International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:10, No:6, 2016

Ramification of Oil Prices on Renewable Energy Deployment

Osamah A. Alsayegh

Abstract**—**This paper contributes to the literature by updating the analysis of the impact of the recent oil prices fall on the renewable energy (RE) industry and deployment. The research analysis uses the Renewable Energy Industrial Index (RENIXX), which tracks the world's 30 largest publicly traded companies and oil prices daily data from January 2003 to March 2016. RENIXX represents RE industries developing solar, wind, geothermal, bioenergy, hydropower and fuel cells technologies. This paper tests the hypothesis that claims high oil prices encourage the substitution of alternate energy sources for conventional energy sources. Furthermore, it discusses RENIXX performance behavior with respect to the governments' policies factor that investors should take into account. Moreover, the paper proposes a theoretical model that relates RE industry progress with oil prices and policies through the fuzzy logic system.

Keywords**—**Fuzzy logic, investment, policy, stock exchange index.

I. Introduction

ALTHOUGH its level of influence varies depending on geopolitical, technological, and environmental factors, oil has been one of the main drivers of world economic development since the 19th century. The aspect, which directly and indirectly associates with world economic development, is the price of oil. At the start of the new millennium oil prices fluctuated in the 20 to 40 US dollar a barrel range, before continuing to climb to reach a record high of more than US$130 a barrel in July 2008, following concerns over reports of Iranian missile tests. This high price did not last long. Oil prices declined sharply within six months, falling to less than $40 a barrel in December 2008. This decline was contributed mainly to the drop of oil demand in the United States and to the global economic downturn. Oil prices rose again to more than $100 and fluctuated around US$100 a barrel until the beginning of the last quarter of 2014. Oil prices then took a sharp decline and hovered around the upper US$20's a barrel by January 2016. This latest oil price plunge has been one of the most discussed topics recently, especially, due its ramifications on the global economy and industry. Such ramifications have been analyzed with respect to emerging industries, among which are the RE industries.

There are two views on the impact of oil prices on RE. The first view argues that RE would not be affected by oil prices, according to Adam Sieminski, Chief Executive of the US Department of Energy's statistical agency, the Energy Information Agency (EIA). RE is protected against oil prices through tax incentives, and oil is no longer competing with RE in the electricity generation sector [1]. Sieminski asserted that the near-term oil price drop will not affect wind and solar installations. Confirming Sieminski's point of view, the International Energy Agency (IEA) has shown that diesel and other petroleum-based fuels account for only 5% of North America and Europe power generation today [2], [3], compared to a 25% in 1973. Therefore, low oil prices would not radically decrease dependence on RE since the link with oil product fuels is weak. Furthermore, because utility-scale clean energy plants are typically planned months or years in advance, the deterioration in the price of oil is unlikely to affect the RE industry [4]. Some analysts contend that low oil prices would encourage using gas more than coal (Europe is an example); however, there is no reason at the moment to expect an impact on wind and solar investments, which are driven largely by national incentive schemes [5].

The second view asserts that RE is influenced by oil prices; however, the economic sensitivity of RE technologies is a function of scale, industrial sector, and project location [6]. Evidence is witnessed in Central and South America and the Middle East, in which oil accounts for 10% and 29%, respectively, in the electricity generation sector [3] compared to 5% in North America and Europe. According to the Environmental Data Interactive Exchange (EDIE), the breakeven for electricity generation from RE compared with oil is as high as $104.7 a barrel for solar CSP technology in Europe and as low as $5.4 a barrel for wind onshore in developing Asian countries [7]. Table I presents some information on the breakeven points of RE technologies in different regions. Moreover, it is pointed out that oil liquid fuel products are the current and future main contributor to the transportation sector with more than 90% [8], [9], and, hence, vehicle technologies that are based on RE sources would be negatively affected. In the US, hybrid car sales were down 11% in November 2014 compared with the same month of 2013 [5]. Sales of some high fuel consumption sports utility vehicles were as much as 91% higher in November 2014 than the year before [5]. One can deduce that biofuels may face greater risk from cheap oil prices.

This paper attempts to model the influence of oil prices on the RE industry, and, hence, RE market development. The approach of modeling this relationship is carried through analyzing historical data of oil prices, the RE market stock index and adapted policies from January 2003 to March 2016, during which oil prices have gone through rough active rides.

Osamah A. Alsayegh is with the Energy & Building Research Center, Kuwait Institute for Scientific Research, P.O. Box 24885 Safat, 13109 Kuwait (e-mail: osayegh@kisr.edu.kw).

The main contributions of this paper include updated analysis of RE industry development with respect to oil prices, focused investigation on an RE market index that only comprises of RE technologies, i.e., it does not include energy efficiency, nuclear and natural gas and other clean (or relatively clean) technologies and services that almost all of the literature has been utilizing. The purpose of focusing on such an index is to provide investors and policy makers an unadulterated picture on the RE industry and market behavior under the oil prices dynamic.

TABLE I
BREAKEVEN POINT IN US DOLLAR PER BARREL OF OIL FOR VARIOUS RE TECHNOLOGIES IN DIFFERENT REGIONS [7]

Technology	Oil price ($/b) breakeven			
	Europe	USA	Middle East	Asia (Developing countries)
Solar PV highest bid	64.3	43.2	33.4	31.8
Solar PV lowest bid	38.0	23.0	15.6	14.4
Solar CSP	104.7	101.3	79.0	69.1
Wind onshore	14.6	10.5	10.9	5.4
Wind offshore	71.7	75.5	51.8	61.9

II. OIL PRICES AND RE MARKET RELATION: REVIEW

In the literature, empirical studies used various global market stock exchange indices (Table II) of renewable/clean energies, energy efficiencies, and related service companies for analysis against oil price dynamics.

Reboredo [10] analyzed the dependencies between oil prices, from one side, and three global RE stock price indices (the S&P Global Clean Energy Index, the Wilder Hill Clean Energy Index and the European RE Index) and three clean energy sectoral indices (the NYSE Bloomberg Global Wind, Solar Energy and Smart Technologies indices), from the other side, from the period December 2005 to December 2013. The study found symmetric tail dependence between oil returns and clean/ RE indices.

Inchauspe et al. [11], noted that investments in RE companies have shown sizeable growth rates in the last decade due to government policies, rising oil prices and evolving stock market liquidity for investments in RE companies. They examined factors that impact the WilderHill New Energy (NEX) index, among which is the oil prices. By analyzing data from August 2001 to February 2014, they found that NEX returns are to some extent influenced by oil prices. The study concluded that the influence of oil prices is relatively weak, although it has become more influential after 2005.

Sadorsky, [12], attempted to define the dynamic correlations and the volatility spillovers between oil prices and the stock prices of clean energy companies and technology companies. The study used the WilderHill Clean Energy Index (ECO), NYSE Arca Technology Index (PSE) and West Texas Intermediate crude oil futures contract (OIL) sample period January 1, 2001 to December 31, 2010. The study concluded that a portfolio of clean energy stocks and oil futures can be built and that oil futures can be used to hedge an investment in clean energy stock prices.

Wen et al., [13], investigated the spillover effects that occur in the stock returns and volatilities of Chinese new energy (RE and nuclear energy) and fossil fuel companies by utilizing data from August 30, 2006 to September 11, 2012. Their study showed significant and asymmetric spillover dynamics of China's energy related stock market between new energy and fossil fuel stocks.

Development progress of the RE sector may also be deduced from the level of investment. RE investment will be is discussed in the following section.

TABLE II
GLOBAL CLEAN ENERGY TECHNOLOGIES STOCK INDICES

Index	No. tracked companies	Technologies
ALTEXGlobal	138	Low Emission Utilities; Renewables; Gas; Uranium; Energy Minerals; and, Environmental Technologies.
Ardour Global Alternative Energy IndexSM	111	Alternative energy resources (technologies for solar, wind, hydro, tidal, wave, geothermal and bio-energy); Distributed generation technologies; Environmental technologies including water and air quality; Energy efficiency; and, Enabling technologies including electronic, batteries, superconductors and advanced materials.
Credit Suisse Global Alternative Energy Index	30	Natural Gas; Wind; Solar; Bio-energy/Biomass; Geothermal; Hydropower; Fuel cells; and, Batteries.
DAXglobal Alternative Energy Index	15	Natural Gas; Solar; Wind; Ethanol; Geothermal; and, Hybrids/Batteries.
DB NASDAQ OMX Clean Tech Index	119	Clean energy; Energy efficiency; Transport; Waste management; and, Water.
European Renewable Energy Index (ERIX)	Not specified	Wind, Solar, Biomass and Hydro energy.
RENIXX World	30	Wind; Solar; Biomass; Geothermal; Hydropower; and, Fuel cell.
S&P Global Clean Energy Index	30	Clean energy production and equipment; Wind; and, Solar.
Wilderhill New Energy Global Innovation Index	86	Wind; Solar; Bio-fuels; Hydro; Wave and tidal; Geothermal; Energy conversion; Storage; Conservation, Efficiency materials; Pollution control; and, Hydrogen and fuel cells.
World Alternative Energy Index	20	RE (solar, wind and biomass); Energy efficiency (energy generation, Energy meters and superconductors); and, Decentralized energy supply (micro-turbines and fuel cells).

III. DEPENDENCE LEVEL OF RENEWABLE SECTOR ON OIL PRICES

In general, the size of investment in any sector is a function of two main factors, namely, economic wellbeing and enacted policies, which oil prices can have direct and indirect effect on. The RE sector is not excluded from such influences. Fig. 1 shows the global investment profile of the past 10 years in RE [14]. The investment profile is imposed on an oil price graph for the same time duration. From 2004 to 2008, investments in RE increased four-fold. During the world economic downturn

2008-2009, investments did not see a negative noticeable change. From 2009 to 2011, investments continued to increase rising from $179 to $279 billion, before witnessing a small dip between 2011 and 2014, and then increasing again from $232 billion in 2012 to $270 billion in 2014, despite oil prices seeing a sharp decline in the latter half of the year. Investment may not reflect how the RE sector is behaving against oil prices for the following reasons. Investment is a long-term process and does not necessarily react to casual short-term influences, i.e., an investment in a particular year is a commitment that is planned earlier for several years to come. Moreover, a decline in investment in a particular year does not necessarily imply a negative impact by some external driver; it may be the consequence of deployment saturation of certain technologies in particular regions.

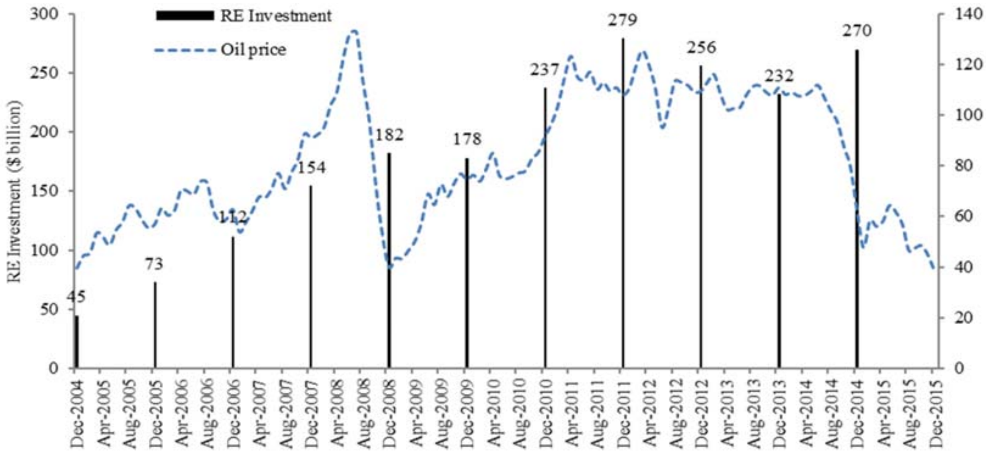

Fig. 1 RE investment and oil prices

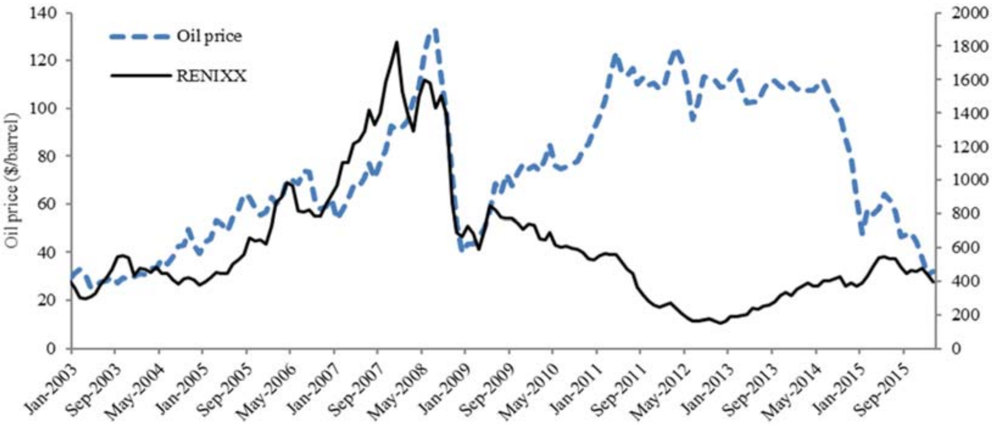

Fig. 2 RENIXX index and oil prices

An alternative effective approach in investigating the behavior of the RE sector with respect to oil price dynamics is analyzing the behavior of daily stock exchange indices of RE companies' portfolios against oil prices. This paper uses the RENIXX, which tracks the world's 30 largest public trade companies developing and manufacturing technologies including solar, wind, geothermal, bioenergy, hydropower and fuel cells. In addition to RENIXX, the paper utilizes oil prices daily data between January 2003 to March 2016. Fig. 2 shows the RENIXX history profile against oil prices. There are two distinguished landmark durations of RENIXX behavior from 2003 to 2016. The first landmark duration is from 2003 to 2009 (before and during the global economic recession). One can see clear association of the index with oil prices (Fig. 2). The calculated correlation coefficient during this period is about 0.9. The main reasons for such high correlation (at that time) were that high oil prices urged importing/consuming countries to substitute oil and oil product fuels with renewable and other sources, and active government polices urged the deployment of clean energy systems.

By the last quarter of 2009, the second RENIXX's landmark behavior has taken on a different reaction profile with respect to oil prices until the present time. It is clear that the performance of the RE sector (represented by RENNIXX) has decoupled from the oil price regardless of its high (from 2010 to 3rd quarter of 2014) or low (from last quarter of 2014 until the present time) price. The main reasons for such behavior are the following. RE policies have become more mature, and more governments are adopting such policies. RE options for many governments (including oil rich exporting countries) has become a strategic choice to diversify their energy source supplies, in addition to comply with environmental obligations. Moreover, the application of RE systems in the power generation sector is well established making it invulnerable to oil prices. In the global power sector, total RE installed capacity was 1,712 GW by the end of 2014 (an increase of about 8.5% over 2013) with total investment of $150 billion [14]. This is clear evidence that the sector has a demanding infrastructure and active value chain that makes it more independent of oil prices.

RE applications in the transportation sector (mostly bio-fuel) is effected by the oil prices for the time being, and this influence may continue within the mid-term future (five to 10 years) until the electric vehicle industry reaches its maturity within this duration.

IV. Modeling the Renewable Deployment Relation with Oil Prices

Fig. 3 summarizes a proposed theory that defines the relationship between RE sector progress deployment and oil prices. Under a low oil prices environment and a lack of enforcing and incentive government policies, it is expected that RE sector development and deployment would have slow or no deployment progress. In contrast, under high oil prices and high effective policies, RE sector progress would have its highest performance. These behaviors are witnessed during the 2003-2009 period in Fig. 2.

Under high oil prices and lack of efficient policies, or low oil prices and efficient policies, the RE sector is expected to have relatively high activity when compared to low oil/ineffective policy environment. An example supporting this claim is the Middle East and North Africa (MENA) region [15].

The relation between RE deployment with oil prices and policies is highly non-linear. One should note that oil prices are functions of world energy demand/supply levels, geopolitics, and global economic wellbeing. Policy effectiveness is a function of environmental concerns, and of a nation's local energy security and socio-economic well being. It is challenging to quantify the relation between oil prices and policies from one side, with geopolitics and environmental concerns on the other side. Furthermore, it is even more challenging to define a clear cut line between low and high policy effectiveness since it is a relative action/consequence in different countries and regions. Therefore, fuzzy logic system [16] is proposed to deal with such a quantification challenge. Two dimensional logic system [17] is anticipated to model the RE status progress as a function of oil prices and policies as follows,

$$R\ (o_m, p_n) = \begin{vmatrix} - & o_1 & \dots & o_N \\ p_1 & R_1 & \dots & R_{1N} \\ \vdots & \vdots & \ddots & R_2 \\ p_M & R_{M1} & \dots & R_M \end{vmatrix}$$

where $RE(o_m,\ p_n)$ is a fuzzy set of RE status progress as a function of the oil price, o_m, and policies, p_n, which can take predefined value/level between 1 and M, 1 and N, respectively. R_{mn} is the progress status level output of the inputs o_m and p_n. The resolution of the value/level is country and region specific.

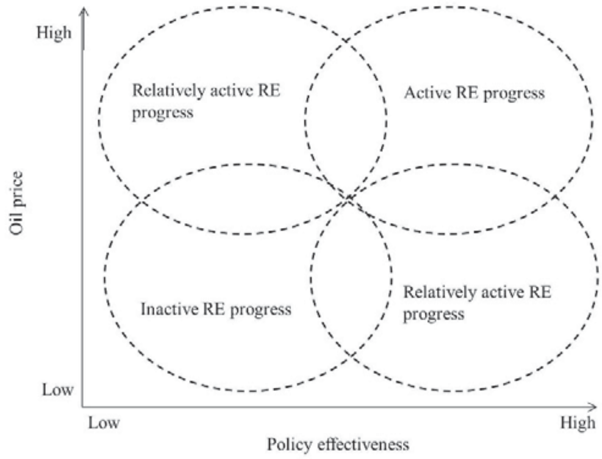

Fig. 3 RE deployment relation with oil prices and government policies

V. Conclusion

This paper presents up to date analysis of RE sector behavior against the dynamics of oil prices. RENNIXX, which is a stock exchange index tracking the world's 30 largest publicly traded companies, was utilized for that purpose. From the past two decades until 2008-2009 (global economic downturn), RE sector progress had been dependent on oil prices (when they were at high levels) due to the urgent desire of energy importing/consuming countries to be less dependent on foreign energy sources (especially oil and gas). During the same period, when oil prices went down, the RE sector slowed its development progress mainly due to economic reasons and ineffective governments' policies. After 2009, and when the oil prices started to rise, a new era of RE progress appeared and showed the decoupling between RE progress and oil prices. Even when oil prices had taken a sharp decline in the last quarter of 2014, the RE sector had shown a negative correlation (the calculated correlation coefficient of this period from 2010 to March, 2016 was -0.6). This is mainly due to more stringent "carrot and stick" -type of policies, in addition to the enacted environmental policies.

This paper proposes a theoretical relationship between RE sector development and deployment, from one side, and oil prices and polices, from the other side (Fig. 3). However, further, investigation is required to quantify this relationship.

References

[1] Low oil prices won't hurt renewable energy, The Guardian, 28 January, 2015. Accessed on 26 February, 2016. (http://www.theguardian.com/environment/2015/jan/28/low-oil-prices-wont-hurt-renewable-energy-says-us-eia).
[2] World Energy Outlook 2014. International Energy Agency, Paris, France, 2014.

[3] M. Hope and P. Rosamund, “What falling oil prices may mean for the future of renewable energy investment,” The Carbon Brief, 6 January, 2015. Accessed on 26 Feb. 2016, (http://www.carbonbrief.org/blog/2015/01/what-falling-oil-prices-may-mean-for-the-future-of-renewable-energy-investment/).
[4] J. M. Davies, “Falling oil prices unlikely to impact renewable energy projects,” The Engineer, 7 January 2016. Accessed on 27 February (http://www.theengineer.co.uk/news/news-analysis/falling-oil-prices-unlikely-to-impact-renewable-energy-projects/1019670.article).
[5] P. Clark, “The Big Drop: Cheap oil burns green energy,” Financial Times, 17 December, 2014. Accessed on 27 February 2016 (http://www.ft.com/cms/s/0/d328ee8a-8605-11e4-a105-00144feabdc0.html#axzz3SxZPhWIw).
[6] E. Terrado, M. Mendis, and K. Fitzgerald, “Impact of oil prices on renewable energy technologies,” Working Paper, Industry and Energy Department, The World Bank, 1989.
[7] B. Allan, “Oil price crash: What it means for the renewables industry,” EDIE Newsroom, Environmental Data Interactive Exchange, 12 January, 2015. Accessed on 27 February 2016. (http://www.edie.net/news/6/Oil-price-crash-What-it-means-for-the-renewables-industry/27499/).
[8] BP Energy Outlook 2035, January 2014, BP (bp.com/energyoutlook).
[9] The Outlook for Energy: A view to 2040, ExxonMobil, 2014.
[10] J. C. Reboredo, “Is there dependence and systemic risk between oil and renewable energy stock prices?” Energy Economics, Vol. 48, pp. 32-45, 2015.
[11] J. Inchauspe, R. Ripple and S. Trück, “The dynamics of returns on renewable energy companies: A state-space approach,” Energy Economics, Vol. 48, pp. 325-335, 2015.
[12] Sadorsky, P., “Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies,” Energy Economic, Vol. 34, pp. 248-255, 2012.
[13] X. Wen, Y. Guo, Y. Wei and D. Huang, “How do the stock prices of new energy and fossil fuel companies correlate? Evidence from China,” Energy Economic, Vol. 41, pp. 63-75, 2014.
[14] Renewables 2015, Global Status Report, Renewable Energy Policy Network for the 21st Century (REN21), Paris, France.
[15] Pan-Arab Renewable Energy Strategy 2030, International Renewable Energy Agency, Abu Dhabi, UAE, 2014.
[16] L.A. Zadeh, "Fuzzy algorithms". Information and Control, Vol. 12, No. 2, pp. 94–102, 1968.
[17] V. M. Rivas, J. J. Merelo, I. Rojas, G. Romero, P.A. Castillo, J. Carpio, “Evolving two-dimensional fuzzy systems,” Fuzzy Sets and Systems, Vol. 138, pp. 381-398, 2003.

Osamah A. Alsayegh has been working for Kuwait Institute for Scientific Research (KISR) since 1992. He is currently the Director of Science & Technologies at the Energy & Building Research Center, KISR. He has led and participated in energy and power system studies involving planning and policy development and analysis for more than 15 years. He was the Technical Coordinator in the former Kuwait National Nuclear Energy Committee. He was the focal point in following up the economic feasibility study of nuclear power application in Kuwait. Dr. Alsayegh had held adjunct professor position for more 10 years teaching engineering and science courses in Kuwait University and American University of Kuwait. He received his B.Sc., M.Sc. and Ph.D. all in Electrical Engineering in 1990, 1995 and 1999, respectively.