TRANISTION TO NEW SOURCES OF ENERGY: TECHNOLOGIES, COSTS AND GEOPOLITICS

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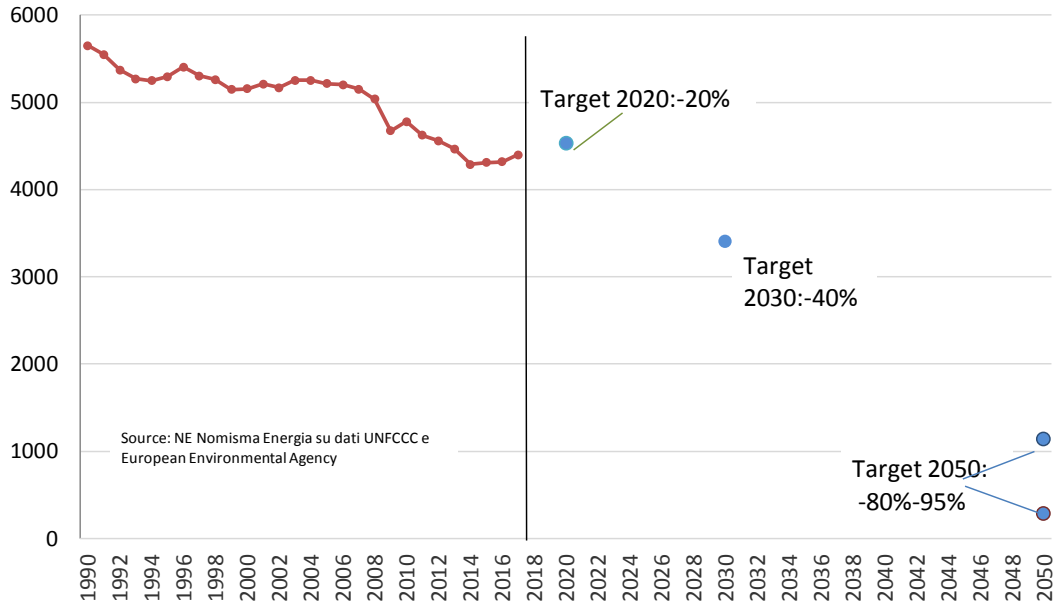
Introduction

Europe has the leadership in trying to solve what is believed to be the main global problem of our times; climate change caused by increasing greenhouse gas emissions from fossil fuel combustion. A commitment it took seriously when the scientific discussion emerged on this field at the beginning of the '70s, strengthened over the following decades until the Paris agreement of December 2015[1]. The opportunity for jobs and increased GDP is immense. Many European Union policies are defined to combat climate change and it is one of the priorities, along with Energy Union, defined by the Commission in 2014 for 2020. Moreover, the Commission in 2011 approved the Road Map to 2050 that aims at reducing CO2 emissions between 80% and 95% compared to 1990 level by 2050.

Fig.1 – EU CO2 Emission
(million tons)



Europe can boast important achievements since its emissions in 2016 were already 22% lower than in 1990, however the reduction trend stopped recently and inverted in 2017 with a sudden increase of 1.8%[2], according to the preliminary estimates of Eurostat, driven mostly by a robust recovery of energy consumption. The target of 20% reduction by 2020 has already been reached, while that of 40%[3] seems now more distant. The present paper after a brief analysis of the present energy market

[1] The Paris Agreement is the convention signed in Paris at the Conference of the Parties (COP) number 21; the first COP took place in Berlin in 1995 after the Earth Summit in Rio de Janeiro of 1992 when the United Nation Framework for Climate Change (UNFCC) was adopted. The COP 3 approved the Kyoto protocol in December 1997 that was not replaced in Copenhagen in 2009. The aim of the Paris agreement is to keep the rise of global temperature below 2 degrees Celsius above the pre-industrial level.

[2] According to the preliminary estimates of Eurostat, http://ec.europa.eu/eurostat/documents/2995521/8869789/8-04052018-BP-EN.pdf/e7891594-5ee1-4cb0-a530-c4a631efec19.

[3] The 20% reduction by 2020 was part of the famous 20-20-20 targets fixed in the energy package presented at the end of January 2007 that brought to the Directive package of April 2008. The 40% target for 2020 is the only one already decided in mid 2018 and was decided

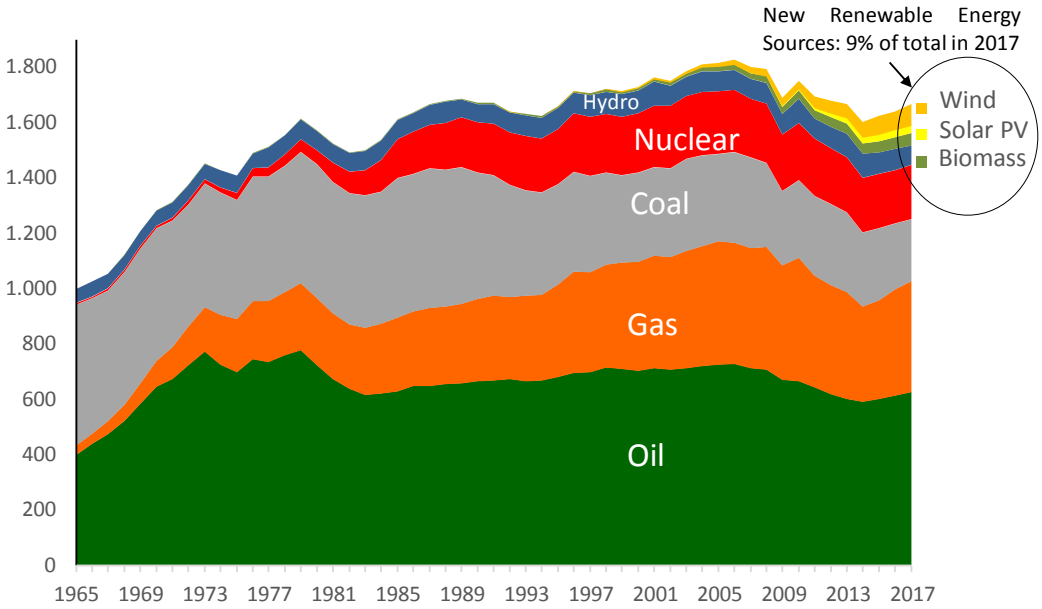
conditions, emphasises that the process of transitioning to a lower carbon society at its most challenging phase. Initial decarbonisation was easier in the first phase from 1990 onward until few years ago, as there were large opportunities to improve energy efficiency and to close some of the most polluting plants. For instance several out-dated coal power stations in central and eastern Europe were replaced by modern plants using gas. In the countries with the biggest GDP in Europe, a huge jump of renewable energy sources (RES) took place due to generous subsidy schemes. Nevertheless renewables are becoming more and more competitive compared to conventional fuels. The latest roadmap from IRENA, prepared with the European Commission shows that the EU could cost effectively double its RES share.

already in the European Council of October 24th, 2014 then repeated in the Winter Package of the end of 2016. The Winter Package is a set of proposals by the European Commission for the energy sector.

Present energy market conditions

According to preliminary data, in 2017 the EU energy demand increased by 1.6% to 1,686 million tonnes of oil equivalent (Mtoe), 144 Mtoe less than the peak of 2006. Oil, natural gas, coal still account for 75% of total final consumption, compared to 82% of ten years ago. RES contribute for 13%[4], but excluding hydro, coming from large dams built last century and that today would be impossible to build, their share dips to 9%. Of this, the most attractive new RES, wind and solar photovoltaic (PV), represent 6% of the total.

Fig.2 – EU Energy Demand
(million tons of oil equivalent)



Wind and solar photovoltaic (PV) produce electricity and their role in the electricity balance is more important than in the total energy balance. In 2017, the wind share reached the record of 12% of total power production, thanks to a climb of almost 20% over 2016 due to favourable weather conditions and to the new capacity commissioned in the North Sea. PV grew less compared to the past, but always with a robust 7% reaching a share of 4%. Wind and PV, together, toped a 16% of total electricity production in 2017, 4 times the value of 10 years ago.

The fall of their costs under those of fossil fuels should pave the way for solid expansion in the future, however recently changes in market conditions are creating some impediments. First, the extraordinary financial support, that topped 50 billion € per year all over Europe in 2015, has been slashed and the ability of the new RES to survive without subsidies is still to be proved. The system in the past created a sort of addiction to certainty of revenues that now makes uneasy for investors to

[4] According to European Union targets and rules set in the Directive 2009/28/EC the share of RES is to be referred to gross final consumption, a denominator lower compared to gross energy consumption used traditionally in energy economics that gives 13%. According to the Directive's rule, the share of RES in 2017 is 17% not far away from the target of 20% in 2020. In the Winter Package presented by the Commission at the end of 2016, the new proposal of a RES directive fixed a target of 27% by 2030, but the Parliament asked for a 35%. In mid 2018 a 30% is the most likely figure to become target.

adapt and operate in risky and competitive markets. Second, power prices are too low and not attractive as in the past. Now that parity of costs with fossil fuels has been successfully achieved, the production of a commodity like electricity that has low prices is no longer so attractive. The main cause of falling power prices is exactly the additional RES capacity of the past that has arrived in the period of weak demand. Third, developers are experiencing growing opposition against wind farms and ground mounted PV plants from local residents. This is why, in North Europe, large wind plants are moving offshore in the North Sea where, besides, wind conditions are more favourable. Yet, the distance from the consumption centres triggers a similar opposition to large electricity transport grids.

Wind and PV are intermittent since they rely on natural resources that are abundant, free, but not constant. So far, they have been smoothly adapted to the grid system thanks to the overcapacity built in the past with lot of large power plants, big hydro dams, nuclear, coal and combined cycle gas plants that all together account for 80% of production. Today, after more than 20 years from the start of the policies in favour of RES production, it is still this capacity that keeps the lights on in Europe[5].

The contribution of RES to power production is extremely different among EU countries, since they developed their own industries with different priorities, different technologies, different possibilities. The most interesting case is Germany, first for being the largest electricity in Europe market with a net production of 655 TWh in 2017, second because it is the country more ahead in the transition to a low carbon economy, third because it is here the difficulties are more evident. In fact, its RES penetration has been the strongest in Europe and it is growing fast, but at the same time coal remains its most important fuel in the generation mix with a share of 37% in 2017[6]. Last May 2018, the government delayed again the creation of a commission to study the phase out from coal of Germany, because of deep differences in views about deadlines among the coalition's parties.

Another 12%, 76 TWh, is coming from nuclear plants that are expected to be fully shut down by 2022, a consequence of the government decisions taken back in the '90s ad strengthened after the Fukushima disaster of 2011. PV and wind production in 2017 reached new records of 40 TWh and 107 TWh respectively, a climb that took more than 15 years to be accomplished. Another important peculiarity of the European electricity industry is the high proportion of nuclear production in France. The second larger consumer of the continent, produced 376 TWh of electricity form its 58 reactors in 2017, the 71% of the total. No other country in the world has such high share of nuclear.

Despite being almost neglected, nuclear has the advantage of emitting no CO2 but, due to the problem of wastes and to the risk of accidents, France decided to reduce its production also because a lot of capacity is ageing and needs frequent and long maintenances. In the 2016-2017 winter, the maintenance period in several plants that was longer than expected caused the lack of capacity with

[5] The remaining 4% are other RES plants that are not intermittent, mostly using biomass that are creating a lot of troubles in terms of emission of particulates and other local pollutants despite being neutral on CO2 emission..

[6] Coal consumption for power generation is still relevant all over Eastern Europe, in particular in Poland and in the Czech Republic that do not want to cut the use of coal for fear to boost dependence on gas from Russia.

spikes of wholesale electricity prices all over Europe. In 2015, the French government announced the intention to reduce the share of nuclear energy in the country's electricity production to 50% by 2025, that means a cut of supply of around 120 TWh[7].
Taking into account this developments in Germany and France, by the mid of next decade lower use of coal and nuclear will create a need for RES production of roughly 200 TWh. Given the fact that the best conditions for producing wind energy are those of the North Sea, the new wind capacity that should be constructed is of 50 GW, where so far only 13 GW were built. The efforts to attract new investments and to solve the technological challenges must be boosted.

Technology needs

Among the myriad of ideas emerging each day in the electricity sector, three deserves more attention being pivotal for the future of electric renewables[8]: electricity storage, electricity transport and final demand management.

A key step of modern electricity as we know it today, was the experiment of Alessandro Volta with its chemical battery in 1799. The future of the RES revolution depends on the possibility to improve this discovery that, in the last 10 years, was not enough improved. In Europe, storage batteries under construction are not more than 10-20 MW of capacity and they are used mostly to keep the grid stable, not for accumulating the huge quantity of power produced during sunny or windy days. The existing large storage facilities and those under construction are mostly traditionally pumped storage. This kind of capacity was built in the past to exploit abundant electricity from nuclear plants that could not be shut down during the night when demand was low. In the same way, in the future, RES power will be used to pump water in lakes located at higher levels in the mountains to be later released to generate again other power when there is higher demand. However, this technology will not be sufficient also because nowadays environmental opposition makes more difficult to build large pump facility. This means that further research is urgent on new batteries to improve the capacity at lower their costs.

To move electricity from where wind and sun are abundant to the consumer centres, big technological efforts are to be made on transmission lines. Today electricity is transported by high voltage alternating current with losses that raise costs. The idea is to develop ultra-high voltage direct current lines able to transport larger volumes of electricity for longer distances. The need is clear in the North Sea, the place where the costs are lower thanks to high speed winds. In order to make available all the planned capacity to the continent, new huge lines must be constructed. If they succeed in being of the new type, using ultrahigh voltage direct current, their capacity will be much higher, cutting the unit costs of transport. Moreover, they will reduce the need of several lines and so limit the risk of delays due to environmental opposition to them by local communities.

[7] In Europe there are in total, France included, 128 reactors where production is slowly shrinking in all countries. France and Finland are building two new plants with a lot of delays and rising costs compared to budgets, while UK initiated the construction of a new unit at Inkley Point.
[8] Other technologies not strictly connected with the future of electric renewables that received a lot of attention in the past are Carbon Capture and Storage and second-generation biofuels for which the results are still far behind expectations.

In order to offset the intermittence of RES production, final demand will play a more important role in the future, by consuming more in abundance and less in scarcity. In order to nudge the consumers to do it, pricing of electricity must change from the todays simple mechanism to new more sophisticated following the load of the whole system. New technologies are expected to help to give to final consumers the right signals during the day, or the night. New meters and other smart solutions will make possible to aggregate small consumers demand in order to flatten out peaks and to reach high level of demand in order to negotiate better prices.

The support of the past for RES helped the EU to gain an edge on new technologies, being more evident in the wind industry for companies like Siemes or Vestas. Its European utilities, like Enel, RWE, EON, EdF, are amongst the most important developers of new wind capacity in the world. In the photovoltaic industry Europeans developed some important technologies for which they keep patents, but the world production capacity of panels is almost entirely concentrated in China and Europe has no company left in the top ten module manufacturers.

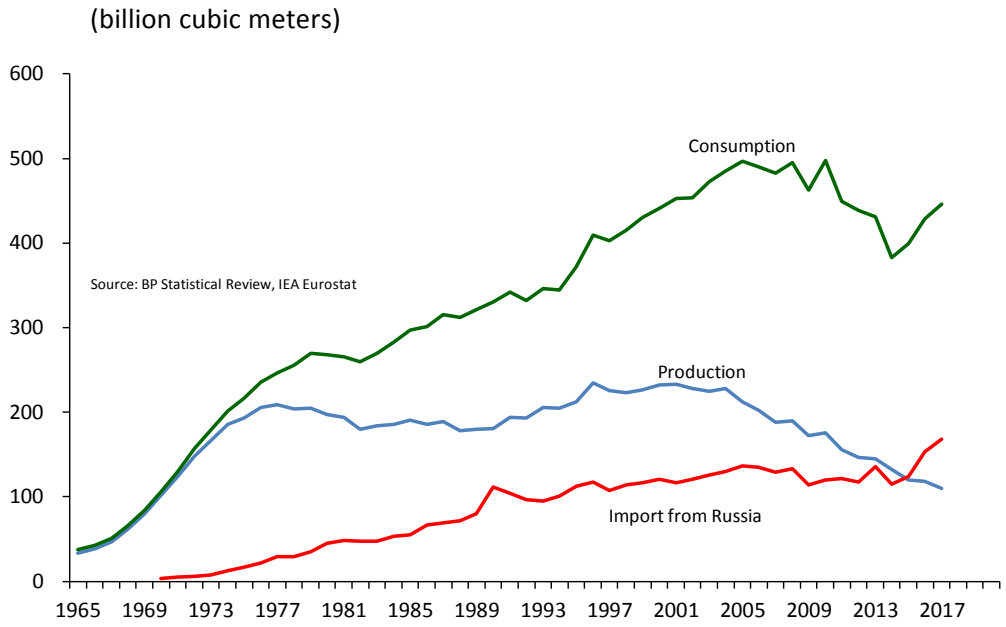
Geopolitics

One of the positive effects of rising RES production was to keep stable the energy dependence of the EU at 50% of its energy consumption, the same level of 10 years ago. This explains in part why the issue of energy security has lost importance in the debate among energy policy makers. Facts, actually, are a little bit more complex and less relaxing. First, the domestic energy production is related mostly to nuclear and coal, the two sources expected to be cut in the future lifting imports of traditional sources if RES do not increase as fast as in the past. Second, the dependency on oil, the first energy source in the EU energy balance, is growing again towards 80%, the level of 30 years ago, mostly because of the fall of domestic production especially in the North Sea. The instability of oil markets is the reason why we started to talk about energy security at the beginning of the '70s. Ever since then, we made a lot of attempts, but the dependency on oil imports remained substantially unchanged. The dominance of oil products in transport is always close to 95%, despite all the recent enthusiasm for electric vehicles[9]. Biofuels have revealed their limits due to the fact that, so far, they are mostly produced starting from feedstocks that compete with food, while the second-generation products, not competing with food, are still struggling to exit from the experimental stage.

The most concerning change is taking place in the gas market with a growing import dependence due to the rise of consumption against a sharp fall of domestic production. Natural gas is likely to be the source that will help to replace nuclear and coal in France and Germany, like it is already happening in UK. Gas use will grow also in order to offset, with small or medium turbines easy to turn on and off, the intermittence of RES thus allowing them to grow faster. Gas will become a kind of storage to be swiftly transformed in electricity when the sun or the wind are not available in enough quantity. For all this advantages gas will be the fuel of the transitions.

Fig.3 – EU Gas Consumption, Production and Imports from Russia

[9] The paper does not discuss the electrification of transport through electric vehicles, first because of the complexity of the topic, second because the future limits to diesel or to other internal combustion engines is a matter more related to local pollutants, like particulates or NOx and less to CO2 emissions, the focus of this document.



However, European gas production is contracting both because reserves have been massively exploited and for the opposition of local people. The typical case is the reduction of production in the Groningen gas field in Netherlands, the largest in Europe, due to micro seismic effects and subsidisation. Other examples are those of Italy, in the North Adriatic, again for problems of subsidence, or in UK, where shale gas projects that should use fracking technologies are too close to villages whose inhabitants fiercely oppose them.

EU gas imports in 2017 reached a new record of 355 billion cubic meters per year (bcm/y) of which half is coming from one country, Russia, and from one single company, Gazprom. This is happening while paradoxically political sanctions on Russia should limit our dependence on it because of its war in Ukraine where the gas is traditionally transiting to Europe. Since 2014, when sanctions were introduced, imports from Russia jumped by 46% to the new peak of 165 bcm/y in 2017. In the last 20 years the EU made a lot of efforts to reform and liberalise its gas sector, however the most interesting development was the construction of the Nord Stream 1, the gas line connecting directly Russia with Germany through the Baltic Sea, likely to be doubled in the next few years. While the focus was on liberalisation our gas dependency from abroad and from Russia has been growing. We could hope in additional supply of liquified natural gas from the US where the booming shale industry is unleashing huge gas volumes for exports. However, Russian gas is likely to be always more competitive compared to that from the US due to the sheer fact that costs is Siberia are extremely lower compared to those of fracking in Texas to which transport expenditures should must be added.

Costs

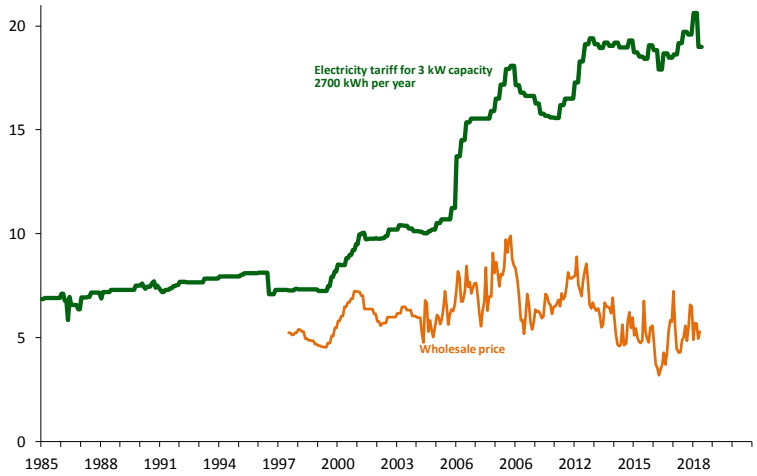
At the beginning of the decarbonisation process there was a solid belief that the market could be the right tool to achieve the ambitious target of pricing pollution. Europe has been at the forefront of implementing a trade in emissions permits, the Emissions Trading System (ETS) introduced in 2003. However, the widely-trusted invisible hand of the market has encountered a fair few difficulties in

the real world. The prices of emission permits for one ton of CO2 have fallen to lows of € 4 per ton in 2016 and 2017, from initial values of over € 20. Only in 2018, permit prices have regained ground toward € 15, but this is still vastly lower than the CO2 cost reductions paid by renewables, ranging between 100 € and 300 € per ton of CO2. Despite this, the ETS is the flagship of the European policies that the rest of the world is attempting to imitate.

The European Commission states that the Energy Union, one of the pillar of its strategy, will ensure affordable energy, implying that costs of the transition to a low carbon society should not rise. Things are not moving in this direction since final electricity prices increased in the last decade while the price gap between the EU and its partners widened. Wholesale power prices are low compared to the past, thanks to the abundance of supply from RES plants. Instead final prices are higher because other components must be added to the wholesale price, like the subsidies to the same RES and the costs for the new electricity grids[10].

Italy and Germany are the most interesting examples of the effects on prices of penetration of RES: wholesale electricity prices are low, while final consumer prices have been constantly growing and are amongst the highest in Europe.

Fig.4 – Italy: Electricity Prices to Families and Wholesale Electricity Prices
(€cent/kWh)

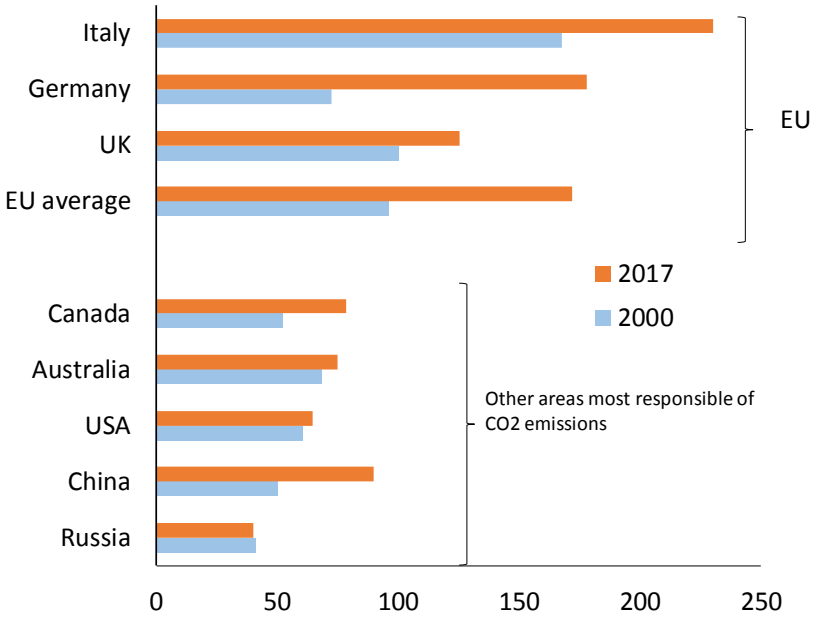


High prices paid by families are worsening the problem of fuel poverty in many parts of Europe where people cannot afford to pay the bills for the supply of electricity. The main problem, however, are the effects on the industrial sector. It is losing competitiveness compared to the rest of the world because higher electricity costs and this exacerbates the deindustrialisation process and the loss of jobs. Electricity prices in Euro per MWh in Italy and Germany, the two leading countries in environmental policies, are double or triple those in China or the United States where lot of products

[10] Smart grid is a byword for the modernisation of the electricity systems for which a lot of enthusiasm has been created but with few results concerning new technologies. A more suitable word is smarter since electricity grid are already today extremely complex system to be kept working properly.

that Europe is importing are manufactured. The risk is that these discrepancies, considering the ambitious targets ahead of Europe, could become even more pronounced in the future.

Fig.5 –Electricity Prices to Industry in 2017 in the World
(€/MWh)



Source: Nomisma Energia estimates on data from OECD, Eurostat and Department of Energy USA

The constant fall of wholesale electricity prices, that had no effect on final consumers, was the reason for business losses of the traditional power company for more than a decade. Among the costs of the RES revolution there are those related to the wrecking of the utility sector of Europe, forced to write off at least 100 billion € of assets all over the last decade because of lower prices. The sector is in a disarray and has no clear idea where to go, exactly when it is requested to lead the decarbonisation process.

Conclusion

The transition towards a low-carbon economy has been slowly taking place for 20 years[11], now heading into a deep implementation phase it will bring about deep transformation. Yet CO2 emissions are still rising. energy consumption from fossil fuels still represents 80% of the total, new renewable sources, despite huge efforts, are still marginal on total energy balance sheet, our gas dependency is worsening and final electricity prices are rising. There is a lot governments need to be doing now to advance climate mitigation plans and help reach the Paris objectives timely. This would help protect our socio-economic and environmental well-being. The potential for improving this not only lies in energy policy but also in other social and economic policies, that go hand-in hand with respect for people and the planet.

Yet to know the problems and to be able to measure them we have to understand them and have full access to data all aspects of the energy market for instance.

Some suggested further policy directions to follow would be:

- Continue to aim high with ambitious targets in energy efficiency. This is the first way to save energy to benefit everybody.
- Facilitate the transfer of technology
- Speed up the development of new technologies in the electricity sector where renewables are encountering barriers;
- Review the costs of the transition to ensure prices are fair for consumers and producers.
- Use existing gas structures with a view to harnessing more biogas in Europe to avoid having to import gas from third countries;
- Act more in coordination with other countries, since the EU, after cutting its CO2 emissions by 1 billion tonnes of CO2 per year, accounts for just 9% of world total; Europe needs to work with the US in particular.

Europe has a cultural and political leadership in the world based, among others, on the principle of a better protection of the environment. Therefore, it has the responsibility, towards its citizens, to better understand the complexity of the low carbon transition and take serious action in order to ensure it is a *Just* Transition for all.

[11] Initial provisions on environment were introduced in the '70s, but only concerned the fuel quality. In 1986, the European Council set out an energy strategy, with fundamental objectives such as the rise of renewable energy sources. The 1995 White Paper and the 1997 Green Paper anticipated Directive 2001/77/EC, which set non-binding targets for renewable energy sources. At the end of 2007 the Commission presented its new energy strategy, the famous 20-20-20, leading to the April 2009 package of directives, for the first time setting binding targets still valid today.