SWITCH
ENERGY ALLIANCE

Switch Energy Case Competition 2023

Team Number and Name:
114, Infinity
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Selected Country Pairing:
France and Saudi Arabia
Home Country:
Saudi Arabia

Outline

- Countries Overview
- Comparative Energy Analysis
- Energy Poverty Assessment
- Key Energy Challenges in Saudi Arabia
- Possible Solutions for Saudi Arabia
- What Solutions Would not Work for Saudi
- Potential Use of Technologies
- Proposed 10-Year Plan
  - Design Pillars
  - Implementation
  - Impact
  - Feasibility
- Community and Stakeholder Engagement
- Conclusion

Countries Overview

France

Area: 643,801 km²

Population: 65.45 million

GDP: $44,408 per capita

Inflation Rate: 5.05%

Main Economic Sectors: Tourism, manufacturing & pharmaceuticals

Saudi Arabia

Area: 2,149,690 km²

Population: 35.49 million

GDP: $32,586 per capita

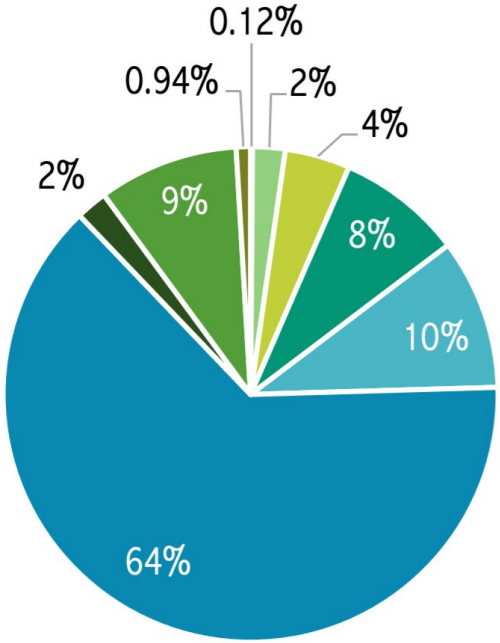
Inflation Rate: 2.8%

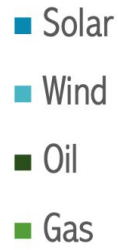
Main Economic Sectors: Petroleum

Data Source; [35],[41]

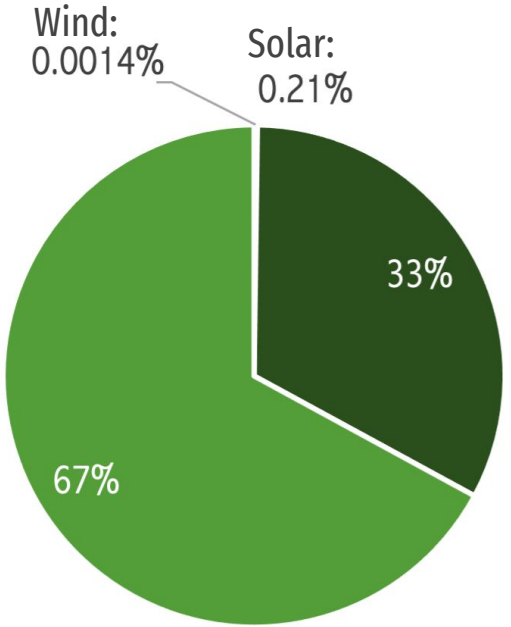
Energy Consumption by Source

France



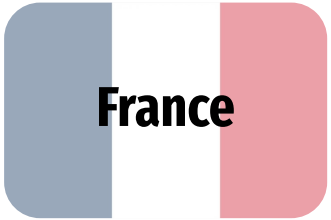


Saudi Arabia

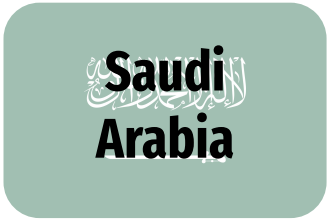


Data Source: [10]

Comparative Energy Analysis

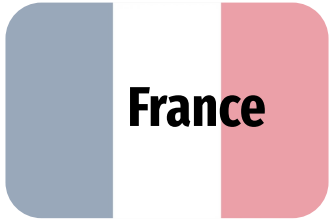


Accessibility



France		Saudi Arabia
❖ 100% household access to electricity [25] ❖ Nuclear power is main source of electricity	Access to Electricity	❖ 100% household access to electricity [25] ❖ Natural gas and oil is main source of electricity
❖ ~ 60 % of households use natural gas [41]	Cooking Fuels	❖ > 80% of households use natural gas
❖ Heating fuels are 100% accessible; while only 17% of households have access to air conditioning [41]	Heating/AC	❖ AC systems are widely used in residential, commercial, and industrial buildings, 100 % accessible [41]
❖ Well-developed transportation infrastructure ❖ Growing emphasis on electric and hybrid vehicles	Transportation	❖ Transportation is reliant on petroleum fuels ❖ Transition into alternative fuels and electric vehicles
❖ Manufacturing is the major industrial sector	Industrial sector	❖ Petrochemicals, manufacturing, mining

Environmental Impact

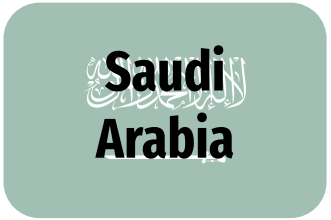


Positive Impacts:

- Low greenhouse gas emissions: 302.33 megatonnes (4.5 tonnes/capita) [35]
- Improved air quality
- Investment in renewable energy, such as solar and wind power

Negative Impacts:

- Nuclear waste
- Impact on biodiversity



Positive Impacts:

- Lowest upstream carbon footprints globally for each barrel of oil produced. [48]
- Saudi Arabia plans the world's largest solar plant (5 GW), a 400 MW wind farm, and a new desalination plant. [41]

Negative Impacts:

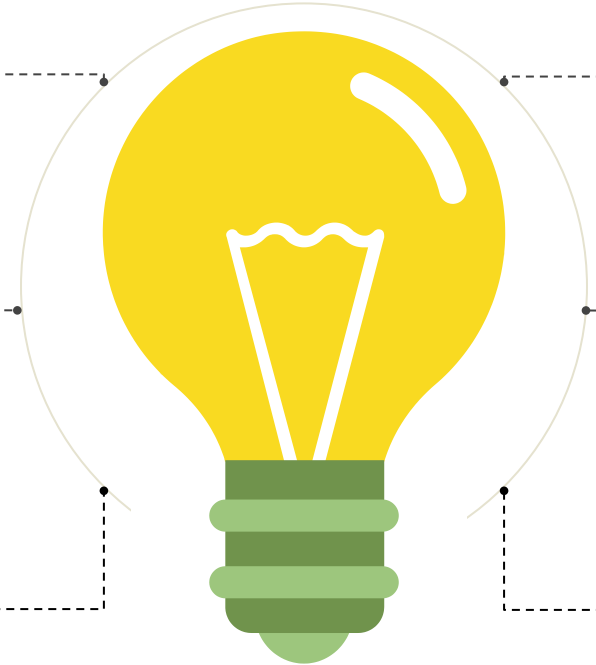
- Land degradation (10% of land), high energy use for desalination (15%), and significant greenhouse gas emissions (600 million tons CO2). [35]

Quality of Energy Services

Energy Demand Reduction Efforts

France

Saudi Arabia



Ecowatt Smart App
Monitoring electricity consumption trends

Smart Meters Rollout
90% of households [38]

Sobriété Enégetique' or energy sobriety
Efficiency campaign
Goal: 10% reduction in energy consumption by 2024 (compared to 2019) [15]

Alkahraba Smart App
Monitoring electricity consumption trends [33]

Smart Meters Rollout
100% of households [34]

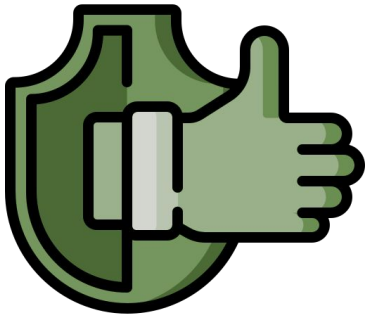
To Last
Efficiency campaign to increase public awareness [21]

Reliability

France

- Gas shortages and demand from neighboring countries pose considerable uncertainties on grid reliability [5]

- Power Intermissions:
  - Labor strikes [6]
  - Grid overload warnings during winter [20]



Saudi Arabia

- Very few cases of power outage incidents reported due to the high reliability of the grid [7]

Affordability

France

The Average Price (/kWh):
0.18 USD

- Energy Prices Below the European Union Average
- Prices are Low because of Energy Diversification and Low Consumption Rate [8]

Saudi Arabia

The Average Price (/kWh):
0.06 USD [4]

- Energy Prices Below International Market Levels
- The Fiscal Balance Program (Part of Vision 2030) Includes Increasing Energy Prices and Linking them to the International Market [1]

Safety

France

Infrastructure: [3]
Safe and Regulated
0.1/1,000 Km Failure Rate

Cooking Fuels: [28]
100% Access to Clean Fuels (2020)

Heating/Air Conditioning: [38,17]
5% AC Penetration Rate with an Average Summer Temperature of 20°C

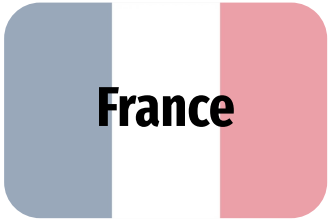
Saudi Arabia

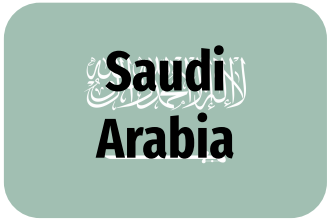
Infrastructure: [24]
Safe and Regulated

Cooking Fuels: [29]
100% Access to Clean Fuels (2020)

Heating/Air Conditioning: [18,31]
100% AC Penetration Rate with an Average Summer Temperature of 41°C

Energy Security





1

Net Exporting Giant

France exported a net of almost 45 billion kWh of electricity to its neighbouring countries, in 20 indicating its energy supply is secure enough to sustain increased demand [9].

2

Import Reliance

France was the top natural gas importer in the EU in 2022, with plans to increase imports, which poses a risk of energy security if political relations with exporters change [9].

3

Promising Energy Investments

France is making multiple long-term investments to decrease energy consumption (Energy Sobriety) and increase the share of renewable energy production by investing in both wind and green hydrogen energy [27].

1

Top Oil Producer and Exporter

Saudi Arabia produced 12.1 million barrels per day in 2022 of liquid fuels, only around ⅓ of which was used for domestic purposes, with the rest exported [9].

2

No Import Reliance

Saudi Arabia doesn't any significant amount of energy to source electricity and energy production, but instead relies on its domestic supply of natural gas to supply electricity [9].

3

Renewable Energy Shift Plans

Saudi Arabia is making major steps to diversify its energy mix up to 50 percent renewable energy by 2030, through investments in green hydrogen and solar energy [32].

Potential For Roadblocks

France

Saudi Arabia

Geopolitical Instability	Financial Challenges	Oil Price Fluctuations	Nuclear Energy Restrictions
The Russia-Ukraine war halted the import of natural gas supply from Russia, jeopardizing the security of energy reserves France needs for the winter [19].	France's energy company is facing large debts that are limiting developments to the energy infrastructure and beneficial long-term investments [19].	The significant oil price fluctuation has severely affected Saudi Arabia,'s economy, it has chosen not to change its oil production levels to help raise prices again [36].	Political obstacles are preventing Saudi Arabia from pursuing nuclear power plant development as negotiations with United States aren't showing promise [28].

Energy Poverty Assessment

Energy Diversity

France

Saudi Arabia

Energy Efficiency

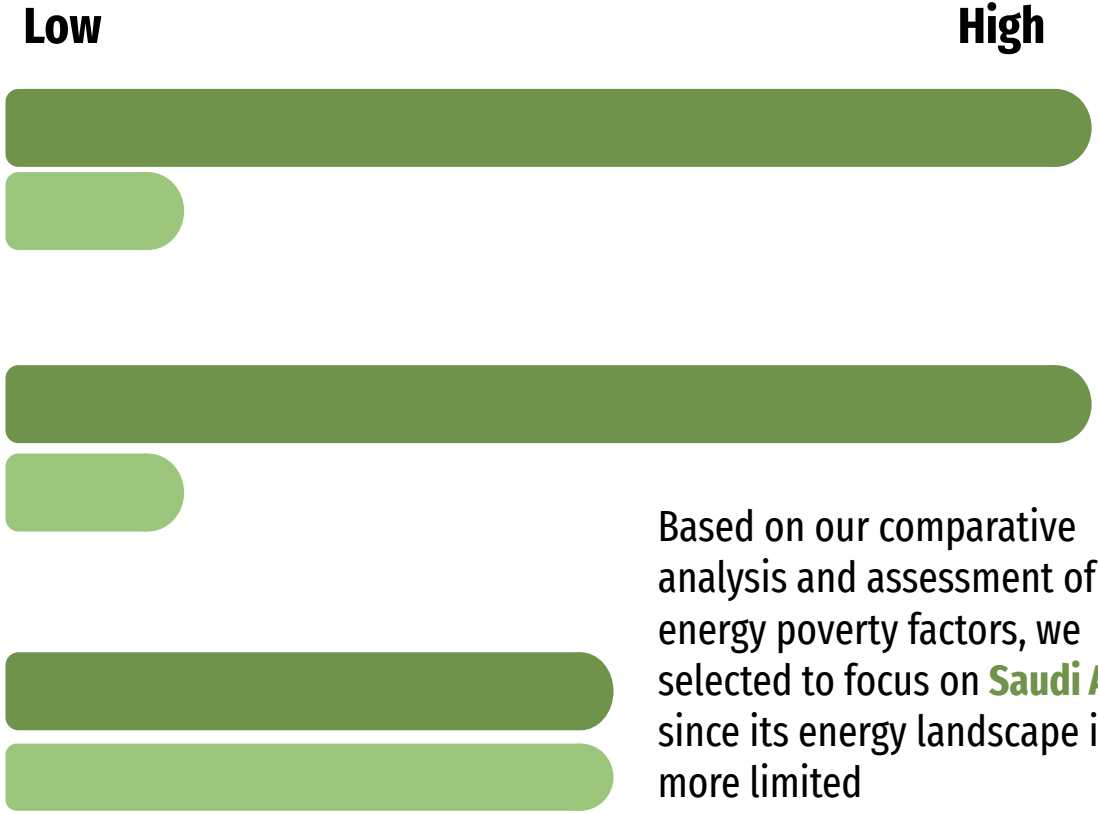
France

Saudi Arabia

Energy Security

France

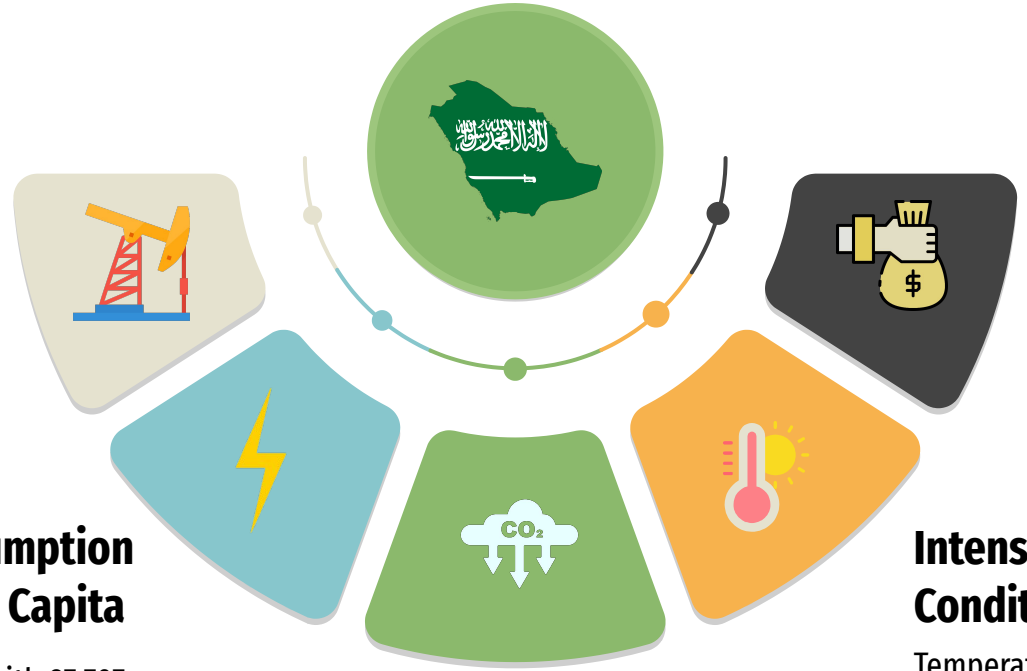
Saudi Arabia



Based on our comparative analysis and assessment of key energy poverty factors, we selected to focus on **Saudi Arabia,** since its energy landscape is more limited

Saudi Arabia Challenges and Solutions

Key Energy Challenges in Saudi Arabia



High Reliance on Fossil Fuels

~100% of electricity is produced from crude oil and natural gas [25]

Energy Subsidies

Highest rate among G20 countries with $7,000 per person [24]

High Electricity Consumption Per Capita

Rank #10 worldwide with 87,707 kWh/capita [25]

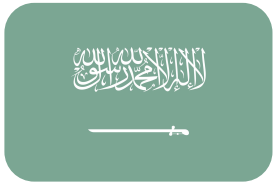
Intense Summer Conditions

Temperatures up to 122 ℉ during the summer [22]

High CO_2 Emission Per Capita

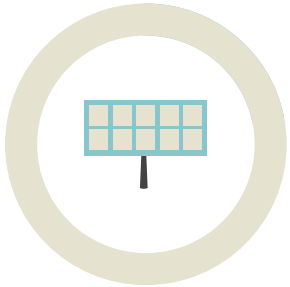
Rank #8 worldwide with 18.7 tonnes/capita [25]

Possible Solutions for Saudi Arabia



Hydrogen

Saudi Has Several Natural Gas Processing Plants, Which Use Methane to Produce Hydrogen [14]



Solar and Wind

Vision 2030 Goal is to Generate 40 GW of Solar Energy and 16 GW of Wind Energy. Saudi has a plenty of prospect to install solar and wind farms [12, 2]

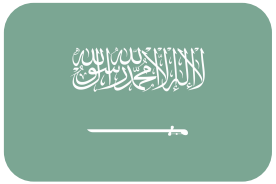
Biomass

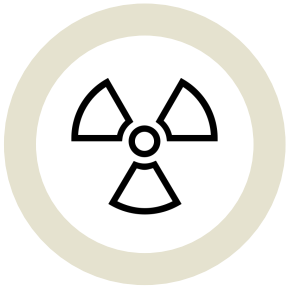
Prospects of Saudi Can Reach Up to 17.8 Million Tons of Oil Equivalent by 2034 [37]

Geothermal

Vision 2030 Goal is to Generate 1 GW of Geothermal Energy [39]. The Activity Concentrates along the Red Sea [11]

What Solutions Would Not Work for Saudi Arabia?





Nuclear

Would not work due to political restrictions, like The Treaty on the Non-Proliferation of Nuclear Weapons (NPT)

Hydropower

Would not work because there is not enough potential (only 530 MW) for the implementation to be economically efficient

Coal

Would not work because It emits substantial quantities of pollutants, harming our health and exacerbating the effects of climate change

Potential Use of Technologies

1

Carbon Capture and Storage (CCS)

Will mitigate emissions from existing infrastructure and ensure a more manageable shift toward a sustainable energy future.

2

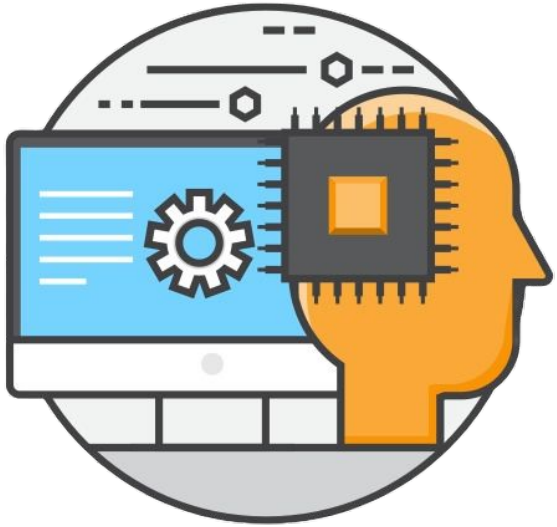
Energy Internet of Things (IoT)

Will enables real-time monitoring, predictive maintenance, and optimal energy consumption patterns.

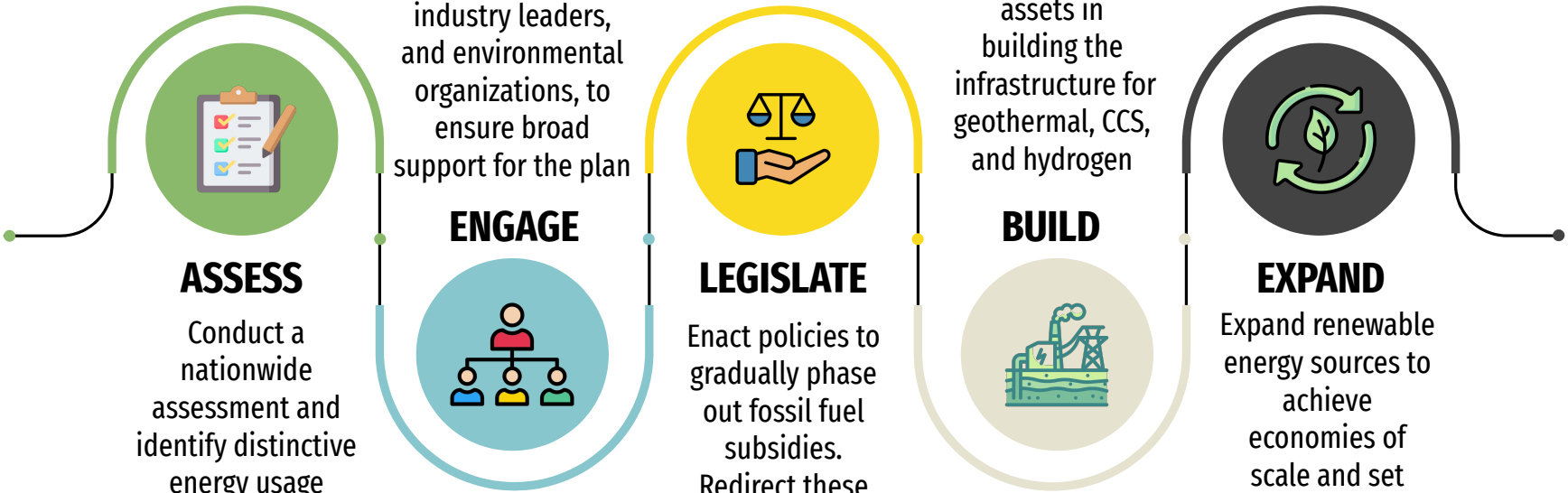
3

Artificial Intelligence (AI)

Will optimize energy systems, predicting demand, improving grid efficiency, and enabling dynamic energy pricing.



Proposed 10-Year Plan: Design Pillars



ASSESS

Conduct a nationwide assessment and identify distinctive energy usage patterns and requirements for different geographic regions

ENGAGE

Engage stakeholders, including the public, industry leaders, and environmental organizations, to ensure broad support for the plan

LEGISLATE

Enact policies to gradually phase out fossil fuel subsidies. Redirect these funds towards clean energy initiatives

BUILD

Utilize existing oil and gas assets in building the infrastructure for geothermal, CCS, and hydrogen

EXPAND

Expand renewable energy sources to achieve economies of scale and set plans to integrate them in the grid mix

Proposed 10-Year Plan Implementation Gantt Chart

Plan Implementation Roadmap

Funding

Offer incentives for businesses and individuals to invest and secure the required budget of $53 billion

Reducing Energy Consumption

Target a 2% reduction per year through promoting energy conservation and efficiency practices

Repurposing Oil and gas infrastructure

Explore geothermal resources, utilize depleted oil and gas fields for carbon storage and hydrogen storage

Hydrogen Production

Start with grey hydrogen produced from natural gas, then move to blue hydrogen with CCS, and finally target green hydrogen production

Renewable Expansion

Subsidize solar panel installation in residential households, and build large scale solar and wind farms. Also, capitalize on biomass for energy production

10-Year Plan Estimated Costs

Saudi Arabia National Grid Capacity in 2022 [34]
84 GW

10-Year Target Renewables Share
50%

10-Year Target Capacity
42 GW

Allocated Budget
$53 Billion

Source	$B/GW	Ref	Target (GW)	Cost ($ B)
Solar	0.72	[43]	37	24.46
Wind	1.25	[45]	14	17.50
Hydrogen	2.18	[46]	1	2.18
Biomass	4.05	[42]	1	4.05
Geothermal	2.50	[47]	1	2.50
Total			**54**	**52.69**
Renewables Share		**64%**		

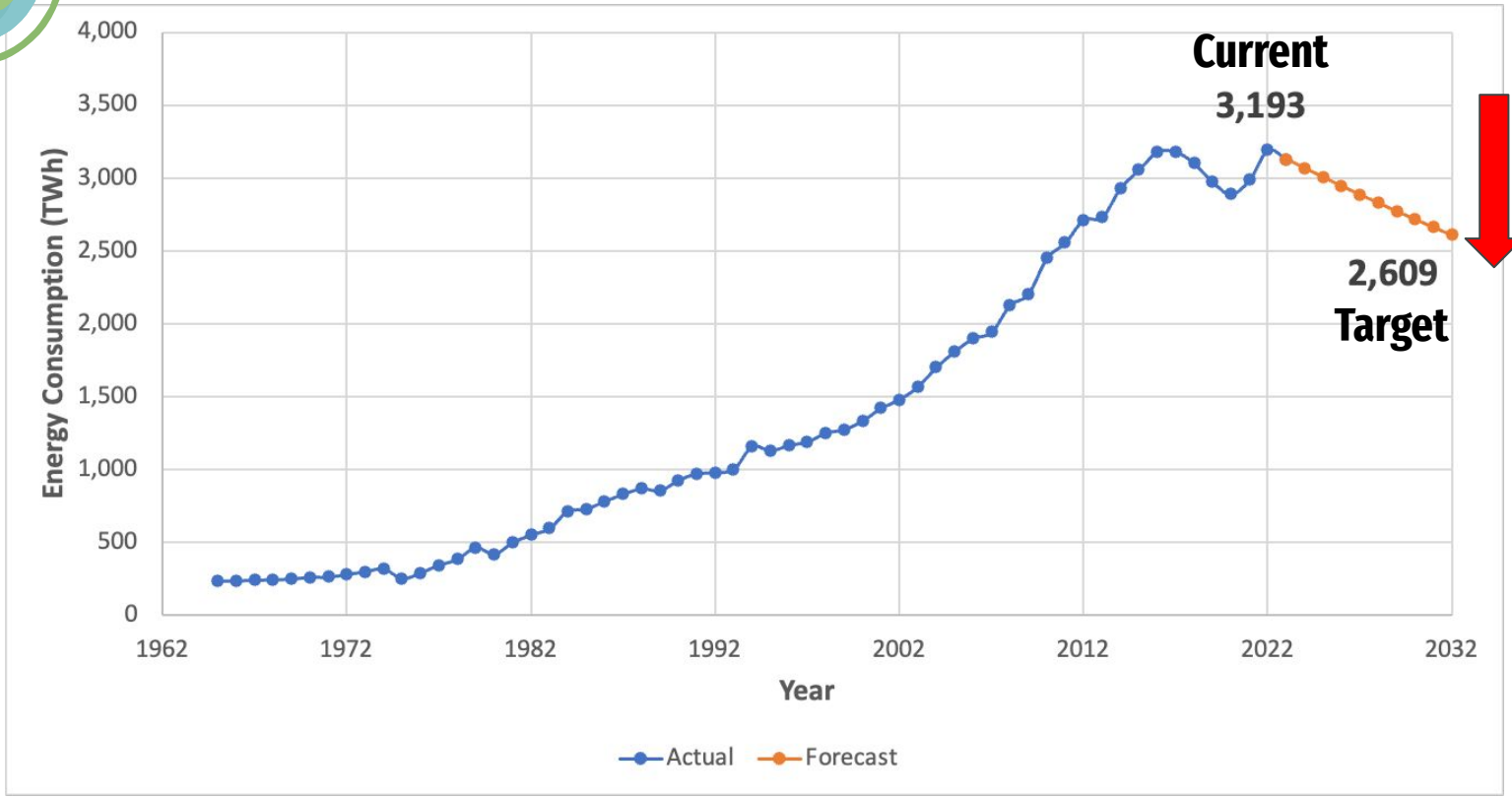
Exceeded target renewables share by **14%**

40 GW of **Solar** Energy
Including the existing 3 GW capacity

16 GW of **Wind** Energy
Including the existing 2 GW capacity

1 GW of **Geothermal** Energy

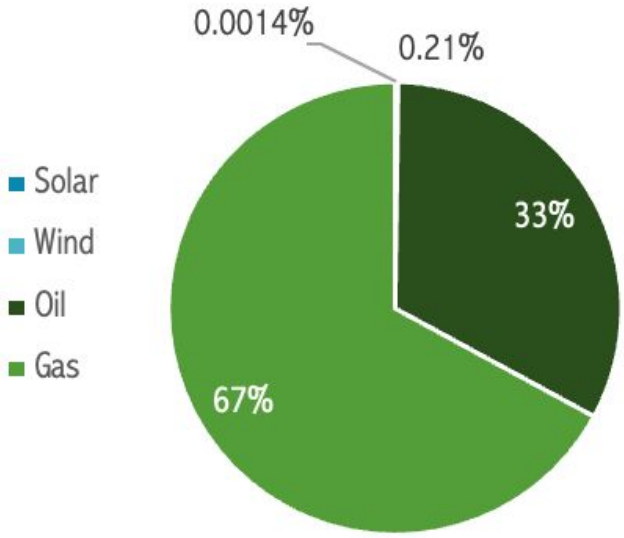
Measuring Success:
Future Energy Consumption in Saudi Arabia



Source for actual data: [25]

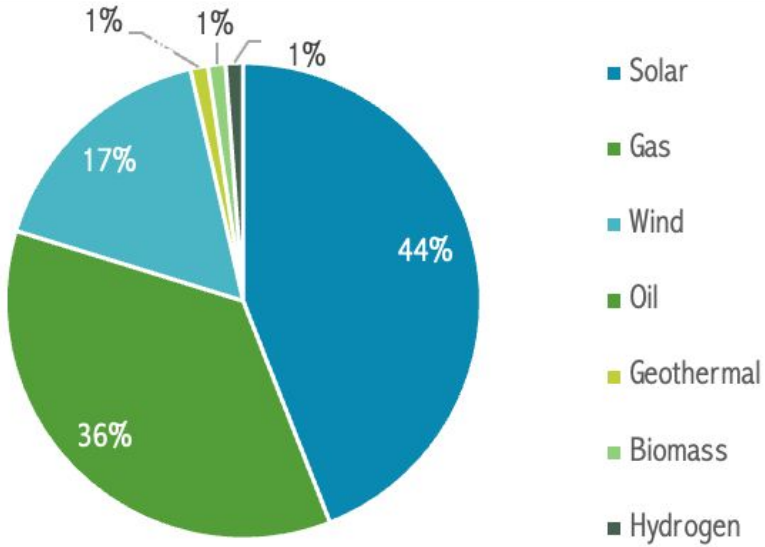
Measuring Success:
Future Energy Mix in Saudi Arabia

2022



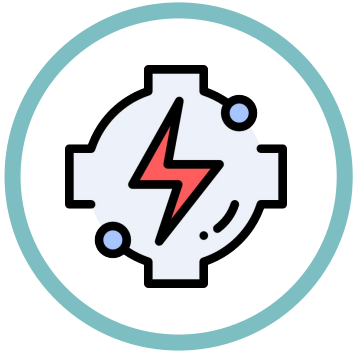
Reduced fossil fuel reliance by 64%

2033 Projection



Data Source: [10]

Measuring Success: Metrics



Increase in Renewable Energy Capacity

Track the increase in renewable energy capacity, including solar, wind, hydrogen, biomass, and geothermal.

Return On Investment (ROI)

Compare the gain generated from renewable energy sources relative to the cost of installation and operation

Consumption Data

Track consumption data, including total consumption and consumption per capita for each renewable source

Reduction in Greenhouse Gas Emissions

Monitor the decrease in greenhouse gas emissions associated with fossil fuels. Transitioning to renewable energy should significantly reduce emissions

Positive Environmental Impact

Reduced carbon emissions

Solar and Biomass are carbon-neutral, emitting no direct greenhouse gases

Enhances energy security

Decreases reliance on imported fossil fuels

Reduced land degradation

Geothermal energy facilities are located underground, causing minimal land disruption

Air quality improvement

Replacing coal and oil with grey hydrogen reduces air pollutants, leading to cleaner air and improved respiratory health.

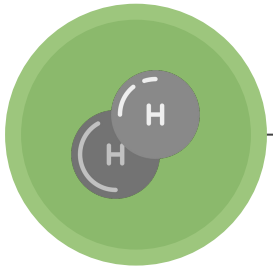
Water conservation

Solar energy production requires little to no water, helping conserve precious freshwater resources in a water-scarce region.

Biodiversity

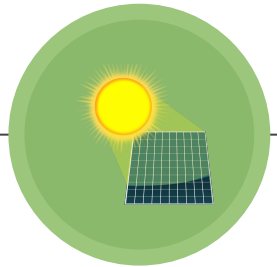
Preserves ecosystems and habitats, avoids deforestation, and promotes responsible land use.

Negative Environmental Impact



Hydrogen

Improper methane handling in natural gas extraction can add to greenhouse gas emissions



Solar

Solar panel and photovoltaic material production may harm the environment, causing habitat disruption, soil and water pollution, and resource depletion without responsible sourcing

Biomass

Deforestation from unsustainable biomass practices causes habitat loss. Inadequate emission control during biomass combustion results in air pollution

Geothermal

Geothermal plants, with their smaller footprint, can disrupt ecosystems when not managed well

Social Impact

Education

Better lighting for educational institutions, heating or cooling, and access to electronic devices for learning

Healthcare

Powering medical equipment, refrigeration for vaccines and medicines, and lighting for healthcare facilities

Food and Hunger

More efficient and sustainable irrigation, mechanized farming, and food processing, improving food security

Water and Sanitation

Sustainable energy for pumping and treating water, and for running sanitation facilities, improving public health.

Economic Benefits

Job Creation

The shift to renewable energy sources often results in the creation of new jobs. This can help stimulate economic growth and reduce unemployment

Reduced Healthcare Costs

Lower air and water pollution have positive effects on public health. Fewer cases of respiratory illnesses and other health issues result in reduced healthcare costs for society

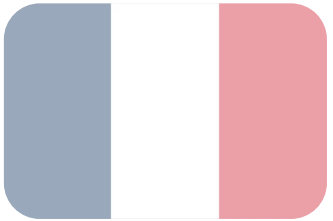
Long-term Savings

The operational costs of renewable energy are lower than those associated with fossil fuels. This can lead to cost savings over the lifespan of the renewable energy systems

Climate Mitigation

Avoiding the costs associated with climate change impacts, such as extreme weather events and sea-level rise, is a significant benefit of transitioning to cleaner energy sources

The Feasibility of Our plan in France



What Can Be Implemented?

In order to meet France's goal in to reach 50% of Nuclear electricity generation by 2025 [13], the following energy sources can be implemented:

- Hydrogen
- Geothermal

What Can Be Expanded?

Since Solar and Biomass Generation of Electricity in France Contributes to only 4.52% and 2.38%, respectively, expanding these energy resources can help in meeting the goal [25]

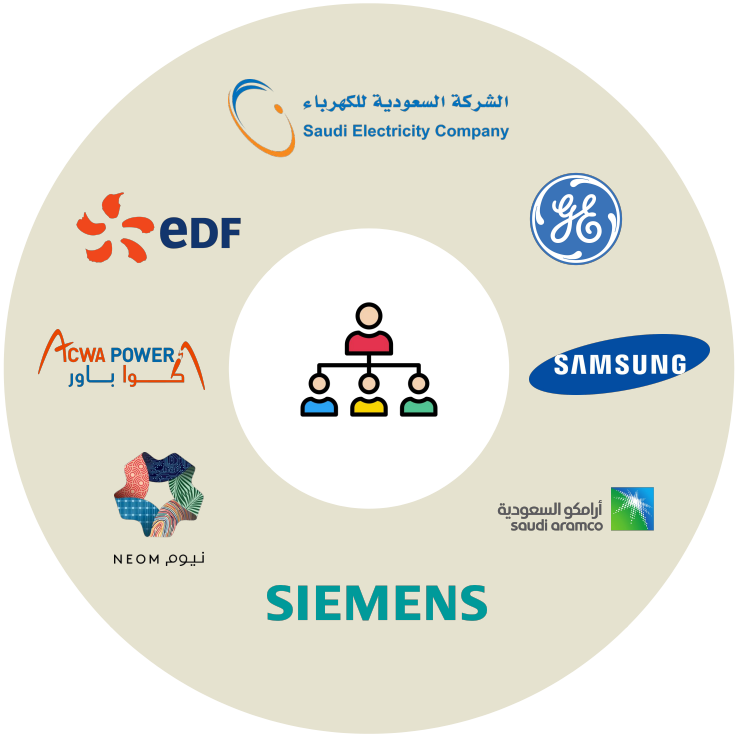
Community and Stakeholder Engagement

Stakeholders

- EDF Renewables (Geothermal)
- ACWA Power (Solar and Wind, Biomass)
- Neom (Grey hydrogen)

Other Companies

- Saudi Aramco
- Saudi Electricity Company
- Samsung
- Siemens
- General Electric (GE)



Local Impact Assessments

Conduct comprehensive impact assessments in collaboration with local communities to identify potential positive and negative effects on their lives and surroundings.

Cultural Sensitivity

The transition to renewable resources, such as the integration of solar panels in residential settings, may face resistance or skepticism from the public.

Conclusion

- Our comprehensive analysis of the energy landscape in France and Saudi Arabia helped us identify the key energy challenges in Saudi Arabia:
  - high reliance on fossil fuels
  - intense electricity consumption
  - high CO2 emissions per capita

- We proposed a 10-year plan that emphasizes the expansion of renewable energy sources, stakeholder engagement, and the implementation of technologies such as carbon capture and storage, Energy Internet of Things, and Artificial Intelligence.

- We examined the social, economic, and environmental impacts of our proposed solutions.

- By addressing the key challenges and considering the unique characteristics of the region, we aim to contribute to a more sustainable and secure energy landscape that benefits both the environment and the people of Saudi Arabia.

THANK YOU!

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Undergraduate Student

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Petroleum Engineering
Undergraduate Student

Zaina Alfakher
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Undergraduate Student

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