Judge Nuclear

Nuclear power is a technology that is available today, has very low greenhouse gas emissions and could be expanded substantially to reduce future emissions.

Nuclear power has very low greenhouse gas emissions and, according to the Intergovernmental Panel on Climate Change's (IPCC) analysis, it has the largest mitigation potential at the lowest average cost in the energy supply sector.

These are the merits on which nuclear power should be judged in climate change deliberations.

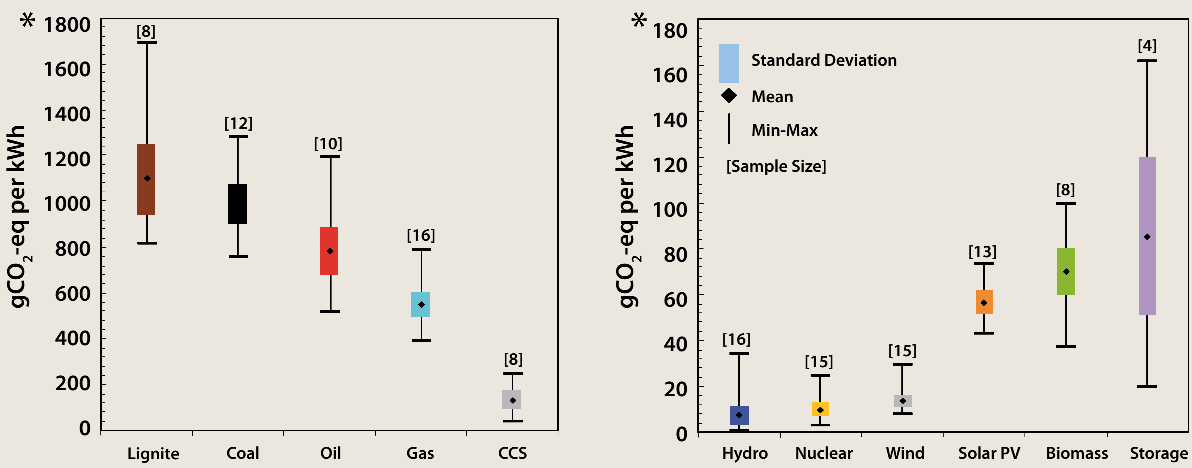
Yet nuclear power is currently excluded from the Clean Development Mechanism and Joint Implementation. Such exclusion is not based on climate concerns.

The Clean Development Mechanism (CDM) and Joint Implementation are two 'flexible mechanisms' included in the Kyoto Protocol to the United Nations Framework Convention on Climate Change to help countries meet their treaty-specified targets in limiting or reducing greenhouse gas emissions. Through the CDM, a country with a treaty-specified target (i.e. most developed countries) can partly meet that target by investing in a project that cuts or eliminates greenhouse gases in a country without a treaty-specified target (i.e. most developing countries). Joint Implementation (JI) is the same thing except between countries that both have treaty-specified targets. Nuclear power projects are explicitly excluded from consideration under both the CDM and JI.

The underlying concerns about nuclear power are that it could be unsafe, uneconomic, or associated with weapons production. But negotiations on climate change are not the appropriate forum to deal with any of these concerns.

As regards safety, the Convention on Nuclear Safety provides an effective international mechanism for review. To judge costs, it is investors who are best equipped to forecast what will be economically attractive now and in the future. And, as concerns proliferation, there is in place the now indefinitely extended Nuclear Non-Proliferation Treaty (NPT), and the growing adherence to the Additional

Fig. 1: Life Cycle GHG Emissions for Selected Power Generation Technologies



**NB: The vertical scales in the two figures differ by a factor of ten.*

Note: [WEISSER, D., A guide to life-cycle greenhouse gas (GHG) emissions from electric supply technologies, Energy 32 (2007) 1543–1559]. Left panel: fossil technologies. Right panel: non-fossil technologies.

on its Merits

by Hans-Holger Rogner, Ferenc L. Toth and Alan McDonald

Protocol that further strengthens the safeguards agreements under this Treaty.

The UN Commission on Sustainable Development has concluded that although countries disagree on the role of nuclear power in sustainable development, "[t]he choice of nuclear energy rests with countries". It is not for climate change agreements to remove that choice.

The best chance for sustainable development — for meeting the needs of the present without compromising the ability of future generations to meet their needs — lies in allowing those future generations to make their own decisions about energy supply options, and allowing these options to compete on a level playing field.

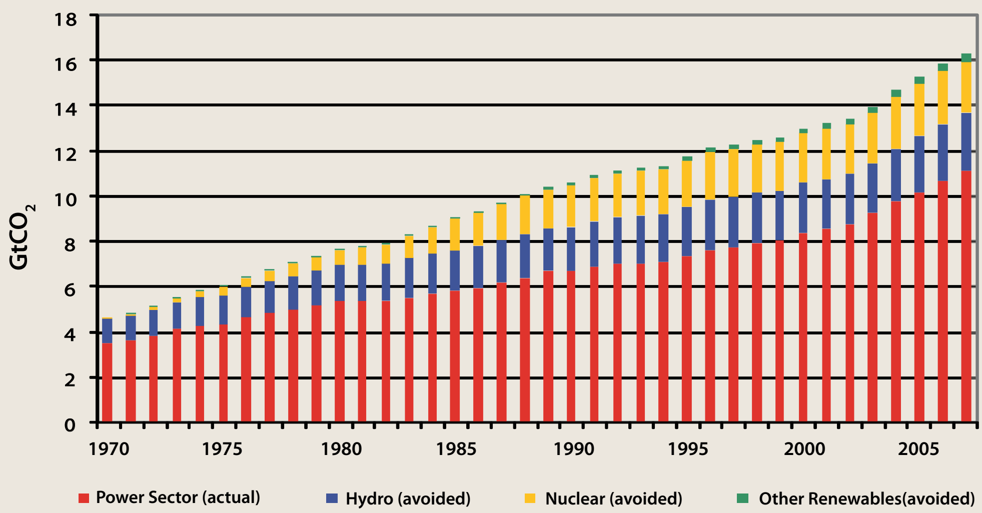
Very Low Greenhouse Gas Emissions

Figure 1 compares greenhouse gas (GHG) emissions from the full nuclear power life cycle — mining uranium; making fuel; building, operating and decommissioning the power plant; and dealing with the waste — to life-cycle emissions from other power generation technologies. Note that the scale in the panel on the right, for non-fossil technologies, is smaller. It only goes from zero to 180 grams of carbon dioxide equivalent per kilowatt-hour (gCO_2-eq/kWh). The scale for fossil fuels in the left panel goes all the way from zero to 1800 gCO_2 eq/kWh.

Hydropower, nuclear power and wind power have the lowest life-cycle GHG emissions, more than an order of magnitude below fossil-fuel power plants and two thirds below the estimates for solar photovoltaics and biomass. For nuclear power, the mean is approximately 10 grams of carbon dioxide equivalent per kilowatt-hour (gCO_2-eq/kWh), a figure derived from 15 estimates ranging from 2.8 to 24 gCO_2-eq/kWh. However, because of their intermittent nature, many renewables cannot provide reliable baseload electricity.

Thus, while wind and solar power can complement baseload generation, they cannot fully substitute hydroelectric and nuclear power.

Fig. 2: Global CO_2 Emissions from the Electricity Sector and Emissions Avoided by Three Low Carbon Generation Technologies



Source: IAEA calculations based on OECD International Energy Agency, World Energy Statistics and Balances: Energy Balances of Non-OECD Member Countries, OECD, Paris (2008).

Most of the GHG emissions come from fuel cycle activities 'upstream' of the power plant, including uranium mining, milling, enrichment and fuel fabrication.

Most of the variation in nuclear power's estimates comes from different assumptions about the technologies used to enrich uranium, specifically whether gaseous diffusion or centrifuge technology is used and what electricity source is used to power the enrichment plant. Centrifuge technology needs only 2% of the electricity needed by gaseous diffusion plants, and if the electricity for enrichment is assumed to come from coal-fired power plants, estimated GHG emissions are high; if it is assumed that nuclear power, hydropower and wind power delivers electricity for enrichment, estimated emissions are low.

As centrifuge plants continue to displace retiring gaseous diffusion plants and as more of the power for enrichment plants comes from low-carbon electricity, GHG emissions from the nuclear power life cycle will tend toward the lower end of the range shown in Figure 1.

GHG Emissions Already Avoided by Nuclear Power

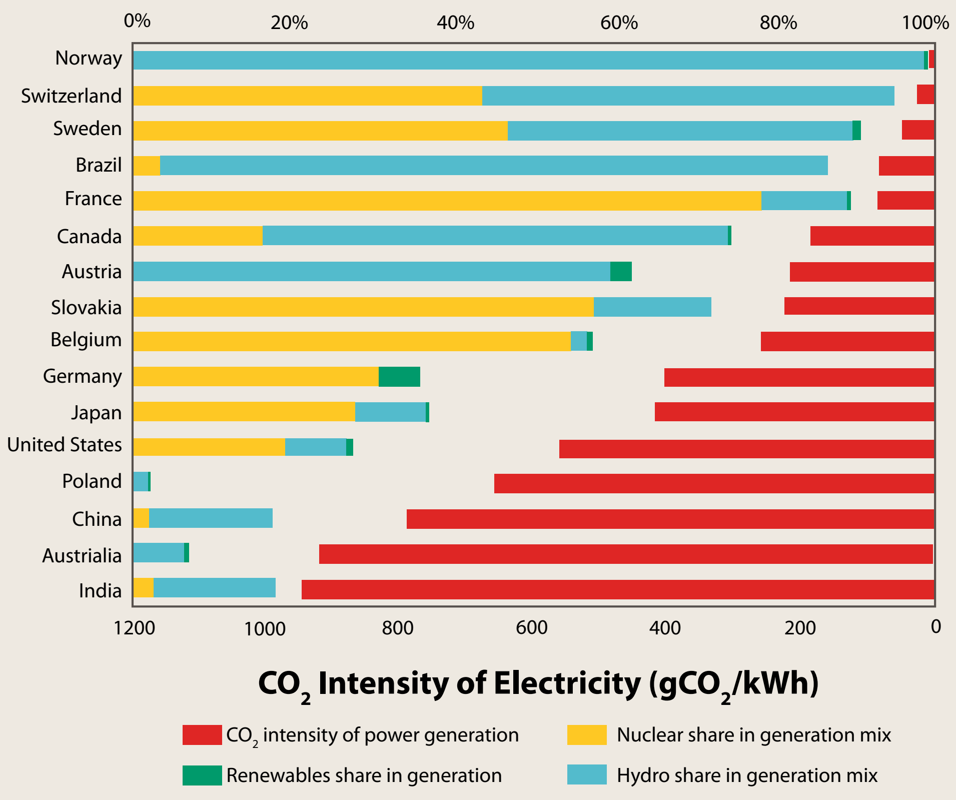
Nuclear power has been part of the world's electricity supply for over 50 years. Today, there are 437 power reactors in operation around the world, and since the mid-1980s, nuclear power's share of global electricity production has been 14 to 16%. Thus nuclear power has already avoided significant GHG emissions, about the same as the emissions avoided by hydropower.

The red bars in Figure 2 show the historical trend of CO_2 emissions from global electricity generation. In 2007, for example, global CO_2 emissions from electricity generation were about 11 gigatonnes (Gt). But without renewables, hydropower and nuclear power, they would have been an estimated 16.4 Gt.

Such estimates of avoided emissions depend very much on what one assumes would have produced the replacement electricity in the absence of renewables, hydropower and nuclear power. For the estimates in Figure 2, it was assumed that the electricity generated by these three sources would have been produced by increasing the coal, oil and natural gas fired generation in proportion to their respective shares in the electricity mix. This approach probably underestimates the emissions avoided by nuclear power in the 1970s and early 1980s. Many of the new nuclear plants built after the oil crises of the 1970s were intended to reduce oil and gas dependence, and coal plants would more likely have been built in their absence than a proportional mix of coal, oil and gas.

Figure 3 shows, at the national level, the correlation between low CO_2 emissions and high shares of hydropower or nuclear power. The chart shows that countries with CO_2 intensities that are less than 20% of the world average, i.e. less than 100 gCO_2/kWh, generate 80% or more of their electricity from either hydropower (e.g. Norway and Brazil) or nuclear power (e.g. France) or a combination of the two (e.g. Switzerland and Sweden).

Fig. 3: Shares of Non-Fossil Sources in the Electricity Sector and CO_2 Intensities for Selected Countries in 2006



Source: IAEA calculations based on OECD International Energy Agency, CO_2 Emissions from Fuel Combustion, Vol. 2008 release 01.

At the other end of the scale, countries with high CO_2 intensities of 800 gCO_2/kWh or more have either no nuclear or hydropower in their electricity mix (e.g. Australia) or only limited amounts (e.g. China and India).

Large GHG Avoidance Potential for the Future

The Fourth Assessment Report of the IPCC estimates the future GHG mitigation potential of various electricity options, specifically fuel switching among fossil fuels, nuclear power, hydropower, wind power, bioenergy, geothermal, solar photovoltaic, concentrating solar power, as well as coal and gas with CO_2 capture and storage. The IPCC analysis starts with the reference scenario in the World Energy Outlook 2004, published by the OECD/International Energy Agency. It then estimates the GHG emissions that could be avoided by 2030 by adopting various electricity generating technologies in excess of their shares in the reference scenario.

The analysis assumes that each technology will be implemented as much as economically and technically possible, taking into account practical constraints such as stock turnover, manufacturing capacity, human resource development and public acceptance. The estimates indicate how much more of each low carbon technology could be deployed at different cost levels (relative to the reference scenario).

The costs are the difference between the cost of the low carbon technology and the cost of what it replaces. The estimates are shown in Figure 4 for technologies with mitigation potentials of more than 0.5 $GtCO_2$-eq. The width of each rectangle in Figure 4 is the mitigation potential of that technology for the carbon cost range shown on the vertical axis. Each rectangle's width is shown by the number directly above or below it. Thus, nuclear power (the yellow rectangles) has a mitigation potential of 0.94 $GtCO_2$-eq at negative carbon costs plus another 0.94 $GtCO_2$-eq for carbon costs up to \$20/tCO_2. (Negative cost options, in the IPCC report, are those options whose benefits such as reduced energy costs and reduced emissions of local and regional pollutants equal or exceed their costs to society, excluding the benefits of avoided climate change). The total for nuclear power is thus 1.88 $GtCO_2$-eq.

The figure indicates that nuclear power has the largest mitigation potential at the lowest average cost in the energy supply sector. Hydropower offers the second cheapest mitigation potential but its size is the lowest among the five options considered here.

The mitigation potential offered by wind energy is spread across three cost ranges, yet more than one third of it can be utilized at negative cost. Bioenergy also has a significant total mitigation potential but less than half of it would be available at costs below \$20/tCO_2-eq by 2030.

Conclusion

With 60 countries considering introducing nuclear power in their energy mix, its role on the world's stage is set to grow. It is important that post-Kyoto agreements judge nuclear power on its merits with respect to climate change, and include nuclear power projects in the Clean Development Mechanism and Joint Implementation.

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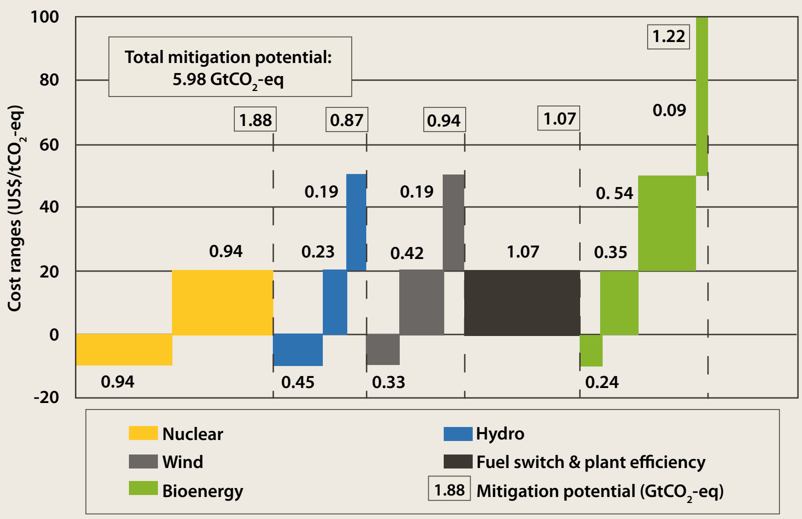
Fig. 4: Mitigation Potential in 2030 of Selected Electricity Generation Technologies in Different Cost Ranges



Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A., Eds), Cambridge University Press, Cambridge (2007).