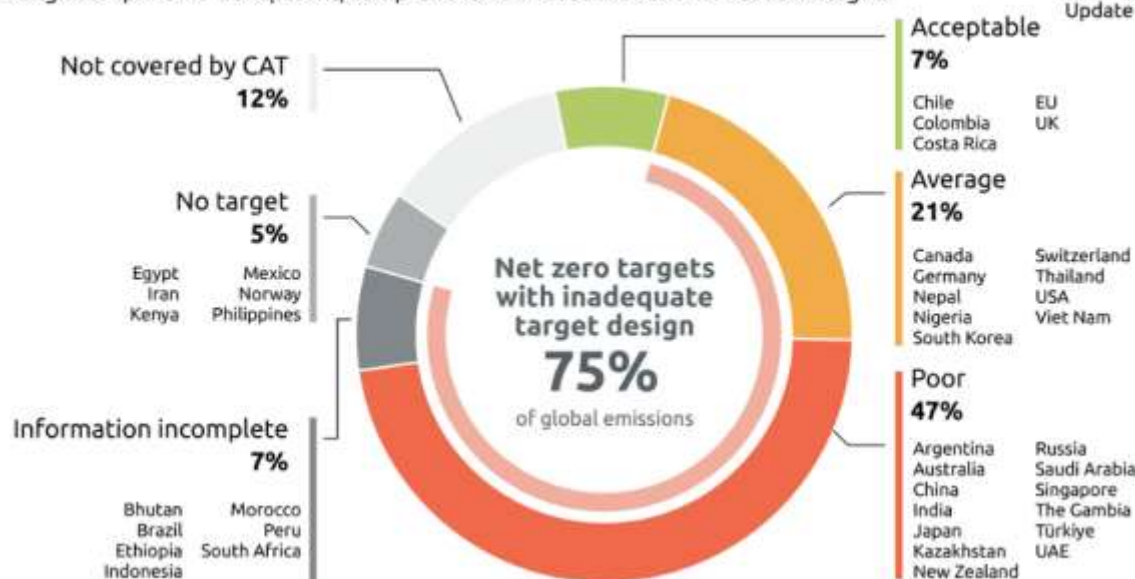
29. Country evaluations as of November 2023

<https://climateactiontracker.org/global/cat-thermometer/>

Net zero target design - mostly inadequate to date

Quality of net zero targets by percentage of global emissions evaluated using the CAT's design blueprint for transparent, comprehensive and robust national net zero targets

Climate
Action
Tracker
Dec 2023
Update



Question for discussion: Which peer practices are transferable to Saudi Arabia, which require adaptation, and which are unsuitable because of different system conditions?"

30. Downstream value chains

<https://normative.io/insight/upstream-downstream-emissions/>

Downstream net-zero measurement focuses on quantifying and reducing greenhouse gas emissions within a company's value chain, specifically those occurring after a product or service is produced and sold. This involves assessing emissions from transportation, distribution, use of products, and end-of-life treatment. It's a crucial part of achieving overall net-zero targets, as it addresses emissions beyond a company's direct operations (Scope 1 and 2).

31. Upstream emissions scope 3 categories

Upstream emissions occur during the production of goods or services that a business purchases or uses. For example: if your retail business uses plastic to produce its products, the emissions resulting from the production and transportation of that plastic would be upstream emissions. The table below contains a simplified version of the eight upstream emissions categories defined by the Greenhouse Gas Protocol:

Category	Description
Purchased goods and services	Extraction, production, and transportation of goods and services purchased or acquired by the company
Capital goods	Extraction, production, and transportation of capital goods purchased or acquired by the company
Fuel- and energy-related activities	Extraction, production, and transportation of fuels and energy purchased or acquired by the company which are not already accounted for in scope 1 or scope 2
Upstream transportation and distribution	Transportation and distribution of products purchased by the company, as well as other transportation and distribution services like inbound logistics, outbound logistics, and transpiration between company facilities
Waste generated in operations	Disposal and treatment of waste generated in the company's operations, in facilities not owned or controlled by the company
Business travel	Transportation of employees for business-related activities in vehicles not owned or operated by the company
Employee commuting	Transportation of employees between their homes and their worksites in vehicles not owned or operated by the company
Upstream leased assets	Operation of assets leased by the company and not included in scope 1 and scope 2

Refer to the Greenhouse Gas Protocol's [Technical Guidance for Calculating Scope 3 Emissions](#) for a more detailed breakdown of the categories.

32. Downstream emissions scope 3 categories

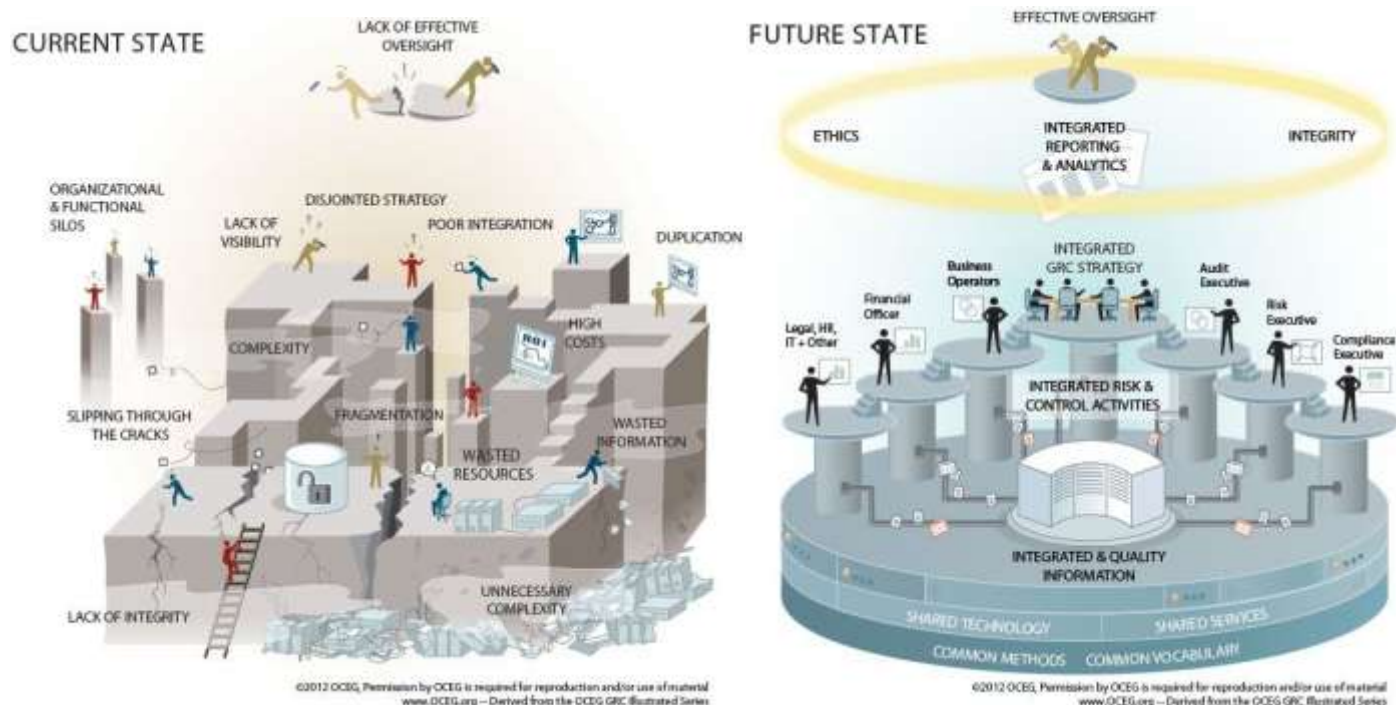
Downstream emissions result from the use or disposal of a business's products or services. For example: if your company manufactures machinery, the emissions that result from the use of that machinery would be considered downstream emissions.

Category	Description
Downstream transportation and distribution	Transportation and distribution of products sold by the company between the company's operations and the end consumer
Processing of sold products	Processing of intermediate products sold by downstream companies
Use of sold products	End use of goods and services sold by the company
End-of-life treatment of sold products	Waste disposal and treatment of products sold by the company, at the end of the products' lives
Downstream leased assets	Operation of assets owned by the company and leased to other entities
Franchises	Operation of franchises in the reporting year, not included in scope 1 and scope2
Investments	Operation of investments, including equity and debt investments and project finance

Session 5: Other tools

33. Introduction

Achieving strategic objectives require the defining of mission critical objectives, aligned to a structure that will enable the effective and efficient achievement of strategic objectives. Below is an illustration of effective structural design:



34. Baseline evaluation

Scan the QR Code and perform an independent anonymous voting using the following rating:

1 – Basic process with similar consequences | 2 – Processes designed, documented with specific alignment to strategic objectives | 3 – Organizational awareness | 4 – Ongoing monitoring of all strategic processes | 5 – Continuous improvement, learning

Element	Rating 1	Rating 2	Rating 3	Rating 4	Rating 5
Effective oversight					
Strategic decisions					
Organizational structure silos					
Visibility – transparency					
Integration of key processes					
Duplication					
Excessive cost					
Fragmentation					
Wasted resources					
Wasted information					
Complexity					
Integrity					



35. UN Sustainable Development goals

The alignment of the UN SDG's to the governance process and the ESG management process allows us to see the significant correlation between GRC and ESG.



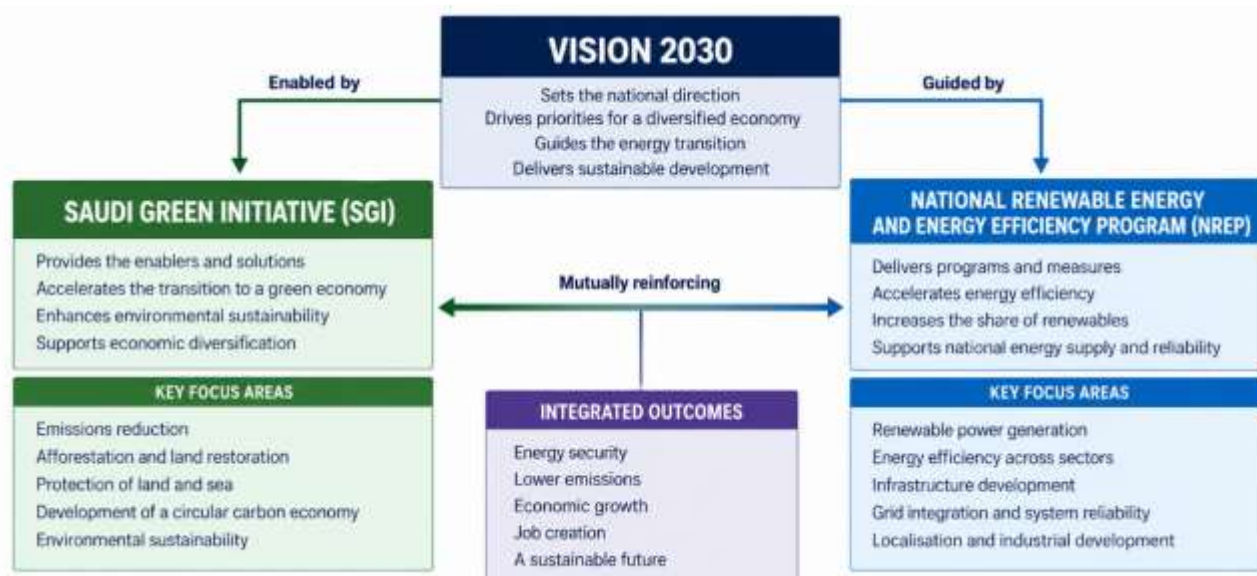
36. Free Climate Tracking tools

GREENHOUSE GAS ACCOUNTING & EMISSIONS TRACKING - GHG Protocol Calculators ghgprotocol.org/calculation - OpenCalc calculators for corporate value chain (Scope 1, 2 & 3) emissions. - COOL CLIMATE CALCULATOR coolclimatecalculator.org - Calculate and understand your business emissions. - SME Climate Hub smeclimatehub.org - Free emissions calculator and tools for SMEs.	CARBON FOOTPRINT CALCULATORS - Carbon Footprint Calculator (UNFCCC) footprint.unfccc.org - Calculate your carbon footprint for lifestyle and businesses. - My Climate myclimate.org/ - Measure, understand and reduce your footprint. - Carbon Independent carbonindependent.org - Calculate, reduce and offset your carbon footprint.	CLIMATE & WEATHER DATA VISUALIZATION - NASA Climate Data climate.nasa.gov - Access global climate data and visualizations. - Copernicus Climate Change Service (C3S) climate.copernicus.eu - Free climate data and tools on global climate change. - NOAA Climate.gov climate.gov - Explore climate data, articles and teaching resources.	ENVIRONMENTAL MONITORING & AIR QUALITY - IQAir Air Quality Index aqi.com/aqi-quality-map - Real-time air quality map and data. - OpenAQ openaq.org - Global open-source air quality data and API. - PurpleAir purpleair.com - Real-time air quality map from global sensors.	DEFORESTATION & LAND MONITORING - Global Forest Watch globalforestwatch.org - Monitor forests, deforestation, and land use change. - Hansen Global Forest Change ghsl.eis.harvard.edu - Explore global forest change from 2000 to present. - Land & Carbon Lab purpleair.com - Free tools to monitor land, carbon and emissions.
RENEWABLE ENERGY & ENERGY DATA - Global Solar Atlas globalsolaratlas.info - Explore solar resource and PV potential worldwide. - Global Wind Atlas globalwindatlas.info - Assess wind energy potential anywhere in the world. - Our World in Data - Energy ourworldindata.org/energy - Explore global energy data and trends.	CLIMATE RISK & IMPACT ASSESSMENT - Climate Impact Explorer climateimpactexplorer.org - Explore future climate impacts by location. - ND-GAIN gain.giss.nasa.gov - Assess climate vulnerability and readiness of countries. - Coastal Risk Screening Tool coastalriskscreening.org - Understand coastal flood and risk exposure.	ESG & SUSTAINABILITY REPORTING TOOLS - B Impact Assessment bimpactassessment.net - Free tool to assess and improve social and environmental impact. - Sustainability Tracker (UN SDGs) onlytrackers.org - Track progress on the UN Sustainable Development Goals. - Open-Source Sustainability (OS-S) os-s.org - Open-source platform for sustainability reporting.	COMMUNITY SCIENCE & CITIZEN MONITORING - iNaturalist inaturalist.org - Track biodiversity and contribute to citizen science. - eBird ebird.org - Track bird observations and biodiversity. - Globe Observer observer.globe.gov - Collect local environmental data and contribute to research.	EDUCATION & LEARNING PLATFORMS - Project Drawdown drawdown.org - Explore climate solutions and track solutions progress. - Climate Literacy Project climate literacy.org - Learn science-based climate concepts and solutions. - FutureLearn - Climate Courses futurelearn.com - Free climate and sustainability courses from top universities.

Module 2: Policy and Regulatory Frameworks

Session 1: Foundations of Saudi's Energy Transition

37. Vision 2030, SGI and NREP – an integrated energy transition framework



The Legal and Policy Framework for SGI	The Legal and Policy Framework for NREP
Establishment and Governance The SGI was launched in 2021 as a top-down, royal-initiated environmental framework embedded in national policy. Legal and Regulatory Foundations: - National Environment Law (2020): Establishes environmental protection obligations and empowers regulatory bodies. - Royal Decrees and Ministerial Orders: Guide inter-ministerial coordination and mandate policy action. - Climate Change Framework: Currently under development to institutionalize long-term climate policy. Key Policy Instruments - National Environment Strategy (NES), - SGI Governance Framework: Oversees implementation across 60+ initiatives, - Biodiversity Protection Regulations: Enforce protected areas and species conservation under SGI.	Legal Basis and Institutional Framework The NREP was established under the supervision of the Ministry of Energy, with legal support from: - Renewable Energy Law (Draft): Under review, to provide statutory clarity on land access, permits, and tariffs. - Electricity Law and its Implementing Regulations (amended 2021): Allow for renewable energy auctions and power purchase agreements (PPAs). - Public-Private Partnership Law (2021): Facilitates investment structures and risk allocation in renewable energy projects. Regulatory and Contractual Instruments - Tendering Framework: Governs the competitive bidding process. - Standard PPA Templates: Ensure investor confidence and legal enforceability. - Environmental Licensing Requirements: Renewable projects must comply with EIA standards enforced by the National Centre for Environmental Compliance (NCEC).

38. What is the Saudi Green Initiative?

The [Saudi Green Initiative \(SGI\)](#) is a national sustainability strategy launched in March 2021 under the patronage of Crown Prince Mohammed bin Salman. It is a cornerstone environmental initiative that supports Vision 2030 by addressing climate change, promoting sustainable economic growth, and ensuring the conservation of natural resources. The SGI is part of a trio of strategic environmental frameworks that also include the Middle East Green Initiative (Regional) and the Circular Carbon Economy (CCE) Approach (Global).

39. Vision and Strategic Purpose of SGI

SGI seeks to rebalance KSA's environmental footprint, accelerate the energy transition, and enhance the quality of life for current and future generations. It serves as a practical mechanism to fulfil:

- KSA's commitments under the Paris Agreement
- The UN Sustainable Development Goals (SDGs)
- The environmental objectives of Vision 2030



40. Assessing the credibility of SGI report on greenwashing?

Greenwashing is the practice of making misleading or unsubstantiated claims about the environmental benefits of a product, policy, or initiative. Critics have levelled this accusation at the Saudi Green Initiative. Defenders reject this accusation entirely. This case study examines both perspectives while providing defense-side communicators with the analytical tools to articulate Saudi Arabia's position.

What the Saudi Green Initiative Actually Promises

Launched in 2021 under Vision 2030, SGI has three official pillars:

- Reduce emissions: Cut 278 million tons of CO₂ equivalent by 2030, reach net-zero emissions by 2060.
- The green initiative – see below:
- Protect nature: Designate 30% of Saudi Arabia's land and marine areas as protected reserves.
- Other commitments include:
 - Sourcing 50% of the country's power from renewables by 2030,
 - Launching a voluntary carbon credit exchange (Regional Voluntary Carbon Market Company), and marketing NEOM as a zero-carbon city.

The trees green initiative for the Gulf region refers primarily to the Saudi Green Initiative and its broader regional extension, the [Middle East Green Initiative](#), which collectively aim to plant billions of trees and restore vast tracts of degraded land.

Key Goals and Targets

- **Planting Trees:** The regional Middle East Green Initiative targets planting a total of 50 billion trees across the Middle East. Within this, the Saudi Green Initiative specifically commits to planting 10 billion trees inside Saudi Arabia.
- **Land Restoration:** The projects aim to rehabilitate hundreds of millions of hectares of degraded land, combat desertification, and reduce dust and sandstorms.
- **Emissions Reduction:** Participating nations aim to significantly cut regional carbon emissions through afforestation and clean energy adoption.

The total target for the entire region is **50 billion trees**. This massive project is led by the **Middle East Green Initiative (MGI)**, with **Saudi Arabia** contributing **10 billion trees** of that total within its own borders.

[Source: [Middle East Green Initiative - Saudipedia](#)]

41. Common Criticisms of SGI and How to Address Them – as guided by SGI

A. The oil contradiction

Critics alleged that Saudi Arabia remains the world's largest crude oil exporter and has no published phase-out date for oil and gas production. Aramco's stated reserves could sustain 2020 production levels for 50+ years. Critics argue that claiming climate leadership while expanding fossil fuel production is contradictory.

Response: Saudi Arabia does not accept the premise that climate action requires ending oil production. The Kingdom advocates for a phase-down of emissions, not a phase-out of production, using the Circular Carbon Economy framework. Carbon capture, blue and green hydrogen, and efficiency improvements allow emissions to be managed while still meeting global energy demand. Furthermore, emissions are counted where fuel is burned, not where it is produced. Importing countries bear responsibility for their own decarbonization.

B. Carbon credits vs. actual cuts

Critics alleged that Saudi Arabia's Regional Voluntary Carbon Market Company held its first auction in Nairobi, Kenya — described as the world's largest voluntary carbon credit auction. Sixteen firms, including Aramco, bought 2.2 million tons of credits. Critics call this a public relations stunt by a major oil producer, noting that carbon credits often offset rather than reduce emissions.

Response: Voluntary carbon markets are a recognized international mechanism for financing emissions reduction projects. Saudi Arabia's participation in these markets demonstrates alignment with global best practices. The credits purchased fund verified reduction projects. This is not a substitute for domestic action but a complement to it.

C. Emissions intensity vs. absolute emissions

Critics alleged that Saudi Arabia often reports emissions intensity (emissions per unit of GDP or per barrel of oil) rather than absolute emissions. Critics note that this can show improvement even if total emissions rise alongside production increases.

Response: For a growing economy and a major oil producer, intensity is a meaningful and pragmatic metric. The goal is to produce the cleanest barrel of oil in the world while using hydrocarbon revenues to fund the transition to renewables and carbon capture. Absolute reductions would require shrinking the economy, which is neither realistic nor required under any international climate agreement.

D. Fossil fuel subsidies

Critics alleged that According to the International Monetary Fund (IMF), Saudi Arabia's pre-tax and post-tax fossil fuel subsidies totalled over \$80 billion in 2022. In per capita terms, this was approximately \$7,000 per person — the highest among G20 economies and representing 27% of GDP. Critics argue that reducing these subsidies would be a more direct climate action than planting trees.

Response: The 2022 figure was an anomaly caused by the global energy price spike following Russia's invasion of Ukraine. More recent IMF data shows per capita subsidies declined to approximately \$4,800 by 2023-2024, a reduction of roughly 31% in a single year. Saudi Arabia has implemented sustained energy price reforms since 2016, gradually increasing domestic gasoline, electricity, and water prices. The introduction of a 15% VAT in 2020 recaptures a portion of the implicit subsidy through consumption taxes. Furthermore, the bulk of the IMF's 2022 figure consisted of implicit environmental costs, not actual government cash outlays. Explicit subsidies made up only 18% of the total.

E. Renewable energy progress vs. targets

Critics alleged that Saudi Arabia has added significant solar and wind capacity, but as of 2024, renewables still account for 2.2% of total electricity generation — far from the 50% target by 2030. The gap is planned to be filled mostly by natural gas, not zero-carbon sources.

Response: Saudi Arabia started from near-zero renewable capacity a decade ago. The country is now building some of the world's largest solar projects at record-low costs. Replacing crude oil and diesel with natural gas for power generation produces immediate emissions reductions. The 50% target by 2030 is ambitious and on track, with billions of dollars in sovereign investment committed through the Public Investment Fund.

F. Scale vs. timeline

Critics alleged that Many analysts describe the goal of 10 billion trees and net-zero by 2060 as bordering on the impossible given current planting rates. According to the Climate Action Tracker, Saudi Arabia's policies are rated "Critically Insufficient" and are not aligned with the Paris Agreement's 2°C target.

Response: The 10 billion tree target includes contributions from partner countries across the Middle East, not only Saudi Arabia. The program is measured in decades, not years. Regarding the Climate Action Tracker rating, that organization applies a framework that assumes fossil fuel phase-out is the only acceptable pathway. Saudi Arabia rejects that framework. Under the Circular Carbon Economy model, the Kingdom is pursuing a different but equally valid path.

G. Net-zero 2060 vs. global benchmarks

Critics alleged that Most developed countries target net-zero by 2050. Saudi's 2060 target, combined with continued oil expansion, means cumulative emissions remain high even if net-zero is eventually reached later than global peers.

Response: A 2060 target is pragmatic for an economy whose core industry is oil production. Saudi Arabia committed to 2060 simultaneous to Russia and after China made similar pledges. The Energy Minister has suggested the Kingdom may achieve net-zero closer to 2050. Moreover, the net-zero pledge applies only to domestic emissions, not to oil burned overseas. Importing countries are responsible for their own emissions. On the question of Western criticism, Saudi officials note that developed countries which lecture oil producers have themselves reverted to coal, the most polluting fossil fuel, to meet energy security needs. Rapid phase-out demands that ignore different national circumstances and capabilities are inherently unfair.

H. No independent third-party audit

Critics alleged that Saudi Arabia has not published an independently audited, third-party assessment of SGI's carbon accounting or emissions baseline. Without this, external observers cannot verify whether reported reductions are absolute or based on emissions intensity.

Response: International scrutiny from bodies such as the Climate Action Tracker and investigative non-governmental organizations continuously evaluates Saudi claims, forcing transparency. Participation in the Regional Voluntary Carbon Market Company requires third-party verification under international carbon market rules.

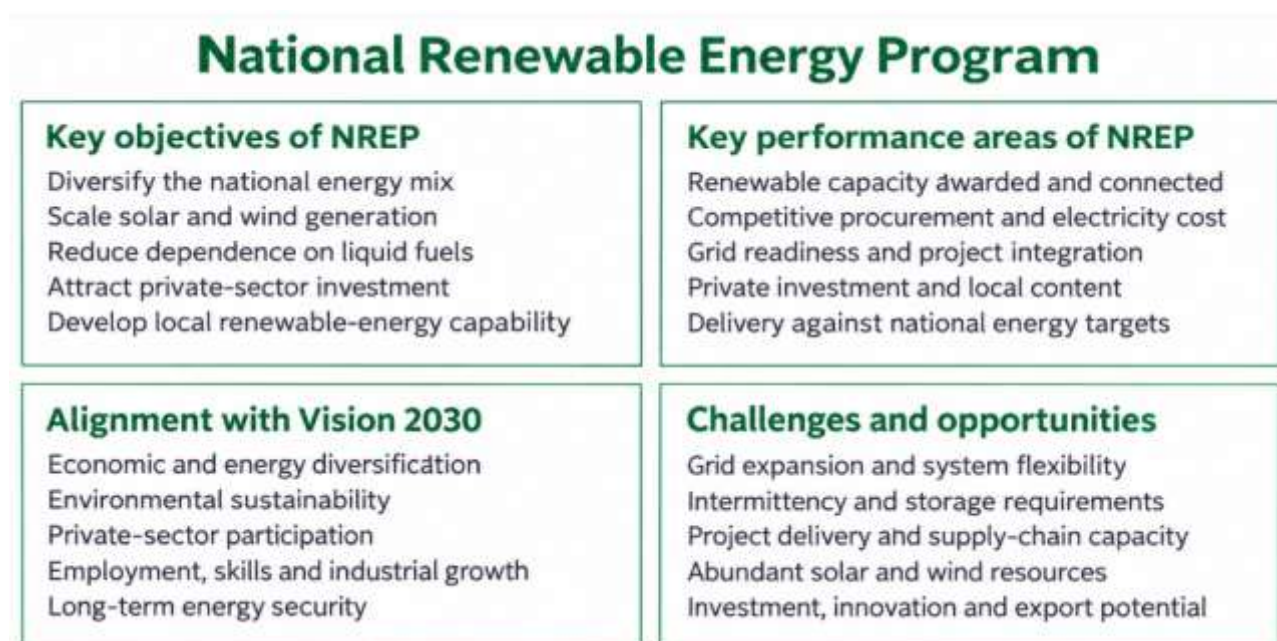
42. What is the National Renewable Energy Program (NREP)?

The [NREP](#) is a strategic initiative launched by the Ministry of Energy. It is a key enabler of KSA's Vision 2030, designed to diversify KSA's energy mix, reduce reliance on fossil fuels, and promote sustainable economic development. Established in 2017, the NREP is part of KSA's commitment to:

- Reduce greenhouse gas emissions
- Enhance energy security
- Create a competitive renewable energy market
- Stimulate private sector investment

The NREP is KSA's flagship vehicle for transforming its energy system in line with Vision 2030. It has made notable progress as of 2025, with nearly 13 GW either operational or in the pipeline, record-low

solar tariffs, and robust private sector engagement. With targets of 64 GW [Source: <https://apps.kapsarc.org/rtracker/>] GW by 2030, including 51.8 GW solar and 12.2 GW wind, the NREP is central to KSA's plan to meet 50% of electricity demand via renewables, reduce emissions, and enable green industrialization and job creation. A new target of 130gw has since been established.



43. SGI, NREP, Vision 2030 | Paris Agreement

KSA's ambitious energy and environmental reforms are underpinned by robust legal and policy frameworks that align with international climate goals, particularly the Paris Agreement. Central to these reforms are the SGI, NREP, and the broader Vision 2030 agenda. Together, they represent KSA's integrated response to climate change, economic diversification, and sustainable development.

The Paris Agreement, adopted in 2015 under the United Nations Framework Convention on Climate Change ([UNFCCC](#)), aims to:

- Limit global warming to well below 2°C, ideally to 1.5°C above pre-industrial levels.
- Enhance countries' adaptive capacities.
- Align finance flows with climate-resilient development pathways.

KSA's Commitment under the Paris Agreement

KSA ratified the Paris Agreement in 2016, committing to:

- Contribute to global mitigation through Nationally Determined Contributions (NDCs).
- Promote economic diversification aligned with environmental sustainability.
- Reduce 278 million tons of CO₂ equivalent annually by 2030, as updated in its 2021 NDC submission.

44. Vision 2030: The Overarching Policy Ecosystem

Legal Structure

Vision 2030 is anchored in a series of strategic plans, implementation regulations, and sectoral laws, including National Transformation Program (NTP), Quality of Life Program, Fiscal Balance Program and the Saudi Energy Efficiency Program (SEEP). The Vision does not exist as a single law but is implemented through mandates to ministries, sovereign wealth funds, and executive agencies.

Environmental and Climate Commitments

Vision 2030 includes a target to increase non-oil revenue through green investment, a pledge to generate 50% of electricity from renewables and a commitment to improve air quality, biodiversity, and waste management.

Paris Agreement Synergy

Vision 2030 aligns with the Paris Agreement through:

- Decarbonization: SGI and NREP fall under Vision 2030's sustainability pillar.
- Resilience: Water reuse, afforestation, and land rehabilitation address climate adaptation.
- Finance: Green finance instruments and a voluntary carbon market (Saudi Carbon Market) foster climate-aligned capital flows.

45. Institutional Coordination and Reporting

Key Stakeholders	Role
Ministry of Energy	Leads NREP and energy transition policies
Ministry of Environment, Water and Agriculture (MEWA)	Oversees SGI implementation and environmental compliance
National Centre for Environmental Compliance (NCEC)	Issues permits, enforces standards
Public Investment Fund (PIF)	Funds large-scale renewable and sustainable projects
K.A.CARE	Develop nuclear and renewable energy technologies, national strategies and implementation plans.
Saudi Energy Efficiency Centre (SEEC)	Drives energy conservation regulations
Vision Realisation Programs (VRPs)	Coordinate execution and reporting of Vision KPIs

46. Challenges and Legal Gaps

Challenge	Policy/Legal Implication
Absence of a standalone Climate Change Law	Hinders long-term legal certainty and enforcement
Land and permitting complexity for renewables	Needs clearer zoning and land-use laws
Water constraints for afforestation	Requires integration with national water law
Environmental data transparency	MRV systems need legal support and public access obligations

KSA has made historic policy and legal commitments to support environmental protection, energy transition, and sustainable development. Through the SGI, NREP, and the broader Vision 2030, KSA has integrated its Paris Agreement obligations into domestic strategies with clear KPIs, institutional accountability, and legal infrastructure. While substantial progress has been made, the future success of these programs depends on:

- Enacting comprehensive climate and renewable energy laws
- Strengthening enforcement capacity
- Enhancing public-private collaboration
- Maintaining alignment with international climate frameworks

As of 2025, KSA stands as a significant regional leader in the transition toward a low-carbon, resilient, and diversified economy, using law and policy as instruments of transformation.

Session 2: Stakeholder Mapping and Regulatory Governance

47. Role of the Minister of Energy in Vision 2030, SGI, and NREP

The Minister of Energy of KSA of KSA holds a central strategic position in the implementation of Vision 2030, particularly in driving the energy transition from a hydrocarbon-based economy to a diversified, sustainable, and technologically advanced energy system. The Ministry, under the leadership of HRH Prince Abdulaziz bin Salman Al Saud, is responsible for setting energy policy, managing energy resources, and ensuring alignment with national goals, including environmental sustainability and economic resilience.

48. Summary of Key Responsibilities

Domain	Minister of Energy’s Role
Vision 2030	Leads energy diversification and energy security policies aligned with economic transformation.
SGI	Drives decarbonization, emissions reduction, renewable energy scale-up, and CCE framework.
NREP	Oversees renewable energy expansion, investor frameworks, and regulatory implementation.
Climate Diplomacy	Represents Saudi energy interests in global climate platforms, advocating balanced approaches.
Institutional Coordination	Aligns ministries, agencies, and private sector partners toward unified energy goals.

The Minister of Energy plays a central leadership role in shaping KSA’s energy and sustainability future. From spearheading Vision 2030 energy transformation, to executing SGI’s ambitious environmental targets, and orchestrating the expansion of renewables under NREP, the Minister ensures that energy policy is integrated, forward-looking, and globally competitive.

By aligning domestic energy reforms with the Paris Agreement, and leveraging KSA’s energy leadership, the Minister is both a national steward and global voice for a sustainable energy transition.

Cross-Ministerial Collaboration: -Works closely with the Ministry of Environment, Water and Agriculture, Ministry of Investment, and PIF to ensure cohesive execution of sustainability goals and ensures that SGI and NREP are embedded in national economic planning, environmental regulation, and infrastructure development.

Vision 2030	Saudi Green Initiative (SGI)	National Renewable Energy Program (NREP)
Minister of Energy's Role: • Policy Maker and Regulator: The Minister defines and implements strategic energy policies aligned with Vision 2030's economic and environmental pillars. • Vision Realisation Program (VRP) Oversight: The Minister contributes to and oversees energy components in Vision Realisation Programs such as: ○ National Industrial Development and Logistics Program (NIDLP) ○ Fiscal Balance Program ○ Quality of Life Program • Economic Diversification Champion: Leads initiatives to reduce KSA's reliance on crude oil exports by promoting downstream industries and clean energy investment.	Minister of Energy's Role: • Architect of the Energy Transition: Shapes the design of KSA's low-carbon pathway, including the SGI's energy-related targets. • CCE Leader: Leads the implementation of the Circular Carbon Economy, a Saudi-endorsed framework balancing emissions through reduction, reuse, recycling, and removal. • Emission Reduction Enforcement: Oversees major emission reduction strategies in the power, transport, and industrial sectors. • Hydrogen Development: Drives the national hydrogen strategy, including blue and green hydrogen as part of SGI's decarbonization plan.	Minister of Energy's Role: • Strategic Leadership: Defines the policy direction and regulatory framework for renewable energy development. • Oversight of SPPC in implementing tenders, auctions, and PPAs. • Investor Engagement: Facilitates an enabling environment for private investment through public-private partnerships, incentives. • Cost Competitiveness Champion: Drives KSA's strategy to achieve world-record low solar LCOEs, economical renewable energy. • Grid Integration Policy: Ensures policy alignment between renewable deployment and grid readiness, including storage and digitalization.

49. KSA's Energy Policy Landscape and Sustainability Commitments

KSA's national energy policy has undergone a major transformation over the past decade. Once known almost exclusively for its role as a leading oil exporter, KSA is now positioning itself as a champion of diversified energy development and sustainability. Driven by a combination of domestic reform goals and global environmental obligations, KSA's policy landscape reflects a deliberate strategy to balance energy security, economic diversification, and environmental responsibility.

Historical Context and Policy Shift

Historically, KSA's energy policy focused on three main objectives:

1. Ensuring domestic energy security through ample oil and gas supply
2. Maximizing revenue from petroleum exports
3. Supporting industrial development using subsidized fossil fuels

However, this model faced increasing pressure due to:

- Volatile global oil markets
- Rising domestic energy demand
- Environmental and sustainability concerns
- The global transition to low-carbon energy

In response, KSA initiated a comprehensive policy shift — a transition away from a fossil-fuel-centric economy toward one based on diversification, innovation, and environmental sustainability.

Vision 2030 as the Strategic Anchor

Vision 2030, launched in 2016, acts as the overarching policy framework for transforming KSA's economy and public sector. Within the energy domain, Vision 2030 promotes:

- Reducing domestic dependence on oil through renewable energy, gas, and nuclear power
- Enhancing energy efficiency and demand-side management
- Localizing clean energy manufacturing and service industries
- Encouraging private sector participation in energy markets
- Positioning KSA as a global hub for green technologies

50. Institutional Framework and Governance

The Saudi energy sector is governed by several key entities, each with defined responsibilities. The structure emphasizes integration between energy production, regulation, policy development, and research.

Key Institutions:

- **Ministry of Energy**
Leads national energy policy, oversees oil, gas, renewable, and nuclear energy sectors, and coordinates with international agencies.
- **King Abdullah City for Atomic and Renewable Energy (K.A.CARE)**
Provides technical oversight and policy support for clean energy research, development, and deployment.
- **Saudi Energy Efficiency Centre (SEEC)**
Develops and enforces efficiency standards across buildings, transport, and appliances.
- **Saudi Energy Co. (SE)**
Operates and manages the national electricity grid and supports renewable energy integration.
- **Public Investment Fund (PIF)**
Invests in strategic clean energy projects, including [NEOM](#), hydrogen hubs, and renewables.
- **Saudi Aramco and ACWA Power**
Play leading roles in hydrogen, CCUS, and renewable energy project implementation.

51. Simulation on roles of key players

Accessed on the online platform – 16 role players – identification of roles and responsibilities with a question bank (20 questions) and application bank (10 different energy projects).

The screenshot shows the 'SAUDI ENERGY TRANSITION Role-Player Collaboration Lab' interface. At the top, it says 'Learn institutional mandates, then design a coordinated pathway for ten transition projects.' Below this is a progress bar showing 'Learning progress 0%'. The interface is divided into five main sections: 1. LEARN, 2. COMPARE, 3. QUIZ, 4. APPLY, and 5. RESULTS. Under the '1. LEARN' section, there are buttons for 'Learn the roles', 'Saved locally', 'SAVE', 'RESET CURRENT', 'RESET EVERYTHING', and a checkbox for 'Facilitator: reveal answers'. Below this, the 'Learn institutional boundaries' section is displayed, which includes a sub-header 'Start with each institution's mandate, strategic objective and decision boundary.' and a grid of seven boxes representing different institutional roles: Policy & Strategic Direction, Regulation, Licensing & Compliance, Procurement & Offtake, System & Infrastructure Operation, Investment & Project Development, Research, Innovation & Technical Advice, and Environmental & Resource Stewardship.

52. The National Energy Strategy and Policy Goals

KSA's national energy strategy is structured around five primary policy goals:

Goal 1: Enhance Energy Security

- Diversify energy sources to reduce dependence on oil for domestic power
- Expand natural gas infrastructure and storage capacity
- Strengthen grid stability and interconnections

Goal 2: Promote Sustainable Energy Development

- Deploy utility-scale solar, wind, and geothermal projects
- Advance small-scale distributed generation and off-grid solutions
- Encourage green buildings and efficiency standards

Goal 3: Achieve Energy Efficiency and Conservation

- Implement strict appliance and building codes
- Introduce energy performance labelling and audits
- Launch public awareness and behavioural change campaigns

Goal 4: Drive Economic Localization

- Develop local manufacturing capacity for solar panels, wind turbines, and energy storage
- Increase local content in energy project value chains
- Create employment opportunities in the clean energy sector

Goal 5: Foster Research and Innovation

- Support applied R and D in renewable energy, CCUS, hydrogen, and nuclear technology
- Collaborate with academic and international institutions
- Establish energy innovation hubs and testbeds

53. KSA's Sustainability Commitments

KSA has signalled a strong pivot toward environmental stewardship through national and international commitments (**The SGI, Circular Carbon Economy (CCE), International Agreements**)

Alignment with Sustainable Development Goals (SDGs)

KSA's energy and sustainability policy framework aligns significantly with several [United Nations SDG's](#):

SDG	Relevance to Energy Policy
SDG 7 – Affordable and Clean Energy	Investment in renewables and grid access
SDG 9 – Industry, Innovation, and Infrastructure	Localization of energy technologies and infrastructure development
SDG 12 – Responsible Consumption and Production	Efficiency programs and reduced fossil fuel subsidies
SDG 13 – Climate Action	Net-zero emissions, CCUS, and hydrogen programs
SDG 17 – Partnerships for the Goals	International collaboration on technology and policy

54. Key Challenges and Considerations

Despite clear progress, KSA faces several challenges in implementing its energy and sustainability policies:

- **Balancing Oil Export Revenue with Domestic Diversification**
KSA must maintain fiscal stability while transitioning toward cleaner domestic energy systems.
- **Technology Readiness and Localization**
Many clean energy technologies remain capital intensive and require significant human capital development.
- **Water-Energy Nexus**
Water-intensive energy solutions, such as green hydrogen, must be evaluated within the context of arid climate conditions.
- **Public Engagement**
A successful energy transition requires behavioural change, especially in consumption and mobility patterns.
- **Data Transparency and Monitoring**
Robust measurement, reporting, and verification (MRV) systems are critical to tracking progress toward net-zero goals.

55. The Role of K.A.CARE in Advancing Policy and Sustainability

K.A.CARE plays a central role in bridging policy vision with technical execution. Its key functions include:

- Conducting techno-economic studies on energy technologies
- Advising on policy design for renewables, hydrogen, and nuclear energy
- Supporting pilot projects and demonstration facilities
- Engaging with international agencies to adopt best practices and standards

As the energy transition accelerates, K.A.CARE's contributions to research, talent development, and regulatory coordination will remain essential.

56. The Evolving Role of K.A.CARE

K.A.CARE was established by royal decree in 2010 with a bold and forward-looking mission: to position KSA as a global leader in the development and deployment of alternative energy solutions. Over the past decade, K.A.CARE has evolved from a policy think tank into a central institutional player supporting KSA's energy transition. As KSA accelerates its move toward sustainability, energy diversification, and economic localization under Vision 2030, K.A.CARE's role continues to expand in both scope and strategic importance.

This chapter explores the transformation of K.A.CARE's mandate, its current functions, strategic contributions, and its growing influence in advancing KSA's national goals in renewable energy, atomic energy, human capital development, and technology innovation.

57. Historical Background and Mandate

K.A.CARE was founded with a dual mission:

- To contribute to the development of atomic and renewable energy as viable sources of power for KSA
- To ensure the sustainability of energy resources through diversification and innovation

Its original mandate focused on:

- Proposing national policies and strategies related to atomic and renewable energy
- Coordinating research and development
- Promoting localization of energy technologies
- Supporting regulatory frameworks for energy safety and performance standards

Over time, K.A.CARE's role has expanded beyond planning and policy support into applied research, project implementation, international collaboration, and talent development.

58. Strategic Alignment with Vision 2030

K.A.CARE plays a vital role in the implementation of Vision 2030, particularly in the following areas:

Renewable Energy Development

- Supporting the National Renewable Energy Program (NREP) through technical inputs and research
- Facilitating the development of solar and wind project feasibility studies
- Partnering with global and regional organizations to enhance renewable energy deployment

Nuclear Energy Planning

- Leading the development of the Saudi National Atomic Energy Project (SNAEP)
- Advising on nuclear technology options, including Small Modular Reactors (SMRs)
- Ensuring alignment with International Atomic Energy Agency (IAEA) safety and regulatory standards

Energy Localization and Innovation

- Promoting domestic manufacturing of energy components (e.g., PV panels, turbine parts)
- Supporting localization of services and technologies through public-private partnerships
- Hosting innovation hubs and testbeds for solar, nuclear, and hydrogen technologies

Human Capital Development

- Designing academic and technical programs in energy sciences
- Supporting scholarship and fellowship opportunities
- Partnering with local universities to foster an R&D-oriented workforce

59. Core Functional Areas of K.A.CARE Today

Policy and Strategic Planning

K.A.CARE advises the Ministry of Energy and other stakeholders by:

- Conducting techno-economic studies on renewable and atomic energy
- Proposing long-term scenarios for national energy mix optimization
- Supporting policy formulation aligned with sustainability and energy security goals

Technical and Scientific Research

Research activities are conducted in areas such as:

- Solar resource assessment and photovoltaic efficiency optimization
- Advanced nuclear fuel cycles and safety design
- Hydrogen production, storage, and integration
- Energy storage and grid flexibility technologies

Technology Demonstration and Testbeds

K.A.CARE develops and manages pilot projects and testbeds to validate emerging technologies under Saudi climatic conditions. These include:

- Solar thermal and photovoltaic demonstration sites
- Wind turbine performance analysis stations
- Hydrogen production through electrolysis from solar power
- Nuclear system simulations and SMR models

Regulation and Safety

In cooperation with the Nuclear and Radiological Regulatory Commission (NRRC), K.A.CARE contributes to:

- Developing regulatory frameworks for nuclear installations
- Establishing safety, security, and environmental standards
- Providing policy guidance on compliance with international norms

International Cooperation

K.A.CARE has established partnerships with:

- The International Atomic Energy Agency (IAEA)
- The International Renewable Energy Agency (IRENA)
- Energy agencies in countries including South Korea, China, France, and Russia

These collaborations support technology transfer, capacity building, and joint research initiatives.

60. Role in the Circular Carbon Economy (CCE) and Sustainability

As KSA champions the Circular Carbon Economy framework, K.A.CARE is contributing to:

- Evaluating low-carbon technologies such as CCUS and hydrogen
- Mapping lifecycle emissions of various energy technologies

- Advising on integration of CCE concepts into national planning
- Exploring options for waste-to-energy and resource recycling

Sustainability is a cross-cutting theme in all K.A.CARE operations. The institution's research and planning emphasize low-emission pathways, energy-water nexus optimization, and responsible land use in project siting.

61. Emerging Focus Areas and Future Directions

As the energy landscape evolves, K.A.CARE is adapting to emerging challenges and opportunities.

Green and Blue Hydrogen

- Supporting pilot projects for solar-powered electrolysis
- Advising on hydrogen export strategies
- Conducting feasibility studies for hydrogen hubs

Nuclear Innovation

- Exploring small modular reactors (SMRs) for distributed energy supply
- Investigating nuclear desalination and hybrid nuclear-renewable systems
- Developing national capabilities in nuclear fuel handling and safety

Digital Energy Systems

- Using artificial intelligence and machine learning in energy forecasting
- Establishing digital twins of energy assets for real-time analysis
- Promoting cybersecurity frameworks for energy infrastructure

Talent and Workforce Development

- Launching specialized programs in solar engineering, reactor physics, and energy economics
- Creating internship and exchange opportunities with global research institutions
- Partnering with universities to update curricula for clean energy careers

Key Opportunities

- Modification of infrastructure to enable RE penetration
- KSA's vast solar and land resources position it for global leadership in solar energy
- Vision 2030 creates a long-term policy environment conducive to innovation
- International partnerships can accelerate technology deployment and knowledge transfer

Key Challenges

- Above average demand growth
- Balancing innovation with strict safety and regulatory compliance in nuclear projects
- Scaling up renewable energy integration without destabilizing grid operations
- Developing robust supply chains for clean energy components
- Ensuring sufficient talent development to support future energy systems

62. Impact Metrics and Progress Indicators

K.A.CARE's success can be measured through:

- Contribution to achieving the 64 GW [Source: <https://apps.kapsarc.org/rtracker/>] GW renewable target by 2030
- Number of research publications and patents filed in clean energy technologies
- Development of local talent (graduates, certifications, technical placements)
- Advisory inputs to major national initiatives such as SGI and the National Energy Strategy

63. Role of Saudi Energy Efficiency Centre in Vision 2030, SGI, NREP

The Saudi Energy Efficiency Centre (SEEC) was established by the Council of Ministers in 2010 and operates under the supervision of the Ministry of Energy. SEEC is the national authority for energy efficiency policy and implementation, mandated to:

- Improve energy consumption efficiency across all sectors (industrial, transportation, buildings)
- Reduce national energy intensity
- Support sustainable energy systems through standardization, regulation, and capacity building

SEEC's mandate complements the energy diversification and emissions reduction strategies defined in Vision 2030, the SGI, and NREP.

64. SEEC's Role in Vision 2030

Vision 2030	Area	SEEC's Role
Vision 2030 calls for: • Energy sustainability • Efficient use of natural resources • Reduced dependence on oil consumption for domestic energy • Lower energy intensity across all economic sectors	Strategic Programs	Leads the Saudi Energy Efficiency Program (SEEP), a Vision Realisation Program focused on energy optimization
	Policy and Standards	Develops and enforces mandatory energy efficiency standards for appliances, vehicles, and industrial equipment
	Capacity Building	Implements training, certification, and outreach programs to build awareness and competency in energy-efficient practices
	Sectoral Transformation	Works with stakeholders in industry, buildings, and transport to improve energy productivity and reduce waste
KPIs Aligned with Vision 2030		
• Improve national energy intensity (energy use per unit of GDP) • Reduce electricity consumption growth • Achieve efficiency gains equivalent to saving hundreds of thousands of barrels of oil per day		

65. SEEC's Role in SGI

SGI	SGI Pillar	SEEC's Function
SGI aims to - Reduce 278 million tons of CO₂ annually by 2030 - Achieve net-zero emissions by 2060 - Promote environmental sustainability through conservation and energy reform	Emissions Reduction	Delivers cross-sectoral energy efficiency programs that directly reduce GHG emissions
	Behavioural Change	Leads public awareness campaigns on efficient consumption in homes, offices, and transport
	Institutional Integration	Provides technical support to ministries, municipalities, and utilities on designing low-energy infrastructure
	Air Quality Improvement	Reduces combustion-related pollution through efficient fuel and electricity use
Example Initiatives		
- Enforcement of energy efficiency labelling for air conditioners, lighting, and home appliances - Roll-out of fuel economy standards for vehicles (aligned with CAFÉ standards) - Industrial audits and retrofitting in cement, steel, and petrochemical sectors		

66. SEEC's Role in the NREP

While SEEC is not directly responsible for deploying renewable energy projects (a function of SPPC), it plays a critical supportive role:

NREP	NREP Area	SEEC's Role
The NREP seeks to: - Add 64 GW [Source: https://apps.kapsarc.org/rtracker/] GW of renewable energy by 2030 - Shift to 50% renewable energy share in power generation - Improve grid efficiency and system reliability	Demand Reduction	Reduces electricity demand growth, making it easier to integrate variable renewables
	Load Management	Helps optimize demand profiles, enabling peak shaving and load shifting that facilitate renewable integration
	Energy Efficiency in Buildings	Enforces building codes (e.g., thermal insulation, smart meters) to improve energy performance in structures that will use renewable power

NREP	NREP Area	SEEC's Role
	Grid Optimization	Collaborates with utilities on smart energy solutions that enhance energy utilization from renewables

The Saudi Energy Efficiency Centre plays a foundational role in ensuring that KSA's energy transition is not just about generating clean energy, but also about using energy wisely and sustainably. By complementing large-scale supply-side reforms (like NREP) with demand-side management, SEEC ensures that Vision 2030 and SGI objectives are met efficiently, affordably, and equitably. Its continued success depends on:

- Strengthened enforcement of standards
- Integration with digital energy platforms
- Citizen engagement and behavioural change
- Supportive legal and fiscal incentives

67. Role of NCEC in Vision 2030, SGI, and NREP

The National Centre for Environmental Compliance (NCEC) is a regulatory agency operating under the Ministry of Environment, Water and Agriculture (MEWA). It was established to enforce environmental laws, monitor pollution, and ensure compliance with national environmental standards across all sectors in KSA.

NCEC plays a vital enforcement and oversight role in KSA's sustainable development agenda. Its responsibilities are integral to the environmental governance framework that underpins Vision 2030, the SGI and NREP.

68. NCEC's Role in Vision 2030

Vision 2030	Function	Role in Vision 2030
Environmental Objectives: • Promote sustainable resource use • Improve air, water, and soil quality • Strengthen environmental protection enforcement • Enhance liveability and biodiversity	Regulatory Oversight	Enforces compliance with the National Environmental Law (2020) and related executive regulations
	Permitting and Licensing	Issues and monitors Environmental Impact Assessments (EIAs) and operating licenses for all major developments
	Inspections and Monitoring	Conducts field inspections and uses remote sensors and satellite data to monitor industrial, energy, and infrastructure activities
	Pollution Control	Sets standards for air, water, noise, and hazardous waste, and monitors pollution trends to inform national policy

Vision 2030	Function	Role in Vision 2030
	Reporting and Transparency	Collects and publishes environmental performance data, supporting public accountability and decision-making

69. NCEC's Role in the SGI

SGI	SGI Pillar	NCEC's Role
SGI Environmental Focus Areas: - Reducing carbon emissions - Expanding protected areas - Improving air and water quality - Enhancing ecosystem health and biodiversity	Air and Water Quality Improvement	Monitors emissions and enforces clean air and water regulations across industries and urban centres
	Protected Areas Management	Participates in zoning, assessment, and compliance for newly designated terrestrial and marine protected areas
	Nature-Based Solutions	Ensures that afforestation, land rehabilitation, and biodiversity projects adhere to environmental standards
	Climate Impact Regulation	Develops environmental criteria for carbon reduction activities and waste-to-energy initiatives under SGI
Example Initiatives: - Green Factory Licensing System – integrates environmental metrics into the industrial permitting process - National Emissions Registry – tracks pollutant and GHG emissions across sectors - Early Warning Environmental Monitoring System – uses real-time data for pollution alerts and compliance tracking		

70. NCEC's Role in the NREP

NREP	Area	Function
NREP Objectives:	Environmental Impact Assessments (EIAs)	Reviews and approves EIAs for all solar and wind energy projects, ensuring projects meet environmental safety standards

NREP	Area	Function
- Install 64 GW[Source: https://apps.kapsarc.org/rtracker/] GW of renewable capacity by 2030 - Integrate solar and wind energy into the national grid - Ensure environmental sustainability of energy transitions	Land Use and Biodiversity Protection	Evaluates project sites for proximity to ecologically sensitive areas, migratory paths, or endangered species habitats
	Construction Oversight	Monitors compliance during construction of renewable projects to avoid soil, air, and water degradation
	Post-Operational Monitoring	Tracks renewable project impacts on local ecosystems, air quality, and noise post-commissioning
	Hazardous Waste Management	Regulates the disposal and recycling of solar panels, batteries, and wind turbine materials in line with national law

By playing a gatekeeping and monitoring role, NCEC ensures that the rapid rollout of renewable projects under NREP is aligned with sustainability and public health standards.

71. Legal Mandate and Enforcement Powers

NCEC derives its authority from The National Environment Law (2020), Executive Regulations for Environmental Impact Assessment, Waste Management, and Air Quality, Royal Decrees and Ministerial Resolutions. The centre has powers to issue, suspend, or revoke permits, impose penalties and fines for non-compliance, order shutdowns of polluting facilities, coordinate with prosecutors in cases of environmental violations

The National Centre for Environmental Compliance is the guardian of environmental integrity in KSA's journey toward sustainable development. It plays a pivotal role in ensuring that the country's major sustainability frameworks—Vision 2030, SGI, and NREP—are implemented within a robust legal and environmental compliance framework. By combining regulatory authority, technical expertise, and digital monitoring capabilities, NCEC is key to building a transparent, accountable, and sustainable environmental governance system in KSA.

72. Role of Saudi Energy Co. (SEC) in Vision 2030, SGI, NREP

The Saudi Energy Co. (SE) is the largest electric utility in the Middle East responsible for power generation, transmission, and distribution across KSA.

It is a publicly listed company, with the government (via the Public Investment Fund) holding a majority stake. SE is at the heart of KSA's energy infrastructure, and its transformation is central to KSA's economic diversification and energy transition agenda.

73. SEC's Role in Vision 2030

Vision 2030	Area	SE's Contribution
Vision 2030 Energy Objectives: - Diversify the energy mix (target: 50% renewables by 2030) - Ensure reliable and sustainable power supply - Promote private sector participation in utilities - Modernize national infrastructure (including smart grids) - Reduce KSA's dependence on liquid fuel for electricity generation	Electricity Infrastructure Development	Leads upgrades to the national grid, builds new generation capacity, and modernizes transmission and distribution systems
	Grid Modernization	Implements smart metering, automation, and digitization to increase efficiency and reduce system losses
	Operational Efficiency	Reduces reliance on crude oil and improves thermal efficiency through combined-cycle and integrated technologies
	Privatization and Unbundling	Supports Vision 2030's push for market liberalization, separating generation, transmission (via National Grid SA), and distribution
	Public-Private Partnership Enablement	Facilitates independent power producer (IPP) models for private sector participation in electricity generation
Vision 2030 KPI Alignment:		
- Reduction of electricity system losses - Increase in transmission grid stability (System Average Interruption Duration Index – SAIDI) - Enhanced customer satisfaction via digitized services - Increased share of gas and renewables in the fuel mix		

74. SE's Role in the SGI

SGI	SGI Pillar	SE's Contribution
SGI Climate and Environmental Goals: - Reduce carbon emissions by 278 million tons by 2030 - Reach net-zero emissions by 2060	Carbon Emissions Reduction	Phases out oil-based generation and integrates cleaner fuels like natural gas and renewables
	Renewable Energy Integration	Connects large-scale solar and wind farms to the national grid through expanded transmission infrastructure
	Smart Grid and Digitalization	Supports demand-side efficiency and renewable dispatch with smart grid technologies

SGI	SGI Pillar	SE's Contribution
- Achieve 50% renewable energy penetration - Improve energy efficiency and air quality	Energy Storage and Innovation	Pilots battery storage and demand-response systems to manage intermittency and support clean energy
	Environmental Performance	Implements environmental management systems across generation assets and aligns to NCEC/ SGI reporting frameworks

75. SE's Role in the NREP

	NREP Function	SE's Role
NREP Objectives: - Install 64 GW [Source: https://apps.kapsarc.org/rtracker/] GW of renewable capacity by 2030 - Reach 50% share of renewables in electricity generation - Attract private sector investment in renewable energy	Grid Connection and Dispatch	Builds and maintains transmission networks that connect renewable projects (solar, wind) to the national grid
	System Integration	Ensures stability of the grid through load balancing, frequency control, and renewable dispatch coordination
	Interconnection Agreements	Signs Power Purchase Agreements (PPAs) and grid interconnection agreements with Independent Power Producers (IPPs) and project developers
	Data and Forecasting	Provides energy demand forecasts and supports renewable resource integration planning with SPPC
	Transmission Expansion	Leads transmission corridor development in remote areas where utility-scale renewable projects are built (e.g., Al-Jouf, Tabuk)
Key Infrastructure Projects:		
- Expansion of 1,100 kV Ultra High Voltage Transmission Lines - Integration of Sudair, Sakaka, and Dumat Al Jandal renewable plants - Planned grid interconnection with GCC countries and Egypt, enabling renewable export potential		

The Saudi Energy Co. (SE) is the backbone of KSA's energy transformation. Its role is evolving from a traditional utility into a grid enabler, smart energy provider, and partner in renewable development. Through its deep involvement in Vision 2030, SGI, and NREP, SEC ensures that the national transition

toward a low-carbon, resilient, and investor-friendly energy ecosystem is technically feasible, commercially viable, and environmentally responsible.

Its continued leadership in grid modernization, transmission investment, and public-private partnerships will determine the success of KSA’s broader sustainability and climate goals.

76. Role of Public Investment Fund (PIF) in Vision 2030, SGI, and NREP

The Public Investment Fund (PIF) is KSA’s sovereign wealth fund, founded in 1971 and restructured under Vision 2030 to act as a key engine for national economic transformation. With assets surpassing \$900 billion (as of 2024), PIF is one of the world’s largest and fastest-growing sovereign wealth funds. PIF plays a dual role:

- Investor in strategic sectors aligned with national development goals
- Developer and operator of giga-projects and infrastructure that advance KSA’s global competitiveness

77. Role of PIF in Vision 2030

	Domain	PIF’s Contribution
Vision 2030 Goals Aligned with PIF’s Mandate: • Diversify KSA’s economy beyond oil • Increase the contribution of investment to GDP • Localize strategic industries (e.g., clean energy, tourism, manufacturing) • Create jobs and enable private sector growth • Attract global partnerships and innovation	National Economic Transformation	Acts as the primary institutional investor to support Vision 2030 sectors such as energy, tourism, logistics, healthcare, and technology
	Giga-Projects Developer	Leads and finances projects like NEOM, Red Sea Project, Qiddiya, and Roshn, embedding sustainability and smart technologies
	Capital Market Deepening	Stimulates the financial ecosystem by creating IPO pipelines and backing green finance
	Job Creation and Localization	Directs investments toward sectors that generate high-quality jobs and localized supply chains
Vision 2030 KPI Alignment:		
• Raise PIF’s assets under management (AUM) to over SAR 7 trillion (~\$1.86 trillion) by 2030 • Increase investment in the domestic economy to 60% of the fund’s assets • Support the creation of 1.8 million direct and indirect jobs		

78. Role of PIF in the Saudi Green Initiative

SGI	SGI Pillar	PIF Contribution
SGI Environmental and Climate Goals: • Reduce carbon emissions by 278 million tons per year • Achieve net-zero emissions by 2060 • Protect 30% of terrestrial and marine ecosystems • Accelerate renewable energy, afforestation, and clean tech investments	Green Investment Mobilization	Anchors multi-billion-dollar investments in renewable energy, green hydrogen, water reuse, and sustainable urban development
	Sustainable City Development	Develops NEOM. The Line is planned and marketed as a low-carbon urban development; future performance should be assessed against disclosed construction and operational emissions.
	Carbon Market Development	Launched the Regional Voluntary Carbon Market Company to facilitate carbon credit trading in the Middle East
	Environmental Infrastructure	Backs projects for desalination using renewable energy, green transportation, and waste-to-energy systems
	Climate Innovation	Establishes partnerships in EV manufacturing, circular carbon technologies, and carbon capture
Key SGI-Aligned Investments by PIF:		
• ACWA Power – PIF owns ~50%, leading solar, wind, and hydrogen project development • Regional Carbon Market – First auction launched in 2022; growing ecosystem for carbon offset trade Green Hydrogen at NEOM – Joint venture with Air Products and ACWA Power to produce 600 tons/day of green hydrogen [Source : https://www.neom.com/en-us/newsroom/neom-accelerates-green-hydrogen-future]		

79. Role of PIF in the NREP

	Function	PIF's Role
NREP Goals:	Strategic Investment	PIF is a co-investor and developer of flagship renewable energy projects via ACWA Power and direct initiatives

	Function	PIF's Role
- Develop 64 GW [Source: https://apps.kapsarc.org/rtracker/] GW of renewable energy by 2030 - Achieve 50% renewables share in electricity generation - Attract private sector investment and localize supply chains	Project Development	Leads mega solar and wind projects like Sudair Solar PV (1.5 GW) and Al Shuaibah Solar Complex (2.6 GW)
	Domestic Industry Development	Supports localization of solar PV panels, wind turbines, and battery technologies through equity stakes in clean tech firms
	Private Sector Enablement	Crowds in capital by de-risking projects and co-financing with international and local investors

80. Simulation of role players, projects and responsibilities

12 KEY ROLE PLAYERS IN KSA ENERGY TRANSITION

1. LEAD	2. THINK	3. THINK	4. GOVERN	5. GOVERN	6. GOVERN
Ministry of Energy (MoE) Leads national energy policy and strategy, oversees the energy transition and ensures energy security and sustainability.	KAPSARC Provides independent energy research, policy analysis and modelling to support evidence-based decision making.	KA CARE Develops atomic, renewable and emerging energy technologies, builds national capabilities and supports research and innovation.	Saudi Energy Efficiency Center (SEEC) Leads national energy efficiency programmes and promotes demand-side efficiency across all sectors.	Saudi Electricity Regulatory Authority (SERA) Regulates the electricity sector, ensures fair competition and protects consumers.	Nuclear and Radiological Regulatory Commission (NRRC) Provides independent regulation of nuclear and radiological activities, ensuring safety, security and environmental protection.
7. OPERATE	8. OPERATE	9. OPERATE	10. INVEST & BUILD	11. INVEST & BUILD	12. INVEST & BUILD
National Grid SA Operates and develops the national transmission network, integrates renewable energy and ensures grid stability and reliability.	Saudi Electricity Company (SEC/SE) Generates, distributes and supplies electricity, modernises networks and implements demand-side management initiatives.	Saudi Power Procurement Company (SPPC) Leads competitive procurement of power projects and manages PPAs and offtake agreements.	Public Investment Fund (PIF) Mobilises strategic capital, invests in energy transition projects and accelerates economic diversification.	ACWA Power Develops, invests in and operates large-scale renewable power, water and hydrogen projects locally and globally.	Saudi Aramco Reduces emissions across its operations, develops CCUS and hydrogen, and invests in lower-carbon and cleaner energy solutions.

Session 3: Policy Instruments - Shaping Energy Markets

81. Introduction

KSA's energy sector is undergoing an unprecedented transformation driven by the goals of Vision 2030, which aim to diversify KSA's energy mix, reduce its dependence on hydrocarbons, and promote environmental sustainability. To guide this transformation, the Saudi government has established a multi-layered regulatory framework—comprising laws, policies, standards, and tariffs—that governs and shapes the national energy market.

These tools are critical not only for ensuring market stability and investor confidence, but also for aligning domestic energy strategies with global climate and sustainability targets, including those set under the Paris Agreement.

82. Regulatory Tools in KSA's Energy Market

The regulatory instruments shaping KSA's energy landscape can be categorized into five main types:

- [Primary Legislation \(Laws and Royal Decrees\)](#)
- [Secondary Regulations and Executive Rules](#)
- [Technical and Operational Standards](#)
- [Tariff and Pricing Mechanisms](#)
- [Incentive-based Policy Instruments](#)

Each of these tools plays a distinct and complementary role in market governance, grid stability, investor protection, and consumer affordability.

83. Primary Legislation

Primary laws provide the legal foundation for the operation, development, and oversight of the energy sector.

Key laws	Purpose
Electricity Law (2021 update)	Regulates the generation, transmission, distribution, and trading of electricity. It supports private sector entry and enables independent power producers (IPPs).
National Environment Law (2020)	Governs environmental impact assessments (EIAs), pollution control, and emissions compliance for all energy-related projects.
Public-Private Partnership Law (2021)	Facilitates PPP frameworks for renewable and utility-scale energy projects.
Energy Efficiency Law (Draft)	Aims to establish national energy efficiency obligations and standards for buildings, vehicles, and industries.

Key laws	Purpose
Renewable Energy Framework Law (Planned)	Expected to create a standalone legal framework to govern renewable energy development, permits, incentives, and grid access rights.
Royal Decrees and Cabinet Decisions	These provide strategic direction and mandate ministerial coordination on national initiatives like: • Saudi Green Initiative (Royal initiative, 2021) • Circular Carbon Economy (G20-endorsed, 2020) • Vision 2030's Energy Market Liberalization Strategy

84. Secondary Regulations and Executive Rules

Secondary regulations operationalize the goals of the primary laws and are issued by sector regulators and government agencies.

Regulatory Authorities Involved include

- Electricity and Cogeneration Regulatory Authority (SERA): Oversees licensing, tariff setting, and service reliability.
- Ministry of Energy: Issues executive regulations and policy guidance for energy diversification and market design.
- National Centre for Environmental Compliance (NCEC): Issues compliance protocols for environmental licensing.
- Saudi Standards, Metrology and Quality Organization (SASO): Regulates energy efficiency, product certifications, and appliance standards.

Examples of Key Executive Regulations

Regulation	Impact
Grid Code Regulations	Define technical requirements for connecting renewable energy projects to the grid.
EIA Regulations	Mandate detailed environmental studies before approval of energy infrastructure.
Licensing Regulations	Establish conditions for power generation, trading, and retailing by private entities.
Market Participation Rules	Allow IPPs and captive producers to bid in competitive procurement rounds.
Curtailment and Dispatch Rules	Prioritize clean energy dispatch and manage system load stability.

85. Technical and Operational Standards

Standards are critical to ensure quality, interoperability, efficiency, and safety in the energy system.

Standards	Content
Grid and Generation Standards	Issued by the Saudi Energy Co. (SE) and enforced by SERA: • Interconnection guidelines for IPPs • SCADA and smart grid integration protocols • Renewable plant performance benchmarks
Renewable Technology Standards	Published by SASO and the Ministry of Energy: • Standards for solar modules, wind turbines, inverters, and battery storage • Certification requirements for imported clean energy components • Compliance with IEC and ISO standards for project bankability
Energy Efficiency Standards	Implemented by SEEC in partnership with SASO: • Appliance efficiency ratings (e.g., HVAC, lighting, white goods) • Building insulation and HVAC design requirements • Vehicle fuel economy standards aligned with CAFÉ benchmark

86. Tariffs and pricing mechanisms

Tariffs and Pricing Mechanisms	Tariff structures determine the economic viability and attractiveness of energy projects and shape consumer behaviour. • Wholesale and Retail Tariffs • Cost-reflective tariffs introduced under the Fiscal Balance Program • Fuel price reforms to reduce consumption subsidies • Time-of-use tariffs to encourage off-peak demand and grid balancing
Feed-in Tariffs and Competitive Pricing	NREP uses competitive auctions, not feed-in tariffs (FiTs), to ensure low LCOEs and investor-driven pricing. Solar PV prices as low as \$0.0104/kWh have been achieved, among the world's lowest.
Incentive-Based Policy Instruments	While not traditional regulations, these tools are crucial for shaping market behaviour and encouraging innovation.

87. Incentives and Support Mechanisms

Instrument	Function
Land Allocation for Projects	MOE facilitates pre-approved land for renewable projects to reduce development risk.
Tax Incentives	VAT exemptions or reductions on renewable technology imports and project inputs.
Loan Guarantees and Financing Access	Support through Saudi Industrial Development Fund (SIDF) and National Development Fund (NDF).
Local Content Requirements	Encourage job creation and domestic manufacturing by requiring minimum local input percentages in project delivery.
Carbon Market Participation	Voluntary carbon market launched under PIF to allow companies to monetize carbon offsets and encourage emissions reductions.

88. Alignment with Global Best Practices and the Paris Agreement

KSA's regulatory instruments increasingly reflect international standards to attract global investors and support climate goals:

Goal	Regulatory Linkage
Paris Agreement (NDC)	National regulations mandate emissions monitoring, reporting, and mitigation planning for energy projects.
UN Sustainable Development Goals (SDGs)	Alignment with SDG 7 (Affordable & Clean Energy), SDG 13 (Climate Action), and SDG 9 (Industry, Innovation, Infrastructure).
Bankability and Project Finance	Regulatory frameworks support long-term PPAs, transparent procurement, and IFC-compliant environmental assessments.

89. Challenges and Opportunities

Challenges	Opportunities
Regulatory fragmentation	Establish a unified Clean Energy Regulatory Authority
Limited public data transparency	Expand open-access environmental and energy performance reporting
Investor complexity with multi-agency coordination	Develop one-stop permitting and compliance portals

Challenges	Opportunities
Need for grid code modernization for storage and hydrogen	Introduce regulatory updates for emerging technologies

KSA's energy transformation is underpinned by a robust, evolving regulatory architecture that balances Investment attraction | Consumer protection | Environmental sustainability | Technological innovation.

Through a combination of laws, regulations, standards, tariffs, and incentives, KSA is building a future-proof energy market that aligns with Vision 2030, fulfils its commitments under the Saudi Green Initiative, and supports a clean, resilient power system under the National Renewable Energy Program. This regulatory environment not only guides current market actors but also signals clarity and confidence to future investors and technology partners, ensuring long-term sustainability and global competitiveness.

90. Economic Instruments Shaping KSA's Energy Markets

Economic instruments are essential tools to influence energy market behaviour by leveraging financial incentives, cost recovery mechanisms, and market-based approaches. In KSA, these instruments are being restructured to support the national energy transition, reduce dependence on fossil fuels, promote clean energy, and ensure financial sustainability in the electricity sector. KSA's reform agenda under Vision 2030, including the SGI and the NREP, increasingly relies on well-calibrated economic levers to encourage investment in renewable energy, improve energy efficiency, rationalize subsidies, and incentivize innovation and local content. Each instrument serves a different purpose in market development, cost recovery, risk mitigation, and consumer affordability. Economic instruments are categorized into:

- [Feed-in Tariffs \(FiTs\) and Power Purchase Agreements \(PPAs\)](#)
- [Tax Incentives and Exemptions](#)
- [Subsidies and Tariff Reforms](#)
- [Auction-Based Pricing Mechanisms](#)
- [Public Financing and Guarantees](#)

91. Feed-in Tariffs and Power Purchase Agreements

Instrument	Description	Impacts:
Feed-in Tariffs (FiTs)	While feed-in tariffs have been widely used in other countries, KSA has not adopted a conventional FiT model. Instead, it relies on long-term Power Purchase Agreements (PPAs) awarded through competitive bidding under the NREP.	KSA has achieved record-low solar prices, e.g., \$0.0104/kWh (Sakaka Solar Project) Ensures price certainty for consumers and viability for developers
Competitive PPA Model	MOE structures projects under the Independent Power Producer (IPP) model, where developers compete to offer the lowest cost of electricity over a fixed longer term.	Replaces the need for open-ended feed-in tariffs with market-competitive outcomes
Features of KSA's PPA Framework: • Fixed-tariff structure (lowest bid wins) • Guaranteed offtake by SPPC (Saudi Power Procurement Company) • Payment denominated in SAR or USD (with optional hedging) • No inflation indexation (contracts are fixed price) Government-backed guarantees, increasing investor confidence		

92. Tax Incentives and Exemptions

Instrument	Description	Impacts
VAT and Import Duty Relief	To support renewable energy deployment and reduce project costs, KSA offers import duty exemptions and VAT reductions on specific clean energy equipment, including: • Solar PV panels and inverters • Wind turbine components • Energy-efficient HVAC systems and insulation materials These exemptions are administered in collaboration with Zakat, Tax and Customs Authority (ZATCA) and Saudi Standards, Metrology and Quality Organization (SASO) for equipment eligibility	Reduces upfront capital expenditure for developers
Corporate Tax Relief for Renewable Projects	Although not universally implemented, the Ministry of Investment offers special economic zone incentives for renewable energy manufacturers and developers: • Corporate tax holidays (for qualified green tech firms)	Supports localization and technology transfer

Instrument	Description	Impacts
	Accelerated depreciation for renewable plant assets Capital investment deductions	Attracts FDI and joint ventures in renewable energy manufacturing
Green Industry Support via NIDLP	The National Industrial Development and Logistics Program (NIDLP) provides soft loans and preferential tax treatment for companies producing solar modules, batteries, EV components, and hydrogen infrastructure	

93. Subsidies and Tariff Reforms

Instrument	Description	Impacts
Electricity Subsidies (Pre-Reform)	Historically, electricity in KSA was heavily subsidized, resulting in: - Inefficient consumption - Budgetary burdens on the government - Disincentives for renewable deployment	Promotes demand-side efficiency Creates a level playing field for renewable energy competitiveness Supports financial sustainability of the Saudi Energy Co. (SE)
Tariff Reform under Vision 2030	As part of the Fiscal Balance Program, the government undertook gradual reforms starting in 2016: - Increased electricity prices for higher consumption tiers - Unified tariffs across residential, commercial, and industrial segments - Introduced time-of-use tariffs for large consumers - Aimed to reflect true cost of electricity production and distribution	
Direct Consumer Protection Measures	To mitigate social impacts of subsidy reforms: - The Citizen's Account Program provides cash transfers to low-income households - Industrial tariffs remain partially subsidized for energy-intensive sectors until transition strategies are fully implemented	

94. Auction-Based Pricing Mechanisms (Reverse Auctions)

A reverse auction (also called a competitive bidding process) is a procurement method where sellers (e.g., power producers) compete to offer the lowest price at which they are willing to deliver a product or service—typically, electricity from renewable sources. Unlike traditional auctions where buyers compete by bidding higher prices, in a reverse auction the lowest bidder win.

Instrument	Description	Impacts
NREP's Competitive Bidding Process	KSA's preferred pricing mechanism is the reverse auction model, managed by SPPC. Auction Structure: • Pre-qualified bidders submit price offers (in SAR/MWh or USD/MWh) • The lowest tariff is selected for PPA signing • Contracts awarded include land access, grid connectivity, fixed offtake Advantages Over FiTs: • Drives price discovery and efficiency • Avoids overpayment or long-term subsidy lock-in • Reduces risks of regulatory capture or price distortions	Solar and wind prices in KSA are among the lowest globally Promotes fiscal responsibility and consumer affordability

95. Public Financing and Government Guarantees

Instrument	Description
Loan Facilities	The Saudi Industrial Development Fund (SIDF) and National Development Fund (NDF) offer: • Concessional loans for project developers • Bridge financing and working capital support • Credit lines for renewable equipment manufacturers
Sovereign Guarantees	For utility-scale projects, the government may offer: • Sovereign payment guarantees through SPPC • Support for foreign exchange hedging in PPA contracts • Land access and permitting streamlining
PIF as Strategic Investor	The Public Investment Fund (PIF): • Co-develops mega renewable projects (e.g., Sudair, NEOM) • De-risks projects through equity investment and blended finance • Supports ESG-aligned projects through its Sustainability Fund

96. Alignment with Vision 2030 and SGI Goals

Instrument	Alignment with Vision 2030 / SGI / NREP
PPAs via competitive bidding	Achieves cost-efficient renewable deployment and market liberalization
Tax and customs relief	Attracts green investment and lowers barriers to entry
Tariff reform	Ensures energy price rationalization and sustainability
Subsidy reallocation	Redirects state support to strategic, socially equitable outcomes
Green financing and PIF support	Crowds in private capital and supports localization

97. Challenges and Policy Considerations

Challenge	Policy Recommendation
Need for permanent tax relief on green tech	Establish clear and codified green tax regime
Investor concern over PPA currency terms	Provide hedging mechanisms or dollar-denominated options
Grid constraints limiting project bankability	Link financial incentives to smart grid investment
Need for small-scale solar incentives	Introduce net metering and rooftop solar subsidies for homes and SMEs

Economic instruments—from competitive PPAs and tax incentives to subsidy reform and green finance—are fundamental to shaping KSA’s new energy economy. These tools are strategically aligned with the goals of Vision 2030, the SGI’s environmental commitments, and the capacity deployment targets of NREP. By integrating transparent market mechanisms with targeted incentives, KSA is transitioning from subsidy-driven energy consumption to investment-driven sustainability, while ensuring a just, efficient, and globally competitive energy market.

98. Market Instruments Shaping KSA’s Energy Markets

KSA is amid a profound energy transition, aiming to diversify its energy mix, reduce carbon emissions, and create a more efficient, investor-friendly energy market. This transformation is anchored by market-based instruments—policy tools that leverage market competition and price signals to drive sustainable energy outcomes.

Unlike traditional command-and-control regulations or direct subsidies, market instruments offer flexibility, transparency, and cost-effectiveness, enabling both the public and private sectors to meet energy and climate goals while stimulating economic growth.

This session explores the key market instruments shaping KSA's energy market:

- Renewable energy auctions
- Green certificates (including potential for Renewable Energy Certificates)
- Carbon pricing mechanisms (voluntary and future compliance markets)

99. Renewable Energy Auctions

KSA has adopted a reverse auction model for procuring renewable energy under the National Renewable Energy Program (NREP). This model allows the government to select the lowest-cost power producer through competitive bidding, replacing fixed feed-in tariffs.

Key Players	Role
MOE (Renewable Energy Project Development Office)	Designs and manages tender processes
SPPC (Saudi Power Procurement Company)	Signs long-term power purchase agreements (PPAs) with winning bidders
SE (Saudi Energy Co)	Facilitates grid connection and interconnection agreements

100. Green Certificates and Renewable Energy Attributes

Green certificates, also known as Renewable Energy Certificates (RECs) or Guarantees of Origin (GOs), represent the environmental attributes of renewable electricity generation. One certificate typically equals 1 MWh of clean energy. These instruments can enable corporate green energy claims, be traded in voluntary or compliance markets and/or support renewable energy tracking and disclosure.

101. KSA's Current Position

KSA now effectively has an emerging national renewable energy certificate / green certificate market, although it is not yet as mature or standardized as markets in Europe or some U.S. states. The market today is mainly based on I-RECs (International Renewable Energy Certificates) rather than a fully standalone domestic Saudi-only certificate regime. KSA has:

- renewable energy projects generating tradable certificates
- active issuance and trading of solar I-RECs
- growing corporate demand for renewable electricity claims
- price reporting and market assessments
- registry infrastructure through the I-TRACK / I-REC ecosystem

Each certificate generally represents 1 MWh of renewable electricity generated.

Regional and Global Alignment

Driver	Implication
International buyers of Saudi clean power (e.g., hydrogen, aluminium)	Demand for traceable green energy attributes
Voluntary disclosure initiatives (RE100, CDP, GRI)	Corporates operating in KSA seek to prove renewable consumption
Carbon border adjustment mechanisms (CBAM)	Require evidence of low-carbon input energy for export products

102. Carbon Pricing and Market Instruments

Carbon pricing assigns a monetary cost to greenhouse gas (GHG) emissions to incentivize emissions reduction, encourage clean technology adoption and create economic value for low-carbon activities

KSA's Current Carbon Market Framework

KSA has launched a voluntary carbon market, driven by the Public Investment Fund (PIF) in partnership with Tadawul Group. Key features include Regional platform: Regional Voluntary Carbon Market Company (RVCMC), first auction in 2022: over 1.4 million tons of CO₂ offsets sold, projects sourced from nature-based solutions and industrial reduction and buyers: Aramco, NEOM, SABIC, and other leading firms. KSA is studying long-term options for carbon pricing, including:

- Sector-specific cap-and-trade mechanisms
- Carbon taxes on high-emitting sectors
- Export-oriented carbon pricing compatibility (e.g., CBAM compliance)

Saudi Arabian companies have purchased **over 6.1 million tons** of voluntary carbon credits across three major regional and international auctions hosted by the [Voluntary Carbon Market](#) (RVCMC). [1, 2]

Major Auction Purchases included - October 2022 (Riyadh): Saudi firms bought **1.4 million tons** of carbon credits at the first regional auction, **June 2023 (Nairobi):** Saudi companies bought **2.2 million tons** of carbon credits at a record-breaking auction in Kenya and **November 2024 (Baku / COP29):** Participants purchased another **2.5 million tons** of carbon credits when the full exchange platform launched. [1, 2, 3, 4, 5, 6]

Key Buyers

Saudi Aramco | Saudi Electricity Company | ENOWA (NEOM's energy and water subsidiary) | Other leading regional banks and industrial firms backed by the [Public Investment Fund](#). [1, 2, 3, 4, 5, 6]

Source : <https://www.pif.gov.sa/en/our-investments/our-portfolio/vcm/>

103. Comparative Benefits of Market Instruments

Instrument	Benefit	Saudi Context
Auctions	Low-cost renewable procurement	Achieved record-low tariffs; transparent investment climate
Green Certificates	Tradeable proof of green electricity	Opportunity to support RE100 goals, green hydrogen trade
Carbon Pricing	Monetizes emission reductions	PIF's voluntary market is a first step; potential for national expansion

104. Integration with Vision 2030, SGI, and NREP

Instrument	Alignment
Auctions	Core delivery tool for NREP renewable capacity; supports Vision 2030 market liberalization
Green Certificates	Emerging instrument to support SGI clean energy tracking and corporate transparency
Carbon Market	Supports SGI emissions reduction and NEOM's vision of net-zero infrastructure; aligns with Vision 2030's environmental pillar

105. Policy Recommendations and Future Directions

Challenge	Recommendation
No formal REC market	Establish a national renewable certificate registry under SPPC or Ministry of Energy
Limited carbon market participation	Expand RVCMC reach and develop pathways to compliance-based carbon markets
Investor demand for green disclosures	Mandate energy attribute tracking in NREP PPAs
Need for integrated data systems	Link grid data, emissions tracking, and RE project outputs via smart grid integration

Market instruments—auctions, green certificates, and carbon pricing—are foundational to KSA's transition to a diversified, low-carbon energy market. They foster competition, innovation, and environmental accountability, aligning economic signals with sustainability outcomes. As KSA moves toward its Vision 2030 goals, SGI climate targets, and Paris Agreement commitments, these instruments will:

- Enhance investment transparency
- Support emissions reductions
- Improve export competitiveness
- Enable a flexible and resilient energy ecosystem

106. Simulation exercise: Economic Instruments

Accessed on the online platform – eight financial instruments with a question bank (20 questions) and application bank (10 different energy projects).

SAUDI ENERGY TRANSITION

Economic Instruments Awareness Exercise

Learn why each instrument is used, then assemble practical financing packages for Saudi energy-transition projects.

Learning progress 35%

☐ Facilitator mode

1. LEARN

2. COMPARE

3. APPLY

4. QUIZ

5. RESULTS

Learn

SAVE PROGRESS

RESET CURRENT ACTIVITY

RESET EVERYTHING

Auto-save active

Begin with the barrier—not the instrument

Economic instruments solve different problems. A project may need competitive price discovery, dependable revenue, affordable consumer treatment, public risk sharing, investment incentives or credible environmental value. Most projects need a coordinated package rather

Session 4: Policy Design - Market Stability + Investment Attraction

107. Introduction

Effective energy policy is not merely a matter of setting ambitious goals—it requires careful design, long-term consistency, and market confidence. As KSA executes a historic transition from hydrocarbon dependence toward a diversified, sustainable energy economy, it faces the challenge of designing policy frameworks that are **ambitious yet predictable, flexible yet stable and environmentally sound yet economically attractive**.

108. Principles of Effective Energy Policy Design

Principle	Definition
Clarity	Policies must have clear objectives, definitions, and mechanisms. Ambiguity creates risk and reduces stakeholder participation.
Predictability	Investors and developers require long-term visibility into policy direction, pricing mechanisms, and regulatory enforcement.
Transparency	Transparent procurement, permitting, and tariff-setting reduce perceptions of favouritism or hidden risk.
Flexibility	Policy must adapt to changing technologies, prices, and external risks (e.g., supply chain disruptions, global inflation, or new ESG standards).
Coherence	Energy policies must align with broader economic, environmental, and social policies.
Inclusivity and Stakeholder Engagement	Effective policy engages developers, utilities, financial institutions, and civil society in its design and feedback loops.

109. Market Stability in Energy Transition

Market stability refers to the predictable operation and evolution of energy markets, where prices reflect actual supply and demand, risks are manageable and transparent, investment and financing can occur without fear of sudden shocks

110. Threats to Stability

Risk Type	Examples
Regulatory Uncertainty	Sudden policy reversals, unclear rules on grid access or curtailment
Macroeconomic Instability	Exchange rate volatility, inflation impacting capital costs
Grid Limitations	Lack of capacity for new renewable connections
Project Delays	Bureaucratic or land-use bottlenecks impacting deployment timelines

111. Investment Attraction: Key Considerations

Factor	Investor Expectation
Revenue certainty	Long-term PPAs or feed-in mechanisms
Currency protection	Dollar-denominated or hedged revenue streams
Permitting predictability	Clear environmental and grid connection timelines
Exit options	IPOs, asset sales, or refinancing strategies
Risk-sharing	Guarantees, sovereign backing, or blended finance options

Tools KSA use include competitive auctions with preapproved sites, sovereign-backed PPAs via SPPC, concessional loans via SIDF for local developers, PIF co-investment in anchor projects to de-risk first movers and localization incentives to attract manufacturers and EPC players.

112. Where Policy Meets Practice: Managing the Balance

The real challenge lies in balancing the design ideals with pragmatic constraints. Over-regulation can stifle innovation, while under-regulation creates investor uncertainty. The NREP Auction Model include:

Policy Design Feature	Market Impact
Fixed PPA pricing	Reduces price risk and attracts low-cost bidders
Open tender process	Enhances competition and investor confidence
Absence of feed-in tariffs	Avoids over-subsidization and fiscal burden
Site pre-qualification	Reduces development risk and accelerates construction

Result: Record-low solar prices and high investor interest, but also challenges with:

- Currency risk (PPAs denominated in SAR)
- Land availability in future rounds
- Need for grid upgrades to match capacity growth

Example: Carbon Market Development -

Voluntary carbon auctions led by PIF show early market innovation, but lack of a compliance market or carbon floor price may limit long-term investor participation. Requires regulatory clarity, environmental integrity standards, and linkage to future trade mechanisms

113. Balancing Design, Stability, and Investment

Principle	Action Required
Clarity	Publish multi-year auction and policy roadmap
Predictability	Avoid abrupt policy shifts; offer transition periods
Transparency	Expand open data on grid capacity, tariffs, auction outcomes
Flexibility	Introduce rolling auctions or hybrid procurement (e.g., CfDs, storage-linked PPAs)
Investor Confidence	Offer optional USD-denominated PPAs for FDI projects
Grid Stability	Prioritize grid reinforcement alongside generation buildout
Carbon Market Integration	Develop compliance pathways linked to SGI and export carbon accountability

Balancing effective policy design with market stability and investment attraction is the cornerstone of a successful energy transition. KSA's energy policy framework reflects many global best practices—competitive auctions, long-term PPAs, and sovereign-backed development—but must continue evolving to:

- Incorporate new technologies (e.g., hydrogen, storage)
- Attract capital under rising global ESG expectations
- Ensure equitable risk-sharing with private investors
- Maintain alignment with Paris Agreement commitments and Vision 2030 goals

Session 5: Ensuring Grid Stability During Transition: Balancing Market Stability and Investment Attraction in KSA’s Energy Future

114. Introduction

The transformation of KSA’s energy sector is reshaping KSA’s energy mix. With a targeted 50% renewable share by 2030, the transition from dispatchable fossil fuel-based power to variable renewable energy (VRE) sources introduces both opportunities and technical challenges, the most critical of which is ensuring grid stability. Grid stability, defined as the ability of the power system to deliver electricity consistently and securely, is a cornerstone of energy market stability. It directly influences investor confidence, customer satisfaction, and the long-term success of the energy transition.

115. The Challenge of Grid Stability in the Energy Transition

Renewable energy sources—especially solar and wind—are intermittent and variable, meaning power output depends on weather and time of day, generation can occur far from demand centres and system balancing becomes complex.

Risk Area	Description
Supply Intermittency	Mismatch between generation and demand (e.g., solar peaks at noon, not during evening peak)
Frequency Instability	Renewable plants provide limited inertial support, risking grid frequency deviations
Congestion and Curtailment	High renewable output in remote areas can overload transmission lines
Reserve Capacity Shortfalls	Reduced fossil fleet may limit backup generation during lulls in renewable output

116. Strategic Importance of Grid Stability in Market Stability/ Investment

Grid stability is not just a technical concern—it is an economic and investor imperative.

Impacts on Market Stability	Impacts on Investment Attraction
- Blackouts or instability undermine public trust and industrial productivity. - Unpredictable dispatch conditions deter investor participation.	- Grid capacity and upgrade timelines for project siting. - Curtailment risk in financial models.

Impacts on Market Stability	Impacts on Investment Attraction
Grid stress can force curtailment of clean energy, undermining decarbonization goals.	- Balancing market mechanisms and system operator transparency. - Infrastructure readiness for technologies like storage and hydrogen.

117. KSA's Grid Landscape and Modernization Drivers

Operated primarily by the Saudi Energy Co. (SE) and National Grid SA. Covers over 99% of KSA, spanning long distances from generation sites (e.g., in Al Jouf) to load centres (e.g., Riyadh, Jeddah).

Current Grid Strengths	Modernization Needs
- Well-established high-voltage backbone. - Growing use of smart meters (over 10 million installed). - Connection to GCC Interconnection Authority (GCCIA) for regional load balancing.	- Expand transmission to renewable clusters (e.g., NEOM, Al Shuaibah). - Increase flexibility via battery energy storage, pumped hydro, or demand-side response. - Introduce dynamic grid codes and forecasting tools for VRE.

118. Tools and Strategies to Ensure Grid stability

Strategies and tools	
Transmission System Expansion	- Build new corridors to high-resource renewable zones. - Upgrade existing lines with dynamic line rating and real-time monitoring. - Implement looped and meshed configurations to reduce congestion.
Grid Code Reforms	KSA is developing modern grid codes to: - Define technical requirements for VRE connection. - Mandate frequency response, voltage support, and ride-through capabilities from renewables. - Integrate storage and hybrid plants into dispatch and ancillary services.
Smart Grid and Digital Tools	- Advanced Distribution Management Systems (ADMS) - SCADA upgrades for predictive load management - Weather-based generation forecasting for renewables
Energy Storage and Ancillary Services	KSA is piloting: Battery Energy Storage Systems (BESS) to provide short-term backup and frequency regulation.

Strategies and tools	
	- Hybrid renewable-storage plants to smooth variability. - Ancillary services markets to reward flexible generation and reserve providers.
Demand-Side Management	- Time-of-use tariffs to flatten peaks. - Industrial curtailment programs for demand response. - Smart appliances and home energy management systems (HEMS) under development.

119. Aligning Grid Stability with Investment Attraction

Measures to Improve Bankability of Projects

Mechanism	Investor Benefit
Curtailment guarantees	Compensation for lost revenue in high VRE penetration zones
Grid connection guarantees	Timely interconnection commitment in PPA contracts
Dispatch transparency	Clear grid availability forecasting and congestion alerts
Priority dispatch rules	Clarity on how clean energy is prioritized in system dispatch

Supporting Private Sector Participation

- Enable private investment in transmission infrastructure (e.g., BOOT models).
- Allow co-location of storage with renewables, with distinct remuneration models.
- Establish Grid Access Code with clear rights and obligations for IPPs.

120. Integration with Vision 2030, SGI, and NREP

Framework	Grid Stability Contribution
Vision 2030	Builds infrastructure to support private sector growth and power sector reform
SGI	Ensures emissions reduction targets are not undermined by renewable curtailment
NREP	Enables delivery of 64 GW [Source: https://apps.kapsarc.org/rtracker/] GW renewables by ensuring grid capacity and integration pathways are robust and investment-ready

121. Discussion points for Possible Policy and Market Alignment

Area	Recommendation
Policy Coherence	Align energy, environment, and infrastructure policies under a unified energy planning framework
Grid Investment	Prioritize public-private partnerships in transmission and energy storage
Data Transparency	Open-access grid maps and congestion forecasts for developers
Incentive Design	Reward flexible assets (storage, responsive demand) in upcoming auctions
Legal Reform	Develop a Grid Access Law defining rights, timelines, and penalties for delays or disconnections

Ensuring grid stability during the energy transition is one of the most crucial enablers of market confidence and long-term investment. As KSA moves toward its ambitious renewable energy goals, it must balance technical resilience, regulatory innovation, and financial attractiveness. A future-ready grid must not only support high volumes of variable energy but must also provide the stability, predictability, and transparency that investors demand. With the right policies, investment in infrastructure, and alignment across institutions, KSA is well-positioned to become a regional leader in grid-integrated clean energy systems.

122. Balancing Investor Confidence with Consumer Protection

A successful energy transition requires attracting significant private sector investment while ensuring the interests of consumers are protected—especially in a context like KSA, where electricity has historically been heavily subsidized and centrally managed.

Investor confidence is essential to mobilize the capital and expertise needed for infrastructure development, renewable energy deployment, and innovation. At the same time, consumer protection is critical to ensure affordability, reliability, and equitable access to energy services. Balancing these objectives is a delicate yet essential policy priority as KSA shifts toward a liberalized, sustainable, and competitive energy market.

123. Understanding the Policy Duality

Objective	Investor Confidence	Consumer Protection
Definition	Creating a stable, predictable environment for private capital	Ensuring energy is affordable, reliable, and fair

Objective	Investor Confidence	Consumer Protection
Key Concerns	Tariff certainty, payment security, regulatory stability	Tariff affordability, supply continuity, transparency
Risk of Imbalance	Overly protective regulation may discourage investment	Unchecked liberalization may harm vulnerable consumers

124. Investor Confidence: Enablers and Expectations

What Investors Require	KSA's Response
- Revenue predictability: Long-term contracts (e.g., PPAs) - Regulatory stability: Consistent laws, procedures, and dispute resolution - Risk-sharing mechanisms: Guarantees, hedging, and sovereign backing - Market access: Grid connection, open procurement processes - Exit options: IPOs, refinancing, secondary markets	- Standardized Power Purchase Agreements (PPAs) backed by the Saudi Power Procurement Company (SPPC) - Sovereign support via Public Investment Fund (PIF) in anchor projects - Transparent auctions under MOE - Steps toward market liberalization under the Electricity Market Law

125. Consumer Protection: Principles and Risks

Core Consumer Protection Principles	Protection Risks in a Liberalized Market
- Affordability: Electricity tariffs should be reasonable and predictable - Transparency: Consumers must understand pricing, billing, and usage - Reliability: The system must provide uninterrupted service - Inclusivity: Low-income and remote populations must not be marginalized - Data privacy and fairness: Especially in smart grid and digital billing systems	- Tariff shocks due to removal of subsidies or market-based pricing - Complex pricing schemes that confuse or mislead consumers - Service disparities between high- and low-income or rural/urban areas - Over-commercialization, leading to aggressive practices

126. Balancing Mechanisms: Aligning Interests of Investors and Consumers

Performance-Based Regulation

Regulators can link investor returns to performance benchmarks such as outage duration (SAIDI/SAIFI indices), customer satisfaction scores and service response times. This ensures that profitability is tied to consumer value, not just investment volume.

Cost-Reflective Tariffs with Social Buffers

KSA is transitioning to cost-reflective pricing, but maintains tiered tariffs to protect smaller consumers, offers subsidies through transfer payments, not cheap electricity and designs auctions to maintain low LCOEs, benefiting end users

Regulatory Predictability and Appeals

Investors are reassured through stable frameworks under Electricity Market Law, independent regulatory oversight from SERA and clear dispute resolution and tariff appeal mechanisms. Consumers are empowered with complaint systems, monitoring dashboards and educational programs on energy usage

Green Market Development with Transparency

As KSA explores carbon trading and renewable energy certificates, transparency ensures investors know their products will command premium ESG value and consumers are not greenwashed or overcharged under “clean tariffs”.

127. Strategic Alignment with Vision 2030, SGI, and NREP

Framework	Relevance
Vision 2030	Calls for private sector-led growth in utilities while ensuring social stability
Saudi Green Initiative	Supports carbon reduction through efficient markets and consumer awareness
National Renewable Energy Program	Structured to ensure low-cost renewable procurement while keeping tariffs affordable

128. Discussion points for Deepening the Balance

Area	Recommendation
Tariff design	Link tariff adjustments to energy efficiency goals and education campaigns

Area	Recommendation
Consumer education	Expand digital tools, mobile apps, and utility engagement programs
Investor risk mitigation	Offer indexed tariffs, sovereign guarantees, and payment security mechanisms
Equity assurance	Keep subsidies targeted and transparent (e.g., cash transfers over blanket discounts)
Consumer-centric innovation	Promote smart appliances, rooftop solar, and net metering under regulated frameworks

Module 3 – Energy security and availability

Session 1: Energy Trilemma in Context of Saudi Vision 2030

129. Introduction

As nations seek to reshape their energy landscapes in response to climate imperatives and socio-economic demands, a key strategic balancing act emerges—the **energy trilemma**. The energy trilemma represents the challenge of delivering **energy security**, **affordability**, and **environmental sustainability** simultaneously. For KSA, navigating this trilemma is both a domestic necessity and a global responsibility.

Vision 2030 and the National Energy Strategy have laid the foundation for this transformation, emphasizing economic diversification, climate stewardship, and innovation. This chapter unpacks each dimension of the trilemma, demonstrates the inherent trade-offs, and situates KSA's policy frameworks and programs within this complex balancing act.

130. Energy Security

Definition and Relevance - Energy security always refers to the uninterrupted availability of energy sources, **at stable prices**, and in a form that meets national demand. It encompasses physical infrastructure, diversified energy sources, emergency response capabilities, and geopolitical stability in energy supply chains.

KSA's Position - Traditionally, KSA's energy security has been tied to its **abundance of hydrocarbons**, allowing KSA to ensure self-sufficiency and global energy market influence. However, **reliance on fossil fuels introduces long-term risks**, including global demand volatility and carbon exposure.

Key Strategic Shifts

- **Diversification of the energy mix:** Integrating solar, wind, and hydrogen into domestic energy use.
- **Grid modernization:** Digitalization and smart grid investments through entities like the Saudi Electricity Company.
- **Resilience strategies:** Emergency fuel storage, cross-border electricity interconnectors (e.g., with the GCC Interconnection Authority).

Challenges

- Managing intermittent renewable energy.
- Ensuring grid stability in extreme weather.
- Balancing exports with domestic energy needs.

131. Energy Affordability

Definition and Relevance - Energy affordability ensures that **energy prices are equitable and do not burden consumers**, while also enabling industrial and economic development. It has both **social and economic dimensions**, impacting household welfare, public satisfaction, and national competitiveness.

KSA's Legacy - Historically, KSA maintained **high energy subsidies**, making electricity, water, and fuel among the most affordable in the world. While beneficial to consumers, this approach led to:

- Overconsumption.
- Inefficient energy use.
- Budgetary strain due to subsidy costs.

Reforms Under Vision 2030 - **Phased subsidy reductions** began in 2016 to align domestic prices closer to market levels.

- **Introduction of energy efficiency programs** through the Saudi Energy Efficiency Centre (SEEC).
- **Targeted support mechanisms** to shield low-income groups from rising energy prices.

Balancing Acts

- Gradualism in pricing reforms to avoid social backlash.
- Protecting industrial competitiveness during the green transition.
- Financing energy transformation without overburdening citizens.

132. Environmental Sustainability

Definition and Relevance - Environmental sustainability entails **meeting present energy needs without compromising ecological health or the ability of future generations to meet their own needs**. It focuses on carbon emissions reduction, biodiversity preservation, pollution control, and resource efficiency.

KSA's Green Transformation - Although historically associated with hydrocarbon production, KSA is increasingly investing in sustainability:

- **Saudi Green Initiative:** Generate 50% of electricity from renewables by 2030.
- **Circular Carbon Economy (CCE):** A holistic model that includes reducing, reusing, recycling, and removing carbon.
- **Carbon Capture, Utilization and Storage (CCUS):** Demonstration projects led by Aramco and other national champions.

Key Challenges

- Achieving carbon neutrality in a fossil-fuel-dependent economy.
- Water-intensive cooling for renewable power stations in arid regions.
- Integrating sustainability into heavy industries like petrochemicals and construction.

133. The Interplay: Navigating Trade-Offs and Synergies

These three pillars—security, affordability, and sustainability—are interlinked but sometimes in tension. For example:

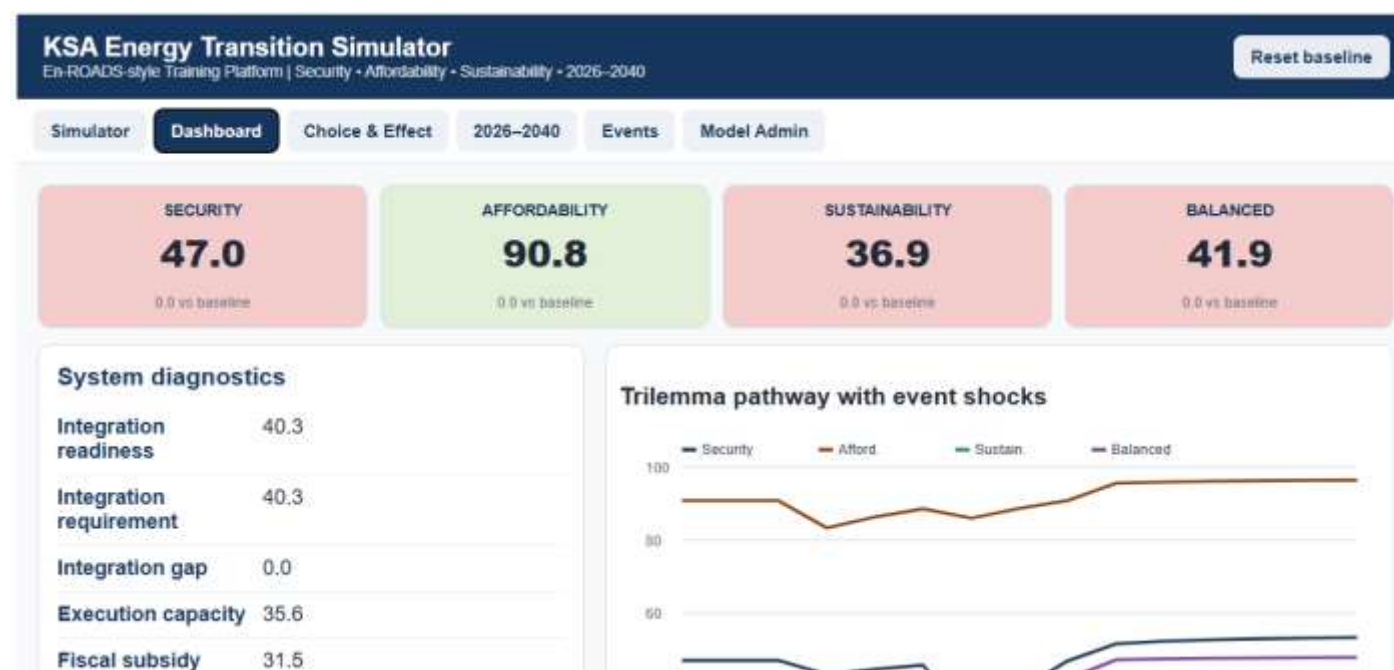
- Increasing renewable energy improves sustainability but may challenge reliability due to intermittency.
- Removing subsidies improves sustainability but may impact affordability.
- Enhancing energy security through natural gas may reduce emissions but still relies on fossil fuels.

KSA's approach is **not to compromise one for another**, but to seek **innovative synergies**, enabled by:

- **Technology adoption:** Smart grids, storage, hydrogen, AI.
- **Policy reform:** Transparent tariff structures, investment incentives.
- **Public-private collaboration:** Leveraging global capital and expertise.

134. Simulation exercise: Aligning the Trilemma

Accessed on the online platform – exploring 16 strategic interventions that will influence security, affordability and sustainability.



Session 2: The Circular Carbon Economy – The Bridge to a Low-Carbon Future

135. The Need for a Balanced Energy Transition

These pillars offer KSA a pathway to decarbonize its economy without compromising energy affordability, security, or industrial growth.

As the global call for climate action intensifies, oil-producing nations face a unique dual challenge: maintaining energy security and economic stability while transitioning to lower carbon pathways. For KSA, the solution is not to abandon hydrocarbons abruptly, but to **decarbonize them intelligently**.

Enter the **Circular Carbon Economy (CCE)**—a practical and inclusive framework that enables KSA to leverage its fossil fuel assets while moving toward climate goals. The CCE was **officially endorsed by the G20 under KSA's presidency in 2020**, positioning it as a global model for sustainable carbon management.

CCE stands apart from linear models that emphasize only reduction. It introduces a **cyclical system of carbon control** through four interconnected pillars: **Reduce, Reuse, Recycle, and Remove**.

Voluntary Carbon Market



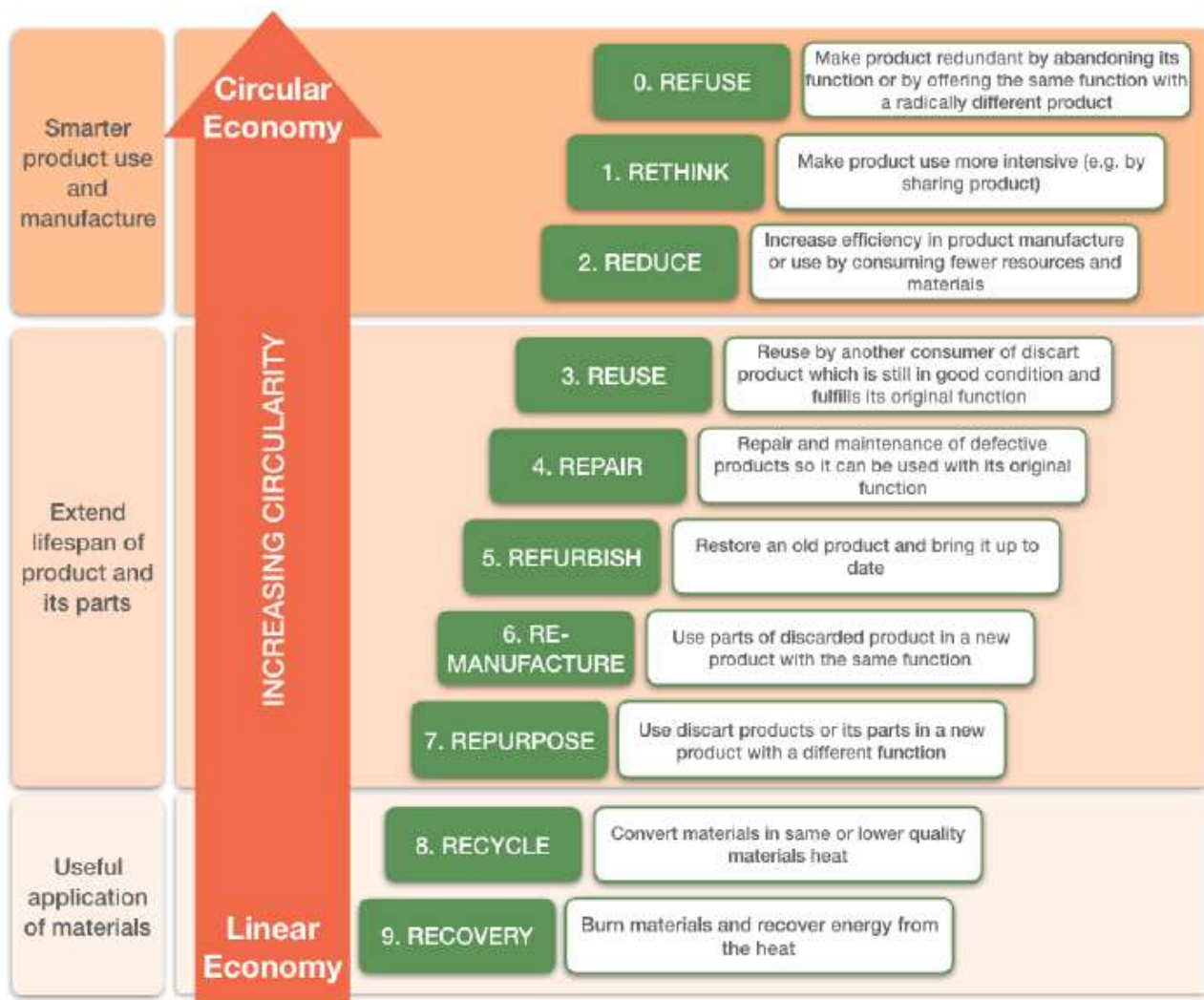
[Circular Carbon Economy and sustainability | Aramco](#)

136. What Is the Circular Carbon Economy (CCE)?

The CCE is an **energy and environmental management framework** that aims to manage carbon emissions holistically and flexibly. It focuses on making carbon **a manageable resource rather than a harmful waste**, enabling a closed-loop system of carbon handling.

Whereas traditional environmental strategies often promote a linear “reduce-only” mindset, CCE acknowledges that **complete elimination of carbon is neither feasible nor desirable** in the short to medium term—especially for nations heavily reliant on hydrocarbons

137. Increasing circularity



140. Reuse

Objective: Capture carbon from industrial processes and **reuse it as a feedstock or energy carrier**.

Strategies and Tools:

- Direct use of captured CO₂ in enhanced oil recovery (EOR).
- Utilization in **greenhouse agriculture** and synthetic fuel production.
- Development of **carbon-to-chemicals** technologies.

Saudi Example: - **Aramco's Enhanced Oil Recovery (EOR)** pilot in Uthmaniyah demonstrates CO₂ reuse by injecting captured carbon back into oil reservoirs to maintain pressure and boost extraction.

141. Recycle

Objective: Transform carbon into **new products through chemical or biological processes**.

Strategies and Tools:

- Algae-based biofuel production using captured CO₂.
- Conversion of carbon into construction materials, plastics, or urea.
- Methanation or synthesis of carbon-neutral fuels.

Saudi Example: - Pilot projects within **KAUST (King Abdullah University of Science and Technology)** are exploring **microalgae technologies** that consume CO₂ and produce valuable by-products like biofuels and animal feed.

142. Remove

Objective: Extract CO₂ from the atmosphere or emission streams and store it **permanently or semi-permanently**.

Strategies and Tools:

- **Carbon Capture, Utilization and Storage (CCUS)** for power plants and industrial facilities.
- **Direct Air Capture (DAC)** technologies.
- Natural sequestration through **afforestation, soil carbon, and ocean sinks**.

Saudi Examples: - The **SGI** includes a target to **plant 10 billion trees** domestically and collaborate across the region to plant 40 billion more—providing large-scale natural carbon sinks. Additionally, Saudi Aramco operates one of the **world's largest CO₂ sequestration projects**. [[Middle East Green Initiative - Saudipedia](#)]

143. Strategic Value of CCE to KSA

CCE provides KSA with a **custom-fit decarbonization model** that reflects its industrial base, resource wealth, and policy priorities. It does not discard hydrocarbons but **modernizes their use**, aligning economic imperatives with sustainability commitments. **CCE Benefits in the Saudi Context:**

- **Supports Vision 2030 goals** of economic diversification and clean energy leadership.
- Ensures **continued competitiveness** of the hydrocarbon sector in a carbon-conscious world.
- Enhances **technological innovation and localization** (e.g., CCUS, green hydrogen, synthetic fuels).
- Positions KSA as a **global thought leader** on pragmatic climate solutions.

International Recognition: - CCE was formally adopted in **G20 energy dialogues** during KSA's presidency, reinforcing its legitimacy and paving the way for partnerships with other energy-producing nations.

Challenges and Considerations: - While the CCE is promising, successful implementation depends on:

- **High capital investment** in infrastructure (e.g., carbon pipelines, CCUS hubs).
- **Technology scaling** for nascent solutions like direct air capture and carbon recycling.
- Ensuring **policy coherence and regulatory support** across sectors.
- Balancing CCE implementation with **international perceptions** of fossil fuel dependence.

The Circular Carbon Economy offers KSA a flexible, inclusive, and technologically advanced pathway to bridge the gap between its hydrocarbon-rich past and its climate-resilient future. As a national decarbonization strategy, it reflects **pragmatic ambition**—addressing emissions without undermining energy security or economic growth.

144. Simulation exercise: Circular economy

Accessed on the online platform – applying the principles of circular economy across 10 different industries | projects

The screenshot displays the 'Circular Carbon Economy Industrial Symbiosis Simulation' interface. At the top, a dark blue header contains the title and a subtitle: 'Build a five-project portfolio, test system dependencies and optimise Reduce, Reuse, Recycle and Remove decisions.' To the right of the header are two buttons: 'OPEN ROUND 1' (green) and 'RESET' (white). Below the header, there are four status boxes: 'State: SETUP', 'Portfolio score: 0.0', 'Budget remaining: SAR 500m', and 'Projects selected: 0 / 5'. A navigation bar below these boxes includes four tabs: 'STRATEGY' (highlighted in green), 'INDUSTRIAL NETWORK', 'DASHBOARD', and 'ROUND COMPARISON'. The main content area is divided into two sections. The left section, titled 'CCE Portfolio', features five buttons: 'ALL' (green), 'REDUCE', 'REUSE', 'RECYCLE', and 'REMOVE'. The right section, titled 'Enabling Infrastructure', shows a progress bar for 'CO2 Pipeline' at 0%.

Session 3: Integrating Large-Scale Solar and Wind Energy into National Grid

145. The Transition to a Diversified Energy Mix

KSA is at a pivotal point in its energy transition. While historically dependent on oil and natural gas for electricity generation, KSA has committed to a major diversification of its energy mix in line with **Vision 2030** and the **SGI**. Central to this shift is the large-scale deployment of **solar photovoltaic (PV)** and **onshore wind** projects through the **National Renewable Energy Program (NREP)**.

While the environmental benefits are clear—such as reduced greenhouse gas emissions and improved air quality—**integrating intermittent renewable energy sources into the national grid** presents a range of **technical and economic challenges and opportunities**. This chapter explores those implications and how KSA is responding with innovation, regulation, and infrastructure investment.

146. KSA's Renewable Energy Ambitions

Targets and Programs

- **50% of electricity generation from renewables by 2030.**
- Development of **64 GW** [Source: <https://apps.kapsarc.org/rtracker/>] **GW** of renewable capacity (51.8 GW solar, 12.2 GW wind) under NREP.
- Landmark projects include:
 - **Sakaka Solar PV Plant** (300 MW)
 - **Dumat Al Jandal Wind Farm** (400 MW)
 - Planned giga-scale projects in **NEOM**, including **The Line** and **Oxagon** powered by green hydrogen and clean energy.

These projects are transforming KSA from a hydrocarbon power generator to a **regional renewable energy hub**.

147. Technical Implications of Integrating Solar and Wind Power

Variability and Intermittency - Unlike fossil fuel-based power, solar and wind output **fluctuate with weather conditions and time of day**. This introduces **volatility** in supply, which must be balanced in real time to ensure grid stability.

Challenges:

- Solar generation peaks mid-day, not during evening demand peaks.
- Wind output is site-specific and may drop unexpectedly.
- Overgeneration during low demand periods can lead to curtailment or grid instability.

Solutions:

- **Smart grid infrastructure** with real-time monitoring and control.
- **Forecasting systems** to predict solar irradiance and wind speeds.
- **Grid flexibility mechanisms**, including spinning reserves and load-shifting.

Grid Stability and Inertia - Traditional power plants (gas, coal) provide **rotational inertia** that helps stabilize grid frequency. Inverter-based renewables (solar PV and wind turbines) do not inherently offer inertia, leading to potential instability.

Implications:

- Greater risk of frequency excursions during sudden load changes or faults.
- Risk of cascading failures if not addressed.

Saudi Response:

- Deployment of **synthetic inertia technologies** and advanced inverters.
- Integration of **grid-forming inverters** in newer solar and wind installations.
- Investment in **battery energy storage systems (BESS)** to provide frequency support.

Transmission and Distribution Capacity Utility-scale renewable projects are often located in remote areas (e.g., northern and western KSA), far from major load centres (e.g., Riyadh, Jeddah).

Challenges:

- Long-distance transmission increases line losses.
- Existing grid may lack capacity for bi-directional power flow.

Infrastructure Needs:

- **Upgrades to transmission networks** (extra-high voltage lines).
- **Substation modernization** to handle intermittent inputs.
- **Grid code revisions** to integrate decentralized energy sources.

Example: The **Dumat Al Jandal Wind Farm** required significant grid reinforcement to connect its remote output to the national grid.

148. Economic Implications of Renewable Energy Integration

Capital Investment and Cost Trends - Renewable energy, especially solar PV, has become highly cost-competitive due to global price declines. However, **initial capital costs for infrastructure and integration remain high.**

Costs Include:

- Renewable generation infrastructure (panels, turbines).
- Grid upgrades and interconnectors.
- Storage systems (batteries or pumped hydro).
- Advanced metering and forecasting systems.

Saudi Strategy:

- Competitive bidding under NREP to drive down tariffs.
- Public-private partnerships (PPPs) to attract global investors.
- Local manufacturing incentives to reduce import costs create jobs.

Operating Costs and Efficiency - Once operational, solar and wind plants have **low marginal costs**, leading to substantial **long-term savings** compared to fuel-based plants. However, integrating them into a fossil-heavy grid **can increase system balancing costs.**

Economic Trade-Offs:

- Savings from zero-fuel-cost renewables vs. higher grid balancing expenses.

- Potential for revenue losses in conventional plants due to merit-order effects.
- Cost of maintaining dispatchable reserves as backup.

Policy Considerations:

- **Capacity remuneration mechanisms** for backup generators.
- **Time-of-use pricing** to incentivize load shifting.
- Investment in **demand response programs**.

Jobs, Localization, and Economic Diversification - Renewable energy creates new jobs in:

- Engineering and construction, Maintenance and operations
- Component manufacturing
- Grid digitalization and data analytics

Alignment with Vision 2030:

- **Local Content Requirements (LCRs)** included in renewable tenders.
- Encouragement of local PV module and wind turbine component manufacturing.
- Upskilling programs via the **Human Capability Development Program**.

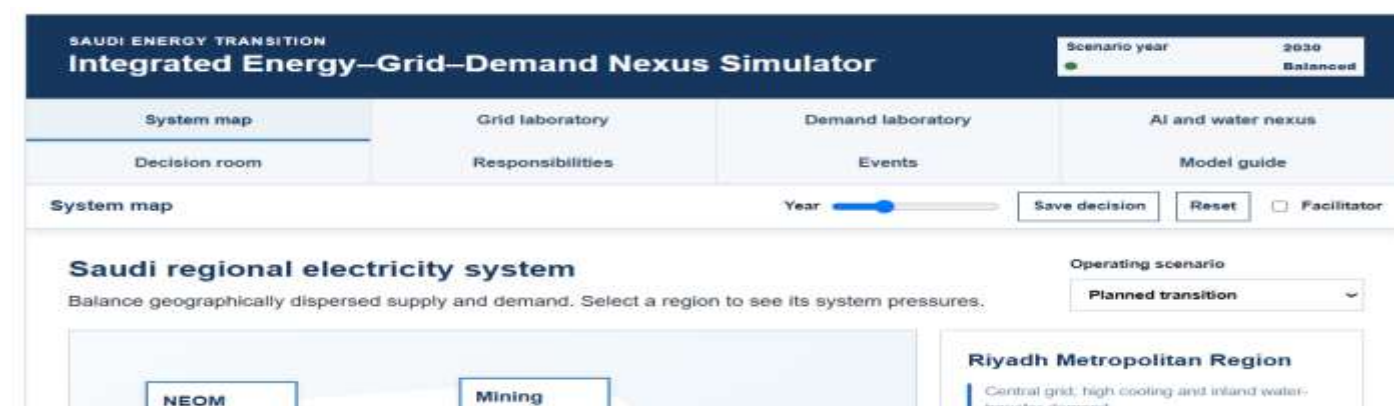
Enabling Technologies for Grid Integration

- **Battery Storage Systems** (e.g., lithium-ion, flow batteries) for short-term load balancing.
- **Green Hydrogen Production** to store surplus electricity and decarbonize hard-to-electrify sectors.
- **AI-powered forecasting models** for demand and weather prediction.

Grid Transformation for a Resilient Future - Integrating large-scale solar and wind energy into KSA's grid is both an **engineering challenge and an economic opportunity**. It requires a paradigm shift—from centralized fossil-based systems to decentralized, variable, and intelligent power systems. KSA is uniquely positioned to lead this transition due to abundant solar and wind resources, strong policy frameworks and financial backing and ambitious national projects like [NEOM](#) that serve as global models.

149. Simulation exercise: Grid stability and demand management

Accessed on the online platform – balancing grid stability with demand management and AI optimization.



Session 4: Energy Pricing Reform – Balancing Economic Efficiency, Political Realities, and Environmental Goals

150. Introduction

Energy pricing reform is a cornerstone of modern energy policy. Historically, many countries—including KSA—have maintained **extensive subsidies for electricity, water, and fuel** to support social equity, industrial growth, and national development goals. However, such subsidies often lead to **overconsumption, inefficiency, and fiscal strain**.

As KSA transitions toward a more diversified and sustainable economy under **Vision 2030**, reforming energy pricing is essential to:

- Promote **efficient energy use**.
- Encourage investment in **renewables and energy-saving technologies**.
- Reduce **fiscal pressure** on public finances.
- Align national carbon emissions with **global climate targets**.

However, reforming energy prices involves significant **trade-offs**—both **economic** and **political**—which must be carefully managed to ensure public acceptance, social stability, and long-term impact.

Energy Subsidies in KSA

Households Keep electricity, water, and fuel prices affordable for citizens and support quality of life.	Transport Lower fuel prices for personal and commercial transport, reducing the cost of mobility for people and goods.	Industry Provide low-cost energy to manufacturing, petrochemicals, mining, and other industrial sectors to enhance competitiveness and attract investment.
Power and Water Support electricity generation and desalination to ensure reliable and affordable supply across the Kingdom.	Economic Development Stimulate economic growth, diversification, and job creation by reducing operating costs for businesses.	Social Stability Help maintain social stability by managing the cost of living and ensuring access to essential energy services.
Strategic Sectors Support strategic sectors such as agriculture, logistics, and construction that are important for food security and infrastructure development.	Regional Development Enable development in remote and less-developed regions by reducing energy costs and improving access to energy services.	Transition Support Provide temporary support to manage the transition to a more efficient and sustainable energy system while protecting the economy and citizens.

151. Understanding Energy Subsidies in KSA

Legacy of Low Energy Prices

For decades, Saudi citizens and industries benefited from **heavily subsidized energy prices**, resulting in:

- Electricity and fuel prices **far below global averages**.
- **High per capita energy consumption**.
- Delayed adoption of energy efficiency measures.
- A significant **burden on government budgets**—energy subsidies often cost billions annually.

Rationale for Subsidies

- Shielding citizens from price volatility.
- Supporting industrial competitiveness.
- Promoting social equity and welfare.
- Maintaining political stability.

However, over time, the negative externalities of such pricing became more pronounced—inefficiency, pollution, and vulnerability to oil price shocks.

152. Economic Trade-Offs in Energy Pricing Reform

Gains from Efficiency and Fiscal Sustainability

Positive Outcomes of Reform:

- Encourages **rational energy use** and conservation.
- Reduces the **budgetary burden** of subsidies.
- Frees up fiscal resources for **social programs**, health, and education.
- Boosts the **economic case** for renewables and energy-efficient technologies.

Example: - KSA's electricity pricing revisions in 2016 and 2018, combined with tariff reforms, led to:

- Decreased residential electricity consumption growth.
- Increased investments in solar water heaters and insulation.
- Lower public spending on fuel subsidies.

Challenges for Households and Businesses

Short-Term Trade-Offs:

- Higher energy bills for low- and middle-income households.
- Rising operating costs for energy-intensive industries (e.g., cement, petrochemicals).
- Inflationary pressure across the economy, especially on transport and food.

Mitigation Strategies:

- **Targeted cash transfers** and **citizen accounts** (e.g., Saudi Citizen Account Program).
- **Tiered pricing structures** to protect low-consumption users.
- **Gradual phase-in** to reduce price shock.

153. Political Trade-Offs in Energy Pricing Reform

Public Acceptance and Social Stability - Energy prices are **highly visible and politically sensitive**. Sudden hikes can lead to public dissatisfaction, protests, or decreased trust in government.

Political Risks:

- Resistance from vested interests (e.g., state utilities, industrial lobbies).
- Urban vs. rural disparities in price impacts.
- Perceived erosion of the social contract.

Key Lesson: - **Political timing, transparency, and communication** are critical. KSA succeeded in avoiding social unrest by:

- Communicating reforms as part of a national transformation strategy.
- Providing **pre-reform awareness campaigns**.
- Launching **compensatory programs** in tandem with price increases.

Industrial Competitiveness - Industries that relied on cheap energy for global cost advantages may become less competitive after reforms.

Sectors at Risk: Cement, Steel, Petrochemicals, Desalination

Policy Options:

- Offer **transitional support** or **energy efficiency grants**.
- Encourage **technological upgrades**.
- Foster **research and innovation** to create cleaner production methods.

Vision 2030 Link: - Energy price reforms are designed to **create a level playing field**, stimulate **private sector innovation**, and align with global carbon regulations (e.g., carbon border taxes, ESG investment requirements).

154. Impact on Consumption Behaviour and Emissions

Price Elasticity of Energy Demand - Numerous studies show that **energy demand is sensitive to price changes**—especially for electricity and gasoline.

Behavioural Impacts include:

- Reduction in unnecessary air conditioning usage.
- Shift to fuel-efficient vehicles or public transport.
- Adoption of energy-efficient appliances and building materials.

Evidence from KSA include:

- KSA's electricity consumption is on a staggering upwards trajectory, making the task of displacing liquids from the power sector an increasingly challenging one. A record 160.5TWh was delivered to customers through the grid over the first six months of 2025, up 10% year-on-year.
- SEEC (Saudi Energy Efficiency Centre) reports increased compliance with energy standards.
- Home insulation, smart meters, and efficient lighting adoption have accelerated.

Emissions Reduction Potential - Higher prices encourage reduced fossil fuel consumption, thus **directly lowering greenhouse gas emissions**.

Emissions Outcomes include:

- Less burning of oil and diesel for power generation.
- Improved energy intensity of GDP.
- Increased penetration of low-carbon alternatives (solar, wind, hydrogen).

CCE Alignment: - Price reform complements the **Circular Carbon Economy** by supporting the “Reduce” pillar—minimizing emissions at source.

155. International Comparisons and Lessons

Global Cases of Pricing Reform:

Country	Reform Outcome	Key Lesson
Iran	Raised fuel prices in 2019, leading to protests	Social communication is essential
India	Phased fuel subsidy cuts over years	Gradualism helps avoid shock
Indonesia	Removed fuel subsidies, reallocated savings	Targeted welfare wins support
UAE	Pegged fuel prices to international benchmarks	Transparency increases credibility

KSA's reform path is often cited as **balanced and effective**, thanks to its use of **targeted support programs**, **clear communication**, and alignment with **national development goals**.

156. Facilitated Discussion Activity: Pricing Reform Dilemma

Scenario: Your team is advising the Ministry of Energy on a new pricing tier for residential electricity.

Challenge: - Design a pricing model that:

- Encourages conservation.
- Protects vulnerable households.
- Maintains revenue for utilities.
- Reduces national carbon emissions.

Discussion Prompts:

- What tiered structure would you propose?
- How will you handle the communication rollout?
- What metrics will you track to measure impact?

Navigating Complexity with Strategy - Energy pricing reform in KSA is a bold, necessary step toward sustainable economic and environmental futures. Though politically and economically sensitive, it offers substantial benefits:

- More efficient energy use.
- Lower emissions.
- Greater fiscal resilience.
- Accelerated renewable energy adoption.

By embedding reforms in a broader national narrative—Vision 2030—and pairing them with social protections and public dialogue, KSA has shown that such transitions are not only possible, but also **transformative**.

Module 4 - Impact of Alternative Energy Technologies

Session 1: Global Drivers of Energy System Transformation

157. The 5 Key Global Drivers of Energy System Transformation

The global energy system is undergoing a historic transition driven by interlocking forces—climate action, technology, market dynamics, and shifting political will. Policymakers, innovators, and energy agencies must adapt quickly.

Driver	Definition	Examples
Decarbonization	Global push to reduce carbon emissions and achieve net-zero goals	Paris Agreement, Net Zero targets, carbon pricing
Digitalization	Use of data, AI, and IoT to optimize generation, distribution, and demand	Smart grids, AI in energy efficiency, predictive maintenance
Decentralization	Shift from centralized plants to distributed energy resources (DERs)	Rooftop solar, microgrids, prosumer models
Electrification	Transition from fossil fuels to electricity in transport and buildings	EVs, electric heating, hydrogen electrolyzers powered by renewables
Energy Security & Geopolitics	Energy supply diversification and reducing reliance on imports	OPEC+ shifts, EU-Russia gas crisis, U.S. Inflation Reduction Act

158. Exercise – Applying the Drivers

Instructions: In the table below, describe how each driver affects KSA’s energy transformation, particularly in K.A.CARE’s areas of focus (renewables, hydrogen, nuclear, policy).

Global Driver	Impact on KSA	Opportunities for K.A.CARE
Decarbonization		
Digitalization		
Decentralization		
Electrification		
Energy Security		

159. Vision 2030 Energy Goals and Climate Commitments

Vision 2030, launched in April 2016 by Crown Prince Mohammed bin Salman, is a blueprint aimed at transforming KSA into a modern, diversified economy. The vision is built on three core pillars:

- A vibrant society
- A thriving economy
- An ambitious nation

Energy transition cuts across all three pillars, particularly the “thriving economy,” where clean energy and sustainability are positioned as key enablers of long-term economic resilience. Key national programs under Vision 2030 include The National Renewable Energy Program (NREP) | The Saudi Green Initiative (SGI) | The National Energy Efficiency Program (NEEP) | The Circular Carbon Economy (CCE) Framework. Each of these initiatives supports the overarching goal of achieving energy security, economic diversification, and environmental sustainability.

KSA’s Energy Sector Transformation

KSA’s energy transition is shaped by five overarching goals under Vision 2030:

Goal 1: Diversify the Energy Mix

KSA seeks to reduce its reliance on oil for domestic power generation. The energy mix is shifting to include natural gas, renewables, and eventually nuclear energy. KSA has set clear targets:

- Achieve 50 percent of power generation from renewable sources by 2030
- Replace inefficient liquid fuel use in the power sector
- Increase natural gas contribution to 50 percent of the mix

This diversification will increase grid flexibility, reduce emissions, and improve energy efficiency.

Goal 2: Scale Renewable Energy Development

The National Renewable Energy Program (NREP), led by the Ministry of Energy, is the central platform for scaling up solar and wind capacity across the country. As of 2023:

- Multiple utility-scale solar PV and wind projects have been commissioned
- Projects like Sakaka PV, Dumat Al Jandal wind farm, and Sudair Solar are milestones in local capacity building
- The goal is to reach 64 GW GW of renewable energy capacity by 2030. [Source: <https://apps.kapsarc.org/rtracker/>]

The program prioritizes local content development, encouraging Saudi firms and talent to participate in the clean energy economy.

Goal 3: Introduce Nuclear Energy Safely

Nuclear energy is envisioned as a long-term component of KSA’s energy security and decarbonization strategy. The Saudi National Atomic Energy Project (SNAEP) outlines plan to:

- Develop nuclear infrastructure
- Launch small modular reactors (SMRs) for localized applications
- Comply with IAEA safety and non-proliferation frameworks

Nuclear energy offers base-load generation potential, supporting grid stability as variable renewables increase.

Goal 4: Promote Energy Efficiency and Demand-Side Management

The National Energy Efficiency Program targets improvements in buildings, industry, and transportation. Key actions include:

- Setting appliance efficiency standards
- Retrofitting public and commercial buildings
- Promoting electric vehicles (EVs)
- Smart meter rollouts and demand-side controls

This supports both economic competitiveness and environmental sustainability.

Goal 5: Enable Innovation and Technology Development

Through partnerships with institutions like King Abdullah City for Atomic and Renewable Energy (K.A.CARE), King Abdulaziz City for Science and Technology (KACST), and [NEOM](#), KSA is investing in energy R and D and pilot projects in hydrogen, carbon capture, and digital energy systems.

Innovation is critical to leapfrogging conventional pathways and creating local intellectual property and manufacturing capabilities.

160. Climate Commitments and International Engagement

KSA's climate policy is evolving rapidly. Although historically cautious in global climate negotiations, KSA is now taking more proactive steps. Key climate-related developments include:

- **Net-Zero Pledge by 2060:** Announced in 2021, the pledge covers the entire economy and relies on technology neutrality, allowing for CCUS, hydrogen, and other advanced solutions.
- **Nationally Determined Contributions (NDCs):** KSA submitted its updated NDC to the UNFCCC in 2021, with targets to reduce emissions by 278 million tons of CO2-equivalent annually by 2030.
- **Circular Carbon Economy Framework:** Endorsed by the G20 under KSA's presidency in 2020, this framework includes reduce, reuse, recycle, and remove carbon strategies to achieve net-zero without compromising energy security.

161. Opportunities and Challenges in Implementation

While the goals are ambitious and strategically sound, implementation presents both opportunities and challenges.

Opportunities:

- Abundant solar resources and land for large-scale renewable projects
- Strong capital investment capabilities from sovereign funds and global partners
- Strategic geographic location for green hydrogen export
- Emerging talent pool and academic institutions focused on clean energy

Challenges:

- Balancing decarbonization with economic dependence on oil exports
- Managing water-energy-food nexus in arid environments
- Ensuring regulatory agility to keep up with technology shifts
- Building public awareness and social acceptance of new technologies

162. Role of K.A.CARE

As a leading scientific and policy body, K.A.CARE plays a vital role in operationalizing Vision 2030's energy and climate ambitions. Key functions include:

- Developing technical standards and policy guidance for renewable and nuclear energy
- Leading research and development in solar, wind, SMRs, hydrogen, and energy storage
- Building local human capital through training, capacity building, and academic collaboration
- Supporting inter-ministerial coordination for integrated energy planning

Vision 2030 represents more than a development roadmap. It is a declaration of intent to redefine KSA's role in the global energy ecosystem. With clear targets for renewable energy, nuclear power, energy efficiency, and emissions reduction, KSA is positioning itself as a proactive leader in energy transition and climate action. To meet these objectives, continuous collaboration among policymakers, technologists, regulators, and researchers is essential. K.A.CARE's ongoing work will be central to ensuring that KSA's energy transformation is not only technically successful, but also globally respected, environmentally sound, and economically inclusive.

163. Megatrends – Decarbonization, Decentralization, and Digitalization

The global energy system is at the forefront of one of the most transformative periods in human history. As the world responds to the climate crisis, energy security challenges, and economic development needs, new patterns are emerging that are reshaping how energy is produced, distributed, and consumed. Among these emerging patterns, three megatrends stand out for their systemic impact: **decarbonization, decentralization, and digitalization**. These three forces, often referred to as the "3 Ds" of energy transition, are not only altering the physical infrastructure of energy systems but also influencing policy frameworks, business models, and consumer behaviour across the globe.

164. Decarbonization: Driving Low-Carbon and Net-Zero Transitions

Definition - Decarbonization refers to the reduction of carbon dioxide (CO₂) and other greenhouse gas emissions from energy systems. It involves a fundamental shift from fossil fuel-based power generation, transportation, and industrial activity toward low- or zero-emission alternatives.

Global Drivers

Several forces are accelerating decarbonization:

- International climate commitments, especially under the Paris Agreement
- Rising investor and stakeholder pressure on corporations to reduce carbon footprints
- Technological innovation making renewables and storage economically viable
- Public demand for cleaner air, sustainable energy, and climate action

Key Technologies and Strategies

- **Renewable Energy:** Solar PV, onshore and offshore wind, hydroelectricity, and bioenergy
- **Green and Blue Hydrogen:** Clean fuel options for heavy industry, transportation, and energy storage
- **Carbon Capture, Utilization, and Storage (CCUS):** Capturing emissions from industrial and power sector sources
- **Electrification of End-Uses:** Replacing fossil fuels in transport (EVs), heating, and cooking with electricity
- **Energy Efficiency:** Retrofitting buildings, optimizing industrial processes, and implementing efficient appliances

Global Progress and Examples

- The European Union aims to be climate neutral by 2050 and has committed to reducing emissions by at least 55 percent by 2030.
- China, the largest emitter, has pledged to peak emissions by 2030 and achieve carbon neutrality by 2060.
- The United States is investing over 350 billion dollars in clean energy through the Inflation Reduction Act.

Relevance to KSA

KSA's 2060 net-zero pledge, delivered through the Circular Carbon Economy framework, aligns with global decarbonization goals. The deployment of renewables, hydrogen initiatives, and CCUS projects reflects a national pivot toward climate-compatible development.

165. Decentralization: Shifting Energy Generation Closer to Consumers

Definition - Decentralization involves a move away from large, centralized power plants toward distributed energy systems. This includes small-scale solar, wind, batteries, microgrids, and other technologies located close to end-users.

Why It Matters

- Enhances energy security and grid resilience
- Enables energy access in remote or underserved areas
- Encourages consumer participation and energy democratization
- Supports lower transmission losses and operational flexibility

Key Components

- **Distributed Renewable Energy (DRE):** Rooftop solar, small-scale wind, grids
- **Prosumers:** Consumers who generate, consume, sell energy back to the grid
- **Energy Communities:** Local groups owning and managing shared energy assets
- **Microgrids and Nanogrids:** Self-contained power systems with local control
- **Peer-to-Peer Energy Trading:** Enabled by blockchain and digital platforms

Global Examples

- India's rural electrification success using mini-grid solar systems
- Germany's Energiewende, where over 40 percent of renewable capacity is owned by citizens and cooperatives
- California's deployment of community choice aggregators and decentralized solar-plus-storage solutions

Opportunities:

Promotes energy access, job creation, and resilience

Challenges:

Requires new regulatory models, pricing mechanisms, and technical standards

Relevance to KSA

KSA has high potential for distributed solar, especially in residential and commercial buildings. Pilot projects in [NEOM](#) and rural regions are testing microgrids and storage-based systems. As smart meters roll out across KSA, decentralization will gain momentum, especially when combined with policy support for prosumers and local generation.

166. Digitalization: Unlocking Efficiency, Transparency, and Intelligence in Energy Systems

Definition - Digitalization refers to the integration of digital technologies into the energy value chain. This includes the use of sensors, artificial intelligence, big data analytics, cloud computing, and automation to improve efficiency, reliability, and consumer interaction.

Core Benefits

- Improves grid management and load balancing
- Enables predictive maintenance and asset optimization
- Enhances consumer awareness and demand-side participation
- Supports real-time energy trading and market operations

Key Technologies

- **Smart Grids:** Real-time monitoring and control of energy flows
- **Internet of Things (IoT):** Networked devices collecting and transmitting data
- **Artificial Intelligence and Machine Learning:** Forecasting demand, optimizing energy use

- **Blockchain:** Transparent and secure energy transactions
- **Digital Twins:** Virtual models of physical energy assets for simulation and diagnostics

Global Examples

- South Korea's digital energy platform enables automated demand response
- The Netherlands has implemented a real-time dynamic pricing model for electricity users

Cybersecurity Considerations - While digitalization offers immense benefits, it also introduces new risks, especially related to data privacy and system vulnerabilities. Strong cybersecurity frameworks must be integrated into all digital energy infrastructure.

Relevance to KSA

KSA has made significant investments in digital infrastructure, including the rollout of smart meters, grid modernization programs, and AI-driven energy analytics. The Digital Government Authority and the Ministry of Energy are encouraging the adoption of Industry 4.0 solutions to optimize operations and reduce emissions. [NEOM](#), a smart city project, is envisioned as a digital-first, carbon-free city powered by renewables and advanced digital grids.

167. Integrating the Three Ds: Systems Thinking for a New Energy Paradigm

While each megatrend has unique drivers and technologies, their full impact emerges when they intersect.

- **Decentralization depends on digitalization** for effective monitoring, management, and control.
- **Digitalization enhances decarbonization** by enabling accurate forecasting, reducing energy waste, and optimizing asset utilization.
- **Decarbonization pressures trigger both decentralization and digitalization** as new low-carbon models and business cases emerge.

The three Ds are ushering in an era of smart, clean, and customer-centric energy systems. To harness these megatrends effectively, energy policymakers must:

1. **Design integrated policies** that simultaneously support renewable deployment, digital innovation, and local energy development.
2. **Reform market regulations** to accommodate prosumers, distributed generation, and dynamic pricing.
3. **Invest in skills and workforce readiness**, particularly in digital and technical competencies.
4. **Foster innovation ecosystems** that support startups, research institutions, and pilot projects.
5. **Ensure data governance and cybersecurity** are embedded from the outset.

K.A.CARE and its partners have a critical role to play in enabling this transition through research, policy advising, and technology development. In the following chapters, we will explore how specific technologies such as hydrogen, energy storage, and nuclear energy align with and accelerate the three Ds.

Session 2: Evaluating Energy Policy - IEA, IRENA, and IPCC

168. Introduction

As countries transition toward cleaner and more secure energy systems, robust frameworks are required to guide, evaluate, and adjust energy policies. Policymakers must balance complex and often competing goals: energy security, environmental sustainability, affordability, and industrial competitiveness. To support these decisions, several global institutions have developed comprehensive frameworks that help countries assess their energy policies in a systematic and data-driven way.

This chapter explores three internationally recognized frameworks developed by the **International Energy Agency (IEA)**, the **International Renewable Energy Agency (IRENA)**, and the **Intergovernmental Panel on Climate Change (IPCC)**. It provides an in-depth look at each organization’s approach to evaluating energy policy and explains how these frameworks can be adapted and applied to KSA’s energy transition strategy.

169. Comparative Summary of Frameworks

Aspect	IEA	IRENA	IPCC
Primary Focus	Global energy systems and security	Renewable energy deployment and transition	Climate change mitigation through energy systems
Key Evaluation Tools	Energy Trilemma, WEO Scenarios	REmap, REPF, FlexTool	Mitigation Pathways, SSPs, IAMs
Use in Policy	Balancing energy objectives	Planning RE integration, enabling environments	Aligning energy strategy with carbon reduction targets
Relevance to KSA	Evaluating energy mix and resilience	Scaling solar, wind, and hydrogen sustainably	Supporting net-zero goals and SGI strategy

170. How Saudi Policymakers Can Use These Frameworks Together

KSA’s energy transformation is multidimensional. To ensure coherence and effectiveness, policymakers can integrate insights from all three institutions:

- Use the **IEA trilemma** to stress-test new energy policy proposals for trade-offs and balance
- Apply **IRENA tools** to optimize renewable energy program design and investment readiness
- Align national climate goals with **IPCC pathways** to ensure global credibility and scientific integrity

K.A.CARE, in its advisory and technical roles, is well-positioned to act as a bridge between these frameworks and local decision-making. By applying them in a coordinated manner, KSA can build an energy system that is secure, sustainable, and globally respected.

In a rapidly evolving global energy landscape, no single framework can offer all the answers. The IEA, IRENA, and IPCC provide complementary perspectives that together enable a more comprehensive evaluation of energy policy choices. By leveraging these approaches, KSA can design energy policies that are economically viable, environmentally responsible, and resilient in the face of future uncertainties.

171. International Energy Agency (IEA)

Mandate and Relevance

The IEA is a leading global authority on energy statistics, analysis, and policy guidance. Established in 1974 to help countries coordinate oil supply security, the agency now plays a central role in shaping global energy transition strategies.



IEA's Energy Policy Evaluation Approach - IEA evaluates national energy policies through two key lenses:

The Energy Trilemma - The energy trilemma is a foundational concept used by the IEA and others to assess how well a country's energy policies balance three competing priorities:

- **Energy Security:** Ensuring a reliable and resilient energy supply
- **Environmental Sustainability:** Reducing greenhouse gas emissions and mitigating climate impacts
- **Energy Equity (Affordability):** Providing accessible and affordable energy for all users

Effective policy must avoid trade-offs that solve one problem while worsening others.

World Energy Outlook and Scenarios - The IEA's flagship **World Energy Outlook (WEO)** uses long-term scenarios to project how energy systems may evolve under different policy choices:

- **Stated Policies Scenario (STEPS):** Projects outcomes based on current policies and announced targets
- **Announced Pledges Scenario (APS):** Reflects countries' net-zero or emissions reduction pledges
- **Net Zero Emissions by 2050 Scenario (NZE):** Aligns with limiting global warming to 1.5°C

These scenarios offer tools for stress-testing national energy strategies, identifying investment gaps, forecasting technology deployment needs

Application in KSA

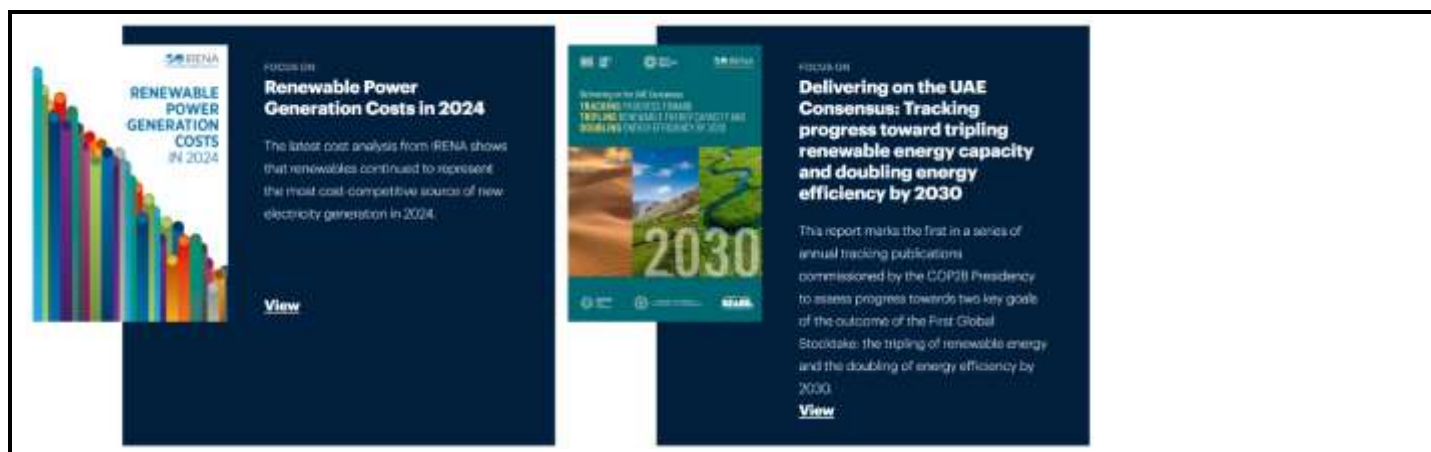
Saudi energy planners can use the IEA's energy trilemma framework to evaluate:

- Whether increasing renewable capacity strengthens or weakens energy security
- How natural gas expansion affects both affordability and sustainability
- The implications of long-term hydrogen or nuclear policies on all three pillars

172. International Renewable Energy Agency – Policy Evaluation

<https://www.irena.org/>

Mandate and Relevance - IRENA is a global intergovernmental organization headquartered in Abu Dhabi that supports countries in their transition to sustainable energy systems, with a particular focus on renewable energy. IRENA provides policy evaluation tools, roadmaps, and methodologies tailored to countries developing renewable energy strategies. Its approach emphasizes technology readiness, investment frameworks, grid integration, and enabling policy conditions.



173. IRENA's Energy Policy Evaluation Frameworks

<https://www.irena.org/Energy-Transition/Policy>

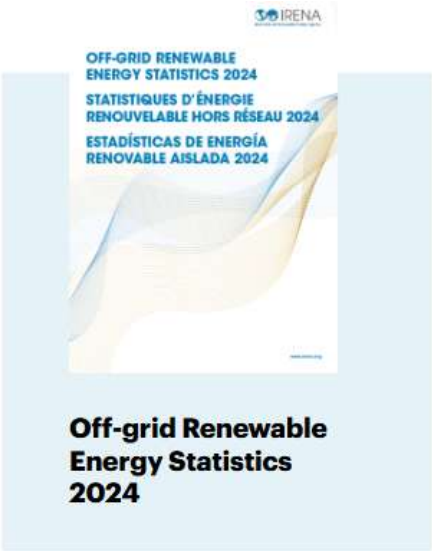
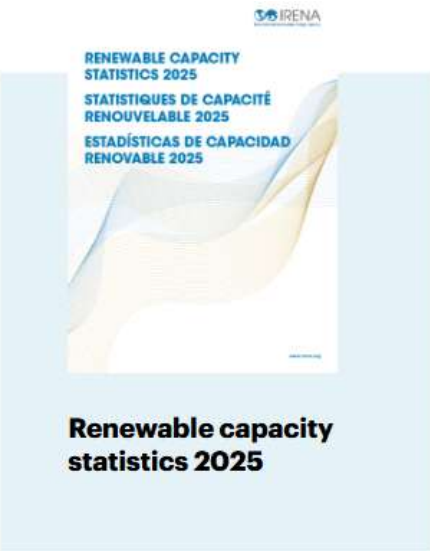
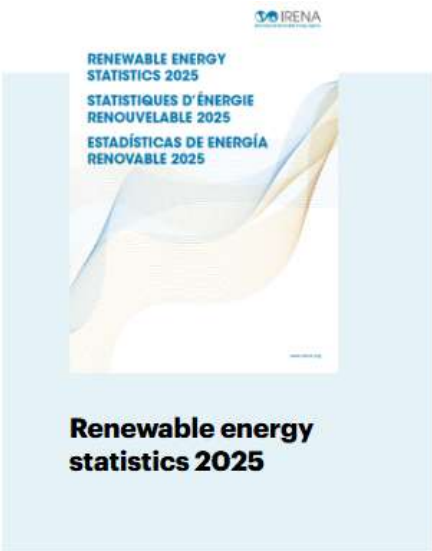
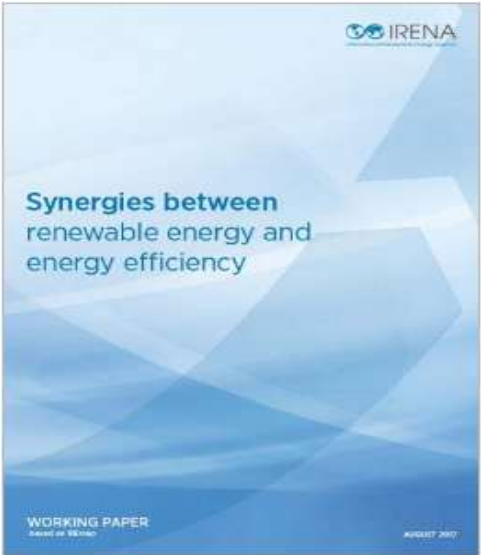
REmap and Energy Transition Scenarios - IRENA's **REmap** tool and global **Energy Transition Scenarios** allow policymakers to:

- Compare current energy mixes with technically feasible renewable pathways
- Quantify the carbon, cost, and employment impacts of renewables
- Model long-term investment needs across sectors

Renewable Energy Policy Framework (REPF)

This framework outlines five pillars critical to renewable energy deployment:

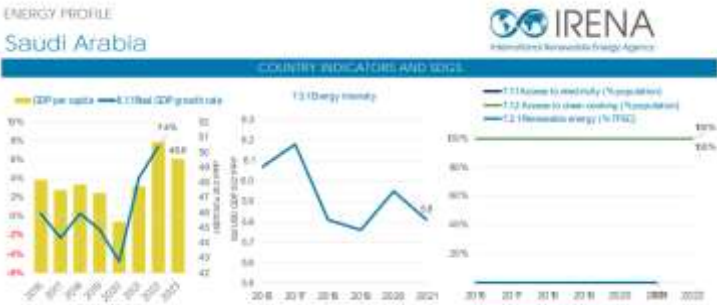
- **Enabling Policy and Legal Environment** - Clear mandates, targets, and laws promoting renewables
- **Investment and Finance Mechanisms** Feed-in tariffs, auctions, green bonds, and public-private partnerships
- **Grid Infrastructure and Integration** Flexible power systems, transmission upgrades, and smart grids
- **Technology and Innovation Ecosystem** Local R&D, manufacturing, and innovation support
- **Capacity Building and Human Capital Development** Training, technical certifications, and education programs



174. Planning and Data Tools

IRENA supports policy evaluation through tools such as:

- FlexTool: Analysing flexibility needs in power systems
- Project Navigator: Supporting renewable project development
- Renewable Energy Roadmaps (REmaps) tailored for specific regions



Application in KSA

- The REmap framework can be used to model the scale-up of solar and wind to meet the 50 percent renewables goal by 2030.
- Policy evaluations can focus on the effectiveness of renewable energy auctions, local content requirements, and grid-readiness.
- FlexTool can assess the energy storage and demand response needs required to support variable renewable integration.

175. Intergovernmental Panel on Climate Change (IPCC)

<https://www.ipcc.ch/>

Mandate and Relevance - The IPCC is the United Nations body responsible for assessing the science related to climate change. Although it does not prescribe policies, the IPCC provides science-based frameworks and projections that inform national and global climate policy, including the role of energy systems in mitigation strategies.

176. IPCC's Evaluation Approach

Mitigation Pathways Framework

The IPCC uses **integrated assessment models (IAMs)** to explore how different energy policies and economic measures can reduce emissions. These models are used in its **Assessment Reports** (e.g., AR6), which serve as key references for national climate strategies.

Key elements include:

- Carbon budgets and temperature targets (1.5°C, 2°C scenarios)
- Sector-specific mitigation options (energy, industry, transport)
- Time-bound pathways to net-zero emissions



Shared Socioeconomic Pathways (SSPs)

SSPs describe future global development patterns and their interaction with climate goals. For energy policy evaluation, they provide insight into what different levels of economic growth, inequality, and technology adoption influence energy use and potential emissions trajectories under various policy environments

Application in KSA

- IPCC scenarios and carbon budgets can guide KSA's net-zero strategy under the SGI.
- IAMs help assess how energy diversification affects long-term emissions trajectories.
- Policymakers can use SSPs to explore how different economic futures influence energy demand and carbon intensity.

Session 3: Utility-Scale vs. Distributed Energy Models

177. Introduction

The transformation of energy systems worldwide is not only about switching from fossil fuels to renewables; it is also about **how energy is produced and delivered**. As countries expand their renewable energy portfolios, they must make strategic decisions about the **scale and structure** of energy generation systems. Two distinct yet complementary models are shaping the future of power generation:

- **Utility-scale energy systems**, which are centralized, large-scale facilities feeding into the national grid
- **Distributed energy systems**, which are smaller, localized sources of generation often located close to the point of consumption

This chapter explores the characteristics, advantages, challenges, and policy implications of both utility-scale and distributed energy models. It provides a framework for understanding how these models can be applied to KSA’s energy transition, especially in the context of its geographic, economic, and social priorities under Vision 2030.

Utility-Scale vs. Distributed Energy Model

Utility-Scale Energy Model	Distributed Energy Model
Purpose and Role Generate large amounts of electricity from centralized facilities to supply the national grid, meeting high demand at the lowest possible cost per unit.	Purpose and Role Generate electricity close to the point of use through smaller, decentralized systems to meet local demand, improve resilience, and complement the national grid.
Key Characteristics Large-scale projects, high upfront investment, connected to the transmission network, economies of scale, and suitable for steady baseload and large renewable generation.	Key Characteristics Smaller-scale systems, located near consumers, modular and scalable, can operate independently or with the grid, and suitable for solar, storage, and other local energy solutions.
Main Benefits Lower cost per unit, reliable large supply, supports national energy security, and enables integration of large renewable projects such as solar and wind farms.	Main Benefits Greater flexibility, improved resilience, reduced transmission losses, faster deployment, and empowers consumers, businesses, and communities to participate in the energy transition.

178. Comparative Analysis: Utility-Scale vs. Distributed Models

Criteria	Utility-Scale Energy	Distributed Energy
Scale and Output	High capacity (hundreds of MW to GW)	Small-scale (kilowatts to several MW)
Location	Remote areas with abundant land	Close to end-users (homes, offices, communities)
Grid Integration	Requires high-voltage transmission infrastructure	Often connects to low-voltage local distribution
Control and Ownership	Utility or government-operated	Individuals, businesses, communities, or municipalities
Installation Cost per Unit	Lower due to economies of scale	Higher per unit, but lower installation and land costs
Deployment Speed	Long lead time (permits, land acquisition, grid tie-in)	Rapid deployment and modular scaling
Resilience	Vulnerable to centralized failure	Enhances local energy resilience and disaster recovery
Policy Considerations	Requires large-scale procurement, PPA frameworks	Needs incentives, net metering, smart grid readiness

Global Examples

United States - A mix of large wind and solar farms (Texas, California) and rooftop solar in residential areas, Federal tax credits support both scales, growing number of community solar projects

Germany - Energiewende policy enabled thousands of citizen-owned distributed installations, over 40 percent of renewable capacity owned by individuals or cooperatives, strong feed-in tariff system catalysed adoption

China - Rapid utility-scale solar and wind expansion, government-led push toward distributed solar in urban and rural areas, grid congestion challenges led to curtailment reforms

179. KSA's Current Landscape and Strategy

Focus on Utility-Scale Development - KSA has prioritized large-scale renewable energy projects under the **National Renewable Energy Program (NREP)**. Key examples:

- **Sakaka PV Plant** – First utility-scale solar project (300 MW)
- **Sudair Solar PV Project** – One of the largest in the Middle East (1.5 GW)

- **Dumat Al Jandal Wind Farm** – First large-scale wind project (400 MW)

These projects are:

- Cost-competitive at scale due to land availability and solar irradiance
- Centralized for easier policy and grid management
- Aligned with Vision 2030 goals to increase renewables to 50 percent of power generation

Emerging Opportunities for Distributed Energy

- K.A.CARE and SEEC are supporting **pilot programs** in rooftop solar and off-grid systems
- High solar rooftop potential in urban residential areas
- Potential for distributed storage and solar in smart city projects like [NEOM](#)
- Net metering and feed-in tariffs are under consideration to encourage participation

180. Policy and Planning Implications

A successful energy transition requires both models to work in harmony. Policymakers must:

- **Design integrated energy planning frameworks** that account for both large-scale projects and local generation
- **Support distributed energy through incentives**, regulations, and awareness programs
- **Invest in smart grid infrastructure** that can manage bi-directional energy flows
- **Develop localized energy governance models** that allow municipalities or communities to plan their own energy needs
- **Ensure equity and inclusion**, so all segments of the population can benefit from distributed energy technologies

181. Future Trends and Considerations

- **Hybrid Models:** Combining utility-scale renewables with distributed microgrids for redundancy and flexibility
- **Digital Platforms:** Enabling virtual power plants (VPPs) that aggregate DERs into grid-scale assets
- **Prosumers and Energy Communities:** Increasing citizen participation in generation and storage
- **Storage Integration:** Batteries and thermal storage bridging variable supply from both centralized and distributed systems
- **Hydrogen and EV Integration:** Creating decentralized hydrogen hubs and home charging networks linked to rooftop solar

For KSA, where abundant solar resources, vast land availability, and strong central planning capacity coexist with growing urban populations and digital infrastructure, the dual deployment of both models is not just possible — it is essential. K.A.CARE and its partners are uniquely positioned to design and implement strategies that harmonize these models, ensuring that KSA's energy future is secure, sustainable, and participatory.

182. Green Hydrogen vs. Blue Hydrogen – Techno-Economic and Policy Perspectives



Fig. 7 Industrial hydrogen consumption in 2020 [10].

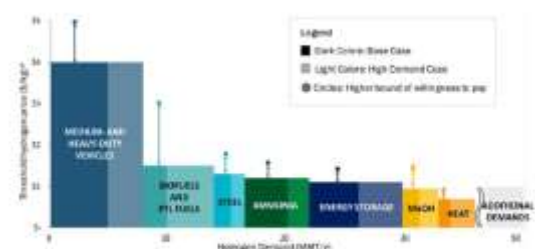


Fig. 8 Scenarios showing estimates of potential clean hydrogen demand in key sectors of transportation, industry, and the grid, assuming hydrogen is available at the corresponding threshold cost [11].

Hydrogen has emerged as a cornerstone of global decarbonization strategies, particularly for hard-to-abate sectors such as heavy industry, aviation, long-haul transport, and power storage. As countries seek to diversify their energy mix and reduce carbon emissions, hydrogen offers a promising solution—especially when produced with low or zero emissions. Among the various forms of hydrogen, **green hydrogen** and **blue hydrogen** have gained the most attention.

This chapter explores the technological, economic, and policy differences between green and blue hydrogen. It provides a comparative analysis of production methods, cost structures, infrastructure needs, and regulatory implications, with a specific focus on KSA's strategic positioning in the global hydrogen economy.

183. Hydrogen Classification by Source

Hydrogen is categorized based on the carbon intensity of its production method:

- **Grey hydrogen:** Produced from natural gas via steam methane reforming (SMR), emitting significant CO₂.
- **Blue hydrogen:** Produced similarly to grey hydrogen but with carbon capture and storage (CCS) to reduce emissions.
- **Green hydrogen:** Produced via electrolysis using renewable electricity (solar or wind), generating zero direct emissions.
- **Other types:** Turquoise (pyrolysis-based), pink (nuclear-powered), and white (naturally occurring) hydrogen are under exploration but are not the current focus of large-scale deployment.

184. Green Hydrogen – Technology and Economics

<https://www.irena.org/Publications/2025/Jun/Analysis-of-the-potential-for-green-hydrogen-and-related-commodities-trade>

Production Process: - Electrolysis splits water (H₂O) into hydrogen (H₂) and oxygen (O₂) using electricity. When powered by renewables, the process is emission-free.

Techno-Economic Highlights:

- **Capital cost:** High due to electrolyser cost and need for dedicated renewable generation.

- **Levelized cost of hydrogen (LCOH):** As of 2024, around 3 to 7 USD/kg, depending on electricity cost and electrolyser efficiency.
- **Drivers for cost reduction:**
 - Decreasing cost of solar and wind
 - Technological innovation and economies of scale
 - Load factor optimization using hybrid solar-wind systems

Infrastructure Considerations:

- Requires new electrolyser facilities, dedicated renewable power, and water supply.
- High water consumption: Around 9 litres of water per kg of hydrogen produced.

Advantages:

- Truly zero-carbon when renewables are used
- Globally scalable, especially in solar-rich regions
- Aligns with long-term net-zero goals and international green certification schemes

Challenges:

- High initial cost and CAPEX intensity
- Requires large renewable capacity, potentially competing with grid electricity
- Water scarcity concerns in arid regions (including parts of KSA)

185. Blue Hydrogen – Technology and Economics

Production Process: Produced via **steam methane reforming (SMR)** or **autothermal reforming (ATR)** using natural gas. Carbon dioxide is captured using CCS technologies and stored underground or reused.

Techno-Economic Highlights:

- **Capital cost:** Lower than green hydrogen; uses existing gas infrastructure.
- **LCOH:** Estimated at 1.5 to 2.5 USD/kg depending on gas price and CCS efficiency.
- **Carbon capture rates:** Typically, 60–90 percent; full decarbonization is not yet achievable.

Infrastructure Considerations:

- Leverages existing gas networks and industrial clusters.
- Requires CO₂ pipelines and secure geological storage facilities.

Advantages:

- Lower production cost in regions with cheap natural gas (e.g., KSA)
- Transitional solution for decarbonizing industry without immediate renewable capacity
- Enables early market development and export capacity

Challenges:

- Not fully emissions-free (residual carbon leakage)
- Requires strong regulatory and monitoring systems for CCS
- May face future competitiveness issues as green hydrogen prices decline

186. Comparing Green vs. Blue Hydrogen

Aspect	Green Hydrogen	Blue Hydrogen
Production Source	Water + renewable electricity	Natural gas + carbon capture
CO ₂ Emissions	Zero (if fully renewable-powered)	Reduced (60–90%), not zero
Tech Maturity	Emerging, scaling rapidly	Mature, in commercial use
Cost (2024 est.)	3–7 USD/kg	1.5–2.5 USD/kg
Infrastructure	Needs new electrolyzers, RES, water pipelines	Can use existing natural gas and CCS infrastructure
Scalability in KSA	High (solar-rich areas like NEOM, Tabuk)	High (abundant gas, access to carbon sinks)
Water Dependency	High (electrolysis)	Low (uses methane, minimal water)
Future Cost Trajectory	Rapid decline with innovation	Relatively stable; may lose cost edge over time
Alignment with Net Zero	Fully aligned	Transitional step, not long-term solution

187. Possible Policy Considerations for Hydrogen Development

Regulatory and Certification Needs

- Establish clear definitions and **colour codes** for hydrogen (aligned with international standards)
- Develop **green hydrogen certification schemes** to track emissions and origin
- Implement **carbon accounting mechanisms** for blue hydrogen projects

Market Creation

- Government procurement for clean hydrogen (e.g., for steel, cement, ammonia)
- Blending mandates in gas pipelines
- Support for early-stage hydrogen vehicles and infrastructure

Incentives and Subsidies

- Feed-in tariffs or contracts for difference (CfDs) for green hydrogen production
- Carbon pricing or taxation of grey hydrogen to level the playing field
- Tax credits or grants for CCS infrastructure in blue hydrogen projects

Export Strategies

- Position KSA as a global **hydrogen exporter** through bilateral trade agreements (e.g., with Europe, Japan, South Korea)
- Invest in hydrogen liquefaction, ammonia conversion, and port infrastructure
- Brand blue hydrogen as **low carbon**, but invest heavily in green hydrogen for long-term competitiveness

188. KSA's Hydrogen Roadmap and Strategic Position

KSA is well-positioned to lead in both green and blue hydrogen:

Strategic Projects:

- **NEOMv Green Hydrogen Project:**
 - Joint venture with ACWA Power, Air Products
 - 4 GW of renewable-powered electrolysis
 - Targeting green ammonia exports by 2026
- **Aramco Blue Hydrogen Pilots:**
 - Production of blue ammonia using natural gas + CCS
 - First export of 40 tons of blue ammonia to Japan (2020)

National Hydrogen Strategy Goals:

- Become one of the world's top three hydrogen exporters by 2030
- Leverage **natural gas reserves** for short-term blue hydrogen
- Use **solar and wind potential** for long-term green hydrogen dominance
- Support innovation and localization through research centres (e.g., K.A.CARE, KAUST)

189. Strategic Integration and Outlook

KSA can adopt a **dual-track approach**:

- Deploy **blue hydrogen** as a short- to medium-term industrial decarbonization solution
- Accelerate investment in **green hydrogen** as global demand, technology maturity, and cost competitiveness improve

Key enablers include:

- Strong policy and regulatory frameworks
- Public-private partnerships
- Export infrastructure and diplomatic energy agreements
- Local innovation and workforce development

Green and blue hydrogen each offer unique advantages and challenges. While blue hydrogen presents a cost-effective bridge to decarbonization, green hydrogen represents the long-term path toward a zero-emission energy future. For KSA, leveraging its vast renewable resources and natural gas wealth allows for a diversified hydrogen strategy that meets domestic needs, supports global climate goals, and reinforces its leadership in the future global energy economy.

190. Global Hydrogen Strategies – Germany and Australia

Hydrogen has become a strategic energy carrier in the global transition toward decarbonization. Countries with differing resources, industrial strengths, and climate goals are shaping their hydrogen roadmaps in unique ways. Germany, Japan, and Australia represent three diverse but instructive national hydrogen strategies that provide important lessons for KSA's own hydrogen development plans.

Let's compare how these three countries are approaching the hydrogen economy. It highlights each nation's policy objectives, investment priorities, international partnerships, and focus on green or blue hydrogen. The chapter also compares the strategies and draws insights relevant to KSA's ambition to become a global hydrogen leader.

Germany – Green Hydrogen as a Cornerstone of Climate Neutrality

Strategy Overview

Germany launched its **National Hydrogen Strategy** in June 2020 as a central element of its effort to achieve climate neutrality by 2045. The strategy is focused primarily on **green hydrogen** and is closely linked to the country's broader goals under the European Green Deal and the EU Fit for 55 packages.

Key Objectives

- Position Germany as a global technology leader in hydrogen
- Create a domestic market for green hydrogen
- Decarbonize industrial sectors such as steel, chemicals, and refining
- Build international partnerships for green hydrogen imports

Investment and Infrastructure

- Over **9 billion euros** allocated, including:
 - 7 billion euros for domestic green hydrogen projects
 - 2 billion euros for international partnerships
- Plan to build at least **10 GW of electrolyser capacity** by 2030
- Establishing hydrogen-ready infrastructure, including pipelines, storage, and port terminals

International Partnerships

- Germany lacks the renewable resources for large-scale green hydrogen production and seeks to **import green hydrogen** from sun-rich regions

- Has signed **bilateral hydrogen cooperation agreements** with countries such as:
 - KSA (green hydrogen and ammonia exports)
 - Namibia, Chile, South Africa, UAE

Industrial Integration

- Funding pilot projects to decarbonize **steel production** and **aviation fuels**
- Launching large-scale **Hydrogen Valleys**—regional ecosystems combining generation, use, and storage

Relevance for KSA

- KSA is positioned to become a **major green hydrogen exporter** to Germany
- Germany's technological leadership in electrolysis and industrial integration offers collaboration potential
- A model for establishing hydrogen clusters with public and private sector alignment

Australia – Hydrogen as an Export and Domestic Growth Engine

Strategy Overview

Australia launched its **National Hydrogen Strategy** in 2019 with a strong export focus. Australia aims to leverage its **renewable resource abundance** and **proximity to Asian markets** to become a leading exporter of low-emission hydrogen.

Key Objectives

- Become a major exporter of clean hydrogen by 2030
- Build competitive domestic hydrogen industries
- Develop hydrogen hubs for production, use, and export
- Reduce hydrogen production cost to under 2 AUD/kg (H₂ Under 2 program)

Export-Focused Projects

- **Green hydrogen and ammonia projects** in Western Australia, Queensland, and South Australia
- **Hydrogen Energy Supply Chain (HESC)** project with Japan: blue hydrogen from lignite + CCS
- **Sun Cable Project:** Massive solar and storage project for power and green hydrogen export to Singapore

Hydrogen Hubs and Infrastructure

- Establishing **regional hydrogen hubs** with co-located generation, users, and ports
- Investing in **hydrogen pipelines, port terminals, and storage** facilities
- Australia is also exploring **hydrogen blending** into natural gas grids

Innovation and Regulation

- National Hydrogen Infrastructure Assessment to guide investment

- State-level strategies complement the federal roadmap (e.g., New South Wales, Victoria)
- Strong R&D support through CSIRO and ARENA (Australian Renewable Energy Agency)

Relevance for KSA

- Like Australia, KSA has abundant land and renewable resources
- Australia's export model and **hydrogen hub design** offer insights for projects like **NEOM**
- The emphasis on port readiness and regulatory frameworks provides a roadmap for Saudi infrastructure planning

191. Strategic Implications for KSA

KSA can draw from each country's strengths to shape a globally competitive hydrogen strategy:

- **From Germany:**
 - Focus on industrial decarbonization (steel, cement)
 - Establishing Hydrogen Valleys and innovation ecosystems
 - Align with European green import standards and certification systems
- **From Japan:**
 - Build full supply chain capability (generation, shipping, import terminals)
 - Invest in carrier technologies (ammonia, liquid hydrogen)
 - Deepen strategic partnerships for long-term offtake agreements
- **From Australia:**
 - Develop dedicated hydrogen export zones with port and pipeline infrastructure
 - Launch large-scale solar and wind hybrid hydrogen projects
 - Integrate national and regional planning for export readiness

192. Carbon Capture, Utilization, and Storage (CCUS) Infrastructure

As countries pursue deep decarbonization pathways, **Carbon Capture, Utilization, and Storage (CCUS)** is emerging as a critical technological solution. Unlike renewable energy sources that replace fossil fuels, CCUS allows continued use of fossil fuels and industrial processes by capturing the carbon dioxide (CO₂) they emit, either storing it underground or repurposing it in industrial applications. For resource-rich nations like KSA—with significant hydrocarbon reserves and ambitions to lead in blue hydrogen and low-carbon exports—CCUS infrastructure is essential to achieving climate goals while preserving economic competitiveness. This chapter explores the components of CCUS infrastructure, its applications, global trends, challenges, and KSA's strategic priorities.

193. What is CCUS?

CCUS refers to the set of technologies used to:

1. **Capture** CO₂ from power generation or industrial sources
2. **Transport** the captured CO₂ to a storage or utilization site
3. **Utilize** CO₂ as a feedstock for industrial or chemical processes (optional)
4. **Store** the CO₂ permanently in deep geological formations

CCUS can be applied at multiple points in the value chain:

- **Post-combustion** (capturing from flue gases)
- **Pre-combustion** (gasification or reforming with CO₂ removal)
- **Direct air capture** (capturing CO₂ directly from the atmosphere)

194. CCUS Infrastructure Components

Capture technologies vary by sector:

- **Power plants:** Typically use post-combustion amine-based absorption
- **Hydrogen production:** Use pre-combustion capture in steam methane reforming (SMR)
- **Industrial plants** (cement, steel, ammonia): Use a mix of capture technologies based on emission source and purity

Infrastructure needs:

- Retrofitting of existing plants with capture systems
- Integration with process design in new facilities
- Steam or electricity input for capture process

Compression and Transport

Once captured, CO₂ must be **compressed into a supercritical fluid** and transported to its destination. Transport methods include:

- **Pipelines:** Most efficient for large volumes and long-term operations
- **Trucks or rail:** Used in early-stage or remote applications
- **Shipping:** Emerging option for cross-border CO₂ transport (under development in Europe and Asia)

Key considerations:

- Pipeline routing and safety
- Regulatory approval and right-of-way
- Integration with existing oil and gas infrastructure

Utilization Options

CO₂ can be reused in:

- **Enhanced oil recovery (EOR):** Injecting CO₂ into oil fields to increase recovery
- **Carbon-based products:** Building materials, synthetic fuels, carbonated beverages, urea
- **Chemical conversion:** Into methanol, polymers, or advanced materials

However, most of these **do not result in permanent sequestration** and must be carefully accounted for in lifecycle assessments.

Storage Sites

Permanent storage involves injecting CO₂ into:

- **Depleted oil and gas reservoirs**

- **Deep saline aquifers**
- **Unmineable coal seams**

Geological storage must meet criteria for:

- **Depth and pressure** (typically over 800 meters)
- **Rock porosity and cap rock integrity**
- **Seismic and hydrological stability**

Monitoring technologies (e.g., seismic imaging, pressure sensors, and tracers) are used to verify that CO₂ remains safely underground.

195. Global CCUS Deployment

Key CCUS Projects Worldwide: Global CCUS capacity remains limited—**about 64 million tons per year captured globally**—but growing rapidly due to climate commitments, net-zero pledges, and public investment. **Total Global Active Pipeline targets 513+ Mtpa** total planned capacity across all stages. Climate pledges & public investments is heavily backed by over **\$30 billion** in public subsidies/tax incentives.

United States: Petra Nova (Texas), Illinois Industrial CCS | **Norway:** Northern Lights project, Sleipner CO₂ storage | **Canada:** Quest CCS project (Shell), Boundary Dam | **China:** Sinopec Qilu Petrochemical CCS

196. Role of CCUS in the Energy Transition

Decarbonizing Hard-to-Abate Sectors - CCUS is one of the only viable pathways to decarbonize:

- **Cement** and **steel** production
- **Ammonia** and **fertilizer**
- **Refineries**
- **Blue hydrogen** production

Supporting Blue Hydrogen Development - CCUS enables low-carbon hydrogen production from natural gas (blue hydrogen) by capturing CO₂ emissions from SMR or ATR processes.

Negative Emissions

When paired with **bioenergy** (BECCS) or **direct air capture**, CCUS can remove CO₂ from the atmosphere—an important tool for net-zero goals.

Circular Carbon Economy (CCE)

CCUS is a key pillar in KSA's **CCE Framework**, which includes strategies to reduce, reuse, recycle and remove carbon

197. KSA's CCUS Strategy

KSA is uniquely positioned to become a global leader in CCUS due to abundant hydrocarbon infrastructure, existing CO₂ reservoirs and oil fields for EOR and National energy transition priorities under Vision 2030

Strategic Projects:

- **Aramco CO₂ EOR Initiatives:**
 - Injecting CO₂ into the Uthmaniyah field for enhanced recovery
 - Exploring CCUS clusters in Dhahran and Jubail industrial cities
- **KSA's National Hydrogen Strategy:**
 - Blue hydrogen production with CO₂ captured and stored locally
 - CO₂ management is integral to ammonia and hydrogen exports
- **K.A.CARE and R&D Initiatives:**
 - Research on carbon utilization technologies
 - CO₂ mineralization and storage innovation

198. Policy and Regulatory Considerations

Effective CCUS deployment requires an enabling policy environment.

Legal and Regulatory Framework

- Define CO₂ as a regulated substance with clear ownership rights
- Establish storage liability, long-term monitoring requirements, and environmental impact assessments
- Align with international frameworks for CO₂ accounting and lifecycle analysis

Incentives and Market Mechanisms

- Carbon pricing or tax credits to make CCUS financially viable (e.g., 45Q in the U.S.)
- Funding for early-stage demonstration projects
- Blending mandates and clean fuel standards that reward low-carbon hydrogen or fuels

Infrastructure Planning and Clustering

- Encourage **shared CO₂ transport and storage hubs** (industrial clusters)
- Co-locate emitters with storage sites to reduce transport costs
- Public-private partnerships to derisk large-scale deployment

Opportunities for KSA:	Challenges:
• Utilize depleted oil fields and deep saline formations for permanent CO₂ storage • Leverage CCUS to make blue hydrogen and ammonia exports climate-compliant	High capital cost of capture systems and pipeline networks • Need for comprehensive geological data and long-term monitoring frameworks

- | | |
|---|---|
| <ul style="list-style-type: none"> Develop local expertise in carbon management technologies Position KSA as a regional CCUS hub serving Gulf and North African partners | <ul style="list-style-type: none"> Global scrutiny around “greenwashing” – CCUS must be implemented with transparency and accountability Public perception and regulatory uncertainty |
|---|---|

199. Strategic Integration with National Climate Goals

KSA’s **Net Zero by 2060 pledge** relies heavily on CCUS, particularly in industrial decarbonization and the scaling of low-carbon fuels. Within the broader **SGI**, CCUS helps:

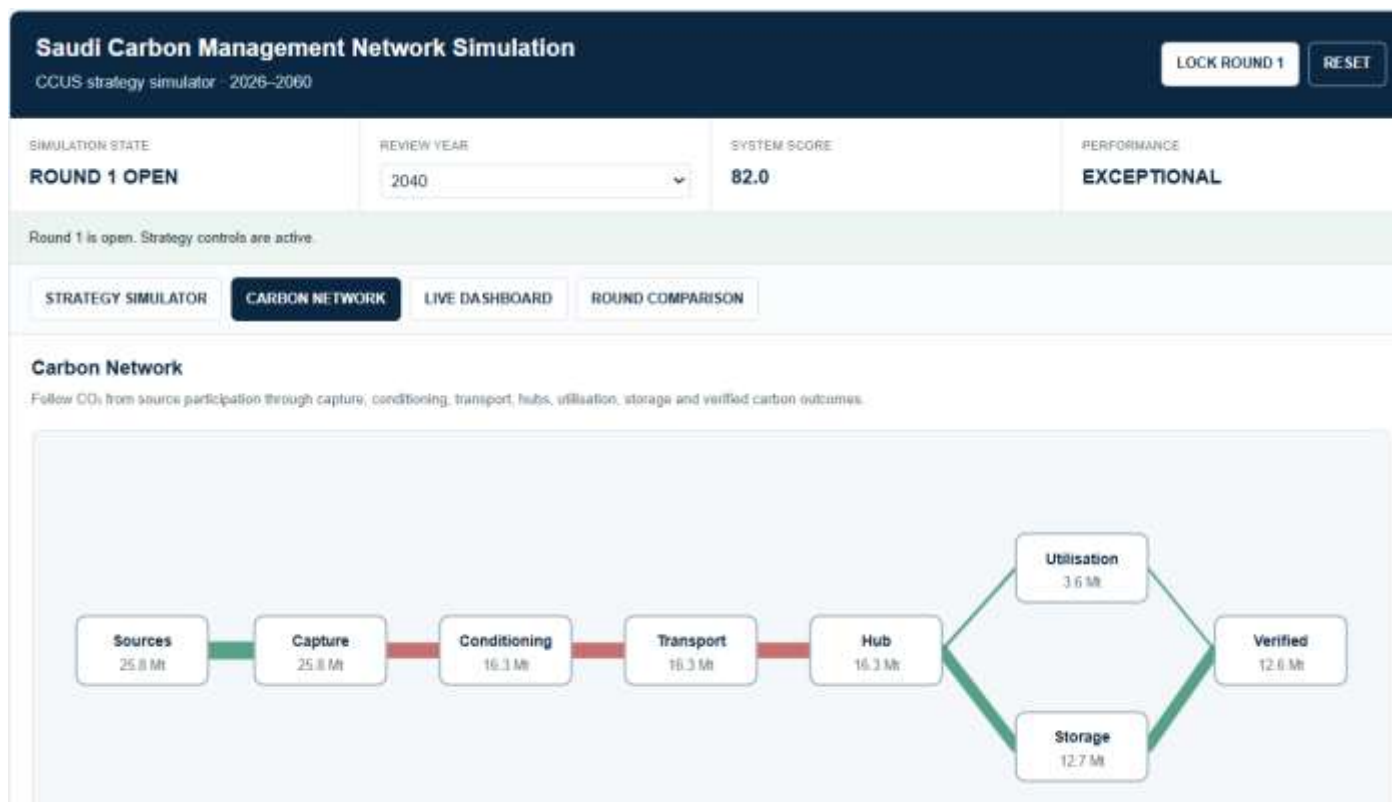
- Reduce carbon intensity of existing oil and gas operations
- Support clean exports in compliance with future border carbon adjustments
- Facilitate partnerships with countries and regions demanding verified low-carbon products

K.A.CARE, as a national policy and technical advisor, plays a critical role in ensuring that CCUS solutions are:

- Technically sound
- Environmentally responsible
- Economically aligned with national interests

200. Simulation exercise: Carbon Management

Available on the online platform



201. Small Modular Reactors (SMRs) and Nuclear Governance

Nuclear energy is re-emerging as a vital pillar of clean energy strategies across the globe, driven by the urgency to achieve net-zero emissions while ensuring energy security and grid stability. Among the latest innovations in this field, **Small Modular Reactors (SMRs)** are gaining attention as flexible, scalable, and safer alternatives to traditional large nuclear power plants.

For KSA, nuclear power represents a strategic opportunity to diversify its energy mix, support industrial development, and reduce greenhouse gas emissions. As KSA advances its nuclear ambitions under the **Saudi National Atomic Energy Project (SNAEP)**, the adoption of SMRs, coupled with robust nuclear governance frameworks, is becoming increasingly relevant.

This chapter explores the technological and policy dimensions of SMRs, their benefits and challenges, and the international governance frameworks guiding their development. It also examines how KSA can position itself to integrate SMRs safely and effectively into its national energy strategy.

202. What Are Small Modular Reactors (SMRs)?

Definition - Small Modular Reactors (SMRs) are advanced nuclear fission reactors that:

- Have a power capacity of **up to 300 megawatts electric (MWe) per unit**
- Are built in **factory-controlled settings** and assembled on site
- Feature **modular designs**, allowing for phased deployment and scalability

SMRs differ from traditional reactors in both **size and deployment strategy**, offering a more flexible and cost-effective option for electricity generation, desalination, and industrial heat applications.

Technology Types

Common SMR designs under development include:

- **Pressurized Water Reactors (PWRs)** – scaled-down versions of conventional reactors (e.g. NuScale, SMART)
- **High-Temperature Gas-cooled Reactors (HTGRs)** – suitable for process heat and hydrogen production
- **Sodium-cooled Fast Reactors (SFRs)** – part of Generation IV designs with fuel recycling capabilities
- **Molten Salt Reactors (MSRs)** – offering inherent safety and high fuel efficiency

203. Benefits of SMRs

Enhanced Safety	• SMRs use passive safety features that reduce the need for external power or operator intervention during emergencies. • Smaller core size and lower operating pressure reduce risk of accidents.
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Grid Flexibility and Resilience	• SMRs are ideal for smaller grids or remote locations with limited transmission infrastructure. • They can complement variable renewable energy sources, providing firm, low-carbon baseload power.
Lower Capital Cost and Faster Deployment	• Modular construction allows shorter build times (estimated 3–5 years vs. 8–10 years for large plants). • Smaller financing requirements make SMRs accessible to a broader range of countries and utilities.
Multi-Purpose Applications	• Provide electricity, district heating, and desalination simultaneously. • Can support green hydrogen production through high-temperature electrolysis or thermochemical processes.

204. Global Developments in SMR Deployment

Commercial Projects	• NuScale Power (USA): First SMR design approved by the U.S. Nuclear Regulatory Commission (NRC); targets 77 MWe per module. • China’s HTR-PM: High-temperature gas-cooled reactor demonstration plant connected to the grid in 2021.
SMR Use in Non-Electric Applications	• Canada and Finland exploring SMRs for off-grid mining and remote communities. • UAE and KSA evaluating SMRs for water desalination and hydrogen production.

205. Nuclear Governance: Principles and Frameworks

Given the dual-use nature of nuclear technology, robust governance is essential. Governance covers **safety, security, safeguards**, and **liability**, both at national and international levels.

International Atomic Energy Agency (IAEA)

- **Safety Standards Series**: Provides regulatory and design guidance for nuclear installations, including SMRs.
- **Milestones Approach**: A step-by-step roadmap for countries introducing nuclear power.
- **Integrated Regulatory Review Services (IRRS)**: Peer-review assessments for national nuclear regulators.
- **INPRO and SMR Platform**: IAEA programs supporting SMR development and cooperation.

Nuclear Non-Proliferation Treaty (NPT) - Ensures peaceful use of nuclear technology and non-diversion of nuclear materials and requires safeguards agreements between countries and the IAEA.

National Nuclear Governance in KSA

KSA is developing a comprehensive governance ecosystem aligned with international best practices.

Institutions and Responsibilities:

- **K.A.CARE:**
 - Policy formulation and technical oversight
 - Coordinates the Saudi National Atomic Energy Project
- **Nuclear and Radiological Regulatory Commission (NRRC):**
 - Independent body for regulation, licensing, and enforcement
 - Responsible for safety, security, and environmental protection

Key National Priorities:

- Establish a **comprehensive legal and regulatory framework**
- Ensure **transparency and international cooperation**
- Build **national capabilities and human capital**
- Participate in international **nuclear safety and security networks**

206. SMRs in the Context of KSA's Energy Strategy

Strategic Fit with Vision 2030 - SMRs support Vision 2030 goals by:

- Diversifying the energy mix with reliable, clean power
- Reducing reliance on oil for domestic electricity generation
- Supporting desalination and industrial development in off-grid regions
- Creating high-value jobs and technology transfer opportunities

Integration with the Saudi National Atomic Energy Project (SNAEP) - SNAEP includes:

- Deployment of **large and small nuclear reactors**
- Development of **nuclear fuel cycle capabilities**
- Establishment of **research and training centres**
- Collaboration with IAEA and global technology providers

Desalination and Hydrogen Use Cases

- SMRs can supply **thermal energy and electricity** for seawater desalination plants.
- High-temperature SMRs can enable efficient **green hydrogen** or **ammonia** production.

207. Key Challenges and Considerations

Technology Maturity and Licensing	• Many SMR designs are still in development or early commercialization phases. • Regulatory bodies must adapt frameworks to accommodate novel designs and modular deployment models.
Waste Management	• Spent nuclear fuel and radioactive waste management require long-term strategies and secure disposal infrastructure.
Public Perception and Social License	• Public understanding and acceptance of nuclear energy must be strengthened through education, engagement, and transparency.

- SMR deployment in KSA will depend on **international technology transfer agreements, vendor partnerships, and skills development** programs.

208. Discussion points for K.A.CARE and National Stakeholders

1. **Develop SMR-specific regulatory capacity** within NRRC to evaluate and license innovative reactor designs.
2. **Participate in IAEA SMR working groups and international pilot projects** to access best practices and expertise.
3. **Select demonstration sites** in regions requiring decentralized power, water, or hydrogen solutions.
4. **Invest in local R&D** on reactor operation, digital twin modelling, and fuel cycle management.
5. **Engage the public** through transparent communication, emphasizing SMR safety features and environmental benefits.

Small Modular Reactors offer KSA a unique opportunity to expand its clean energy portfolio with flexible, scalable, and secure nuclear power solutions. Their potential to support desalination, hydrogen production, and industrial applications makes SMRs especially relevant for KSA's economic and environmental ambitions under Vision 2030. However, SMR deployment must be accompanied by robust nuclear governance that ensures safety, security, and non-proliferation compliance. As K.A.CARE leads the nation's nuclear development strategy, it must continue building institutional capacity, advancing international cooperation, and integrating SMRs into broader energy and sustainability planning.

209. Digital Grids and Demand-Side Management

As energy systems evolve to accommodate increasing shares of renewables, electrification of end uses, and changing consumer behaviours, the **traditional centralized grid model** is no longer sufficient. Instead, a new model is emerging built on real-time data, distributed resources, two-way communication, and intelligent control. This is the **digital grid**.

Alongside this transformation, **demand-side management (DSM)** is becoming a powerful tool to balance supply and demand dynamically, reduce peak loads, enhance energy efficiency, and lower emissions. For a country like KSA, with ambitious Vision 2030 energy goals, vast geographical spread, and growing urban centres, investing in digital grid infrastructure and DSM programs is vital for grid resilience, affordability, and sustainability.

This chapter explores the core components of digital grid technologies, principles of demand-side management, and how the integration of these systems supports a modern, responsive energy future in KSA.

210. What Is a Digital Grid?

Definition - A **digital grid** is an electricity system that uses advanced digital technologies—such as sensors, artificial intelligence, automation, and communication networks—to monitor, analyse, and optimize the flow of electricity in real time across the entire value chain: generation, transmission, distribution, and consumption.

Key Characteristics:

- **Two-way communication** between utilities and customers
- **Real-time data analytics** and predictive forecasting
- **Automation and control systems** for grid stability
- **Integration of distributed energy resources (DERs)**, such as rooftop solar, battery storage, and electric vehicles
- **Cybersecurity architecture** for data integrity and operational safety

211. Core Components of the Digital Grid

Component	Function
Smart Meters	Provide real-time consumption data, enable dynamic pricing and remote control
Supervisory Control and Data Acquisition (SCADA)	Monitor and control grid operations from central platforms
Advanced Distribution Management Systems (ADMS)	Optimize voltage control, load balancing, and fault detection
Sensors and IoT Devices	Measure grid conditions (voltage, frequency, temperature) at multiple points
Big Data and AI Platforms	Predict demand patterns, renewable availability, and fault risks
Communication Infrastructure	Use of fibre optics, 5G, and wireless mesh networks for rapid data transfer

Together, these components allow for greater transparency, control, and flexibility across the grid.

212. Demand-Side Management (DSM): Principles and Tools

Definition - Demand-side management (DSM) refers to strategies and technologies used to adjust consumer electricity demand to align more effectively with supply conditions. Rather than increasing generation, DSM focuses on **changing how and when** electricity is consumed.

DSM Objectives:

- Reduce peak electricity demand
- Shift load to off-peak periods
- Improve overall energy efficiency
- Lower energy costs for consumers
- Enhance grid stability and reduce stress

213. Key DSM Strategies:

Strategy	Description
Load Shifting	Moving energy use from peak to off-peak hours
Peak Shaving	Reducing maximum power demand during critical periods
Energy Efficiency	Implementing technologies and behaviours that reduce total consumption
Demand Response (DR)	Automatically or manually reducing usage during grid emergencies or price spikes
Time-of-Use Pricing	Charging different rates based on the time of day to influence behaviour

214. Integration of Digital Grids and DSM

The synergy between digital grid technology and DSM is essential for grid modernization. A digital grid enables the implementation of sophisticated DSM programs, while DSM helps ensure that the digital grid operates efficiently and economically.

Digital Grid Function	Enabling DSM Application
Real-time metering and billing	Supports time-of-use tariffs and dynamic pricing
Grid status monitoring	Triggers automated demand response during grid stress
Consumer data analytics	Identifies high-consumption users and tailors efficiency campaigns
Smart home integration	Enables automated appliance control (e.g. smart thermostats, EV chargers)
DER coordination	Uses customer-sited solar and batteries to reduce grid demand

This integration allows for **flexible demand**, which is key to accommodating intermittent renewable energy such as solar and wind.

215. Global Examples

United States – Smart Grid Investment Grants - Deployment of over 15 million smart meters, Dynamic pricing and real-time feedback helped reduce peak demand by up to 20% in pilot regions

South Korea – National Smart Grid Roadmap - Integrated smart appliances, electric vehicle charging, and renewables, Intelligent DR programs with real-time incentives via mobile platforms

United Kingdom – Demand Flexibility Services - National Grid ESO pays consumers to reduce electricity during peak hours, Smart meter penetration enables time-based energy management

216. KSA’s Digital Grid and DSM Landscape

Progress and Initiatives:

- **Smart Meter Rollout:** Saudi Energy Co. (SE) installed over 10 million smart meters by 2021, enabling real-time billing and usage monitoring.
- **National Energy Efficiency Program (NEEP):** Led by the Saudi Energy Efficiency Centre (SEEC), focusing on buildings, appliances, and industrial optimization.
- **Distributed Energy Pilots:** Projects in NEOM, the Red Sea Project, and Qiddiya are testing demand response, microgrids, and smart infrastructure.
- **K.A.CARE’s Role:** Conducting research on grid innovation, smart cities, and intelligent energy control systems.

Opportunities:

- Integrate smart EV charging into the grid
- Launch demand response programs for large commercial users
- Deploy AI-based forecasting tools for solar-rich regions
- Enable distributed storage and V2G (vehicle-to-grid) capability

217. Challenges and Considerations

Challenge	Implication
Data privacy and cybersecurity	Need for secure communication and data handling protocols
Regulatory gaps	Tariff structures and DSM incentives require policy updates
Consumer awareness	Public education on smart meters, dynamic pricing, and energy-saving actions
Interoperability issues	Diverse technology vendors must align on common protocols
Investment costs	Requires sustained public-private investment in digital and grid infrastructure

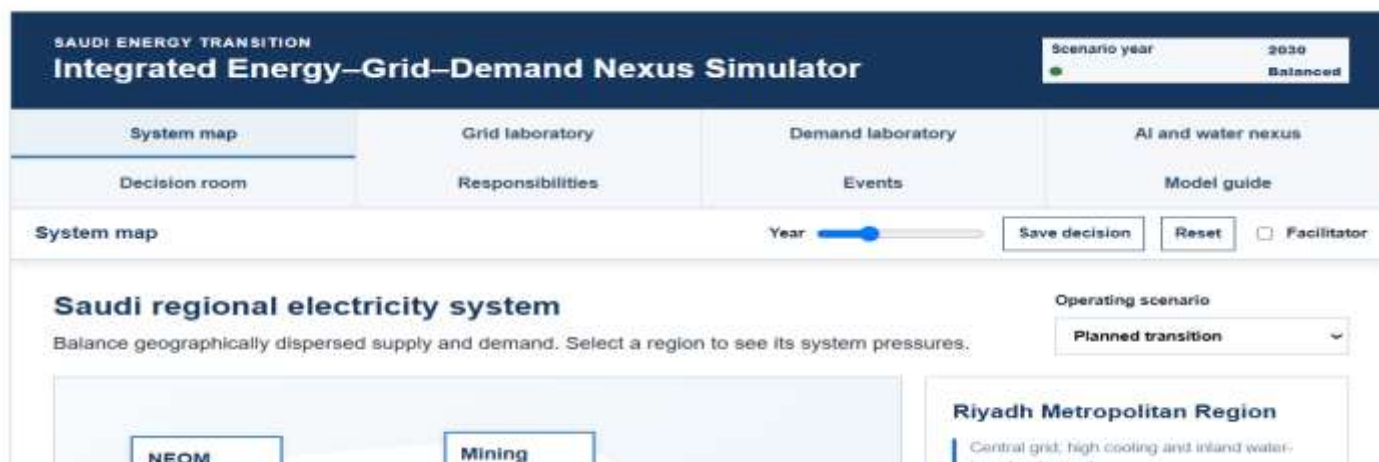
218. Policy and Strategic Recommendations

To fully leverage digital grids and DSM, KSA should consider:

1. **Establishing regulatory frameworks** for time-of-use pricing, DR participation, and distributed energy compensation
2. **Incentivizing smart appliances** and consumer-side technologies through rebates and standards
3. **Developing digital grid training programs** for utility engineers, policymakers, and IT professionals
4. **Integrating digital energy platforms** into new city projects like [NEOM](#) and The Line
5. **Enhancing public awareness campaigns** to explain benefits and address concerns about technology and data use

219. Simulation exercise: Grid stability and demand management

Accessed on the online platform – balancing grid stability with demand management and AI optimization.



Session 4: Innovation Adoption Lifecycle and Energy Technology Readiness

220. Introduction

In the fast-evolving landscape of energy systems, the successful deployment of new technologies hinges not only on their technical performance but also on how well they are adopted by stakeholders—utilities, policymakers, industries, and consumers. Understanding the **innovation adoption lifecycle** and evaluating **technology readiness** are essential for designing effective energy transition strategies. This chapter explores two interconnected frameworks:

- The **Innovation Adoption Lifecycle**, which explains how new technologies diffuse through a market or society.
- The **Energy Technology Readiness Levels (TRLs)** framework, which assesses the maturity of energy innovations.

By integrating these models, energy planners and policymakers—especially in a country like KSA—can make informed decisions about investment timing, public-private partnerships, and policy support needed to accelerate clean energy deployment in line with Vision 2030.

221. The Innovation Adoption Lifecycle

Definition - The **Innovation Adoption Lifecycle** is a sociological model that describes how different groups of people adopt new technologies over time. It categorizes adopters into five segments:

Adopter Category	Characteristics	Share of Market
Innovators	Risk-takers, technologists, early testers, often involved in pilot projects	2.5%
Early Adopters	Opinion leaders, trendsetters, willing to try new technology based on proven benefits	13.5%
Early Majority	Pragmatic users, adopt once benefits and reliability are visible	34%
Late Majority	Sceptical users, adopt under pressure or regulatory incentives	34%
Laggards	Traditionalists, resist change until necessary	16%

Adoption Curve

The adoption curve resembles a bell shape, moving from innovators to laggards. Successful technologies “cross the chasm” between early adopters and the early majority—a key phase that determines whether the innovation becomes mainstream or stalls.

222. Applying the Adoption Lifecycle to Energy Technologies

Different energy technologies reside at different points on the adoption curve depending on:

- **Market readiness**
- **Policy support**
- **Cost competitiveness**
- **Social acceptance**

Examples include:

Technology	Adoption Stage	KSA Context
Rooftop Solar	Early Adoption	Pilots in residential areas; limited due to policy and awareness
Utility-scale Solar	Early Majority	Strong deployment through NREP projects like Sakaka and Sudair
Green Hydrogen	Innovator Phase	NEOM project under development; not yet commercially deployed
Smart Meters	Early Majority	Nationwide rollout by SEC complete; now enabling DSM strategies
EVs and Charging Stations	Early Adoption	Initial adoption with incentives and infrastructure underway
Small Modular Reactors	Innovator Phase	Under technical evaluation as part of SNAEP

223. Overcoming Barriers to Adoption

Each stage of the adoption lifecycle presents distinct challenges:

Stage	Key Barriers	Support Needed
Innovator	High risk, unproven models	R&D funding, pilot zones, international partnerships
Early Adopter	High cost, limited awareness	Demonstration projects, media visibility
Early Majority	Infrastructure gaps, policy misalignment	Regulatory reform, subsidies, technical training
Late Majority	Scepticism, resistance to change	Incentives, mandates, education
Laggards	Entrenched habits, lack of trust	Mandatory policies, long-term engagement

224. Technology Readiness Levels (TRLs) in the Energy Sector

Definition - Technology Readiness Levels (TRLs) provide a standardized method for assessing the development stage of a technology. Originally developed by NASA, TRLs have been adapted for energy applications by the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), and various national research bodies.

TRL	Description	Example (Energy Context)
TRL 1	Basic principles observed	Lab experiments on new solar materials
TRL 2	Technology concept formulated	Early designs for high efficiency electrolyzers
TRL 3	Experimental proof of concept	Bench-scale carbon capture prototype
TRL 4	Lab validation of components	Solid-state battery in controlled lab environment
TRL 5	Component validation in relevant environment	Wind turbine blade tested in simulated wind conditions
TRL 6	System/subsystem model demonstration	Full microgrid operating in test bed
TRL 7	Prototype demonstration in operational setting	Hydrogen fuelling station trial near port
TRL 8	Complete system qualified	Solar PV system operational in field, monitored for performance
TRL 9	Actual system proven in operational use	Commercial utility-scale solar, wind, or storage plant

225. Aligning TRLs with the Adoption Lifecycle

Successful energy planning requires synchronizing TRL levels with the target market's position in the adoption curve.

TRL Stage	Typical Adoption Phase	Required Action
TRL 1–4	Innovator	Government and institutional R&D funding
TRL 5–6	Early Adopter	Public-private pilots, regulatory sandboxing
TRL 7–8	Early to Late Majority	Scale-up support, incentives, international standards
TRL 9	Late Majority to Mainstream	Full market competition, de-risking through infrastructure support

226. Implications for KSA

KSA can harness the innovation lifecycle and TRL model to:

- **Sequence investments** appropriately, avoiding premature commercialization or over-subsidization
- **Design policies** tailored to the maturity level of each technology
- **Accelerate local R&D**, especially through K.A.CARE and local universities
- **Engage industry and consumers** at the right time with clear value propositions

Strategic Tools:

- **Innovation readiness maps** for technologies like hydrogen, CCUS, and SMRs
- **National demonstration programs** aligned with TRL 5–7
- **Tech adoption dashboards** for tracking real-time progress across Vision 2030 projects

227. Policy Levers to Promote Energy Innovation Adoption

Policy Tool	Purpose	Best Applied At
Research and Innovation Grants	Fund early-stage R&D	TRL 1–4
Pilot and Demonstration Programs	Support pre-commercial validation	TRL 5–6
Regulatory Sandboxes	Test new technologies under relaxed rules	TRL 6–7
Feed-in Tariffs/Subsidies	Reduce cost barriers for first movers	TRL 7–8
Public Procurement Mandates	Guarantee demand for clean technologies	TRL 8–9
Consumer Incentives	Encourage adoption by households and businesses	Early Majority stage
Standards and Certification	Build trust and market discipline	Late Majority stage and beyond

228. Example – NEOM’s Energy Innovation Ecosystem

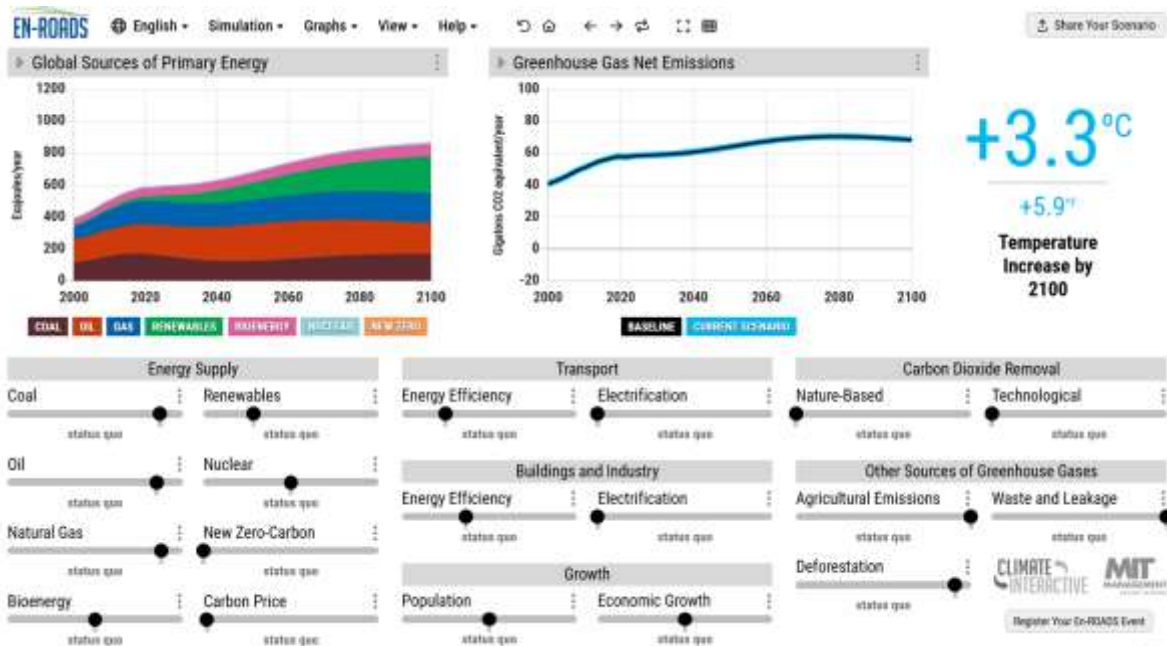
NEOM provides a living example of aligning technology readiness and adoption planning:

- **Green Hydrogen Plant:** TRL 6–7, early adopter phase, backed by international partners
- **Smart Grid and AI Energy Management:** TRL 8, entering early majority, embedded in city infrastructure
- **Modular Desalination Powered by Renewables:** TRL 6–8, in demonstration phase

Session 5: Comprehensive study – road to net zero

229. The En-ROADS Climate Solutions Simulator

En-ROADS is an online simulator that provides policymakers, educators, businesses, the media, and the public with the ability to test and explore cross-sector climate solutions.



230. Charting a Sustainable Energy Future for KSA with En-ROADS

Background and Rationale

KSA has committed to achieving **net-zero emissions by 2060** while preserving its role as a global energy leader. As part of its energy transition strategy under **Vision 2030**, K.A.CARE plays a central role in driving nuclear, renewable, and energy efficiency programs.

En-ROADS, a dynamic system dynamics model developed by Climate Interactive and MIT Sloan, offers a science-based simulation tool to test policy options across sectors. This Example challenges participants to use En-ROADS to model realistic energy pathways, incorporating Saudi-specific conditions (e.g., fossil revenue dependence, population growth, water-energy nexus).

Objectives

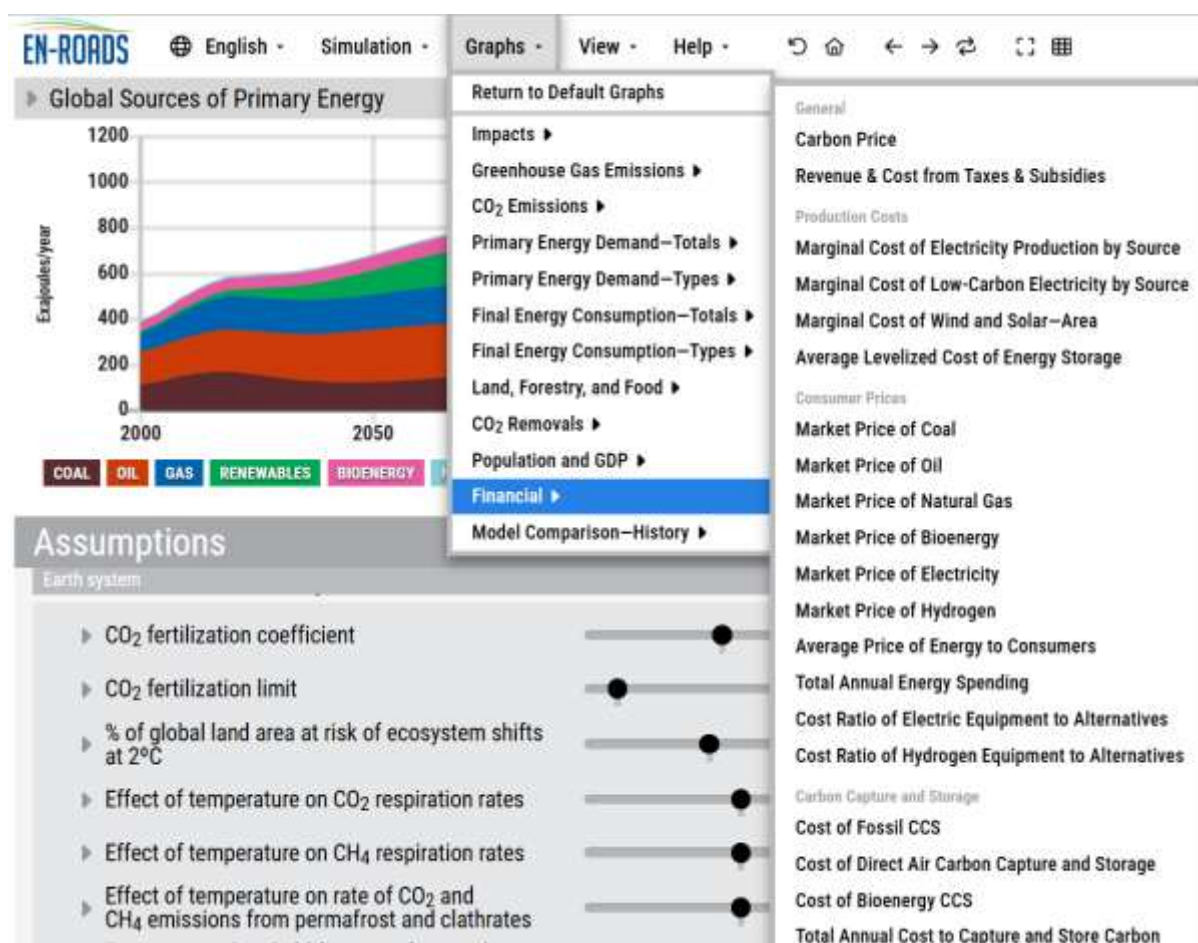
- Build systems thinking capacity in energy and climate policy.
- Apply En-ROADS to explore pathways for KSA to reach net-zero while maintaining economic stability.
- Assess trade-offs and co-benefits of various interventions (e.g., carbon pricing, renewables, CCS, EV adoption).
- Align policy scenarios with Vision 2030, Circular Carbon Economy, and the Middle East Green Initiative.

Example Scenario

KSA: The 2025 Policy Dilemma - It's the year 2025. K.A.CARE has been tasked with proposing an integrated policy roadmap to the Council of Ministers. You must recommend a package of interventions to meet the following goals:

- Reach **net-zero by 2060**
- Maintain **economic resilience** amidst declining oil demand
- Enhance **grid stability** while expanding renewables and nuclear
- Ensure **water security** through energy-smart desalination
- Generate **green jobs** and enhance innovation capacity

Your challenge: Use En-ROADS to simulate policies that meet these objectives, demonstrate feasibility, and present trade-offs.

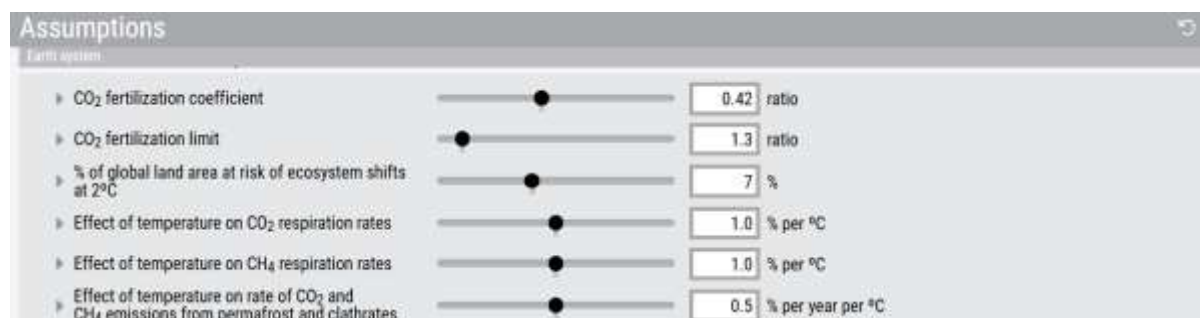


Activities and Deliverables

Activity 1: Familiarization with En-ROADS

- Guided walkthrough of En-ROADS interface and sectors
- Custom input training on regional assumptions (e.g., population growth, baseline emissions, energy mix)

Activity 2: Baseline Assessment



- Input Saudi-specific data or use default global baseline as proxy
- Run business-as-usual (BAU) scenario to determine 2100 global temperature rise
- Record current emissions trajectory and system constraints

Deliverable: Baseline Report (1-page) with key diagnostics

Activity 3: Policy Package Design

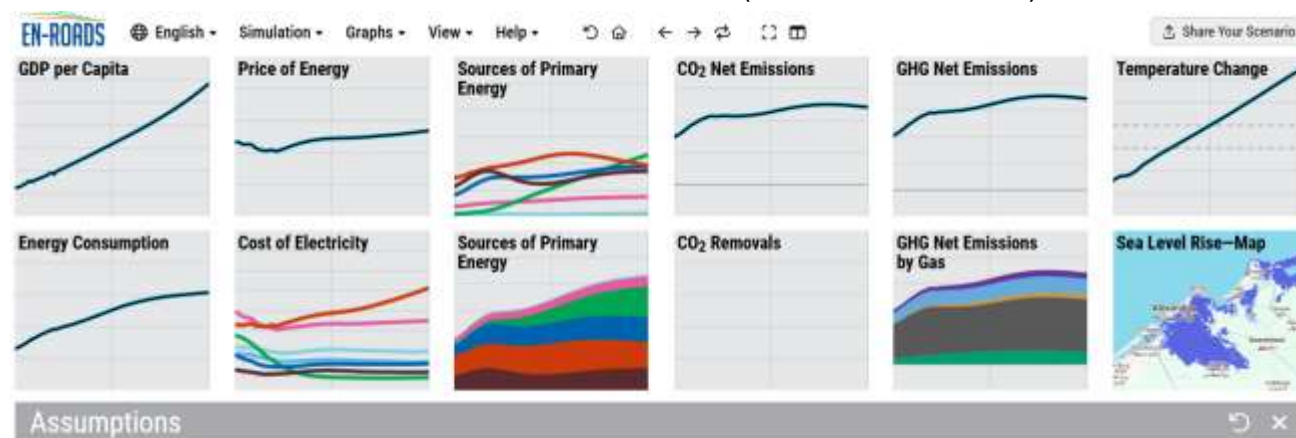
Participants form three groups:

1. **Tech-Driven Team:** Focus on advanced nuclear, CCS, green hydrogen, and EVs
2. **Behavioral & Efficiency Team:** Prioritize demand reduction, pricing, and efficiency
3. **Nature & Circular Carbon Team:** Push afforestation, CCE strategies, and methane reduction

Each team will:

- Select 5–7 policies across energy supply, demand, and land use
- Justify assumptions with Saudi data or analogues
- Run simulations iteratively in En-ROADS
- Monitor key indicators: temperature, emissions, energy mix, air quality, and GDP proxy

Deliverable: Team En-ROADS Simulation Dashboard (screenshots + notes)



Activity 4: Cross-Team Policy Negotiation

- Teams merge to form a National Task Force
- Negotiate a **hybrid policy package**
- Consider economic, political, and social feasibility

- Test hybrid scenario in En-ROADS

Deliverable: Executive Policy Brief (max 3 pages) with:

- Final scenario
- Key enablers
- Risks and mitigations
- Alignment to Vision 2030 and net-zero pathway

Evaluation and Reflection

Debrief Session - Facilitated discussion on:

- Insights from systems thinking
- Surprising results from the model
- Trade-offs between technology, behaviour, and nature-based solutions
- Policy levers that showed the greatest impact
- How En-ROADS influenced strategic alignment with Vision 2030

Optional Debrief Exercise:

Each team member reflects on:

- “What policy lever did I underestimate?”
- “What should be prioritized in real-world policymaking?”

231. Integration with K.A.CARE Strategy

Participants will be asked to map their final scenario onto:

- K.A.CARE's **National Energy Strategy Goals**
- Current and future role of **nuclear, renewables, and hybrid grids**
- Synergies with the **Circular Carbon Economy** framework
- Support for **Saudi Green and Middle East Green Initiatives**

Module 5: Geopolitics and Market Dynamics

Session 1: Global Energy Geopolitics – The Shifting Landscape

232. Introduction

The share of renewable energy in the global energy mix would increase from 16% in 2020 to 77% by 2050 in IRENA's 1.5°C scenario. Total primary energy supply would remain stable due to increased energy efficiency and growth of renewables. Use of renewables would increase across all end-use sectors, while a high rate of electrification in sectors such as transport and buildings would require a twelve-fold increase in renewable electricity capacity by 2050, compared to 2020 levels. Tripling renewables and doubling efficiency by 2030 form the central pillar of the decarbonisation strategy, also affirmed at COP28 in December 2023.

Transitioning away from fossil fuels is set to alter global trade, leading to a substantial regionalisation of energy trade. Approximately 40% of maritime cargo today is made up of fossil fuels, and shipping heavily relies on these fuels. Transitioning away from oil, gas and coal will reduce long-distance trade in energy. Electrification will promote cross-border trade and clean energy commodities such as green hydrogen will not be traded in volumes comparable to fossil fuels, or over such great distances. Going forward, global trade in clean energy-related technologies or semi-finished products is expected to diversify and intensify.

New trade flows in electricity, hydrogen, materials and clean technologies will emerge, differing significantly from traditional fossil fuel dependencies. Disruptions in most of these areas would not immediately affect end-users' energy security. Interruptions in electricity, however, would be instantaneous, changing the nature of energy security policy where cross-border trade is introduced or expanded compared to fossil fuels.

Cross-border trade in electricity fosters mutual benefits, contrasting the asymmetric dependencies seen in oil and gas. Given that the electricity trade may flow in both directions, it should be viewed through the lens of interdependency and mutual benefits. This is evident in the largely integrated EU electricity market, where all 27 member states, including net exporters, benefit from imports. In 2023, none of the EU member countries were exporters all of the time. The interconnectors that facilitate this trade can thus be considered channels for greater integration and co-operation, but such a view implies considerable political trust.

Critical materials, as key inputs to energy technology manufacturing, require attention in the short to medium term due to the high concentration of their supply chains. Diverse and resilient supply chains are essential for the energy transition and both mining and processing volumes and locations are already expanding. Innovation is already relieving the pressures currently being felt in markets and, from the next decade, recycling and circular economy will play a greater role. Continued support for R&D to improve efficiency, find alternatives and shape product design with circularity in mind can reduce long term vulnerabilities and risks.

No country masters every aspect of clean technologies, so it is essential to consider the impact of domestic policies within a broader web of interdependence. A renewables-dominated future will see energy security focus shift to trade in technologies or semi-finished products. However, the pattern

of technology dependency in that system will be vastly different from what it has been in the fossil fuel-dependent world. For instance, most jobs in solar PV are “downstream”, as more workers install solar panels than build them. In that context, tariffs and other trade protection measures may have an adverse impact of threatening local jobs.

While renewable resources remain largely unaffected by geopolitical interruptions, harnessing them depends on availability of technologies and finance at scale. This can be challenging for many developing countries due to a lack of access to technology and the prohibitively high cost of capital. Therefore, facilitating technology transfers and ensuring access to intellectual property rights (IPR) is needed to encourage widespread deployment of renewables and to promote equitable development.

Developing nations can enhance the resilience of regional and global energy markets while improving their own economic and energy security, if access to technology and finance is provided to them. Doing so not only fosters domestic growth but can position these nations as competitive players in the global clean technology market. Their integration into the global green economy can favour a more equitable distribution of benefits and technological advancements and help in reducing dependency on a small number of countries, thus making energy markets more resilient.

Geopolitical Landscape in KSA

Regional Security KSA operates in a volatile region with ongoing tensions, including Iran, Yemen, and wider Middle East security risks, requiring strong defence, diplomacy and regional cooperation.	Energy Markets KSA plays a central role in global oil and gas markets through OPEC+, influencing supply, prices and energy security, while managing the transition to a more diversified energy mix.	Global Power Relations KSA balances relationships with the United States, China, Russia, the European Union and other major powers to protect its strategic interests and expand economic opportunities.
Economic Diversification KSA is reducing its dependence on oil through Vision 2030, attracting foreign investment, building new industries and positioning itself as a global hub for trade, logistics and technology.	Regional Influence KSA seeks to strengthen its leadership role in the Arab world and the broader Islamic world through diplomacy, development aid, investment and mediation in regional conflicts.	Strategic Partnerships KSA is building strategic partnerships across energy, defence, technology and infrastructure to support its transformation and enhance its global influence.
Technology and Innovation KSA is advancing its geopolitical position through investments in clean energy, hydrogen, AI, digital infrastructure and smart cities, aiming to become a global innovation leader.	Supply Chain Resilience KSA is working to secure critical supply chains for energy, food, water, technology and defence, reducing vulnerabilities and strengthening self-reliance.	Climate and Energy Transition KSA is navigating global climate pressures while leveraging its hydrocarbon resources, renewable potential and circular carbon economy to maintain economic strength and international relevance.

233. Understanding Key Geopolitical Forces Impacting Global Energy Markets

	Key Considerations	Strategic Implication for KSA
OPEC + Dynamics and the Politics of Oil Supply	• Production Quotas: OPEC+ coordinates production levels among member states to stabilize oil prices, directly impacting global supply and KSA's fiscal planning. • KSA's Role: KSA plays a balancing role between maintaining oil revenue and ensuring global market stability. • Oil Price Volatility: Disagreements within OPEC+—e.g., between KSA and Russia—can lead to market shocks, as seen during the COVID-19 oil price collapse in 2020 and subsequent cuts in 2023–2024 to maintain prices amid slowing demand. • Green Transition Pressures: OPEC+ countries are facing global calls to reduce fossil fuel dependency, adding political pressure to adjust strategies without undermining revenue.	Maintain a delicate diplomatic and strategic balance between OPEC unity, price stabilization, and readiness for lower-carbon transitions via the Circular Carbon Economy.
U.S.–China Energy and Technology Rivalry	• Clean Tech Race: Both powers are heavily investing in solar, wind, hydrogen, and battery technologies, leading to competition in setting global standards and control over critical mineral supply chains. • Global Influence: The U.S. Inflation Reduction Act (IRA) and China's Belt and Road Initiative (BRI) both influence global investment flows in energy infrastructure, including in Africa and the Middle East. • Strategic Partnerships: KSA's neutral positioning allows it to engage in strategic collaborations with both the U.S. and China—e.g., oil sales to China in yuan, while pursuing defense and energy technology cooperation with the U.S.	Leverage bilateral relationships with both countries while building national capabilities in energy technologies to reduce reliance on foreign innovation ecosystems.

	Key Considerations	Strategic Implication for KSA
Russia–EU Tensions and Global Gas Markets	• LNG Market Reconfiguration: As Europe diversifies away from Russian gas, demand for LNG from Qatar, the U.S., and others has surged—reshaping trade routes and prices. • Energy Security Focus: The EU’s aggressive decarbonization and energy independence strategy has global spillovers, including new opportunities for green hydrogen partnerships. • Middle East Leverage: Gulf nations, including KSA, have strengthened ties with the EU for green hydrogen, ammonia, and solar exports as part of the EU’s Green Deal diplomacy.	Russia’s invasion of Ukraine in 2022 caused massive disruptions in natural gas supply to Europe, creating ripple effects in LNG markets and accelerating Europe’s shift to renewable and alternative energy sources.
WEF Global Risk Radar 2024–2025: Geopolitical and Energy Insights	• Geoeconomic Confrontation: Increased use of trade restrictions, investment controls, and sanctions—disrupting energy supply chains and cross-border financing. • Critical Resource Shortages: Competition for minerals used in energy transition technologies may lead to “resource nationalism,” further fuelling global tensions. • Weapons of Mass Disruption (Cyber): Growing cyberattacks on energy infrastructure, including oil pipelines and grid systems. • Disrupted Energy Transitions: Risk of backlash or uneven decarbonization across regions, potentially destabilizing traditional producers. • Climate-Driven Migration and Instability: Rising climate-induced migration and food insecurity could lead to regional political instability, affecting oil and gas infrastructure in fragile states.	Strengthen national resilience through energy infrastructure protection, diversified trade relationships, and long-term planning for minerals and clean energy capabilities.

234. Assessing the Influence of Geopolitical Dynamics on Oil and Gas Production, Pricing, and Trade

Geopolitics and global market dynamics are increasingly decisive in shaping the behaviour of oil and gas production, pricing, and trade. As KSA of KSA embarks on a dual journey of sustaining its oil economy while transitioning to a cleaner energy future under **Vision 2030**, it is vital for energy professionals to understand, assess, and respond to these forces across three key dimensions: **financial, operational, and compliance risks**.

235. Financial Risk Dimensions

Price Volatility and Budget Planning

- **Geopolitical events** such as OPEC+ production decisions, wars, or sanctions often trigger sharp **price fluctuations** in crude oil.
- For a country like KSA—where over 60% of public revenue is oil-dependent—price drops or spikes immediately impact **fiscal budgets**, public investment programs, and subsidy frameworks.

Key Considerations:

- **Scenario 1:** A military escalation in the Strait of Hormuz disrupts tanker traffic, causing oil prices to spike by \$20/barrel.
- **Scenario 2:** The U.S. and Iran resume negotiations, easing sanctions, increasing supply, and pushing prices down.

Impact on KSA:

- Revenue volatility undermines **long-term budgeting** and creates uncertainty in sovereign investment portfolios.
- Petrochemical and downstream investments tied to price thresholds face **delays or reprioritization**.

Exchange Rate and Credit Risk Exposure

- Global political tensions and trade restrictions affect **foreign exchange markets** and the **availability of credit** for energy trade deals.
- Oil trade denominated in US dollars becomes **exposed to dollar volatility**, especially amid U.S.–China tensions or inflationary pressures.

Practical Example:

Saudi Aramco issuing bonds or expanding refinery joint ventures in China could face credit rating shifts due to U.S.–China standoffs.

236. Operational Risk Dimensions

Supply Chain Disruptions

Geopolitical shocks often affect the **energy supply chain**—from upstream exploration to downstream refining and export.

Examples: - **Russia-Ukraine war** caused LNG redirection to Europe, affecting availability and prices in Asia and the Middle East. **Shipping chokepoints** like the Suez Canal or Strait of Hormuz are vulnerable to conflict, piracy, or political blockades.

Saudi Response Measures: Building **strategic oil reserves** and regional supply hubs. Investing in **resilient logistics infrastructure** including east-west pipelines and the Ras Al Khair export terminal.

Labor and Operational Continuity in High-Risk Zones

Operations in politically unstable countries (e.g., Sudan, Libya) pose risks to Saudi investments in **oilfield services, pipelines, and off-take agreements**. Regional alliances can either **enable or hinder** access to these markets.

Mitigation Strategy: - Adopt **business continuity plans**, deploy **remote monitoring technologies**, and strengthen **local partnerships** with guaranteed security protocols.

237. Compliance Risk Dimensions

Sanctions and Trade Restrictions: - Entities trading with sanctioned nations (e.g., Iran, Venezuela, Russia) face reputational damage and **secondary sanctions**. Navigating **U.S., EU, and UN sanctions regimes** requires robust internal controls and legal due diligence in cross-border deals.

Practical Implication for Saudi Energy Firms: - All export agreements, particularly for petrochemical derivatives or joint ventures with global firms, must go through **sanctions compliance screening**.

ESG and Decarbonization Reporting: - Global investors are applying **Environmental, Social, and Governance (ESG)** compliance filters to oil and gas investments. Lack of transparent **decarbonization disclosures** can limit access to green bonds, international financing, or global partnerships.

Response Strategy: -Implement ESG-aligned reporting systems across exploration and refining operations. Engage in **voluntary carbon markets** or green hydrogen initiatives to future-proof compliance.

238. KSA - Geopolitical Actor in Energy Diplomacy

KSA, long recognized as the world's swing oil producer and the anchor of OPEC, has rapidly evolved into a **global energy diplomacy leader**. Through a calibrated mix of **oil market stewardship, energy diversification**, and **ESG-aligned mega-initiatives**, KSA is reshaping its global role—balancing energy security, climate responsibility, and economic diversification.

Its **strategic energy vision** is neither a retreat from fossil fuels nor a wholesale embrace of decarbonization, but a **“dual track” approach**:

- **Stabilize and monetize hydrocarbons efficiently,**
- **Transition progressively into clean energy leadership**—regionally and globally.

239. Strategic Pillars of KSA's Energy Diplomacy

Oil Market Stewardship (OPEC+ Leadership)

- As the de facto leader of **OPEC+**, KSA influences **global oil supply and pricing policy**.
- KSA has coordinated **production cuts, strategic surpluses, and pricing floors** to stabilize markets—especially during shocks like the COVID-19 pandemic and Ukraine crisis.
 - Through this, KSA maintains diplomatic capital with **Russia** (energy collaboration despite Western sanctions), **China and India** (as top oil importers), **U.S.** (as a security and market ally, albeit with tension).

Strategic Insight: Saudi's geopolitical clout in oil production is not just economic—it is leveraged to maintain **regional influence**, bargain power in bilateral relations, and leadership in energy forums (e.g., G20, OPEC Summits).

Energy Transition Positioning: Pragmatic, Not Idealistic - KSA acknowledges the global push for decarbonization—but asserts that **Oil and gas will remain essential** to the global economy for decades, **The energy transition must be inclusive, realistic, and technologically neutral**. **Key National Statements: “We believe in energy coexistence”** – meaning oil, gas, renewables, and clean tech all have roles to play. **Circular Carbon Economy (CCE)** is promoted by KSA as an **alternative model** to net-zero, based on **Reduce, Reuse, Recycle, Remove** (including carbon capture), **Hydrocarbon optimization** through efficiency, rather than elimination.

Strategic Insight: KSA offers a **middle-ground narrative** in climate diplomacy—appealing to emerging economies that cannot afford abrupt fossil fuel transitions.

240. ESG Diplomacy Through Domestic Initiatives

KSA has launched massive ESG-aligned programs to project **environmental and social leadership**: - **Saudi Green Initiative (SGI), Middle East Green Initiative (MGI), NEOM and The Line, Aramco and SABIC ESG Disclosure Standards** (both entities publish **TCFD-aligned sustainability reports**, participate in **green financing**, and pursue **net-zero operations (scope 1 and 2)** by 2050).

Strategic Insight: Through domestic ESG projects, KSA reshapes its global image—from oil dependence to sustainable leadership—enhancing credibility in **climate negotiations and green capital markets**.

241. Diplomatic Engagement in Multilateral Forums

KSA is increasingly assertive in **global and regional energy diplomacy platforms**: -

- **G20 and UNFCCC (COP Conferences)** where it promotes **Circular Carbon Economy** as an alternative to “phase-out” language and voices the perspective of **hydrocarbon-producing countries**, advocating for fair timelines and technology funding.

- **Asian Energy Partnerships** with long-term oil contracts with China, South Korea, and India and new deals on **green hydrogen** and **low-carbon fuels** for export.
- **Africa and the Global South** where it investment in **solar and desalination projects** in North Africa and provide diplomatic support for a “just energy transition” that accommodates development goals.

242. Strategic Leverage and Challenges

Leverage Points includes **Oil supply control** through OPEC+, **Financial capacity** through PIF and sovereign reserves to invest globally, **Technology partnership flexibility** with both East and West and **Brand repositioning** as a future-focused energy innovator.

Challenges include: Western scepticism over long-term oil dependency, ESG scrutiny from global rating agencies and activist investors and maintaining strategic neutrality amid U.S.–China and Russia–EU rivalries.

243. Alignment with Vision 2030

KSA’s energy diplomacy is not ad hoc—it is a **coherent extension of Vision 2030**:

- **Diversify economy** while maintaining oil as a revenue pillar.
- Build **global investment partnerships** in renewables and clean tech.
- Assert regional leadership in both **energy policy** and **environmental action**.

KSA’s evolving role as a **geopolitical energy actor** is built on credibility, capacity, and clarity:

- **Credibility** as a market stabilizer and ESG implementer.
- **Capacity** to invest, adapt, and lead in oil and clean energy.
- **Clarity** in energy messaging—neither apologizing for oil nor ignoring the future.

244. Simulation: Mapping Geopolitical Energy Hotspots and Strategic Implications

Online access to explore the geopolitical importance in Energy Transition

SAUDI ENERGY TRANSITION
Geopolitical Energy Strategy Simulator

Team readiness: 0%

1. Briefing | 2. Map hotspots | 3. Strategic impact | 4. Trigger event | 5. Present | 6. Results | Facilitator

2. Map hotspots | Save | Reset team | ☐ Reveal facilitator guidance

Step 2: Map two hotspots | Enter the team, assign two regions, classify each hotspot and record concise evidence.

Team name: Team 1 | Assignment method: Select regions | Assign regions

Hotspots on map:

- European Union CBAM Policy
- Black Sea
- East Mediterranean
- Sahel Region
- Red Sea and Bab el-Mandeb
- Strait of Hormuz
- Taiwan Strait
- Venezuela
- Asia Clean-Energy Partnerships

Session 2: International Agreements & Pressures for Decarbonization

245. The Paris Agreement and Its Influence on KSA's Energy Policies

The **Paris Agreement**, adopted in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC), is a landmark global accord that seeks to limit global warming to **well below 2°C**, preferably **1.5°C** above pre-industrial levels. It marked a shift from top-down obligations to **nationally determined contributions (NDCs)**—voluntary commitments by each country to reduce greenhouse gas (GHG) emissions and adapt to climate change.

Key components include:

- Submission and regular updating of NDCs every five years.
- Transparency and reporting through enhanced monitoring and verification frameworks.
- Encouragement of financial flows, technology transfer, and capacity-building to support developing countries.

246. KSA's Position on the Paris Agreement

Accession and Commitment

KSA **formally ratified** the Paris Agreement in **November 2016**. As a leading oil producer and a developing country, its approach has emphasized:

- The right to pursue **sustainable development** without compromising energy security.
- The need for a **balanced and technology-neutral** path to emissions reduction.
- Promotion of a “**Circular Carbon Economy**” (CCE) as an alternative to one-size-fits-all net-zero frameworks.

KSA's **first NDC (2016)** focused on:

- Avoiding up to **130 million tonnes of CO₂ equivalent** per year by 2030.
- Enhancing energy efficiency, public transport, waste management, and afforestation.
- Emphasizing **economic diversification** rather than aggressive fossil fuel curtailment.

The **updated NDC (2021)** significantly raised ambition, in line with KSA's Vision 2030 and the SGI:

- Targeting an **annual emission reduction of 278 million tonnes** by 2030.
- Introducing carbon capture, renewable energy, methane abatement, and hydrogen development.

247. Influence on Saudi Energy Policies

Energy Diversification and Clean Energy Integration - The Paris Agreement has accelerated KSA's efforts to **diversify its energy mix** beyond hydrocarbons.

Key Policy Impacts:

- **National Renewable Energy Program (NREP):** Aims to reach **50% renewable power capacity** by 2030.

- **NEOM and The Line projects:** Designed as **zero-carbon smart cities**, powered by solar and wind.
- **Hydrogen Strategy:** KSA aspires to be a global leader in **green and blue hydrogen** exports.

These efforts are directly tied to KSA's **ESG commitments**, influenced by global climate expectations and investor requirements.

Emissions Reduction and Circular Carbon Economy (CCE) - The Paris Agreement catalysed KSA's formalization of the **CCE framework**, endorsed at the **G20 Summit (Riyadh, 2020)**. CCE is **KSA's climate response model**, positioning hydrocarbons not as obsolete, but as manageable within a global low-emissions context.

Climate Finance and Investment Alignment - As a Paris Agreement signatory, KSA increasingly aligns with **international green finance standards**, influencing:

- **Aramco, SABIC, and PIF strategies** to issue **green sukukuks and bonds**.
- Enhanced **TCFD (Task Force on Climate-related Financial Disclosures)** compliance.
- Attraction of foreign investment from **sovereign wealth funds and climate funds** requiring Paris-aligned portfolios.

The Paris Agreement has also influenced KSA's participation in:

- **Carbon markets** (e.g., voluntary trading schemes under SGI).
- **Sustainable investment platforms** (e.g., One Planet Sovereign Wealth Fund initiative).

248. Regulatory and Institutional Development

KSA has created or strengthened several institutions to meet its Paris-aligned goals:

Institution	Role
Saudi Energy Efficiency Centre (SEEC)	Drives national energy efficiency standards.
National Centre for Environmental Compliance (NCEC)	Monitors emissions, enforces air quality laws.
Renewable Energy Project Development Office (MOE)	Manages utility-scale solar and wind projects.
Ministry of Energy	Leads on CCE, hydrogen, and renewable energy policy integration.

Strategic Balancing: Oil Leadership and Climate Commitment

KSA's position in global climate diplomacy is marked by **constructive pragmatism**:

- It acknowledges the need for global climate action, but emphasizes “**equity, flexibility, and innovation**” in achieving it.
- The country continues to invest in **oil efficiency and value-added downstream production**, even while growing its renewables.
- Rather than **phasing out oil**, KSA advocates for **phasing in cleaner solutions** and **offsetting technologies**.

249. Challenges and Forward Trajectory

Challenges:

- Balancing **international climate expectations** with domestic economic reliance on hydrocarbons.
- Navigating **ESG-related investor pressure** without undermining energy sovereignty.
- Coordinating **cross-sector implementation** of the updated NDCs.

Future Trajectory:

- Integration of **carbon markets** and **nature-based solutions** in national strategies.
- Strengthening **climate resilience** through adaptation projects, particularly in agriculture and water.
- Scaling **green hydrogen**, CCUS, and smart grid development to meet global expectations.

The Paris Agreement has become a **global benchmark** influencing KSA’s transformation from a traditional oil powerhouse into a **resilient, low-carbon energy leader**. Through Vision 2030, the SGI, and robust energy diplomacy, KSA is aligning its economic vision with international climate commitments—while maintaining energy security, national sovereignty, and innovation leadership. Saudi energy professionals must understand the Paris framework not as a constraint, but as an evolving **opportunity** to lead, shape policy, and attract capital in the 21st-century energy ecosystem.

250. Understanding the Implications of COP28 Outcomes on KSA’s Energy Initiatives

The **28th Conference of the Parties (COP28)** to the United Nations Framework Convention on Climate Change (UNFCCC) was held in **Dubai, United Arab Emirates**, in **December 2023**. It marked a crucial moment in global climate governance, particularly for oil-producing nations, as it delivered the first **Global Stocktake (GST)** of progress under the Paris Agreement. COP28 occurred at a time of rising global temperatures, geopolitical instability, and pressure to accelerate the **energy transition**, making it pivotal for countries like KSA—who must balance **climate ambition** with **economic reliance on hydrocarbons**.

The Global Stocktake (GST) and Path Forward - The GST concluded that the world is **not on track** to limit global warming to 1.5°C. It urged countries to adopt **transformational changes** in energy systems by 2030. The final text **called for a transition away from fossil fuels in energy systems**, not a phase-out—a subtle but important diplomatic win for fossil fuel-producing nations, including KSA.

Implication for KSA: - KSA must now **demonstrate tangible progress** toward its updated NDC goals, particularly in reducing emissions by **278 MtCO₂e/year by 2030**. The GST reinforces the

need to **showcase measurable outcomes** from the SGI, especially in renewable capacity and carbon capture.

Tripling Renewable Energy and Doubling Energy Efficiency by 2030 - Over 130 countries endorsed the target to **triple global renewable energy capacity** and **double energy efficiency**. Although KSA did not sign the pledge, its **existing targets** already align with similar ambitions: - Achieving **50% renewable electricity mix** by 2030 and deploying **clean hydrogen, smart grid systems, and energy-efficient transport**.

Implication for KSA: - Acceleration of flagship projects such as **NEOM Green Hydrogen** plant, **MOE's solar and wind auctions**, **Electric public transport** in Riyadh and Jeddah. Need to strengthen **data collection and reporting mechanisms** to track efficiency improvements nationally.

Fossil Fuels and the Transition Language - While the final COP28 agreement acknowledged the role of fossil fuels, it emphasized “accelerating efforts towards the phase-down of unabated fossil fuels.” It gave **credibility to carbon capture technologies (CCUS)** and **low-emissions fuels**, long championed by KSA.

Implication for KSA: - **Validation of the Circular Carbon Economy (CCE)** framework as a legitimate transition pathway. Expansion of national CCUS programs, including **Jubail industrial CCUS hub and Blue ammonia exports** as a transition fuel. It reinforces KSA's **narrative of “energy coexistence”**—positioning hydrocarbons within a low-emissions future rather than in opposition to it.

Climate Finance and Loss and Damage Fund - COP28 operationalized the **Loss and Damage Fund**, with initial pledges from developed countries to support vulnerable nations. Discussions continued around scaling up **climate finance** to USD 100+ billion annually and ensuring **access to green capital markets** for developing economies.

Implication for KSA: - KSA, as a **regional funder and investor**, may participate in **South-South climate financing** to MENA and African partners and supporting Islamic finance-based green bonds via the **Public Investment Fund (PIF)**. It is also an opportunity to strengthen its ESG investment posture, especially in partnerships with sovereign wealth funds and multilateral banks.

Just Energy Transition and Regional Leadership - COP28 emphasized **"just and equitable transitions"**—recognizing the different capabilities and development needs of countries. MENA states, including KSA, highlighted the importance of **customized pathways** rather than a uniform global decarbonization roadmap.

Implication for KSA: - Leverage this discourse to advocate for **hydrocarbon efficiency** and **transition fuels** (e.g., hydrogen, ammonia) as credible solutions. Lead regional collaboration through the **Middle East Green Initiative (MGI)** and **cross-border renewable trade**.

251. Strategic Alignments with Vision 2030 and SGI

COP28 Theme	Saudi Energy Initiative	Alignment
Global renewable targets	National Renewable Energy Program (MOE)	✓
Fossil fuel transition	Circular Carbon Economy, Aramco CCUS	✓
Climate adaptation & finance	Saudi ESG and Green Sukuk programs	✓
Regional climate diplomacy	Middle East Green Initiative (MGI)	✓

COP28 did not undermine Saudi energy policy—it **validated its flexible approach**, centred on **CCE**, **emissions reduction technologies**, **energy efficiency**, and **regional leadership** without renouncing hydrocarbons.

252. Challenges and Forward Priorities

Challenges

- External pressure from climate advocates for KSA to adopt a **net-zero by 2050** target for the entire economy.
- Need to **quantify and communicate progress** across green metrics, including ESG scores and carbon reduction in industry.
- Competition in green hydrogen exports from the EU, Australia, and the U.S.

Priorities Moving Forward

- Invest in **MRV (Measurement, Reporting, Verification)** systems for emissions and renewable projects.
- Align **national reporting frameworks** with UNFCCC transparency mechanisms.
- Develop **climate diplomacy capacity** to influence future COPs and international energy standard-setting.

253. Analysing Growing Global Pressure s to Diversify and Decarbonize

As the world faces intensifying climate change impacts, rising temperatures, and net-zero pledges from nearly every major economy, **oil-producing nations** are under unprecedented **global pressure to diversify their economies and decarbonize their energy sectors**.

This pressure stems from:

- Multilateral climate agreements (e.g., Paris Agreement, COP28 outcomes),
- ESG investment frameworks,
- Decarbonization targets in consumer nations,

- Shifting energy demand patterns,
- Technological breakthroughs in renewables, hydrogen, and storage.

For **KSA**, this represents both a **strategic challenge**—given its heavy reliance on hydrocarbons—and a **historic opportunity** to lead a new form of energy diplomacy, regional cooperation, and industrial innovation.

254. Sources of Global Pressure

International Climate Agreements and Net-Zero Targets - Over **140 countries** have committed to **net-zero emissions** by mid-century. Agreements like the **Paris Agreement** and outcomes from **COP28** call for reducing fossil fuel dependency, especially **unabated oil and gas**.

Implication: Oil-producing nations must present credible, transparent pathways toward low-emissions economies—or risk losing access to global finance, trade preferences, and diplomatic leverage.

Carbon Border Adjustment Mechanisms (CBAMs) - The **EU's Carbon Border Adjustment Mechanism** will impose carbon tariffs on imports of high-emissions goods like steel, cement, and potentially **petrochemicals**. Other regions are exploring similar tools, increasing pressure on exporters to **decarbonize their production chains**.

Implication: Hydrocarbon-based exports that do not meet carbon intensity benchmarks may be penalized, impacting competitiveness and market share.

255. ESG and Green Finance Expectations

Institutional investors now screen portfolios using **Environmental, Social, and Governance (ESG)** criteria. Multilateral banks and sovereign wealth funds require climate-aligned disclosures, including **Scope 1, 2, and 3 emissions**.

Implication: Oil companies and state-owned enterprises (like Aramco) must improve **sustainability reporting, decarbonization plans, and project transparency** to access capital.

256. Public and Legal Pressure

Litigation risk is increasing against oil majors for their contributions to climate change. Global civil society movements and consumer preferences are accelerating a shift away from fossil fuels.

Implication: Energy-producing governments face pressure not just from markets and regulators, but from **public opinion and legal systems**, particularly in global partnerships.

257. Strategic Implications for KSA

KSA is at the heart of these shifting dynamics. It must reconcile its position as a **top global oil producer** with the need to respond to global decarbonization expectations without undermining energy security or economic growth.

National Oil Revenue Dependency - Oil represents **55% of national revenue**. Budget resilience is still closely tied to oil price fluctuations. **Vision 2030** targets include reducing oil dependence to less than 40% of GDP.

Pressure Point: Global calls to phase down fossil fuel consumption pose a **fiscal and macroeconomic risk** if diversification is delayed or underdelivered.

Energy Sector Diversification Initiatives - KSA has launched several ambitious initiatives to respond constructively: - **SGI, Hydrogen Strategy and Circular Carbon Economy (CCE)**.

Strategic Insight: KSA positions itself not as resisting change, but as **shaping the narrative** of realistic, sovereign-led transitions.

Institutional and Investment Shifts - Public Investment Fund (PIF) is investing heavily in renewables, EVs, mining, and sustainable tourism (NEOM, Red Sea Project). Saudi Aramco is investing in Carbon Capture Utilization and Storage (CCUS), low-emissions fuels and methane abatement and ESG disclosure standards

Strategic Insight: By diversifying both its state investment portfolio and energy technologies, KSA is responding to pressure without sacrificing control of its economic model.

258. Risk of Inaction or Delay

Risk Area	Description
Market Risk	Loss of long-term customers shifting to green suppliers (e.g., EU, Korea, Japan)
Reputational Risk	Being labelled a "climate laggard" may reduce diplomatic influence
Capital Access Risk	Difficulty in attracting ESG-linked investment and green bonds
Trade Risk	Exposure to carbon tariffs and exclusion from green trade zones
Technology Gap Risk	Falling behind in renewable manufacturing, storage, and AI-enabled systems

259. KSA's Strategic Response: A Balanced Approach

Positioning Strategy: KSA frames its energy transition as *"Responsible, realistic, and economically viable built on inclusivity and technological neutrality."*

Response Measures:

- **Avoids abrupt fossil fuel exit:** Instead focuses on **cleaner production** (e.g., reducing flaring, CCUS).
- **Promotes coexistence** of oil and renewables as complementary.

- **Invests in regional leadership:** via the **Middle East Green Initiative** and **renewable interconnectivity**.

Vision 2030 Integration:

The diversification and decarbonization agenda are deeply embedded in:

- **Industrial strategy** (e.g., localization of solar panel and EV manufacturing)
- **Human capital development** (e.g., green skills, STEM education)
- **Energy diplomacy** (e.g., hosting key global climate and energy summits)

Navigating Between Oil and Opportunity

KSA stands at a crossroads where **growing global pressure to decarbonize** coincides with its **own economic transformation goals**. Rather than resist these pressures, KSA is:

- **Reframing the narrative** through CCE and ESG diplomacy,
- **Rebuilding its economy** with diversified sectors and clean technology,
- And **reinventing itself** as both a reliable energy exporter and a climate-conscious actor.

260. Practical exercise: Debate: “Should KSA Commit to a Net-Zero Target Date?”

Setup Instructions - Group Division -

- Divide into **three groups**:
 - **Pro Side**: Advocates *for* KSA committing to a net-zero target (e.g., by 2060).
 - **Con Side**: Argues *against* setting a fixed target date, emphasizing flexibility and sovereignty.
 - **Judges Panel / Observers**: Takes notes, asks clarifying questions, and evaluates arguments.

1. Preparation Phase

Each debating group receives:

- A **fact sheet** with data on Saudi emissions, the SGI, Vision 2030 goals, and global net-zero trends.
- A list of **prompt questions**, e.g.:
 - How would a net-zero commitment affect investor perception?
 - Would it constrain or accelerate domestic innovation?
 - How can KSA remain a leader in oil and commit to net-zero?
 - How would such a pledge affect diplomacy with EU, China, or the US?

Each group identifies 2–3 **key arguments** and assigns speakers (2 max per side).

2. Debate Format

Segment	Time	Details
Opening Statement – Pro Side	3 min	Presents case for Saudi net-zero target
Opening Statement – Con Side	3 min	Presents case against setting a fixed target
Rebuttals	2 min each	Each side counters the other’s points
Q&A from Judges/Observers	5–7 min	Clarifying questions or challenges
Closing Statements	2 min each	Summary and final appeal

3. Debrief and Strategic Reflection

Reflection Questions:

- What were the strongest arguments on each side?
- How does this debate reflect real-life stakeholder dynamics?
- Which global or regional trends may force a shift in position?
- What would be a “Saudi-specific” version of net-zero (e.g., sectoral targets, flexibility in timelines)?

Session 3: Market Dynamics & Investment Trends in Renewable Energy

261. Shift in Global Capital Flows from Fossil Fuels to Renewables

Over the last decade—and accelerating since the Paris Agreement and COP28—there has been a marked **reallocation of global capital** from traditional fossil fuel projects toward **renewable energy**, clean technologies, and low-carbon infrastructure. This financial transformation is being driven by a convergence of **climate policy, investor activism, technological innovation, and ESG mandates**. While fossil fuels remain a core part of the global energy mix, the **flow of money is moving elsewhere**, signalling a strategic shift that oil-producing nations must analyse and act upon.

262. Key Drivers of Capital Reallocation

Climate Policy and Net-Zero Commitments - Governments representing over **90% of global GDP** have committed to **net-zero emissions by 2050 or sooner**. Multilateral agreements (e.g., Paris Agreement, EU Green Deal, IRA in the U.S.) explicitly direct capital into **decarbonized infrastructure**.

Implication: Policy certainty drives **investment predictability** in renewables—while fossil fuel assets face future regulatory constraints.

Financial Sector Transformation and ESG Mandates - **ESG** (Environmental, Social, and Governance) investing has surged over **\$40 trillion in assets under management (AUM)** globally in 2024. Major banks, insurers, and sovereign wealth funds are **divesting** from coal and high-emissions oil fields, **prioritizing renewables, storage, and green hydrogen** and disclosure frameworks like **TCFD, ISSB, and EU Taxonomy** influence access to capital and equity valuations.

Example: BlackRock, the world's largest asset manager, now offers **Paris-aligned investment products** that exclude fossil fuel expansion.

Technological Maturity and Cost Competitiveness - The **levelized cost of energy (LCOE)** for solar and wind is now **cheaper than new fossil fuel plants** in most regions. **Battery storage, smart grids, and hydrogen electrolyzers** are becoming commercially viable—drawing R&D and private equity.

Implication: - Renewables are not only ethical investments—they are **profitable, scalable, and technologically mature**, attracting global capital.

Risk Perception: Fossil Fuel Assets as Stranded Assets - Carbon-intensive investments face **asset stranding risk** due to climate regulation, carbon pricing schemes, and future demand decline. Fossil fuel investments are increasingly seen as **short-term plays**, while clean energy offers **long-term portfolio resilience**.

Quote from IEA (2023):

"No new coal, oil or gas fields are needed in a net-zero pathway. Every dollar invested in fossil expansion increases climate and investment risk."

263. Implications for KSA

Challenges in Attracting Capital for Fossil-Focused Projects - International finance for **new crude production or oil infrastructure** is increasingly constrained. ESG-conscious investors **scrutinize national emissions targets**, methane management, and transparency.

Mitigation Strategy: Saudi Aramco and PIF have launched **sustainability-linked financial instruments** and improved **ESG disclosures** to remain competitive.

Opportunity to Attract Green Investment KSA is uniquely positioned to attract capital into clean energy, if it **demonstrates credible renewable pipelines** (e.g., NREP, NEOM, hydrogen zones), aligns with **sustainability metrics** (e.g., SDGs, green bonds), **de-risks projects** through sovereign guarantees and strong governance.

Major Examples: **NEOM Green Hydrogen Project:** \$8.4 billion secured in financing from global investors and development banks. **Green Sukuk Program:** Issued by the Ministry of Finance to fund solar, wind, and smart mobility initiatives.

Sovereign Strategy: From Petrodollars to “Green dollars” KSA’s long-term strategy under Vision 2030 involves **diversifying investment portfolios** toward renewables, EVs, tourism, and manufacturing. Utilizing PIF and other national funds to act as **first movers in emerging sectors** like green hydrogen, sustainable mining, and battery manufacturing.

264. Role of the SGI and Vision 2030

Both frameworks aim to **leverage global capital trends** through **energy mix reform** (targeting 50% renewables by 2030), **carbon offset projects** (tree planting, land restoration), and **Circular Carbon Economy (CCE)**: Packaging hydrocarbons into a low-emission value chain using CCUS and methane reduction. By aligning these initiatives with **Paris-aligned capital markets**, KSA can **access blended finance** from multilateral development banks, **form international green energy alliances**, and build **soft power and climate diplomacy credentials**.

265. Discussion points for Energy Professionals and Policymakers

Area	Recommendation
Finance	Integrate ESG metrics into energy investment pipelines and project evaluations.
Policy	Design fiscal incentives for clean energy innovation (e.g., green R&D credits, IPPs).
Stakeholder Engagement	Proactively engage with ESG funds, climate investors, and green bond issuers.
Transparency	Improve carbon disclosures across all SOEs and major infrastructure projects.

266. Navigating the Investment Transition

The global capital landscape is evolving rapidly, with **money flowing toward climate resilience, energy innovation, and sustainability**. For oil-producing nations like KSA, the challenge is not whether to transition—but how quickly, credibly, and competitively. KSA has the **sovereign wealth, technical capacity, and geopolitical leverage** to lead this shift—provided it:

- Aligns its domestic ambitions with global investor expectations,
- Designs bankable clean energy projects,
- And maintains its leadership as an energy innovator—not just an energy exporter.

267. Evaluating the Impact of Divestment Campaigns and Green Finance Tools

The global investment landscape is being reshaped by two major forces:

- **Fossil fuel divestment campaigns**—efforts by investors, universities, faith groups, pension funds, and sovereign wealth funds to withdraw investments from carbon-intensive assets.
- **Green finance tools**—mechanisms such as green bonds, sustainability-linked loans, and ESG indices that direct capital toward environmentally responsible projects.

Together, these forces exert powerful influence on the **perception, credibility, and attractiveness** of countries and companies seeking capital. For KSA—a nation undergoing a high-stakes energy transition under Vision 2030—the implications are profound.

268. What Are Divestment Campaigns?

Divestment campaigns aim to:

- Pressure institutions to **withdraw investments from fossil fuel companies** or high-emissions projects.
- **Reframe oil and gas** as morally and financially risky investments.
- Accelerate the global energy transition by **redirecting capital** into renewables and climate-aligned solutions.

Global Momentum:

- Over **1,600 institutions**, managing more than **\$40 trillion** in assets, have pledged fossil fuel divestment.
- Influential groups include **Norway's Sovereign Wealth Fund, Harvard University, Church of England**, and **New York State Pension Fund**.

Key Messaging:

- Fossil fuel investments are becoming **stranded assets**.
- Divestment is both a **financial risk management** and **ethical imperative**.

269. What Are Green Finance Tools?

Green finance refers to financial instruments specifically designed to fund **climate-positive or environmentally sustainable projects** and incentivize decarbonization through **performance-linked financing**.

Green Finance Tools

Green Bonds Debt instruments used to raise capital for environmentally beneficial projects such as renewable energy, clean transport and sustainable infrastructure.	Green Loans Loans provided at favorable terms to finance projects with clear environmental benefits, such as energy efficiency, renewable energy and low-carbon technologies.	Sustainability-Linked Financing Financing that links the interest rate or other terms to the borrower's performance against predefined environmental, social and governance targets.
Green Sukuk Shariah-compliant financing instruments used to raise funds for environmentally sustainable projects, such as renewable energy and sustainable water infrastructure.	Blended Finance Combines public, private and development finance to reduce risk and mobilize additional investment in green and climate-resilient projects.	Green Grants and Incentives Non-repayable funding and financial incentives provided by governments or development institutions to support pilot projects, innovation and early-stage green investments.
Carbon Finance Financial mechanisms based on carbon credits or emission reduction units that generate revenue from verified greenhouse gas emission reductions or removals.	Green Investment Funds Pooled investment vehicles that allocate capital to companies and projects with strong environmental performance and alignment with sustainability objectives.	Transition Finance Financing provided to support high-emitting sectors in their credible and measurable transition to a low-carbon and more sustainable business model.

Market Size: Green bond issuance **\$575 billion – \$600 billion** (For pure green bonds) / **~\$900 billion** (For all combined GSSSB debt) **globally** in 2026 and is forecasted to expect **\$5 trillion in cumulative** or **\$1 trillion+ in annual** issuance by 2030.



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Green finance policies, institutions, tools and governance

Addressing climate change, as well as biodiversity and other environmental goals, will require an unprecedented acceleration of investment and financing towards climate-friendly, nature-positive and sustainable pathways, and a shift away from harmful activities. Policies, public financial institutions, and a whole-of-government approach will need to be further leveraged to drive transformation of the financial system, along with a focus on environmental integrity and outcomes.



270. Impact on National Investment Attractiveness

Reputational Capital Matters - Countries that are perceived as **climate-responsible and transition-ready** are more likely to attract **ESG-conscious investors**, join **green investment alliances**, and secure favourable financing terms from development banks and global bond markets.

Saudi Implication: KSA must maintain **narrative control** to present itself as a **credible partner** in the global energy transition.

Funding Costs and Access to Capital - Divestment campaigns can **raise borrowing costs** for fossil-heavy jurisdictions, while green finance lowers them through **risk-based capital pricing**, **green premiums** (“greeniums”), and **sustainability performance incentives**.



KSA's issuance of **green sukuk** through the Ministry of Finance and PIF enabled:

- Access to **lower-cost capital**,
- Demonstration of **alignment with ESG principles**, and
- Credibility among **international sovereign debt markets**.

Investor Screening and Policy Signals - Global institutional investors are increasingly adopting **exclusion criteria** (e.g., thermal coal, flaring, methane leakage), **transition benchmarks** (e.g., Science-Based Targets Initiative), and **portfolio stress tests** based on **net-zero alignment**.

Saudi Implication: Investors may scrutinize Aramco, SABIC, and other SOEs for: Climate transition plans, scope 1, 2, and 3 emissions disclosures and governance transparency. Lack of alignment may result in **capital flight or underweighting** in major indices.

Regional Competition - Other oil-exporting countries (e.g., UAE, Qatar, Brazil) are accelerating **green finance market development**, **sustainability-linked debt instruments**, and global green diplomacy.

Saudi Implication: To remain regionally competitive, KSA must: Deepen its **green capital markets infrastructure** (e.g., Tadawul ESG index, green sukuk pipeline), Expand **public-private project pipelines** that qualify for green funding, Incentivize **local banks** to issue sustainability-linked products.

271. Strategic Saudi Responses and Opportunities

a) Sovereign Investment Vehicles and ESG Signalling -

- **Public Investment Fund (PIF)** has committed to **net-zero by 2050** and is Investing in **renewables, EVs, smart cities**, issuing **sustainability-linked bonds**, and becoming a **green finance leader** in the region.

b) Aramco and SABIC Transition Strategy - Both entities have launched:

- **ESG disclosures aligned with TCFD**, and investments in **CCUS, blue hydrogen, and methane reduction**.

c) Green Sukuk and Sustainable Development Bonds

- In 2023, KSA launched a successful **green sukuk issuance**—backed by solar, wind, and rail infrastructure. Further **local bond innovation** can attract Islamic finance, sovereign wealth funds, and international pension funds.

272. Key Risks if Left Unaddressed

Risk Category	Description
Capital Access Risk	Exclusion from ESG capital markets and sustainability indices
Debt Pricing Risk	Higher interest rates or risk premiums for sovereign or corporate debt
Regional Competition	Losing investor preference to faster-moving MENA peers like UAE
FDI Diversion	Foreign direct investment diverted to countries with clearer climate policies

273. Aligning Strategy with the Green Finance Era

Divestment and green finance trends are not temporary—they represent a structural transformation in how capital flows are allocated and assessed. For KSA to remain an attractive investment destination:

- **Energy diversification and transparency** must accelerate.
- Green finance must be **scaled, standardized, and institutionalized**.
- Climate credibility must be paired with **strong ESG narratives and market instruments**.

Through Vision 2030, the SGI, and financial innovation, KSA can **not only retain capital but lead the region** in sustainable finance and strategic energy transition.

274. How Fluctuations in Oil Demand Are Reshaping the Global Energy Mix

Oil has long been the backbone of the global energy system, powering transportation, manufacturing, petrochemicals, and economic growth. However, in recent years, **fluctuations in oil demand**—driven by market shocks, structural transitions, and policy interventions—have significantly **reshaped the global energy mix**. From the COVID-19 pandemic to COP28 climate pledges, shifts in demand are no longer temporary dips but part of a broader, more volatile and uncertain landscape. For major oil-producing nations like **KSA**, understanding these patterns is essential for **strategic energy planning, economic resilience, and future competitiveness**.

Transportation Electrification - Electric vehicles (EVs) are rapidly gaining market share, particularly in China, Europe, and the U.S. By 2030, over **30% of global new vehicle sales** are expected to be electric. Airlines and shipping sectors are also investing in **sustainable fuels**, reducing long-term dependency on oil.

Impact: Road transport—previously responsible for nearly **50% of global oil demand**—is shifting toward electricity and hybrid alternatives.

Decarbonization Policies and Carbon Pricing - Carbon taxes, emissions trading systems, and fossil fuel subsidy removals are driving **energy substitution** away from oil. Major economies (EU, UK, Canada, Japan) have integrated **oil demand reduction targets** into their national climate policies.

Impact: Demand-side restrictions are forcing oil-exporting nations to **adapt to more competitive, lower-margin markets**.

Petrochemicals and Industrial Demand Growth - Despite transport-sector declines, **petrochemicals remain a growth driver**, particularly in developing economies (e.g., India, Southeast Asia). However, sustainability trends are pushing industries toward **bioplastics, recycling, and alternative feedstocks**.

Impact: Petrochemical demand is becoming more region-specific and policy-sensitive, requiring **targeted expansion strategies**.

Role of Natural Gas and Transitional Fuels - Natural gas, seen as a **bridge fuel**, is growing in markets where oil demand is declining. **Liquefied Natural Gas (LNG)** and **blue hydrogen** are increasingly integrated into national energy systems as flexible, lower-emission options.

Implication: Nations with **gas infrastructure** (like KSA) can leverage this as part of a **transitional energy strategy**.

Oil Producers Diversifying Into Renewables - Oil companies (IOCs and NOCs) are expanding their portfolios - **BP, Shell, TotalEnergies** are investing in offshore wind and EV infrastructure. **Aramco and ADNOC** are scaling **blue hydrogen, CCUS, and green fuels**.

Implication: The future energy mix is not oil vs. renewables—it's **portfolio resilience**, with oil companies evolving into **energy companies**.

275. Implications for KSA

Domestic Demand Restructuring - Through the **Saudi Energy Efficiency Centre (SEEC)** and the **SGL**, KSA is reducing domestic oil combustion in power generation and expanding renewable capacity to **50% of electricity mix by 2030**.

Export Strategy Realignment - Aramco is pivoting toward **long-term contracts with Asia, downstream petrochemical integration, hydrocarbon decarbonization using CCUS** whilst preserving high-value markets while developing new export products like **low-carbon fuels** and **blue hydrogen**.

Energy Mix and Investment Planning - Vision 2030 prioritizes: Clean mobility (EVs, public transport), Smart cities (NEOM, The Line), Green manufacturing (solar panel and battery plants). KSA must

prepare for **lower long-term demand ceilings, more competition for fewer barrels, Increased expectations for transparency, efficiency, and climate action**

276. Strategic Recommendations

Area of Focus	Recommendation
Resilience Planning	Use scenario modelling to plan for multiple demand futures (high, low, plateau).
Export Diversification	Expand downstream and value-added hydrocarbon products.
Technology Investment	Invest in green hydrogen, ammonia, and carbon recycling.
ESG Positioning	Align with global climate benchmarks to remain investment attractive.
Domestic Reform	Accelerate energy efficiency and renewable deployment across sectors.

277. Practical Activity: Scenario Planning – Forecasting Oil Prices in 2030 Under Alternative Investment Climate Scenarios

The concept of **scenario planning** (vs. traditional forecasting) | The uncertainty and volatility of global oil pricing. The objective: "**Predict Saudi crude oil price in 2030 under three distinct global investment climate scenarios.**" Divide into **three groups**, each assigned **one scenario**:

Scenario A – Accelerated Green Capital Shift

- Governments and investors **rapidly divest** from fossil fuels.
- Global renewable investment **triples by 2030**.
- Carbon pricing becomes universal.
- Oil demand declines sharply in transport and industry.
- Major tech breakthroughs in **battery storage and hydrogen** scale up alternatives.

Key Questions:

- What is the likely price of oil in 2030 under this scenario?
- How should KSA respond (export strategy, investment, diplomacy)?

Scenario B – Delayed Transition and Policy Fragmentation

- Political instability slows global decarbonization.
- Investment in oil and gas remains steady but not growing.
- Renewables grow, but inconsistently across regions.
- Electric vehicle rollout is slower than expected.
- Energy security concerns revive oil demand in Asia and Africa.

Key Questions:

- How does policy inconsistency affect oil prices?
- What role can KSA play as a stabilizer in this scenario?

Scenario C – Technological Stalemate and Fossil Lock-in

- Green innovation stagnates due to supply chain bottlenecks.
- Global recession limits investment in clean energy.
- OPEC+ continues to dominate global energy supply.
- Developing nations continue heavy oil use due to cost barriers.
- ESG pressures ease due to investor fatigue and geopolitical tension.

Key Questions:

- What price ceiling or floor might we expect?
- What are the risks of overdependence on fossil exports in this world?

Session 4: Regional Cooperation and Strategic Alliances

278. Examining Regional Cooperation Frameworks: [GCC Interconnection Authority](#)

With growing energy demand, decarbonization pressure, and grid modernization, **regional cooperation** in energy has become a cornerstone of sustainable development and energy security. The Gulf Cooperation Council (GCC) countries, including KSA, have recognized the strategic value of **cross-border power integration** and **energy diplomacy**, especially in the context of the energy transition.

The **GCC Interconnection Authority (GCCIA)** is one of the most successful regional infrastructure and governance projects in the Arab world. It offers a model for **grid resilience, resource optimization, and economic collaboration**, while supporting national ambitions such as **KSA’s Vision 2030, SGI, and decarbonization goals**.

GCCIA provides physical interconnection and emergency support. Deeper competitive trade requires transparent data, transmission access and pricing, coordinated system operation and harmonised market rules.

279. Overview of the GCC Interconnection Authority (GCCIA)

Formation and Mission	Established in 2001 and operational since 2009, the GCC Interconnection Authority (GCCIA) was created to interconnect the electricity networks of six GCC countries - KSA, Kuwait, Bahrain, Qatar, United Arab Emirates (UAE), Oman Mission: “To build and operate a resilient, secure, and cost-effective regional grid that enhances energy security, economic efficiency, and integration of renewables.”
Technical Infrastructure	• Total Grid Capacity: Over 1,200 MW transfer capability between countries. • Transmission System: 400kV double-circuit backbone with back-to-back converters and advanced control systems. • Coverage: 965 km of transmission lines across the GCC.
Interconnection Capabilities	• Enables real-time power exchange between member states. • Supports emergency energy needs and frequency stabilization. • Provides backup during system failures or peak demand periods.

280. Strategic Functions of GCCIA

KSA's Role: As the largest GCC country with ambitious solar and wind targets, KSA can become a **renewable energy exporter** to neighbouring states through GCCIA infrastructure.

Enhancing Energy Security	- Allows GCC states to share reserve capacity and reduce individual storage costs. - Provides emergency power support—a key feature during outages or demand surges (e.g., heatwaves). - Reduces dependence on imported fuel for power generation by optimizing regional sources.
Enabling Cost Optimization and Efficiency	- Reduces need for overinvestment in peak-load capacity by leveraging regional load diversity. - Encourages load sharing, grid balancing, and demand response strategies across borders. - Estimated cumulative economic benefit > USD 3 billion since inception (as of 2023).
Supporting Renewable Energy Integration	- Facilitates cross-border transmission of solar and wind power. - Improves grid flexibility and reliability, essential for variable renewable energy. - Enables the future development of regional green energy corridors.

281. Strategic Value to KSA

Grid Resilience and Operational Support	- KSA's vast grid benefits from reinforced regional links, reducing stress on local infrastructure. - GCCIA enables frequency control, reducing blackouts and instability.
Vision 2030 Alignment	Directly supports Vision 2030 goals of Energy diversification, Public-private partnerships, Regional integration and soft power
Export Pathway for Clean Energy	Supports future exports of Solar power from projects like Sudair and Sakaka, Green hydrogen-derived electricity, Clean energy credits under regional carbon mechanisms
Platform for Pan-Arab Energy Integration	GCCIA is part of a broader vision to link the GCC with Iraq, Jordan, Egypt , Ultimately, Europe through the Euro-Arab electricity corridor.

282. Recent and Future Developments

Expansion Projects	- Plans to increase interconnection capacity by 2030. - New interties with Iraq, Jordan, and Egypt. - Link GCCIA with the Pan-Arab Electricity Market.
Smart Grid and Digital Upgrades	- Investment in AI-based grid balancing, predictive analytics, and digital twins. - Enhancing cybersecurity protocols to protect critical infrastructure.
Market Liberalization and Trading	- Piloting of electricity market platforms for cross-border energy trading. - Long-term vision: establish a GCC Electricity Market, governed by clear rules, tariffs, and incentives.

283. Challenges and Mitigation Strategies

Challenge	Mitigation
Regulatory Misalignment	Harmonize technical and market regulations across GCC members
Lack of Commercial Market	Expand on pilot trading mechanisms and develop standard contracts
Geopolitical Sensitivities	Maintain energy as a neutral, unifying policy space
Infrastructure Investment Needs	Increase public-private partnerships and regional development finance

284. Strategic Discussion points for Saudi Energy Stakeholders

Area	Action
Policy	Strengthen regional energy diplomacy through the Ministry of Energy and SGI
Projects	Prioritize renewable energy zones with high interconnection potential
Finance	Use GCCIA as a platform to attract regional green finance and blended capital
Technology	Co-lead the digital grid innovation agenda in the GCC with UAE and Qatar
Sustainability	Align all GCCIA-linked projects with ESG reporting frameworks

The GCC Interconnection Authority is more than just a power grid—it's a symbol of **regional integration, shared prosperity, and energy resilience**. For KSA, it offers a strategic tool to:

- Expand **clean energy exports**,
 - Reduce infrastructure redundancy,
 - Position KSA as a **regional leader in sustainable energy transition**.
- As the world moves toward decarbonization, platforms like the GCCIA will become critical enablers—not only of energy reliability—but of **regional climate leadership**.

285. KSA’s Leadership in the Middle East Green Initiative (MGI)

KSA’s commitment to environmental sustainability and climate action has extended beyond its national borders through the launch and leadership of the **Middle East Green Initiative (MGI)**. First announced in **March 2021** by **His Royal Highness Crown Prince Mohammed bin Salman**, the MGI positions KSA as a **regional climate convener**, aiming to coordinate collective action across the **Middle East and North Africa (MENA)** region. Building upon the foundation of the **SGI**, which focuses on domestic sustainability goals, the **MGI is a pan-regional strategy** for:

- Combating desertification,
- Reducing emissions,
- Enhancing regional cooperation in clean technology,
- Fostering environmental diplomacy.

286. Vision and Objectives of the Middle East Green Initiative

MGI Strategic Vision	<i>“We share a responsibility to protect our planet. The Middle East Green Initiative will bring together regional and international efforts to achieve global targets.”</i> — Crown Prince Mohammed bin Salman
Key Objectives	• Plant 50 billion trees across the MENA region (including 10 billion in KSA) Middle East Green Initiative - Saudipedia. • Reduce carbon emissions from hydrocarbon production by 60% through cleaner technologies. • Cut regional carbon emissions by over 670 million tonnes, equivalent to more than 10% of global contributions. • Establish the largest reforestation program in the world. • Strengthen regional cooperation on clean energy, sustainable agriculture, and water conservation.

287. KSA's Strategic Leadership Role

Convening Power and Regional Diplomacy	KSA initiated and hosts the annual Middle East Green Initiative Summit, attended by: • Heads of state from MENA and African nations, • Climate envoys from the G20 and UN, • Major development banks and technology leaders. Diplomatic Outcomes: • Creation of a pan-regional climate platform to coordinate actions. • Commitment to shared funding for green infrastructure and afforestation. • Strengthening the collective voice of MENA in global climate forums (e.g., COP28, UNFCCC).
Funding and Technical Support	• KSA committed to contributing 15% of the total 50 billion trees, with funding, expertise, and land area. • Establishment of a Regional Carbon Capture and Storage Centre in partnership with the King Abdullah Petroleum Studies and Research Centre (KAPSARC). • Launch of a Clean Fuel Solutions for Cooking Initiative, in partnership with the United Nations, to support clean energy access for 750 million people globally.
Innovation and Knowledge Transfer	• Saudi institutions (e.g., King Abdullah University of Science and Technology (KAUST) and Saudi Aramco) lead research in: ◦ Arid-zone afforestation using treated water and drones, ◦ Methane abatement and carbon capture innovation, ◦ Smart irrigation and water-efficient agriculture. • Technical cooperation with neighbouring countries to deploy solar-powered desalination, large-scale wind projects, data-sharing platforms on emissions, land use, and water scarcity.
Building a Regional Climate Ecosystem	MGI acts as a collective climate infrastructure platform, linking: • Policy (through the MGI Summit), • Capital (via the Saudi Investment Fund and Gulf partnerships), • Technology (through cross-border renewable projects), • Implementation (through coordinated planting, emissions tracking, and resilience projects).
Advancing Shared Climate Resilience	• MENA is one of the world's most climate-vulnerable regions—facing rising temperatures, water stress, and desertification. • Through MGI, KSA shares tools and strategies for: ◦ Sustainable water use, ◦ Dust storm mitigation, ◦ Urban heat island reduction.

288. Alignment with Vision 2030 and Saudi Green Initiative

Together, SGI and MGI offer a **coherent national-to-regional transformation framework** under the umbrella of **Vision 2030**, positioning KSA as a **global green economy influencer**.

SGI focuses on:	Middle East Green Initiative (MGI) focuses on:
• Domestic renewable energy, • Circular Carbon Economy (CCE), • Protected areas and biodiversity conservation, • Green job creation and environmental awareness.	• Regional reforestation and emission reductions, • Environmental diplomacy and capacity building, • Joint research and innovation platforms, • Cross-border sustainability projects.

289. Opportunities and Challenges

Opportunities:	Challenges:
• Positioning KSA as the regional climate hub and green diplomacy leader. • Strengthening bilateral relations through environmental cooperation. • Creating green economy jobs and innovation pipelines across the region. • Access to climate finance and carbon markets through regional platforms.	• Cross-border alignment on land use, emissions measurement, and verification. • Political and economic instability in parts of the MENA region. • Resource constraints (water, finance, governance capacity) in partner nations.

290. KSA as a Regional Climate Convener

The Middle East Green Initiative reflects a bold evolution in KSA's energy and environmental policy—from **global oil exporter** to **regional sustainability leader**.

By spearheading the MGI, KSA is:

- **Redefining its influence** in the Arab and Islamic world through climate stewardship,
- Offering **practical tools** for regional resilience,
- And setting an example of **visionary leadership in the Global South**.

As the energy transition accelerates, MGI ensures that KSA remains **at the centre of both climate conversation and regional cooperation**.

291. Identifying Strategic Opportunities for Cross-Border Energy Collaboration

As the global energy landscape evolves toward decarbonization, energy security, and sustainability, **cross-border collaboration** is becoming a strategic imperative. Regional energy integration—whether through **shared infrastructure, joint investments, or policy harmonization**—enhances:

- Grid stability,
- Economic diversification,
- Export potential of low-carbon energy.

For KSA and the wider Middle East, strategic collaboration around **green hydrogen, electricity interconnectors, and green energy corridors** offers a pathway to:

- Monetize abundant renewable resources,
- Support regional resilience,
- And become a **key global supplier of clean energy**.

292. Strategic Drivers of Cross-Border Energy Collaboration

Complementarity of Resources and Demand	• KSA, with its vast solar and wind potential, can produce low-cost green hydrogen and electricity. • Neighbouring countries (e.g., Egypt, Jordan, Iraq) are both emerging producers and growing consumers. • Europe and Asia offer high-demand export markets for green energy, especially as they phase out fossil fuel imports
Economies of Scale and System Efficiency	• Shared energy infrastructure reduces redundancy. • Joint procurement and transmission reduce costs and investment risk. • Enables 24/7 balancing between solar, wind, hydro, and gas systems across countries.
Energy Diplomacy and Regional Stability	• Energy interdependence promotes geopolitical alignment and peacebuilding. • Supports climate cooperation under the Paris Agreement, COP28 follow-ups, and regional green initiatives.

293. Key Strategic Areas for Cross-Border Collaboration

Green Hydrogen Export and Collaboration	KSA is emerging as a hydrogen powerhouse with projects such as: • NEOM Green Hydrogen Project (joint venture with Air Products and ACWA Power) • Planned capacity: 4 GW electrolyser powered by 100% renewables. Cross-Border Opportunities: • Export Agreements: Germany, Japan, South Korea, and the EU have signed MoUs • Hydrogen Pipelines: GCC-level feasibility studies for hydrogen pipelines to UAE, Oman, Bahrain. • Maritime Trade Routes: Development of green ammonia and liquid hydrogen shipping terminals at Yanbu and NEOM. • Technology Cooperation: Joint R&D on electrolysers, hydrogen storage, and safety standards with Asian and European partners.
Electricity Interconnectors and Grid Integration	KSA is at the centre of multiple regional grid integration efforts, including: 1. GCC Interconnection Authority (GCCIA) • Links KSA with Kuwait, Bahrain, Qatar, UAE, and Oman. • Facilitates electricity trade, grid balancing, and emergency backup. 2. Saudi–Jordan–Egypt Interconnector • Transmits surplus electricity from KSA’s west to Egypt’s east. • Enables eventual integration into the Pan-Arab Electricity Market. 3. Saudi–Iraq Grid Interconnection • Aims to enhance Iraq’s grid resilience while creating export pathways for Saudi electricity.
Development of Green Energy Corridors	Green corridors refer to infrastructure and policy platforms that: • Prioritize low-carbon energy flows, • Harmonize regulations and carbon pricing, • Promote green industrial zones near borders. Saudi Opportunities: • NEOM–Jordan–Egypt Green Corridor: Supports electricity export, green ammonia shipments, and sustainable logistics. • Gulf to India Maritime Corridor: Linking Saudi green hydrogen and clean fuels to India via ports like Dammam and Duqm.

294. Enablers for Successful Cross-Border Collaboration

Enabler	Description
Bilateral and Multilateral Agreements	Harmonize energy trade frameworks, grid codes, and environmental standards
Joint Investment Platforms	Use of GCC funds, multilateral banks, and sovereign wealth partnerships
Regional Energy Markets	Piloting electricity trading and hydrogen certification markets (GCC, Pan-Arab)
Technology and Innovation Hubs	Establish shared R&D centres in NEOM, KAUST, and UAE's Masdar
Carbon and Green Certificate Systems	Standardize emissions tracking to support green claims in trade

295. Challenges and Mitigation Strategies

Challenge	Mitigation Strategy
Infrastructure Investment Gaps	Leverage blended finance and public-private partnerships
Regulatory Misalignment	Develop regional coordination platforms and unified standards
Geopolitical Tensions	Use energy diplomacy as a peacebuilding tool and buffer for shared interests
Technical and Grid Stability Risks	Invest in grid modernization, smart control systems, and AI forecasting

296. Implications for KSA - Opportunities:

- Position as the **regional clean energy hub** and mover in green hydrogen exports.
- Monetize renewable overcapacity and reduce curtailment risk.
- Strengthen **regional influence through energy diplomacy**.
- Attract **foreign direct investment** in green manufacturing and transmission.

297. Strategic Alignment with Vision 2030:

- Enhances **economic diversification** through energy sector innovation.
- Supports **energy security, export growth, and climate diplomacy**.
- Advances regional cooperation goals under the **Middle East Green Initiative (MGI)**.

298. Exercise: Stakeholder Mapping – Advancing Energy Transition in Middle East

Context for Participants: Facilitator introduces the concept of **stakeholder mapping** as a tool for strategic planning. The **Power vs. Interest Grid** with four quadrants:

- **High Power–High Interest:** Engage closely (e.g., GCC governments)
- **High Power–Low Interest:** Keep satisfied (e.g., global oil buyers)
- **Low Power–High Interest:** Keep informed (e.g., NGOs, academia)
- **Low Power–Low Interest:** Monitor only

Focus Prompt:

“Who are the key actors shaping energy transition in the region, and what are their interests, influence, and alignment with Saudi goals?”

2. Group Work: Stakeholder Identification

Participants are divided into **small groups**. Each group identifies **10–12 key stakeholders** in the Middle East energy transition. Suggested categories include:

- **Governments:** KSA, UAE, Egypt, Iraq, Jordan, Oman, etc.
- **Regional Organizations:** GCC, OPEC, Arab League, GCCIA
- **National Energy Champions:** Aramco, ACWA Power, Masdar, QatarEnergy
- **Utilities & Regulators:** SEC (Saudi), EWEK (UAE), EETC (Egypt)
- **International Partners:** IRENA, World Bank, UNFCCC, Germany, Japan
- **Investors/Finance:** PIF, Mubadala, sovereign wealth funds, IFC
- **Research & Academia:** KAUST, KAPSARC, Masdar Institute
- **Civil Society:** NGOs, local communities, media influencers

3. Mapping Stakeholders on the Matrix

Each group maps their stakeholders onto the **Power–Interest Grid**, based on consensus. For each stakeholder, participants also annotate:

- **Their specific interest** (e.g., clean hydrogen, energy security, market access)
- **Level of alignment with KSA's Vision 2030 or MGI**
- Any known **conflicts, dependencies, or strategic opportunities**

4. Group Presentations and Peer Feedback

Each group presents 2–3 **key insights** from their stakeholder map, one surprising **risk or opportunity** and a proposed **engagement strategy** for one stakeholder in each quadrant

5. Debrief and Strategic Reflection

- Which stakeholders have **disproportionate influence** (e.g., UAE, IRENA, PIF)?
- Where is KSA well-positioned—and where does it need more **alliance-building**?
- How can stakeholder mapping inform **clean energy diplomacy, project design, or communication strategies**?

Session 5: Integrating Global Forces into Domestic Energy Planning

299. Consolidated Learnings to Inform KSA's National Energy Strategy

1. Geopolitical Awareness Enhances Strategic Agility

KSA must continuously monitor and respond to **shifting global geopolitical dynamics**:

- **OPEC+ leadership** gives KSA leverage but also requires flexibility in coordinating supply strategies amid rising global decarbonization pressures.
- Tensions such as the **Russia–EU gas crisis**, **U.S.–China tech rivalry**, and climate diplomacy at **COP28** affect oil demand, pricing, and investor sentiment.
- KSA's "**energy coexistence**" model—balancing hydrocarbons with clean technologies—offers a **realistic alternative** to zero-fossil fuel narratives.

Strategic Implication: - Embed geopolitical scenario planning into national energy policy formulation. Strengthen diplomatic engagement in energy forums and climate negotiations.

2. Net-Zero and ESG Pressures Require Transparent, Flexible Responses

The global shift toward **net-zero targets**, **ESG standards**, and **climate finance eligibility** demands that KSA:

- Continue **decarbonizing oil production** (e.g., through CCUS and methane management).
- Improve **climate-related disclosures** for Aramco, PIF, and energy-related SOEs.
- Communicate Saudi-specific pathways (e.g., Circular Carbon Economy) that maintain development and security goals.

Strategic Implication: - Adopt a **flexible net-zero positioning** that commits to emissions reduction without compromising economic sovereignty. Ensure all major energy and infrastructure projects meet **international ESG standards**.

3. Global Investment Trends Are Shifting Capital from Fossil Fuels to Clean Energy

KSA must adapt to a **financial landscape increasingly favouring renewables, hydrogen, and ESG-linked investments**:

- Fossil fuel divestment campaigns and green finance tools (e.g., green sukuk, sustainability-linked bonds) are changing capital flows.
- Investors increasingly screen projects based on **transparency, risk, and climate alignment**.

Strategic Implication: - Expand green finance frameworks domestically and align energy projects with **Paris Agreement-compatible investment criteria**. Leverage sovereign funds (e.g., PIF) to lead in green capital deployment.

4. Oil Demand Volatility Reinforces the Need for Diversification

Oil demand is being shaped by:

- **Transport electrification**, energy efficiency, and changing consumption patterns.
- Emerging market dynamics and fossil fuel substitution.

Strategic Implication: - Accelerate investment in **renewable power, green hydrogen, and energy efficiency** to diversify domestic supply and reduce dependence on oil revenues. Focus on **exporting clean energy products** in parallel with petrochemicals and value-added hydrocarbons.

5. Regional Cooperation Offers Strategic Leverage

Through platforms like the [GCC Interconnection Authority \(GCCIA\)](#) and the **Middle East Green Initiative (MGI)**, KSA can:

- **Export renewable electricity** to neighbours.
- Develop **joint hydrogen corridors** and **regional carbon markets**.
- Share **best practices in afforestation, water security, and decarbonization**.

Strategic Implication: - Position KSA as the **regional hub** for low-carbon energy trade and technical cooperation. Expand cross-border interconnectors, harmonize regulations, and promote green diplomacy.

6. Strategic Use of Scenario Planning and Stakeholder Mapping Improves Risk Management

Tools such as:

- **Oil price scenario planning**
- **Stakeholder influence mapping**
- **Futures thinking**

...equip national planners to anticipate disruptions and **build resilient strategies** based on credible foresight.

Strategic Implication: - Institutionalize these tools within ministries and energy agencies to strengthen **strategic foresight**, especially for projects with long-term implications (e.g., NEOM, green hydrogen exports, CCUS infrastructure).

7. Green Export Leadership and Value Chain Development Are Emerging Opportunities

KSA is well-positioned to:

- Become a **leading exporter of green hydrogen**, ammonia, and clean electricity.
- Anchor **regional value chains** in solar, EVs, battery storage, and green steel.

Strategic Implication: - Invest in **green industrial zones, domestic content development, and skills transfer programs** to support these industries and create local employment.

8. National Strategy Must Remain Adaptive, Integrated, and Mission-Driven

The energy transition is **not linear**, and KSA's success depends on an adaptive, learning-based approach that:

- Aligns energy, economic, environmental, and diplomatic strategies.
- Embraces **technology-neutral pathways** (e.g., CCE, hydrogen, digital grids).
- Strengthens **public-private partnerships**, R&D, and global collaboration.

Strategic Implication: - Embed energy transition efforts into a **whole-of-government framework**, linked to Vision 2030 KPIs and regularly updated based on scenario-based reviews and global trends.

300. Summary of National Strategy Recommendations

Strategic Domain	Key Action
Geopolitical Foresight	Incorporate scenario planning and risk mapping into policy cycles
ESG and Finance	Scale green finance and improve disclosure standards
Renewables & Hydrogen	Accelerate project development and export readiness
Regional Integration	Expand interconnectors and MGI cooperation platforms
Domestic Transition	Invest in energy efficiency, EVs, and green industry
Stakeholder Engagement	Build alliances with aligned regional and global actors

301. Leading the Energy Transition on Saudi Terms

KSA has the capital, leadership, and geographic advantage to shape a **strategic, sovereign energy transition** that leverages global trends, enhances regional cooperation, and secures its place as a **leader in clean energy, innovation, and climate diplomacy**. The path forward must be bold, flexible, and aligned with both **Vision 2030's aspirations** and **global sustainability imperatives**.

302. Practical Exercise: The Disruption: Designing Scenarios for KSA's Energy Strategy

Context for Participants: The year is 2030. KSA faces increasing external risks, including:

- Fluctuating global oil prices driven by economic uncertainty and oversupply.
- A new wave of **sanctions targeting Middle Eastern oil exports** due to political unrest in a neighbouring country.
- The EU and G7 have accelerated enforcement of **carbon border adjustment mechanisms (CBAMs)**, penalizing high-emission exports.

Instructions: Divide into teams of 4–6. Each team must:

- **Select Three External Risks** from the following list:
 - Global oil price volatility
 - Diplomatic sanctions or trade embargoes
 - Climate and decarbonization treaties (e.g., Paris Agreement, CBAMs)
 - Accelerated EV adoption globally
 - Renewable energy cost breakthroughs
 - ESG-linked capital flight
- **Construct Two Future Scenarios** for 2035:
 - **Scenario A: Global Alignment with Net-Zero Goals**
 - High enforcement of climate treaties
 - Low oil demand
 - Investor preference for green-only portfolios
 - **Scenario B: Fragmented Global Order**
 - Regional conflict and sanctions
 - High fossil fuel demand in Asia
 - Sluggish decarbonization progress in major economies
- For each scenario, answer the following:
 - **What is the likely impact on KSA's:**
 - Energy exports and revenue
 - Global partnerships and trade access
 - Energy diversification plans
 - ESG positioning and investor sentiment
 - **What mitigation or adaptation strategies should KSA adopt?**
- Present a short summary of:
 - Two main risks and how they affect Saudi strategy
 - A brief strategy roadmap to mitigate each risk

303. Practical Exercise: Translating Geopolitical and Market Knowledge into Actionable Strategic Recommendations

Context for Participants: KSA operates in a world of fluctuating oil demand, rising climate diplomacy, investment pressure, and regional instability. The goal is to **transform awareness into strategic decision-making power**. Participants are split into **small strategy teams (4–5 people)**.

Each team receives a **scenario briefing card** from one of the following categories:

Scenario Card A – Climate-Aligned World

- COP29 results in aggressive fossil fuel financing restrictions.
- Major economies implement border carbon adjustments.
- Saudi renewable projects are gaining visibility, but exports remain fossil dependent.

Scenario Card B – Energy Security Trumps Climate

- Conflict in a major transit corridor (e.g., Strait of Hormuz) disrupts global oil supply.
- Oil prices spike; energy security dominates global policy.
- Clean energy investment stalls outside the EU.

Scenario Card C – Global Green Investment Race

- China and India outpace Western countries in green hydrogen.
- GCC countries begin to compete for green energy market share.
- KSA is seen as technologically strong but diplomatically neutral.

Required: Each team must do the following:

Part 1: Identify Three Strategic Insights

Use your geopolitical and market knowledge to identify three relevant insights from the scenario, for example:

- “Carbon-adjusted trade regimes will erode market access for emissions-intensive exports.”
- “The MENA region is emerging as a competitive hydrogen hub.”
- “Volatile prices may mask deeper structural decline in oil demand.”

Part 2: Develop Strategic Recommendations

For each insight, propose one concrete, high-level recommendation. Examples:

- **Policy:** Introduce a national carbon disclosure framework.
- **Investment:** Scale green hydrogen partnerships with Germany and India.
- **Diplomacy:** Lead an energy security dialogue among OPEC+ and ASEAN countries.
- **Technology:** Expand local R&D funding for solar electrolyzers and smart grid tools.

Step 3 – Present and Defend

Each group presents one insight and one recommendation in a **3-minute strategic pitch** to a simulated **Ministerial Steering Committee** (played by facilitator and peers). They must justify why the insight matters and why their recommendation is timely, feasible, and high impact.