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Do Low Hydrocarbon Prices Help or Hinder Geothermal Development?

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ABSTRACT

As a constant and independent form of renewable energy supply, geothermal can play a key role in the world's future energy balance. Yet, the total contribution of the geothermal sector to global power generation remains relatively small. Some believe that continued low fossil fuel prices and high project development risk have created unfavorable conditions for geothermal power development, while others think that low oil prices represent a major opportunity for the geothermal industry, lowering costs of drilling and services. Geothermal energy growth has also lagged behind the exponential growth in wind and solar power generation. This raises the question of whether it would be more appropriate to focus on the competitiveness of geothermal energy vs. other renewable sources, rather than against conventional fossil fuels. This paper reviews historical trends in installed geothermal capacity (thermal and electrical) against drilling rig count and oil and gas price, while considering energy incentives and policies, and R&D opportunities for pilot projects while drilling and services costs remain low.

1. INTRODUCTION

Although geothermal energy is regarded as essential to the world's future energy mix, its total contribution to global power generation is currently at 0.3% (IRENA, 2017). According to the International Energy Agency (IEA, 2017a), geothermal electricity production did not experience significant growth between 1990 and 2016, with an average annual rate of 2.3%, from 28.6 TWh to 51.8 TWh. Based on the IEA's '2°C Scenario' (2DS), which lays out a pathway for energy system deployment and an emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C (reducing CO_2 emissions by almost 60% by 2050, compared with 2013) (IEA, 2016), geothermal exploitation is not on track. **Figure 1** shows the interim 2025 targets of the IEA 2DS to achieve a more sustainable and secure global energy system, with the expected contribution from geothermal energy, while **Figure 2** shows geothermal delivery and projected trends vs. the 2DS target.

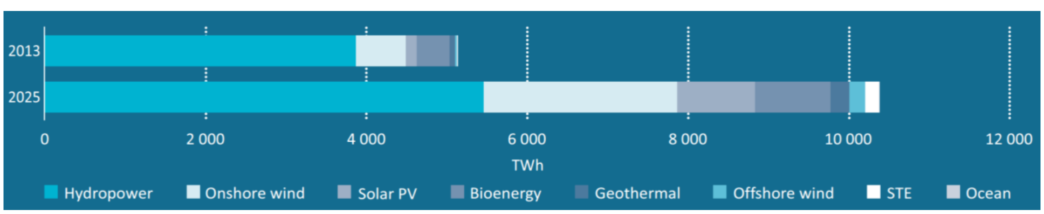

Figure 1: Interim 2025 targets of the IEA 2DS (IEA, 2016).

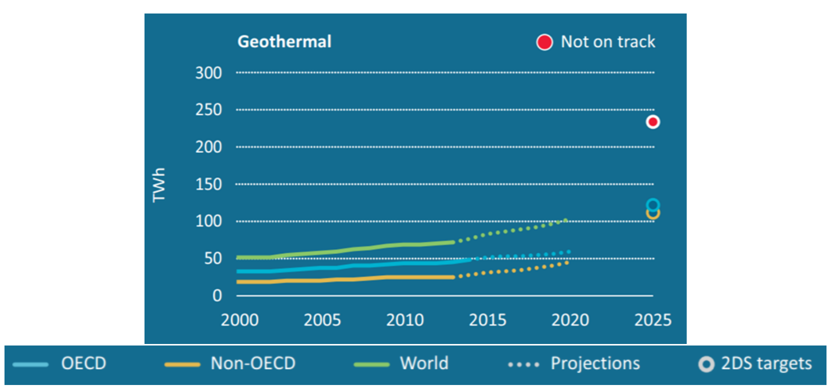

Figure 2: Comparison of geothermal delivery and projected trends vs. the IEA 2DS target (IEA, 2016). OECD: Organisation for Economic Co-operation and Development.

Prior to the 2014 oil price crash, Augustine et al. (2006) proposed a correlation between oil and gas completed well costs and modelled geothermal well costs (using the MIT Depth Dependent drilling cost index to normalize well costs) as a function of depth, as shown in **Figure 3.** The authors suggested that EGS and hydrothermal well costs tend to be 2-5 times higher than hydrocarbon well costs of similar depth.

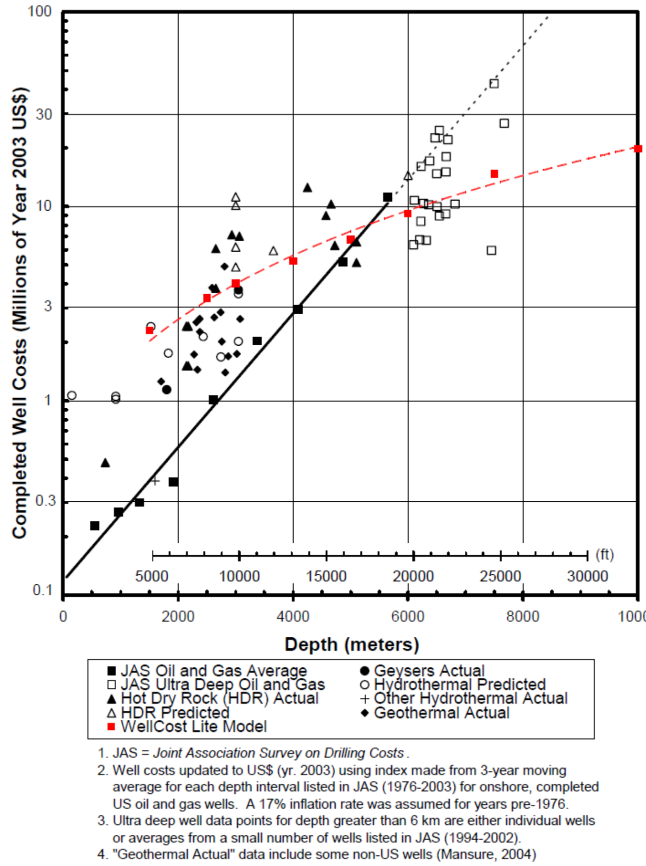

Figure 3: Completed well costs in year 2003 US $ as a function of depth (Augustine at al., 2006).

In its 2016 market report, post-2014 oil price crash the European Geothermal Energy Council (EGEC) highlighted that the geothermal industry uses the same drilling rigs as the oil and gas industry - approximately 4,000 worldwide - with geothermal drilling costs typically following the general trend of the oil and gas sector, as shown in depicted in **Figure 4.** The EGEC felt that this was likely to continue unless the geothermal drilling sector started to build a significant market share of its own (EGEC, 2016). Hence, EGEC pointed at the possible impact of the 2014 oil price crash.

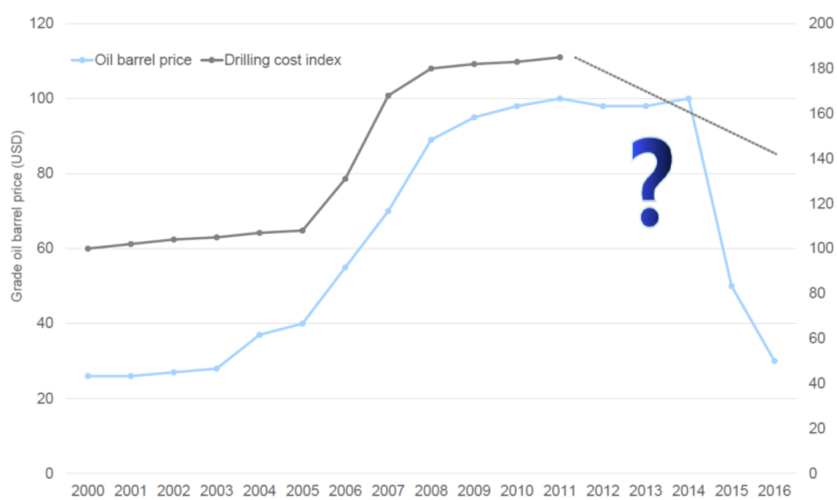

Figure 4: Geothermal drilling cost index vs. oil price (EGEC, 2016).

Another aspect to take into consideration when extrapolating trends of drilling costs vs. oil price is that drilling and completion efficiency increases as more lessons are learnt by doing and new technologies developed. In 2016, the EGEC stated that, in Turkey, there was an expectation to reduce the number of drilling hours by a factor of more than two and that, across Europe, technology advances could decrease costs by more than 20% over the next ten years (EGEC, 2016). In the US, the shale revolution has already changed the way wells are drilled, driving costs down, as shown in **Figure 5**, and since 2014 the oil and gas sector is known to have reduced drilling and services costs by 25-30%.

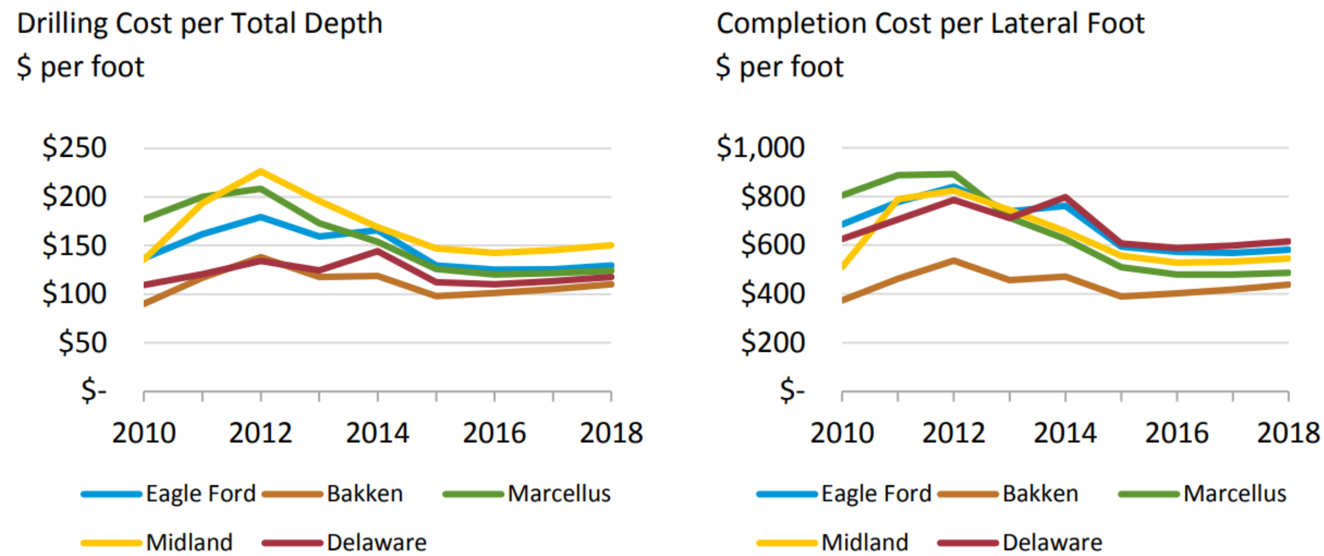

Figure 5: Cost per vertical depth and horizontal length. Source: IHS Oil and Gas Upstream Cost Study commissioned by EIA (EIA, 2016)

In the same report, EGEC concluded that it was difficult to predict the impact of the drilling costs on geothermal development.

Figure 6 compares the levelized cost of electricity (LCOE), calculated as the ratio of lifetime costs to lifetime electricity generation (with a discount rate that reflects the average cost of capital), for different renewable energy resources and vis-à-vis the fossil fuel power cost range as of 2014.

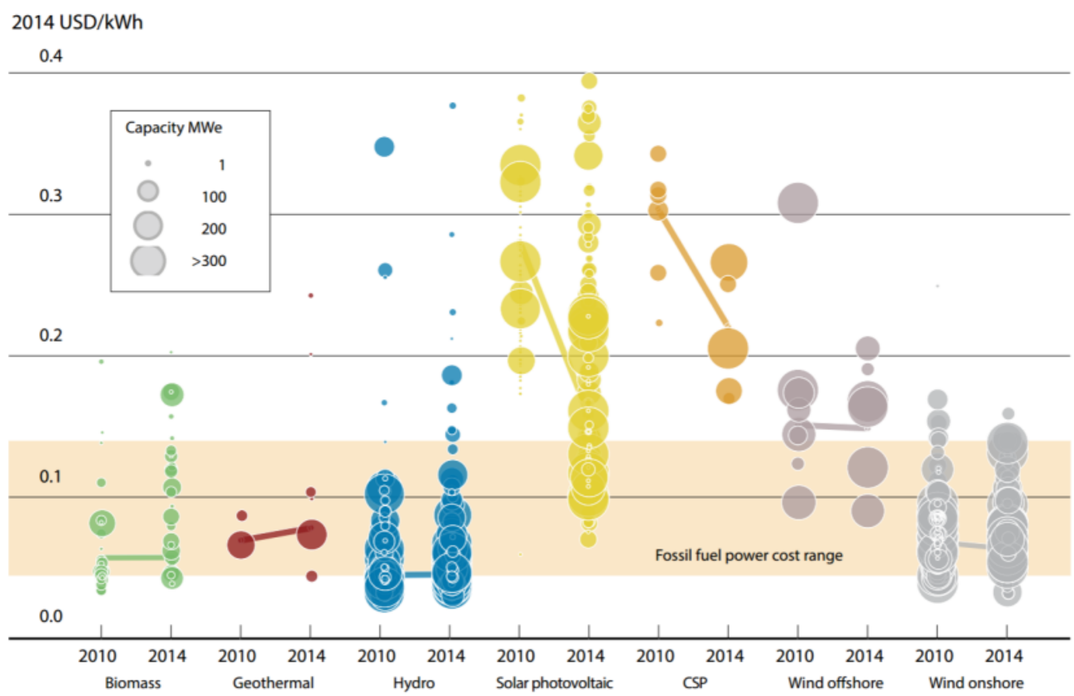

Figure 6: Comparative cost-competitiveness of energy sources (IREA, 2015).

It would seem that geothermal power costs are not only well within the range of conventional fossil fuels, but more competitive than the ones for solar. Yet, geothermal energy growth has lagged behind the exponential rise in wind and solar power generation. Within a decade, starting from almost nothing, solar and wind in the USA have overtaken the geothermal output. This raises the question of whether it would be more appropriate to focus on the competitiveness of geothermal energy vs. other renewable sources, rather than against conventional fossil fuels.

In 2017, the IEA (IEA, 2017b) recommended devising plans to address technology-specific challenges to achieve faster growth and improving policies tackling pre-development risks for geothermal energy. In this picture, the role of natural hydrocarbon gas also plays a relevant role, depending on how gas (and LNG) price relates to oil price.

A search for historical databases of international drilling rig activity, geothermal well counts and commodity prices was therefore performed during this study to gather independent data see if any relevant correlations could be extracted. In what follows, a summary of the information identified in the public domain is provided.

2. DATA GATHERING

Following a thorough search for international data in the public domain, the following were identified as key information sources for this study:

2.1 Baker Hughes Rig Counts

Baker Hughes has compiled rotary rig counts for 70 years. The Baker Hughes Rig Counts database includes weekly counts from North America and monthly international rig counts. It is cross-referenced by analysts and government officials, and included in several industry statistical reports (BHGE, 2017a). As confirmed by Baker Hughes (BHGE, 2017b), geothermal rig counts are included in the database, though not individually reported; they are combined in a "Miscellaneous" category, together with injection and exploration wells. The database also offers a "Land/Offshore" option, allowing a filter by "Miscellaneous/Land" from 2012, which can be be applied for this study, knowing that no offshore geothermal resource is being utilized today. Even after applying this filter, however, it is not possible to quantify the rig counts that correspond solely to geothermal activity.

2.2 International Finance Corporation Study

In 2013, the International Finance Corporation (IFC, 2013) issued a study on the success of geothermal wells. It was the first time that a global database of geothermal wells was produced, consisting of fields that jointly contributed to 71% of the world installed geothermal power capacity. The database was compiled from both sources available in the public domain and confidential information from individual geothermal developers, covering a total 2,613 wells. Annex D of the report lists wells from 1959 by: completion date, initial and current status, power capacity (as estimated on the date shown in the adjoining column), depth, geology type, resource type, well casing size, success of the well, whether a pump is used on the well, and whether the well has been re-drilled. For the purpose of the research presented here, the categories 'production', 'injection' and 'unknown' were added up for a given year. Whenever the well completion date was missing, a data gap was assumed, possibly leading to underestimation to geothermal activity in that period.

2.3 U.S. Energy Information Administration (EIA) / Spot Prices

The EIA reports historical spot prices for crude oil (Cushing, Oklahoma WTI, USD per Barrel) and natural gas (Henry Hub, USD per million Btu) (EIA, 2018a and b).

3 RESULTS AND DISCUSSIONS

After processing the raw data from the sources describes in 2.1-2.3, **Figure 7** was generated.

A quantitative comparison between the Total and Oil+Gas rig counts highlights a small contribution of Miscellaneous, which is therefore plotted on the secondary axis.

The Miscellaneous/Land line, available from 2012, appears to overlap with Miscellaneous.

Prior to the 2014 oil price crash, Miscellaneous seems to suggest increasing geothermal activity with increasing oil price, up to c.a. 6 months before the oil price crash; 6 months after the oil price crash, Miscellaneous increases with decreasing oil price, implying greater geothermal activity at low oil prices (and possibly R&D opportunities for geothermal pilot projects) up until 2017.

Following the oil price crash, the Gas count decreases, though Miscellaneous/Land increases, possibly suggesting that gas and geothermal are not in direct competition, contrary to common perception.

Between 1995 and 2002, Miscellaneous drops to a third, although oil prices remain relatively stable. Overall, the IFC data seem to track the Miscellaneous trend, except pre-1999 and post-2010.

The IFC geothermal wells count does not allow closing the gap between Miscellaneous/Land and number of geothermal wells drilled in a given month or year. First of all, as previously mentioned in section 2.2., an IFC data gap was assumed whenever the well completion date was missing. Secondly, there is not linear correlation between the IFC and Baker Hughes datasets for number of wells and rig counts, respectively. To be counted as active in the Baker Hughes Rig Counts database, *a rig must be on location and be drilling or 'turning to the right'. A rig is considered active from the moment the well is "spudded" until it reaches target depth or "TD". Rigs that are in transit from one location to another, rigging up or being used in non-drilling activities such as workovers, completions or production testing, are NOT counted as active* (BHGE, 2017a). Thus, one rig count does not correspond to one well being drilled. Between 2006 and 2007, for example, Miscellaneous increases, but IFC decreases, with the latter showing no correlating trend with other curves between 2010 and 2012.

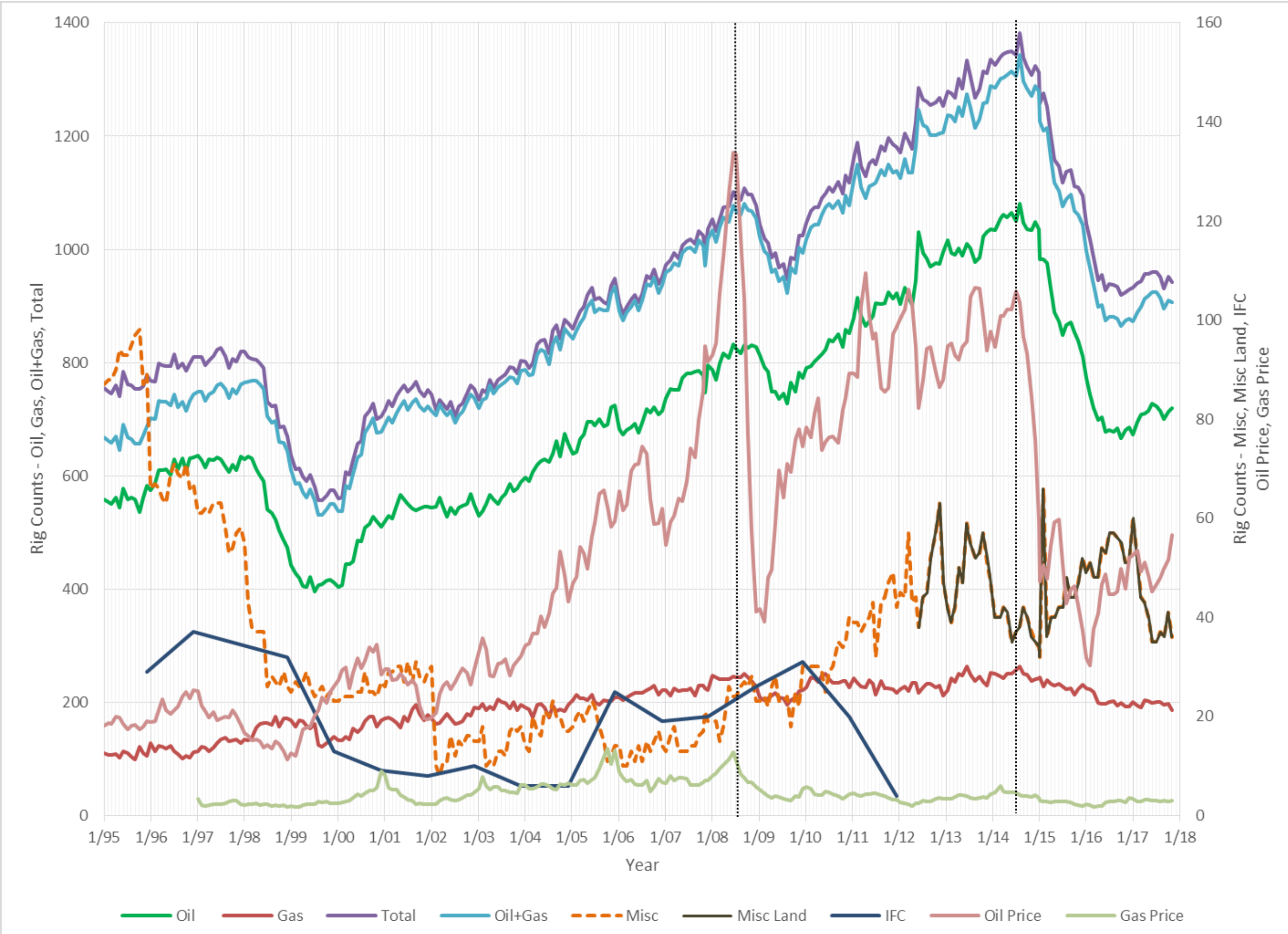

Figure 7: Baker Hughes rig counts vs. IFC geothermal well counts vs. oil and gas prices (up to and including December 2017). Oil price in USD per Barrel, gas price in USD per million Btu.

To complement these data, one can consider the plot shown in **Figure 8**, from which it transpires that geothermal installed generation capacity has been growing steadily since the 1950s.

A peak in geothermal installed capacity is observed after each decline in oil price. Low oil prices would typically imply more rigs available on the market and lower drilling and services costs, opening up a window for increased geothermal activity.

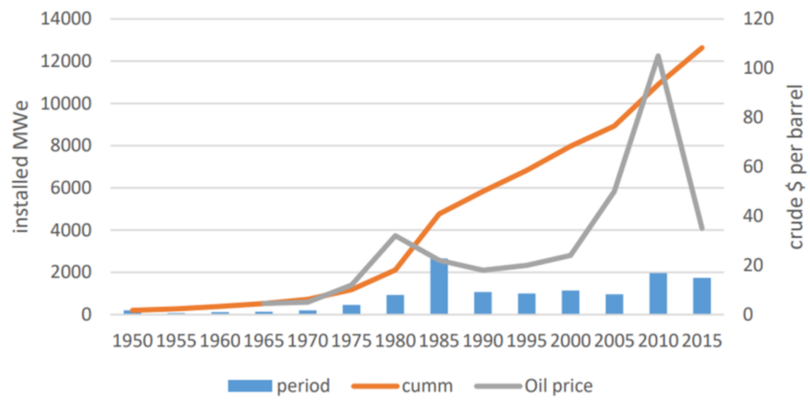

Figure 8: Geothermal Installed Generation Capacity (WEC, 2016).

4 CONCLUSIONS

The data search performed during this study led to the realization that there is currently no formal repository of geothermal drilling activity worldwide, nor is there a unified way of reporting geothermal activity. This is a significant shortcoming for the geothermal community.

A critical analysis of historical databases of international drilling rig activity, geothermal well counts and commodity prices allowed a systematic comparison of trends, from which some of the expected correlations to hydrocarbon prices can be observed. Yet, the data available in the public domain are not truly reconciled, leaving room for further speculation and more considerations on the future impact of technological advances and lessons learnt, besides oil and price.

LOOKING AT ENERGY INCENTIVES AND POLICIES, THE IEA WEBSITE (IEA, 2018) RETURNS 39 RESULTS FOR IN-FORCE RENEWABLE ENERGY POLICIES SINCE 2000, INCLUDING GEOTHERMAL. A JOINT EVALUATION OF LEVELIZED COSTS OF ELECTRICITY AND NET PRESENT VALUE WOULD BE REQUIRED TO COMPARE, ON EQUAL GROUNDS, THE VALUE OF INVESTMENT IN GEOTHERMAL PROJECTS VS. OTHER ENERGY PROJECTS, TAKING INTO ACCOUNT INCENTIVES AND POLICIES.

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