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2010

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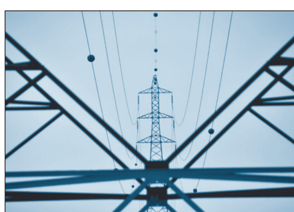
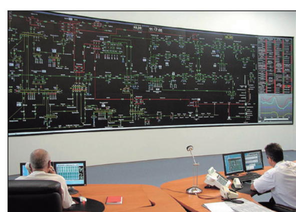
The Security of Energy Supply and the Contribution of Nuclear Energy

Executive Summary

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NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Executive Summary

THE SECURITY OF ENERGY SUPPLY AND THE CONTRIBUTION OF NUCLEAR ENERGY

E.1 Security of energy supply in the OECD area

The continuous availability and affordability of energy and, in particular, electricity supply is an indispensable condition for the working of a well-functioning modern society. This is especially true for advanced industrial or post-industrial societies, where electricity provides the services essential for production, communication and exchange. Unsurprisingly, governments of OECD countries are thus concerned with understanding the factors influencing the security of energy and electricity supplies and seek to develop policy frameworks and strategies to enhance them.

As a domestically produced, largely carbon-free source of electricity nuclear energy is, in principle, well-placed to play a constructive role in this context. However, before proceeding towards the demonstration of the contribution of nuclear energy, the complex concept of "security of energy supply" must itself be defined and made amenable both to the formulation of concrete policy objectives and numerical verification. A general starting point is the following consensus definition:

Security of energy supply is the resilience of the energy system to unique and unforeseeable events that threaten the physical integrity of energy flows or that lead to discontinuous energy price rises, independent of economic fundamentals.

Further analysis shows that "import dependency and diversification", "resource and carbon intensity" as well as "infrastructure adequacy" are three key verifiable parameters that can be derived from this general definition. It is important, however, to keep in mind that these three parameters are not identical with energy supply security but continue to demand qualification and contextualisation in each individual case.

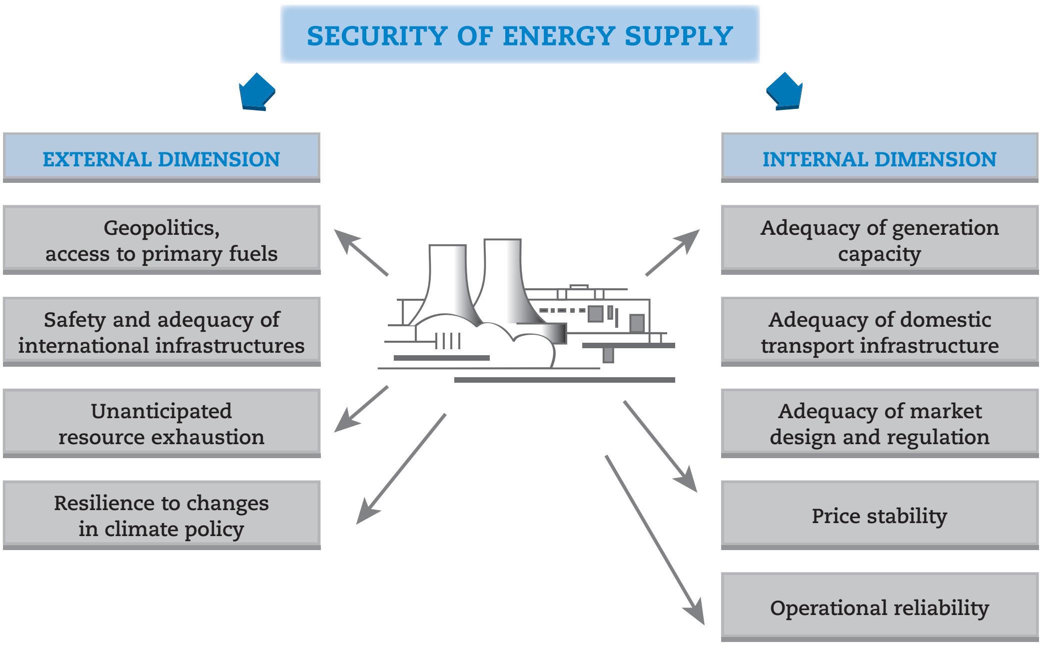
E.2 The importance of electricity and the two key dimensions of energy supply security

The sector in which security of supply issues pose themselves with the greatest insistence is the power sector. The need to balance supply and demand in power markets where electricity is non-storable and demand inelastic has always demanded close coordination between suppliers and the operators of electricity transmission grids.

Energy supply security is a classic example of an externality, i.e. of an issue that affects the well-being of individuals and society but which markets alone are not providing at adequate levels. Being a negative externality, energy supply risk constitutes a policy issue. This means private individuals cannot cover themselves for such risks due to their informational complexity and unquantifiable nature. This is where governments need to step in.

This study focuses on energy supply risks in two dimensions, the external or geopolitical dimension and the internal dimension that includes technical, financial and economic issues as illustrated in Figure E.1.

Figure E.1: Dimensions of energy supply security and the potential contributions of nuclear energy



E.3 The external dimension: import dependence, resource exhaustion and carbon policy

Geopolitical risk refers almost always to primary energy carriers (oil, gas, coal, uranium or renewables) since their location depends on the vagaries of geology and climate. Production and consumption are thus often physically far apart and take place in countries and regions with different histories, cultures and values. Apart from exploration and production, all other steps of the energy chain such as refinement or enrichment, conversion and distribution can be moved physically closer to the final customer or are, like consumption, directly under the latter's control.

Geopolitical energy supply risks are thus a function of relations between producer and consumer countries for which both of them share responsibilities. However, even in the best of cases these relations are very difficult to predict. The issue is further complicated by the fact that the majority of the easily accessible stocks of hydrocarbons are located in potentially unstable regions.[1] There is thus only so much that can be done about the sources of geopolitical supply risk. On the demand side, the best-known strategy is the diversification of supply sources and of transport routes.

1. To some extent such instability is endogenous and not the result of a global geological lottery. Notions such as the "resource curse" or the "Dutch disease" highlight the increased economic and political instability that may affect overly resource-dependent economies. The resulting lack of diversification as well as the allocation of resources to rent capture, rather than productive investment, can thus hamper economic, social and political progress. There exist, of course, counterexamples. Norway is a frequently cited example, but by and large resource dependency does not correlate with geopolitical stability.

Given that the fundamental condition for geopolitical supply risks is the physical separation of the centres of production of primary energy and their consumption, it is tempting to address the issue by striving to bring production home ("energy independence"). Whether this is a good approach depends on a country's geographical position, its own energy endowment, the state of its physical infrastructures for transport and storage, the diversification of its supplies, the willingness of its population to accept higher average long-term prices for lower volatility and a host of other issues.

In an ideal world, security of energy supply would not equate to energy independence or self-sufficiency. Free and global energy trade through smoothly functioning competitive markets would guarantee timely delivery of all necessary energy resources. Most countries are relying at least partially on the international trade of energy and will continue to do so. What is important in this case is not so much the security of the single shipment but rather the security of the system in which both producers and consumers have a stake.

The issue of self-sufficiency does assume though a particular significance in electricity markets, since due to the high costs of storage, electricity can be economically transported only over relatively short distances. In island countries such as Japan and Australia or *de facto* isolated countries such as the Republic of Korea, national electricity generation must be able to cover national demand.

E.4 The internal dimension: economic, financial and technical conditions for energy security

Energy security begins at home. The most important responsibility for OECD governments is setting appropriate framework conditions providing incentives for private actors to install domestically an adequate level of facilities for the production, transport, conversion and consumption of energy. Important elements in this strategy are regulatory stability, market organisation, fiscal coherence and predictability of environmental policy.

The challenge in the electricity sector is the creation of framework conditions that:

- do not discriminate against domestically producing, low-carbon energy sources such as nuclear and renewable energies; and
- allows for the construction of adequate transport, production and conversion capacity with appropriate long-term financial arrangements.

OECD governments thus have a responsibility to create market conditions that allow low-carbon technologies with lower supply risks to compete on a level playing field. Governments also have a role to play with regard to the provision of adequate levels of transport, distribution and conversion capacity. Partly, such capacity can be provided by markets themselves, but in other cases, it requires regulation and supervision. First, regulation must provide sufficiently attractive financial conditions for investment in transport and conversion infrastructure. Second, political backing must support projects that are necessary at the national level against blockage by repeated legal appeals, through appropriate technical regulations and zoning laws as well as adequate mechanisms of consultation, mediation and compensation.

E.5 Different approaches towards designing security of supply indicators

Approaches to assign numeric values to aspects of security of supply risks can be broadly categorised as follows:

- import dependency and diversification of fuel and energy supply;
- resource and carbon intensity; and
- system adequacy.

The first category of security of supply indicators covers primarily the external security of supply dimension, whilst the second and third ones broadly refer to the internal security of supply dimension.

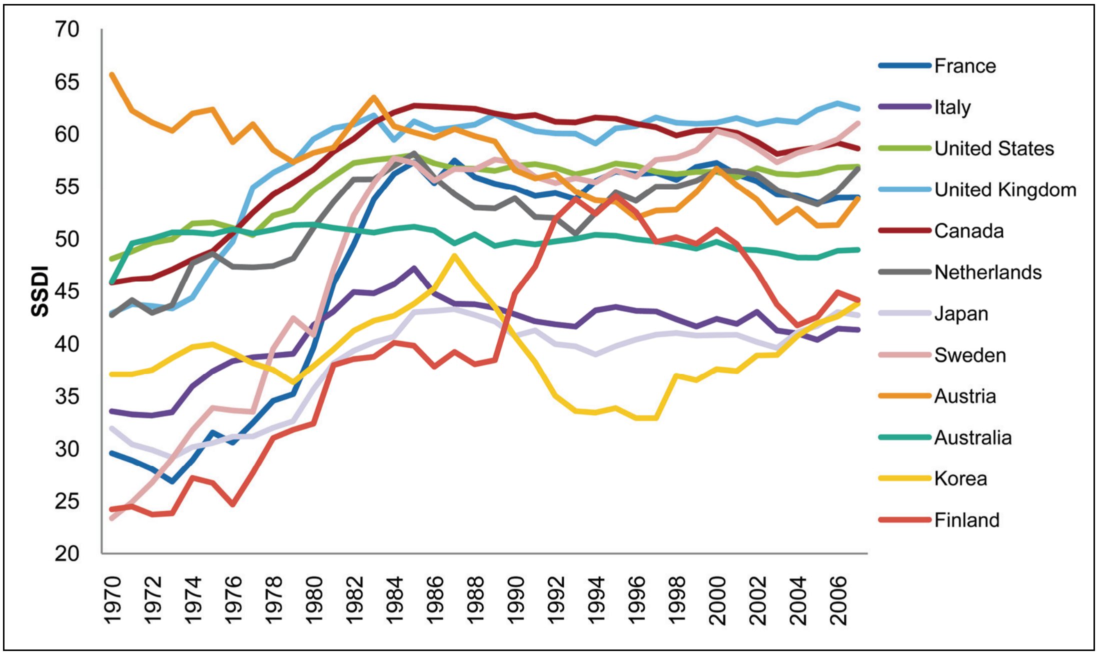
One indicator in particular seems to have substantial merits for the analysis in this report, capturing aspects of all three categories mentioned above. The generalised Simplified Supply and Demand Index (SSDI) is a composite security of supply indicator for a defined region in the medium and long run that includes major underlying supply-side and demand-side factors. This index is normalised to range from 0 (extremely low security) to 100 (extremely high security). It is based on the generalised SSDI but adapted here to be able to work with the only available consistent data set available for the past 40 years, the IEA *Energy Statistics*.

The SSDI is composed of three weighted contributions: demand, infrastructure and supply. These contributions take into account the degree of diversity and supply origin of different energy carriers, the efficiency of energy consumption by the main economic sectors, and the state of the electricity generation infrastructure.

The evolution of the SSDI through time (1970-2007) was analysed for several OECD countries: Australia, Austria, Canada, Finland, France, Italy, Japan, Korea, the Netherlands, Sweden, the United Kingdom and the United States (see Figure E.2). This allows one to track changes in the SSDI and provides an illustration of the security of energy supply of the selected countries for the last 40 years. It enables the identification of changes in the trend when important policy changes have been implemented, such as the United Kingdom's switch from coal to gas or the introduction of nuclear programmes in France and the United States.

One can see that the value of the SSDI has considerably increased between 1970 and 2007 in the case of most economies under study: Australia, Canada, Finland, France, Japan, the Netherlands, Sweden, the United Kingdom and the United States. On the contrary, the value of the SSDI is low or not increasing between 1970 and 2007 for Austria, Italy and Korea. Also, the gap among different countries has decreased. The improvement in the SSDI of a number of these countries coincides with the introduction of nuclear power, while decreases often relate to increases in imports.

Figure E.2: Evolution of the SSDI for selected OECD countries



In the United States, the value of the SSDI is generally high because of large domestic resources of fossil energy suppliers and an important share of reliable imports from Canada. An important increase in the SSDI may be noted in the second part of the 1970s because the energy intensity of the United States economy decreased, and nuclear power plants started to be widely deployed.

E.6 The role of nuclear energy in reducing security of supply risk

Nuclear energy has some distinct advantages in strengthening the external dimension of energy supply security. These include:

- Nuclear power plants produce electricity domestically. Their capital and labour inputs are also provided domestically. With more than 90% of its inputs in terms of value sourced domestically, it can be considered a largely domestic source of energy and electricity.

- Of course, a majority of OECD countries import part or all of their requirements of uranium. However, these imports frequently come from other OECD countries. Even where imports come from non-OECD countries, such supplies are well-distributed globally and have never given rise to security of supply issues in the past.

- Nuclear energy is capable of providing large amounts of baseload power at stable costs and would be unaffected by a sudden tightening of restrictions on the emission of greenhouse gases. Unsurprisingly, the great majority of long-term scenarios interested in the question of sustainable concentrations of greenhouse gas emissions include a large expansion of nuclear power.[2]

2. The influential Stern Report, for instance, advocates a doubling of global nuclear capacity by 2055 to 700 GW as one of the measures to stabilise greenhouse gas concentrations (Stern, 2006, p. 207).

For uranium, the majority of supplies are coming from politically stable OECD countries such as Australia and Canada. The only major geopolitical change in the supply of uranium is rapid mining development in Kazakhstan. According to *Uranium 2009: Resources, Production and Demand*, (NEA/IAEA, 2010), in 2008 Kazakhstan became the second world largest uranium producer (8 512 tU), between Canada (9 000 tU) and Australia (8 433 tU). Nevertheless, one can state that the uranium supplies used in nuclear energy production do not pose any major risk to energy security.

Overall, in the face of geopolitical supply risks, whether due to import dependence, resource exhaustion or changes in the global carbon regime, nuclear energy holds advantages that other fuels such as oil, coal and gas do not enjoy: wide availability of resources for a long time to come, modest impacts of increases in resource prices and resilience against carbon policy shifts.

In terms of internal risks, one needs to consider the investment costs and the functioning of the grid systems. With the first issue, the point is whether nuclear energy has specific characteristics which make it intrinsically a more attractive investment option than other generation technologies, in particular in liberalised power markets with uncertain prices. The joint IEA/NEA study on the *Projected Costs of Generating Electricity: 2010 Edition* provides some general information on the levelised cost of electricity (LCOE) per MWh for different technologies.[3] The report shows that nuclear energy is a very attractive option at real interest rates that are below or only slightly above 5%.

The attractiveness of an investment in power generation, however, is not only defined by its LCOE that corresponds to the average discounted revenue, i.e. the price of a MWh of electricity that would allow the investment in question to break even. One key element is the uncertainty to which investors are exposed. The advantage of nuclear energy in this context is that its average cost remains very stable in the light of changes in the fuel or in the carbon price. In particular, it is protected against fuel price changes by the low proportion of fuel costs in the total lifetime costs of nuclear power generation.

Investors in fossil fuel plants and, in particular, coal-fired power plants are also exposed to carbon price risk: the variation in the price of CO_2 permits, which constitutes a major source of uncertainty for coal-fired power production. Doubling the carbon price, for instance, from USD 30 per tonne of CO_2 to USD 60 per tonne would increase the total average cost of coal-produced power by 30%, more than doubling its variable cost in the process. This is not an unrealistic number. Given current commitments to reduce global carbon emissions by 2050 by 50% in order to limit the rise of global mean temperatures to 2°C, modelling results imply marginal costs for carbon abatement of at least USD 100 per tonne of CO_2 and perhaps much higher.[4]

Some countries in the world are currently showing interest in developing nuclear power to strengthen their level of security of supply. Particular examples are the countries that have decided to phase out nuclear power in the past: Belgium, Italy and Sweden. For countries like Finland, France, Japan and Korea, the increase of the SSDI is partly due to the introduction of nuclear power plants (Figure E.3).

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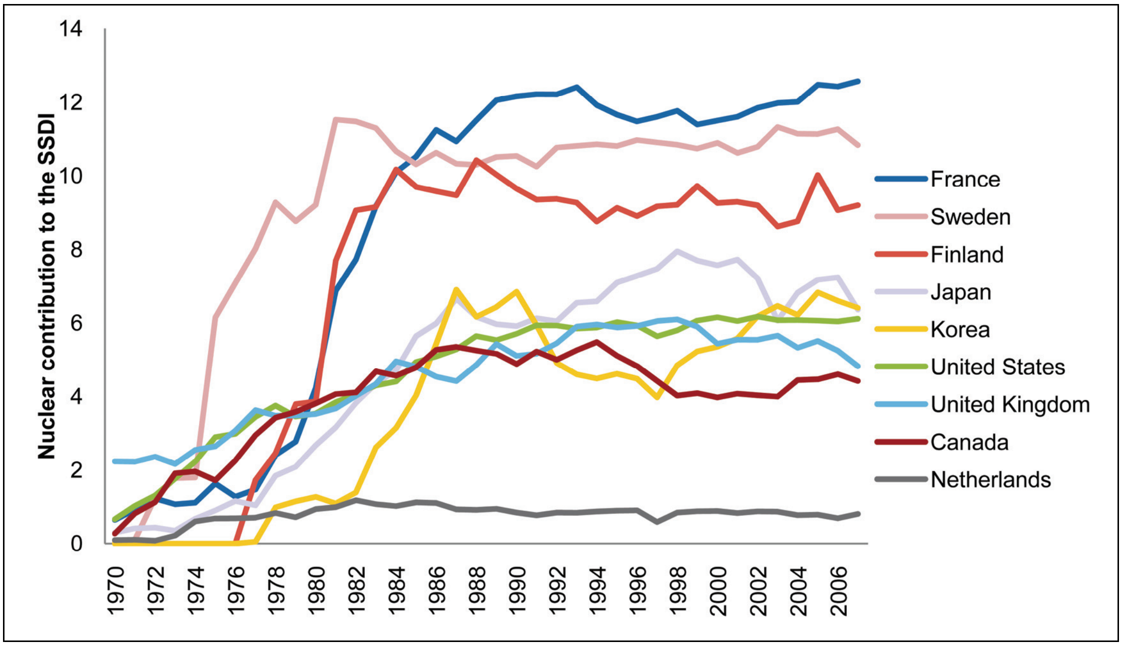
3. The LCOE are calculated by discounting or compounding all costs to the date of commissioning and dividing them by the time value of total production. They thus indicate the discounted average (unit) cost of production. In the present case, the LCOE were calculated including a carbon price of USD 30 per tonne of CO_2.

4. Carbon capture and storage (CCS), on which the future of the coal industry will depend, is currently still a highly uncertain option that has yet to be deployed on an industrial scale.

Figure E.3: The contribution of nuclear power to progress in the SSDI



In the case of France, the contribution of nuclear power to the SSDI was more than 12 points in 2007 (about 30% of the SSDI score), followed by Sweden with 11 points (21%), Finland with 9 points (26%), and Japan and Korea with approximately 6 points (about 17% of the total SSDI score).

E.7 Public concerns over security of supply and the role of nuclear

It is of interest to know how the perceptions of consumers regarding security of energy supply correlate with the indicators of such security. To investigate this idea, *Eurobarometer* opinion polls, issued in 2007 and 2010, were analysed to see the correlation between public concerns and two main indicators:

- import dependency; and
- volatility of energy prices.

Citizens of the European Union (EU) are generally aware of the fact that energy dependency is one of today's most challenging energy questions. Overall, 61% of respondents believe that their country is entirely or very much dependent on energy coming from abroad. EU countries face different situations of energy dependency: Denmark is the only country where energy exports exceed energy imports, while the energy dependence rate is highest in small countries such as Cyprus, Luxembourg, Malta and Portugal. However, the level of awareness is not consistently high. For example, for Ireland, the energy dependency rate is approximately 90%, but only 64% of its citizens are aware of that.

When comparing the respondents' opinions and indicators, one finds that the results of the survey show better correlation between the values of the SSDI discussed previously than with the simple import dependency ratio. For example, the values of the SSDI for the United Kingdom are approximately at the same level as the perceived concern over energy dependency in public opinion polls. This suggests that the public implicitly has quite a good understanding of the complexity of the issue.

This is important for public acceptance of nuclear energy. A study of the correlation between the change in public support for nuclear energy between 2005 and 2008 with the respondents' answers to other questions in the Eurobarometer questionnaire in the same years suggests some insights into the factors that influence public acceptance. In particular, it becomes clear that the benefits of nuclear power in terms of diversification of the energy mix and alleviation of oil dependence were duly appreciated, and progressively more so by Europeans from 2005 to 2008. This in turn has contributed to greater overall support for nuclear power generation.

In Europe, the highest proportions of citizens who say that the share of nuclear energy should be maintained or increased are found in Bulgaria (90%) and Poland (88%), where the possibility of building a first nuclear power plant was recently discussed. Moreover, several countries that in the past shut down or put on hold their nuclear power programmes, but have recently changed their policy, like Italy or the United Kingdom, also display high shares of public support for nuclear energy with 73% and 75% respectively.

The main conclusion is that nuclear's political and social acceptability depends on a good understanding of its benefits to diversification, energy supply security and reductions in greenhouse gas emissions.

E.8 Conclusions

Due to its complexity and the dynamic evolution of the many parameters involved, as well as the public perception of "secure" supply, energy security remains an uninternalised externality or a public good that markets are unable to provide for at the appropriate level. Even in the presence of a globalised marketplace for most energy commodities, energy supply security thus remains a policy issue for which governments need to assume responsibility.

An external and an internal dimension of energy supply security are of importance, in both of which nuclear energy can play a constructive role. The external dimension is mainly defined by concerns about import dependence from potentially unstable countries. The internal dimension instead is about creating appropriate incentive mechanisms and frameworks to allow public and private actors to invest in adequate levels of production and transport capacity that provide continuous access to energy services at stable prices.

As an essentially carbon-free, largely domestic source of energy, nuclear power does indeed possess a number of attractive characteristics for improving the security of energy supply. It is a competitive power generation source with high energetic density and low sensitivity to the variations of the price of uranium, unlike fossil fuel technologies. Uranium resources are also well-distributed, with OECD countries such as Australia, Canada or the United States holding important shares.

This study shows empirically that nuclear energy has in effect contributed to improving energy supply security in OECD countries in a significant manner. It achieved this result by diversifying the energy mix, as well as by decreasing the overall share of fossil fuels, in particular natural gas imported from outside the OECD. The SSDI has been used to analyse energy supply security based on both supply and demand data. This shows that the security of supply situation in OECD countries has unequivocally improved since the early 1970s. This was due to three different factors:

- the introduction of nuclear power for electricity generation;
- a decrease in the energy intensity of OECD countries; and
- greater diversification of primary energy sources.

Quite naturally, the public at large remains unconcerned by the development of complex synthetic indicators. However, individual parameters such as import dependence and price volatility are consistently highlighted as issues of public concern, in particular in the regularly published *Eurobarometer* opinion polls. This suggests that nuclear is viewed more favourably if it is not pushed as an autonomous issue for its own sake but integrated into the context of broader policy objectives such as ensuring the security of energy supply or the reduction of greenhouse gas emissions. Nuclear energy is no longer a quasi-ideological "yes" or "no" issue. This insight holds both promises and challenges for nuclear energy. The promise is to become accepted as an essential element of broad energy policy strategies. The challenge is to bring about an evolution in its features and decision-making mechanisms to engage in real public debate on issues of concern to the general public as well as to energy investors.

Due to its large fixed costs (not only at the level of the individual plant but also at the level of education, regulatory infrastructures, fuel cycle strategies, etc.), nuclear energy will never be wholly an ordinary industry. Nevertheless, as a concrete response to real problems, nuclear is now being viewed more dispassionately and judged on its merits as a solution to questions of security of supply, cost stability and reductions in greenhouse gas emissions.

References

BP (2009), *BP Statistical Review of World Energy June 2009*, BP p.l.c., London, United Kingdom, www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english.

EC, *Eurobarometer*, European Commission, Brussels, Belgium.

ECOFYS, ERAS, REDPOINT (2009), *Analysis of impacts of climate policies on energy security. Final Report*. Report prepared for DG Environment of the European Commission. London/Utrecht.

IEA (2010a), *Energy Statistics*, International Energy Agency, Paris, France.

IEA (2010b), *Energy Technology Perspectives*, International Energy Agency, Paris, France.

IEA/NEA (2010), *Projected Costs of Generating Electricity: 2010 Edition*, International Energy Agency, OECD, Paris, France.

NEA (2006), *Forty Years of Uranium Resources Production and Demand in Perspective – The Red Book Retrospective*, OECD, Paris, France.

NEA/IAEA (2010), *Uranium 2009: Resources, Production and Demand*, OECD, Paris, France.

NEA/IAEA (2008), *Uranium 2007: Resources, Production and Demand*, OECD, Paris, France.

Stern, N. (2006), *Stern Review: The Economics of Climate Change*, Cambridge University Press, Cambridge, United Kingdom.

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