The Potential of Enhanced Geothermal Energy Systems in Saudi Arabia*

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Abstract

Saudi Arabia is a major oil and gas producing country, but additionally it has good potential for other sources of energy such as solar and geothermal energy. The potential of geothermal energy in Saudi Arabia is evidenced by vast Harrat fields covering huge areas along the Red Sea coast. Harrats are volcanic rocks resulted from previous eruptions started with the opening of the Red Sea 30 million years ago. The last documented eruption in the Hijaz Province happened more than 700 years ago. Yet, in 2009, several earthquakes rocked the towns of UmLuj and Alais. The earthquakes were related to an upward movement of volcanic magma in the Lunayyir Volcanic Field. The eruption has not occurred yet, but it is expected to happen at any time.

The basic components of a geothermal energy system are heat source, water and a reservoir where heat is exchanged. The heat source is abundantly available along the Red Sea coast, especially in the Jizan Province. Several hot springs exist in that area where the measured heat exceeds 50 degrees C at the surface of the Earth.

The petroleum-related activities have proven the existence of sedimentary reservoirs where hydrocarbons are trapped. These reservoirs and other sedimentary formations can be developed for geothermal energy reservoirs. Those formations are available in Jizan and Umluj on the Red Sea shoreline.

Water is a serious problem in Saudi Arabia and could be a limiting factor on the utilization of geothermal energy. However, since most of the promising areas are adjacent to the shoreline of the Red Sea, sea water could be used in the system. Using the sea water will produce energy and desalinated water as a by-product.

Saudi Arabia has a good source of clean and sustainable energy if the government decides to utilize it. It exists on the other side of the country away from the giant oil and gas fields, which substantially reduces the cost of transportation and provides cheaper energy.

Reference

Rehman, S., 2010, Saudi Arabian geothermal energy resources-an update: Proceedings World Geothermal Congress 2010, 25-29 April 2010, Bali, Indonesia, Paper No. 0107.

Website

Seach, J., Volcano Live: Volcanoes of Saudi Arabia – John Seach: Internet resource, Web accessed 16 August 2012. http://www.volcanolive.com/saudi.html

THE POTENTIAL OF ENHANCED GEOTHERMAL ENERGY SYSTEMS IN SAUDI ARABIA

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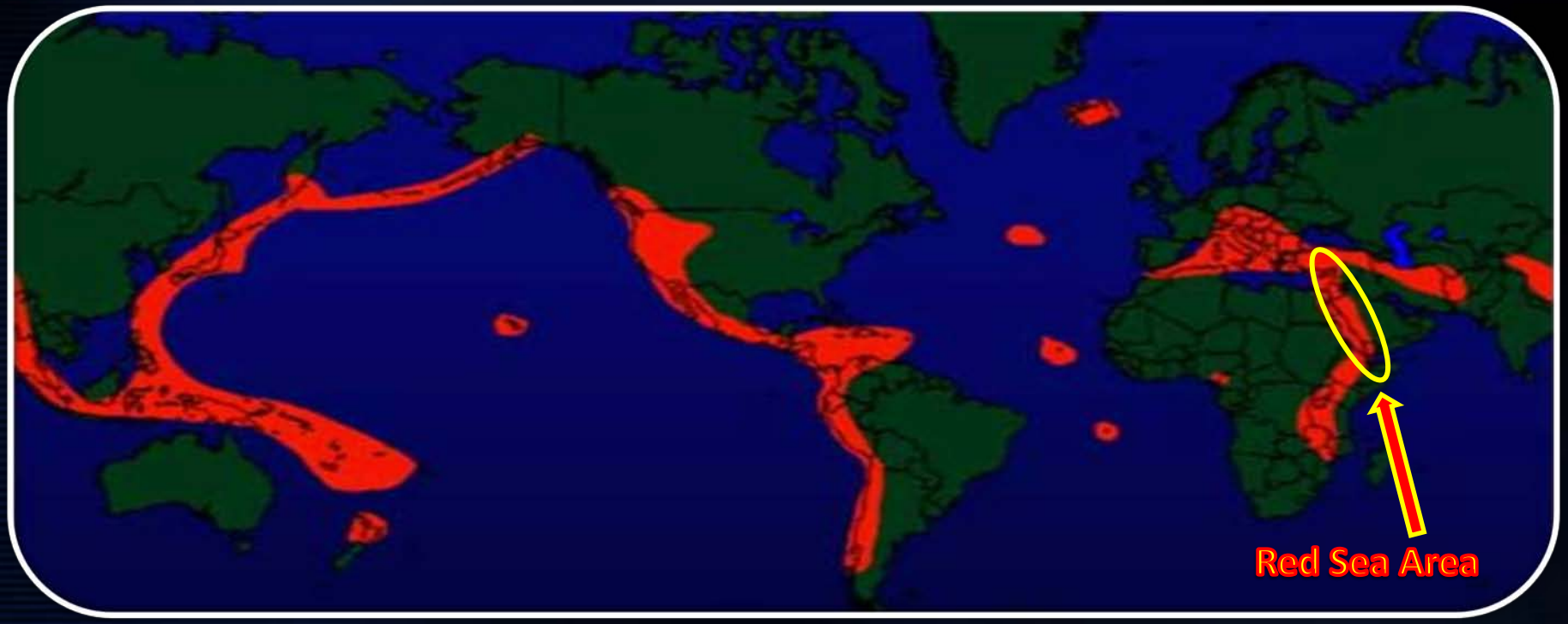
Hottest Known Geothermal Regions in the World



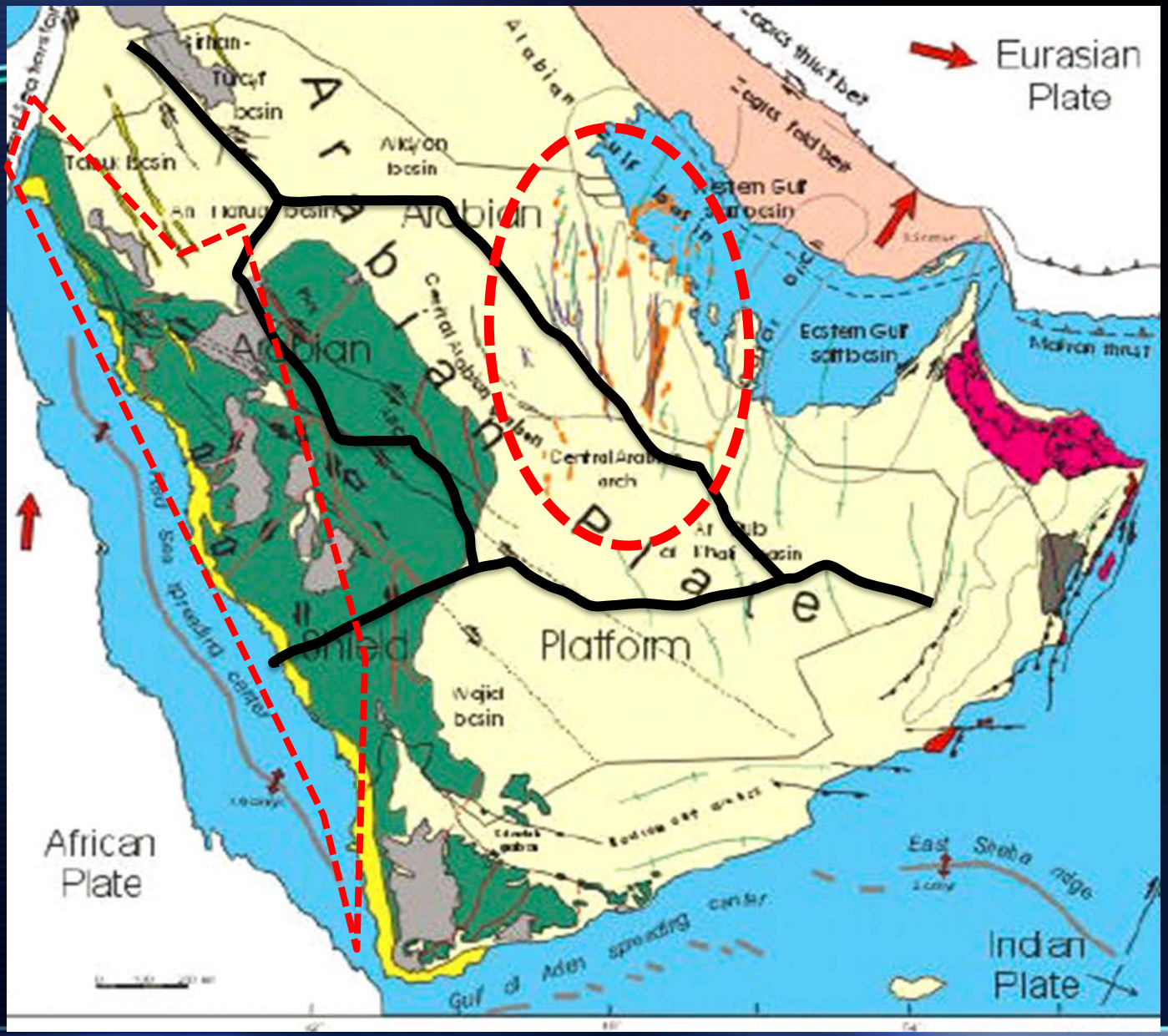
The hottest places exist in areas of high tectonic and volcanic activities
At or near plate margins

Source: Geothermal Energy Association(GEA)

The potential of the geothermal energy systems depends on:

- The availability of system elements
  - ✓ Heat source
  - ✓ Reservoir
  - ✓ Water
- Energy demand
- Oil/Gas consumption
- Geographic location
- Economic capability
- Technical experience

Energy Sources in Saudi Arabia



Geothermal Energy System – Heat Source

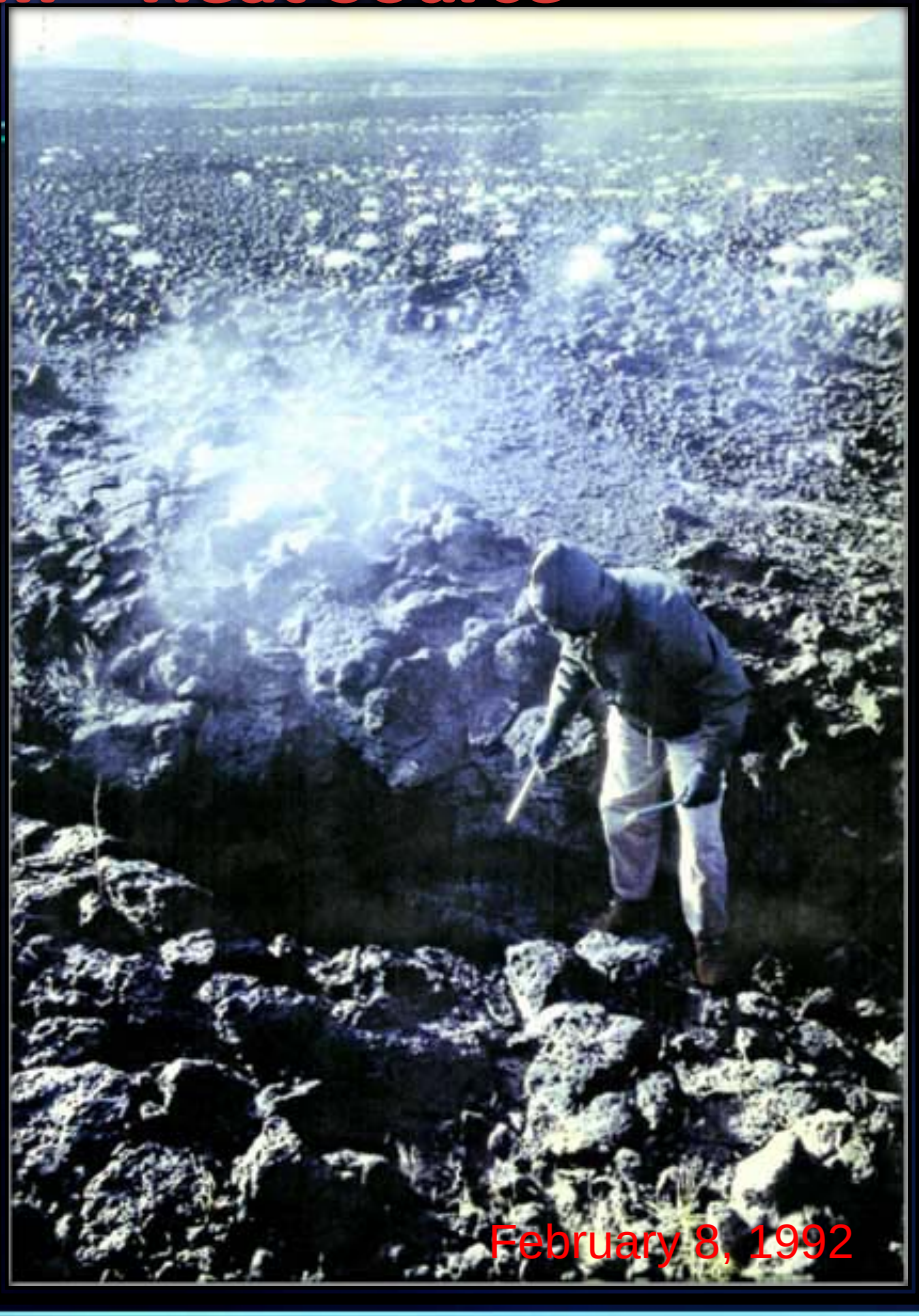
Volcanic Sites (Harrat) in Saudi Arabia (Geothermal prospects)

Volcanic Site	elevation	Location	Eruptions	
Al Harrah	1100 m	near Jordan Borders	no recent eruptions	
Harrat Ar Raha	1660	Tabuk	no recent eruptions	
Harrat 'Uwayrid	1900	Madinah	640 AD	
Harrat Lunayyir	1370	Ummlujj/Tabuk	1000 AD	Active
Harrat Ithnayn	1625	Ha'il	eruptions in past 1500 years	
Harrat Khaybar	2093	Madinah	650 AD	
Harrat Rahat	1744	Jeddah-Madinah	1292?, 1256, 641 AD	
Harrat Kishb	1475	Cental Saudi Arabia	no recent eruptions	
Harrat al Birk	381	North of Jizan	maybe in the past 100 years	
Jabal Yar	305	Jizan	1810 AD	

Source: John Seach, Volcanoes of Saudi Arabia
http://volcano.asia/saudi.html

Geothermal Energy System – Heat Source

Steam fumarole in an eroded lava flow in Harrat Khaybar.



Source: Saudi Geological Survey (SGS).

Geothermal Energy System – Heat Source

This crater, which is about 200 m deep and 2 km wide, resulted from a phreatic explosion caused by the near-instantaneous generation of steam at the contact between rising magma and ground water.

(Source SGS)

May 2009 Earthquakes

May 2009 Earthquakes

Geothermal Energy System – Heat Source

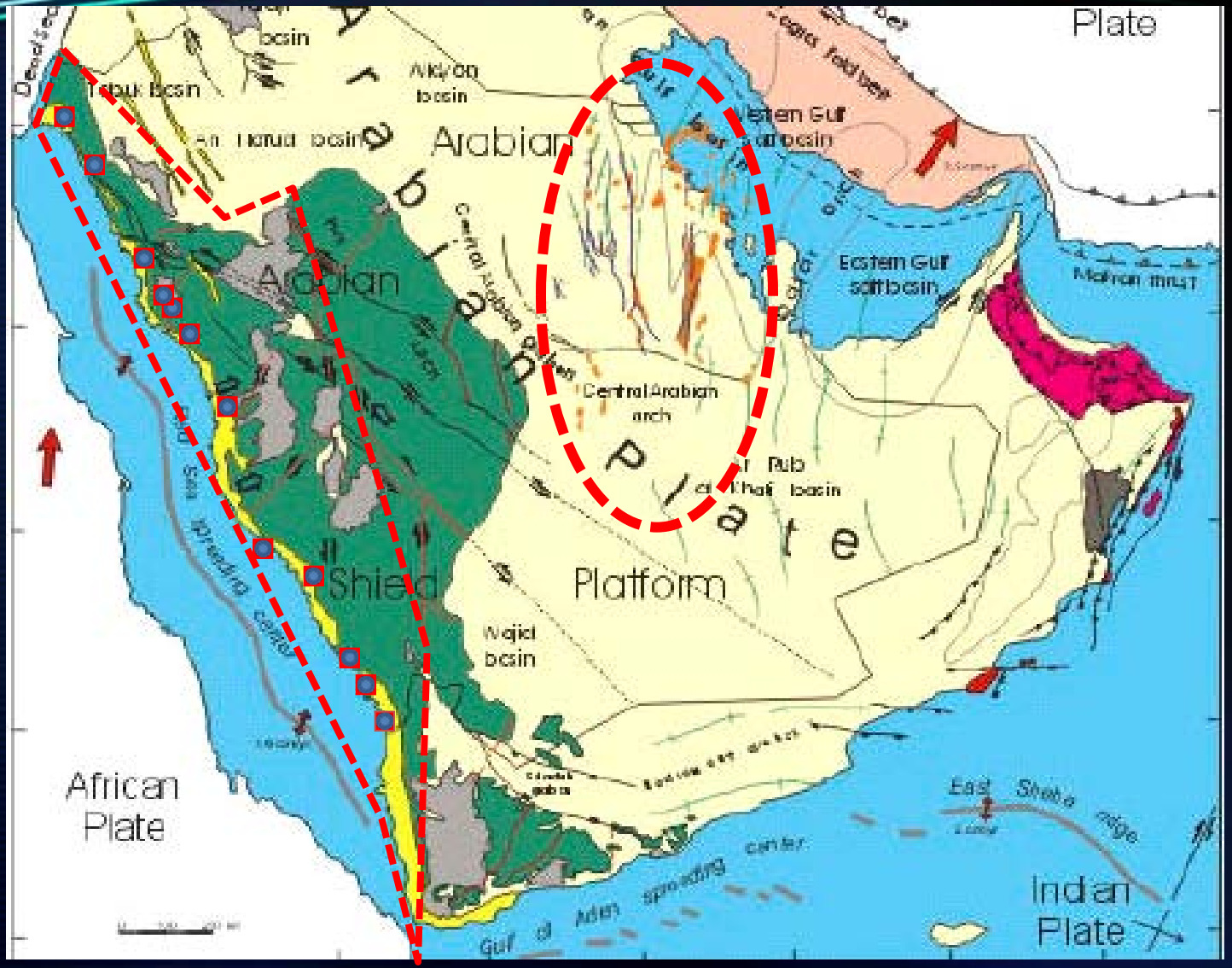
Name	Latitude	Longitude	Temperature (°C)	Flow Rate (L/min)	Aquifer type
Ain Khulab (Gizan)	16°45N	43°07E	75.5	1 - 2	TS*
Wadi Khulas (Gizan)	-	-	31.4	10.0	Wadi
Ain Khulab Quwa (Gizan)	16°48N	43°12E	59.0	2.0	TS*
Ain al Wagrah (Gizan)	17°03N	42°59E	55.0	1.5	TS*
Ain al Wagrah Dam (Gizan)	17°03N	42°59E	59.0	20.0	TS*
Ain al Harra (Al Lith)	20°29N	40°28E	79.0	4 - 5	TS*
Ain al Jumah (Al Lith)	20°18N	40°42E	46.0	0.3	TS*
Ain Markus (Al Lith)	20°33N	40°09E	46.0	0.3	TS*
Ain al Darakah (Al Lith)	20°39N	40°01E	39.5	0.1	TS*

*TS - Thermal Spring

Thermal Springs in Saudi Arabia

Source: Rehman S., 2010

Geothermal Energy System – Reservoir



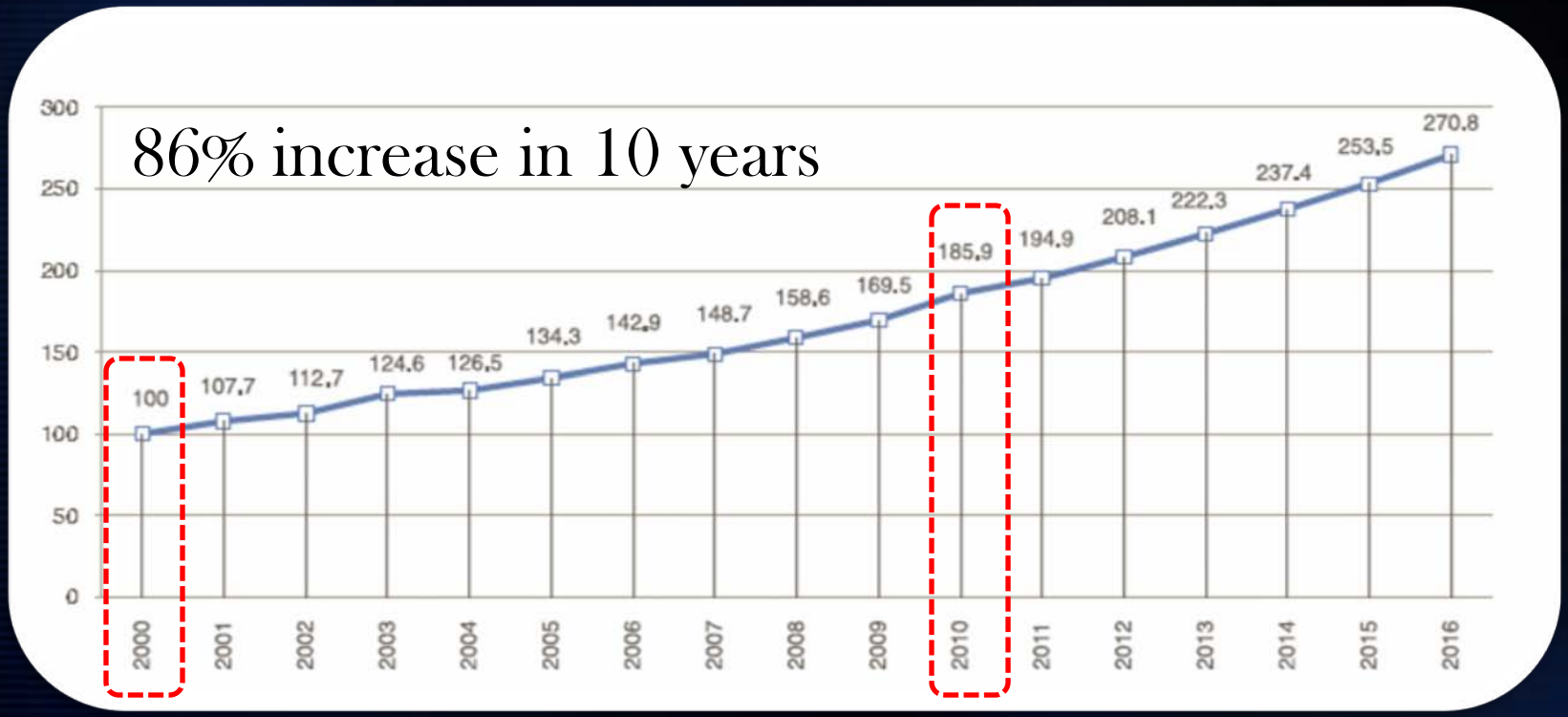
Geothermal Energy System – Water Source

Potential Geothermal Site in Jizan

Geothermal Energy System – Water Source

Potential Geothermal Site in Jizan

Relative Growth Level of Produced Energy 2000-2010



Peak Demand Forcast by Region

REGION	Gigawatts						Average Annual Growth	Growth 11' - 21'
	2011	2013	2015	2017	2019	2021		
Eastern	14.3	15.9	17.4	19.2	21.4	24.5	**7%**	71%
Central	14.3	15.9	17.2	18.6	20.0	21.5	5%	50%
Western	14.2	15.7	17.0	18.4	19.9	21.6	5%	52%
Southern	3.6	4.5	5.1	5.8	6.5	7.2	**10%**	98%
Total	**46.5**	**52.0**	**56.8**	**61.9**	**67.7**	**74.8**	**6%**	**61%**

Source: Electricity & Co-Generation Regulatory Authority (ECRA), 2011

Peak Demand Forcast by Sector

SECTOR	Gigawatts						Average Annual Growth	Future Growth 11' - 21'
	2011	2013	2015	2017	2019	2021		
Residential	27.0	30.1	32.9	35.7	38.8	42.2	5%	56%
Commercial	4.8	5.4	6.1	6.7	7.4	8.4	7%	74%
Government	57	6.1	6.5	6.8	7.1	7.5	3%	34%
Industrial	5.6	9.3	10.4	11.6	13.2	15.6	8%	90%
Ag & Other	8.2	1.0	1.0	1.1	1.1	1.2	3%	33%
Total	**46.5**	**52.0**	**56.8**	**61.9**	**67.7**	**74.8**	**6%**	**61%**

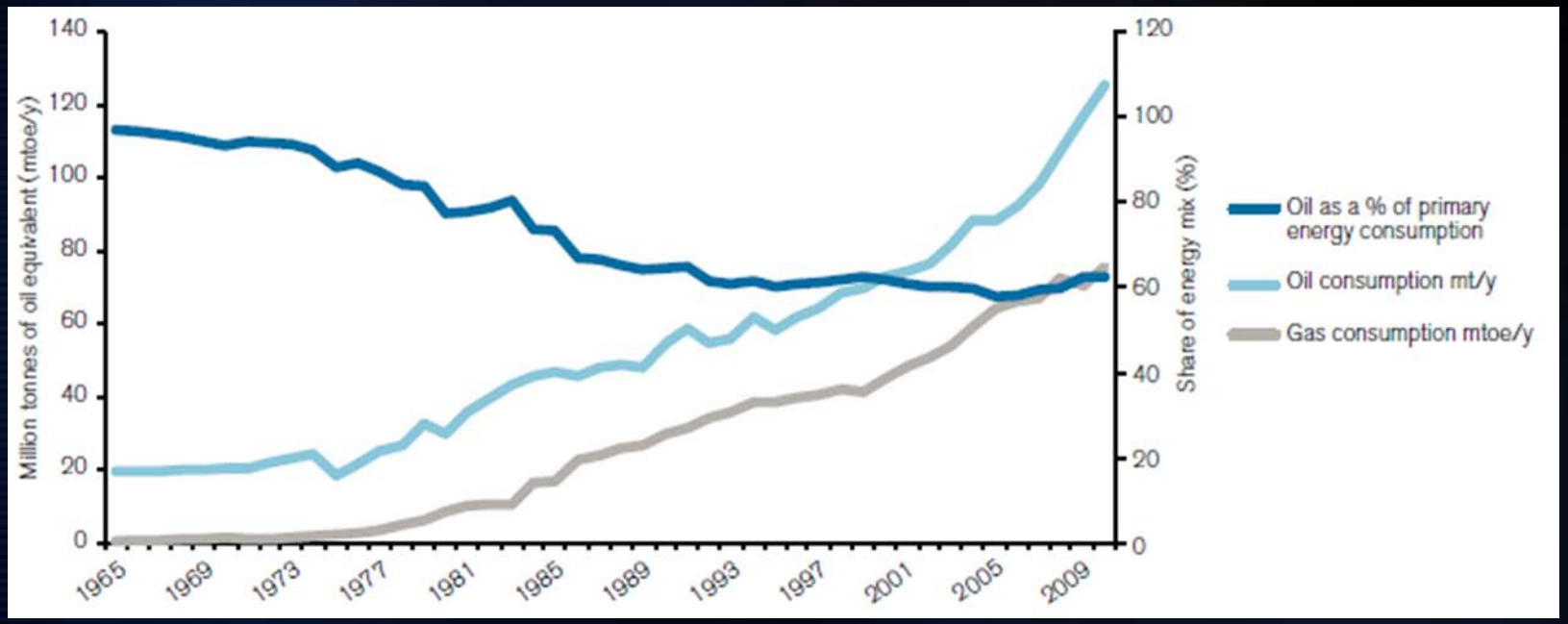
Source: Electricity & Co-Generation Regulatory Authority (ECRA), 2011

Fuel Consumption by Region

Fuel consumption SEC	2008				2009				2010			
	Gas	Crude	HFO	Diesel	Gas	Crude	HFO	Diesel	Gas	Crude	HFO	Diesel
	Million M^3	Tonne			Million M^3	Tonne			Million M^3	Tonne		
East	15,235	321,600	0	1,022,897	12,756	3,164,875	0	1,199,003	11,443	3,484,757	0	1,387,808
Central	8,806	4,234,739	0	1,497,883	9,340	4558,431	0	1,349,330	8,483	5,172,275	0	1,807,976
West	0	3,165,718	6,949,185	3,665,976	0	7,173,020	3,880,873	4,109,658	0	9,562,130	2,482,811	4,076,487
South	0	1,233,487	0	3,901,700	0	1,507,309	0	4,129,802	0	1,462,733	0	3,711,081
Total	24,141	8,955,544	6,949,185	10,088,459	22,095	16,403,635	3,880,873	10,787,794	19,926	19,681,895	2,482,811	10,983,152
Estimation on diesel consumption for off-grid systems				208,609				280,348				294,957

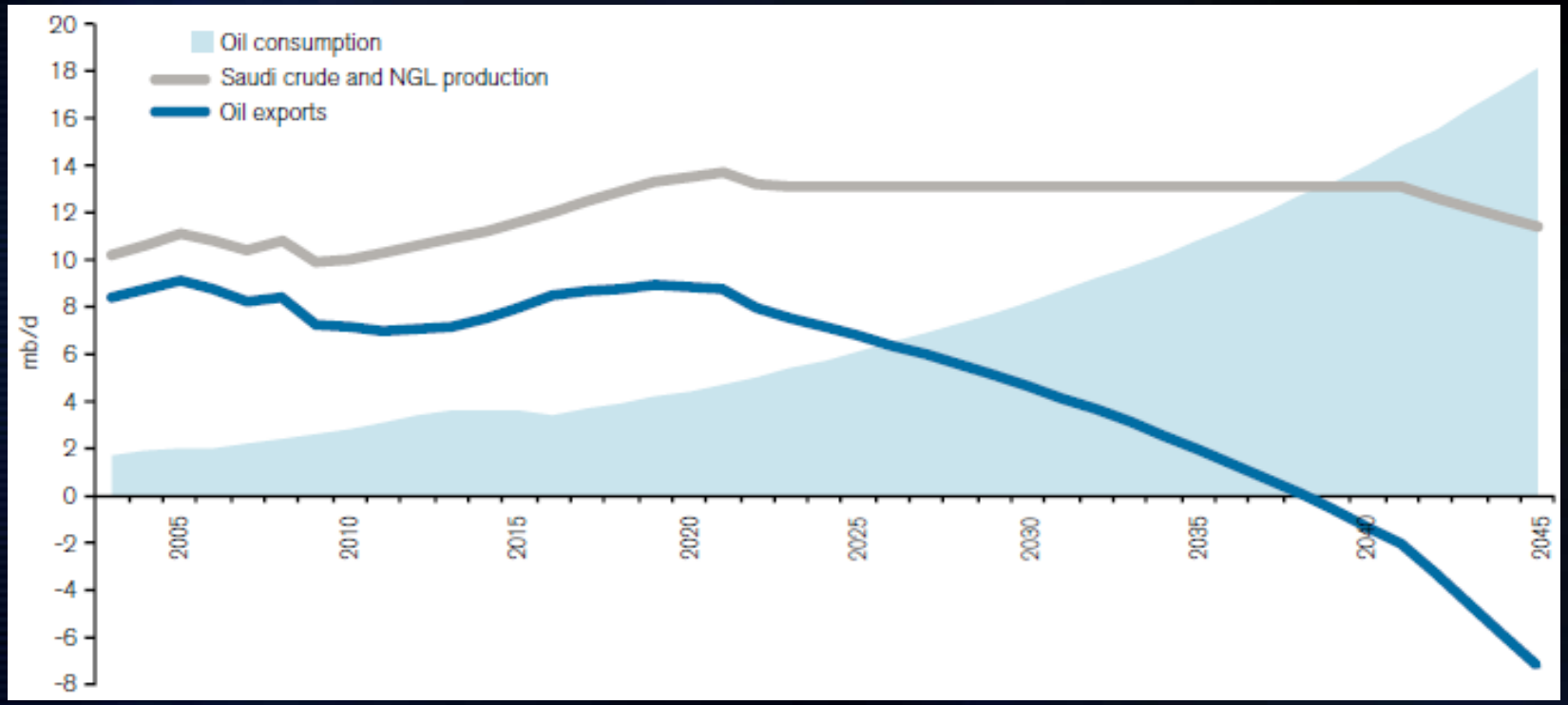
Source: Electricity & Co-Generation Regulatory Authority (ECRA), 2011

Saudi Arabia's historical energy consumption pattern



Source: Chatham House research, 2010

Saudi Arabia's Oil Balance



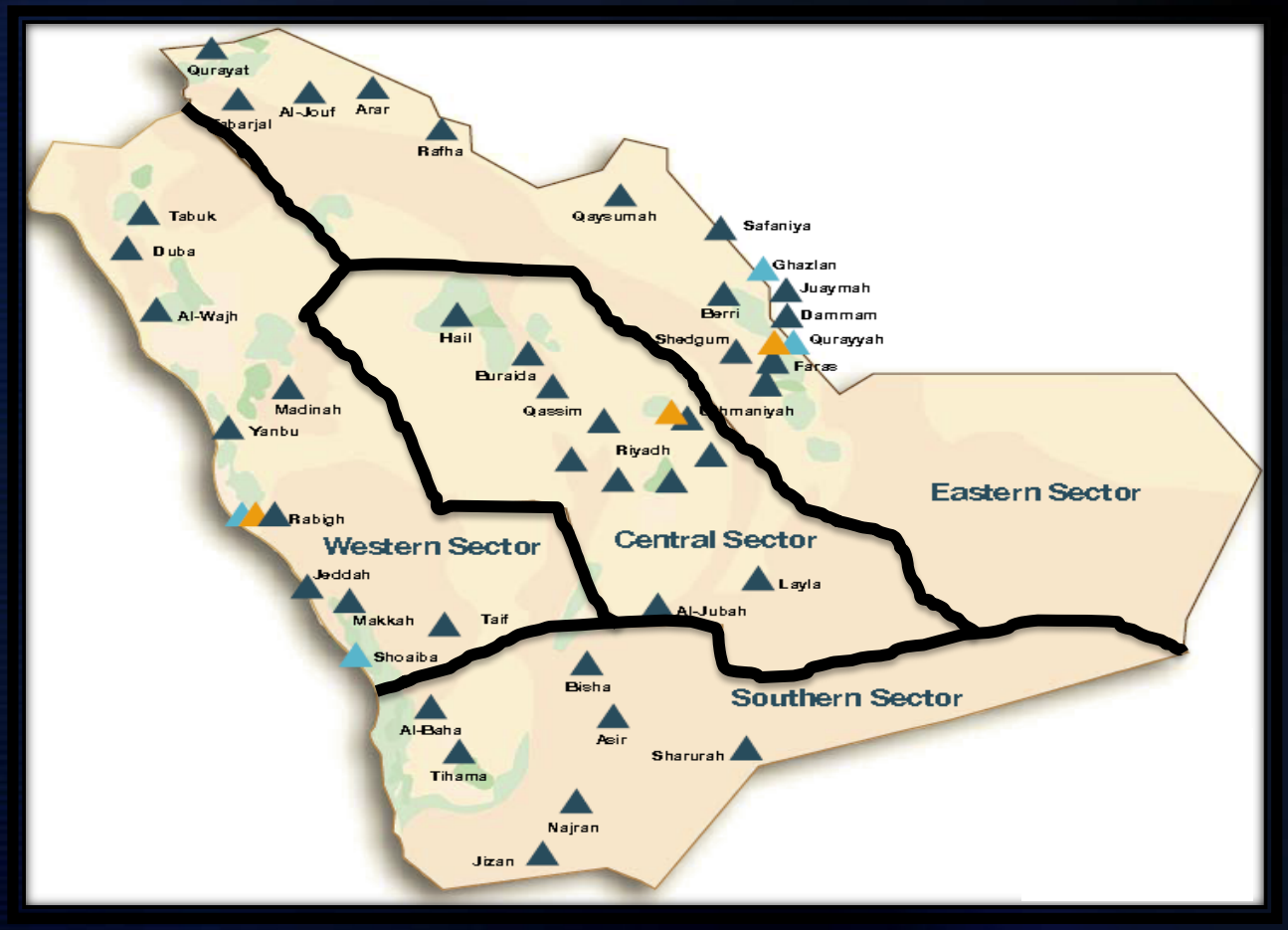
Source: Chatham House research, 2010

Summary

- There is a good potential for geothermal Energy in Saudi Arabia
  - Heat sources are available in several locations along the Red Sea
  - Reservoirs are also available:
    - Oil/gas wells penetrated ~ 15000 ft within the sedimentary section.
    - Oil/gas found in some of these wells .
  - Water resources are short but sea water and/or waste water can be used
- Saudi Arabia has the ability and technical experience in:
  - Exploration & Drilling
  - Sea water treatment and injection
  - Reservoir management
- Utilizing the geothermal resources will reduce the amount of oil & gas burned for Electricity generation.
- It will make important industrial and economic Impact in Southern and Western regions

Thank you

Energy Sectors (Regions) in Saudi Arabia



Source: Electricity Company report, 2011