Nuclear energy and the security of energy supply

E. Bertel *

Security of energy supply was a major concern for OECD governments in the early 1970s. Since then, successive oil crises, volatility of hydrocarbon prices, as well as terrorist risks and natural disasters, have brought the issue back to the centre stage of policy agendas.

Security of energy supply is clearly part of current government concern. Most often, the issue takes on added importance in OECD countries with energy-intensive economies and/or lacking fossil fuel resources. Despite this, after more than three decades of apparent threats on oil supply and prices, the global dependency of OECD countries on imported oil and gas has not been reduced. In fact, their levels of imports have increased and at the same time the demand from non-member countries, China in particular, has progressed at a high rate. This suggests that so far neither market mechanisms nor government policy measures have tackled the security of supply issue completely. Some of the key questions to be asked in order to do so, as highlighted in the findings of a recent joint IEA/NEA workshop on "Security of energy supply for electricity generation"[1], are:

- What is security of energy supply?
- Can it be measured and monitored?
- Is it an issue to be addressed by governments?
- What are the policy measures available to ensure it? And, last but not least,
- Can nuclear energy play a role in "secure" energy mixes?

What is security of energy supply?

Defining security of energy supply is not an "academic" concern; it is a prerequisite, from a decision-making viewpoint, for designing adequate policy measures to ensure security of supply and for monitoring their effectiveness. The definition is needed up front to identify the risks raised by insecurity. Furthermore, the choice of the most efficient policy measures aiming at reducing those risks should rely on robust cost/benefit analyses that cannot be achieved without a clear definition of the goal pursued.

The notion of security of energy supply seems clear enough and may be defined in a broad sense as the lack of vulnerability of national economies to volatility in volume and price of imported energy. However, a precise definition of the concept specifying its boundaries is not easy to obtain. Security of energy supply has economic, social and political dimensions at the same time. Energy system analysts and economists can define the economic aspects, but the social and political dimensions are more difficult to capture. In addition, the analysis of energy system evolution shows that national policies aiming at security of energy supply have different objectives depending on the country context and global situation, and therefore follow different approaches.

It is generally agreed that insecurity of supply may result not only from physical disruptions, but also from increases in the prices of imported energy products. Physical disruptions may be caused by insufficient production or transport capabilities resulting from natural causes, socio-political conflicts or by abuse of market power on the part of monopolistic or oligopolistic producers.

** Dr. Evelyne Bertel (evelyne.bertel@oecd.org) works in the NEA Nuclear Development Division.*

Similarly, a price increase might result from market mechanisms – demand exceeding supply – or from political decisions.

Can security of supply be measured and monitored?

Generally, to assess the importance of a concern and to measure progress towards addressing it, policy makers rely on indicators. Examples of indicators designed by analysts and commonly used by policy makers in the energy field to evaluate the efficiency of alternative policy measures include gross domestic product (GDP), as well as primary energy consumption per capita and per GDP. Regarding security of energy supply, although some indicators have been proposed by economists or other experts, there is no consensus on a set of relevant indicators and consequently no historical series of data available to assess trends in the field.

A number of energy dependency indicators exist which have been measured, reported and stored in databases together with other energy indicators. For example, it is easy to find time series covering, for each imported energy source, ratios of domestic supply versus total requirements and respective shares of each foreign supplier in total supply. The level of strategic inventories and physical capacities of storage are also relevant indicators which are monitored by some countries and international organisations. But indicators of security of energy supply should represent a degree of risk and the risk associated with dependency varies according to the geopolitical situation of the supplier and importer countries as much as, or even more than, the size of imports.

Another way to quantify the value of security of energy supply is to consider it as an externality and to apply the methods used for valuing other externalities such as environmental impacts. Traditionally, environmental externalities are valued either through damage cost estimates or through the "willingness to pay" for avoiding those damages. Both approaches have proven difficult to apply to security/insecurity of supply and published literature on the subject matter remains scarce.

The complexity of the issue explains why well-established and commonly agreed indicators of security of energy supply do not exist yet. Decision makers, therefore, generally rely on a basket of parameters and qualitative assessments. Ongoing academic studies and empirical analyses of past experience provide some insights into trends in security of energy supply, but more needs to be done to gain a better understanding of the impacts of various policy measures. It is generally agreed that more research is necessary on quantifying benefits of security of supply in order to support policy making.

What role for governments?

When the energy sector of OECD countries was regulated, governments were expected to take energy security into account by carefully planning the energy mix of their country, aiming at a diversified and secure portfolio of supply sources. As the liberalisation of energy markets is implemented progressively in all OECD countries, the role of governments in energy policy making is evolving. In liberalised markets, each supply source competes for shares on purely economic/competitiveness grounds, at least in principle, and decisions are taken by private investors not by governments.

In theory, the market should be sensitive to security risks and react accordingly. In the electricity sector, for example, if oil or gas supplies are interrupted or if prices rise dramatically, there is the possibility that electricity generating profits will suffer. However, the capabilities of liberalised markets to address security of supply concerns are not at all demonstrated. Recent trends, including the rush to gas for electricity generation, tend to demonstrate that markets are not very sensitive to security of supply risks.

Several reasons can explain the relative indifference of markets to security of supply. Maybe the market considers that the costs of reducing the risks of supply interruption would exceed the benefits of enhanced security. Or, perhaps the market relies on the government to alleviate the risks, confident that it will intervene for social and political reasons thereby eliminating economic consequences for private industry. Other reasons are quoted by experts but the point is that if markets fail to respond adequately, governments that wish to ensure security of energy supply for social as well as global macro-economic reasons must address the issue.

It does not mean that government regulation is always needed. The rationales for intervention have multiplied in recent years – the enviroment, climate considerations, energy security, protecting vulnerable groups, regional balance, and more.Over-regulating may make the investment climate hostile and be counterproductive. On the other hand, government regulation is a means to internalise external costs and to integrate social concerns in the establishment of market prices. The difficulty is to find the right balance between market mechanisms and regulation to ensure the result at the lowest cost to society.

Measures for ensuring security of supply

Assuming that governments recognise the existence of security of supply risks and decide to address them, many policy measures are available to do so. Moreover, some measures that could address security of supply are also relevant for environmental protection and climate change risk mitigation purposes. The following non-exhaustive list of policy measures provides an overview of the main tools that governments may use to strengthen security of energy supply:

- promoting energy efficiency and conservation through norms, standards, information campaigns, subsidies, etc.;
- imposing a share of "secure" energy sources in new generation capacity;
- introducing taxes on "insecure" energy sources;
- subsidizing "secure/domestic" energy sources;
- supporting investments in energy storage options through norms or regulation;
- implementing tradable permits or certificates for secure energy sources.

Clearly, the list illustrates that the task for governments is to select a relevant policy taking into account uncertainties on indicators and potential adverse impacts of regulation on the effectiveness of energy markets. The adaptation of policy measures to the national context and the evolution of the security of supply risk also raise some issues. For example, political events beyond the control of energy policy makers, such as conflicts in major oil-producing regions of the world, may change drastically the security of oil supply and thereby the value of policy measures taken to alleviate the risks associated with imports from these regions.

As is the case with measures for environmental protection, measures aiming at energy efficiency are win/win options for security of supply as they reduce total demand. Measures to promote domestic sources enhance security of supply, but should be assessed taking into account the relative costs of domestic versus imported sources.

Comparisons between the costs and benefits of enhancing security of supply are essential in support of decision making. Indeed, if the costs are higher than the benefits, society as a whole is losing. The first part of the equation is simple to evaluate in general, but the second is not easy to quantify. Indeed, measuring in strict economic terms the cost of insecurity or the benefit for consumers of secure energy supply at affordable prices is not straightforward. Macroeconomic models and assessments provide some insights into the impact on the national economy of insecurity of energy supply. But ultimately, society's willingness to pay to avoid power cuts and/or gasoline price spikes should be estimated, albeit with some difficulty.

The role of nuclear energy

Nuclear energy offers opportunities for diversifying energy supply and ensuring long-term security. Once technology transfer, if needed, has been achieved, nuclear power plants provide a largely or entirely domestic supply of energy. For this reason, several OECD countries consider nuclear energy as a key policy option for improving security of supply.

The main advantages of nuclear energy in this regard are the limited importance of raw material – natural uranium – in the entire fuel chain producing nuclear electricity, the geopolitical distribution of uranium resources and production capabilities, and the easiness for users to maintain strategic stockpiles of fuel.

Natural uranium is widely available in the world, including in many countries where the geopolitical risk is limited. Its cost represents only a few per cent of the total cost of generating nuclear electricity and therefore uranium price volatility is not a major concern for nuclear power plant owners/operators. Furthermore, maintaining strategic stockpiles representing several years of consumption is physically easy and does not represent a significant financial burden for users.

Reasonably assured uranium resources recoverable at less than 40 USD/kgU represent 25 years of consumption at the present level, while known and total conventional resources recoverable at less than 130 USD/kgU represent respectively 65 and 200 years of consumption. Furthermore, advanced reactors have the potential to reduce significantly the specific consump-

Availability of uranium resources

Million tU	
Reasonably assured resources <40 USD/kgU	1.7
Known conventional resources <130 USD/kgU	4.6
Total conventional resources <130 USD/kgU	14.4
Years of consumption at 2005 level	
Reasonably assured resources <40 USD/kgU	25
Known conventional resources <130 USD/kgU	65
Total conventional resources <130 USD/kgU	200

tion of uranium per kWh of electricity generated; fast neutron breeder reactors, for example, can multiply by 50 or so the amount of energy extracted from natural uranium.

In terms of security of supply the geopolitical distribution of uranium resources and production guarantees against risk of disruption. Known uranium resources are found in countries as diverse as Australia, Canada, the United States, Kazakhstan, the Russian Federation, Namibia, Niger and South Africa. Most producing countries, e.g., Kazakhstan, Niger, Namibia, the Russian Federation and the United States, contribute less than 10% to the total. The two major producers, Canada and Australia with 27% and 20% of the total respectively, are OECD countries.

Shares of uranium resources and production

	% of resources*	% of production**
Australia	23	20
Canada	12	27
United States	7.5	2
Namibia	5.5	7
Niger	5	8.5
South Africa	8.5	2.5
Kazakhstan	18.5	9
Russian Federation	6	8.5
Uzbekistan	2.5	6.5
Ukraine	1.5	2

* Total known resources recoverable at less than 130 USD/tU; ** in 2003.

The various other steps of the fuel cycle present different degrees of security of supply. Some fuel cycle services, such as fabrication and transport, are provided by a wide range of suppliers ensuring security and competitive prices. For others, such as enrichment and reprocessing, the number of suppliers is more limited and the competition less effective. However, there has been no example of supply disruption or signs of risk in this field in the past.

In addition to uranium resource availability, safety, physical protection and non-proliferation regulations may have an impact on the reliability of services delivered by nuclear power plants and the security of nuclear material supply. However, past experience with more than 10 000 reactor-years of operation has shown that such issues have not affected the reliability of nuclear electricity supply.

In countries where a large fleet of standardised reactors is in operation, generic safety problems could require shutting down simultaneously multiple units for refurbishment and upgrade. But such a threat has been a strong incentive for regulators and operators concerned to take efficient preventive measures. Similarly, the evolution of safety regulations could entail in principle extensive unavailability of nuclear power plants needing safety upgrades. However, operators have been able in the past to meet strengthened safety standards without jeopardizing reliability and security of electricity supply.

The international safeguards regime aiming at preventing proliferation of nuclear weapons creates some constraints on nuclear fuel markets associated with declaration, controls and verification of the peaceful uses of nuclear materials. The framework implemented under the auspices of the IAEA does provide, however, a well-defined set of stable rules. Within this framework, complemented by national laws and regulations, nuclear materials for peaceful uses can be traded freely between countries and operators.

Concluding remarks

Energy policy is based on many factors including economic competitiveness, social equity, environmental protection and industrial development goals. From a long-term perspective, the overarching goals of sustainable development will provide the framework for policy making in the energy field, as in other sectors of the economy.

In this context, security and diversity of supply, with their social, environmental and economic dimensions, will remain key drivers in the energy policies of most countries. Better understanding the challenges facing governments and the policy measures available to address them should help in designing and implementing efficient policies. Analysing the role of all energy options, including nuclear energy, is needed to base policy measures on comprehensive, robust assessments. ■

Note:

1. The proceedings of the workshop, held on 24 March 2005 at IEA Headquarters, are available on the IEA and NEA websites.