THE ENERGY MIX FOR THE NEXT GENERATION: WITH OR WITHOUT NUCLEAR?

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ABSTRACT

This paper has been prepared as a contribution to the ongoing debate on nuclear energy and sustainable development. Some of the supporters of sustainable energy systems do not see nuclear power as part of the future: an UNDP (United Nations Development Program) document "Energy after Rio" suggests a role for nuclear power in a sustainable energy future in very doubtful terms; the Swedish Parliament's February 1997 law launching the phase out of nuclear power is entitled "Government Bill on a Sustainable Energy Supply"; many environmental organizations underlined the incompatibility of nuclear power and sustainable energy systems; the European Parliament recently excluded nuclear power from the energy sources that can fit into flexibility mechanisms because of its unsustainability. The supporters of nuclear power see climate change concerns as a way to revitalize interest in nuclear power. They call for a significant role of nuclear power in sustainable energy systems mainly because it does not emit any CO_2. Member countries of International Energy Agency (IEA) recognize the potential contribution of nuclear power to a sustainable energy mix. The Nuclear Energy Agency of OECD recognizes the potential role of nuclear power in sustainable development. In the framework of the United Nations Convention on Climate Change, the nuclear industry as a Non Governmental Organization (NGO) involved in the climate negotiations, emphasizes the role of nuclear power in reducing the greenhouse gas effect. In this debate, radioactive waste is the main argument against the sustainability of nuclear power whilst the fact that nuclear power does not produce emissions of airborne pollutants or CO_2 is used to argue that it can be a great contributor to sustainable energy systems. Our purpose is to go further in the debate: sustainability is not only about climate change and the role of nuclear power in achieving a "sustainable development" goes further than the reduction of greenhouse gas emissions.

THE CONCEPT OF SUSTAINABLE DEVELOPMENT

Sustainability is not a new concept: it didn't appear with the climate change negotiations, which are in fact the final step of a very long process. The idea that there is a limit on production activity whether nature is treated as a resource or as a receptacle for waste is not a new one.

It was first formally advocated for forestry in the 19th century: sustainable management of the forests means maintaining the fertility of the forests and allowing constant and regular returns, it was necessary to conserve the renewal character of the forest and the fertility of the soil. This first step was "intuitive".

In the early seventies, public opinion became more and more aware of the consequences of human activities on the environment, because of scientific reports (report for the Club of the Rome's project, 1972) and conferences dealing with economic development and the environment on a international level, within the United Nations.

In the 80's, sustainability appears as a worry about the inequity between the North and the South and the risk for the environment and the global economy. It was then formalized and called "ecodevelopment" (Sachs, 1980).

With the Brundtland report (UNCED, 1987) published in 1987 by the United Nations Commission on Environment and Development, the concept of sustainable development was widely disseminated.

It became one of the leading principles of many international and intergovernmental organizations : the United Nations Program for the Environment (UNEP) ; The Maastricht Treaty mentioned it and it was one of the major themes of the Rio Conference. The International Chamber of Commerce has written a chart for companies for sustainable development.

What is new are the mobilization and the consensus both in public opinion and in the political arena about the diagnostic made by the scientific community: the present development path is not sustainable.

We are now at the stage of elaboration of strategies of sustainable development, with international negotiations on climate change representing the most advanced stage of the process.

Sustainable development has become a synonym for the future we want for the next generations: a development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

It brings a new norm of development which refers not only to economic growth but calls for a development in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change enhance both current and future potential to meet human needs and aspirations (WCED, 1987).

Energy can be a great tool for achieving sustainable development; the adequate provision of energy services is a crucial prerequisite for sustainable development. At the same time, energy use is also a main cause of environmental degradation. That's why sustainable development poses constraints on energy futures and choices have to be made.

SUSTAINABLE DEVELOPMENT POSES SOME CONSTRAINTS ON OUR FUTURE ENERGY CHOICES

To meet the sustainability goal, the energy choices must meet the needs of the present generations but in a way that does not prevent future generations from making their own choices.

Energy policies are about technological choices made in the matrix of our social institutions: they may be a decision of consumers that wish to enjoy a new product developed by a technology. It may be a business decision that a particular exploitation of a the new technology will be profitable. It may be a political decision to spend public funds to exploit a particular technological opportunity (Simon, 1973).

Development can't be conceived without changes to the nature of energy flows and every change in these flows has profound implications. There is no such thing as a simple energy choice. They are all complex and they involve trade-offs. Some appear better than others do, depending on what constraints we put on them.

The constraints sustainable development put on energy choices are of many kinds: they are environmental but also physical, economic and political.

The physical constraints seem to be the most obvious: sustainability is supposed to ensure the availability of the energy resources for all within the present generation and for the future generations.

The growth of energy demand in response to industrialization, urbanization and higher living standards has led to an extremely unsustainable distribution of primary energy consumption. The consumption of energy per person in industrial market economies is, for example, more than 80 times greater than in sub-Saharan Africa. And about 20% of the world's population consumes 55% of the world's primary and final energy.

Furthermore, today the richest 20% use three quarters of all electricity while the poorest 20% use less than three percent. (WEC, 1995). In 2020 developing countries are expected to account for 43 percent of the world's total electricity consumption. Long term growth in electricity consumption is expected in the developing economies of Asia, followed by Central and South America; the projected growth rates for electricity consumption averages nearly 5% per year from 1996 to 2020.

In the industrialized economies, annual growth in electricity consumption is expected to reach 1.6% between 1996 and 2020 with continuing penetration of electric equipment in the end-use sectors and despite slowing population growth and higher energy efficiencies (International Energy Outlook, 1999).

It would be unrealistic to expect that present disparities will disappear and that global consumption levels will approach the levels of today's consumption in industrialized countries. However, these disparities combined with population growth will be an important driver of future energy demand and supply.

These paths become even more unfeasible if these energy futures rely to a greater extent on fossil fuels: resulting environmental damage is one of the reasons but moreover, their exhaustion horizon is finite and they have better alternative uses (petrochemicals, plastics, transportation…) with more added value.

Environmental constraints imply energy uses that minimize impacts on the environment but the environmental risks linked to the energy futures are disturbing: for developing countries, air pollution from industrialization caused by the atmospheric pollutants (from the combustion of fossil fuels) has now become a major challenge.

In the industrialized countries, environmental concerns have moved toward very long term and global issues like climate change.

Environmental sustainability calls for technological change to cleaner energy end uses but also to cleaner fuels and waste reducing technologies instead of “end of pipe” solutions.

Economic constraints: sustainability calls for energy costs reflecting both the private and the social cost of the activity of production. That means that the “polluter pay's” principle is applied and external costs are included in the price.

The external costs represent the damage caused by the activity of production and that are not taken into account by society, which means not reflected in the price.

As sustainable development gains momentum, the price of energy is going to reflect the private and the social cost of the activity of electricity production that means internalizing environmental and social costs through expenses for safety, environment protection, plants dismantling….

Political and social constraints: public opinion and evaluation of risk linked to a technology cannot be easily dismissed even when they differ from the expert's assessments. They are respected in democratic societies and they influence political opinion and actual policy choices in the field of energy. They are the choices of consumers but also political decisions to spend public funds to exploit a particular technology.

The other aspect of political sustainability not so often underlined is energy supply security: reliability of physical energy supply is vital in view of the fundamental role energy plays in a nation's economy – reliance on another country for energy puts the recipient in an extremely vulnerable position.

Though it is very difficult to say what the future energy systems will be like, sustainable development, through its associated constraints, gives some indications.

NUCLEAR ENERGY IN SCENARIOS FOR SUSTAINABLE DEVELOPMENT

Sustainable development gives direction to future energy developments but energy systems are complex, their behavior is not always well understood and information is often incomplete. Their evolution is associated with uncertainty and prediction or forecasting remains very difficult.

Scenarios are neither predictions nor forecasts but useful tools for investigating alternative energy developments and their implications Scenarios are images of alternative futures. Scenarios are not value-free and we often distinguish between the descriptive and the normative ones. The first explore paths into the future without any preconceived endpoint; the second are explicitly value-based and explore the paths to desired or undesired endpoints.

During the last three decades, there have been a number of global studies that have used scenarios as a tool to assess future energy system development paths.

They cover a wide range of alternative future developments but despite the diversity of the images, the World Energy Council identifies some trends allowing us to foresee the direction in which energy consumption is headed (WEC, 1995):

- World energy needs will increase with population growth and economic development: people will want higher levels of more efficient and cleaner energy services. The WEC study expects a one and a half to three-fold increase in primary energy requirements by 2050 and a two to five fold increase by 2100.
- The question of what kind of energy sources will supply this demand is wide open but the energy end-use patterns will converge with a shift toward electricity and higher quality fuels and a shift away from non commercial use of biomass and coal.
- Environmental concerns, technology needs and political reasons could be a constraint on the resource availability. Pollution will reach unsustainable levels and the natural capacity of the environment to absorb higher levels of pollution will become a limiting factor for the unconstrained use of fossil fuels.

All these factors will lead to the decarbonization of the energy system; that means lower adverse environmental impacts which translates directly to less CO_2 emissions.

Among all the futures described by the scenarios, energy scenarios for sustainable development describe desirable energy futures achievable but with fundamental changes or major paradigm shifts.

These scenarios can be characterized by low environmental impacts on all scales and a better allocation of resources and wealth compared to the current situation. The number of global studies that consider futures with radical policy and behavioral changes to achieve a transition to a sustainable development is increasing.

The World Energy Council (WEC, 1993, 1995) formulated one of the most influential series of scenarios that included the assessment of sustainable development. The Intergovernmental Panel on Climate Change (IPCC) has developed a set of scenarios that gave a very detailed treatment to energy sector developments; some of them describe futures that include elements of sustainable development. The European Commission (DGXVII) in its report 'European Energy to 2020' developed scenarios that provide a comprehensive and detailed view of how coherent energy policies, adopted on an international basis, can affect environmental and economic trends.

These scenarios illustrate the alternative development paths in the structure of the energy system that might characterize the next transition; they all lead to a partial shift from fossil fuels to other sources of energy. They all incorporate challenging policies to protect the environment and enhance economic equity leading to growth, especially in the South.

In most of these scenarios, we observe a shift from fossil fuels to renewable and nuclear options and very high levels of energy efficiency. Environmental impacts are therefore quite low as a result of the energy mix and environmental control technologies and policies, including incentives to encourage efficient use and production of energy, green taxes, international agreements and technology transfer.

In the WEC scenarios, only the “ecologically driven” case C scenario (with two variants C_1 and C_2) leads in 2100 to the level of emissions recommended by the IPCC to stabilize greenhouse gas concentration in the atmosphere (60% fall from 1990 levels).

The C_2 variant characterizes a future with nuclear and renewables meeting more than half of the energy demand. Nuclear energy finds widespread social acceptability, provided with small reactors (150 to 250 Mwe), well suited to areas of scarce land resources and high population densities that limit the potential supply from renewables.

With nuclear and renewable energy sources providing a third of energy needs, the Forum scenario of the European Union shows that carbon dioxide emissions in Europe can be reduced in 2020 to 89% of 1990 levels. This scenario, simultaneously reduces world-wide CO_2 emissions and brings us one step further towards a sustainable future.

The LESS (Low CO_2 Emitting Supply System) scenarios of IPCC (IPCC, 1995) illustrate the potential for reducing emissions by using various combinations of low CO2 emitting energy supply technologies, including renewable or nuclear energy sources, as in the "Nuclear Intensive" case. A central finding of this study is that large reductions in CO_2 emissions from the energy sector are technically possible within 50 to 100 years, using alternative strategies. This large number of combinations allows for flexibility as to how the energy supply system could evolve and shows that political, environmental and socioeconomic circumstances could have a great influence.

Looking at the directions identified by the WEC study and at the constraints sustainability puts on energy systems, we can see that renewables and nuclear energy will be the main components of the energy supply system that will both meet the higher level of future energy demand and the requirements of sustainable development.

NUCLEAR ENERGY AND SUSTAINABLE DEVELOPMENT

There are several links between nuclear energy and sustainable development and climate change is just one of them and refers to the environmental dimension.

- Environmental sustainability: as a CO_2 avoidance technology, nuclear energy contributes to sustainable development by generating 16% of the world's electricity and thereby avoiding each year the release of some 1.8 billion tons of CO_2 world wide.

Furthermore, nuclear wastes are manageable. The small amount of nuclear waste produced annually is easily identified and detected, and can be sorted into well defined categories of waste which then undergo the appropriate treatments. The waste becomes less toxic with time and due to the substantial investments that have been made on both a national and international scale; it is now technically and economically possible to isolate it from the environment.

From the very beginning, the nuclear industry has faced up to its responsibilities towards society, the environment and future generations; it has adopted a waste management policy, which meets the highest safety requirements. Reducing the volume of waste and ensuring its effective disposal is an integral part of this management program. An example of this is the RCR option (reprocessing-conditioning-recycling) which allows both the volume of waste and the final radiation level of the waste to be reduced (the closed cycle produces $0.5m^3$/tonU of waste).

Among the electricity technologies, nuclear is the one for which the environmental expenses (safety, waste management, plants dismantling) are the highest. They represent 15 to 45% of the total cost of electricity production versus 0 to 9% for gas and 12 to 42 % for coal, mainly measures to control NOx et SO_2 emissions (OCDE, NEA, 1998).

- Physical sustainability: uranium resources are abundant and diversified. According to the OECD/NEA, known uranium reserves represent 90 years of consumption at present levels though this can be easily increased if other sources are taken into consideration such as phosphate deposits or sea water which both contain uranium at low concentrations.

Recycling uranium and plutonium can also extend uranium resources. In fast neutron reactors, plutonium is produced as a by-product of electricity generation; this can further increase resources by up to 2500 years at current consumption levels.

- Economical sustainability: in electricity production, external costs of fossil fuels are quite substantial and related, for the main part, to climate change.

Nuclear, in contrast, is seen to generate very small external costs. There is no external climate impact from nuclear power and the cost to society from nuclear accidents – exceedingly rare – are taken into account in the assessment, becoming barely perceptible when spread across all the kilowatt-hours produced: 1.6cF per kWh versus 10.4cF/kWh for coal and 7.3 cF/kWh for gas (ExternE, DGXII, 1994).

The cost of nuclear kWh is the one which best reflects the social costs of electricity production. It includes costs of treatment and other expenses for safety and environment.

In the face of deregulation and an increasingly competitive market place, nuclear's competitiveness will be enhanced if all other energy sources incorporate external costs in the price.

- Political and social sustainability are key issues for nuclear energy and pose major constraints on it. Uranium reserves are however well distributed throughout the world, with large ore deposits in what are generally regarded as politically stable countries e.g. Australia (27%), Canada (13%), USA (5%), and to some extent Africa (9%). Substantial reserves also exist in the CIS. This distribution of resources allows for diversity in fuel suppliers and avoids potential conflicts resulting from the geographical concentration of oil reserves.

At the same time, one must acknowledge that nuclear energy has to face opposition from public opinion or/ and policy makers, based on a mixture of valid concerns combined with fundamental misperceptions.

CONCLUSION

Climate change is one of the challenges energy systems will have to face to be sustainable. But they must satisfy many other criteria: other aspects of environmental sustainability, economic viability, accessibility of

resources, energy security and social and political acceptance.

Nuclear industry, since the beginning, is engaged in the process of increasing flexibility and cost effectiveness and developing wastes processing and disposal technologies to decrease their volumes and their radiotoxicity.

Lack of acceptance by the public as well as by policy makers continues to be the major hurdle for nuclear development. So the problems are not technical ones: they are more about achieving public acceptance and policy makers' adhesion.

To satisfy the world's growing need for large base-load power production without exacerbating the hazards of environmental damage, nuclear energy will be needed but the public's assessment of the risk related to this technology will be the ultimate determinant of the final choice.

The real challenge for nuclear industry is to give the public a full and impartial assessment of the benefits, costs and risks involved.

Communication will be our main task if we want nuclear energy to be part of the energy mix for the future generations.

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