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Climate change and nuclear energy

POLICY PAPER JUNE 2016

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What is the outlook for nuclear energy? While this is by no means a new question, answering it has now become a matter of some urgency. The need to act fast on climate change, together with the commitments taken at COP21, make this essential. The absolute need to ensure safety makes it a priority, at a time when countries around the world are developing nuclear power fleets. Furthermore, the economic and financial situation amplifies this question, as it brings with it a great deal of uncertainty, especially in deregulated markets.

A new global context

First, the disaster in Fukushima in 2011 has shaken many convictions. While Japan's safety regulations have since been revealed as inadequate and ineffectively applied, Japan is one of the most advanced countries in the world and one of the leading players in the nuclear power industry. In light of the accident, we must weigh the benefits of our use of atomic energy against the risk to people and the environment. German Chancellor Angela Merkel decided to speed up the process of phasing out nuclear power production. In France, although public opinion remains favourable to nuclear power, people are still concerned, particularly with regard to widespread fears of an accident or a terrorist attack.

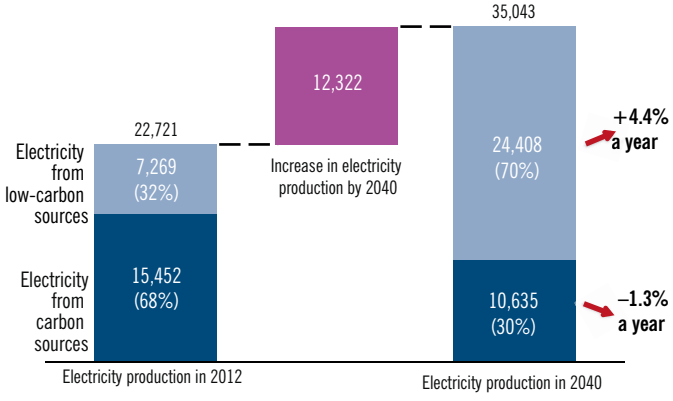
However, the risks associated with the use of nuclear power should not cloud our vision of the valuable contribution to be made by this low-carbon energy source as part of the drive to mitigate global warming: at this point in time, it is unrealistic to think that we can do without atomic energy if we want to keep global warming below

1.5°C, the objective recently set by the international community in signing the Paris Agreement at the end of COP21 in December 2015.

Reference forecasts indicate an estimated 25% increase in demand for primary energy worldwide by 2030. In addition, due to increasing access to electricity in countries with high demographic growth and the development of information and communication technologies (accounting for around 10% of the world's electricity consumption in 2013[1]), electricity consumption is obviously set to rise in the coming years. Apart from these trends, major efforts must be made to speed up the substitution of uses in favour of electricity, especially in the transport sector. In its forecasts, the IEA estimates that to achieve the 450 scenario, i.e. the scenario in line with the commitments made at COP21, electricity consumption shall increase by over 1,200 TWh. Furthermore, in the same scenario, 70% of the electricity produced must be low-carbon, as compared with 30% in 2012. For the purposes of comparison, to meet such a demand for low-carbon electricity will imply building around 47 EPRs a year if nuclear is the only means used to generate electricity, or building just over 47,000 5 MW wind turbines a year between now and 2040, if wind power is the only technology used!

[1] Mark P. Mills, The cloud begins with coal: big data, big networks, big infrastructure and big power, an overview of the electricity used by the Global Digital Ecosystem, 2013.

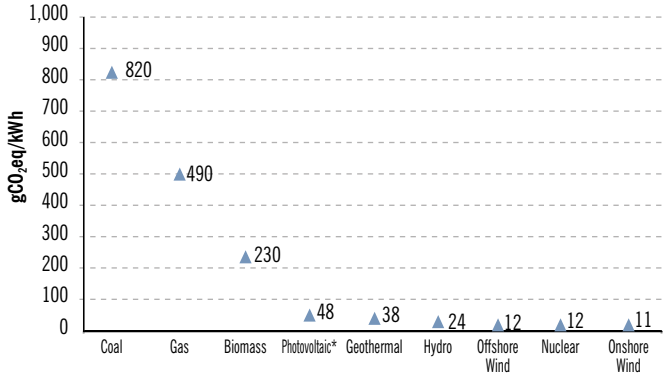
Figure 1: Trends in electricity production in TWh



Source: IEA, World Energy Outlook, 2014, the 450 Scenario.

At a time when reducing the use of carbon fuel sources has become a priority, the development of renewable energy sources only will be inadequate to the task, bearing in mind the pace at which they can be deployed, their lack of competitiveness, technical issues and additional costs resulting from their intermittent performance. Their development is certainly to be desired, but it must go hand in hand with the development of nuclear power, the main low-carbon energy source capable of mass electricity production («baseload» production, to use the technical term, i.e. in large quantities, at high voltage and for over 8,500 hours/year), in a way that can be managed and coordinated.

Figure 2: CO_2 emissions per source of electricity production



** Large-scale solar power plants*

Sources: IPCC, « IPCC Working Group III – Mitigation of Climate Change, Annex II I: Technology - specific cost and performance parameters », 2014.

Global energy market trends – the extremely volatile price of oil and gas, and the ramp up of renewables – lead us to question how competitive nuclear power is compared to other energy sources. However, the pledges made to reduce greenhouse gas emissions imply that political leaders must make technical and economic decisions to give a new boost to the nuclear power industry, given that carbon-based energy sources still make up two-thirds of the global energy mix.

For the European Union, energy policy can no longer remain limited to liberalising the market and providing subsidies for renewables, which lead to overcapacity. Europe must get over the idea that nuclear power is “shameful” and accept that this energy source forms a substantial part of the solution to climate change.

As for France, whose economic and industrial growth has undoubtedly benefited from the competitive advantage of its development of nuclear power, it has now come to a turning point in history. With the adoption of the Act on energy transition for green growth (LTE), in August 2015, a new strategic direction for France's electricity-generation mix has been defined. This strategy, while confirming the role of nuclear as the base of France's energy mix, focuses above all on diversifying supply sources, the aim being to reduce France's dependency on nuclear power and promote the use of renewables.

Regarding the situation of French nuclear industry, some questions may arise. In a difficult context, it shall renovate the fleet, invest in the United Kingdom and build new power plants in France and abroad, after an almost 15-year time period with no major project, during which industrial expertise have decayed.

This implies huge challenges for the nuclear power industry and, as an essential component in France's, Europe's and the world's energy supply, it needs to have ambitions on a similar scale.

The challenges faced by the nuclear power industry

In the opinion of the Institut Montaigne, nuclear power is faced with an entirely new environment, in which it must deal with two major challenges. First, on the technical side, the challenge entails making further improvements to global levels of facility safety and finding effective radioactive waste management solutions. Safety and waste management are determining factors in shaping opinion regarding the acceptability of nuclear power. The second challenge is an

economic challenge, relating to financing the construction of new plants and making the energy offer more competitive, for business and households alike. This implies demonstrating, in the present situation, the viability of the economic equation of nuclear electricity generation, in a context in which energy costs no longer cover production costs alone, but must also cover external costs (carbon pricing, grid and storage costs, and the costs of dismantling and waste management).

If nuclear power is to play the key role required of it in the drive to mitigate climate change, it must successfully deal with these two challenges. At global and European levels, as well as for France, this implies that enlightened, rational choices must be made without delay.

The implementation of a high level of safety, worldwide, is a precondition for the global development of nuclear power, as an asset in managing climate change

It is essential that a very high level of safety is implemented in all nuclear-power generating nations. There are solutions, provided that there is coordination between these nations.

It would appear to be essential that the safety regulation frameworks of all nuclear nations be brought into line with current best practices. Perhaps if this had been the case in Japan, the accident in Fukushima could have been prevented. At the least, the consequences could have been significantly less serious. We can see that such global convergence is possible, as it already happened in civil aviation for

example. For example, the International Civil Aviation Organization (ICAO) issues Standards and Recommended Practices which must be implemented in national regulatory frameworks. Such an action is supported by a specific body responsible for performing regular audits on the implementation of major safety standards and practices. In addition, bilateral airworthiness agreements to mutually recognise national standards are signed between nations to enable licences to be issued after assessing each other's *"national delta"*. Last, at European level, the EASA (European Aviation Safety Agency) was set up to fully harmonise national regulatory frameworks.

In the nuclear sector, taking account of other countries' experience in the area of safety would lend credibility to a more cohesive approach and gradually lead to mutual recognition, and then to standardising regulations, practices and certification, thereby meeting the public's legitimate expectations. On these issues, initiatives led by WANO at global level and WENRA in Europe deserve a mention. For example, they have led to implementation of systematic peer reviews, and even, in Europe, to operating reference levels which are stipulated in thevarious national regulations, a significant step in the right direction. Nonetheless, WANO's activities are limited to operating, which is also the focus of WENRA's activities. This means that safety standards relating to reactor design and construction are not harmonised by a higher authority.

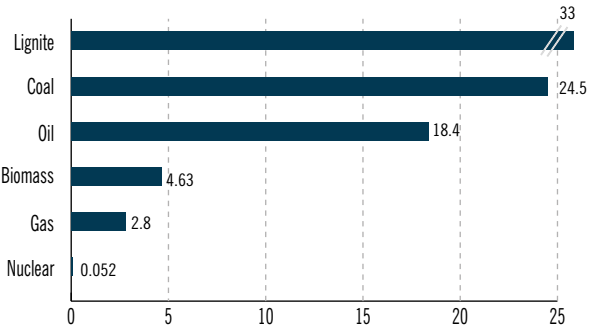
The same approach, based on real examples of international cooperation, should be adopted to deal with the key issue of waste management. Rising to this challenge depends on governments and independent administrative authorities taking action.

In any case, this challenge must not be invoked merely to overshadow the absolute priority of combating the risks of climate change. It would obviously be impossible to make the public accept an explicit choice between the risk of a nuclear accident, which would have significant albeit localised consequences, and the disasters announced, and already being observed, induced by global warming and the many types of pollution caused by other energy sources. That said, the role of public, national and international authorities entails the ability to prioritise.

Indeed, although a nuclear accident may have major consequences, these need to be seen in relation to other sources of energy. This was the aim of researchers in a paper published in *The Lancet*[2] in 2007. In their study, based on a review of many other scientific papers, the number of deaths caused by different energy sources was assessed for entire facility life-cycle, factoring in operating accidents and air pollution.

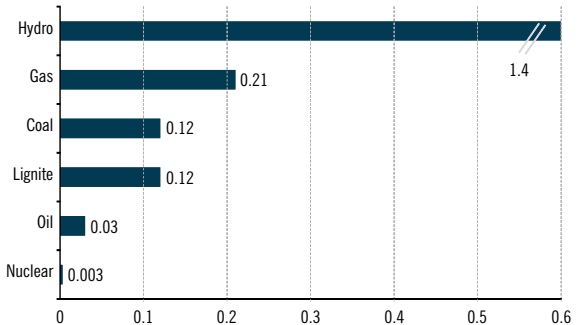
[2] Anil Markandya & Paul Wilkinson, "Electricity generation and health" – *The Lancet,* (2007).

Figure 3: Comparison of the number of deaths due to air pollution by different energy sources, as number of deaths per TWh produced



Source: *The Lancet,* OMS.

Figure 4: Comparison of the number of deaths due to operating accidents during the life-cycle of different energy sources, as number of deaths per TWh produced



Source: *The Lancet,* OMS.

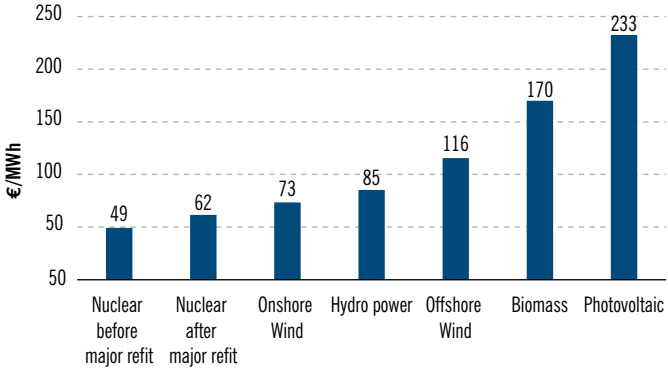
It should be borne in mind that these figures do not factor in CO_2 emissions from fossil fuels nor their impact on climate change. In the long term, there is a risk that the harmful effects of climate change will be on a whole different scale. In its fifth report, published in 2014, the IPCC made very gloomy forecasts regarding the impact of global warming in the coming decades, including the extinction of plant and animal species, an increase in climate-related disasters, population displacement and the risk of war.

The competitiveness of nuclear power

In France, there is no question that nuclear power production as it has been developed is competitive. With sustained development over several decades leading to the construction of consistent reactor series, and without compromising safety, France has successfully produced abundant, cheap electricity, which also saves spending on foreign currency markets.

The French fleet, known as second-generation reactors, will remain competitive in the long term, provided that upgrade programmes are implemented to extend the operating life of existing reactors.

Figure 5: Estimated average costs of nuclear power production and of production using alternative renewable sources in France, in euros per MWh



Sources: ODGEC, 2008 updated by the UFE in 2011; "Energie 2050", 2012; *Cour des Comptes;* CRE.

Even though this is the case, nuclear-generated electricity must still deal with rising costs worldwide. Some of the factors involved in rising costs are structural factors. For example, Generation III reactors are subject to tighter safety requirements in relation to reactor design and building standards. Tighter requirements obviously mean higher construction costs for these new plants. Furthermore, nuclear power is also penalised by the cost of financing construction, since initial investment costs are high and construction and then operating periods are long, implying more uncertainty.

The increasing cost of nuclear power can be explained by other economic factors. Thus, the first Generation III reactors built are

used as a standard against which to compare the costs of new nuclear technology with the costs of other energy sources. Yet these are still prototypes, and industrial leverage exists to reduce the cost of constructing the next series of Generation III reactors.

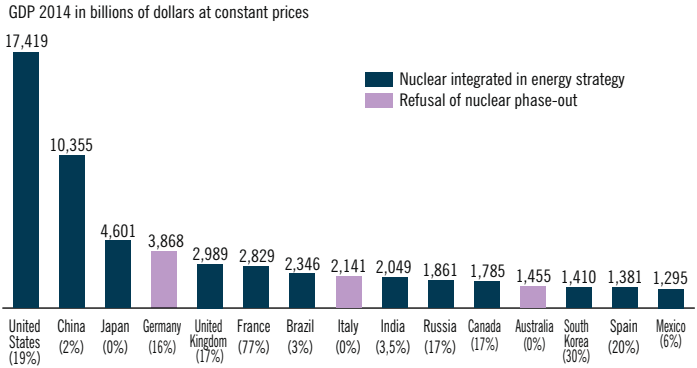
Also, in the future, comparing the competitiveness of electricity generation sources must involve more than just the cost of production, and also take account of external factors, i.e. including expenditure related to intermittent performance in the case of renewables (storage and network costs), and negative effects related to carbon emissions in the case of fossil fuels.

Assessing the competitiveness of different energy sources and securing financing for the nuclear industry – included in deregulated markets, like in Europe – will lead on adjusting financial mechanisms designed to achieve technological neutrality in the choices made to develop low-carbon energy sources. On this point, both debate and action must include the basic principles of economic regulation of the markets, even raising questions regarding pricing policy which, in most deregulated markets, has mainly been to the advantage of investors in renewable energy sources and, symmetrically, has left other operators with less room for manoeuvre in financial terms. It might also be useful to question the validity of "economic precedence" in gaining access to the networks, which is now more or less based on marginal production costs and largely ignores other costs and negative externalities.

Most of the world's major economic powers opt for nuclear

The fifteen largest economic powers in the world, with the exception of Australia, Italy and Germany, continue to commit to the nuclear pathway. What they have all concluded is that nuclear power can provide abundant and competitively-priced energy, under conditions which, bearing in mind the level of technological progress and of control achieved in the sector, already make it one of the safest forms of energy production in terms of accidentology and measurable impact on the environment and human health.

Figure 6: The 15 major economies in the world by GDP, and the position of nuclear in their energy strategy



Figures in brackets: nuclear power as a percentage of total electricity production in 2014. Japan: nuclear power plants shutdown following the Fukushima accident.

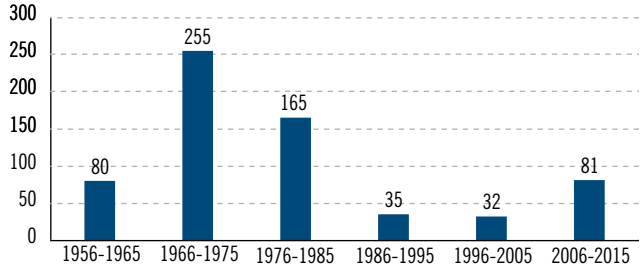
Source: World Bank, 2014.

China and India both have very ambitious building objectives, and demonstrate a desire to develop their own domestic nuclear industries. This drive can also be seen in traditional nuclear nations, who give nuclear a significant share in their energy mixes and are investing to ensure the future of their nuclear industries. The United States, for example, is extending the operating life of its existing fleet and strongly encourages innovation, mainly in developing SMRs. Russia is developing its installed base to export gas and is implementing a very aggressive policy to export its nuclear expertise. In addition to the existing nuclear nations, many other countries, such as the United Arab Emirates, Saudi Arabia, Turkey and Poland, are now looking into the possibilities for developing a nuclear power programme.

Thus, in the ten years from 2006 to 2015, construction began on more than 80 reactors, i.e. 2.5 times more than during the preceding ten years. This trend looks set to increase in the coming years. The World Nuclear Association (WNA) estimates that, worldwide, there are currently 173 construction projects which have been approved and either wholly or partly financed, and are scheduled to be in operation by 2026.[3]

[3] World Nuclear Association, The Nuclear Fuel Report, 2016

Figure 7: Number of reactors built worldwide between 1956 and 2015



Source: World Nuclear Association.

For Europe and France, the time has come to make strategic choices

The European Commission's desire to establish an "Energy Union" is to be lauded, as long as we admit that more is involved than just ensuring compliance with the rules of competition, in a market which is, all things considered, not exactly a "single" market. This calls into question the dogma of the individual Member States' sovereignty in determining their energy mixes. It does not involve entirely renouncing the principle of subsidiarity, nor depriving national and local authorities of their ability to state their energy choices and have them taken into consideration. However, the choice must be made within a framework in which solidarity between EU Member States is affirmed and taken into account, especially within electricity network interconnection areas. Within the planned Energy Union, nuclear power must find a specific place in the choice of sources, enabling the European Union to ensure its security of supply, its

economic competitiveness and its contribution to mitigating the effects of climate change. the Energy Union also assumes that the cost effectiveness of carbon pricing mechanisms will be ensured and that the principle of technological neutrality will prevail in financing low-carbon energy production infrastructures.

With regard to France, thanks to nuclear energy production, it is completely aligned with a European strategy based around security of supply, economic competitiveness and sustainable development, a strategy which absolute priority is to reduce global warming. A self-evident response, for France, would thus be a good balance between the development of renewable energies and that of the nuclear programme. The Act on energy transition for green growth (LTE) has made it possible to set a goal and enact diversification of the energy mix. This is a very positive step forward. Nonetheless, the objectives set for nuclear-generated electricity, in particular setting a cap of 50% by 2025 and limiting total authorised production capacity to 63.2 gigawatts, imposes the pace of transition and does not allow for any flexibility, which may jeopardise not only France's interests but also the chances of success for energy transition. Enforcing these limits would entail the closure of a number of existing NPPs, in spite of the fact that they could continue to produce competitively-priced low-carbon energy, with safety levels approved by ASN, France's Nuclear Safety Authority. These closures would imply additional costs for the State, amounting to several billion euros, without mentioning the impact on the economy, the environment and jobs, which has not been assessed.

The Institut Montaigne finds it regrettable that the government's statements regarding the schedule for extending the operating life of France's nuclear fleet, which produces 75% of the country's

electricity, are somewhat inconsistent, while it now seems unavoidable if we are to continue enjoying the benefits of Generation II plants. Following several months of research, and around forty interviews with experts and stakeholders, the task force has come up with the conclusion that extending the operating life of the current generation of reactors is not merely an option, but a necessity. Scheduling the renewal of part of the fleet by 2017, and then building new reactors, to be in service by 2030, and overcoming the technical and financial challenges faced by the industry, is another. In this context, and against a public discourse which is changeable and ambiguous, the French government must clarify its strategy, and improve visibility across its domestic market, as the British, for example, have done. Establishing a clearly-defined strategy is the only way to ensure the development of a French, European and global economy that is cleaner, more competitive and provides security of supply.

A matter of urgency

The most serious threat for Europe, France and their industries is indecision, and the lack of clear policy choices. Hesitation on the part of successive governments in France and the lack of a common energy policy in the European Union raises questions and is seen as a threat to the whole energy sector and, more particularly, to a consistent energy policy for France and Europe and, ultimately, for their entire economies.

RECOMMENDATION 1: Ensure that nuclear power is part of the equation in implementing the conclusions of COP21.

RECOMMENDATION 2: Promote the alignment of national regulatory frameworks relative to nuclear safety with best practices in all countries, gradually establishing, through agreements, a system of mutual recognition of national safety regulations relative to design, construction and operating.

Task ASN with defining the conditions and procedures and supervising implementation, and provide it with the resources to do this.

RECOMMENDATION 3: Ensure an open-minded communication, without taboo, from public authorities in order to bring more rationality into the debate on nuclear energy, by being objective about the pros and cons from the perspectives of sustainable growth, competitiveness, safety and real threats about health and environment in comparison with other energy sources.

RECOMMENDATION 4: Ask the European Commission to integrate nuclear energy as appropriate in proposals regarding an Energy Union. Failing this, encourage the development of initiatives restricted to Member States which wish to be involved.

RECOMMENDATION 5: Incorporate decarbonisation issues in EU economic mechanisms relative to energy, namely:

- withdraw all subsidies for carbon energies, be they from European funds or national aid mechanisms;
- promote technological neutrality in the choice between alternative low-carbon energy sources;

- reform the European Union Emission Trading System (EU-ETS), enabling sufficiently high EU carbon pricing to emerge:
  – establish a carbon floor price for the entire European Union,
  – establish measures to prevent industrial products made in countries which are major emissions producers from distorting competition in Europe.

RECOMMENDATION 6: Establish the conditions required to finance nuclear projects in Europe, i.e. authorising long-term price guarantee mechanisms, both public (prices guaranteed by the public authorities, mainly meaning solutions such as the "Contract for Difference" mechanism) and developed by private operators (long-term contracts for electro-intensive industry customers, for example) and/or granting other forms of aid or State guarantees.

The Institut Montaigne warmly thanks the following people for their contribution to this work. Neither they nor the organisations they stand for shall be accountable for the opinions that are presented in this paper.

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THERE IS NO DESIRE MORE NATURAL THAN THE DESIRE FOR KNOWLEDGE

Climate change and nuclear energy

What is the outlook for nuclear energy? While this is by no means a new question, answering it has now become a matter of some urgency. The need to act fast on climate change, together with the commitments taken at COP21, make this essential. The absolute need to ensure safety makes it a priority, at a time when countries around the world are developing nuclear power fleets. Furthermore, the economic and financial situation amplifies this question, as it brings with it a great deal of uncertainty, especially in a context of deregulated markets.

After several months of research and around forty interviews with experts and stakeholders of the nuclear field, the Institut Montaigne comes up with a set of conclusions so that nuclear power can fully play the key role to mitigate climate change.

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