Nuclear power is part of the solution for fighting climate change

"Nuclear for Climate" is an initiative undertaken by the members of the French Nuclear Energy Society (SFEN), the American Nuclear Society (ANS) and the European Nuclear Society (ENS). It brings together nuclear scientists from all parts of the globe, through the representation of 60 regional and national nuclear associations.

The French Nuclear Society (SFEN) is a non-profit, international, scientific and educational organization. Founded in 1973, SFEN includes 3,600 members, researchers, engineers, professionals, physicians working mostly in the nuclear field. Its purpose is to promote the progress of nuclear science and technology and to contribute to the public knowledge about this form of energy.

The contribution of SFEN to the preparation of the Climate Conference in Paris (COP21)

As a scientific association, SFEN recognizes the conclusions of Working Group I of the IPCC (Intergovernmental Panel on Climate Change), which states that human activity and greenhouse gas emissions are - with "95% certainty"[1]- responsible for climate change.

These findings are the result of the collective work of experts from 40 countries who analyzed and assessed 9,200 scientific publications, according to the principle of "peer reviewing".

Basic context:

- **The 2DS scenario of the IEA** (International Energy Agency) describes the energy options available for limiting the average global temperature increase to 2°C.
- **The 6DS IEA scenario** outlines the energy scenario if no effort is made to reduce CO_2 emissions.
- **Working Group I** of the IPCC assesses climate change.
- **Working Group III** of the IPCC assesses the technological options available for mitigating climate change by limiting or preventing CO_2 emissions.
- The IPCC has defined a "**carbon budget**"[2] of cumulative CO_2 emissions that should not be exceeded if average global warming is to be contained to 2°C. It estimates that the total amount will be some 2,900 billion tons of CO_2 accumulated between the beginning of the pre-industrial era to 2050.

[1] IPCC Working group I report : http://www.climatechange2013.org/images/report/WG1AR5_SummaryVolume_FINAL.pdf

[2] *Carbon Brief* from based on figures from the IPCC: http://www.carbonbrief.org/blog/2014/11/six-years-worth-of-current-emissions-would-blow-the-carbon-budget-for-1-point-5-degrees/

The Kyoto Protocol (1997) signatories have pledged to reduce emissions of greenhouse gases in order to limit to 2°C the rise in the average temperature of the planet by 2050. Beyond this threshold the environmental and societal impacts would be dramatic and irreversible.

To achieve this goal SFEN believes that:

- **Given the scale of the challenge, the world will need all low-carbon energy sources, including nuclear**
  According to the IPCC[3], in 35 years' time 80% of global electricity will need to be low-carbon (compared with 30% today) in order to contain climate change. At the same time, the global demand for electricity is expected to double. This challenge requires the use of all low-carbon technologies: renewables, nuclear and CCS (fossil fuels with CO_2 capture and sequestration).

- **It is urgent to use now all available low-carbon energy sources**
  The planet has already consumed two-thirds of its carbon budget. To contain climate change it will need to reduce CO_2 emissions without waiting for future operational technologies. Nuclear energy is one of the industrial solutions that can be implemented immediately on a large scale.

- **Each country needs access to the widest possible portfolio of low-carbon technologies**
  Very few scenarios (8 of 1200)[4] permit the containment of the rise in temperature to 2°C without the contribution of nuclear energy. The UNFCCC (United Nations Framework Convention on Climate Change) Protocols must allow countries who wish to do so, to use nuclear energy and have access to climate change financing, as is the case for all other low-carbon energy sources.

[3] IPCC Working Group I Report :
http://www.climatechange2013.org/images/report/WG1AR5_SummaryVolume_FINAL.pdf
[4] IPCC Working Goup III Report: http://ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf

Given the scale of the challenge, the world will need all low-carbon energy sources, including nuclear

The challenge is historic: in 35 years' time 80% of electricity will need to be low-carbon[5]

Today, 70% of the world's electricity comes from fossil fuels (coal, gas, oil). Electricity is the main source of CO_2 emissions. By contrast, low-carbon energy sources account for only 30% of the electricity mix.

To reverse this tendency, significant efforts will be needed, especially as the share of fossil fuels is not declining: since 2010, the growth of coal was actually higher than that of all non-fossil energy sources combined[6].

Since 1990 (the reference year for the Kyoto Protocol), CO_2 emissions, far from decreasing, have actually continued to increase (+ 60%)[7]. If the electricity mix continues to be dominated by fossil fuels, the average global rise in temperature will be 6°C[8], well beyond the objective of 2°C.

The equation is complex: reduce CO_2 emissions and meet the basic needs of humanity

By 2050 the world's population will be around 9.6 billion[9]. Progress in the field of energy efficiency, even significant, will not be sufficient to meet rising electricity demand (which is growing faster than energy demand).

The IEA[10] scenarios, although ambitious in terms of energy efficiency, predict an increase in electricity demand by 2050 from 80% (warming to 2°C, 2DS scenario) to 130% (warming to 6°C, 6DS scenario), which is mainly driven by emerging economies.

The fight against climate change should not jeopardize the development of emerging countries: 1.2 billion[11] people - the equivalent of the population of India or Africa – do not have access to electricity. And 2.8 billion use wood or other biomass products for cooking and heating, which creates pollution that is harmful for human health.

The main emitters of CO_2 in the world, China and India, are among these emerging countries. In both countries coal represents respectively 70% and 80% of total electricity

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5 IPCC Working Group III Report: http://ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf
6 Energy Technology Perspectives 2014, IEA
http://www.iea.org/publications/freepublications/publication/EnergyTechnologyPerspectives_ES.pdf
7 *Carbon brief* http://www.globalcarbonproject.org/carbonbudget/14/hl-compact.htm
8 Energy Technology Perspectives 2014, IEA
http://www.iea.org/publications/freepublications/publication/EnergyTechnologyPerspectives_ES.pdf
9 United Nations http://esa.un.org/wpp/documentation/pdf/wpp2012_press_release.pdf
10 Technology Roadmap 2014, IEA http://www.iea.org/publications/freepublications/publication/technology-roadmap-nuclear-energy-1.html
11 World Bank http://documents.banquemondiale.org/curated/fr/2013/01/17747859/global-tracking-framework-vol-1-3-resume-general

production. These countries have mastered nuclear technology. Therefore, the development of their nuclear plants must be encouraged for them to meet their climate targets.

The IPCC identifies three types of carbon-free electricity: renewables, nuclear and CCS

Nuclear power is a low-carbon energy source. Throughout its life cycle (construction, operation, decommissioning) its emissions are comparable to those of renewable energy sources. Nuclear power emits an average of 15g CO_2/kwh[12].This is thirty times less than gas (400g/kwh), 50 times less than coal (700g/kwh), the same level as wind power (11g/kwh) and three times less than the photovoltaic (45g/kwh).

Nuclear and renewables have proven to be effective. By contrast, the IEA considers that CCS (Carbon Sequestration and Capture) had developed "slowly, due to high costs and a lack of political and financial commitment."

Electrification is an effective vector for decarbonizing[13]

Electricity is required to replace fossil fuels in many sectors (e.g. housing and transport) thereby reducing CO_2 emissions. To achieve global climate targets, the IEA recommends that electricity account for 25% of the energy mix (compared to 17% today)[14] by 2050.

In the transport sector, the second largest CO_2 emitter, deployment of rail transport using low-carbon electricity significantly reduces the consumption of oil and coal, pending the development of electric vehicles. In buildings, the development of low-carbon electricity is also an important means of reducing CO_2 emissions.

It is urgent to use now all available low-carbon energy sources

70% of the carbon budget has been consumed: it is time to act

Once released, CO_2 remains in the atmosphere for a long time.

The IPCC has defined a "carbon budget"[15] of cumulative CO_2 emissions that must not be exceeded if we are to contain average global warming to 2°C. It is estimated that a total of 2,900 billion tons will have been emitted between the start of pre-industrial era to 2050.

2000 billion tons have already been released into the atmosphere, with a strong acceleration recorded in recent years (1000 billion tons in 40 years). It is, therefore, necessary to initiate immediate reduction efforts, without waiting for future technologies that will contribute in proportion to their availability.

[12] NEEDS projects, 2009
[13] Energy Technology Perspectives 2014, IEA
http://www.iea.org/publications/freepublications/publication/EnergyTechnologyPerspectives_ES.pdf
[14] 2DS Scenario of the IEA
[15] Carbon Brief according to the IPCC data: http://www.carbonbrief.org/blog/2014/11/six-years-worth-of-current-emissions-would-blow-the-carbon-budget-for-1-point-5-degrees/

Nuclear energy is an available, low-carbon and efficient industrial solution

With 438[16] nuclear reactors in operation, nuclear energy is available in 30 countries.

Nuclear power has demonstrated its effectiveness. Currently, only six countries meet or exceed the recommendations of the IPCC electricity mix (80% of low-carbon electricity). Four of them - Switzerland, Sweden, France and Brazil - have a mix including a notable share of nuclear power. 40% of electricity from Switzerland and Sweden comes from nuclear. In France[17] the total is 77%. For its part, Brazil has two nuclear reactors.

In OECD countries nuclear energy is the primary source of low-carbon electricity: we must preserve this asset to achieve our climate goals

In the US, nuclear power accounts for 66% of the low-carbon electricity generated. Of the hundred in operation, 75 reactors have already been allowed to operate for 60 years.

In the European Union, nuclear energy accounts for more than half of all low-carbon electricity. Finland, the Netherlands, the United Kingdom, Sweden and Switzerland have also launched programmes to extend the lifetime of their reactors. In France, EDF intends to complete the renovation of its 58 reactors, and to have them operate safely beyond 40 years.

Extending the operating lifetime of the existing nuclear fleet is undeniably interesting because it permits the use of an efficient industrial resource that has broken even, and enables efforts to reduce CO_2 emissions to be concentrated on the share of energy consumption from fossil fuels.

Japan still has 48 nuclear reactors. Their shutdown after the Fukushima accident led the country to increase the share of fossil fuels in its energy mix, to 85%, the opposite of what is recommended by the IPCC. Japan's CO_2 emissions increased by 6% in 2012. It had to 'decommit' from meeting its targets as set by the Kyoto Protocol. The restart of some reactors could enable Japan to reduce its CO_2 emissions.

Nuclear power is a solution for supporting low-carbon growth in emerging countries

In 2050, the six largest economies will be the United States and the "BRICS" (Brazil, Russia, India, China and South Africa). All already operate nuclear reactors and have ambitious nuclear programmes. In China, more than 20 reactors are under construction[18]. According to IEA[19], to achieve its climate goals, China alone is expected to account for a third of the world's nuclear fleet by 2050.

For these countries economic development is essential. For growth to be low-carbon, such development should support China's nuclear energy programme.

[16] IAEA 2014 http://www.iaea.org/About/Policy/GC/GC58/GC58InfDocuments/English/gc58inf-6_en.pdf
[17] RTE, 2014 http://www.rte-france.com/sites/default/files/bilan_electrique_2014.pdf
[18] IAEA 2014 http://www.iaea.org/About/Policy/GC/GC58/GC58InfDocuments/English/gc58inf-6_en.pdf
[19] 2DS Scenario of the IEA

Nuclear power will continue to be an asset for reducing CO_2 emissions

According to IEA[20] since 1971 nuclear power has enabled the avoidance worldwide of the equivalent of two years of CO_2 emissions. This is to date the most significant contribution made by low-carbon energy sources[21]. By 2040, nuclear power could have saved the equivalent of four years of CO_2 emissions.

In Europe, nuclear power avoids annual CO_2 emissions equivalent to those produced every year by all the cars on the roads in Germany, Spain, France, the United Kingdom and Italy[22] put together.

Each country needs access to the widest possible portfolio of low-carbon technologies

Very few scenarios without nuclear manage to stay below the 2°C threshold

Only 8 of the 1,200[23] scenarios recorded and evaluated by the IPCC simultaneously promote the limiting global warming to 2°C and the phasing out of nuclear power. In an open letter[24] published in late 2013, four major climate scientists stated: "*There is no credible way to climate stabilization that does not include an important role for nuclear energy*"….*we cannot afford to turn our back on any technology".*

According to the 2DS scenario, which is considered to be its most effective blueprint for keeping to the target of a 2°C rise, the IEA forecasted that gross nuclear capacity could be more than doubled by 2050, from its current level of around 400 GWe to 930 GWe. This corresponds to an increase in the share of nuclear power in the global energy mix from 11% to 17%[25].

For each country involved in the fight against climate change all national objectives and specific characteristics must be integrated

Generally speaking, energy policies pursue several objectives: economic and territorial development, security of supply, energy efficiency, purchasing power, industrial development, etc. Each country has to deal with a wide variety of constraints in terms of natural resources, infrastructure, skills, public opinion, transport networks and distribution and electricity demand.

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[20] World Energy Outlook, IEA, 2014
http://www.iea.org/newsroomandevents/pressreleases/2014/november/signs-of-stress-must-not-be-ignored-iea-warns-in-its-new-world-energy-outlook.html
[21] World Energy Outlook, IEA, 2014
http://www.iea.org/newsroomandevents/pressreleases/2014/november/signs-of-stress-must-not-be-ignored-iea-warns-in-its-new-world-energy-outlook.html
[22] Eurostat, 2014
[23] Report of the IPCC Group III: http://ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf
[24] Washington Post, 2013
http://www.columbia.edu/~jeh1/NuclearPowerInClimateBattle.WashingtonPost_2013.11.03.pdf
[25] World Energy Investment Outlook, IEA, 2014
http://www.iea.org/newsroomandevents/pressreleases/2014/june/name,72035,en.html

For the COP 21 talks in Paris each country will have to submit its national contribution to the overall global effort to reduce carbon emissions. To succeed, it is necessary that countries have access to the broadest possible portfolio of low-carbon energy options, which will allow them maximum flexibility to meet national challenges and contribute to the global objective.

Nuclear energy reduces CO_2 emissions, while helping to improve security of supply and economic security

Nuclear energy can contribute significantly to the energy security of a country, as it reduces its need to import coal and gas.

Unlike fossil fuels, whose prices are subject to significant fluctuations, the production costs of nuclear energy are stable over time. This represents genuine economic security for States and economic players alike.

In electrical systems the production profiles of nuclear energy and renewables are complementary

The use of renewable energy sources for electricity generation, including hydropower, provides countries with a solution - to varying a degree - depending upon each country's available resources. Nuclear power offer's another solution for countries that can and want to develop it. Intermittent and "controllable" sources complement each other to ensure the optimal use and flexibility of power systems.

Nuclear, hydro, bio-electricity and geo-electricity afford very high levels of availability (operating 24 hours a day with programmed maintenance shutdowns). They offer services that allow systems to accommodate the variability of solar and wind energy.

In tropical and equatorial areas, where air conditioning is developed, the production of solar electricity is highest during peak demand hours. By combining solar and nuclear the development of an electricity generating fleet with very low CO_2 emissions can be achieved.

In about 15 to 20 years' time, innovative multi-energy systems, including renewables and nuclear power (cogeneration, heat and power coupling, coupling with electrolysers), will facilitate the broader use of low-carbon electricity by harnessing new applications, such as carbon-free heat, biofuels, electric and hydrogen mobility, (bio)gas networks, storage services, etc.

Over the next 35 years the technology portfolio will have been expanded to include storage, renewables and Generation IV reactors

Just as today it is essential to apply the widest possible portfolio of low-carbon solutions, so will it be possible by 2050 to have access to a broad portfolio of new technology solutions, including electricity storage, new renewable energy sources and nuclear.

One deliverable that it is expected to emerge from COP21 is the provision for the nuclear industry of a calm environment that will help stimulate innovation, promote more efficient

energy solutions, give rise to even greater safety standards, and facilitate the production of less waste.

Research into Generation IV reactors is already well advanced, and France is one of the leaders in this field.

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