Dominant Contribution of the Developing Countries to the Renewable Energy Sector[1]

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Abstract: Several developing countries have become world leaders in the field of renewable energy, of which China, but also Brazil and India stand out. This research paper focuses on the positions they occupy in the world rankings of hydro, wind, solar and bio energy capacities, as compared to the developed countries. At the same time, the investigation points to specific catalysts or, on the contrary, deterrents of the "green revolution" in the developing world. Hydropower is the most important form of renewable energy in all the three countries included in this evaluation. It is underscored that China is the first one in each of the four world rankings, taking into account the total installed capacity of renewable energy: hydro, wind, solar and bio. It is also the largest investor in renewable energy capacity worldwide. Brazil ranks second as regards hydropower and bioenergy capacities, while India ranks fourth in wind and bioenergy.

Key-Words: renewable energy, green economy, installed capacity, national energy policies
JEL Classification: Q 42, Q 48

1. Introduction

Developing countries have gradually become dominant players in the demand and supply of renewable energy. Among them, China, Brazil and India stand out, with a cumulative installed capacity of renewable energy of over 1,000 GW, representing more than 40% of the world total. The three mentioned countries are also among the top five ranking actors according to the number of jobs generated by the renewable energy technology industry, along with the EU and the USA (REN21, 2019).

National energy policies, international initiatives, associated with protectionist trends culminating in trade wars and more recently the Covid-19 pandemic are among relevant factors with a strong impact on developments in the field of renewable energies, even though with different intensities.

On the one hand, the abundance of fossil fuels in some regions and revenues obtained from their exploitation, sale and consumption are an impediment of the energy transition in countries such as the Russian Federation. Conversely, scarce resources as compared to high domestic energy demand represent an incentive for other players, such as China and Brazil to stimulate their renewable energy sector. About a quarter of Russia's fiscal revenues are provided by taxes levied on fossil fuel production, as compared to 18% in India, 7% in Brazil and South Africa, and 4% in China (IISD, 2019).

On the other hand, energy security and the goal of reducing dependency on certain import sources, but also the political will to express a firm commitment to decrease greenhouse gas emissions are among major determinants of the current energy transition worldwide. However this transition is only gradual, as long as economic development continues to be based on coal consumption in many countries, for instance in China and India. By contrast, renewable energy accounts for almost 45% of Brazil's primary energy demand, making its energy sector one of the least carbon-intensive in the world (IEA, 2021).

[1] Analysis included in the study „Development of Renewable Energy Sources within the Energy Union in the Context of the Paris Agreement Commitments", coordinator Dr. Petre Prisecaru, Institute for World Economy, research plan of the Romanian Academy, 2020.

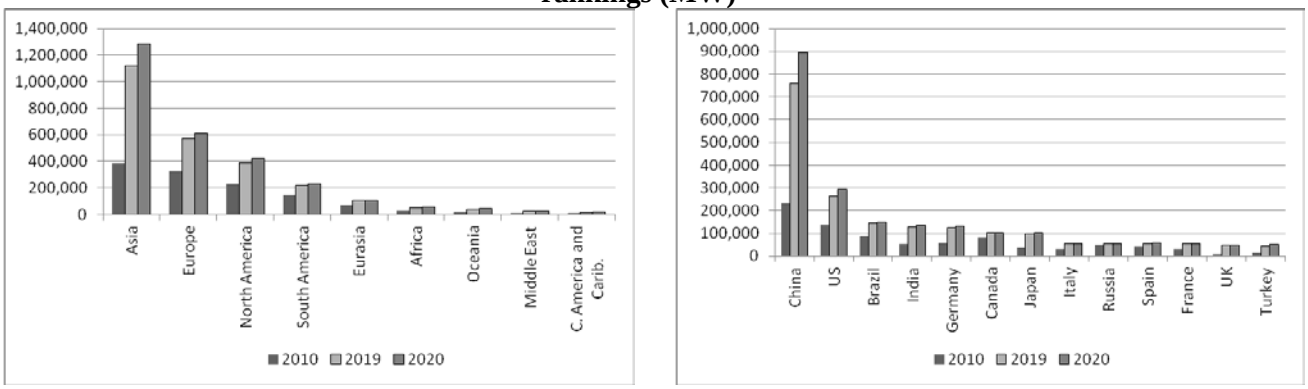
2 China, the undisputed leader in terms of total installed capacity of renewable energy

Strongly committed to implementing the Paris Agreement on climate change, ***China*** is currently the largest producer and consumer of renewable energy, promoting the ***energy revolution*** on multiple levels (demand, supply, technology, security) (MEE, 2019).

Taking into account its total installed capacity of renewable energy (almost 900 GW in 2020, as compared to 760 GW in 2019 and less than 300 GW in 2011), China holds about 70% of the Asian total and 32% of the world total, ranking first in the international hierarchy (IRENA, 2020; IRENA 2021). In comparison, the EU plus the UK concentrates almost 21%, and the US over 10% of the total, so China's total installed capacity is equivalent to that of the EU, the US and the UK taken together.

Chart 1 shows the rankings by regions and countries according to the total installed capacity of renewable energy in 2019-2020, as compared to 2010. There is almost a tripling of the capacity in Asia, with an increase of more than three times the installed capacity in China in 2010-2020.

Chart 1: Total installed capacity of renewable energy in 2010, 2019 and 2020, regional and global rankings (MW)

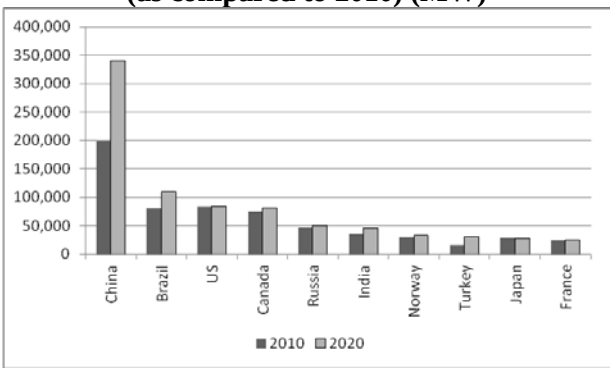


Source: Chart elaborated by the author, based on IRENA (2020; 2021).

In 2019, China's total installed renewable energy capacity was distributed as follows: 326 GW ***hydropower*** (43% of the total), 210 GW ***wind energy*** (28%), 205 GW ***solar energy*** (mainly photovoltaic) (27%) and almost 17 GW ***bioenergy*** (2%). Comparatively, worldwide, the percentages were as follows: 47%, 25%, 23% and 5%, respectively (IRENA, 2020). Compared to the previous year, in 2020 the share of wind energy in China increased to 31.5% and that of the solar energy to 28.4%, while the hydropower share reduced to 38% (IRENA, 2021). Worldwide, in 2020 as compared to 2019, the shares of solar energy and wind energy increased approximately by 2 percentage points each.

During the analyzed period, China increased its renewable hydropower 1.7 times (from 200 GW in 2010 to almost 340 GW in 2020), wind energy more than 9 times (from 30 GW to almost 282 GW) and bioenergy more than 5 times (from 3.5 GW to 18.7 GW) (Charts 2, 3 and 5). As regards the solar energy, the jump was spectacular, from 1 GW to 254 GW (Chart 4).

Chart 2: Ranking of the top ten countries according to the total installed hydropower capacity in 2020 (as compared to 2010) (MW)



Source: Chart elaborated by the author, based on IRENA (2020; 2021).

China ranks first in each of the four rankings, taking into account the total installed capacity of renewable energy: hydro, wind, solar and bio (Charts 2, 3, 4 and 5). The lowest share in the world total is recorded by China in bioenergy, and the highest in wind energy (Table 1).

Table 1: Shares of the top three leaders in each renewable energy category in the world total in 2020, as compared to the EU plus UK plus US (%)

Energy type	Countries/groups of countries	Shares (%)
Hydro	***1. China***	***28.1***
	2. Brazil	9.0
	3. US	6.9
	EU+UK+US	17.8
Wind	***1. China***	***38.5***
	2. US	16.1
	3. Germany	8.5
	EU+UK+US	43.5
Solar	***1. China***	***35.6***
	2. US	10.6
	3. Japan	9.4
	EU+UK+US	32.0
Bio	***1. China***	***14.8***
	2. Brazil	12.4
	3. US	9.8
	EU+UK+US	42.8

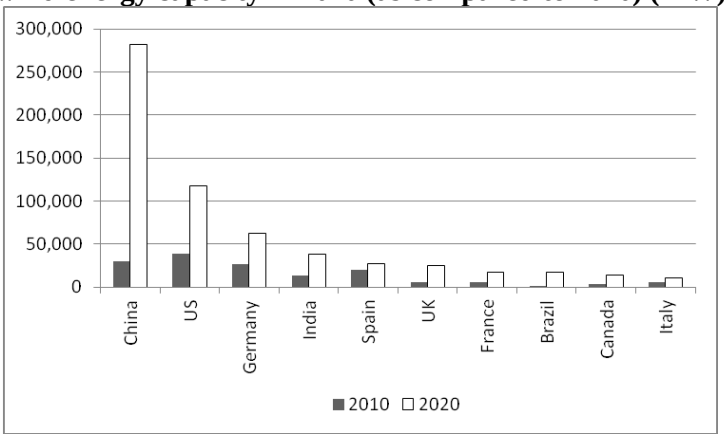
Source: Table elaborated by the author, based on IRENA (2020; 2021).

Developed countries play a much more important role in wind and bio energy than in solar and hydro, taking into account their shares in the world renewable energy capacity. Although there are various rankings of major solar panel companies, depending on capacity sold, they all have in common that most are from China (Jinko Solar, JA Solar, Trina Solar, Longi Solar Technology, Risen Energy, SunTech, in some including Seraphim Energy Group and Must Solar), along with those from Canada, USA, Germany, Japan and South Korea (Solar Power Nerd, 2021; PV Magazine, 2020).

3. India and Brazil in world rankings

The positions occupied by ***India*** in the four hierarchies of 2020 (depending on the total installed capacity of hydro, wind, solar and bio renewable energy) are as follows: sixth (almost 4% of the world total), fourth (5.3%), fifth (5.5%) and the fourth (8.3%), respectively. ***Brazil*** is not in the top ten countries in the world in terms of installed solar energy capacity, but it is second in hydropower (9% of the world total) and bioenergy (12%) and eighth worldwide in terms of the total installed capacity of wind energy (2.3%) (Charts 2, 3, 4 and 5).

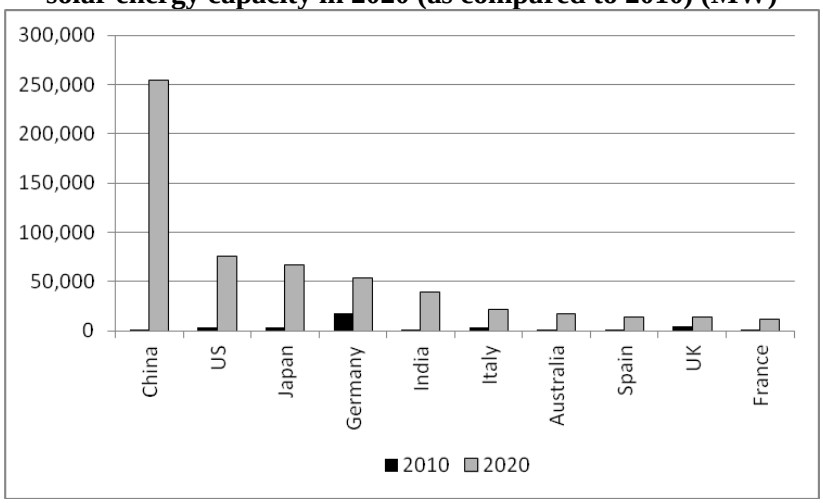
Chart 3: Ranking of the top ten countries according to the total installed wind energy capacity in 2020 (as compared to 2010) (MW)



Source: Chart elaborated by the author, based on IRENA (2020; 2021).

It is noteworthy, therefore, that in Brazil, hydropower is the most important (109 GW in 2020), wind and bio energy capacities are almost equal (17.2 GW and 15.7 GW, respectively), while Brazil has an installed capacity of solar energy of only 7.9 GW.

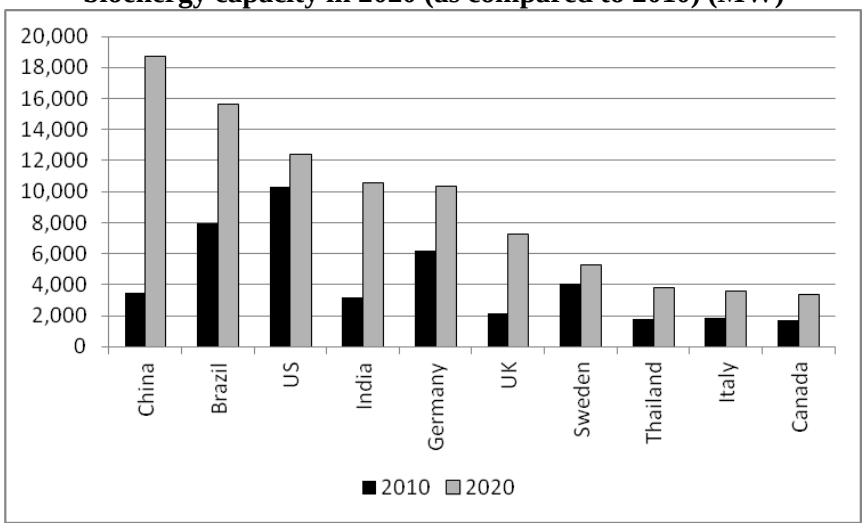
Chart 4: Ranking of the top ten countries according to the total installed solar energy capacity in 2020 (as compared to 2010) (MW)



Source: Chart elaborated by the author, based on IRENA (2020; 2021).

The distribution of the four categories of renewable energy in ***India*** is as follows: hydro about 34.2% (installed capacity of 45.9 GW), wind 28.7% (38.6 GW), solar 29.2% (39 GW) and bio 7.8% (10.5 GW) (IRENA, 2021).

Chart 5: Ranking of the top ten countries according to the total installed bioenergy capacity in 2020 (as compared to 2010) (MW)



Source: Chart elaborated by the author, based on IRENA (2020; 2021).

4 China, leading in the new wind energy capacity

In 2020 ("the best year in history for the global wind industry", recording a year-over-year growth of 53%, with a total new installed capacity of 93 GW, in spite of disruptions at the level of global supply chain and project construction), China remained the world's largest market for new ***onshore*** additions. Similarly, in the ***offshore*** market, a capacity of 6.1 GW was added worldwide in 2020, and China installed half of that new capacity (GWEC, 2021).

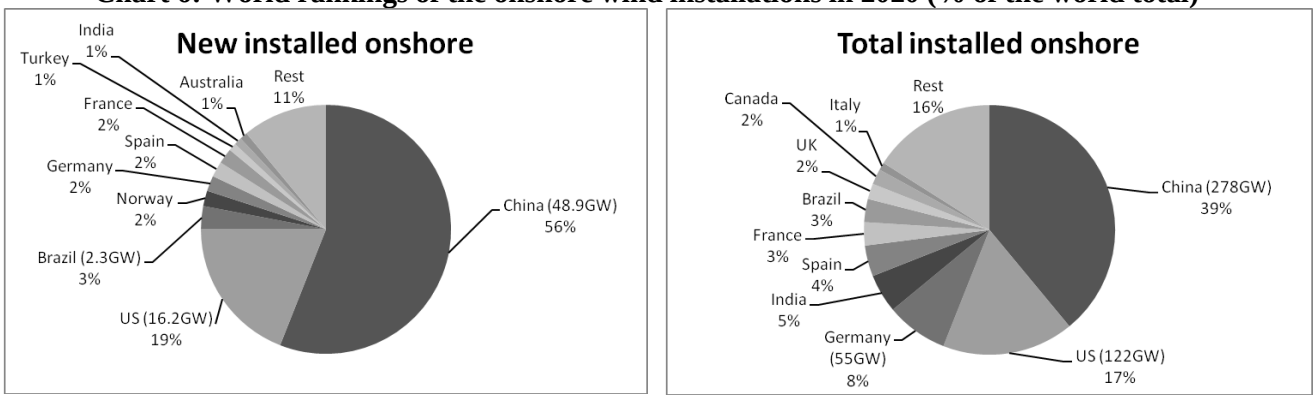
Total new onshore installations in China were 48.9 GW (out of which grid connected new installations of 42.3 GW). One significant impetus was the new policy released by the National Development and Reform

Commission (NDRC), including a roadmap towards "subsidy-free" onshore wind energy.[2] China pledged to peak CO2 emissions before 2030 and reach carbon neutrality by 2060. In December 2020, President Xi Jinping presented the target of 1,200 GW of wind and solar installed capacity and 25% share of non-fossil fuels in a primary energy consumption by 2030. In accordance to those commitments, the wind industry released the "Beijing Declaration on Wind Energy", targeting to install 3,000 GW of wind power by 2060 (GWEC, 2021; 2020; 2019).

The EU used to be the dominant investor in renewables, however it was overtaken by China in 2013, "as the solar booms in Germany and Italy cooled off dramatically and China raised its ambitions in both photovoltaics and wind". China invested in renewable energy capacity USD 83.4 billion in 2019, followed by the US (USD 55.6 billion) and the EU (around USD 55 billion) (Frankfurt School-UNEP Centre/Bloomberg NEF, 2020).

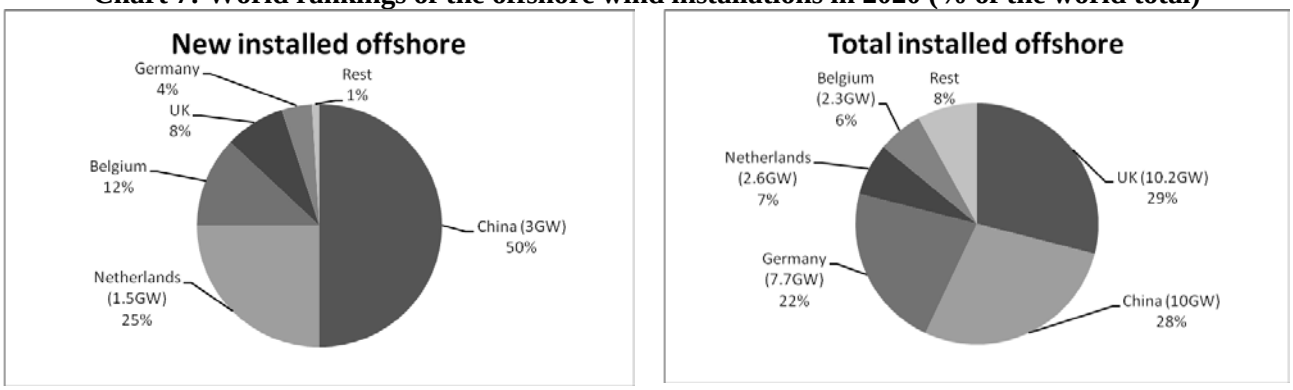
The following charts show China's positions in the 2020 world rankings of the wind installations onshore/offshore. The offshore market is much more concentrated as the onshore one, and China ranks second only as regards the total offshore wind installations.

Chart 6: World rankings of the onshore wind installations in 2020 (% of the world total)



Source: Chart elaborated by the author, based on GWEC (2021).

Chart 7: World rankings of the offshore wind installations in 2020 (% of the world total)



Source: Chart elaborated by the author, based on GWEC (2021).

5 Legislative framework for renewable energy in China

Since 2006, when it has overtaken the United States, China ranks first worldwide in terms of its share of global carbon dioxide emissions. It currently accounts for about 27-28% of the world total, followed by the US (15%), the EU (10%) and India (7%). In comparison, Brazil ranks 13th – 14th (1.2%) (IEA, 2020a; Fleming, 2019; Sandalow, 2019).

China consumes about half of the world's coal used each year, and between 2000 and 2018, its carbon dioxide emissions nearly tripled. With an economy continuing to be based on coal consumption (with a share of 59% of total energy consumption in 2018), ***China's energy transition is a long-term process***. That is why, given the risks associated with excessive pollution, China is one of the countries strongly committed to reducing

[2] Projects already approved until 2018 will continue to receive the Feed-in-Tariff if they are grid-connected before the end of 2020.

greenhouse gas emissions, and it is ***currently the largest clean energy market in the world***. At the same time, its investments in renewable energy projects abroad have intensified, with China being the main investor in clean energy in the nine years from 2009-2018 (Larson, 2019; MEE, 2019).

Schuman and Lin (2012) point out that since 2006, China has seen a rapid increase in the use of renewable energy resources, facilitated by the ***Renewable Energy Law*** (in force since January 1, 2006, amended in 2009). The Medium and Long-Term Renewable Energy Development Plan was adopted in 2007, with a number of "green" objectives. In the aftermath of the international financial and economic crisis of 2008, the manufacturing industry was severely affected by declining global demand. For this reason, the ***renewable energy equipment sector*** has been included in the category of emerging industries of strategic importance. With substantial financial support, this sector has become a formidable engine of economic growth (Chen, 2019), and China is currently the largest supplier of renewable energy equipment. Therefore, the development of this industry has a double role, first of accelerating economic growth and second of reducing long-term greenhouse gas emissions.

The ***Paris Agreement on Climate Change***, signed and ratified by China in 2016, was an additional impetus for the development of the renewable energy sector at the national level. In June 2015, China presented its national targets (the so-called Intended Nationally Determined Contribution, INDC) to the Secretariat of the United Nations Framework Convention on Climate Change, with its commitments for 2030 including: (1) reaching the peak of carbon dioxide emissions at the latest in 2030; (2) reduction of carbon dioxide emissions per unit of GDP (energy intensity) by 60% -65% compared to 2005 levels; (3) increasing the share of non-fossil fuels in primary energy consumption to about 20% and (4) expanding the volume of forest stock by about 4.5 billion cubic meters compared to 2005 level.

In November 2016, the NDRC and the National Energy Administration (NEA) published the ***13th Five-Year Plan for the development of the energy sector*** (the previous plan dedicated to energy being that of January 1, 2001, as a part of the Tenth Five-Year Plan). A ***specific NEA Renewable Energy Plan*** followed on December 10, 2016, with clear objectives. Those included: increasing the share of energy based on non-fossil fuels (renewable and nuclear) in total consumption to 15% by 2020 and 20% by 2030; increasing the installed capacity of renewable energy to 680 GW by 2020 (target already exceeded); increasing the installed capacity of wind energy to 210 GW (target already exceeded); stimulating innovation in the field of renewable energy technologies; providing support to the renewable energy industry and reducing dependence on foreign companies in the field; solving the problem of interruption of electricity supply from renewable sources (IEA / IRENA, 2018, CNESA, 2016). In 2017, China adopted the Emissions Trading Scheme (ETS), which started operating in 2021 (ICAP, 2021).

In 2018, the NDRC revised the share of energy based on non-fossil fuels (renewable and nuclear) in total consumption by 2030, from 20% to 35%, proposing a system of penalties for companies that do not meet the targets, penalties that will partially offset the volume of subsidies granted. China has invested more in clean energy infrastructure than the US and EU taken together so far. In 2019, the first projects for solar and wind energy without subsidies were approved, the period 2019-2020 being one of test and analysis, in order to eliminate subsidies starting from 2021. Considering that there are no restrictions regarding capacities, and the costs for the projects of solar and wind energy are on a downward trajectory, experts estimate that the solar and wind energy will be able to compete with coal-based energy in terms of costs until 2026 (Renewable Energy World, 2019).

The Ministry of Ecology and Environment (MEE) has included five explicit tasks in the 14th National Plan for Economic and Social Development for the period 2021-2025: (1) encouraging local governments and major industries to formulate objectives, roadmaps and clear plans related to the carbon footprint; (2) achieving a stable and efficient mode of operation on the national carbon dioxide market; (3) improving climate change legislation and strengthening the capacity of local authorities; (4) upholding the principles of equity, common but differentiated responsibilities in terms of global governance, while providing support to developing countries; and (5) mitigating and adapting to climate change, and updating China's national adaptation strategy.

These proposals must be linked to: the three-year action plan for "winning the blue sky defence battle" (July 2018), the National Plan for the Modernization of Agriculture 2016-2020, the 13th Forest Development Plan 2016-2020 and 13th Five-Year Plan for the control of greenhouse gas emissions.

Although China has the lowest share of total installed renewable energy capacity in the world in terms of bio-energy compared to hydro, wind and solar energy, significant progress has been made in this area in the last 15 years. In 2003, about 20% of China's total greenhouse gas emissions came from agricultural production and waste from fields and livestock farms. In about 15 years, the percentage has been halved. Renewable energy law promotes biomass-based energy production (Zhang *et al.*, 2010). At the same time, a national strategy on

biomass energy has been adopted, and the Ministry of Agriculture has clear objectives on specific technologies for the production of biomass energy in rural areas (biogas, liquid and solid biofuels).

The above-mentioned measures and proposals are part of the "energy revolution" called for by President Xi Jinping in June 2014, with the major objective of reducing the share of coal in the energy mix, while increasing the share of non-fossil fuels in the country's energy mix, in parallel with increasing energy efficiency. Gradually, the subsidies granted in the field of renewable energy are also given up, an example in this regard being the "subsidy-free" onshore wind energy (GWEC, 2019).

6 Renewable energy prospects in China and other developing countries

Uncertainties in the renewable energy industry have intensified recently, beginning with the protectionist "America first" strategy (reflected for example by additional tariffs imposed by the US in 2018 on imports of solar panels and photovoltaic cells produced in China) and ending with the disruption of supply chains amid the Covid-19 pandemic (Sunrun, 2020).

In the electricity sector, during the period of isolation, energy demand fell considerably, by 20% or even more in some countries that resorted to total isolation (IEA, 2020b). The increase in demand in the residential sector was far outweighed by the drastic reduction in demand in the commercial and industrial sectors. The International Energy Agency forecasts a 20% drop in energy investment in 2020, but the renewable energy sector is considered more resilient, so the decline in investment in renewable energy projects is estimated at 10% in 2020.

However, renewable energy production in developing countries continues to be encouraged. The new policies have a number of major objectives. In China, for example, price reductions are being considered (in this regard, with a system of auctions being introduced in 2018), energy trade between provinces is stimulated and companies are encouraged to purchase renewable energy. In May 2019, the Renewable Portfolio Standard (RPS) was adopted, which sets a minimum level of renewable energy consumption in Chinese provinces. Cai *et al.* (2019) points out that since 2006, when the guaranteed purchase system (feed-in tariff FIT) was introduced, the capacity to generate renewable energy has increased considerably. There are also negative effects, as the financial burden borne by the state has increased, reaching an unsustainable level. To eliminate distortions, China's National Energy Administration adopted the RPS system on May 15, 2019, which can have a significant impact on the market structure, consumer behavior and economic performance. However, this requires a transition period, so that investors can adapt, in order to be able to choose the optimal alternative.

The Paris agreement on climate change was an additional impetus for the development of the renewable energy sector in most countries worldwide. In turn, the highly ambitious EU Green Deal has the potential to inspire other countries, including China, to adopt progressive targets in the field of renewable energy, all the more so as the EU and China have been cooperating intensively since 2005 on the climate change (Kuo, 2020).

China dominates each of the four rankings taking into account the total installed capacity of renewable energy: hydro, wind, solar and bio, and Chinese companies are the most numerous in the rankings of major manufacturers of wind turbines and solar panels. This analysis does not detail the factors that propelled these companies among the world leaders, but it is obvious that rigorous national economic policies and partnerships with developed countries are the key incentive.

National energy policies will continue to be intertwined with the major countries' goal of reducing excessive dependence on certain import sources, with the political will to diminish greenhouse gas emissions, but also with growing protectionist trends of some countries and with the effects of the Covid-19 pandemic.

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