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Renewable Energy Economy: The Impact of Private Financing

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Renewable Energy Economy: The Impact of Private Financing

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1. The Preamble

In 2013, Professor Gopal Kadekodi, who has been acknowledged internationally as a reputed environmental economist, published a research paper titled 'Is a Green Economy Possible' in Vol. 48, Issue 25 of the *Economic and Political Weekly*. He argued, "The Green Economy model is portrayed as an opportunity to enhance ecosystem services, and enable growth and sustainable livelihoods for the poor. But this well-intended vision is without a design to enable green **investments** to reduce carbon intensities". Professor Kadekodi's core concern is about lack of investment designs and plans to promote and nurture the green economy or the low-carbon energy systems[1]. It is in this context, the core objectives of this paper are:

a. To what extent countries make the transition to the renewable energy (RE) economy– with the expectation for Paris targets achieved by 2030?

b. How to deepen the private sector stocks underpinning renewable energy solutions?

Specifically this paper:

i. Examines the priority private sector investment needed for the region to attain the Nationally Determined Commitments (NDC) targets

[1] Definition of RE energy systems: a process of technologies that produce power with substantially lower amounts of CO_2 emissions than is emitted from conventional fossil fuel power generation. It includes renewable energy systems such as wind power, solar power, biomass, hydropower and including clean coal couple with carbon capture storage system and energy efficiency improvements across sectors. Here, we restrict our analysis to renewable energy systems only.

ii. Identifies regulatory barriers (technical, fiscal and market based) to scale up private renewable investments in key sectors

iii. Proposes innovative policy solutions that will unleash the potentials of private finance to support the transition pathway

Global Trends in Renewable Energy Investment 2017 report by the UN Environment-Bloomberg New Energy Finance revealed that total investments stood at $287 billion for clean energy in 2016, which is about 17% decline from the 2015 investment of $349 billion (Figure 1). This decrease in RE investment is mainly due to the technology cost reduction and slowing down of the Chinese economy. Figure 2 shows that the decline in 2016 in renewable energy investment occurred not only in developing countries, but also in developed countries too. (Frankfurt School-UNEP Centre/BNEF, 2017). Nevertheless, it is important to note that the world spent more money adding solar, wind and other renewable sources than it did adding coal, natural gas or nuclear plants. As a consequence, the ratio of global electricity emanating from these RE sources increased from 10.3% in 2015 to 11.3% in 2016, which means an estimated reduction in the emission of 1.7 giga tonnes of CO_2. While more RE generation was added last year than fossil fuels, CO_2 emissions will continue to increase (Figure 3). For example, Sudo (2016) has argued that the CO_2 emissions will increase at an annual growth rate of 2% and are projected to contribute more than half of world CO_2 emissions in 2035.

It is in this context, there is an urgent need to increase the pace of transition into renewable energy systems. This necessitates unconditional support not only from the governments, but also from the private sector to sustain technological research and development in innovating and disseminating the renewable energy systems around the world. An example is China's solar panel market. Being considered as a sunrise industry, Chinese government provides large support to these enterprises, and the outcome has been quite satisfying in the sense that output from this industry has been growing significantly in recent years. China has become the world's leading installer of solar photovoltaics since 2013. Germany receives 25% of its electric power from renewables. From 2010 to 2015 the capacity of solar photovoltaic in Australia increased from 130 megawatts to 4.7 gigawatts, which is an annual growth rate of 96% (ARENA, 2017). Nevertheless, private financing enterprises always reluctant to invest in this kind of industry without government's support because of the need for large initial investment, and the risk involved in dealing with the new industry.

Unfortunately, not all governments or government agencies seem to consistently support the growth of the RE industry. For example, the California Public Employees' Pension Fund (CalPERS), which is an agency of the California State Government, led many private investors into the RE industry by launching a dedicated clean energy fund in 2007. However, it has now reduced its financial support to investors due to its annual losses of almost 10% since the start of the fund (CalPERS, 2016). Further, most importantly, the RE resources are not distributed on an equal basis around the globe. Each country has different varieties and quantities of RE sources. Hence, each RE system is in varying stages of development and commercialization. Therefore, it is rational to expect imbalances in private investment in RE across countries and also across sectors within countries (Figure 4). In this context, the objectives of this study are to gauge the existing imbalances in RE private investments across countries and across sectors; to identify the determinants of private investment in RE across countries; and to suggest policy prescriptions to eliminate the constraints to private investment in RE.

The following section discusses briefly the existing imbalances in RE private investment across countries highlighting the imbalances across sectors too. The determinants of RE private investment are searched through a theoretical framework in the next section. Empirical analysis of the determinants of RE private investment across developing countries is explained along with the data sources in the following section. Section 5 discusses the empirical findings with particular emphasis on the constraints to private investment and a final section brings the overall conclusions of this study along with policy suggestions.

2. Imbalances in Private Investment in RE[2]

The types of private RE investment that are examined in this study are: Asset finance, venture capital, private equity, public market, small distributed capacity, and Greenfield investment. The inflow of private investment into RE industry has been volatile for quite some time that needs to be made as a steady flow to boost the contribution of RE towards reducing emissions globally. Infrastructure Investor Research & Analytics has observed a general decline in fundraising in RE industry since Citigroup’s $4.3 billion Citi Venture Capital International (CVCI) Growth Fund II closed in 2008. In 2009 and 2012 showed decline of 88 percent and 86 percent respectively when compared with the previous 12 months. It is interesting, however, to note that Asian fund managers have increasingly focused on renewables. Of the $7.2 billion

[2] This section draws heavily from the latest *Global Trends in Renewable Energy Investment 2017* report by the UN Environment-Bloomberg New Energy Finance (Frankfurt School-UNEP Centre/BNEF, 2017).

raised for the sector in 2008, Asian funds were responsible for 3 percent. By 2014, that had grown to 38 percent of $1.96 billion raised. Venture capital (VC) and private equity (PE) investment in renewable energy declined by almost half in 2013, down 46% to $2.2 billion, which was its third consecutive annual decline. However, the VC and PE investment in wind energy increased to $1 billion, while it declined to $500 million from $1 billion in solar in 2012 and from $700 million to $300 million in biofuels. Investment in smaller sectors, such as biomass and waste-to-energy, marine, geothermal and small hydro, all declined between 50% and 80% (UNEP, 2015). With the impact of the INDC initiatives, total venture capital and private equity investment in RE increased to $3.49 billion in 2015. While the majority of private equity finance was allocated to fossil-fuel focused businesses, many of the largest generalist funds, such as Blackstone's Onyx Renewable Partners, TPG Alternative & Renewable Technologies, and Assets paid special attention to energy-focused investment vehicles including RE electricity projects. Despite the rapid growth of the renewables industry, the track record for private equity investments in RE is generally considered to be not strong (Krupa, 2016). In terms of Greenfield investment, Renewable energy is on the rise again, with project numbers increasing by 50% and capital investment reaching $76 billion that accounts for more than 10% of all capital investment globally in 2015 (Financial Times, 2016)

With respect to the RE private investment in 2016, it may be noted that the investment in developing countries stood at $116.6 billion, which is about 30% less than that in the previous year. In developed countries too the investment declined by 14% from that in 2015 to $125 billion. Of the decline in investment in developing countries, China's was the largest one in dollar terms. It is worth noting that China's RE private investment declined for the first time after showing an increasing trend for the past decade. Besides delays in financings, RE investment in Mexico, Chile, Uruguay, South Africa and Morocco declined by more than half from the previous year's investment level mainly due to the delays in completing auction programmes. On the contrary, Jordan was one of the few new markets, where investment increased by 148% from the last year's investment.

Now turning to the RE private investment in the developed countries in 2016, the RE private investment in the United States fell by 10% and stood at $46.4 billion. Though the overall RE investment in Europe enjoyed a 3% increase to $59.8 billion, it declined in the United Kingdom (UK) and Germany by 1% and 14% respectively from the level of the previous year. In the Asian continent, besides China, Japan's investment in 2016 shrank by 56% to $14.4 billion (Figure 5).

Private finance, particularly for the developing and emerging economies, is more indispensable to increase the pace of transition to LCE systems and in this context both Greenfield and Brownfield investments play crucial roles. Greenfield investment is particularly welcome by developing and emerging economies due to its impact on many macroeconomic variables of the host economies, including employment generation and emissions reductions. Wind power and solar power have been continuing as dominant sectors attracting the Greenfield investment over the years. For example, about slightly more than two thirds of all renewable FDI between 2010 and 2015 went to these two energy sources. Egypt recorded $5.9 billion of announced FDI projects in solar power in 2015. Within Europe, the UK attracted the most of Greenfield investment of around $8 billion for wind power projects in 2015. It is worth noting that though in 2010, the developed countries dominated FDI by capital investment in renewable energy, developing economies stood ahead in investments in 2015. For example, Chinese companies Sany Group and Chint Group were keen to invest a total of $5bn in the country's renewable energy sector. Besides India, Myanmar, South Africa, Panama and Pakistan were at the top 10 table for capital investment in renewable energy in 2015.

While examining the pattern of investment in different RE categories, it is obvious that there is no uniform increase or decrease in all categories of RE investment. The offshore wind attracted a large sum of investment totalling $25.9 million in Europe due to the recently completed investment decisions on mega-arrays such as the 1.2GW 'Horn sea offshore' wind project in the UK North Sea. In the Asian continent, the offshore wind boom was in China, which invested $4.1 billion in the technology. On the other hand, new investment in solar in 2016 declined by 34% from the all-time high in 2015 to totalled $113.7 billion due to mainly the combination of sharp cost reductions and to real slowdowns of the economies of China and Japan. Nevertheless, India constructed the 'Ramanathapuram solar complex' in Tamil Nadu, which is considered as the world's largest ever solar PV project currently. It is interesting to note that of the purchases of assets such as wind farms and solar parks, corporate takeovers reached $27.6 billion in 2016, which is about 58% more than in 2015. Even with the relatively higher investments in wind and solar compared to other categories of RE, in terms of the contribution to energy generation, while solar increased its capacity to a record high of 75GW from 56GW, wind capacity declined from 63 GW in 2015 to 54GW in 2016.

The performance of new investments in other RE categories in 2016 varied significantly across categories (Figure 6). Biofuels declined by 37% to $2 billion, which is the lowest for at least

13 years. Investment in biomass and waste was steady at \$7 billion, while in geothermal increased by 17% to \$3 billion. Investment in marine fell by 7% to \$200 million.

Thus, drawing on the above evidence based research, it is clear that there has been imbalance in the overall pace of transition to the RE due to the differences in RE private investments across countries and across different categories of RE within countries. It is rational to expect that a balanced RE private investments across countries would contribute more positively to the shift to an environmentally sustainable global economy. Hence, identification of the determinants of RE private investments becomes important from the policy perspective to scale up the transition impact and RE private financing across countries.

3. Determinants of RE Private Investment: Theoretical Framework

The profits theory of investment can facilitate identifying the determinants of private investment. .Generally, there are two types of investments: autonomous and induced. Drawing on Keynes, autonomous investment is an investment expenditure made by governments with an objective of increasing the level of aggregate demand in the economy. Autonomous investment is not influenced by expected profitability of level of income and hence is not influenced by changes in demand. On the other hand, induced investment is influenced by changes in demand and is motivated by profit. Thus, RE private investment is more of induced investment by characteristic because the decision to invest mainly depends on the return on investment, which is profit (Kinda, 2010).

The two core methods of financing of any businesses are borrowing from any banks as a loan, and/or through approaching equity capital, which are of many different categories, such as venture capital, private equity, and public market. Also, it is possible for companies to raise funds through ‘balance sheet’ from the company’s own corporate funds as part of their corporate strategy. Such companies draw on monies raised from the financial markets through bond issuance or general corporate bank facilities that are available to the business as a whole, or following the sale of other parts of the business. Often a company will choose whether to use project finance or corporate facilities depending on which offers the cheaper source of funding to the project so that profit from the project is enhanced.

Profit (π) is the difference between total revenue (R) and total cost (C). In functional form, (π) can be written as

$$\pi = f(P, Q, C) \quad (1)$$

Where, P = Price of the output (Q) which is mainly determined in the competitive market; and C = Total cost that includes input cost, operational cost and hidden cost, such as the difference between the government's announced business licence costs and the actual cost to the businesses.

The theory of profits emphasises that profit will be larger in a country where investors can operate their businesses at a lower cost. This implies that the variables that determine profit can equivalently determine the inflow of investment in any country. Therefore, the investment function in the reduced form is as follows:

$$I = f(P, Q, C) \tag{2}$$

The above version of the theoretical *I* function can be transformed into an empirical *I* function applying the arguments developed in the theory of profits. Drawing on the theory of profits, it is logical to argue that businesses will prefer to invest in countries where they can produce large amount of production at a lower cost and therefore, the size of the economy, which is proxied by the gross domestic product (GDP), is an important factor for making investment decisions. Further, UNCTAD (2000) noted that investors who mainly make Greenfield investment in foreign countries preferred to invest in countries with large domestic market. It is rational to expect that not all market seeking foreign investors will invest in foreign countries fully to serve the host economies and some would also be keen to export their products to other countries as well besides serving the host economy. This means that a country with small domestic market, but with open trade regime can also provide scale economies similar to the countries with large domestic market, to foreign investors. Thus, openness to global market is another important determinant of the inflow of *I*.

Besides wages and physical infrastructure, business environment including regulations relating to investments such as subsidies to fossil fuels also affect the cost of doing business in a country, which in turn influence the investment decisions. Business friendly environment is expected to significantly reduce the operational and hidden costs. Thus profit seeking investors would prefer to invest in countries where there is business friendly environment. Governance with respect to particularly regulatory framework, bureaucratic hurdles and red tape, judicial transparency, and the extent of corruption in the country would influence profit by affecting the efficiency, productivity and cost structure.

Even projects with considerable expected returns in developing countries could not receive financial support because of their perceived high risks and limited liquidity of financial flows

(Stadelmann & Newcombe 2011). The risks are perceived due to many unstable factors like immature technology and financial market. Venugopal and Srivastava (2012) have classified the risks into two categories: political and macroeconomic risks, and RE market risks. Though it is possible to some extent to include political and macroeconomic risks, it is difficult to include RE market risks because of lack of full information.

4. Determinants of RE Private Investment: Empirical Model and Data

4.1 Empirical Modelling

Equation (2) needs to be formulated in an empirical model with appropriate variables to represent the above discussed theoretical aspects of the determinants of investment. Investment in this study includes both domestic and foreign (Greenfield and Brownfield) private investment. Variables 1 to 9 are all represented in logarithmic values. In order to incorporate the effect of the size of the economy and its growth potential on I inflow into the RE industry, GDP measured at current US dollar (x_1) and the annual GDP growth rate (x_2) are included in the empirical model. To represent the effect of the economy's trade openness (x_3), the sum of exports and imports of goods and services measured as a ratio of gross domestic product (GDP) is included. Another aspect of trade openness is the number of membership in regional groupings, which is included as variable (x_{10}). The effect the economy's resources and infrastructure on the inflow of I into the RE industry is represented by the following three variables: the variable total labour force comprising of all economically active people both employed and unemployed who are 15 years or older (x_4) is included to proxy the economy's resource; the number of internet (x_5) and telephone users (both fixed and mobile phone users) (x_6) per 100 people. To proxy the effect of the economy's business environment, regulatory framework and macroeconomic stability on I inflow into the RE sector, the days required to start a business (x_7), time required to prepare and pay tax (x_8) and inflation (x_9) are included in the empirical model[3]. The variables (x_7) to (x_9) indicate to some extent the prevailing macroeconomic risk. However, incorporating the RE risks and other forms of perceived risks over and above the measured macroeconomic risk directly into the model is very difficult because of lack of full information, though the impact on I is known to be negative, which is country-specific. Drawing on the literature on stochastic frontier production function, when the

[3] Days required to start a business is the number of calendar days needed to complete the procedures to legally operate a business. Time required to prepare and pay taxes is the time, in hours per year, to prepare, file, and pay (or withhold) three major types of taxes: the corporate income tax, the value added or sales tax, and labour taxes. Inflation is measured as the annual growth rate of the GDP implicit deflator that shows the rate of price change in the economy as a whole.

impact of the variables are known, though their direct identification is not feasible, it is possible to measure the impact, which is observation-specific, by including a truncated above zero normal random variable '*u'* with mean μ (Kalirajan and Anbumozhi, 2014).

This variable '*u*' varies between 0 and 1. When there are no risks, the variable '*u*' takes the value 0. Depending on the level of risk, the variable '*u*' will move towards 1, which is the limit of 100% risk. Given the heterogeneity in attracting I into the RE sector across developing countries, the data from developing countries are classified into countries from Asia, Africa, and Latin America (Figures 7 & 8). The base equation is for Asia. The variable D_1x_{11} takes the value 1 when the data represents developing countries from Africa and otherwise zero. The variable D_2x_{12} takes the value 1 when the data comes from the developing countries in Latin America and otherwise zero. Drawing on the existing literature and for unit less interpretation of results, a Cobb-Douglas type of functional form is assumed. The deviation of the functional form from its original shape, measurement errors in variables, and to consider the impact of other left out variables, a random variable '*v*' with a stochastic nature is introduced in the model, which is distributed normally with zero mean and a constant variance.

This specification of '*u*' and '*v*' enables estimation of ɤ, which is the ratio of the variance of '*u*' to the total variation of '*u*' and '*v*', so as to find out, on the basis of the size of ɤ, whether the differences in I across countries were accidental or due to perceived risk. The smaller the ratio, the higher is the probability of differences in I across countries emanating from perceived risks. The empirical model is written as follows:

$$\boldsymbol{lnI = \beta_0 + \sum_{i=1}^{9} \beta_i \, lnx_i + \beta_{10} \, x_{10} + D_1 \, x_{11} + D_2 x_{12} + v_j - u_j}$$

(3)

4. 2 Data

This study is based on the data on private RE investment compiled from the Global Trends in Renewable Energy Investment 2017 and International Renewable Energy Agency (2016) from 2004 to 2016. All other data have been compiled from the World Development Indicators, 2017 by the World Bank (2017). The empirical estimation of the equation (3) is done by considering the three year average from 2013 to 2015 of the above defined variables that were included in the model. 30 developing countries were chosen for empirical analysis from each one of the regions of Asia, Africa, and Latin America. Only countries which have made RE investment in all the years from 2013 to 2015 were included in the analysis. The countries were chosen from the descending order of investment made in 2015 to reach the required sample of 30 each.

5. Econometric approach and estimation results

Due to the heteroscedastic error structure of (*v*-*u*) in equation (3), ordinary least squares estimation methods will not give efficient estimates of the coefficients of the investment function. However, it is assumed that the variables '*u*' and '*v*' follow a truncated normal and full normal distribution respectively. Further, they are independently distributed. Given the truncated and full normal density functions for '*u*' and '*v*', the density function for I can be defined. The latter facilitates writing the likelihood function of I, which is the probability density of obtaining the sample, I_1, I_2,..I_{30}. The maximum likelihood estimates that maximises the likelihood function can be obtained by setting the first order partial derivatives with respect to the coefficients of the investment function equal to zero. The software FRONTIER 4.1 is used to obtain the maximum likelihood estimates of equation (3). The estimated results are presented in Table 2.

All the coefficient estimates are significant at least at the 5% level except the estimates of the variables of internet users and telephone users. The estimate of the size of ɤ is 0.8254 and is statistically significant at the 1% level. The implication is that variation in RE private investment across countries is not accidental and is mainly due to the perception of country-specific risk. In this context, the estimated value of I with the risk related variable '*u*' being 0 provides the potential RE private I for the concerned country. Now, the ratio of the actually realized private investment to this estimated investment with the assumption that '*u*' is zero is an indicator of how successful the concerned country is achieving its RE private investment potential. Table 3 shows the different levels of realizing the RE investment potential by different countries in the selected three regions in a frequency format. Both the results of table 2 and table 3 indicate that overall, Asian developing countries have realized their potential RE investment relatively more than the developing countries in Africa and Latin America. Among the developing countries in Asia, China is the only country, which has realized its RE private potential of 83% (Table 3). Thus, it is imperative to eliminate, if not reduce the perceived risk in making RE private investment and the role of governments in tailoring appropriate macroeconomic policies plays a crucial role. This finding is supported by other results shown in Table 1. For example, a 1% increase in macroeconomic risk of a country, which is proxied by the days required to start a business, and the time required to file taxes, would reduce RE investment by 0.78%. Thus, countries with unfavourable business environment and with stringent rules and regulations would be less successful in attracting RE private investment.

It is important to note the results concerning the trade openness and the number of membership in regional cooperation agreements. With the increasing openness to trade in countries, RE private domestic and foreign investment would be attracted towards those countries, as investment in this study includes both domestic and foreign private investment. More participation in regional groupings would increase the levels of RE investment, as such participation is likely to improve the business environment through the learning-by-doing approach. Drawing on the Kuznets's doctrine, it is worth noting that RE investment would increase by almost more than 2.5% for a 1% increase in GDP. This result is emphasised by the significant coefficient of GDP growth rate too. The result shows that the increase in the working age population is significantly and positively associated with the RE investment, which is one of the basic assumptions of the profit theory of investment.

6. Conclusions and Policy Suggestions

IEA estimates of infrastructure investment suggest that a transition to a renewable energy economy need not add substantially to the required energy investment. The transition would increase global energy investment by 9% to 12% of fixed capital formation, which is equivalent to less than 0.5% of global gross domestic product (GDP) (The New World Economy, 2014). The empirical results of this study indicate that on average only very few developing countries across the regions are able to achieve about 60% to 70% of their RE investment potential. This means that about 30% to 40% of investment is not being used for the transition to RE.

As obtaining this investment at an business acceptable cost and at the pace required will be crucial, there is an urgent need to adding new sources of finance, particularly from the private sector with innovative risk-sharing methods into the RE industry. The empirical results in this study shows that perceived risk plays a major role in attracting investment to the RE sector, which necessitates feasible methods to reduce risk associated with the RE sector. The approach of financing the RE system through 'blended finance' elaborated by Mustapha, Prizzon, and Gavas (2014) is one appealing method to private RE investors due to its effective risk sharing mechanism. With respect to the role of governments, the analytical results show that developing countries across the globe can attract substantial amount of RE investment domestically and internationally just by adopting more outward oriented trade policy and by providing more business friendly environment to the investors. Policy support from the governments is needed to promote private finance into the RE sector by encouraging to come up with innovative ways, such as the establishment of the green investment bank. Another policy support can be tax reduction for capital used on RE energy investment. Some incentives concerning stock markets such as promised dividend and bonus, give out equity on green enterprises, setting up a hedge fund to offset risks to a certain level are all methods to motivate private investors into the RE sector.

Besides, seeking assistance from regional and international cooperation, such as the one that happened in the context of the "Green Revolution" across the world, could be a better solution to attract financial and technology support to the transition to RE. Not only does product matter, the production process is creating emissions as well. Adjusting this part demands transformation of energy structure and increasing energy efficiency, so that domestic supply can be relatively clean. OECD develops an international ranking system of energy intensity, which adopts a four grading level of A, B, C, D. Among the 17 OECD country average of 0.15, Ireland, Italy, Switzerland, UK, Denmark, Austria all get 'A' mark. The secrets of these countries' success are: transforming to lower intensity industries which are high value- added, raising efficiency of electricity generation, and make economic growth exceed energy intensity. Some of these experiences can be followed by other developing and emerging economies. One of them is to establish an energy intensity supervision and ranking system to monitor each country's performance.

It is interesting to note that one of the up-and-coming innovations in renewable power is the establishment of two different technologies in the same location, to make use of shared land, grid connections and maintenance, and to reduce intermittency. Some 5.6GW of these 'hybrid' projects have been built or are under development worldwide, including hydro-solar, wind-solar, PV-solar thermal, solar thermal-geothermal and biomass-geothermal (Frankfurt School-UNEP Centre/BNEF (2017). Such innovations need to be disseminated across countries in a way of knowledge-sharing for which the regional cooperation agreements will be of immense help.

Table 1: Global RE investment (in $ billion) trend by asset groups, 2004-2016

Category (Year / Unit)	2004 $bn	2005 $bn	2006 $bn	2007 $bn	2008 $bn	2009 $bn	2010 $bn	2011 $bn	2012 $bn	2013 $bn	2014 $bn	2015 $bn	2016 $bn	2015-16 Growth %	2004-16 CAGR %
1 Total Investment															
1.1 New investment	47.0	72.7	112.7	159.3	181.4	178.3	243.6	281.2	255.5	234.4	278.2	312.2	241.6	-23%	15%
1.2 Total transactions	56.8	99.1	148.5	217.9	240.9	242.5	302.4	354.2	322.1	300.5	364.8	406.3	351.9	-13%	16%
2 New Investment by Value Chain															
2.1 Technology development															
2.1.1 Venture capital	0.4	0.6	1.2	2.1	3.3	1.6	2.7	2.7	2.5	0.9	1.1	1.6	1.1	-30%	9%
2.1.2 Government R&D	1.9	2.0	2.2	2.7	2.8	5.4	4.9	4.8	4.7	5.2	4.5	4.4	5.5	25%	9%
2.1.3 Corporate RD&D	2.1	2.4	2.9	3.2	3.6	3.8	3.9	4.5	4.2	4.0	3.9	4.2	2.5	-40%	2%
2.2 Scale-up															
2.2.1 Private equity expansion capital	0.3	1.0	3.1	3.5	6.9	3.1	5.5	2.4	1.7	1.4	1.8	1.9	2.2	17%	17%
2.2.2 Public markets	0.3	3.6	9.3	21.4	10.8	12.7	10.8	9.9	4.0	10.3	15.9	13.3	6.3	-53%	30%
2.3 Projects															
2.3.1 Asset finance	33.7	53.0	85.5	114.9	135.6	120.5	155.1	183.5	169.4	159.3	194.4	237.4	187.1	-21%	15%
Of which re-invested equity	0.1	0.1	0.8	2.6	3.6	1.9	1.5	1.8	2.6	1.0	3.3	6.1	2.9	-53%	-
2.3.3 Small distributed capacity	8.5	10.3	9.4	14.0	22.1	33.0	62.2	75.2	71.6	54.4	60.0	55.5	39.8	-28%	14%
Total Financial Investment	34.6	58.0	98.3	138.4	153.0	136.1	172.5	198.7	174.9	170.8	208.8	248.1	193.8	-22%	15%
Gov't R&D, corporate RD&D, small projects	12.5	14.7	14.4	19.9	28.5	42.2	71.0	84.5	80.5	63.5	68.3	64.1	47.8	-25%	12%
Total New Investment	47.0	72.7	112.7	159.3	181.4	178.3	243.6	281.2	255.5	234.4	278.2	312.2	241.6	-23%	15%
3 M&A Transactions															
3.1 Private equity buy-outs	0.8	3.7	1.9	3.4	5.1	2.2	1.9	3.0	3.3	0.5	4.2	3.4	3.4	-2%	12%
3.2 Public markets investor exits	0.4	2.4	2.8	4.0	0.9	2.5	4.9	0.2	0.4	1.7	1.7	1.8	6.7	269%	28%
3.3 Corporate M&A	2.3	7.6	11.2	20.4	16.9	21.9	19.3	29.4	9.8	16.5	11.4	17.5	27.6	58%	23%
3.4 Project acquisition & refinancing	6.3	12.6	19.9	30.9	36.4	37.6	32.7	40.3	53.1	47.4	69.2	71.3	72.7	2%	23%
4 New Investment by Sector															
4.1 Wind	19.6	28.5	39.7	61.1	74.8	79.7	101.6	84.2	84.4	89.0	108.5	124.2	112.5	-9%	16%
4.2 Solar	11.2	15.9	21.9	38.9	61.3	64.0	103.6	154.9	140.6	119.1	143.9	171.7	113.7	-34%	21%
4.3 Biofuels	4.0	9.9	28.6	27.4	18.4	10.2	10.5	10.6	7.2	5.2	5.3	3.5	2.2	-37%	-5%
4.4 Biomass & w-t-e	8.3	9.8	12.8	23.0	17.5	15.0	16.6	19.9	14.9	12.4	10.8	6.7	6.8	0%	-2%
4.5 Small hydro	2.7	7.4	7.5	6.4	7.6	6.2	8.1	7.5	6.4	5.6	6.4	3.5	3.5	0%	2%
4.6 Geothermal	1.2	1.2	1.4	1.7	1.7	2.8	2.9	3.9	1.6	2.9	2.9	2.3	2.7	17%	7%
4.7 Marine	0.0	0.1	0.8	0.8	0.2	0.3	0.2	0.2	0.3	0.2	0.3	0.2	0.2	-7%	16%
Total	47.0	72.7	112.7	159.3	181.4	178.3	243.6	281.2	255.5	234.4	278.2	312.2	241.6	-23%	15%
5 New Investment by Geography															
5.1 United States	5.7	11.9	29.3	39.3	35.8	23.9	35.3	49.6	40.6	33.8	38.4	51.4	46.4	-10%	19%
5.2 Brazil	0.9	2.7	5.1	9.8	11.5	7.8	7.4	10.3	8.1	4.4	8.2	7.1	6.8	-4%	18%
5.3 AMER (excl. US & Brazil)	1.8	3.3	3.7	4.8	5.9	5.5	12.4	9.5	10.4	12.3	14.0	13.1	6.1	-54%	10%
5.4 Europe	25.0	33.1	46.8	67.4	81.3	82.5	113.9	123.8	88.9	59.4	63.0	58.1	59.8	3%	8%
5.5 Middle East & Africa	0.6	0.8	1.2	1.9	2.3	1.7	4.2	3.2	10.2	9.2	8.4	11.4	7.7	-32%	24%
5.6 China	3.0	8.7	11.1	16.6	25.3	38.1	41.4	46.0	58.3	63.3	87.3	115.4	78.3	-32%	31%
5.7 India	2.8	3.2	5.4	6.8	5.7	4.2	9.0	13.7	8.0	6.6	8.4	9.6	9.7	0%	11%
5.8 ASOC (excl. China & India)	7.2	9.0	10.1	12.8	13.6	14.5	20.0	25.1	30.9	45.3	50.5	46.1	26.8	-42%	12%
Total	47.0	72.7	112.7	159.3	181.4	178.3	243.6	281.2	255.5	234.4	278.2	312.2	241.6	-23%	15%

Source: Frankfurt School-UNEP Centre/BNEF (2017), p.14.

Table2: Maximum Likelihood Estimates of the Determinants of Private RE Investment in the Developing Countries, 2013-2015

Dependent variable: ln *I*

Determining variable	Coefficient estimate	Standard error	Level of significance
Constant	3.4226	1.8143	10%
ln GDP	2.6295	0.5188	1%
ln GDP growth	1.2006	0.6109	5%
ln trade openness	2.0562	0.7020	1%
ln labour force	0.8678	0.4224	5%
ln internet users	0.1185	0.2846	Not significant
ln telephone users	0.1210	0.8368	Not significant
ln days to start business	-0.4216	0.2056	5%
ln days to file taxes	-0.3672	0.1824	5%
ln inflation	-0.1376	0.0729	10%
Regional membership	1.1086	0.5126	5%
African countries	-2.5562	0.7238	1%
Latin American countries	-1.2678	0.5821	5%
Gamma, ɤ	0.8254	0.1625	1%

Source: Authors' estimation

Table 3: Region wise Realized RE Potential Private Investment, 2013-2015

Realized Potential Investment (%)	Number of countries in Asia	Number of countries Africa	Number of countries in Latin America
Less than 40	0	5	1
41 – 50	0	6	5
51 – 60	12	6	7
61 - 70	13	10	11
71-80	4	3	6
81 and above (China)	1	0	0
Total	30	30	30

Source: Authors' estimation.

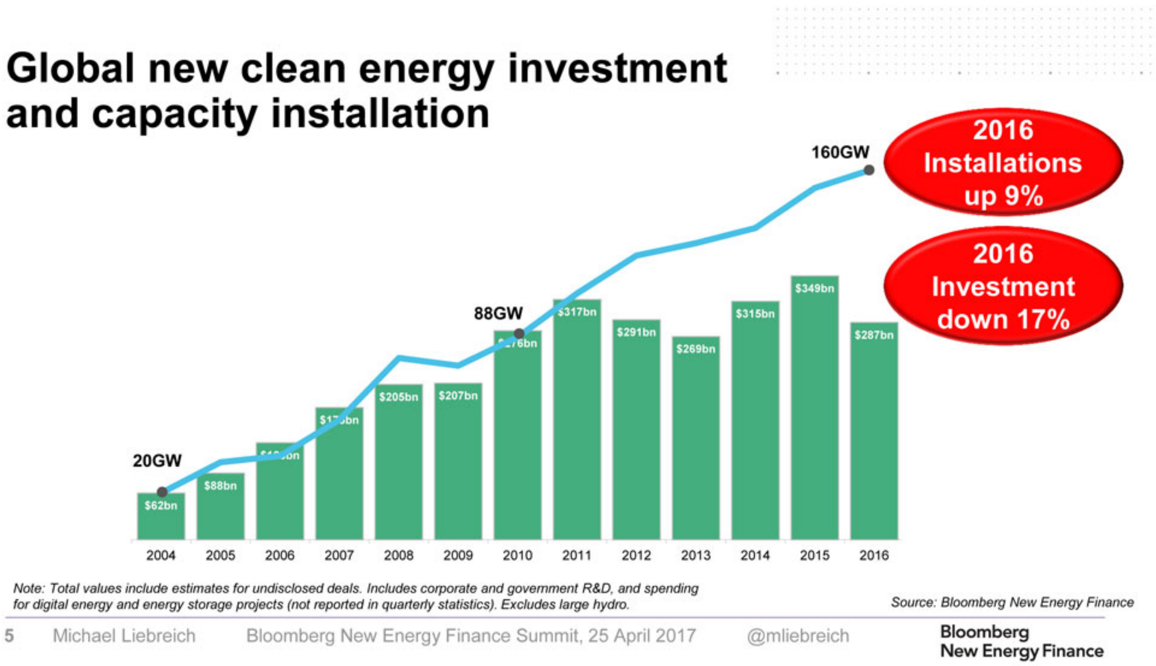
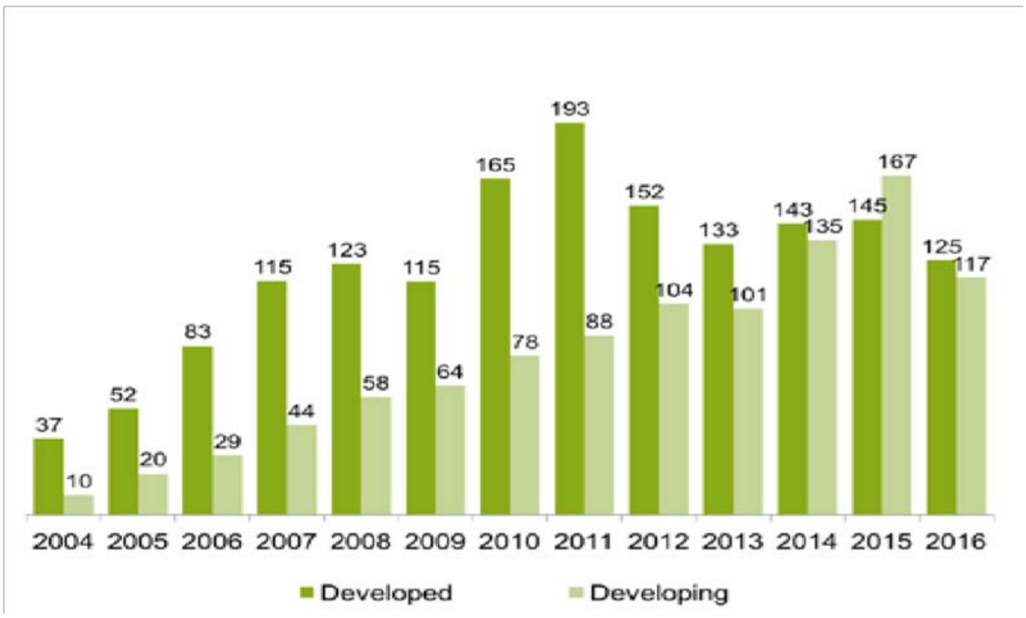
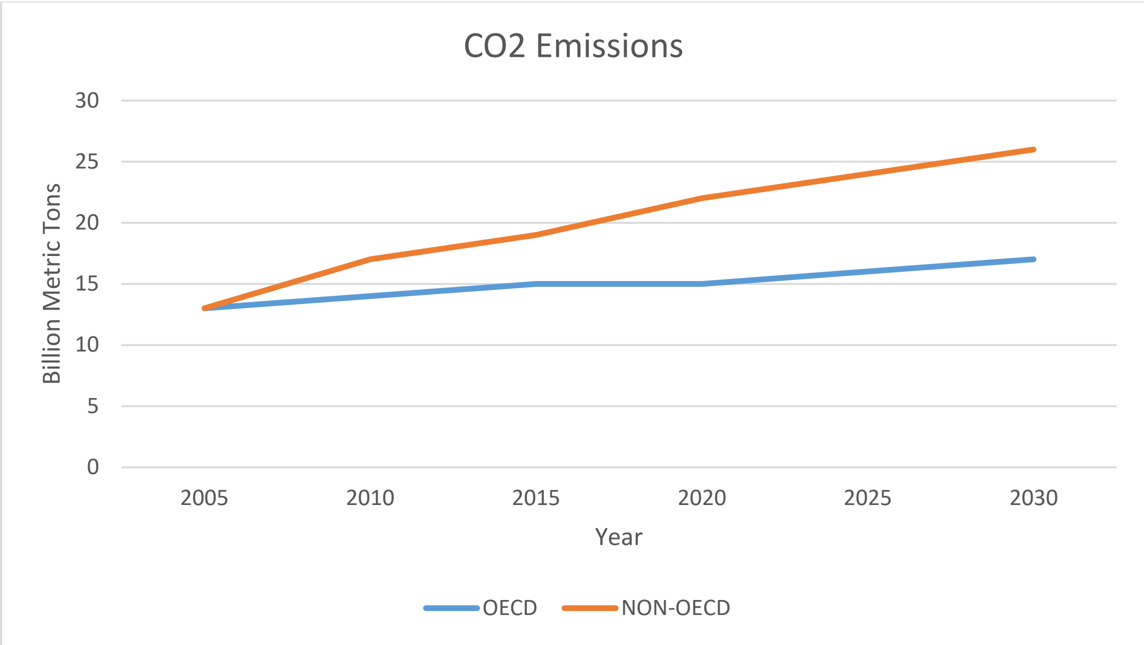


Figure 1: Global New Investment in Renewable Energy, 2004-2016.



Source: Frankfurt School-UNEP Centre/BNEF (2017)

Figure 2: New Investment in Renewable Energy across Regions, 2004-2016.



Sources: EIA (2015).

Figure 3: Global CO2 Emissions by regions

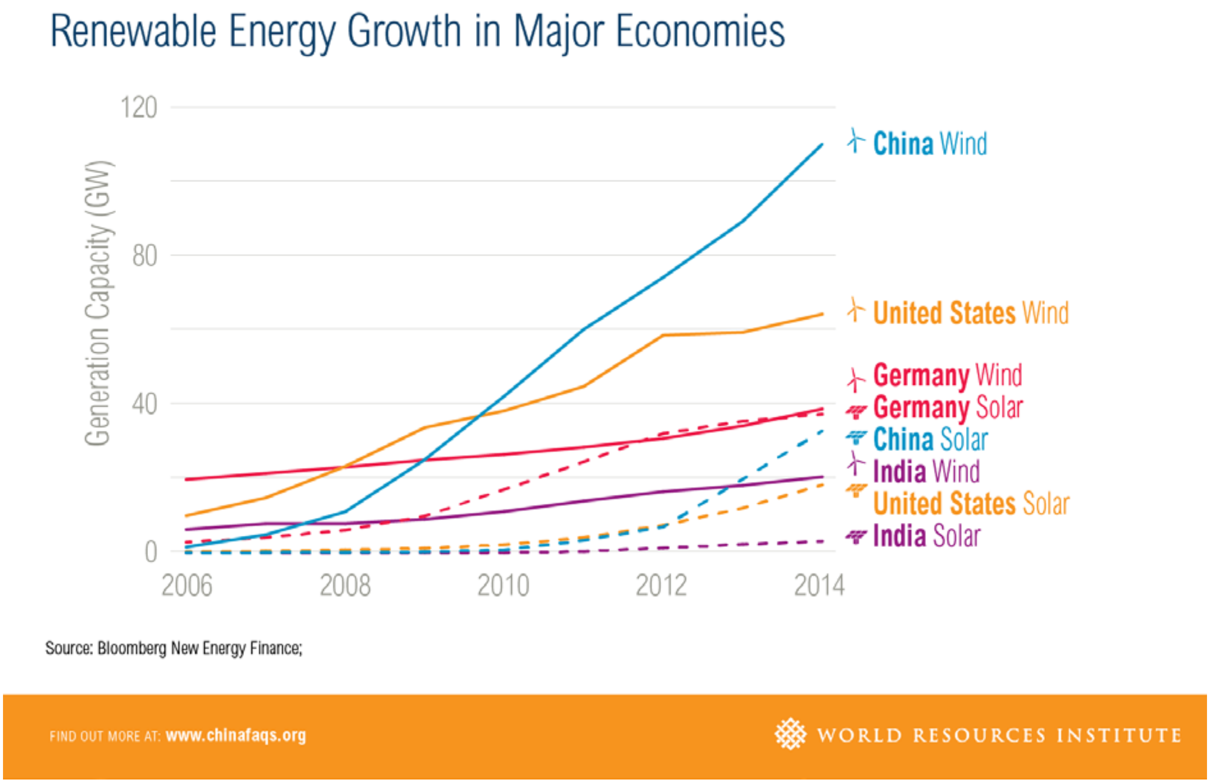
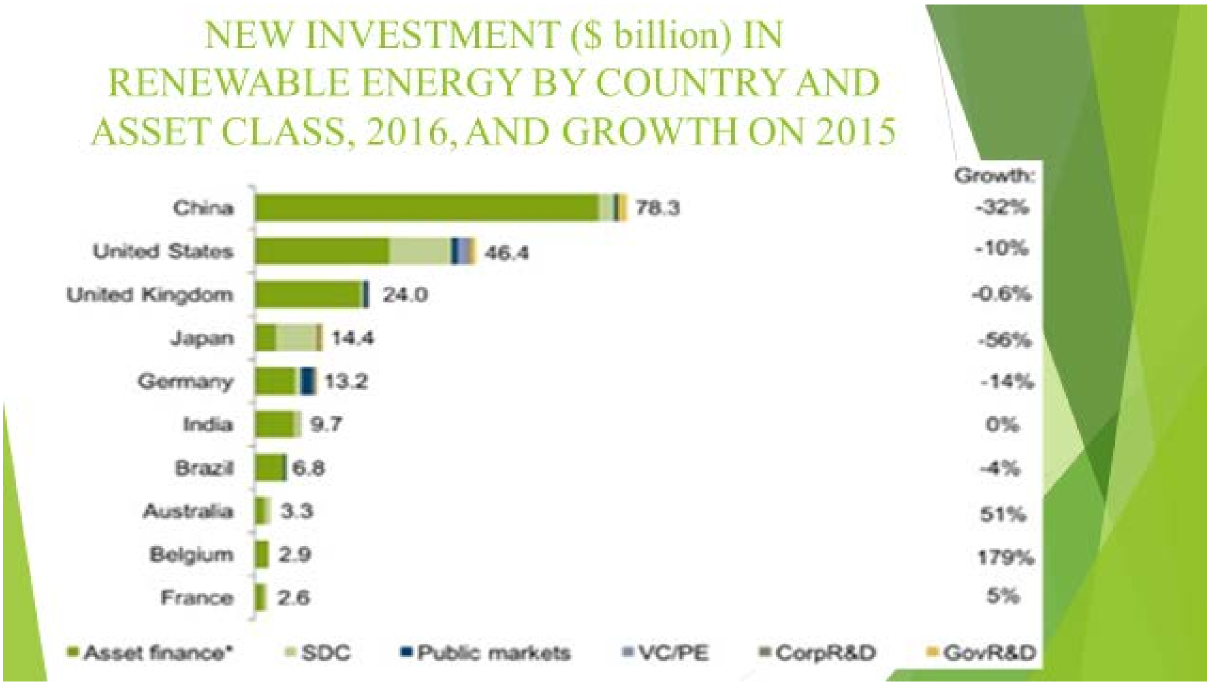
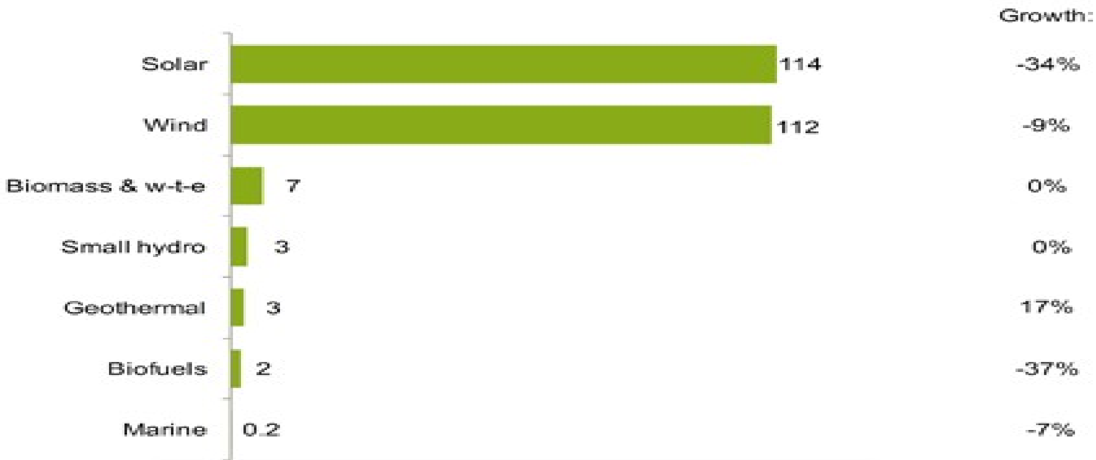


Figure 4: Variations in Renewable Energy Investment across Countries and Sectors



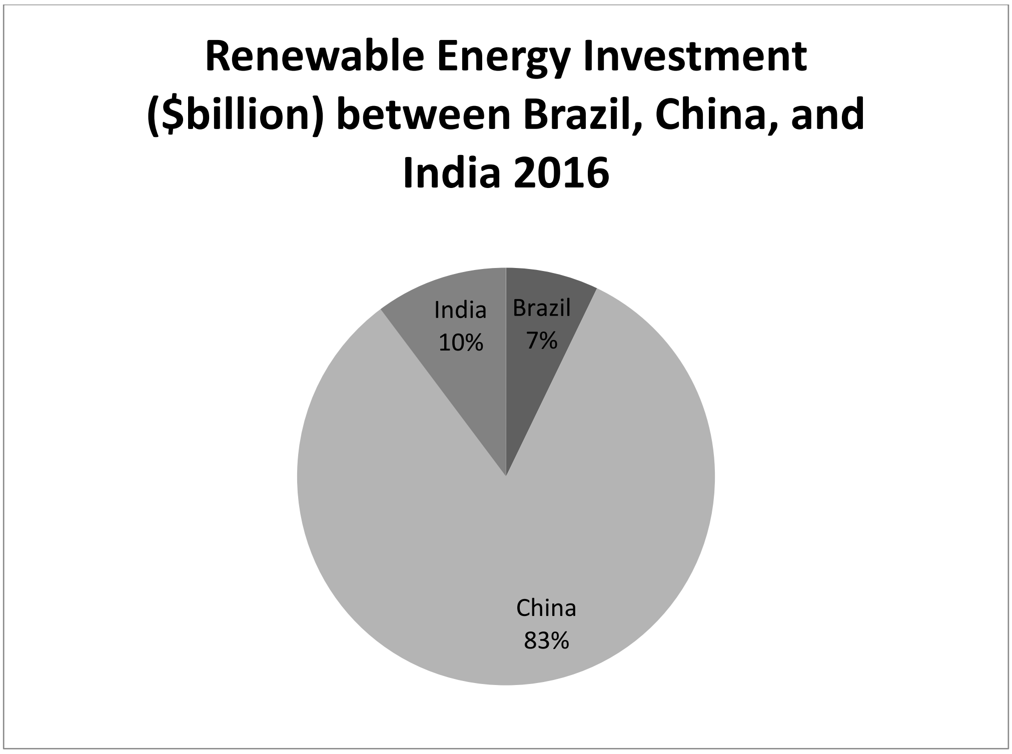
Source: Frankfurt School-UNEP Centre/BNEF (2017)

Figure 5: New RE investment in selected countries by asset classes.



Source: Frankfurt School-UNEP Centre/BNEF (2017)

Figure 6: Global New RE investment by categories in 2016 and growth on 2015.



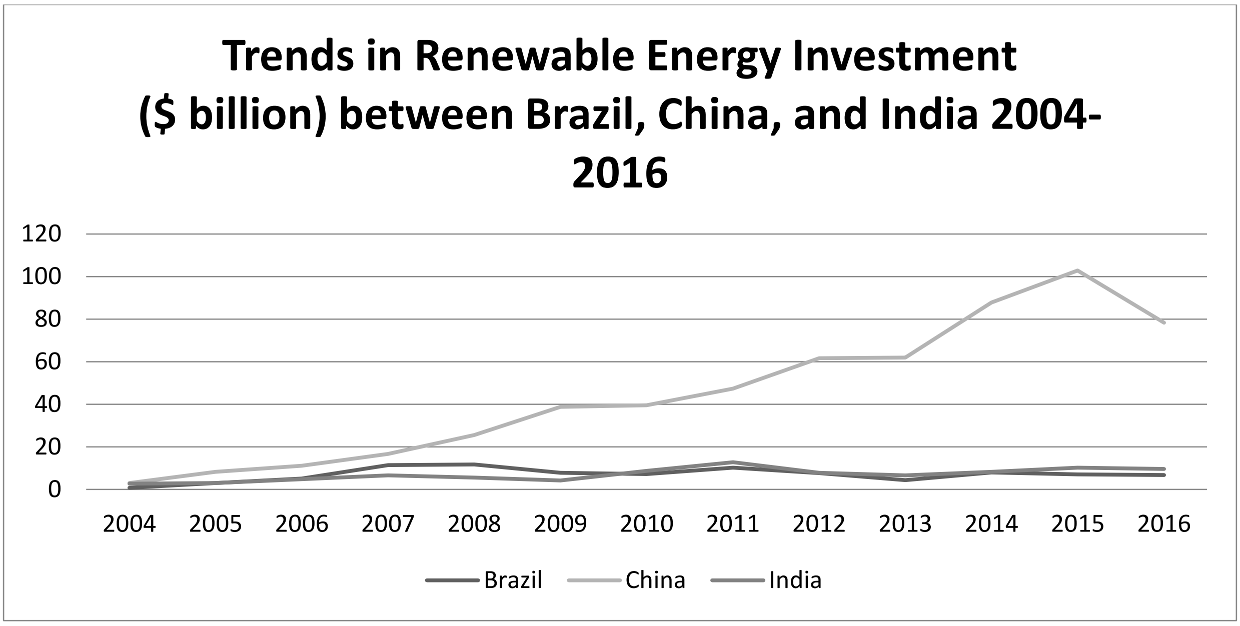
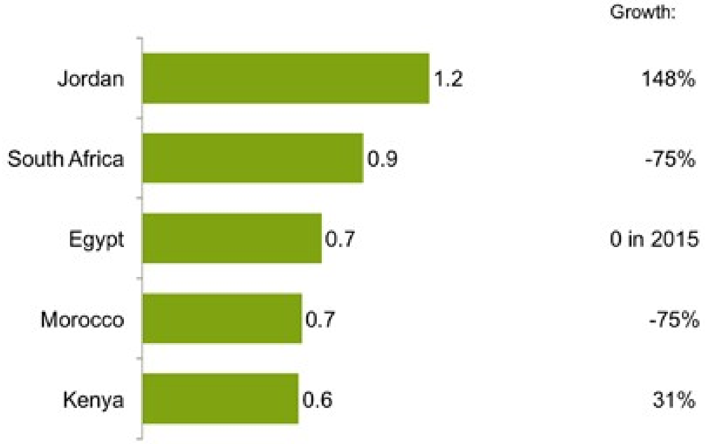


Figure 7: Renewable Energy Investment: Developing Countries

RE Investment: Africa and Middle East, 2016



RE Investment: Latin America

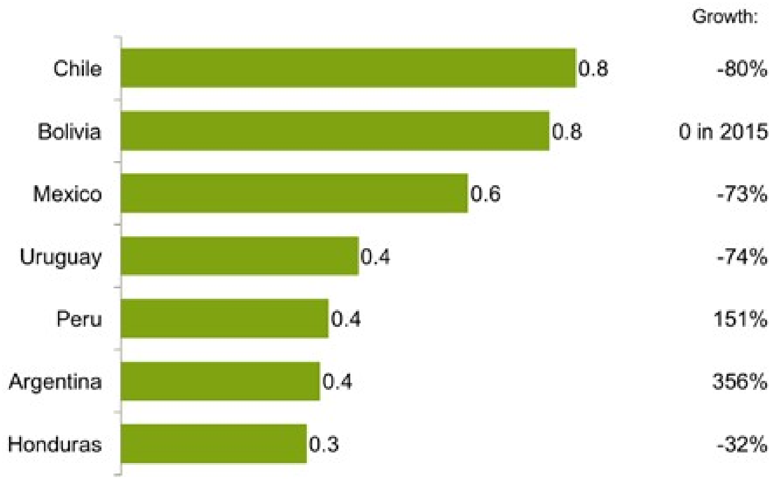


Figure 8: Renewable Energy Investment: Developing Countries

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Appendix I

“DEFINITIONS: Bloomberg New Energy Finance tracks deals across the financing continuum, from R&D funding and venture capital for technology and early-stage companies, through to asset finance of utility-scale generation projects. Investment categories are defined as follows:

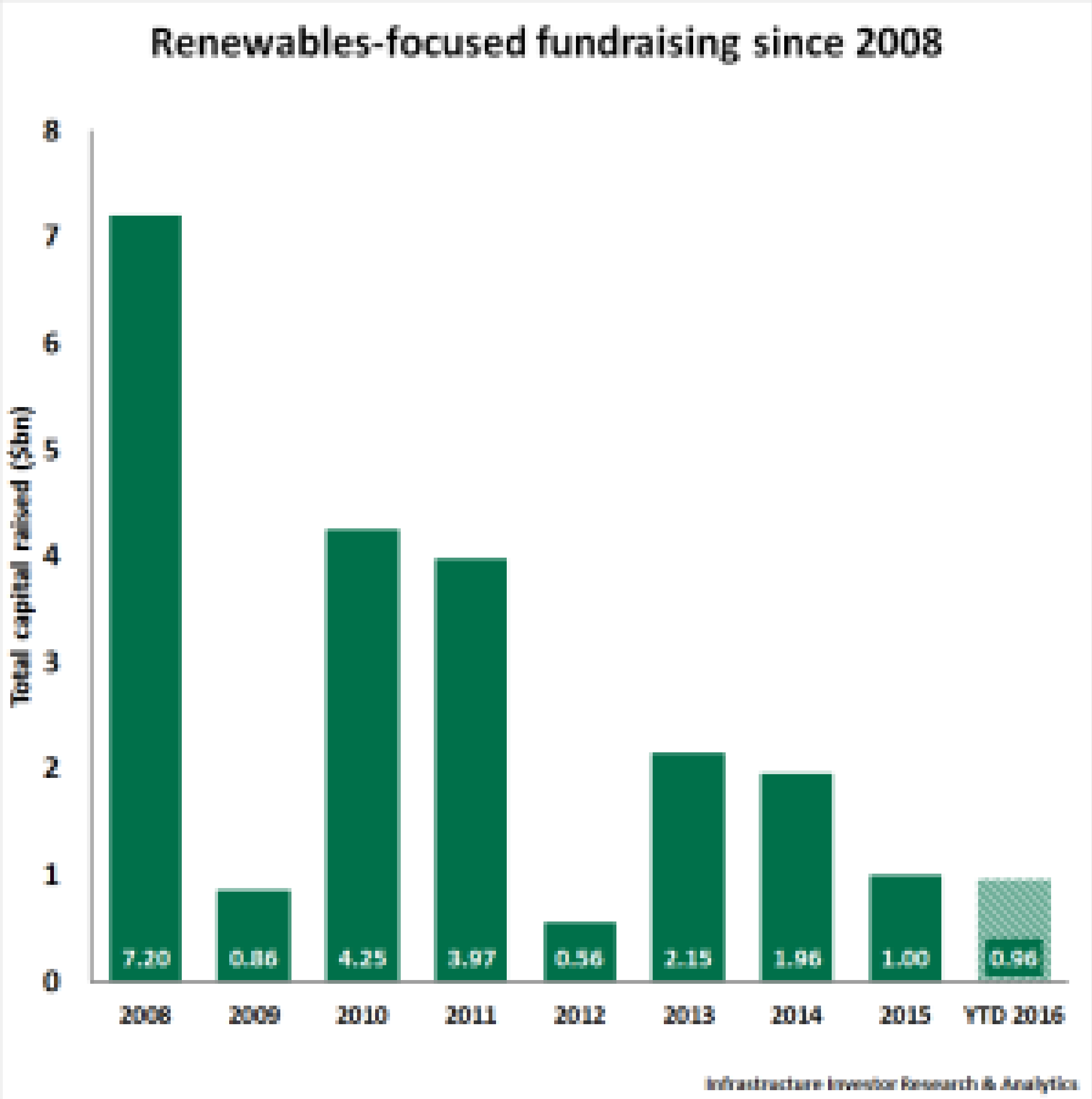
1. Venture capital and private equity (VC/PE): all money invested by venture capital and private equity funds in the equity of specialist companies developing renewable energy technology. Investment in companies setting up generating capacity through special purpose vehicles is counted in the asset financing figure.

2. Public markets: all money invested in the equity of specialist publicly quoted companies developing renewable energy technology and clean power generation.

3. Asset finance: all money invested in renewable energy generation projects (excluding large hydro), whether from internal company balance sheets, from loans, or from equity capital. This excludes refinancings.

4. Mergers and acquisitions (M&A): the value of existing equity and debt purchased by new corporate buyers, in companies developing renewable energy technology or operating renewable power and fuel projects”.

Source: Frankfurt School-UNEP Centre/BNEF (2017), p.10.


Renewables-focused fundraising since 2008
Total capital raised ($bn)
8
7
6
5
4
3
2
1
0
7.20
0.86
4.25
3.97
0.56
2.15
1.96
1.00
0.96
2008
2009
2010
2011
2012
2013
2014
2015
YTD 2016
Infrastructure Investor Research & Analytics