Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

# Current and Future Status of Geothermal Energy in Yemen

Ramzi Hazza Abdullah Murshed

Ministry of Electricity and Energy. Republic of Yemen

ramzykoradh@gmail.com

Keywords: Renewable Energy ,Geothermal, Market Access, Sustainable Development

**ABSTRACT**

The issue of the use of new and renewable energy, especially Geothermal Eneryg, has emerged on the world stage as a strategic resource to meet the future needs of local and global energy. It is clear that there is a strong link between the success of development and the energy available as the main engine. Is a very important dimension, as the depletion of traditional sources of energy over the next 30 years, in addition to this, another issue related to the contribution of the energy saving process based on the traditional sources of the steady rise in the rates of global pollution, especially the large urban centers as the most used energy. Therefore, the research seeks to identify the appropriate mechanisms to activate the systems of the use of thermal energy from the underground in our country and our communities To achieve and activate the principles of sustainability in the development process, the most important of which: research and development, partnership and funding, awareness and motivation, legislation and law, inclusion in the development plans of the regions and urban communities.

## 1. INTRODUCTION

The issue of the use of new and renewable energy, especially geothermal energy, has emerged as a strategic choice to meet the local and global energy needs. It is clear that there is a strong correlation between the success of development and the energy available as the main engine, Is reflected in the beginning of depletion of traditional sources of energy over the next thirty years, in addition to another issue related to the contribution of the energy saving process based on traditional sources of the rise in global rates of pollution, especially centers Urban large as the most used energy, Therefore, the research seeks to identify appropriate mechanisms to activate the thermal energy systems from the underground in our country and our communities to achieve and activate the principles of sustainability in the development process, and the preservation of the environment and its resources.

## 2. METHODOLOGICAL FRAMEWORK

### 2.1 Research objectives

The aim of the research is to try to advance efforts towards the implementation of a strategy for the sustainable development of urban communities, especially the major ones, which, in their multiple axes, rely on the new energy generated from the ground as a means to reduce the negative environmental impacts of increasing urban development and sustainability.

In addition, the research aims to "focus on the issue of energy saving from geothermal as a source of clean energy in Yemen, the Arab world and worldwide in order to obtain a clean environment for sustainable development.

### 2.2 Methodology of research

In view of the close correlation between environmental pressures and high pollution rates on the one hand, and increasing urban development, on the other hand, the research adopts a set of mechanisms to reduce the negative effects of increasing urbanization on the environment by using renewable energy sources, especially from geothermal energy at all levels through:

• Monitoring the effects of conventional energy use on the steadily increasing rates of pollution in urban centers based on several experiments.
• Draw the most positive effects of using this technology in protecting the environment and achieving the principles of sustainability.
• Identify the appropriate mechanisms to activate the systems for the use of geothermal energy applications and access to sustainable cities.
• Review of the most important experiments in the application of geothermal energy technologies (Geothermal) and its effects on pollution reduction.

## 3. BASIC CONCEPTS

### 3.1 Renewable Energy

is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and Geothermal I heat.

### 3.2 Geothermal

Geothermal energy is the direct generation of energy from Earth. The word geothermal comes from the Greek words geo, meaning earth and thermal mean heat. They are the heat of the earth and are used to translate the geothermal temperature of this word. The geothermal energy begins from underground rocky rocks that heat the outer crust of the Earth.

The rising heat of these molten rocks heated the underground water pools called geothermal reservoirs.

### 3.3 Sustainable Development

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

## 4. MAIN ISSUES OF RESEARCH

The main issues that will be addressed in the research are:

* The use of geothermal energy to generate electricity in the Republic of Yemen

* Current and Future Status of Renewable Energy from Yemen's Geothermal Energy (Trends and Policies)

* Development & Market Access

* THE IMPLEMENTATION OF THIS FRAMEWORK SO FAR.

*Constraints and constraints facing the development of renewable energy

The discussion below discusses these issues, leading to a set of outcomes that enable the realization of a sustainable development model.

### 4.1 - The use of geothermal energy to generate electricity in the Republic of Yemen

The study and exploration of thermal energy in Yemen began in 1980 and 1981 by the Italian Center (ELC): Work carried out during the years (2001 to 2006)

Geochemical survey of hot spots in Yemen was carried out

More than 414 water samples were collected 30 gas samples were collected:

Exxon company drilled an oil exploration well in the area of the depth of this well 5331ft and the results of the drilling of this well showed that the highest temperature recorded (232 ° f) (105 ° C) at a depth (1625m) It is a sign of existence high thermal gradient and heat flow

1- Jabal Al-Yissi area, Mif'at Anas, Dhamar Governorate.

2 - Al-Qafar district, Ab

3 - Dumet district of Al-Dali'a Governorate.

This source is considered one of the cheapest sources of electricity generation and is not affected by the climatic changes associated with other renewable sources such as solar, wind, tidal and hydro power. This source is considered one of the cheapest sources of electricity generation and is not affected by the climatic changes associated with other renewable sources such as solar, wind, tidal and hydro power.

This source is one of the ideal solutions for generating electricity in the Republic of Yemen. The thermal reservoirs of the floor are divided into two main types:

The first is the high temperature, which is above 240 ° C and is found mainly in areas with volcanic potential and is usually used for electric power stations.

Second: the same medium and low temperature and are usually used in household heating and agriculture.

It is noted that our country enjoys the first type of geothermal reservoirs since we have a volcanic history that we can observe and deduce. Also, there are hot water sources in different parts of the country. This indicates the existence of this energy and at depths that may be close. For more than 100 areas containing the springs to complete studies on the production of electric energy economically feasible, where the government agencies are responsible for signing a number of agreements with foreign American and German specialized in this type of projects as the establishment of such stations In the appropriate places of high economic feasibility

Because this source is considered one of the cheapest renewable sources used in power generation map No. (2) Source Authority spaces.

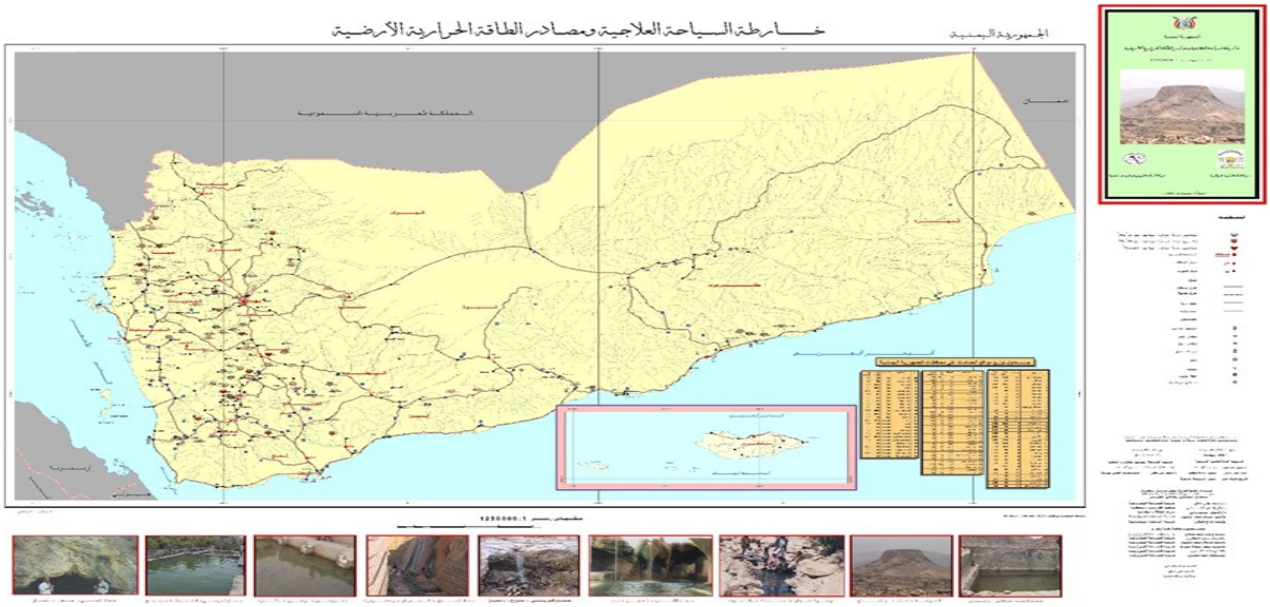



**Figure (1) shows Map of remedial tourism and energy sources Geothermal, Source: Geological Survey Authority Republic of Yemen**

**Table (1) Illustrates the hot springs areas in the Republic of Yemen.**

| Governorateate | Hot springs | Geological features | Uses | Remarks |
|---|---|---|---|---|
| Hadramawt | 11 | Tertiary sediments represented by Umm Er-Radhumah Formation | Medical Tourism Drying of fish, vegetables | Scattered small Volcanic fields |
| Shabwah | 5 | Bir Ali Quaternary basaltic Volcanic field (700 km2) | Medical Tourism | |
| Abyan | 5 | Shuqrah-Al-Urqoob Quaternary-Recent basaltic volcanic field (>4000 km2) | Medical Tourism | |
| Lahj | 4 | Basement rocks, and Tertiary volcanics | Medical Tourism | |
| Dhamar | 14, and Fumaroles | Quaternary- Recent volcanic field associated with silicic domes, and Tertiary volcanics | Medical Tourism Agriculture | Seismically Active |
| Ad-Dhala | 18 | Cretaceous Tawilah sandstone, and Tertiary volcanics | Medical Tourism Agriculture | |
| Ta'iz | 8 | Cretaceous sandstone, but mostly Tertiary volcanics, and scattered Quaternary volcanics | Medical Tourism Agriculture | |
| Ibb | 16 | Tertiary volcanic rocks | Medical Tourism Agriculture | Seismically Active |
| Al-Hudaydah | 8 | Basement rocks, Tertiary volcanics, Quaternary volcanoclastic sediments | Medical Tourism Drying of fish, vegetables | |
| Hajjah | 11 | Mainly basement complexes | Medical Tourism Agriculture | Slight seismic Activity |

From this point of view, the source is permanent, sustainable and environmentally friendly. It does not require much effort and effort. Drilling machines, which are the main problem of exploiting this source, are similar or may be drilling machines.

This source can be considered as the ideal power generation in our country.

### 4.2 Medical Tourism

Spa baths are spread in many areas of Yemen and the most important, Bath Hammam in Taiz, Hammam of the Russians in the Directorate of the Land of the Russians, Hammam Jabal Al-Lus in Dhamar, Hamam Ali in Anse Hadidah, Hammam al-Huwaimi in Lahj, Hammam Radhoum in Shabwah, Hammam-Tebala, Hami, Wadi al-Sharqiyah and Suwaybir in Hadramout. It is estimated that the total hot mineral baths in Yemen is about 79 baths, which is meant daily thousands of tourists and visitors from Yemen and the Gulf and different nationalities for the purpose of hospitalization of intractable rheumatic and skin diseases, such as joint pain and spine and sensitivity of the skin and eyes and stimulate blood circulation and other diseases that are unable Modern medicine about its therapeutics. It is a vast area for the development of medical tourism. Currently, the Government of Yemen is seeking to improve the conditions of hot mineral water use in Yemen.Hammamet will see a boom in medical tourism:- Treatment of rheumatic infections and chronic arthritis primitive or secondary.

Treatment of joint diseases caused by the deposition of urine acid salts.

Treatment of chronic and non-festering skin diseases.

Treatment of dry allergies.

Treatment of fungal infections.

Stomach infections associated with high pH.

Chronic bronchitis.

Cases of chronic inflammation of the reproductive system of women.

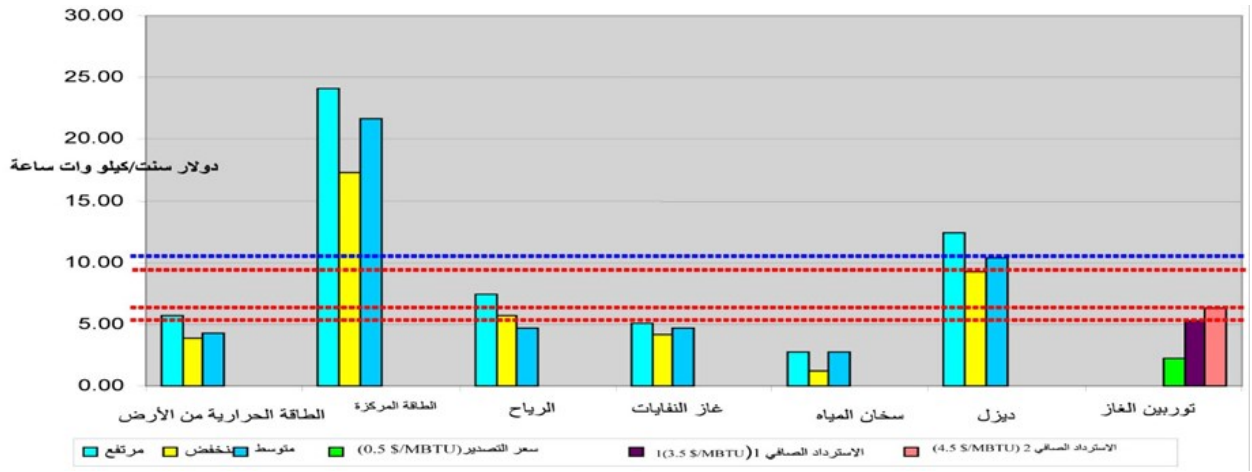
## 5 CURRENT AND FUTURE STATUS OF RENEWABLE ENERGY FROM YEMEN'S GEOTHERMAL ENERGY (TRENDS AND POLICIES)

In view of the vital role played by electricity in the development of the national economy and meet the needs of economic and social development programs and the increasing demand for electrical power day by day, which must be set up to establish new stations and networks to meet the increased demand and cover the gap..

The global trend in the use and exploitation of renewable and clean sources of energy is seen as an economic, political and environmental alternative to traditional sources of environmental problems and pollution to water, air and life in general.

Therefore, the aim of using such resources by the political leadership of the State represented by the Ministry of Electricity and Energy and the General Department of Renewable Energy was a priority. This stage started with the preparation of the national renewable energy and energy efficiency strategy. During the measured data and available from the relevant government agencies

Figure (2) represents the wide range of the cost of the dynamic unit with the support of the hydro and thermal propulsion system, which enjoys the high density of electricity from the thermal energy from the ground.




source: Renewable energy strategy and acation-plan- Republic of Yemen (lahmeyer inational)

### 5.1 Geothermal energy resources in Yemen

Renewable energy resources are available in Yemen, in particular

Thermal energy from the ground

In fairly large quantities, this energy can also be exploited in Yemen. The assessment of geothermal energy resources covers both volcanic and non-volcanic areas in Yemen. The volcanic areas covered by the study are those located in the volcanic rock heights of Yemen. The sandstone layers extend to productivity in the long stretches of the coastal strip of the Red Sea from Lahj al-Hudaydah and penetrate into the interior lands to the governorate of Sakha. The study took into account the volcanic zone surrounding the province of Dhamar only.

*The theoretical potential exceeds 304 gigawatts of power

* Total technical capacity is about 2666

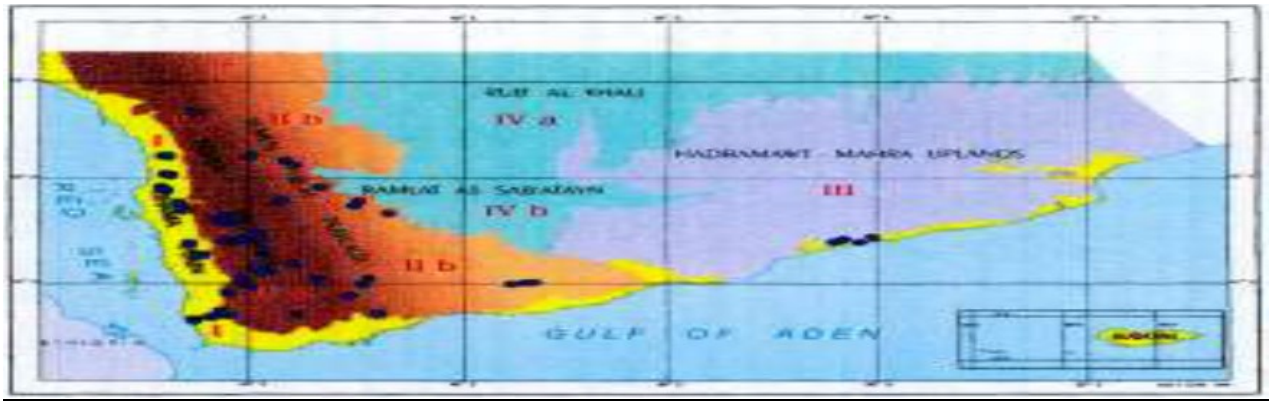



**Figure (3). Generalized topographic map showing the main distribution of the hot springs areas along the Gulf of Aden and the Red Sea**

Source: Mohamed A. Mattash (2)

*The theoretical potential is more than 3 gigawatts of thermal spherical capacity.

*The technical feasibility of a total thermal capacity of 278 MW was estimated. This capacity was also assessed as a practical technical possibility.

**Table (2 ) Summary of the technical theoretical possibilities of renewable energy from the ground**

| Technical capability | | Theoretical possibilities (mw) | Resources |
|---|---|---|---|
| (Applied (MW | (Total (MW | | |
| 34،286 | 123،429 | 304.722 | Thermal energy from the ground |

**5.2Development priorities for renewable energies in cities**

*Priority calibration:

**Table (3) shows the priorities of the regions and the corresponding economic potentials**

| Economic potential (MW )( | Governorates | Resources |
|---|---|---|
| mw2157 | | Geothermal energy |
| 250 | Dhamar | Volcanic areas |
| 450 | Hodeidah | |
| 1165 | Sana'a | Non-volcanic areas |
| 292 | Taiz | |

**5.3 Scenario for the development of renewable energy from geothermal energy**

5.3.1 Thermal energy scenario

For geothermal energy, the target is 123 MW which is expected to be embodied until about 2025.

**Table (4) for power and geothermal power generation.**

| Total generation (GWh) | Power(MW) Thermal energy from the ground | Scenarios |
|---|---|---|
| (%20 )3467 | 200 | High penetration scenario |
| (%15 ) 2600 | 160 | Reference scenario |
| (%10 )1733 | 125 | Low penetration scenario |

**5.4 Summary of general objectives of power and power generation**

*from renewable sources of underground energy in 2025

**Table (5) from renewable sources of underground energy in 2025**

| | |
|---|---|
| **3267 GWh (20% of total power generation) 1577 GWh** | **Spread scenario in the high marke *Thermal energy from the ground** |
| **2600 GWh (15% of total power generation) 1501 GWh** | **Reference scenario •Thermal energy from the ground** |
| 1733 **GWh** %10)**of the total electricity generation) 1183 GWh** | **Low-market deployment scenario** • **Geothermal** |

**6. DEVELOPMENT & MARKET ACCESS**

**Table (6) Priorities of regions to develop energy and economic potential**

| Resource | Governorate | Economic Potential (MW) |
|---|---|---|
| **Wind energy** | | **19199 MW** |
| *Coastal areas* | Abyan | 4813 |
| | Aden | 475 |
| | Lahej | 2540 |
| | Taiz | 5125 |
| | Al Hodeidah | 5094 |
| *Highlands* | Dhamar | 1152 |
| **Geothermal energy** | | **2157 MW** |
| *Volcanic areas* | Dhamar | 250 |
| *Non-volcanic areas* | Al Hodeidah | 450 |
| | Sana'a | 1165 |
| | Taiz | 292 |
| **Landfill gas** | | **6 MW** |
| | Sana'a | 3 |
| | Aden | 1 |
| | Al Hodeidah | 1 |
| | Taiz | 1 |

**6.1 Incentives Framework**

Financial Parameters

**Table (7) Financial Parameters**

| | |
|---|---|
| **Capital structure (debt/equity ratio)** | **75%** |
| **Target ROE** | **15%** |
| **Loan interest rate** | **9%** |
| **Repayment period** | **10 years** |
| **Grace period** | **2 years** |
| **Import tax** | **5% of the equipment cost** |
| **Corporate income tax** | **35%** |
| **Insurance** | |
| • **During construction** | **1.5% of the equipment cost** |
| • **During operational phase** | **1.2% of the sales revenue** |
| **Debt service reserve account** | **100% is maintained in the account** |

**6.2 Incentives Framework**

50 MW Geothermal Power Project (Dhamar or Al Hodeidah)

**Table (8) Tariff requirements of the project coupled with different catalytic mechanisms (50 MW thermal power from the ground**

| Incentives | Tariff Requirement (USc/kWh) | % Change |
|---|---|---|
| 1. Base case | 11.11 | - |
| 2. Tax holiday (15 years) + duty exempt | 9.39 | -15.48 |
| 3. Soft loan (9% to 3%) | 8.90 | -19.89 |
| 4. no grid connection | 10.92 | -1.71 |
| 5. exploration subsidy | 10.75 | -3.24 |
| 6. combination (2+4+5) | 8.94 | -19.53 |
| 7. combination (2+3+4+5) | 7.10 | -36.09 |
| 8. combination (2+4+5) + CDM (12$/tCO2) | 8.19 | -26.28 |
| 9. PEC average generation cost (with diesel fuel subsidy) | 8.69 | |
| 10. PEC average tariff | 6.44 | |
| 11. PEC average generation cost (without diesel fuel subsidy) | 17.4 | |

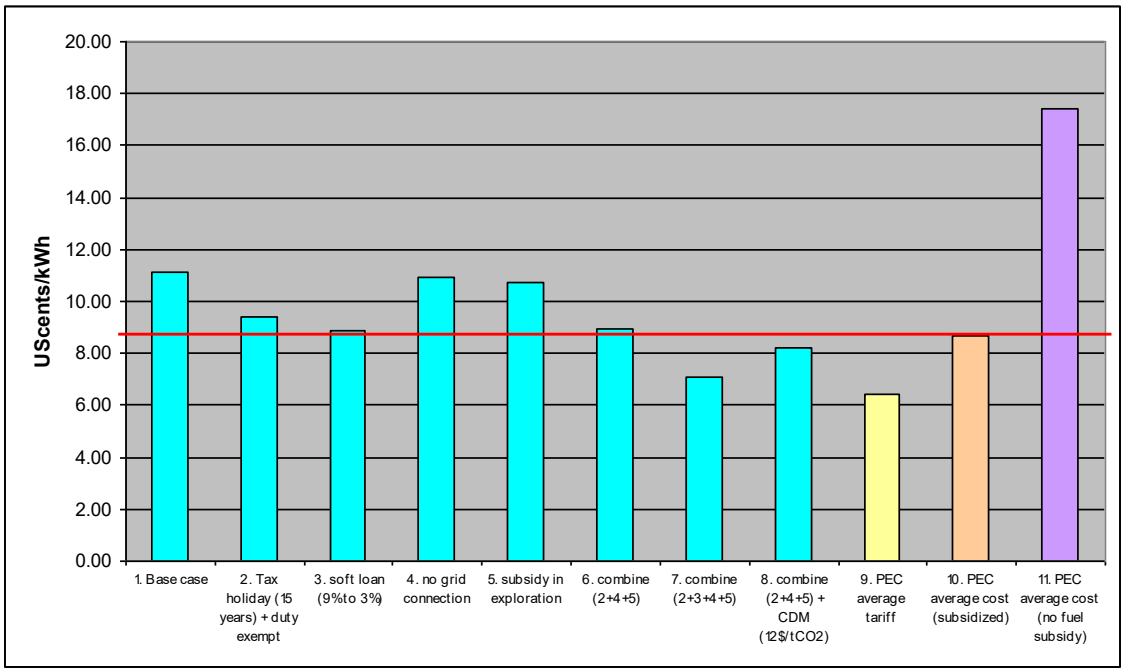



**Figure:(4) Tariff requirements of the project coupled with different catalytic mechanisms (50 MW thermal power from the ground**

source: Renewable energy strategy and acation-plan- Republic of Yemen (lahmeyer inational)

## 7. THE IMPLEMENTATION OF THIS FRAMEWORK SO FAR

### 7.1. In the field of thermal energy

A list of high potential fields was identified by the Ministry of Oil and Minerals (Geological Survey Authority). Energy resources were estimated through the study prepared by Lamayer Consulting Company in 2006 and initial studies are required to be updated according to the operation data (drilling of exploratory wells) At least 2,900 megawatts, most of which are located in Dhamar and Dali

Energy resources have been estimated through a study prepared by Lamayer Consulting in 2006, preliminary studies that need to be updated according to the operation data (drilling of exploratory wells) estimated at at least 2,900 megawatts, most of which are located in Dhamar, Dali and the coastal strip of the Red Sea.

A tender was issued to conduct the exploratory drilling in Al-Lasi area in Dhamar governorate. The Supreme Authority placed it on one of the local contractors in addition to the delay of the procedures for Tender Control. The exploratory study was carried out by the Italian consultant, who was contracted through the Geological Survey.

## 8. CONSTRAINTS AND CONSTRAINTS FACING THE DEVELOPMENT OF RENEWABLE ENERGY

Restrictions in Yemen are classified as follows:

1 -Institutional constraints

2 - Financial and economic constraints

3-Technical constraints

4- Information and awareness raising

5 - The current war in Yemen (Saudi-UAE aggression)

## 9. SEARCH RESULTS: GEOTHERMAL ENERGY STRATEGY IN YEMEN AND GEOTHERMAL ENERGY (TRENDS AND POLICIES)

Yemen and the Arab world are characterized by the fact that God has loved it abundantly in energy is one of the most important sources of energy that will change the map of its production globally in a clear period during the next short period, which will not exceed thirty years, is the supplier of heat from the ground, a huge resource characterized by our country Yemen in particular And the Arab world in general. Therefore, ignoring this resource, which will be pursued by the global energy markets, especially the European Union, in formulating the strategic axes of sustainable development at the national, regional and local levels will lead to the loss of these strategies of credibility and effectiveness.

According to the report, the research has come up with a set of mechanisms that provide a model for including energy use in sustainable development, as follows:

* Legislation and law: There must be a legislative and legal framework for the process of saving energy through underground energy..

*Partnership and funding: Yemen and the Arab world have the resource so it is necessary to speed coordination between Yemen and the Arab nation within the framework of a unified agreement that supports the position of these countries in negotiating with European governments and global investors in this field.

*Stimulation, and encouragement: Stimulate the production of electricity generated from renewable energy sources Private sector to invest in sustainable renewable energy.

*Planning and Development: The government agencies concerned with development and planning should seek to include the system of using new and renewable energy, especially underground, in the development plans of the regions and cities at all levels.

## REFERENCES:

1- Atkin Donald, Hisham Mahmawi, "Transition to the Future of Renewable Energy", International Solar Organization, 2005 Economic and Social Survey for Western Asia, ESCWA, 2001, Html/http://www.alarabiya.net/ar/aswaq/2014/04/14

2-Our Common Future, World Commission on Environment and Development, translated by Mohammed Kamel Aref, World of Knowledge Series, Kuwait, 1989, p. 83.-

2-- Mattash, M. A, Al-Ganad I. N, Al-Kadasi M, Orlando Vasseli, Angelo Minnisali (2003): Hot springs in the Republic of Yemen and their importance in the geothermal energy, tourism

4- Ministry of Oil and Minerals Geological Survey and Mineral Resources Authority Geothermal Energy in Yemen Numbers: Project Crew 2013

5 - Ali Mohammed Al- Sabri Geothermal Exploration in Al Lisi–Isbil Geothermal field inYemen *Supervisor* Dr. Mohamed Ali Mattash

6-Mattash, M.A., Bilik, I., 1990. Volcanic rocks of Yemen. IESCA, Izmir-Turkey 2, 397–409

7- Fournier, R.O., 1991. Water geothermometers applied to geothermal energy. In: D'Amore, F. (Ed), Application of Geochemistry in Geothermal Reservoir Development, UNITAR, Rome, pp. 37–65.

8- -Mattash, M.A., Buda, G., 1993. The evolution of Yemen basalt in relation to rift development and the chemistry of their mineral constituents. Bull. Geol. Soc. Greece 28, 499–514.

9- -Mattash, M.A., Al-Ganad, I.N., As-Sarari, A.N., As-Saruri,M.A., Al-Kadasi, M.A., Ba-Quhaizel, M.A., Ash-Sheibani,M.S., Ash-Shami, H., Abd-Ellah, A.A., Al-Antari, K.A.,

10--Monassar, A.H., Ismail, S.A., 2001. Cenozoic Volcanics and Geothermal Potential in the Republic of Yemen. Ministry of Oil and Mineral Resources, Sana'a (Yemen), Scientific Report.

11 -Dr Ramio. Bakoudan (2008) Renewable energy and energy efficiency strategy Ministry of Electricity Yemen June 2008 Lameralduler GmbH

12- Renewable energy strategy and acation-plan- Republic of Yemen ( lahmeyer inational)