



Navigating the Energy Transition

Aligning Vision. Accelerating Transformation. Leading with
Purpose.

THE 5 KEY GLOBAL DRIVERS OF ENERGY SYSTEM TRANSFORMATION

Powering a secure, sustainable and prosperous future for all.



DECARBONIZATION

Reducing emissions and transitioning to net zero through clean energy, efficiency and innovation for a healthier planet.



DIGITALIZATION

Leveraging data, AI and advanced technologies to optimize operations, enable smart decisions and unlock new value across the energy system.



DECENTRALIZATION

Empowering diverse energy resources and local solutions to enhance resilience, enable consumer choice and support sustainable communities.



ELECTRIFICATION

Shifting to electric solutions across transport, buildings and industry to improve efficiency and reduce emissions.



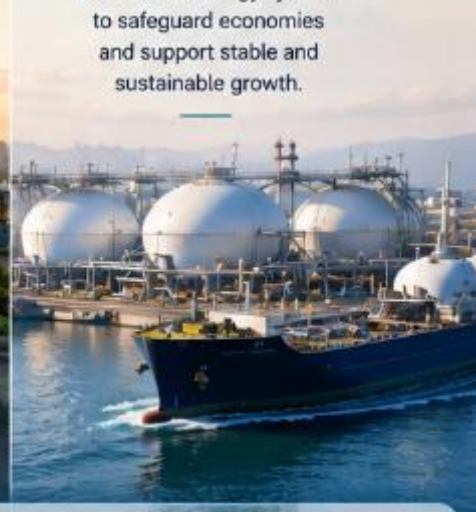
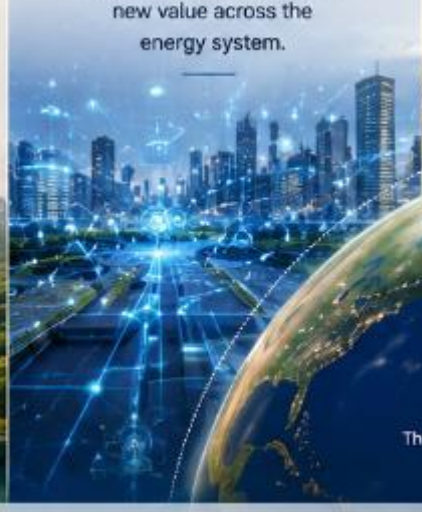
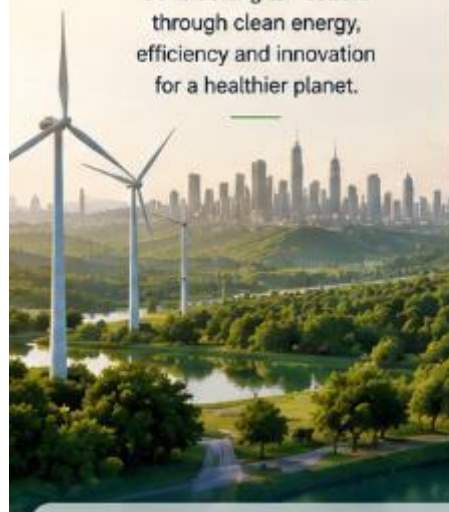
ENERGY SECURITY

Ensuring reliable, affordable and resilient energy systems to safeguard economies and support stable and sustainable growth.



INTERCONNECTED DRIVERS. ONE TRANSFORMATIVE JOURNEY.

These drivers are interdependent and mutually reinforcing. Together, they enable a resilient, inclusive and sustainable energy future.



1. Renewable Deployment

Growing Renewable Capacity

Solar, wind and other renewables are added over time.

2. Grid Integration Capabilities

Transmission & Connection

Reinforces the network and provides connection capacity.

Demand Response

Shifts flexible demand to times of high renewable generation.

Forecasting & System Operations

Improves visibility and enables more efficient system management.

Interconnection & Flexible Capacity

Provides additional flexibility and access to other regions.

Storage Coverage

Absorbs surplus electricity and supplies it when needed.

3. Grid Readiness

Base Grid Readiness

Existing grid infrastructure, transmission and operational capability.

+

Intervention Effect

Combined impact of transmission, demand response, forecasting, interconnection, flexible capacity and storage.

Resulting Grid Readiness

Overall system capability to integrate renewable generation.

4. Energy System Outcomes

Indicative Renewable Curtailment

Share of potential renewable generation that cannot be accepted by the system. Lower is better, but zero is not always optimal.

Integration Pressure

How challenging it is to integrate renewable generation. Higher indicates greater pressure on the system.

System Stress

Overall level of strain on the electricity system. Higher indicates increased operational and reliability risk.

Connection & Flexibility Readiness

Indicate the system's ability to connect, balance and absorb renewable generation.

5. Cleaner, More Secure Energy System

Higher Share of Renewable Electricity

Reduces emissions and diversifies the energy mix.

Reliable System Operation

Maintains stability as renewables grow.

Productive Use of Renewable Generation

More electricity is consumed, shifted, stored or transferred.

Lower Curtailment and System Stress

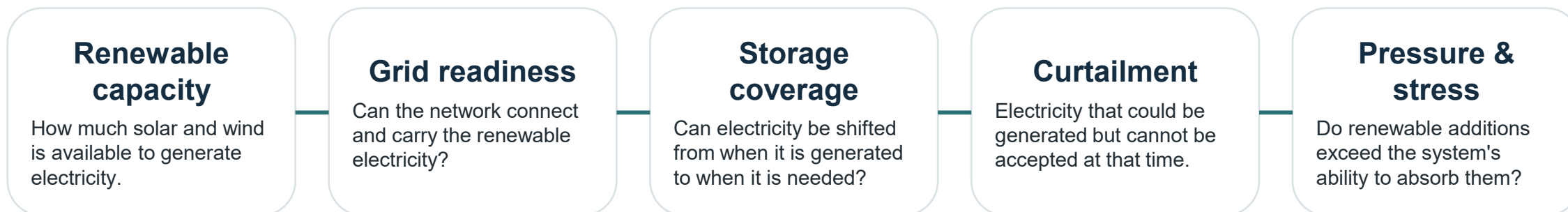
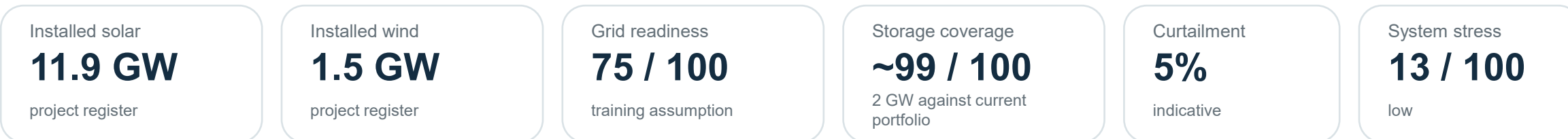
Renewable capacity is integrated more effectively.

Feedback Loop

Insights from system outcomes inform future renewable deployment and grid integration investments.

1. Start with the system we have

First understand the variables before changing them.

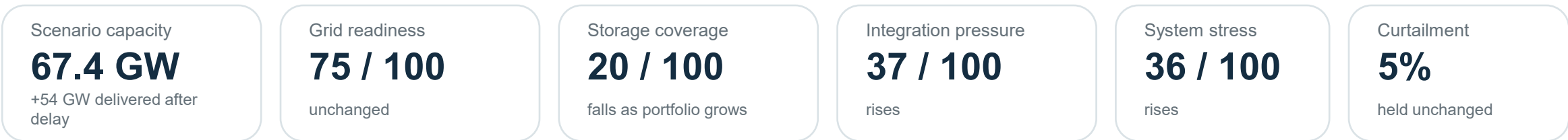


Core idea

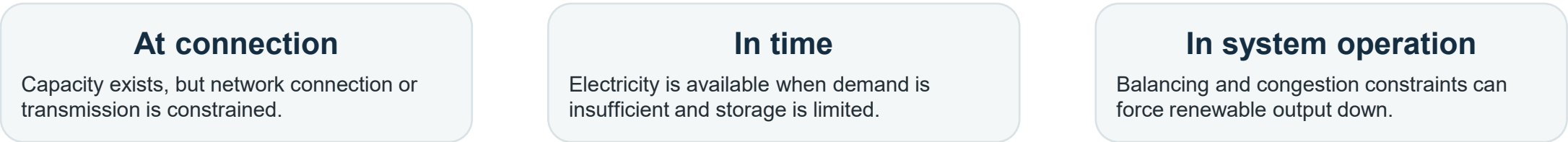
Building renewable capacity is only the first step. Value is realised when the grid can connect it, flexibility can balance it, and demand can absorb it.

2. Add renewable energy — change nothing else

Illustrative step: add 40 GW solar + 20 GW wind; keep grid and storage assumptions unchanged.

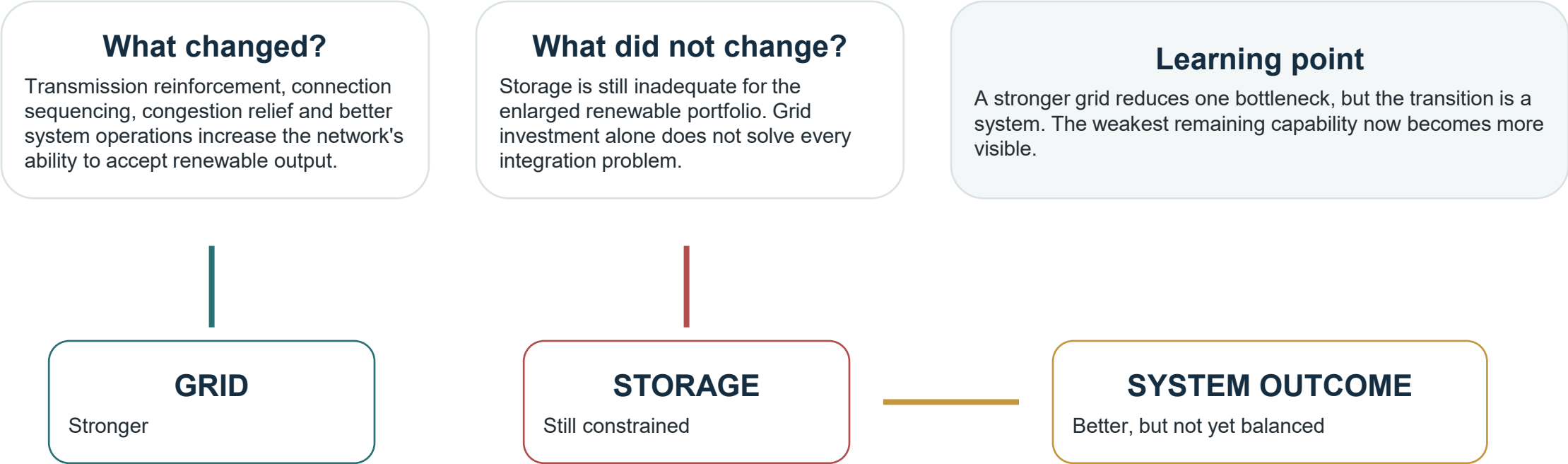


WHERE CAN ENERGY VALUE BE WASTED?



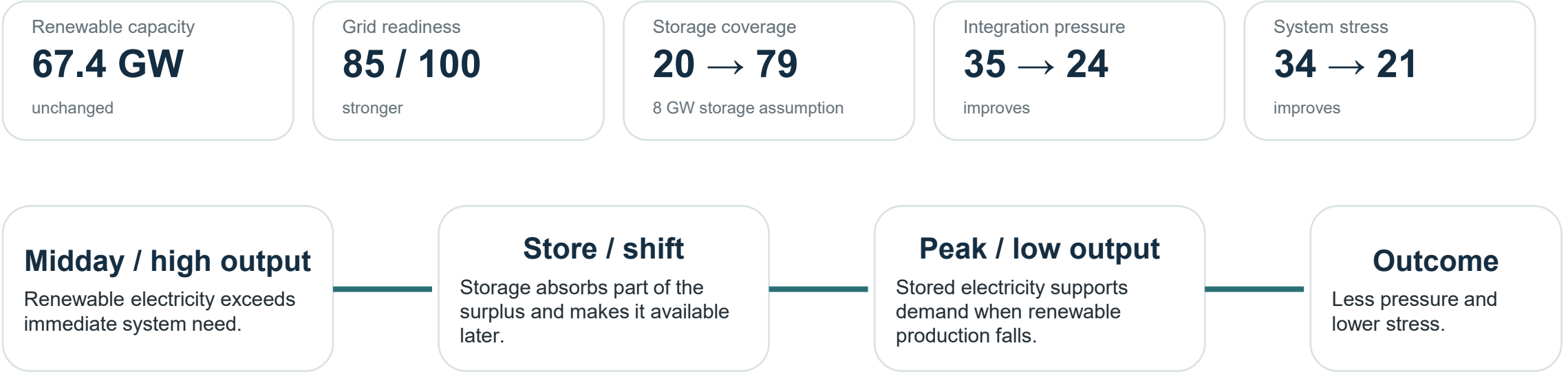
3. Improve grid readiness

Now strengthen transmission, connection capacity and operational readiness.



4. Improve storage coverage

Add flexibility so renewable electricity can be shifted and balanced.

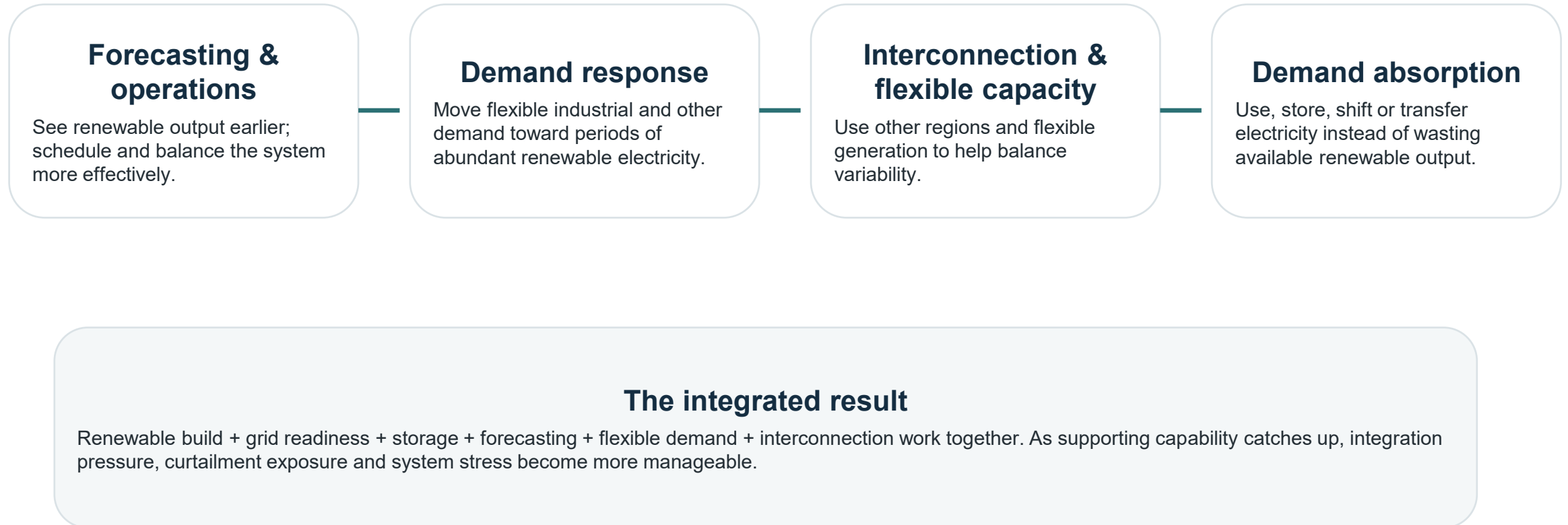


Important

Storage is not 'free energy'. It adds cost. The question is whether the value of reduced curtailment, improved balancing and greater reliability justifies the investment.

5. Continue balancing the system

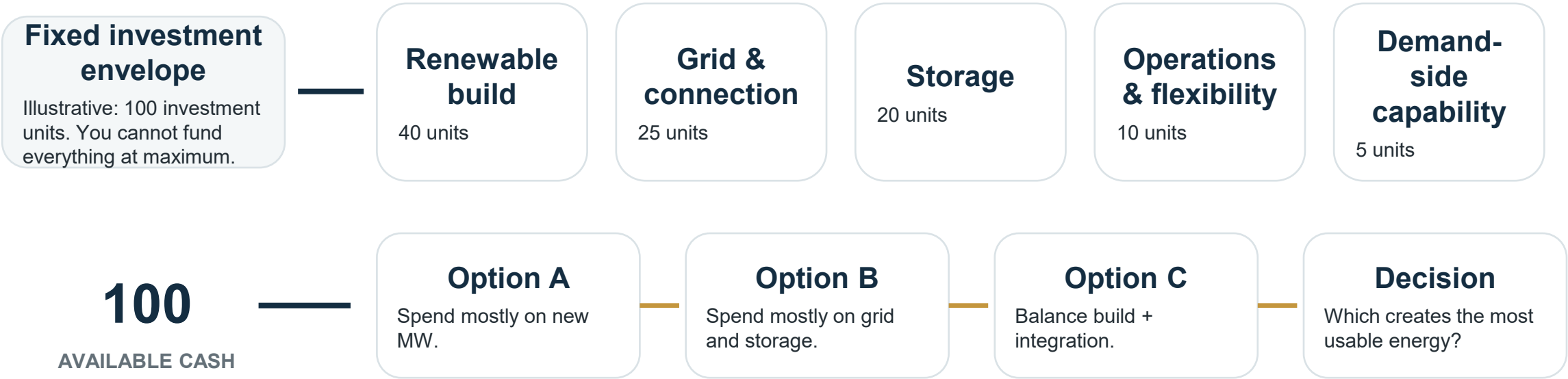
The simulator is about coordinated capability, not maximising one slider.



The objective is not the highest renewable capacity at any cost. It is the highest credible transition value from the available system.

6. Now restrict the cash

A simple classroom decision: the transition has more needs than the available investment envelope.



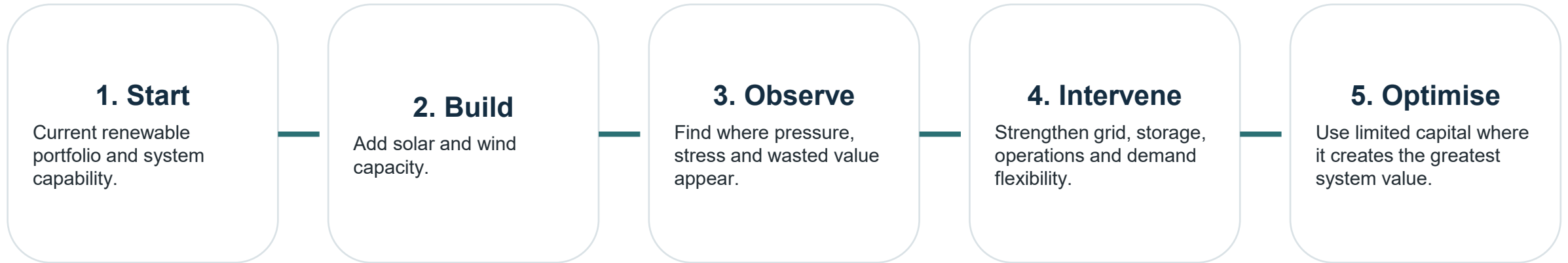
Class challenge

With restricted cash, every additional unit spent on renewable capacity is a unit not spent on connection, storage or flexibility. Teams must decide where the next unit of investment creates the greatest system value.

Illustrative investment units for teaching trade-offs; this is not a Saudi budget or project-cost estimate.

7. What the simulator is teaching

Use the sliders to expose bottlenecks, trade-offs and sequencing decisions.



The question for participants

Can we increase renewable capacity while keeping the electricity system reliable, economically sensible and capable of using the energy we produce?

**CAPACITY → CONNECTION → FLEXIBILITY → ABSORPTION → SYSTEM
VALUE**

PROJECT REGISTER

RENEWABLE PORTFOLIO

2030 PROGRESS

2030 SCENARIO
SIMULATOR

GRID INTEGRATION

PROJECT ECONOMICS

ENERGY TRANSITION
VIEW

SOURCE REGISTER

MODEL ADMINISTRATION

WALKTHROUGH

Selected project

Shuaibah 2

Status

Installed

Capacity

2 060 MW

Indicative delivered energy

2,3 TWh/yr

Transition value score

81/100

STEP 1 · 100/100

**Renewable
project**

Shuaibah 2 · 2 060 MW

Solar PV

Installed · 2024 ·

Shuaibah. Delivery

maturity score 100/100.

STEP 2 · 50/100

Generation

Indicative output 2,3
TWh/yr

Using a 24% capacity
factor, 10% curtailment
and 60% grid-readiness
assumption. Gross
potential is 4,3 TWh/yr.

STEP 3 · 58/100

Grid connection

Connection readiness
58/100

Named location:

Shuaibah. A 2 060 MW
project requires timely
connection capacity,
transmission availability
and congestion
management.

STEP 4 · 84/100

**System
flexibility**

Flexibility readiness
84/100

Current scenario
combines storage
coverage,
forecasting/operational
readiness and
curtailment exposure.
The project creates
more usable value when
balancing resources
develop with capacity.

STEP 5 · 80/100

**Demand
absorption**

Demand absorption
80/100

Output must be
consumed or shifted
when available. Flexible
industrial load,
desalination, storage,
interconnection and—
where economic—
hydrogen can increase
absorption.

STEP 6 · 81/100

**National
outcome**

Transition value
81/100

Indicative training score
combining delivery
maturity, connection,
flexibility, demand
absorption and system
readiness. National
value depends on
reliable delivered
energy, not nameplate
MW alone.

Weakest-link signal: Step 2 — Generation. This is the lowest-scoring part of the selected project's six-step transition chain in the current training scenario. Improve the relevant scenario or Grid Integration assumptions and return here to see the project outcome change.

Gross potential = 4.3 TWh/year

This represents electricity production based on the assumed **24% capacity factor**:

Annual generation = Capacity (GW) × 8,760 hours × Capacity factor

The model then applies two reductions.

1. Curtailment = 10%

Curtailment means some electricity could be generated but cannot be accepted by the system at that time.

$4.3 \times (1 - 10\%) = \mathbf{3.87 \text{ TWh/year}}$

2. Grid readiness = 60%

The current calculation then assumes only 60% of the remaining generation can effectively be integrated/delivered:

$3.87 \times 60\% = \mathbf{2.32 \text{ TWh/year}}$

Rounded:

Indicative output = 2.3 TWh/year

So mathematically the calculation is:

$\mathbf{4.3 \text{ TWh} \times 90\% \times 60\% = 2.32 \text{ TWh/year}}$

The mathematics works, but “**grid readiness = 60%**” should probably not be used as a direct **40% deduction from electricity output**. Grid readiness is a **system capability/readiness indicator**. A grid-readiness score of 60% does not necessarily mean that 40% of the electricity produced will be lost. Doing that risks double-counting the consequences of poor grid integration because **curtailment already represents generation that cannot be absorbed**.

Why does the project's 2,060 MW matter?

A 2,060 MW renewable project represents a very substantial injection of generation at a particular connection point.

The system therefore needs to consider several things simultaneously:

- Is the **physical grid connection** ready when the project is commissioned?
- Is there sufficient **transmission capacity** to move the electricity away from Shuaibah?
- Could high renewable output create **congestion** on parts of the network?
- Is sufficient **flexibility** available when renewable production changes?
- Can the system manage periods when renewable generation is high but local/system demand is lower?
- Are reinforcement, storage, demand response or other interventions required?

The **58/100** is therefore intended as an aggregated training signal representing these types of considerations.

What does 58 actually tell the participant?

I would interpret the scale approximately as:

Score	Interpretation	Meaning
0–39	Low readiness	Significant connection/integration constraints require attention
40–59	Moderate	Connection is feasible but material constraints or dependencies remain
60–79	Good	Most connection requirements are reasonably developed
80–100	Strong	High level of connection and transmission preparedness

Therefore **58/100 sits at the upper end of Moderate.**

What does Flexibility Readiness 84/100 mean?

Flexibility Readiness measures the system's assumed ability to **respond when renewable electricity generation and electricity demand do not perfectly match**.

Renewable generation varies. Solar output changes through the day and with weather conditions; wind generation also varies. The electricity system therefore needs resources capable of responding to these changes.

A score of **84/100 indicates strong modelled flexibility capability**. It does **not** mean that 84% of the project's electricity will be delivered or that 16% will be lost.

What creates the 84/100 score?

The wording says that the indicator combines three factors:

Storage coverage — whether sufficient storage is available to absorb electricity when renewable production exceeds immediate demand and release energy when needed.

Forecasting and operational readiness — how effectively the system can anticipate renewable generation and demand and adjust system operations accordingly.

Curtailement exposure — the extent to which renewable generation may have to be reduced because the system cannot accommodate it.

Conceptually, the relationship is:

More storage + better forecasting/operations + lower curtailement exposure → higher Flexibility Readiness

That creates the potential for a circular relationship:

Curtailement → Flexibility Readiness → Curtailement

A cleaner causal structure would be:

Storage + Demand Response + Forecasting/Operations + Flexible Capacity → Flexibility Readiness

and then:

Grid Readiness + Flexibility Readiness + Renewable Penetration → Curtailement + Integration Pressure + System Stress

Demand Absorption 80/100 is intended to measure the system's ability to **find a productive use for renewable electricity when it is available**, particularly during periods of high solar or wind generation.

A score of **80/100 means strong modelled demand-absorption capability**. It does **not** mean that electricity demand is at 80% of supply or that exactly 80% of the project's electricity will be consumed.

The underlying issue is timing. A solar plant might produce very strongly around midday, but electricity supply and demand have to remain balanced. If normal demand is insufficient at that moment, the system needs other ways to use, shift, store or transfer that electricity. Otherwise, some renewable generation may have to be curtailed.

The items in the description provide those alternative uses. **Flexible industrial loads** can move energy-intensive processes toward periods of abundant electricity. **Desalination** can potentially shift some production to high-generation periods. **Battery/storage systems** absorb electricity now for later use. **Interconnection** can move surplus electricity to other parts of the system or, where arrangements permit, other markets. **Hydrogen production** can convert electricity into an energy carrier, although the qualification "where economic" is important because hydrogen should not automatically be treated as the preferred destination for surplus electricity.

For training purposes, I would interpret the score roughly as **0–39 Low, 40–59 Moderate, 60–79 Good, and 80–100 Strong**. Thus, **80/100 = Strong demand-absorption readiness**. These should be clearly labelled as simulator ranges, not official Saudi grid thresholds.

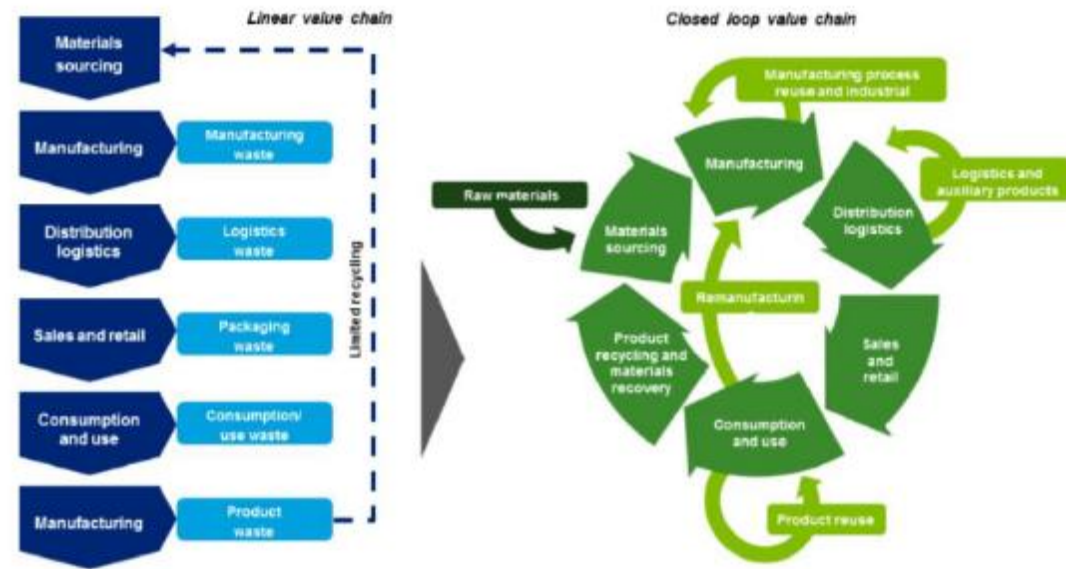


Figure 8. Simplified illustration of a linear and a circular economy³⁰

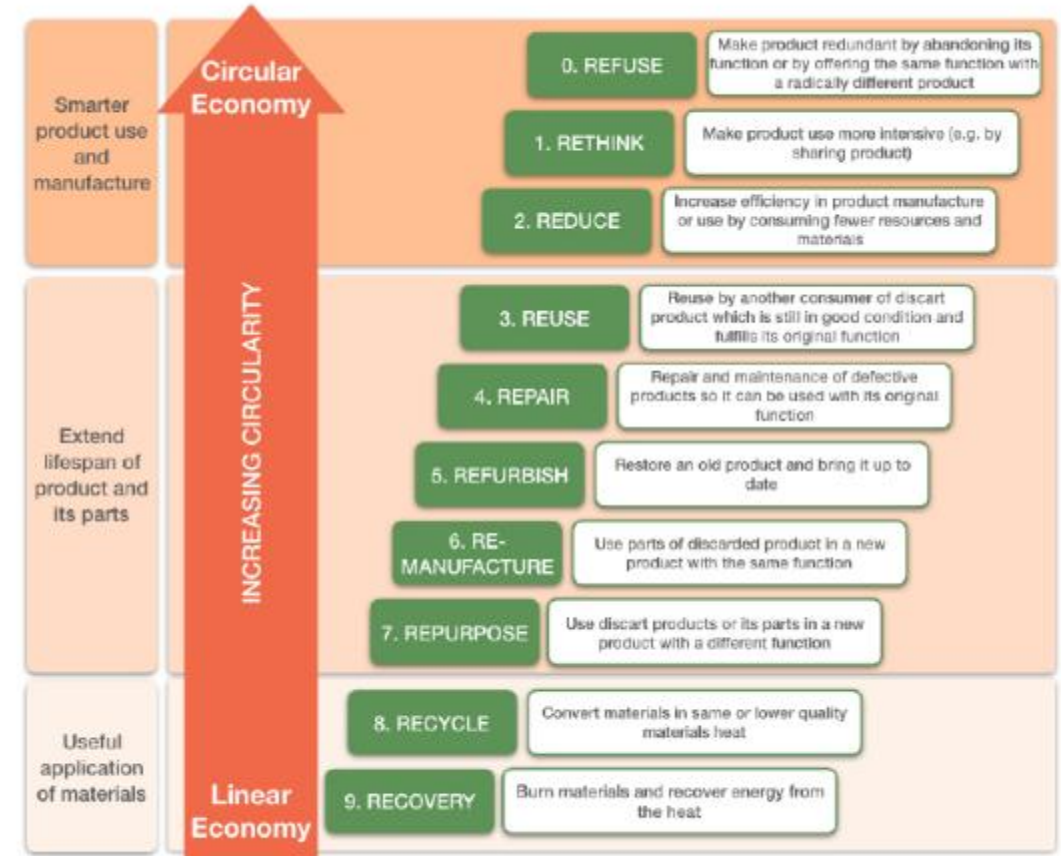


Figure 12. The 9R model for circular economy (Source: Lankester, 2018)

Cultural	Technological	Market	Regulatory
Company culture	Circular design	High upfront investment costs	Obstructing laws and regulations
Willingness to collaborate in the value chain	Ability to deliver high quality remanufactured products	Limited funding for circular business models	Limited circular procurement
Consumer interest and awareness	Lack of data, e.g. on impacts	Low virgin material prices	Lacking global consensus
Operating in a linear system	Too few large scale pilot projects	Standardisation	

■ Most pressing barriers
 ■ Intermediate pressing barriers
 ■ Least pressing barriers

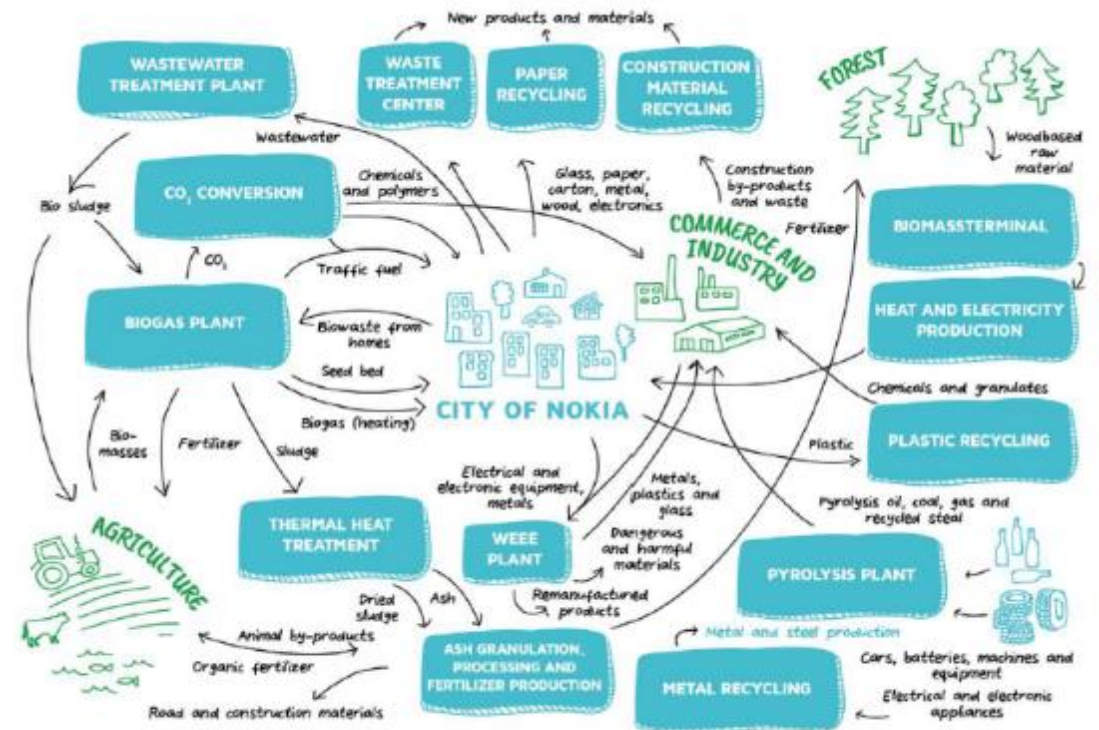


Figure 39. Industrial symbiosis at ECO3. (Source: Nordregio, 2019)

Our Objectives



Attracting investment from both local and global partners to foster sustainable growth.



Leveraging cutting-edge knowledge and technology to champion recycling best practices.



Advancing sustainable development and enhancing the quality of life for communities.



Driving economic growth by creating job opportunities and expanding the recycling sector

Key Pillars of the Circular Economy in KSA

1. Waste Management and Recycling Targets

The Kingdom has committed approximately SAR 100 billion to overhaul its waste management infrastructure by 2035. National benchmarks are moving away from landfilling toward material circularity: [YouTube · Frost & Sullivan](#)

- **2035 Goals:** Divert 85% of industrial waste from landfills, recycle 42% of municipal waste, and compost 35%.
- **Entities Involved:** The [National Center for Waste Management \(MWAN\)](#) acts as the regulatory authority, while SIRC operates large-scale processing and recycling facilities across the country. [Recycling Expo Middle East +2](#)

Economic and Business Impact

- **Economic Growth:** The circular economy push is expected to contribute approximately SAR 120 billion to the national GDP.
- **Job Creation:** The industry transition is slated to create nearly 100,000 new green jobs across various sectors.
- **ESG Compliance:** Industrial and commercial operators are rapidly aligning procurement and vendor practices with these targets to satisfy national ESG reporting requirements. [www.emerald.com +1](#)

ACTIVITY 3: GROUP EXERCISE – MATCHING REAL PROJECTS TO CCE PILLARS

Objective: Reinforce understanding of the four CCE pillars by connecting them to real Saudi initiatives.

INSTRUCTIONS SUMMARY

1 FORM GROUPS



Divide into four groups.
Each group gets 8–10 project cards or this project matrix.

2 TASK



Review project descriptions and match each project to one CCE pillar.

3 GUIDING QUESTIONS



- What is the project's main mechanism for addressing carbon?
- Could a single project fall under multiple pillars?
- What assumptions must be true for this project to succeed?

4 OUTPUT



Create a visual map placing each initiative under the correct pillar and present for 5 minutes.

THE FOUR CCE PILLARS



REDUCE

Reduce emissions at the source through efficiency, clean energy and process improvements.



REUSE

Reuse CO₂ or resources for productive applications and extended value.



RECYCLE

Recycle waste or CO₂ into new materials, fuels or products.



REMOVE

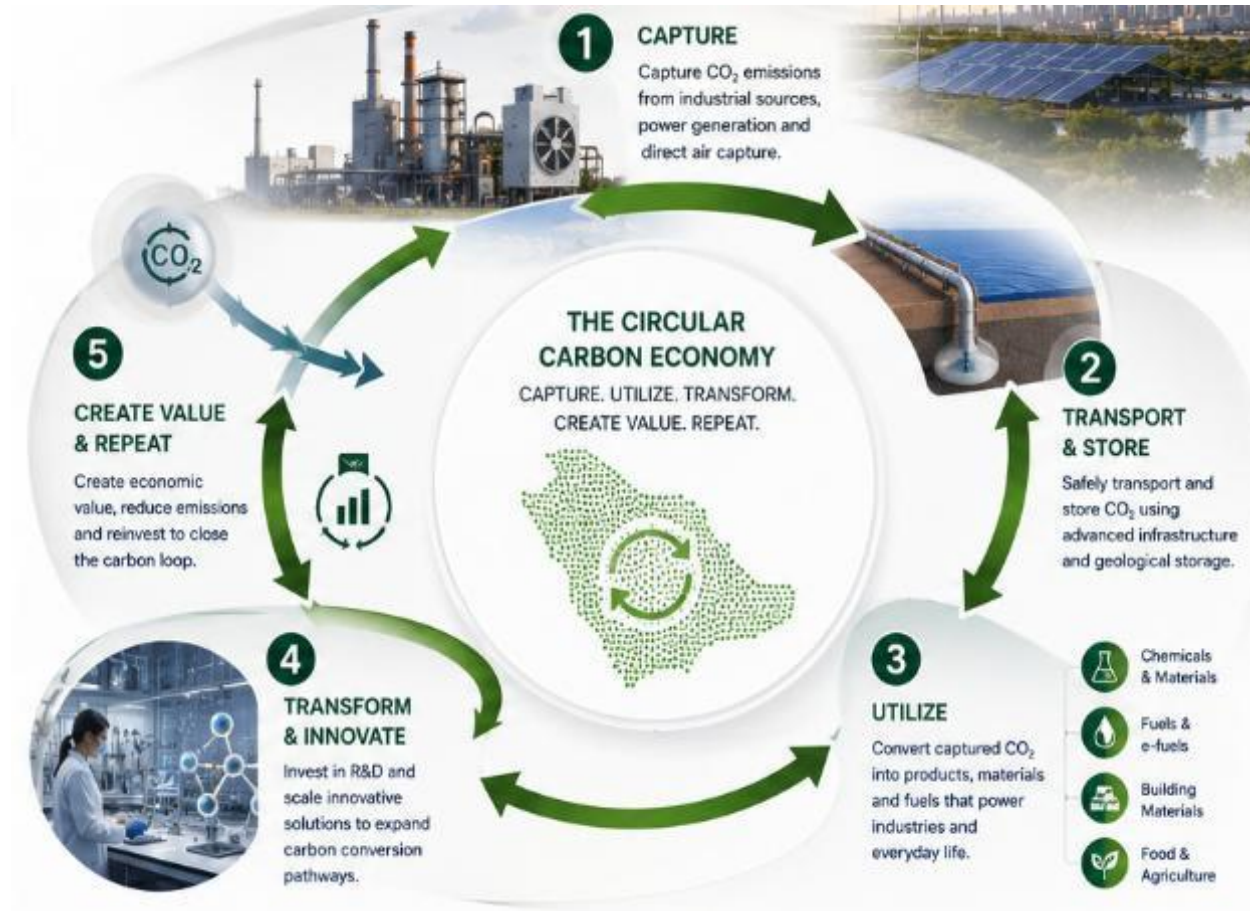
Remove CO₂ from the atmosphere and store it durably in sinks.

PROJECT MATRIX – 9 REALISTIC KSA PROJECTS

#	PROJECT / INITIATIVE	DESCRIPTION	PRIMARY CCE PILLAR (PLACE YOUR MATCH)	WHY THIS PILLAR? (KEY MECHANISM)
1	Sakaka Solar Plant (Al Jouf Province)	Utility-scale solar PV plant supplying electricity to the grid and displacing fossil-fuel generation.	REDUCE	Displaces natural gas/diesel power generation, reducing CO ₂ emissions at the source.
2	Energy Efficiency Program (Buildings & Government)	National program to improve efficiency in public buildings (HVAC, lighting, insulation, controls).	REDUCE	Lowers energy demand and associated emissions through efficiency improvements.
3	Aramco CO ₂ -EOR (Enhanced Oil Recovery)	Inject captured CO ₂ to enhance oil recovery from existing reservoirs.	REUSE	CO ₂ is reused as an input to increase oil production and reservoir performance.
4	NEOM Green Hydrogen for Ammonia	Produce green hydrogen using renewables and use it to make green ammonia for export and local use.	REUSE	Hydrogen (from water) is reused to create ammonia—a zero-carbon energy carrier.
5	Algae-Based CO ₂ -to-Biofuel Research (KAUST)	Use algae to convert captured CO ₂ into biofuels and valuable bioproducts.	RECYCLE	CO ₂ is recycled into fuels and chemicals through biological conversion.
6	Sadara Chemical Recycling Pilot (Plastics to Feedstock)	Convert plastic waste into chemical feedstocks to produce new materials.	RECYCLE	Waste plastics are recycled into usable chemical feedstocks.
7	Aramco CCUS Project at Hawiyah	Capture CO ₂ from gas processing facilities and store it in deep saline aquifers.	REMOVE	CO ₂ is captured and permanently stored underground, removing it from the atmosphere.
8	Saudi Green Initiative – Afforestation & Restoration	Planting 10B trees and restoring degraded lands across the Kingdom.	REMOVE	Trees absorb CO ₂ from the atmosphere and store carbon in biomass and soils.
9	Waste-to-Energy (Riyadh Waste Management Project)	Convert municipal solid waste into electricity and heat through advanced incineration with energy recovery.	REDUCE	Reduces methane from landfills and displaces fossil-based electricity with recovered energy.

CIRCULAR CARBON ECONOMY

Building a sustainable future for Saudi Arabia



CARBON CAPTURE, UTILIZATION & STORAGE (CCUS)

A STRATEGIC ADVANTAGE FOR KSA. A SUSTAINABLE FUTURE FOR THE WORLD.

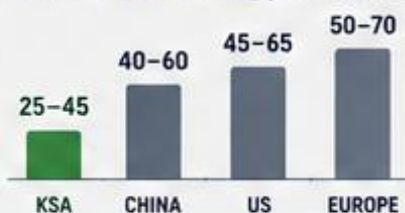
ECONOMIC COMPARISON (2030E)

COUNTRY	ANNOUNCED CAPACITY (Mtpa CO ₂)	EST. COST OF CAPTURE (USD/TON CO ₂)	STORAGE POTENTIAL	POLICY & SUPPORT ENVIRONMENT
UNITED STATES	~ 80	45 – 65	EXCELLENT	STRONG
CHINA	~ 50	40 – 60	MODERATE	STRONG
CANADA	~ 30	45 – 70	EXCELLENT	STRONG
AUSTRALIA	~ 25	45 – 65	EXCELLENT	MODERATE
NORWAY	~ 10	50 – 70	EXCELLENT	STRONG
SAUDI ARABIA (PROJECT PIPELINE)	~8–10	25 – 45	EXCELLENT (LARGE GEOLOGICAL POTENTIAL)	IMPROVING (RAPIDLY ADVANCING)

WHY KSA HAS A COST ADVANTAGE

-  Low-cost energy
-  Large storage potential
-  Centralized CO₂ hubs
-  Proximity to export markets

COST TO CAPTURE CO₂ (USD/TON CO₂)



THE UPSIDE FOR KSA



ECONOMIC OPPORTUNITY

CCUS market potential for KSA

\$50 – \$100B+
by 2035



CO₂ EXPORTS

Export up to

50 – 100 Mtpa CO₂
by 2035 to global markets



INDUSTRIAL COMPETITIVENESS

Enable cleaner production in cement, steel, chemicals & power – protecting jobs and exports



EMISSIONS REDUCTION

Avoid up to

200 – 300 Mt CO₂/yr
by 2035



JOBS & VALUE CREATION

Create

40,000+ high-skilled jobs across the CCUS value chain



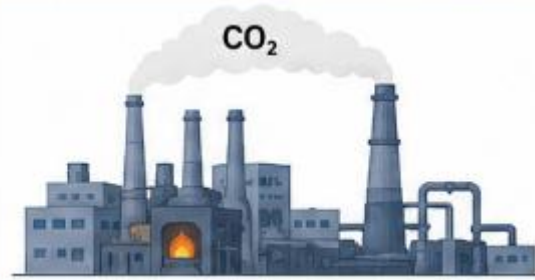
KSA COMPETITIVE ADVANTAGES

- ✓ Abundant energy resources
- ✓ Strategic location between Asia, Europe & Africa
- ✓ Vast storage potential in saline aquifers
- ✓ Existing industrial base & infrastructure
- ✓ Strong government commitment &

HOW CO₂ IS CAPTURED

Capturing today. Securing tomorrow.

1. INDUSTRIAL SOURCES



2. POWER GENERATION



3. DIRECT AIR CAPTURE (DAC)



4. TRANSPORT



OR



OR



5. PERMANENT STORAGE



CO₂ is injected deep underground into suitable geological formations (in depleted oil & gas reservoirs or saline aquifers) for permanent storage.

6. UTILIZATION (OPTIONAL)



E-FUELS



CHEMICALS



BUILDING MATERIALS



BEVERAGES

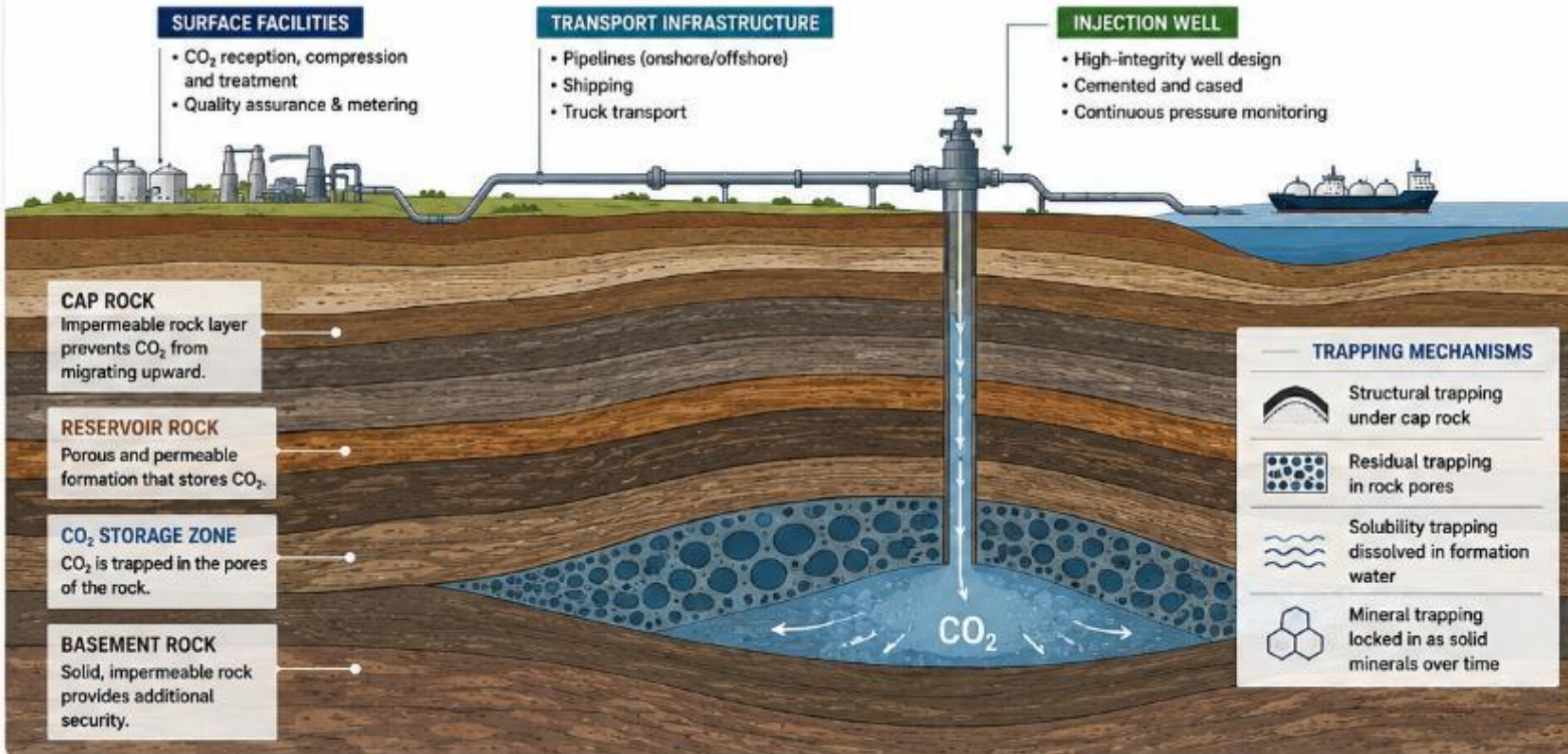


AGRICULTURE

Captured CO₂ can be used as a valuable resource in various industrial and commercial applications.

SAFE CO₂ STORAGE: ADVANCED INFRASTRUCTURE & GEOLOGICAL STORAGE

Capturing today. Storing safely. Protecting tomorrow.



5. MONITORING & VERIFICATION



Seismic surveys track subsurface changes.



Pressure monitoring ensures well and formation integrity.



Groundwater monitoring protects overlying aquifers.



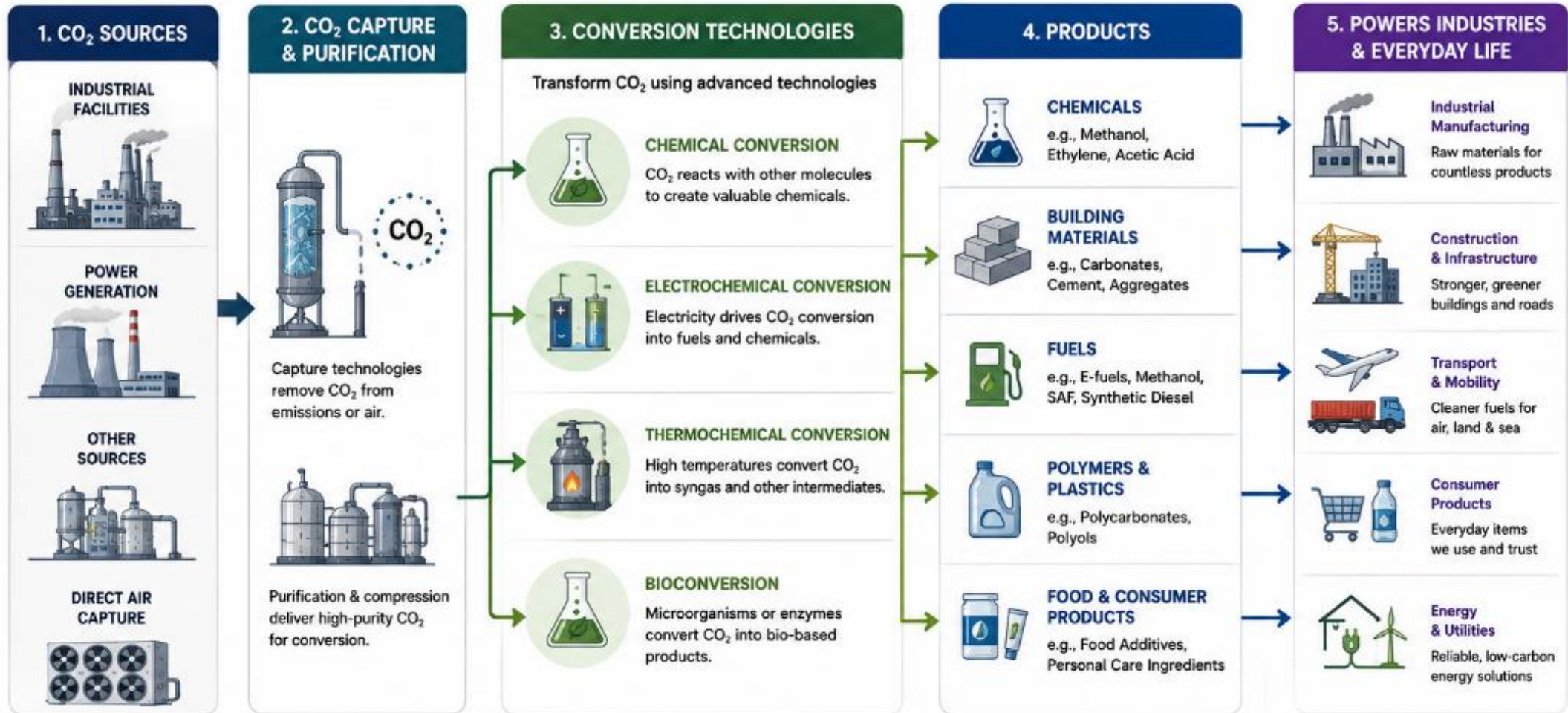
Satellite & surface monitoring for long-term oversight.

6. SAFETY BY DESIGN

- ✓ Site selection & geological assessment
- ✓ Engineered well integrity
- ✓ Robust monitoring & verification
- ✓ Regulatory oversight & reporting
- ✓ Long-term stewardship

TURNING CO₂ INTO SOLUTIONS

From Emissions to Products. Powering Industries and Everyday Life.

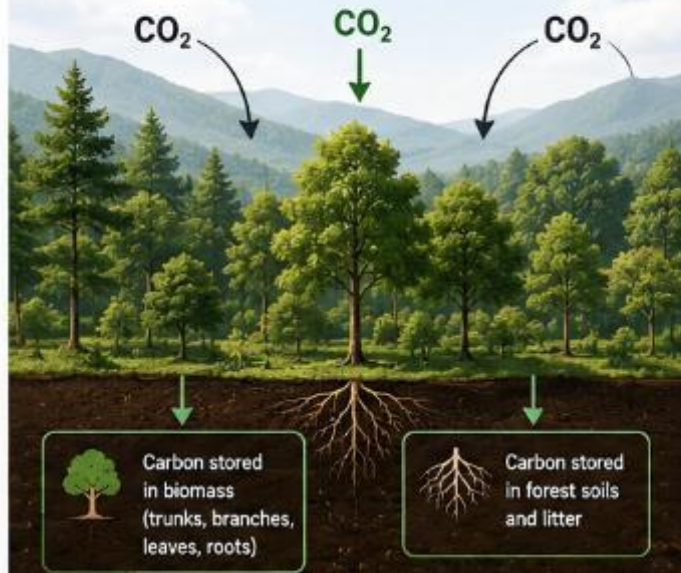


NATURAL SEQUESTRATION: NATURE'S POWER TO STORE CARBON

Afforestation, Soil Carbon and Ocean Sinks – Working Together for a Sustainable Future

1. AFFORESTATION & REFORESTATION

Trees absorb CO₂ from the atmosphere through photosynthesis and store carbon in biomass and soils.

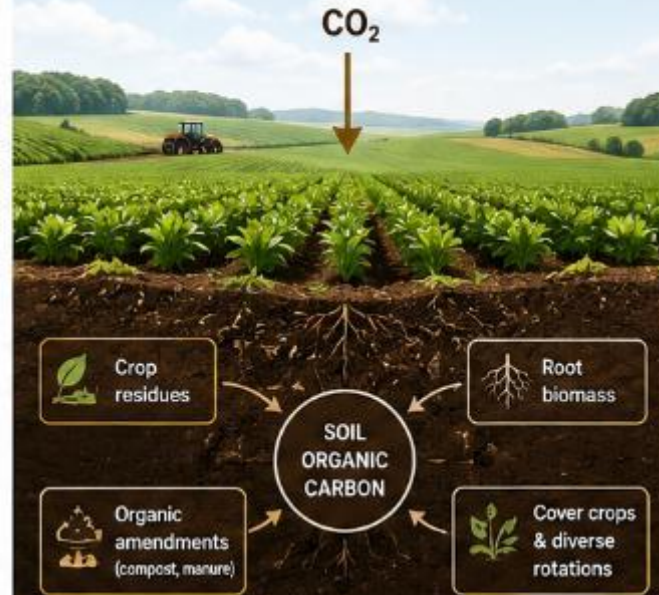


KEY ACTIONS

- Planting new forests
- Restoring degraded lands
- Protecting existing forests
- Promoting native species diversity

2. SOIL CARBON SEQUESTRATION

Healthy soils capture and store CO₂ in organic matter, improving soil health and productivity.

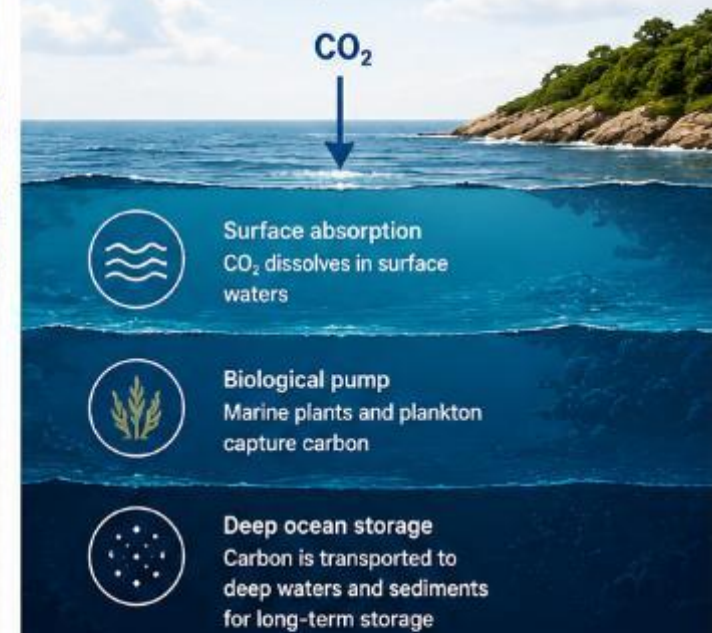


KEY PRACTICES

- Reduced tillage
- Cover cropping
- Organic amendments
- Agroforestry
- Crop rotation
- Managed grazing

3. OCEAN SINKS

Oceans absorb CO₂ from the atmosphere. Carbon is stored in marine biomass and deep ocean waters.



KEY SOLUTIONS

- Protect and restore coastal ecosystems (mangroves, seagrass, salt marshes)
- Support ocean health and productivity

THE 5 KEY GLOBAL DRIVERS OF ENERGY SYSTEM TRANSFORMATION

Powering a secure, sustainable and prosperous future for Saudi Arabia and the world.

Five Drivers. One Transformation.

Different perspectives. Shared responsibility. Better decisions.



DECARBONIZATION

Transitioning to low-carbon energy systems to achieve net zero and protect our planet.



DIGITALIZATION

Leveraging data, AI and advanced technologies to optimize systems, enhance efficiency and enable smarter decisions.



DECENTRALIZATION

Empowering diverse energy resources and local solutions to improve resilience, consumer choice and community participation.



ELECTRIFICATION

Shifting to electric solutions across transport, buildings and industry to improve efficiency and eliminate emissions.



ENERGY SECURITY

Ensuring reliable, affordable and resilient energy systems to safeguard economies, support growth and deliver energy for all.

KA CARE
Operational realities, cost competitiveness and impact on downstream industries.

MINISTER OF ENERGY
National priorities, policy direction and long-term value.

SEEC
Economic efficiency, competitiveness and private sector perspective.

KAPSARC
Evidence-based analysis, modeling and scenario insights for informed decisions.

SERA
Market structure, regulation and fairness in enabling the energy transition.



DIVERSE PERSPECTIVES. STRONGER OUTCOMES.

Let's collaborate to shape the right energy future.

NRRC
Protecting vulnerable groups and ensuring a just and inclusive transition.

TRIGGER QUESTIONS FOR DISCUSSION



DECARBONIZATION

- How can we accelerate decarbonization while maintaining energy affordability and competitiveness?
- What are the highest impact actions to achieve net zero?



DIGITALIZATION

- How can data, AI and digital technologies unlock value across the energy system?
- What are the key enablers for digital trust, cybersecurity and capabilities?



DECENTRALIZATION

- How can we scale decentralized solutions while ensuring reliability and system integration?
- What policies and business models best empower local participation?



ELECTRIFICATION

- Which sectors and applications should we electrify first for the greatest impact?
- How do we build the infrastructure and skills needed to support large-scale electrification?



ENERGY SECURITY

- How do we strengthen energy security in an increasingly complex world?
- What mix of resources, partnerships and resilience measures should we prioritize?

One study found that applying AI-powered digital twin models to [renewable energy facilities](#) could cut unplanned downtime by 35 per cent and increase energy production by 8.5 per cent. It also improved fault detection accuracy by 98 per cent while reducing energy costs by 26 per cent.

Other studies indicate similar efficiencies could be made in other sectors. In agriculture, for example, researchers found that AI could potentially enable large reductions in the power used to [heat greenhouses](#), and [predict energy consumption patterns](#) in irrigation based on factors such as light and heat, allowing farmers to plan watering to minimise energy use.

The differentiator is orchestration. An unprecedented convergence of new technologies—digital twins, quantum computing and physical AI, to name just three — is making possible a fundamentally different kind of organization. How will you translate breakthrough innovations into a tangible business win?

Former US energy secretary Steven Chu once described energy efficiency as “not just low-hanging fruit” but “fruit that is lying on the ground”. Yet despite being cost-effective, this critical method of decarbonisation is widely underused.

The process of identifying where and how energy is wasted is complex and time-consuming, which is why technologies and management practices in this area are not adopted as widely as they could be. Artificial intelligence could now be changing that.

But if complexity is hampering progress on energy efficiency, it is something AI is effective at managing. “AI is really good when you’ve got complex and highly unpredictable data,” says Kimmins.

In factories and other large industrial operations, he explains, sensors attached to every piece of equipment generate large volumes of data that AI can use to identify inefficiencies in equipment or processes.

ARAMCO: PROGRESSING TOWARDS A CIRCULAR CARBON ECONOMY IN KSA



Transforming carbon into value. Powering a more sustainable future.

Aramco is leveraging our scale, technology and partnerships to close the carbon loop—reducing emissions, reusing carbon and creating new opportunities for the Kingdom and the world.

OUR VISION



A Circular Carbon Economy that supports a lower-carbon future while creating value for generations to come.

OUR APPROACH



INNOVATE

Develop and deploy breakthrough technologies to convert and reuse carbon.



COLLABORATE

Partner across industries, government, and academia to scale solutions.



INVEST

Allocate capital to high-impact opportunities that drive the energy transition.



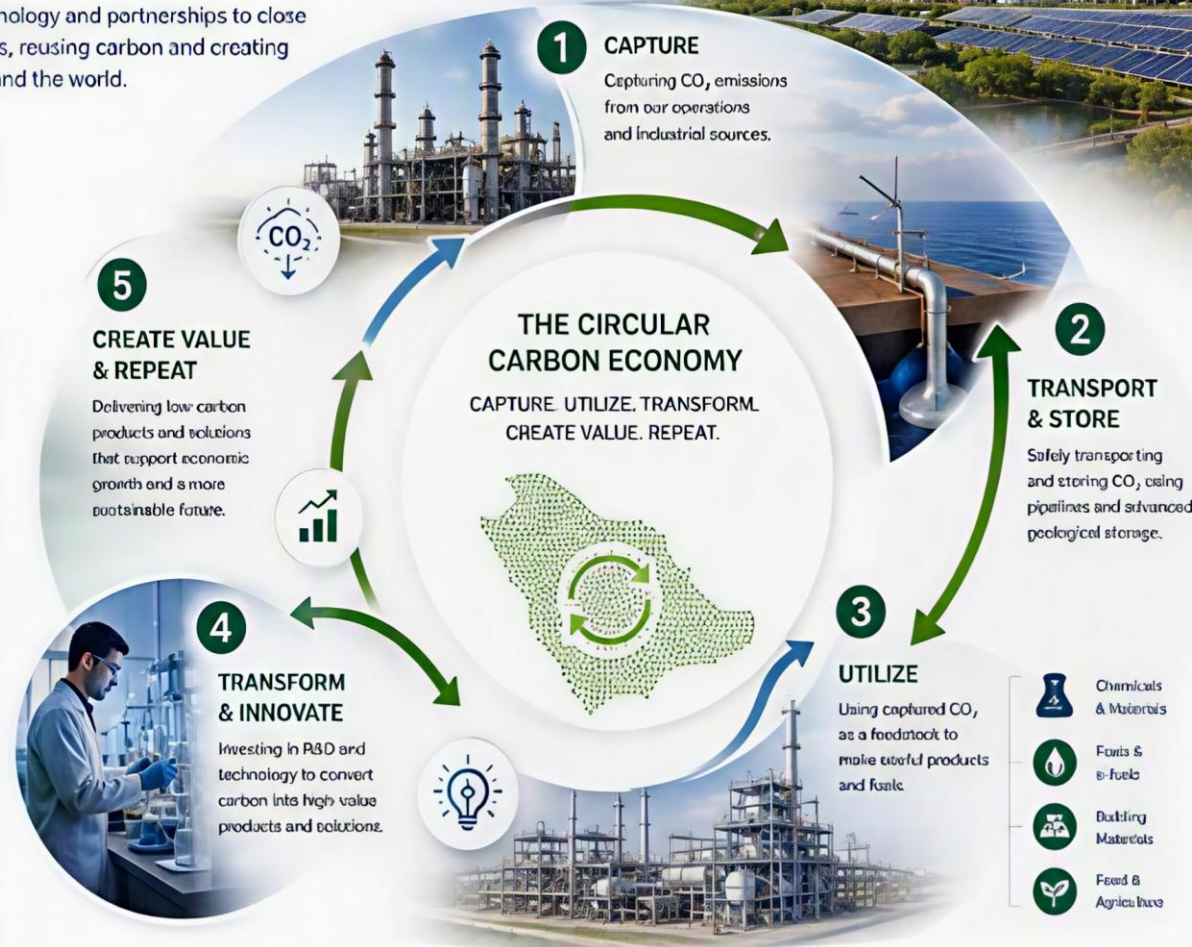
OPERATE RESPONSIBLY

Apply the highest HSE standards and minimize environmental impact.



CREATE VALUE

Turn carbon into products and solutions that benefit people, the economy and this planet.



WHERE WE CREATE VALUE

LOW CARBON FUELS

Lower carbon fuels for transportation, shipping and aviation.



CHEMICALS & MATERIALS

CO₂ based chemicals and polymers for everyday products.



BUILDING A BETTER FUTURE

Low carbon building materials for sustainable infrastructure and cities.



FOOD & AGRICULTURE

Innovative solutions to support food security and sustainable farming.



Chemicals & Materials



Fuels & e-fuels



Building Materials



Food & Agriculture

OUR PROGRESS

OUR COMMITMENT

Advancing Innovation. Acting today.

ARAMCO AND THE CIRCULAR CARBON ECONOMY

Manage carbon through Reduce, Reuse, Recycle and Remove.

Process stage	What happens
1. Capture	Separate CO ₂ from an industrial gas stream.
2. Transport and store	Compress and transport CO ₂ ; inject it into suitable geological formations for permanent storage.
3. Utilise	Use captured CO ₂ as an input where there is a suitable market.
4. Transform and innovate	Develop technologies that convert CO ₂ into useful products.
5. Create value and improve	Measure emissions performance, costs and product demand; improve the next cycle.

How the 4Rs fit

REDUCE

Efficiency, methane control and low-carbon power.

REUSE

Use captured CO₂ directly in suitable processes.

RECYCLE

Convert CO₂ into chemicals or materials.

WHERE WE CREATE VALUE

LOW CARBON FUELS

Lower carbon fuels for transportation, shipping and aviation.



CHEMICALS & MATERIALS

CO₂ based chemicals and polymers for everyday products.



BUILDING A BETTER FUTURE

Low carbon building materials for sustainable infrastructure and cities.



FOOD & AGRICULTURE

Innovative solutions to support food security and sustainable farming.



Examples are illustrative, not a list of confirmed Aramco projects. Carbon benefits depend on lifecycle emissions;

CASE STUDY

NEOM: A GIGA-PROJECT FOR A ZERO-EMISSION FUTURE

A Vision in Action. A Model for the World.

NEOM is Saudi Arabia's giga-project and a living laboratory for sustainability, designed to function as a zero-emission city powered entirely by renewable energy, hydrogen, and smart technologies.



NEOM AT A GLANCE



Population (Target)
1 Million+
by 2030s



100%
Renewable energy
by design



Hydrogen
Key energy carrier
and export



Net Zero
Emissions across all
sectors



AI-Driven City
Smart systems optimize
every resource

1. NEOM: A ZERO-EMISSION CITY OF THE FUTURE

NEOM integrates innovation, sustainability, and circularity to build one of the world's most advanced sustainable urban ecosystems.



Hydrogen-Based Public Transport

FCEV (fuel cell electric vehicles) and hydrogen-powered buses, ferries, and logistics form the backbone of clean mobility.



Zero-Waste Construction

Circular construction practices, modular building, local sourcing, and waste-to-resource systems ensure minimal waste and maximum reuse.



AI to Optimize Energy Flows

Artificial Intelligence and digital twins balance supply and demand in real-time, optimizing energy, water, mobility, and waste systems for maximum efficiency.



Carbon-Neutral Urban Design

Compact design, passive cooling, regenerative landscapes, and nature-positive solutions create a city that enhances biodiversity while staying carbon neutral.



2. SAUDI CCE DIPLOMACY CONTEXT



G20 LEADERSHIP IN 2020

- During its 2020 G20 Presidency, Saudi Arabia championed the Circular Carbon Economy (CCE) agenda.
- The CCE framework was formalized in the G20 Energy Ministers' Communiqué, recognizing its role in achieving energy security, economic growth, and environmental sustainability.
- This was the first time the CCE concept was officially endorsed at the multilateral level.



GLOBAL PARTNERSHIPS & CLIMATE DIPLOMACY

- International Energy Agency (IEA):** Collaborative initiatives on emissions measurement, clean energy transitions, and energy data transparency.
- International Renewable Energy Agency (IRENA):** Partnerships to scale renewable energy, green hydrogen, and capacity building.
- Saudi Arabia's Role:** Bridging producers and consumers, promoting pragmatic solutions, and advocating for a just and inclusive transition through CCE diplomacy.



CCE Diplomacy Mission: Build global trust, enable technology collaboration, and accelerate climate action while safeguarding national development priorities.



3. DISCUSSION PROMPTS FOR PARTICIPANTS



1 How does NEOM integrate multiple CCE pillars simultaneously?

Consider how NEOM uses Reduce, Reuse, Recycle, and Remove in its energy, mobility, construction, and urban design systems.



2 What message does Saudi Arabia send globally by championing the CCE model?

Think about leadership, responsibility, innovation, and the ability to deliver real-world, scalable solutions for climate and development.



3 Can the CCE framework be a "third way" that balances global decarbonization with national sovereignty?

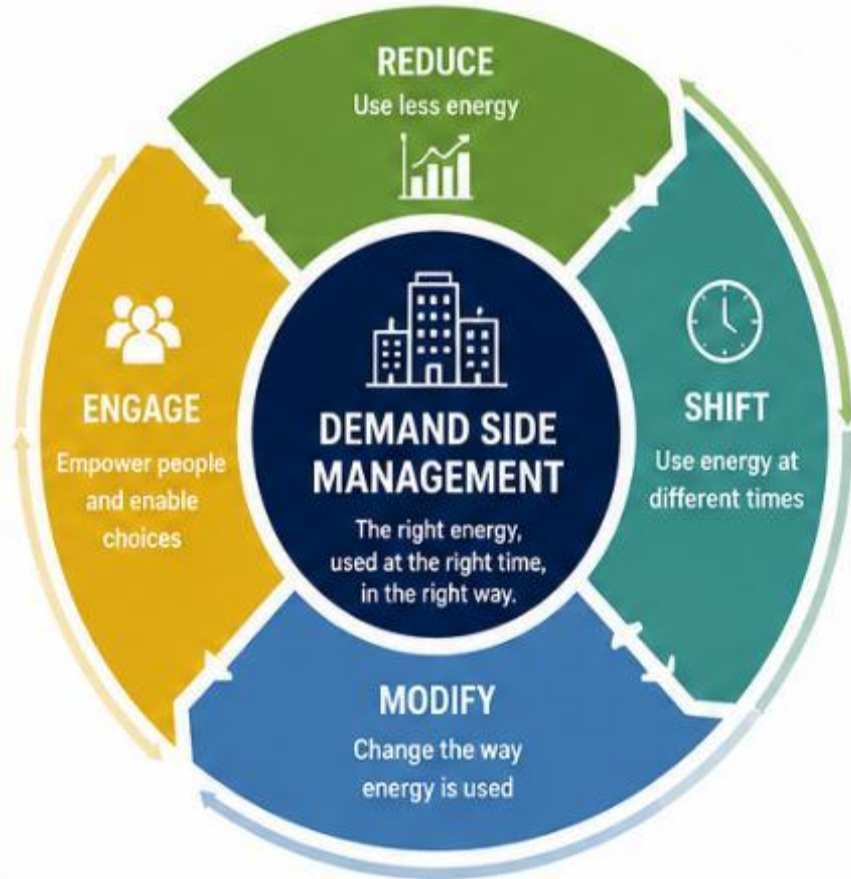
Discuss how CCE supports energy security, economic diversification, and climate goals without compromising national interests.



TAKEAWAY

NEOM demonstrates how the CCE framework turns ambition into action—creating a replicable model for cities, industries, and nations to achieve a sustainable, resilient, and prosperous future.

DEMAND SIDE MANAGEMENT



WHY IT MATTERS

-  Reduces peak demand and overall energy use
-  Lowers energy costs for consumers
-  Defers infrastructure investments
-  Improves grid reliability and resilience
-  Reduces emissions and environmental impact

KEY STRATEGIES & TOOLS

-  **Time-of-Use (TOU) Pricing**
Incentivize lower usage during peak times
-  **Demand Response (DR)**
Adjust or reduce demand in response to incentives or grid needs
-  **Energy Efficiency**
Use efficient equipment and processes to reduce consumption
-  **Smart Controls & Automation**
Optimize energy use with smart thermostats, sensors and controls
-  **Behavioral Change**
Encourage energy-saving behaviors through awareness and feedback

DIGITAL GRIDS AND DEMAND-SIDE MANAGEMENT

SMARTER GRIDS. EMPOWERING CONSUMERS. SUSTAINABLE FUTURE.

VISION 

WHAT ARE DIGITAL GRIDS?

Digital grids leverage advanced technologies, real-time data and automation to monitor, predict and optimize power flows across the network.



Real-time Monitoring

Sensors and IoT devices provide end-to-end visibility.



Advanced Analytics & AI

Forecast demand, detect faults and optimize operations.



Automation & Control

Self-healing networks and automated response to events.



Cybersecurity

Protecting critical infrastructure and customer data.



DEMAND-SIDE MANAGEMENT (DSM)

Empowering consumers to make smarter energy choices and actively manage demand.



Load Shifting

Move energy use to off-peak periods



Demand Response

Incentivize customers to reduce or shift usage during peak times



Energy Efficiency

Use less energy through smarter devices and behaviors



Dynamic Pricing

Price signals that reflect real-time supply and demand



Customer Engagement

Apps and platforms that provide insights and control

DIGITAL GRIDS & DEMAND-SIDE MANAGEMENT

THE IMPACT



Lower Peak Demand



Lower Energy Costs



Reduced Emissions



Improved Reliability



Deferred Investments



A SMARTER, CLEANER, STRONGER ENERGY FUTURE



Enable innovation,
protect consumers
and ensure fairness



Modernize grid,
deploy smart
technologies



Secure, interoperable
and scalable
solutions



Government, industry
and academia working
together



Build skills and
foster a culture of
innovation

DIGITAL GRIDS & DEMAND-SIDE MANAGEMENT

TRIGGER QUESTIONS FOR GROUP DISCUSSION



1 STRATEGIC ALIGNMENT

- How do digital grids and DSM support KSA's Vision 2030, SGI and Net Zero 2060 goals?
- What should be our top 3 strategic priorities over the next 5 years?



2 CONSUMER & SOCIETY

- How can we better engage and empower consumers to participate in DSM?
- What incentives or programs will drive lasting behavior change?



3 TECHNOLOGY & DATA

- What digital technologies and data capabilities will deliver the most value?
- How do we ensure cybersecurity, data privacy and system interoperability?



4 GRID OPERATIONS & FLEXIBILITY

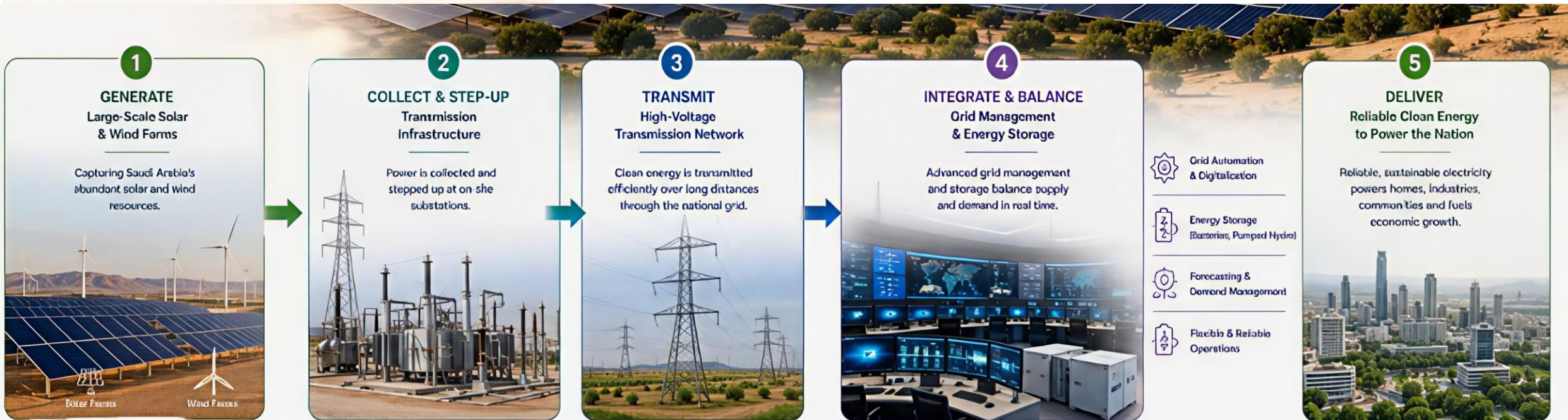
- How can we use digital tools to enhance grid flexibility and reliability?
- What investments are needed to modernize the grid for the future?



5 POLICY, REGULATION & MARKET

- What policy and regulatory changes are needed to enable DSM at scale?
- How can market mechanisms encourage flexibility and innovation?

INTEGRATING LARGE-SCALE SOLAR & WIND ENERGY INTO THE NATIONAL GRID



Ireland just got a bright glimpse of its clean-energy future, and it came from the sky. During a sunny spell, utility-scale solar supplied a record 37.06% of national fuel demand at 2:30 p.m. on May 24, according to Green Collective data cited by Solar Ireland.

That should be great news for households, businesses, and anyone worried about imported fossil fuels. But Solar Ireland is warning that the country may be letting too much clean electricity slip away because grid upgrades, [storage](#), flexibility, and day-to-day system operations are not moving as fast as solar generation itself.

UTILITY-SCALE DISTRIBUTED ENERGY MODELS

Two Approaches. One Goal: Affordable, Reliable, Sustainable Energy for All.

UTILITY-SCALE ENERGY MODEL

Centralized. Large-Scale. Grid-Driven.



Centralized
Generation



High-Voltage
Transmission



Centralized
Grid Operation



One-Way Power
Flow



SCALE & CAPACITY

Large plants deliver power to millions; economies of scale.



RELIABILITY & CONTROL

Proven reliability with established operations and grid management.



COST STRUCTURE

Lower cost per unit at scale; high upfront capital investment.



INFRASTRUCTURE NEEDS

Extensive transmission & distribution networks; long lead times.



FLEXIBILITY

Less flexible; slower to adapt to changing demand and technologies.



RESILIENCE

Vulnerable to single points of failure and extreme events.



ENVIRONMENTAL IMPACT

Can integrate large-scale renewables but needs land and water resources.

VS.

BOTH MODELS ARE IMPORTANT



Energy Security



Affordability



Sustainability



Innovation



Economic Growth



Energy Access

The right mix – today and tomorrow – depends on technology, geography, policy and people.



DISTRIBUTED ENERGY MODEL

Decentralized. Flexible. Customer-Centric.



Distributed
Generation



Energy Storage
& Flexibility



Smart, Local
Grid Management



Two-Way Power
Flow



SCALE & CAPACITY

Modular and scalable; empowers communities and businesses.



RELIABILITY & CONTROL

Local resilience; less impact from centralized outages.



COST STRUCTURE

Lower upfront for small-scale; costs depend on technology mix.



INFRASTRUCTURE NEEDS

Reduced need for long-distance transmission; leverages existing assets.



FLEXIBILITY

Highly flexible; adapts to local needs and new technologies.



RESILIENCE

More resilient; diverse and distributed resources.



ENVIRONMENTAL IMPACT

Enables high renewable penetration and lower local emissions.

TRIGGER QUESTIONS FOR DISCUSSION



STRATEGIC DIRECTION

- What is the optimal balance between utility-scale and distributed models for KSA's future?
- How do these models align with Vision 2030 and Net Zero 2060?



COST & VALUE

- What are the total system costs of each model over the long term?
- How do we ensure affordability while driving innovation?



RELIABILITY & RESILIENCE

- Which model better ensures energy security in the face of climate risks and cyber threats?
- How do we strengthen grid resilience across all regions?



SUSTAINABILITY & ENVIRONMENT

- Which model enables faster decarbonization and higher renewable integration?
- What are the land, water and biodiversity implications?



PEOPLE & COMMUNITIES

- How do we empower communities and create local jobs and industries?
- What skills and capabilities are needed for each transition pathway?



POLICY & REGULATION

- What policies and market designs best support the right mix of both models?
- How do we enable private investment and fair competition?



COLLABORATION & GOVERNANCE

- How can stakeholders collaborate to plan, invest and operate together?
- What data, standards and governance frameworks are needed?

General Electric nuclear reactors. According to Constellation Energy, one of the contractors responsible for the plant, the pair of reactors has an output of 2,646 megawatts, which generated 21,944,000 MWh (megawatt-hours) of electricity in 2025.

Towards the solar energy side, a single solar panel from Tesla that sits right on top of your house generates up to 420 watts of electricity, or about enough to power a small refrigerator.

One megawatt is 1 million watts. So, doing the math, it would take more than 2,380 Tesla solar panels to generate one megawatt of electricity. A single reactor at Peach Bottom makes 1,323 megawatts. That means it would take 3.15 million Tesla solar panels to cover the output of a single nuclear reactor.

Core
components
of a grid
P169

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

Innovation Adoption Lifecycle P174

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

TECHNOLOGY READINESS ACROSS THE ENERGY TRANSITION SPACE

From Innovation to Impact: Building the Technologies of a Sustainable Future



Examples – Adoption Lifecycle P175

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

TECHNOLOGY READINESS LEVEL (TRL) SCALE

AND ITS APPLICATION TO ENERGY INNOVATION

TRL LEVEL	1	2	3	4	5	6	7	8	9
	BASIC PRINCIPLES OBSERVED	TECHNOLOGY CONCEPT FORMULATED	EXPERIMENTAL PROOF OF CONCEPT	TECHNOLOGY VALIDATION IN LAB	TECHNOLOGY VALIDATION IN RELEVANT ENVIRONMENT	TECHNOLOGY DEMONSTRATED IN RELEVANT ENVIRONMENT	SYSTEM PROTOTYPE DEMONSTRATION IN OPERATION	SYSTEM COMPLETE AND QUALIFIED	ACTUAL SYSTEM PROVEN IN OPERATION

KSA READINESS ASSESSMENT FOR KEY ENERGY INNOVATION AREAS							
(Rated on a scale of 1 to 5*)							
INNOVATION AREA	DESCRIPTION	KSA READINESS LEVEL (1-5)					RATING
		1	2	3	4	5	
 SOLAR PV	Utility-scale solar and PV manufacturing, cost reduction, and deployment at scale.	☐	☐	☐	☒	☐	4 Advanced
 WIND ENERGY	Onshore wind deployment and resource assessment.	☐	☐	☒	☐	☐	3 Developing
 GREEN HYDROGEN	Electrolyzer technology, production, infrastructure, and export value chains.	☐	☐	☒	☐	☐	3 Developing
 CARBON CAPTURE, UTILIZATION & STORAGE (CCUS)	Capture technology, infrastructure, storage capacity, and commercialization.	☐	☐	☒	☐	☐	3 Developing
 ENERGY STORAGE (BATTERIES)	Grid-scale storage technologies and integration.	☐	☒	☐	☐	☐	2 Emerging
 SMART GRID & DIGITALIZATION	Grid flexibility, AI/ML, IoT, and digital solutions for energy systems.	☐	☐	☐	☒	☐	4 Advanced
 CIRCULAR CARBON ECONOMY (CCE) SOLUTIONS	Circular carbon technologies, industrial use of CO ₂ , and carbon management.	☐	☐	☒	☐	☐	3 Developing
 NUCLEAR ENERGY	Nuclear power program development and regulatory readiness.	☐	☐	☒	☐	☐	3 Developing
* 1 = Initial / Research 2 = Emerging 3 = Developing 4 = Advanced 5 = Leading / World Class							
 KSA is making strong progress in key technologies, with opportunities to accelerate commercialization and innovation to reach global leadership.							

Aligning TLR's with Adoption Lifecycle P177

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

Challenges P172

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

THE ECONOMIC IMPLICATIONS OF RENEWABLE ENERGY INTEGRATION

Powering Sustainable Growth and Long-Term Prosperity

KEY ECONOMIC BENEFITS



LOWER COST OF ENERGY

Falling costs of solar and wind reduce the levelized cost of electricity, lowering power sector costs over the long term.



ENERGY SECURITY

Reduced reliance on fuel imports and price volatility improves energy security and stabilizes economic planning.



ECONOMIC DIVERSIFICATION

Renewables stimulate new industries, supply chains and investments, reducing dependence on hydrocarbons.



JOB CREATION & HUMAN CAPITAL

Creates quality jobs across manufacturing, construction, operations, and R&D while developing a skilled local workforce.



INNOVATION & TECHNOLOGICAL ADVANCEMENT

Drives innovation, local manufacturing and technology transfer, boosting productivity and competitiveness.



ENVIRONMENTAL & HEALTH SAVINGS

Lower emissions lead to reduced health costs and environmental impact, improving quality of life and productivity.

THE ECONOMIC IMPACT FLOW



MACROECONOMIC IMPACTS



GDP GROWTH

Investment in renewables and related industries boosts GDP and creates multiplier effects across the economy.



FISCAL BENEFITS

Lower fuel costs free up government resources for investment in social programs, infrastructure and innovation.



TRADE BALANCE IMPROVEMENT

Reduced fuel imports improve the trade balance and strengthen external economic resilience.



PRICE STABILITY

Diversified energy mix helps stabilize electricity prices and reduces exposure to global fuel price shocks.



PRIVATE SECTOR INVESTMENT

Clear policies and bankable projects attract domestic and foreign investment and unlock new business opportunities.

COSTS & CONSIDERATIONS



UPFRONT INVESTMENT

High initial capital requirements for renewable projects and grid infrastructure.



GRID & STORAGE NEEDS

Investments in grid flexibility, storage and digitalization are essential for reliability.



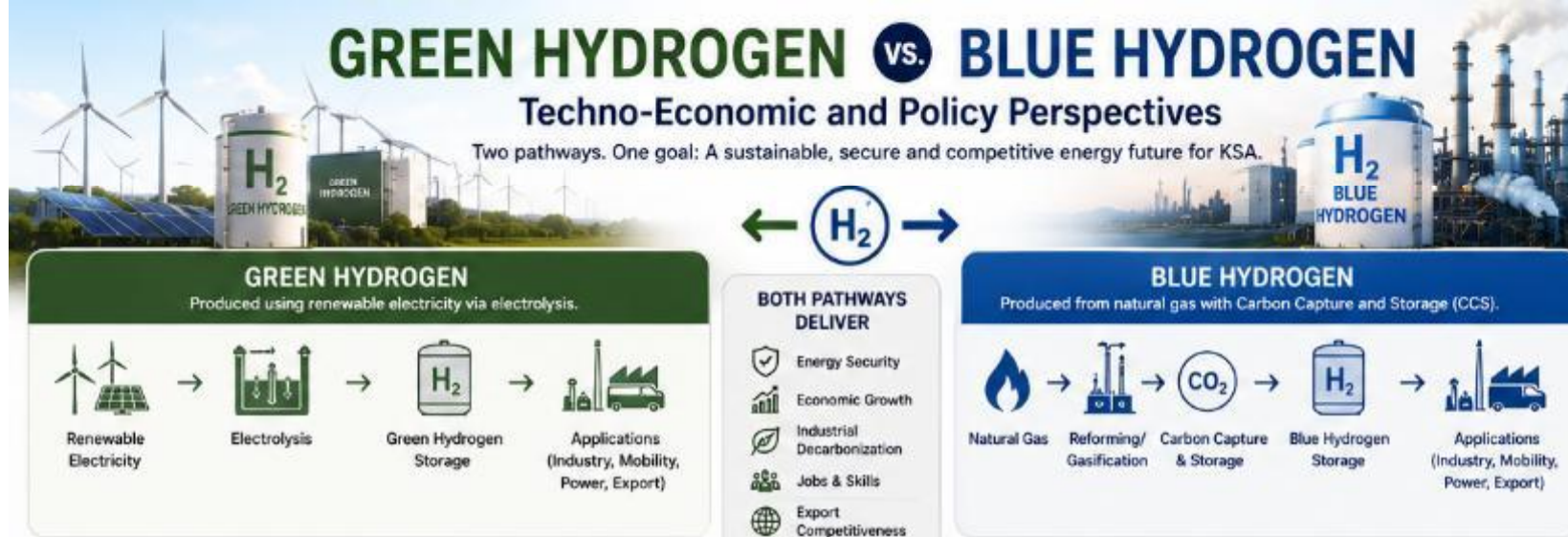
TRANSITION MANAGEMENT

Managing the transition of the workforce and communities dependent on traditional energy sectors.



POLICY & REGULATORY CERTAINTY

Stable policies, clear regulations and long-term visibility are critical to reduce investment risk.



TECHNO-ECONOMIC COMPARISON (INDICATIVE TODAY – WILL E	
Lower (falling with renewable cost decline)	PRODUCTION COST (USD/kg H ₂)
High (electrolyzer CAPEX, renewable, grid)	CAPITAL INTENSITY
Near-zero (operational emissions negligible)	CARBON EMISSIONS
High flexibility with power system; locations need renewable & water	TECHNOLOGY MATURITY
Lowest operational cost (no fuel)	OPERATING COST
Improving; requires scale & supply chain build-out	COMMERCIAL READINESS
Strong long-term decarbonization and export potential	LONG-TERM OUTLOOK

TRIGGER QUESTIONS FOR DISCUSSION



STRATEGIC DIRECTION

- What role should green and blue hydrogen play in KSA's energy transition?
- How do they align with Vision 2030 and Net Zero 2060?



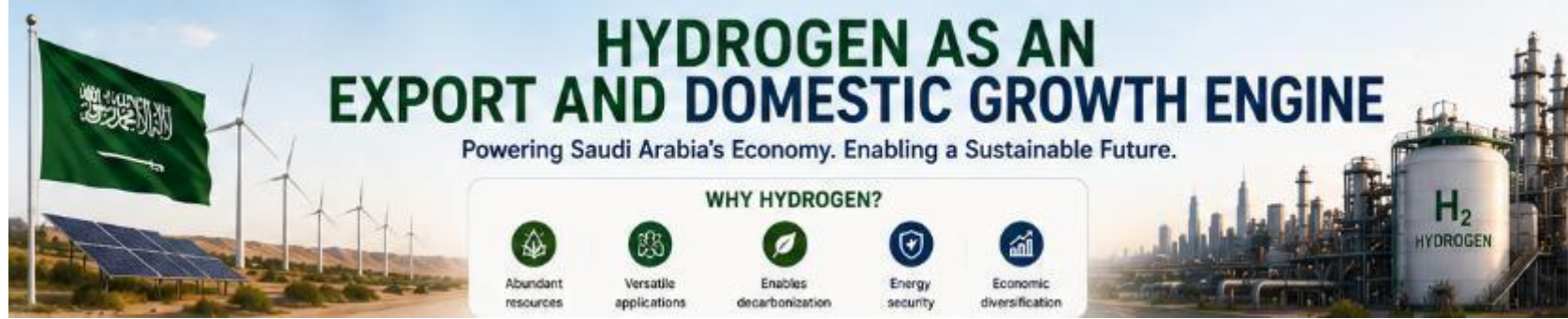
TECHNO-ECONOMIC

- What is the optimal balance between green and blue hydrogen in the near, medium and long term?
- What are the key cost drivers and how can we reduce them?



INFRASTRUCTURE & RESOURCES

- What infrastructure is needed for each pathway (power, gas, CO₂, water, ports)?
- Where should we prioritize investment and why?



HYDROGEN AS AN EXPORT AND DOMESTIC GROWTH ENGINE

Powering Saudi Arabia's Economy. Enabling a Sustainable Future.

WHY HYDROGEN?



Abundant resources



Versatile applications



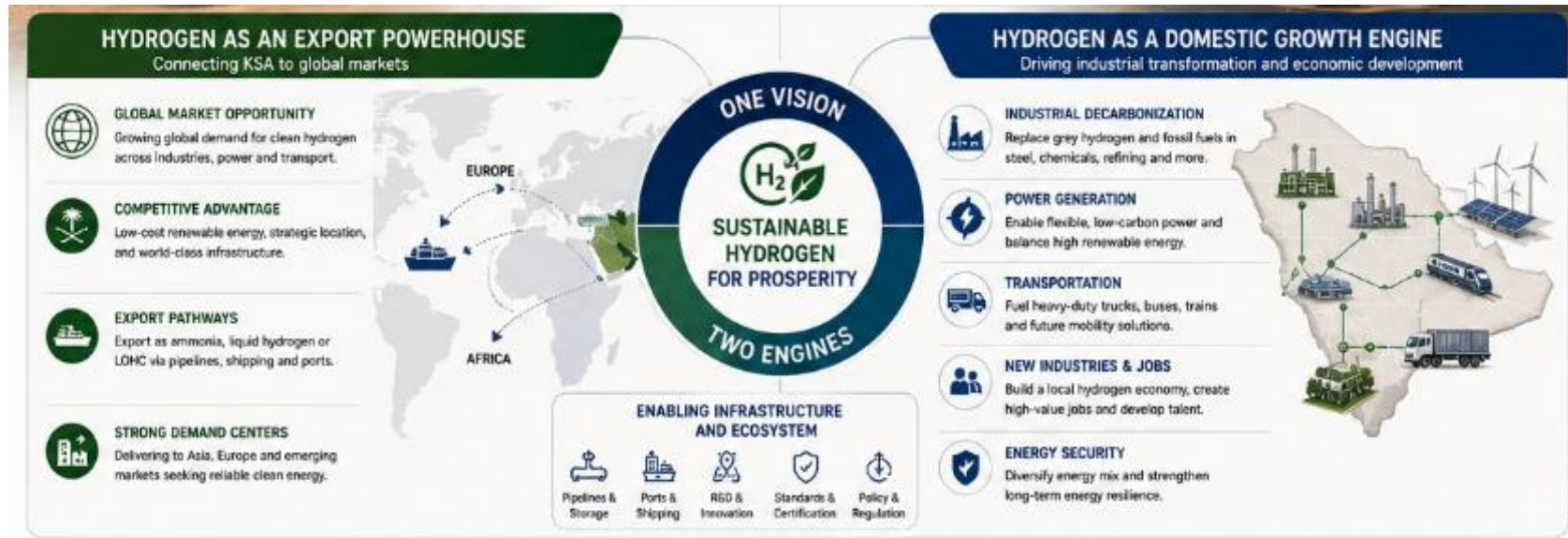
Enables decarbonization



Energy security



Economic diversification



TRIGGER QUESTIONS FOR DISCUSSION



STRATEGIC DIRECTION

- How can hydrogen best support KSA's Vision 2030 and Net Zero 2060 ambitions?
- What role should exports vs. domestic use play in our hydrogen strategy?



MARKETS & COMPETITIVENESS

- Which international markets should we prioritize and why?
- How can we maintain cost leadership and ensure long-term competitiveness?



DOMESTIC VALUE CREATION

- Which sectors should be our first movers for domestic hydrogen use?
- How do we maximize local content, jobs and technology development?



INFRASTRUCTURE & INVESTMENT

- What infrastructure (pipelines, storage, ports) is needed and where should we invest first?
- How can we de-risk investments and attract private capital?



POLICY & REGULATION

- What policies, standards and incentives are needed to scale hydrogen?
- How do we ensure safety, sustainability and clear market signals?



SUSTAINABILITY & IMPACT

- How do we ensure a just transition and community benefits?
- What are the key environmental and water considerations?



COLLABORATION & GOVERNANCE

- How can we strengthen collaboration across government, industry, research and international partners?
- What governance model will best deliver speed, coordination and accountability?

GLOBAL COMPETITIVE HYDROGEN STRATEGIES FOR KSA

Learn. Adapt. Lead. Building a globally competitive hydrogen economy.



ENERGY PRICING REFORM

Balancing Economic Efficiency, Political Realities, and Environmental Goals

Smart pricing today. Sustainable prosperity tomorrow.

ECONOMIC EFFICIENCY

Allocate resources wisely. Drive sustainable growth.



TRUE COST REFLECTION

Align prices with the true cost of supply to promote efficient consumption.



FISCAL SUSTAINABILITY

Reduce government subsidies and reallocate resources to priority sectors like health, education, and infrastructure.



INVESTMENT & COMPETITIVENESS

Attract investment, boost productivity, and enhance the competitiveness of the Saudi economy.



ENERGY EFFICIENCY

Incentivize efficient energy use across households, businesses, and industries.

THE BALANCE WE SEEK

Reforming energy prices is about achieving the right balance for a stronger, fairer, and more sustainable future for Saudi Arabia.



POLITICAL REALITIES

Fair. Inclusive. Managed for long-term success.



SOCIAL EQUITY

Protect vulnerable groups through targeted support and safety nets.



PUBLIC ACCEPTANCE

Engage transparently and communicate the benefits clearly and consistently.



GRADUAL TRANSITION

Implement reforms in phases to ensure stability and build public trust.



STRONG GOVERNANCE

Establish clear policies, regulations, and institutions for effective implementation.

ENVIRONMENTAL GOALS

Price for a cleaner future. Protect our planet.



LOWER EMISSIONS

Price signals reduce consumption and support lower greenhouse gas emissions.



SUPPORT CLEAN ENERGY

Encourage investment in renewables and clean technologies.



RESOURCE CONSERVATION

Promote responsible use of natural resources for future generations.



ALIGN WITH NET ZERO

Support Saudi Arabia's commitment to net zero by 2060.

A PATH FORWARD

Practical steps for effective reform.



ASSESS & ANALYZE 1

Evaluate current subsidies, market impacts, and socioeconomic effects.



DESIGN REFORM 2

Develop a phased pricing strategy with targeted support measures.



COMMUNICATE & ENGAGE

Build public understanding through transparent and consistent communication.



IMPLEMENT GRADUALLY

Roll out reforms in stages with monitoring and feedback.



REINVEST FUTURE 5

Reinvest savings in people, innovation, and clean energy solutions.

THE RESULT

A balanced approach delivering long-term value for Saudi Arabia.



Stronger Economy

Efficient markets and sustainable growth.



Resilient Finances

Reduced fiscal burden and better resource allocation.



Social Benefits

Improved services and protection for those in need.



Cleaner Environment

Lower emissions and a healthier planet.



Sustainable Future

A prosperous Saudi Arabia for generations to come.

ECONOMIC TRADE-OFFS IN ENERGY PRICING REFORM

Balancing Affordability, Efficiency, Growth and Sustainability

Every pricing decision involves trade-offs.

The goal is to balance short-term impacts with long-term value.

LOWER PRICES (Subsidized)

Benefits in the Short Term



AFFORDABILITY

Keeps energy affordable for households and businesses.



SOCIAL STABILITY

Reduces cost-of-living pressure and supports equity.



ECONOMIC SUPPORT

Low energy costs support industries and economic activity in the near term.



POLITICAL ACCEPTABILITY

Easier to implement and maintain in the short run.

THE TRADE-OFF

Finding the right balance for a prosperous and sustainable Saudi Arabia.



HIGHER PRICES (Reformed)

Benefits in the Long Term



ECONOMIC EFFICIENCY

Encourages efficient energy use and reduces waste.



FISCAL SUSTAINABILITY

Reduces subsidy burden and frees up resources for priority investments.



INVESTMENT & INNOVATION

Attracts investment in clean energy, infrastructure and new technologies.



ENVIRONMENTAL BENEFITS

Lower emissions and reduced environmental impact support a sustainable future.

THE PRICING REFORM DILEMMA

Balancing Competing Priorities for a Sustainable Energy Future

One Decision. Many Perspectives. Shared Future.
Let's shape the right balance for Saudi Arabia.



TRIGGER QUESTIONS FOR DISCUSSION



STRATEGIC DIRECTION

- What is the right pace for pricing reform in Saudi Arabia?
- What are our non-negotiables vs. areas of flexibility?
- How do we align pricing reform with Vision 2030 goals?



ECONOMIC IMPACT

- How will different pricing scenarios impact GDP, jobs, and competitiveness?
- What are the implications for industries and SMEs?
- How do we attract investment while reforming prices?



SOCIAL CONSIDERATIONS

- How will pricing changes affect households and vulnerable groups?
- What safety nets or support mechanisms are needed?
- How do we ensure a just and inclusive transition?



FISCAL SUSTAINABILITY

- How can reform reduce fiscal burdens and improve resource allocation?
- How do we balance subsidy reduction with economic stability?
- What is the long-term impact on government finances?



ENVIRONMENTAL & ENERGY TRANSITION

- How does pricing reform accelerate our net zero journey?
- How do we send the right signals for energy efficiency and renewables?
- What are the environmental trade-offs of different approaches?



IMPLEMENTATION & GOVERNANCE

- What regulatory, institutional, and market enablers are required?
- How do we ensure transparency and build trust?
- How do we monitor, evaluate, and adapt over time?

- Egypt has significantly boosted oil production in its Western Desert, increasing output by almost 12,000 barrels per day recently.
- Partnerships with companies like Apache Corporation and Agiba Petroleum have increased daily outputs, with Khalda Petroleum raising production by over 10,000 barrels per day.
- The use of advanced technologies, such as AI and aerial surveys, has contributed to improved efficiency and resource mapping.
- Egypt plans to drill 100 new exploratory wells by 2026, aiming to further increase reserves, bolster long-term energy security, and maintain its role as a leading regional producer.

K.A.CARE - Navigating the Energy Transition Program

Program Schedule Everyday Sunday June 14 through Thursday June 18 from 8:00 a.m. to 2:00 p.m. Lunch from 2:00 p.m. to 3:30 p.m.

DAY 1 (Sunday) Global Energy Landscape and Saudi Vision 2030	DAY 2 (Monday) Policy, Governance and Regulatory Frameworks	DAY 3 (Tuesday) Energy Security and Sustainability	DAY 4 (Wednesday) The Impact of Alternative Energy Technologies	DAY 5 (Thursday) Geopolitics and Market Dynamics
- Review global energy trends and Saudi Arabia's strategic direction. - Examine how the Kingdom's Vision 2030 blueprint drives energy sector transformation. - Link international developments and national ambitions.	- Review the policy and regulatory frameworks governing Saudi Arabia's energy transition. - Navigate policy and regulatory complexity. - Discuss solutions to drive national progress in the energy sector, from renewable energy targets and regulations to climate initiatives like the Saudi Green Initiative (SGI). - Investigate the key public sector stakeholders (regulators, government agencies, etc.) involved in driving the energy transition. - Examine tools used by government (laws, regulations, incentives, tariffs) to shape energy markets. - Understand how effective policy design can encourage renewable energy investment, ensure grid reliability, and protect consumers, thereby creating a sustainable market ecosystem.	- Explore how to balance the Kingdom's need for a reliable, affordable energy supply with sustainability and climate goals. - Review applicable frameworks such as the Circular Carbon Economy and strategies for reducing carbon emissions while maintaining energy security. - Undertake case studies (for example, integrating solar and wind projects into the national grid). - Assess how to manage the trade-offs and synergies between economic and environmental goals.	- Investigate the policy implications of technologies shaping the future of energy. (This includes renewable energy technologies (solar, wind), energy storage solutions, green and blue hydrogen, carbon capture utilization and storage (CCUS), nuclear energy, electric vehicles (EVs), energy storage and other solutions as part of the energy mix.) - Assess how emerging technologies can be integrated into Saudi Arabia's energy portfolio and what challenges and opportunities they bring. - Cultivate an innovative mindset to understand the emerging energy solutions, and technological change in their organizations. (This segment includes global best practices in renewable energy, using a simulation for maximum learning impact. MIT En-Roads and others)	- Analyze external factors influencing the energy transition, including geopolitical developments, international agreements (e.g. the Paris Agreement), global oil and gas market dynamics, and regional cooperation. - Discuss scenarios such as fluctuations in oil demand, investments by other nations in renewable energy, international pressure for decarbonization, and how these affect Saudi energy policy and projects. - Understand big-picture forces supports participants to anticipate risks and leverage opportunities. (This theme reinforces strategic thinking, enabling leaders to factor in global drivers when planning and executing domestic energy initiatives.)

THREE GLOBAL PERSPECTIVES. BETTER POLICIES. STRONGER ENERGY FUTURE.

Leading independent organizations. Trusted data. Actionable insights.

Supporting countries to design effective, sustainable and equitable energy policies.

 IEA International Energy Agency	 IRENA International Renewable Energy Agency	 IPCC Intergovernmental Panel on Climate Change
Secure. Affordable. Sustainable. Together.  FOCUS Energy security, markets, technology, and policy to ensure reliable, affordable and clean energy.  KEY STRENGTHS • In-depth data & market analysis • Short to medium-term outlooks • Policy advice for energy security and economic growth  KEY TOOLS & REPORTS • World Energy Outlook • Energy Policies of IEA Countries • Net Zero by 2050 • Energy Technology Perspectives  SUPPORTS Policy makers in IEA member countries and beyond with practical solutions and best practices.	Renewables for a sustainable energy future.  FOCUS Scaling up renewable energy and supporting the energy transition worldwide.  KEY STRENGTHS • Renewable energy data & statistics • Cost analysis & technology roadmaps • Capacity building & global cooperation  KEY TOOLS & REPORTS • Renewable Capacity Statistics • Global Renewables Outlook • Renewable Power Generation Costs • Energy Transition Outlook  SUPPORTS Governments, industries and partners to accelerate renewable energy deployment and achieve climate goals.	Science for climate action. Evidence for impact.  FOCUS Assessing the scientific basis of climate change, impacts, adaptation and mitigation.  KEY STRENGTHS • Comprehensive climate science • Consensus of thousands of experts • Long-term, policy-relevant insights  KEY TOOLS & REPORTS • Assessment Reports (AR6) • Special Reports (1.5°C, Land, Oceans) • Emissions Scenarios (SSPs) • Climate Data & Indicators  SUPPORTS Policy makers worldwide with the best available science to inform climate policies and global agreements.

IEA EVALUATION OF KSA

Advancing a Secure, Sustainable and Competitive Energy Future

The IEA provides independent analysis and recommendations to support Saudi Arabia in achieving its energy and climate goals under Vision 2030 and Net Zero 2060.

IEA KEY FINDINGS FOR KSA



STRONG FOUNDATIONS

Abundant energy resources, financial strength and ambitious national strategies provide a solid base for transformation.



SYSTEM TRANSFORMATION UNDERWAY

Rapid progress in renewables, hydrogen, and infrastructure development is driving the energy transition.



EMISSIONS & EFFICIENCY OPPORTUNITIES

Greater focus on energy efficiency and industrial emissions abatement can accelerate progress toward Net Zero 2060.



MARKET & REGULATORY ENABLING STEPS

Continued reforms, transparent markets and stronger governance will attract investment and enhance competitiveness.



PEOPLE & SKILLS ARE KEY

Building local capabilities, workforce skills and innovation ecosystems is essential for a just and inclusive transition.

IEA FLAGSHIP REPORTS & TOOLS APPLIED



Energy Policy Review KSA 2024



World Energy Outlook 2024



Net Zero by 2050
A Roadmap for the
Global Energy Sector



Energy Technology
Perspectives 2023



World Energy Balances
& Statistics



KAPSARC
Evidence-based
analysis, scenario
modeling and
policy insights.

COLLABORATIVE DIALOGUE – TURNING INSIGHTS INTO ACTION

IEA RECOMMENDATIONS FOR KSA

- ✓ Accelerate cost-competitive renewables and storage
- ✓ Scale up hydrogen and low-carbon fuels
- ✓ Enhance energy efficiency across all sectors
- ✓ Unlock private sector participation and innovation
- ✓ Strengthen data, monitoring and governance
- ✓ Ensure a just transition and skills development



KA CARE
Operational realities,
cost competitiveness
and impact on
downstream
industries.



MINISTER OF ENERGY
Setting national priorities,
mobilizing investment and
driving cross-sector action.



SEEC
Economic efficiency,
competitiveness and
private sector
enablement.



SERA
Market design,
regulation and
infrastructure for a
reliable transition.



NRRC
Social equity, regional
development and a just
and inclusive transition.

OUR SHARED GOAL
A thriving KSA energy system
that is secure, sustainable
and globally competitive

TRIGGER QUESTIONS FOR DISCUSSION



STRATEGIC DIRECTION

- How should KSA prioritize investments to maximize long-term value and emissions impact?
- What are the most critical actions to achieve Net Zero 2060?



ECONOMIC & COMPETITIVENESS

- How can we enhance the competitiveness of our energy and downstream industries?
- What reforms will best attract private investment and innovation?



MARKETS & REGULATION

- What market designs and regulatory reforms will unlock efficiency and enable new business models?
- How can we balance affordability, reliability and investment signals?



DECARBONIZATION & TECHNOLOGY

- How can we accelerate low-carbon solutions in power, industry and mobility?
- What are the key barriers to scaling hydrogen, CCUS and emerging technologies?



PEOPLE & JUST TRANSITION

- How do we ensure the transition creates quality jobs and supports our communities?
- What skills and capabilities are most needed for the future workforce?



ENERGY SECURITY

- How can we strengthen resilience against global uncertainties and supply risks?
- What role should domestic resources and regional cooperation play?



COLLABORATION & GOVERNANCE

- How can we enhance coordination across institutions and stakeholders?
- What data, transparency and governance improvements are most important?

IRENA EVALUATION OF KSA

Accelerating the Energy Transition with Renewables

IRENA provides data, analysis and recommendations to support Saudi Arabia in unlocking the full potential of renewable energy for a sustainable energy future.



IRENA KEY FINDINGS FOR KSA



ABUNDANT RENEWABLE RESOURCE POTENTIAL
KSA has world-class solar and wind resources that can power economic diversification and decarbonization.



STRONG PROGRESS, GREATER AMBITION NEEDED
Significant renewable capacity additions and targets are in place. Scaling up faster is key to 2030 and beyond.



SYSTEM INTEGRATION IS CRUCIAL
Grid flexibility, storage, demand-side management and regional interconnection are essential to integrate high shares of renewables.



COST COMPETITIVENESS AND INVESTMENT
Renewables are cost-competitive. Stable policies, innovative financing and investor confidence will drive large-scale deployment.



RENEWABLES FOR INDUSTRY & HYDROGEN
Renewables can power green industries and low-carbon hydrogen, creating jobs, exports and value chains.



INCLUSIVE TRANSITION & CAPACITY BUILDING
Value creation are central to a just transition and long-term energy resilience.

IRENA FLAGSHIP REPORTS & TOOLS

-  Renewable Capacity Statistics 2024
-  Renewable Energy Outlook 2024
-  Green Hydrogen Cost Reduction
-  Innovation Outlook
-  Renewable Readiness Assessment
-  Global Atlas for Renewable Energy

COLLABORATIVE DIALOGUE – TURNING INSIGHTS INTO ACTION



TRIGGER QUESTIONS FOR DISCUSSION

- 

STRATEGIC DIRECTION

 - How can KSA accelerate renewable deployment while maximizing economic and social value?
 - What are the most important actions to meet 2030 targets and go beyond?
- 

SYSTEM INTEGRATION

 - What investments are most needed for grid flexibility, storage and digitalization?
 - How can regional interconnection enhance reliability and market opportunities?
- 

INDUSTRY & HYDROGEN

 - How can renewables best support green hydrogen and industrial decarbonization?
 - What policies and incentives will unlock private sector investment?
- 

MARKETS & REGULATION

 - What market and regulatory reforms are needed to integrate high shares of renewables?
 - How can we ensure bankable projects and attract long-term investment?
- 

PEOPLE & JUST TRANSITION

 - How do we build the skills and local capabilities needed for the energy transition?
 - How can we ensure the transition creates quality jobs and is inclusive?
- 

RESILIENCE & SUSTAINABILITY

 - How can renewables strengthen energy security and reduce exposure to global volatility?
 - What are the key risks and how should we manage them?

IPCC KEY FINDINGS RELEVANT TO KSA



CLIMATE IMPACTS ALREADY OBSERVED

- Rising temperatures in KSA are higher than the global average.
- Increasing heat extremes, sea level rise in the Red Sea and Gulf, and water stress.



FUTURE RISKS AT 1.5°C AND 2°C

- Severe heat stress, health impacts and productivity losses increase.
- Critical infrastructure, coastal areas and ecosystems face higher risks.



MITIGATION OPPORTUNITIES

- Rapid emission reductions are feasible and cost-effective.
- Renewables, hydrogen, CCUS and efficiency gains can enable Net Zero pathways.



ADAPTATION IS ESSENTIAL

- Strengthen water security, early warning systems and climate resilient infrastructure.
- Protect vulnerable communities and natural ecosystems.



SUSTAINABLE DEVELOPMENT CO-BENEFITS

- Climate action delivers jobs, cleaner air, energy security and economic diversification.
- Just and inclusive transition is critical.



URGENT ACTION, LIMITED WINDOW

- Every fraction of a degree matters.
- Immediate, integrated action across all sectors is required to secure a livable and prosperous future.

TRIGGER QUESTIONS FOR DISCUSSION



STRATEGIC DIRECTION

- How should KSA align climate action with Vision 2030 and Net Zero 2060?
- What are the highest impact, near-term actions to reduce climate risks and seize opportunities?



MITIGATION & TRANSFORMATION

- Which sectors should prioritize deep emission reductions and why?
- How can we scale renewables, hydrogen and CCUS cost-effectively?



ADAPTATION & RESILIENCE

- What are the most critical climate risks for KSA's water, cities, coasts and ecosystems?
- How can we strengthen resilience and early warning systems?



JUST TRANSITION & PEOPLE

- How do we ensure a just transition that creates quality jobs and supports communities?
- What skills and capabilities are needed for the future workforce?



FINANCE & INVESTMENT

- What policy and financial instruments can unlock private investment at scale?
- How can we align incentives for long-term, low-carbon development?



DATA, SCIENCE & GOVERNANCE

- How can we improve climate data, research and transparency to inform decisions?
- What governance and partnerships will drive coordinated action?

IPCC ASSESSMENT REPORTS & TOOLS



AR6 WGI
The Physical Science Basis



AR6 WGII
Impacts, Adaptation and Vulnerability



AR6 WGIII
Mitigation of Climate Change



AR6 Synthesis Report
Integrated findings and policy relevance



Special Reports
(1.5°C, Ocean & Cryosphere, etc.)



KAPSARC
Evidence-based analysis, scenario modeling and policy insights.

COLLABORATIVE DIALOGUE – TURNING SCIENCE INTO ACTION



KA CARE
Operational realities, cost competitiveness and impact on downstream industries.

IPCC INSIGHTS FOR KSA

- ✓ Deepen emission reductions in energy, industry and transport
- ✓ Scale up zero and low-carbon solutions (renewables, hydrogen, CCUS)
- ✓ Build climate resilience for water, food, health and ecosystems
- ✓ Invest in data, research and innovation for informed decisions
- ✓ Ensure a just transition that leaves no one behind
- ✓ Enhance regional and global collaboration on climate action

SEEC

Economic efficiency, competitiveness and private sector enablement.



SERA
Market design, regulation and infrastructure to accelerate the energy transition.



NRRC
Social equity, regional development and a just and inclusive transition.

KSA'S NET ZERO BY 2060 PLEDGE

POWERING PROSPERITY. PROTECTING THE PLANET.

OUR PLEDGE: Achieve Net Zero Greenhouse Gas Emissions by 2060



Reduce emissions
to net zero by 2060



Drive economic
growth and jobs



Enhance energy
security



Protect the
environment



Contribute to global
climate goals

VISION
2030
KINGDOM OF SAUDI ARABIA

A THRIVING ECONOMY.
A VIBRANT SOCIETY.
AN AMBITIOUS NATION.



CCUS: A CRITICAL ENABLER ON OUR PATH TO NET ZERO

DECARBONIZING INDUSTRY WITH CCUS

CCUS is essential to abate emissions from hard-to-abate industries while sustaining economic growth.



Cement



Steel



Chemicals



Refining &
Petrochemicals



Mining &
Minerals

HOW CCUS WORKS



CAPTURE

Capture CO₂
at industrial
sources



TRANSPORT

Transport CO₂
via pipeline, ship
or truck



UTILIZATION

Use CO₂ to create
valuable products
and fuels



STORAGE

Store CO₂
safely and
permanently



SCALING LOW-CARBON FUELS WITH CCUS

CCUS enables the production of low-carbon fuels to meet domestic demand and drive global energy transition.



Low-carbon
Hydrogen



Low-carbon
Ammonia



Sustainable
Aviation Fuel



e-Fuels &
Synfuels



Low-carbon
LNG

PATHWAY TO LOW-CARBON FUELS



CLEAN ENERGY

Renewables power
electrolysis or low-carbon
processes



PRODUCTION

Produce low-carbon
fuels with CCUS



DELIVERY

Deliver to global
markets



IMPACT

Lower lifecycle
emissions

CCUS AT SCALE THE GAME CHANGER



Up to 278 MtCO₂/yr
of emissions abatement
potential by 2050¹



Multiple CO₂ storage
hubs across the Kingdom
with multi-billion tonne
storage potential



Extensive pipeline
network connecting
sources to sinks
and markets

CCUS IS THE BRIDGE BETWEEN TODAY'S REALITIES AND
TOMORROW'S NET ZERO FUTURE.

VISION
2060
رؤية
NET ZERO EMISSIONS



ENABLERS
OF SUCCESS



STRONG POLICY
AND REGULATION

Enabling framework,
clear standards
and long-term
policy certainty



INVESTMENT
AND INCENTIVES

Attract capital through
incentives, funding
and risk mitigation



INFRASTRUCTURE
AND CLUSTERS

Build CO₂ transport
and storage infrastructure
and industrial clusters



INNOVATION
AND R&D

Advance technologies
to improve efficiency
and reduce costs



PARTNERSHIPS
AND COLLABORATION

Work with industry,
academia and global
partners



TALENT AND
CAPABILITIES

Develop skills and
capabilities for a
low-carbon future



IMPACT
FOR KSA

- ✓ Net zero emissions by 2060
- ✓ Competitive, diversified economy
- ✓ Energy security and resilience
- ✓ Global leadership in CCUS and low-carbon fuels
- ✓ A sustainable future for generations to come

KSA'S NUCLEAR GOVERNANCE

SAFE. SECURE. SUSTAINABLE. FOR A PROSPEROUS FUTURE.

Kingdom of Saudi Arabia is committed to the highest standards of nuclear safety, security, non-proliferation and transparency in the development and operation of nuclear energy for peaceful purposes.



OUR COMMITMENT



Protect people and the environment



Ensure national security and non-proliferation



Uphold strong regulation and independent oversight



Build national capabilities and human capital



PRINCIPLES OF KSA NUCLEAR GOVERNANCE



Safety First



Security Always



Compliance with International Obligations



Independence and Accountability



Transparency and Public Confidence



Sustainability and Long-term Value

1. GOVERNANCE FRAMEWORK



National Policy

Nuclear energy for peaceful purposes to support sustainable development and diversification in line with Vision 2030.



Legal & Regulatory Basis

Comprehensive legal framework aligned with international conventions, IAEA standards and best practices.



Institutional Structure

Clear roles and responsibilities across government entities with separation of functions between promotion and regulation.

2. KEY GOVERNANCE ENTITIES & ROLES



MINISTRY OF ENERGY

Overall policy, strategy and program oversight.



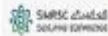
KING ABDULLAH CITY FOR ATOMIC AND RENEWABLE ENERGY (K.A.CARE)

Program implementation, project management, industry development and human capital.



NUCLEAR REGULATORY COMMISSION (NRC)

Independent regulator responsible for safety, security, safeguards and environmental protection.



SAUDI NUCLEAR AND RADIOLOGICAL SAFETY COMMISSION (SNRSC)

Radiation protection, nuclear safety, emergency preparedness and response.



NATIONAL NUCLEAR SECURITY AUTHORITY

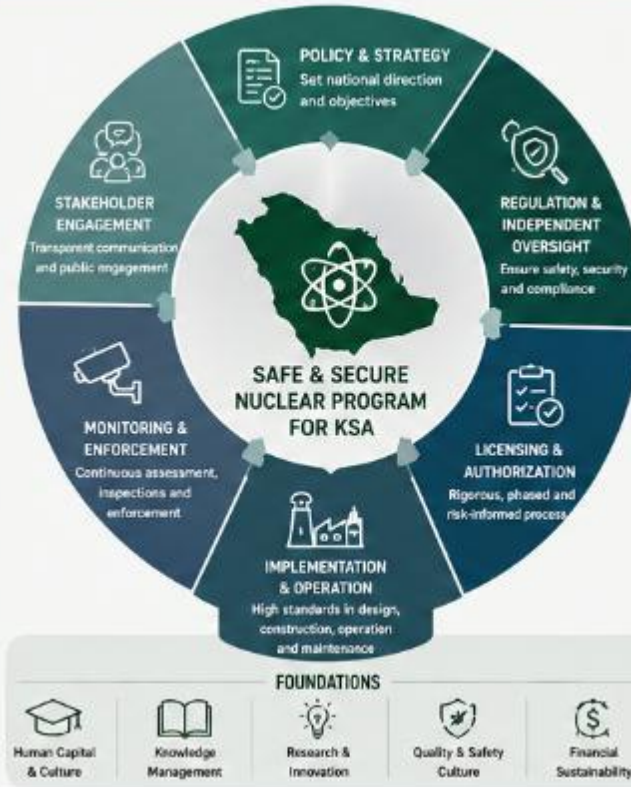
Nuclear security, physical protection and safeguards implementation.



OTHER STAKEHOLDERS

Environment Authority, Civil Defense, Local Authorities, and other partners.

3. NUCLEAR GOVERNANCE SYSTEM



4. INTERNATIONAL COMMITMENTS



- ✓ NPT Party in good standing
- ✓ Comprehensive Safeguards Agreement with the IAEA
- ✓ Additional Protocol in force
- ✓ Adherence to IAEA Safety Standards
- ✓ Active participation in international nuclear forums and peer reviews



Non-proliferation



Safeguards



Safety



Security



Transparency

5. SAFETY, SECURITY & EMERGENCY PREPAREDNESS



Defense-in-depth and multi-layered safety approach



Robust nuclear security and physical protection



National emergency preparedness and response plans



Regular drills, training and continuous improvement



Protection of people, property and the environment



6. BENEFITS TO THE KINGDOM



Reliable & Clean Energy



Economic Diversification



Industrial & Technological Development



Jobs & Human Capital Growth



Sustainable Future for Generations

INTERNATIONAL FRAMEWORKS AROUND KSA'S NUCLEAR GOVERNANCE

Global Standards. Strong Partnerships. Safe and Secure Nuclear Future.

Kingdom of Saudi Arabia upholds the highest standards of nuclear safety, security, non-proliferation and transparency through adherence to international frameworks and active global cooperation.

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KINGDOM OF SAUDI ARABIA



KSA'S NUCLEAR GOVERNANCE IS ALIGNED WITH INTERNATIONAL BEST PRACTICES



1. KEY INTERNATIONAL TREATIES & CONVENTIONS

- Treaty on the Non-Proliferation of Nuclear Weapons (NPT)**
KSA is a Party to the NPT (acceded 1988) and reaffirms its commitment to non-proliferation and peaceful use.
- IAEA Comprehensive Safeguards Agreement (CSA)**
KSA has a CSA in force with the IAEA, ensuring that all nuclear material is used exclusively for peaceful purposes.
- Additional Protocol (AP)**
KSA has an Additional Protocol in force, strengthening transparency and confidence-building measures.
- Comprehensive Nuclear-Test-Ban Treaty (CTBT)**
KSA supports the CTBT and its universalization.
- Convention on Nuclear Safety (CNS)**
KSA is committed to high levels of nuclear safety and continuous improvement.
- Convention on the Physical Protection of Nuclear Material (CPPNM)**
KSA is Party to the CPPNM and its Amendment, ensuring strong measures to protect nuclear material.

2. IAEA SAFETY & SECURITY STANDARDS

KSA applies the IAEA Safety Standards and Security Guidelines across all stages of the nuclear lifecycle.



KSA'S COMMITMENT
KSA is committed to the highest international standards and will continue to work with the international community to ensure a safe, secure and sustainable nuclear future.



3. INTERNATIONAL REVIEW & PEER ENGAGEMENT

- Integrated Regulatory Review Service (IRRS)**
Engaging with IAEA peer reviews to strengthen the regulatory framework.
- Integrated Nuclear Infrastructure Review (INIR)**
Assessing national readiness for safe and sustainable nuclear programs.
- ARTEMIS & EPREV Missions**
Enhancing emergency preparedness and response capabilities.

OUR GUIDING PRINCIPLES



4. STRATEGIC PARTNERSHIPS & COOPERATION

- Bilateral Cooperation**
Working with leading nuclear nations and organizations on technology, safety, security, and human capital development.
- Knowledge & Capacity Building**
Training, education and knowledge exchange with the IAEA and international partners.
- Research & Innovation**
Collaborating on advanced nuclear technologies, SMRs, fuel cycle and waste management.
- Supply Chain & Industry Development**
Engaging with global industry to develop a responsible, resilient and secure nuclear supply chain.

5. REGIONAL & GLOBAL CONTRIBUTION

- Promoting Peaceful Use**
Supporting the peaceful use of nuclear energy for sustainable development in the Kingdom and the region.
- Strengthening Global Security**
Active role in global non-proliferation, nuclear security and counter-terrorism efforts.
- Supporting Global Goals**
Contributing to climate action, energy security and the UN Sustainable Development Goals.

WORKING TOGETHER FOR A BETTER FUTURE

Through strong governance and international cooperation, KSA is building a nuclear program that supports economic growth, energy sustainability and a better future for generations to come.



KEY INTERNATIONAL PARTNERS & ORGANIZATIONS



KSA'S NUCLEAR GOVERNANCE AND INTEGRATION WITH THE SAUDI NATIONAL ATOMIC ENERGY PROJECT (SNAEP)

Safe. Secure. Sustainable. Powering Progress. Supporting Vision 2030 and Net Zero by 2060.

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KINGDOM OF SAUDI ARABIA

OUR SHARED GOAL



Safety
First



Security
Always



People &
Capabilities



Sustainability &
Environment



Transparency &
Accountability



Peaceful Use &
Non-Proliferation



FOUNDATIONS FOR SUCCESS



Robust Governance
& Clear Mandates



Effective Coordination
& Collaboration



Strong Regulation
& Oversight



Sustainable Financing
& Value Creation



Local Content
& Innovation



Skills & Talent
Development



Public Trust &
Stakeholder Engagement



Continuous Improvement
& Learning



TOGETHER, WE WILL BUILD A WORLD-CLASS NUCLEAR PROGRAM THAT IS SAFE, SECURE, SUSTAINABLE
AND A SOURCE OF PRIDE FOR THE KINGDOM—TODAY AND FOR FUTURE GENERATIONS.

TRIGGER QUESTIONS FOR GROUP DISCUSSION



1 STRATEGIC ALIGNMENT & VALUE CREATION

- How does SNAEP best support KSA's energy transition, economic diversification and Net Zero by 2060?
- What is the long-term value proposition of nuclear energy for the Kingdom?



2 ROLES & RESPONSIBILITIES

- Are the roles and mandates of all stakeholders clear and complementary?
- How can we strengthen coordination and avoid overlaps?



3 REGULATION, SAFETY & SECURITY

- How do we ensure the highest standards of nuclear safety, security and safeguards?
- What more can we do to build a strong safety culture and public confidence?



4 INTEGRATION & INFRASTRUCTURE READINESS

- How do we ensure successful integration of nuclear power into the national grid?
- What infrastructure, technologies and system capabilities must be prioritized?



5 CAPABILITIES, TALENT & LOCAL INDUSTRY

- How do we develop the right skills and national capabilities for a nuclear future?
- How can we maximize local content and grow a competitive domestic supply chain?



6 FINANCING & ECONOMICS

- What are the key financing models to ensure bankability and long-term sustainability?
- How do we manage costs while delivering value?



7 RESEARCH, INNOVATION & KNOWLEDGE

- How can we leverage research, data and innovation to improve outcomes?
- What role can KSA play in regional and global nuclear innovation leadership?



8 STAKEHOLDER ENGAGEMENT & COMMUNICATION

- How do we engage communities and stakeholders transparently and effectively?
- What are the key messages to build trust and long-term support?

EMERGING ENERGY TECHNOLOGIES

POWERING A SUSTAINABLE FUTURE

Innovative technologies are transforming the way we produce, store, distribute and use energy, enabling a cleaner, smarter and more resilient energy future for the world.



ADVANCED RENEWABLES

- Next-gen solar PV (bifacial, perovskite, tandem cells)
- Floating wind turbines
- Offshore wind expansion
- High-altitude wind energy



ENERGY STORAGE NEXT GENERATION

- Solid-state batteries
- Flow batteries
- Long-duration storage
- Gravity & mechanical storage



HYDROGEN SOLUTIONS

- Green hydrogen production
- Hydrogen storage & transport
- Fuel cells for industry
- Ammonia & e-fuels



CARBON CAPTURE, UTILIZATION & STORAGE

- Carbon capture technologies
- Industrial decarbonization
- Carbon utilization (CCU)
- Geological storage (CCS)



SMART GRIDS & DIGITALIZATION

- AI and machine learning
- Digital twins
- Advanced sensors & IoT
- Predictive analytics



NUCLEAR INNOVATION

- Small Modular Reactors (SMRs)
- Advanced Gen IV reactors
- Improved safety & flexibility
- Nuclear for clean hydrogen



ELECTRIFICATION & EVOLUTION

- Electric vehicles (EVs)
- Electrified public transport
- Charging infrastructure
- Vehicle-to-grid (V2G)



SUSTAINABLE FUELS & MATERIALS

- Sustainable Aviation Fuels (SAF)
- Biofuels & biogas
- E-fuels and synthetic fuels
- Green steel & low-carbon materials



GEOTHERMAL ENERGY

- Enhanced Geothermal Systems
- Deep geothermal exploration
- Direct lithium extraction
- Reliable baseload power



OCEAN ENERGY

- Tidal energy
- Wave energy
- Ocean thermal energy conversion (OTEC)
- Salinity gradient power

EMERGING ENERGY TECHNOLOGIES UNLOCKING OPPORTUNITIES FOR KSA AND THE WORLD

Powering Prosperity. Driving Innovation. Building a Sustainable Future.

Emerging energy technologies create new opportunities for economic diversification, energy security, industrial growth and global leadership — supporting KSA Vision 2030 and a Net Zero 2060 future.

VISION رؤية
2030
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KSA ADVANTAGES

-  Abundant solar and wind resources
-  Strategic global location
-  Strong investment capacity
-  World-class infrastructure
-  Commitment to innovation
-  Vision 2030 & Net Zero 2060

KEY OPPORTUNITIES



CLEAN ENERGY LEADERSHIP



- Scale up renewables and become a global clean energy leader
- Drive the region's energy transition



GREEN HYDROGEN EXPORTS



- Develop a world-scale green hydrogen industry
- Export clean fuels to power the world



ECONOMIC DIVERSIFICATION & NEW INDUSTRIES



- Enable new high-value industries and technologies
- Create jobs and develop local capabilities



ENERGY SECURITY & RELIABILITY



- Enhance grid flexibility and resilience with smart technologies
- Ensure reliable, low-carbon energy for future demand



TECHNOLOGICAL INNOVATION & R&D LEADERSHIP



- Position KSA as a hub for energy innovation and R&D
- Attract global talent and technology partnerships



SUSTAINABLE INDUSTRIAL GROWTH



- Decarbonize industries and improve efficiency
- Support metals, chemicals, cement and other sectors



ENVIRONMENTAL & CLIMATE IMPACT



- Reduce emissions and improve air quality
- Protect ecosystems and natural resources

ENABLERS FOR REALIZING OPPORTUNITIES



Supportive policies and regulation



Targeted investment and financing



Talent development and education



Strategic partnerships and collaboration



Digitalization and advanced technologies



Market creation and demand growth

GLOBAL IMPACT



-  Accelerate the global clean energy transition
-  Strengthen energy security worldwide
-  Create shared economic growth and prosperity
-  Build a more sustainable planet for future generations



EMBRACING INNOVATION TODAY
BUILDS A PROSPEROUS, SUSTAINABLE TOMORROW
FOR KSA AND THE WORLD.



SOLAR & WIND
ENERGY



HYDROGEN &
CLEAN FUELS



ENERGY
STORAGE



CARBON CAPTURE,
UTILIZATION & STORAGE



SMART GRIDS &
DIGITAL SOLUTIONS



ADVANCED NUCLEAR
TECHNOLOGIES



OCEAN & WAVE
ENERGY



GEOTHERMAL
ENERGY

NUCLEAR INNOVATION: POWERING PROSPERITY. SECURING THE FUTURE.

A STRATEGIC ADVANTAGE FOR KSA AND THE WORLD

Nuclear energy is evolving. Advanced technologies, modular designs and innovation are making it safer, cleaner and more economical—unlocking trillions in value and new opportunities for nations that act today.

**CLEAN & RELIABLE ENERGY**
Low-carbon baseload power for decades

**ENERGY SECURITY**
Reduce reliance on fossil fuels and imports

**ECONOMIC GROWTH**
High-value jobs, local industry & exports

**TECHNOLOGICAL LEADERSHIP**
Innovation, R&D and advanced capabilities

**NET ZERO ENABLEMENT**
Essential for deep decarbonization

THE GLOBAL NUCLEAR OPPORTUNITY

**~\$2.7TRILLION**
Global nuclear market size by 2050

**~700 GW**
New nuclear capacity needed by 2050

**>1 MILLION**
High-quality jobs supported globally

**>6 Gt CO₂/yr**
CO₂ emissions avoided by 2050



ECONOMIC COMPARISON (2024–2030)

ENERGY SOURCE (NEW BUILD)	CAPITAL COST (USD/KW)	LEVELIZED COST OF ELECTRICITY (USD/MWH)*	CAPACITY FACTOR (AVG.)	LIFETIME
 NUCLEAR (Gen III+ & SMR)	\$4,000 – \$6,500	\$50 – \$70	90%+	60 – 80 YEARS
 SOLAR PV	\$700 – \$1,000	\$30 – \$45	20 – 25%	25 – 30 YEARS
 ONSHORE WIND	\$1,200 – \$1,800	\$35 – \$55	30 – 40%	25 – 30 YEARS
 NATURAL GAS (CCGT)	\$600 – \$1,000	\$60 – \$90	55 – 65%	30 – 40 YEARS

*LCOE varies by project, financing and location. Source: IEA, Lazard LCOE 2024, World Nuclear Association

THE UPSIDE FOR KSA

**ECONOMIC IMPACT**
\$100 – \$150B+
Potential contribution to GDP by 2050 through power, industry & exports

**JOBS & HUMAN CAPITAL**
80,000+
Direct and indirect high-skill jobs by 2050

**INDUSTRIAL DEVELOPMENT**
Local manufacturing, supply chains, engineering & technology ecosystem

**EXPORT OPPORTUNITIES**
SMRs, components, fuel services and nuclear expertise to regional and global markets

**EMISSIONS REDUCTION**
Avoid up to 110 Mt CO₂/yr by 2050 supporting KSA Net Zero goals

**ENERGY SECURITY**
Diversified, reliable baseload power for decades



- Abundant financing capacity
- Strategic location connecting Asia, Europe & Africa
- Strong government commitment & long-term vision
- Developing world-class infrastructure & talent

NUCLEAR ENERGY. A PILLAR OF KSA'S SUSTAINABLE FUTURE.

NUCLEAR INNOVATION DRIVING THE FUTURE

**SMALL MODULAR REACTORS (SMRs)**

- Lower capital cost
- Faster construction
- Flexible siting
- Ideal for KSA's grid and industrial needs

**ADVANCED REACTORS (Gen III+/Gen IV)**

- Higher safety & efficiency
- Longer operating life
- Greater economic performance
- Proven global designs

**FUEL INNOVATION**

- Advanced fuels improve safety and performance
- Longer cycles, less waste
- Supports closed fuel cycle

**NUCLEAR UTILIZATION BEYOND POWER**

- Hydrogen production
- Desalination
- Industrial heat & chemicals
- District cooling

**DIGITAL & AI-ENABLED OPERATIONS**

- Enhanced safety & reliability
- Predictive maintenance
- Optimized performance
- Workforce empowerment



KEY ENABLERS FOR KSA SUCCESS

 Strong Policy & Regulation

 Strategic Partnerships

 Financing & Investment

 Talent Development & Education

 R&D & Innovation Ecosystem

 Infrastructure Excellence

KSA: POISED TO LEAD

- ✓ Vision 2030 aligned
- ✓ Strong financial position
- ✓ Energy leadership ambition
- ✓ Regional hub potential
- ✓ Long-term value creation



Invest in nuclear innovation today.
Power a prosperous tomorrow for KSA and the world.

GREEN HYDROGEN EXPORTS

A COMPETITIVE ADVANTAGE FOR KSA. A SUSTAINABLE FUTURE FOR THE WORLD.

Green hydrogen is set to become a \$1+ trillion global market by 2050.

Saudi Arabia is uniquely positioned to lead.



100% CLEAN ENERGY
Zero-carbon fuel of the future



GLOBAL DEMAND
Growing demand across industry, transport and power



ENERGY SECURITY
Diversifies markets and strengthens long-term resilience



ECONOMIC GROWTH
High value exports, jobs and technology leadership

رؤية
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

GLOBAL GREEN HYDROGEN MARKET SHARE (ANNOUNCED PROJECT PIPELINE*)

- 1 AUSTRALIA** 24%
- 2 CHILE** 19%
- 3 EUROPEAN UNION** 17%
- 4 SAUDI ARABIA (RISING FAST)** 12%
- 5 OMAN** 8%

OTHERS 20%

* Based on announced projects >10 ktpa H₂ by 2030. Source: IEA, Hydrogen Projects Database 2024

GREEN HYDROGEN PRODUCTION COST COMPARISON (2030E)

USD/kg H ₂				
COUNTRY	PRODUCTION COST (USD/kg H ₂)	RENEWABLE RESOURCE QUALITY	INFRASTRUCTURE READINESS	COMPETITIVENESS
SAUDI ARABIA	1.2 – 1.6	EXCELLENT	HIGH	HIGH
AUSTRALIA	1.4 – 1.8	EXCELLENT	MEDIUM	HIGH
CHILE	1.6 – 2.0	EXCELLENT	MEDIUM	MEDIUM
OMAN	1.5 – 2.0	EXCELLENT	MEDIUM	MEDIUM
EUROPEAN UNION	2.0 – 2.8	GOOD	HIGH	MEDIUM
GLOBAL AVERAGE	1.8 – 2.6	–	–	–

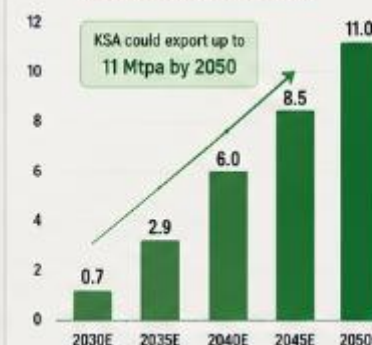


KSA has the potential to be among the lowest cost producers with world-class renewables and strategic advantages.

SAUDI ARABIA GREEN HYDROGEN EXPORT POTENTIAL

Million tonnes per annum (Mtpa H₂)

EXPORT VOLUME POTENTIAL



KEY EXPORT MARKETS



EUROPE
Industrial decarbonization, energy security



NORTHEAST ASIA
Power generation, ammonia, refining, steel



SOUTHEAST ASIA
Industrial and transport applications



GLOBAL SHIPPING
Bunkering and e-fuels

THE UPSIDE FOR KSA



ECONOMIC IMPACT
\$120 – \$160B
Annual export revenues by 2050
Up to 8% contribution to non-oil GDP by 2050



JOB CREATION
100,000+
Direct & indirect jobs by 2050
Opportunities across the entire value chain



INDUSTRIAL LEADERSHIP
Position KSA as a global energy & chemicals hub
Attract investment in downstream sectors: ammonia, methanol, e-fuels, steel, and more



CLIMATE LEADERSHIP
Avoid up to **200 Mt CO₂/yr**
Support global Net Zero while creating sustainable value at home



ENERGY SECURITY & MARKET DIVERSIFICATION
Reduce reliance on hydrocarbons
Build long-term partnerships and stable demand for decades



KSA IS UNIQUELY POSITIONED TO LEAD THE GLOBAL GREEN HYDROGEN ECONOMY

Abundant renewables. Competitive costs. Strategic location. Strong execution.

POWERING PROSPERITY. FUELLING A SUSTAINABLE FUTURE.

THE GREEN HYDROGEN VALUE CHAIN



RENEWABLE ENERGY



WATER DESALINATION



ELECTROLYSIS (GREEN H₂)



STORAGE & TRANSPORT



EXPORT TO GLOBAL MARKETS



END USES (INDUSTRY, POWER, TRANSPORT, SHIPPING)

KEY ENABLERS FOR KSA SUCCESS



SUPPORTIVE POLICY & REGULATION



COMPETITIVE FINANCING & INCENTIVES



WORLD-CLASS INFRASTRUCTURE & PORTS



STRATEGIC PARTNERSHIPS & OFFTAKE



R&D, INNOVATION & TALENT DEVELOPMENT

THE CHALLENGES OF EMERGING ENERGY TECHNOLOGIES

IMPLICATIONS FOR KSA AND THE WORLD

Emerging energy technologies offer great potential, but significant challenges must be addressed to ensure successful deployment and long-term sustainability.



KSA CONTEXT

- Abundant solar and wind resources
- Strong vision and investment capacity
- Growing energy demand
- Strategic location and export potential
- Commitment to Net Zero 2060

KEY CHALLENGES



HIGH CAPITAL COSTS & FINANCING RISKS



- High upfront investment needs
- Perceived technology and market risks
- Limited track record for some technologies (e.g., hydrogen, CCUS, advanced storage)



INFRASTRUCTURE & GRID INTEGRATION



- Grid needs modernization for variable renewables
- Need for long-distance transmission
- System flexibility and reliability requirements



ENERGY STORAGE LIMITATIONS



- Storage technologies still costly at scale
- Limited long-duration storage solutions
- Supply chain and raw material constraints



TECHNOLOGY MATURITY & SCALABILITY



- Many technologies are at demonstration stage
- Scaling up while reducing costs remains a challenge
- Performance and durability uncertainties



SUPPLY CHAIN & RAW MATERIAL CONSTRAINTS



- Critical minerals demand is rising
- Global supply chains are concentrated and vulnerable
- Potential for price volatility and resource nationalism



POLICY, REGULATION & MARKET DESIGN



- Need for clear, long-term policy signals
- Regulatory frameworks still evolving
- Market structures must adapt to new technologies



TALENT, CAPABILITIES & SOCIAL ACCEPTANCE



- Shortage of skilled workforce and specialized expertise
- Need for local R&D and innovation ecosystems
- Public awareness and acceptance are critical

THE ECONOMIC REALITY OF ENERGY TRANSITION INVESTMENT

1. CAPITAL REQUIREMENTS

Energy infrastructure and technology require substantial upfront investment.

Investment spans solar, wind, storage, hydrogen, CCUS and nuclear power.

2. ECONOMIC CAPACITY

Assess fiscal space, debt, external balances and financing conditions.

Country comparisons require consistent definitions and dated sources.

3. INVESTMENT AFFORDABILITY

Match project spending to available public and private capital.

Test financing costs, execution risks and lifecycle value.

4. SHORT-TERM PRIORITIES

Scale renewable energy and localize technology.

Build infrastructure and industrial capability.

5. MEDIUM-TERM PRIORITIES

Develop new export industries and clean-energy innovation.

Support job creation and private-sector growth.

6. LONG-TERM SUSTAINABILITY

Strengthen energy security and economic diversification.

Improve public-finance resilience and long-term living standards.

7. INVESTMENT ACTIONS

Prioritize bankable projects and public-private partnerships.

Invest in local capabilities and R&D while maintaining fiscal discipline.

LATEST REGIONAL STATISTIC

28.9%

Growth in Middle East renewable power capacity in 2025, led by Saudi Arabia.

Capacity growth, not electricity generation share.

THE ECONOMIC REALITY: HIGH CAPITAL COSTS, REAL-WORLD IMPACT, SUSTAINABLE FUTURE

Balancing Today's Investments with Tomorrow's Prosperity

Investing in infrastructure and technology is capital intensive today, but essential to secure long-term economic resilience and sustainability.

THE INVESTMENT IMPERATIVE

- High capital cost today
- Stronger infrastructure
- Competitive industries
- Diversified economy
- Sustainable prosperity

1 HIGH CAPITAL COST FOR INFRASTRUCTURE & TECHNOLOGY

Typical Capital Cost Range (USD per kW)

Solar PV Utility Scale	Onshore Wind	Battery Storage (4-hour)	Green Hydrogen Electrolyzer	CCUS (Industry)	Nuclear (Gen III+)
800 – 1,000	1,200 – 1,800	400 – 600	900 – 1,500	1,500 – 2,500	5,000 – 8,000



These upfront investments are significant, long-lived, and necessary to build a competitive, low-carbon economy.

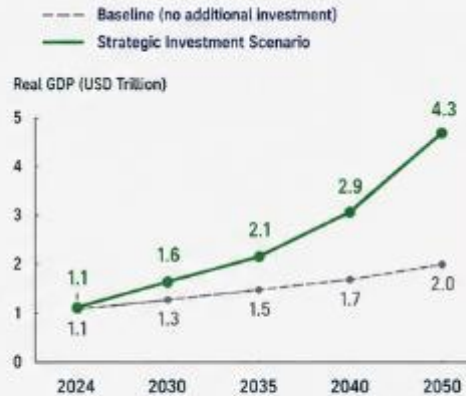
2 CURRENT ECONOMIC REALITY – COUNTRY COMPARISON (2024)

	SAUDI ARABIA	UNITED STATES	CHINA	GERMANY
Nominal GDP (USD Trillion)	1.09	27.36	17.79	4.46
GDP per Capita (USD)	30,300	81,000	12,600	53,000
Government Debt (% of GDP)	27%	123%	83%	64%
Current Account Balance (% of GDP)	14%	-3%	2%	7%
Capital Expenditure (Infra & Energy, % of GDP)	6.8%	2.6%	6.5%	2.2%
Energy Subsidy (% of GDP)	3.3%	0.6%	1.3%	0.2%
Sovereign Wealth / Reserves (USD Billion)	925	-	3,400	-



KSA has strong fiscal space, low debt, and high current account surplus, providing a solid foundation to absorb high capital investments.

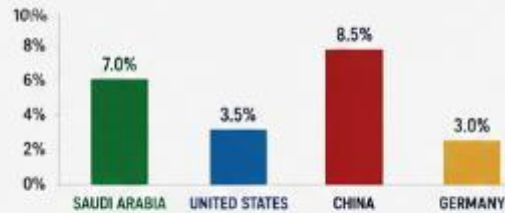
5 ECONOMIC IMPACT OVER TIME (KSA PROJECTION)



+2.3 Trillion Potential GDP Upside by 2050
~2x Higher GDP Compared to Baseline

3 COST VS CURRENT ECONOMIC CAPACITY (2024)

Estimated Annual Investment Need for Energy Transition & Infrastructure (% of GDP)



Investment Affordability Index* (Higher is Better)	KSA	US	CHINA	GERMANY
	0.97	0.47	0.68	0.44

*Index = (Fiscal Space Score × Current Account Score) ÷ Investment Need Score
Fiscal Space (low debt) ÷ Current Account Surplus ÷ Investment Need as % of GDP

4 PROJECTED FUTURE SUSTAINABILITY OF KSA



SHORT TERM (1-3 YEARS)

- Continue economic growth (+3.5%–4.5% CAGR)
- Leverage strong oil revenues to fund diversification
- Scale renewables, localize technology
- Build infrastructure and industrial capability

OUTLOOK: STRONG FOUNDATION FOR TRANSFORMATION



MEDIUM TERM (4-10 YEARS)

- Non-oil GDP contribution > 50%
- Export new industries (hydrogen, green ammonia, chemicals, metals)
- Regional hub for clean energy & innovation
- Job creation and private sector-led growth

OUTLOOK: DIVERSIFIED GROWTH & COMPETITIVENESS



LONG TERM (10+ YEARS)

- Net Zero by 2060
- Knowledge-based, high-tech economy
- Sustainable public finances post-oil
- Higher quality of life & intergenerational prosperity

OUTLOOK: SUSTAINABLE PROSPERITY & GLOBAL LEADERSHIP



KSA'S UNIQUE ADVANTAGE: ABUNDANT RESOURCES, STRATEGIC LOCATION, STRONG FINANCIAL POSITION, AND A CLEAR VISION FOR THE FUTURE.

Key Long-Term Benefits

- Higher GDP & Incomes
- Energy Security
- Industrial Leadership
- Fiscal Sustainability
- Global Competitiveness

KEY TAKEAWAYS

- High capital costs are real, but necessary.
- KSA is well-positioned financially compared to global peers.
- Strategic investments today unlock exponential economic value tomorrow.

SUMMARY COMPARISON

	SAUDI ARABIA	UNITED STATES	CHINA	GERMANY
Ability to Invest (Fiscal Space)	★★★★★	★★★	★★★★	★★★★
Need for Investment (Transition Urgency)	★★★★★	★★★	★★★★★	★★★★
Long-Term Sustainability Outlook	Very Strong	Moderate	Strong	Stable

RECOMMENDATIONS FOR KSA

- Prioritize high-impact, bankable projects
- Leverage PIF and public-private partnerships
- Invest in local capabilities and R&D
- Maintain fiscal discipline while investing strategically
- Accelerate regional and global collaborations



THE COST OF INACTION IS HIGHER THAN THE COST OF INVESTMENT. KSA IS READY TO INVEST, TRANSFORM, AND LEAD.

INVESTING TODAY.
TRANSFORMING TOMORROW.
LEADING FOREVER.



Are there any
new ideas
out there?

1 SPACE-BASED SOLAR POWER

Energy from space, 24/7



- Continuous solar energy from orbit
- Wireless power transmission to Earth
- Virtually unlimited, clean baseload power

RELEVANCY TO KSA

- Power remote mega-projects (NEOM, Red Sea)
- Enable energy exports without borders
- Position KSA as a global space energy leader

2 ARTIFICIAL PHOTOSYNTHESIS

Turning sunlight, water & CO₂ into fuels



- Convert CO₂ and water into hydrogen and synthetic fuels
- Produce green methanol, ammonia, aviation fuels and more
- Potential to outperform electrolysis

RELEVANCY TO KSA

- Create new fuel export industries
- Leverage sun, water & CO₂ abundance
- Support aviation & shipping decarbonization

3 OCEAN THERMAL ENERGY CONVERSION (OTEC)

Clean energy from the ocean



- Uses temperature difference in ocean layers to generate power
- Produces electricity, desalinated water and cooling
- Ideal for coastal and island communities

RELEVANCY TO KSA

- Ideal for Red Sea mega-projects & islands
- Dual benefit: energy + fresh water
- Strengthen tourism & coastal development

4 GRAVITY ENERGY STORAGE

Storing energy with gravity



- Uses gravity to store and release energy
- Long life, low cost, no critical minerals
- Perfect for large-scale, long-duration storage

RELEVANCY TO KSA

- Leverage mining expertise & infrastructure
- Store renewable energy from vast desert sites
- Enhance grid stability & energy security

5 DIRECT AIR FUEL SYNTHESIS

From air to fuel



- Capture CO₂ directly from air
- Combine with green hydrogen to make carbon-neutral fuels
- Produce e-kerosene, e-diesel, e-methanol

RELEVANCY TO KSA

- Become global leader in sustainable aviation fuels
- Utilize Aramco infrastructure & expertise
- High-value export for a low-carbon future

6 DEEP GEOTHERMAL – SUPERHOT ROCK

Unlocking Earth's limitless heat



- Access superhot rock at great depth
- Provide baseload power, industrial heat & hydrogen
- Reliable, clean and land-efficient

RELEVANCY TO KSA

- Leverages oil & gas drilling and service capabilities
- Long-term baseload for industry & hydrogen
- Supports energy security for decades

7 ENERGY-PRODUCING SMART MATERIALS

Infrastructure that generates energy



- Buildings, roads and materials generate clean energy
- Solar, piezoelectric, thermoelectric & self-healing materials
- Embedded energy generation in everyday infrastructure

RELEVANCY TO KSA

- Power smart cities (NEOM, THE LINE) sustainably
- Reduce energy demand & operational costs
- Build next-gen infrastructure leadership

SCENARIO A – ACCELERATED GREEN CAPITAL SHIFT

A world moves fast toward a low-carbon future, reshaping energy markets and geopolitics.

KEY DRIVERS OF THIS SCENARIO



RAPID DIVESTMENT FROM FOSSIL FUELS

Governments and investors rapidly divest from fossil fuels, redirecting capital to clean energy and low-carbon technologies.



RENEWABLE INVESTMENT TRIPLES BY 2030

Global investment in renewables triples by 2030, driving massive deployment of solar, wind, and grid infrastructure.



UNIVERSAL CARBON PRICING

Carbon pricing mechanisms become universal, creating a strong economic signal to reduce emissions across all sectors.



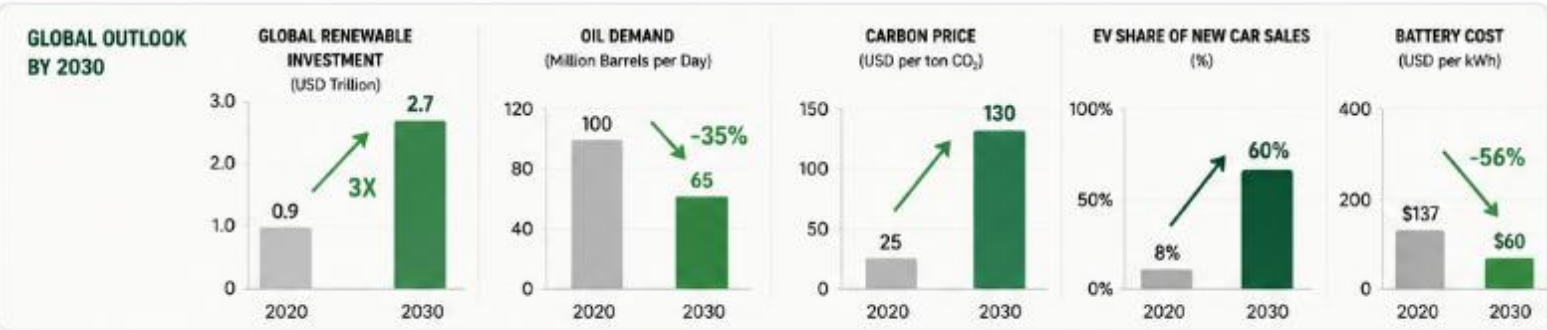
SHARP DECLINE IN OIL DEMAND

Oil demand declines sharply in transport and industry due to electrification, efficiency and behavior change.



TECH BREAKTHROUGHS SCALE ALTERNATIVES

Major breakthroughs in battery storage, green hydrogen, and fuels accelerate scalable, affordable alternatives.



SAUDI ARABIA: RESPONSE ROADMAP IN THIS SCENARIO



ACCELERATE ECONOMIC DIVERSIFICATION

- Scale non-oil sectors: tourism, mining, logistics, advanced manufacturing, digital economy.
- Grow the PIF portfolio in future growth sectors.



BECOME A GLOBAL CLEAN ENERGY LEADER

- Scale green hydrogen and ammonia for export.
- Develop e-fuels and sustainable aviation & shipping fuels.



INVEST IN CARBON MANAGEMENT SOLUTIONS

- Scale CCUS hubs and direct air capture.
- Turn captured carbon into chemicals and materials.



DRIVE INNOVATION & HUMAN CAPITAL

- Invest in R&D, startups and technology partnerships.
- Build world-class talent for the new energy economy.



SHAPE THE GLOBAL ENERGY NARRATIVE

- Lead with pragmatism, equity, and realism.
- Promote energy security, affordability and sustainability.

KEY QUESTIONS & IMPLICATIONS



1. WHAT IS THE LIKELY PRICE OF OIL IN 2030 UNDER THIS SCENARIO?

\$40 – \$50 per barrel (Brent)

Lower demand, strong efficiency, and abundant clean alternatives keep prices under downward pressure.



2. HOW SHOULD SAUDI ARABIA RESPOND?



EXPORT STRATEGY



INVESTMENT STRATEGY



DIPLOMACY & LEADERSHIP

SCENARIO B – DELAYED TRANSITION AND POLICY FRAGMENTATION

A slower, uneven path to decarbonization creates a more complex and uncertain energy future.

KEY DRIVERS OF THIS SCENARIO

 POLITICAL INSTABILITY SLOWS DECARBONIZATION Geopolitical tensions, elections, and policy uncertainty delay strong climate action and international cooperation.	 OIL & GAS INVESTMENT REMAINS STEADY Investment in upstream oil and gas continues at current levels but does not expand significantly.	 RENEWABLES GROW INCONSISTENTLY Progress in renewables continues, but uneven across regions due to policy gaps, grid issues and financing constraints.	 EV ROLLOUT SLOWER THAN EXPECTED High costs, infrastructure gaps and consumer hesitation slow electric vehicle adoption worldwide.	 ENERGY SECURITY DRIVES OIL DEMAND Energy security concerns in Asia and Africa lead to continued reliance on oil, supporting demand at moderate levels.	 POLICY FRAGMENTATION & TRADE BARRIERS Divergent climate policies, carbon border measures and subsidies create fragmented markets and inefficiencies.
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THE WORLD IN 2030 UNDER THIS SCENARIO

- UNEQUAL PROGRESS**
Some regions advance, others lag creating competitiveness and equity tensions.
- HIGHER EMISSIONS**
Global emissions decline slowly and unevenly, missing earlier targets.
- MARKET VOLATILITY**
Policy uncertainty and supply shocks keep energy markets volatile.
- ENERGY POVERTY PERSISTS**
Limited access to clean and affordable energy in many developing regions.

MARKET OUTLOOK BY 2030



SAUDI ARABIA: HOW TO ACT AS A STABILIZER

 ENSURE MARKET STABILITY - Maintain spare capacity for market modulation. - Act with OPEC+ to support balanced and stable markets.	 STRENGTHEN GLOBAL ENERGY SECURITY - Be a trusted supplier for key markets in Asia, Africa and beyond. - Support energy access through affordable and reliable supply.	 ADVANCE ENERGY DIPLOMACY - Build bridges between producers, consumers and transition stakeholders. - Support inclusive climate dialogue and practical solutions.	 INVEST ACROSS THE ENERGY MIX - Continue investing in hydrocarbons efficiency and lower-carbon solutions. - Scale renewables, hydrogen, CCUS and energy efficiency.	 SUPPORT DEVELOPING ECONOMIES - Provide financing, technology transfer and capacity building. - Focus on just transition and sustainable development.	 ENHANCE RESILIENCE AT HOME - Strengthen domestic energy security. - Diversify economy under Vision 2030. - Build human capital and innovation ecosystems.
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OPPORTUNITIES FOR SAUDI ARABIA

 Sustained demand for reliable oil supports revenues.	 Stronger partnerships in high-growth markets.	 Leadership in hydrogen exports to meet rising demand.	 Scale CCUS exports and carbon management services.	 Grow downstream industries and petrochemicals.	 Accelerate innovation and economic diversification.
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IMPACT SUMMARY

 Oil prices remain higher than in Scenario A.	 Energy security concerns keep oil relevant.	 Volatility persists due to policy uncertainty.	 Global progress on net zero is delayed.	 Opportunity for Saudi Arabia to lead with balance and pragmatism.
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Scenario B is not a dead-end—pragmatic leadership, reliable energy, and strategic investment can keep the world moving forward.

Saudi Arabia can be the bridge between today's needs and tomorrow's goals.



SCENARIO C – TECHNOLOGICAL STALEMATE AND FOSSIL LOCK-IN

The world remains dependent on fossil fuels as innovation stalls, economies struggle, and geopolitics drive energy choices.

KEY DRIVERS OF THIS SCENARIO



GREEN INNOVATION STAGNATES

Supply chain bottlenecks, critical mineral shortages, and weak R&D investment slow clean technology breakthroughs.



GLOBAL RECESSION LIMITS INVESTMENT

Weak growth and high debt levels crowd out public and private investment in clean energy.



OPEC+ CONTINUES TO DOMINATE SUPPLY

OPEC+ maintains disciplined production control, shaping global oil prices and market balance.



DEVELOPING NATIONS REMAIN OIL-HEAVY

Affordability, infrastructure needs, and energy poverty keep oil as the primary energy source in many regions.



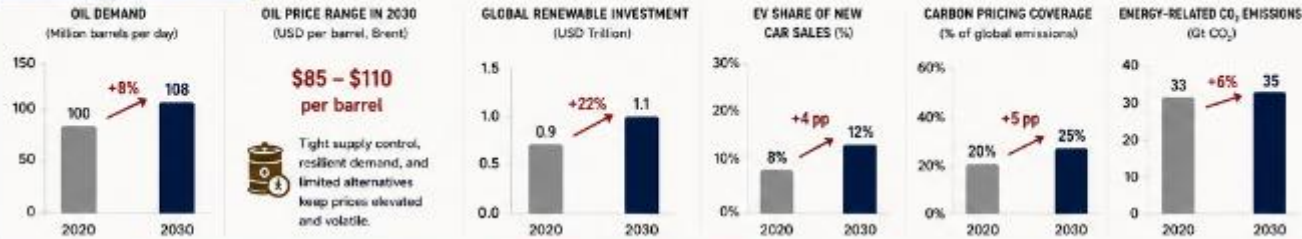
ESG PRESSURES EASE

Investor fatigue, political pushback, and geopolitical tensions reduce ESG pressure and climate ambition.



A HIGHER-CARBON WORLD.
FEWER OPTIONS. GREATER RISKS.

MARKET OUTLOOK BY 2030



SAUDI ARABIA: STRATEGIC ROLE IN A FOSSIL-DEPENDENT WORLD



ENERGY SUPPLY STABILIZER

- Leverage spare capacity to stabilize markets.
- Act as a responsible supplier to avoid extreme price volatility.



DOWNSTREAM & VALUE CAPTURE

- Expand refining, petrochemicals, and specialty products.
- Capture more value from every barrel.



AFFORDABLE ENERGY PARTNER

- Support developing nations' energy access and economic growth.
- Strengthen long-term customer relationships.



GEOPOLITICAL BRIDGE BUILDER

- Use diplomatic influence to ease tensions and secure energy routes.
- Promote dialogue on energy security.



SELECTIVE INVESTMENT IN TRANSITION TECH

- Invest in lower-emission technologies with strong commercial cases (CCUS, hydrogen, efficiency).
- Maintain optionality for future shifts.



HUMAN CAPITAL & ECONOMIC DIVERSIFICATION

- Continue diversification to reduce vulnerability.
- Build future-ready industries and capabilities.

OPPORTUNITIES FOR SAUDI ARABIA



Sustained demand for reliable oil and gas supplies



Expand downstream and petrochemical exports



Strengthen strategic partnerships in Asia, Africa & Latin America



High cash flows to fund economic transformation



Leverage CCUS to lower emissions intensity



Build technology capabilities for future readiness

KEY QUESTIONS



1. WHAT PRICE CEILING OR FLOOR MIGHT WE EXPECT?

- Likely price range: \$85 – \$110 per barrel in 2030.
- Price floor supported by supply discipline, high cost of alternatives, and energy security needs.
- Price ceiling limited by weak economic growth, efficiency gains, and demand destruction at very high prices.



2. WHAT ARE THE RISKS OF OVERDEPENDENCE ON FOSSIL EXPORTS IN THIS WORLD?



VOLATILE REVENUES
High price volatility and potential future demand shocks can create fiscal instability.



STRANDED ASSETS RISK
Sudden policy or technology breakthroughs could quickly erode asset value.



GEOPOLITICAL & POLICY RISK
Tighter future regulations, carbon taxes, or trade barriers could target fossil exporters.



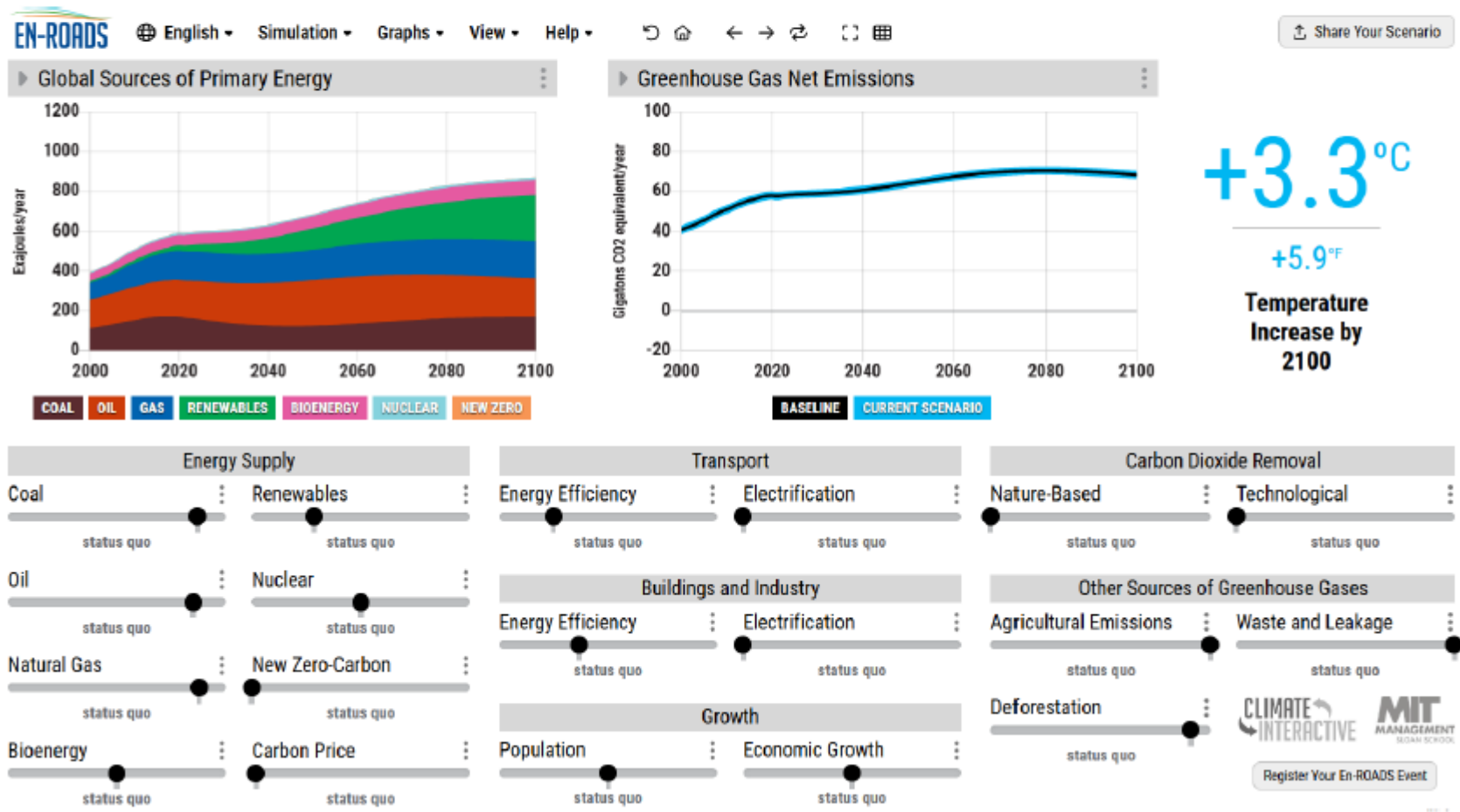
REPUTATIONAL RISK
Easing ESG now may lead to future penalties and loss of market access.



MISSED DIVERSIFICATION WINDOW
Delaying diversification increases long-term economic vulnerability.

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.



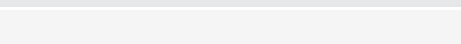
The En-ROADS Climate Solutions Simulator

Assumptions

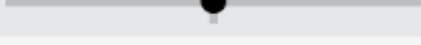
Energy

- ▶ Energy supply policy timing
- ▶ Energy supply progress ratios
- ▶ Initial fossil fuel resource remaining
- ▶ Breakthrough commercialization time
- ▶ Plant development time
- ▶ Plant construction time
- ▶ Bioenergy
- ▶ Renewables flow constraint on source
- ▶ Air pollution from energy
- ▶ Electrification and energy efficiency

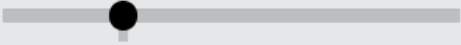
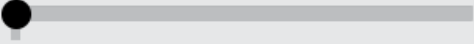
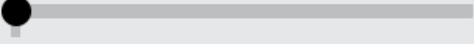
Electricity storage and demand response

- ▶ Max potential for demand response  50 %
- ▶ Demand response progress ratio  0.80 ratio
- ▶ Other storage progress ratio  0.80 ratio
- ▶ reductions  10 years

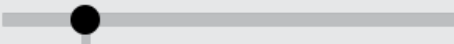
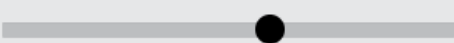
Initial fossil fuel resource remaining

- ▶ Coal  21500 billion tons
- ▶ Oil  3000 billion barrels
- ▶ Gas  18000 trillion cubic feet

Plant development time

- ▶ Nuclear  6 years
- ▶ Hydro  1 years
- ▶ Renewables  1 years
- ▶ New Zero-Carbon  5 years

Electrification and energy efficiency

- ▶ Years to achieve electric transport and equipment subsidies  10 years
- ▶ Time to build transport charging infrastructure for future demand  30 years
- ▶ Electric equipment progress ratio  0.80 ratio
- ▶ Years to achieve energy efficiency improvement rates  76 10 years

The En-ROADS Climate Solutions Simulator

Assumptions

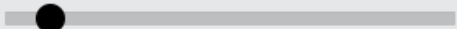
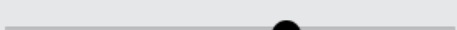
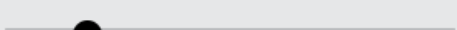
Energy

- ▶ Energy supply policy timing
- ▶ Energy supply progress ratios
- ▶ Initial fossil fuel resource remaining
- ▶ Breakthrough commercialization time
- ▶ Plant development time
- ▶ Plant construction time
- ▶ Bioenergy
- ▶ Renewables flow constraint on source
- ▶ Air pollution from energy
- ▶ Electrification and energy efficiency

▼ Electricity storage and demand response

- | | | |
|-------------------------------------|---|------------|
| ▶ Max potential for demand response |  | 50 % |
| ▶ Demand response progress ratio |  | 0.80 ratio |
| ▶ Other storage progress ratio |  | 0.80 ratio |

▼ Hydrogen

- | | | |
|--|---|-------------|
| ▶ Hydrogen leakage rate |  | 2 %/year |
| ▶ Rate of improvement in efficiency of hydrogen production |  | 0.50 %/year |
| ▶ Hydrogen production via electrolysis progress ratio |  | 0.85 ratio |
| ▶ Hydrogen policy phase-in time |  | 10 years |

The En-ROADS Climate Solutions Simulator

Assumptions

Energy

► Hydrogen

► Industrial feedstocks

Carbon capture and removals

► Afforestation and reforestation

► Agricultural carbon dioxide removal

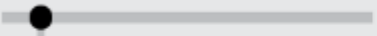
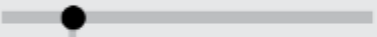
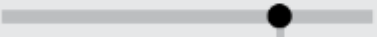
► Mineralization

► Direct air carbon capture and storage (DACCS)

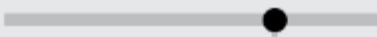
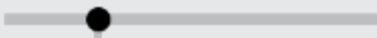
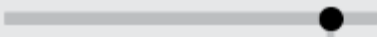
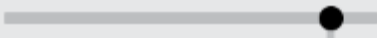
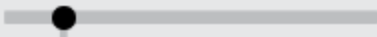
► Carbon dioxide storage

► Carbon dioxide capture and transport

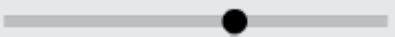
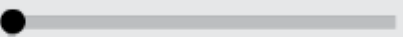
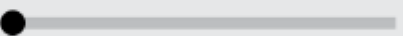
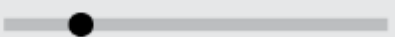
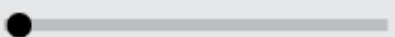
▼ Direct air carbon capture and storage (DACCS)

► DACCS market at cost parity		0.3	Gtons CO ₂ /year
► DACCS capacity for cost to double		20	Gtons CO ₂ /year
► Progress ratio (DACCS)		0.90	ratio
► Initial cost of DACCS		650	\$/ton CO ₂

▼ Carbon dioxide capture and transport

► CCS capture effectiveness		80	%
► CCS completion time		15	years
► Progress ratio (CCS infrastructure)		0.95	ratio
► Progress ratio (CCS energy use)		0.95	ratio
► CCS capacity for cost to double		200	Gtons CO ₂ /year

▼ Carbon dioxide storage

► CO ₂ storage for cost to double		700	Gtons CO ₂
► CO ₂ storage leak rate		0.0	%/year
► Mineralization loss rate		0.0	%/year
► Agricultural soil carbon loss rate		1.0	%/year
► Biochar loss rate		0.2	%/year

USING EnRoads CLIMATE SOLUTIONS MONITOR

DATA-DRIVEN INSIGHTS. SMARTER DECISIONS. STRONGER IMPACT.

VISION CL



TRIGGER QUESTIONS FOR GROUP DISCUSSION



1 STRATEGIC ALIGNMENT & PRIORITIES

- How does EnRoads help us track progress towards Net Zero 2060 and Vision 2030?
- Are we focusing on the right priority actions and sectors?



2 DATA & INSIGHTS

- What key insights are most valuable from the EnRoads dashboard?
- Are there data gaps or quality issues we need to address?



3 PERFORMANCE & IMPACT

- Which initiatives are delivering the greatest impact?
- Where are we off-track and why?



4 COLLABORATION & COORDINATION

- How can we better use EnRoads to enhance inter-agency collaboration?
- What decisions require joint action?



5 RISKS & OPPORTUNITIES

- What are the top climate-related risks to our plans?
- What opportunities should we prioritize to accelerate progress?



6 DECISIONS & NEXT STEPS

- What key decisions can we make today using EnRoads insights?
- What actions will drive the biggest impact in the next 12-24 months?



7 TRANSPARENCY & REPORTING

- How can we improve reporting and disclosures using EnRoads?
- Are we effectively communicating our progress and impact?

One Platform.

MARKET DYNAMICS & INVESTMENT TRENDS IN RENEWABLE ENERGY



K.A.CARE - Navigating the Energy Transition Program

Program Schedule Everyday Sunday June 14 through Thursday June 18 from 8:00 a.m. to 2:00 p.m. Lunch from 2:00 p.m. to 3:30 p.m.

DAY 1 (Sunday) Global Energy Landscape and Saudi Vision 2030	DAY 2 (Monday) Policy, Governance and Regulatory Frameworks	DAY 3 (Tuesday) Energy Security and Sustainability	DAY 4 (Wednesday) The Impact of Alternative Energy Technologies	DAY 5 (Thursday) Geopolitics and Market Dynamics
- Review global energy trends and Saudi Arabia's strategic direction. - Examine how the Kingdom's Vision 2030 blueprint drives energy sector transformation. - Link international developments and national ambitions.	- Review the policy and regulatory frameworks governing Saudi Arabia's energy transition. - Navigate policy and regulatory complexity. - Discuss solutions to drive national progress in the energy sector, from renewable energy targets and regulations to climate initiatives like the Saudi Green Initiative (SGI). - Investigate the key public sector stakeholders (regulators, government agencies, etc.) involved in driving the energy transition. - Examine tools used by government (laws, regulations, incentives, tariffs) to shape energy markets. - Understand how effective policy design can encourage renewable energy investment, ensure grid reliability, and protect consumers, thereby creating a sustainable market ecosystem.	- Explore how to balance the Kingdom's need for a reliable, affordable energy supply with sustainability and climate goals. - Review applicable frameworks such as the Circular Carbon Economy and strategies for reducing carbon emissions while maintaining energy security. - Undertake case studies (for example, integrating solar and wind projects into the national grid). - Assess how to manage the trade-offs and synergies between economic and environmental goals.	- Investigate the policy implications of technologies shaping the future of energy. (This includes renewable energy technologies (solar, wind), energy storage solutions, green and blue hydrogen, carbon capture utilization and storage (CCUS), nuclear energy, electric vehicles (EVs), energy storage and other solutions as part of the energy mix.) - Assess how emerging technologies can be integrated into Saudi Arabia's energy portfolio and what challenges and opportunities they bring. - Cultivate an innovative mindset to understand the emerging energy solutions, and technological change in their organizations. (This segment includes global best practices in renewable energy, using a simulation for maximum learning impact. MIT En-Roads and others)	- Analyze external factors influencing the energy transition, including geopolitical developments, international agreements (e.g. the Paris Agreement), global oil and gas market dynamics, and regional cooperation. - Discuss scenarios such as fluctuations in oil demand, investments by other nations in renewable energy, international pressure for decarbonization, and how these affect Saudi energy policy and projects. - Understand big-picture forces supports participants to anticipate risks and leverage opportunities. (This theme reinforces strategic thinking, enabling leaders to factor in global drivers when planning and executing domestic energy initiatives.)



“Great leaders do not create followers — they create owners.”



Deon van der Westhuizen

Integrated Governance and Risk | Integrated Reporting |
Psychological safety | Oil and gas and ESG | Supply Chain
Sustainability | Artificial Intelligence | | Leadership Development and
Coaching |

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