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DEVELOPMENTS, TRENDS AND ORIENTATIONS REGARDING THE REALIZATION OF RENEWABLE ENERGY CONVERSION SYSTEMS

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Abstract: *This article presents some considerations on the generation and use of renewable energies as well as the benefits of using them as an alternative to the current fossil fuel-based power generation system. It is shown the evolution of renewable energies in the last ten years, the trends and new orientations in the development of renewable energy conversion systems, as well as some elements regarding the evolution of the costs and investments in the field.*

Keywords*: Renewable energy, energy efficiency, functional optimization, clean energy, wind energy, hydraulic energy*

1. Introduction

The prospect of exhaustion of fossil energy resources, still dominating global consumption, as well as focusing on environment-friendly technologies, has led to an avalanche of technologies for the superior use of renewable energy sources as an alternative to the future of mankind.
The pace of development and spread of new technologies for all types of renewable sources is explosive, the growth of them being almost exponential.
However, classic / fossil fuels, oil, gas, coal remain the main sources of energy for a long time, Figure 1 [1]. Positive is the fact that the amount of renewable energies in total planetary consumption is continually increasing.

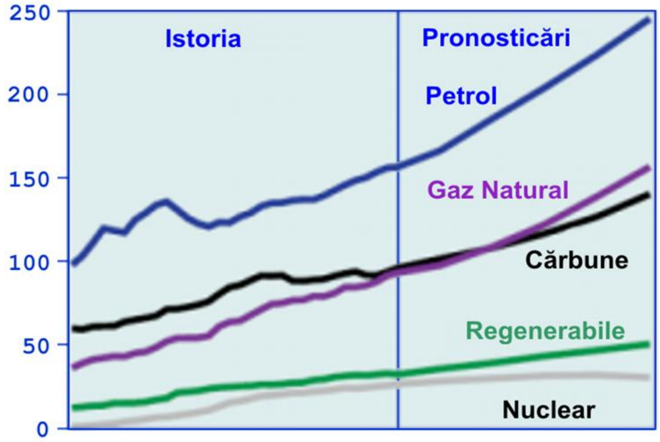

Fig. 1. Global energy consumption, 1970-2025 [1]

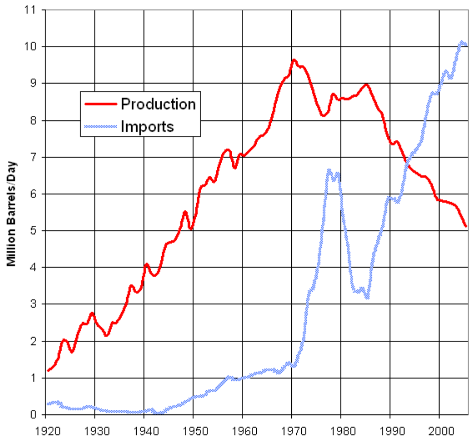

Fig. 2. Production and import of oil in the USA [1]

For example, the same pattern of exponential growth was also the evolution of oil production and import in the USA, with production peaking in 1970, after which import is accentuated, due to a strategic policy of this country, as shown in Figure 2 [1].
A brief analysis of the curve, demonstrates the very similarity to the Hubbert standard curve.
Based on past oil production data, the HUBBERT curve was built, and used to make estimates of future production performance. According to this estimate, in Figure 3, it can be seen that the maximum oil and gas production quota has already been reached around 2007.

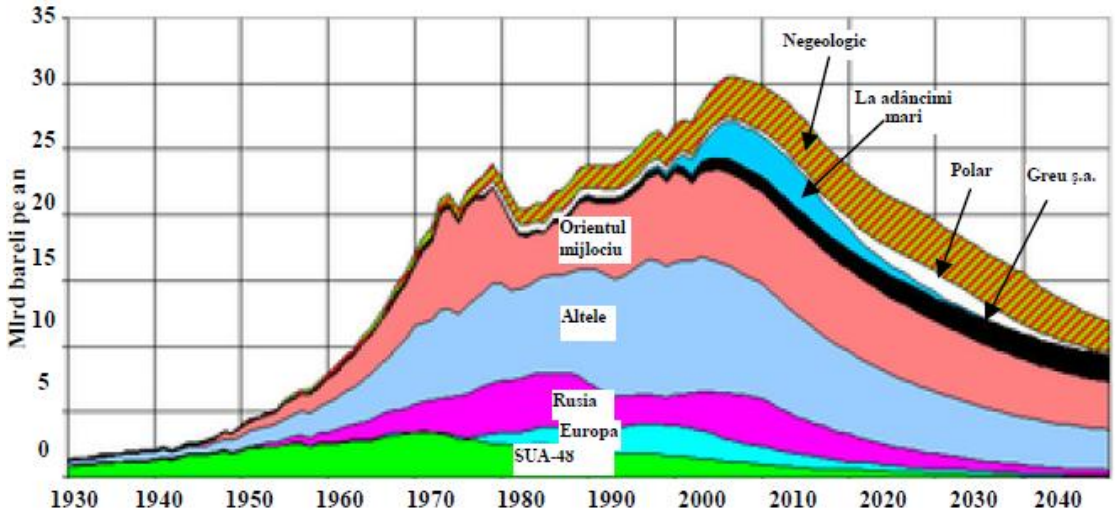

Fig. 3. Estimation of the maximum oil and gas production quota [1]

Interestingly is that, using other estimation methods, the results obtained are similar.
Therefore, in this context, it is important to estimate the energy production in the future, in order to know the moment when the regenerative energies will become the main sources of energy that will ensure the necessity of the development of the human society.
That is why today we can talk about a global energy policy and a concerted strategy to reduce pollutant emissions into the atmosphere, based on concrete technical and economic solutions for rational use of fossil fuel reserves (which still have the main share in the production of energy) and on a growing scale of renewable energy sources, the so-called "clean" energies or unconventional energies, an alternative to the current energy recovery system of the Earth's fossil fuel reserves. However, environmentally friendly renewable (solar, wind, hydraulic and so on) are not able today to meet these ever-increasing needs [1].

2. Overview of the development of renewable energies

Renewable energy comes from natural resources that are constantly renewed over relatively short periods of time. Currently, the functioning of the world economy relies heavily on energy from non-renewable resources (coal, oil, natural gas). Factors such as greenhouse gas emissions that favour global warming (see Figure 1), pollution, acid rain, all caused by the use of these conventional resources, but also the alarm signals that draw attention to the fact that oil - the main fuel source for transport - is about to run out, have triggered a significant global investment process in order to capitalize on renewable energy resources [2].
Worldwide, some renewable energy technologies have reached a certain degree of maturity, but others are in the testing or even applied research phase.
As a result of global population growth and the decline in fossil fuel, oil and natural gas reserves, research and development is increasingly focusing on renewable energy [3].
Renewables are now established around the world as main-stream sources of energy. Rapid growth, particularly in the power sector, is driven by several factors, including the improving cost-competiveness of renewable technologies, dedicated policy initiatives, better access to financing, energy security and environmental concerns, growing demand for energy in developing and emerging economies, and the need for access to modern energy. Consequently, new markets for both centralised and distributed renewable energy are emerging in all regions [4].
Global investment also climbed to a new record level, with further declines in per unit costs of **wind and solar** photovoltaics (PV). For the sixth consecutive year, renewables outpaced fossil fuels for net investment in power capacity additions [4].

In parallel with growth in markets and investments, saw continued advances in renewable energy technologies, ongoing energy efficiency improvements. The year also saw expanded use of **heat pumps**, which can be an energy-efficient solution for heating and cooling [4]. The **power** sector experienced its largest annual increase in capacity ever, **Wind and solar PV** had record additions for the second consecutive year, accounting for about 77% of new installations, and **hydropower** represented most of the remainder [4].
Renewable energy accounted for an estimated **4% of global fuel for road transport** in 2015.
The **solar PV market** was up 25% over 2014 with an annual market in 2015 was nearly **10 times** the world's cumulative solar PV capacity of a decade earlier.
Wind power was the **leading source** of new power generating capacity in Europe and the United States in 2015, and the second largest in China. The **offshore sector** had a strong year.
Global new investment in renewable power and fuels climbed to a record in 2015. This represents a rise of 5% compared to previous year.The global new investment in renewable power and fuels, developed, emerging and developing countries, in peroid of ten years, 2005–2015, is preyented in figure 4.

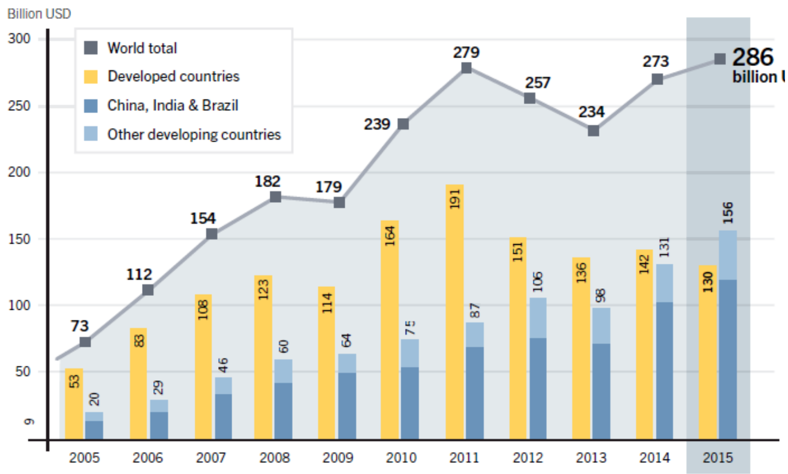

Fig. 4. Global new investment in renewable power and fuels [4]

Energy efficiency improvements reflect, in part, increasing investments. The global primary energy intensity and total primary energy demand, in period 1990–2014, is shown in figure 5.

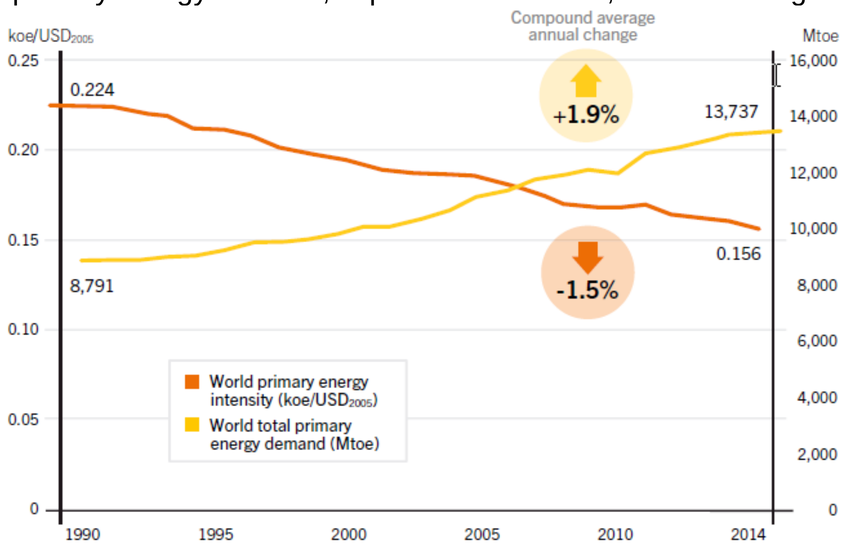

Fig. 5. The global primary energy intensity and total primary energy demand [5]

3. Evolution of regenerative energies in the last ten years [5]

3.1. Power

Renewable power generating capacity saw its largest annual increase ever in 2016, Total global renewable power capacity was up almost 9% compared to 2015.
Solar PV saw record additions and, for the first time, accounted for more additional power capacity than any other generating technology. Solar PV represented about **47%** of newly installed renewable power capacity in 2016, and **wind** and **hydropower** accounted for most of the remainder, contributing about 34% and 15.5%, respectively.In 2016, renewables accounted for an estimated nearly 62% of net additions to global power generating capacity. At the 2016 year's end, renewables comprised an estimated 30% of the world's power generating capacity – enough to supply an estimated 24.5% of global electricity, with hydropower providing about 16.6%.
By the end of 2016, the top countries for total installed renewable electric capacity continued to be China, the United States, Brazil, Germany and Canada. China was home to more than one-quarter of the world's renewable power capacity. The ongoing growth and geographical expansion of renewable energy was driven by the continued decline in prices for renewable energy technologies (in particular, for solar PV and wind power), by rising power demand in some countries and by targeted renewable energy support mechanisms. Solar PV and **onshore wind** power are now competitive. Bid prices for offshore wind power also dropped significantly in Europe during 2016.

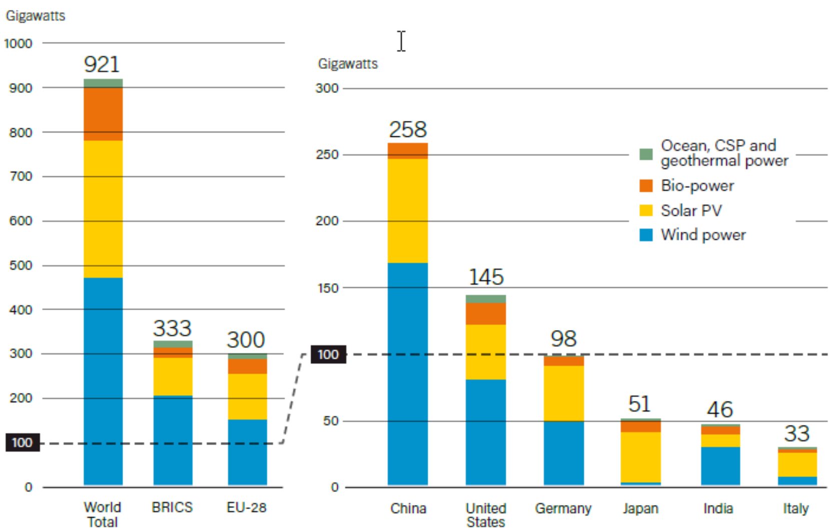

Fig. 8. Renewable power capacities in world, BRICS, EU-28 and Top 6 countries, 2016 [5]

3.2. Biomass Energy

Bioenergy (in traditional and modern uses) is the largest contributor to global renewable energy supply There are many pathways by which biomass feedstocks can be converted into useful renewable energy, figure 9.

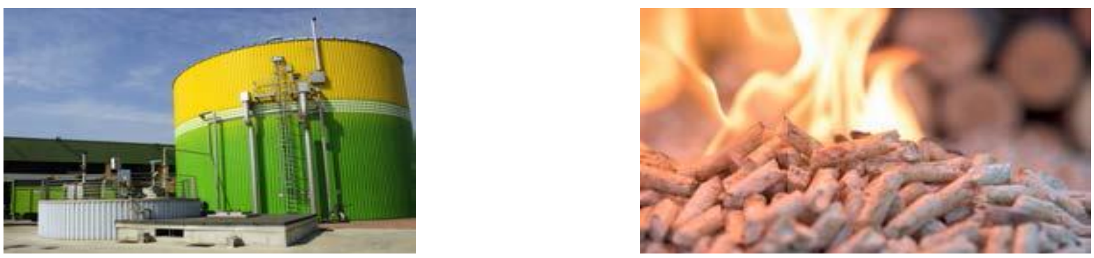

Fig. 9. Generating and using energy from biomass [5]

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3.3. Hydropower

Global hydropower capacity additions in 2016 are estimated to be in increasing. The top countries for hydropower capacity are China, Brazil, the United States, Canada, the Russian Federation, India and Norway, which together accounted for about 62% of installed capacity at the end of 2016. Global hydropower generation was estimated to be up about 3.2% over 2015. Global **pumped storage** capacity (which is counted separately) also in increasing in 2016, figure 10.

Fig. 10. Hydropower plant [5]

Pumped storage is the dominant source of large-scale energy storage, and new projects are under development. Global pumped storage capacity rose by more than in 2016, with new capacity installed in China, South Africa and Europe. On a smaller scale, pumped storage is being pursued to supplement mini-grids and to help integrate variable renewable energy. For example, a pumped storage facility is being implemented in the Canary Islands as part of a larger programme to improve grid stability and to accommodate variable generation. In Gaildorf, Germany, a **hybrid wind** power and pumped storage pilot project is under way; the upper reservoirs are being integrated into the towers and bases of the wind turbines, creating the added benefit of taller hub heights and thus greater potential wind power generation.

3.4. Solar Photovoltaics (PV)

More solar PV capacity was installed in 2016 (up 48% over 2015) than the cumulative world capacity five years earlier. Figure 11 presents the solar photovoltaics panels.

Fig. 11. Solar photovoltaics panels [5]

By year's end, global solar PV capacity totalled will be pncreased (see Figure 12). For the fourth consecutive year, ASIA eclipsed all other markets, accounting for about two-thirds of global additions. The top five markets – China, United States, Japan, India and the United Kingdom – accounted for about 85% of additions; others in the top 10 for additions were Germany, the Korea, Australia, the Philippines and Chile. For cumulative capacity, the top countries were China, Japan (which passed Germany) and the United States, with Italy a distant fifth (see Figure 13).

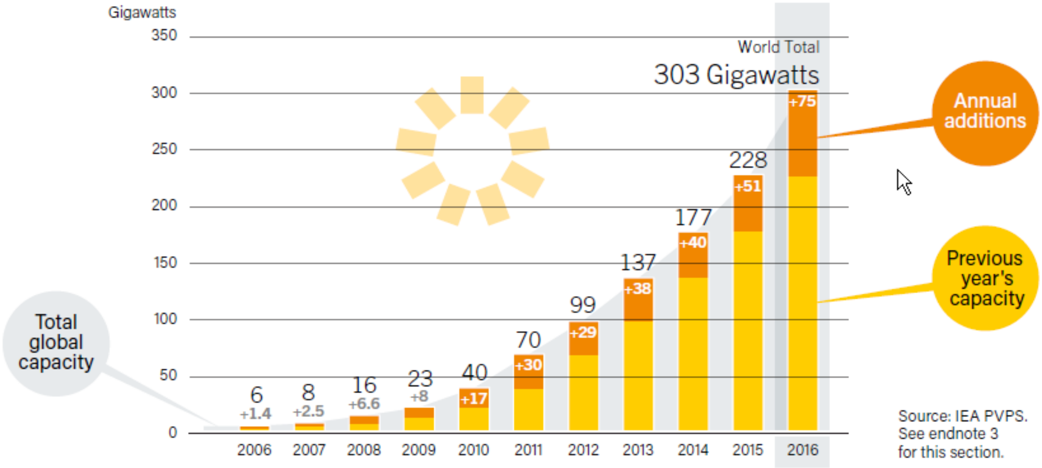

Fig. 12. Solar PV global capacity and annual additions, 2006-2016 [5]

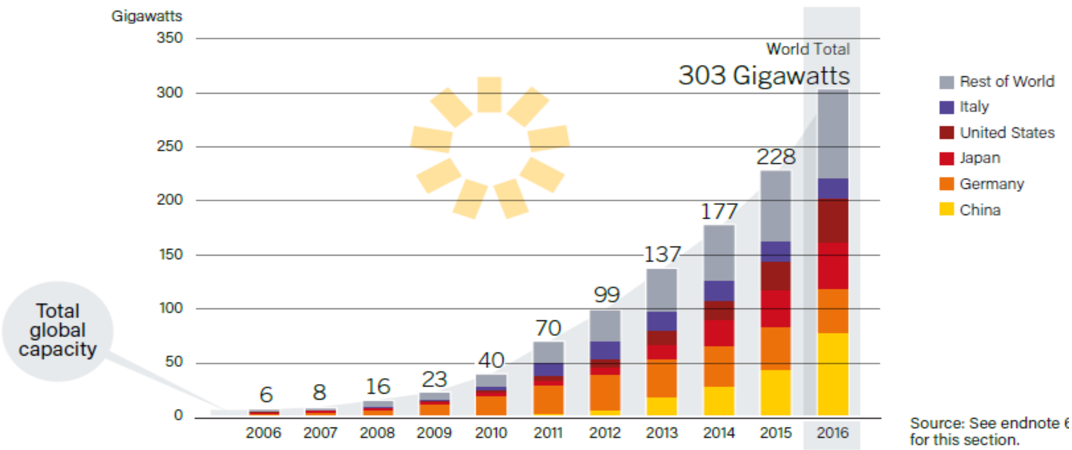

Fig. 13. Solar PV global capacity, by country and region, 2006-2016 [5]

While China continued to dominate both the use and manufacturing of solar PV, emerging markets on all continents have begun to contribute significantly to global growth. In 2016, China added capacity up 126% over 2015, increasing its total solar PV capacity 45% , far more than that of any other country, Figure 14.

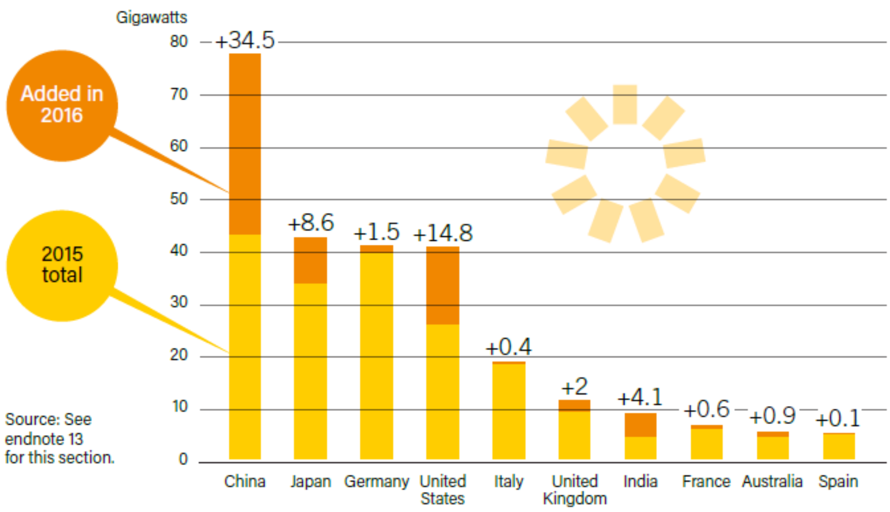

Fig. 14. Solar PV capacity and additions, Top 10 countries, 2016 [5]

Despite tremendous demand growth in 2016, the year brought unprecedented price reductions for modules, inverters and structural balance of systems. Due to even greater increases in production capacity, as well as to lower market expectations, particularly in China, for 2017, **module prices** plummeted. by an estimated 29%, vs the fourth quarter of 2015, dropping to historic lows.
The year 2016 also saw an increased interest in hybrid projects that locally integrate solar PV with other renewables and energy storage technologies, an innovation that can strengthen a plant's generation profile and enable sharing of resources for construction and maintenance.

3.5. Solar thermal heating and cooling

Solar thermal technology is used extensively in all regions of the world to provide hot water, to heat and cool space, to dry products and to provide heat, steam or refrigeration for industrial processes or commercial cooking, figure 15.

Fig. 15. Solar thermal systems [5]

By the end of 2016, solar heating and cooling technologies had been sold in at least 127 countries. The cumulative capacity of glazed (flat plate and vacuum tube technology) and unglazed collectors in operation increased to a year-end total of 456 GWth, up from 435 GWth a year earlier, figure 16.

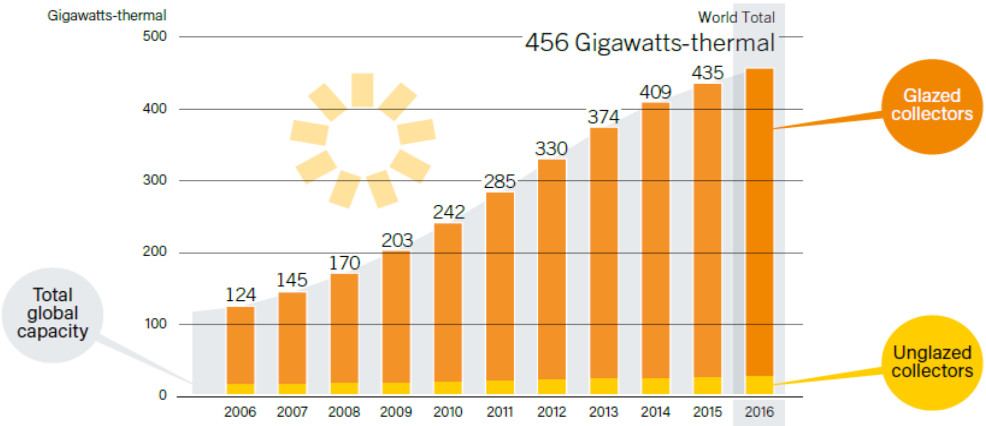

Fig. 16. Solar water heating collectors global capacity, 2006-2016 [5]

The solar water heating collector additions and the Top 20 countries for capacity added in 2016, are presented in figure 17.
Solar PV-thermal technologies capture the waste heat from solar PV modules, which utilise only 12-15% of the incoming sunlight, to provide heat for space and water. Solar thermal cooling continued to face challenges during 2016 in the key markets of Europe and China due to falling solar PV prices, which allow for the cost-effective operation of compression chillers powered by solar electricity during daylight, and to low fossil fuel prices. Even so, significantly hot summer periods in southern Europe, have increased the awareness of solar cooling technologies in the region's construction industry.

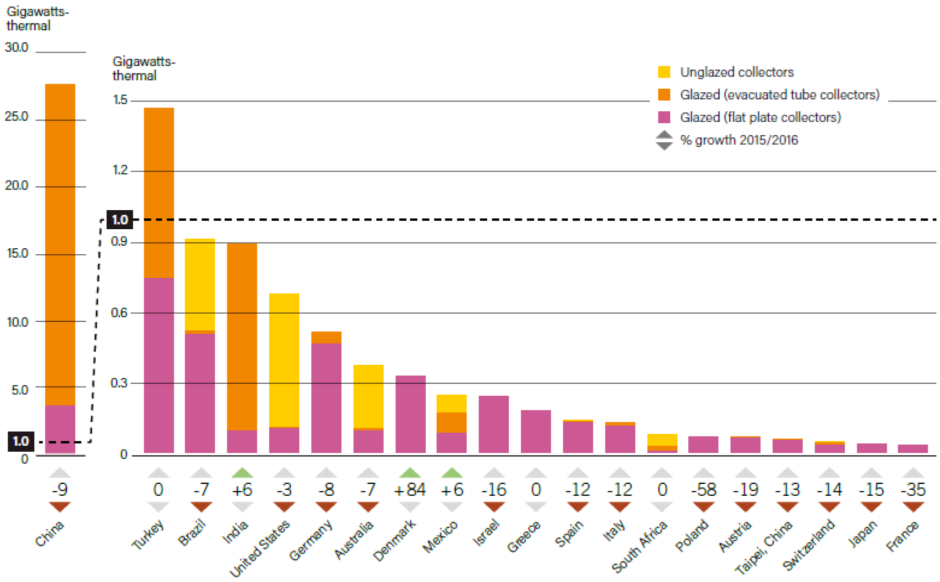

Fig. 17. Solar water heating collector additions, Top 20 countries for capacity added, 2016 [5]

3.6. Wind power

An important quantity of wind power capacity was added during 2016, increasing the global total about 12% vs 2015. Gross additions were 14% below the record high in 2015, but they represented the second largest annual market to date, figure 18

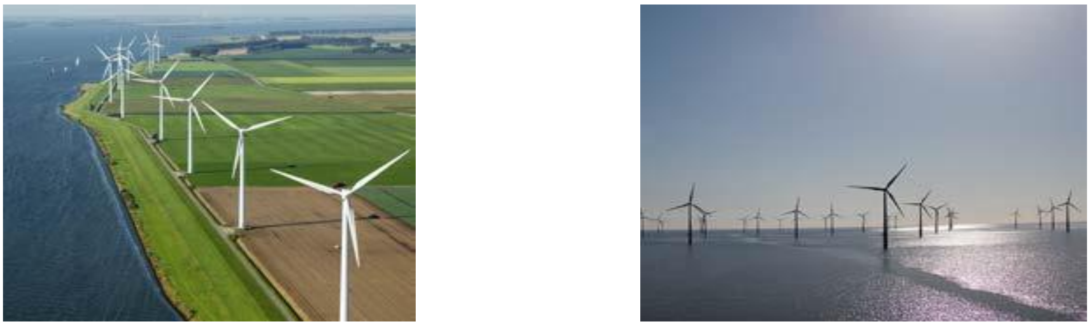

Fig. 18. Wind power plants [5]

By the end of 2016, over 90 countries had seen commercial wind power activity, figure 19.

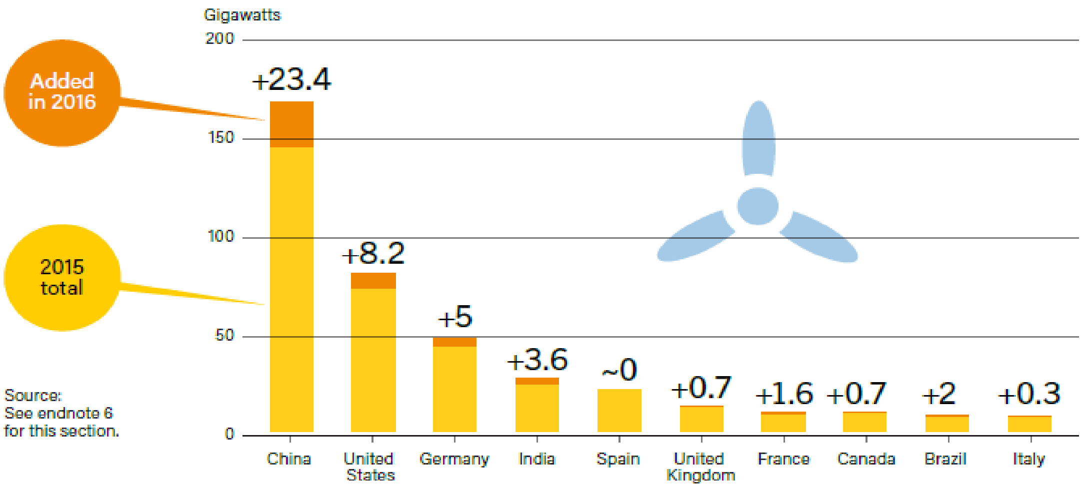

Fig. 19. Wind power capacity and additions, Top 10 countries, 2016 [5]

The wind power global capacity and annual additions are presented in Figure 20.

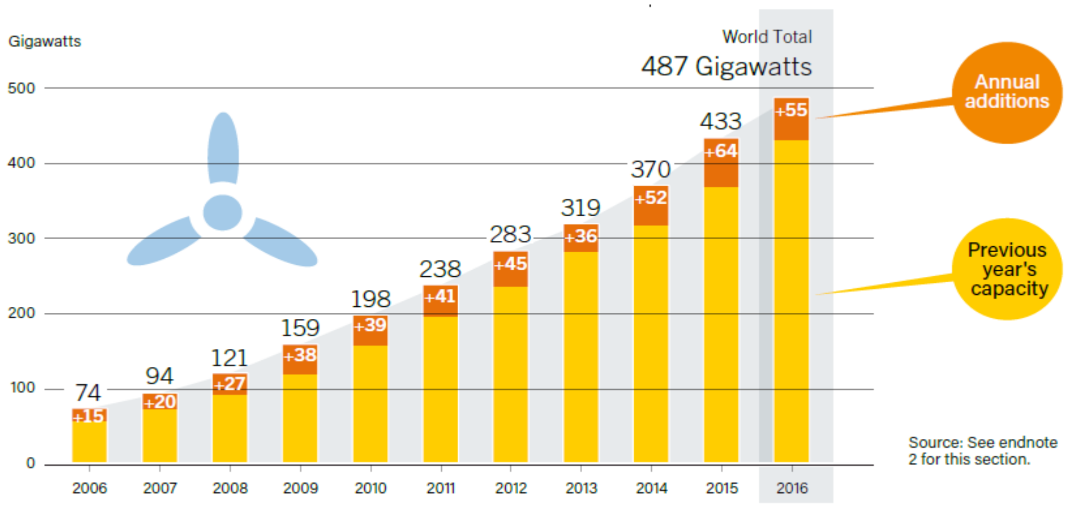

Fig. 20. Wind power global capacity and annual additions, 2006-2016 [5]

A significant decline in the Chinese market, following a very strong 2015, was responsible for most of the market contraction. Even so, China retained its lead for new installations, followed distantly by the United States and Germany, with India passing Brazil to rank fourth. Others in the top 10 for additions were France, Turkey, the Netherlands, the United Kingdom and Canada..
For the eighth consecutive year, Asia was the largest regional market, representing about half of added capacity, with Europe and North America accounting for most of the rest. Wind deployment was driven by cost- ompetitiveness and by environmental and other factors. Wind has become the least-cost option for new power generating capacity in an increasing number of markets.
Offshore wind plants, was connected to grids in 2016, As in previous years, Europe was home to the majority of capacity brought online, 70% of global additions, and total operating offshore, almost 88%, figure 21. Germany, the Netherlands and the United Kingdom were the only European countries to add capacity offshore, although several gigawatts of projects were under construction in European waters at year's end, driven by rapidly falling costs.

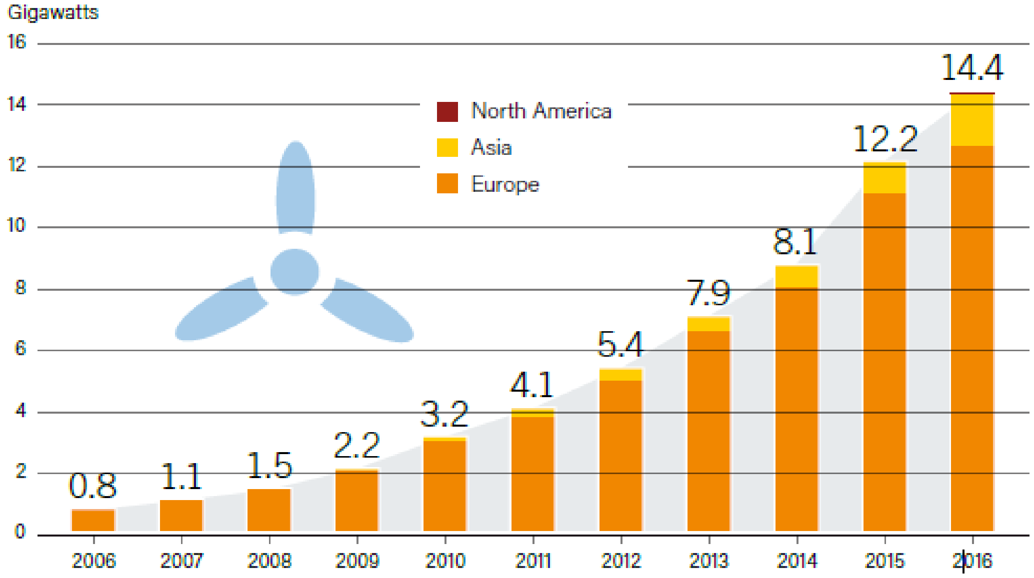

Fig. 21. Wind power offshore global capacity, by region, 2006-2016 [5]

While most countries have some small-scale turbines in use, the majority of units and capacity operating at the end of 2015 was in China, the United States and the United Kingdom. Other leaders included Italy and Germany, with Italy seeing a significant increase in 2016.
Repowering has become a billion-dollar market, particularly in Europe. While most repowering involves the replacement of old turbines with fewer, larger, taller, and more-efficient and reliable machines, some operators are switching even relatively new machines for upgraded turbines (including software improvements). During 2016, at least 721 turbines were decommissioned, representing a significant increase in numbers and capacity over 2015. Germany dismantled 242 turbines, followed by Denmark, the United States, Finland, Canada, the United Kingdom, the Netherlands, Sweden and Japan. In the United States, the extension of federal tax credits has incentivised repowering and retrofitting of existing assets, which enables owners to quality for another decade of credits.
Wind power is playing a greater role in power supply in a growing number of countries. In 2016, wind energy covered an estimated 10.4% of EU demand and equal or higher shares in at least 11 EU member states,
Globally, wind power capacity in place by the end of 2016 was enough to meet an estimated 4% of total electricity consumption.
WIND has become the LEAST-COST option for new power generating capacity in an increasing number of markets. Small-scale wind turbine costs also are trending downwards, while capacity factors are rising. To increase the competitiveness of small-scale wind, several leading US companies begun offering long-term leases to build on of third-party financing for solar PV.

4. Cost trends of the renewable power technology in period of 2010-2016 [5]

Among the most transformative events of the current decade has been the dramatic, and sustained, improvement in the competitiveness of renewable power generation technologies. Around the world, renewables have benefited from a cycle of falling costs spurred on by accelerated deployment, and the competiveness of renewable power generation technologies continues to improve. Bio-power, hydropower, geothermal and onshore wind power all can be competitive with fossil fuel-fired power generation where good resources exist.
Of all renewable energy technologies, utility-scale (larger than 1 MW capacity) **solar PV** has experienced the most rapid decline in the *levelised cost of electricity* (LCOE), driven by reductions in module prices and balance of systems costs.
Onshore wind power has undergone a quiet revolution over the years. During the period 1983 to 2016, and considering the 12 countries that accounted for 87% of deployment, the LCOE dropped by an average of 15% for each doubling of installed capacity. The weighted average investment cost of onshore wind declined by more than two-thirds, from USD 4,880 per kW in 1983 to USD 1,457 per kW in 2016, due to increasing economies of scale and to improvements in manufacturing and technology. Due in large part to technology advances, the global weighted average capacity factor for onshore wind power rose from 20% in 1983 to 29% in 2016.
The global weighted average of *Organization for Economic Co-operation and Development* (LCOE) of onshore wind power fell by 18% between 2010 and 2016 alone, to USD 0.07 per kWh for wind farms commissioned in 2016. China and India have some of the world's lowest total installed costs, resulting in a weighted average LCOE of USD 0.065 per kWh in 2016 (down 7% from 2010); average LCOEs were higher in OECD countries (USD 0.074 per kWh; down 26% from 2010) and in the world (USD 0.083 per kWh; down 29% from 2010).
The global weighted average LCOE of onshore wind power fell by 18% between 2010 and 2016 alone, to USD 0.07 per kWh for wind farms commissioned in 2016. Onshore wind power has seen a significant convergence in average LCOEs across regions, despite differences in regional cost structures, market sizes and technical skills, and varying dynamics in supply chains. China and India have some of the world's lowest total installed costs, resulting in a weighted average LCOE of USD 0.065 per kWh in 2016 (down 7% from 2010); average LCOEs were higher in OECD

countries, Organization for Economic Co-operation and Development, (USD 0.074 per kWh; down 26% from 2010) and in the rest of the world (USD 0.083 per kWh; down 29% from 2010).
Offshore wind power costs, in general, are higher than for other renewable power generation technologies. However, they are falling due to several factors – including technology advances and economies of scale – and good cost reduction opportunities remain. In OECD countries, where most offshore wind capacity is deployed, the average LCOE of projects commissioned in 2016 was estimated at USD 0.15 per kWh.
Concentrating solar thermal power (CSP) costs also remain higher than those for other renewable power generation options on average, but they have good cost-reduction opportunities, and costs are falling. It is estimated that the weighted average LCOE of CSP plants fell by 18% between 2010 and 2016, with an LCOE of USD 0.27 per kWh for plants commissioned in 2016.
LCOEs of the more mature renewable power generation technologies – bio-power, geothermal and hydropower – have been broadly stable, with some short-term exceptions. For example, the global weighted average LCOE of geothermal and hydropower rose between 2010 and 2016. The weighted average total installed cost of hydropower projects reached USD 1,755 per kW (weighted average LCOE of USD 0.05 per kWh) for plants commissioned in 2016, more than offsetting an increase since 2010 in the weighted average capacity factor of new plants.

5. Conclusions

- As a synthetic conclusion, it can be said that the use of renewable energy sources is in full swing and encompasses all existing forms with an explosive evolution;
- The most important renewable energy source is the running water;
- The solar energy has developed greatly, both through photovoltaic collectors and thermal panels;
- Wind power plants also have a very important development;
- The offshore industry moved to deeper waters and continued to grow;
- The interest in storing and storing energy is growing, where many technologies have developed;
- R & D focuses more on renewable sources;
- Some aspects of the economy have also been analyzed, which has shown that the investments made are still expensive, but the cost of a kWh is constantly decreasing.

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