# GEOTHERMAL DEVELOPMENT ROADMAP FOR THE KINGDOM OF SAUDI ARABIA

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Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Despite the availability of some potentially resources-rich geothermal locations, the Kingdom of Saudi Arabia has not undertaken any serious geothermal projects. With the growing demand on power, the kingdom has initiated a renewable energy program aimed towards reducing dependency on fossil fuel to build the country's future. Providing a holistic roadmap that identifies critical elements for the effective utilization of geothermal potential in the Kingdom of Saudi Arabia is an essential step towards a healthy and sustained energy development program.

## INTRODUCTION

Much of today's energy in the Kingdom of Saudi Arabia is derived from finite fossil fuel sources. Dependency on fossil fuel for future economic growth is not a sustainable option.

Economic growth in the Kingdom will lead to a rapid increase in energy demand over the coming decades. Sustainable development must at minimum meet the needs of the present without compromising the ability of future generations to meet their own needs.

Current oil prices allow the Kingdom of Saudi Arabia to actively develop resource rich geothermal locations to offer substantial advantages as they are a clean, stable and indigenous supply of energy.

To achieve this, the Kingdom of Saudi Arabia has created King Abdullah City for Atomic and Renewable Energy (K.A.CARE) tasked with the development of renewable resources and enabling renewable development.

## GEOTHERMAL RESOURCE

Saudi Arabia is among the most geothermally active countries in the Middle East as preliminary estimates indicate potential for several thousand MW, electric and thermal, of clean, sustainable and affordable energy Still, the geothermal resources remain untapped . A recent report on geothermal energy shows that Saudi Arabia is rich in terms of various geological features, with hot springs discovered in the southern part of the country as well as geological reconnaissance of a large volcanic are in the Western Region (Figure 2). These areas show geothermal activity which takes the form of shallow water wells with elevated temperatures, fumaroles and hot springs with visible steam columns.

Due to the fact that the Kingdom of Saudi Arabia is a major oil producing nation, renewable energy potentials have not yet received adequate attention. Like all types of energy options, the use of geothermal power is influenced by a set of factors that could affect its potential or exploitation. Political, financial, social, and educational aspects of geothermal project development must be established to allow the effective deployment of these projects.

*Figure 1. Map of Kingdom of Saudi Arabia.*

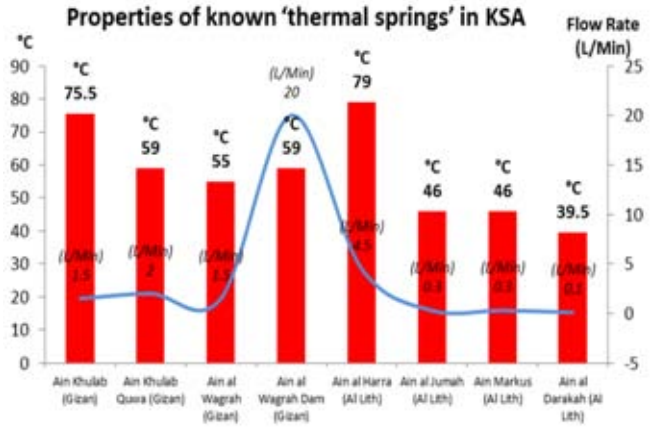


*Figure 2. Properties of known thermal springs in KSA.*

**Table 1. Geothermal Properties of KSA.**

| | Sedimentary Infill | Rift Escarpment | Location (Harrat) |
|---|---|---|---|
| Heat Source | Regional heat gradient | Rift gradient with heat upflow | Basaltic volcanic magma chambers |
| Temperature | Low enthalpy (<140˚C) | Medium enthalpy (<180˚C) | High enthalpy (>180˚C) |
| Water Availability | High (sedimentary reservoirs) | Medium (high vertical permeability) | Low (fissure-dependent) |
| Locations | Eastern Region, Red Sea Coast | Jizan (Ain Al Wagrah), AL-Lith) | Harrats east of the escarpment |

## CURRENT & PROJECTED POWER DEMAND

In 2011, the peak demand leveled at 45 GW. It is projected that the demand will reach 121GW in 2032. The residential sector demanded 23.4GW and 16.9GW were used for air conditioning.

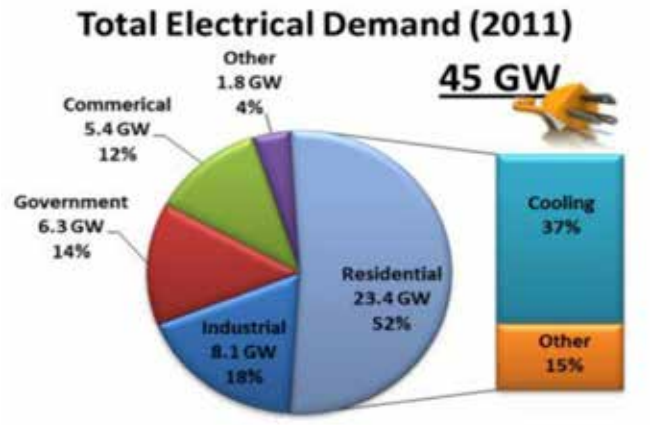


*Figure 3. Total energy demand for Kingdom of Saudi Arabia.*

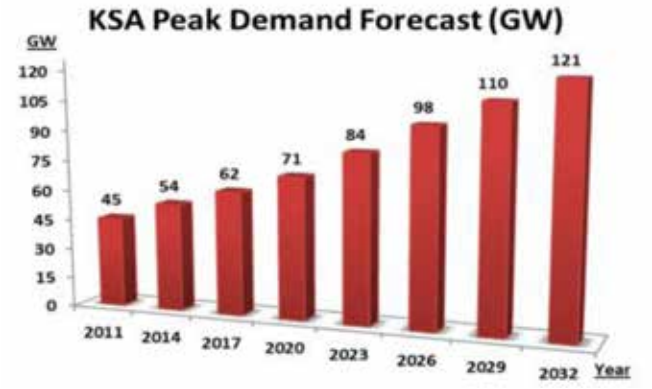


*Figure 4. KSA Peak Demand Forcast.*

## ELECTRICAL GENERATION

Currently, the Kingdom of Saudi Arabia is dependent on fossil fuel to generate electricity. More than 270 million barrels of oil per year are burned in oil fired power plants. By 2020, about 430 million barrels of oil will be burned to generate electricity; and by 2030, this number will be about 850 million barrels.

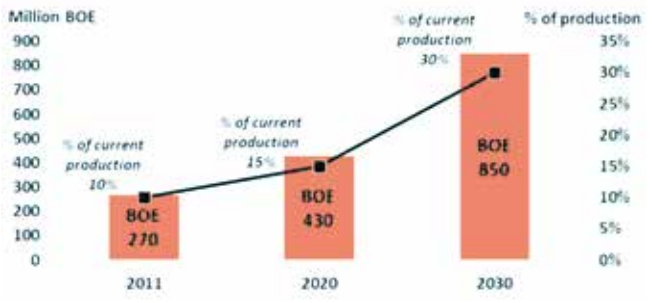


*Figure 5. Forecast for amount of barrels of oil used for power production.*

## REQUIREMENTS FOR THE UTILIZATION OF GEOTHERMAL RESOURCES IN SAUDI ARABIA

### Political

The development of geothermal resource requires compliance with relevant National and International laws and regulations to ensure sustainability.

The political will to explore, then exploit, all the potential geothermal resources in the country is a crucial step in realizing a true geothermal development.

Policies need to be developed as they are closely linked to the regulations, incentives and initiatives. These would include but are not limited to:

- A geothermal kWh FIT structure should be supported.
- Local demand and risk factors to be assessed.
- Fiscal incentives are to be set.
- Public finance structures to be enabled.
- Government subsidies and guarantees should be provided to cover commercial upfront exploration costs, including initial drilling costs.

### Economical

Providing economic structures to enable geothermal development is essential, due to the high upfront costs associated with geothermal development.

Introducing financial incentives such as capital-investment subsidies or rebates is essential.

An economic framework would include incentives for:

- Avoided fuel, capital, and financing costs associated with oil fired power plant
- Providing Feed in Tariff that support kWh production costs.
- Providing financing schemes that enables geothermal development.
- Carbon credit.
- Introducing financial incentives such as capital-investment subsidies or rebates.

### Social

To educate the general public about geothermal development and the benefits it holds to the local economy is important. Furthermore, the society must be educated about what risks are claimed including the release of toxic gases during the drilling, and volcanic hazards and hydrothermal eruptions.

The social involvement must address fears regarding the misconception of volcanic and geothermal resources' possible threat to nearby populations and the claims that these developments have a health impact on workers who might be exposed to gases or acid particle emissions. Educational programs must be created and launched nationwide before engagement in active projects to gain public acceptance and support to these projects. One such

way could be through establishing competitions and awards for innovative efforts in the field of geothermal projects.

And finally, the society must recognize that geothermal projects provide jobs and infrastructure creation while maintaining a clean energy to the community with low environmental impact.

### Educational

To support the geothermal development initiative, educational programs aimed towards capacity building should include the establishment of a renewable energy degree program in Saudi universities and incorporating renewable energy courses into the Saudi formal education system with emphasis on geothermal development.

Also, Stakeholder engagement and education is important to gain alliance and to focus efforts, holding geothermal workshops and various activities to educate and involve all types of stakeholders is essential.

### Technical

Bearing in mind that geo-scientific investigations are the first step in the process of the discovery of geothermal resources, these investigations include surface geologic mapping to map the lateral extent, depth and distribution of active geothermal systems and exploration drilling at a later stage.

Setting up collaborative and joint-venture agreements using international expertise is essential to overcome technical issues and build local capacities.

## POTENTIAL USES OF GEOTHERMAL ENERGY IN THE KINGDOM

- Power generation using Organic Rankine Cycle (ORC) with temperatures over 110°C
- Cooling:
  - Absorption chillers (80°C -130°C) (proven cooling method)
  - Adsorption chillers (70°C and 95°C) (smaller and somewhat less proven)
- Desalination with:
  - Multi stage flash (100°C - 120°C)
  - Multi effect Distillation (75°C - 105°C)
  - Forward osmosis (65°C - 90°C)
- Hot water for domestic use and some industrial use

## CONCLUSION

With the presence of some potential resource rich geothermal locations in Saudi Arabia, geothermal energy becomes a realistic and a highly promising source of renewable energy. The Kingdom stands to benefit from a holistic roadmap that will identify the required critical elements for the effective utilization of geothermal energy to be developed and implemented by K.A.CARE.

By successfully implementing geothermal energy development programs, the Kingdom of Saudi Arabia will be in a position to supply the GCC with cheap renewable energy, providing thousands of MW of base-load power, and replace thousands more MW through direct industrial applications. Saudi Arabia can reduce its emissions and help achieve sustainability for the present and for future generations.

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