Chinese Leadership in Photovoltaic Production Opens New Era to Replace Polluting Energy Sources

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Abstract

The polluting effects of the energy matrix that humanity currently uses are huge, and big changes are needed to avoid irreparable damage to biosphere. Development of technologies and markets for clean renewable energy is urgent. This article analyzes how in the first years of the XXI century sources of vast natural availability, as the energies of the sun and wind, are becoming cost competitive and technologically mature. Describes how huge consumption of coal has caused a serious deterioration of global environment, especially acute in China, factor which coupled with its strong industrial policy, is turning this country into a technological and market leader on renewable energy, with an enhanced production capacity of clean energy systems that are spreading across the planet, starting to become reality "the beginning of the end of fossil fuels".

Keywords: Renewable energy, Solar energy, Wind energy, Global warming, China, Substitution of fossil resources

1. Introduction

Effects of human activities on the natural environment of the planet and the resulting pollution are producing increasing impacts, generating abnormalities with severe consequences in many communities from all continents: global warming, ocean acidification, water and air pollution, accelerated melting of glaciers, among others (Fifth Assessment Report on Climate Change, 2013). The anthropogenic origin of these activities, i.e. generated by human activity, is directly related to the intensity of economic processes developed over time by growing volumes of population, and lifestyles that demand high energy consumption. The countries where the industrial revolution and the massive use of coal originated have brought greater burden of global cumulative emissions, while those that in recent decades have accelerated the process of industrialization, such as China and other developing nations, also increase substantially pollutant loads.

Countries with high population densities require more goods to meet their needs: from the daily diet to construction of roads, hospitals or ports, needs that are suited to enjoy higher standards of living than those reached by previous generations, exponentially consuming natural resources of all types, many of them non-renewable. Within these, the energy of fossil fuels such as coal and oil, have not only rendered an immense service to humanity to satisfy their needs but also have a polluting side, or high carbon footprint. Thus, fossil energy matrix that mankind used extensively becomes today a sword that in its downside threatens the sustainability of human and natural life on the planet.

It is analyzed in this article the global use of fossil resources and it will be demonstrated that new clean and renewable sources, such as wind and solar, have recently reached technological and economic maturation that enable them tobe used actively worldwide. Europe was until last years the region of the globe that performed more investments in renewable energy installations, but due to the financial crisis of 2009, the highly indebted governments reduced several financial stimulus, and this process made the dynamic of production and installation to be moved to Asia, especially to China, Taiwan and Japan. The United States and most countries which base their economies on oil and gas have failed to maintain a stable framework with incentives for clean industries, which has made them somewhat marginal and at the shadow of its investments in oil and gas (Campbell, 2014).

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2. The Meeting Energy Needs

According to the International Energy Association -IEA (Key World Energy Statistics, 2014: 6 and 45) world energy supply was 13,371 Mtoe [2]by 2012 and was composed 81.7% by fossil fuels (petroleum 31.4%, coal 29.0% and natural gas 21.3%), resulting in 31,734 Mt emissions of carbon-dioxide (excluding other emissions), gigantic amount of greenhouse gases that were released into the biosphere at an annual growth rate of 1.85% since 1973 (IEA, 2014)and aggravates global warming. The primary energy production from renewable sources (Key World Energy Statistics, 2014: 6) contributed to only 13.5% of the total in 2012 (10.0% biofuels and charcoal + 2.4% hydro + 1.1% wind, solar and others / Nuclear energy contributed with other 4.8%). What is important to appreciate from these figures is that technology and economic foundations of all countries "create" so large CO2 emissions that the planet cannot afford to recycle this waste by its natural processes. In fact, CO2 emissions were in 2012 double than 40 years ago (IEA, 2014).

Graph Nr. 1 shows CO2 emissions distributed by regions of the globe, highlighting those generated by OECD countries and in recent years by China + Asia. Continents like Africa and Latin America, despite their population size, contaminate relatively slightly with CO2. If the growing events of weather catastrophes across the globe and the urgent appeals from organizations of scientists researching global warming are considered, it is regrettable that at present, only a small amount of global primary energy is met through renewable resources, and especially with those who have minor negative side effects: wind, solar and geothermal energies. [3] It would be worth asking whether this deficiency is due to lack of development of clean and cost-competitive technologies, or if there are market and/or political related reasons, which make polluting energy matrix remains so strongly predominant.

2.1 Power Generation Costs with Different Energy Sources

According to estimates of costs of energy production (based on statistics of "US D.O.E. Annual Energy Outlook 2014"), shown in graph Nr 2, it is today technically feasible and financially profitable to produce energy from new renewable sources thanks to recent rapid technological developments in the generation of wind, solar photovoltaic, geothermal, and biomass energy.

For all the above energy sources it is feasible to produce a kilowatt/hour below 14 cents US-Dollar (2014), the retail price of residential electricity in populated states of the Union like California and New York[4]. This cost puts PV-electricity price at similar levels with utilities where coal and gas are used. This cost-structure was not possible at the first years of this century. [5]

[2] Mtoe = Millions of Tons of Oil Equivalent

[3] Energy production from biomass using foodstuffs such as corn, presents great contradictions: "The US is the world's largest producer and exporter of corn, giving it the power to dictate global market responses. Domestic consumption of corn, as ethanol, has driven up the price of corn worldwide, according to studies from the World Bank and other institutions. The high prices for corn – while driving hunger in Africa – have encouraged other farmers to turn over land from wheat, soybeans, or even pasture to corn production… The concern over the global food crisis added new urgency to existing campaigns against the use of corn ethanol. Environmental groups had argued that its use offered no meaningful reduction in greenhouse gas emissions – in part because of the vast use of energy and water in the ethanol conversion process. As a food crop, corn is also far more damaging to the environment than other crops, such as soybeans, because it uses more pesticides and fertilizer." http://www.theguardian.com/environment/2011/aug/15/us-corn-belt-farmers Accessed 26.11.14

[4] For USA electricity prices see: www.eia.gov For coal, natural gas and wind energies of the graphic Nr. 2, it´s presented two different costs (Ex: Coal "a" and Coal "b") due to maximum and minimum representative costs of production in the USA (less and more efficient producers), differing by placing, technology, providers, and particular states´ regulations. New technologies for wind and PV tend to produce more efficient and cheaper than old ones,thanks to rapid innovation´s rate, which it´s not possible for mature technologies like coal.

[5]To better understand the figures of graph Nr. 2 there should be taken into account two important factors: a) These costs are calculated for the US and are based on its available infrastructure, grid-connection with regional distribution networks, and state incentives, which may differ from average costs of other countries, and b) Cost of energy production from coal and natural gas in graph Nr. 2 are not yet charging negative externalities attached to contaminant effects (the carbon-tax), charge which is progressively adopted in many countries and that is making fossil resources more expensive, especially for coal, the material more widelyused to generate electricity (50.8% in USA 2012 – EIA, 2014).

2.3 Decreased Cost-structure of Wind Power Generation

In graph Nr 3 can be seen how prices of wind turbines have consistently dropped in recent years due to technological innovations and installation of higher and powerful mills, making that wind energy could be today considered as a "mature" or consolidated technology, and thus available for massive use. The turbines produced in China had a price close to half of the usual international prices, and they have reached its minimum cost in 2010. Installation of large wind-farms is attaining significant proportions: in July 2013 the British Prime Minister James Cameron opened the "Thames Estuary Wind Farm" with installed capacity of 630 MW, with 175 turbines that can supply electricity for 470,000 British homes and avoid the generation of 925,000 t CO2 per year. [6]

2.4 Production Costs of Solar PV

While wind energy is already competitive in many countries, photovoltaic (PV) has experienced huge price reductions, especially since 2009, allowing its inclusion in the portfolio of renewable energy sources at competitive costs. Many studies from Europe and USA (NREL, 2014) show how prices of solar modules have experienced great reductions: they used to cost more than US$3/w in 2000 and they are now under US$1 [7].

Reduction on installation costs are also on-going, and have decreased up to 50% from 2000 to 2011 (NREL, 2014). This trend indicates how both the costs of purchasing and installation of solar modules are experiencing declining prices, making them accessible to individual users, residential or commercial sets, and public utilities.

2.5 Growth in Installed Capacity of PV and Wind Energy in the World

Wind and PV sources have seen rapid growth of their installed capacity in recent years, thanks to technological developments and new capitals that are now investing in renewables. Their profitability has also improved due to higher prices of fossil fuels in the first decade of the century, which stimulated European and other governments to approve fiscal incentives and feed-in tariff systems. It also played an important role, the need to replace the polluting energy matrix. Wind energy has grown at an annual average rate of 23.6% between 2005 and 2013 (calculated from figures of NREL, 2014), while the photovoltaic (PV), after having a minimum installed capacity in 2005, began its takeoff by 2010 and has grown on average 50.8% annually (NREL, 2014).These high rates can only be explained by constant technological innovation fostered by favorable state regulations in countries like Germany, Italy and Spain, and more recently in People´s Republic of China and Japan. Graph Nr 4 shows the fast growth and magnitudes of the installed capacities. [8]

Countries that have made major additions of wind power capacity in recent years are Germany, Denmark, Spain, Italy and the US. Since 2009 a new great player, the People´s Republic of China, has entered into this group andit´s providing the highest annual volumes of new installations. This was achieved thanks to regulation through the renewable energy framework (Campbell, 2014), whose axis is constituted by the feed-in-tariff, which guarantees a stable and profitable purchase value of the energy produced, similar to that used in Germany or Japan. Graph Nr. 5 shows how Europe has steadily added new capabilities; North America does it in cycles, while Asian countries were from 2009 the region that systematically added more new wind capacities. In 2013 China installed 16 GW, equivalent to 45.4% of all additions of the year (reaching 92 installed GW), Germany added 9.1% (overall 34.2 GW), Britain 5.3% (10.5 GW cumulative) and India 4.9% (20.2 GW cumulative). In Latin America, Mexico and Brazil are initiating significant investments in the area, while in Africa and the Middle East wind energy is still marginal (GWEC, 2013).

It should be noted that among the programs for new generating capacity, China has appointed wind power as a key and stable source of future additions. Assuming that this country had an installed capacity of 31.3 GW in 2010, with a goal of 200 GW by 2020, capacity reached by 2013 was 92 GW, meaning that China are meeting its goals faster than planned.

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[6] http://www.theguardian.com/environment/2013/jul/04/offshore-windfarm-opens-thames-estuary Accessed 26.11.14

[7] See for example "National Renewable Energy Laboratory – USA 2014" or International Energy Association –IEA / Technology Roadmap (2014: 13) "In the first half of 2014, Chinese Tier 1 module players were selling at USD 0.59-0.60/W in China, and USD 0.67-0.79/W in other countries (BNEF, 2014). German modules were selling at EUR 0.69 (USD 0.95)/W". The trade agreement reached between the European Union and China in 2013 states that Chinese companies are not allowed to sell a PV watt under US$0.74.

[8] 1 GW (Gigawatt) = 1,000 MW = 1 Million KW

And the goal for 2050 is 1,000 GW installed, which would provide about 17% of its electricity consumption, avoiding the emission of approx. 1,600 million t CO2 eq. (China Wind Energy Development Roadmap 2050, 2011: 25, 26).

2.6 Growth in Installed Capacity of Photovoltaic Energy in the World

Although Sun is by far the largest source of energy on earth [9] and its radiation is cost-free, the world´s PV industry is just emerging from its infancy. However, as we saw earlier, it is no longer an expensive source without economic competitiveness, due to rapid innovation, use of economies of scale, and competition within the industry. There has been an industrial boom in China during recent years through massive creation of products like silicon, wafers, cells, modules and parts. "Over the past decade, module production has shifted from the United States, to Japan, to Europe, and back to Asia, with China dominating shipments since 2009. By 2013, Asia accounted for 87% of global production (up from 85% in 2012), with China producing 67% of the world total" (Renewables, 2014: 48). This developing country has been able to create a powerful industrial sector that is offering productive leadershipto the world's nations and the possibility for the first time in history of using the power of sun to meet the energy needs of humanity at competitive prices. In other words, creation of this industrial capacity may be starting to come true the substitution of polluting fossil fuels at major scale. Other big and technologically advanced countries were not able to make this trend real, in spite that substitutionof fossil resources is environmentally really urgent.

The PV industrial take-off [10]occurred a little later than that of wind energy, but in 2013 the PV reached 137 installed GW worldwide,[11] and grew to a spectacular annual average rate of 51% since 2005. While most of the PV capacity were in 2013 installed in Europe (Germany 26% / 35.5 GW, Italy 13% / 17.6 GW), Japan (10% / 13.6 GW), and the USA (9% / 12 GW), rapid installation of capacities in People´s Republic of China (11.3 GW only in 2013) increased its share in the global total to 13% / 18.2 GW. (IEA, 2014). Note that just four years ago, a geographically small country like Germany had 44% of worldwide installed capacity, while China only reached 2%. View Graph Nr 6.

China has become the nation of the world that recently more PV capacities added. It has also the largest industries producing solar PV modules, it innovates technologically like other developed nations, and it is the strongest exporter supplying more than half of global demand. In terms of some Chinese researchers (Sun et al, 2014: 225-6):

"Chinese PV cell technology is rapidly developing towards becoming low cost and highly efficient. Silicon material is developing towards becoming low cost, low pollution and low energy consumption. Crystalline silicon cell is developing towards high efficiency and thinner slicing. The components are developing towards becoming diversified and integrated. Production line equipment is developing towards becoming highly reliable, highly automated and low energy consumption. Thin-film battery technology is developing towards becoming highly efficient and highly stable. Novel solar cell technology such as high concentrator cells, HIT cells, black silicon cells and dye sensitization cells are constantly emerging… The domestic leading PV enterprises are making great investment now in technology R&D.

[9] "…the total annual electrical energy (different from "primary" energy) consumed in the world from all sources in 2011 was 22,126 TWh (International Energy Agency -IEA). Thus the available solar energy is over 10,056 times the world's consumption. The solar energy must of course be converted into electrical energy, but even with a low efficiency conversion of only 10% the available energy will be 22,250,400 TWh or over a thousand times the consumption".
www.mpoweruk.com/solar_power.htm accessed 28.11.14

[10] "The emergence of the global PV market has coincided with rapid reductions in the costs of modules and systems. The levelized cost of energy (LCOE) from PV systems is already below retail electricity prices (per-kWh charge) in several countries, and rapidly approaching the level of generation costs from conventional alternatives, especially new coal with strict air pollutant emission standards, new nuclear plants with increased safety standards, or new gas plants in areas with high gas prices." (IEA, Technology Roadmap 2014: 12)

[11] By means of comparison, Canada had at the end of 2012 a total installed capacity of 137 GW of electrical generation, the U.K. 85 GW, Colombia 13.5 GW, and Nigeria 5.9 GW.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/337649/chapter_5.pdf
Accessed 27.11.14

Several enterprises are equipped with national level key laboratories or engineering research centers. The supporting R&D equipment covers almost every link between solar cells and components manufacturing."

One of the biggest drivers of PV production in China to 2004-09 was the great European demand. However, considering that PV exports decreased after the global financial crisis from 2009, the Chinese leadership has managed to find support to its local industries, directing production orders to its huge domestic potential. The Government´s goal of building a low-carbon economy is a strategic decision that creates the conditions for decreasing its absolute reliance on coal by 2030. In recent communication Xinhua News Agency published:

"The Chinese state press agency, Xinhua, has reported that Beijing is looking to ban coal use by 2020 — a massive development in a country known for smoggy cities and developing world energy-usage. "Beijing will ban coal sales and use in its six main districts and other regions by the end of 2020 to cut air pollution, local authorities said on Monday." Furthermore, clean energy is expected to replace coal in the districts, though the specifics of such a move are as yet unclear."[12]

It is to be noted that use of coal is strong in China: 3,881 Mt. in 2013 (3,561 million ton produced + 320 Mt. imported), and it constitutes almost half of all coal burned in the world (49.6% - IEA, 2014). Such a huge quantity would imply that this country should involve itself into a great effort to massively develop clean energy substitutes. Additionally**,** China has crude oil supply deficit (5.1% of world production vs. 11.6% of world consumption in 2013 -IEA), and natural gas (3.3% of prod. Vs. 4.7% of consumption -IEA), deficits which have to be covered and that will require strategies that allow this country to structure its energy security and to continue reaching high economic growth rates. In order to meet this challenge, China has the advantage that it is one of the few countries of the world who practices an industrial policy through five-year development plans (Kümmerle, 2014), which include strong support from the central and provincial governments to industries, through loans for building industrial facilities, to finance exports, to develop research centers, and other stimulus. A framework of state incentives has been gradually introduced, with programs such as the "Golden Roofs" and "Golden Sun pilot project" started in 2009, or the Feed-in-Tariff -FIT implemented nationally in 2011 (Campbell, 2014), regulatory framework that led to the installation of large and numerous PV-industries across the country.

Other considerations which have recently helped to develop these technologiesworldwide are environmental problems such as the Fukushima nuclear disaster in Japan (March 2011) that led authorities of that country to stimulate rapid deployment of PV power capacities. Japan plans to install 10 new PV/GW between July 2014 and June 2015[13]. It is therefore offsetting part of the recent PV demand decline of Germany and Italy. There is also an important addition of PV capacities in India and many other developing countries.

However, cost reductions in PV technology have been on top of the reasons to install new capacities:"… the sharply reduced cost of solar photovoltaic systems, which meant that a record amount of PV capacity (some 39GW) was constructed in 2013, and for less money than the smaller 2012 total of 31GW… 2013 cost reductions and efficiency improvements enabled onshore wind and PV projects to be built in a growing number of locations around the world without subsidy support. Wind and PV may be able to out-compete fossil-fuel options as long as there are plentiful local sunshine or wind resources, low capital costs, and no cheap, indigenous coal or gas feed stocks… Last year (2013) was the first ever that China invested more in renewable energy than the whole of Europe. The Chinese total, although down 6% to $56 billion, finished well ahead of Europe's shrunken $48 billion." (Global Trends, 2014: 11)

3.The Trade Dispute between China and the US in the Photovoltaic Industry

In 2009, China consumed locally only 0.16 GW of its 3.6 GW of PV production, while the bulk of its production was exported. The global financial crisis in 2009 dramatically reduced its exports (Kümmerle, 2014: 9), forcing authorities to launch an ambitious strategy for domestic consumption and hence to improve the framework of incentives for local PV installations based on the "Renewable Energy Law" of 2005 (Campbell, 2014). Already in 2011 China managed the installation of 2.5 GW.

[12]http://cleantechnica.com/2014/08/06/beijing-ban-coal-2020/ Accessed 02.12.14

[13]Readmore: http://www.pv-magazine.com/news/details/beitrag/japan-poised-to-top-8-gw-solar-installations-this-year_100016536/#ixzz3KmYxIOli accessed 02.12.14

Trade disputes between China, the European Union and the US since 2011 also forced the Chinese government to reformulate the target set in its 12th. five-year plan, increasing it from initial 21GW to 35 GW, which should be installed by 2015 (Kümmerle, 2014) in order to compensatein the local market the sales lost from declining exports to the US and Europe.

Allegation of Chinese dumping by US companies in 2011 led the US Commerce Department approval of trade sanctionson May 2012, consistent on tariffs starting with 29% for Chinese exporters (Bloomberg, 02.12.13). This penalty boosted Chinese companies to incorporate parts produced in Taiwan into its modules as a way to avoid the tariff, situation which led in July 2014 the Commerce Department to also include Taiwanese companies [14] under the tariff (Bloomberg, 2014). Dumping charges were also argued by the European Union, but an agreement was signed in 07.27.2013 (Bloomberg, 2013) [15] which consisted in that Chinese companies accepted not to sell below the price of Euro 0.56 / Watt (US$ 0.74) and to export a share not exceeding 7 GW / year to EU. [16]
In spite of these measures, PV capacities continued to grow worldwide (as seen in Gr. Nr. 6), but the strong dynamic of production and installation is now led by Asian countries, which constitute the world's largest manufacturers, including companies from China, Taiwan, Japan, Malaysia, Singapore, Korea and India, countries which also began to rapidly increase their local installed capacities. The ten largest PV-firms in the world produced 15.5 GWp in 2013 (Statista, 2014), participating the Chinese companies Yingli, Trina, JA Solar, Canadian Solar, and Jinko with 62.6% of this group´s production; the Japanese Kyocera, Sharp, and Solar Frontier accounted for 20%, Flextronics from Singapore with 7.1%, and First Solar from USA with 10.3%. In terms of world market share, seven Chinese companies were positioned between the top 10 (48% of participation), while two Japanese companies (Kyocera and Sharp) stocked up 8.5%, and First Solar of USA reached 4.2% of the world market, which had a value of US$80 billion in 2012 (Statista, 2014). [17]

Considering the weight of the USA economy in the world and the likely impacts of tariff sanctions against the first PV world producers, the trade dispute between China and USA failed to break the will to invest in new PV installations and the relative price increase of modules due to higher tariffs in USA was assimilated by importers of that country, indicating that the takeoff of PV energy production remains a positive reality. It can be concluded, that US trade sanctions against Chinese firms did not stop them from growing, innovating, and keeping on delivering PV technology to many countries all around the world.

3.1 Agreement on Reducing Emissions China - USA

At the Asia-Pacific Cooperation Meeting of Nov. 2014, the leaders of USA and China, Barack Obama and Xi Jinping [18], representing the two biggest polluters of the world, announced they have agreed to reduce their CO2 emissions between 26 and 28% for the USA (compared to 2005), and a reduction of the growth of coal used by China, and also raising its renewable energy mix to 20% by 2030. These two nations had previously refused to set specific CO2-reduction targets and to ratify the Kyoto Protocol of 1997. These new goals will force them to accelerate expansion of their photovoltaic, wind, hydro and biomass production capacities. This commitment is a positive indicator for the negotiations at the Conference of the United Nations on Climate Change that will be held in Paris in December 2015, where it is expected that concrete and more demanding commitments will be achieved. If this political trend keeps on, investment in renewable energies will steadily increase its share of the market.

Before the announcement of these world leaders some companies producing PV panels had financial problems due to over-supply, intense competition and lower prices in the world market, including the leading Chinese firm Suntech, who declared bankruptcy in 2013.

[14] http://www.bloomberg.com/news/2014-07-26/u-s-sets-duties-on-solar-energy-gear-from-china-taiwan.html Accessed 03.12.14

[15] See: Bloomberg "EU Nations Approve Pact With China on Solar-Panel Imports" By Jonathan Stearns - Dec 2, 2013.

[16] Dumping charges against China are mainly based on the extensive financing offered by state Chinese banks with cheap loans. However, all states of producing countries of PV technology provide subsidies to their industries, from finance, feed-in-tariffs, support to technology development, among others. All these stimuli have enabled the world to have a better chance today to launch a comprehensive program to replace polluting energy sources.

[17] http://www.statista.com/topics/993/solar-pv/ Accessed 04.12.14

[18] See: The Washington Post. Nov. 12.2014

However, adoption of solar technology has continued to grow rapidly in many nations of Asia, some of Europe and America, remaining China, Japan and USA the biggest markets for the near future (Global Renewable, 2014).

4.Recent Reduced oil Prices and Likely Impact on New PV Power Installation

The commodity prices have been falling since 2013 due to accumulation of inventories and low demand (Infomine, 2014). In particular the international price of a barrel of oil has approached $45 in January 2015, returning to levels post financial crisis 2009. It is clear that oil is the fuel base of the transport industry, but it does not compete directly for the generation of electricity [19]. Instead, coal and natural gas do compete with PV and wind electrical generation. In Gr. Nr 7 can be seen how the coal and gas prices have not fallen in the same proportion that oil, and for the past ten years (except pre-financial crisis 2008) have varied around US$50-60/ton. for coal, and US$3-4/mmBtu for gas (Infomine, 2014).

Additionally, it is worth to remember that big changes in oil prices are "normal" because it is a very volatile market, subject to all kind of pressures. By contrast, gas and coal prices are usually subject to medium and long term purchase contracts, and more stable prices. Furthermore, all electricity generation projects should consider this price-variation on at least 20 years, the minimum life-timehorizont of power plants. In contrast, PV-energy is from nature price-free and its provision more stable, allowing rationally deferred installation and distribution costs. Present current low oil prices could delay decisions about installations of new PV systems in the short run, but constant oil price instability, environmental concerns, and stable price reduction of PV systems will help to ease positive decisions about new projects. See Graph Nr 7.

5.Conclusions

Increasing levels of contamination by use of fossil fuels continue to exacerbate the climate problems on the planet. Man-made climate change claims for reduction of pollutants, and it is forcing the rapid incorporation of new clean energy sources in all countries.

Energy produced by renewable sources like wind and sun have in recent years achieved competitive costs versus fossil resources, reaching “cost convergence”.This fact is encouraging growing and massive investment in new clean power systems in many countries. Technological innovations and deployment of larger economies of scales of production have made pricesof these equipment and their installation costs to decline steadily.

Price of coal use is tending to rise due to its negative polluting effects, since it is being charged with carbon-tax in several countries, and new stricter pollutant control norms make coal systems every new day more expensive.European nations took the lead in PV and wind installations since the late 1990s, but due to financial crisis of 2009 that caused reduction of state subsidies in big countries of Europe, they have recently lost the leadership against some Asiatic countries.

While use of coal to produce electricity in China keeps on growing, despite permanent closure of its less efficient and polluting plants, recent commitment of its Government to rapidly expand the use of renewable energies is pushing this country towards increasing substitution of fossil resources. Huge investment in PV industries in China and other Asian nations are creating the necessary supply of PV systems at competitive prices to steadily allow substitution of traditional dirty energy sources around the world.This trend is currently consolidated by continuous technological advances, cost reductions and expanded world sales, generating a virtuous circle.

Trade sanctions imposed by the US on Chinese producers of PV modules since 2013 did not produced any serious reversal that could stop the development of this sector thanks to globalized production, increased marketing efforts, and demand growth from other countries.

Recent fall in oil prices does not seem to have a marked impact on discouraging renewable energy investments, because prices of coal and natural gas do not fall in similar levels.

[19] Electricity was produced in the USA in 2012 from: Coal 50.8; Nuclear 19.7%; Natural gas 16.7%; Hydro 6.9%, and Petroleum only 3.1%. Renewables and others: 2.9% (See: http://gm-volt.com/ Acc. 29.01.15). “Electricity production from coal sources (% of total) in China was last measured at 78.95% in 2011, according to the World Bank”. (See: http://www.tradingeconomics.com/china/electricity-production-from-coal-sources-percent-of-total-wb-data.html. Acc. 29.01.15)

In addition, stricter environmental norms are applied in most countries, and coal-tax will continue to be charged as a means of offsetting the negative effects of using these resources.

Commitments on CO2 emission control announced in November 2014 by the leaders of USA and China indicate that this time, they will not block agreements like Kyoto 1997, and that new commitments could be attainable in Paris 2015, allowing replacement of fossil energy resources on a more accelerated rate.

Achievements in technology and steady price reductions make massive use of PV technology in developing countries more feasible, both in rural and urban areas and connected to large power grids. They require specific investments in infrastructure, but agreements likely to be achieved in Paris 2015, can significantly accelerate financing of these programs.

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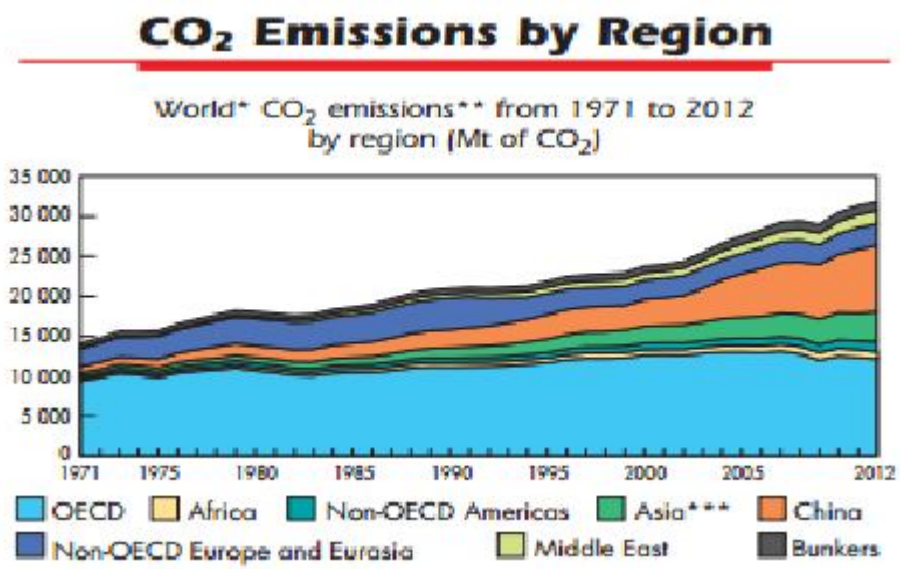
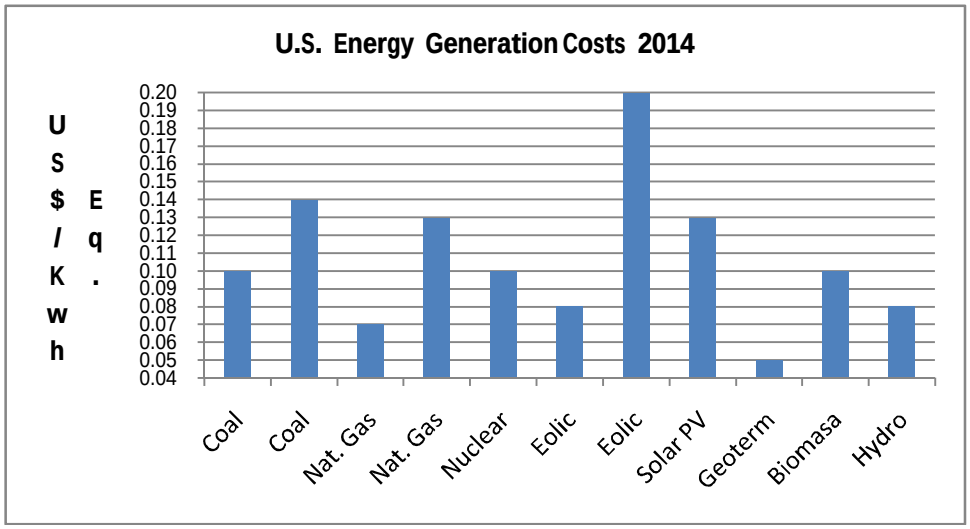
Graph Nr 1



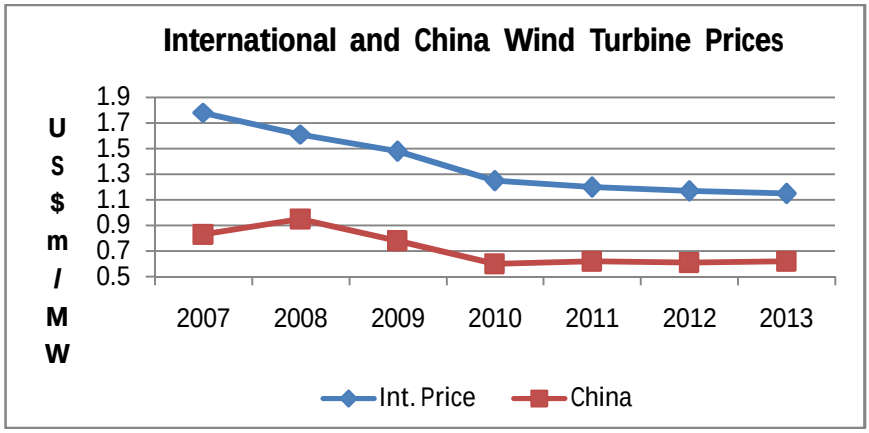
Source: International Energy Agency –IEA. Key World Energy Statistics 2014.

Graph Nr 2



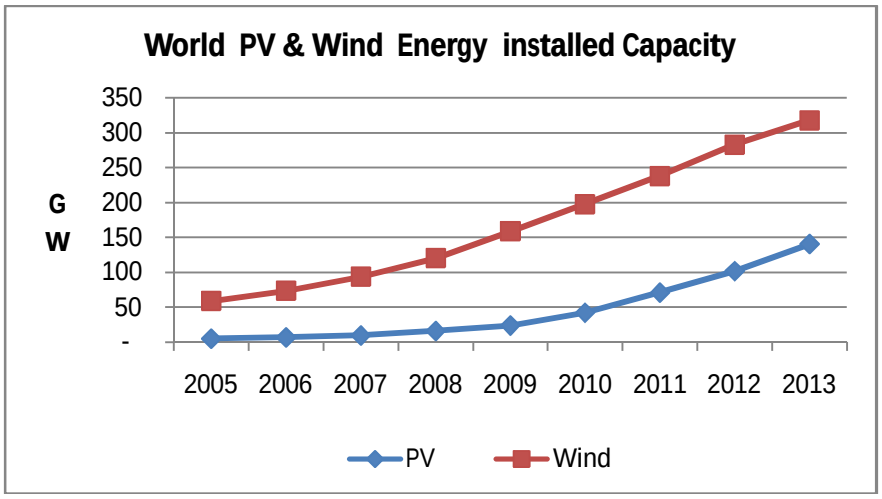
Source: http://www.renewable-energysources.com/ Cons. 08.10.14

Graph Nr 3



Source: Global Renewable Energy Report 2014. Hanergy Energy Group (Bloomberg NEF).

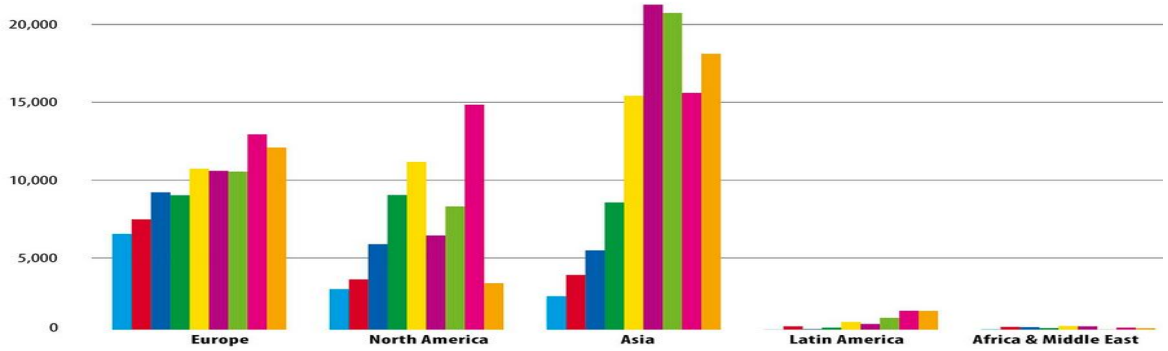
Graph Nr 4



Source: www.nrel.gov National Renewable Energy Laboratory – USA.

Graph Nr 5

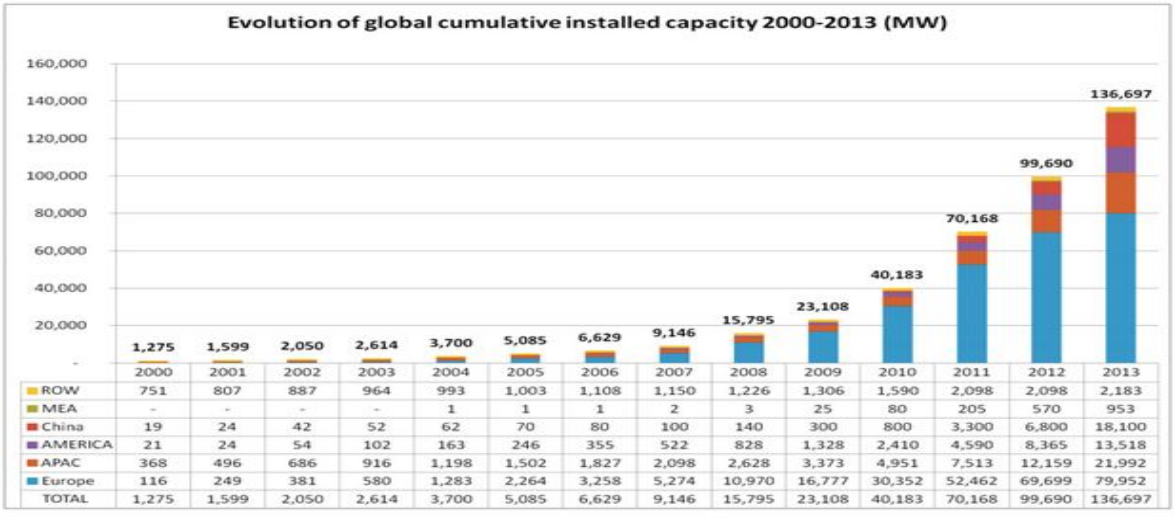
New Installed Wind Capacity by Regions (2005 left bar / 2013 right bar - MW per Year)



Source: http://www.gwec.net/wp-content/uploads/2014/04/7_21-3_annual-installed-capacity-by-region-2005-2013.jpg Accessed 26.11.14

Graph Nr 6

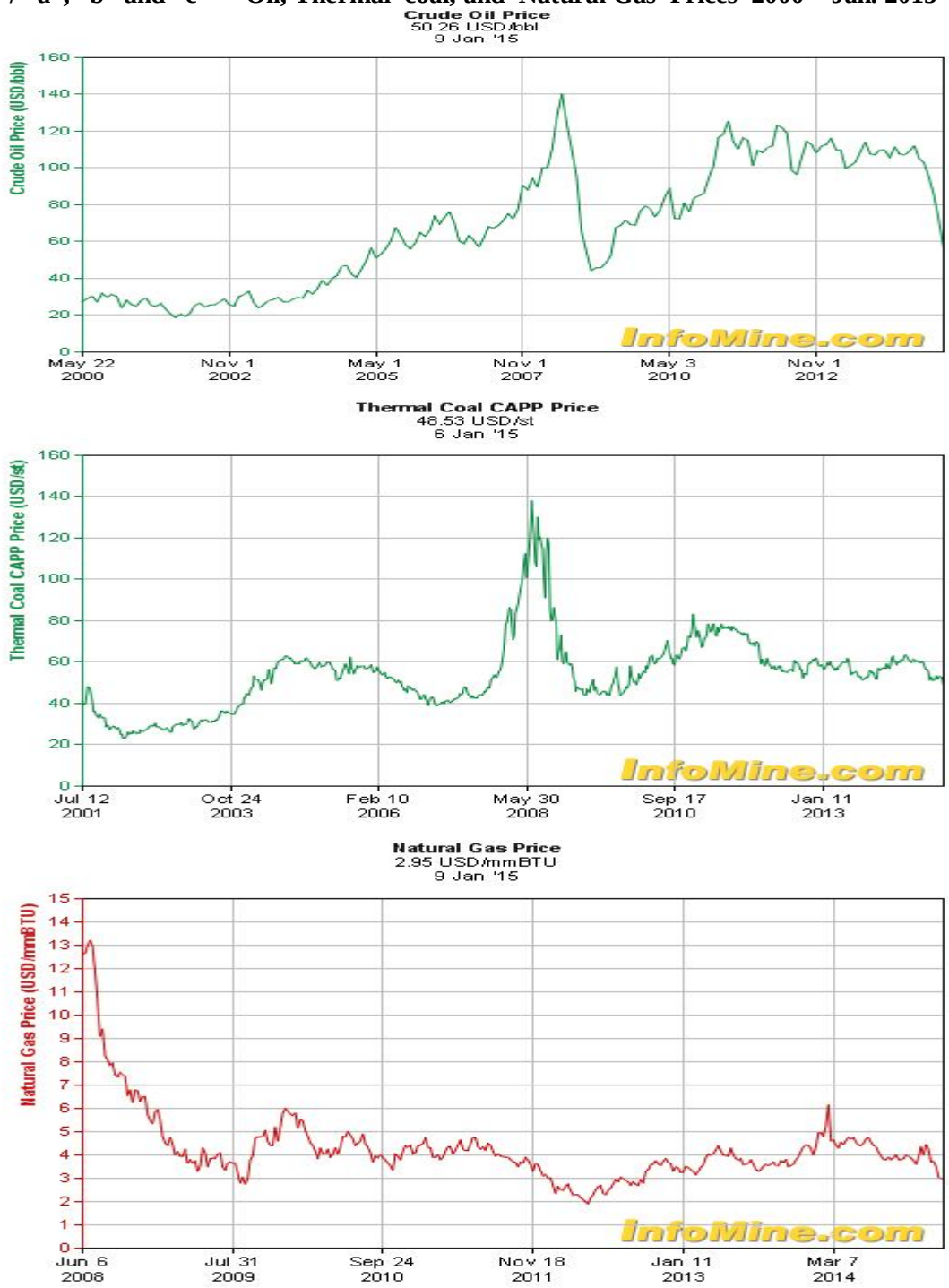
Global cumulative PV installed capacity 2000-2013 (MW)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ROW	751	807	887	964	993	1,003	1,108	1,150	1,226	1,306	1,590	2,098	2,098	2,183
MEA	-	-	-	-	1	1	1	2	3	25	80	205	570	953
China	19	24	42	52	62	70	80	100	140	300	800	3,300	6,800	18,100
AMERICA	21	24	54	102	163	246	355	522	828	1,328	2,410	4,590	8,365	13,518
APAC	368	496	686	916	1,198	1,502	1,827	2,098	2,628	3,373	4,951	7,513	12,159	21,992
Europe	116	249	381	580	1,283	2,264	3,258	5,274	10,970	16,777	30,352	52,462	69,699	79,952
TOTAL	1,275	1,599	2,050	2,614	3,700	5,085	6,629	9,146	15,795	23,108	40,183	70,168	99,690	136,697

Source: European Photovoltaic Industry Association, 2014. Pg. 17.Accessed 27.11.14.

Graph Nr 7 / "a", "b" and "c" - Oil, Thermal coal, and Natural Gas Prices 2000 – Jan. 2015



Sources: http://www.infomine.com/investment/metal-prices/coal/5-year/ (University of California- Riverside). Accessed 09.11.15